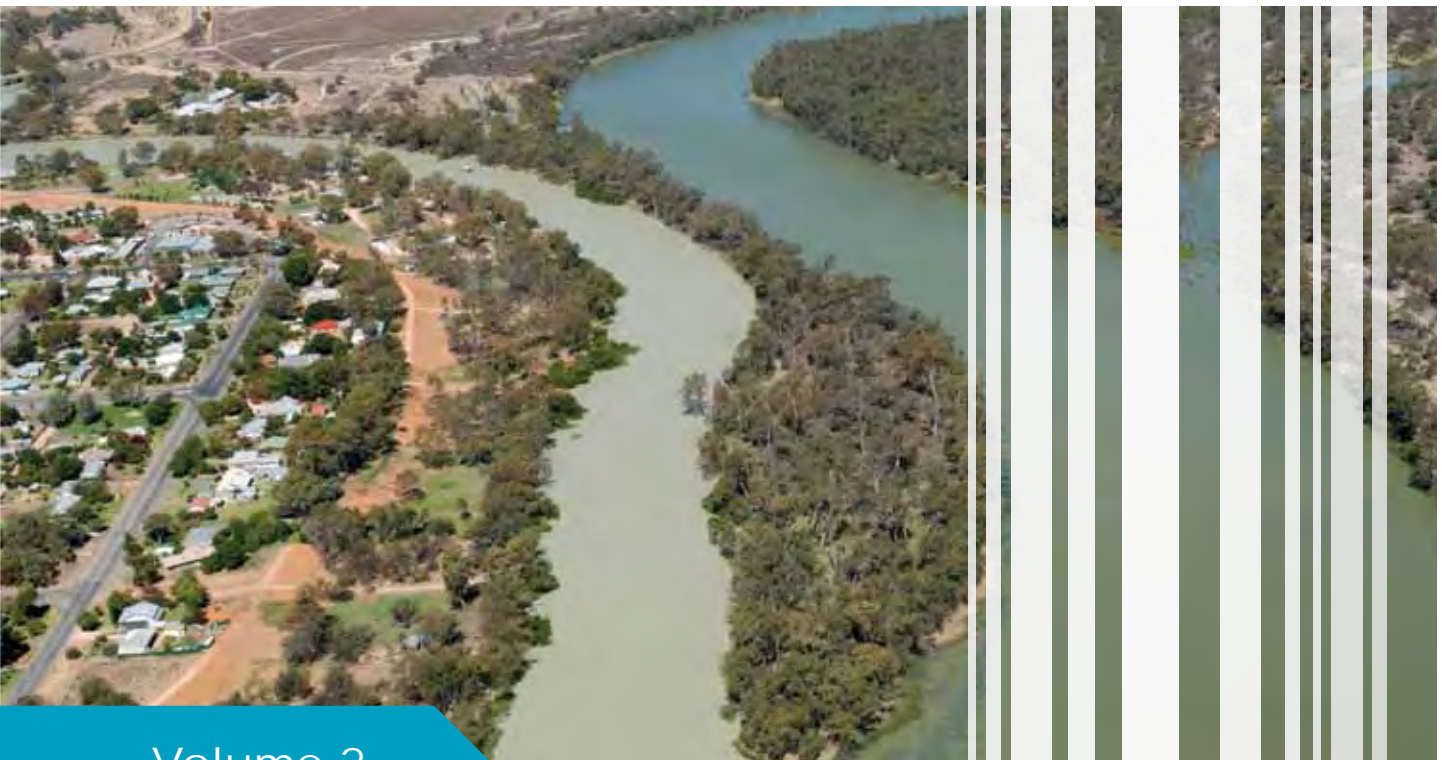




Australian Government



Guide to the proposed Basin Plan



Volume 2

Technical background

Guide to the proposed Basin Plan

Volume 2

Technical background | Part I

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Disclaimer

This document has been prepared by the Chief Executive of the Murray–Darling Basin Authority to inform public discussion about the proposed Basin Plan.

The material in this document has not been endorsed by the Murray–Darling Basin Authority. To the extent that there is a material inconsistency between this document and the *Guide to the proposed Basin Plan: overview*, then the policy intent in the *Guide to the proposed Basin Plan: overview* prevails.

The opinions, comments and analysis (including those of third parties) expressed in this document are for consultation purposes only. This document does not indicate the Murray–Darling Basin Authority's commitment to undertake or implement a particular course of action, and should not be relied upon in relation to any particular action or decision taken. Users should note that developments in Commonwealth policy, input from consultation and other circumstances may result in changes to the approaches set out in this document.

Descriptive information about the Basin, regions within it, and their history and development has been collated primarily from previously published sources. The Murray–Darling Basin Authority makes no warranty as to the accuracy or completeness of this information. Material in this volume is based on the latest information available at the time of writing.

Cover image:

*Junction of the Murray and the
Darling rivers at Wentworth,
New South Wales*



Volumes of the *Guide to the proposed Basin Plan*

The *Guide to the proposed Basin Plan* comprises a series of publications which are being prepared to inform consideration and discussion of the draft Murray–Darling Basin Plan.

While the Basin Plan itself will be a legislative instrument, the *Guide to the proposed Basin Plan* provides information on the background and process of developing all the different parts of the proposed plan. This information includes:

- a summary of the history and current state of Basin water resources
- the factors driving change in use and management of water resources
- the proposed new arrangements under the Basin Plan, and their impacts
- implementation of the Basin Plan.

The volumes of the *Guide to the proposed Basin Plan* are:

- 1 Overview
- 2 Technical background
- 3 Barwon–Darling region
- 4 Border Rivers region
- 5 Campaspe region
- 6 Condamine–Balonne region
- 7 Eastern Mount Lofty Ranges region
- 8 Goulburn–Broken region
- 9 Gwydir region
- 10 Lachlan region
- 11 Loddon region
- 12 Lower Darling region
- 13 Macquarie–Castlereagh region
- 14 Moonie region
- 15 Murray region
- 16 Murrumbidgee region
- 17 Namoi region
- 18 Ovens region
- 19 Paroo region
- 20 Warrego region
- 21 Wimmera–Avoca region

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In preparing this volume of the *Guide to the proposed Basin Plan*, the Chief Executive of the Murray–Darling Basin Authority has drawn on the knowledge and support of many individuals, organisations and communities. Some of these have been involved in developing underpinning information and knowledge, assisting with the development of policy positions, or technical scrutiny of early drafts. On behalf of the authority, the Chief Executive would like to thank everyone for their assistance, including the community members who participated in workshops and forums and provided feedback and comments (see Acknowledgements at the back of this volume).

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Introduction



Chapter 1

*Torrumbarry weir pool on the River Murray, downstream of Echuca,
on the Victorian and New South Wales border*

1.1 Purpose of the *Guide to the proposed Basin Plan*

The Murray–Darling Basin Authority (MDBA) was established by the *Water Act 2007* (Cwlth) and charged with preparing a plan — the Basin Plan — which will provide a foundation for managing the water resources of the Murray–Darling Basin in an enduring and sustainable way.

The Water Act requires MDBA’s proposed Basin Plan to become the basis for public input and consultation before it is provided to the Commonwealth Water Minister for adoption as a legislative instrument.

MDBA has produced the *Guide to the proposed Basin Plan* to assist all interested parties in understanding the basis of the proposed Basin Plan before the formal, legislated consultation process begins. This will enable people to see all the details of what is being proposed in plain English, and the rationale behind MDBA’s proposed positions. In addition, the guide will give interested parties the opportunity to provide MDBA with feedback ahead of the release of the proposed Basin Plan next year.

The *Guide to the proposed Basin Plan* consists of an overview of the Murray–Darling Basin Plan, separate guides to the 19 Basin regions, and this volume — the technical background.

MDBA understands there is significant community interest in what the proposed Basin Plan will contain. Release of the guide will help to ensure stakeholders are fully informed when the proposed plan is released and the formal 16-week consultation period, as required by the Water Act, commences.



River red gum on the bank of the River Murray, Gunbower Forest, Victoria

1.2 What’s covered in this volume

This volume reflects the content of the overview and the regional guides, but at a more detailed level, with more of the technical background identified and explained.

The *Water Act 2007* (Cwlth) requires the Basin Plan to include information about the Basin’s water resources; the uses to which these resources are put; who their users are; and the socioeconomic circumstances of communities dependent on the Basin’s water resources. Chapter 2 of this volume examines all this information in detail.

Chapter 3 deals with the development of the proposed Basin Plan, including the setting of objectives and desired outcomes aimed at addressing risks to the Basin’s water resources and establishing a sustainable framework for managing the Basin’s water resources into the future. The chapter also explains the proposed water management boundaries, and describes the evidence base that underpins the proposed Basin Plan.

The proposed long-term average sustainable diversion limits (SDLs) on the volume of water that can in future be taken from the Basin’s water resources and aquifers are discussed in Chapter 4, together with a description of the

Basin's environmental assets and of the socioeconomic information that is helping to develop the SDLs. The chapter also discusses the effects of climate change on the SDLs, and explains the proposed provisions for critical human water needs (as defined in the Water Act).

The transition to the new arrangements is examined in Chapter 5, including the time frames for commencement and measures that will be undertaken in the adjustment period to provide support to entitlement holders and communities. These include risk allocation, temporary diversion provisions and other assistance under the Water for the Future program.

Chapter 6 examines the implementation of the new arrangements, detailing in particular the framework of two major elements required by the Water Act to be included in the Basin Plan — the Environmental Watering Plan and the Water Quality and Salinity Management Plan. The chapter also looks at the rules governing water trade, the requirements that must be met before a water resource plan will be accredited and the accreditation process itself.

A discussion of the Murray–Darling Basin Authority's strategies to monitor implementation of the Basin Plan's measures can be found in Chapter 7; specifically, how compliance will be enforced and non-compliance dealt with, along with details of the monitoring, evaluation and reporting framework. Finally, the chapter contains information on the ongoing process of reviewing the Basin Plan itself.

1.3 Role of the Commonwealth

Murray–Darling Basin Authority

The *Water Act 2007* (Cwlth) requires the Murray–Darling Basin Authority (MDBA) to develop a Basin Plan that will provide for the long-term integrated management of the Basin's water resources, so as to promote the objectives of the Water Act.

The Basin Plan is required to:

- describe the Basin water resources
- identify water resource plan areas and water accounting periods
- identify the risks to the condition or continued availability of Basin water resources and strategies to manage those risks
- specify management objectives and outcomes to be achieved by the Basin Plan
- set long-term average sustainable diversion limits (SDLs) that reflect an environmentally sustainable level of take for the Basin's surface-water and groundwater resources
- set temporary diversion provisions
- specify the method for determining compliance with SDLs
- include an Environmental Watering Plan
- include a Water Quality and Salinity Management Plan
- specify accreditation requirements for water resource plans
- specify water trading rules
- specify a program for monitoring and evaluating the effectiveness of the Basin Plan



Waterbirds on Mundoo Island at the mouth of the River Murray, South Australia

- specify various matters in relation to providing for critical human water needs, including the volume of water required to meet critical human water needs in the River Murray system
- identify the Commonwealth's share of risks arising from changes to the volume or reliability of water allocations.

Commonwealth Water Minister

Under the Water Act, the Commonwealth Water Minister is responsible for adopting the Basin Plan.

After the plan commences, MDBA is responsible for implementing and enforcing the Basin Plan. The minister's central role in this is to determine, on considering MDBA's recommendations, whether or not to accredit water resource plans as being consistent with the Basin Plan. Once a water resource plan is accredited it will provide certainty of water management arrangements in that local area for up to 10 years.

The minister has a number of other related roles including:

- certain step-in powers with respect to water resource planning activities
- determining any payments to be made by the Commonwealth under the risk allocation framework
- making water charge and water market rules
- requesting MDBA to review the Basin Plan if the minister considers that the plan's outcomes are not being achieved or its objectives are no longer appropriate for all or part of the Basin's water resources.

The minister also chairs the Murray–Darling Basin Ministerial Council.

Commonwealth Environmental Water Holder

The Water Act established the office of Commonwealth Environmental Water Holder, which is responsible for managing the Commonwealth's environmental water holdings for the purpose of protecting and/or restoring the Murray–Darling Basin's environmental assets and those of other areas outside the Basin where the Commonwealth holds water (Department of the Environment, Water, Heritage and the Arts 2010a).

Water held and managed by the Commonwealth Environmental Water Holder helps to ensure Australia's compliance with commitments made under international agreements (such as the Convention on Wetlands of International Importance, also known as the Ramsar Convention). For example, in 2008–09, 10.9 GL of water from Commonwealth environmental water holdings were used at 10 sites in South Australia, Victoria and New South Wales (Department of the Environment, Water, Heritage and the Arts 2010b). This watering program was aimed at protecting mature river red gum (*Eucalyptus camaldulensis*) communities, pockets of healthy ecosystems in drought-affected floodplains and wetlands, and refuges for threatened species, such as the Murray hardyhead (*Craterocephalus fluviatilis*) and the southern bell frog (*Litoria raniformis*) (Department of the Environment, Water, Heritage and the Arts 2010b).

Once the Basin Plan comes into effect the Commonwealth Environmental Water Holder must manage the water it holds in the Basin in accordance with the Environmental Watering Plan.

Australian Competition and Consumer Commission

According to the Water Act (s. 22(1) item 12), the Basin Plan must include rules for the trading and transfer of tradeable water rights, to ensure a Basin-wide approach to water trade. MDBA is required to obtain and have regard to the advice of the Australian Competition and Consumer Commission in preparing water trading rules under the Basin Plan (s. 42 (2)).

On 6 March 2009, the commission released an issues paper seeking stakeholder views on water trade within the Basin; 21 submissions were received in response. The commission then released its *Water trading rules position paper* on 10 September 2009; 18 submissions were received in response.

The Australian Competition and Consumer Commission released its draft advice on the development of water trading rules on 17 December 2009. The stakeholder consultation on the draft advice closed on 1 February 2010. The commission provided its *Water trading rules: final advice* to MDBA in March 2010.

National Water Commission

Under the Water Act, the National Water Commission may audit the effectiveness of the implementation of the Basin Plan. The first audit must be completed within five years of the commencement of the Water Act (which will be March 2013) and subsequent audits must be completed within five years of each previous audit. The National Water Commission must give the Commonwealth Water Minister a written report on each of its audits and give copies of the report to MDBA and to the relevant minister of each Basin state.

The National Water Commission will periodically report on the plan's implementation, while MDBA will continue to monitor and evaluate the impact and effectiveness of plan provisions.

Bureau of Meteorology

As part of its new role in water information under the Water Act (s. 120), the Bureau of Meteorology is developing a water information service, the Australian Water Resources Information System. This system will consolidate information on water flow, water storage, groundwater, water trading and water quality from more than 200 sources across Australia (Bureau of



Canoeing on environmental flows in Gunbower Forest, 2002, Victoria

Meteorology 2010). The Bureau of Meteorology also has an obligation to collect water information, including information about rights, allocations and trades in relation to water. The bureau gathers information on a national level, while MDBA focuses on more specific and detailed information for the Basin. MDBA will work with the bureau and other relevant agencies to enable coordination of these functions.

1.4 Role of the Basin states

The Australian Government and Basin states (Queensland, New South Wales, the Australian Capital Territory, Victoria and South Australia) are signatories to the Murray–Darling Basin Agreement, the purpose of which is to promote and coordinate effective planning and management for the equitable, efficient and sustainable use of the water and other natural resources of the Basin. Signatories to this agreement have membership on the Murray–Darling Basin Ministerial Council and as such are an integral part of the planning and management process.

As the holders of data, information and knowledge about the Basin’s water resources and environmental assets, Basin states play a key supporting role in relation to the Basin Plan’s development. Basin states must be and are being consulted in the preparation of the proposed Basin Plan.

After the Basin Plan is adopted, the Basin states will continue to administer water entitlement and allocation arrangements through their water resource plans. These water resource plans will be progressively reviewed under state and territory legislation and amended so that they are consistent with the Basin Plan’s diversion limits and other requirements. A process of accreditation will be used to ensure that the water resource plans are consistent with the Basin Plan — this involves the Murray–Darling Basin Authority (MDBA) providing advice to the Commonwealth Water Minister as to whether the water resource plan is consistent with the Basin Plan.

Basin states must act consistently with the Basin Plan, which will require them to undertake various activities such as monitoring, evaluation and planning for environmental watering. The Water Act requires the Basin states to report annually on compliance with the plan’s diversion limits.

1.5 What's next

With the release of the *Guide to the proposed Basin Plan*, the Murray–Darling Basin Authority (MDBA) will commence a period of explaining its proposals for the Basin Plan. The proposed Basin Plan itself will be in the form of a legislative instrument. When it is released, together with a plain English summary, the official public consultation period will commence (under the *Water Act 2007* (Cwlth); this must last for a minimum of 16 weeks), and the process of informing, explaining and listening will continue. The community will be invited to provide feedback on the guide and make submissions on the proposed Basin Plan; further information will also be available through peak bodies and at MDBA's website, www.mdba.gov.au. The website will explain how feedback or submissions can be made and how other information on the proposed Basin Plan can be accessed. MDBA can also be contacted by calling 1800 230 067 or emailing engagement@mdba.gov.au.

Submissions received will be published on the MDBA website, and when the public comment period has finished, a summary of the submissions received will be produced, together with information on any resulting amendments to the plan.

When MDBA has taken comments into account, the Murray–Darling Basin Ministerial Council will consider the proposed Basin Plan, together with MDBA's assessment of the likely socioeconomic implications of any reductions to diversion limits. MDBA will then present the proposed plan to the Commonwealth Water Minister for consideration and adoption. It will become law when the minister adopts it, which is expected to happen in 2011.

The long-term average sustainable diversion limits (SDLs) set out in the Basin Plan will not be implemented until existing water plans are replaced by accredited water resource plans that include the SDLs and other elements required by the Basin Plan. The current plans begin to be replaced in 2012 and will be completely replaced by 2019. Once accredited, the water resource plans will remain in effect for 10 years, with the possibility of a one-year extension period.

Restoring the Murray–Darling Basin to health and managing its resources sustainably into the future will be an ongoing and evolving task, and to reflect this, the Basin Plan will be reviewed and revised as the consequences of its application are monitored and evaluated, and as knowledge about the Basin expands.

The Murray–Darling Basin



Chapter 2

*Phragmites australis, the common reed,
at Lake Wetherell, Menindee Lakes, New South Wales*

The *Water Act 2007* (Cwlth) (s. 22(1) item 1) requires the Basin Plan to include information on all aspects of the water resources of the Murray–Darling Basin, and specifies that the plan must describe:

- (a) the size, extent, connectivity, variability and condition of the Basin water resources; and
- (b) the uses to which the Basin water resources are put (including by Indigenous people); and
- (c) the users of the Basin water resources; and
- (d) the social and economic circumstances of Basin communities dependent on the Basin water resources.

This chapter discusses all these aspects of Basin water resources in detail.

2.1 A description of the Basin

The Murray–Darling Basin is Australia’s most iconic river system, defined by the catchment areas of the Murray and Darling rivers and their many tributaries. Table 2.1 summarises some key facts about the Basin.

Comprising 23 river valleys, the Basin extends over 1 million km² of south-eastern Australia, covering three-quarters of New South Wales, more than half of Victoria, significant portions of Queensland and South Australia, and all of the Australian Capital Territory. Figure 2.1 shows the 19 regions of the Basin used for the Basin Plan. The regions used by CSIRO for its Murray–Darling Basin Sustainable Yields Project (CSIRO 2008), also used as the basis for some of the statistics presented in the *Guide to the proposed Basin Plan*, are shown in Figure 2.2.

A consequence of the extent of the Basin is the great range of climatic and natural environments; however, most of the Basin is arid or semi-arid, with a narrow humid region along the east and south. The environments range from the rainforests of the cool eastern uplands, to the temperate mallee country of the south-east, the inland subtropical areas of the far north, and the hot, dry semi-arid and arid lands of the far western plains. In the north are semi-arid ephemeral river systems, while in the south, highly regulated river systems are fed from the Australian Alps.

To the east and south, the highlands of the Great Dividing Range form the limit of the Basin, while in the north, west, and south-west the boundaries are much less distinct. By far the greater proportion of the Basin comprises extensive plains and low undulating areas, mostly below 200 m above sea level.

Table 2.1 Fast facts: Murray–Darling Basin

Attribute	Murray–Darling Basin
Area ^a	1,042,730 km ² (14% of mainland Australia)
Average annual rainfall (1997–2006) ^b	469 mm
Long-term average annual rainfall (1895–2006) ^c	457 mm
Population ^d	2,100,000 (10% of the Australian population)
Gross value of agricultural production ^d	\$14,991 million (39% of the national value)
Average annual inflows (includes inter-Basin transfers) ^e	32,800 GL
Major water storage capacity ^e	22,663 GL
Average annual outflows (modelled) ^e	5,105 GL

a MDBA calculation based on GIS data

b Potter et al. (2008)

c CSIRO (2008)

d ABS, ABARE & BRS (2009)

e MDBA unpublished modelled data

The headwaters of the Murray and Darling rivers and most of their tributaries rise in the Great Dividing Range. These mountains are not high by world standards and the rivers have a low gradient for most of their length as they flow across extensive riverine plains. This is especially the case in the catchment of the Darling in the north, where the mountains in which the rivers rise are lower than in the Murray catchment in the south (Young et al. 2001).

The natural environment of the Basin includes vast floodplains at the heart of a system of over 30,000 wetlands that supports biodiversity of national and international significance. The Basin has one World Heritage site (the Willandra Lakes Region), 16 wetlands listed under the Convention on Wetlands of International Importance (the Ramsar Convention), and in excess of 200 listed in *A directory of important wetlands in Australia* (Environment Australia 2001; CSIRO 2008). The Basin is also home to around 45 species of native fish (Lintermans 2007), 35 endangered species of birds and 16 endangered species of mammals (Department of the Environment, Water, Heritage and the Arts 2010a).

Across the Basin from the south and east to the north and west, average annual rainfall decreases, and evaporation and climate variability generally increase. Overall, the climate of the Basin varies greatly from year to year, which means that flows in the rivers of the Basin are highly variable and unpredictable, and the Basin has a long history of floods and droughts (Puckridge et al. 1998; Young et al. 2001; Arthington & Pusey 2003).

Water run-off in the Basin is very low compared with other major river systems around the world; river systems in the Basin also experience much higher flow variability than those of any other continent. Inflows from rainfall to the rivers of the Basin have ranged from around 117,907 GL in 1956 to around 6,740 GL in 2006 (MDBA unpublished modelled data). The average annual flow of the River Murray is only about 16% of that of the Nile, 3% of the Mississippi and just 0.25% of the Amazon (McMahon et al. 1992). See Figure 2.3 and Figure 2.4 for information on run-off and evapotranspiration in the Basin.

Australia's social and economic development owes much to the Basin's water resources. For thousands of years, the Basin's land and waters have provided natural resources for its Aboriginal peoples, for whom these resources have always held deep spiritual significance. The health of the Basin's environmental assets is therefore of great consequence to its original inhabitants.

By 2006, 2.1 million people living in the Basin were directly reliant on Basin water resources, with 1.3 million outside the Basin also fully or partly dependent on this supply (ABS 2009). For example, River Murray water is supplied to many communities, both within and outside the Basin. Many towns on the river draw water directly, but major pipeline systems now transport water great distances.



Pelicans on the Goolwa Barrage near the mouth of the River Murray, South Australia



Figure 2.1 Basin Plan regions

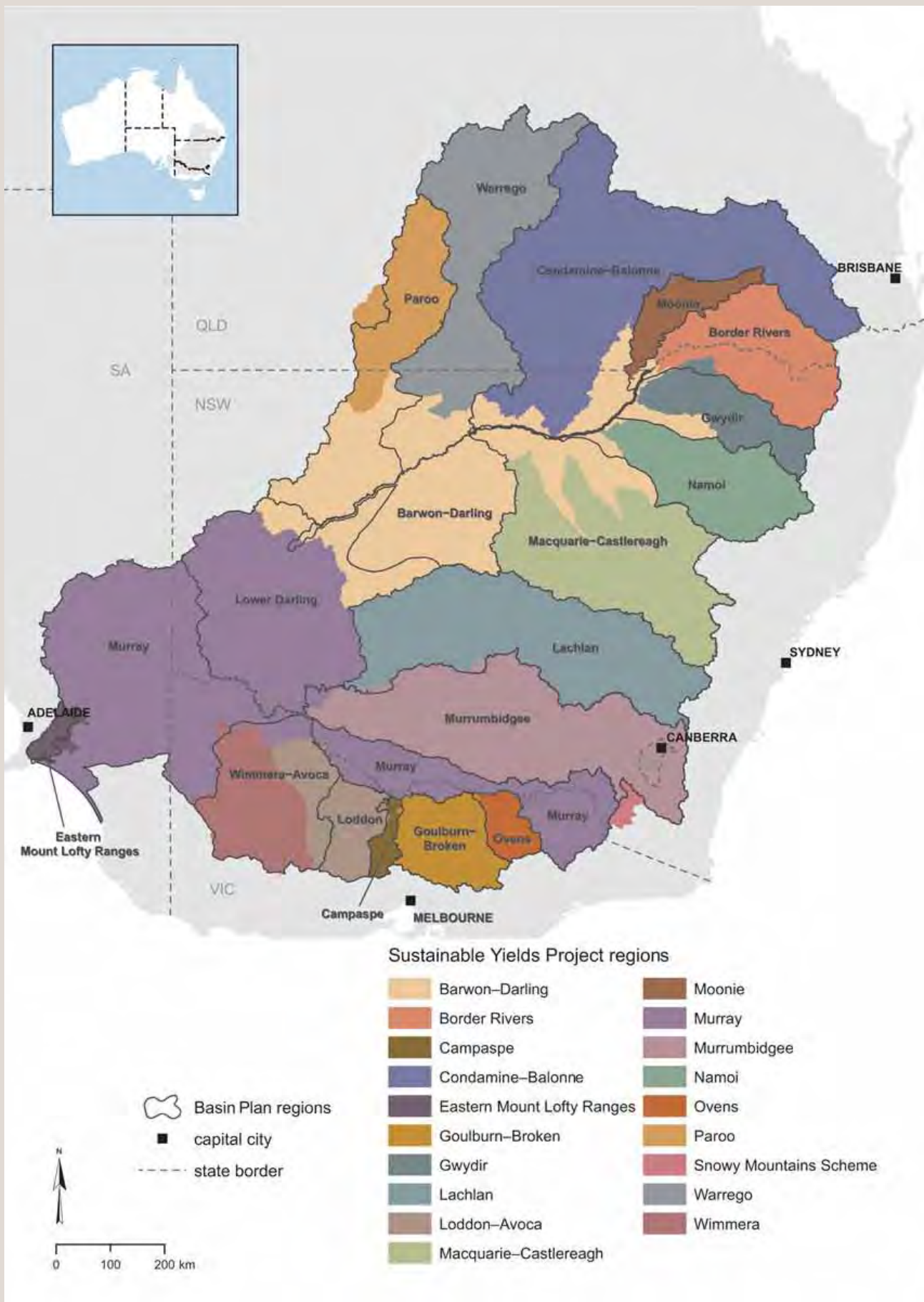


Figure 2.2 CSIRO Murray-Darling Basin Sustainable Yields Project regions



Figure 2.3 Mean annual run-off, 1895–2008

Source: Mean annual run-off modelled using the method in the CSIRO Murray–Darling Basin Sustainable Yields Project (Chiew et al. 2008; CSIRO 2008)

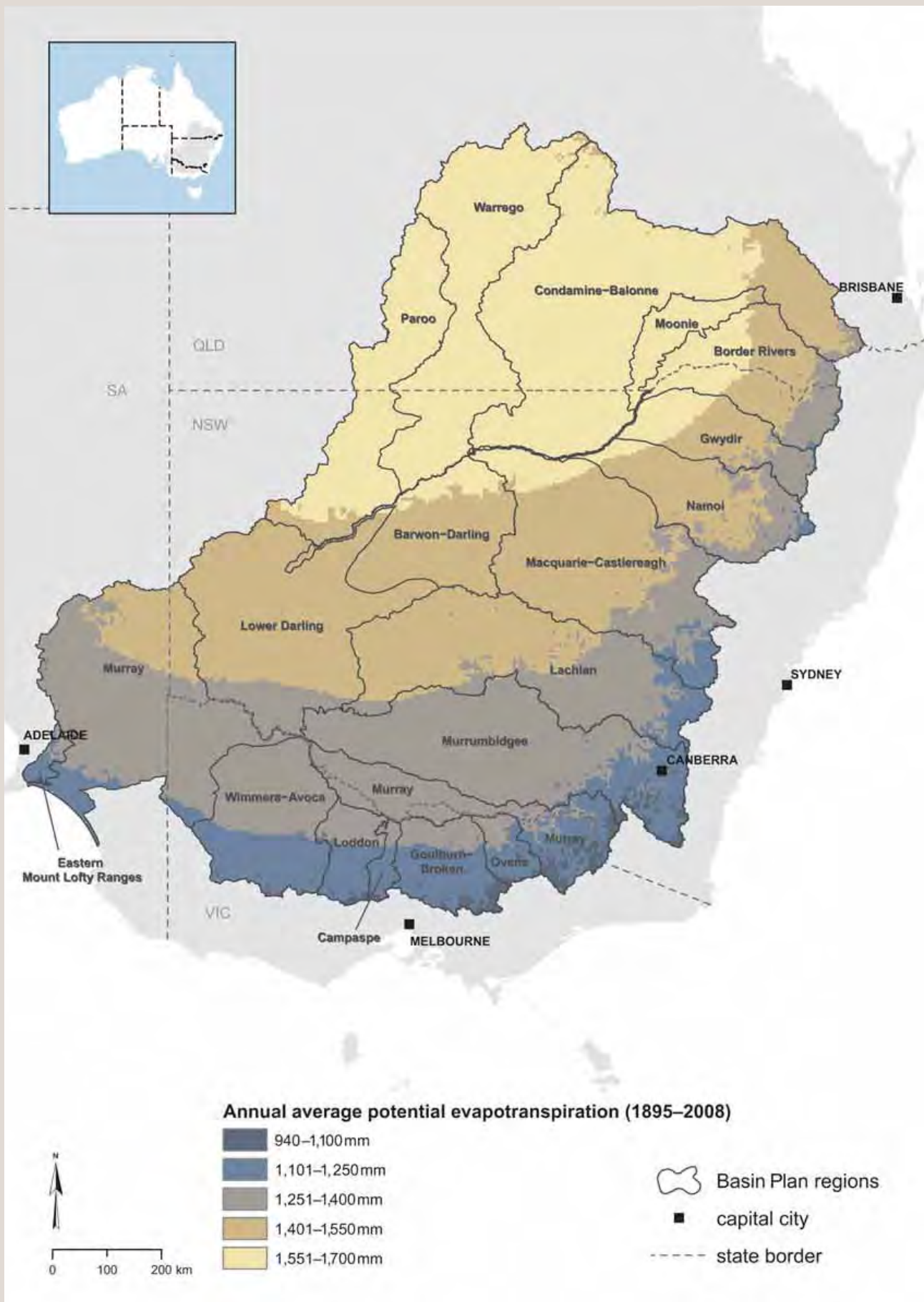


Figure 2.4 Annual average potential evapotranspiration, 1895–2008

Source: Mean annual potential evapotranspiration calculated from SILO gridded data using Morton's wet environment algorithms (Morton 1983; Chiew & McMahon 1991)

In Victoria, the Northern Mallee Pipeline Project, which started in 1992 and was subsequently extended, provides water from the River Murray to communities from Swan Hill to Ouyen, and surrounding districts. The Wimmera Mallee Pipeline system draws water from the Murray for the Berriwillock–Culgoa area (Department of the Environment, Water, Heritage and the Arts 2010c). More recently, with construction starting in 2007, the Goldfields Superpipe has been built to connect Ballarat and Bendigo to the Goulburn River system (Victorian Department of Sustainability and Environment 2010a). The Sugarloaf Pipeline, completed in 2010, connects Melbourne’s water supply to the Goulburn River (Victorian Department of Sustainability and Environment 2010b).

South Australia has long depended on the River Murray for regional and Adelaide water supply. Construction of the Morgan – Port Augusta – Whyalla Pipeline was completed in 1944. Extensions were made from the original pipeline from Port Augusta to Woomera, with branches serving Iron Knob, Jamestown, Peterborough and numerous other country towns and farming areas. In 1962, construction began on a duplicate pipeline to Whyalla. The Mannum–Adelaide Pipeline has operated since 1955 to supply River Murray water to Adelaide. A second pipeline to Adelaide, from Murray Bridge to the Onkaparinga River, was constructed from 1968 to 1973. The Swan Reach – Stockwell Pipeline supplements supplies to the Barossa Valley, Lower North and Yorke Peninsula areas. Thirteen towns and a large agricultural area in South Australia’s upper south-east region are supplied with water via the Taillem Bend – Keith Pipeline (Atlas of South Australia 2000–2010).

The Basin contains approximately 40% of all Australian farms, and produces wool, cotton, wheat, sheep, cattle, dairy products, rice, oilseeds, wine, fruit and vegetables for domestic and overseas markets (ABS 2009). Agriculture also provides the raw materials for most of the manufacturing activity within the Basin and for many processing companies outside the Basin. Today, farming, forestry and pastoral industries cover nearly 80% of the land in the Basin and, with inland fisheries, generate more than 40% of the gross value of Australian agricultural production. The Basin also generates 3% of Australia’s electricity and 33% of its hydro-electricity (ABS 2008).

Since before Federation, successive governments have championed the use of water for agriculture to encourage economic and social development within the Basin. There has been considerable investment in water storage and delivery infrastructure by the Australian and state governments, and through private investment, over more than 100 years (Martin 2005). As a result, agriculture is the primary water user in the Basin, accounting for around 83% of consumptive water use in 2004–05 (ABS, ABARE & BRS 2009, p. vi). The storage, release and use of water to meet the needs of irrigated agriculture are increasingly understood to conflict with the needs of natural ecosystems (Davies et al. 2008).

Historical setting

The Basin landscape has been home to Aboriginal people for at least 50,000 years, sustaining their cultural, social, economic and spiritual life. Trade routes, major gathering places and sacred sites exist across the length and breadth of the Basin.

In 1824, explorer Hamilton Hume and navigator William Hovell crossed the Murrumbidgee River and ventured into mountainous country, eventually reaching the Murray (which they named the Hume); they were the first Europeans to set eyes on the river. They then headed south-west, and crossed the Ovens River and the Goulburn River (which they named the Hovell). Captain Charles Sturt reached the Hume River in 1830 and named it the Murray after the British secretary of state for the colonies, Sir George Murray (Australian Dictionary of Biography 2006).

The Murray Mouth area was explored by Captain Collet Barker in 1831. Cattle drovers followed after 1838, bringing cattle and sheep from New South Wales to Adelaide. Squatters settled along the riverfronts and established pastoral runs and homesteads (Wood, Edmonds & Westell 2005).

In 1852, Francis Cadell became the first European to travel the whole length of the River Murray. Six years later, Victorian Government zoologist William Blandowski, with Gerard Krefft, explored the lower reaches of the Murray and Darling rivers, compiling a list of birds and mammals found there (Blandowski 1858).

In the north of the Basin, botanist Allan Cunningham (1791–1839) was the first European to explore the Darling Downs region in 1827 and 1828. He found a pass through the Great Dividing Range, subsequently named Cunninghams Gap, leading from the penal settlement and the coast at Moreton Bay to the inland (Powell 1991). Early squatters and then pastoralists established large sheep and cattle properties throughout the northern parts of the Basin.

European farming practices and industries changed the landscapes of the Murray–Darling Basin and diminished the ready availability of natural food and other resources. Encroachment on Aboriginal lands by Europeans reduced Aboriginal peoples' access to spiritually and culturally significant sites and areas (Long & Edmonds 1997).

The paddle-steamer trade on the River Murray had its origins in 1853 when the South Australian Government offered a prize of £2,000 for each of the first two iron boats to sail from Goolwa to the Darling River junction. The steamboat trade was soon established (MDBC 2003a) and thrived until the railway reached Echuca in 1864 (Department of the Environment, Water, Heritage and the Arts 2008a).

In the late 1890s and early 1900s, major rail lines were extended to regional towns, boosting the Basin's economic development by providing access to the growing townships and transport for inbound and outbound goods and services. Trains also transported water supplies to the towns that were without their own water during drought (Ward & Associates 1986). The expanding regional rail network led to a decline in shipping along the river (Painter 1993; Powell 1993).



Construction of Lock 8 on the River Murray west of Wentworth, 1935, New South Wales

Harnessing the water resources

Since European settlement of the Murray–Darling Basin in the mid-1840s, water resources have been controlled for consumption, including for agriculture, irrigation, manufacturing and domestic use. This, combined with the subsequent growth in the dependent population and economy, has placed increasing pressure on the Basin’s water resources.

Small-scale pumps began drawing water from the Murray in the 1850s, and the first large-volume pumps for irrigation were constructed by the Chaffey brothers at Renmark and Mildura in 1887 and 1888 (Painter 1993). The introduction of pumping stations along the river and the major tributaries promoted an expansion of farming and led ultimately to the development of many irrigation areas. There was early concern expressed by other users who relied on the river system for shipping, and for domestic and stock water supply; from the late 1800s, water levels in the region around the Lower Lakes were said to be adversely affected (Sim & Muller 2004).

The Federation drought (1895–1902) increased the use of large-scale irrigation, both to alleviate the effects of drought and to support regional development and settlement (Boughton 1999).

Following World War I, state governments (and after World War II, the Australian Government) set up schemes in the southern Basin to settle returned soldiers on smallholdings in irrigation areas (Powell 1993). The irrigation schemes of the early 20th century aimed to increase agricultural productivity in the dry hinterland of the Basin and were seen by the governments of the day as ‘nation building’. From the 1960s, extensive private investment resulted in further expansion in irrigated areas.



Release of water from Jounama Dam into Blowering Dam, New South Wales

In the north of the Basin, the irrigation industry boomed in the 1980s and 1990s. Cotton was the major commodity; other crops included cereals, oilseeds and fodder (Crabb 1997).

During the 1880s the importance of the Great Artesian Basin and its water supply was recognised. In 1882, hydraulic engineer John Henderson successfully bored for subartesian water near Cunnamulla in southern Queensland (Powell 1991). By 1890, pastoralists had proved that groundwater could be found at various depths across the entire Western Downs area (Powell 1991) and by 1892 a government artesian bore had been created at Muckadilla, west of Roma, with a depth of 994 m and a daily yield of 0.1 ML (Powell 1991). Most bore drains were left as large open distribution drains. The tapping of the Great Artesian Basin in the early 1880s and 1890s provided an alternative water supply for sheep and cattle.

Widespread development of groundwater resources began in the 1960s with the advent of rotary drilling technology (CSIRO 2008). To date, the most developed areas of groundwater use are in the Lower Murrumbidgee, Lower Murray, Namoi, Lower Lachlan, Lower Macquarie and Upper Condamine.

Major infrastructure

Major water supply and water regulation infrastructure has been built by Australian and state governments on the river systems and in the headwaters over more than 100 years.

Most of the major tributaries of the Murray and Darling rivers have headwater storages, with dams on the Macintyre Brook and Pike Creek (both in Queensland), the Macintyre, Gwydir, Namoi, Macquarie, Lachlan and Murrumbidgee rivers (in New South Wales), the Murray (on the New South Wales and Victorian border), and the Mitta Mitta and Goulburn rivers (in Victoria). Several are described further in this chapter.

In New South Wales a comprehensive scheme was approved in 1906 that included the building of Burrinjuck Dam and Berembed Weir in the Murrumbidgee region. By 1912 the scheme was supplying water for irrigation to the Murrumbidgee Irrigation Area in the New South Wales Riverina region (Boughton 1999).

In Victoria, Lake Eildon (then known as Sugarloaf Reservoir) was built between 1915 and 1929. There followed a series of enlargements, the first immediately following its construction, and again in 1935, increasing the storage capacity to 377 GL. Further expansion took place between 1951 and 1955, taking the capacity to today's 3,334 GL, six times the size of Sydney Harbour. The enlarged reservoir was renamed Lake Eildon (Goulburn–Murray Water 2007a).

On the Murray, the Hume Dam, now jointly managed by Victorian and New South Wales authorities on behalf of the Murray–Darling Basin Authority (MDBA), was constructed between 1919 and 1936. Initially named the Mitta Mitta Dam, it was renamed in 1920 in honour of Hamilton Hume (Goulburn–Murray Water 2007b). Between 1934 and 1939 a diversion weir was constructed at Yarrawonga, the point of greatest diversion of water from the River Murray (MDBC 2006a).

In 1915 New South Wales, Victoria and South Australia also agreed to construct 26 weirs and locks on the Murray; only 14 were in fact constructed. A further two were constructed on the Murrumbidgee (of the agreed nine weirs and locks) to maintain more than 1,600 km navigable waters all year round — from the river's mouth near Goolwa to Echuca and on the Murrumbidgee as far as Hay. Lake Victoria, in the south-western corner of New South Wales, was built in the mid-1920s on a large natural wetland to provide mid-river storage on the River Murray system (Connell 2007).

In South Australia, barrages were completed by 1940 in an attempt to prevent saltwater intrusion from the ocean to the freshwater lakes Alexandrina and Albert, and the lower reaches of the Murray (Penney 1993).

By the 1930s, rising watertables and the resulting increase in salinity were causing major problems in the Murray Mallee region. Between 1934 and 1938, drainage outfall systems for irrigation areas were constructed in the Mildura, Merbein and Red Cliffs areas (Hallows, Lucas & Thompson 1995).

Following World War II, the northern part of the Basin continued to develop. In 1948, building of the Jack Taylor Weir started on the Balonne River to supply water to the township of St George and for irrigation schemes (Powell 1991). The weir was completed in 1953; however, the first associated irrigation farms were not occupied until 1957 (Powell 1991). Irrigation development in the St George and Dirranbandi districts was hampered by a lack of permanent water supply until the introduction of large on-farm

storages. Water could now be pumped into the storages when the rivers flowed, and then used on the irrigated crops as required.

In the 1950s and 1960s, weirs, levees, regulators and channels were installed in the Menindee Lakes to improve the ability of the lakes to store and release water. This increased the reliability of supply for the surrounding area, including Broken Hill (Moore et al. 2002).

In South Australia, pipelines were constructed to deliver River Murray water into regional areas and Adelaide — the Morgan–Whyalla pipeline in 1944 (duplicated in 1962); Mannum–Adelaide in 1954; Murray Bridge – Onkaparinga in 1973; and Swan Reach – Stockwell and Tailem Bend – Keith in the 1960s (Government of South Australia 2004). In Victoria, the Goulburn River – Melbourne pipeline was completed in 2010.

In 1950, work started on enlarging Hume Dam, eventually increasing the storage capacity of Lake Hume from 1,540 to 3,038 GL. This provided more flexibility for river operators and increased security of supply for irrigators (Boughton 1999).



Tumut 3 power station, part of the Snowy Mountains Scheme near Talbingo, New South Wales

The Snowy Mountains Hydro-electric Scheme was constructed between 1949 and 1974. The scheme generates power by making use of the steep drop that several major snow-fed rivers undergo to reach the plains (Water Conservation and Irrigation Commission 1971). The scheme has two separate parts, the Snowy–Tumut and the Snowy–Murray developments. In the Snowy–Murray section, the waters of the Geehi and Snowy rivers (partly diverted at Island Bend Dam) are combined and, after going through two power stations, are released to the Khancoban storage on the River Murray more than 762 m

below (Water Conservation and Irrigation Commission 1971). Similarly, the Snowy–Tumut section diverts the Eucumbene, Upper Murrumbidgee and Tooma rivers to the Tumut River to generate electricity before being released back to the Murrumbidgee River.

During the 1960s and 1970s, elevated levels of salinity emerged as a problem, prompting investigations into salinity across the Basin. Studies included the Murray Valley Salinity Investigation in 1970 and the release of the River Murray Working Party Report in 1975. In response, governments invested in dilution flows, and the building and operation of salt interception schemes. Salinity action plans and land and water management plans were prepared (Chartres et al. 2003) and from around 1990, salt interception schemes were constructed along the Murray between Waikerie in South Australia and Euston in New South Wales.

Dartmouth Dam on the Mitta Mitta River in north-east Victoria was constructed between 1973 and 1979, creating Lake Dartmouth which has a storage capacity of 3,906 GL. Construction costs were shared equally by the Commonwealth and the governments of Victoria, New South Wales and South Australia.

More recently, in response to growing awareness of environmental issues across the Basin, new infrastructure has been developed. This includes the construction of fish passages from Hume Dam to the sea to support implementation of the Native Fish Strategy; and an infrastructure investment program to facilitate water distribution and application at six sites of high ecological value, known as ‘icon sites’, under The Living Murray river restoration program.

2.2 The Basin economy

Much of the Basin economy is based on the use of surface water and groundwater. The consumptive use of water increased steadily over the 20th century, particularly in the decades following World War II, with the spread of irrigated agriculture, manufacturing and other industries, and the increase in the Basin’s population. In particular, the development of irrigated agriculture was a central part of settlement and national development policies in the 20th century (Quiggin 2001). While the consumptive use of water continued to increase throughout the century, its rate slowed somewhat in the 1980s and 1990s (ABS 2007). As a result of drought and low annual inflows, agricultural use of Basin water has declined since 2002 (Figure 2.5).

While there are various competing demands for water within the Murray–Darling Basin, the consumptive use of water is dominated by the irrigated agriculture sector. In 2004–05, agriculture accounted for 7,204 GL (83%) of water use in the Basin (Figure 2.6), while the mining and manufacturing sectors together used around 73 GL of water, equating to less than 1% of total water consumption in the Basin (ABS 2008). Households in the Basin consumed approximately 2% of water resources in 2004–05 (ABS, ABARE & BRS 2009). The remaining 13.8% is accounted for by transmission losses, mainly due to agriculture.

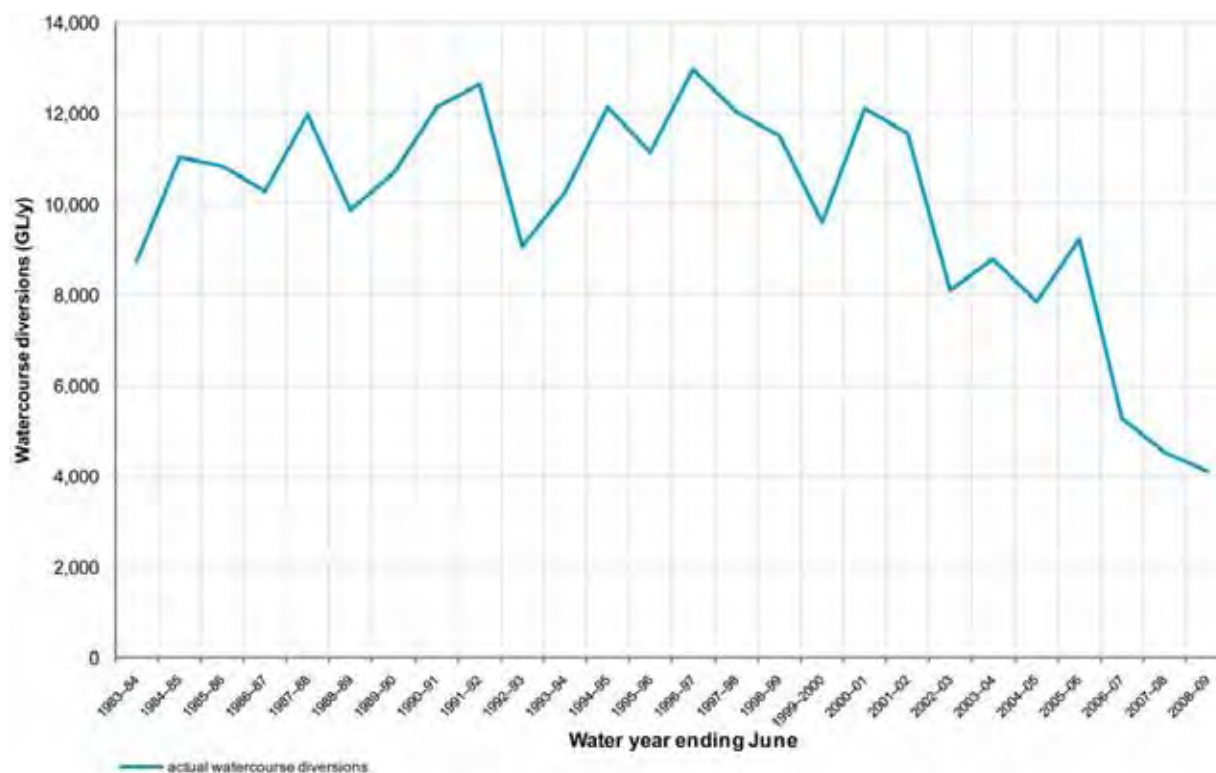


Figure 2.5 Surface-water use, 1983–84 to 2008–09: Murray–Darling Basin

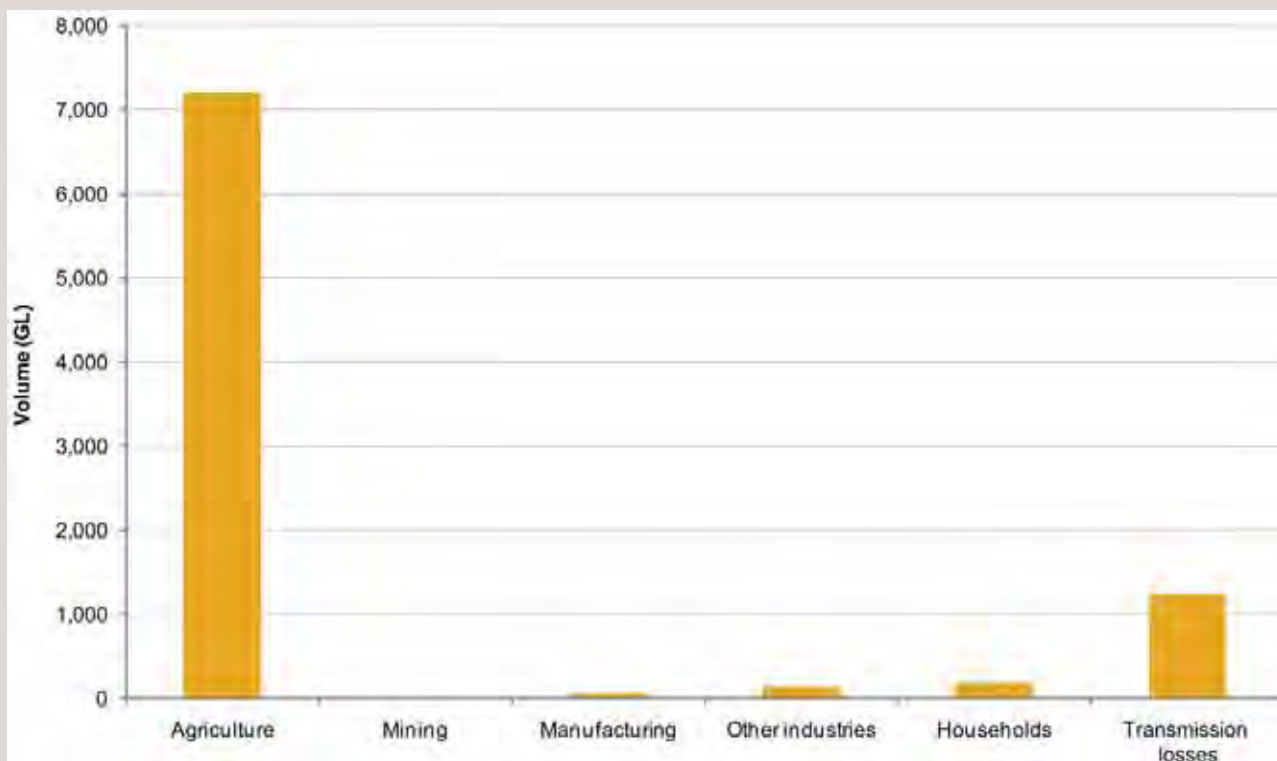


Figure 2.6 Consumptive water use, 2004–05: Murray–Darling Basin

Source: ABS (2008)

Agriculture

The 2005–06 agricultural census (ABS 2009) recorded that the Murray–Darling Basin contributed 39% (\$15 billion) to national agricultural production, representing just over half the agricultural production of the Basin states.

In dollar terms, the most significant commodities produced in the Basin during 2005–06 were grain (\$3.4 billion), beef cattle (\$2.8 billion), and sheep and other livestock (\$1.7 billion). The recent prolonged drought significantly curtailed both cotton and rice production (ABS 2009). The Basin was responsible for 45% (\$5.5 billion) of Australia’s total 2005–06 irrigated production (\$12.2 billion) (ABS 2009).

The Basin is home to a number of important irrigation areas; for example, all of Australia’s irrigated rice is produced in the Murrumbidgee and NSW Murray irrigation regions, and 90% of the nation’s cotton comes from the northern Basin. The Basin also provides 56% of Australia’s total grape crop, 42% of Australia’s total fruit and nut production, and 32% of Australia’s total dairy production (ABS 2009).

Table 2.2 gives details on water use for irrigation in the Basin compared to the whole of Australia, and Table 2.3 shows the gross value of irrigated agricultural production, broken down by key commodities, for the Basin and for the whole of Australia. The dairy industry in the Basin is facing multiple pressures affecting production. Before the global financial crisis, high world prices led to a 150% increase in dairy-farm cash income to an average of \$109,000 per farm, despite increases in expenditure on hay and grains to increase production or, in areas of low water availability, maintain production (ABARE 2009a). Since then, lower world demand has reduced world prices and led ABARE (2009a) to forecast farm cash income to fall to around \$74,000 for 2008–09 and a continuing decline in farm-gate milk price

Table 2.2 Key irrigation statistics, 2008–09: Murray–Darling Basin and Australia

	Murray–Darling Basin		Outside the Basin		Australia	
Number of agricultural businesses	54,098		81,899		135,997	
Total businesses irrigating	15,077		24,863		39,940	
Water use	ML		ML		ML	
Irrigation	3,492,407		3,008,170		6,500,577	
Other uses	260,129		524,928		785,057	
Total water use	3,752,535		3,533,098		7,285,633	
Purchases of extra water	ML	\$,000	ML	\$,000	ML	\$,000
On a temporary basis	500,850	138,166	51,679	8,520	552,529	146,686
On a permanent basis	60,767	90,189	14,506	17,033	75,273	107,222
Sales of water	ML	\$,000	ML	\$,000	ML	\$,000
On a temporary basis	452,018	134,209	44,328	4,414	496,346	138,623
On a permanent basis	282,384	402,315	19,389	18,017	301,773	420,332
Irrigation	\$,000		\$,000		\$,000	
Expenditure	819,280		595,881		1,415,161	
Value of equipment and infrastructure	5,007,488		3,483,562		8,491,050	

Source: ABS (2010)

Table 2.3 Gross value of irrigated agricultural production, 2000–01, 2005–06 and 2006–07: Murray–Darling Basin and Australia

Commodity	Gross value of irrigated agricultural production (\$ million)					
	Murray–Darling Basin			Australia		
	2000–01	2005–06	2006–07	2000–01	2005–06	2006–07
Cereals for grain and seed	148.7	180.3	190.8	167.6	200.3	223.2
Hay	79.9	160.5	175.7	133.8	240.0	295.4
Pastures for seed	3.5	–	–	9.4	–	–
Cotton	1,110.6	797.9	456.9	1,220.5	869.8	485.8
Rice	349.2	273.6	55.0	350.3	273.7	55.0
Sugar cane	–	–	–	308.3	496.9	583.1
Other broadacre activities	–	–	–	102.8	65.7	52.6
Fruit and nuts	701.2	1,011.0	1,207.1	1,454.6	2,137.2	2,913.2
Grapes	785.2	720.8	650.5	1,319.6	1,251.5	1,040.5
Vegetables for human consumption and seed	467.7	554.5	556.3	1,625.5	2,453.2	2,677.9
Nurseries, cut flowers and cultivated turf	90.3	149.8	128.7	536.5	1,165.9	1,187.4
Dairy production	803.6	901.4	762.8	1,553.9	1,877.7	1,697.1
Beef cattle	382.8	592.5	559.1	697.2	968.1	989.0
Sheep and other livestock	125.3	143.3	163.9	189.2	257.2	287.3
Total	5,048.0	5,485.6	4,906.8	9,669.2	12,257.2	12,487.5

Source: ABS (2009)

in 2009–10. Compounding the pressure on the industry is the current high Australian dollar, which reduces farm prices. To the degree that current market conditions persist, the irrigated dairy industry is under pressure, which will continue to drive structural adjustment, including reducing herd size and selling water entitlements (Frontier Economics 2010).

Rice production in the Basin has decreased significantly in the face of low seasonal water allocations as a result of drought conditions. At the same time, commodity prices have increased due to increasing global demand, rising from \$328 per tonne of rice in 2007–08 up to \$550 per tonne in 2009–10. The degree to which rice will remain a viable agricultural product in the short to medium term depends largely on water availability and the degree to which processing infrastructure can re-start after a period of low production (Frontier Economics 2010).

The wine industry in the Basin is facing similar pressures to the dairy industry, including falling prices, slowing export growth and low water availability. Farm profitability will also remain a key catalyst of change in the region, particularly where irrigators, already dealing with low water availability, are facing declining world prices and increasing input costs, all of which place increasing pressure on farm profitability (Frontier Economics 2010).

Cotton production has significantly reduced in recent years in the face of drought that reduced water availability for irrigation. However, irrigated cotton remains the most profitable irrigated broadacre crop in traditional growing areas (ABARE 2009b). Despite smaller areas of planting and pressures from the global financial crisis, crop yields have improved due to the use of transgenic crops and technology improvements (Frontier Economics 2010). Further, ABARE (2009b) expects cotton to remain the most profitable irrigated crop in traditional growing areas over the medium term. Production is projected to increase to around 719,000 tonnes by 2013–14 from a projected 494,000 tonnes in 2009–10. However, this relies on a return to average seasons in terms of water availability.

Mining

The mining industry consumed 0.2% of the total water (around 20 GL) used for consumptive purposes in the Murray–Darling Basin in 2004–05. Most water (80%) used for mining is sourced from groundwater, while only 15% comes from surface water and 5% from mains infrastructure (CSIRO 2009a). Within the mining industry, the highest consumers of water were the metal ore mines and coalmines, with 56% and 29% of total mining water consumption respectively (ABS 2006).

Despite the comparatively low level of water consumption, it is recognised that mining interests are growing in some regions of the Basin. Where water systems are approaching, or are at, full allocation, current and future mining developments could, if not adequately managed and regulated, affect surface-water or groundwater systems at a regional scale (ABS, ABARE & BRS 2009).

General industry

Manufacturing industries in 2004–05 used around 0.5% of the total water consumed in the Basin (ABS 2008). Within the manufacturing sector, the food, beverage and tobacco industries used the highest volume of water, accounting for over a third of total manufacturing water consumption. The next highest users of water were the metal products sector (24%), and then the wood and paper products industry (16%) (ABS 2006).



Historic gold fields in Ophir established in 1851, New South Wales

Recreational use

The Murray–Darling Basin offers many and varied landscapes and features that are known to all Australians and also internationally. For many, recreation is based around their attraction to the natural environments associated with the river (e.g. through pastimes such as bushwalking, camping, boating, fishing and bird watching). Each year the Basin attracts significant numbers of visitors to its natural landscapes and regional towns. Most of those who live on or visit the river engage in some form of passive or active recreation activity, whether land- or water-based (Lethlean 2003).

Household use

Households use water for drinking, food preparation, bathing, washing, and for outdoor uses such as gardening or private swimming pools. Household use of water makes up a small proportion of the use of Basin water resources, accounting for only 2% of Basin water consumption in 2004–05 (ABS, ABARE & BRS 2009).

2.3 Aboriginal interests in Basin water resources

Today, more than 30 major Aboriginal nations maintain their traditional lands within the Basin, and the Basin's waters, waterways and wetlands remain significant places. Twenty-one nations in the north of the Basin are represented by the Northern Murray–Darling Basin Aboriginal Nations, and 10 in the south of the Basin are represented by the Murray Lower Darling Rivers Indigenous Nations.

The Northern Murray–Darling Basin Aboriginal Nations represents the Barkindji, Barunggam, Bidjara, Bigambul, Budjiti, Euahlayi, Gamilaroi, Githabul, Gunggari, Gwamu (Kooma), Jarowair, Kunja, Kwiambul, Malangapa, Mandandanji, Mardigan, Murrawarri, Ngemba, Ngiyampaa, Wailwan and Wakka Wakka (Northern Murray–Darling Basin Aboriginal Nations 2010).

The Murray Lower Darling River Indigenous Nations represents the Barapa Barapa, Latji Latji, Mutti Mutti, Ngarrindjeri, Taungurung, Wadi Wadi, Wamba Wamba, Wergaia Wiradjuri and Yorta Yorta (Murray Lower Darling Rivers Indigenous Nations n.d.).

Aboriginal people have diverse and multiple interests in the water resources of the Murray–Darling Basin, including consumptive and commercial interests, along with social, cultural and environmental interests.

In the Murray–Darling Basin, the concept of cultural flows is an emerging water management consideration of importance to Aboriginal people and organisations.

Aboriginal people all along the Murray and Darling rivers, and throughout the Basin, talk of their deep relationship to the Rivers. People like Ngiyampaa Elder Beryl Carmichael say:

[The river] it's like the blood in my veins. Without it, with no water, mate, we will die. It will kill us. It will kill our spirit. It will kill our spiritual connections. It will also kill our spiritual selves (*Murrundi ruwe pangari ringbalin (River country spirit ceremony)* — *Aboriginal perspectives of river country* 2010).

Ms Carmichael is describing an ancient Aboriginal world view where water sustains a complex relationship between people, their environment and their spirits; all these things are one and the same. Euahlayi Elder Michael Anderson describes what happens when this relationship is affected:

To disturb these ecosystems is to destroy Aboriginal people's ancestors; without country and connection we become spiritually sterile. As a culture and as a people, cultural water flows are absolutely essential to our wellbeing. (M. Anderson 2010 pers. comm., 10 June).

In this context, 'culture' is taken to embrace the full dimensions of social, environmental and economic values, laws, customs, beliefs and practices shared by Aboriginal peoples in the Murray–Darling Basin. The concept of 'cultural flows' puts this complex set of relationships that comprise 'culture' into the terminology of contemporary water management and, therefore, it is relatively new to the language of Aboriginal people and natural resource managers.

The Murray Lower Darling Rivers Indigenous Nations developed the following definition of cultural flows:

Water entitlements that are legally and beneficially owned by the Aboriginal nations and are of a sufficient and adequate quality and quantity to improve the spiritual, cultural, environmental, social and economic conditions of those Aboriginal nations; this is our inherent right (Murray Lower Darling Rivers Indigenous Nations 2007; Northern Murray–Darling Basin Aboriginal Nations 2009; S Ross [Murray Lower Darling Rivers Indigenous Nations] 2010, pers. comm., 10 June).

This definition was endorsed by the Northern Murray–Darling Basin Aboriginal Nations (a confederation of 21 Aboriginal nations in the northern part of the Basin) at the Northern Gathering at Moree on 9–10 December 2009 (Northern Murray–Darling Basin Aboriginal Nations 2009).

The provision of cultural flows has potential benefits for Aboriginal people, such as improved self-esteem and empowerment from being able to care for their country, and improved health and wellbeing through being able to see their country in a healthy state where they can undertake cultural activities, particularly without witnessing degradation of the environment, which they see as part of themselves.

2.4 The social fabric of the Basin

The descriptive report *Socio-economic context for the Murray–Darling Basin* (ABS, ABARE & BRS 2009) provides a detailed analysis of the socioeconomic circumstances of Basin communities.

As previously noted, in 2006, 2.1 million people were living within the Basin and were dependent on its water resources, as were a further 1.3 million people living outside the Basin, including in Adelaide. The Basin population grew by 3% from 2001 to 2006, a period which saw relatively strong growth in the Australian economy amid a continuing drought. This compares to a 6% growth in population nationally. In the Basin, the total rural population declined by 1.7% between 2001 and 2006, while populations in large and medium-sized urban centres (with more than 5,000 people) grew by 8%. Overall, the number of Basin residents living in very remote areas fell by 32%.

The total population of Australia is ageing, and this trend is slightly more pronounced in the Murray–Darling Basin. In 2001, 13.1% of the Basin population was aged over 65, and this increased to 14.5% in 2006. Not only

is there a smaller proportion of younger people in the Basin, but the proportion is particularly low in the 25–34 age group.

The working-age population (aged 15–64) generally provides social and economic support to younger and older people in their communities. In 2006, there were 1.3 million people aged 15–64 in the Basin, representing 64.5% of the Basin population. There were proportionally slightly fewer people of working age in the Basin compared with the rest of Australia.

In 2006, about 69,500 Aboriginal people lived in the Murray–Darling Basin, just over 3% of the Basin’s population. This number had increased by 17% from 2001. During 2001–06, the number of Aboriginal people living in very remote areas fell by 34%.

There are many places in the Basin — primarily townships in the central and western parts of New South Wales and south-west Queensland — with a relatively high proportion of Aboriginal people (more than 20% of the population).

In 2006, almost a quarter of Australia’s population was born overseas, compared with only 10.7% of the Basin population. More than half of the Basin’s overseas-born population lived in Canberra or the inner regional areas of the Basin. The proportion of overseas-born residents in all regions of the Basin is consistently lower than in the rest of Australia.

Employment

In 2006, more than 920,000 people were employed across the Basin. Wholesale and retail trade was the largest employment sector in the Murray–Darling Basin, employing 161,100 (14.3%) of employed persons. At 98,100 (10.8%) of employed persons, the agriculture sector was also a very large Basin employer. Other important industry sectors in terms of employment include public administration, 94,500 (11.7%, with many in Canberra), education and training services, 71,600 (10.6%), manufacturing, 83,900 (9.1%) and health care and social assistance, 97,600 (8.1%).

In 2006, 80.1% of employed men in the Basin and 49.4% of employed women worked full time (35 hours or more per week). The figures for Australia generally were 79.0% for employed men and 50.6% for employed women. There were higher proportions of women working full time in remote areas (51.8%) and very remote areas (60.5%) of the Basin.

The unemployment rate for the Basin as a whole was 5.0% in 2006, close to the prevailing Australian total of 5.2%. Following an Australia-wide trend, unemployment rates fell across the Basin between 2001 and 2006. Unemployment rates for youth (aged 15–24) are consistently higher across Australia, at 10.2% in 2006 — the same rate as in the Basin.

At the national level, professionals formed the largest occupation group in 2006 (1.7 million or 20% of all employed people) and this was also the fastest growing occupation group between 1996 and 2006. Professionals were the largest occupation group in Canberra, comprising 28.6% of employed people, while for the rest of the Basin 14.4% of employed persons were professionals. This varied according to the remoteness of the area.

Farmers

In 2006, there were 65,472 businesses in the agriculture, forestry and fishing sector in the Basin, comprising 32% of the Basin total. The largest decline in Basin employment was in this sector, reducing by 11.9% between 2001 and 2006 (13,300 employees).



Picking apples in an orchard near Batlow, New South Wales. The trees are watered using drip irrigation and a computerised pulse system, which saves water.

Australian Bureau of Statistics census figures show that between 1996 and 2006, the number of people identifying themselves as ‘farmer’ or ‘farm manager’ in the Murray–Darling Basin declined by 10% — from 74,000 to 67,000.

In the 10 years to February 2009, employment across Australia’s agriculture, fisheries and forestry sectors fell by 14.9%, equating to a decline of 1.6% per annum. Agriculture experienced the largest declines in employment in any industry. It has the highest proportion of workers aged over 45 years (56.8%) and over 65 (15.2%). In 2006, 66.8% of Australian farmers were aged over 45 and 18.1% were over 65. The age profile of farmers in the Basin was very similar, with 67.6% aged over 45 and 18.6% over 65.

Income

In 2006, 17.1% of the Basin population aged over 15 earned more than \$1,000 a week, a lower proportion than the Australian average, in which 20% earned over \$1,000 a week. Of all the high earners in the Basin, 37.2% lived in Canberra. Average wages were \$37,282 for the Basin in 2004–05, lower than the Australian average of \$40,585.

For the Basin, the average income for business owners was \$35,072 in 2003–04, of which an average of \$31,544 was generated from unincorporated businesses. Unlike the steady growth in income for wage and salary earners, the Basin showed some declines in the average annual growth of business owners’ income for the period 2001–02 to 2003–04, at a time when the income of business owners in most of the rest of Australia showed some growth.

Between 2001 and 2006 there was an increase in the agricultural areas of the Basin declared to be experiencing ‘exceptional circumstances’ due to the drought.

2.5 Basin environment

The Basin can be divided topographically into five different river section types. These can be divided again by climate into northern rivers (Darling catchment) and southern rivers (Murray catchment). In the north, rainfall is less seasonal, but greater in summer, more influenced by tropical systems and producing higher peak flows. The northern Basin is also hotter, with higher evaporative demand, and flow is less predictable, with more frequent and longer periods of very low flow (Young et al. 2001).

The ecology of the Basin’s rivers is determined by the high variability of their natural flow regimes (Puckridge et al. 1998; Boulton 1999; Kingsford 2006). Flows define the Basin’s physical and ecological processes, creating diverse river and floodplain forms and functions, and great ecological variability (Young 2001).

The distribution of wetlands and flood-dependent vegetation on floodplains is a result of flooding from rivers (Hughes 1988; Young 2001). The life cycles of many aquatic plants, eucalypt forests and woodlands, invertebrates, waterbirds, amphibians, reptiles and fish, as well as many terrestrial species, are tied to, and dependent on, high variability in flow regimes (Boulton 1999; Young 2001; Jenkins & Wolfenden 2006; Kingsford 2006).

The Basin contains 16 of Australia’s Ramsar-listed wetlands (Table 2.4). Ramsar sites are listed under the Convention on Wetlands of International Importance (the Ramsar Convention) in recognition of their international importance in one or more of the following areas: ecology, botany, zoology, limnology or hydrology. All Ramsar sites in the Basin have been included



Shearing on a property near Blighy, New South Wales

in the Murray–Darling Basin Authority’s list of key environmental assets (see Appendix A). The Basin also has one World Heritage site — the Willandra Lakes Region.

The water-dependent ecosystems in the Basin provide critical habitat for 95 state- and Commonwealth-listed fauna species. Their distribution across the Basin Plan regions is shown in Table 2.5.

Table 2.4 Ramsar-listed wetlands: Murray–Darling Basin

Ramsar site name	Basin Plan region
Banrock Station Wetland Complex	Murray
Barmah Forest	Murray
Currawinya Lakes	Paroo
Fivebough and Tuckerbil Swamps	Murrumbidgee
Ginini Flats Subalpine Bog Complex	Murrumbidgee
Gunbower Forest	Murray
Gwydir Wetlands: Gingham and Lower Gwydir (Big Leather) Watercourses	Gwydir
Hattah–Kulkyne Lakes	Murray
Kerang Wetlands	Murray
Lake Albacutya	Wimmera–Avoca
Macquarie Marshes	Macquarie–Castlereagh
Narran Lake Nature Reserve	Condamine–Balonne
NSW Central Murray State Forests	Murray
Paroo River Wetlands	Paroo
Riverland	Murray
The Coorong, Lake Alexandrina & Lake Albert	Murray

Source: Department of the Environment, Water, Heritage and the Arts (2009a)

Table 2.5 Basin-wide distribution of state- and Commonwealth-listed fauna species

Basin Plan region	Number of state- and Commonwealth-listed endangered/threatened species
Barwon–Darling	9
Border Rivers	23
Campaspe	23
Condamine–Balonne	20
Eastern Mount Lofty Ranges	28
Goulburn–Broken	41
Gwydir	17
Lachlan	21
Loddon	25
Lower Darling	24
Macquarie–Castlereagh	23
Moonie	2
Murray	58
Murrumbidgee	34
Namoi	20
Ovens	32
Paroo	8
Warrego	9
Wimmera–Avoca	27

Source: MDBA, unpublished

The Basin supports a great number of plants, animals and ecosystems that are nationally and internationally significant. More than half its native fish species are considered threatened or of conservation significance (Lintermans 2007). Many species of waterbirds breed in large numbers only during flooding of wetlands and lakes. The large wetlands on the lower reaches of the Condamine–Balonne, the Gwydir, the Macquarie, the Lachlan and the Murrumbidgee rivers are among the most important sites of their type in Australia for species of waterbirds that breed in large colonies (Kingsford & Johnson 1998; Kingsford, Curtin & Porter 1999; Kingsford & Thomas 2004; Kingsford & Auld 2005).

The Murray–Darling Basin is the most heavily regulated river basin in Australia, with 24 of its 26 major rivers regulated by dams and weirs (Kingsford 2000; Arthington & Pusey 2003). This regulation has affected the flow regime of these rivers and that of the entire Basin. Because of the critical dependence of so many plants and animals on the natural flow regime, these changes have affected flood- and flow-dependent species and ecosystems (Boulton 1999; Kingsford 2000; Kingsford & Thomas 2004).

Regulation of rivers causes major changes in geomorphological and ecological processes downstream of dams (Kingsford 2000; Sheldon et al. 2000). For example, construction of barrages has caused erosion, declining water quality, and loss of wetlands in Lake Alexandrina and Lake Albert (Bourman & Barnett 1995). In 1991 the Darling River suffered a bloom of blue-green algae more than 1,000 km long, caused partly by river regulation (Bowling & Baker 1996; Arthington & Pusey 2003). At least 90% of the Gwydir Wetlands, 75% of the wetlands of the Lower Murrumbidgee floodplain, and 40–50% of the Macquarie Marshes have been lost (Keyte 1994; Kingsford & Thomas 1995, 2004).

River regulation and extraction of water have reduced the breeding of colonially nesting waterbirds in the Barmah–Millewa Forest on the Murray (Leslie 2001), and the number of waterbirds and waterbird nests, and the frequency of waterbird breeding in the Macquarie Marshes (Kingsford & Thomas 1995; Kingsford & Johnson 1998). Native fish populations have also suffered damaging effects, and their resistance to invasion by alien species has been lowered (Gehrke et al. 1995; Gehrke 2001). Changing flow patterns and degraded riparian zones increase bank erosion, turbidity and sedimentation, filling pools and smothering habitat. Changes to seasonal flows have affected fish breeding, and constant low flows reduce ecosystem productivity by removing the high-flow and low-flow cues that trigger and sustain aquatic cycles (Poff et al. 1997; Humphries, Serafini & King 2002; MDBIC 2003b).

The health of riparian and wetland vegetation, which plays a key part in riverine ecology, has declined. Many areas remain under significant pressure from the combined effects of human activity and the drought. For example, in 2003, 80% of remaining river red gums on the River Murray floodplain in South Australia were stressed to some degree, and 20–30% were severely stressed. In the Macquarie Marshes, over half the river red gum forest and woodland has more than 40% dead canopy, and over 40% has more than 80% dead canopy (Bowen & Simpson 2009).

The National Land & Water Resources Audit 2000 Assessment of River Condition indicated that the ecological health of Basin rivers was poorer than that required for ecological sustainability (Norris et al. 2001).



Little friarbird at Black Swamp in the Gunbower–Koondrook–Pericoota Forest, Victoria

The Sustainable Rivers Audit provides a comprehensive assessment of the ecosystem health of 23 river valleys in the Basin. On the basis of the first assessment, the Paroo valley in the north-west of the Basin was the only one to achieve a health rating of ‘good’. The Condamine and Border Rivers valleys were rated as being in ‘moderate health’, and all others were rated ‘poor’ or ‘very poor’, with the lowest ranked being the Murrumbidgee and Goulburn valleys (see Table 2.6) (Davies et al. 2008).

The Sustainable Rivers Audit reported that the condition of the native fish population in the Basin was at best moderate, and most macroinvertebrate populations showed a lower diversity than expected, especially in the Campaspe, Castlereagh, Wimmera and Avoca valleys. More than two-thirds of sites were rated as being in moderate to good condition in terms of long-term hydrologic regimes (i.e. not including the current dry period). Sites that were rated as being in poor hydrologic condition are in the lowland reaches of the major river systems and on reaches affected by river regulation and extraction for irrigation (see Table 2.7) (Davies et al. 2008).

Table 2.6 Sustainable Rivers Audit ecosystem health assessments by valley, 2004–07: Murray–Darling Basin

Health rating	Valley
Good	Paroo
Moderate	Border Rivers, Condamine
Poor	Namoi, Ovens, Warrego
	Gwydir
	Darling, Murray Lower, Murray Central
Very poor	Murray Upper, Wimmera
	Avoca, Broken, Macquarie
	Campaspe, Castlereagh, Kiewa, Lachlan, Loddon, Mitta Mitta
	Murrumbidgee, Goulburn

Source: Davies et al. (2008).

Table 2.7 Sustainable Rivers Audit hydrologic health assessments by valley, 2004–07: Murray–Darling Basin

Health rating	Valley
Good	Castlereagh, Kiewa, Mitta Mitta, Namoi, Ovens, Paroo, Warrego
Moderate to good	Avoca, Border Rivers, Broken, Condamine, Gwydir, Lachlan, Macquarie, Upper Murray
Moderate	Campaspe, Loddon, Central Murray
Poor to moderate	Murrumbidgee
Poor	Darling, Goulburn, Lower Murray, Wimmera
Very poor	–

Note: ‘Hydrologic health’ measures ecologically significant aspects of the flow regime including volume, variability, extreme flow events and seasonality.

Source: Davies et al. (2008).



Stock watering trough on a property near Beechworth, Victoria

2.6 Basin water resources

Rainfall

The long-term average annual rainfall (1895–2006) for the whole Basin is 457 mm; however, this figure does not reflect climate variability throughout the Basin. Across the Basin from west to east, the average annual rainfall increases from as little as 200 mm on the plains to more than 2,000 mm along parts of the Great Dividing Range (Jeffrey et al. 2001). Potential evaporation plays a significant role, ranging from 950 mm per year in the south to 1,700 mm in the north (Morton 1983; Chiew & McMahon 1993). See Figure 2.7 for 10-year average annual rainfall, and Figure 2.8 for long-term average annual rainfall in the Basin.

In addition to these broad differences, the northern and southern parts of the Basin display markedly different seasonal patterns. The northern Basin experiences intense and sporadic summer-dominated rainfall, as opposed to winter-dominated rainfall in the south. Due in part to these climate characteristics, most rainfall evaporates or is transpired by vegetation.

Surface-water resources

Water availability

Rainfall in the Basin varies widely between years, producing variation in inflows and water availability. This variability is measured by the coefficient of variation, which measures the relative range of modelled annual water availabilities (shown for selected catchments in Table 2.8). A low value (e.g. the Murrumbidgee coefficient of variation, 0.5) indicates a relatively reliable year-to-year value, whereas a high value (e.g. the Barwon–Darling coefficient of variation, 3.1) reflects a large inter-annual variation.

Table 2.8 also reflects the difference in climate between north and south. Water availability in the northern regions is generally less reliable than in the southern regions.

Table 2.8 Variation in water availability in selected catchments

Catchment	Coefficient of variation
Barwon–Darling	3.1
Border Rivers	0.9
Broken	0.8
Campaspe	0.7
Condamine–Balonne	1.1
Goulburn	0.5
Gwydir	1.0
Lachlan	0.9
Loddon	0.7
Macquarie–Castlereagh	0.9
Moonie	1.4
Murray	0.4
Murrumbidgee	0.5
Namoi	1.3
Nebine	0.7
Ovens	0.5
Paroo	0.9
Warrego	1.2
Wimmera–Avoca	0.5
Whole Murray–Darling Basin	0.5

Source: MDBA unpublished modelled data

The development of the Basin Plan requires a measurement of the size of the surface-water resource, both at regional and Basin scale. Fundamentally, the amount of available water is determined by the volume of inflows entering rivers and streams. The long-term (1895–2009) average rainfall across the Basin is in the order of 500,000 GL/y. Much of this water evaporates, recharges groundwater through seepage, or is used by the natural environment through transpiration. Rain that finds its way into creeks, streams and eventually into the rivers of the Basin is the inflow. One way to estimate available water in the Basin river system is to sum the total inflows, prior to any instream losses. The Murray–Darling Basin Authority (MDBA) has adopted a best estimate of surface-water run-off across the Basin using modelled inflows, incorporating where necessary the effects of interception activities (e.g. farm dams and forestry plantations).

Accordingly, MDBA estimates that under without-development conditions (conditions prior to significant human development), 31,800 GL/y (or about 6% of average rainfall) would occur as run-off and flow into rivers and streams.



Farmscape near Stuart Town, New South Wales

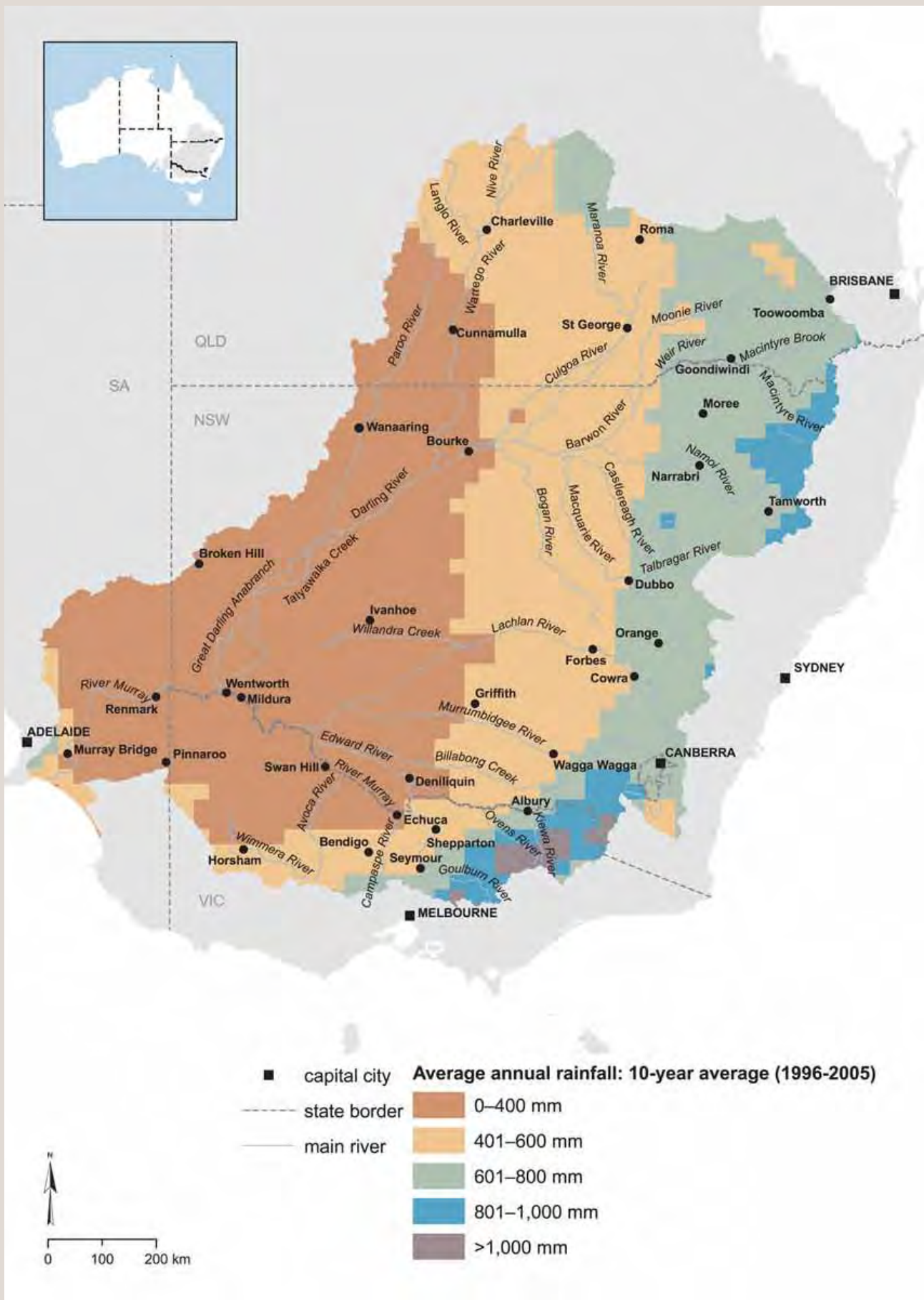


Figure 2.7 Ten-year average annual rainfall (mm), 1996–2005

Source: MDBA

On average, an additional 997 GL/y is transferred into the Basin from external sources, comprising transfers into the Murray and Murrumbidgee rivers from the Snowy Mountains Hydro-electric Scheme, and transfers into the Wimmera region from the Glenelg River. Therefore, the Basin receives average annual inflows of 32,778 GL. As about 2,735 GL run-off is intercepted each year, it is estimated that 30,043 GL/y flows into rivers and streams.

The Basin can be broken into component systems. The total inflows into the Darling River and its tributaries are 13,547 GL/y. Total inflows into the River Murray and its tributaries are 15,959 GL/y. A further 2,155 GL/y flows into the disconnected systems (the Lachlan and Wimmera–Avoca systems) and 120 GL/y flows into the Eastern Mount Lofty Ranges.

The CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008) adopted a different approach to measuring the size of the surface-water resource. The surface water available for a region, and for the Basin as a whole, was assessed at the ‘point of maximum flow’ under without-development conditions. A point of maximum flow typically aggregates all inflows and is at a location in the system with a long and reliable historical record and is thus a robust measure of long-term average water availability. This is a different measure to the total average inflows, as a fraction of inflows leave the river system naturally (via evaporation, environmental use or seepage into groundwater) and some water use occurs prior to the inflows entering streams.

MDBA adapted the sustainable yields project modelling framework for the Basin Plan requirements. The updated estimated long-term average (1895–2009) water availability in the Murray–Darling Basin using this modelling is 23,313 GL/y, which is approximately 71% of the average annual inflows across the Basin, as described earlier.

Water availability between 1999 and 2009 has been approximately 40% less than the long-term average — this is the driest 10-year period in the past 114 years. This trend is particularly pronounced in the southern Basin; water availability in the Campaspe, Loddon and Wimmera regions since 1999 has been approximately 75% less than the long-term average (based on MDBA unpublished modelled data).

Water storages

From the early 20th century, government and private investors constructed water storage infrastructure across the entire Basin to mitigate the high natural inter-annual flow variability of Basin river systems and provide a secure water supply for a developing nation. Primarily driven through growth of irrigated agriculture, most large public dams were constructed between 1950 and 1980, and today they combine to provide the Basin with a storage capacity of 22,663 GL (using the approach described in MDBA 2010b).

Most of the largest storages exist in the southern connected system and eastern ranges where high annual rainfall, cooler temperatures and topography provide conditions suitable for locating large and efficient storages (see Table 2.9).

In contrast, the storage capacity in the northern Basin is dominated by large-scale, private on-farm storages that capture highly variable, monsoonal floodwaters for irrigation. In the Barwon–Darling, Paroo, Warrego, Condamine–Balonne and Moonie regions, 90% or more of the total storage capacity is private storage (CSIRO 2008). Although individual capacities of on-farm storages are generally low, the impact on inflows of their continued growth is a significant risk to Basin water resources.

Table 2.9 The nine largest reservoirs in the Murray–Darling Basin

Major on-stream storage	Basin Plan region	Completion date	Storage capacity (GL)
Dartmouth Reservoir	Murray	1979	3,906
Eildon Reservoir	Goulburn–Broken	1955	3,334
Hume Reservoir	Murray	1936–61	3,038
Menindee Lakes	Lower Darling	1960–68	1,730
Burrendong Reservoir	Macquarie–Castlereagh	1967	1,188
Blowering Reservoir	Murrumbidgee	1968	1,631
Copeton Reservoir	Gwydir	1973–76	1,361
Wyangala Reservoir	Lachlan	1968–71	1,220
Burrinjuck Dam	Murrumbidgee	1928–57	1,026

Source: MDBA

Surface-water use

The surface-water resources of the Basin are diverted or intercepted for a range of consumptive purposes, including irrigation, urban supplies, stock water, domestic supplies and industry.

Most consumptive water users in the Basin (such as irrigators and water supply authorities) hold a licence to take water, referred to as an ‘entitlement’. Entitlements are of several types and have varying reliabilities, e.g. New South Wales’s high security, general security and supplementary access, and Victoria’s high reliability and low reliability water shares.

Based on the amount of water available in the system at a given time, water authorities announce an ‘allocation’, which specifies what proportion of an entitlement can be taken in that year. Allocated water is one form of water authorised for use. Other forms of water authorisations include water trade, carryover, supplementary access, and unregulated uses.

Total surface-water use includes diversions from watercourses and associated floodplains, and interception activities such as farm dams and plantation forestry. However, data on interception activities is limited and available annual water-use data does not include these activities.

The available data shows that annual surface-water use has been decreasing and in recent years has been quite low due to drought conditions (see Table 2.10 and Figure 2.9). For example, total water use was around 5,260 GL in 2006–07, 4,514 GL for 2007–08 and 4,119 GL for 2008–09 (MDBA 2010c), which is around a 60% reduction from the water used in an average year. Usage totals are dominated by extractions in the Murray, Murrumbidgee and Goulburn–Broken regions.

Interception activities

Interception activity is defined in the *Water Act 2007* (Cwlth) as the interception of surface water or groundwater that would otherwise flow, directly or indirectly, into a watercourse, lake, wetland, aquifer, dam or reservoir that is a Basin water resource. There is some regulation of farm dams in the Basin. However, the interception effects of forestry plantations and mining are currently mostly outside state water planning frameworks. There is an expectation under the National Water Initiative that significant interception activities will be effectively regulated by no later than 2011 (National Water Commission 2009a).

Table 2.10 Surface-water actual watercourse diversions by region (GL): Murray–Darling Basin

Region	1997–98	1998–99	1999–2000	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08	2008–09
Barwon–Darling	198	233	175	246	76	20	268	157	157	1	210	149
Border Rivers	388	306	360	536	362	215	323	316	277	217	341	293
Campaspe	96	76	73	113	124	74	73	40	22	14	26	26
Condamine–Balonne	545	467	366	360	162	123	575	167	186	57	776	190
Goulburn–Broken	1,846	1,649	1,477	1,468	1,618	1,043	1,564	1,504	1,524	642	675	624
Gwydir	532	306	448	424	462	238	169	165	230	139	89	154
Lachlan	429	293	301	423	457	253	59	36	128	73	46	40
Loddon	63	49	77	101	82	32	33	49	68	10	9	4
Lower Darling	68	194	85	241	126	107	23	29	41	16	11	9
Macquarie–Castlereagh	442	396	437	522	597	411	219	102	224	252	75	106
Moonie	8	8	8	31	6	6	26	23	2	9	41	29
Murray	4,262	4,465	3,407	4,420	4,624	3,338	3,372	3,333	3,810	2,617	1,450	1,638
Murrumbidgee	2,630	2,529	1,901	2,781	2,384	1,833	1,803	1,645	2,232	985	530	621
Namoi	305	322	350	355	363	294	173	190	234	166	142	188
Ovens	35	28	24	23	26	32	25	21	25	17	17	25
Paroo	0	0	0	0	0	0	0	0	0	2	4	1
Warrego	5	13	7	12	14	10	14	14	6	24	26	9
Wimmera–Avoca	184	159	103	68	84	60	66	50	60	19	45	11
Basin total	12,036	11,494	9,600	12,124	11,567	8,091	8,785	7,842	9,228	5,260	4,514	4,119

Note: No data is available for the Eastern Mount Lofty Ranges region.

Source: MDBA (2010c)

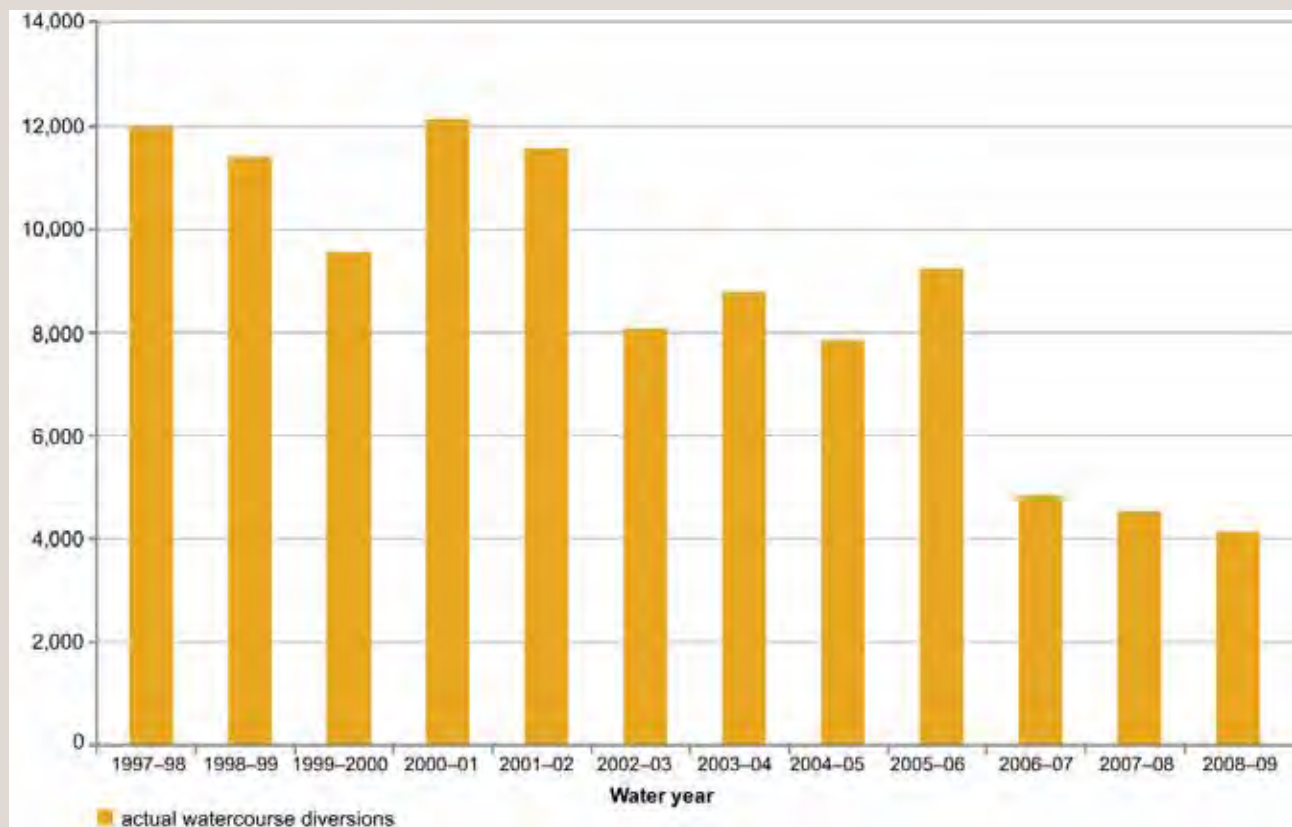


Figure 2.9 Surface-water actual watercourse diversions, 1997–98 to 2008–09: Murray–Darling Basin

Source: MDBA (2010c)

The storage volume of farm dams across the Basin has been estimated as 2,168 GL (SKM 2007). The assessment used data from previous studies to estimate the surface area covered by farm dams, and a method for estimating farm dam volume from surface area. Other studies have arrived at similar estimates for the volume of farm dams in the Basin (e.g. 2,213 GL from Agrecon (2005); 2,200 GL from Van Dijk et al. (2006)). Using a relationship between the volume of farm dams and the impact on catchment water yield (SKM, CSIRO & BRS 2010), the estimated reduction in run-off across the Basin due to farm dams is 2,395 GL/y.

Projections by CSIRO (2008) based on historical farm dam expansion and the policy controls in place when the study was undertaken indicated that farm dam capacity across the Basin could increase by about 10% by 2030; however, there is considerable uncertainty in the projection of these increases. A 10% increase in capacity was estimated to result in an increase of 170 GL/y in surface-water use across the Basin.

Existing commercial forestry plantations in the Basin cover about 290,000 ha (CSIRO 2008). These plantations are estimated to reduce run-off by 341 GL/y (SKM, CSIRO & BRS 2010). The assessment of run-off impacts considered only forestry plantations, mainly for timber production, not the impacts on catchment water yields where plantations had replaced native forest or where plantations had been established on land that previously had a plantation (e.g. second rotation planting).

Bureau of Rural Sciences projections indicate that, with the trends and policy in place in 2008, commercial forestry plantations could expand by 52,000 ha or 18% by 2030 (CSIRO 2008). The increases would be concentrated in the Murray (33,000 ha), Murrumbidgee (17,000 ha) and Eastern Mount Lofty Ranges (2,000 ha).

Forestry plantations significantly reduce local run-off in the areas where they are located; however, for the projected forestry developments the regional impacts on run-off are small (CSIRO 2008). The expansion in plantations was estimated to result in an increase of 28 GL/y in surface-water use across the Basin (CSIRO 2008). However, the possible future introduction of an emissions trading scheme could significantly drive the expansion of plantations.

A summary of the estimated take by interception by farm dams and forestry plantations is provided in Chapter 4 (see Table 4.14).

Of the approximately 320 mines listed as operating throughout Australia in 2009, around 10% were in the Murray–Darling Basin (ABS, ABARE & BRS 2009). Around half of all mines in the Basin were mining metallic minerals (largely gold and copper) with a further one-third mining black coal.

While direct consumptive use of water is relatively small, mining activities can have a large, localised incidental water use or impact associated with ore production or oil and gas extraction (Natural Resource Management Ministerial Council 2010), although precise quantities are difficult to determine. Table 2.11 provides a qualitative assessment of the potential impact on the water balance of a range of mining activities (National Water Commission 2010a).

It is expected that mining activities will continue to expand in the Basin, although it is difficult to predict the extent of this future growth.



Low water levels in a farm dam near Urana, New South Wales, during drought

Table 2.11 Evaluation of mining activities that can intercept water

Activity	Potential impact on water balance	Priority for management
Oil and gas extraction, coal seam methane gas extraction	High	High ^a
Open-cut mining	High	High
Pit lakes and mines wastewaters	Medium	Medium
Dewatering, mine voids	High	High

a Much of this activity relates to non-Basin resources beyond the responsibility of the Basin Plan and MDBA
Source: National Water Commission (2010a)

Groundwater resources

The Basin has large groundwater resources in three main aquifer types: alluvial, porous rock and fractured rock. Covering the largest area are the alluvial and porous rocks of the sedimentary basins. The storage in these aquifers is significant, but only a small percentage is accessible in terms of yield and quality. While the Great Artesian Basin is a major groundwater resource under the Basin, its management is not included in the Basin Plan.

There is limited data on groundwater use in the Basin, as metering has historically not been widespread, and groundwater use in many areas is estimated. Groundwater extraction is metered in irrigation areas and other sites of intense extraction. Larger individual extractions (including for some irrigation, town water supply and industrial purposes) are also metered. Most groundwater use, by volume, is metered. However, most bores throughout the Basin are used for stock and domestic purposes and are not metered.

Use for the most highly developed groundwater systems is summarised in Table 2.12. According to current MDBA estimates, total groundwater use in the Basin is approximately 1,700 GL/y. Figure 2.10 shows the areas currently covered by a groundwater plan.

Table 2.12 Estimated groundwater use in highly developed groundwater systems

SDL area	Entitlement (GL)	Average use (2003–04 to 2007–08)
Angas Bremer	6.5	6.7
Lower Gwydir Alluvium	32.3	32.3
Lower Lachlan Alluvium	108	117.9
Lower Macquarie Alluvium	69.3	41.9
Lower Murray Alluvium (shallow)	39.5	39.5
Lower Murray Alluvium (deep)	83.7	86.3
Lower Murrumbidgee Alluvium	280.1	303.7
Lower Namoi Alluvium	86	99.4
Mid-Murrumbidgee Alluvium	80.4	44
Peel Valley Alluvium	9.3	7.3
Upper Lachlan Alluvium	183	77.1
Upper Macquarie Alluvium	13.7	13.7
Upper Murray Alluvium	41	11
Upper Namoi Alluvium	122.1	95.0
Upper Condamine Alluvium	128	117.1
Victorian Riverine Sedimentary Plain (shallow)	221.2	83.3
Victorian Riverine Sedimentary Plain (deep)	177.6	89.6

Note: SDL areas are described in Section 3.2 of this volume.

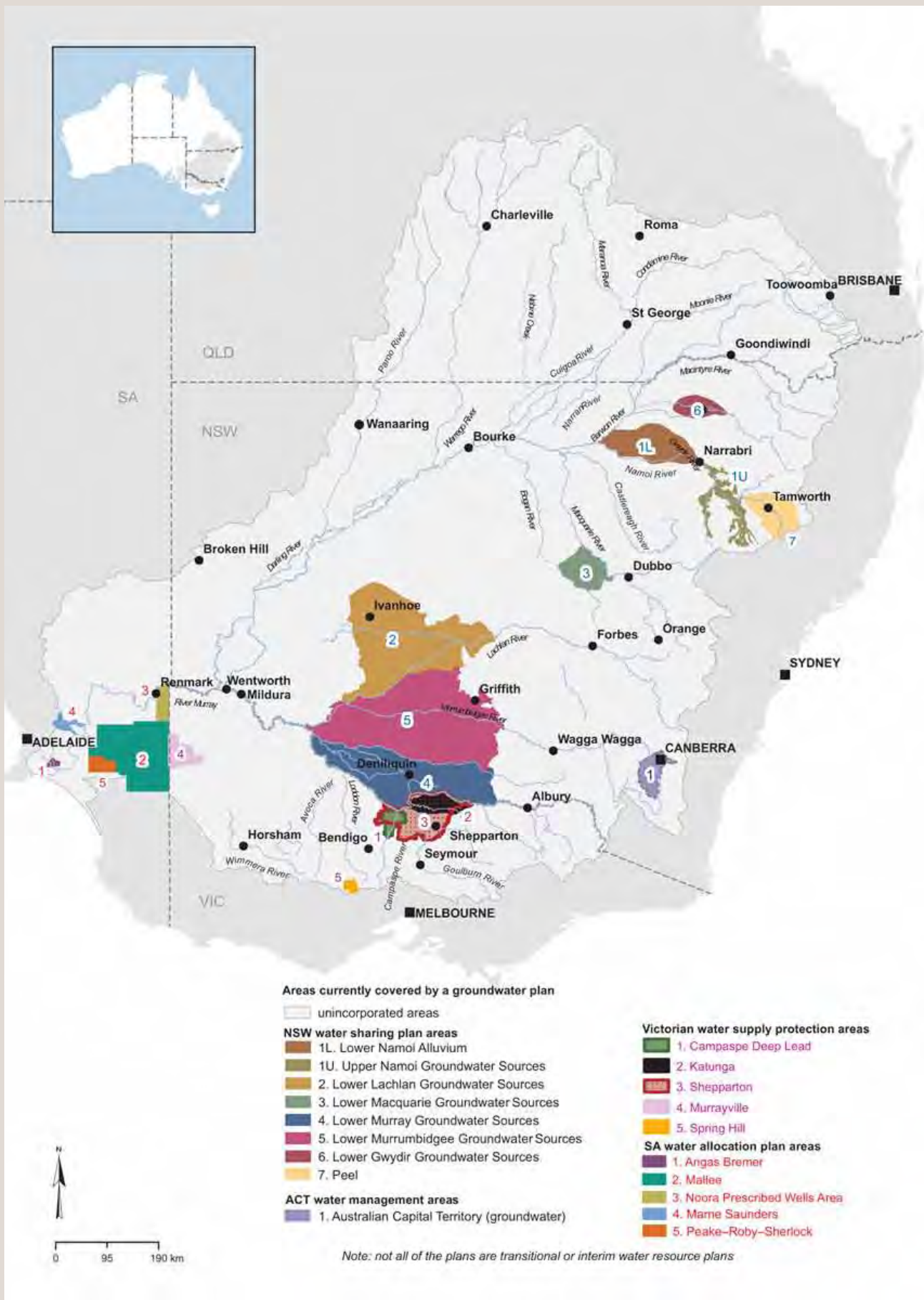


Figure 2.10 Areas currently covered by a groundwater plan: Murray–Darling Basin

Source: MDBA

Groundwater use

Groundwater is used across the Basin, primarily for agriculture. However, it is also important for stock and domestic, industrial, mining and other uses. Groundwater represents less than 20% of the total water use across the Basin. However, groundwater is locally important, particularly in the large riverine plains, where it plays a major role in irrigated agriculture, and in the western parts of the Basin where, although volumetrically small, it may provide the only source of water. There has been a marked increase in groundwater use across the Basin since the introduction of the Cap on surface-water diversions in 1995.

During dry periods, a greater proportion of the water used in the Basin is groundwater. For example, in the three-year period when use of surface water was lowest, groundwater use was about 15% of total water use in the Border Rivers region compared to 10% in times of moderate use. In the Lachlan region the difference was more dramatic, with groundwater use at more than 80% of total water use in dry times, and 50% in times of more moderate use (CSIRO 2008).



Hovells Creek, south-east of Cowra, New South Wales

Modelling undertaken by CSIRO (2008) indicated that continuation of the current extraction rates in seven of the Basin groundwater management units — the Condamine, Border Rivers, Lower Namoi, Lower Macquarie, Lower Lachlan, Upper Lachlan and mid-Murrumbidgee — could result in large reductions in groundwater levels.

Connectivity

The availability of water resources within the system needs to be considered in terms of how they are connected. The understanding

of connectivity between surface water and groundwater is increasing, as is appreciation of the need to manage the use of these resources as a whole rather than separately.

Surface water and groundwater connectivity

Surface-water and groundwater systems are not separate resources but are components of one system. Where the connection is strong, groundwater extraction may directly affect surface-water streamflow by inducing leakage to groundwater, or intercepting groundwater-derived base flow over short and long time frames. Similarly, surface-water extraction and management regimes may affect the availability of groundwater.

Stream losses and groundwater-derived base-flow reductions as a result of past and current groundwater extraction will increase in future due to the delayed response of the movement of water in groundwater systems. The time lag between groundwater extraction and observation of its impact on surface-water flows can range from instantaneous to several decades.

Research shows that the potential impact of past and current groundwater extraction on streamflow is one of the key uncertainties in determining Basin water resources (Evans 2007). The CSIRO Murray–Darling Basin Sustainable

Yields Project (CSIRO 2008) reported that groundwater extraction at the 2004–05 level of development would reduce streamflow across the Basin by 447 GL/y by 2030 and therefore 24% of the 2004–05 level of groundwater extraction would eventually come from surface water through induced river recharge. This represents a 4% reduction in surface-water availability at 2004–05 levels of development.

The separate management of surface-water and groundwater resources has often led to the same water being counted twice: once as groundwater and a second time as the base flow of rivers (Evans 2007). The result has been a reduction in the security of supply to surface-water users and reduced flow in rivers, in some cases causing the complete drying out of streams. Double accounting is often not recognised because of the time lag between extraction of groundwater and reduction in streamflow (Evans 2007).

Surface-water and groundwater connectivity assessments by Parsons, Evans & Hoban (2008) identified the interaction between surface-water and groundwater systems in terms of whether the river is losing or gaining groundwater and at what rate. This is the relationship at its most basic and represents only a ‘snapshot’ of the current state of interactions. In practice such interactions are dynamic, fluctuating both seasonally and over the long term in response to climatic variability and the delayed impact of groundwater extractions.

In some areas, groundwater extraction is significantly affecting the interactions between surface water and groundwater. Virtually all river reaches in the Basin that are losing water at the maximum rate (i.e. where groundwater levels have fallen below the base of the stream) are in areas of the greatest and most concentrated groundwater development. This suggests that maximum losing river conditions in the Basin may largely be caused by intensive groundwater development (Parsons, Evans & Hoban 2008).

Over the critical dry-season low-flow period, groundwater discharge may represent 100% of the streamflow, particularly in upper catchments. This underscores the importance of groundwater discharge in maintaining the health of most streams and rivers in the Basin.

Hydrologic connectivity

Hydrologic connectivity is the level of capability for two sources to be connected for a given period of time such that water can be diverted from one of the sources to the other without unacceptable incremental losses or adverse third-party impacts (SKM 2009). It is a function of both river connectivity (where the water can flow naturally) and the connectivity of water infrastructure in the system.

Surface-water delivery efficiency is one indicator of connectivity, quantifying the average loss that naturally occurs between regions. This delivery efficiency indicator has been used in the CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008) to show what proportion of the run-off generated in the region naturally makes it to the Murray Mouth.

As shown in Table 2.13, the level of connectivity is highly variable between the regions of the Basin, with the percentage of flow that reaches the Murray Mouth ranging from 3% for the Warrego to 84% for the Murray (CSIRO 2008). (The regions are those used in the CSIRO Murray–Darling Basin Sustainable Yields Project, which differ from the Basin Plan regions). The Paroo, Lachlan and Wimmera rivers terminate in floodplain wetlands, and only in very large floods contribute any flow to the Darling, Murrumbidgee or Murray rivers respectively (CSIRO 2008).

Table 2.13 Hydrologic connectivity: Murray–Darling Basin

Region ^a	Fraction of flow reaching Murray Mouth
Barwon–Darling	
Bourke	0.46
Menindee	0.54
Border Rivers	0.32
Campaspe	0.75
Condamine–Balonne	0.18
Eastern Mount Lofty Ranges	–
Goulburn–Broken	0.75
Gwydir	0.17
Lachlan	–
Loddon–Avoca	
Avoca	–
Loddon	0.45
Macquarie–Castlereagh	
Castlereagh	0.25
Macquarie	0.17
Moonie	0.34
Murray	0.84
Namoi	0.36
Ovens	0.70
Paroo	–
Warrego	0.03
Wimmera	–

a The regions are those used for the CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008)

The level of connectivity of the system will differ between wet and dry years. While in wet years a river ‘loses’ water to the floodplain, lakes and wetlands, in dry years river flow is subject to increased losses due to seepage and evaporation.

The average delivery efficiency does not fully describe whether wet or dry years have a larger impact in each region. Drier years have a bigger impact on the connectivity of regions that connect to the Murray only in times of high flow or flood, such as the Warrego, Wimmera, Paroo, Condamine–Balonne and Moonie, or where zero flows have been observed through history, such as the Border Rivers, Barwon–Darling and Lower Darling (SKM 2009).

In addition, some channel capacity constraints reduce the connectivity of the rivers in the system at high flow, for example the Barmah Choke. The Barmah Choke, a naturally occurring narrow stretch of the River Murray, restricts the capacity for delivering water from the upper Murray to the lower Murray, forcing flows of more than 8,500 ML/d to spill into the Barmah Forest. The Barmah Choke is currently a significant constraint to trade between the upper and lower Murray at the peak of the irrigation season. Other known constraints in the system include the channel capacity of:

- the Mitta Mitta River between Dartmouth and Hume dams
- the River Murray between Hume Dam and Yarrawonga
- the Lower Darling (SKM 2009).

In addition, infrastructure capacity sometimes constrains the transfer of water from one location to another for trading or environmental purposes. Some identified constraints include:

- all major offtakes to irrigation areas
- the Edward River and Gulpa Creek offtakes
- inlet and outlet channels to Lake Victoria
- release rates from Menindee Lakes
- the outfall from Mulwala Canal to the Edward River, and other escapes (SKM 2009).

Environmental connectivity

Environmental connectivity consists of links between water-dependent ecosystems that allow migration, colonisation and reproduction of species. These connections also enable nutrients and carbon to be transported throughout the system to support the healthy functioning and biodiversity of rivers, floodplains and wetlands.

There are two types of links caused by flow: downstream (or longitudinal) movement between different sections of a river; and lateral movement between the river and the floodplain. Water, sediment and nutrients flow downstream and support processes in downstream river sections. Lateral flows in a river exchange water, sediment and nutrients between the river and its floodplain.

As flows increase, the river overflows its banks, inundating previously dry areas of floodplain, backwaters and billabongs, connecting them with the river channel, depositing suspended material on previously dry areas, and picking up nutrients and organic matter. Inundation reorganises the plant community and stimulates the growth of invertebrate populations (Boulton 1999). As water levels subside, organic material, including bacteria, other microorganisms and dissolved nutrients, is carried back to the main stream.

Connections upstream and downstream, and between a river and its floodplains and wetlands, are important for transferring energy and nutrients, and in the life cycles of many plants and animals. For example, plant seeds are dispersed downstream; many species of Australian fish move upstream to reproduce; and a river free of barriers is important for fish to maintain the health of their populations.

River regulation has greatly reduced these environmental connections. The effectiveness of exchanges between rivers and their floodplains is reduced by floodplain development and by floodplain fragmentation and isolation caused by levee construction. In some cases the frequency and duration of the wetting phase has declined, while in other cases wetlands that previously used to dry out are permanently wet. Overall, this has led to a reduction in the amount and frequency of nutrient exchange between rivers, floodplains and wetlands (Young et al. 2001).

Water quality

The beneficial uses of water in the Basin, such as irrigation, drinking, recreation and watering aquatic ecosystems, depend on acceptable water quality. Threats to this water quality include salinity, algal toxins, high nutrient and suspended sediment loads, cold-water pollution, toxicants, pH and low dissolved oxygen levels.



The Barmah Choke, a narrow part of the River Murray upstream of Echuca, Victoria

Salinity is arguably the best known threat to water quality in the Basin. Risks are most pronounced during extremes of climate: extended dry periods when surface-water storage levels are low, providing little opportunity for dilution of saline groundwater inflows; and in wet periods when increased salt is mobilised from tributary valleys, irrigation areas and floodplains (MDBA 2009a).

High-salinity events are related to:

- the location of major sources of salt
- hydrologic loading on the landscape (including both rainfall and irrigation)
- salt mobilisation processes
- the flow regime available to dilute the impacts of salt loads on overall water quality (MDBA 2009a).

Understanding the salinity threat therefore involves a detailed appreciation of the groundwater and surface-water hydrology within the various landscapes, and the instream salt transport mechanisms that affect the water resources of the Basin (MDBA 2009a).

Salinity across the various landscapes, particularly the southern Basin, is managed through the Basin Salinity Management Strategy 2001–2015 (MDBC 2001). The strategy holds the Basin states accountable for land and water management actions that significantly affect river salinity. The strategy has delivered some significant achievements, including building and operating salt interception schemes, introducing and maintaining salinity registers, and creating an environmental accountability framework to track the impacts of Basin state actions that cause significant increases or decreases in river salinity. The strategy also includes river salinity targets and a salinity-monitoring network (MDBA 2009a). The Basin states and the Australian Government report each year on their activities in relation to the strategy.

The salt interception schemes are primarily located in the lower Murray region where groundwater is most saline. Every year they collectively divert an estimated half a million tonnes of salt away from the river to salt management basins (MDBA 2009a). These schemes, together with other initiatives such as managed dilution flows, have provided significant water quality benefits to the river in recent years, reducing river salinity by up to 800 electrical conductivity units during 2007–08 — a year when salinity levels would have reached an estimated 1,300 electrical conductivity units if not for mitigation works and measures (MDBA 2009a).

Instream salinity targets have been established in the Basin Salinity Management Strategy for most of the tributary valleys and within the River Murray. A Basin target is set at Morgan in South Australia. These instream targets are based on long-term salinity levels over a defined variable climate (currently the period 1975–2000) rather than on day-to-day levels. The Basin target is intended to maintain river salinity at Morgan at less than 800 electrical conductivity units for 95% of the time over the defined variable climate. Tributary valley targets include those for the River Murray within the Mallee zone and aim to address local sources of salt mobilisation.

Catchment actions initiated by Basin states with support from Commonwealth funding programs have been targeted variously towards land-based salinity and instream water quality. Generally, programs to address salinity have been incorporated into regional catchment strategies, and therefore consider trade-offs between salinity outcomes and other natural resource management outcomes. Implementing regional-scale actions

associated with salinity mitigation has included improved irrigation systems and on-farm water-use efficiencies, groundwater pumping, revegetation, and the incorporation of deep-rooted rain-fed grasses or fodder crops into agronomic systems to reduce groundwater recharge, which is the principal driver of salt mobilisation to rivers and streams (MDBA 2009a, 2010a).

When the Basin Salinity Management Strategy was being developed, the legacy of increased recharge as a result of land clearance was considered likely to cause future increases in salt loads to the river (National Land & Water Resources Audit 2001). More recently, a review of groundwater and salinity data within NSW tributary valleys indicated that future salt mobilisation from dryland catchments is unlikely to realise these predictions (NSW Department of Environment and Climate Change 2009). For many catchments, local stream salt loads reflect the changing nature of short- and medium-term rainfall patterns, rather than long-term increases in salt exports.

Nevertheless, major salinity threats to the Basin's water quality remain.

In particular, large floods in the lower Murray are known to mobilise significant salt loads. This occurred during the wetter years of the 1970s, 1980s and early 1990s, when large floods from both the Darling and Murray rivers inundated the lower Murray floodplain. These floods caused a fall in river salinity during the flood, but when the flood receded, salinity levels rose dramatically as a consequence of the primed groundwater system leaking highly saline groundwater back to the river. Following larger floods, such changes have been recorded in water salinity monitoring for 12 or more months, depending on the magnitude of the flood event.



Algal bloom at Lake Mokoan before decommissioning

High nutrient and suspended solids loads are widespread stressors on the environmental health of waterways in the entire Murray–Darling Basin. The only reaches where there are no major water quality effects are in the upper parts of the catchments and the western Queensland part of the Basin.

Most of the sediment loads are generated in the upland and mid-slope areas, but the impact is seen in lowland rivers, weir pools and reservoirs where the sediment is deposited and where high nutrient levels can lead to algal blooms (National Land & Water Resources Audit 2001).

Algal blooms have always been present in the river system and are a natural phenomenon, with their recorded history dating back to 1830. In 1878 the blue-green algae (*Nodularia spumigena*) bloomed in Lake Alexandrina, killing animals that drank the water (Sim & Muller 2004). Blooms of blue-green algae in the River Murray in South Australia have been recorded intermittently since records began in 1947 (MDBA 2010d). In the Darling River in 1991, a toxic bloom of blue-green algae occurred over a distance of 1,000 km and caused the NSW Government to declare a state of emergency (Crabb 1997).



Barwon River near Walgett, northern New South Wales

During recent periods of very low flow, blooms have probably become more intense and possibly more frequent. The regulation of the River Murray system ensures that the river continues to flow through most summers when blooms would otherwise have been most likely. However, during severe drought, the reduction or stopping of river flow, combined with the additional nutrients now present from eroded soils and waste discharges, means that intense blooms are more likely. The decay of algal blooms and associated low levels of dissolved oxygen can have catastrophic ecological effects.

Release of cold water from the bottom of large dams also remains a significant water quality problem, as it hinders the recovery of native fish populations in the Murray–Darling Basin (Boys, Miles & Rayner 2009). For example, in the Macquarie River during summer when ambient water temperatures average around 25 °C, the temperature of water in the river downstream of Burrendong Dam is around 13 °C (Astles et al. 2003). These suppressed temperatures persist for more than 300 km downstream. Similar examples of cold-water pollution include downstream of Lake Eildon in the Goulburn valley, and the Keepit Dam in the Namoi valley. Up to 3,000 km of river channel in the Basin is estimated to be affected by cold-water pollution (Gehrke, Gawne & Cullen 2003).

Water trade

The water market provides a mechanism for water users to adapt to limited water availability. Trade provides benefits to the buyer and seller, including income and the ability to manage risk. Trade benefits the Basin as a whole, as it allows for water to move to more productive uses. However, it can potentially affect communities through a shift in wealth from one area to another, which may lead to a reduction of goods and services required in one area, but an increase in goods and services required in another area.

Trade is constrained by trading rules and the degree of hydrologic connectivity between locations.

Surface-water trade

In 2008–09, the bulk of Australia’s water-trading activity was in the southern connected Basin. More than 1,000 GL of water entitlements were permanently traded between market participants. A further 1,739 GL of water allocations were temporarily traded.

Figure 2.11 summarises the net interstate trade of allocations from 2006–07 to 2008–09. The graph illustrates the movement of water downstream from New South Wales to Victoria and South Australia.

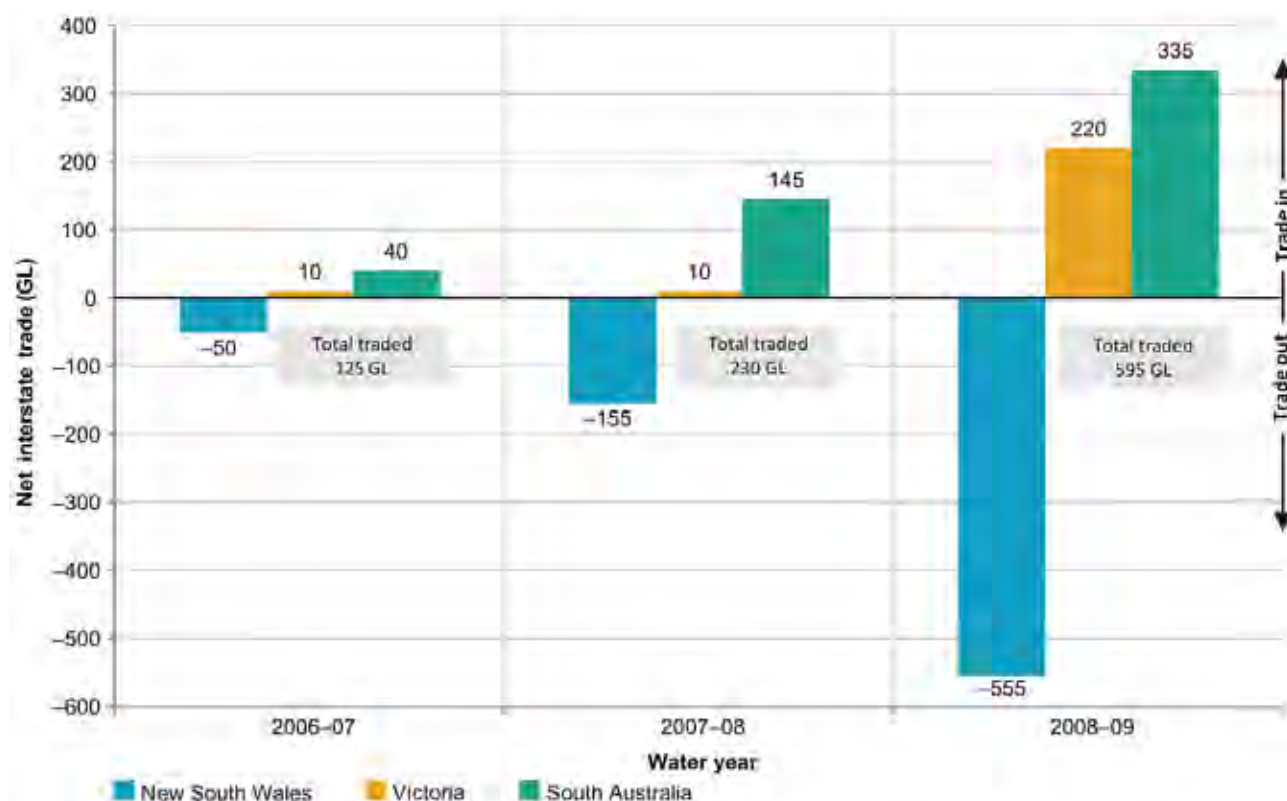


Figure 2.11 Net interstate trade of allocations, 2006–07 to 2008–09: Murray–Darling Basin

Groundwater trade

The proportion of trading is small compared with overall groundwater extraction, but groundwater trading has increased since 2002–03 and allocation trade has been substantial, particularly in recent years.

Allocated volumes of groundwater traded within the New South Wales portion of the Murray region have increased each year since 2006. In recent years, allocation volumes traded have been a substantial part of the overall groundwater resource management arrangements for New South Wales. These include structural adjustment mechanisms that allow irrigators to trade allocations in response to restricted entitlements under the relevant water sharing plan (National Water Commission 2009b). In the Lower Gwydir Groundwater Source, 33 groundwater allocations totalling 5.39 GL were traded in 2008–09. For the same year, 5.9 GL were traded in the Lower Namoi Groundwater Source, and 4.32 GL in the Upper Namoi Groundwater Source. In 2008–09, the total volume of groundwater traded in the Lower Macquarie and Lower Lachlan regions was 5.42 GL and 36.45 GL, respectively (National Water Commission 2009b).

Groundwater trading is negligible in all groundwater management units in the Victorian portion of the Murray catchment, other than the Katunga Water Supply Protection Area, where volumes traded have increased each year since 2004.

In the Mid-Loddon Groundwater Management Unit, volumes of allocation trade range between zero and around 3.5 GL/y, which is about 15% of peak annual diversions. Trade in the Mid-Loddon increased substantially during 2006–07, which coincided with an increase in diversions (National Water Commission 2009a). Groundwater trading in the Campaspe region did not start until 2003–04, and the volumes traded were less than 1 GL/y and limited to the Campaspe Deep Lead Groundwater Management Unit. Trading of groundwater allocations has been increasing steadily, with volumes ranging up to 5 GL/y. The total groundwater diversions (including trade) in this management unit are managed within a water sharing plan framework, and it is apparent that the extreme drought conditions and relaxed controls of the past few years have coincided with trade volumes exceeding 5 GL/y (National Water Commission 2009c).

Groundwater trading in all other areas of the Basin is considered to be negligible.

2.7 Management of Basin water resources

Australians have been aware for many generations of the significance of the Basin's water resources, an awareness that is reflected in a long history of management initiatives — from before Federation to the present day.

Before Federation

In the years before Federation, the water of the River Murray and its tributaries was recognised as critical for the socioeconomic development of the Basin's southern colonies, and there was much debate and argument on its management and sharing. The Murray was also a major conduit for transport, which explains the presence of several clauses relating to trade in the Australian Constitution of 1901 (Wright 1978).

One of the first discussions on managing the Basin took place in 1863 at a conference in Melbourne, where New South Wales, Victoria and South Australia discussed placing locks on the rivers to improve navigability. The conference concluded that the commerce, population and wealth of Australia could be largely increased by rendering navigable, and otherwise making use of, the great rivers of the interior such as the Murray, Edward, Murrumbidgee and Darling (Eastburn 1990).

Many other conferences were held over the next 40 years, but little progress was made, largely due to the parochialism of the three colonies. With the first diversions of water from the Murray for irrigation in the 1880s, conflict developed between those parties concerned with use of the river for navigation and those with an interest in irrigation development (Eastburn 1990).

River flows and the need to provide water for irrigation had become political issues by the 1880s. The reduction in River Murray flows was raised in the South Australian Parliament from 1878. In 1885, the colonies of New South Wales and Victoria signed an agreement to share the waters of the Murray evenly between those two colonies, without provision for the downstream use or needs of South Australia. By 1887, concerns were raised in South Australia that extraction for irrigation would cause intrusion of salt from the ocean into the lower River Murray because river flows could no longer hold back the sea (Sim & Muller 2004).



Effects of salinity near Wellington, New South Wales

Federation

On Federation in 1901, the states of Victoria, New South Wales and South Australia were focused on ensuring the security of their own water resources to meet their respective population and economic development needs.

The Murray was the subject of many inquiries and commissions relating to its administration, to the use of the river for navigation and other purposes, and particularly to ensure that South Australia received guaranteed minimum flows throughout the year (Powell 1993).

The severe Federation drought between 1895 and 1902 largely brought the states together. A non-government-organised conference in Corowa in 1902 provided the catalyst that eventually resulted in a workable agreement between the states. After Federation in 1901, South Australia was also able to use the leverage provided by its participation in the federal process to force the up-river states to take a more cooperative approach to future River Murray management (Blackmore 2001).

The result was the River Murray Waters Agreement, approved in 1915; effectively a treaty supported by parallel legislation passed by each of the parliaments. It took a further two years to establish the River Murray Commission which had the task of putting the River Murray Waters Agreement into effect (MDBC 2006b).

River Murray Waters Agreement

In keeping with government policy of the day, the River Murray Commission managed the waters of the River Murray for use during periods of water shortage; using federal funds, it constructed a number of major water conservation works along the Murray (Martin 2005). For much of the 20th century, management of the Basin's water flows equated to control, principally for diversion for human needs and supply for agriculture.

The main provisions in the River Murray Waters Agreement for regulation of the River Murray were:

- the construction of a storage on the Upper Murray
- the construction of a storage at Lake Victoria
- the construction of 26 weirs and locks on the Murray between Blanchetown in South Australia and Echuca in Victoria
- the construction of 9 weirs and locks on the lower part of either the Darling or Murrumbidgee rivers (the Murrumbidgee was selected) (Eastburn 1990).

Over the 70 years it was in operation, various amendments were made to the River Murray Waters Agreement, reflecting shifts in community values and changes in economic conditions. By no means were all the changes free of conflict, including some actions of the River Murray Commission, in particular the abandonment of the Chowilla Dam proposal and the construction of Dartmouth Dam (Wright 1974). The powers of the commission were gradually extended both by amendment and informal practice (see Table 2.14), but its prime concern remained water quantity.

In the late 1960s, the River Murray Commission conducted salinity investigations in the Murray Valley. This ultimately led to the further amendment of the River Murray Waters Agreement in 1982 and the broadening of the commission's role to take account of water quality issues in its water management responsibilities. With the increasing evidence that successful management of the Basin's river systems was directly related to land use throughout the catchment, further amendments to the agreement in

1984 enhanced the commission's environmental responsibilities, but only in a very limited way (MDBC 2006b).

In spite of the changes made to the River Murray Waters Agreement in the early 1980s, it was recognised that the agreement and the River Murray Commission were increasingly unable to meet the needs of the Basin's management and its growing resource and environmental problems. This was also a time when important changes were taking place in water resources administration at both state and Commonwealth levels. Further, individual agencies within the separate states were unable to tackle the developing problems of environmental degradation, including such issues as rising water salinity and irrigation-induced land salinisation. It was gradually realised that critical issues were no longer confined within distinct states, but extended across state boundaries (MDBC 2006b).

There were also increasing calls for action from individuals and groups within the wider community, especially the predecessor of the Murray Darling Association (Wells 1994).

Table 2.14 Evolution of the River Murray Waters Agreement, 1914–81

Matters beyond the powers of the River Murray Commission in 1914
Problems arising on tributary rivers
Problems caused by adjacent land use
Problems of flood mitigation and protection
Problems of erosion and catchment protection
Problems of water quality and pollution from agricultural and other sources
Problems of influent and effluent waters
The needs of flora and fauna
Possible recreational, urban or industrial use
The environment or aesthetic consequences of particular proposals
Matters permitted by previous amendments and informal practice before 1976
Limited powers of catchment protection
Power to initiate future proposals
Provision of certain dilution flows to maintain water quality
Lock maintenance work, improving navigability
Provision of recreational facilities
Expenditure on salinity investigations
Expenditure on redesigned works to protect fish
Construction and operation of storages on tributaries
Principal innovations in agreement reached in October 1981
Power to consider any or all relevant water management objectives, including water quality, in the investigation, planning and operation of works
Power to monitor water quality
Power to coordinate studies concerning water quality in the River Murray
Power to recommend water quality standards for adoption by the states
Power to make recommendations to any government agency or tribunal on any matter that may affect the quantity or quality of River Murray waters
Power to make representations to any government agency concerning any proposal that may significantly affect the flow, use, control or quality of River Murray waters
Power to recommend future changes to the agreement
New water accounting provisions

Source: Clarke (1982)

In 1981–83, the River Murray mouth closed for the first time since regulation of the river system, leading to an increased awareness of environmental water requirements.

Murray–Darling Basin Agreement

The River Murray Waters Agreement was first amended in 1987 and then, in 1992, replaced by the Murray–Darling Basin Agreement. This agreement aimed to promote and coordinate effective planning and management, so that the water, land and other environmental resources of the Basin could be used in an equitable, efficient and sustainable way. Under the agreement, managing the quality as well as the quantity of the Basin’s water resources became a priority (MDBC 2006b).

The agreement established the Murray–Darling Basin Ministerial Council. In 1988 the Murray–Darling Basin Commission succeeded the River Murray Commission to act as the executive arm of the Ministerial Council. The new commission was to advise the council on land and environmental matters in the Basin, in addition to its traditional role of managing and distributing the waters of the River Murray and lower Darling River. The agreement also established the council’s Community Advisory Committee (Martin 2005).

However, the effect of the agreement was largely restricted to resolving the Murray’s salinity and surface-water sharing issues; it did not establish an integrated management plan for surface-water and groundwater resources with Basin-wide sustainability objectives (Martin 2005).

In 1996 Queensland became a signatory to the agreement, and in 1998 the Australian Capital Territory formalised participation through a memorandum of understanding.

The Cap on diversions

From 1988 to 1994, water diversions from the Basin increased significantly — by nearly 8% (Murray–Darling Basin Ministerial Council 1995). Combined with changed river flow regimes, the rise in water diversions reduced the number of healthy wetlands and affected native flora and fauna, such as fish, with a commensurate increase in salinity levels and blue-green algal blooms. These negative effects were confirmed in a Murray–Darling Basin Ministerial Council report, *An audit of water use in the Murray–Darling Basin* (1995), which outlined the decline in Basin river health and pointed to significant future problems if the Basin’s health issues were not addressed effectively.

In 1995 the Murray–Darling Basin Ministerial Council introduced an interim Cap on water diversions from the Basin; this Cap became permanent from 1 July 1997 (MDBC 2008a). However, while the Cap restrained further increases in surface-water diversions, it did not restrain groundwater development (MDBC 2008a). Implementation of the Cap was hampered by the continued reliance on consensus-based governance rather than enforcement powers.

Natural resource management initiatives

The Ministerial Council had established a framework for management of the Murray–Darling Basin’s water, land and other environmental resources, which included Basin-wide policies and strategies, along with on-ground management actions underpinned by scientific investigations. The Natural Resources Management Strategy, developed under the framework in 1989 (Murray–Darling Basin Ministerial Council 1990), was supported by issue-specific strategies, some of which included the Barmah–Millewa Forests



*The Loddon River at Loddon Falls
Scenic Reserve near Glenlyon, Victoria*

Water Management Strategy, the Floodplain Wetlands Management Strategy, the Human Dimension Strategy and the Fish Management Plan.

During this period, concern mounted over dryland salinity. In 1999 the Murray–Darling Basin Commission carried out a salinity audit to predict the impacts of both dryland and irrigation salinity on the Basin, and in 2001 the Ministerial Council adopted the Basin Salinity Management Strategy 2001–2015.

Over the decade 2000–09, the Murray–Darling Basin Ministerial Council initiated a number of other natural resource management initiatives: in native fish recovery, water for the environment, water trade, salinity management, and natural resource auditing (MDBA 2009b).

Native fish species in the Basin have suffered serious decline in both distribution and abundance, perhaps to only 10% of pre-European-settlement levels. This decline is due to many factors, including habitat deterioration, predation and competition from alien fish, reduction of water quality and human-made barriers to fish movement. The Native Fish Strategy (formerly

the Fish Management Plan) aims to return native fish communities in the Basin back to 60% of their estimated pre-European-settlement levels, after 50 years of implementation. The strategy has been in place since 2004 (MDBA 2009b).

In response to evidence showing the declining health of the River Murray system, the Australian, New South Wales, Victorian, South Australian and Australian Capital Territory governments agreed to recover 500 GL of water over 2004–09 under The Living Murray program, to improve the ecological health of the River Murray system and to contribute to a healthy, working River Murray. The water recovery

objective has been achieved (MDBA 2009b).

The Water Trade Program seeks to ensure the effective and efficient operation of an interstate water market within the southern connected Murray–Darling Basin. The program arrangements and rules are codified in Schedule D to the Murray–Darling Basin Agreement.

The Basin Salinity Management Strategy was adopted by the Ministerial Council in 2001; some aspects of the strategy, including salinity credits and debits, and the salinity registers, are codified in Schedule B to the Murray–Darling Basin Agreement.

The Sustainable Rivers Audit provides a long-term assessment of the condition and health of the 23 river valleys in the Murray–Darling Basin. It is overseen by a panel of ecologists, the Independent Sustainable Rivers Audit Group, which reports to the Murray–Darling Basin Authority (MDBA). Data collection uses scientific methods that are applied consistently across the Basin. The audit group has published its first Basin-wide assessment of river health, based on data collected in 2004–07 on three environmental themes: fish, macroinvertebrates and hydrology (MDBA 2009b).



A fishway at Torrumbarry Weir on the River Murray

In response to the continuing drought, the Ministerial Council approved an Integrated Catchment Management Policy statement in 2000, and a House of Representatives inquiry was held into management of the catchment.

Water reform framework

In 1994 the Council of Australian Governments adopted a strategic water reform framework, which was incorporated into the National Competition Policy agreements. The main objectives of the strategic framework were to establish an efficient and sustainable water industry, and to arrest widespread natural resource degradation partly caused by consumptive water use. The strategic framework covered pricing, the appraisal of investment in rural water schemes, the specification of, and trading in, water entitlements, resource management (including recognising the environment as a user of water through formal allocations), institutional reform and improved public consultation. The Council of Australian Governments reinforced and extended these strategic water reforms in 2004 through the Intergovernmental Agreement on a National Water Initiative (National Water Commission 2010b).

In particular, the National Water Initiative includes specific commitments to returning overallocated and overused systems to environmentally sustainable levels of extraction; the creation of perpetual share-based water access entitlements; a risk allocation framework to be applied once overallocation and overuse are dealt with; removal of barriers to trade; and improved water accounting (National Water Commission 2010c).

Water management today

The *Water Act 2007* (Cwlth) was enacted to deal specifically with the management of the water resources of the Murray–Darling Basin. The Water Act established MBDA and its powers and functions, and specified that MBDA must prepare a Basin Plan for the management of the Basin water resources. In 2008, the Prime Minister and the premiers of the Basin states (supported by the Chief Minister of the Australian Capital Territory) reached agreement on a referral of certain powers to the Commonwealth. The Water Act and the Murray–Darling Basin Agreement were amended, and MDBA took over the responsibilities of the former Murray–Darling Basin Commission.

In concert with the Water Act, the Australian Government in 2008 announced a new national initiative, Water for the Future. This initiative aimed to address increasing concerns regarding water scarcity in the face of climate change through a comprehensive national response to meet water availability challenges in both rural and urban areas. An ongoing program, it has four key priorities: taking action on climate change, using water wisely, securing water supplies and supporting healthy rivers (Department of the Environment, Water, Heritage and the Arts 2010a).

These priorities will be delivered through an investment over 10 years of more than \$12.6 billion in strategic programs, including infrastructure investment, to help water users adapt to a future with less water, for the purchase of water for the environment and a renewed commitment to water reform nationally. The funds include \$5.8 billion for rural water use and infrastructure projects to improve the efficiency of water use on farms and in irrigation delivery systems, and \$3.1 billion for purchasing water entitlements. Other aspects include securing water supplies for cities and towns through projects such as recycling, desalination and stormwater harvesting (Department of the Environment, Water, Heritage and the Arts 2010a).

In addition to Commonwealth initiatives, the Basin state governments have also legislated for the regulation and protection of water resources as part of wider management initiatives.

At the time the Basin Plan comes into effect, a number of state transitional and interim water resource plans will also be in effect. These plans are listed in Tables 2.15 and 2.16.

A transitional water resource plan is an existing Basin state plan that is either listed in Schedule 4 of the Water Act or is recognised by a regulation under the Water Act. The transitional water resource plans listed in Schedule 4 will cease to have effect from late 2012 through to mid 2017 (see Table 2.15). Water management arrangements in Victoria are intended to be prescribed as transitional water resource plans through regulation; these plans will continue to have effect until 2019.

An interim water resource plan is one that is made under a state water management law on or after 25 January 2007 and before the Basin Plan first takes effect. Interim water resource plans cease to have effect at the end of 2014, or five years after they are made, whichever is later (see Table 2.16). While a transitional or interim water resource plan is in effect, it prevails over the Basin Plan where there is any inconsistency. This means that the proposed long-term average sustainable diversion limits and other provisions of the Basin Plan will not take effect in a water resource plan area until the transitional or interim water resource plan for the area expires.

Queensland

Water resources are managed in Queensland under the *Water Act 2000* (Qld). Under this Act, provisions are made for the planning and management of water via a two-stage process — preparation of a water resource plan followed by a resource operations plan.

Water resource plans are the fundamental allocation planning instruments that advance the sustainable management of water by establishing a sharing framework between human and environmental needs. These plans are generally catchment based, and manage water in watercourses within that catchment. They also include subartesian water and overland flow water if deemed necessary (Hamstead & O’Keefe 2009). Overland flow is defined in Queensland as water flowing over land, other than in a watercourse or lake, after having fallen as rain. The regulation of overland flow is included in all water resource plans in the Queensland part of the Basin.

Water resource plans are required to take account of relevant national, state and regional strategies, policies and priorities. Of particular significance to the development of these plans are the Intergovernmental Agreement on a National Water Initiative, the Queensland State Water Plan and regional water supply strategies (Hamstead & O’Keefe 2009).

Water resource plans include the following provisions (Hamstead & O’Keefe 2009):

- outcomes, including ecological outcomes for sustainable management of water for the plan area
- environmental flow and water allocation security objectives for specified performance indicators
- strategies to achieve the outcomes
- water and natural ecosystem monitoring and reporting to assess the effectiveness of management strategies
- an implementation schedule.



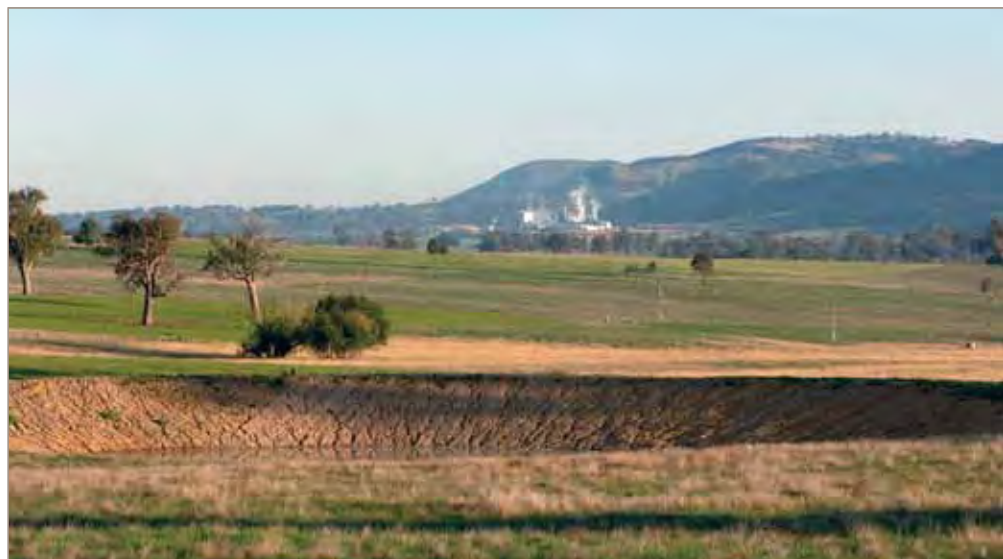
Wetlands by the side of the Gore Highway on the Darling Downs, Queensland

Resource operations plans are the means for implementing water resource plans. They are structured to ensure that water in a plan area is managed in a way that is consistent with the objectives and outcomes specified in the water resource plan for that area. Resource operations plans include detailed rules and requirements for water sharing (Hamstead & O’Keefe 2009), including for:

- seasonal water assignment
- environmental flow management
- operation of infrastructure
- grant, amendment or conversion of water entitlements
- issue of resource operations licences and distribution operations licences where applicable
- water allocation change (water trading)
- water and natural ecosystem monitoring and reporting.

Queensland has finalised transitional water resource plans for surface water and associated resource operations plans for all its Murray–Darling Basin valleys, providing a framework that limits diversions from watercourses, lakes, springs and overland flows.

Water resource planning has not been undertaken for any Basin groundwater resource in Queensland. To do so, existing surface-water plans must be amended to include all groundwater (excluding the Great Artesian Basin) underlying the plan area or part of the plan area. The Queensland Department of Environment and Resource Management has announced its intention to amend the Condamine–Balonne Water Resource Plan to include the groundwater resources of the Central Condamine Alluvium.



Low water levels in a farm dam near Tumut, New South Wales

New South Wales

The two key pieces of state legislation for the management of water in New South Wales are the *Water Management Act 2000* (NSW) and the *Water Act 1912* (NSW). The objective of the Water Management Act is the sustainable and integrated management of the state’s water. The Act provides for water sharing plans as the main tool for managing surface water. As these are introduced, the *Water Act 1912* (NSW) is being phased out.

The water sharing plans are used to set out rules for sharing a particular water source between water users and the environment, rules for granting and managing access licences, rules for allocating available water, rules for operating water supply systems, rules for trading water entitlements, and requirements for monitoring the performance of the plan. Various regulations, proclamations and orders assist in implementing and defining the provisions of the Act, for instance the Water Management (General) Regulation 2004.

Water sharing plans have been completed for most of the state's major regulated river systems and groundwater systems — the areas of most significant water extraction. Water sharing plans were prepared for only 20 out of 500 unregulated subcatchments in New South Wales as part of the first round of water sharing plans developed in 2003. Given the number of unregulated subcatchments still to be completed, New South Wales has adopted a broad approach to the development of water sharing plans, covering much larger areas than the previous single subcatchment units. Macro water sharing plans will cover the remaining unregulated catchments and groundwater systems across the state, and New South Wales has indicated to MDBA that these will be finalised before the Basin Plan comes into effect.

Where floodplain harvesting occurs it is included in plan limits, but the plans do not include specific provisions relating to floodplain harvesting. A state-wide floodplain harvesting policy is being developed to bring floodplain harvesting activities into a statutory framework for water management under the Water Management Act.

In 2005, in recognition of the unsustainable levels of water extraction from some groundwater systems, the New South Wales and Australian governments agreed to a joint program to target groundwater overallocation in these systems. Where groundwater entitlements in a system were identified as exceeding the defined sustainable yield, they were termed 'overallocated'. The Achieving Sustainable Groundwater Entitlements program was set up to help groundwater users in the Upper and Lower Namoi, Lower Macquarie, Lower Lachlan, Lower Murray, Lower Gwydir and Lower Murrumbidgee groundwater sources to manage the reduction in their entitlements. Water sharing plans have been developed for these areas.

Australian Capital Territory

The *Water Resources Act 2007* (ACT) establishes the regulatory framework for the management of water in the Australian Capital Territory. Water access entitlements (the right to an amount of surface water or groundwater within a water management area) are generally required for the taking of water from rivers and groundwater in the territory. The amount must be stated (Water Resources Act s. 19) as the lesser of:

- a percentage of the total amount of the surface water or groundwater available for taking from time to time in the water management area stated in the entitlement
- a stated maximum volume.

A licence to take water is required to extract water under a water access entitlement. The licence states the location from which water can be taken and used, and conditions related to the taking and use of that water.

The Water Resources Act does not provide for the making of a statutory water resource management plan, but for specific instruments for the management of water, which can be amended from time to time. When considered as a whole, these instruments constitute the main elements of a typical water allocation plan.

These instruments are:

- the limits on water available in defined management areas
- the environmental flow guidelines.

Under the Water Resources Act (s. 16), the minister declares water management areas for the purpose of managing the water resources of the territory. An order was made in July 2007 declaring 14 areas, based on

watershed boundaries. While plans as such are not made for each of these areas, the areas are used as the unit for defining limits on water available under water access entitlements.

The environmental flow guidelines describe the flows that are to be protected and water infrastructure operation rules for each water management area in the Australian Capital Territory. Licences are issued subject to conditions to provide compliance with these guidelines. The issue of additional water access entitlements is subject to there being water available within the prescribed available water determinations for the relevant water management area.

Victoria

In Victoria, the primary water legislation is the *Water Act 1989* (Vic.), which provides the basis for the state's allocation and entitlement framework.

Under the Act, the Minister for Water may grant bulk entitlements to urban and rural water corporations, giving them the right to surface-water resources in regulated and unregulated waterways for the purposes of supplying customers in their delivery area. The Minister for Water may also issue environmental entitlements to the Minister for Environment for the purposes of meeting environmental objectives and improving environmental values. These bulk entitlements and environmental entitlements specify relevant conditions, such as limits on the volume, rate and timing of water extraction, supply restriction rules, infrastructure operating arrangements, passing flow requirements, cost-sharing arrangements and reporting requirements.



Irrigation pipes extending into the Ovens River, eastern Victoria

Following the unbundling of water entitlements in northern Victorian regulated systems on 1 July 2007, individuals may be issued with a water share (high or low reliability), which entitles the owner to a share of the available water resource in a particular regulated water system. Water shares are specified as a maximum volume of seasonal allocation, and apply to diversions directly from regulated waterways as well as within irrigation districts. Individuals must hold a water-use licence to use water for irrigation, or a water-use registration for purposes other than irrigation (e.g. for domestic and stock use). Water shares are all supplied by the relevant rural water corporation under its bulk entitlement. Individuals in irrigation districts may also hold a delivery share, which provides an entitlement to have water delivered to certain land, and allows access to a share of the flow when the delivery system is congested (for individuals drawing direct from waterways, this entitlement is called an extraction share) (Hamstead & O'Keefe 2009).

Entitlements within unregulated systems remain bundled. In these areas, the Minister for Water (or the minister's delegate) may issue individuals with a licence under the *Water Act 1989* (Vic.) (s. 51), allowing diversion from a waterway or aquifer. These licences may specify a range of conditions, such as a volumetric limit, maximum rate of take, limiting take to certain months, and other access rules. The total take from an area is limited by restricting the issuing of new licences and by limiting the trade and transfer of licences between different areas in order to protect certain peak and base flows.

Generally, the relevant limits and rules for unregulated systems are set out in local management rules (Victorian Department of Sustainability and Environment 2009). In the case of unregulated rivers declared as water supply protection areas, more detailed studies are done and separate plans prepared.

The Act defines two types of statutory documents which, along with bulk entitlements and environmental entitlements, form part of the water management and planning framework (Hamstead & O’Keefe 2009), namely:

- regional sustainable water strategies, which provide for the strategic planning of the use of water resources at a regional level, integrating urban and rural water supply planning with river and aquifer sustainability planning
- streamflow management plans for stressed or highly used unregulated surface waterways that are declared as water supply protection areas; these plans may reduce the total licensed volume and set out detailed water sharing arrangements that balance the rights of diverters and the environment.

Further, the Act also provides for statewide 15-year reviews of water resources, which allow entitlements to be adjusted if required (Hamstead & O’Keefe 2009). The first such review is due to take place in 2019.

Victoria has also developed the Northern Region Sustainable Water Strategy, which identifies and analyses threats to water availability and quality from Victoria’s share of the River Murray and the major Victorian rivers that flow north into it (Victorian Department of Sustainability and Environment 2010c). The strategy sets out actions to secure the water future for all uses (including environmental) for the next 50 years, and provides more choice and flexibility for entitlement holders to manage the risks associated with drought and climate change.

For groundwater, Victoria has declared areas of intensive extraction as groundwater management areas and has set permissible annual volumes for these areas. When extraction grows to reach the permissible annual volume, more detailed management arrangements are put in place. There are five of these areas in Victoria.

South Australia

The *Natural Resources Management Act 2004* (SA) governs the management and protection of water resources within South Australia. In response to water management and usage pressures, the Act provides for declaration of defined water resources to be ‘prescribed water resources’. Once a water resource is prescribed, it triggers a series of actions leading to the regulation of water extraction by a licensing regime, and the development and implementation of a water allocation plan to set out how the prescribed water resources will be managed. Water licensing is administered in accordance with water allocation plans.

Water allocation plans are developed in the context of the relevant regional natural resources management plan and, when made, are taken to be part of that regional natural resources management plan.

The regional natural resources management plan manages some aspects of water interception and extraction through the section on water-affecting activity permit policy. In particular, a water-affecting activity permit is required to construct or enlarge a dam or other water diverting structure, or to drill a well. The natural resources management plan applies across the whole region, so provides some management of these activities for water resources that are not prescribed. The controls provided by water-affecting activity permits are limited, as the permit is required only for the activity of dam or well construction (or forest planting), and so cannot directly control the volume taken. However, the permit can:

- control the allowable dam capacity (and hence total volume that could be intercepted)
- require the dam to be constructed such that it will bypass low flows
- set rules on where and how the dam can be constructed (e.g. avoid ecologically important areas)
- set rules on where a well can be drilled (e.g. to set buffer zones to avoid interference to groundwater-dependent ecosystems, including watercourses that interact with groundwater)
- set rules on area and location of plantation forestry that recognise impact on run-off and recharge (e.g. the volumetric equivalent of the impact of the forest on run-off and recharge would be determined, and forestry allowed only if there is room in the diversion limit).

South Australian water allocation plans generally work on the basis of restricting allocation as a means of limiting actual diversion, on the assumption that the volume allocated will all be taken. Added to this are measures to limit localised impacts, such as limits on extraction rates and buffer zones.

Where ‘interception’ activities such as farm dams and forestry are considered to be a significant risk to future water availability, the South Australian approach is to bring them into the water allocation regime, or address them through water-affecting activity permits. For unregulated rivers, additional measures are added to protect very low flows. These are developed on the basis of scientific assessments of water requirements of ecosystems, and models. Trade-offs of risk are included when limits are set, where scientific requirements are not fully met.

Table 2.15 Transitional water resource plans (Water Act 2007 (Cwlth) Schedule 4)

Basin state	Name of plan	Type of plan	Date plan ceases to have effect
New South Wales	Adelong Creek Water Source 2003 — Water Sharing Plan	Transitional	1 June 2014
New South Wales	Castlereagh River above Binnaway Water Source 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Gwydir Regulated River Water Source 2002 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Lachlan Regulated River Water Source 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Lower Gwydir Groundwater Source 2003 — Water Sharing Plan	Transitional	30 June 2017
New South Wales	Lower Macquarie Groundwater Sources 2003 — Water Sharing Plan	Transitional	30 June 2017
New South Wales	Lower Murray Groundwater Source — Water Sharing Plan	Transitional	30 June 2017
New South Wales	Lower Murrumbidgee Groundwater Sources 2003 — Water Sharing Plan	Transitional	30 June 2017
New South Wales	Macquarie and Cudgegong Regulated Rivers Water Source 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Mandagery Creek Water Source 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Murrumbidgee Regulated River Water Source 2003 — Water Sharing Plan	Transitional	1 June 2014
New South Wales	New South Wales Murray and Lower Darling Regulated Rivers Water Sources 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Phillips Creek, Mooki River, Quirindi Creek and Warrah Creek Water Sources 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Rocky Creek, Cobbadah, Upper Horton and Lower Horton Water Source 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Tarcutta Creek Water Source 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Tenterfield Creek Water Source 2003 — Water Sharing Plan	Transitional	1 July 2014
New South Wales	Upper and Lower Namoi Groundwater Sources 2003 — Water Sharing Plan	Transitional	30 June 2017
New South Wales	Upper Namoi and Lower Namoi Regulated River Water Sources 2003 — Water Sharing Plan	Transitional	1 July 2014
Queensland	Water Resource (Border Rivers) Plan 2003	Transitional	1 September 2014
Queensland	Water Resource (Condamine and Balonne) Plan 2004	Transitional	1 September 2014
Queensland	Water Resource (Moonie) Plan 2003	Transitional	1 September 2014
Queensland	Water Resource (Warrego, Paroo, Bulloo and Nebine) Plan 2003	Transitional	1 September 2014
South Australia	Angas Bremer Prescribed Wells Area Water Allocation Plan	Transitional	2 January 2013
South Australia	Mallee Prescribed Wells Area Water Allocation Plan	Transitional	21 December 2012
South Australia	Noora Prescribed Wells Area Water Allocation Plan	Transitional	2 January 2013
South Australia	River Murray Prescribed Watercourse Water Allocation Plan	Transitional	1 July 2014

Table 2.16 Interim water resource plans

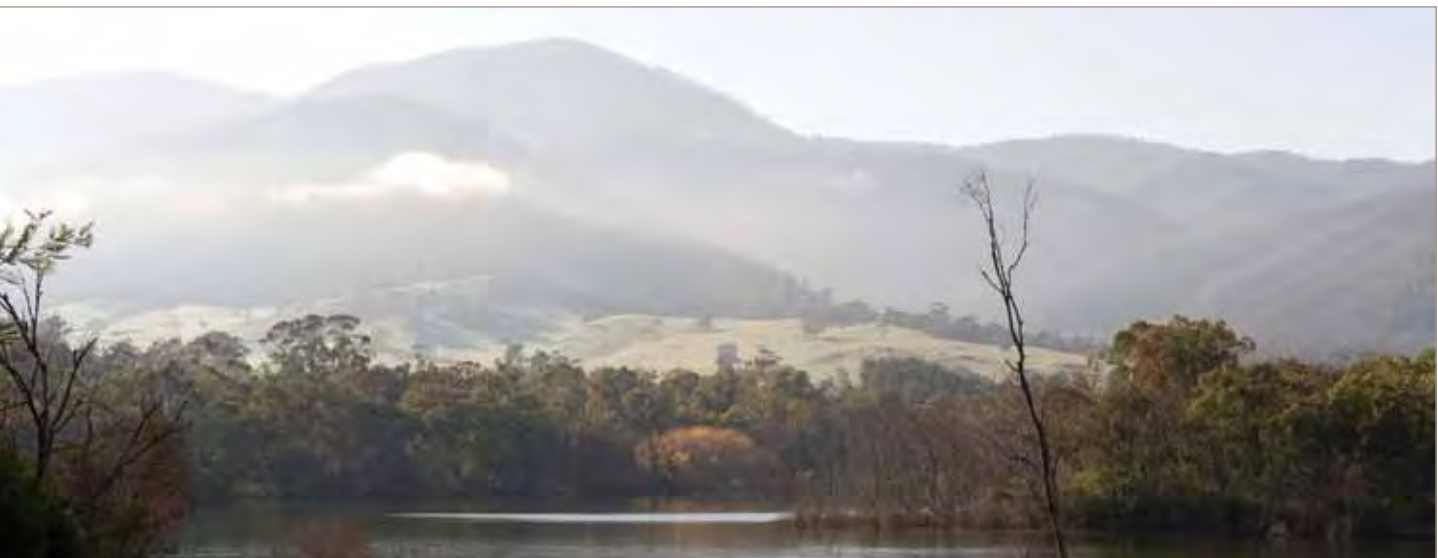
Basin state	Name of plan	Type of plan	Date plan ceases to have effect
New South Wales	Proposed water sharing plan for the Barwon–Darling unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
New South Wales	Proposed water sharing plan for the Intersecting Streams unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
New South Wales	Water Sharing Plan for the New South Wales Border Rivers Regulated River Water Source 2009	Interim	31 December 2014
New South Wales	Proposed water sharing plan for the New South Wales Border Rivers unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
New South Wales	Proposed water sharing plan for the Gwydir unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
New South Wales	Proposed water sharing plan for the Lachlan unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approx Dec 2015 (5 years from when plan is made)
New South Wales	Proposed water sharing plan for the Lower Murray–Darling unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
New South Wales	Proposed water sharing plan for the Macquarie and Bogan unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is proposed to be made)
New South Wales	Proposed water sharing plan for the Castlereagh unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is proposed to be made)
New South Wales	Proposed water sharing plan for the Murray unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
New South Wales	Proposed water sharing plan for the Murrumbidgee unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
New South Wales	Proposed water sharing plan for the Lower Murrumbidgee unregulated water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
New South Wales	Water Sharing Plan — Peel Valley regulated, unregulated, alluvial and fractured rock water sources	Interim	1 July 2015
New South Wales	Proposed water sharing plan for the Namoi unregulated and alluvial water sources	Interim (when finalised by New South Wales — proposed date December 2010)	Approximately December 2015 (5 years from when plan is made)
South Australia	Water Allocation Plan for the Marne Saunders Prescribed Water Resources Area	Interim	18 January 2015
South Australia	Regional natural resources management plan for the South Australian Murray–Darling Basin This is an integrated natural resources management plan that manages some aspects of water interception and/or extraction via the water-affecting activity permit policy section	This plan is not recognised as an interim or transitional plan for the purposes of the Water Act	2019
South Australia	A water allocation plan for the Eastern Mount Lofty Ranges Prescribed Water Resources Area is proposed, but a draft has not yet been released for comment	A draft plan is currently under development. An adopted plan is expected to become an interim plan	If a draft plan is adopted before the end of 2010, it would cease to have effect towards the end of 2015

The proposed Basin Plan



Chapter 3

Lake Wetherell, one of the Menindee Lakes storages south-east of Broken Hill, New South Wales, 2010



Lake Dartmouth, Victoria

The Basin Plan will establish integrated management for all the Basin’s water resources. Management will include enforceable long-term average sustainable diversion limits (SDLs), arrangements for the coordination and management of environmental water, and rules for water trading.

To develop these arrangements, the Murray–Darling Basin Authority (MDBA) has collated the best available information and scientific knowledge and has undertaken hydrologic modelling, technical work and analysis. This work forms the evidence base for the plan described later in this chapter. This guide is part of the iterative approach MDBA has chosen to develop the plan — with the next steps being the release of the proposed Basin Plan for public comment and consideration of those comments ahead of the Basin Plan being considered by the Murray–Darling Basin Ministerial Council and the Commonwealth Water Minister.

While MDBA will be responsible for implementing the Basin Plan, Basin states will continue to play a central role in management of the Basin’s water resources. Water resource plans will continue to set out the arrangements for allocating water. These water resource plans will implement the Basin Plan’s arrangements once ‘accredited’ by the Commonwealth Water Minister as being consistent with the Basin Plan. In this way, there will be a two-tiered management approach, the Basin Plan setting Basin-scale arrangements and water resource plans continuing to manage water resources at a local level.

Achieving these results will address the current threats to the Basin’s water resources and improve certainty for the Basin’s communities and environment. Some risks to the plan’s success remain, however, and ensuring it achieves its objectives may mean some of its provisions will need to be refined and revisited. MDBA will monitor whether the plan is delivering the desired outcomes and will review the plan at least every 10 years.

The development of the proposed Basin Plan has been informed by the best available science (biophysical, social and economic), but MDBA recognises there will always be more to learn as new issues, challenges, research and knowledge emerge. Therefore, management settings in the plan will recognise and provide for adaptive management of uncertainties, driving and contributing to review and revision of the Basin Plan into the future.

3.1 Management objectives and outcomes

The Basin Plan is the first attempt to manage the Basin's water resources on an integrated basis. This new approach recognises that the future economic strength of the Basin is inextricably linked to the wellbeing of the environment. Under the *Water Act 2007* (Cwlth), the Basin Plan can provide for management of water resources in a way that promotes maximum economic return, only to the extent that this does not compromise environmentally sustainable levels of extraction or the ecological values and ecosystem services of the Basin.

With the current understanding of the Basin's water resources in mind, the Murray–Darling Basin Authority (MDBA) has developed the proposed Basin Plan to achieve the following objectives:

- maintain and improve the ecological health of the Basin, and in doing so optimise the social, cultural, and economic wellbeing of Basin communities. This objective relates to the following provisions of the *Water Act*:
 - relevant international agreements (ss. 3(b), 20(a), 21(1)–(3))
 - optimisation of economic, social and environmental outcomes (ss. 3(c) and (d)(iii), 20(d), 21(4)(c)(ii) and (v))
 - environmentally sustainable level of take (ss. 3(d)(i), 20(b), 22(1) item 6, 23(1))
 - environmental watering (ss. 3(d)(ii), 20(c), 22(1) items 9, 28)
 - water quality and salinity management (ss. 20(c), 22(1) items 10, 25)
 - principles of ecologically sustainable development (s. 21(4)(a))
- establish limits on the quantity of surface water and groundwater that can be taken from the Basin's resources for consumptive use, based on a determination of what is environmentally sustainable at a catchment and a whole-of-Basin level. This objective relates to the following provisions of the *Water Act*:
 - relevant international agreements (ss. 3(b), 20(a), 21(1)–(3))
 - optimisation of economic, social and environmental outcomes (ss. 3(c) and (d)(iii), 20(d), 21(4)(c)(ii) and (v))
 - environmentally sustainable level of take (ss. 3(d)(i), 20(b), 22(1) items 6, 23(1))
 - principles of ecologically sustainable development (s. 21(4)(a))
- improve the resilience of key environmental assets, water-dependent ecosystems and biodiversity in the face of threats and risks that may arise in a changing environment. This objective relates to the following provisions of the *Water Act*:
 - relevant international agreements (ss. 3(b), 20(a), 21(1)–(3))
 - optimisation of economic, social and environmental outcomes (ss. 3(c) and (d)(iii), 20(d), 21(4)(c)(ii) and (v))
 - environmentally sustainable level of take (ss. 3(d)(i), 20(b), 22(1) items 6, 23(1))
 - environmental watering (ss. 3(d)(ii), 20(c), 22(1) items 9, 28)
 - water quality and salinity management (ss. 20(c), 22(1) items 10, 25)
 - principles of ecologically sustainable development (s. 21(4)(a))



Woolshed Falls near Beechworth, Victoria

- maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin. This objective relates to the following provision of the Water Act:
 - water quality and salinity management (ss. 20(c), 22(1) items 10, 25)
- improve the transparency and efficiency of water markets in the Basin. This objective relates to the following provisions of the Water Act:
 - efficient and cost-effective water management (s. 3(g))
 - water to reach its most productive use (s. 20(e))
 - water trading (ss. 22(1) items 12, 26))
- provide a clear transition path for entitlement holders and communities through the period from plan adoption to implementation at a local level. This objective relates to the following provisions of the Water Act:
 - optimisation of economic, social and environmental outcomes (ss. 3(c) and (d)(iii), 20(d), 21(4)(c)(ii) and (v))
 - temporary diversion provisions (ss. 22(1) items 7, 24)
 - risk allocation provisions (Division 4 of Part 2).

Meeting these objectives is anticipated to result in the following outcomes:

- water-dependent ecosystems in the Basin would be more able to withstand short and long-term changes in watering regimes resulting from a more variable and changing climate
- use of Basin water resources would not be adversely affected by water quality, including salinity levels
- there would be improved clarity in water management arrangements in the Basin, providing improved certainty of access to the available resource
- Basin entitlement holders and communities would be better adapted to less water.

Achieving the plan's management objectives and outcomes

The Basin Plan's management objectives and outcomes will be achieved through the implementation of its management settings, which together are expected to deliver the outcomes on the ground. Achieving these objectives and outcomes will take time and will require a robust partnership between the Australian Government, Basin state governments and the Basin community, with clarity of roles, responsibilities and accountability.

The plan's objectives and outcomes will provide the reference point against which the success of the Basin Plan will be measured. While the water resource plans will remain in place for 10 years, adjustments to the plan may be needed in the meantime to ensure it achieves its desired outcomes. Assessment of any necessary adjustment will be assisted by careful monitoring of the plan's results through the monitoring, evaluation and reporting arrangements described in Chapter 7 of this volume.



Tumut River, New South Wales



Aerial view of the mouth of the River Murray, South Australia

3.2 Water resource plan areas

The Basin Plan's management arrangements will be implemented at a local scale through water resource plans prepared by the Basin states for accreditation by the Commonwealth Water Minister.

The Basin has been divided into water resource plan areas — 19 for surface water and 23 for groundwater. These boundaries are shown in Figure 3.1 (surface water) and Figure 3.2 (groundwater). Within these water resource planning areas are 107 long-term average sustainable diversion limit (SDL) areas (Figures 3.3 and 3.4).

The water resource plan areas cover the entire Basin, including those areas not previously subject to water planning arrangements. The water resources in the Murray–Darling Basin to which the Basin Plan will apply are identified in the *Water Act 2007* (Cwlth). These resources do not include the Great Artesian Basin water resources.

The Water Act (s. 22(1) item 2) requires that boundaries of water resource plan areas must align as far as possible with existing water management boundaries. Accordingly, the Murray–Darling Basin Authority (MDBA) used existing water planning areas as a starting point in the identification of new water resource plan areas. In some cases, existing state planning boundaries have been varied to include, for example, water resources that are not currently covered by water planning areas, or as a result of consultation with Basin states. Hydrologic, geological and hydrogeological units, such as river catchments, geological formations and aquifers, were also used to identify the new boundaries. The surface-water water resource plan areas are largely based on surface-water catchment boundaries, while the groundwater areas are based chiefly on hydrogeological units. This has meant that in most cases, different boundaries have been needed for surface water and groundwater. As the individual Basin states are responsible for developing water resource plans, each water resource plan area is wholly contained within a single Basin state.

The Basin states will be required to report to MDBA on compliance with SDLs in each water resource plan area within four months of the end of a standard water accounting period (1 July to 30 June), providing consistency across the Basin for compliance reporting, and aligning arrangements with the development of a National Water Account.

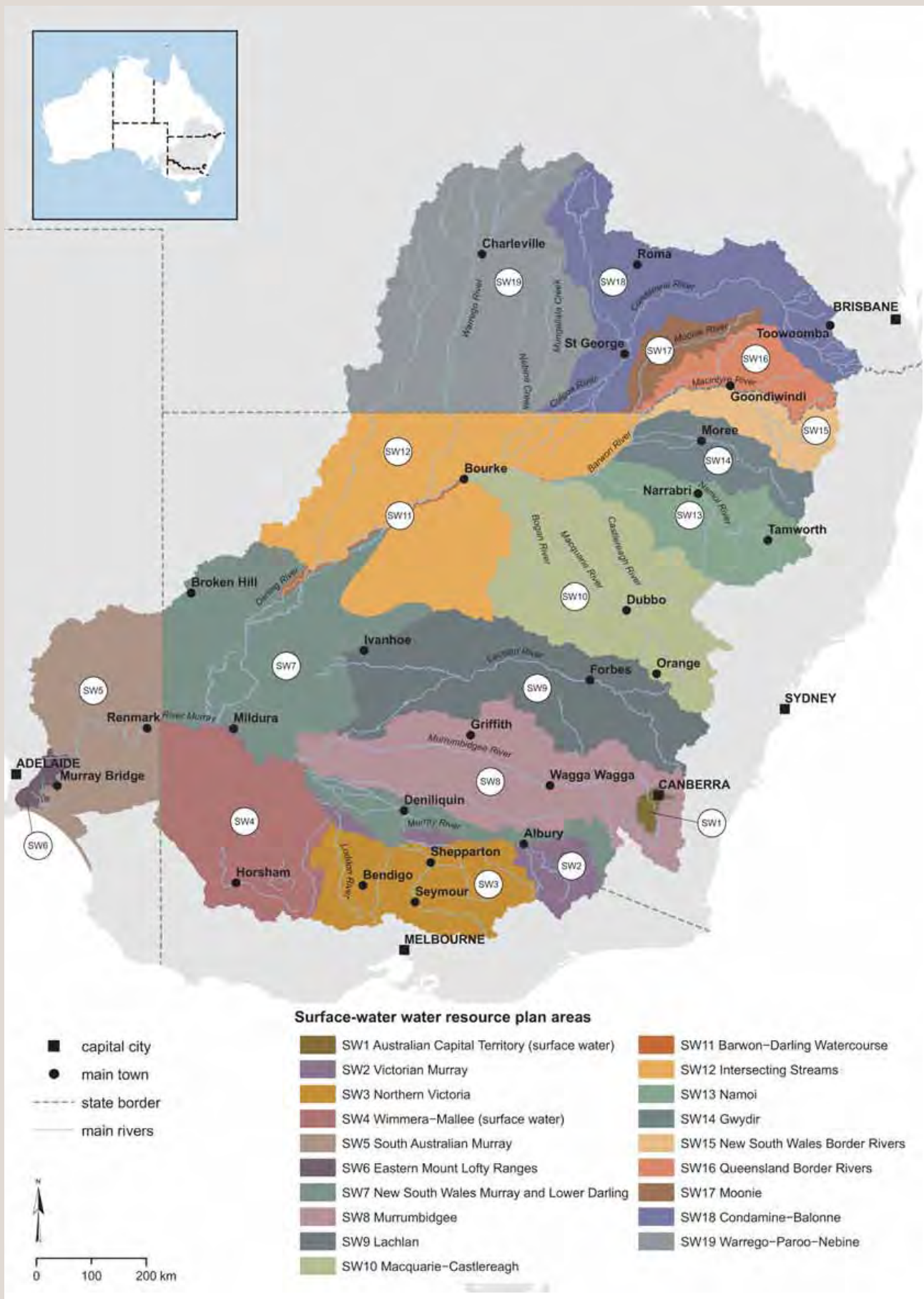


Figure 3.1 Surface-water water resource plan areas: Murray–Darling Basin

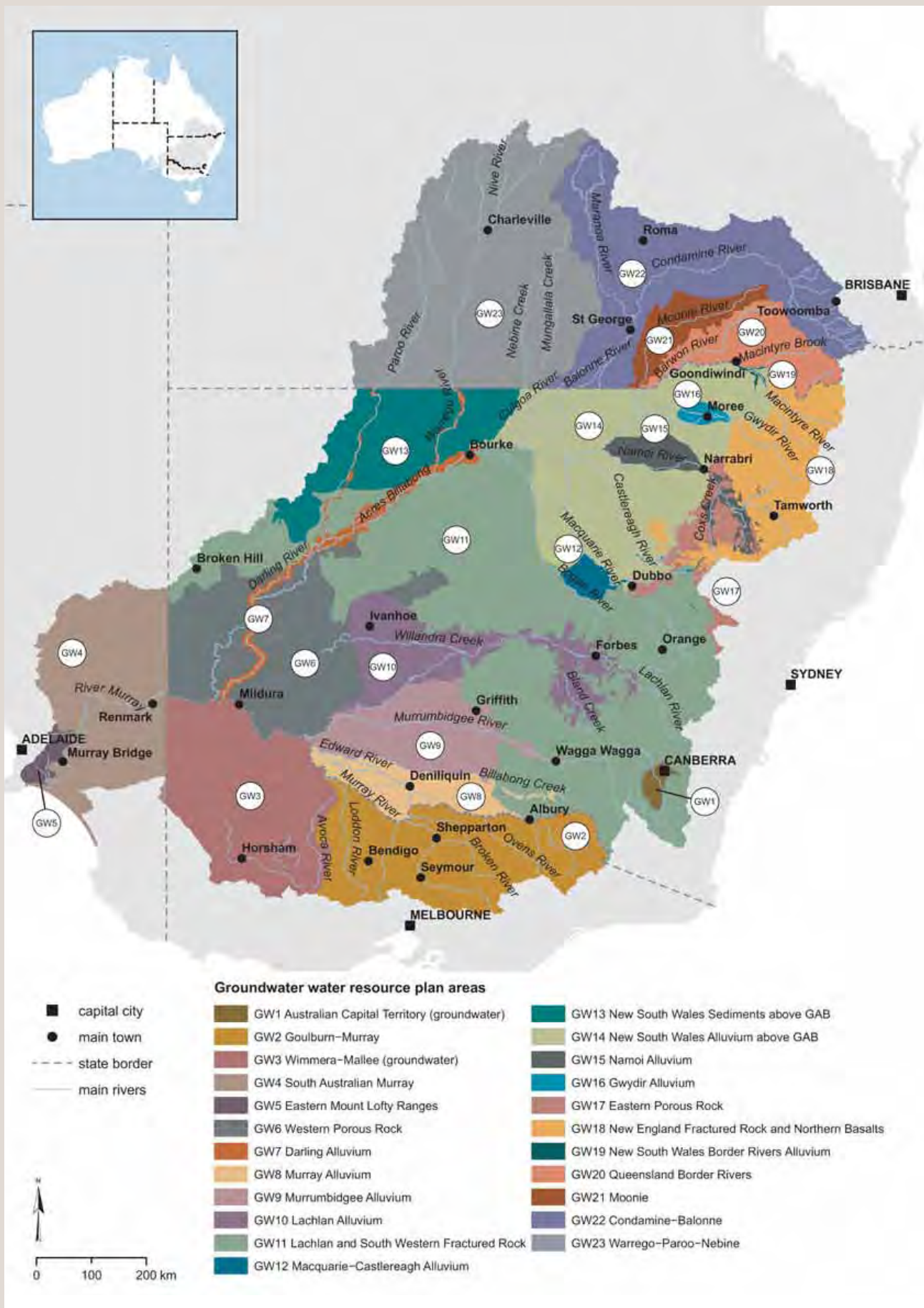


Figure 3.2 Groundwater water resource plan areas: Murray–Darling Basin



Figure 3.3 Groundwater SDL areas: Murray–Darling Basin

Groundwater SDL areas

	Not Basin water resources		GS40 Lower Macquarie Alluvium
	GS1 Angas Bremer		GS41 Lower Murray Alluvium
	GS2 Eastern Mount Lofty Ranges		GS42 Lower Murrumbidgee Alluvium
	GS3 Mallee		GS43 Lower Namoi Alluvium
	GS4 Mallee Border Zone		GS44 Manilla Alluvium
	GS5 Marnie Saunders		GS45 Mid-Murrumbidgee Alluvium
	GS6 Peake-Roby-Sherlock		GS46 NSW Alluvium above the Great Artesian Basin
	GS7 SA Murray		GS47 NSW Border Rivers Alluvium
	GS8 SA Murray Salt Interception Schemes		GS48 NSW Border Rivers Tributary Alluvium
	GS9 Goulburn-Broken Highlands		GS49 NSW Sediments above the Great Artesian Basin
	GS10 Loddon-Campaspe Highlands		GS50 New England Fold Belt: Border Rivers
	GS11 Murray Highlands		GS51 New England Fold Belt: Gwydir
	GS12 Ovens Highlands		GS52 New England Fold Belt: Namoi
	GS13 Ovens-Kiewa Sedimentary Plain		GS53 Orange Basalt
	GS14 Victorian Riverine Sedimentary Plain		GS54 Peel Valley Alluvium
	GS15 West Wimmera		GS55 Upper Darling Alluvium
	GS16 Wimmera-Avooca Highlands		GS56 Upper Gwydir Alluvium
	GS17 Wimmera-Mallee Border Zone		GS57 Upper Lachlan Alluvium
	GS18 Wimmera-Mallee Sedimentary Plain		GS58 Upper Macquarie Alluvium
	GS19 Adelaide Fold Belt		GS59 Upper Murray Alluvium
	GS20 Bell Valley Alluvium		GS60 Upper Namoi Alluvium
	GS21 Belubula Alluvium		GS61 Upper Namoi Tributary Alluvium
	GS22 Billabong Creek Alluvium		GS62 Warrumbungle Basalt
	GS23 Castlereagh Alluvium		GS63 Western Porous Rock
	GS24 Collaburragundry-Talbragar Alluvium		GS64 Young Granite
	GS25 Cudgegong Alluvium		GS65 Australian Capital Territory (Groundwater)
	GS26 Eastern Porous Rock: Macquarie-Castlereagh		GS66 Condamine Fractured Rock
	GS27 Eastern Porous Rock: Namoi-Gwydir		GS67 Queensland Border Rivers Alluvium
	GS28 Inverell Basalt		GS68 Queensland Border Rivers Fractured Rock
	GS29 Kanmantoo Fold Belt		GS69 Sediments above the Great Artesian Basin: Border Rivers
	GS30 Lachlan Fold Belt: Lachlan		GS70 Sediments above the Great Artesian Basin: Condamine-Balonne
	GS31 Lachlan Fold Belt: Macquarie-Castlereagh		GS71 Sediments above the Great Artesian Basin: Moonie
	GS32 Lachlan Fold Belt: Murray		GS72 Sediments above the Great Artesian Basin: Warrego-Paroo-Nebine
	GS33 Lachlan Fold Belt: Murrumbidgee		GS73 St George Alluvium: Condamine-Balonne
	GS34 Lachlan Fold Belt: Western		GS74 St George Alluvium: Moonie
	GS35 Lake George Alluvium		GS75 St George Alluvium: Warrego-Paroo-Nebine
	GS36 Liverpool Ranges Basalt		GS76 Upper Condamine Alluvium
	GS37 Lower Darling Alluvium		GS77 Upper Condamine Basalts
	GS38 Lower Gwydir Alluvium		GS78 Warrego Alluvium
	GS39 Lower Lachlan Alluvium		

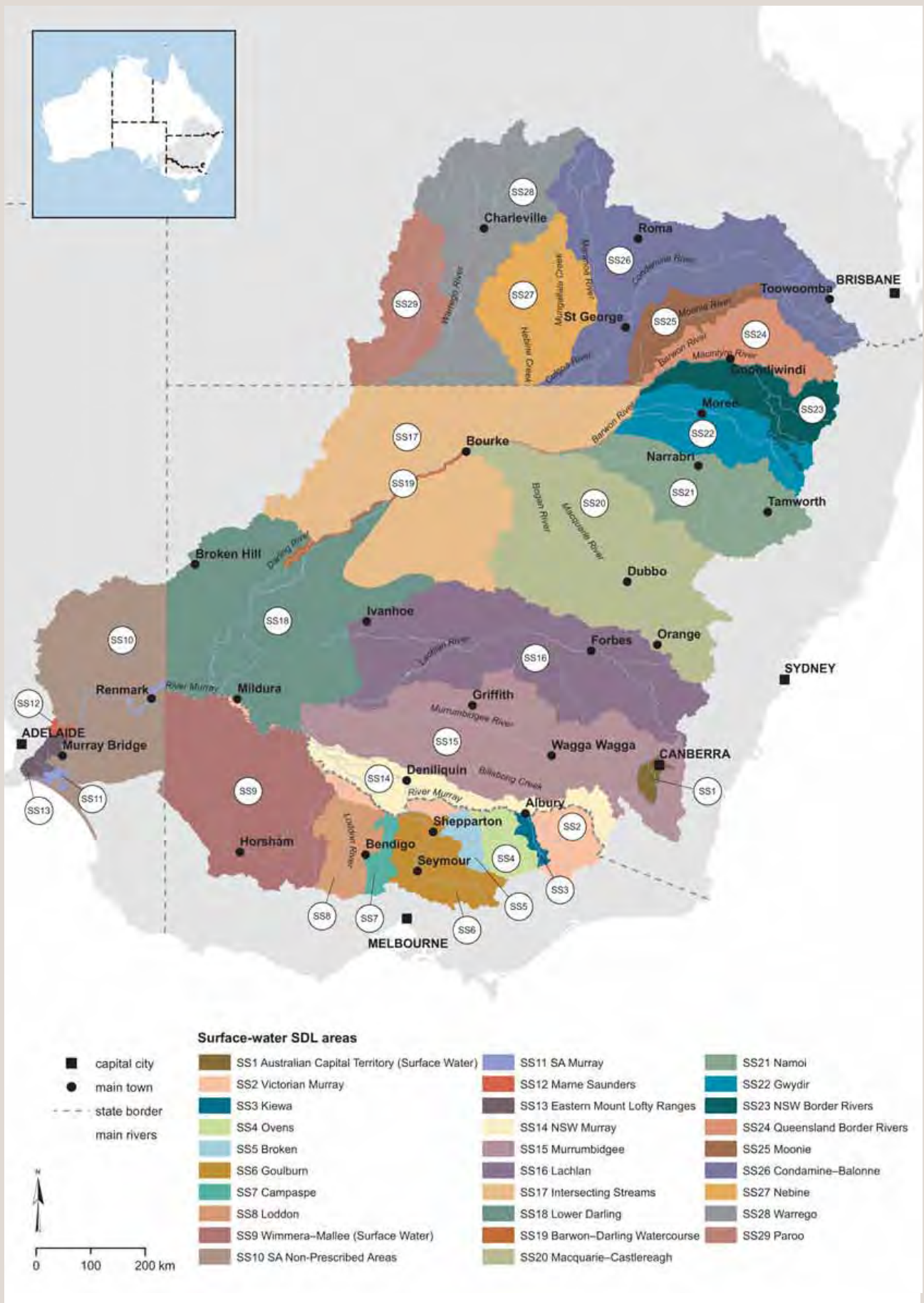


Figure 3.4 Surface-water SDL areas: Murray–Darling Basin

3.3 Risks to the Basin's water resources

In 2004, the Murray–Darling Basin Ministerial Council identified six factors posing a risk to the shared water resources of the Basin: climate change, a rise in the number of farm dams, increased groundwater extraction, afforestation, bushfires and decreasing irrigation return flows.

While fulfilment of the plan's objectives will address the impact of these threats to the Basin, some risks remain. To identify what further actions will be needed to support the implementation of the Basin Plan, the Murray–Darling Basin Authority (MDBA) has undertaken a comprehensive examination at a Basin scale of future risks to water resource condition and continued availability. The risk assessment was then used in developing the management strategies outlined in Section 3.4.

Risk assessment approach

To assess the future risks to the Basin's water resources once the Basin Plan is in place, MDBA conducted a risk assessment using the Australian/New Zealand and International Standard on risk management, ISO 31000. This included identification of the risks that could arise and the factors that contribute to the risks. As the purpose of the assessment was to identify and evaluate the risks that will remain when the plan is in operation, a 10-year time frame was chosen to correspond with the requirement to review the plan at least every 10 years.

The Basin Plan's risk assessment was undertaken at Basin scale. MDBA identified approximately 140 contributing factors, which were grouped into four risks:

- insufficient water for the environment
- water quality unsuitable for use
- poor health of water-dependent ecosystems
- policy with unintended adverse impacts.

These four categories are based on the residual risks that could arise after the Basin Plan is in operation. Risks that will be mitigated by the Basin Plan were therefore excluded from the assessment.

The first three risks were analysed to identify the contributing factors for each and to assign a rating. This analysis was completed using a purpose-made Bayesian network, a modelling tool that is used to analyse and manage the linkages between the factors that contribute to the likelihood of a risk arising, and to transparently incorporate both qualitative and quantitative information from a variety of sources (Pollino et al. 2010). The model identified significant links between the contributing factors across these three categories of risk, with central factors being lack of knowledge and lack of compliance. Each of the first three risks was assigned a rating according to its likelihood of occurrence, on a scale from low (less than 40%) to moderate (40–80%) to high (greater than 80%). This approach assumed that it is unacceptable to have any of these three risks become reality — sometimes referred to as an 'all or nothing', or binary, approach. The risk likelihood and the contributing factors were then used to identify and prioritise the risk management strategies, as detailed in Section 3.4.



Reed Beds Swamp in the Barmah–Millewa Forest, showing a positive response after receiving environmental water

MDBA took a different approach in relation to the fourth risk, policy with unintended adverse impacts; it was not assessed via the Bayesian network model. This risk is difficult to quantify as it differs from the other identified categories, which are primarily related to quantifiable physical attributes. MDBA commissioned an initial investigation into the policies that may incidentally impact on the condition and continued availability of the Basin water resources; examples include promoting afforestation, stormwater harvesting and expanding urbanisation. This initial study (Dyson 2009) presents an overview of the types of legislation and policy that have the potential to adversely affect the Basin's water resources. By establishing whole-of-Basin arrangements for water resource management, the Basin Plan will itself manage some of these risks. A greater understanding of the scale and nature of the effects of policies with unintended adverse impacts is required; this need for further work is identified in the strategies to manage this risk described in Section 3.4.

Risks and their contributing factors

Insufficient water for the environment

Using the Bayesian network-based model, the risk of insufficient water for the environment was assessed as having a moderate (40–80%) likelihood of arising. The study identified the following contributing factors:

- lack of knowledge — the Basin Plan has been developed based on the knowledge, information and data that is available. While this has provided a substantial evidence base, gaps in the available knowledge about the Basin's water resources, 'take' activities and environmental water requirements may act as a factor contributing to the risk that the amount of water allocated will leave insufficient water for the environment
- lack of compliance — this risk is likely to be higher in dry periods when pressure on water users is greater
- suspension — parts or all of a water resource plan may be suspended in extremely dry conditions when the ability to meet critical human water needs is threatened.

Water quality unsuitable for use

Historical data was used to assess the risk to the quality of the Basin's water resources. The findings therefore do not take into account how the Basin Plan might affect water quality and salinity.

A further study will be undertaken to assess risk against the water quality and salinity targets specified in the plan and to ensure that the management strategies identified remain appropriate. In the meantime, the existing assessment provides a good indicator of future risks and clear priorities for their management.

Risk ratings and contributing factors were assessed by considering the risk of water quality being unsuitable for the following purposes:

- Aquatic ecosystem protection — the risk was assessed as high (greater than 80%). The risk factors, in order of importance, are salinity, turbidity, total nitrogen content and total phosphorus content. Guidelines on acceptable levels for all these factors have been exceeded in existing records.
- Irrigated agriculture — the risk was assessed as moderate (40–80%). The factors considered were salinity, nitrogen and phosphorus, as other water quality attributes do not have a significant impact.
- Drinking water — the risk was assessed as low (less than 40%). Salinity was the only factor considered in the assessment, as it is assumed that other contaminants would be removed through treatment.
- Recreation — the risk was also assessed as low. The assessment results were, however, potentially influenced by the lack of measurements of blue-green algal concentrations; the risk of blue-green algal blooms may be more significant at a regional or local scale.

Poor health of water-dependent ecosystems

The risk of further decline in the health of water-dependent ecosystems was assessed as moderate (40–80%) once the Basin Plan is in place. As poor health of water-dependent ecosystems is in part a consequence of scarcity of water for the environment, the factors that cause this scarcity will also contribute to the poor health of water-dependent ecosystems. Poor current condition and lack of knowledge of the extent of wetlands and any changes to their extent are also significant contributing factors.

Risk to water resource availability

The *Water Act 2007* (Cwlth) requires that the risk assessment includes risks to the availability of Basin water resources that arise from the taking and use of water (including through interception activities), the effects of climate change, changes to land use and limitations on the state of knowledge used to make estimates about the Basin's water resources (s. 22(1) item 3).

Each of these threats was considered as a contributory factor in the Bayesian network model. MDBA, however, also looked at the profile of these risk factors on the availability of water resources, using the results of the Bayesian network-based risk assessment, with the following results:

- Limited knowledge was identified as posing a high risk, reflected in findings of the Bayesian-based assessment.
- Taking and using of water was assessed as a low risk once the Basin Plan is in effect, as the long-term average sustainable diversion limits would limit both direct extraction and indirect forms of take, such as via farm dams.



Lake Mokoan near Glenrowan, Victoria

- Risks posed by the effects of climate change were examined in the context of their potential impact on water availability. Overall, the assessment concluded that as these risks will be factored into the Basin Plan's management settings, climate change will pose only a low level of risk to water availability. Under a drier climate, the likelihood of compliance issues and the suspension of water resource plans would increase.
- Risk to water availability from changes to land use was considered to be low, since only major changes are likely to pose a risk at Basin scale. The risk could, however, be higher at a water-resource-plan scale.

3.4 Risk management

Using the results of the risk assessment, management strategies were developed for the key factors identified as contributing to the likelihood of the four primary risks (Pollino & Glendining 2010).

Prioritisation of the management of the identified risks and their contributing factors is based on a combination of the likelihood of the risk arising and the feasibility of the strategy or strategies required to address it. This included consideration of the role of the Murray–Darling Basin Authority (MDBA) and that of the Basin Plan. Climate change, for example, may be a major cause of scarcity of water for the environment, but it is not within the capacity of the Basin Plan to develop strategies to combat climate change. (The plan will, however, include many strategies to address the effects of climate change.)

Prioritisation is based on four categories:

- highest — should be initiated as soon as practical once the Basin Plan comes into effect
- high — should be initiated within six months of the plan or water resource plan coming into effect
- medium — should be initiated within 12 months of the plan or water resource plan coming into effect
- low — should be initiated as and when opportunity provides.

Table 3.1 sets out the management strategies identified for each primary risk and the priority of each strategy. It should be noted that the factors that contribute to the risk of insufficient water for the environment also contribute to the risk of poor health of water-dependent ecosystems, and therefore the strategies that will manage the first risk will also help to manage the second.

The strategies identified will be used by MDBA in the development of its future programs, noting that these may be the responsibility of other agencies. Some of these strategies correspond to work currently under way to support implementation of the Basin Plan, including the development of an integrated Basin-wide modelling platform and of a compliance framework to support implementation of the plan.

Table 3.1 Risk management strategies

Item	Risk factor	Management strategies to be adopted	Priority
Risk — insufficient water for the environment (moderate risk)			
1	Lack of knowledge of environmental assets and ecosystem functions	To improve knowledge of environmental assets and ecosystem functions including quantifying watering requirements where assets or ecosystem functions are known to be vulnerable	Highest
		To implement the monitoring and evaluation program as it relates to the Environmental Watering Plan	Medium
2	Lack of compliance with the Basin Plan (including the Environmental Watering Plan)	To ensure the compliance regime reflects the likelihood of decreased compliance in dry periods	High
		To promote cooperative compliance arrangements with Basin states	High
		To ensure compliance is an overt activity	Medium
		To ensure compliance is open, accountable, transparent and fair	High
		To engage the community in voluntary compliance	High
		To encourage rigorous compliance with water resource plans	Highest
3	Lack of knowledge of water availability, including knowledge of inflows and quality of groundwater modelling	To invest in greater flow gauging in regions where knowledge gaps exist	High
		To invest to improve modelling of groundwater in catchments where knowledge gaps exist	Highest
		To invest to improve modelling of surface water in catchments where knowledge gaps exist	Medium
4	Lack of knowledge of take activities, including floodplain harvesting interceptions by farm dams and agricultural and industrial water use	To acquire better knowledge of estimating floodplain harvesting and interceptions by farm dams in areas where knowledge gaps exist, including the Barwon–Darling, Border Rivers, Condamine–Balonne, Namoi, Paroo and Warrego regions identified by the CSIRO Murray–Darling Basin Sustainable Yields Project	High
		To improve metering data used to estimate extractions and diversions in regions where knowledge gaps exist	Medium
5	Suspension of all or part of a water resource plan	To require water resource plans to examine and deal with specified climate scenario circumstances	Medium
		To encourage suspension to only be undertaken in tightly defined and extreme circumstances	High
Risk — water quality unsuitable for use (low to high risk)			
6	Water quality is unsuitable for: <ul style="list-style-type: none"> • aquatic ecosystem protection • irrigated agriculture • drinking water • recreational use 	To improve flow management in accordance with the Basin Plan	Highest
		To invest to improve non-salinity water quality models, including by: <ul style="list-style-type: none"> • improving Basin-wide understanding of causes of water quality degradation • linking models to instream flow models • incorporating blue-green algal predictions • representing relationships between flow and water quality to enable a better assessment of water quality changes in the Basin Plan and water resource plans 	High
		To conduct further research into the causes of water quality degradation	High
		To develop guidelines for managing causes of water quality degradation	High
		To revise water quality targets for aquatic ecosystems to improve the relationships between targets and ecological conditions and functions	High
		To ensure that Basin water quality monitoring integrates with other MDBA programs (e.g. the Native Fish Strategy)	Medium
		To ensure Basin-wide water quality monitoring is developed by MDBA in cooperation with Basin states and regional agencies, and the monitoring of causes of water quality degradation	Medium
		To implement the monitoring and evaluation program including the reporting requirements for the Commonwealth and the Basin states and the 5-yearly reviews of the Environmental Watering Plan and the water quality and salinity targets in the Water Quality and Salinity Management Plan	High
To seek to align, as far as possible, Commonwealth natural resource management and research programs with achieving outcomes of the Basin Plan	Low		

... continued

Table 3.1 Risk management strategies (continued)

Item	Risk factor	Management strategies to be adopted	Priority
Risk — poor health of water-dependent ecosystems (moderate risk)			
7	Poor current condition of environmental assets and ecosystem functions	To improve linkages between the water requirements of environmental assets and ecosystem functions in accordance with the Environmental Watering Plan, and local and regional processes that are likely to compromise meeting objectives in the Environmental Watering Plan	Highest
		To coordinate the implementation of the Environmental Watering Plan with Basin states and regional agencies	High
		To, as far as possible, use Commonwealth funding programs (e.g. Caring for our Country) to target on-ground riparian activities, which will lead to improved health of water-dependent ecosystems	High
		To use adaptive management to address knowledge gaps that exist in the relationship between water flow and biodiversity	Medium
		To increase effort to develop and implement threat abatement plans and threatened species recovery plans for water-dependent species in the Basin	Medium
		To ensure adequate funding is available for continuing programs (e.g. the Native Fish Strategy) that assess impacts of and prioritise removing, or mitigation of, instream and floodplain barriers	Medium
8	For the risk factors identified in items 1, 2, 3, 4 and 5 as they relate to poor health of water-dependent ecosystems	To improve inventories and mapping of wetlands in the Basin	Highest
Risk — policy with unintended adverse impacts			
9	Policies with unintended adverse impacts	To implement the Basin Plan, and to prepare and implement water resource plans	Highest
		To improve understanding of interactions between policy with unintended adverse impacts and the Basin Plan, to allow more precise management strategies to be developed cooperatively with all Basin states	High

Future risk assessment

The Basin Plan will also establish the arrangements for water-resource-plan-scale assessment through the requirement that an accredited water resource plan incorporates the results of a risk assessment that used a Bayesian network-based tool or equivalent. This will ensure that water planning decisions and management arrangements are developed in the light of a credible risk assessment approach. This consistency of method will also enable future reviews of the plan to use the outcomes of water-resource-plan-scale risk assessments, thus supporting future Basin-scale risk assessments through the acquisition and use of comparative data.

3.5 The evidence base

The Basin Plan has been developed by drawing on the available evidence base. This falls into three broad categories: the collation of existing data; the use of hydrologic and socioeconomic modelling; and a consideration of existing scientific knowledge and socioeconomic analysis. Of the three, the hydrologic evidence is considered the most consistent and most suitable for adaptation to the development of the Basin Plan.

To illustrate its confidence in the quality of the evidence used to develop the guide, and to address any concerns that the existing information used in developing the guide is difficult to find, the Murray–Darling Basin Authority (MDBA) is providing a catalogue on its website, which shows how to access the resources used (thebasinplan.mdba.gov.au/bpkid).

Hydrologic data and information

Observed data for rainfall, temperature, evaporation, streamflow and metered diversions between 1895 and 2009 are the key inputs to the surface-water models available for the Murray–Darling system. To be able to study system performance under a range of climatic conditions, a continuous record of this input data is needed. For the Basin Plan, it was decided to study system performance for climatic conditions from 1895 to 2009, as this period covers the Federation drought, the current drought and a range of wet periods.

Hydrologic data, as well as information on crop types and planted areas used to calculate water demand by the agricultural sector, was sourced by MDBA from Basin state agencies. There are gaps in water data records over time and to overcome these shortcomings in observed records, a variety of well-established techniques were used to fill the gaps. This ensured that the extended datasets described the full range of behaviour of the water resource system between 1895 and 2009 for a given set of water management conditions. Based on this extended dataset, the models were able to provide estimates of flows and water use at locations where measurements had not been made.

The surface-water models have been calibrated using measured data and are also tested for performance by comparing their results with measured data from a period not used for calibration. Measured data is not available to calibrate models under all potential long-term ranges of climatic variability; model performance can therefore vary when conditions differ significantly from those for which models were calibrated and tested.

Similarly, the groundwater models used were calibrated against observed data sourced from the Basin states. Water quality data from Basin state agencies was also collated as the starting point for determining the Basin Plan's water quality and salinity management targets.

The water data was assembled from sources including:

- Cap model audit reports
- state-held datasets and calibration reports
- the Bureau of Meteorology (for climate data).

Currently, hydrologic data is collected and held by several organisations. Under the *Water Act 2007* (Cwlth), the Bureau of Meteorology has been given responsibility for compiling and disseminating water information across Australia. This will improve the coverage, accuracy and currency of water information and make it freely accessible online. Central to this is the development of the Australian Water Resources Information System, which will generate information on water storage, groundwater, water trading and water quality (Department of the Environment, Heritage, Water and the Arts 2010d).



Burrinjuck Dam in New South Wales at 38.6% capacity, May 2009

Ecological data

Ecological data for the Basin Plan was derived from a range of information about the estimated 30,000 wetlands and many thousands of kilometres of rivers and streams in the Basin. The ecological data was assembled from existing international, Commonwealth and state sources, including:

- declared Ramsar wetlands
- wetlands listed in *A directory of important wetlands in Australia* (Department of the Environment, Water, Heritage and the Arts 2001)
- High Conservation Value Aquatic Ecosystem sites (Department of the Environment and Water Resources 2007)
- icon sites established under The Living Murray initiative
- published and unpublished literature (e.g. state management plans and peer-reviewed scientific journals)
- the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
- spatial databases (e.g. the Species Profile and Threats Database (Department of the Environment, Water, Heritage and the Arts 2009b)).

These databases have been populated by government scientists and other ecologists over many years, and form the basis for mapping the ecological status of species across the nation. The databases have been used particularly by states for recording threatened species and communities. Other ecological datasets include long-term databases from universities and non-government organisations.

Socioeconomic data

Socioeconomic data has been primarily sourced from the Australian Bureau of Statistics (ABS), Bureau of Rural Sciences (BRS) and the Australian Bureau of Agricultural and Resource Economics (ABARE). These organisations maintain national datasets, with the data collected over various time frames. This often means that the most recent data is a few years old; the ABS agricultural census data, for example, is from 2005–06. In addition to large-scale datasets, there was a requirement to understand the socioeconomic impact at a local scale. This need was addressed by using the national datasets and undertaking targeted data capture at a community, regional and state level. This work and its application through the social impact assessment is detailed later in this section.

Hydrologic modelling

Hydrologic models are computer software tools that mathematically represent the complexity of water movement through a river system (river-system models) or an aquifer (groundwater models) in time and space. They use a variety of input data to represent the behaviour of a river system or an aquifer, including the variability of the system under changing climate conditions. Such models are used worldwide to support water resource management and planning, and are key tools that support the preparation of the Basin Plan.

To understand the complex surface-water management arrangements that exist in the Basin, MDBA is using 24 existing state river-system models that have been linked together to represent Basin-wide hydrology and water sharing arrangements. This linked or integrated model was originally developed by the CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008). However, to adapt to the specific needs of the Basin Plan, the methods and tools underpinning the Sustainable Yields Project have been updated by MDBA, with considerable technical assistance from CSIRO and



Softwood plantation in the Bremer River catchment near Strathalbyn, South Australia

its subcontractor, SKM, and with input from state agency technical staff. These models use climate records from 1895 to 2009 to determine the impact of providing water for the environment on the amounts and patterns of consumptive water use. The modelling can also explore the impact of a range of possible future climates on the water management regime.

MDBA is using baseline condition models received from the Basin states, which represent reference points from which changes to water management strategies can be assessed. The baseline represents existing infrastructure (dams and weirs), entitlements and water sharing rules in current water sharing plans, current operating rules, current environmental flow rules, and the streamflow impacts of current groundwater use.

In addition, MDBA has received without-development models from the Basin states, which are used to understand river flow regimes in the absence of water resource development. These without-development models are set up by modifying a baseline model to remove all water resource infrastructure, all irrigation demands and all water management rules. In this way, it is possible to provide a 'natural' flow regime description (the 'without-development' model) as an environmental reference point.

The individual river-system models provided by the Basin states — or, in the case of the Murray and Lower Darling regions, by MDBA — have been calibrated by the state agencies and, in most cases, detailed calibration reports have been produced, although these are seldom published. These reports have been scrutinised via the independent audit of Cap models conducted by the Murray–Darling Basin Commission/MDBA. This process has led to significant revisions and improvements to the river models.

The integrated model in the framework used to develop the Basin Plan was first tested by the CSIRO Murray–Darling Basin Sustainable Yields Project, which was independently reviewed by an expert panel headed by a commissioner from the National Water Commission. Since updating this framework for Basin Plan application, the modelling system's design and methods have been documented and subjected to two additional independent scientific reviews.

Groundwater modelling is not as well developed in the Murray–Darling Basin as river-system modelling. MDBA has, however, made extensive use of existing groundwater models. In total, 11 groundwater models were considered in calculating groundwater long-term average sustainable diversion limits (SDLs). These numerical models represent 73% of the Basin-wide 2007–08 extraction

of around 1,700 GL. Of the 11 models, seven are state models used for their water resource planning processes, three were developed as part of the sustainable yields project and one was in the process of being developed.

The 11 high-priority groundwater flow models were upgraded and improved by updating and extending datasets in the calibration model, including:

- rainfall recharge (in addition to extending the existing rainfall recharge time series, an attempt was made for all 11 models to incorporate rainfall recharge data that is consistent with WAVES recharge modelling results)
- irrigation recharge
- river stage elevation
- groundwater extraction
- groundwater-level observations.

For further detail about how surface-water and groundwater modelling was used to develop SDLs, see Section 4.4 of this volume.

Social and economic assessments

The Water Act requires that, in meeting the additional environmental water needs of the Basin, MDBA must optimise social, economic and environmental outcomes and, at a minimum, the impacts need to be well understood; however, the social and economic evidence base for the Basin is not adequate to undertake this assessment at a fine degree of resolution.

To overcome the weakness of the available information, MDBA commissioned several projects to assess the likely socioeconomic implications of each scenario. These projects include work undertaken by the Australian Bureau of Statistics (ABS) in conjunction with the Australian Bureau of Agricultural and Resource Economics (ABARE) and the Bureau of Rural Sciences (BRS) to look at baseline social and economic information about the circumstances of Basin communities. The issues covered included population trends, analyses of water use by industry and community, and indicators of economic and community wellbeing (ABS, ABARE & BRS 2009).

Work to develop regional community profiles was also undertaken and a comprehensive data store of available social and economic information was developed to enable ongoing monitoring and review work. A synthesis of current knowledge around the concepts of community resilience, vulnerability and adaptive capacity was also undertaken with an emphasis on understanding the drivers of change in regional and rural communities, especially in regard to reductions in water availability. The BDA Group in conjunction with The Australian National University undertook a review and synthesis of the results of previous socioeconomic studies conducted in the Murray–Darling Basin, particularly relating to changes in water availability and policy (BDA Group 2009; Marsden Jacob Associates et al. 2010).

In addition, economic modelling was undertaken to estimate the direct impacts on agricultural industries of various scenarios of reductions in current diversion limits. The modelling identified changes in the value of irrigated agricultural production, land use and water use as well as estimating the flow-on economic and employment impacts at a regional, Basin, state and national level. The work also identified regions and towns that may be particularly vulnerable to a reduction in irrigation activity (ABARE–BRS 2010a).

Work to understand the effects of change in current diversion limits on Aboriginal people of the Murray–Darling Basin was also undertaken (by CSIRO). This work highlighted water planning requirements that need to be considered in order to ensure Aboriginal interests are duly considered when finalising the plan, and in accreditation of water resource plans (Jackson, Moggridge & Robinson 2010).

Structural adjustment pressures on irrigated agriculture in the Murray–Darling Basin were examined by Frontier Economics. This provided a review of the range of structural adjustment pressures facing irrigated agriculture and its dependent communities so that the likely impact of the proposed Basin Plan could be understood in the broader context of ongoing structural change in the Basin (Frontier Economics 2010).

Work on the economic valuation of environmental benefits in the Basin was also undertaken, in particular non-market values likely to be associated with SDLs in the Basin (Morrison & Hatton Macdonald 2010).

Many Basin residents became participants in work undertaken for MDBA by Marsden Jacob Associates. This work on the economic and social profiles and impact assessment in the Murray–Darling Basin delivered information at the local and regional scale (including 12 irrigation district case studies) to enhance MDBA’s understanding of the social and economic circumstances of Basin communities. It assessed the likely impacts of reductions in current diversion limits on communities, especially in terms of community vulnerability and adaptive capacity.

The project gathered information about regional community opportunities, risks, constraints and aspirations as well as an appreciation of how communities can transform and adapt in response to changed diversion limits in the context of developing the Basin Plan (Marsden Jacob Associates et al. 2010).

Effects of changes to water policy on financing the agricultural sector, small business and individuals in the Murray–Darling Basin were also analysed. This work analysed the factors affecting the availability and cost of debt and equity capital in agricultural and tertiary industries in the Basin as a result of potential reductions in current diversion limits (Rizza 2010).

The Nous Group undertook an analysis that integrated much of the socioeconomic assessments and synthesised key findings (Nous 2010).

A number of further assessments have also been commissioned by MDBA to better understand the likely implications of each scenario. ABARE is undertaking a project to model the socioeconomic implications of each scenario in the Murray–Darling Basin and assess the more immediate economic implications of each scenario on the agricultural sector. The Centre of Policy Studies (Monash University) is also carrying out modelling to assess the short-, medium- and long-term economic implications, as well as downstream flow-on effects, of each scenario. (ABARE–BRS 2010a; Wittwer 2010).



*Hindmarsh Island Marina,
South Australia*

MDBA is also commissioning a series of social cost–benefit analyses of the effects of scenarios for introducing SDLs on each of the 19 regions within the Murray–Darling Basin and for the Basin as a whole.

The various reports prepared for MDBA use quite different methods; for example, both ABARE and the Marsden Jacob Associates report have addressed the socioeconomic impacts of possible scenarios but differ significantly in their techniques and underlying assumptions. Rizza (2010) takes a more general look at how the finance sector may be expected to respond to the Basin Plan itself, and Nous (2010) provides an integrated analysis and evaluation of the findings of these three reports and the ABS data.

ABARE has analysed the socioeconomic implications of the Basin Plan through ABARE’s water trade model (used to estimate the direct effects of changes in the SDLs on the value of irrigated agriculture) and a computable general equilibrium model to estimate economy-wide effects of change at the industry and regional levels. Marsden Jacob Associates, on the other hand, conducted face-to-face interviews with community representatives and a phone survey of households across the Basin to establish a social profile of regional communities. Rizza’s work on the finance sector is based on information collected from the sector as well as from his own knowledge of financing in the agrifood sector.

The Marsden Jacob Associates work taps into community understanding and knowledge of Basin agriculture and water resource management, but is limited in respect of the insight it can provide to understand the dynamic responses of industry and communities to increased water scarcity and changes in relative prices of water and other inputs. However, ABARE’s work is very useful in this regard and when considered together, the ABARE and Marsden Jacob Associates reports provide a solid foundation for consideration of the socioeconomic issues relevant to considering an SDL regime.

Scientific knowledge

The final piece of the evidence base is scientific knowledge. There is a significant body of scientific literature relevant to specific locations in the Basin, or to methods and approaches that have been used in similar fields of endeavour in Australia and internationally.

In developing the Basin Plan, MDBA drew on existing knowledge such as that of CSIRO, including its Murray–Darling Basin Sustainable Yields Project (CSIRO 2008), ABARE, the Sustainable Rivers Audit (Davies et al. 2008), and the work of research bodies and institutions such as the Murray–Darling Freshwater Research Centre and Geoscience Australia.

To provide transparency about the level of confidence in this material, a framework was developed to categorise the data, information and publications that were used as part of the evidence base for the plan. This framework was developed following extensive literature review to identify and determine the appropriateness of similar frameworks in Australia and overseas, and involved categorising the confidence level for data, information and scientific knowledge as either:

- high — broadly incontestable knowledge, formally peer-reviewed and published, repeatable
- medium — knowledge and data are available from a range of sources but may not have been subject to formal peer review, and/or the validity of the source may not be strong
- low — scientific knowledge is limited or emerging, requiring research investment.



Kinnairds Swamp, east of Numurkah, Victoria; after receiving environmental water, waterbird numbers increased

Overall, most of the evidence base falls into the medium confidence category, primarily through being government datasets or publications that have not undergone any significant peer-review scrutiny.

While the framework provides transparency as to the level of confidence in a given piece of material, the relationship with best available science is complex. For example, new or emerging scientific knowledge may have a low confidence level, but at the same time may still be the best available scientific knowledge.

MDBA remains concerned that much of this evidence is difficult to find, is often subject to restrictions on access, and is not easy to integrate. As a result it is very difficult to get a clear picture of the Basin or specific sites in the Basin. To address this issue, MDBA has committed to progressively making the evidence base available for public scrutiny. MDBA is providing a catalogue on its website, which shows how to readily access the resources that were used (thebasinplan.mdba.gov.au/bpkid).

The evidence base, including scientific knowledge, has been used by MDBA as the basis for the methods and approaches used to develop the Basin Plan's management settings. A scientific peer-review process has been adapted by MDBA as a mechanism to test these methods and approaches to ensure that they are rigorous, fit-for-purpose and based on the best available science.

This process involved review of the science and policy bases of the proposals by national experts from fields such as ecology and environmental management, risk, monitoring and evaluation, economics, sociology, water planning, hydrologic modelling, hydrogeology, and water quality and salinity management. These reviewers tested the underpinning evidence base and its treatment for the key elements of the plan. Peer reviews supported the overall approach taken to the various elements of the proposed plan. In summary, the reviews considered that the best available science was used, given the constraints of available time frames, data and knowledge. The reviewers also identified areas of refinement and alternative approaches that have been considered in developing the management arrangements described in the *Guide to the proposed Basin Plan*, as well as areas for further work in the longer term.

In addition to a detailed review of individual elements of the proposed Basin Plan, MDBA drew on international expertise to review the plan's overall methods and approaches. This review examined whether the evidence base

had been treated in an integrated way across all elements of the plan and whether the approaches proposed would operate cohesively to provide for integrated management. The international reviewers had high-level expertise and experience in the fields of environmental science, environmental and water resource management, ecology, and resource and environmental economics. Overall, the reviewers found that the central approaches used were a sensible and practical use of the information available. The review also highlighted the importance of effective engagement, monitoring and evaluation and implementation.

New arrangements



Chapter 4

Definitions

Key ecosystem functions — the fundamental physical, chemical and biological processes that support the Basin’s environmental assets; for example, the transport of nutrients, organic matter and sediment in rivers, wetting and drying cycles, and provision for migration and recolonisation by plants and animals along rivers and across floodplains.

Key environmental assets — include the rivers, lakes, billabongs, wetlands, groundwater-systems, floodplains and their flood-dependent forests and the estuary of the Basin. They encompass water-dependent ecosystems, ecosystem services and sites with ecological significance.

The productive base — the support offered by ecosystems to human economic and social production.

Key environmental outcomes — defined in the Water Act to include ecosystem functions, biodiversity, water quality and water resource health.

Ecosystem services — benefits people obtain from ecosystems. Rivers, floodplains and wetlands provide important ecosystem services, including clean water, food, timber, livestock production, flood control and mitigation, groundwater replenishment, sediment and nutrient retention and transport, reservoirs of biodiversity, cultural values, and recreation.

Hydrologic indicator sites — have been used to quantify the environmental water requirements across the Basin. These sites comprise 18 hydrologic indicator sites for assets, a subset of 2,442 key environmental assets and 88 sites for key ecosystem functions.

This chapter addresses three key questions fundamental to determining long-term average sustainable diversion limits (SDLs) for the Murray–Darling Basin:

- How much water is required to achieve the environmental objectives of the *Water Act 2007* (Cwlth)? (Section 4.1)
- How should the Basin Plan take account of the expected impacts of climate change? (Section 4.2)
- What are the likely social and economic implications of reducing current diversion limits? (Sections 4.3 and 4.5)

Together, these questions help to define the ‘decision space’ for the Murray–Darling Basin Authority (MDBA) in determining the SDLs for the proposed Basin Plan. The SDL proposals are described in Section 4.4, including significant detail about the methods used to calculate them.

In light of the SDL proposals, Section 4.5 outlines what the economic impacts may be for sectors and regions. It is important to also look at the wider picture presented in the transition arrangements (Chapter 5) to get more information about how MDBA and governments are working to minimise the effects on entitlement holders and communities.

The chapter ends by setting out the arrangements under the proposed Basin Plan for meeting critical human water needs, building on the experience gained with this complex issue during the recent drought (Section 4.6).

4.1 Environmental water requirements

One of the primary purposes of the *Water Act 2007* (Cwlth) is to ensure environmentally sustainable levels of extraction, or take, from the Basin’s water resources. The Water Act defines an environmentally sustainable level of take as the level of water that can be taken from a water resource which, if exceeded, would compromise its key environmental assets (i.e. water-dependent ecosystems, ecosystem services and sites with ecological significance), key ecosystem functions, the productive base, or key environmental outcomes. The productive base of a water resource includes those attributes that establish its capacity to contribute to social and economic outcomes.

For surface water, the determining factors for a healthy water-based environment are the key ecosystem functions and the key environmental assets.

Estimating an environmentally sustainable level of take from the water resources of the Murray–Darling Basin is a challenging task. The approach taken for surface water combines two elements:

- an analysis of the environmental water requirements of fundamental physical, chemical and biological processes, known as ‘hydrologic indicator sites for key ecosystem functions’
- an analysis of the environmental water requirements for specific sites, known as ‘hydrologic indicator sites for key environmental assets’.

From a surface-water flow perspective, many of the key ecosystem functions and key environmental assets are hydrologically connected and interdependent. This means that if sufficient water is provided for key ecosystem functions at one location it will be sufficient for those functions at many locations, both upstream and downstream. This same water will also provide for floodplain and wetland ecosystem functions associated with environmental assets, as well as contributing to the ecosystem functions associated with the rivers connecting the assets together. Moreover, this water

will provide for the broader environmental water requirements of ecosystem services, the productive base, and the key environmental outcomes for the water resource.

The assessment of environmental water requirements for 88 hydrologic indicator sites for key ecosystem functions is applicable to the full spectrum of flow regimes (i.e. from low flows through to floods) across the entire Basin. It provides a mechanism to determine low-flow environmental water requirements, as well as inform the high-flow environmental water requirements of environmental assets.

The assessment of environmental water requirements for 18 hydrologic indicator sites for key environmental assets provided detailed, site-specific analysis of high-flow environmental requirements. This analysis has been undertaken in recognition that high flows provide the greatest contribution to the volume of available water, and therefore high-flow environmental requirements must be assessed rigorously.

A total of 106 hydrologic indicator sites have been used to determine the surface-water environmental water requirements of the Basin. The integration of water requirements for all the hydrologic indicator sites has been estimated to provide the flow needs for all water-dependent ecosystems across the Basin.

This approach assumes that the water requirements to support the productive base and the environmental outcomes of the resource will be met if the water requirements of key environmental assets and key ecosystem functions are met, along with the water quality targets contained in the Water Quality and Salinity Management Plan (see Section 6.3).

As a result of the inherent differences between surface-water and groundwater systems, the assessment of environmental water requirements for groundwater considered the productive base and key environmental outcomes for the water resource more explicitly in developing groundwater long-term average sustainable diversion limits (SDLs) (see 'Environmental water requirements for groundwater' later in this section, and Section 4.4).

Key environmental assets

Identifying key environmental assets

One of the objects of the Water Act is to give effect to international agreements relevant to the use and management of the Basin water resources. To support this object, in conjunction with determining an environmentally sustainable level of take, key environmental assets were selected from the many tens of thousands of wetlands and floodplains, rivers, streams and other water-dependent ecosystems in the Basin. This involved the development of selection criteria, the identification of potential key environmental assets, and their assessment against the selection criteria. The criteria for identifying key environmental assets were developed with regard to the requirements of relevant international agreements (see Table 4.1).

The initial process to identify potential key environmental assets used a combination of literature review, compilation and assessment of existing inventories of aquatic ecosystems, and input from Basin states and independent scientific experts. In addition, relevant spatial data sources, such as data describing the distribution of threatened species and ecological communities, were extensively analysed.

Potential key environmental assets identified from these various sources were then assessed against specific indicators developed for each of the five



Southern Macquarie Marshes Nature Reserve, New South Wales



Shoots on trees after a flood at Narran Lakes, New South Wales

selection criteria. An asset was considered to be ‘key’ for the purposes of the Basin Plan if it met at least one of these criteria.

This approach identified 2,442 named key environmental assets across the Basin (see Figure 4.1 and Appendix A, tables A1–A19), ranging from small alpine headwater streams to large, meandering lowland rivers and extensive floodplain wetland complexes. Table 4.2 lists the number of these key environmental assets in each of the Basin Plan regions. Groundwater systems have been assessed in terms of their contribution to the maintenance of these key environmental assets.

The water requirements of individual assets overlap: flows that inundate one asset often inundate many others. This is an important concept — it means that the environmental water requirements for a number of assets is less than the sum of the requirements for individual assets. So, while there is a lack of detailed information on the environmental water requirements for many of the 2,442 key environmental assets, the approach taken by the Murray–Darling Basin Authority (MDBA) to estimating the environmental water requirements for all key environmental assets relied on this connectivity between sites.

By carefully selecting a subset of the better-studied key environmental assets across the Basin with significant and representative high-flow requirements, it has been possible to build a picture of the environmental water requirements of the larger group of key environmental assets. Due to the size and location of the key environmental assets in this subset, a water regime that delivers their environmental water requirements is likely to also meet the environmental water requirements of many other key environmental assets (particularly wetlands and floodplains).

Table 4.1 Criteria for identifying key environmental assets

Criterion	Explanation
1. Formally recognised in, and/or is capable of supporting species listed in, relevant international agreements	This criterion identifies all Ramsar sites in the Basin and any wetland that supports birds listed in any of the international migratory bird agreements to which Australia is a signatory and that are relevant to the management of the Basin's water resources.
2. Natural or near-natural, rare or unique	This criterion is developed to give effect to the Convention on Biological Diversity.
3. Provides vital habitat	This criterion acknowledges the variable and dynamic nature of the Basin, and includes refugia such as drought refuges and pathways for dispersal and ephemeral breeding, and nursery sites for water-dependent plants and animals. This criterion supports the long-term retention of regional biodiversity, and thus contributes to the objective of conserving biodiversity under the Convention on Biological Diversity.
4. Supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities	This criterion identifies the ecosystems that support species and ecological communities listed under relevant Commonwealth, state or territory legislation as being threatened. It gives effect to the Convention on Biological Diversity.
5. Supports, or is capable of supporting, significant biodiversity	This criterion provides for the identification of assets supporting large numbers of species, as well as those assets with high levels of taxonomic diversity. Inclusion of such sites is important in providing for the long-term viability of the Basin's biodiversity. This criterion therefore also gives effect to the Convention on Biological Diversity.

Table 4.2 Number of key environmental assets in each Basin Plan region, and number of key environmental assets that meet each selection criterion in each region

Region	Number of key environmental assets	Number of key environmental assets meeting each selection criterion ^a				
		Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5
Barwon–Darling	64	21	22	25	63	28
Border Rivers	166	1	24	80	136	96
Campaspe	13	8	2	8	10	13
Condamine–Balonne	294	5	51	174	159	107
Eastern Mount Lofty Ranges	18	14	11	14	18	14
Goulburn–Broken	153	34	43	60	149	50
Gwydir	47	7	6	6	47	7
Lachlan	58	32	19	25	58	33
Loddon	42	33	5	23	34	22
Lower Darling	73	7	5	18	71	8
Macquarie–Castlereagh	20	7	8	9	20	5
Moonie	27	0	3	20	19	18
Murray	477	171	149	250	475	193
Murrumbidgee	258	8	13	46	257	44
Namoi	20	0	1	2	17	2
Ovens	101	101	101	101	101	27
Paroo	251	251	251	251	53	251
Warrego	278	278	278	278	28	278
Wimmera–Avoca	82	55	29	58	75	34
Total	2,442					

a The selection criteria are listed in Table 4.1.



Figure 4.1 Location of 2,442 key environmental assets across the Murray–Darling Basin

A scientific peer review of this approach concluded that, in partnership with the assessment of environmental water requirements of key ecosystem functions, it is a robust scientific approach.

The key environmental assets in this selected subset are part of a suite of hydrologic indicator sites that MDBA has used to estimate the environmental water requirements for the Basin. This particular subset drives the high-flow environmental water requirements of the Basin. MDBA has also selected hydrologic indicator sites to estimate the environmental water requirements for key ecosystem functions, described in 'Environmental water requirements of key ecosystem functions', later in this section.

For groundwater, the level of risk to particular key environmental assets was also considered in determining SDLs. The analysis for groundwater took into account whether water resource plans would be required to include mechanisms to manage localised threats to groundwater-dependent key environmental assets.

The process followed in determining environmental water requirements of the hydrologic indicator sites for key environmental assets is shown in Figure 4.2.

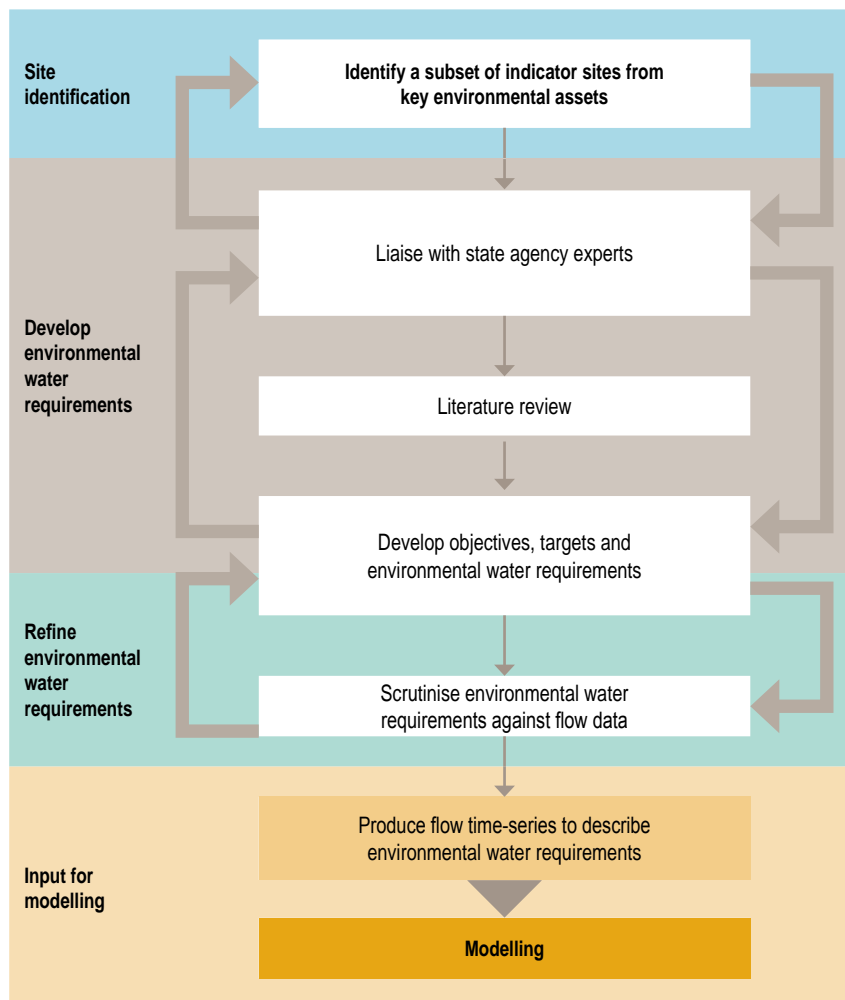


Figure 4.2 Determining the environmental water requirements of the hydrologic indicator sites for key environmental assets

Identifying hydrologic indicator sites for key environmental assets

The following criteria were used to identify the hydrologic indicator sites for key environmental assets:

- the asset meets one or more of the criteria for determining key environmental assets (see Table 4.1)
- the asset contains water-dependent ecosystems requiring high flows
- the asset is located in a valley/region where the natural flow regime has been significantly affected by water resource development
- in a regional context, the asset requires large volumes of water, so that its water needs will also provide for those of other, smaller assets
- the group of assets is geographically spread across the Basin
- the group of assets avoids overlap and repetition in determining environmental water requirements.

The process and criteria outlined above were used to identify 18 hydrologic indicator sites, believed to be of the greatest hydrologic significance in defining the environmental water requirements for the key environmental assets of the Basin:

- Barmah–Millewa Forest
- Booligal Wetlands
- Edward–Wakool River System
- Great Cumbung Swamp
- Gunbower–Koondrook–Perricoota Forest
- Gwydir Wetlands
- Hattah Lakes
- Lachlan Swamp
- Lower Balonne River Floodplain System
- Lower Darling River System
- Lower Goulburn River Floodplain
- Lower Murrumbidgee River Floodplain
- Macquarie Marshes
- Mid-Murrumbidgee-River Wetlands
- Narran Lakes
- Riverland–Chowilla Floodplain
- The Coorong, Lower Lakes and Murray Mouth
- Wimmera River Terminal Wetlands.

These 18 hydrologic indicator sites contain 335,000 ha of wetlands covered by the Ramsar Convention, and are associated with 1,300,000 ha of wetlands listed in *A directory of important wetlands in Australia* (Environment Australia 2001). The only substantial directory-listed sites within the Basin that are not included in the hydrologic indicator sites are those in the Paroo, Warrego, Ovens and Eastern Mount Lofty Ranges regions, and on the Kiewa River.

The only Ramsar sites not included are the Paroo, Banrock Station Wetland Complex, Kerang Lakes, Fivebough and Tuckerbil Swamps, and Ginini Flats Wetland Complex. The Ginini Flats Wetland Complex and surrounding catchment are in Namadgi National Park in the Australian Capital Territory, and their hydrology is unaffected by surface-water diversions. The water requirements of the remaining sites can be provided by regulated supplies,



*Swans on the Coorong,
South Australia*

meaning that their requirements are relatively small and will be adequately represented through other hydrologic indicator sites in those regions.

Given the extent and nature of the floodplains and wetlands contained within the suite of hydrologic indicator sites, this subset of key environmental assets is believed to be sufficiently representative to guide the determination of SDLs.

Environmental water requirements of key environmental assets

The first step in identifying environmental water requirements was to determine environmental objectives and targets required to protect and restore a hydrologic indicator site to a level consistent with the requirements of the Water Act. The objectives and targets do not seek to return the sites to their pre-European settlement condition, but to restore them to the extent required to protect plant and animal populations and the ecological function of the Basin.

To provide for the full suite of environmental outcomes, these sites require a range of flows persisting for varying periods. Each flow event will generate a range of environmental responses in the flood-dependent ecosystems; it is these responses which, when quantified, determine whether targets have been met and outcomes achieved.

The ecologically sustainable flow regime that underpins the environmental water requirements for a hydrologic indicator site is formed by a number of discrete flow events. The regime consists of the minimum range of events to ensure that targets are met.

In determining water requirements and flow regimes to sustain the selected hydrologic indicator sites, species that depend on flooding to complete their life cycle were identified for each site and their habitat requirements defined. Species with similar requirements were grouped, and targets were selected to protect habitat types that fulfilled these requirements. Where the targets associated with habitat types or vegetation communities were considered to provide a flow regime sufficient to meet the needs of other plants and animals represented in the objectives, then no further targets were specified. Where it was considered that some important species would require additional flows, then additional targets were specified.

The flow events were specified in terms of:

- either a flow threshold or total flow volume
- the required duration for that flow threshold, or duration over which the volume should be delivered
- the required timing (seasonality) of the event (if important)
- the required frequency of events
- the level of groundwater dependency.



*South Australian swamp paperbark (Melaleuca halmaturorum),
Dunn's Lagoon, Lake Alexandrina,
South Australia*



Werta Wert–Chowilla wetlands after receiving an environmental water allocation, South Australia

There is significant uncertainty associated with defining the environmental water requirements of plant and animal populations, particularly the required frequency of flooding. Recognising these uncertainties, ‘low-uncertainty’ and ‘high-uncertainty’ frequency of flood events were specified.

For the low-uncertainty frequency, there is a high likelihood that the environmental objectives and targets will be achieved. It is likely that there are thresholds for many plants and animals beyond which their survival or ability to reproduce is lost, but the precise details of those thresholds are mostly unknown. The high-uncertainty frequencies attempt to define these thresholds. The high-uncertainty frequency is considered to represent a boundary beyond which there is a high likelihood that the objectives and targets will not be achieved.

Determination of flow events was based on identifying flow or volume thresholds relating to the specific targets (e.g. the flow required to inundate a certain vegetation community). These were determined from known inundation and flow relationships (either documented or based on expert opinion). The duration, frequency and timing of the flow events were then determined, based on the requirements of the plants and animals represented in the targets, and using all available detailed site-specific information. Where site-specific information was unavailable, observed patterns or relationships from other sites, together with hydrologic analysis, were used to estimate appropriate values.

Once the specific environmental water requirements were established for each hydrologic indicator site, they were scrutinised by assessing them against the modelled without-development (conditions prior to significant human development) flow patterns and the flow patterns under current arrangements. The period analysed was from 1895 to 2009. This process ensured that the flow events specified were sensible in comparison to conditions without development, and conditions under current arrangements.

An example of identifying the environmental water requirements of a hydrologic indicator site is provided in Table 4.3, which details the flows needed to achieve each target set for the Riverland–Chowilla Floodplain hydrologic indicator site. Figure 4.3 shows the frequencies of modelled flows with a low and high uncertainty and plots these against without-development and current conditions. Detailed information on the environmental water requirements of the 18 hydrologic indicator sites for key environmental assets is included in Appendix B.

Table 4.3 Identifying the environmental water requirements of a hydrologic indicator site (Riverland–Chowilla Floodplain)

Target	Event			Proportion of years event required to achieve target (%)		Proportion of years event occurs under modelled without-development conditions (%)	Proportion of years event occurs under modelled current arrangements (%)
	Flow required (measured as flow to South Australia) (ML/d)	Duration	Timing	Low uncertainty	High uncertainty		
Maintain 80% of the current extent of wetlands in good condition	40,000	30 days total (with 7-day minimum)	June to December	70	55	80	39
Maintain 80% of the current extent of river red gum forest in good condition	40,000	90 days total (with 7-day minimum)		50	33	58	22
Maintain 80% of the current extent of river red gum woodland in good condition	60,000	60 days total (with 7-day minimum)		33	25	42	12
Maintain 80% of the current extent of river red gum forest in good condition Maintain 80% of the current extent of river red gum woodland in good condition	80,000	30 days total (with 7-day minimum)	Preferably winter/spring but timing not constrained to reflect that high flows are dependent on occurrence of heavy rainfall and will be largely unregulated events	25	17	34	11
Maintain 80% of the current extent of black box woodland in good condition	100,000	21 days total (with 1-day minimum)		17	13	19	6
	125,000	7 days total (with 1-day minimum)		13	10	17	5

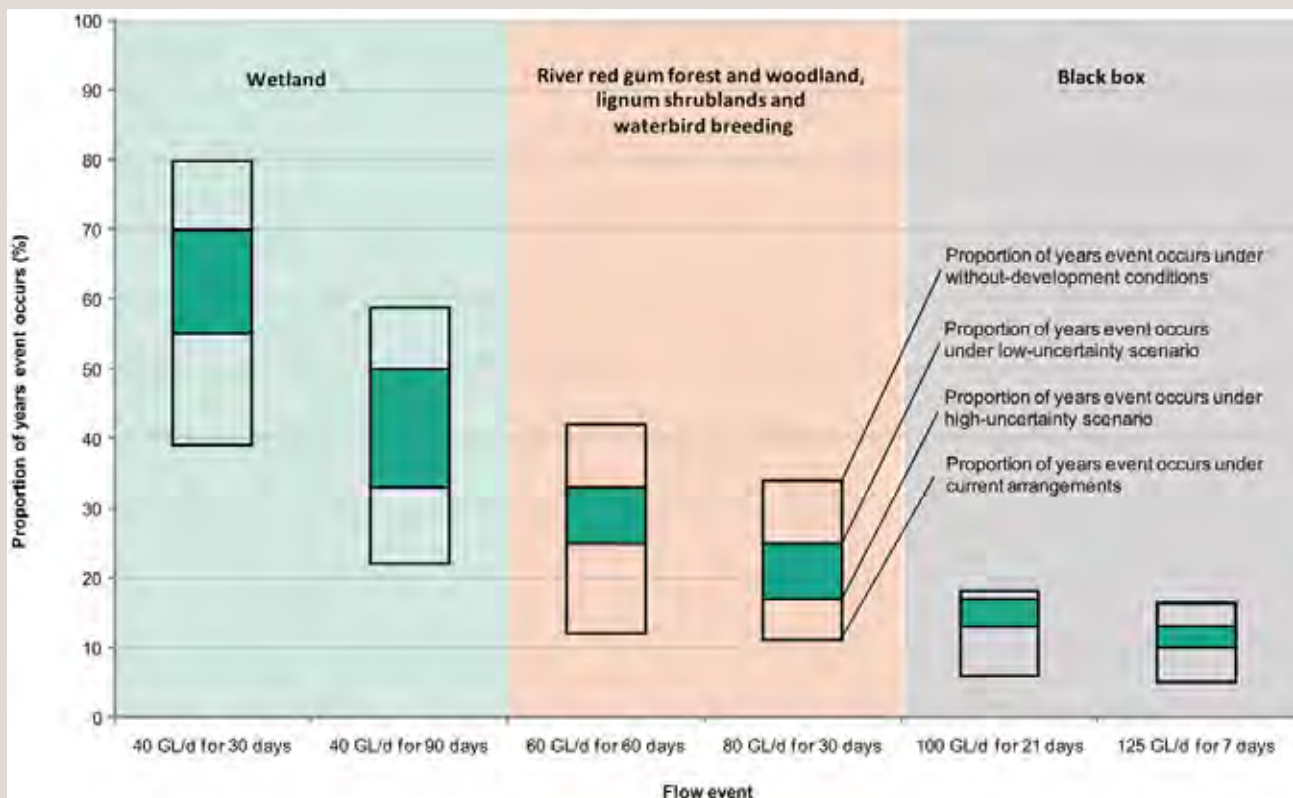


Figure 4.3 Proposed environmental water requirements for Riverland–Chowilla Floodplain



*Paroo River near Wanaaring,
New South Wales*

Key ecosystem functions

Identifying key ecosystem functions

Key ecosystem functions are the fundamental physical, chemical and biological processes that support the Basin's environmental assets — for example, the transport of nutrients, organic matter and sediment in rivers; wetting and drying cycles; and provision for migration and recolonisation by plants and animals along rivers and across floodplains.

Ecosystem functions shape and support the Basin's riverine, floodplain, wetland and estuarine ecosystems. Many functions depend on flows, and in many rivers of the Basin the flow regime has been significantly altered to the extent that these functions are compromised. This has been detrimental to the health of these river systems as well as to the wetlands and floodplains that rely on them.

The key flow-dependent ecosystem functions of the Basin have been identified using a systematic analysis of the functions occurring in the rivers of the Basin. The key ecosystem functions identified in the Basin, and that were considered in the development of SDLs, are:

1. the creation and maintenance of habitats for use by plants and animals (including fish)
2. the transportation and dilution of nutrients, organic matter and sediment
3. providing connections along rivers for migration and recolonisation by plants and animals (including fish)
4. providing connections across floodplains, adjacent wetlands and billabongs for foraging, migration and recolonisation by plants and animals (including fish).

Groundwater key ecosystem function is considered in terms of how it contributes to streamflow and thereby maintains these four functions. Across the Basin more than 60% of the groundwater systems were assessed as being highly connected to surface-water systems.

Due to the highly variable climate and rainfall in the Basin, healthy ecosystem functions must have frequent but irregular and variable water flows. Different parts of the flow regime support different functions. It is therefore important to assess the various parts of the flow regime to ensure that sufficient flow is provided to enable each function to occur effectively.

In addition, the timing of flows for functions is important as many ecosystems have evolved with the higher- and lower-flow seasons that occur across the Basin. Therefore the water requirements for some flow components have been determined on a seasonal basis; particularly the base flows and freshes. In general, the high-flow season occurs during winter/spring in the southern and eastern parts of the Basin, and in summer in the north. Conversely, low-flow season occurs in summer/autumn in southern and eastern regions and in winter months in northern parts of the Basin. The components of flow required by key ecosystem functions were identified as (also see Figure 4.4):

- overbank flows
- bankfull flows
- high-flow-season freshes
- low-flow-season freshes
- high-flow-season base flows
- low-flow-season base flows
- cease-to-flow events.

Figures 4.4 and 4.5 illustrate the links between ecosystem functions and flow components. Figure 4.4 indicates the links between flow components, the flow hydrograph and a typical river cross-section to explain what is meant by each of the flow components. Figure 4.5 shows examples of ecosystem functions associated with each flow component.

Detailed analysis of the ecosystem functions and flow components showed that all flow types are needed to support the key ecosystem functions. Complementing this finding, further analysis linking key ecosystem functions and river types revealed that a Basin-wide approach could be used to determine environmental water requirements for key ecosystem functions (Alluvium 2010).

For groundwater, the level of risk to key ecosystem functions was considered in determining SDL volumes and also in the development of water resource plan requirements.

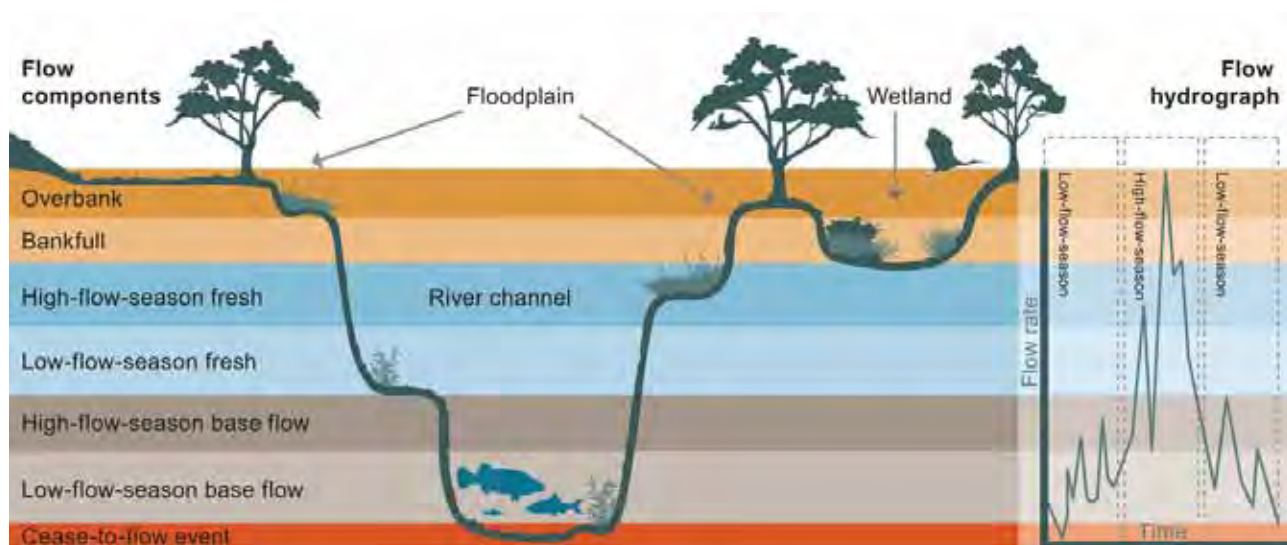


Figure 4.4 Linking flow components and a flow hydrograph to determine the water requirements of key ecosystem functions

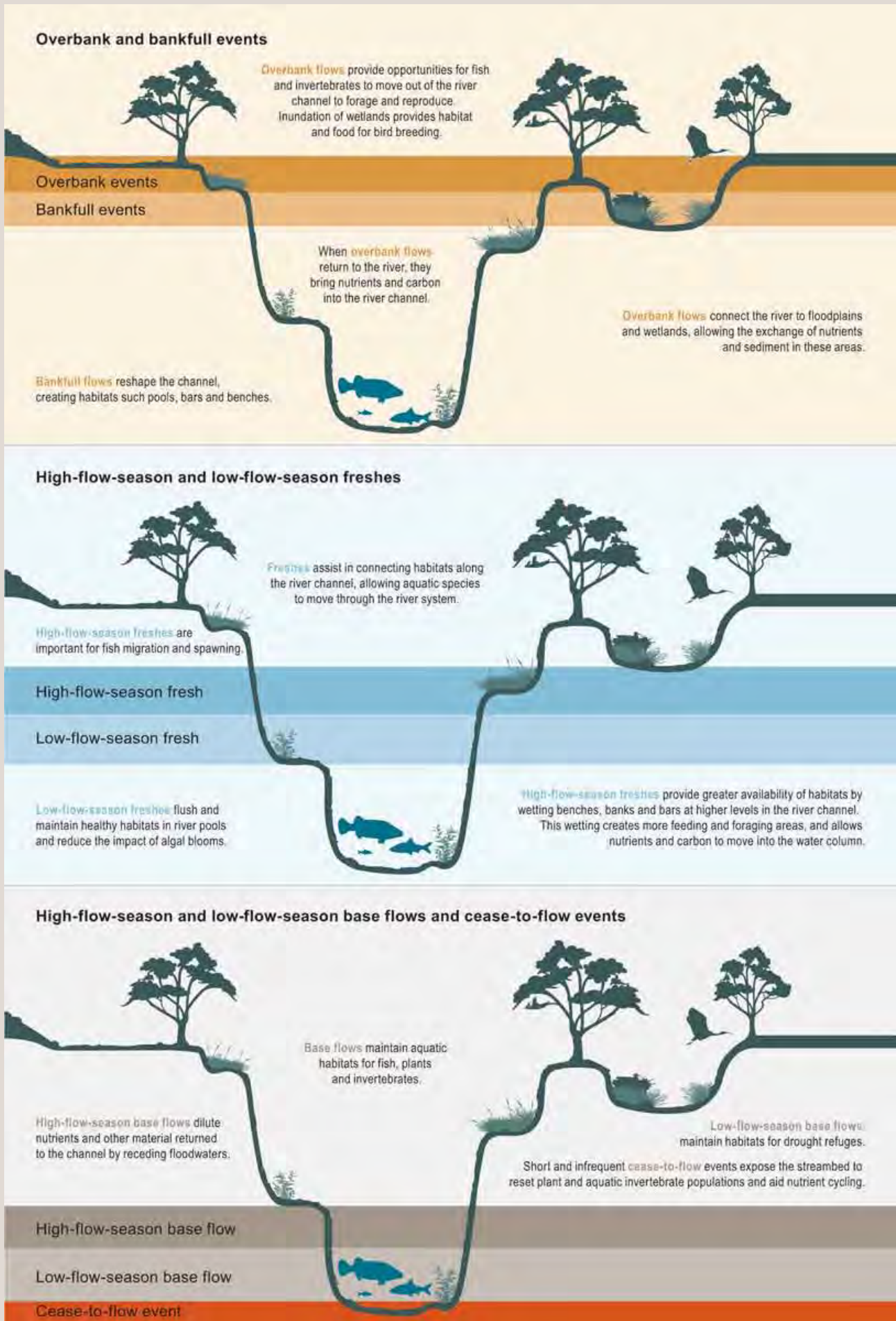


Figure 4.5 Relationship between key ecosystem functions and flow

Identifying hydrologic indicator sites for key ecosystem functions

The assessment of water requirements for key ecosystem functions has taken place at 88 hydrologic indicator sites across the Basin.

The 88 hydrologic indicator sites for key ecosystem functions represent a broad geographic spread throughout the Basin, and include the variety of river types found in the Basin. Most sites are the same as those reported on in the Sustainable Rivers Audit (Davies et al. 2008). The choice of locations was based on:

- representing an array of sites across the range of elevations within each region that characterise changes associated with river types and flow regimes
- sites where reliable modelled flow data could be assessed, resulting in sites largely confined to the regulated parts of the Basin (also corresponding to those rivers where the determination of SDLs is most significant).

Most regions contain 3 to 8 sites with the exception of the Murray, Lower Darling, Moonie and Eastern Mount Lofty Ranges regions. The Murray contains 11 sites; the Lower Darling and Moonie regions contain fewer sites owing to modelling constraints (2 sites and 1 site respectively). No sites were located in the Eastern Mount Lofty Ranges due to a lack of information on modelled flow for that region.

Environmental water requirements of key ecosystem functions

Each of the key ecosystem functions depends on different parts of the flow regime. Therefore, in determining the environmental water requirements of key ecosystem functions, each component of the flow regime was considered.

The components of flow were assessed using standardised flow metrics at the 88 hydrologic indicator sites for key ecosystem functions. Flow metrics are statistics that can be used to analyse the flow important for driving ecological processes and functions (Kennard et al. 2009). The flow metrics at these sites provide a measure of the magnitude, frequency, duration and timing of each flow component. The metrics measure these attributes as a proportion of the without-development flow regime. The proportion of change, when compared to current arrangements, is used as a surrogate estimate of the extent to which the ecosystem function is compromised by flow alteration.

Target values for the flow metrics have been set as a proportion of without-development flows. These targets use the same framework used in the Sustainable Rivers Audit (Davies et al. 2008). The indicator values are assigned ratings of 'good', 'moderate' and 'poor', depending on the proportion of without-development values. Target ratings of 'moderate' (60–80% of without-development value) or 'good' (80–100% of without-development value), at an aggregate regional level, have been chosen for the purpose of developing the Basin Plan. A rating of 'poor' is considered to imply that the key ecosystem functions are compromised.

In regions where flow regimes are relatively intact and a 'good' rating is provided under current arrangements, the Basin Plan will provide policy to protect the existing flow regime. Where a 'poor' rating (<60% of without-development value) is provided under current arrangements, the proposed Basin Plan will seek to restore flow regimes to provide a 'moderate' rating, at an aggregate level. No specific improvement is sought in regions with a 'moderate' rating under current arrangements, although flow regimes and indicator values in those regions may be influenced by the need to supply water to downstream regions.

In most regions, therefore, the proposed Basin Plan will seek to improve ratings from 'poor' to 'moderate'. This equates to a target of between 60% and 80% of without-development values. Figure 4.6 shows how these targets and certainty ratings are interpreted.

Proportion of without-development value	Rating	Certainty of achieving Basin Plan objectives
100%	Good	High
80%	Moderate	High
60%		Low
0%	Poor	Compromised

Figure 4.6 How targets and certainty ratings for achieving environmental water requirements for key ecosystem functions are interpreted

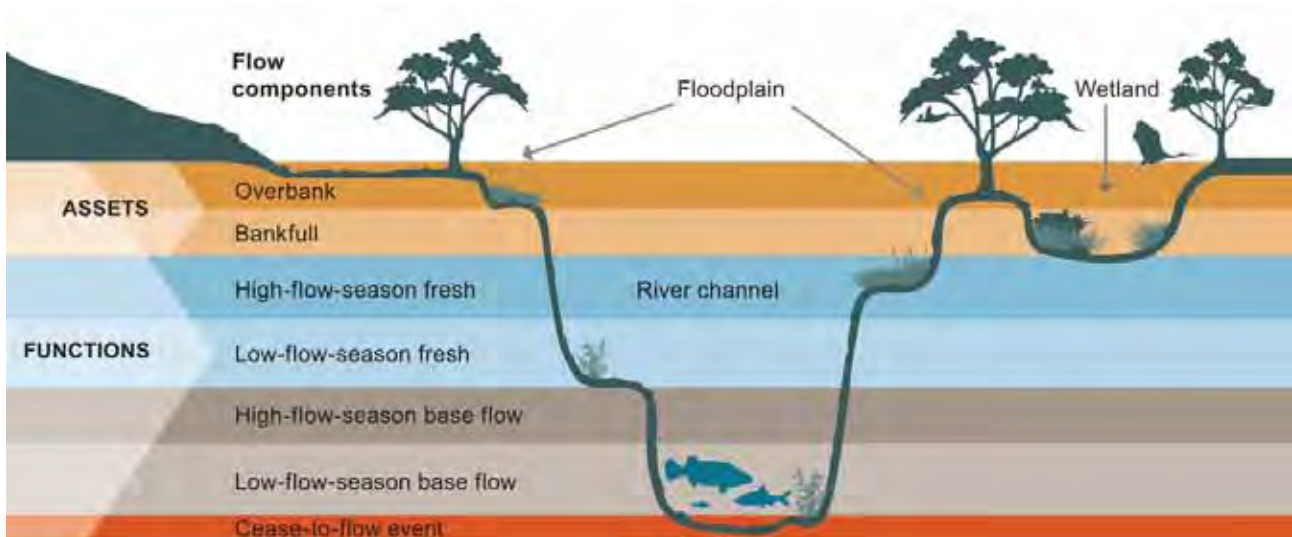


Figure 4.8 The overlap in environmental water requirements for key environmental assets and key ecosystem functions

Integrating the surface-water requirements of key environmental assets and key ecosystem functions

From environmental water requirements to SDLs

The 88 hydrologic indicator sites for key ecosystem functions, together with the 18 hydrologic indicator sites for key environmental assets, add up to a total of 106 hydrologic indicator sites used to assess the surface-water environmental water requirements of the Basin (see Figure 4.7 for their locations). The integrated water requirements for the 106 hydrologic indicator sites have been estimated to provide the flow needs for all water-dependent ecosystems across the Basin.

High flows provide the greatest contribution to the total volume of available water and the flows required to support the ecological values of the assets therefore provided the largest input to determining SDLs. Low flows are important for a variety of reasons, including maintaining the health of drought refuges in rivers and low-lying wetlands, and they were also considered in determining SDLs. Figure 4.8 represents the overlap in determining surface-water requirements of the key environmental assets and the key ecosystem functions.

Hydrologic modelling and other analyses have been used to estimate the impact of required flow regimes on current surface-water diversion limits needed to achieve the combined environmental water requirements of key environmental assets and key ecosystem functions. The hydrologic models analyse flows and diversions across the Basin, using data for the past 114 years (1895–2009) as the basis.

For example, for key environmental assets, the first step in estimating the impact of required flow regimes on current surface-water diversion limits was to analyse modelled flows under current arrangements to determine what additional environmental flows would be required to achieve the environmental water requirements. A software package known as eFlow Predictor (a product of the eWater Cooperative Research Centre) was used to do this. This software tool augments flows under current arrangements to achieve environmental flow targets, and in doing so constrains the augmented flow to that which existed without development.

Environmental flow time series were developed in this way for each of the hydrologic indicator sites and for the full 114 years of record. These flow time series were then set as specific demands in the hydrologic models. The models then estimated the SDLs required to achieve the environmental targets.



Straw-necked ibis nests, Narran Lakes, New South Wales



Figure 4.7 Locations of 106 hydrologic indicator sites across the Murray–Darling Basin

Hydrologic indicator sites for key environmental assets

Site #	Region	Hydrologic indicator site
A1	Murray	Barmah–Millewa Forest
A2	Lachlan	Booligal Wetlands
A3	Murray	Edward–Wakool River System
A4	Lachlan	Great Cumbung Swamp
A5	Murray	Gunbower–Koondrook–Perricoota Forest
A6	Gwydir	Gwydir Wetlands
A7	Murray	Hattah Lakes
A8	Lachlan	Lachlan Swamp
A9	Condamine–Balonne	Lower Balonne River Floodplain System
A10	Lower Darling	Lower Darling River System
A11	Goulburn–Broken	Lower Goulburn River Floodplain
A12	Murrumbidgee	Lower Murrumbidgee River Floodplain
A13	Macquarie–Castlereagh	Macquarie Marshes
A14	Murrumbidgee	Mid-Murrumbidgee River Wetlands
A15	Condamine–Balonne	Narran Lakes
A16	Murray	Riverland–Chowilla Floodplain
A17	Murray	The Coorong, Lower Lakes and Murray Mouth
A18	Wimmera–Avoca	Wimmera River Terminal Wetlands

Hydrologic indicator sites for key ecosystem functions

Site #	Region	Hydrologic indicator site
F1	Barwon–Darling	Barwon River at Dangar Bridge (Walgett)
F2	Barwon–Darling	Darling River at Bourke
F3	Barwon–Darling	Darling River at Wilcannia
F4	Border Rivers	Macintyre River at Wallangra
F5	Border Rivers	Macintyre River at Goondiwindi
F6	Border Rivers	Macintyre River at dam site
F7	Border Rivers	Barwon River at Mungindi
F8	Campaspe	Coliban River at Leyll Road
F9	Campaspe	Campaspe River upstream of Campaspe Weir
F10	Campaspe	Campaspe River at Rochester Town
F11	Campaspe	Campaspe River at Echuca
F12	Goulburn–Broken	Broken River at Moorngag
F13	Goulburn–Broken	Broken River upstream of Caseys Weir
F14	Goulburn–Broken	Broken River at Gowangardie Weir
F15	Goulburn–Broken	Goulburn River downstream of Eildon
F16	Goulburn–Broken	Goulburn River at Trawool downstream of Yea River
F17	Goulburn–Broken	Goulburn River upstream of Goulburn Weir
F18	Goulburn–Broken	Goulburn River at Mooroopna
F19	Goulburn–Broken	Goulburn River at McCoys Bridge
F20	Condamine–Balonne	Condamine River at Warwick
F21	Condamine–Balonne	Condamine River at Chinchilla
F22	Condamine–Balonne	Balonne River at Weribone
F23	Condamine–Balonne	Culgoa River at Brenda
F24	Condamine–Balonne	Narran River at Wilby Wilby
F25	Gwydir	Gwydir River at Stoneybatter
F26	Gwydir	Gwydir River downstream of Copeton Dam
F27	Gwydir	Gwydir River at Pallamallawa
F28	Gwydir	Gwydir River at Collymogle
F29	Lachlan	Belubula River downstream of Carcoar Dam
F30	Lachlan	Lachlan River downstream of Wyangala Dam
F31	Lachlan	Lachlan River at Jemalong Weir
F32	Lachlan	Lachlan River at Willandra Weir
F33	Lachlan	Lachlan River at Booligal

Hydrologic indicator sites for key ecosystem functions

Site #	Region	Hydrologic indicator site
F34	Loddon	Tullaroop Creek downstream of Tullaroop Reservoir
F35	Loddon	Loddon River downstream of Cairn Curran Reservoir
F36	Loddon	Loddon River upstream of Serpentine Weir
F37	Loddon	Loddon River downstream of Serpentine Weir
F38	Loddon	Loddon River at Appin South
F39	Loddon	Loddon River downstream of Kerang Weir
F40	Lower Darling	Darling River at Menindee
F41	Lower Darling	Darling River at Burtundy
F42	Macquarie–Castlereagh	Macquarie River at Bathurst Post Office
F43	Macquarie–Castlereagh	Macquarie River downstream of Burrendong Dam
F44	Macquarie–Castlereagh	Macquarie River at Dubbo
F45	Macquarie–Castlereagh	Macquarie River at Gin Gin
F46	Macquarie–Castlereagh	Macquarie River at Carinda
F47	Macquarie–Castlereagh	Castlereagh River at Mendooran
F48	Macquarie–Castlereagh	Castlereagh River at Gilgandra
F49	Macquarie–Castlereagh	Castlereagh River at Coonamble
F50	Moonie	Moonie River at Gundablouie
F51	Murray	Swampy Plains River at Khancoban
F52	Murray	River Murray at Jingellic
F53	Murray	River Murray at Corowa
F54	Murray	River Murray downstream of Torrumbarry
F55	Murray	River Murray at Wakool River Junction
F56	Murray	River Murray downstream of Euston
F57	Murray	River Murray at Mildura
F58	Murray	River Murray upstream of Lock 9
F59	Murray	River Murray upstream of Lock 7
F60	Murray	River Murray downstream of Lock 3
F61	Murray	River Murray at Morgan
F62	Murray	River Murray at Wellington
F63	Murrumbidgee	Murrumbidgee River at Burrinjuck Dam inflow
F64	Murrumbidgee	Tumut River at Oddys Bridge
F65	Murrumbidgee	Murrumbidgee River at Wagga Wagga
F66	Murrumbidgee	Murrumbidgee River at Darlington Point
F67	Murrumbidgee	Murrumbidgee River downstream of Balranald Weir
F68	Namoi	Peel River downstream of Chaffey Dam
F69	Namoi	Peel River at Piallamore
F70	Namoi	Namoi River downstream of Keepit Dam
F71	Namoi	Namoi River at Mollee
F72	Namoi	Namoi River at Goangra
F73	Ovens	King River upstream of Lake William Hovell
F74	Ovens	Ovens River at Eurobin
F75	Ovens	Ovens River at Wangaratta
F76	Ovens	Ovens River at Peechelba
F77	Paroo	Paroo River at Yarronvale
F78	Paroo	Paroo River at Caiwarro
F79	Paroo	Paroo River at Willara Crossing
F80	Paroo	Paroo River at Wanaaring
F81	Warrego	Warrego River at Augathella
F82	Warrego	Warrego River at Wyandra
F83	Warrego	Warrego River at Cunnamulla
F84	Warrego	Warrego River at Barrington
F85	Warrego	Warrego River at Fords Bridge
F86	Wimmera–Avoca	Wimmera River at Glenorchy
F87	Wimmera–Avoca	Wimmera River upstream of Dimboola
F88	Wimmera–Avoca	Wimmera River at Lake Hindmarsh

Estimating long-term average environmental water requirements

To determine the SDLs required to achieve the environmental water requirements of key environmental assets and key ecosystem functions, the environmental water requirements must be converted to, and expressed as, a long-term average volume of additional water required by the environment.

Initially MDBA used detailed hydrologic models to undertake the analysis, as outlined above. This analysis gave an initial indication of the volume of additional water required by the environment; however, it became clear that these complex models are not well suited to exploring the range of environmental water requirements and various policy scenarios for setting SDLs in a timely way. An analytical tool that allowed this exploration was required. The analysis used to determine the range of environmental water requirements (from low to high uncertainty) is explained here, while the analysis used to determine SDLs is described in Section 4.4.

The environmental water requirements for hydrologic indicator sites cover the full range of flows, from base flows through to overbank floods (see Figure 4.8). The analysis and associated tools used to estimate the volume of water required must therefore give due consideration to the full breadth of flows.

There are many analytical tools that can be used to quantify and assess flow regimes. For the purpose of estimating the volume of additional water required by the environment, MDBA used flow duration curves (also sometimes called a flow exceedence curve) as one of the main analytical tools.

Flow duration curves show the proportion of time that flows are exceeded. They show the full range of flows, from lowest to highest. As the magnitude of flows can vary by many orders of magnitude (i.e. from less than 1 ML/d to many hundreds of thousands ML/d), flow duration curves often use a logarithmic scale to present flow data. An example for River Murray flow at the Murray Mouth is shown in Figure 4.9. Importantly, in the context of the proposed Basin Plan, the use of flow duration curves enables volumes of water to be calculated, while retaining a connection to specific parts of the flow regime (and therefore to assets and functions).

For key ecosystem functions, targets seek to achieve a moderate rating for each flow regime component; that is, a metric value at least 60% of the without-development value. For hydrologic indicator sites the environmental water requirements are based on the best available information for the site. Figure 4.10 shows the environmental water requirements for each indicator site as an average proportion of the without-development frequency. (Environmental water requirements for four sites — The Coorong, Lower Lakes and Murray Mouth; Gwydir Wetlands; Wimmera River Terminal Wetlands and Lower Murrumbidgee River Floodplain — are not shown as their environmental water requirements are not expressed in a way which makes this comparison meaningful.) While there is some variation in the environmental water requirements, there is also some similarity between the sites. Variation is due to differences in the sites, as well as differences in available scientific information.

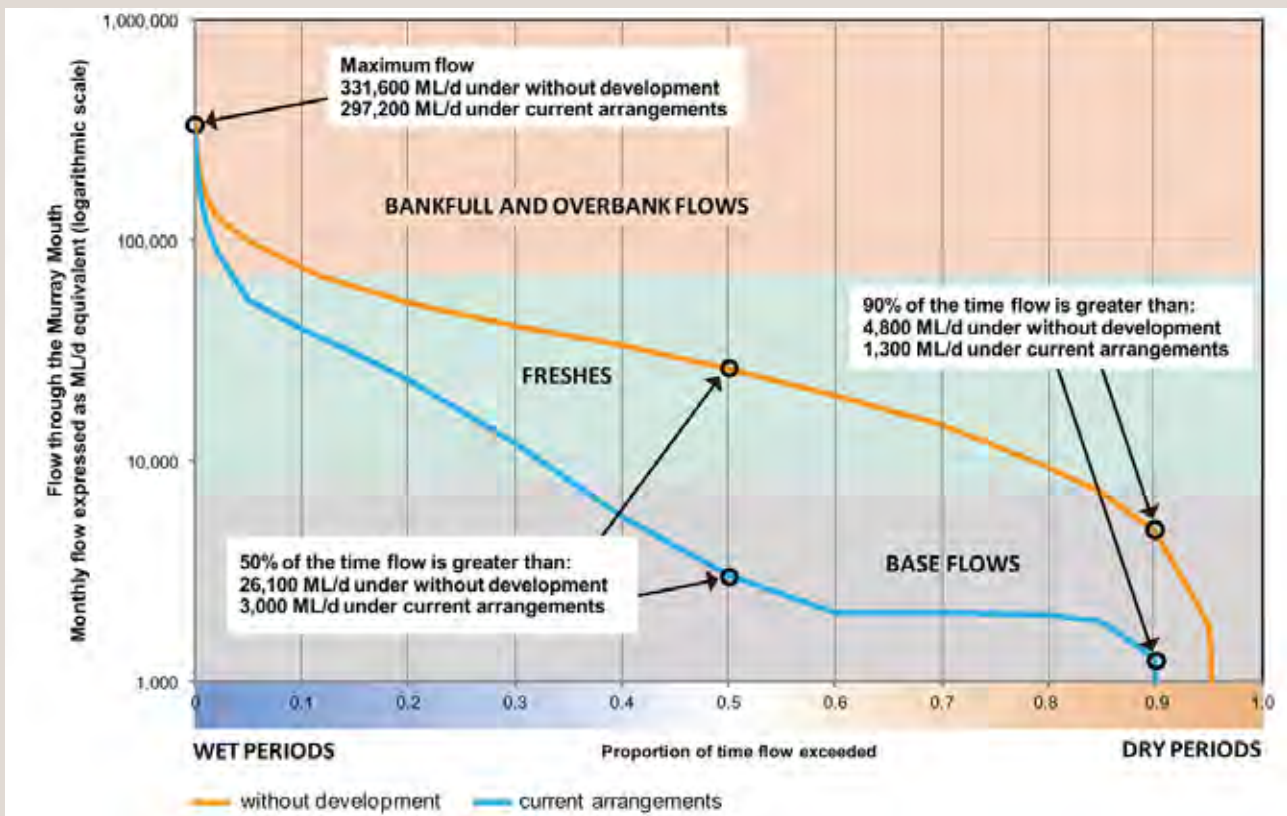


Figure 4.9 Example flow duration curve for River Murray flows at the Murray Mouth

Source: MDBA unpublished modelled data, 1895–2009

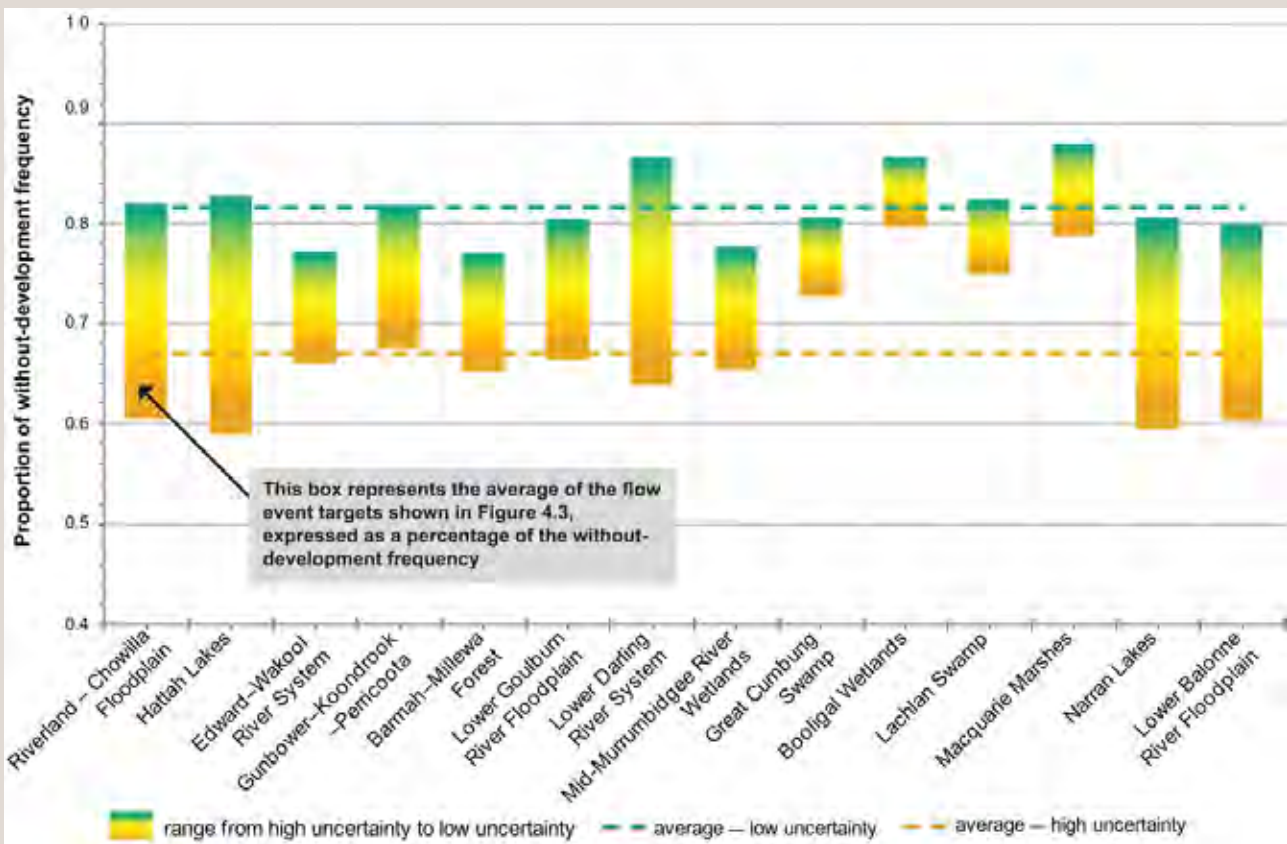


Figure 4.10 Environmental water requirements for hydrologic indicator sites — frequency of flow targets are expressed as a proportion of the without-development frequency



*Mouth of the River Murray,
South Australia*

On the basis of these targets, and for the purposes of determining the aggregate amount of water required by the environment, MDBA has set a common target range for environmental flow provision. Recognising that the environmental water requirements cover the full range of flows, this target range applies across the full range of the flows shown on the flow duration curve. The target range is between 60% (high uncertainty) and 80% (low uncertainty) of the without-development flows. Where flows are currently at or above the target range they may be supporting key environmental assets or key ecosystem functions, or be required for the supply of consumptive water. Maintaining these assets, functions or consumptive use is likely to be important, and should not come at the expense of other assets and functions supported by other parts of the flow regime. Consequently, where current flows exceed the 60% or 80% target, the analysis assumes those flows are to be maintained at their current level. Figure 4.11 shows the end-of-system flow for the River Murray at the Murray Mouth as an example. Both logarithmic and linear scales are provided. The linear scale graph gives a more accurate representation of the volume of additional environmental water required, and the relative proportions.

This analysis has been undertaken at end-of-system locations in each region. End-of-system locations have been used because they provide a measure of water sharing in the region as a whole. They also provide a measure of connectivity between regions, which is important to maintain for key ecosystem functions such as transport of nutrients and carbon, and migration of fish. Results from this analysis, expressed as long-term average end-of-system flows, are shown in Table 4.4.

In many regions where additional environmental water is required, average end-of-system flows associated with the Basin Plan targets are between about 60% and 80% (as shown in Table 4.4). However, as the method retains current flows where they are greater than the target range (to protect existing key environmental assets, key ecosystem functions and consumptive supply), the average end-of-system flow can be higher. One example is the Namoi (see Figure 4.12), where median to low flows are significantly below the target value (as low as 25% of without-development flows). However, high flows (in this instance flows that occur less than 15% of the time) are relatively unaffected by diversions and river regulation, and are above the target value. High flows provide a proportionally large contribution (about 90%) to the average end-of-system flow, and this contribution means the long-term average end-of-system flow is greater than 60% and 80% respectively.

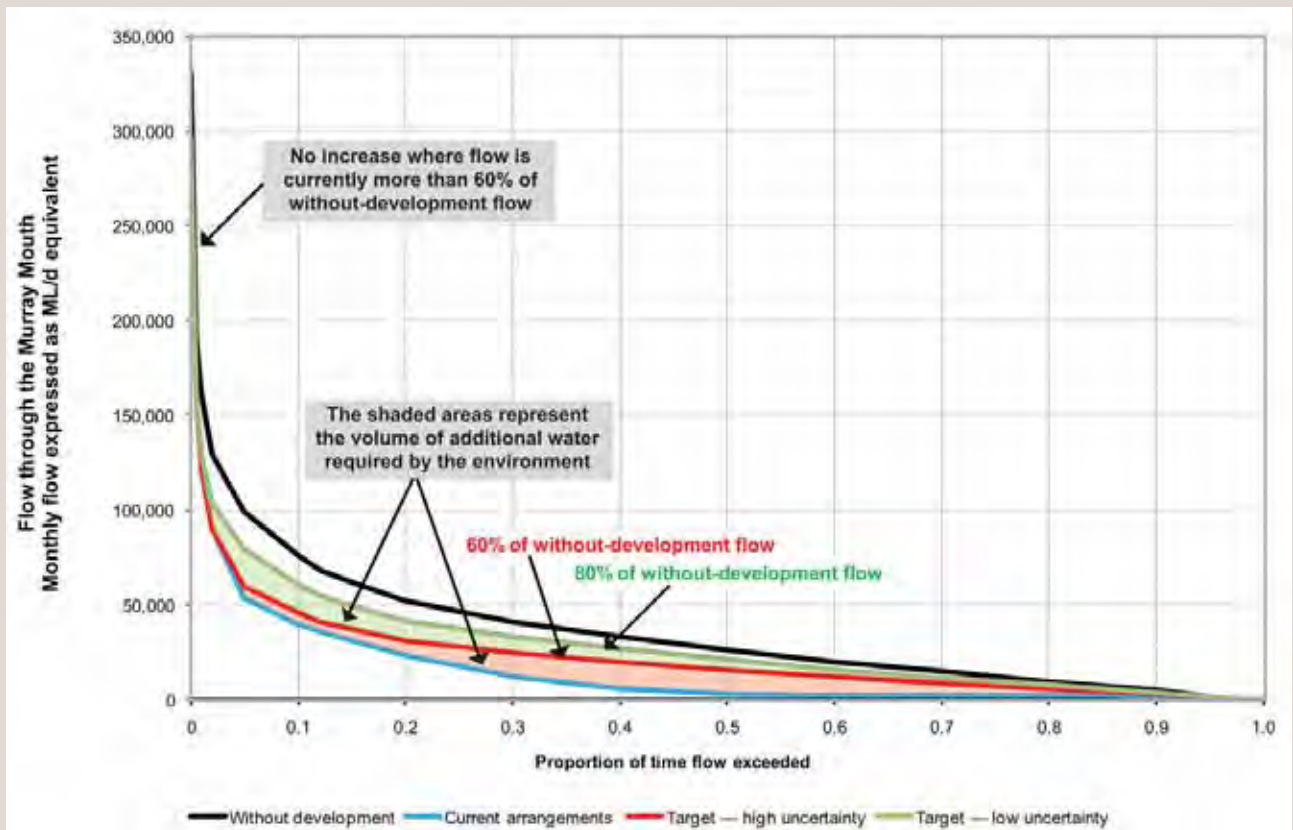
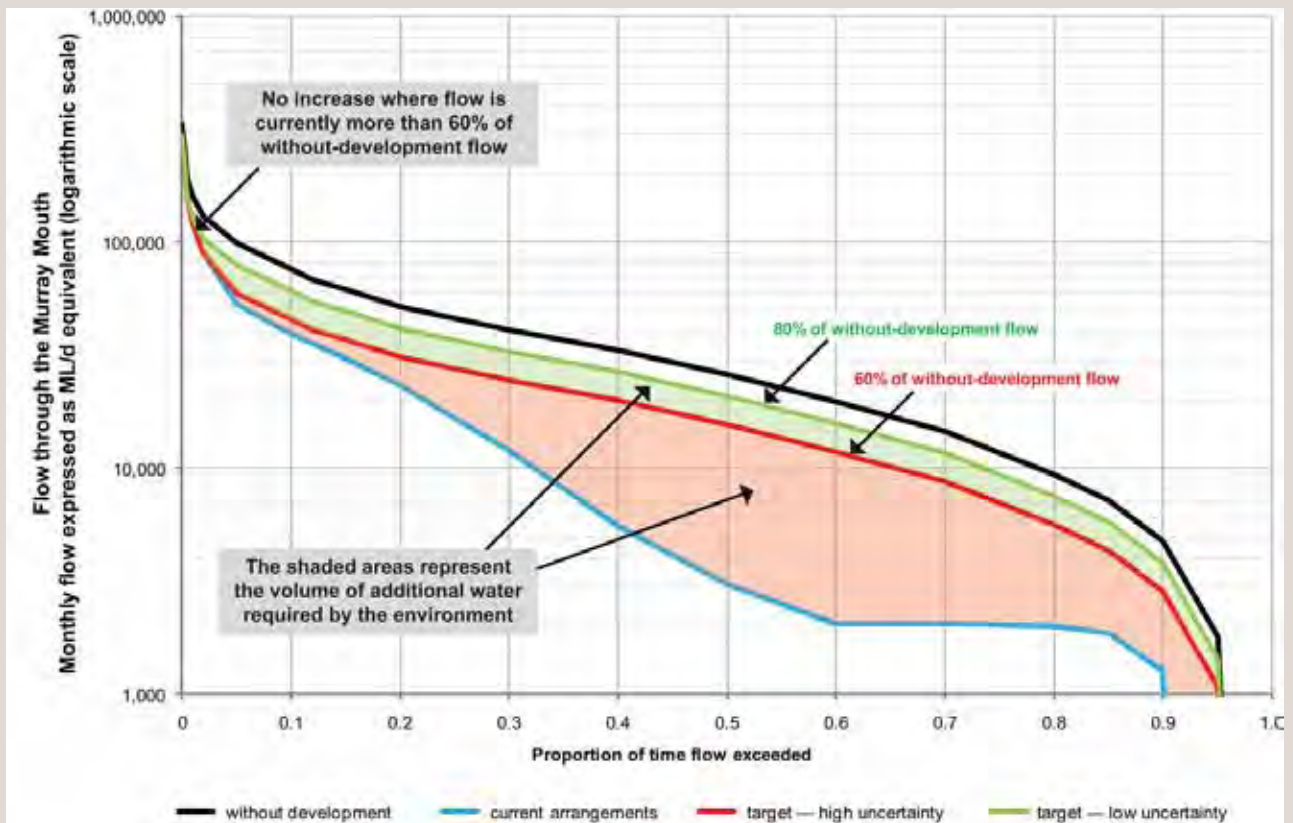


Figure 4.11 Flow duration curve for the River Murray at the barrages showing target range

Source: MDBA unpublished modelled data, 1895–2009

Table 4.4 Environmental water requirements of regions, expressed as end-of-system flows

Region	End-of-system gauge(s)	End-of-system flow — GL/y long-term average (% of without-development value)			
		Without development	Current arrangements	High uncertainty	Low uncertainty
Northern Basin					
Barwon–Darling (represents whole of Darling at Menindee)	Darling River at Menindee	3,273	1,721 (53%)	2,213 (68%)	2,639 (81%)
Border Rivers	Barwon River at Mungindi, Boomi River at Neeworra, and Weir River flow to Barwon	797	513 (64%)	560 (70%)	653 (82%)
Condamine–Balonne	Narayan, Culgoa and Bokhara flow to Darling	569	241 (42%)	355 (62%)	456 (80%)
Gwydir	Gil Gil Creek at Galloway, Gingham watercourse flow into Gil Gil Creek, Gwydir River at Collymongle, and Mehi River at Collarenebri	429	173 (40%)	260 (61%)	344 (80%)
Macquarie ^a (including Bogan)	Marthaguy Creek at Carinda, Macquarie River at Carinda, Bogan River at Gongolgin, and Marra Creek at Billy Bingbone Bridge	664	481 (72%)	490 (74%)	571 (86%)
Castlereagh	Castlereagh River at Coonamble	96	96 (100%)	No additional flow required ^c	No additional flow required ^c
Moonie	Moonie flow to Barwon	96	71 (74%)	74 (77%)	82 (85%)
Namoi	Namoi River at Goangra, Pian Creek at Waminda	828	653 (79%)	688 (83%)	733 (89%)
Paroo	Paroo flow to Darling at Wilcannia	59	59 (100%)	No additional flow required ^c	No additional flow required ^c
Warrego	Warrego River at Fords Bridge	69	58 (84%)	60 (86%)	61 (88%)
Southern Basin					
Campaspe	Campaspe River at Echuca	281	153 (54%)	191 (68%)	231 (82%)
Eastern Mount Lofty Ranges	Not applicable	73	67 (92%)	No additional flow required ^c	No additional flow required ^c
Goulburn–Broken	Goulburn River at McCoys Bridge	3,368	1,646 (49%)	2,114 (63%)	2,706 (80%)
Lachlan ^a	Lachlan River at Oxley	160	97 (60%)	116 (73%)	136 (85%)
Willandra	Willandra Creek end of system	122	113 (92%)	No additional flow required ^c	No additional flow required ^c
Loddon	Loddon River at Appin South	145	61 (42%)	91 (63%)	116 (80%)
Lower Darling	Not applicable	Included in Murray analysis			
Murrumbidgee ^a	Murrumbidgee River at Balranald	2,724	1,223 (45%)	1,701 (62%)	2,185 (80%)
Billabong Creek	Billabong Creek at Darlot	124	322 (260%)	No additional flow required ^c	No additional flow required ^c
Ovens	Ovens River at Peechelba	1,728	1,728 (99%)	No additional flow required ^c	No additional flow required ^c
Wimmera–Avoca ^b	Wimmera River upstream of Lake Hindmarsh	212	157 (74%)	No additional flow required ^c	No additional flow required ^c
Murray (represents whole of Murray–Darling Basin)	Barrage flow	12,503	5,105 (41%)	7,824 (63%)	10,046 (80%)

a The Macquarie, Lachlan and Murrumbidgee regions have multiple end-of-system flow locations that are affected to different extents by consumptive use and/or river regulation, requiring separate assessment, as shown.

b No reduction in diversions is proposed in the Wimmera–Avoca region. This is due to the positive environmental impacts of the Wimmera–Mallee Pipeline Project (a partnership between the Victorian Government, the Australian Government and GWMWater), which will return around 83 GL/y of water to the environment. MDBA analysis shows that provision of this additional environmental water is likely to achieve the environmental water requirements for the Wimmera River Terminal Wetlands, and other key environmental assets and key ecosystem functions as it flows through the river system to the wetlands.

c No additional flow required for local key environmental assets and key ecosystem functions.

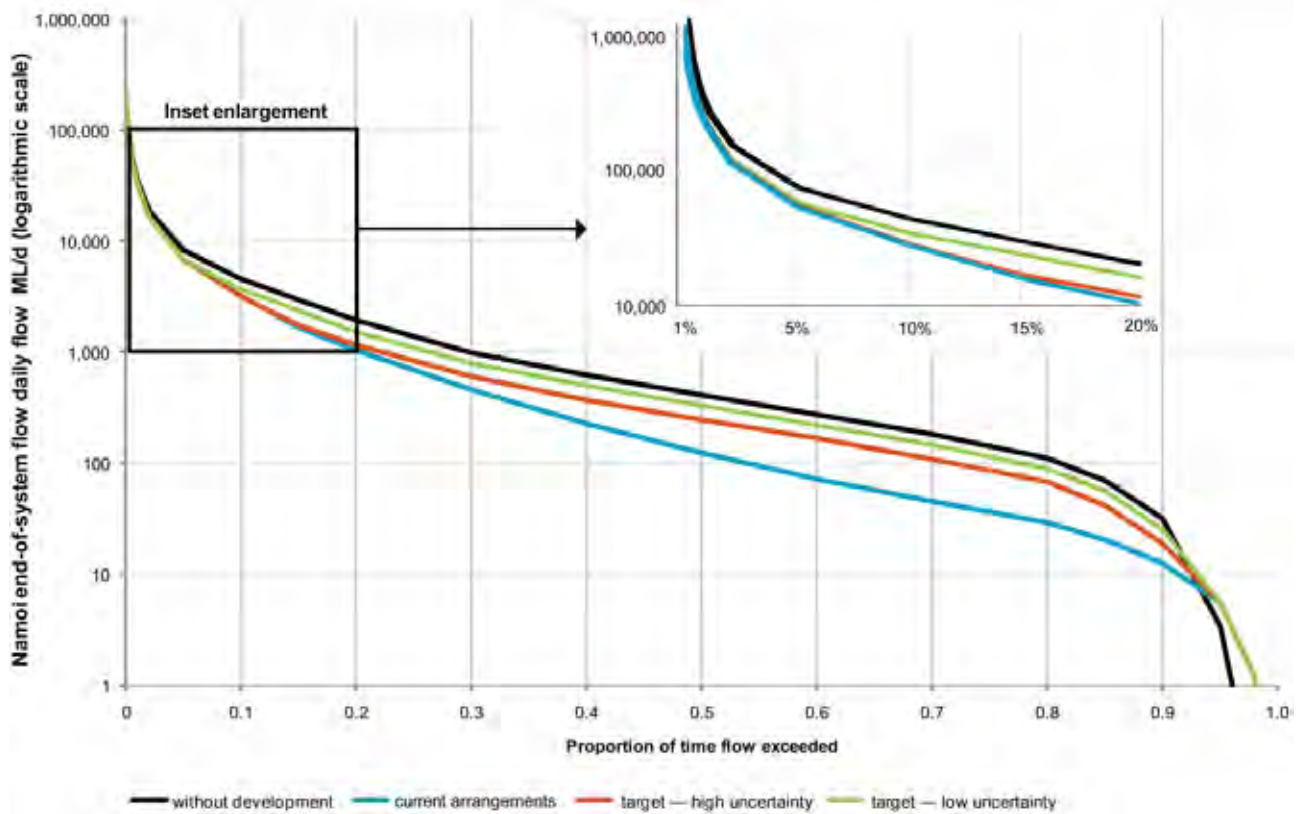


Figure 4.12 Flow duration curve for the Namoi end-of-system flow (combined flow for Namoi River at Goangra and Pian Creek at Waminda) showing target range

Reductions in diversions required to achieve end-of-system flows have been estimated using hydrologic modelling of the relationship between diversions and end-of-system flows in each region (Table 4.5). This modelling takes into account the evaporation and infiltration losses associated with the movement or delivery of water through these regions. Some regions incur greater losses than others. In general, southern basin regions incur smaller losses than northern basin regions.

MDBA considers the approach outlined above is appropriate to determine the aggregate environmental water share; however, it should not be inferred that the proposed Basin Plan recommends simply providing a fixed percentage of the without-development flow to the environment. Implementation of environmental watering requires adaptive management to accommodate priorities and opportunities, operational constraints, and mitigation of potential negative impacts (e.g. flooding of urban areas).

Actual environmental watering will involve variable provision of water to the environment. In some years environmental watering priorities and opportunities (e.g. unregulated flow conditions, volumes in storage, availability of planned environmental water and allocations to held environmental water entitlements) may mean that provision of a high proportion of available water to the environment will be appropriate. In other years, owing to different priorities and water availability, the proportion provided to the environment will be less.

Table 4.5 Reductions in diversions required to achieve environmental water requirements

Region	Reduction in diversions required to achieve target end-of-system flow in each region — (GL/y) (% reduction)	
	High uncertainty	Low uncertainty
Northern Basin		
Border Rivers	70 (17%)	207 (50%)
Condamine–Balonne	261 (37%)	478 (68%)
Gwydir	115 (36%)	215 (68%)
Macquarie–Castlereagh ^a	26 (7%)	174 (47%)
Moonie	1 (3%)	12 (36%)
Namoi	40 (15%)	113 (42%)
Paroo	No reduction required for local key environmental assets and key ecosystem functions	No reduction required for local key environmental assets and key ecosystem functions
Warrego	6 (13%)	12 (28%)
Total reduction required in northern basin (includes Barwon–Darling region)	806 (35%)	1,428 (62%)
Additional reduction required in northern basin (includes Barwon–Darling region)	293	229
Southern Basin		
Campaspe	36 (32%)	71 (63%)
Eastern Mount Lofty Ranges	No reduction required for local key environmental assets and key ecosystem functions	No reduction required for local key environmental assets and key ecosystem functions
Goulburn–Broken	452 (29%)	985 (63%)
Lachlan	57 (20%)	145 (51%)
Loddon	36 (39%)	63 (67%)
Lower Darling	Included in Murray region	
Murrumbidgee	621 (29%)	1,307 (62%)
Ovens	No reduction required for local key environmental assets and key ecosystem functions	No reduction required for local key environmental assets and key ecosystem functions
Wimmera–Avoca	No reduction required for local key environmental assets and key ecosystem functions	No reduction required for local key environmental assets and key ecosystem functions
Total reduction required in southern basin (includes Murray region)	2,987 (38%)	5,398 (68%)
Additional reduction required in southern basin (includes Murray region)	1,842	2,972
Basin total reduction in diversions	3,856	6,983

a Flows in the Castlereagh River are relatively unaffected by diversions and regulation. This reduction therefore applies to the Macquarie/Bogan catchments rather than Castlereagh.

MDBA is undertaking modelling and other analysis to verify that this end-of-system flow approach provides an aggregate environmental water share that aligns with the specific estimates of environmental water requirements for key environmental assets and key ecosystem functions, and that these environmental water requirements can be implemented within operational constraints. This verification will continue through the public consultation period, but modelling to date has shown that the approach is consistent with the specific estimates of environmental water requirements, and that there are no insurmountable operational issues.

The modelling to date has shown that there will be operational efficiencies associated with environmental water delivery. There are also inherent

uncertainties associated with measurement of flows, diversions and interceptions; estimation of environmental water requirements; and hydrologic modelling. MDBA's best estimates are that the end-of-system flow analysis represents the environmental water requirements of the key environmental assets and key ecosystem functions with a confidence limit of about $\pm 20\%$ for the high-uncertainty target. MDBA therefore believes the environmental water requirements for key environmental assets and key ecosystem functions can be achieved with a high level of uncertainty with a Basin-wide reduction in diversions of 3,000 GL/y.

MDBA considers that the low-uncertainty end of the range would not optimise economic, social and environmental outcomes, and has therefore not invested as much resources in assessing confidence limits at this end of the range. However, MDBA is of the view that the environmental water requirements for key environmental assets and key ecosystem functions can be achieved with a low level of uncertainty with a Basin-wide reduction in diversions of about 7,600 GL/y. This represents a confidence limit in the end-of-system flow analysis of about $\pm 10\%$.

Environmental water requirements for groundwater

Considerations for identifying groundwater environmental water requirements

The environmental water requirements of groundwater systems are influenced by their hydrogeological characteristics and the nature of the ecosystems that depend on groundwater, which vary significantly across the Basin. To determine the environmental water requirements of groundwater, updated groundwater recharge modelling has been undertaken for the entire Murray–Darling Basin and in some cases detailed numerical modelling has also been used. The water needs of key ecosystem functions, key environmental assets, the productive base and key environmental outcomes of groundwater systems have determined the environmental groundwater requirements. These have been assessed in terms of the following key factors:

- maintaining base flow — for some aquifers, groundwater contributes significantly to base flow for rivers and streams, particularly in low-flow periods, and is therefore an important contributor to maintaining key ecosystem functions
- accounting for groundwater-induced recharge — where groundwater and surface-water systems are connected (including systems where time lags are significant), appropriate adjustments in environmental water requirements have been made so there is no double counting of water extractions, to protect key ecosystem functions
- protecting against continued drawdown of groundwater levels — so that groundwater levels are stabilised within a 50-year time frame, to a level that protects the integrity of the groundwater resource and the productive base
- maintaining key environmental assets that depend on groundwater (e.g. key environmental assets such as the Lower Goulburn River Floodplain and the Great Cumbung Swamp)
- protecting against salinisation — much of the groundwater resource in the Murray–Darling Basin is highly saline. In areas that contain both fresh and saline water, the extraction of groundwater can pose a threat to the environment through the contamination of fresh groundwater resources by the vertical or lateral inflow of saline groundwater.

Determining the Basin's environmental groundwater requirement

The relative importance of these factors in determining the environmental requirements for groundwater has been assessed for each of the 78 groundwater SDL areas. This has been done using a risk assessment framework, which is explained in detail in Section 4.4, and which explicitly considers the risk that groundwater extraction poses to the sustainability of the groundwater resource.

The key ecosystem function for groundwater is the maintenance of groundwater connections with surface water. This is particularly important in upper catchments where groundwater provides base flow that supports related ecosystem functions that are critical to maintaining the ecological health of the Basin's rivers and wetlands. Across the Basin more than 60% of the groundwater systems were assessed as being highly connected to surface-water systems.

While groundwater does not support key environmental assets for all parts of the Basin, it is significant in some areas. Groundwater systems have

been assessed in terms of their contribution to the maintenance of the key environmental assets and key ecosystem functions identified in the Basin.

In some major areas of groundwater use in the Basin, the productive base is threatened by continued long-term declines in water levels. Arresting these declines is a critical consideration in determining the additional water that must be provided for the environment by these groundwater systems.

The productive base relates to the ability of a groundwater system to function and specifically implies the maintenance of groundwater volume

(and groundwater level) and quality. The productive base is important in many groundwater systems that do not contribute water to key environmental assets, and may have only a small role in terms of key ecosystem functions.

The identification of a volume of environmental water required to meet the productive base and/or key environmental outcome requirements is implicit rather than explicit and involves identifying the maximum volume that can be taken without compromising the productive base and key environmental outcomes. The volume of environmental water is in effect the remaining volume of recharge that is not taken.

The Basin's environmental groundwater requirements have been determined using a three-step process:

1. Determine water resource plan areas and finer-scale management areas for groundwater systems.
2. Undertake updated groundwater recharge modelling for the entire Murray–Darling Basin and apply a risk assessment framework to identify the proportion of recharge that should be reserved for the environment to achieve the objectives of the Basin Plan.



The Goolwa Barrage, Coorong area where the River Murray comes out to the sea near Goolwa, South Australia. The lake was at a record low with the level approximately 60 cm below sea level, January 2008.

3. Undertake detailed numerical modelling for 11 of the largest alluvial groundwater systems (for which suitable models are available), and which represent more than 73% of Basin groundwater resources.

Additional groundwater to meet environmental needs

The additional groundwater that needs to be provided for the environment is estimated to be between 99 GL and 227 GL. This range of additional groundwater for the environment reflects the uncertainty of groundwater model predictions and the risks associated with not achieving the environmental objectives of the Basin Plan. Accordingly, the lower end of this range represents a ‘high’ risk approach and the upper end of the range represents a ‘low’ risk approach. In summary:

- The current diversion limits of 67 groundwater systems have been assessed as reflecting an environmentally sustainable level of take.
- Of the remaining groundwater systems, the current diversion limits of the Upper Namoi Alluvium, Lower Macquarie Alluvium, Peel Valley Alluvium and the Australian Capital Territory (Groundwater) do not reflect an environmentally sustainable level of take. Accordingly, a reduction in the diversion limit will be required in each case to meet the environmental water requirements. The level of use in these four systems is lower than the current diversion limits and the current use has been assessed as at or below an environmentally sustainable level of take.
- The final seven groundwater systems (Lower Lachlan Alluvium, Lower Namoi Alluvium, Angas Bremer, Upper Condamine Alluvium, Upper Condamine Basalts, Upper Lachlan Alluvium and Lake George Alluvium) are considered to be overdeveloped, and the current diversion limits do not reflect an environmentally sustainable level of take. It is across these seven systems that the additional groundwater needs for the environment have been estimated to be between 99 GL and 227 GL (see Table 4.6). The table indicates the range (from ‘high’ to ‘low’ risk) of additional environmental water requirements that have been identified using the methods described in this chapter and associated potential range in reduction in the current diversion limits.

Table 4.6 Overview of the environmental water requirements for the seven groundwater systems that are considered to be overdeveloped

Groundwater SDL area	Current diversion limit (GL/y)	Additional groundwater required for environment (GL/y)		Potential reduction associated with requirement (%)	
		High risk	Low risk	High risk	Low risk
Lower Lachlan Alluvium	108.0	43.2	80.0	40	74
Lower Namoi Alluvium	86.0	0.0	24.0	0	28
Angas Bremer	6.5	0.0	2.5	0	38
Upper Condamine Alluvium	117.1	40.3	68.1	34	58
Upper Condamine Basalts	76.1	15.0	24.1	20	32
Upper Lachlan Alluvium	77.1	0.1	28.1	0	36
Lake George Alluvium	1.1	0.0	0.6	0	55
Total	472	99	227	21	48

4.2 Factoring climate change into the Basin Plan

Climate change effects on water availability

Ecosystems, water users and planners are accustomed to dealing with the Basin's highly variable climate and the resulting effect on water availability. Climate change has added to this complexity, and reduced confidence in predicting future climatic conditions.

In the past, scientists used records of the Basin's weather collected over a century as a guide to expected climatic conditions. This included estimating the frequency of droughts and floods as well as their intensity and duration.

Future weather and climate is expected to be different from past conditions. Extreme weather events, including droughts and floods, are likely to be more intense. Storms are likely to be larger and stronger, and droughts longer and drier, than in the past (NSW Department of Environment and Climate Change 2010).

Annual rainfall in the past 12 years in the southern Murray–Darling Basin is more than 10% lower than the long-term mean. A decline in autumn rainfall is the most significant component of this rainfall decline. However, the rainfall in each of the eight months from March to October over this period is also lower than the long-term mean (CSIRO 2008). Nevertheless, rainfall is highly variable from decade to decade, and there were similar dry periods around 1900 (the 'Federation drought') and around 1940 (the 'World War II drought').

The run-off in the southern Murray–Darling Basin in the past 12 years is about 40% lower than the long-term mean. This extreme decline in run-off has been attributed to:

- the decline in mean annual rainfall
- significantly larger rainfall decline in autumn
- rainfall decline in winter when most run-off is generated
- lack of high-rainfall years in the past decade
- higher temperatures accentuating the effect of low rainfall on run-off and possible changes in the hydrological processes (CSIRO 2008).

Several research studies have suggested that at least part of the most recent drought is associated with global warming, but it is difficult to separate any effect of global warming from the high natural climate variability. For these reasons, water resource planning needs to consider a range of possible scenarios to assess system robustness and resilience to historical droughts, as well as future climate projections (Chiew, Cai & Smith 2009).

The CSIRO Murray–Darling Basin Sustainable Yields Project highlighted that, while average surface-water availability would fall by 11% under the median 2030 climate scenario, diversions under this scenario and existing water planning arrangements would reduce by an average of only 4% (CSIRO 2008).

This shows that current water sharing arrangements would not evenly distribute the relative effects of climate change between consumptive users and the environment. As conditions become drier, existing rules in Basin state water resource plans generally favour continuation of supply to consumptive users at the expense of environmental requirements.



River Murray between Morgan and Blanchetown, South Australia

Setting a climate baseline

The Murray–Darling Basin Authority (MDBA) has conducted planning in the context of the most recent scientific information available at the international, national, state and regional level (e.g. from the Intergovernmental Panel on Climate Change, CSIRO, the Bureau of Meteorology, the NSW Department of Environment and Climate Change, and University of New South Wales).

For hydrologic planning, where long climate sequences are required to encapsulate the range of likely conditions, the entire historical record (1895–2009) is a useful climate baseline (Chiew, Cai & Smith 2009) for the following reasons:

- it offers a long sequence for hydrologic and environmental system modelling and planning
- it covers three prolonged drought periods
- it has similar mean annual rainfall and mean annual run-off to the most recent 30-year period (1979–2008) and to the period of the Intergovernmental Panel on Climate Change’s studies (1961–2008).

Because rainfall and run-off in the southern Murray–Darling Basin in the past 10 years are considerably lower than the long-term mean, and there is an apparent link between the dry conditions and global warming, the recent period can also be used to represent a very dry scenario for conservative risk-based considerations (Chiew, Cai & Smith 2009).

Although historical records alone are no longer sufficiently robust for long-term planning, they are still useful. Actual climate records for 1895–2009 provide a useful baseline on which to make predictions about how wet or dry it could get, or in what percentage of years a given amount of water will be available. The records also include the effects of climate change that have already occurred. However, the extent of climate change effects associated with recent low inflows has yet to be accurately measured (Chiew, Cai & Smith 2009).

Along with the 1895–2009 climate records, three possible future climate scenarios for 2030 have been selected to assist in the development of the proposed Basin Plan (CSIRO 2008):

- the wet extreme 2030 climate
- the median 2030 climate
- the dry extreme 2030 climate.

The median scenario is defined by considering the projected outcome for Basin run-off from 15 global climate models. Each model is run using data that simulates the Intergovernmental Panel on Climate Change’s median predicted level of global warming by the year 2030. Each model adjusts the 114 years of rainfall values from the historical climate record (1895–2009) to produce 114 annual run-off values. These 114 values are averaged to give a long-term run-off projection under median 2030 conditions. The 15 models are ranked from lowest to highest average annual run-off. The median 2030 scenario is the output from the eighth-ranked model.

The 15 models were also used with the Intergovernmental Panel on Climate Change’s high-range predictions of global warming by 2030. The dry and wet extreme scenarios were derived from the models ranked second (extreme dry) and fourteenth (extreme wet) for projections of mean annual run-off across the Basin.

This approach considers two components of uncertainty:

- uncertainty in the level of warming
- uncertainty in the hydrologic consequences of a given level of warming.

The second of these sources of uncertainty is by far the larger, as demonstrated for the Murray region in Table 4.7, which shows the percentage changes in mean annual run-off in the Murray region for high, medium and low global warming. The table also shows that the dry extreme and wet extreme scenarios are both associated with high global warming, indicating the greater climate uncertainty associated with higher levels of global warming.

The percentages in Table 4.7 reflect differences in averages over the full time frame of each model. It is also important to recognise wet and dry sequences of 10–15 years that have occurred in the past. For example, Figure 4.13 shows historical patterns of variability in total annual stream flow at Wentworth on the River Murray. Flow in the wettest 15-year sequence (1950–1964) is 42% higher than the long-term average. In the driest 15-year sequence (1995–2009), flow is 32% lower than the long-term average.

Table 4.7 Percentage change in mean annual run-off in the Murray region^a under different potential levels of global warming

Global climate model	High global warming	Medium global warming	Low global warming
Second wettest global climate model	+7% (‘wet extreme’ climate scenario)	+4%	+2%
Median global climate model	-14%	-10% (‘median’ climate scenario)	-5%
Second driest global climate model	-37% (‘dry extreme’ climate scenario)	-26%	-12%

^a The region is as used in the CSIRO Murray–Darling Basin Sustainable Yields Project.
Source: CSIRO (2008)

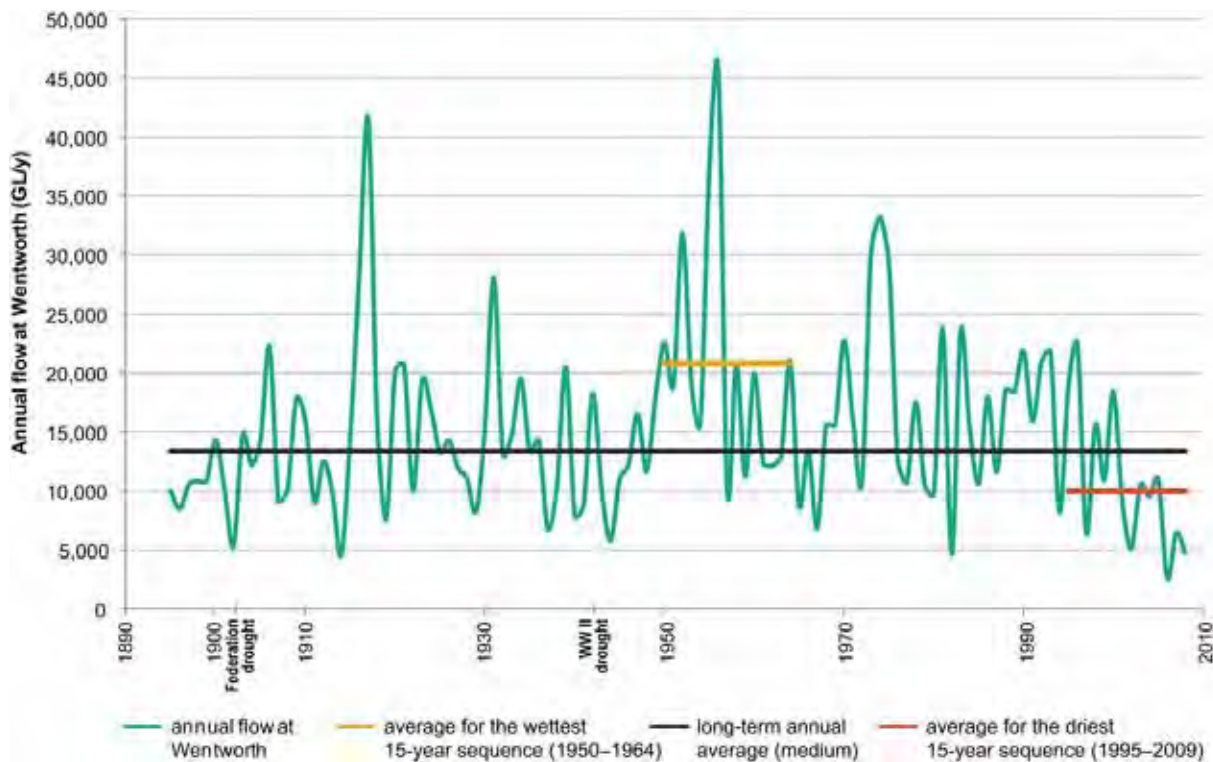


Figure 4.13 Modelled without-development streamflow at Wentworth on the River Murray, 1895–2009

Approach to including climate change in the Basin Plan

In the context of climatic uncertainty, MDBA has adopted an approach based on exploring a wide range of plausible climate futures to better understand the vulnerabilities of the water resource system. This understanding has been used to develop water planning arrangements that avoid or minimise system failure, regardless of future circumstances. The intent is to have a Basin Plan that will work well regardless of the climatic conditions over the next 20 years.

Climate change considerations have been addressed in the proposed Basin Plan in three main ways:

- including a climate change allowance in the proposed surface-water long-term average sustainable diversion limits (SDLs)
- requiring water resource plans developed by Basin states to demonstrate the capacity to operate effectively across a broad range of climatic conditions that could occur as a result of climate change
- ensuring that within the SDL, the burden of climate change effects over the long term are shared evenly between the environment and water users.

These processes are detailed below, but should also be considered in the general context of discussions about the setting of SDLs (see Section 4.4), and of water resource plan accreditation requirements (see Section 6.1).

Including a climate change allowance in SDLs

Including climate change into the SDL is needed to manage long-term average trends in water availability rather than year-to-year variations.

The median climate change scenario estimates that there will be a 10% reduction in surface-water availability across the Basin between 1990 and 2030 (updated figure from the CSIRO Murray–Darling Basin Sustainable Yields Project (2008)).

The Basin Plan will apply to water resource planning in the Basin for successive 10-year periods commencing between 2012 and 2019, and the plan must be reviewed by around 2021 if not before. Therefore, MDBA considers it unnecessary to incorporate the full effect of the 10% predicted decline in average annual water availability under median 2030 conditions in the first Basin Plan.

In light of the various issues associated with climate change, MDBA has determined that 3% is an appropriate allowance to account for the effect of climate change in the proposed Basin Plan. That is, the reduction being considered necessary to achieve an environmentally sustainable level of take includes a 3% allowance in the SDL proposals.

Although the effects of climate change are expected to vary across the Basin, the system is highly connected, with most areas contributing to downstream flows well beyond their SDL area. Thus the distribution of long-term climate effects on surface water across the Basin to reflect possible local variations is considered inappropriate. This is because of the degree of uncertainty in climate predictions and the interconnection of the surface-water sources.

The 3% allowance in the reduction in current diversion limits will also apply for the purposes of risk allocation for climate change (see Section 5.2).

For groundwater, the predicted effect of climate change on dryland diffuse groundwater recharge (the largest component of recharge) under a range of future climates has been modelled. For the predicted 2030 median climate change scenario, modelling results show no strong deviation from historical median recharge (measured as an average annual recharge over a 15-year period) (Crosbie, McCallum & Walker 2010).

As a result, and as there are uncertainties associated with long-term climate modelling, for groundwater the historical median 15-year recharge sequence has been adopted as being representative of the climate for the Basin Plan planning period. Accordingly, no allowance is provided for in groundwater planning to account for climate change in the proposed Basin Plan.

Water resource plan requirements

Accreditation requirements for water resource plans have been developed such that water allocations will be low in drought years and high in wet years, similar to what has happened in the past, and regardless of the reason for the weather conditions. Accordingly, Basin states will need to consider how their plans would cope with climatic extremes, particularly extended dry sequences.

In particular, it is proposed that water resource plans explain how they will perform under the most extreme dry (15-year) sequence in the dry 2030 climate model scenarios or continuation of the historic worst 10-year drought. These requirements are intended to define the range of climatic conditions to be included in the scope of the water resource plans. Further, the accreditation of water resource plans will be conducted against the appropriate long-term climate sequences for the plan area.

Once a water resource plan has been accredited and comes into effect, the implementation of the water management arrangements in the plan will be the primary way in which SDLs are complied with and environmental water requirements satisfied.



River red gum on the Campaspe River near Barnadown, Victoria

To demonstrate that the implementation of water resource plans is complying with the SDLs and other water resource plan requirements of the proposed Basin Plan, models accredited as part of water resource plan accreditation are proposed to be used with the actual climate and inflows at the end of each water year. This would derive an annual estimate of diversions that should have been made under these arrangements. These model runs will be part of an annual audit and compliance process. Details of the compliance arrangements for the proposed Basin Plan are provided in Chapter 7.

Sharing climate change effects

The principle of equitable sharing of any reductions in water availability between consumptive and environmental uses has been applied. This requirement will be managed as part of the accreditation of water resource plans. The principle has been applied to address the current situation in which most water resource plans are biased significantly towards allocation for consumption under drier future climates. This approach will need to be applied in a manner that does not put at risk water requirements for meeting critical human water needs.

First, water resource plans will be required to show that, under the historical climate scenario (1895–2009), application of the rules under the water resource plan will result in diversions that are within the SDL specified in the Basin Plan.

Second, surface-water water resource plans will also be required to show that, under a median 2030 climate scenario, diversions will not be allowed to exceed the SDL adjusted by the proportional change in surface-water availability as compared to the historical climate scenario.

Given the projected variability in 2030 climate across the Basin, a water resource plan must use 2030 climate projections that are specific to the region to which the plan applies.

For example, if the SDL was set at 100 GL/y in a particular catchment, the water resource plan prepared by the Basin state would have to show that the average take permitted by the rules in the plan would not exceed 100 GL/y under modelling of a repeat of the historical climate scenario. Further, if the median 2030 climate scenario modelling indicated that the average surface-water availability would be 20% less, the same water resource plan rules would be required to show that average diversions would not exceed 80 GL/y under the 2030 climate scenario (i.e. 100 GL/y less 20%). This test is designed to be neither more stringent nor lenient than the historical climate scenario test. Rather, the requirement has been included to ensure equitable sharing of any reductions in current diversions between consumptive and environmental uses, if such a reduction partially or fully eventuates. It also reduces the need to rely on a prescriptive forecast of the climate expected during the planning period for the Basin Plan.

Sea-level rise

The scientific evidence indicates that sea levels in South Australia are not expected to rise by more than about 1 m by the year 2100 (Bureau of Meteorology 2003; Antarctic Climate & Ecosystems Cooperative Research Centre 2007). Further, the region is relatively low risk for climate-change-related increases in storm surges (Antarctic Climate & Ecosystems Cooperative Research Centre 2008). Given the inherent uncertainties and the low rate of change expected relative to the first Basin planning cycle, the effects of climate change on sea level at the Murray Mouth are expected to be negligible compared with the effects of the changes proposed in the Basin Plan for water-flow regimes across the barrages. It is therefore proposed that

no special provisions be made to account for climate change effects on sea-level rise. However, the issue of sea-level rise will be monitored by MDBA into the future.

Climate change information updates

There has already been a need to update the information on climate change that was used in the modelling for the Murray–Darling Basin Sustainable Yields Project (CSIRO 2008). While the same models have been used, the expected temperatures that apply to 2030 modelling have changed and three more years have been added to the historic baseline for determining climatic variability (2006–07 to 2008–09). These refinements were made for development of the proposed Basin Plan, and further refinements will continue to be made, affecting future water resource plan amendment and accreditation processes.

Future climate scenarios for south-eastern Australia will improve with continuing research in climate and hydrologic modelling science. Key areas of research include:

- characterising climate drivers (such as patterns of sea-surface temperature) and their interactions over a range of time scales for south-eastern Australian rainfall
- attributing changes in climate to changes in these drivers
- improving climate science and global climate modelling
- defining future warming scenarios and selecting global climate models for climate change impact assessment studies
- downscaling tools to translate global climate model simulations to the catchment scale suitable for linkage to hydrologic models
- developing decadal prediction systems
- improving understanding and modelling of potential changes in the relationships between rainfall, temperature and run-off, and in dominant hydrologic processes in a warmer, drier climate with higher levels of carbon dioxide.

This research will be carried out by organisations, universities and government agencies in Australia and overseas, including CSIRO and the Bureau of Meteorology. MDBA will monitor and report on changes to the state of climate science as it relates to Basin Plan water availability and access provisions.

*Degraded farmland near Urana,
New South Wales*



4.3 Social and economic implications of providing additional water to the environment

This section describes the conceptual framework, approach and findings from studies used to assess the potential social and economic impacts of meeting the environmental water requirements of the proposed Basin Plan. The information provided by the studies that comprise this assessment was used to assist the Murray–Darling Basin Authority (MDBA) estimate long-term average sustainable diversion limits (SDLs) and other related aspects of the proposed Basin Plan.

Requirements of the Water Act

One of the purposes of the Basin Plan is to provide for water resource use and management in a way that optimises economic, social and environmental outcomes (*Water Act 2007* (Cwlth) s. 20(d)). A related objective is to maximise net economic returns from the use and management of Basin water resources (*Water Act* s. 3(d)(iii)). MDBA is also obliged to have regard to social, cultural, Aboriginal and other public benefit issues when preparing the Basin Plan. The Water Act requires that these social and economic Basin Plan objectives be pursued to the extent that they do not interfere with the overarching objectives of the Water Act, such as ensuring the return to environmentally sustainable levels of extraction, and protecting, restoring and providing for the Basin's ecological and ecosystem services.

Focus of social and economic assessment

Reductions in current diversion limits are expected to have a range of economic, social and environmental implications for Basin communities and the nation as a whole. Accurately predicting the full nature and extent of these implications is inherently complex as there are many interrelated factors that will contribute to determining the future outlook for the Basin's diverse economies and communities. Furthermore, the effects of reducing diversion limits will not be evenly distributed; while many of the environmental benefits will accrue to a wide distribution of people, including well beyond the boundaries of the Basin, most of the costs will be borne by specific local communities.

Although there are many uses of water in the Basin, including for mining, manufacturing, construction and household activities, as well as recreational uses (see Chapter 2), agriculture accounts for more than 80% of consumptive water use (ABS 2009). Figure 4.14 illustrates some of the likely changes and the pathways by which they might affect Basin communities. Changes to current diversion limits as a result of the Basin Plan are likely to significantly affect the agriculture sector and, more broadly, communities in the Basin where irrigated agriculture makes up a large component of the economic base. Therefore, while recognising that reductions in current diversion limits may affect other industries and water uses (see for instance ABARE, BRS & ABS 2009 and ABARE 2010), MDBA's analysis has focused primarily on the implications for irrigated agriculture and the people, businesses and communities that rely on this sector for their livelihood. A range of the potential environmental, economic, social and cultural benefits of the changes has also been considered.

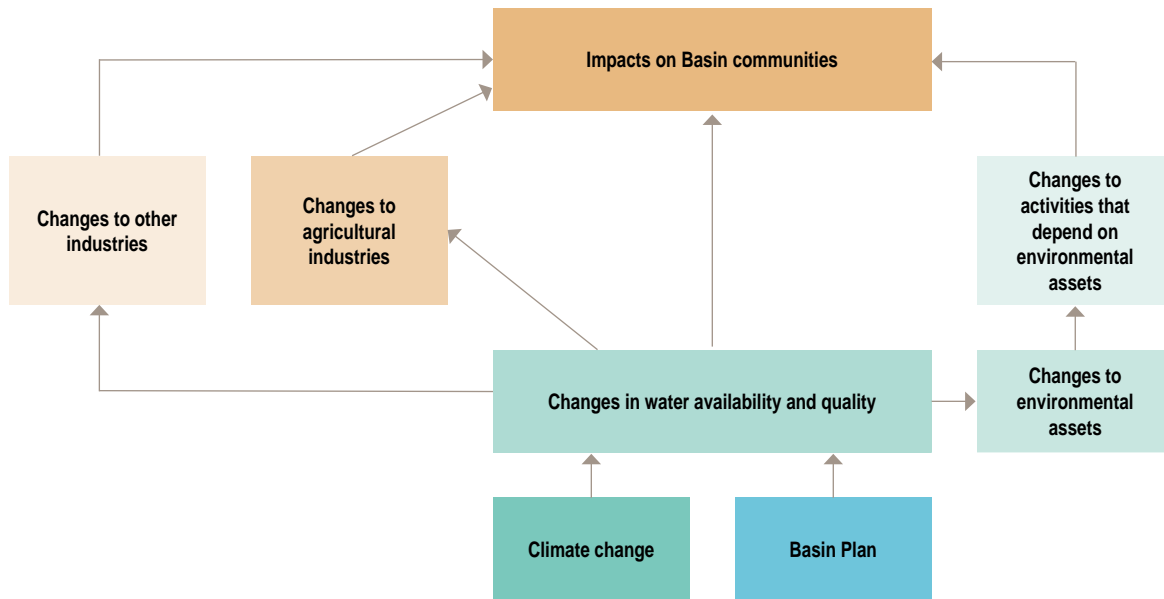


Figure 4.14 Pathways by which changes in water diversions could affect Basin communities

Source: ABARE, BRS & ABS (2009)

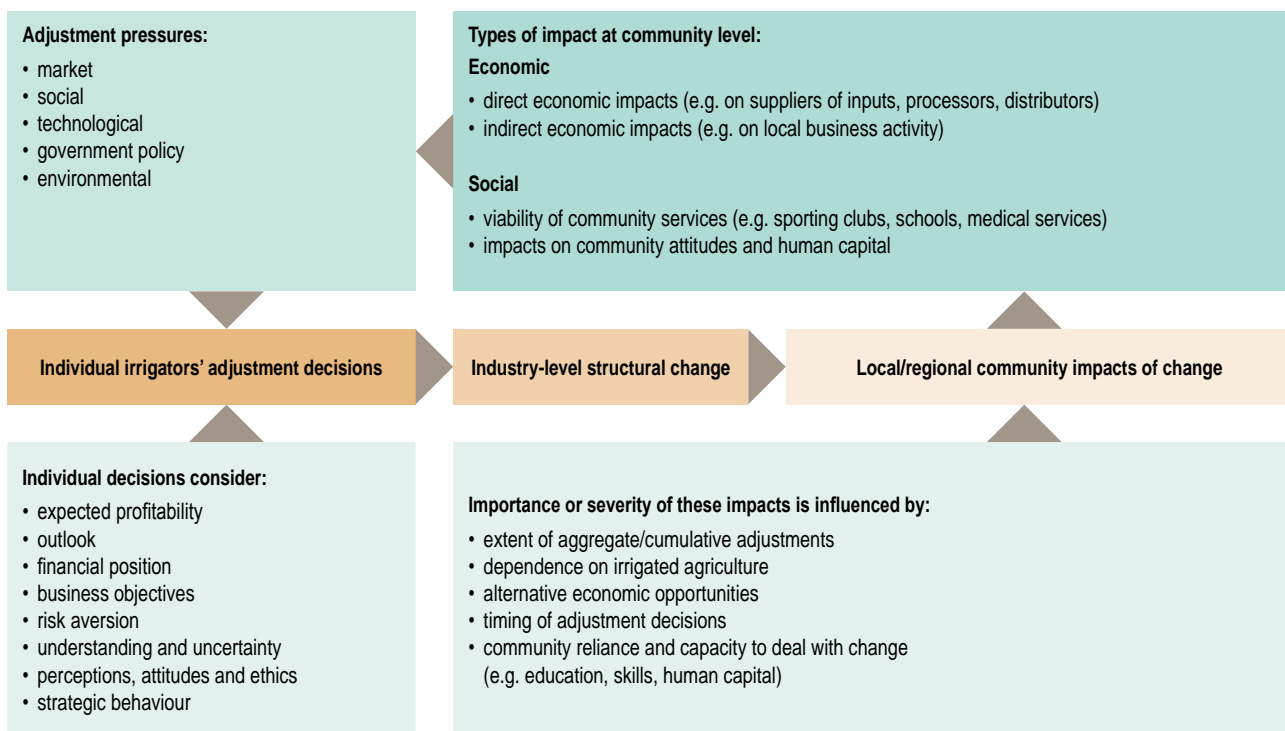


Figure 4.15 Irrigators' adjustment decisions and their economic and social impacts

Source: Frontier Economics (2010)

Conceptual framework

Economic and social change is driven by the adjustment decisions of individuals in response to various factors and pressures. In communities where irrigated agriculture is a significant component of the economic base, the decisions of irrigators will largely drive change. An overview of irrigators' adjustment decisions and their potential economic and social impacts is shown in Figure 4.15. Fundamentally, these decisions are driven by expectations about the future profitability of irrigators' individual enterprises based on the range of market, social, technological, government policy and environmental factors (Frontier Economics 2010).

These individual adjustment decisions are based on all factors affecting expected profitability in combination. The impact on expected profitability is a useful way to assess the relative importance of any particular adjustment pressure. However, attribution of adjustment outcomes to any single pressure is often difficult as decisions reflect a range of factors (Frontier Economics 2010) including:

- Outlook — each farmer will have a different outlook in relation to a range of factors influencing expectations regarding future profitability. Future commodity prices and climatic conditions are key examples where outlook can vary significantly.
- Financial position — each farmer will have a different level of debt versus equity, face slightly different capital costs, have a different level of reliance on off-farm versus on-farm income, be seeking different rates of return on their capital investments, and have a different propensity or ability to take on more debt. Relatively higher levels of debt and poor cash flow may increase the likelihood of a farmer exiting the irrigation sector. However, farmers will also consider overall wealth, such as impacts on the capital value of their land and water.
- Business and lifestyle objectives — some farmers will be aiming to grow and develop their business, others might want things to remain the same, while others may be planning to exit the industry, particularly in ageing family farming businesses. Others may sacrifice profitability and wealth where farming provides them with lifestyle benefits. These factors will have a major influence on the propensity to make adjustment decisions in response to external change.
- Capacity to change — older farmers, and those with less education and skills, may be relatively unwilling to change their production systems.
- Risk aversion — each farmer will have a different attitude towards adjustment. Some may embrace change, while others will resist it.
- Perceptions and intangibles — personal views and societal norms play a key role in determining adjustment decisions, and feed into shared perceptions about future outlook.
- Understanding and uncertainty — it will be critically important that farmers fully understand the profitability implications of adjustment decisions for their businesses, both now and into the future. Uncertainty about the expected costs and benefits will influence outcomes and will typically slow adjustment responses.
- Strategic behaviour — farmers may avoid making adjustment decisions or take a certain course of action if they believe it could lead to other, more favourable outcomes in the future, or a deferment of inevitable adverse outcomes.

The framework in Figure 4.15 recognises that the decisions made by individuals can affect industries and local and regional communities. Economic impacts include direct impacts — such as those on the activity and viability of local input suppliers and output processors — as well as indirect impacts on local communities through reduced economic activity and spending.

In some cases these economic impacts might lead to capital leaving an area and population declining, which might affect the viability of community services such as health, education and training. Such outcomes, and the fear or perceptions that they may induce, can also affect community attitudes, human capital (such as labour, skilled workers and education levels in a community) and resilience to shock.

Where it is possible to measure these outcomes, it is important to remember that they reflect the range of adjustment pressures facing the individuals in a community, and it is often difficult to attribute such outcomes to any single factor (Frontier Economics 2010).

Community-level outcomes

It is broadly recognised that adjustment outcomes vary considerably from community to community. The severity of economic and social impacts is strongly influenced by:

- the extent and timing of individual adjustment decisions
- reliance or dependence of a regional community on irrigated agriculture
- availability of alternative economic opportunities and social services
- resilience of a community or capacity to deal with change.

For example, a study on the economic and social impacts of water trade by Frontier Economics et al. (2007) found that large regional centres are more diverse and relatively less dependent on irrigated agricultural production than a number of smaller localities, which were affected by adjustment in the irrigation industry. This study highlighted how rapid changes in water diversions in local communities can affect economic and social outcomes. For example, community services and housing in Robinvale (near Mildura) struggled to keep up with the influx of investment and employment associated with the new horticultural developments over the past 10 years (Frontier Economics 2010).

Vulnerability and adaptive capacity framework

The evaluation of how Basin communities will be affected by, and respond to, a reduction in current diversion limits is grounded in a conceptual framework drawn from the literature on vulnerability and adaptive capacity assessment (see Smit & Wandel 2006; Preston & Stafford-Smith 2009; Fay, Block & Ebinger 2010). Similar frameworks have been used to evaluate the community- and regional-level adaptive capacity and vulnerability of Basin farmers to drought and climate change (Nelson et al. 2010).

The core premise of the vulnerability and adaptive capacity framework is that the vulnerability of a community to a change event can be understood in terms of the level of exposure, the sensitivity of the community to the change event, and the community's adaptive capacity. Exposure is the amount of external stress or change a community is likely to experience (in this case, reduction in current diversion limits). Sensitivity is a measure of how dependent a community is on the factor that is changing. For instance, a community that makes no use of water in a local river would be relatively unaffected by reductions in current diversion limits. Exposure and sensitivity



Harvesting cotton near Dalby on the Darling Downs, Queensland

together determine the magnitude of potential impact. Greater potential impacts are likely to occur where a community is both very dependent on water and is facing a large reduction in diversions. The adaptive capacity of a community is the ability to change in response to a shock or stress and is related to the resources available in the community (Marsden Jacob Associates et al. 2010; ABARE–BRS 2010). Figure 4.16 illustrates the relationship between these concepts.

The resources of a community are not just tangible assets such as water, money or farm machinery. Resources also include intangible assets such as the depth and breadth of community skills, mental and physical wellbeing of residents, education attainment, and community relationships. The stock of tangible and intangible assets within a community plays a significant role in determining the sensitivity of that community to a shock, and to its adaptive strategies. In the vulnerability and adaptive capacity literature, the tangible and intangible assets of a community are often framed using a ‘five capitals’ approach. These are:

- human capital — labour and influences on the productivity of labour including education, skills and health
- social capital — claims on others by virtue of social relationships
- natural capital — land, water and biological resources
- physical capital — produced by economic activity including infrastructure, equipment and technology
- financial capital — savings and credit.

Communities that are less vulnerable to shocks are often described as resilient; that is, their adaptive capacity enables them to minimise the social and economic damage that might result from potential impacts (Burnside 2007; Ellis 2000; Nelson et al. 2005; Yohe & Tol 2002; ABARE–BRS 2010, Marsden Jacob Associates et al. 2010).

The framework adopted for the assessment of the potential social and economic impacts of reductions in current diversion limits recognises that social and economic systems are complex. One way of characterising this complexity is to recognise that there are feedback loops between community-level outcomes and individual adjustment decisions. For example, changes in the availability of community services may affect the geographic location of investment decisions of individuals and firms. More broadly, the social and economic factors contributing to the movement of young people out of farming over recent decades has had a feedback effect on the succession planning and adjustment decisions of ageing farmers. The importance of such interrelationships is likely to be highest when there are direct interdependencies between irrigators and downstream employment, or where the viability of transport and distribution links requires a critical mass of production in order to remain competitive (Frontier Economics 2010).

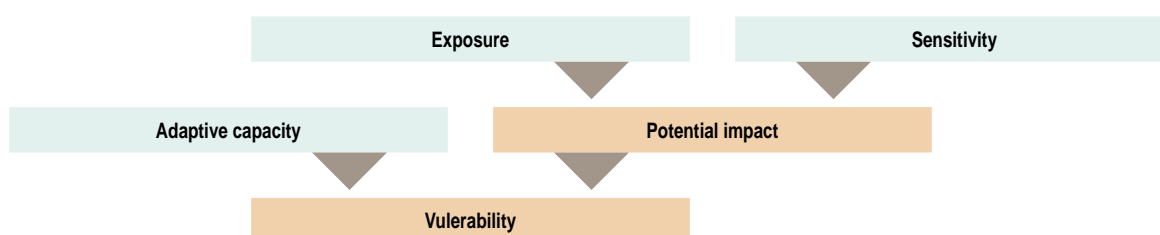


Figure 4.16 Relationship between exposure, sensitivity, impact, adaptive capacity and vulnerability

Source: Allen Consulting Group (2005), based on Schroter (2004)



*Street scene in Wagga Wagga,
New South Wales*

Approach to the social and economic analysis of the Basin Plan

Consistent with these frameworks, a range of studies has been undertaken to capture some of the complexity and interconnectedness of the Basin's social and economic system. The analysis sought to better understand the direct and indirect effects of reducing current diversion limits on irrigated agricultural production, related industries and wider community wellbeing. The potential social and economic impacts of reductions in diversion limits were assessed at four scales: Basin-wide, regional, industry, and local community level. A combination of approaches was used for the assessments. Economic models were used to assess impacts at Basin-wide, regional and industry levels in terms of effect on irrigated agricultural production. Social impact assessment methods were used to complement this analysis and to describe in more qualitative terms the potential impacts at industry and local community levels.

From a range of studies conducted, six formed the basis of the analysis:

- Economic modelling was used to estimate the potential impact of a range of reductions in current diversion limits on the irrigated agriculture sector and its flow-on effects to the Basin's regional economies. This modelling was primarily undertaken by the Australian Bureau of Agricultural and Resource Economics (ABARE) using its water trade and AusRegion models. Additional modelling was done by the Centre of Policy Studies at Monash University and the University of Queensland (ABARE 2010; Wittwer 2010; Mallawaarachchi et al. 2010).
- Consultative methods were used to gain an understanding of the vulnerability and adaptive capacity of regional communities to a range of potential water reduction scenarios. This involved preparing regional community profiles and gathering stakeholder information about the likely impacts and responses of industries and communities in particular irrigation regions (Marsden Jacob Associates et al. 2010).
- An assessment of community resilience in the face of reduced water diversions across the Basin as a whole was undertaken by the Bureau of Rural Sciences and the University of New England. The aim was to characterise communities on the basis of their relative sensitivity, adaptive capacity and vulnerability to represent how well they might be able to respond to changes in diversion limits based on their initial social characteristics (ABARE–BRS 2010b).

- A review of Aboriginal cultural, social, economic and environmental interests in the Basin's water resources was undertaken by CSIRO. This study included consultations for three case studies to gain a descriptive characterisation of the potential impacts of the proposed Basin Plan on Aboriginal groups and their interests (Jackson, Moggridge & Robinson 2010).
- An assessment of likely actions and responses of the financial services sector to the proposed Basin Plan was provided by an independent consultant (Rizza 2010).
- A review of existing studies about economic valuation of potential environmental benefits in the Basin was conducted by Charles Sturt University and CSIRO. The review analysed diverse information about market and non-market values associated with Basin environmental assets and considered how these economic estimates of values may change as a result of changes in current diversion limits (Morrison & Hatton MacDonald 2010).

In isolation, none of these analyses provides perfect insight into the socioeconomic impacts of additional water to for the environment. However, when findings from the studies are combined, they provide an understanding of the social and economic capacities of communities, and improve information about the likely upper and lower bounds of impacts. In weighing up the results of this analysis, MDBA considered that the economic modelling was more likely to underestimate potential impacts on communities, at least in the short term, and the consultation process was more likely to overestimate any implications. It is likely that the actual impacts lie between the two perspectives, with a range of complex and interrelated factors exerting influence on the ultimate outcome, including ongoing rural restructuring, technological change, commodity price fluctuation, short- and long-term climatic variation, long-term demographic changes, and degree of remoteness. All these factors make assessing the separate and specific effects of the proposed Basin Plan on regional economies and communities difficult to determine in a definitive manner. The approach used in each of the six studies is described in more detail below.

Use of economic models

Economic modelling by ABARE was primarily based on a two-stage modelling approach.

The first stage involved using the ABARE water trade model to estimate the direct effects of changes in current diversion limits on the gross value of irrigated agricultural production by region and by major commodity group (cotton, rice, dairy and horticulture). These estimates are presented as changes in gross value of irrigated agricultural production, and profit, which compare estimates before a reduction in water use is made (baseline), and after the Basin's industries have adjusted to the new level of water diversions. The regions used in the modelling are those used in the CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008).

The second stage involved using the estimates of gross value of irrigated agricultural production as inputs into ABARE's AusRegion model, a computable general equilibrium model of the Australian economy, to estimate flow-on effects of reductions in water diversions to agriculture overall to regional, Basin and national economies. These economic impacts are generally stated in terms of changes in gross domestic product at a national level and gross regional product at Basin and regional scales.

It should be noted that AusRegion analysed seven regions in the Basin compared with 24 for the water trade model (ABARE 2010). The seven Basin regions used in AusRegion were based on aggregations of the CSIRO sustainable yield regions. As the model analyses comprehensive interactions within a given economy, its capacity to analyse a large number of small regions at one time is limited.

Given that neither model is capable of analysing the effect of SDLs below regional level, ABARE undertook additional regional analysis using a combination of regional gross value of irrigated agricultural production estimates, irrigation survey data on the amount and location of irrigation farm expenditure, and spatial data on irrigated land use (ABARE 2010). The purpose of this finer-scale analysis was to identify towns that may be more vulnerable to declines in irrigation farm expenditure arising from any reductions in current diversion limits.

Use of different economic models to analyse the effects of change can often produce variation in results. This is mainly because models differ in their composition, or analytical capabilities, the spatial boundaries they adopt and the primary datasets and assumptions they use. For this reason, MDBA commissioned analyses from a number of economic modelling groups. Using results from alternative models provides the opportunity to compare and test the validity of results and thus provide a broader understanding of them and the complexity of the adjustment that may take place with reductions in water diversions. Modelling was undertaken by the Risk and Sustainable Management Group at the University of Queensland and by the Centre of Policy Studies at Monash University to provide additional insights, especially in relation to regional flow-on effects and variability (Wittwer 2010; Mallawaarachchi et al. 2010). These analyses were also used to complement and expand on the local information gathered by Marsden Jacob Associates et al. (2010), who met with community groups and representatives as part of their community profiling and social and economic impact study.

Community profiling and social impact assessment

While the models used for this analysis describe the potential economic effects of the proposed Basin Plan at a broad regional scale, they do not provide information about the finer-scale economic and social impacts that might occur at the local community level. Social impact assessment, as well as analysis of community vulnerability and adaptive capacity, was conducted to gain an understanding of these local-level impacts. As part of the local impact assessment attention was given to the particular vulnerability of Aboriginal communities to reductions in current diversion limits.

The details of the assessment are explained below, but it should be emphasised that this study was not a formal social impact assessment. The study diverged in two ways from the framework recommended by The Interorganisational Committee on Principles and Guidelines for Social Impact Assessment (2003). First, social impact assessments are usually localised at a project or community level. While extensive consultations were carried out with key stakeholders and local communities who are likely to be affected by the proposed Basin Plan, the aim of the assessment was to gain a strategic social and economic impact assessment that profiled and assessed potential impacts at a Basin-wide level, into:

- the contexts and value dispositions of Basin communities towards potential reductions in current diversion limits (via telephone surveys and direct community consultation)



*Fishing at the Menindee Lakes,
New South Wales*

- community vulnerability to the implementation of reduced water diversions
- regional adaptive capacity, and likely adaptations in response to the reductions in current diversion limits. The approach aimed to understand industry-specific short-, medium-, and long-term adaptations likely to result from the implementation of the proposed Basin Plan.

Second, while many of the procedural steps in a social impact assessment were carried out, the emphasis was on the profiling, prediction and impact mitigation phases.

A key aspect of the project was to ascertain information from stakeholders at a local level about the likely impacts of a range of possible reductions in current diversion limits. The scenarios consulted on were hypothetical and based on an assumption of no transition assistance to account for water recovered for the environment. This is an extreme scenario, given that measures to manage the transition will be in place (see Chapter 5).

The project covered 12 areas along the Murray and Murrumbidgee rivers and in the Namoi, Gwydir, Border Rivers and Condamine–Balonne catchments (see Table 4.8), where the potential social and economic impacts of reducing current diversion limits were deemed more likely to be pervasive, due to the history and extent of water use for irrigation (Marsden Jacob Associates et al. 2010).

Regional consultation and surveys were carried out by teams with established reputations and relationships in the regions they were investigating. As part of the process, pre-consultation interviews were conducted, starting with Basin Community Committee members to help identify participants, key issues and proposed timing for meetings in the region. Teams spent several days in each of the 12 areas consulting with key interest groups. The engagement process focused on targeted discussions, either one-to-one or in small group meetings, and a telephone survey of approximately 1,300 individuals (Marsden Jacob Associates et al. 2010).

Table 4.8 Locations of targeted consultations

State	Area
Queensland	Lower Balonne section of the Condamine–Balonne
Northern NSW	Border Rivers Gwydir Namoi Macquarie
Southern NSW	Lachlan Murrumbidgee NSW Central Murray
Northern Victoria	Goulburn Murray Irrigation District Nyah to the SA border (Sunraysia)
South Australia	SA Riverland SA River Murray below Lock 1

Source: Marsden Jacob Associates et al. (2010)

The meetings targeted individuals from the following groups:

- the Murray–Darling Basin Community Committee
- the main irrigation supply organisations
- key influential farmers (irrigators and graziers)
- industry bodies
- local government
- catchment management authorities
- local irrigation associations
- large commercial irrigation companies
- food processing companies and other supply chain organisations
- regional representatives from key state agencies
- rural finance advisers
- other regional individuals with relevant expertise.

The study by Marsden Jacob Associates et al. (2010) is presented in Appendix C.

Community resilience — adaptive capacity and vulnerability

The Bureau of Rural Sciences in conjunction with the University of New England's Institute for Rural Futures developed a range of statistical indicators to assess community vulnerability to reductions in current diversion limits. Again, the aim was to characterise communities on the basis of their relative sensitivity, adaptive capacity and vulnerability, and provide a representation of how well a community might be able to respond to change, based on the initial social characteristics of that community. These indices were mapped across the Basin in a manner that allows for an informative visual and spatial representation of the relationships between communities that are vulnerable to reductions in current diversion limits.

For this project, various indicators were used to characterise water dependence, agricultural dependence, economic diversity, human capital and social capital of communities across the Murray–Darling Basin. For local economy agricultural dependence and human capital, there were many potential indicators that the literature identified as appropriate. In these two cases, principal components analysis was used to examine the relationships among the potential measures and choose a limited set of relatively uncorrelated indicators. Most indicators were reported at the Australian Bureau of Statistics (ABS) census collection district scale except for irrigation incidence and irrigation intensity, which were reported at the ABS statistical local area scale (ABARE–BRS 2010b).

Consideration of Aboriginal interests in water

The Murray–Darling Basin is home to numerous Aboriginal groups, including the Barkindji, Nari Nari, Muthi Muthi, Gamilaroi and Yorta Yorta nations. The Basin has a population of just over two million, of which approximately 70,000 people are Aboriginal, constituting 15% of the national Aboriginal population.

CSIRO undertook a review and synthesis of knowledge of Aboriginal cultural, social, economic and environmental interests in the waters of the Basin. The study included consultations for three case studies to gain a descriptive characterisation of the potential impacts of the proposed Basin Plan on Aboriginal groups and their interests.

The three case studies were chosen in consultation with Aboriginal representatives from the Northern Murray–Darling Basin Aboriginal Nations and the Murray Lower Darling Rivers Indigenous Nations. The case studies aimed to reveal the diversity of Aboriginal interests in the Basin’s water resources. They describe the water management practices and aspirations of three Aboriginal groups in separate regions of the Basin: the Nari Nari in the Murrumbidgee; the Ngemba in the Barwon–Darling; and the Yorta Yorta in the Murray.

The case studies drew on a range of sources to generate context reports. These were followed by interviews with nominated representatives for each group during field visits and by telephone. The participating groups are involved in water management in their capacities as traditional owners with rights and interests in land and water under their own systems of law, as water licence holders, and as owners of land of recognised heritage and environmental significance. These groups report significant barriers to accessing water under current water sharing or allocation plans (Jackson, Moggridge & Robinson 2010).

Potential implications for financing regional business

Changes to current diversion limits may affect the extent and pattern of economic activity in the Basin’s regions. Access to financial capital is a key input to agricultural and flow-on economic production activities and, consequently, changes to its allocation and cost can have a material effect on the level and distribution of economic activities.

An independent study was undertaken to identify the ways in which investment (availability and allocation of debt and equity capital) in the Basin may be affected by the release of the proposed Basin Plan, including how financial capital providers may respond to the potential change in risk profile for their investments. The study reviewed a range of information and interviewed stakeholders from a number of sectors including banking, business and accountancy (Rizza 2010).



Stone tool created as part of a traditional knowledge project developed by the North East Catchment Management Authority, Victoria

Economic valuation of environmental benefits

One of the objectives of the Basin Plan is to maintain and improve the ecological health of the Basin water resources, and in so doing optimise the social, cultural, and economic wellbeing of Basin communities. Another objective is to maintain appropriate water quality standards, including salinity levels, for environmental, social, cultural, and economic activity in the Basin.

An indication of the benefits of increasing environmental flows through introducing SDLs can be ascertained from the range of market and non-market studies that estimate the value the wider Australian community places on maintaining and enhancing the environmental health of the Basin.

A study by Charles Sturt University and CSIRO was commissioned to review and summarise existing market and non-market valuation studies associated with Basin environmental assets and consider how these economic estimates of values may alter as a result of changes in current diversion limits. Estimates

of values for each region of the Murray–Darling Basin were identified for up to five attributes: recreation; the extent of healthy native vegetation; numbers of native fish; numbers of waterbirds; and the frequency of waterbird breeding events. The application of these valuation estimates required assessment of the likely effect of changes in diversion limits on the relevant environmental attributes (Morrison & Hatton MacDonald 2010).

Implications for irrigated agriculture and communities

Any reduction in current diversion limits could affect Basin communities that rely on irrigated agricultural production. Across the Basin, the fundamental effect of any reduced diversion limits will be a reduced intensity of economic activity within each region. The social and economic analysis commissioned by MDBA provides a strong body of evidence, when considering the social and economic implications for regions and communities, of providing additional water to the environment and reducing current diversion limits. The following section outlines the current status of the people, industry and communities of the Basin. It addresses the sensitivity of these groups to changes in diversion limits.

Sensitivity to change — farmers, industries and communities

The material in this and the following sections is largely based on the commissioned report by Marsden Jacob Associates et al. (2010). As described above, extensive face-to-face community consultations and a large telephone survey were carried out to obtain qualitative information on community views and potential adaptation strategies regarding reductions in current diversion limits.

The Basin’s farmers are generally optimistic and have strong connections to place and community, despite the damaging effects of the recent drought on wealth and employment (Marsden Jacob Associates et al. 2010). However, farmers are not homogeneous and do not exhibit uniform sensitivity to change. In general, farmers with greater dependency on irrigation and those with a greater debt-to-assets ratio will be more sensitive to changes in current diversion limits. Older farmers, those who have been farming longer and those who have low at levels of wellbeing and optimism levels are also more likely to exit farming should current diversion limits be reduced.

As a result of the drought and commodity price variability, and as a generalisation across the cotton, dairy, rice and horticulture sectors:

- many farmers have been surviving on exceptional circumstances payments and off-farm income with considerable accumulated liabilities and liquidised (eroded) capital reducing their adaptive capacity (e.g. ability to consolidate and invest)
- many farmers have exited the agricultural sector (or are likely to do so soon)
- farmers who have been in farming longer, and are in the 36–55 and 56–65 age brackets, are most sensitive to reductions in current diversion limits and most likely to exit as they are more indebted (particularly those aged 36–55), feel time pressured and are financially stressed.

Communities that rely directly on access to water for irrigation are likely to be affected by reductions to current diversion limits. Through social and economic connections, other communities are likely to experience flow-on effects from a reduction in irrigated agricultural production capacity. A range



Cotton crop with irrigation channels, Cecil Plains, Queensland

of secondary processing and service sectors within these communities depend on the primary production sector. In short, shops and clubs in country towns often flourish only when farmers earn a living, while the wealth and employment generated by irrigation also supports a critical mass of activity that leads to the provision of essential public sector services in education, social services and healthcare.

The main irrigation regions of the Basin are highly productive working communities producing food and fibre products for domestic and export markets. Figure 4.17 shows the gross value of irrigated agricultural production for 2005–06 in 10 irrigation areas within the Murray–Darling Basin and illustrates the different crop production profiles of the northern and southern parts of the Basin. It should be noted that 2006 was a drier than average year, which would have affected the relative amounts of some crops grown, particularly annual crops such as rice and cotton.

As for farmers, for farm systems there is no typical farm type or business, even within the distinct irrigated agricultural sectors. The following provides an overview of the status of the major irrigated agriculture industries of the Basin and an indication of their sensitivity to reductions in current diversion limits.

The northern Basin

Cotton is a significant crop in the Lower Balonne (part of the Queensland Condamine–Balonne region), Border Rivers (NSW/Qld) and in the northern NSW regions of Gwydir, Namoi and Macquarie–Castlereagh. Cotton is also grown within the Lachlan region and minor plantings are reported to occur within the Murrumbidgee region. It is a highly adaptable annual crop. The area planted is readily adjusted in response to water diversions, and the crop is experiencing ongoing improvements in yields, quality and productivity.

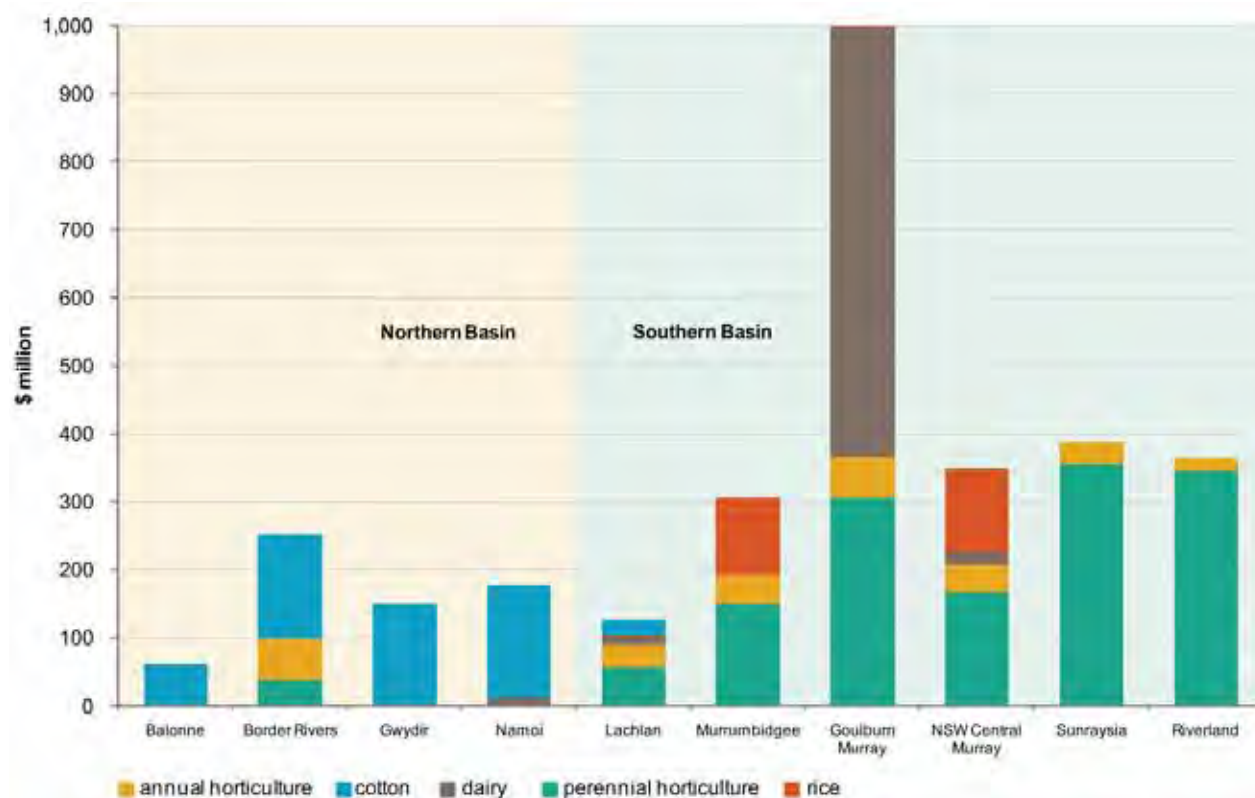


Figure 4.17 Irrigated agricultural production by sector and area, 2005–06

Source: adapted from Marsden Jacob Associates et al. (2010)

Once cotton farmers have exploited water-use efficiency to the extent commercially feasible, their next response to reduced watercourse diversions would be to diversify from permanent cotton crops to mixed cropping and other crops, including dryland cropping and/or pastoral farming. However, returns to dryland cropping are lower than returns to irrigated cotton, in terms of both yields and employment. In turn, this would have negative effects on cotton farmers that would tend to flow through to regional communities (Marsden Jacob Associates et al. 2010).

Across the cotton regions of northern New South Wales and the Queensland Lower Balonne, reductions at the lower end of the range of environmental water requirements are likely to result in investment in water-use efficiency and some sale of entitlements where this is allowed (Marsden Jacob Associates et al. 2010). With reductions at the higher end of the range, the area of cotton is likely to reduce, farmers may become increasingly likely to exit, some properties are likely to consolidate and cotton gins would start to close, with a consequent decline in employment opportunities and increased migration of people from the region.

The irrigation communities of the Gwydir, Namoi, Border Rivers, Macquarie–Castlereagh and Lachlan regions are highly dependent on cotton. Even small reductions in current diversion limits would most likely see significant loss of economic activity in communities such as Goondiwindi. At mid-range reductions the economic impact would be larger, and at high end could significantly affect smaller cotton-based towns such as Warren, Wee Waa and Moree, and to a lesser extent Narrabri (Marsden Jacob Associates et al. 2010).

While the Macquarie–Castlereagh and Lachlan regions are also highly dependent on cotton, the larger urban centres of Dubbo, Forbes and Cowra have more diverse economies and would be relatively less likely than smaller towns to be affected by reductions in current diversion limits.

In terms of differing regional sensitivity to reductions in current diversion limits, regions and communities further inland, often lacking a diversity of economic drivers, tend to be more sensitive to potential reductions. For example, the agriculture sector in Condamine–Balonne in Queensland directly employs around 36% of workers in the region — a greater percentage than any other region in Queensland. The small cotton-dependent communities of this region often face significant social issues. They have highly mobile workforces that follow job opportunities and if these workers leave because cotton-related activities have declined, towns may lose critical mass for community services and face increased risk of welfare dependency.

The southern Basin

Rice

Rice is the predominant crop in the NSW Central Murray and Murrumbidgee irrigation regions. While the rice farming system is a mixed enterprise farm, the rice crop and winter cereal crops grown in rotation with rice that tend to underpin farm financial returns. Like cotton, rice is an adaptable annual crop, although the level of rice production tends to decline at a greater rate than the respective decline in water availability. If crop profitability is high enough and water is affordable, rice growers will tend to buy water to supplement allocations when faced with reduced diversion limits. However, if the price of water is higher (often in response to low allocations) and/or crop profitability is lower, they will tend to sell their water (often to horticulture or dairy farmers). Rice farmers irrigate more than half their land and have the highest holdings of general security entitlements of any sector (Marsden Jacob Associates et al. 2010).



Saline lake and dead trees near Ouyen, Victoria

On average, rice farmers hold nearly 60% of their assets as water assets. Rice farmers would be relatively highly sensitive to any reduction in current diversion limits that decreased the value of their water assets, assuming they were not recompensed. Of the Murray–Darling Basin’s two dominant rice regions, the relatively higher volume of water per hectare for each entitlement in the Murrumbidgee suggests that it is relatively less sensitive (on this measure) than the Murray region.

The Murray and Murrumbidgee regions and communities are likely to be particularly hit, even by relatively smaller reductions in current diversion limits. Across these two regions smaller farms would typically tend to become unviable. Larger enterprises that can leverage economies of scale may attempt to restructure, including securing water entitlements or annual allocated water, to maintain productivity. At a mid-range reduction, many rice farms could become unviable and the number of farmers could decline significantly. A large reduction in current diversion limits may make rice farming unviable, with consequent impacts on dependent local communities (Marsden Jacob Associates et al. 2010).

Towns in the rice-growing regions of the Murrumbidgee and Central Murray in New South Wales are highly sensitive to economic decline caused by a downturn in rice farming. For example, employment opportunities in the town of Deniliquin have declined in recent years, a situation exacerbated by the recent drought. As with cotton towns, rice-growing towns could lose skilled workers and their families, affecting critical community population mass increasing the struggle to sustain businesses and provide community services.

Dairy

The dairy industry of the Basin is focused in the Victorian Goulburn–Murray Irrigation District, but also includes some farms in the NSW Central Murray and in South Australia. The past 40 years have seen declining farm numbers and increasing average farm size, while more recent years have seen low milk prices and high water prices (in response to low allocations). This has led to increased farmer debt, decreased milk production and some rationalising of processing capacity. However, both irrigation efficiency and fodder productivity have increased, so farmers tend to balance the cost of growing feed themselves with the cost of buying it from farmers with mixed enterprises. Dairy farmers irrigate more than 70% of their land and hold more high-reliability than low-reliability entitlements, reflecting the

importance of reliability of supply, particularly to sustain herds in dry years (Marsden Jacob Associates et al. 2010).

For the northern Victorian regions of Goulburn–Broken, Murray, Campaspe and Loddon (the Goulburn–Murray Irrigation District), a low-range reduction in current diversion limits could be adjusted through water trading, and dairying may even expand from current levels of production as these volumes of water would be greater than experienced in the recent drought. At a mid-range reduction, it is likely that negligible water would be available for mixed and broadacre farming and the dairy industry would probably remain static and uncertain or could experience some contraction. To offset reduced diversion limits some farms could buy water from mixed farming and the NSW rice-growing regions. A large reduction in current diversion limits could mean the Goulburn–Murray Irrigation District dairy industry would experience a more serious decline, with a possible rationalisation of milk processing factories (Marsden Jacob Associates et al. 2010). In the lower Murray, a low-range reduction may result in some milk factory closures; at mid-range reductions, dairy farming on the reclaimed swamps could face serious adjustment; dairy farming by the Lower Lakes has already largely converted to dryland so would be less affected.

Across the Goulburn–Murray Irrigation District, farming and food processing are important sources of wealth and employment. Towns in this district have varied exposure to the impacts of reductions to current diversion limits. While some towns have other industries such as tourism (e.g. around the River Murray and the Kerang Lakes) and are more resilient to reduced diversion limits, these industries could not be expected to replace the economic contribution made by agriculture.

Horticulture

Horticultural production is located throughout the Murray–Darling Basin, but is particularly important in southern Basin regions. Horticultural farmers irrigate more than half their land and predominantly hold high-reliability entitlements, reflecting the importance of a reliable water supply, particularly to maintain trees and vines in dry years.

For annual horticulture, water is a small component of input costs and the response to reduced diversion limits would be to buy water on the market. However, as water prices rise, annual horticulture could move to more water-reliable, lower-cost regions outside the Basin.

Perennial horticulture is highly variable in profitability across the different crops and water is a relatively small input cost for most crops. Low water allocations due to the recent drought have forced some enterprises to choose between drying off less viable plantings (i.e. either stop irrigating or remove), or buying-in water. The Murrumbidgee and NSW Sunraysia regions have had greater volumes of water per hectare for each entitlement historically; therefore, the New South Wales regions have tended to be net sellers of water allocations, while the Victorian Sunraysia and South Australian Riverland districts tend to buy water in dry years (Marsden Jacob Associates et al. 2010).

For the Nyah to the South Australian border region (the Sunraysia Irrigation District in New South Wales and Victoria) and the Riverland Irrigation District (South Australia), horticulture irrigators could cope with a low-range reduction in current diversion limits through water trading and may dry off plantings. At a mid-range reduction, drying off would expand and some industries could be threatened, with negative flow-on effects to communities that rely on horticulture and food processing for economic activity. A large reduction in current diversion limits could mean the industry would contract to private diverter areas.



Picking peaches near Cobram in Victoria



Harvesting wine grapes near Mildura, Victoria

Across horticulture industry sectors, medium-sized farms are likely to be more adversely affected by reduced diversion limits as they have the least capacity to adjust, either via scale (as larger farms can) or supplementation with off-farm income (as is possible for smaller farms).

Socioeconomic benefits

For the South Australian Murray below Lock 1 (including the stretch of the River Murray from Blanchetown south to the Lower Lakes), raised water levels in the river and the Lower Lakes as a result of reductions in current diversion limits would have a number of important social and economic benefits to the region in addition to the environmental benefit. To date, this region has borne the most significant effects of declining water flows in the lower Murray. Social and economic benefits of a healthier environment and higher water levels would be expected to include benefits for ecotourism, boating and commercial fishing as well as improved optimism and wellbeing in the community. Horticulture in the region could close or leave the region, except for some boutique wineries with cellar-door sales (Marsden Jacob Associates et al. 2010).

Potential effects of reductions in current diversion limits on irrigated agriculture

The potential economic impacts of a reduction in current diversion limits should be considered in the context of the status, complexity and adaptive capacity of the Basin's people, industries and communities. Economic impacts are the outcome of a combination of the extent of the adjustment shock, decisions made by individuals (in the context of their own specific circumstances), the reliance of a community on irrigated agriculture, access to alternative economic opportunities and the capacity of individuals and communities to deal with change. MDBA has judged, based on the information presented in the remainder of this chapter, that while 3,000–7,600 GL/y is the range of additional water required to meet environmental water requirements, reductions in diversions greater than 4,000 GL/y would not enable it to meet its obligations under the Water Act to optimise environmental, social and economic outcomes. MDBA has therefore judged that it can only consider reductions in current water diversions of between 3,000 GL/y and 4,000 GL/y. Accordingly, this section outlines the potential economic and social impacts of providing an additional 3,000–4,000 GL/y to the environment.

With less water available for agriculture in the Basin, the long-term production capacity of the irrigated agriculture sector may be constrained. The degree of constraint will depend on a range of factors, including future climatic conditions, commodity prices, input costs, water-use efficiency improvements, infrastructure developments, and any transitional arrangements set in place. Economic modelling has been used to better understand the impacts on the irrigated agricultural sector for a range of reductions in current diversions.

Reductions in water diversions in the 3,000–4,000 GL/y range are likely to result in a fall in gross value of irrigated agricultural production in the Basin of \$0.8–1.1 billion/y, or 13–17% (ABARE–BRS 2010a). In 2005–06 the Basin’s gross value of irrigated agricultural production was around \$5.5 billion (ABARE, ABS & BRS 2009). In the context of the broader Basin economy, excluding the Australian Capital Territory (given its predominantly non-agricultural economy), irrigated agriculture accounted for around 5.6% of Basin gross regional product in 2006, while dryland agriculture accounted for around 9.4%. Manufacturing accounted for around 12.8%, mining and other primary industries around 5.5%, and utilities and services accounted for the remainder (Wittwer 2010).

As less water becomes available for irrigation, the economic impact of reduced water use would become progressively more pronounced (see Figure 4.18). A small reduction in current diversion limits would be most likely to affect lower-value activities only, whereas greater reductions in water use would also affect higher-value agricultural production, resulting in a relative larger economic impact.

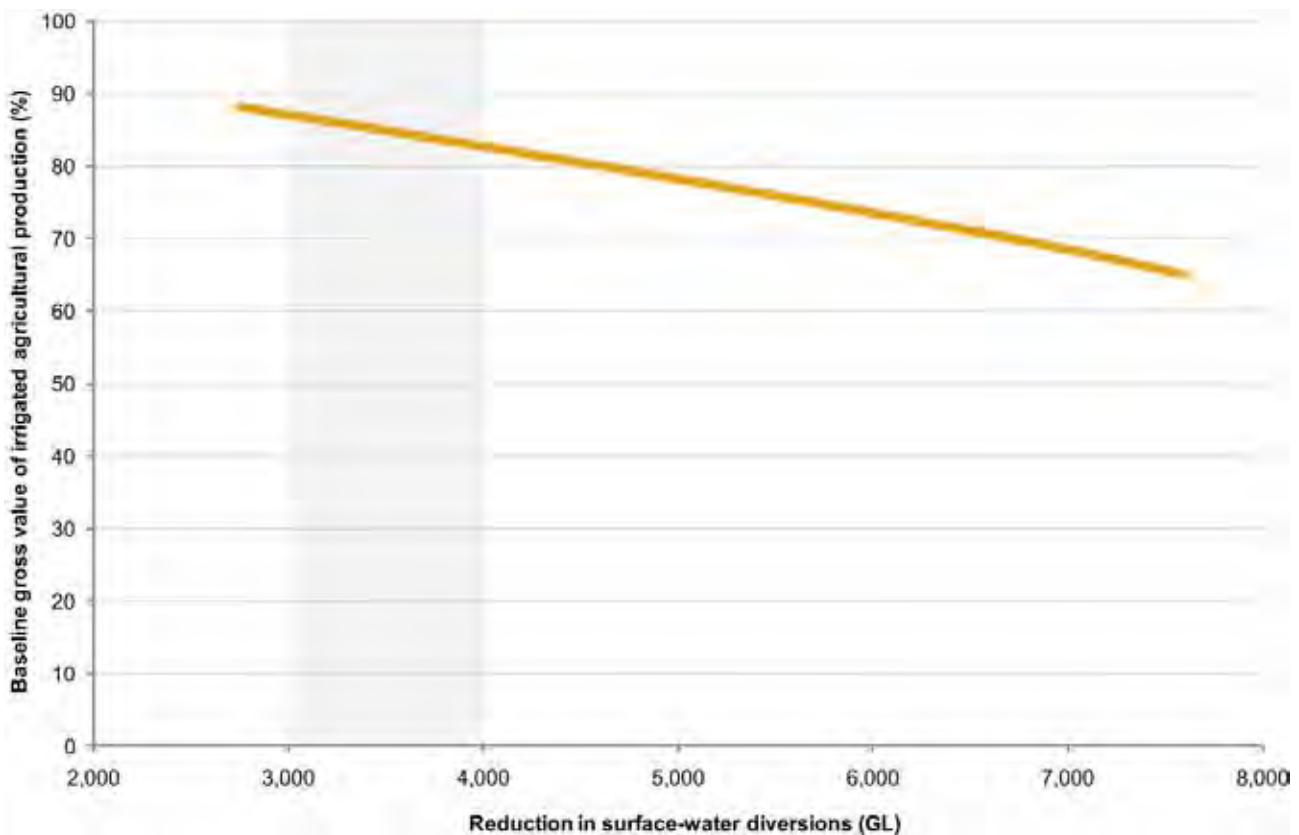


Figure 4.18 Projected changes in estimated gross value of irrigated agricultural production from the long-term historical average due to reductions in surface-water diversions

Source: ABARE–BRS (2010a); impacts are estimated with interregional trade.

Modelling by ABARE (2010) using its water trade model provides commodity-based estimates of the annual gross value of irrigated agricultural production in the Basin before a reduction is made and, for each scenario, an estimate after the Basin has adjusted to a new level of diversion.

The starting point, or baseline for the modelling, in terms of water use, land use and gross value of irrigated agricultural production is ABS agricultural census data for the years 2001 and 2006, with the overall level of water availability reflecting that of 2001 (in which the observed levels of water availability are more representative of the long-term average levels of use). The model makes assumptions about how irrigators will behave, how water will be used (and traded) and which crops will be grown. As such, the model does not predict a future but rather informs on the potential extent of change that may occur for a region (ABARE 2010).

ABARE's water trade model baseline uses an alternative measure of water-use data to the long-term average diversions used in MDBA's hydrologic modelling. The two sets of estimates are generated using different assumptions and data, with water diversion estimates representing long-term average modelled diversion levels over a 114-year climate sequence (1895–2009) and ABARE baseline estimates calibrated to ABS water-use and land-use figures for two representative years: 2000–01 and 2005–06 (ABARE 2010).

Overall, the differences between baseline water diversion figures and water-use figures are considered to have minimal implications for estimating the likely economic effects of reducing current diversion limits. ABARE has assumed that percentage changes in diversions estimated by MDBA are expected to result in equivalent percentage changes in water use (ABARE 2010).

The relative economic effects of reductions in current diversion limits will vary widely across the Basin, due to the diversity of the Basin's agriculture industries, communities and regions. A number of factors will shape how each business, sector, community and region is affected by the reduction in water. These factors include:

- The marginal value of water — water may be differentially valued by some agricultural sectors in comparison to others. For example, rice and other broadacre irrigated crops represent high water intensity – low-value agricultural commodities. In comparison, horticultural products tend to be high-value agricultural commodities.
- The overall profit margin and underlying capital, debt and cost structures of different enterprises — including individual farms and other agricultural undertakings — will affect their relative competitive position in the market, and hence their capacity to absorb a reduction in diversions.
- Farms, businesses and industries differ in size. In general, larger farms and businesses that rely on a more diversified mix of agricultural activities (including the range of substitution possibilities) are likely to be more economically sustainable and more able to respond to a reduction in current diversion limits.



*Rice crop at Benerambah,
New South Wales*

- The extent to which farms have access to other sources of (off-farm) income.
- The global financial crisis, which may have reduced ready access to capital, combined with declining terms of trade, foreign exchange rates and volatile commodity prices represent a broader range of macroeconomic pressures that may affect the ability of individual sectors and farmers to adjust to any change in current diversion limits in the short term.
- The long-term consequences of severe and prolonged drought across the Basin has substantially diminished agricultural production over a number of years, resulting in economic hardship for agriculture in places and, more broadly, the wider economy in some regions of the Basin.

It should be noted in interpreting the information presented in Figures 4.19, 4.20 and 4.21 that the apparent divergence of regional and, to a lesser extent, commodity-level impacts is partly driven by the unequal distribution of reductions to current diversion limits. For the range of scenarios assessed, the modelling reflects that the largest reductions in diversions in the northern Basin occur in the Moonie, Warrego and Condamine–Balonne regions, while the largest reductions in the southern Basin occur in the Loddon, Campaspe, Ovens and Murrumbidgee regions. Regions with large reductions in diversions will tend to experience a higher level of economic impact relative to regions with lower diversion cuts for any particular scenario.

The interaction between these different, complex factors means that MDBA has exercised caution in considering and attempting to estimate social and economic impacts. The following assessments should be read with this in mind.

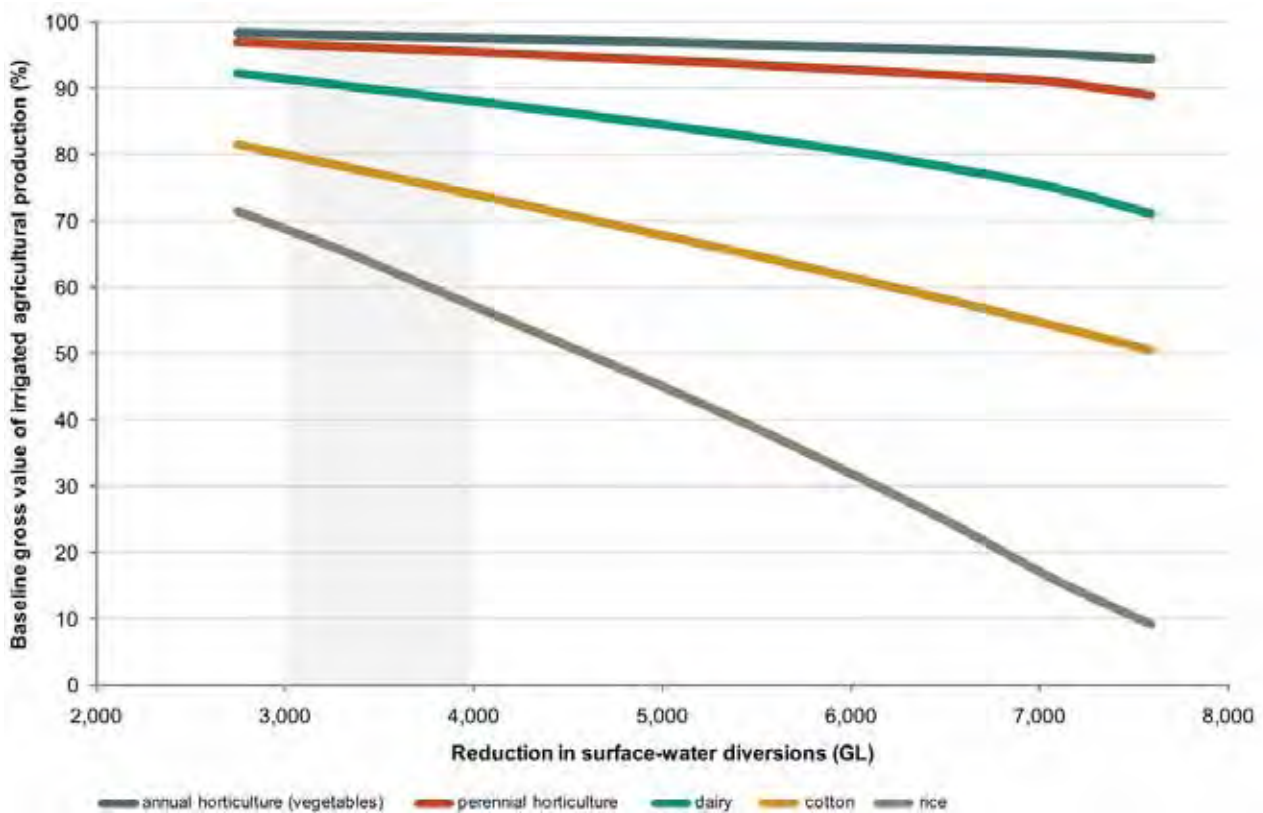


Figure 4.19 Reduction in baseline gross value of irrigated agricultural production for selected commodities due to reductions in surface-water diversions

Source: ABARE–BRS (2010a)

Potential impacts by sector and region

Some irrigated agriculture sectors could suffer larger declines than others in response to a reduction in current diversion limits. Sectors with relatively lower-value product, such as broadacre crops (including hay and cereals) and rice, are likely to experience larger relative reductions in size than industries with higher-value products that include horticultural crops such as nuts, fruit, vegetables and grapes. Both the cotton and dairy industries are estimated to experience a median reduction in the gross value of irrigated agricultural production (see Figure 4.19).

An indication of how reductions in current diversion limits could affect the productive capacity of irrigated agriculture, as measured by gross value of irrigated agricultural production across regions for the northern and southern Basin, respectively, is provided in Figures 4.20 and 4.21.

Comparison between scenarios for reducing current diversion limits

In determining the SDL proposals, MDBA must exercise judgement within the bounds of the best available science, which sets the range of additional environmental water requirements, and the social and economic analysis, which quantifies the likely effect of reductions on the economic productivity and the social fabric of the Basin.

After consideration of early economic modelling and socioeconomic analyses, in light of the scale of the estimated economic and social implications that may be experienced if current diversion limits were reduced by more than 4,000 GL/y, MDBA concluded that such a reduction would not meet the requirements of the Water Act to optimise outcomes. The focus of the economic modelling was therefore narrowed to reductions in the 3,000–4,000 GL/y range.

Table 4.9 provides estimates of gross value of irrigated agricultural production in the Basin under 3,000 GL, 3,500 GL and 4,000 GL reduction scenarios assuming interregional trade in the connected southern Basin. At an aggregate level, it is estimated that Basin gross value of irrigated agricultural production would decline by around 13% under the 3,000 GL/y scenario to a new level of \$5,415 million. Under the 3,500 GL/y scenario the decline in gross value of irrigated agricultural production would be 15%. At a 4,000 GL/y reduction the decline in gross value of irrigated agricultural production would be 17%. Without interregional trade the estimated reductions in gross value of irrigated agricultural production would be 14%, 16% and 19% under the 3,000 GL/y, 3,500 GL/y and 4,000 GL/y scenarios, respectively.



Bore water used for watering cattle near Walgett, New South Wales

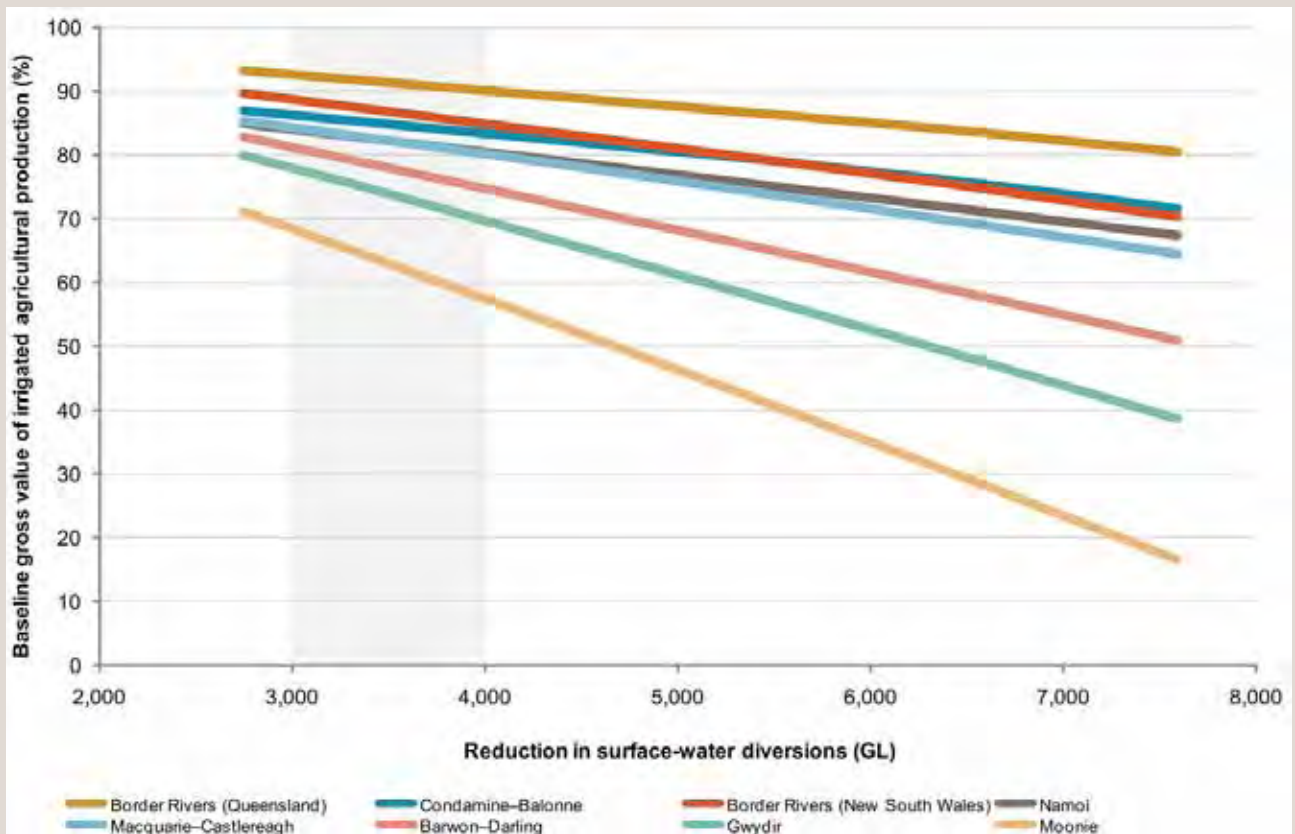


Figure 4.20 Reduction in baseline gross value of irrigated agricultural production due to reductions in surface-water diversions: northern Murray-Darling Basin regions

Source: ABARE-BRS (2010a)

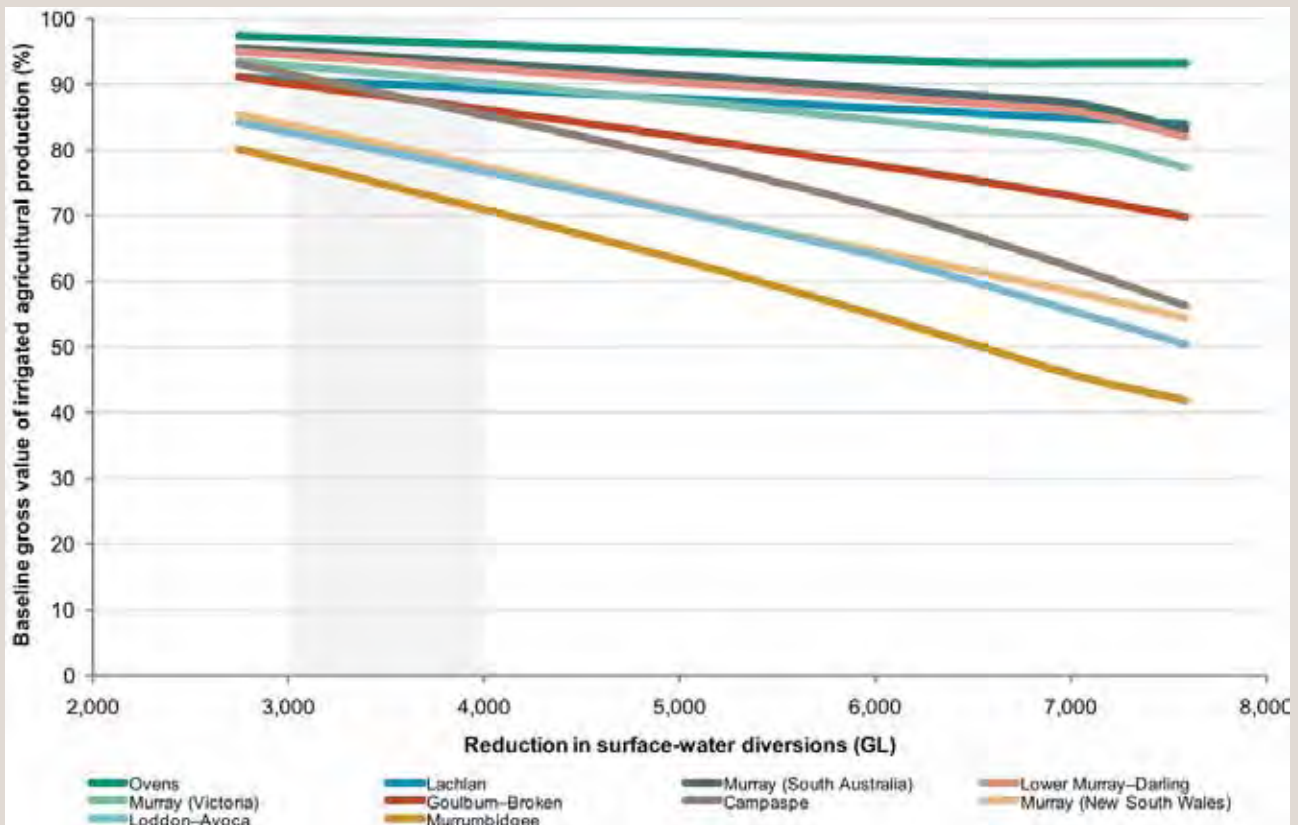


Figure 4.21 Reduction in baseline gross value of irrigated agricultural production due to reductions in surface-water diversions: southern Murray-Darling Basin regions

Source: ABARE-BRS (2010a)

Table 4.9 Estimated gross value of irrigated agricultural production with hypothetical reductions in diversions for irrigation^a

Region ^b	Baseline	3,000 GL/y		3,500 GL/y		4,000 GL/y	
	\$ million	\$ million	Change (%)	\$ million	Change (%)	\$ million	Change (%)
Barwon–Darling	172	139	–19	134	–22	129	–25
Border Rivers (New South Wales)	185	164	–11	160	–13	157	–15
Border Rivers (Queensland)	245	227	–7	224	–9	221	–10
Condamine–Balonne	457	394	–14	387	–15	380	–17
Gwydir	321	250	–22	237	–26	223	–30
Macquarie	275	231	–16	226	–18	221	–20
Moonie	40	26	–34	25	–37	23	–42
Namoi	332	279	–16	273	–18	268	–19
Paroo	6	6	0	6	0	6	0
Warrego	7	6	–12	6	–12	6	–13
Northern Basin total	2,039	1,722	–16	1,679	–18	1,634	–20
Campaspe	134	121	–9	118	–12	115	–14
Eastern Mount Lofty Ranges	163	163	0	163	0	163	0
Goulburn–Broken	704	634	–10	621	–12	607	–14
Lachlan	165	151	–9	149	–10	147	–11
Loddon–Avoca	284	241	–15	226	–20	220	–23
Lower Murray–Darling	71	67	–6	66	–7	65	–8
Murray (New South Wales)	409	343	–16	330	–19	317	–23
Murray (South Australia)	514	488	–5	484	–6	479	–7
Murray (Victoria)	779	723	–7	713	–8	702	–10
Murrumbidgee	890	696	–22	665	–25	630	–29
Ovens	56	54	–3	54	–3	53	–4
Wimmera	13	13	0	13	0	13	0
Southern Basin total	4,181	3,693	–12	3,601	–14	3,510	–16
Basin total	6,220	5,415	–13	5,280	–15	5,145	–17

a Estimates assume interregional water trade in the southern Basin.

b The regions are those used in the CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008).

Source: ABARE–BRS (2010a)

At a regional level and assuming interregional trade, the largest reductions in average annual gross value of irrigated agricultural production are spread throughout the northern and southern Basin. The largest absolute reductions in value occur in the Murrumbidgee region under all three scenarios, while the Loddon, Murray (New South Wales) and Campaspe regions all have large percentage reductions. This is primarily because the Murrumbidgee region is expected to trade water to downstream regions such as Murray (South Australia) and Lower Murray–Darling. This trade has the effect of reducing the overall impact on average annual gross value of irrigated agricultural production, but exacerbating the impact in some regions (such as Murrumbidgee) and reducing the impact in others (such as Murray (South Australia)).

The largest percentage reductions occur in the northern Basin, in Moonie and Gwydir regions, in all three scenarios.

Implications for the Basin economy and broader community

Broader economic implications may occur due to flow-on effects from reductions in current diversion limits through the agriculture supply chain, and through related businesses dependent on demand from irrigated agriculture. MDBA estimates that the decline in gross regional product for the Basin for reductions in diversions in the range 3,000–7,600 GL/y could be between \$0.7 billion and \$2.6 billion.

The short-term economic effects on the Basin are even more difficult to determine as they depend on the particular circumstances of the Basin's businesses and individuals and their capacities to adapt to reductions in current diversion limits. At the broad regional level, most areas of the Basin contain a mix of small and medium-sized towns, as well as larger regional centres. The regional centres tend to have a broad economic base, which will act to cushion the impact of a decline in irrigated activity. However, due to their narrow economic base, some of the smaller towns highly reliant on irrigated activity may be less resilient to a decline in water available for irrigation.

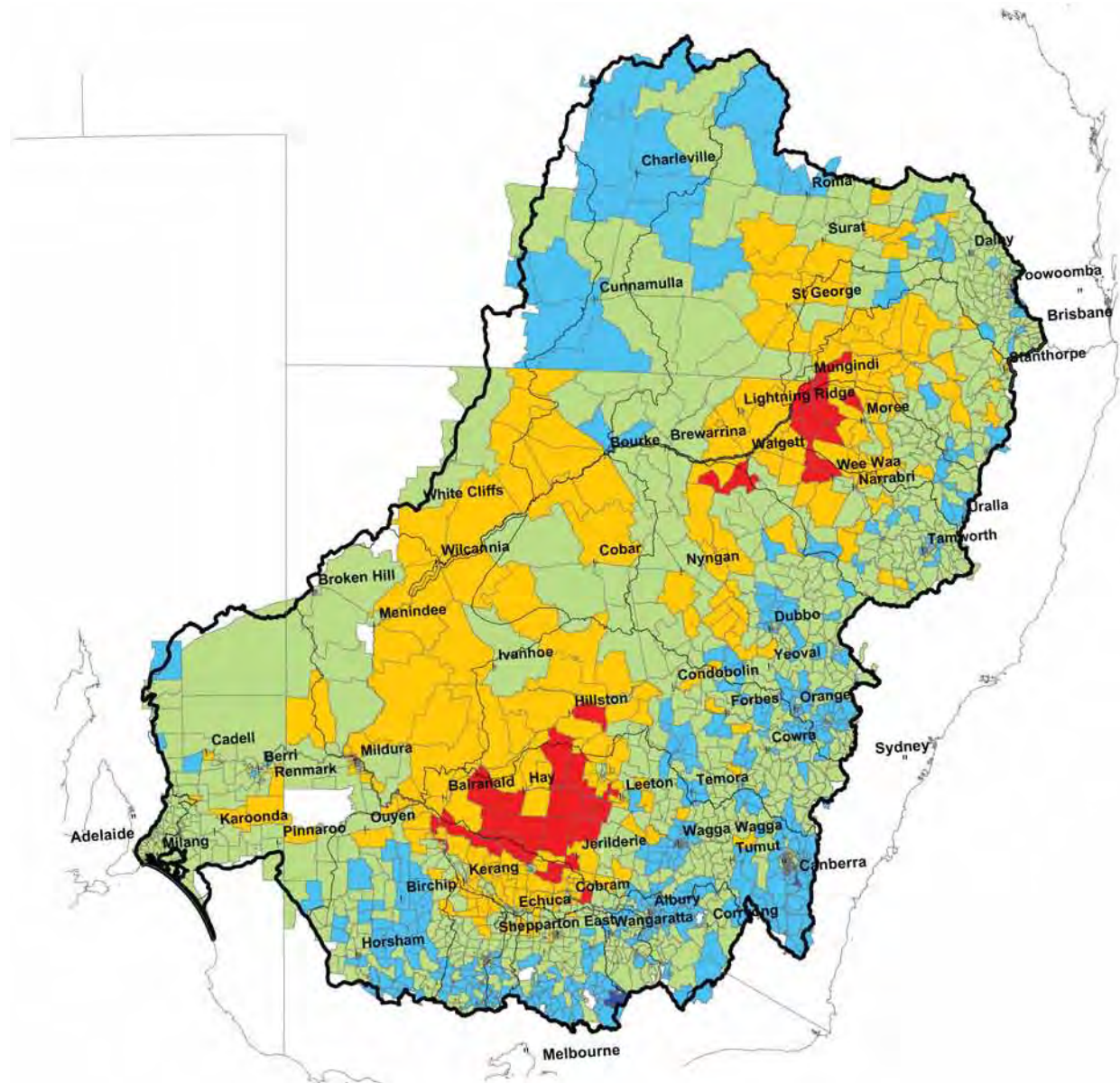
Impacts on communities

While the economic implications of reductions in current diversion limits are estimated to be smaller at the national and Basin scales, the major impacts of the SDL proposals are expected to be realised at the local community level for certain irrigation-dependent communities, where significant social and economic effects may be felt, particularly in the short term as they adjust to change. Larger cities such as Toowoomba, Albury–Wodonga and Bendigo are less likely to be significantly affected.

The reason for this in large part is that irrigated agriculture delivers greater flow-on employment and economic activity to its local communities than dryland farming per unit area. Service industries such as retail and wholesale trade, transport, finance and machinery repairs, which comprise many small and medium-sized enterprises, are all affected by the spending patterns of irrigators. Employment opportunities for town residents and opportunities for off-farm employment for farmers are likely to be closely linked to expenditure by irrigators in many towns within or near the Basin.

A map indicating community vulnerability before any reductions in current diversion limits is shown at Figure 4.22. Although community vulnerability is a complex concept to articulate, and a single index or metric cannot capture the full experience of specific communities undergoing rapid change, the value of the representation lies in the illustration of the relationships between communities and the resources on which they depend for their livelihoods. It thus enables a clearer picture to emerge of the relative reliance on water for consumptive purposes among communities of the Basin. Nonetheless, the analysis needs to be interpreted carefully; it reflects one expert view of inherent vulnerability that could potentially be subject to alternative interpretations based upon the exact indicators chosen and the weighting given to each indicator in deriving the overall index.

While a significant number of Murray–Darling Basin communities show only a low to moderate level of vulnerability to changes in current diversion limits, several communities show a very high vulnerability. Communities that show higher vulnerability to reductions in current diversion limits have a combination of higher sensitivity to changes in water use (i.e. they have a very high dependence on water for agriculture and high agri-industry employment) and more limited levels of adaptive capacity (i.e. low levels of human capital, social capital and economic diversity) compared with other Basin regions.



Data not available due to:
 - Census district or statistical local area lies largely outside the Basin boundary
 - Census district is sparsely populated and ABS did not make the data available

Data sources:
 Australian Bureau of Statistics:
 - Analysis of 2005-06 Community profile data
 - Census districts 2006
 - Urban centre localities 2006
 Murray-Darling Basin and Basin Plan regions

Vulnerability

- very low (0.0 - 0.2)
- low (0.2 - 0.4)
- moderate (0.4 - 0.6)
- high (0.6 - 0.8)
- very high (0.8 - 1.0)
- Data not available

Figure 4.22 Index of community vulnerability across the Murray–Darling Basin

Source: ABARE–BRS (2010b)

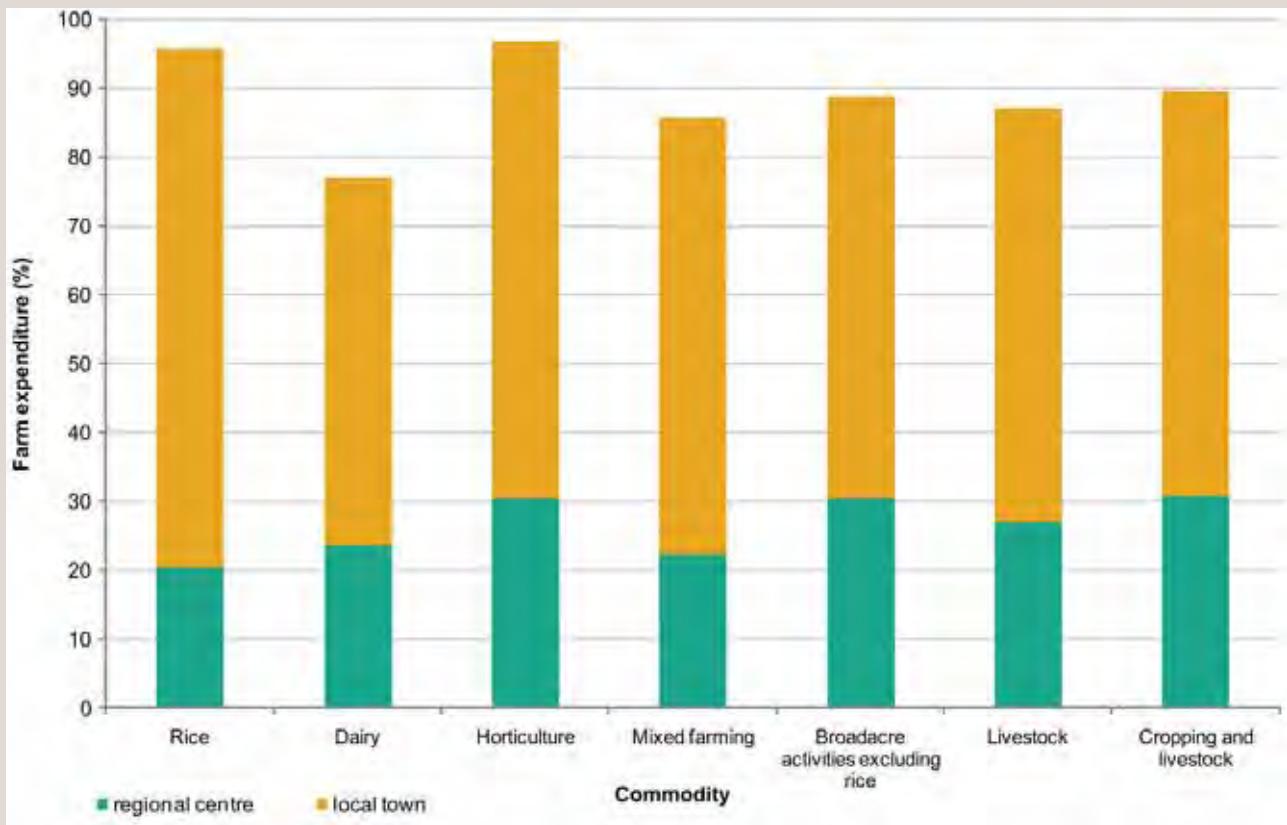


Figure 4.23 Farm expenditure by commodity: Murray–Darling Basin

Source: Marsden Jacob Associates et al. (2010)

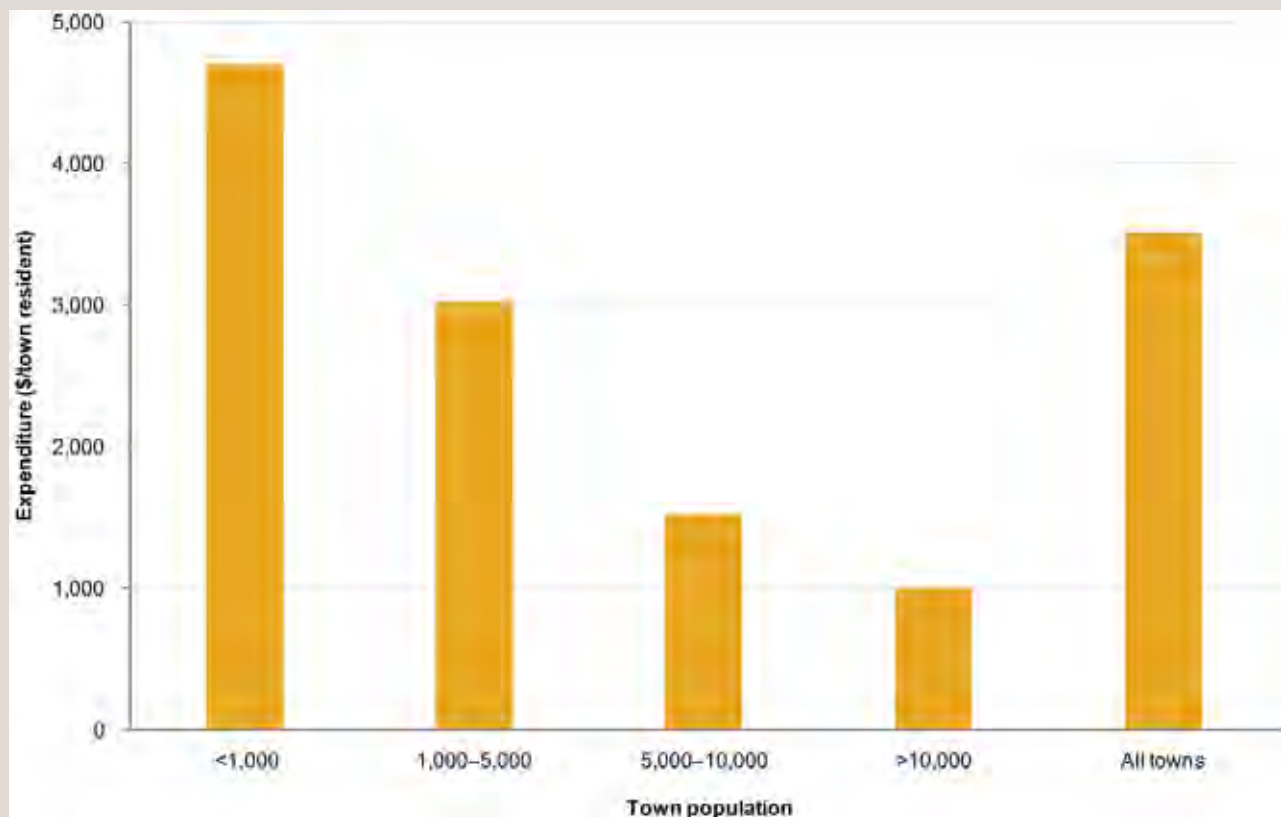


Figure 4.24 Total irrigation farm expenditure per town resident: Murray–Darling Basin

Source: ABARE–BRS (2010a)



Silverbeet crop irrigated with groundwater near Toowoomba, Queensland

Impacts on local economic activity

Irrigated agriculture businesses and related regional businesses are likely to be affected by reductions in current diversion limits. The extent to which individual businesses are affected will generally be shaped by the sector in which they operate.

There are more than 200,000 businesses across the Basin, of which 135,000 are not farms. Many small to medium-sized enterprises are directly dependent upon irrigated agriculture or reliant upon agricultural revenues and irrigator expenditure as a key source of income.

Small businesses are one of the largest employers in the Basin and, in some cases, small to medium-sized enterprises account for more than 90% of all employment in regional towns. Small to medium-sized enterprises are thus critical to regional towns and communities.

Rizza (2010) found that, largely as a result of the severe and prolonged drought over the past decade, debt in the Basin is high and the cash flows of farms, households and businesses in the agriculture, industry and related sectors have been adversely affected. Consequently, financial institutions could review the loans of any customers whose businesses they assess as likely to be significantly affected by reductions in current diversion limits.

Across the regions, analysis indicates that around 75% of total farm expenditure takes place within the regional economy (Marsden Jacob Associates et al. 2010). Across all farm types and all regions, except the Gwydir, 50–70% of total farm expenditure is in nearby towns (i.e. within 15 km of the farm) with a further 20–30% in regional centres (i.e. towns with a population greater than 10,000). Figure 4.23 shows the distribution of farm expenditure by commodity.

Analysis by ABARE (2010) reveals similar results. In aggregate, most irrigation farm expenditure in 2007–08 occurred in the Basin's larger towns. Centres with more than 5,000 people attracted around 79% of irrigators' expenditure. Conversely, towns with a population of 5,000 or less accounted for around 21% of total irrigation farm expenditure.

This analysis shows that irrigators' expenditure made a larger contribution to the economy of smaller towns when considered on a per capita basis. Total annual expenditure by irrigation farmers ranged from \$4,700 per resident in towns with fewer than 1,000 people to \$1,000 in towns with more than 10,000 residents. Figure 4.24 shows an inverse relationship between town size and total expenditure by irrigators per town resident. This implies that smaller

towns are more reliant than larger towns on irrigation expenditure and will, therefore, tend to be more affected by any proportional reduction in irrigated production. Larger towns tend to have more diverse economies, resulting in lower overall dependence on expenditure by irrigators.

Towns with approximately \$2,000 or greater in terms of irrigation expenditure per town resident have been classified as being highly reliant on irrigators' expenditure. Many of the towns identified as highly reliant are in the southern part of the Basin, with most in the Murrumbidgee and Murray (New South Wales and Victorian divisions) regions. Highly reliant towns were also identified in the northern Basin, particularly in the Condamine–Balonne and Namoi regions (noting that the survey was not undertaken in the Gwydir region). These results are also broadly consistent with community vulnerability assessment findings from an ABARE–BRS (2010b) study.

A decline in business activity across these regional towns and communities may have long-term consequences. In particular, a decline in the rateable base for local government authorities and reduced levels of demand for major community services would mean that the level of service provision would be likely to decline over time. As a consequence, there would be a greater likelihood that:

- access to health services and education would become more difficult
- fewer funds would be available to local government authorities to invest in, and maintain community infrastructure
- social and community networks would come under increasing pressure.

On the other hand, across the Basin, increased urbanisation means that increasingly more people reside in major regional centres that are the primary sources of employment and economic activities, including construction, manufacturing, government administration and defence, health and community services, and education. These larger centres are more resilient with their lower sensitivity to water-dependent industry and more diverse business base.

Possible implications for the Basin's Aboriginal communities

The study *Effects of changes in water availability on Indigenous people of the Murray–Darling Basin* (Jackson, Moggridge & Robinson 2010) was commissioned to assist in scoping the most significant issues relating to the likely effects of change in current diversion limits on Aboriginal communities.

The Basin's river systems are of critical importance to the social, cultural and economic life of Aboriginal people, who hold distinct cultural perspectives on water relating to identity and spiritual attachment to place, environmental knowledge and the exercise of custodial responsibilities to manage interrelated parts of customary estates. In Aboriginal belief systems, water is a sacred and elemental source and symbol of life. Aquatic resources also constitute a vital part of the customary economy. The pursuit of livelihoods derived from water-based enterprises on Aboriginal lands, such as pastoralism, horticulture and sport fishing, expand the range of interests Aboriginal people have in water to include a commercial element (Jackson 2008; Jackson & Altman 2009).

A great diversity of Aboriginal interests in water exists across river basins in terms of Aboriginal land use, population and social priorities, as well as forms of social organisation and resource management institutions. Traditional systems of land tenure and the nature of customary rights and interests in

land and waters are complex and vary from region to region (Behrendt & Thompson 2004). Similarities can be distilled, however, with Aboriginal people sharing ‘a desire to retain their identity, a belief in their right to their land, a desire to control their own affairs, and a desire to remove economic and social disadvantages’, although the strategies employed to achieve these aims vary (Horton 1994).

There are many accounts of detrimental social and economic impacts on Aboriginal people arising from the environmental and sociopolitical changes that have occurred with Basin water resource development. Other literature relevant to impacts on Aboriginal people outside the Basin is also available (e.g. Strang 2001; Langton 2002). Modifications to Basin stream flow through river regulation, overallocation of water, salinity and land-use change are all cited as causes of significant environmental degradation and subsequent loss of access and enjoyment of water (see for example, McFarlane 2004; Weir 2007; Forward NRM & Arilla – Aboriginal Training and Development 2003). Further negative effects can be attributed to the loss of control by Aboriginal landowners who consistently express distress over their inability to manage their country holistically, exercise custodial responsibility and authority, and to prevent further ecological degradation (Weir 2007). Given this background, there is a critical need to take into consideration Aboriginal interests in waters of the Basin and to make an assessment of the potential effects of the Basin Plan on the Basin’s Aboriginal communities.

Among the findings of the Jackson, Moggridge & Robinson (2010) study are that:

- critical data gaps exist, such as:
 - a severe lack of quantitative data on Aboriginal water uses and values
 - a lack of data about Aboriginal interests in water at the Basin and regional level
 - a lack of data about Aboriginal commercial interests in water
- enhanced environmental flows are highly likely to generate positive impacts for Aboriginal people
- structural change may provide new opportunities for Aboriginal people in emerging natural-resource-based industries (e.g. payment for environmental services, stewardship arrangements, small-scale bush tucker businesses and tourism)
- long-term structural adjustment programs could enhance positive impacts of the proposed Basin Plan.

On the other hand, reductions in current diversion limits could reduce commercial development options for Aboriginal communities, most directly for those that hold formal entitlements to water and/or whose people are employed in irrigated agricultural industries. A number of other issues are also of concern, for example:

- assessment of environmental flow requirements tends not to include Aboriginal values (e.g. preferred places, favoured wild resources), which



Brewarrina Weir with ancient fish traps, New South Wales

continues to entrench a pattern of exclusion of Aboriginal values from environmental water management

- governance arrangements for environmental water management so far do not recognise Aboriginal resource governance systems nor allow for co-management with Aboriginal people
- improvements in environmental flows alone would not address the full range of Aboriginal water requirements (Jackson, Moggridge & Robinson 2010).

Social and economic valuation of environmental benefits

A key issue in assessing likely implications is that while many of the environmental benefits accrue to a wide distribution of people, arguably to the nation as a whole, the costs are largely localised.

However, unlike the values of agricultural outputs, environmental goods and services are not traded in markets where prices provide a largely straightforward estimate of value; environmental benefits are inherently difficult to quantify in monetary terms.

While a number of methods are available for estimating the value of these non-market benefits, they remain somewhat controversial and the results need to be interpreted with care (Morrison & Hatton MacDonald 2010; Henry 2010). In relation to the review undertaken for MDBA, it is apparent there are a number of limitations with the data used and that various assumptions have been required to generate the estimates. On the other hand, these studies often represent only a partial valuation of the total ecological benefits that will be provided and the cost of undertaking such studies to capture the full range of benefits can be significant. The results should therefore be seen as an important information source when understanding benefits in the Murray–Darling Basin, but only one input into this process.

As noted earlier, estimates of values for each region of the Murray–Darling Basin were identified for up to five attributes: recreation; the extent of healthy native vegetation; numbers of native fish; numbers of waterbirds; and the frequency of waterbird breeding.

The largest values for each of the attributes were identified for the River Murray. For most of the remaining attributes, the next highest values were for the Goulburn River, while the lowest were for the Moonie River. In general, the values for the New South Wales and Victorian rivers were fairly similar for vegetation, fish, waterbirds and other species, although the values for Queensland and South Australian rivers were lower. High values for waterbird breeding primarily occurred for rivers in New South Wales and Queensland, although the values for waterbird breeding were higher in New South Wales than Queensland (Morrison & Hatton MacDonald 2010).

Morrison and Hatton MacDonald (2010) report that the aggregate value of improving the Coorong from poor to good quality is estimated to be about \$4.3 billion, while a 1% improvement in the health of native vegetation and of native fish populations in the Basin is estimated to have present values to the community of \$132–187 million and \$95–117 million respectively. An increased frequency of bird breeding events is also highly valued by large segments of the Australian community.

For recreation, it is estimated that in the Murray, Murrumbidgee, Macquarie–Castlereagh and Lachlan regions fishing has a value of around \$366 per person per visit while a 1% improvement in access to the Coorong has been estimated to have a present value of around \$173 to each visitor.



*Olive grove near Mudgee,
New South Wales*

The aggregate value of an improvement in riverine health in a catchment can be calculated by identifying the increase in non-use values and adding to this the increase in recreation value. For the Murray, for example, if there was a 10% increase in healthy native vegetation, a 15% increase in fish populations, the frequency of waterbird breeding increased by 3 years, and 20 waterbird and other species benefiting, the total increase in non-use value would be equivalent to about \$3.3 billion. If the quality of the Coorong also improved from poor quality to good quality, as noted above, the total change in non-use value (present value) for the River Murray and the Coorong would be approximately \$7.5 billion.

The application of these valuation estimates to determine overall environmental benefits requires estimation of the effect of changes in diversion limits on relevant environmental attributes, which are difficult to measure accurately.

While the ecological response to increased environmental watering likely to arise from a reduction in current diversion limits is not precisely known, the above estimates are indicative of the benefits expected to accrue to the wider community from the Basin Plan. These findings represent the best available evidence about economic benefits of environmental improvements in the Basin. However, as there are a number of inherent assumptions and limitations with the data used to generate the estimates, they should be seen as an indication of the likely benefits only, and not a full and precise valuation. Further work on estimating the economic values of these environmental benefits is currently being undertaken for MDBA.

Other benefits

A range of benefits are also expected to accrue in areas other than non-use environmental values and recreation. They include improved water quality for human consumption and industry, environment-based tourism, floodplain grazing, commercial fishing and general lifestyle and wellbeing. While these can be quantified to some degree, MDBA has not investigated these benefits in detail in its assessment of socioeconomic implications to date. As explained in Section 4.5, tangible benefits would accrue to the tourism, recreation and fishing industries in the vicinity of the Lower Lakes and Coorong, and further investigation would indicate tangible benefits from enhanced flows to environmental assets within other parts of the Basin.

4.4 The long-term average sustainable diversion limit proposals

Approach to setting SDLs

The Basin Plan is required, under the *Water Act 2007* (Cwlth), to set long-term average sustainable diversion limits (SDLs) on the quantities of water that can be taken from the Murray–Darling Basin. These limits must reflect an environmentally sustainable level of take, which means that extractions must not compromise the key environmental assets, key ecosystem functions, the productive base or key environmental outcomes of the Basin’s water resources (see Section 4.1). The Water Act also calls for the Basin Plan to promote the use and management of the Basin water resources in a way that optimises social, economic and environmental outcomes.

Using the best available science, as described in Section 4.1, it is estimated that the Basin-wide reductions in the current surface-water diversion limits, and thus the range of additional environmental water needed to ensure a sustainable level of take, is between 3,000 GL/y and 7,600 GL/y, on a long-term average basis. Returning an additional 3,000 GL/y to the environment would ensure the Basin’s environmental water requirements are met, albeit at a high level of uncertainty of achieving environmental outcomes. Returning an additional 7,600 GL/y of water to the environment would result in a lower level of uncertainty of achieving environmental outcomes. This range incorporates a 3% allowance in recognition of projected climate change, as proposed in Section 4.2. The proposed reductions for surface water are based on assessments of the impact of environmental water requirements within the above range on current diversion limits using hydrologic modelling and complementary analytical techniques.

It is estimated the Basin-wide reductions in the current groundwater diversion limits to meet the Basin’s environmental requirements are between 99 GL/y (corresponding to a high level of uncertainty) and 227 GL/y (having a low level of uncertainty). This range reflects the uncertainty of groundwater model predictions and the associated risks of not achieving the environmental objectives of the Basin Plan. These reductions are concentrated in a small number of groundwater systems (Table 4.6). As indicated in Section 4.2, it is not considered necessary to include a climate change allowance for groundwater systems. The proposed reductions for groundwater are based on assessments of the proportion of groundwater recharge that can be sustainably taken; these assessments use recharge modelling and numerical models where available.

In setting SDLs, the Murray–Darling Basin Authority (MDBA) has focused on three critical matters:

- the fundamental obligation of the Water Act to determine an environmentally sustainable level of take based on the best available science
- the need to optimise economic, environmental and social outcomes and to make a judgement about how best to achieve the optimisation requirements
- the need to take account of the Basin’s physical constraints, which limit from where water can be sourced. This includes taking account of the hydrologic characteristics and interdependencies of each catchment and the need to deliver on individual catchment- and Basin-level environmental outcomes.

This has meant that MDBA has been required to develop a clear understanding of how the SDL proposals will affect water users and the environment. This is a complex area, and while substantial analysis has been completed to date, work will continue to improve these analyses and reduce the uncertainties in the results. In particular, MDBA has and is continuing to invest in comprehensive social and economic studies to inform its deliberations in this area. Further analysis, particularly using the suite of surface-water and groundwater models, will also continue to verify and refine the hydrologic assessments used to determine the SDL proposals that satisfy environmental water requirements.

While separate groundwater and surface-water SDLs have been determined, current and expected future interactions have been accounted for. Where groundwater and surface-water systems are highly connected, appropriate adjustments have been made to ensure that there is no double counting of water extractions.

Determining the surface-water SDL proposals

In determining the surface-water SDL proposals to meet the associated environmental water requirements, the following factors and constraints have been considered:

- The additional environmental water requirements for upstream catchments can come only from reductions in diversions within that catchment. However, choices have to be made as to how additional environmental water is sourced to meet the environmental water requirements associated with the Darling River and with the River Murray, including the Coorong and Lower Lakes. For example, additional water for the Chowilla floodplain on the River Murray near the South Australian border could be sourced from a number of locations including the River Murray itself and any or all of the tributaries of the Murray.
- Catchments that are hydrologically disconnected, or are connected only during rare flood events, cannot contribute additional environmental water downstream. This applies to the Paroo, Lachlan, Wimmera–Avoca and Marne Saunders catchments.
- Hydrologically connected catchments can contribute environmental water, but to varying degrees depending on their natural outflows and their level of development. More highly developed catchments with larger natural outflows can make bigger contributions.
- Due to the more ephemeral nature of the rivers in the northern Basin (the Darling River and its tributaries) and the high level of natural losses due to floodplain inundation and evaporation, there is limited ability to provide contributions from the northern Basin to additional environmental water requirements of the River Murray below the Darling River junction. On a long-term average basis without development, the northern Basin naturally contributes around 17% of the flow below its junction with the Murray, compared with the southern Basin's (the Murray and its tributaries upstream of the Darling junction) natural contribution of 83%. Also, under without-development conditions, only 18% of inflow to northern Basin streams flows out of the Darling River, compared with 74% of inflow to southern Basin streams reaching the Murray at the Darling River junction. That is, losses in the Darling system are naturally significantly higher than the Murray system.
- Catchment contributions to additional environmental water requirements cannot be made at the expense of the critical human water needs for the catchment.



Irrigated paddock near Coleambally, New South Wales

- As explained later in this section, current diversion limits and the surface-water SDL proposals include all forms of water extraction, including watercourse diversions for irrigation, industry town water supplies, stock and domestic supplies, floodplain harvesting, and interception activities such as farm dams and forestry plantations. Because of the practical difficulties implementing reductions in the interception components of current diversion limits, Basin states are likely to consider first reducing watercourse diversions only. Therefore, an upper bound has been placed on the reduction as a percentage of the watercourse diversion component of the current diversion limit (except in the Eastern Mount Lofty Ranges and Marne Saunders SDL areas, where use is not split between interceptions and watercourse diversions by South Australia).

The choice of where to source additional environmental water for downstream requirements has implications for the distribution of social and economic effects, and consequently has been the focus of significant work. A number of approaches were explored, including sourcing environmental water:

1. from catchments where the price of water is lowest or where social and economic assessments indicate the community impacts are lowest
2. from a catchment in proportion to the catchment outflows under without-development conditions
3. from each catchment in proportion to the impact of the current levels of diversion on flows at a downstream location
4. in a way that would equalise the relative level of use (i.e. percentage of inflows or surface-water availability that is diverted for consumptive purposes) in each catchment
5. from the closest and most highly connected catchments
6. in proportion to the current diversion limit (i.e. equal percentage reductions in the current diversion limits).

There were advantages and disadvantages with each of these approaches. Using the price of water or social and economic considerations in the first approach was not considered appropriate. There is insufficient accurate information, and costs and benefits will change over time as relative commodity prices and costs of production change. Further, MDBA is of the view that water users are best placed to make decisions about how they use the water they have access to, and such choices should not play a part in how proposed reductions are distributed. The second, third and fourth approaches, based on flows or level of use, also had limitations due to data accuracy and practical application, particularly in applying the approach consistently between catchments with and without contributing upstream catchments (e.g. between the Murray region and its tributaries). The fifth approach, if fully applied, would result in very large cuts in some catchments.

The approach adopted for surface-water SDLs was based on the last approach, that is, in proportion to current diversion limits. This approach recognises the current diversion limits established by existing water resource plans, as per the Water Act, as an equitable starting point from which to base reductions and means that the impact will be shared as much as possible within the constraints described earlier.

The proposed reductions in each of the current diversion limits are not the same percentage as the overall Basin-wide percentage reduction because of these constraints.



Mildura Weir, Victoria

This approach resulted in the following steps:

- The environmental water requirements within each upstream catchment were first met by reducing the current diversion limit within the respective catchment.
- All connected tributaries in the Darling system, as well as the Barwon–Darling River itself, provided for the additional environmental water requirements of the Darling River through reductions in proportion to current diversion limits. In catchments where the percentage reduction for within-catchment environmental water requirements was higher than the overall percentage reduction necessary, no further reduction was made.
- Because of the Darling River system’s limited ability to contribute to additional environmental water requirements of the River Murray, no further reductions were applied to the Darling and its tributaries for the River Murray requirements. However, some additional flows to the Murray do occur as a result of reductions in the northern Basin, and these were accounted for in determining the reductions required in the southern Basin.
- All connected tributaries in the Murray system (excluding the Darling River), as well as the River Murray itself, provided for the additional environmental water requirements of the River Murray by reductions in proportion to current diversion limits. Catchments where the percentage reduction for within-catchment environmental water requirements was higher than the overall percentage reduction necessary were not reduced further.

Determining the groundwater SDL proposals

In determining the groundwater SDL proposals to meet the environmental water requirements for groundwater, the social, economic and environmental outcomes have been optimised by:

- Protecting against continued drawdown of groundwater levels — so that groundwater levels are stabilised within a 50-year time frame. The full impact associated with past groundwater extraction can take many decades to be completely realised and the SDL proposals have been set such that groundwater systems are not subject to continued drawdown.
- Limiting reductions in diversions to no more than 40% in any one SDL area, on the basis that groundwater models are highly uncertain when they are used to predict outcomes that lie outside their calibrated range.

- Protecting against groundwater salinisation that can occur due to groundwater extraction causing vertical or lateral inflow of saline groundwater.
- Providing for potential increases in groundwater take in unplanned areas where the risk-based assessment has shown that an increase is sustainable.
- Requiring groundwater water resource plans to implement local management restrictions to protect zones within an SDL area that are at risk from overextraction and thereby allow a higher overall extraction for the SDL area.
- Requiring water resource plans to include measures to ensure groundwater take does not compromise the environmental watering needs of key environmental assets, key ecosystem functions, key environmental outcomes and the productive base of the water resource.

SDL proposals for the Basin

For surface water, MDBA examined three scenarios for providing additional water to the environment at the lower end of the range that will provide for an environmentally sustainable level of take. These scenarios are for an increase in water available to the environment of 3,000 GL/y, 3,500 GL/y and 4,000 GL/y. This represents proposed average reductions of between 22% and 29% in surface-water current diversion limits at the Basin scale.

MDBA has not settled on a preferred position for surface-water SDLs. Due to the significance of the reductions required in current diversion limits, MDBA has presented the analysis of scenarios across the range of total reductions within which MDBA considers that the level of reductions lies. This will provide a basis for meaningful discussion with stakeholders. MDBA will then decide the surface-water SDLs to be included in the proposed Basin Plan released for formal consultation.

The three scenarios are:

- scenario 1 — target an additional volume of 3,000 GL/y for the environment
- scenario 2 — target an additional volume of 3,500 GL/y for the environment
- scenario 3 — target an additional volume of 4,000 GL/y for the environment

MDBA also examined a range of SDL reductions for groundwater and proposes a total reduction in diversion limits for the Basin of 186 GL or an average reduction of 10% across the Basin. The reductions in current diversion limits are required in only 11 of the 78 groundwater SDL areas. No reductions are proposed for the remaining 67 groundwater SDL areas where the current diversions are assessed as sustainable.

It should be noted that long-term limits alone are not sufficient to ensure that environmental water requirements are satisfied. The nature of environmental water requirements means that the limits placed on diversions to ensure an environmentally sustainable level of take also need to include constraints that vary over time and vary with the location of the diversion. Consequently, new water resource plans will not only need to ensure that diversions are limited to SDLs, they will also need to include spatial and temporal limits on diversions. This will be achieved through requirements specified for water resource plans (see Section 6.1). These requirements differ for surface-water and groundwater resources, reflecting the physical, spatial and temporal differences in these systems.



Floating flag indicates the level of the watertable near Lyrup, South Australia

The water resource plans Basin states develop will determine the distribution of water available for use under the SDLs among various water entitlement holders. That is, the impact on particular water entitlements that will result from the establishment of SDLs is a matter for the new water resource plans. It is possible that, depending on the decisions of the relevant state, some water entitlement holders in a particular area may not be greatly affected as a result of the Basin Plan while others in the same area holding a different type of water entitlement may experience more substantial impacts. Within any particular water entitlement type, all water users in the same SDL area are likely to be treated equally.

Surface-water SDLs for individual SDL areas

MDBA has identified 29 surface-water SDL areas. A map of these areas is in Section 3.2 of this volume (Figure 3.4). SDLs have been developed for each surface-water SDL area.

The following subsections outline in more detail how the SDL proposals have been developed.

Table 4.10 provides an overview of the surface-water SDL proposals for the three scenarios and how they compare with the current diversion limits. The amounts are shown for each SDL area, each Basin state and for the whole Basin. Figure 4.25 presents the surface-water SDL scenarios as percentage reductions in current diversion limits.

The surface-water current diversion limits and SDLs in Table 4.10 are divided into two main components — interception activities and watercourse diversions. Interception activities include the effects of farm dams and forestry plantations. Watercourse diversions include all diversions from watercourses and floodplain harvesting. The forms of take that are limited by SDLs and the approach taken for different components of the SDL are described later in this section. Because of the practical limitation of reducing the interception components of the SDL described earlier, the proposed reductions in current diversion limits as a percentage of just the watercourse diversion component are also shown. The upper bound placed on reductions as a percentage of watercourse diversions is 40% for scenarios 1 and 2, and 45% for scenario 3. The higher upper bound of 45% for scenario 3 was necessary because of the larger overall percentage reductions.

A description of the application of the approach described earlier and the resulting reductions in current diversion limits for the northern and southern Basin is provided below.

In the northern Basin for the Barwon–Darling Watercourse SDL Area and all SDL areas upstream of the Barwon–Darling:

- The environmental water requirements within each SDL area (excluding the Barwon–Darling Watercourse SDL Area) were first met by reducing the current diversion limit within the respective SDL area. In the case of the Condamine–Balonne SDL Area (located in Queensland), the environmental water requirements also included those associated with the Narran Lakes and the New South Wales part of the Lower Balonne River Floodplain.
- These reductions in current diversion limits not only satisfy the environmental water requirements within each of these SDL areas, but also result in increases in average end-of-system flows. These increased flows contribute to the environmental water requirements in the Barwon–Darling Watercourse SDL Area.

- To fully satisfy the environmental water requirements in the Barwon–Darling Watercourse SDL Area, additional environmental water was sourced by reducing the current diversion limit in the Barwon–Darling Watercourse SDL Area and by further reductions in upstream SDL areas. The resulting total percentage reduction in current diversion limits was an equal percentage for all SDL areas, except where the constraints described earlier applied. This equal percentage reduction ranges from 14% for scenario 1 to 18% for scenario 3. A reduction of 14–17% is proposed for the Moonie SDL Area, 14–16% for the Warrego SDL Area and 8–9% for the Nebine SDL Area.
- The Condamine–Balonne and Gwydir SDL areas have larger percentage reductions required to satisfy their within-catchment environmental water requirements. In line with the approach adopted, no further reduction is proposed to provide for the additional environmental water requirements of the Darling River. The largest reduction in current diversion limit in both percentage and volumetric terms is proposed for the Condamine–Balonne SDL Area (between 21% and 28% and 203 GL/y and 272 GL/y). The next largest reduction in current diversion limits is proposed for the Gwydir SDL Area (between 20% and 27% and 89 GL/y and 121 GL/y). These reductions are less than the other reductions described above because of the 40% (scenario 1 and 2) or 45% (scenario 3) limit on reductions as a percentage of the watercourse diversion component of the current diversion limit. As described earlier, the upper limit of 40% or 45% in watercourse diversion component was used because of the practical difficulties associated with implementing reductions in the interception components of current diversion limits.
- The proposed SDL for the Paroo SDL Area has been set at the current level of use (9.9 GL/y). This is because the current level of use in the Paroo is low and has been assessed as being a sustainable level of take. In addition, the Paroo is rarely connected to the Darling River system and therefore water for downstream environmental water requirements was not sourced from the Paroo.



Gin Gin Weir on the Macquarie River between Narromine and Warren, New South Wales

In the southern Basin including the Lower Darling SDL Area:

- The environmental water requirements within each SDL area (excluding the NSW, Victorian and South Australian Murray SDL areas, and Lower Darling SDL Area) were first met by reducing the current diversion limit within the respective SDL area.
- The additional environmental water required for the River Murray was then sourced by reducing the current diversion limits for the NSW, Victorian and SA Murray SDL areas and Lower Darling SDL Area, and by further reductions in upstream SDL areas in the southern Basin. The resulting total percentage reduction in current diversion limits was an equal percentage for all SDL areas, except where the constraints described earlier applied. This equal percentage reduction ranges from 26% for scenario 1 to 35% for scenario 3.
- The following reductions are less than 26% and 35% in the lower and upper ranges, respectively. These reductions are less because the 40% (scenario 1 and 2) or 45% (scenario 3) limit on reductions of the watercourse diversion component of the current diversion limit is reached in these catchments
 - 21–23% reduction in the current diversion limit for the Loddon SDL Area
 - 18–20% reduction in the current diversion limit for the Kiewa SDL Area
 - 12–13% reduction in the current diversion limit for the Ovens SDL Area.
- The Lachlan is not hydrologically connected to the River Murray system and a reduction of 7–11% is proposed to meet the environmental water requirements of key environmental assets and key ecosystem functions in the Lachlan SDL Area.

The proposed SDLs for the Wimmera–Mallee (Surface Water), SA Non-Prescribed Areas and Marne Saunders SDL areas have been set at the current level of use. This approach was taken because these areas are not hydrologically connected to the River Murray system (or not significantly) and the current level of take has been assessed as sustainable.

Table 4.10 Overview of SDL scenarios for surface water — additional 3,000 GL/y, 3,500 GL/y and 4,000 GL/y for the environment^a

Region	Code ^b	SDL area	3,000 GL/y									
			Current diversion limit components (GL/y)			SDL components (GL/y)			Reductions in current diversion limits		Proposed reduction in watercourse diversions ^d	
			Inter-ception ^c	Watercourse diversions	Total	Inter-ception ^c	Watercourse diversions	Total	(GL/y)	(%)		
Barwon–Darling	SS19	Barwon–Darling Watercourse	108	197	305	108	154	262	43	14	22	
	SS17	Intersecting Streams	2.4	3.0	5.4	2.4	2.2	4.6	0.8	14	25	
Border Rivers	SS23	NSW Border Rivers	95	210	305	95	167	262	43	14	21	
	SS24	Queensland Border Rivers	78	223	301	78	180	259	43	14	19	
Campaspe	SS07	Campaspe	40	115	155	40	75	115	40	26	35	
Condamine–Balonne	SS26	Condamine–Balonne	265	706	971	265	503	768	203	21	29	
	SS27	Nebine	25	6	31.3	25	3.6	28.9	2.4	8	40	
Eastern Mount Lofty Ranges	SS13	Eastern Mount Lofty Ranges	10.7	included in interception	10.7	7.9	included in interception	7.9	2.8	26	–	
	SS12	Marne Saunders	1.8	included in interception	1.8	1.8	included in interception	1.8	0	0	–	
Goulburn–Broken	SS05	Broken	43	14	57	43	8	51.4	5.6	10	40	
	SS06	Goulburn	109	1,593	1,702	109	1,151	1,260	442	26	28	
Gwydir	SS22	Gwydir	125	326	451	125	237	361	89	20	27	
Lachlan	SS16	Lachlan	316	302	618	316	258	574	44	7	15	
Loddon	SS08	Loddon	90	95	185	90	57	147	38	21	40	
Lower Darling	SS18	Lower Darling	6	55	61	6	39	45	16	26	29	
Macquarie–Castlereagh	SS20	Macquarie–Castlereagh	310	425	735	310	321	631	104	14	24	
Moonie	SS25	Moonie	51	32	83	51	20	71	12	14	37	
Murray	SS03	Kiewa	14	11	24.7	14	7	20.3	4.4	18	40	
	SS14	NSW Murray	104	1,721	1,825	104	1,247	1,351	474	26	28	
	SS11	SA Murray	0	665	665	0	492	492	173	26	26	
	SS10	SA Non-Prescribed Areas	3.5	0	3.5	3.5	0	3.5	0	0	–	
	SS02	Victorian Murray	45	1,656	1,701	45	1,214	1,259	442	26	27	
Murrumbidgee	SS01	Australian Capital Territory (Surface Water)	12	39	51	12	26	38	13	26	34	
	SS15	Murrumbidgee	501	2,061	2,562	501	1,396	1,897	665	26	32	
Namoi	SS21	Namoi	165	343	508	165	271	437	72	14	21	
Ovens	SS04	Ovens	58	25	83	58	15	73	10	12	40	
Paroo	SS29	Paroo	9.7	0.2	9.9	9.7	0.2	9.9	0	0	0	
Warrego	SS28	Warrego	83	45	128	83	27	110	18	14	40	
Wimmera–Avoca	SS09	Wimmera–Mallee (Surface Water)	62	74	136	62	74	136	0	0	0	
		Australian Capital Territory	12	39	51	12	26	38	13	26	34	
			New South Wales	1,732	5,643	7,375	1,732	4,092	5,824	1,551	21	27
			Queensland	513	1,012	1,525	513	734	1,247	278	18	27
			South Australia	16	665	681	13	492	506	175	26	26
			Victoria	462	3,583	4,045	462	2,601	3,063	982	24	27
Basin total			2,735	10,942	13,677	2,732	7,945	10,677	3,000	22	27	

a MDBA is aware of the limitations in the accuracy of the data in this table; however, figures have not been rounded at this stage to allow reference to the source analysis.

b This code relates to each SDL area in Figure 3.4, Section 3.2 of this volume.

c Interception includes farm dams and forestry plantations

d Percentage reduction if only applied to watercourse diversion component

... continued

Table 4.10 Overview of SDL scenarios for surface water — additional 3,000 GL/y, 3,500 GL/y and 4,000 GL/y for the environment^a (continued)

SDL area	3,500 GL/y						4,000 GL/y					
	SDL components (GL/y)			Reductions in current diversion limits		Proposed reduction in watercourse diversions ^d	SDL components (GL/y)			Reductions in current diversion limits		Proposed reduction in watercourse diversions ^d
	Inter-ception ^c	Watercourse diversions	Total				Inter-ception ^c	Watercourse diversions	Total			
				(GL/y)	(%)	(GL/y)				(%)	(%)	
Barwon–Darling Watercourse	108	147	256	50	16	25	108	141	249	56	18	29
Intersecting Streams	2.4	2.1	4.5	0.9	16	29	2.4	2	4.4	1	18	33
NSW Border Rivers	95	160	255	50	16	24	95	154	249	56	18	27
Queensland Border Rivers	78	174	252	49	16	22	78	168	246	55	18	25
Campaspe	40	69	109	46	30	40	40	63	103	52	33	45
Condamine–Balonne	265	468	734	238	24	34	265	434	699	272	28	39
Eastern Mount Lofty Ranges	7.4	included in interception	7.4	3.3	30	–	7	included in interception	7	3.7	35	–
Marne Saunders	1.8	included in interception	1.8	0	0	–	1.8	included in interception	1.8	0	0	–
Broken	43	8	51	5.6	10	40	43	8	50.7	6.3	11	45
Goulburn	109	1,075	1,184	518	30	33	109	1,000	1,109	593	35	37
Gwydir	125	221	346	105	23	32	125	205	330	121	27	37
Lachlan	316	245	561	57	9	19	316	233	549	69	11	23
Loddon	90	57	147	38	21	40	90	52	142	43	23	45
Lower Darling	6	37	42	18	30	33	6	34	39	21	35	38
Macquarie–Castlereagh	310	305	615	120	16	28	310	290	600	135	18	32
Moonie	51	19	70	12.8	15	40	51	18	69	14	17	45
Kiewa	14	6.6	20	4.4	18	40	14	6.1	19.8	4.9	20	45
NSW Murray	104	1,165	1,269	556	30	32	104	1,086	1,190	635	35	37
SA Murray	0	462	462	203	30	30	0	433	433	232	35	35
SA Non-Prescribed Areas	3.5	0	3.5	0	0	–	3.5	0	3.5	0	0	–
Victorian Murray	45	1,138	1,183	518	30	31	45	1,064	1,109	592	35	36
Australian Capital Territory (Surface Water)	12	23	36	16	30	40	12	21	34	18	34	45
Murrumbidgee	501	1,281	1,782	780	30	38	501	1,169	1,670	892	35	43
Namoi	165	260	426	83	16	24	165	249	415	94	18	27
Ovens	58	15	73	10	12	40	58	14	72	11	13	45
Paroo	9.7	0.2	9.9	0	0	0	9.7	0.2	9.9	0	0	0
Nebine	25	3.6	28.9	2.4	8	40	25	3.3	28.6	2.7	9	45
Warrego	83	27	110	18	14	40	83	25	108	20	16	45
Wimmera–Mallee (Surface Water)	62	74	136	0	0	0	62	74	136	0	0	0
Australian Capital Territory	12	23	36	16	30	40	12	21	34	18	34	45
New South Wales	1,732	3,824	5,557	1,819	25	32	1,732	3,562	5,295	2,081	28	37
Queensland	513	692	1,205	320	21	32	513	647	1,160	365	24	36
South Australia	13	462	475	206	30	31	12	433	446	235	35	35
Victoria	462	2,443	2,904	1,140	28	32	462	2,281	2,743	1,302	32	36
	2,731	7,445	10,177	3,500	26	32	2,731	6,946	9,677	4,000	29	37

a MDBA is aware of the limitations in the accuracy of the data in this table; however, figures have not been rounded at this stage to allow reference to the source analysis.

b This code relates to each SDL area in Figure 3.4, Section 3.2 of this volume.

c Interception includes farm dams and forestry plantations

d Percentage reduction if only applied to watercourse diversion component

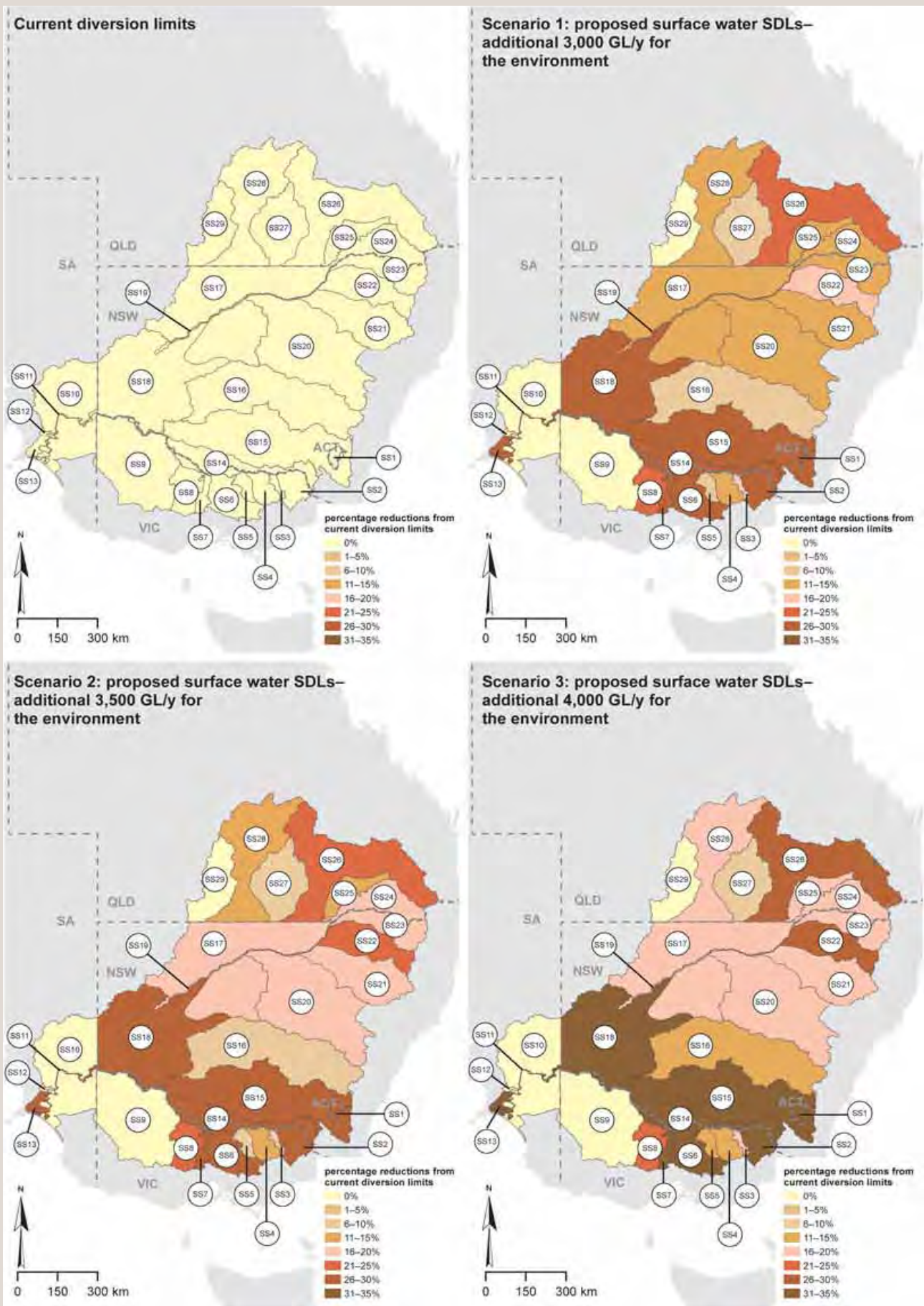


Figure 4.25 Surface-water SDL scenarios as percentage reductions in current diversion limits

Groundwater SDLs for individual SDL areas

MDBA has identified 78 groundwater SDL areas and SDLs have been proposed for all of these areas. Maps of these areas are in Section 3.2 of this volume.

Table 4.11 provides an overview of the groundwater SDL proposals and how they compare with the current diversion limits. In summary, the proposed changes are:

- no reductions to the current diversion limits for 67 groundwater systems
- reductions in current diversion limits, but not in use, for four groundwater systems
- reductions in current diversion limits and use for seven groundwater systems.

Figure 4.26 presents the groundwater SDLs as percentage reductions in current diversion limits.

The groundwater SDL areas can also be placed in seven broad groups, reflecting the variety of changes to current diversion limits across the Basin.

1. Seven SDL areas where the proposed SDL is a reduction in current diversion limit and use

- Three SDL areas with interim or transitional plans are proposed to have a reduction in current diversion limit and use in order to achieve an environmentally sustainable level of take. These areas are the Lower Lachlan Alluvium and Lower Namoi Alluvium in New South Wales and Angas Bremer in South Australia.
- Four SDL areas do not have interim or transitional plans, and a reduction in use is proposed. These are the Upper Condamine Alluvium and Upper Condamine Basalts in Queensland, and Upper Lachlan Alluvium and Lake George Alluvium in New South Wales.

These seven SDL areas require additional water for the environment for groundwater take to be sustainable. In limiting the reduction in any one area to a maximum of 40%, a total reduction of 126 GL per year is proposed for these SDL areas. The reduction varies between 13% and 40% for the seven SDL areas.

2. Four SDL areas where the proposed SDL represents a reduction in current diversion limits, but not in use

In these areas, the plan limit was considered to exceed the environmentally sustainable level of take. However, it was determined that recent historical use was able to meet an environmentally sustainable level of take, provided that additional surface-water losses are accounted for. These SDL areas are the Lower Macquarie Alluvium, Upper Namoi Alluvium and Peel Valley Alluvium in New South Wales and Australian Capital Territory (Groundwater). The combined reduction in plan limit for these four SDL areas is 60 GL per year.

3. Seven SDL areas where environmental water requirements can be met by setting the proposed SDL at the existing plan limit

Existing water plan limits in seven SDL areas provide sufficient water to meet environmental water requirements and therefore are considered to provide an environmentally sustainable level of take. These SDL areas are the Lower Gwydir Alluvium, Lower Murray Alluvium (deep aquifer), and Lower Murrumbidgee Alluvium in New South Wales, and Marne Saunders, Peake–Roby–Sherlock, Mallee, and Mallee Border Zone in South Australia.

4. Eighteen SDL areas where the environmental water requirements are consistent with 'limiting' the proposed SDL at current use

These areas are considered to be highly connected to surface water. While the impact of current groundwater take on streamflow has been accounted for in the determination of the surface-water SDL proposals, additional groundwater take would further reduce surface-water streamflow. The groundwater SDLs for all of these areas are capped at current levels of use, with no proposed reduction.

5. Sixteen SDL areas where the environmental water requirements are consistent with 'limiting' SDLs at current use with a trade offset

These areas are also highly connected to surface water. However, it is recognised that further development of groundwater resources is possible, provided the jurisdiction undertakes an assessment to identify the maximum sustainable volume that could be taken from groundwater systems and provided that impacts on surface-water flows are accounted for. One mechanism to achieve this is by tagged trade from surface water to groundwater. Water resource plans will be required to implement management rules that reflect the connected nature (such as by creating appropriate links between groundwater management rules and those for surface water).

6. Twenty-six SDL areas where the environmental water requirements allow the proposed SDLs to be set higher than current use, but water quality and accessibility may restrict use

None of these areas has an existing plan and, further, may be capable of sustaining an increase in groundwater use. Some 'unassigned water' has been identified in these groundwater systems. Development of these additional resources is subject to appropriate monitoring and reporting. Although much of this groundwater is saline and/or inaccessible for agricultural consumptive use, it may be suitable for industrial uses, including mining.

7. Areas of fossil groundwater

There are some areas of fossil groundwater in the Basin, such as in the Mallee in South Australia (for which there are interim and transitional plans) and in western Victoria (for parts of which some state plans exist that have not yet been recognised as transitional plans). In these areas the current diversion limits have been assessed as sustainable in the context of the time frame involved (15% depletion in 200 years), and the proposed SDLs have been set to reflect the rate of decline contained in existing state agreements. This rate of decline has also been adopted as the basis of the environmental water requirements for fossil groundwater resources in these aquifers in adjoining SDL areas.



Windmill pumping groundwater near Horsham, Victoria

Table 4.11 Overview of SDL proposals for groundwater

Main region	Code ^a	SDL area	Current diversion limit ^b (GL/y)	Current use ^c (GL/y)	SDL ^d (GL/y)	Reduction in current diversion limit		Reduction from current use (GL/y)	
						GL/y	%	GL/y	%
Reduction in current diversion limit and use required (7 SDL areas)									
Lachlan	GS39	Lower Lachlan Alluvium	108	117.9	64.8	43.2	40	53.1	45
Namoi	GS43	Lower Namoi Alluvium	86	99.4	75	11	13	24.4	25
Eastern Mount Lofty Ranges	GS1	Angas Bremer	6.5	6.7	4	2.5	38	2.7	40
Condamine–Balonne	GS76	Upper Condamine Alluvium	117.1	117.1	76.8	40.3	34	40.3	34
Condamine–Balonne	GS77	Upper Condamine Basalts	76.1	76.1	61.1	15	20	15	20
Lachlan	GS57	Upper Lachlan Alluvium	77.1	77.1	63	14.1	18	14.1	18
Murrumbidgee	GS35	Lake George Alluvium	1.1	1.1	0.75	0.35	32	0.35	32
Reductions in current diversion limit but not in use (4 SDL areas)									
Namoi	GS60	Upper Namoi Alluvium	122.1	95	95	27.1	22	–	–
Macquarie–Castlereagh	GS40	Lower Macquarie Alluvium	69.3	41.9	41.9	27.4	40	–	–
Namoi	GS54	Peel Valley Alluvium	9.3	7.3	7.3	2	22	–	–
Murrumbidgee	GS65	Australian Capital Territory (Groundwater)	7.25	0.5	4.4	2.85	39	–	–
Cap at current diversion limit (7 SDL areas)									
Murrumbidgee	GS42	Lower Murrumbidgee Alluvium	280	303.7	280	–	–	23.7	8
Murray	GS41	Lower Murray Alluvium (deep; Renmark Group and Calivil Formation)	83.7	86.3	83.7	–	–	–	–
		Lower Murray Alluvium (shallow; Shepparton Formation)	40	40	40	–	–	–	–
Murray	GS3	Mallee	41.2	24.4	41.2	–	–	–	–
Gwydir	GS38	Lower Gwydir Alluvium	32.3	32.3	32.3	–	–	–	–
Murray	GS4	Mallee Border Zone	22.2	16.4	22.2	–	–	–	–
Murray	GS6	Peake–Roby–Sherlock	5.2	1.7	5.2	–	–	–	–
Eastern Mount Lofty Ranges	GS5	Marne Saunders	4.7	2.5	4.7	–	–	–	–
Cap at current use (18 SDL areas)									
Murrumbidgee	GS45	Mid–Murrumbidgee Alluvium	44	44	44	–	–	–	–
Ovens	GS13	Ovens–Kiewa Sedimentary Plain	14.7	14.7	14.7	–	–	–	–
Macquarie–Castlereagh	GS58	Upper Macquarie Alluvium	13.7	13.7	13.7	–	–	–	–
Border Rivers	GS67	Queensland Border Rivers Alluvium	13.4	13.4	13.4	–	–	–	–
Murray	GS59	Upper Murray Alluvium	11	11	11	–	–	–	–
Namoi	GS27	Eastern Porous Rock: Namoi–Gwydir	10.3	10.3	10.3	–	–	–	–
Loddon	GS10	Loddon–Campaspe Highlands	9.4	9.4	9.4	–	–	–	–
Border Rivers	GS47	NSW Border Rivers Alluvium	6.6	6.6	6.6	–	–	–	–
Lachlan	GS64	Young Granite	4.3	4.3	4.3	–	–	–	–
Macquarie–Castlereagh	GS24	Collaburragundy–Talbragar Alluvium	3.7	3.7	3.7	–	–	–	–
Macquarie–Castlereagh	GS20	Bell Valley Alluvium	2.2	2.2	2.2	–	–	–	–
Namoi	GS61	Upper Namoi Tributary Alluvium	2	2	2	–	–	–	–
Lachlan	GS21	Belubula Alluvium	1.9	1.9	1.9	–	–	–	–
Namoi	GS44	Manilla Alluvium	1.9	1.9	1.9	–	–	–	–

a This code relates to each SDL area in Figure 3.3, Section 3.2 of this volume.

b Current diversion limit is based on plan limit or current use if there is no plan.

c Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data were available, the average of these values were used.

d SDL figures exclude unassigned groundwater (see Table 4.16).

... continued

Table 4.11 Overview of SDL proposals for groundwater (continued)

Main region	Code ^a	SDL area	Current diversion limit ^b (GL/y)	Current use ^c (GL/y)	SDL ^d (GL/y)	Reduction in current diversion limit		Reduction from current use (GL/y)	
						GL/y	%	GL/y	%
Macquarie–Castlereagh	GS25	Cudgegong Alluvium	1.6	1.6	1.6	–	–	–	–
Gwydir	GS56	Upper Gwydir Alluvium	0.8	0.8	0.8	–	–	–	–
Border Rivers	GS48	NSW Border Rivers Tributary Alluvium	0.5	0.5	0.5	–	–	–	–
Macquarie–Castlereagh	GS23	Castlereagh Alluvium	0.4	0.4	0.4	–	–	–	–
Cap at current use with trade offset (16 SDL areas)									
Macquarie–Castlereagh	GS31	Lachlan Fold Belt: Macquarie–Castlereagh	47.7	47.7	47.7	–	–	–	–
Murrumbidgee	GS33	Lachlan Fold Belt: Murrumbidgee	30.9	30.9	30.9	–	–	–	–
Lachlan	GS30	Lachlan Fold Belt: Lachlan	23.1	23.1	23.1	–	–	–	–
Namoi	GS52	New England Fold Belt: Namoi	15.6	15.6	15.6	–	–	–	–
Goulburn–Broken	GS9	Goulburn–Broken Highlands	9.8	9.8	9.8	–	–	–	–
Border Rivers	GS68	Queensland Border Rivers Fractured Rock	6.8	6.8	6.8	–	–	–	–
Macquarie–Castlereagh	GS26	Eastern Porous Rock: Macquarie–Castlereagh	5.2	5.2	5.2	–	–	–	–
Murray	GS32	Lachlan Fold Belt: Murray	5.1	5.1	5.1	–	–	–	–
Murray	GS11	Murray Highlands	4.4	4.4	4.4	–	–	–	–
Gwydir	GS51	New England Fold Belt: Gwydir	4.1	4.1	4.1	–	–	–	–
Border Rivers	GS50	New England Fold Belt: Border Rivers	3.4	3.4	3.4	–	–	–	–
Ovens	GS12	Ovens Highlands	3.2	3.2	3.2	–	–	–	–
Border Rivers	GS28	Inverell Basalt	2.9	2.9	2.9	–	–	–	–
Namoi	GS36	Liverpool Ranges Basalt	2.7	2.7	2.7	–	–	–	–
Condamine–Balonne	GS66	Condamine Fractured Rock	2.1	2.1	2.1	–	–	–	–
Wimmera–Avoca	GS16	Wimmera–Avoca Highlands	0.2	0.2	0.2	–	–	–	–
Unassigned water (26 SDL areas) ^d									
Goulburn–Broken	GS14	Victorian Riverine Sedimentary Plain (deep; Renmark Group and Calivil Formation)	89.6	89.6	89.6	–	–	–	–
		Victorian Riverine Sedimentary Plain (shallow; Shepparton Formation)	83.3	83.3	83.3	–	–	–	–
Lower Darling	GS63	Western Porous Rock	29.3	29.3	29.3	–	–	–	–
Eastern Mount Lofty Ranges	GS2	Eastern Mount Lofty Ranges	19.3	19.3	19.3	–	–	–	–
Murray	GS8	SA Murray Salt Interception Schemes	11.1	11.1	11.1	–	–	–	–
Condamine–Balonne	GS73	St George Alluvium: Condamine–Balonne (deep)	7.5	7.5	7.5	–	–	–	–
Condamine–Balonne		St George Alluvium: Condamine–Balonne (shallow)	2.5	2.5	2.5	–	–	–	–
Murray	GS17	Wimmera–Mallee Border Zone (Loxton Parilla Sands)	0	0	0	–	–	–	–
		Wimmera–Mallee Border Zone (Murray Group Limestone)	8.8	8.8	8.8	–	–	–	–
		Wimmera–Mallee Border Zone (Tertiary Confined Sand Aquifer)				–	–	–	–
Lower Darling	GS29	Kanmantoo Fold Belt	8.2	8.2	8.2	–	–	–	–
Lachlan	GS53	Orange Basalt	6.9	6.9	6.9	–	–	–	–

a This code relates to each SDL area in Figure 3.3, Section 3.2 of this volume.

... continued

b Current diversion limit is based on plan limit or current use if there is no plan.

c Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data were available, the average of these values were used.

d SDL figures exclude unassigned groundwater (see Table 4.16).

Table 4.11 Overview of SDL proposals for groundwater (continued)

Main region	Code ^a	SDL area	Current diversion limit ^b (GL/y)	Current use ^c (GL/y)	SDL ^d (GL/y)	Reduction in current diversion limit		Reduction from current use (GL/y)	
						GL/y	%	GL/y	%
Wimmera–Avoca	GS15	West Wimmera (Loxton Parilla Sands)	0	0	0	–	–	–	–
		West Wimmera (Murray Group Limestone)	1.9	1.9	1.9	–	–	–	–
		West Wimmera (Tertiary Confined Sand Aquifer)	0.8	0.8	0.8	–	–	–	–
Paroo	GS55	Upper Darling Alluvium	2.4	2.4	2.4	–	–	–	–
Murrumbidgee	GS22	Billabong Creek Alluvium	2	2	2	–	–	–	–
Murray	GS7	SA Murray (Groundwater)	1.8	1.8	1.8	–	–	–	–
Lower Darling	GS19	Adelaide Fold Belt	3	3	3	–	–	–	–
Lower Darling	GS37	Lower Darling Alluvium	1.4	1.4	1.4	–	–	–	–
Macquarie–Castlereagh	GS46	NSW Alluvium above the Great Artesian Basin	1.2	1.2	1.2	–	–	–	–
Barwon–Darling	GS34	Lachlan Fold Belt: Western	1.2	1.2	1.2	–	–	–	–
Warrego	GS72	Sediments above the Great Artesian Basin: Warrego–Paroo–Nebine	1.1	1.1	1.1	–	–	–	–
Paroo	GS49	NSW Sediments above the Great Artesian Basin	1	1	1	–	–	–	–
Warrego	GS78	Warrego Alluvium	0.7	0.7	0.7	–	–	–	–
Wimmera–Avoca	GS18	Wimmera–Mallee Sedimentary Plain	0.6	0.6	0.6	–	–	–	–
Moonie	GS71	Sediments above the Great Artesian Basin: Moonie	0.5	0.5	0.5	–	–	–	–
Moonie	GS74	St George Alluvium: Moonie	0.5	0.5	0.5	–	–	–	–
Macquarie–Castlereagh	GS62	Warrumbungle Basalt	0.5	0.5	0.5	–	–	–	–
Condamine–Balonne	GS75	St George Alluvium: Warrego–Paroo–Nebine	0.3	0.3	0.3	–	–	–	–
Condamine–Balonne	GS70	Sediments above the Great Artesian Basin: Condamine–Balonne	0.3	0.3	0.3	–	–	–	–
Border Rivers	GS69	Sediments above the Great Artesian Basin: Border Rivers	0.1	0.1	0.1	–	–	–	–
		Queensland	229	229	174	55.3	24	55.3	24
		New South Wales	1,211	1,204	1,086	125.15	10	115.65	10
		Australian Capital Territory	7	0.5	4	2.85	39	0	0
		Victoria	227	226.7	227	–	–	0	0
		South Australia	112	83.9	110	2.5	2	2.7	3
		Basin total^e	1,786	1,744	1,601	185.65	10	174	10

a This code relates to each SDL area in Figure 3.3, Section 3.2 of this volume.

b Current diversion limit is based on plan limit or current use if there is no plan.

c Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data were available, the average of these values were used.

d SDL figures exclude unassigned groundwater (see Table 4.16).

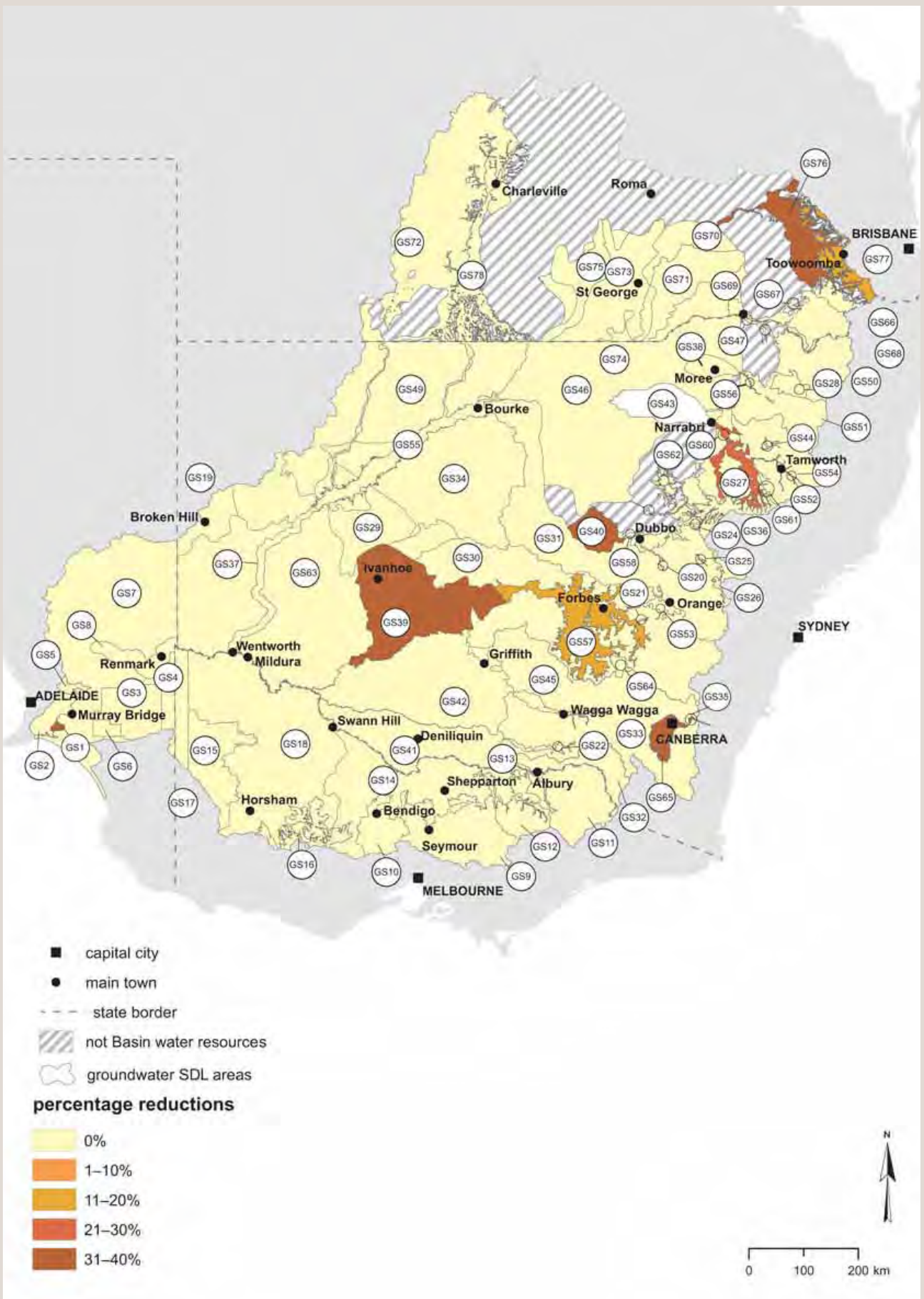


Figure 4.26 Groundwater SDL proposals as percentage reductions in current diversion limits

Methods and considerations for developing SDLs

The development of surface-water and groundwater SDLs involves a mix of technical work and policy judgements. This section documents the key policy choices in the development of SDL proposals.

Surface water and groundwater connectivity

All adjacent surface-water and groundwater systems are connected, but the degree to which water exchanges between these two types of water resources varies in time and across the Basin. Where the connection is strong, groundwater extraction may directly affect surface-water streamflow by inducing leakage to groundwater, or by reducing groundwater discharge to streams. Similarly, changes to surface-water management can have significant impacts on groundwater systems.

Historically, integration of the management of surface water and groundwater in the Basin has been inadequate, in some cases leading to allocation of the same water twice, particularly where time lags are long.

The approach taken for the proposed Basin Plan is to set separate surface-water and groundwater SDLs that account for current and expected future interactions between the systems. For the Basin Plan, accounting risks have been identified (Section 5.2) and water resource plan requirements specified (Section 6.1) in such a way as to reflect the connected nature of these systems. Also, the impact of current groundwater extractions on future streamflow has been accounted for, where data were available, in the baseline for river system models.

A highly connected groundwater system is defined as one where at least 50% of the groundwater extraction volume is manifest as a surface-water flow reduction in the relevant surface-water system within 50 years.

Research shows that the potential impact of past and current groundwater extraction on streamflow is one of the key uncertainties in understanding Basin water resources. The CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008) indicated that the impact of groundwater extraction, at the 2004–05 volume of take, would eventually (by 2030) be to reduce streamflow across the Basin by 447 GL/y, meaning that 24% of the 2004–05 volume of groundwater extraction would eventually be sourced from surface water through induced river recharge. This equated to 4% of existing surface-water use.

Management of connectivity can be considered in two categories: short term and long term.

Short-term management is aimed at managing impacts on streamflow that occur within a year or so, such as in the narrow alluvial systems that are generally not represented by a groundwater model. Water resource plans will be required to implement local management rules that reflect the severity of the potential short-term impact of groundwater extraction on surface-water availability.

Long-term management is aimed at ensuring long-term impacts are accounted for, including the management of future impact on surface-water flow from both present and past groundwater pumping. When developing SDLs, connectivity has been taken into account in the following ways:

- For surface-water SDLs, the impact of past and current groundwater extractions on current and future (to 2030) streamflow (time-lag effect) has been accounted for by including the estimated impact, where this is significant, as a 'loss' component in the surface-water river system models.



*Macquarie River at Burrendong Dam,
New South Wales*

- For groundwater SDLs developed using groundwater models (generally the large alluvial systems), the volume of recharge from surface water is identified in the models as part of the water balance.

Water accounting within SDL areas

To address the consequences of past and current overextraction of groundwater and appropriately account for them, the proposed Basin Plan will adopt the following strategies.

In narrow upper catchment alluvial groundwater systems that are highly connected to surface water in a short time frame, the relationship between surface water and groundwater is deemed to be 1:1. This means that modification of either surface-water or groundwater extraction patterns are rapidly manifested in the physical response of the other. Therefore, all groundwater extractions in these systems have the potential to contribute to streamflow reductions within short time frames and may be considered as equivalent to surface-water extractions.

In fractured rock aquifers, the relationship between surface water and adjacent groundwater is also deemed to be 1:1. This approach, while conservative, is necessary both to protect streamflow and to facilitate offsets to allow some development of groundwater systems that are not, themselves, fully allocated. This approach is warranted given that there is insufficient available information to support an alternative approach.

For these connected systems, the approach has been to set the groundwater SDL at recent historical use. Water resource plans will be required to implement management rules that reflect the connected nature (such as by linking groundwater management rules to those for surface water).

Take that is limited by SDLs

The Water Act's definition of 'take' is very broad, essentially equating it to all activities that modify streamflow. This section describes which forms of take will and will not be limited by the SDLs.

In general, SDLs will limit the amount of water that is taken for consumptive purposes. Therefore, SDLs will include limiting all diversions from watercourses and aquifers for irrigation, industry town water supplies, and stock and domestic supplies. Floodplain harvesting, which is a significant

form of take in the northern part of the Basin, will also be limited by SDLs. (Floodplain harvesting is the capture, storage and use of water that has exited a watercourse in flood and water from rainfall run-off on floodplains.)

Evaporation from public onstream constructed storages (e.g. Wyangala Dam, Beardmore Dam) — including impoundments upstream of weirs (e.g. Goulburn Weir, Berembed Weir) — that do not form part of the distribution network within an irrigation area or district will not be limited by SDLs. However, evaporation from private storages and impoundments that form part of the distribution network within an irrigation area or district (e.g. Waranga Basin, Barren Box storage and wetland) will be limited by SDLs. That is, evaporation from these private storages and impoundments will be considered similarly to other types of delivery losses that are associated with distributing water within irrigation areas and districts. These latter evaporation and delivery losses occur after the original diversion occurs from a watercourse or onstream storage. This approach is consistent with that currently taken for the Cap (the limit on the volume of surface water used for consumptive purposes in river valleys within the Basin).

The provisions of the Water Act recognise that take limited by SDLs should include water that is taken by interception activities (s. 20(b)). Furthermore, the Basin Plan must specify water resource plan requirements relating to the regulation of interception activities that have a significant impact on Basin water resources (s. 22(3)(d)). On the basis of these two provisions, MDBA has concluded that the types of interception activities to be included in SDLs are those that have been assessed in previous studies (e.g. Zhang, Dawes & Walker 2001; Agrecon 2005; MDBC 2006c; Van Dijk et al. 2006; SKM 2007; CSIRO 2008; SKM, CSIRO & BRS 2010) as having a potentially significant impact on Basin water resources. These interception activities are forestry plantations, farm dams and floodplain harvesting. Water resource plans will be required to ensure that water access rights are held for certain new interception activities, including mining (see Section 6.1).

Water access rights that are held specifically for the purposes of achieving environmental outcomes and used in a way that is consistent with the Environmental Watering Plan will not be limited by the relevant SDL. However, any water that is not used in a manner consistent with the Environmental Watering Plan will be limited by the relevant SDL (see Figure 7.3).

Water for critical human needs will be included in the take that is limited by SDLs (see Section 4.6).

Unauthorised take will be dealt with as a compliance issue rather than being formally recognised as a form of take limited by SDLs (see Section 7.2).

Components of SDLs

The SDL proposals will place limits on a number of different forms of take with a significant variation in the accuracy and extent to which the forms of take are measured or estimated. Also, existing tools, including hydrologic models and analytical assessment methods, are not readily available to assess the impacts of all forms of take. This especially applies to interception activities. Therefore, SDLs have been divided into separate components that, when added together, give the total SDL.

The need for separate components of SDLs is particularly important for surface water. Diversions from regulated rivers and major unregulated rivers are reasonably well measured and are explicitly represented in the hydrologic models. The models are the main tools used to determine the surface water

SDLs. In regulated rivers, water supplies are managed by the storage and later delivery of water to users from one or a number of dams and weirs. The term ‘unregulated river’ applies to rivers without storages or dams, as well as to rivers where the storages do not release water downstream (but provide water to other locations). Examples of major unregulated rivers are the Barwon–Darling River, sections of the Condamine–Balonne River and the Moonie River. Minor unregulated rivers include Mandagery Creek in the Lachlan region, Tarcutta Creek in the Murrumbidgee region, and Upper Billabong in the Murray region. Along these rivers, water users access supplies from flows as they occur, often by harvesting water into offstream storages. Floodplain harvesting that occurs on the major river floodplains in the northern Basin is less well measured, but is included in the hydrologic models where diversions are significant. It will be important that the data and accuracy of floodplain harvesting representation in hydrologic models are improved over time.

While diversions from these regulated and major unregulated rivers and floodplains comprise some 80% of surface-water diversions in the Basin, the remaining diversions or forms of take are still substantial. These remaining diversions, which include diversions from unregulated rivers and interception by farm dams and forestry plantations, are not well measured and are not explicitly included in hydrologic models. Estimates and results from existing studies have been used to determine these remaining diversions (see Table 4.13). The studies used acknowledge the limitations to the accuracy of their results. It is likely that the accuracy of these estimates will improve. The approach taken in the Basin Plan accommodates these limitations in accuracy without unintended adverse consequences.

The proposed approach in calculating SDLs is to retain these different types of surface-water diversions as separate components within an overall total SDL. The separate components will comprise:

- watercourse diversions
 - under water access entitlements from regulated and major unregulated rivers (explicitly represented in hydrologic models; floodplain harvesting is included in this component)
 - under water access entitlements from minor unregulated rivers (not represented in models)
 - under basic rights (stock and domestic rights, native title rights)
- interceptions
 - by farm dams under basic rights
 - by farm dams other than basic rights (irrigation and other uses)
 - by forestry plantations.

Some or all of these components will be used to specify the surface-water SDL in each SDL area. The specific watercourse diversions and interceptions limited by each component will be described for each SDL area. Water resource plans will be required to specify which types of water access rights will be accounted for under each SDL component.

The significant component for most SDL areas comprises diversions that are explicitly represented in the hydrologic modelling framework used for the Basin Plan. This is termed ‘watercourse diversions’. It is the component for which hydrologic models are used to determine what adjustments are required to satisfy the environmental water requirements. The implementation of this SDL component will require Basin states to demonstrate, by using an appropriate hydrologic model, that their water resource plan will limit long-term average diversions to the specified amount under the relevant climate scenario.



*Pelican Point on the Coorong Lagoon,
South Australia*

For those components based on estimates (i.e. not explicitly represented in hydrologic models), the approach taken is to set a limit equivalent to the corresponding current diversion limit component as described in the section ‘Defining the baseline’. This will be the current limit established by existing water management arrangements, or the current level of use where the form of take is not currently limited. The specified amount of the SDL component is the best estimate of this current diversion limit. The water resource plan requirements that relate to the implementation of these SDL components will require Basin states to include rules and other arrangements to ensure that the long-term average level of use is no greater than the level of use permitted or occurring under existing arrangements. The exception will be the use of appropriate offsetting arrangements, as described later in this section.

This approach will prevent any inaccuracy of the SDL component estimates being used to allow a level of diversion higher than was intended by the SDL. It will also prevent unanticipated reductions in diversions due to more accurate estimates showing different levels of actual long-term average use than first estimated. It will be necessary to incorporate newer and more accurate estimates into future amendments of the Basin Plan. The compliance method and the states’ statutory reporting obligations will therefore be important in ensuring that states implement SDLs effectively.

Groundwater SDLs have been developed based on a method that primarily involves estimating the proportion of recharge that can be sustainably extracted, rather than quantifying a component for each form of take separately (see ‘Developing groundwater SDLs’ later in this section). Therefore, groundwater SDLs are not divided into separate components, although components of take will be required to be reported on to determine the volume of groundwater actually taken for each SDL area.

The components of SDLs and the general principles that have been used to quantify each component are summarised in Table 4.12.

Table 4.12 Components for surface-water and groundwater SDLs and general methods of quantification

SDL components	General method of quantification
Surface water	
Take under water access entitlements from regulated watercourses in the Basin and major unregulated rivers in the northern Basin, and take by floodplain harvesting	Using a specified hydrologic model.
Take under a water access entitlement from minor unregulated watercourses	Information provided by Basin states from farmer surveys of crop area and existing planting behaviour and other estimations (MDBA 2010c).
Take from watercourses under basic rights (stock and domestic rights, native title rights)	Some implicit inclusions in models; refinement as data become available.
Interception by forestry plantations (as it affects run-off)	Application of a model that assesses the impact of plantations on run-off (SKM, CSIRO & BRS 2010).
Interception by farm dams under basic rights (stock and domestic rights, native title rights and harvestable rights)	Quantification of the storage capacity of dams (<5 ML) and estimation of the hydrologic impacts of these storages (SKM, CSIRO & BRS 2010).
Interception by farm dams other than under basic rights (irrigation and other purposes)	Quantification of the storage capacity of dams (>5 ML) and estimation of the hydrological impacts of these storages (SKM 2007; SKM, CSIRO & BRS 2010).
Groundwater^a	
Take under water access entitlements	A combination of metered and estimated data. This take is explicitly included in both modelled and unmodelled areas.
Take under basic rights (stock and domestic rights, native title rights)	Estimated data. In areas covered by a model, current take is represented either explicitly, or implicitly, or a combination. In unmodelled areas, this take is estimated.
Take by forestry plantations (as it affects aquifers)	Impacts of existing plantations implicitly included in modelled areas for the period covered by the model calibration. Not included in unmodelled areas. Take to be estimated for future expansion of plantation forestry and for reforestation, and accounted for within SDL volume.
Interception by extractive industries estimated using a model or method (includes mining and quarrying), including water extracted as a by-product of the activity; does not include water use for the industrial process as this will be covered by a water access entitlement	Estimated. Not explicitly modelled but impacts of existing mining implicitly included in modelled areas for the period covered by the model calibration. Not included in unmodelled areas. Future take to be identified and accounted for within SDL volume.

a Groundwater SDLs are not divided into separate components, although there are separate components for reporting actual take

Offsetting components of take

As described earlier, surface-water SDLs will comprise the sum of separate SDL components for the different forms of take. Both the volume of the SDL and the volume of its components will be specified for each surface-water SDL area identified in the Basin Plan. In developing a water resource plan, a Basin state may wish to offset different components (i.e. increase the limit of one form of take and reduce the limit of another, while not exceeding the overall SDL). This will be permitted, but only where the Basin state can demonstrate that any change to an SDL component can be estimated accurately enough to allow offsetting without resulting in an actual level of diversion higher than was intended by the SDL. Offsetting components of take must not compromise key environmental assets, key ecosystem functions, the productive base or key environmental outcomes.

Offsetting arrangements are likely to be required particularly where Basin states wish to allow basic rights to continue to grow. While action to address the issue of growth in the exercising of basic rights, particularly in peri-urban areas, has been the subject of some action by Basin states, it is unlikely that Basin states will wish to place a fixed limit on water use under basic rights. Growth in basic rights can be provided for by this offsetting arrangement.

Defining the baseline

In the context of the proposed Basin Plan, the baseline represents a reference point from which changes to water management strategies can be assessed. The baseline is important for a number of reasons:

- it represents the knowledge about the Basin water resources upon which development of the Basin Plan has been based
- it is used as a point of comparison with take under SDLs
- where a transitional or interim water resource plan is in place, it is the reference point for risk allocation purposes (Section 5.2), which determines how the risks of reduced or less-reliable water allocations are to be shared between water access entitlement holders and governments
- it will be used in monitoring and evaluating the effectiveness of the Basin Plan (Section 7.3).

The baseline for each SDL area takes account of a number of elements, including:

- current limits on take defined by existing water resource plans or current water management arrangements
- all existing water access rights including water access entitlements and stock, domestic and riparian domestic rights
- the current use of existing water access rights
- all other known forms of take that may not be currently covered by water access rights
- climate characteristics.

Where transitional or interim water resource plans are in place, the baseline reflects the limits on take expressed in those plans. Where transitional or interim water resource plans are not in place, or the plans do not apply to certain types of take, the baseline reflects the current level of take. However, where a Basin state was developing a plan intended to become an interim water resource plan, the most up-to-date information available from the Basin state on the proposed limits to be established by the plan was used. (See Section 6.1 for more information about transitional and interim water resource plans.)

For groundwater, the current diversion limits are defined as:

- the current plan limit where a plan exists; or
- current use if there is no plan.

Groundwater use has been calculated as an average of the past five years or, if data for the past five years are not available, the take in 2007–08. This represents the best available data across most groundwater systems.

For surface water, hydrologic modelling is the primary tool used to determine take under the baseline. The models represent the various water management, sharing and operating rules that currently exist in each jurisdiction (including under water plans and other instruments), the infrastructure and other relevant physical characteristics of the water resources, and the existing spatial and temporal patterns of take.

The 114-year period from July 1895 to June 2009 is the longest period for which robust hydrologic and climatic information can be assembled Basin-wide. On this basis, the climate information (e.g. rainfall, evaporation) used in the hydrologic models represents the historical climate for the 114-year period. Therefore, for the forms of take that are explicitly included in hydrologic models, the long-term average current diversion limit is the average modelled diversion based on this 114-year historical climate sequence.

It is important that a baseline is determined for all forms of take to be limited by SDLs. Where forms of surface-water take are not explicitly represented in the hydrologic models, the baseline is generally defined by the current level of take (quantified by the most appropriate method, as described earlier in this section).

In relation to the treatment of existing environmental water in the surface-water baseline, water recovered for The Living Murray and Water for Rivers programs (recovering water for the Murray and Snowy rivers) has been incorporated in the baseline. Incorporation of The Living Murray arrangements includes the works and measures that have been completed to date and those committed to being built.

No environmental entitlements secured or made available to the Australian Government through infrastructure savings under the Water for the Future program have been included because of the ongoing nature of this program. This water will be available to offset the reduction in the proposed diversion limits resulting from the Basin Plan.

For surface-water current diversion limits and SDLs, separate quantities will be specified for each of the components (as described in Table 4.12). The current surface-water diversion limits for each SDL area divided into the separate watercourse diversion and interception components are listed in Table 4.13. As a result of the method discussed here, these figures may be different from the Cap, 'plan limit' or other figures associated with these areas.

Inter-Basin and intra-Basin transfers

In a number of locations across the Murray–Darling Basin, water is transferred into or out of the Basin. These transfers were taken into account in developing SDLs. Some examples of inter-Basin transfers are:

- release of water from the Snowy Scheme (from outside the Basin) into the Murrumbidgee and Murray systems (inside the Basin)
- release of water from the Murrumbidgee system (inside the Basin) into the Snowy Scheme (outside the Basin)
- take of water from the Glenelg catchment (outside the Basin) for use in the Wimmera system (inside the Basin), and vice versa
- diversion of water from the South Australian River Murray (inside the Basin) to supply Adelaide (outside the Basin).

In the case of most transfers of water out of the Basin, these must be accounted for as a form of take of the Basin water resources — just like any other form of take — and will therefore be limited by the SDL. In the case of the Snowy Scheme, where water is transferred both in and out of the Basin, when a greater amount is transferred in, the net increase has been treated as an inflow to the Basin water resources.

Table 4.13 Overview of surface-water current diversion limit components

SDL area	Watercourse diversions ^a			Interception ^b				
	Regulated and major unregulated rivers ^c	Minor unregulated rivers ^d	Total watercourse diversions	Farm dams under basic rights	Farm dams other than basic rights (irrigation and other uses)	Forestry plantations	Total interception	Total current diversion limit
Australian Capital Territory (Surface Water)	39		39	0.4	0.7	11	12	51
Barwon–Darling	197		197	3.3	105		108	305
Broken	14	0.5	14	11	19	13	43	57
Campaspe	112	2.8	115	16	23	1.2	40	155
Condamine–Balonne	706		706	61	203	1.1	265	971
Eastern Mount Lofty Ranges	Included in interception				7.5	3.2	10.7	10.7
Goulburn	1,564	29	1,593	39	47	23	109	1,702
Gwydir	316	10	326	20	104	0.7	125	451
Intersecting Streams	3		3	2.4			2.4	5.4
Kiewa	11		11	4.5	2.1	7.1	14	24.7
Lachlan	287	15	302	57	230	29	316	618
Loddon	93	1.6	95	26	59	5.2	90	185
Lower Darling	55		55	5.5			6	61
Macquarie–Castlereagh	380	45	425	110	156	44	310	735
Marne Saunders	Included in interception				1.8		1.8	1.8
Moonie	32		32	11	40		51	83
Murrumbidgee	2,019	42	2,061	41	344	116	501	2,562
Namoi	265	78	343	21	139	5.3	165	508
Nebine	6		6	25	0.3		25	31.3
NSW Border Rivers	191	19	210	16	79	0.1	95	305
NSW Murray	1,693	28	1,721	10	70	24	104	1,825
Ovens	25		25	17	9.4	32	58	83
Paroo	0.2		0.2	9.7			9.7	9.9
Queensland Border Rivers	223		223	16	61	1.4	78	301
SA Murray	665		665				0	665
SA Non-Prescribed Areas	0		0	3.5			3.5	3.5
Victorian Murray	1,656		1,656	10	13	22	45	1,701
Warrego	45		45	33	50		83	128
Wimmera–Mallee (Surface Water)	73	0.9	74	22	39	1.3	62	136
Basin total	10,670	272	10,942	591	1,803	341	2,735	13,677

a Take from watercourses under basic rights is not separately included

b Interception includes impact of farm dams and forestry plantations

c Includes major unregulated rivers in the northern Basin, and take by floodplain harvesting

d This component will be specified in detail for each SDL area in the Basin Plan.

Water transferred into the Basin will be treated as part of Basin water resources that are available for meeting environmental and consumptive water requirements, just like any other Basin water resources. Where such transfers into the Basin are reflected in the river system models, the transferred water will already have been taken into account in modelling diversions and developing the SDL. This is the case for most transfers into the Basin. Since SDLs will be set assuming that these transfers are part of the available resource, water resource plans will need to ensure that any variation of the transfer arrangements from those used in developing SDLs will not compromise environmental requirements.

In many locations, particularly in the southern interconnected Basin, water is transferred by pipeline or channel from one catchment to another within the Murray–Darling Basin. Where these catchments are located within different SDL areas, consideration has been given to how these transfers are taken into account in developing the proposed SDL for each area. Examples of such intra-Basin transfers are:

- transfer of water from the Goulburn River (Goulburn SDL Area) to water users located in the Loddon catchment (Loddon SDL Area) via the Waranga Western Channel
- transfers from the Goulburn catchment water (Goulburn SDL Area) to Lake Eppalock in the Campaspe catchment (Campaspe SDL Area) via the Goldfields Superpipe.

The approach that has been applied for the purposes of developing SDLs is that diversions are accounted for at the original point of take. For instance, water diverted from the Goulburn River at Goulburn Weir and transferred to users located within the Loddon catchment via the Waranga Western Channel will be limited under the SDL for the Goulburn SDL Area. This approach is necessary to allow consideration of the impact of all diversions from the water resources of each SDL area. In the above example, the total diversions from the Goulburn River are what need to be limited by the SDL, rather than just what water is used within the SDL area.

In some cases, water taken from the Basin water resources may be returned to watercourses from irrigation districts and urban centres and may then contribute to meeting environmental values downstream. For example, water returned to the watercourse at the end of an irrigation distribution network (referred to as irrigation returns) can include irrigation channel outfalls, channel escapes and drainage flows. Returns from urban and industrial areas include discharges from sewage treatment plants and industrial units.

In principle, it could be argued that any water taken and then returned to the watercourse should not be included in the SDL, as it is the net impact on streamflows that should determine an SDL. However, information about return flows is generally poor and not all return flows can be included in accounting against SDLs. The trend towards increasing water-use efficiency, and associated reduction in return flows, means that any reduction in return flows not accounted for in quantifying diversions results in an increase in the effective net diversion. The downstream flow regime could, therefore, suffer as a consequence of reduced return flows.

Any return flows that are currently accounted for in implementing the Cap have also been accounted for in developing SDLs. As measurement of return flows improves over time, it is anticipated that this will be reflected in future amendments of the Basin Plan.



Campaspe Weir on the Campaspe River between Elmore and Rochester, Victoria

Developing surface-water SDLs

The hydrologic modelling used for the development of surface-water SDLs has been briefly described in Section 3.5. Hydrologic river system models allow the analysis of the interaction between streamflows and water use under different policy positions, infrastructure and operational rules over the longer term. Using climate data extending back to 1895, particular arrangements can be simulated to see how they might perform over the range of streamflows experienced since that time. For example, hydrologic models can be used to simulate conditions as if the major infrastructure (e.g. dams, weirs, irrigation systems) were in place since 1895. They can also be used to estimate the without-development flows in the river system up to the present day. These flow conditions are a useful reference point.

Hydrologic models have been developed by jurisdictions for all major rivers in the Basin. These models have been used in most water planning in the Murray–Darling Basin in recent decades. They are an essential tool to analyse and understand how much water is available and how different water sharing arrangements, including limits on diversions, affect streamflows. MDBA has used the current best available hydrologic models, in conjunction with the Basin states and model integration framework developed for the CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008), and refined them for the purposes of the proposed Basin Plan. The modelling framework has provided the means to explore different scenarios for reducing current diversion limits to satisfy environmental water requirements.

After using the hydrologic modelling framework to analyse some early scenarios for SDLs, it became clear that an additional analytical tool was needed to more quickly explore the potentially large number of options for the distribution of SDLs across the Basin that would satisfy the environmental water requirements at both catchment and Basin scale. An analytical tool using a spreadsheet that sets out flows and diversions under the conditions of without development, current diversion limits and SDLs was developed.

The key elements of the process for developing surface-water SDLs set out here have been independently peer reviewed for incorporation into the proposed Basin Plan. The reviews covered the technical analysis carried out in relation to the modelling framework for surface water as well as the policy settings. To support this process, MDBA contracted CSIRO and SKM to provide modelling support and also harnessed the modelling skills in Basin state water agencies.

Hydrologic river system models

For most of the 29 surface-water SDL areas, the hydrologic modelling framework was the primary tool used to determine the modelled component of SDLs. The SDL areas included in the hydrologic modelling framework are the Warrego, Nebine, Condamine–Balonne, Moonie, NSW Border Rivers, Queensland Border Rivers, Gwydir, Namoi, Macquarie–Castlereagh, Barwon–Darling Watercourse, Lachlan, Murrumbidgee, Lower Darling, NSW Murray, SA Murray, Victorian Murray, Goulburn, Broken, Campaspe, Loddon and Wimmera–Mallee (Surface Water). Within these SDL areas, most of the take from watercourses and floodplain harvesting is explicitly represented in the hydrologic modelling framework, as shown in Table 4.13.

Figure 4.27 shows the hydrologic models used and how they link together within the modelling framework.

Hydrologic indicator sites

- 1 The Coorong, Lower Lakes and Murray Mouth
- 2 Riverland – Chowilla Floodplain
- 3 Lower Darling River System
- 4 Hattah Lakes
- 5 Wimmera River Terminal Wetlands
- 6 Gunbower–Koondrook –Perricoota Forest
- 7 Edward–Wakool River System
- 8 Barmah–Millewa Forest
- 9 Lower Goulburn River Floodplain
- 10 Lower Murrumbidgee Floodplain
- 11 Mid-Murrumbidgee–Wetlands
- 12 Great Cumbung Swamp
- 13 Booligal Wetlands
- 14 Lachlan Swamp
- 15 Macquarie Marshes
- 16 Gwydir Wetlands
- 17 Narran Lakes
- 18 Lower Balonne River Floodplain System

▶ Major dams and weirs

Models indicated in green have been used only for assessing water availability or for baseline runs to determine inflows. They have not been used to determine SDLs for these areas.

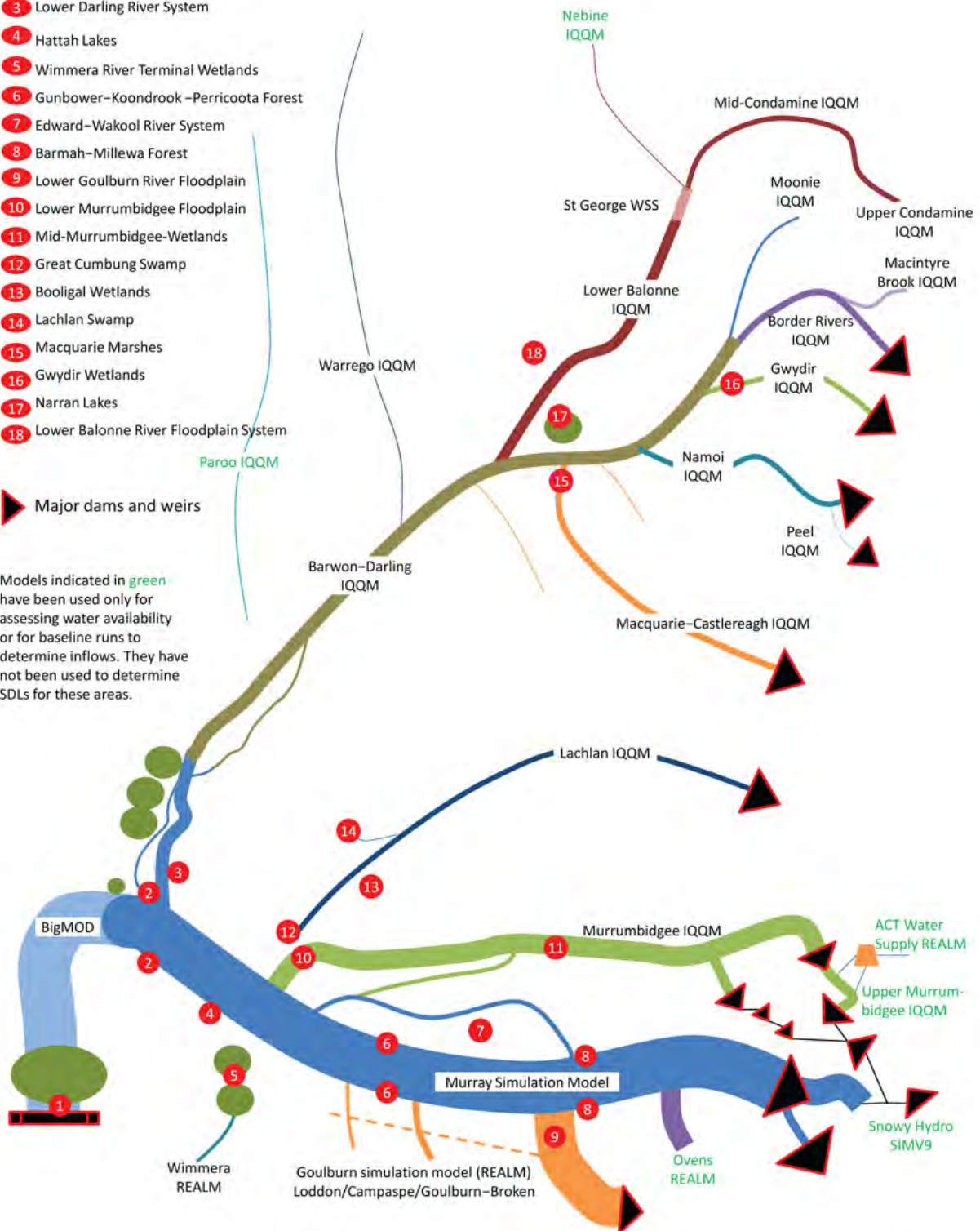


Figure 4.27 Hydrologic modelling framework

The hydrologic modelling framework was not used to develop SDLs for the remainder of the 29 SDL areas. However, consideration has been given to reductions in these areas as part of applying the approaches described earlier in this section.

Table 4.14 sets out the reasons for not using the modelling framework in these areas and the approach used to develop SDLs.

Overall, about 80% of current surface-water use under current diversion limits in the Basin is explicitly represented in the hydrologic modelling framework.

Table 4.14 SDL areas where the modelling framework is not used and reasons for not using the framework

SDL area	Reason for not using modelling framework	Approach to developing SDL
Australian Capital Territory (Surface Water)	Small area relative to other SDL areas. Outflows included in the modelling framework.	Set SDL based on applying the approach to contributing to downstream requirements.
Intersecting Streams	Low level of use. Diversions included in models developed by Queensland for upstream catchments (Nebine, Condamine–Balonne and Moonie), but concerns about the accuracy of the representation in these models.	Set SDL based on applying the approach to contributing to downstream requirements.
Kiewa, Ovens	Relatively low level of use. Outflows included in the modelling framework. Limited capacity to modify end-of-system flows to meet downstream water requirements.	Set SDL based on applying the approach to contributing to downstream requirements.
SA Non-Prescribed Areas	No models available. Limited water available and low level of use. Currently not prescribed, which means that limited regulation is in place.	Hold use to no more than current level. Place minimum water resource plan requirements that recognise the limited need for any additional planning or regulation beyond that currently in place.
Eastern Mount Lofty Ranges, Marne Saunders	South Australian model available but small area with limited flow contribution to rest of Basin. Development of water resources mainly by small farm dams.	Set SDL based on applying the approach to contributing to downstream requirements.
Paroo	Low level of use. Very low connectivity to the rest of the Basin.	Set SDL based on current diversion limit, and specify water resource plan requirements that ensure local environmental water requirements are determined and satisfied.

Because of the complexity of the hydrologic modelling framework, it was difficult to use it to consider a large range of SDL scenarios in a timely way. While the analytical tool described below proved a useful means of exploring the range of scenarios, the hydrologic modelling framework is still essential to verify and refine the results from the analytical tool. In particular, the hydrologic modelling allows more detailed consideration of how reductions in current diversion limits affect the reliability and timing of water use, as well as how best to satisfy the temporal and spatial nature of environmental water requirements. It is important to recognise that SDLs and the resulting long-term average additional environmental water is only an average representation of the complex interactions between consumptive water use and environmental water requirements. Further hydrologic modelling is continuing to provide greater detail on the results achieved to date.

One limitation on being able to present more detailed results on the impact of the long-term average reductions in current diversion limits is that the detailed water sharing arrangements between consumptive water use and the environment will only be developed when Basin states prepare their water resource plans. An important factor in these sharing arrangements will be how much of the additional environmental water requirements will be provided by entitlements secured for environmental purposes. Nevertheless, MDBA intends to provide more detailed results based on a range of assumptions from the hydrologic modelling as they become available.

Analytical tool

An analytical tool was developed to enable a more rapid exploration of the scenarios for the distribution of SDLs across the Basin than could be achieved with the use of hydrologic models. It was also developed because MDBA wanted to consider these scenarios without being limited to just the SDL components that are explicitly included in hydrologic models.

The analytical tool used was a spreadsheet that set out flows and diversions under the conditions of without-development, current diversion limits and SDLs for all SDL areas in the Basin. The various policy positions and constraints developed by MDBA were also included as rules in the spreadsheet. The computational power of the spreadsheet allowed MDBA to adjust the numbers in an iterative way until the environmental water requirements and policy positions were satisfied. The results for the three scenarios considered by MDBA, of reductions in current diversion limits of 3,000 GL/y, 3,500 GL/y and 4,000 GL/y, are presented in Appendix C.

Appendix D includes explanatory notes to assist in understanding the spreadsheets. Each analytical spreadsheet includes the following:

- Inflows, water used by the environment, and losses and outflows for each catchment under without-development conditions. These are based on results from the hydrologic modelling framework under without-development conditions using the historical 1895–2009 climate scenario.
- Transfers into the Basin, inflows, current diversion limits, water used by the environment, and losses and outflows for each catchment under current diversion limits. These are based on results from the hydrologic modelling framework using the historical 1895–2009 climate scenario.
- The number of hydrologic indicator sites and the range of additional environmental water requirements from high uncertainty to low uncertainty based on the hydrologic indicator sites. These are the results of the analysis described in Section 4.1 ‘Estimating long-term average environmental water requirements’.
- Transfers into the Basin, inflows, SDLs, water used by the environment, and losses and outflows for each catchment under SDLs. The SDLs are based on applying the approach to distributing reductions in current diversion limits described earlier in this section. The outflows and resulting water used by the environment and losses have been estimated using the results from the hydrologic modelling completed to date and the relationship between changes in diversions and end-of-system flows in each region. It is recognised that these outflows will need to be verified for the actual SDLs determined using the hydrologic modelling framework.
- A range of volumes and statistics for the changes in diversions and environmental water. These are simply calculated from the previous results.
- The environmental water available for offset against any reductions in current diversion limits and the residual reduction after current water recovery — based on data collected by MDBA on environmental water recovery in the Basin. It excludes all environmental entitlements that have already been included in the determination of current diversion limits as explained earlier in this section. Most environmental water available for offset is that secured by the Australian Government and held by the Commonwealth Environmental Water Holder as at 30 June 2010. It may differ slightly from the data provided on the Department of Sustainability, Environment, Water, Population and Communities website due to changes over time and due to the data here including some other environmental entitlements not held by the Commonwealth Environmental Water Holder.

While the analytical tool has been useful in determining SDL proposals, the results will continue to be verified and refined using the detailed analyses with the hydrologic modelling framework.

Developing groundwater SDLs

Unlike the management of surface water, where the Cap provides a precedent, there has been little previous experience in developing a consistent and transparent approach for groundwater resource management across the Basin. Indeed, a large fraction of the Murray–Darling Basin is covered by unincorporated areas (areas not covered by an existing groundwater plan or a groundwater management area), for which there are no extraction limits and for which there are limited data. The variation of groundwater systems with respect to size, geology, level of extraction, documentation and monitoring makes the task of developing a consistent approach more difficult.

The task of determining groundwater SDLs has been divided into a three-step process:

1. Determine water resource plan areas and SDL areas to which groundwater SDLs are applied.
2. Undertake updated groundwater recharge modelling for the entire Murray–Darling Basin, and develop and apply a risk assessment framework to identify the proportion of recharge that could be allocated (recharge risk assessment method). This method has been used to generate SDLs for unincorporated areas. It has also been used as a tool to compare and assess proposed limits for those groundwater systems with existing limits, and to determine their suitability to meet the objectives of the Basin Plan.
3. Undertake additional, detailed numerical modelling for 11 of the largest alluvial groundwater SDL areas (for which suitable models are available).

Groundwater SDLs across the Basin will not be set higher than current diversion limits (or the recent historical level of use where there is no existing plan limit). However, in unincorporated areas where there are no current limits, SDLs set higher than current use are considered where it can be demonstrated that increases will not compromise the environmentally sustainable level of take, nor negatively affect surface-water availability within a 50-year time frame.

The key elements of the process have been independently peer reviewed for incorporation into the proposed Basin Plan. To support this process, MDBA contracted CSIRO and SKM to provide technical expertise. MDBA also convened a groundwater Technical Reference Panel and a state Expert Panel for each of the five Basin states. Comprising experienced groundwater practitioners, these forums were used to review technical work including methods and results.

Recharge risk assessment method

For the purposes of developing groundwater SDLs across the Basin, a method known as the ‘recharge risk assessment method’ was developed and applied. This was the primary tool used across the Basin for areas where more detailed methods were not available.

An initial estimate of the SDL for each SDL area was developed using the recharge risk assessment method. This consists of estimating the recharge, and then determining a sustainability factor based on an assessment of risk or threat to the environmentally sustainable level of take. An initial estimate SDL is created by multiplying the sustainability factor by the estimated recharge.



Windmill and stock watering point between Booligal and Ivanhoe, New South Wales



Bore used to supplement the water supply at an orchard near Cobram, Victoria

The recharge risk assessment method is a contemporary method similar to methods that have been used previously in parts of the Murray–Darling Basin for recharge estimation.

Recharge has previously been estimated for different areas of the Murray–Darling Basin using a variety of approaches. As part of the current methodology, a consistent approach has been used to estimate the diffuse dryland recharge (i.e. the recharge that occurs through infiltration below the root zone across the broader landscape). Other forms of recharge are derived from irrigation, streams, channels and floods. Across the Basin, diffuse recharge is generally the dominant recharge mechanism, but for many of the major groundwater irrigation areas, which comprise a small area but most of the extraction, other forms of recharge can be important.

WAVES (Zhang & Dawes 1998), a soil–vegetation–atmosphere model using Basin-wide datasets and a historical climate dataset based on SILO (Bureau of Meteorology n.d.), has been used to produce recharge estimates for wet, median and dry 15-year sequences for all SDL areas, including for the areas of different salinity classes within each SDL area for the historical climate and for three 2030 climate scenarios based on the CSIRO Murray–Darling Basin Sustainable Yields Project scenarios. Where field or other studies are thought to have more reliable recharge estimates, these are used. Where numerical models are available, the water balance component of numerical models has been used in preference. These models incorporate all forms of recharge including recharge to the productive aquifer.

The development and application of a sustainability factor for each groundwater system was made based on a risk assessment of the impact that groundwater extraction will have on key environmental assets, key ecosystem functions, the productive base and key environmental outcomes.

A risk ranking (high, medium or low) is given to each of the first three criteria. The risk ranking to the environmentally sustainable level of take is then established as the highest risk ranking of any of these three criteria. A risk ranking may be mitigated to one level lower where local management rules may mitigate the risk (e.g. zonal management provides protection for an environmental asset). Finally, the sustainability factor is modified based on the ranking of the fourth criteria, key environmental outcomes.

In summary, each SDL area was assessed for:

- the existence of key environmental assets within the boundary of the SDL area
- the dependency of the key environmental assets on groundwater
- the sensitivity of the key environmental assets to groundwater take.

Key ecosystem functions are the physical, chemical, and biological processes and exchanges that contribute to the self-maintenance of an ecosystem. In terms of groundwater, the fundamental physical process underpinning key ecosystem functions in the Basin is groundwater discharge (or base flow) to streams. The determination of the SDL has included an assessment of key ecosystem functions (base flow) in terms of aquifer type and the occurrence of groundwater-derived base flow. Base flow from groundwater discharge accounts for a significant proportion of flow in rivers of the Murray–Darling Basin, particularly during low-rainfall periods. The result of the base-flow assessment provides a technical background with regard to the key ecosystem function. For example, if an unregulated river reach receives groundwater base flow, it was ranked in the high-risk category, independent of the quantitative proportion of groundwater-derived streamflow determined from the base-flow assessment.

The Basin groundwater resources provide for a range of uses, including support of environmental assets and ecosystem functions, irrigation water, and drinking water for people and animals. The preservation of the productive base means the maintenance of the groundwater volume and quality, such that these uses can be maintained. Given that groundwater quality (in particular groundwater salinity) was considered as part of the key environmental outcomes for the resource, the analysis for the productive base focuses on maintaining the volume of the resource. The risk to the productive base was informed by calculating the ratio of aquifer storage to aquifer recharge. The ratio of storage to recharge provides an indication of the intrinsic nature of the aquifer, particularly in terms of its sensitivity to short-term overextraction. For example, an aquifer that has a small storage to recharge ratio will be sensitive to short-term overextraction and will also be sensitive to error in the recharge calculation, given that the SDL is derived from recharge. A reduction in recharge without a corresponding reduction in the SDL could result in the mining of the groundwater resource. For these reasons, an aquifer system with a low storage to recharge ratio has been assigned a high-risk ranking, such that a smaller proportion of recharge is allowed to be taken.

The Water Act (s. 4) defines the key environmental outcomes as a combination of ecosystem function, biodiversity, water quality and water resource health. In terms of the groundwater resources of the Basin, the key environmental outcome is considered to relate to groundwater salinity. Each SDL area was considered in terms of the risk to groundwater quality. Where an aquifer contains a mixture of good-quality and poor-quality groundwater, the risk of salinisation is greater than that for a predominantly fresh or predominantly saline aquifer. A smaller proportion of recharge was assigned where the risk of salinisation is higher.

An uncertainty ranking (high or low) is also assigned to each analysis. If the WAVES modelling alone has been used, this will produce a high uncertainty ranking. Other analyses such as numerical modelling or specific field data that constrain flux estimates may change this to a low ranking. Intensively developed groundwater resources are typically well investigated, often via the development of a numerical groundwater flow model. For SDL areas



Salinity levels near Loxton, South Australia are managed by pumping saline groundwater into an evaporation pond (foreground)

represented by a numerical groundwater model, there is more certainty inherent in the following parameters:

- Recharge — numerical modelling considers rainfall infiltration, flood recharge, irrigation accessions, throughflow and river leakage recharge sources. Areas that are not represented by a numerical model have diffuse recharge determined by WAVES modelling.
- Storage — the numerical model results will provide an indication of the volume of groundwater in storage, whereas non-modelled areas will have a less precise estimate of this volume.
- Extraction — areas represented by numerical models are more likely to incorporate good-quality metered groundwater usage data, whereas non-modelled areas are often managed less rigorously and groundwater usage may be based on an estimation of extraction.

For areas of high uncertainty, the sustainability factor has been reduced to make an allowance for the potential margin of error associated with that factor. An area of identical risk ranking but lower uncertainty (e.g. an area represented by a numerical groundwater model) will have a higher overall sustainability factor, given that there is greater confidence associated with that actor.

The sustainability factor is assigned on the basis of the:

- risk ranking of the environmentally sustainable level of take
- risk ranking of the key environmental outcome
- uncertainty ranking.

For low uncertainty ranking, the sustainability factor is assigned to be 0.1, 0.5 and 0.7 for high, medium and low environmental risk rankings, respectively. For groundwater where salinisation is a risk, this is multiplied by 0.8 for where the salinity levels are lowest (salinity class 1: fresh water), 0.9 for where the salinity levels are low (salinity class 2: relatively fresh water) and by 1 in other cases. Where there is high uncertainty in relation to groundwater information, the sustainability factor is halved commensurate with this uncertainty.

The complete methodology was then applied at the scale of groundwater SDL area to develop initial SDL estimates by multiplying the sustainability factor by the recharge.

Numerical groundwater modelling

Numerical groundwater modelling represents the third stage of the process for quantifying SDLs in those cases where a detailed groundwater model is available. This step follows the determination of water resource plan areas for groundwater and the calculation of initial estimate SDLs for these areas from the application of a recharge risk assessment method.

The objectives of numerical modelling are to provide information to support the determination of the SDL proposals, to aid the specification of any requirements for the groundwater water resource plan and to provide information on impacts on surface-water streams. In order to satisfy the environmentally sustainable level of take:

- where a key environmental asset that is also a groundwater-dependent ecosystem has been identified in the vicinity of the extraction zone, impacts of the extraction over a 50-year period on water levels in the surficial aquifer at the site of the environmental asset should be such that the key environmental asset is not compromised
- the numerical model also estimates the impact of extraction over a 50-year period on nearby streams in order to assess that key ecosystem functions are not compromised, particularly during low rainfall periods when base flow from groundwater discharge accounts for a significant proportion of flow in rivers
- for productive base, an SDL volume should be such that groundwater levels are stabilised within a 50-year time period to a level that protects the integrity of the groundwater resource
- in terms of the groundwater resources of the Basin, the key environmental outcome is considered to relate to groundwater salinity. The numerical models may also be able to inform some situations where groundwater salinisation is an issue, but generally the models are not specifically designed for this purpose.

Groundwater models have been developed and calibrated for the freshwater aquifers that support most of the groundwater extraction in the Murray–Darling Basin. Eleven groundwater models were considered in determining the groundwater SDL. These are models that were developed or modified in the CSIRO Murray–Darling Basin Sustainable Yields Project (CSIRO 2008). In addition, results from some other existing models (where appropriate fit-for-purpose state or territory models existed) were used to inform the recharge risk assessment method results (e.g. Angas–Bremer, Eastern Mount Lofty Ranges).

The 11 numerical models are all based on MODFLOW software. They cover most of the major extraction zones of the Murray–Darling Basin (Upper Condamine, Lower Gwydir, Lower Namoi, Upper Namoi, Lower Macquarie, Upper Macquarie, Lower Lachlan, Upper Lachlan, Lower Murrumbidgee, Mid-Murrumbidgee and the Southern Riverine Plains) (Figure 4.28). The models cover areas that represent 73% of the Murray–Darling Basin 2007–08 extraction (CSIRO 2008). Most of these areas are located in New South Wales and the models were generally developed by NSW state agencies. New models were not constructed for the development of the proposed Basin Plan. These 11 groundwater flow models were, however, upgraded and improved by updating and extending datasets in the calibration model.

For SDL areas that are represented by a numerical model, the modelled water balance was used to develop the proposed SDL. This means that the total recharge for the purposes of developing an SDL included contributions from rainfall infiltration, flood recharge, irrigation accession, throughflow and river leakage.



*Blue damselfly or wandering ringtail
at Reedy Swamp near Shepparton,
Victoria*

For each numerical model, a suite of prediction scenarios was prescribed involving various settings for extraction limit, entitlement and other features associated with the management of the groundwater system. All scenarios were run for 50 years. These scenarios were designed to test the sensitivity of the proposed extraction limit to a range of drivers and to test the robustness of the SDL proposals.

The model results of these future development scenarios were assessed in relation to four environmentally sustainable level of take characteristics:

- stabilisation of groundwater levels (productive base and key environmental outcome requirement)
- ability to maintain volume of extraction (productive base requirement)
- prevention of dewatering of confined aquifers (productive base and key environmental outcome requirement)
- impact on surface-water streamflow (key environmental assets and key ecosystem functions requirement).



Figure 4.28 The 11 largest and most developed alluvial groundwater systems where models were used to calculate groundwater SDLs

Trade from surface water to groundwater

For the groundwater SDL areas listed in Table 4.15, further development is possible provided the relevant states undertake an assessment to identify the maximum volume that could be taken from the groundwater system without compromising the environmentally sustainable level of take. This assessment would need to meet the water resource planning requirements (see Section 6.1) to limit take spatially and temporally to ensure that environmentally sustainable level of take characteristics are not compromised.

One mechanism to achieve this is by trade from surface water to groundwater. This approach will ensure there is no reduction in surface-water planned environmental water and allow groundwater use to grow where feasible without compromising environmentally sustainable level of take characteristics (see Section 6.2 for a definition of planned environmental water). This approach relies on a 1:1 relationship between surface water and groundwater; that is, surface water and groundwater are effectively components of one water resource.

Table 4.15 Groundwater SDL areas where trade from surface water is feasible

Groundwater SDL area	Jurisdiction	SDL (GL/y)
Australian Capital Territory (Groundwater)	ACT	4.4
Eastern Porous Rock: Macquarie–Castlereagh	NSW	5.2
Inverell Basalt	NSW	2.9
Lachlan Fold Belt: Lachlan	NSW	23.1
Lachlan Fold Belt: Macquarie–Castlereagh	NSW	47.7
Lachlan Fold Belt: Murray	NSW	5.1
Lachlan Fold Belt: Murrumbidgee	NSW	30.9
Liverpool Ranges Basalt	NSW	2.7
New England Fold Belt: Border Rivers	NSW	3.4
New England Fold Belt: Gwydir	NSW	4.1
New England Fold Belt: Namoi	NSW	15.6
Condamine Fractured Rock	Queensland	2.1
Queensland Border Rivers Fractured Rock	Queensland	6.8
Goulburn–Broken Highlands	Victoria	9.8
Murray Highlands	Victoria	4.4
Ovens Highlands	Victoria	3.2
Wimmera–Avoca Highlands	Victoria	0.2

Unassigned groundwater

In some areas where there are no transitional or interim water resource plans, groundwater resources exist that are not fully developed to the limit beyond which an environmentally sustainable level of take would be compromised. In these areas, unassigned groundwater is the difference between an environmentally sustainable level of take and the current level of take. The volumes of unassigned water appear to provide a significant opportunity for growth, but the low level of use in these systems may reflect factors such as inaccessibility, high costs of extraction, low yield or poor-quality (high salinity) groundwater. See Table 4.16 for volumes of unassigned groundwater.

Table 4.16 Overview of groundwater SDLs including unassigned water

Region	Code ^a	SDL area	Current diversion limit (GL/y) ^b	Current use (GL/y) ^c	SDL (GL/y) ^d	SDL (including unassigned water) (GL/y) ^e
Barwon–Darling	GS34	Lachlan Fold Belt: Western	1.2	1.2	1.2	13
Border Rivers	GS69	Sediments above the Great Artesian Basin: Border Rivers	0.1	0.1	0.1	42
Condamine–Balonne	GS70	Sediments above the Great Artesian Basin: Condamine–Balonne	0.3	0.3	0.3	5
	GS73	St George Alluvium: Condamine–Balonne (deep)	7.5	7.5	7.5	12.6
		St George Alluvium: Condamine–Balonne (shallow)	2.5	2.5	2.5	40
	GS75	St George Alluvium: Warrego–Paroo–Nebine	0.3	0.3	0.3	6.5
Eastern Mount Lofty Ranges	GS2	Eastern Mount Lofty Ranges	19.3	19.3	19.3	33.5
Goulburn–Broken	GS14	Victorian Riverine Sedimentary Plain (deep: Renmark Group and Calivil Formation)	89.6	89.6	89.6	127
		Victorian Riverine Sedimentary Plain (shallow: Shepparton Formation)	83.3	83.3	83.3	85
Lachlan	GS53	Orange Basalt	6.9	6.9	6.9	24
Lower Darling	GS19	Adelaide Fold Belt	3	3	3	3.3
	GS29	Kanmantoo Fold Belt	8.2	8.2	8.2	27.5
	GS37	Lower Darling Alluvium	1.4	1.4	1.4	1.9
	GS63	Western Porous Rock	29.3	29.3	29.3	71
Macquarie–Castlereagh	GS46	NSW Alluvium above the Great Artesian Basin	1.2	1.2	1.2	29
	GS62	Warrumbungle Basalt	0.5	0.5	0.5	0.6
Moonie	GS71	Sediments above the Great Artesian Basin: Moonie	0.5	0.5	0.5	9
	GS74	St George Alluvium: Moonie	0.5	0.5	0.5	1.7
Murray	GS7	SA Murray (Groundwater)	1.8	1.8	1.8	19
	GS8	SA Murray Salt Interception Schemes	11.1	11.1	11.1	28
	GS17	Wimmera–Mallee Border Zone (Loxton Parilla Sands)	0	0	0	9.7
		Wimmera–Mallee Border Zone (Murray Group Limestone)	8.8	8.8	8.8	14.1
Wimmera–Mallee Border Zone (Tertiary Confined Sand Aquifer)	1.1					
Murrumbidgee	GS22	Billabong Creek Alluvium	2	2	2	6.1
Paroo	GS49	NSW Sediments above the Great Artesian Basin	1	1	1	46
	GS55	Upper Darling Alluvium	2.4	2.4	2.4	4.8
Warrego	GS72	Sediments above the Great Artesian Basin: Warrego–Paroo–Nebine	1.1	1.1	1.1	25.4
	GS78	Warrego Alluvium	0.7	0.7	0.7	26.6
Wimmera–Avoca	GS15	West Wimmera (Loxton Parilla Sands)	0	0	0	12
		West Wimmera (Murray Group Limestone)	1.9	1.9	1.9	25.5
		West Wimmera (Tertiary Confined Sand Aquifer)	0.8	0.8	0.8	4
	GS18	Wimmera–Mallee Sedimentary Plain	0.6	0.6	0.6	27

a This code relates to each SDL area in Figure 3.3, Section 3.2 of this volume.

b Current diversion limit is based on plan limit or current use if there is no plan.

c Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data were available, the average of these values were used.

d SDL figures exclude unassigned groundwater

e SDL figures in this column include unassigned groundwater

Fossil groundwater

Fossil groundwater is a resource that has recharge rates so low as to effectively be zero within the time frame of consideration of the proposed Basin Plan, yet significant volumes exist in many fossil groundwater systems. Any extraction from these resources is essentially mining the resource. A fossil groundwater resource exists in the Mallee in Victoria and South Australia and it is possible that similar resources may be discovered and developed in the future.

The extraction of groundwater in the Mallee in South Australia and western Victoria along the state border is regulated by a cross-border agreement contained in both South Australian and Victorian state legislation (the *Groundwater (Border Agreement) Act 1986* (SA and Vic.)). There are no key environmental assets associated with this fossil resource, therefore no key environmental asset is compromised by the take.

The designated area, which is a 40-km-wide strip centred on the South Australia – Victoria border, is not connected to surface-water resources. Therefore, there is no key ecosystem function (contribution to streamflow) that can be compromised.

At the current rate of use it has been estimated that the fossil groundwater resource in the Mallee in South Australia and in western Victoria will be depleted by approximately 15% in 200 or more years. Continuing this rate of take does not compromise the productive base.

The risk of salinisation of this groundwater will not be increased by the above rates of groundwater extraction. Therefore, the key environmental outcome is not compromised.

Hence it is considered that the level of extraction regulated by the border agreement will not compromise the environmentally sustainable level of take.

The SDL proposals for fossil water in the Mallee in South Australia and in western Victoria reflect the maximum permitted use under the state Acts. This rate of decline (15% in 200 years) has also been adopted as the basis of the SDL for connected fossil groundwater resources in adjacent SDL areas.

In the case that other fossil groundwater resources are discovered after the Basin Plan is made, it is unlikely that they will be as large as the Mallee and a different rate of depletion may be appropriate. For newly discovered fossil groundwater resources, the resource should not be exhausted within a period of 200 years, except where the proposed use is solely for critical human water needs, in which case a period of 100 years is proposed.

Other considerations

Works and measures

The Living Murray program commenced in 2004, aiming to recover 500 GL/y for six environmental assets (icon sites) along the River Murray including the river channel itself. A number of works and measures (e.g. regulating structures, delivery channels) are being built to ensure that the water can be effectively delivered to the identified assets.

The baseline model for the River Murray reflects The Living Murray program's environmental works and measures that have been built to date, and those that are committed to be built. In the modelling undertaken to develop surface-water SDLs, environmental demands for the various environmental assets have been included either as a series of minimum flow requirements or using environmental flow rules to achieve environmental targets. These demands have not incorporated the environmental works

and measures consistent with the hydrologic indicator site method. (That is, indicator sites are used to inform provision of water to a range of locations that are not neatly matched to particular works and measures.)

Snowy Mountains Hydro-electric Scheme (Snowy Scheme)

Provisions of the Basin Plan must not be inconsistent with the Snowy Water Licence (Water Act s. 21(6)), and any variation to the licence after 3 March 2008 is to be disregarded for the purposes of the Basin Plan unless the variation is prescribed by a regulation of the Australian Government (s. 21(7)).

The Snowy Water Licence was recently amended by the NSW Government.

The NSW Government and the federal Department for Sustainability, Environment, Water, Population and Communities are aware of the implications of the licence variation in relation to the Water Act and the department has advised its intention to seek an amendment to the relevant regulations in 2010 to recognise this variation.

The proposed Basin Plan has been developed consistent with the Snowy Water Licence as amended, anticipating a regulation being made before finalisation of the Basin Plan.

Salt interception schemes

Salt interception schemes divert saline groundwater before it enters rivers and streams. They are constructed and operated for the purpose of meeting river water quality targets. In most cases, a multiple wellpoint borefield and pump system extracts groundwater and pumps it to an evaporation basin some distance from the river. In some cases, saline surface water (irrigation drainage, including irrigation return flows, saline groundwater discharge and rainfall run-off) is also diverted to evaporation basins.

Salt interception schemes have not traditionally been included in Basin state entitlements and allocations, but the diversion of water by salt interception schemes falls into the definition of 'take' described in the Water Act (s. 4), and will be limited by SDLs.

While salt interception schemes in some cases remove water that has already been accounted for as surface-water take (i.e. by removing water that has recharged in the form of leakage from irrigation areas), it is impossible to differentiate between the various forms of recharge.

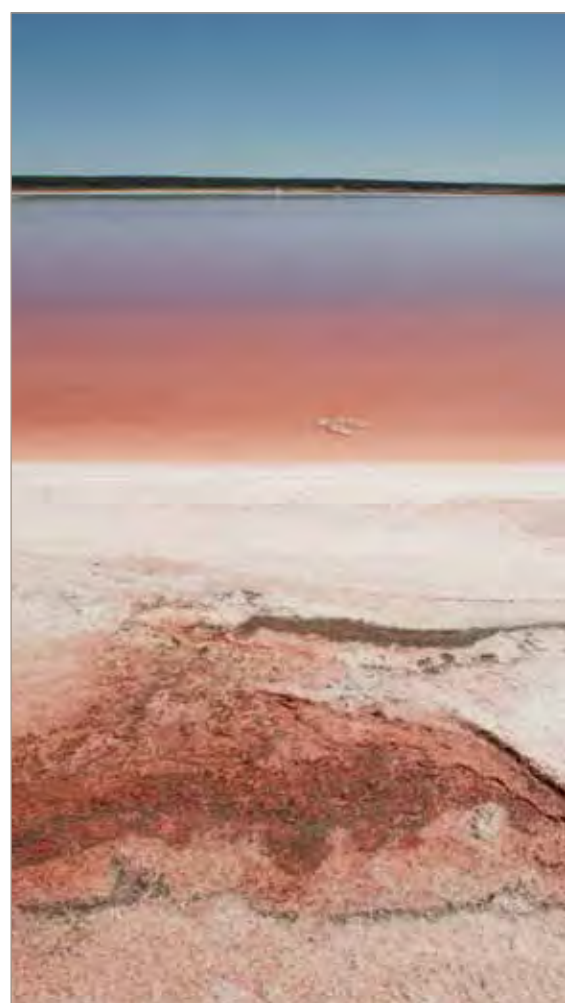
In South Australia, the SA Murray Salt Interception Schemes SDL Area (GS8) has been created for salt interception schemes along the River Murray, from upstream of Morgan to the NSW and Victorian border, defined by a 10-km band north and south of the river. Other than salt interception schemes, there is no known groundwater take in this area as it is mostly highly saline.

For New South Wales and Victoria, SDL proposals have been developed to reflect the salt interception schemes take in these areas.

Basin states will be required to put in place appropriate arrangements to address this form of take for both existing and planned salt interception schemes.

Managed aquifer recharge

Managed aquifer recharge is the intentional recharge of water to aquifers for subsequent recovery or environmental benefit and is a similar concept to that of return flows. Managed aquifer recharge can help to sustain groundwater supplies (Dillon et al. 2009) and includes many different techniques that use



Buronga groundwater salt interception scheme near Buronga, New South Wales

combinations of infrastructure, such as rivers, ponds and boreholes, to achieve the desired objective of aquifer recharge. A number of managed aquifer recharge schemes exist or are proposed within the Basin.

The National Water Quality Management Strategy, adopted in 1994, is an Australian guideline that includes a framework for managing the health and environmental risks of managed aquifer recharge.

Possible water sources for managed aquifer recharge are:

- stormwater
- water recycled from wastewater treatment plants
- water from streams and lakes
- groundwater drawn from other aquifers or drawn remotely from the same aquifer
- water from drinking water distribution systems, including desalinated seawater.

All recharge water for a managed aquifer recharge project sourced from Murray–Darling Basin water resources is considered ‘take’ and must be accounted for appropriately under the relevant water resource plans. Under the proposed Basin Plan, groundwater recovered from a managed aquifer recharge scheme will not be take that is limited by the relevant groundwater SDL. However, any part of take related to the managed aquifer recharge scheme that is in excess of the volume of managed aquifer recharge plus losses will be limited by the relevant groundwater SDL. There may be additional regulations with respect to the recoverable volume of water under state or territory law.

4.5 Implications of the proposals for long-term average sustainable diversion limits

Implementation of the proposals for long-term average sustainable diversion limits (SDLs) in the Basin Plan will cause significant change to the diversion and use of water resources, and consequently to the allocation of other productive resources in the Basin and national economy.

The Murray–Darling Basin Authority (MDBA) recognises that reducing current diversion limits in accordance with the proposal to provide additional water for the environment will have a range of economic, social and environmental implications, both positive and negative.

Section 4.3 of this chapter describes the conceptual framework and approach used to analyse the potential social and economic implications of the diversion limit scenarios to be included in the proposed Basin Plan. This section assesses the likely implications of each scenario.

The section first discusses the implications for agriculture and other industries in the Basin, focusing specifically on irrigated agriculture as the largest consumer of water in the Basin. The analysis considers the effect on the Basin’s major irrigated agricultural industries — cotton, rice, dairy and horticulture. Associated regional impacts are also assessed, as well as the effect on local communities and flow-on effects for the wider economy. Finally, this section considers some of the benefits likely to be provided by the SDL proposals.

Implications for irrigated agriculture

As noted in Chapter 2, in 2005–06 the Basin accounted for approximately 39% (\$15 billion) of Australia’s agricultural output, which in turn contributed about 2.3% to the nation’s gross domestic product. Of the Basin’s agricultural output, irrigated agriculture accounted for 45% (\$5.5 billion) of the value of production in 2005–06.

To understand the likely impacts of introducing an SDL on irrigated agriculture and the flow-on effects to the wider Basin economy, MDBA commissioned the Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences (ABARE–BRS 2010a) to undertake economic modelling to estimate changes in land and water use and in the gross value of irrigated agricultural production for a number of agricultural sectors and the Basin regions.

Not unexpectedly, the analysis indicates that the greater the reduction in current diversion limits, the greater the economic impact on the agriculture sector. The estimated Basin-scale impacts for irrigated agriculture are shown in Table 4.17. Unless stated otherwise, the analysis presented in this section assumes an interregional trade scenario.

At Basin scale, it is estimated that gross value of irrigated agricultural production would decline by around 13% under a 3,000 GL/y scenario to a new level of \$5,415 million. Under a 3,500 GL/y scenario, the decline in gross value of irrigated agricultural production would be 15%; at 4,000 GL/y, it would be 17%. These results assume trade of water away from relatively lower value broadacre activities to relatively higher value horticultural activities.

Table 4.17 Summary of economic impacts of reduced diversion limits on irrigated agricultural activity: Murray–Darling Basin^a

	Baseline	Basin Plan	Change (%)	Value change
3,000 GL Basin Plan scenario				
Water use (GL/y) ^b	10,403	7,736	-26	-2,666
Gross value of irrigated agricultural production (\$m/y)	6,220	5,415	-13	-805
Profit (\$m/y)	1,956	1,833	-6	-123
Gross regional product (\$m/y)	59,033	58,359	-1.1	-674
Basin employment ('000) ^c	922	921	-0.09	-0.76
3,500 GL Basin Plan scenario				
Water use (GL/y) ^b	10,403	7,311	-30	-3,091
Gross value of irrigated agricultural production (\$m/y)	6,220	5,280	-15	-940
Profit (\$m/y)	1,956	1,804	-8	-152
Gross regional product (\$m/y)	59,033	58,240	-1.3	-793
Basin employment ('000) ^c	922	921	-0.1	-0.92
4,000 GL Basin Plan scenario				
Water use (GL/y) ^b	10,403	6,895	-34	-3,507
Gross value of irrigated agricultural production (\$m/y)	6,220	5,145	-17	-1,075
Profit (\$m/y)	1,956	1,773	-9	-183
Gross regional product (\$m/y)	59,033	58,122	-1.5	-911
Basin employment ('000) ^c	922	921	-0.12	-1.1

a Estimates are based on modelling that includes intraregional and interregional water trade in the southern Basin.

b Water use includes irrigation sourced from groundwater and surface water, and is based on estimates of use in irrigation. It differs from long-term average diversion limits, which include additional volumes of water not used for irrigation, such as that lost during transmission through irrigation channels.

c Percentage impacts for employment differ across scenarios while employment levels reported here are the same. This reflects the effects of rounding.

Source: ABARE–BRS (2010a)

Without interregional trade, the estimated fall in gross value of irrigated agricultural production would be 14, 16 and 19% under the 3,000, 3,500 and 4,000 GL/y scenarios respectively. Without interregional water trade in the southern Basin, the loss is estimated to be greater because water would not be moving freely across regional borders to more profitable uses. It is likely that actual water trades would result in impacts between the two estimates for 'with' and 'without' trade.

Table 4.17 also shows much longer-term estimates for gross regional product and employment for the Basin as a whole, resulting from the flow-through impact of reduced irrigated agricultural activity. Under the three scenarios, reductions in irrigated agricultural activity are estimated to result in permanent, long-term reductions in gross regional product of about 1.1 to 1.5%. However, these modelling results provide estimates of the economic impacts in the Basin in isolation from other relevant government water policy. Impacts will be lessened in accordance with the effectiveness of other policies. For example, recent ABARE estimates for a 3,500 GL/y scenario indicate that the Australian Government's \$12.6 billion Water for the Future program would reduce the impact on the long-term Basin gross regional product from about 1.4% to about 0.7%. Gross regional product is the measure of total economic production in the Basin; the estimate of the fall in Basin gross regional product excludes effects on the economy of the Australian Capital Territory. Gross regional product estimates are only partial estimates of changes in welfare and do not include any social costs or benefits associated with the proposed SDLs, or any social, economic or environmental benefits from increased environmental flows.

The Water for the Future program includes the Restoring the Balance water entitlement purchase program and the Sustainable Rural Water Use and Infrastructure Program. Water for the Future is likely to mitigate the eventual impacts on regional communities by providing additional water savings which offset diversion limit reductions (through infrastructure investments), and by providing regional economic stimulus (through entitlement sale proceeds and infrastructure investment expenditure) (ABARE–BRS 2010c).

In terms of employment impacts, in isolation from other government programs that may affect employment levels, the estimates provided for MDBA (ABARE–BRS 2010a) indicate that in the long term, approximately 800–1,000 full-time jobs would be lost Basin-wide, or around 0.1% of current employment levels. At the national level, in the long term, the decline in gross domestic product (from a baseline of \$759 billion) is estimated to be in the order of 0.11% to 0.15% (\$0.8 to \$1.1 billion) with about 0.03% (approximately 3,000) fewer jobs in the future economy.

Comparison with other model results

As described in section 4.3, additional analysis was undertaken by the Centre of Policy Studies at Monash University (Wittwer 2010) and the Risk and Sustainable Management Group at the University of Queensland (Mallawaarachchi 2010) to provide further insights into the likely impacts.

As would be expected, some differences emerge from the results. For the 3,500 GL scenario, ABARE's Water Trade Model estimates a decline in Basin gross regional product of –1.3%, whereas the Centre of Policy Studies estimates a significantly smaller reduction of –0.12% of gross regional product.

One of the primary reasons for output variance between the two models is the extent to which factors of production (land, labour and capital) are assumed to be mobile. The Centre of Policy Studies model implicitly assumes

that factors of production are highly mobile between the sectors of the economy, whereas the ABARE modelling framework has a more restrictive degree of mobility. The two sets of results illustrate that the net economic effects of reducing diversion limits depend on a variety of factors, as discussed in Section 4.3, and caution needs to be exercised in interpreting results. The results also show that the ability of regional economies to reallocate economic activity from irrigated to non-irrigated agriculture and the flow-on effect from agriculture to other economic activities requires closer scrutiny to understand the impacts in more detail.

The University of Queensland's Risk and Sustainable Management Group assessed the potential impacts of one of the earlier scenarios used in MDBA's consideration of socioeconomic implications, which was equivalent to a 35.5% reduction in agricultural water use (Mallawaarachchi 2010). Results indicate a 16% reduction in gross value of irrigated agricultural production, equating reasonably closely to ABARE's analysis of a 15% reduction in gross value of irrigated agricultural production for a 3,500 GL scenario. The similarity in results in these two model outputs provides some level of confidence in the estimate of impacts on irrigated production.

For a better understanding of the flow-on effects, MDBA commissioned additional consultancies, in particular those by Marsden Jacob Associates et al. (2010) and the Bureau of Rural Sciences and University of New England (ABARE–BRS 2010b), as noted in Section 4.3.

Regional implications

When viewed from a national or Basin-wide perspective, the effects of the scenarios for reducing current diversion limits are estimated to be quite modest. However, this analysis disguises the fact that the most significant negative impacts of a reduction in water available for consumptive use will be concentrated in particular subregions and their local communities. It is in these communities that significant social and economic impacts will be felt, particularly in the short term, as they adjust to the changes that result from implementation of the Basin Plan.

At a regional level, it is estimated that the largest reductions in average annual gross value of irrigated agricultural production would be spread across the northern and southern Basin (ABARE 2010a). Figure 4.29 shows the range of results for all regions. It should be noted that the SDL proposals vary between regions for both volumetric and percentage measures.

The largest estimated decreases in gross value of irrigated agricultural production across the range of proposed diversion limits are likely to occur in the southern Basin, with relatively large declines estimated for the Murrumbidgee, Goulburn–Broken, NSW Murray, Victorian Murray and Loddon–Avoca regions. In percentage terms, the biggest reductions would be in the Murrumbidgee (22–29%), NSW Murray (16–23%) and the Loddon–Avoca (15–23%) regions.

Overall, the largest percentage changes are estimated in the northern Basin — in the Moonie (34–42%) and Gwydir (22–29%) regions — while the biggest absolute reductions in the northern Basin are likely to be in the Gwydir, Condamine–Balonne, Namoi and Macquarie–Castlereagh regions. The estimated reductions in gross value of irrigated agricultural production in the Moonie, Gwydir and Barwon–Darling regions are high in relation to the reductions in water use; this is due to a relatively undiversified land-use pattern and little opportunity for water trade, with cotton tending to represent more than 80% of total irrigated land use in these regions.



Hay-baling contractor with equipment used to bale failed cereal crops to supply stockfeed for farmers in the Oaklands area, New South Wales, during drought in 2007

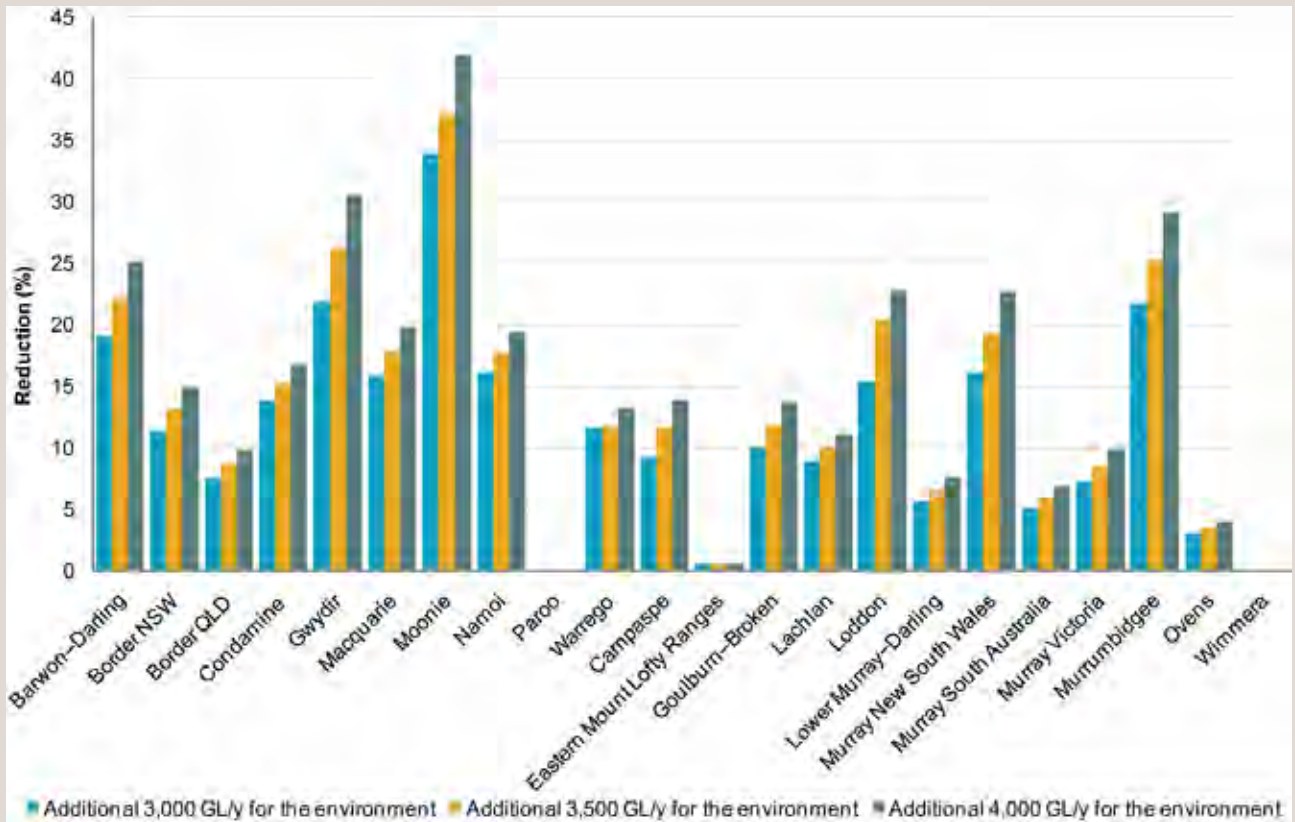


Figure 4.29 Estimated reductions in gross value of irrigated agricultural production, due to reductions in current diversion limits: Murray-Darling Basin

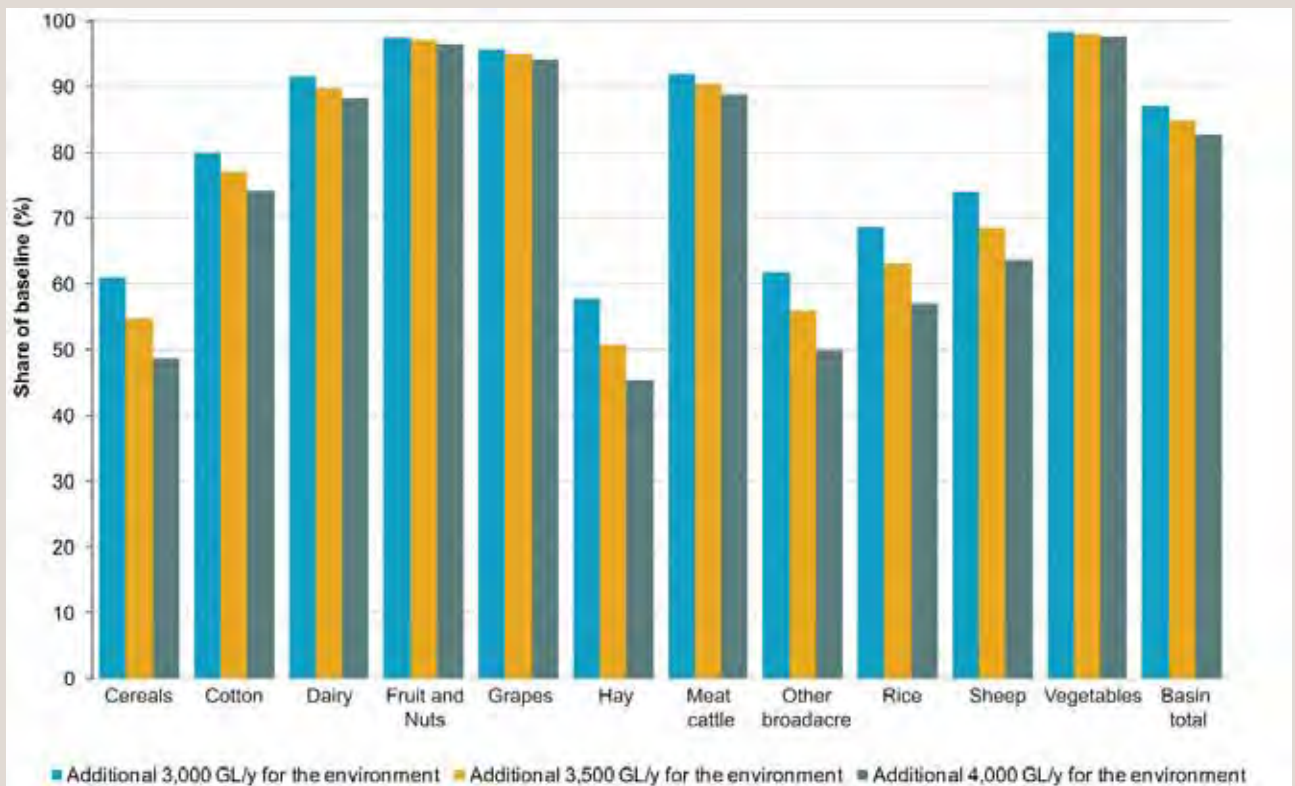


Figure 4.30 Estimated share of baseline gross value irrigated agricultural production for key commodities, due to reductions in current diversion limits: Murray-Darling Basin

Source: ABARE-BRS (2010a)

Effects of interregional trade

ABARE undertook an analysis of the effects of each diversion limit scenario on the average annual gross value of irrigated agricultural production in the Basin, assuming both interregional trade (as presented above) and no interregional trade. Intraregional trade (within regions) is accounted for in all scenarios.

Notably, the larger the SDL reduction, the more difference in the results caused by allowing for interregional water trade in the connected southern Basin.

Under a 3,000 GL scenario, the decline in gross value of irrigated agricultural production was around \$84 million higher without interregional trade, while for a 4,000 GL scenario, the decline in gross value of irrigated agricultural production was around \$115 million higher without interregional trade.

The significance of the difference in the estimates is more apparent at a regional scale. In the southern Basin, the ability to engage in interregional trade can reduce the overall impact of reductions in current diversion limits on gross value of irrigated agricultural production (Frontier Economics 2010; ABARE–BRS 2010a). Trade allows for water to be moved to relatively higher-value uses out of regions where irrigators are heavily engaged in relatively lower-value activities. However, while interregional trade can offset the impacts of reduced diversion limits on gross value of irrigated agricultural production in some regions, it can exacerbate impacts in other regions, depending on whether regions are net buyers or sellers of water.

The net result of the movement of water to relatively higher-value production activities is that the estimated reduction in gross value of irrigated agricultural production tends to fall in the Lower Murray–Darling, Campaspe, Goulburn–Broken, Victorian Murray and SA Murray regions, and increases in the Murrumbidgee and NSW Murray regions.

In practice, it could be expected that the indicative outcome may lie somewhere between the two estimates, depending on how rapidly adjustment occurs and the flexibility of water trade markets.

Implications for industry

As with individual regions, each scenario will have different effects across commodities. Figure 4.30 shows the impact of the range of the proposed diversion limits on gross value of irrigated agricultural production for key commodities.

Figure 4.30 outlines the estimated revised capacity relative to the analysis baseline for each commodity, and indicates that broadacre irrigated agriculture would be most likely to be affected, while most perennial and annual horticultural crops are less likely to be affected.

These results are consistent with water being traded away from lower value broadacre activities to higher value horticultural activities.

In terms of commodities, the results suggest annual irrigated broadacre activities would incur the largest reductions in the gross value of irrigated agricultural production (both in percentage change and absolute terms), whereas the decline in the value of horticultural activities (both annual and perennial) is relatively modest. Least affected of the broadacre activities is cotton, with an estimated 20–26% decline in gross value of irrigated agricultural production compared with rice (31–43%) cereals (39–51%) and hay (42–55%). Livestock activities, dependent on the production of irrigated fodder, are estimated to be variously affected, with gross value of irrigated agricultural production for sheep being reduced by 26–36%, and beef cattle and dairy by around 10% (ABARE–BRS 2010a).



*Canola crop near Temora, 2010,
New South Wales*

Northern Basin and southern Basin

In examining the broader social and economic implications, it is important to recognise the key differences between the northern and southern areas of the Basin. In the northern Basin there are highly variable river flows, few public storages and many large-volume private storages. There are some small farms and a limited number of communal irrigation schemes. Cotton represents more than 50% of the gross value of irrigated agricultural production in the northern Basin, and the economic and social outcomes of many communities are notably linked to this commodity and its related activities, such as processing. In contrast, southern Basin irrigation is highly regulated with large public storages, many small farms and large communal irrigation schemes. Dairy, rice and horticulture are the predominant activities.

The implications of each diversion limit scenario by region and sector for the northern and southern Basin respectively are discussed in the following sections.

Northern Basin

The estimated impacts on water use and gross value of irrigated agricultural production for the northern Basin regions are presented in Table 4.18.

A summary of the likely flow-on effects and responses for key irrigation districts, as recorded by Marsden Jacob Associates et al. (2010) for 20% and 40% scenarios respectively, is shown in Table 4.19. The 3,000 GL, 3,500 GL and 4,000 GL scenarios represent proposed average reductions of between 22% and 29% in current diversion limits at Basin scale.

The Warrego, Paroo, Moonie and Barwon Darling regions were not analysed in this study and the areas shown relate to the associated irrigation districts within the broader CSIRO Murray–Darling Basin Sustainable Yields Project regions (CSIRO 2008). In recording responses from regional stakeholders, it was assumed that no government adjustment assistance would be provided.

Table 4.18 Estimated water use and share of baseline gross value of irrigated agricultural production, due to reductions in current diversion limits: northern Murray–Basin

	Baseline		3,000 GL				3,500 GL				4,000 GL			
	Water use	Gross value of irrigated agricultural production	Water use		Gross value of irrigated agricultural production		Water use		Gross value of irrigated agricultural production		Water use		Gross value of irrigated agricultural production	
			GL	% of base-line	\$m	% of base-line	GL	% of base-line	\$m	% of base-line	GL	% of base-line	\$m	% of base-line
Condamine–Balonne	458	457	324	71	394	86	310	68	386.99	85	296	65	380	83
Border Rivers (Old)	216	245	178	82	227	93	172	79	224.25	91	166	77	221	90
Border Rivers (NSW)	245	185	197	80	164	89	190	77	160.3	87	182	74	157	85
Warrego	11	7	7	61	6	88	7	61	6.15	88	6	56	6	87
Paroo	4	6	4	100	6	100	4	100	6.14	100	4	100	6	100
Namoi	581	332	469	81	279	84	458	79	273.47	82	446	77	268	81
Macquarie–Castlereagh	465	275	352	76	231	84	339	73	225.9	82	326	70	221	80
Moonie	63	40	40	64	26	66	38	60	25.05	63	35	55	23	58
Gwydir	575	321	428	74	250	78	402	70	236.88	74	376	65	223	70
Barwon–Darling	480	172	376	78	139	81	360	75	133.77	78	344	72	129	75
Northern Basin	3,099	2,039	2,374	77	1,722.27	84	2,279	74	1,678.9	82	2,182	70	1,634	80

Source: ABARE–BRS (2010a)

Table 4.19 Summary of indirect (flow-on) responses to changes in diversion limits: northern Murray–Darling Basin

Region	Key sectors	–20% scenario	–40% scenario
Lower Balonne (Condamine–Balonne)	Cotton, grapes and other horticulture	Some positive impacts from implementation of water-use efficiency as temporary investment and employment to establish new infrastructure occurs. Lower ongoing levels of employment in gins and other upstream and downstream sectors (e.g. farm inputs and transport).	One gin in broader Lower Balonne could close. Permanent migration out of the region, changing demographics (fewer people of working age) and affecting the viability of many businesses and the potential viability of some government services.
Border Rivers	Cotton, horticulture, livestock	Significant loss of economic activity in water-dependent communities.	Major loss of economic activity in water-dependent communities and significant loss of activity in more diverse centres.
Gwydir	Cotton, broadacre, livestock	Significant loss of economic activity in water-dependent communities.	Major loss of economic activity in water-dependent communities and significant loss of activity in more diverse centres.
Namoi	Cotton, broadacre, livestock	Significant loss of economic activity in water-dependent communities.	Major loss of economic activity in water-dependent communities and significant loss of activity in more diverse centres.
Macquarie Valley (Macquarie–Castlereagh)	Cotton processing	A permanent reduction in production would see consolidation of processing capacity with closure of one gin.	Probable halving of the processing capability with closure of two gins. Significant reduction in employment and value adding.
	Service sectors	Some loss of capacity and employment across sectors including retail, pubs and clubs.	Major impact on service sectors, undermining the quantum needed to support these services.

Source: Marsden Jacob Associates et al. (2010)

Cotton

Cotton, as the dominant irrigated crop in the northern Basin, warrants further analysis. Cotton growing is an annual activity where the area planted can be varied dramatically between seasons in response to fluctuations in water availability. Drought conditions in recent years have seen a significant reduction in the areas of cotton planted and cotton production across the Basin. Cotton is grown in the Queensland Condamine–Balonne region, the NSW regions of Gwydir, Namoi, Macquarie–Castlereagh and Lachlan, and the Border Rivers region (New South Wales and Queensland). While effects on downstream processing sectors are complex and may depend on a range of factors, changes in cotton production (as estimated by the modelling) provide an indication of places where downstream processing may be affected. While generally considered part of the southern Basin, Lachlan has been incorporated to better reflect its connection to the northern Basin.

For each region the estimated revised capacity, relative to the analysis baseline, is shown in Figure 4.31.

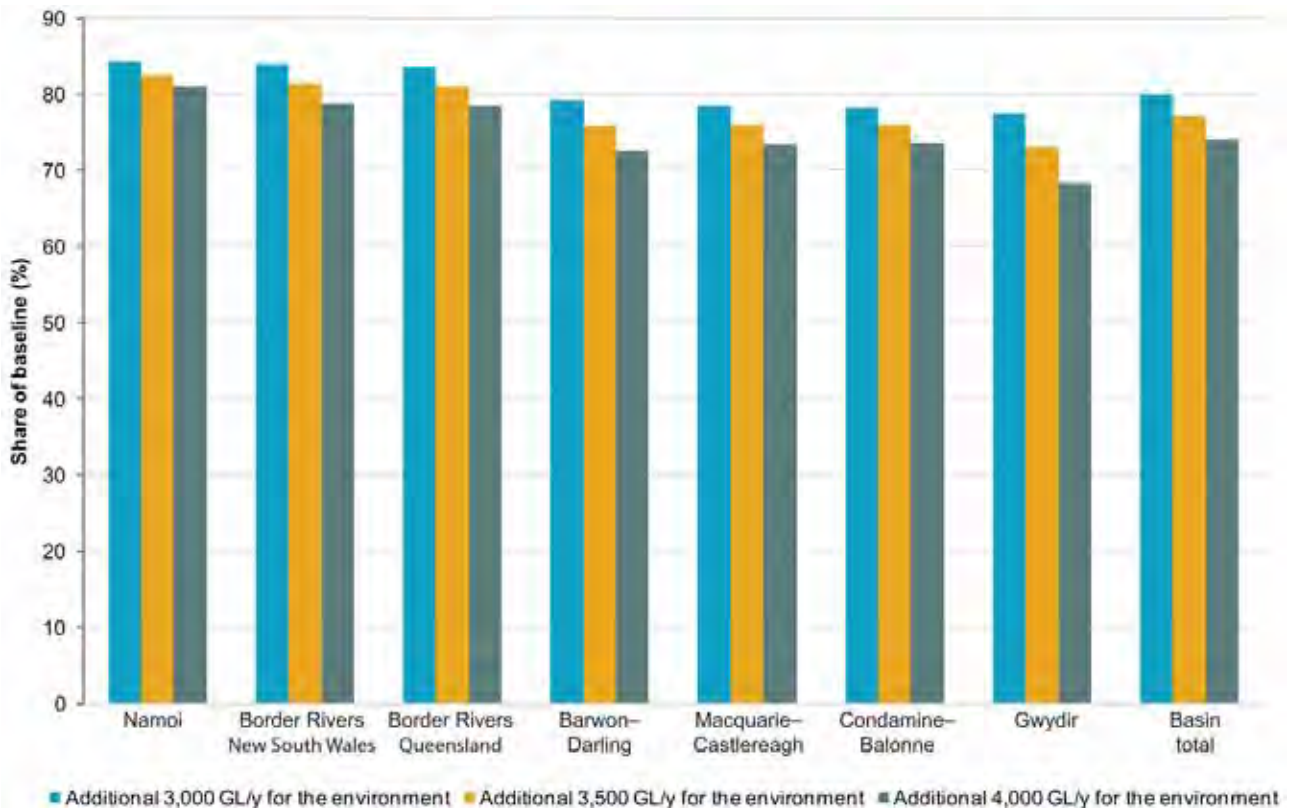


Figure 4.31 Estimated share of baseline gross value irrigated agricultural production for cotton industry, due to reductions in current diversion limits: Murray–Darling Basin

Source: ABARE–BRS (2010a)

The ABARE Water Trade Model results indicate that water use for irrigated cotton would decline by between 20 and 26% over the range of SDL proposals. These proposals would result in a reduction in value of annual irrigated cotton production of between 19 and 26%. This is in contrast to recent experience during the drought, in which 2006–07 cotton production in the Basin was 59% lower than in 2000–01.

The recent run of poor seasonal conditions has been reflected in irrigation survey data (ABARE–BRS 2010a), with a limited number of sample farms reporting planting cotton (2% in 2006–07). The effect of the drought has also been reflected in financial performance, with an estimated mean net unit return for cotton of approximately –\$1,300/ha planted in 2006–07 (Hughes, Mackinnon & Ashton 2009). This negative return per ha planted is because of poor yields and a substantial proportion of drought-induced crop failure. While estimated average enterprise returns are significantly negative for cotton, whole-of-farm returns were still positive, as farms with cotton generally undertake a range of other cropping and livestock activities, particularly during drought.

Analysis identifies a number of cotton gins in the Basin that have been noticeably affected by the reduced water diversions during the recent drought (Marsden Jacob Associates et al. 2010). For example, this year it was reported that nine gins in the Gwydir region were running well below optimum levels; in the Macquarie–Castlereagh region, one of five gins is reported to have closed, while only one of the remaining four has operated consistently through recent seasons. Cotton processing in the region has traditionally provided skilled employment in the more remote communities based around the gins, and has been a major source of investment. Significant changes in economic activity that result from the SDL proposals may affect the ability of some of these gins to recommence production (Marsden Jacob Associates et al. 2010).

Southern Basin

The results in Table 4.20 show the estimated revised irrigated agriculture water use and change in gross value of irrigated agricultural production for regions and industries of the southern Basin over the range of SDL scenarios.

A summary of the likely flow-on effects and responses for key irrigation districts, as recorded by Marsden Jacob Associates et al. (2010) for scenarios of 20% and 40% respectively, is shown in Table 4.21. For reference, the 3,000 GL, 3,500 GL and 4,000 GL scenarios represent proposed average reductions of between 22% and 29% in current diversion limits at the Basin scale.

Some of the Victorian Murray and the Goulburn–Broken, Campaspe and Loddon–Avoca regions were grouped together as the Goulburn–Murray Irrigation District for the purposes of the study. Ovens, Wimmera and Eastern Mount Lofty Ranges regions were not analysed by this study.

Table 4.20 Estimated water use and share of baseline gross value of irrigated agricultural production, due to reductions in current diversion limits: southern Murray–Darling Basin

	Baseline		3,000 GL				3,500 GL				4,000 GL			
	Water use	Gross value of irrigated agricultural production	Water use		Gross value of irrigated agricultural production		Water use		Gross value of irrigated agricultural production		Water use		Gross value of irrigated agricultural production	
			GL	% of base-line	\$m	% of base-line	GL	% of base-line	\$m	% of base-line	GL	% of base-line	\$m	% of base-line
Lachlan	249	165	197	79	151	91	190	77	149	90	184	74	147	89
Murrumbidgee	2,825	890	1,820	64	696	78	1,666	59	665	75	1,503	53	630	71
Ovens	22	56	18	83	54	97	18	80	54	97	17	77	53	96
Goulburn–Broken	765	704	613	80	634	90	586	77	621	88	558	73	607	86
Campaspe	149	134	122	82	121	91	115	77	118	88	109	73	115	86
Wimmera	6	13	6	100	13	100	6	100	13	100	6	100	13	100
Loddon–Avoca	499	284	360	72	241	85	320	64	226	80	301	60	220	77
Murray (NSW)	1,331	409	952	72	343	84	886	67	330	81	820	62	317	77
Murray (Vic)	943	779	800	85	723	93	778	82	713	92	754	80	702	90
Lower Murray Darling	65	71	58	90	67	94	57	88	66	93	55	86	65	92
Murray (SA)	372	514	341	92	488	95	335	90	484	94	329	89	479	93
Eastern Mount Lofty Ranges	79	163	77	97	163	100	77	97	163	100	77	97	163	100
Southern Basin	7,303	4,181	5,363	73	3,693	88	5,033	69	3,601	86	4,713	65	3,510	84

Source: ABARE–BRS (2010a)

Table 4.21 Summary of indirect (flow-on) responses to changes in diversion limits: southern Murray–Darling Basin

Region	Key sectors	–20% scenario	–40% scenario
Lachlan	Horticulture	Post-farm processing and direct marketing expected to continue at similar levels, subject to commodity and water prices.	Post-farm processing and direct marketing expected to continue at lower levels, subject to commodity and water prices.
	Broadacre	Freight of hay and grain and grain handling and storage requirements reduced. Cotton gin at Hillston to reduce capacity.	Freight of hay and grain and grain handling and storage requirements reduced. Cotton gin at Hillston to reduce capacity.
Murrumbidgee	Horticulture	Post-farm processing expected to continue at similar levels subject to commodity and water prices.	Post-farm processing expected at lower levels; may involve rationalisation of citrus-packing facilities. Any rationalisation of wine industry infrastructure and citrus juicing infrastructure will depend on a broader restructure of these industries in the Riverland, Sunraysia and Murrumbidgee regions.
	Rice	Rice aerated storages to be rationalised. Only one mill in the region likely to operate.	Rice mill at Coleambally unlikely to operate.
Central Murray	Horticulture	Post-farm processing expected to continue, subject to commodity process and water prices.	Post-farm processing expected to continue, subject to commodity prices and water prices, at a lower level due to fewer growers.
	Dairy	Milk processing expected to continue in northern Victoria.	Milk processing expected to continue in northern Victoria, at a lower level due to fewer growers.
	Rice	Rice aerated storages to be rationalised. One of two mills at Deniliquin unlikely to operate.	Rice mill at Deniliquin unlikely to operate.
Goulburn–Murray Irrigation District	Dairy, horticulture, mixed	Already delivered by buybacks and Northern Victoria Irrigation Renewal Project.	Already delivered by buybacks and Northern Victoria Irrigation Renewal Project, although may affect confidence, leading to towns dependent on dairy coming under threat.
Nyah to Border (including NSW and Victorian Sunraysia)	Perennial and annual horticulture	Some loss of plantings resulting in reduced seasonal work and closure of some wineries.	Larger-scale losses of plantings and resulting in lost direct and indirect employment. Community district viability questionable for some areas. Large-scale social impacts would be expected, e.g. high unemployment and social costs.
Riverland	Perennial and annual horticulture	Some loss of plantings resulting in reduced seasonal work and closure of some wineries.	Larger-scale losses of plantings, resulting in lost direct and indirect employment. Community district viability questionable for some areas. Large-scale social impacts would be expected, e.g. high unemployment and social costs.

Rice

Rice is a significant annual crop in the NSW Murray and Murrumbidgee irrigation regions, and planted areas vary greatly depending on water availability.

The ABARE Water Trade Model results indicate that water use for rice would fall by between an estimated 31 and 44% on average across the three scenarios, resulting in an estimated 30 and 43% reduction in the average annual gross value of rice produced in the Basin. To put this in perspective, as a result of the recent drought, 2006–07 rice production in the Basin was 84% lower than in 2000–01.

For the NSW Murray and Murrumbidgee regions, the estimated revised capacity relative to the analysis baseline is shown in Figure 4.32. This shows that rice-growing in the Murrumbidgee region is expected to be affected slightly more than in the NSW Murray.

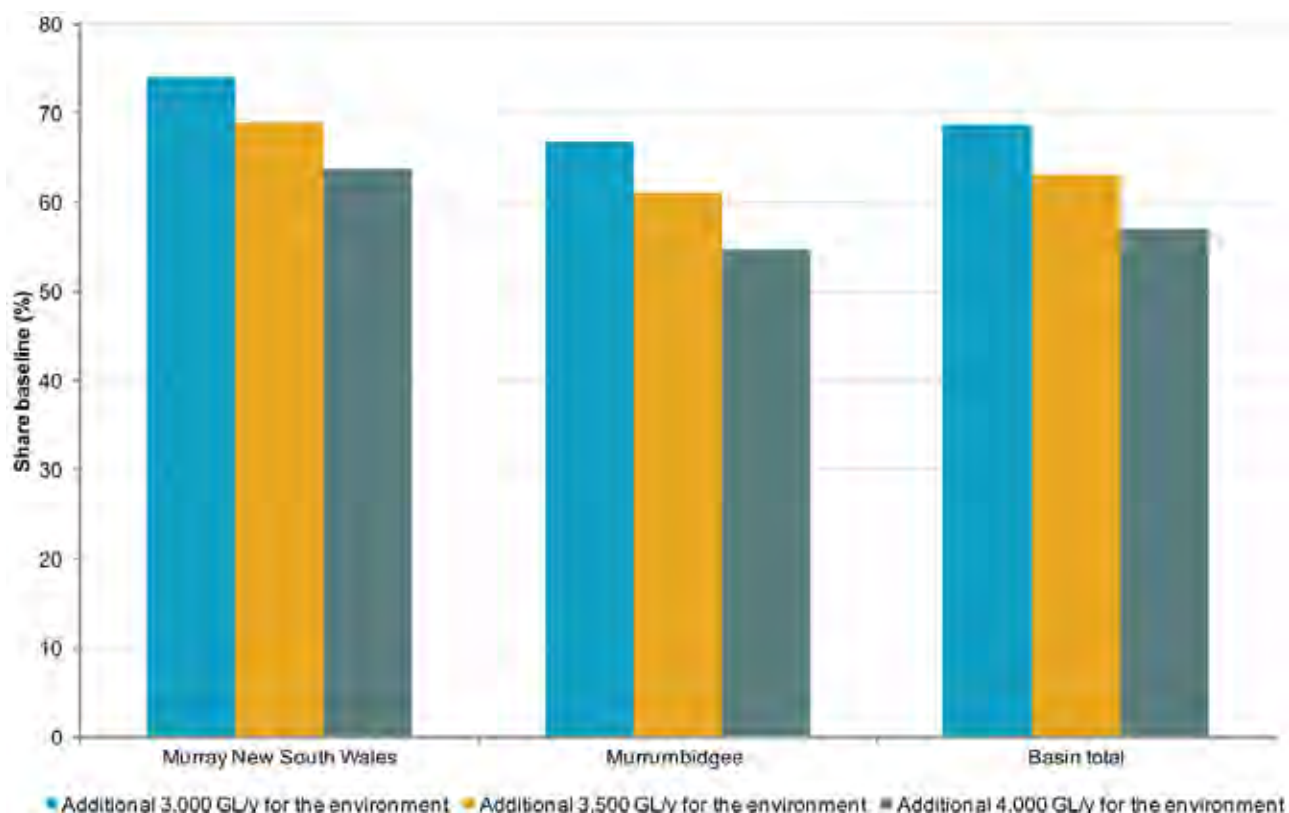


Figure 4.32 Estimated share of baseline gross value irrigated agricultural production for rice industry, due to reductions in current diversion limits: Murray–Darling Basin

Source: ABARE–BRS (2010a)

The recent drought has been reflected in irrigation survey data (ABARE–BRS 2010a), with only 3% of sampled farms in 2006–07 reporting having planted rice. A mean net unit return for rice of over $-\$1,000/\text{ha}$ planted was estimated in 2006–07 (Hughes, Mackinnon & Ashton 2009). The negative return reflects poor yields and a substantial proportion of failed crops. As with cotton, whole-of-farm returns were still positive on average, given that farms with rice generally undertake a wide range of other livestock and cropping activities, particularly during drought.

The low production of the past seven years has had significant flow-on effects to processing facilities, with a number of rice mills and many of the storage depots having reportedly been placed in care and maintenance mode. This has significantly affected employment. According to Marsden Jacob Associates et al. (2010), employment in Australian rice storage and processing fell from approximately 1,300 people at the peak of production in 2000–01 to 400 in 2009–10. It is suggested that a return to long-term average production would be likely to result in full use of all facilities (Marsden Jacob Associates et al. 2010).

Before the drought, the rice industry operated milling facilities at Griffith, Leeton and Coleambally in the Murrumbidgee region and at Deniliquin in the NSW Murray region. The Griffith mill has since been decommissioned and the Leeton facility is the only mill currently operating (Marsden Jacob Associates et al. 2010). The ABARE assessment of the Australian Government’s water purchase program (Hone et al. 2010) considered the rice processing industry in some detail.

The combined processing capacity of the Leeton, Coleambally and Deniliquin mills is around 1.2 million t/y (Hone et al. 2010). The Leeton mill has a capacity of 200,000–250,000 t/y if operated on a three-shift basis, and produces smaller packed products mainly for the domestic market. In comparison, the Deniliquin mill is the largest rice processing mill in the southern hemisphere and has a capacity of 600,000–630,000 t/y. It processes rice mainly for the export market. The Leeton and Deniliquin mills can process around 800,000–880,000 t/y, which is in line with industry expectations for future production.

In the past, all rice produced in the NSW Murray was stored and processed in the region, with the majority exported as labelled supermarket produce. However, since the storage and processing infrastructure was placed in care and maintenance mode, rice has been transported to processing facilities in the Murrumbidgee region. Employment at the Deniliquin rice mill is reported to have fallen from 400 to approximately 80 between 2000 and 2005, with the mill in care and maintenance mode (Marsden Jacob Associates et al. 2010).

A long-term 20–40% reduction in current diversion limits would be expected to lead to a proportional reduction in product throughput, affecting employment at processing facilities (Marsden Jacob Associates et al. 2010). Under this scenario, a number of the regional aerated storages might be rationalised and transport requirements could be significantly reduced. The gross domestic return from the industry would fall in proportion to the fall in production.

Dairy

Dairy farming in the Basin takes place mainly in northern Victoria, in the Campaspe, Goulburn–Broken, Loddon–Avoca and Victorian Murray regions, and in the NSW Murray region. Generally, there are more adaptation options (such as purchasing feed for cattle) than for rice and cotton growers. As such, for a given reduction in water use, dairy production is not expected to fall to the same extent as in those industries.

The ABARE Water Trade Model results indicate that water use for irrigated dairy could fall by between around 11–16% on average across the three scenarios, resulting in an estimated 7 and 12% reduction in the average annual gross value of dairy produced in the Basin (ABARE–BRS 2010a).

For each dairy region, the estimated revised capacity relative to the analysis baseline is shown in Figure 4.33. Although the Loddon–Avoca region shows a slightly larger reduction in gross value of irrigated agricultural production, the results are fairly evenly spread across all the regions.

While dairy production is less variable than cotton and rice from year to year, the drought saw a 5% fall in the Basin between 2000–01 and 2006–07.

Important coverage of the dairy industry is provided by ABARE dairy industry data (Dharma & Martin 2010) and in the survey of irrigation farms in the Basin (Ashton & Oliver 2009). Much of the improvement in the industry's financial performance between 2006–07 and 2007–08, as shown in Table 4.22, can be explained by a significant increase in milk prices. ABARE (2010a) has forecast world dairy product prices to remain relatively firm in 2010–11 after rebounding from the low prices experienced in mid-2009.



Friesian dairy cattle near Tongala, Victoria

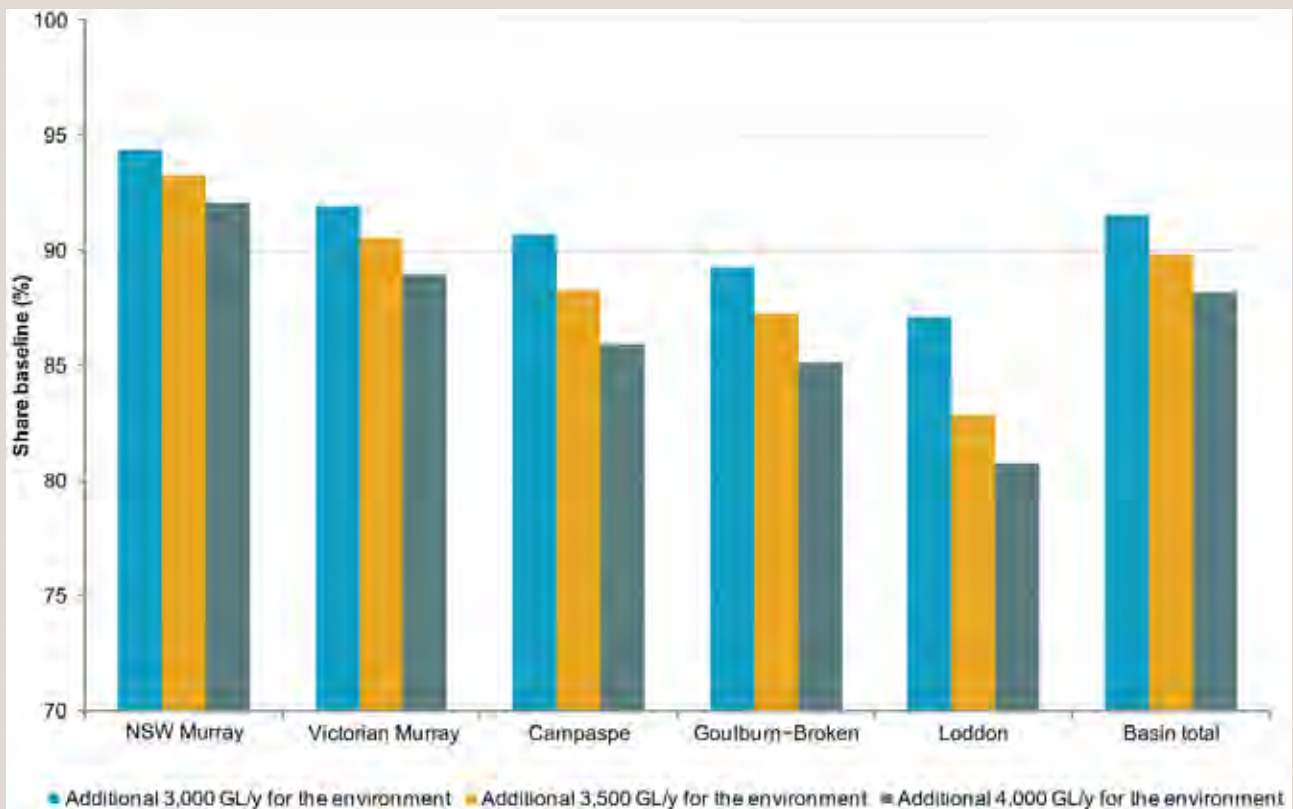


Figure 4.33 Estimated share of baseline gross value irrigated agricultural production for dairy industry, due to reductions in current diversion limits: Murray–Darling Basin

Source: ABARE–BRS (2010a)

Table 4.22 Average financial performance of irrigated dairy farms by region, 2006–07 and 2007–08: Murray–Darling Basin

Region	Farm cash income		Farm business profit		Rate of return	
	2006–07 \$	2007–08 \$	2006–07 \$	2007–08 \$	2006–07 %	2007–08 %
Condamine–Balonne	41,058	69,975	–46,395	24,226	–0.6	3.8
Murray	97,429	128,777	3,134	6,924	1.7	2.1
Goulburn–Broken	17,916	56,225	–62,981	–44,630	–1.7	–0.3
Loddon–Avoca	43,536	95,689	–33,643	26,578	–0.2	3
Eastern Mount Lofty Ranges	67,877	189,112	482	79,891	0.9	3.4
Murray–Darling Basin	54,836	91,379	–30,312	–8,178	0.1	1.5

Source: ABARE–BRS (2010a). Caution should be used when comparing estimates.

A detailed analysis of the dairy industry in the southern Basin (the Murray, Eastern Mount Lofty Ranges, Goulburn–Broken, Loddon–Avoca and Campaspe regions) is provided in Beale, Radcliffe & Ryan (2009). Due to high transport costs, around 95% of raw milk is generally transported to a dairy processing facility within 200 km of the farm gate (Beale, Radcliffe & Ryan 2009), so any effects on dairy processing would probably be seen fairly close to areas where dairy production is projected to decline most significantly.

Dairy processors produce a range of products for domestic and international markets. In Victoria, around two thirds is exported in the form of manufactured products such as butter, cheese and milk powder, with less than 10% destined for domestic drinking milk (Beale, Radcliffe & Ryan 2009).

There are six major dairy processing companies in the southern Basin: Murray Goulburn Co-operative, Fonterra, National Foods, Parmalat, Tatura Milk Industries and Bega Cheese. In 2009, these companies were operating 13 dairy manufacturing facilities in the southern Basin. Murray Goulburn is the largest dairy processor in the region (and in Australia), employing around 2,500 workers in 2009 (Beale, Radcliffe & Ryan 2009). Its processing plants are at Cobram, Kiewa and Rochester, with the Leitchville site having closed in February 2010.

Most of the land, water and dairy herd resources owned by dairy farms exiting the industry during the 1990s were purchased by other dairy businesses to expand their operations. More recently the resources of exiting farms have been put to alternative uses (Marsden Jacob Associates et al. 2010). Lower milk production is reported to have resulted in excess processing capacity in the region and a rationalisation of manufacturing infrastructure (Marsden Jacob Associates et al. 2010).

While a 20% reduction is already expected through water buybacks and irrigation infrastructure upgrades, a 40% scenario could pose a threat to the economy and employment in towns that are dependent on dairy farming and processing, such as Cohuna, Kyabram, Numurkah and Stanhope. More significant reductions in diversion limits may lead to closures of some dairy production facilities in Victoria (Marsden Jacob Associates et al. 2010).

Horticulture

Annual and perennial horticulture takes place at significant levels in several Basin regions, particularly in the connected southern Basin (Murrumbidgee, Goulburn–Broken, Victorian Murray and SA Murray regions). For each of these regions, the estimated revised capacity relative to the analysis baseline is shown in Figure 4.34.

The main perennial horticultural crops grown in the Basin are wine grapes, table grapes, dried fruit, almonds and nuts, stone and pome fruit (Marsden Jacob Associates et al. 2010). Approximately one third of Australia's perennial horticulture is in the southern Basin. The major growing areas in the Basin include the Goulburn and Murrumbidgee irrigation regions, the Sunraysia district of Victoria/New South Wales and the Riverland region of the SA Murray. Perennial horticulture farms in these regions are typically less than 100 ha in size.

Some wine grape growers are reported to be suffering from high debt and low profitability due to the current oversupply of wine grapes (Marsden Jacob Associates et al. 2010). As a result, some growers may be less able to afford water purchases to offset reduction in diversions. In such a scenario, these growers may need to remove more plantings than they would under conditions of normal profitability.



Granny Smith apples grown near Cobram, Victoria

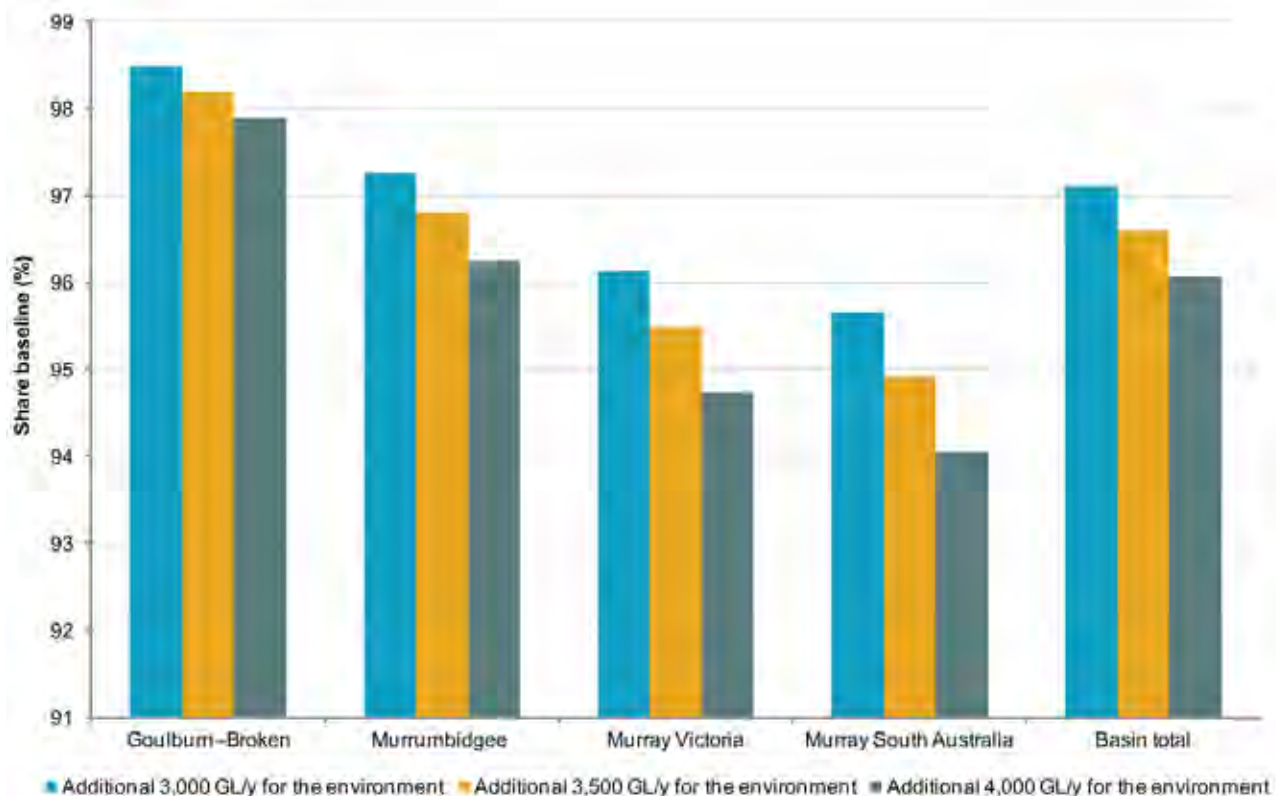


Figure 4.34 Estimated share of baseline gross value irrigated agricultural production for horticulture industry, due to reductions in current diversion limits: Murray-Darling Basin

Source: ABARE-BRS (2010a)

The main annual horticultural crops grown in the Basin are potatoes, lettuce, melons, sweet corn, fresh and processing tomatoes, onions, pumpkins, carrots and asparagus. The Murray and Murrumbidgee regions, Border Rivers and Goulburn-Murray Irrigation District are all important for annual horticulture.

Production and processing of annual horticultural crops is labour-intensive, with generally perishable produce requiring timely harvest and delivery to markets. There was a 45% increase in the area planted between 1996-97 and 2001-02, with major increases in the larger growing regions. However, the planted area fluctuates between seasons depending on expected demand and prices.

Producers of higher-value annual horticultural commodities are reasonably well placed to offset a reduction in diversion limits by purchasing water. Producers of lower-value commodities may respond to lower diversion limits by reducing planting areas.

ABARE estimates indicate that production in horticulture will remain relatively unaffected with the introduction of SDLs. This is primarily because water is expected to be traded from lower-value activities to horticulture in each region, and in the case of the connected southern Basin, across regions. The largest reductions in horticulture in value terms are expected in the SA Murray and Victorian Murray regions, where production is estimated to decline by \$25 million and \$20 million per year respectively under the 3,500 GL scenario.

Variability

The SDLs will reduce the long-term average volumes of water available for private consumptive use and may also have an effect on the year-to-year variability of supply of this water. The effect of the SDLs on variability will depend on a range of factors, including how the SDLs are implemented at state level, the manner in which environmental water is acquired, the extent of storage capacity access rights (carryover) for consumptive and environmental users, the environmental need for water in any given year, and the extent of any seasonal trade in water between environmental and consumptive use.

As a result, determining with any degree of certainty the economic impacts of this year-to-year variability in diversions is difficult and an area where more analysis is required. Although work undertaken for MDBA by ABARE–BRS (2010b) and the University of Queensland (Mallawaarachchi 2010) indicates that these impacts will vary across regions and by commodity, there is currently insufficient information to determine their level.

In considering the modelling results, it is important to note that the maintenance of horticultural crops at the expense of broadacre crops is based on an assumption that the SDLs would not have an effect on the variability of water supply, only on the long-term average level of availability. Any impacts on variability may influence the viability of perennial horticulture, given its need for a reliable supply of water.

Effects on dryland agriculture

The economic effects of a fall in irrigated agricultural output can be expected to be offset to some extent by an increase in dryland farming output.

Many irrigation farms typically operate a mix of irrigated and non-irrigated agriculture and earn much of their income off-farm. Broadacre farms, in particular, often have the capacity to vary the proportion of land that is irrigated between seasons, depending on prevailing water availability (ABARE–BRS 2010a). For example, in many NSW irrigation regions, results from a survey of irrigators indicate that around 64% of total income (varying from 51 to 71% between regions) was estimated as being earned from farming activities in 2005–06, with 51% (varying from 28 to 66%) being earned from irrigated crops and pastures (NSW Department of Water and Energy 2007). In total, therefore, around 32% of income was earned from irrigated agriculture, bearing in mind that the survey was conducted during drought. A complementary survey in 2009, after a further extended dry period, showed that 56% of total income was estimated to be earned from farming, with 30% of this coming from irrigated crops and pastures (NSW Office of Water 2010).

ABARE–BRS (2010a) has estimated that the range of SDL scenarios would lead to a 13 to 21% fall in irrigated land use. Assuming that all land withdrawn from irrigated agriculture reverts to dryland agriculture, the modelling suggests there would be an offsetting increase in dryland agricultural production of between \$55 million/y and \$81 million/y across the Basin. This estimate takes account of the fact that the gross value of dryland agriculture per unit of land is substantially lower than that of irrigated agriculture.

In separate modelling and analysis, the Centre of Policy Studies (Wittwer 2010) used its TERM-H2O model to estimate the effects of increased investment arising from mobility of farm factors (labour, capital and land) between irrigation and dryland agriculture. The modelling results indicate that the value of the production increase in dryland agriculture would constitute around 50% of the estimated decline in value of irrigated agricultural production by 2026. As noted earlier in this section, these two models assume different levels of mobility of capital which helps explain the differences in the results. The actual degree to which dryland production will substitute lost production from irrigation depends to a large extent on how mobile these farm factors really are, as well as on a range of other factors, such as commodity prices, water availability and climatic conditions.

Effects on other water users and industries

The SDL proposals will have a range of effects beyond the agricultural sector to the wider Basin economy. For example, they will lead to a decline in irrigated output, which could have implications for industries engaged in the processing of agricultural outputs such as food manufacturing.

Results at a broad sectoral level are displayed in Table 4.23. Changes in output for non-agricultural sectors are estimated to be relatively small. In general, non-agricultural sectors in the Basin are anticipated to experience a modest increase in output, with the exception of manufacturing in the Victorian, Queensland and South Australian Basin regions, which is predominately a result of a likely decline in downstream (food) processing sector output, particularly in north-east Victoria. Potential flow-on effects of the SDL proposals are considered in further detail later in this chapter.

As noted earlier, impacts of changes in current diversion limits on processing facilities such as cotton gins and rice mills are complex and may be subject to various threshold effects. For small changes in diversion limits, processing facilities may be able to lower production by reducing variable inputs (e.g. reducing labour demand). However, larger reductions in diversion limits may lead to temporary closures, particularly during drought, or even permanent closure of some processing facilities in the long term.

Table 4.23 Change in sector output, due to reductions in current diversion limits: Murray–Darling Basin

3,000 GL					
Region	Agriculture % change	Fisheries/forestry % change	Mining % change	Manufacturing % change	Services % change
Northern New South Wales	-3.4	0.3	0.3	0.1	-
Riverina	-5.2	0.3	0.3	0.2	0.1
Western New South Wales	-4.3	0.4	0.5	0.4	0.1
North-east Victoria	-5.1	0.2	0.1	-0.6	-
North-west Victoria	-2.8	0.1	0.1	-0.3	-
Queensland Basin	-2.8	0.2	0.1	-0.1	-
SA Basin	-2.2	0.1	0.1	-0.3	-

3,500 GL					
Region	Agriculture % change	Fisheries/forestry % change	Mining % change	Manufacturing % change	Services % change
Northern New South Wales	-3.9	0.3	0.3	0.2	-
Riverina	-6.1	0.4	0.3	0.2	0.1
Western New South Wales	-5.1	0.5	0.6	0.4	0.2
North-east Victoria	-6.0	0.2	0.2	-0.7	-
North-west Victoria	-3.4	0.2	0.1	-0.3	-
Queensland Basin	-3.3	0.2	0.1	-0.1	-
SA Basin	-2.6	0.1	0.1	-0.3	-

4,000 GL					
Region	Agriculture % change	Fisheries/Forestry % change	Mining % change	Manufacturing % change	Services % change
Northern New South Wales	-4.5	0.4	0.4	0.2	0.1
Riverina	-7.1	0.5	0.4	0.3	0.1
Western New South Wales	-5.9	0.5	0.7	0.5	0.2
North-east Victoria	-7.0	0.2	0.2	-0.8	-
North-west Victoria	-3.9	0.2	0.2	-0.4	-
Queensland Basin	-3.8	0.2	0.2	-0.1	-
SA Basin	-3.0	0.2	0.2	-0.4	-

Source: ABARE–BRS (2010a)

Note: – denotes negligible impact, i.e. less than 0.05%

Basin-wide economic implications

The estimates of economy-wide impacts of the SDL proposals presented in Table 4.17 were derived using the AusRegion model. This analysis estimates flow-on effects associated with changes in agricultural production under the three scenarios, and assumes water can be traded between connected southern Basin regions. As noted in Section 4.3, AusRegion aggregates the Basin into fewer regions than the Water Trade Model (ABARE–BRS 2010a). This analysis excludes the effect of other government policies such as water entitlement purchases and infrastructure investment programs (ABARE–BRS 2010a).

For the Basin as a whole, the range of scenarios would be estimated to lead to a 1.1–1.5% fall in gross regional product, or \$0.7–\$0.9 billion/y and a 0.09–0.12% fall in employment (800–1,000 fewer jobs) compared with the baseline scenario (ABARE–BRS 2010a; see Table 4.24). As irrigated agriculture represents only a small share of the Basin’s total economic base, estimated at less than 6% (Wittwer 2010), the estimated impacts at this scale are relatively small.

At the national level, gross domestic product would fall by approximately 0.11 to 0.15%, while the decline in employment is estimated to be in the order of 0.03%, or about 3,000 fewer jobs in the Basin economy compared with the baseline (ABARE–BRS 2010a).

Analysis by ABARE–BRS (2010a) suggests that the Queensland portion of the Basin will be least affected by the SDL scenarios, whereas the NSW Riverina is likely to be the most affected region.

The extent that gross regional product will be affected by the proposed Basin Plan will depend on the impact the SDL proposals have on regional agricultural production and/or the share agricultural and regional processing activities comprise of total regional output. For example, although South Australia faces relatively smaller estimated percentage reductions in gross value of irrigated agricultural production, its gross regional product is likely to decline by around 1.1–1.5%. This is because irrigated agriculture in the SA region is a relatively high proportion of the economy compared with other regions.

Analysis shows that the impacts of the SDLs on the Basin economy would be in the order of a 1.3–1.8% reduction in Basin gross regional product. The projected impact on Australian gross domestic product ranges from a reduction of 0.008% (Wittwer 2010) to 0.11–0.15% (ABARE–BRS 2010a).

As with the estimates for gross value of irrigated agricultural production presented earlier in this section, this would suggest the ABARE–BRS estimates are a little higher than those derived from comparable models and as such may be regarded as being somewhat conservative in their estimates.

It should be noted that gross domestic product and gross regional product estimates are only partial estimates of changes and do not include any social costs or benefits associated with the proposed SDLs, or any environmental benefits from increased environmental flows (ABARE–BRS 2010a). Some of these effects are considered later in this section.

Table 4.24 Change in gross regional product and employment, due to reductions in current diversion limits: Murray–Darling Basin^a

Region ^b	3,000 GL		3,500 GL		4,000 GL	
	Gross regional product (% change)	Employment (% change)	Gross regional product (% change)	Employment (% change)	Gross regional product (% change)	Employment (% change)
Riverina	-2.2	-0.13	-2.6	-0.16	-2.9	-0.19
Western New South Wales	-1.7	-0.24	-2.0	-0.30	-2.3	-0.36
North East Victoria	-1.3	-0.05	-1.5	-0.06	-1.8	-0.11
North West Victoria	-0.9	-0.03	-1.1	-0.04	-1.3	-0.11
Queensland Basin	-0.7	-0.08	-0.8	-0.09	-0.9	-0.11
South Australian Basin	-1.3	-0.03	-1.5	-0.03	-1.8	-0.03
Basin	-1.1	-0.09	-1.3	-0.10	-1.5	-0.12

a excludes the Australian Capital Territory

b The regional demarcation in AusRegion is an aggregate of the CSIRO Sustainable Yield regions (CSIRO 2008).

Source: ABARE–BRS (2010a)

Employment impacts

Around a third of Basin businesses are in the agriculture, forestry and fishing sector. In recent years, the sector has experienced a decrease in employment, from 111,000 employees in 2001 to 98,000 in 2006; a drop of about 12% (ABS, ABARE & BRS 2009).

Changes in employment at a regional level do not necessarily correspond with changes in gross regional product, given differing labour intensities across industries and regions and the potential for labour migration between regions. In practice, movement of labour from agriculture to other industries in a region may coincide with migration from more remote smaller towns into larger regional centres.

In the long term, a relatively small percentage drop in employment is estimated by AusRegion, with a 0.1% fall across the Basin relative to the baseline for all three scenarios. MDBA estimates that this would equate to around 800–1,000 fewer jobs in the Basin and up to 3,000 nationally. Similarly, the modelling undertaken by the Centre of Policy Studies assesses the decline in employment at less than 1,000 jobs relative to the baseline (Wittwer 2010). However, given the inherent uncertainties and limitations of the models in estimating employment effects, these estimates need to be treated with a degree of caution (ABARE–BRS 2010a).

The largest percentage impact on employment is estimated in the western New South Wales region, where agriculture forms a high proportion of total economic output (ABARE–BRS 2010a). AusRegion employment estimates represent long-term predictions and allow for movement of labour between industries and regions over time. Although production and employment in the irrigated agricultural industries is predicted to decline, it is anticipated that other industries in the region would absorb a significant proportion of the labour released from agriculture (ABARE–BRS 2010a).

The short-term employment effects may be more pronounced but are difficult to estimate with accuracy. In practice, there remains uncertainty over likely effects on employment and the estimated results need to be treated with a degree of caution (ABARE–BRS 2010a).

On the other hand, the Basin's irrigated agricultural and associated processing industries, particularly broadacre activities such as cotton and rice, are accustomed to significant year-to-year fluctuations in water availability and

output. These industries and their workforces are thus expected to have the flexibility to respond quickly to changes in output, noting that estimated long-term average levels of outputs under the 3,500 GL scenario are far greater than the experience of the recent drought.

Despite the fall in employment recorded in the agriculture sector between 2001 and 2006, which has probably continued in line with the drought, overall unemployment across the Basin fell in the same period from 6.5 to 5% (ABS, ABARE & BRS 2009). This increase in Basin employment reflects a time of relatively good economic growth for Australia. When combined with the boom in the resources sector and an ageing population, the agriculture sector is reported to have experienced difficulty in sourcing skilled and unskilled labour (Sheales & Gunning-Trant 2009).

Labour-force projections indicate that a skills shortage in the agriculture sector prevails with an unmet demand for labour in the sector of approximately 100,000 workers in 2008 (Australian Farm Institute 2010). Against this backdrop, it is estimated that an additional 10,000– 20,000 new workers must be employed each year for the next five years to meet demand (AgriFood Skills Australia 2010). The National Farmers' Federation (2008) suggests that in order for agricultural production to approach pre-2002 levels, the sector must employ some 80,000– 100,000 people. These estimates apply to Australia as a whole but it would be reasonable to assume that given the Basin's share of national agricultural output and the importance of its horticultural sector, there is significant unmet demand for labour in the Basin.

Given the favourable labour-market conditions across Australia in recent years and that unemployment rates in the Basin have been comparable to the national average, it could be expected that labour displaced by changes in irrigated agricultural output should have less difficulty gaining employment in other sectors or regions. As with other projections into the future, the actual employment effects of introducing the SDLs will depend on a number of variables such as commodity prices, prevailing seasonal conditions, growth in other industries and the cumulative effects of government policies.

Implications for towns and communities

As outlined in Section 4.3, the social and economic impacts of each diversion limit scenario will probably be greatest at the local or community scale in certain irrigation-dependent parts of the Basin. Flow-on effects of each scenario for regional communities and economies will depend on the extent to which agricultural production levels are affected, and the extent to which there are additional linkages to regional economies, such as through regional processing of agricultural outputs. In addition, the distribution of economic effects across towns and communities in any given region is likely to vary substantially, as the SDLs will generally be set at a regional scale rather than for smaller localities. The following sections explain some of the challenges and uncertainties in assessing the local-scale implications, briefly characterising some of those likely effects and identifying some of the regions that will probably be most affected by implementing SDLs.

Uncertainties in assessing local-scale implications

The relationships between individuals, households, businesses, and other organisations in rural areas are spatially diffuse; people interact over often wide areas and long distances. They may live, work, spend, and depend upon services in a range of different places. Communities are complex, adaptive socio-economic systems in continuous flux, and have varying capacities to



*Old bank building in Manilla,
New South Wales*

absorb and respond to stress or shock (ABARE–BRS 2010b). As a result of these inter-relationships, predicting local-scale impacts is complex.

Further, the difficulty of separating the effects of reductions in diversion limits from the impacts of other factors, such as commodity prices and exchange rates, as outlined in Section 4.3, tends to compound this complexity.

In addition to the social and economic considerations identified above, there are practical analytical limitations to determining impacts at local scale. These include:

- Computable general equilibrium models, such as those used by MDBA in assessing impact, are generally designed to assess impacts at larger scales, including large regional and national scales.
- Data needed to undertake analyses at local scale is often either not available or is less reliable for analytical purposes.
- ABARE's AusRegion model is designed to analyse comprehensive interactions in a given economy and is less capable of analysing a large number of small-scale regions at one time.

The nature of local-scale impacts

Marsden Jacob Associates et al. (2010) suggest that towns may experience a range of impacts from reduced diversion limits, including:

- reduction in employment levels within the agriculture sector, and within associated industries such as food processing
- reduction in local scale gross value of irrigated agricultural production and the consequent impacts of productivity loss
- change in land use intensity and impacts relating to changes in enterprise mix.

A fall in the rateable base for local government authorities and reduced levels of demand for major community services, including health and education, could mean that the level of service provision in some towns would decline over time. As a consequence, there is a greater likelihood that:

- access to health services and education may become more difficult
- there could be fewer funds available to local government authorities to invest in, and maintain community infrastructure
- social and community networks could come under increasing pressure.

When faced with reductions in water diversions, there may be a potential for mental and physical health breakdown within Basin communities. A factor such as drought and reductions in diversion limits place stress on the entire community, not only the irrigators and primary producers. Such stress can be associated with family dislocation and relocation, interrupted schooling, substance abuse and possibly violence. Stress and stressors that can accumulate over a period of time for farmers and farm families under such conditions also include financial difficulties that often require difficult decisions to be made on the sale of water and/or land, drying-off of crops, a change in cropping mix or even whether to exit farming. The Australian Institute of Health and Welfare (2010) found that people in rural and remote locations are more likely to experience mental and physical health issues than those in the cities. Some studies have found that reductions in diversion limits can trigger this. The Department of Health and Aged Care (2000) found that the stress associated with a long-term drought, specifically, can have serious consequences including anxiety, depression, family breakdown, grief and anger.

In addition to these sources of stress, when it comes to water reform, it is clear there is a degree of reform fatigue, which comes on top of long-term, ongoing, structural adjustment in the agricultural sector and rural communities, and the effects of drought (Barr 2009). In a study exploring the social impacts of declining water allocations on farmers, families and communities, Alston, Whittenbury & Haynes (2010) note that the lingering drought has caused significant hardship to people and communities and is contributing, along with other structural drivers of change such as technology and global markets, to creating 'growing pockets of socially excluded people and communities and significant welfare stress'. There is considerable anxiety over the perception that farmers and the communities they support are being abandoned by governments and the broader Australian community in favour of pursuing environmental outcomes (Barr 2009; Alston, Whittenbury & Haynes 2010; Marsden Jacob Associates et al. 2010).

Some of the social impacts that may be exacerbated by the uncertainty generated by the SDL proposals were found by Alston, Whittenbury & Haynes (2010) to include:

- family stress, including disruption to family life and marital and intergenerational conflict
- involuntary separation of family members in order to secure off-farm income as a result of increased long-distance commuting for work
- increased risk of accident, injury and other health impacts
- loss of jobs in small communities and difficulties sourcing off-farm income
- loss of access to health and welfare services
- feelings of uncertainty and lack of control by farm families over their lives, and the associated emotional distress, including concern over lack of input into water policies, planning and decision-making which will affect their future livelihood
- the potential of unplanned water recovery leading to stranded assets.

An extensive survey of irrigators undertaken as part of the work by Marsden Jacob Associates et al. (2010), which assumed no adjustment assistance from government, found that when faced by lower water availability, decisions made by farmers about their farming businesses were strongly influenced by:

- farm irrigation water dependency e.g. in terms of the irrigated area of the farm, value of water entitlements as a percentage of the farm's asset base, water as a proportion of operating costs and the security of water entitlements held
- financial situation, particularly the debt to asset ratio
- personal wellbeing and optimism
- age.

As a broad generalisation, farmers whose businesses rely more on irrigation water, who have a high debt to asset ratio, and/or who have lower wellbeing and optimism scores are more likely to exit farming if faced with permanent reductions in diversion limits. The influence of age is more complex. Farmers aged under 35 and over 65 are more likely to stay on their farm but not change their operations. It is likely that these two groups will have different reasons for this response (Marsden Jacob Associates et al. 2010).

In general, older farmers are less sensitive to potential reductions in diversion limits because they have built up sufficient financial capital and have no need to alter their farm operations. Because they do not run their farms at maximum capacity, they probably have free capacity in their existing farming systems to absorb the shock of reduced diversion limits.



Grapes growing near Irymple, near Mildura, Victoria

Young farmers may be less sensitive than those in their late 30s to early 60s because, having entered farming during the drought, they have set up their operations to be lean, water-efficient and drought-resistant. They see a good future in farming and realise they have time to make a success of it (Marsden Jacob Associates et al. 2010).

Unlike their younger counterparts, farmers aged 40 to 60 typically made pre-drought capital investments in their farms and have borne the full brunt of the drought downturn. These farmers have generally drawn down farm equity to stay where they are and have less time left than their younger counterparts to recover any lost equity. Accordingly, they must decide whether, faced with a permanent future of much less water, they should stay in farming and attempt to recover, or exit and seek an alternative livelihood (Marsden Jacob Associates et al. 2010).

Literature on the topic of community vulnerability and adaptive capacity notes that potential impacts, adaptive capacity and the resulting vulnerability of communities depend on the specific nature and scale of the impacting event, and on local history and conditions (ABARE–BRS 2010b). In the Basin, potential local impacts of diversion limit reductions will clearly depend on their scale and local incidence. They will also depend on, for example, recent climatic conditions. Irrigators who have recently experienced drought are likely to have less financial capacity to adapt to further reductions in diversions, unless rainfall returns to more ‘normal’ patterns in the interim. This suggests that the analysis of adaptive capacity, vulnerability and the impacts of the SDL proposals should ideally be based on information about the proposals’ likely implications in specific places.

Nevertheless, some general conclusions can be drawn from the work undertaken and other literature investigating the impacts of water reductions on communities. Judith Stubbs & Associates (2010) found that a number of factors predicted changes in indicators of community wellbeing and resilience, including changes in employment and population. Other key indicators were degree of remoteness, degree of urbanisation (population size), proportion of Aboriginal residents (particularly for remote populations) and age of the population. Degree of economic diversity and opportunities to diversify the economic base were also identified as relevant factors, although these are often a function of other more endogenous factors such as remoteness or proximity to a large urban centre or other economic resource (e.g. extractive industries or areas of scenic beauty). Although factors such as community leadership and collaborative initiatives are important, it can be

difficult for communities to respond to major stress factors where they have characteristics that work against their ability to adapt to change.

Economic modelling, analysis of ABARE's irrigation farm survey (ABARE–BRS 2010a) and an assessment of community vulnerability to reduced diversion limits across the Basin were used to identify the regions likely to be most affected by the SDL proposals. The findings of these studies are outlined in the following section.

Estimating local-scale impacts of the SDL proposals

Economic modelling was used to inform MDBA where the risks of local-scale impacts from introducing SDLs are likely to be highest (ABARE–BRS 2010a). Table 4.25 identifies six CSIRO Sustainable Yield regions where the range of SDL scenarios is estimated to lead to a reduction in the value of irrigated activity of more than \$70 million/y. The results suggest that gross value of irrigated agricultural production in the Murrumbidgee, Gwydir, Goulburn–Broken and NSW Murray regions will be most affected by a reduction in current diversion limits.

The second stage of the sub-regional analysis involved using ABARE survey data (ABARE–BRS 2010a) on irrigation farm expenditure to identify towns that rely greatly on this expenditure. This analysis made use of survey data for 2007–08. The irrigation survey covers most of the Basin's major irrigation areas but excludes the Gwydir, Moonie, Warrego, Paroo, Barwon–Darling, Wimmera, Campaspe and Ovens regions.

At the broad regional level, most of the Basin regions contain a mix of small- and medium-sized towns, as well as larger regional centres. The regional centres tend to have a broad economic base, which will act to cushion the impact of a decline in irrigated activity. However, some of the smaller towns may be less resilient to a decline in irrigation activity due to their narrower economic base. As such, the impacts of the SDL proposals are likely to be more substantial in smaller regional towns than in larger regional centres.

Towns likely to be affected tend to be concentrated in the southern Basin, especially above the confluence of the Murray and Darling rivers. When estimates of expenditure reliance are combined with gross value of irrigated agricultural production estimates associated with the SDL proposals, it would appear that many highly reliant towns are also in regions where gross value of irrigated agricultural production is estimated to fall significantly (ABARE–BRS 2010a).

Table 4.25 Estimated changes in gross value of irrigated agricultural production from the long-term historical average for the most affected CSIRO Sustainable Yield regions, due to reductions in current diversion limits: Murray–Darling Basin

Region	3,000 GL		3,500 GL		4,000 GL	
	Change in gross value of irrigated agricultural production (\$m/y)	Change in gross value of irrigated agricultural production (%)	Change in gross value of irrigated agricultural production (\$m/y)	Change in gross value of irrigated agricultural production (%)	Change in gross value of irrigated agricultural production (\$m/y)	Change in gross value of irrigated agricultural production (%)
Murrumbidgee	194	-22	-225	-25	260	-29
Gwydir	70	-22	-84	-26	98	-30
Goulburn–Broken	70	-10	-83	-12	97	-14
Murray (NSW)	66	-16	-79	-19	92	-23
Condamine–Balonne	63	-14	-70	-15	76	-17
Murray (Victoria)	56	-7	-66	-9	77	-10

Source: ABARE–BRS (2010a)

To gain further insight into which towns may be most affected by changes in diversion limits, estimates of changes in gross value of irrigated agricultural production were compared with agricultural land-use data. These estimates were broken down by irrigated activity for regions likely to see a considerable decline in such activity. Analysis suggests that irrigated annual cropping and activities involving irrigated pastures are likely to decline more significantly than horticulture production as a result of reduced diversions.

Through an analysis of land-use data, it was considered that towns in the upper Murray, including Deniliquin, Coleambally, Kerang and Numurkah, would be more likely to be adversely affected because they are not only in regions where gross value of irrigated agricultural production is estimated to decline significantly, but are also surrounded by irrigated cropping and pastures (ABARE–BRS 2010a).

The analysis also suggests that towns surrounded by a more diversified crop mix, such as Griffith, are likely to be affected to a lesser extent than those surrounded by irrigated annual activities. Towns further down the Murray, around Mildura and Robinvale, also appear likely to be relatively less affected as they are surrounded by horticulture, which is estimated to suffer the lowest impacts from reduced diversion limits. This is not intended to minimise the impact of other factors such as drought, recent low water allocations or commodity prices on some people in these communities.

The assessment by the Bureau of Rural Sciences and University of New England of community vulnerability to reductions in diversion limits is broadly consistent with ABARE's results (ABARE–BRS 2010b). Although a significant proportion of Basin communities exhibit only a low to moderate level of vulnerability to changes in diversion limits, several areas were identified as exhibiting very high community vulnerability to potential diversion limit changes, as follows:

- in the northern Basin, regions with very high, inherent community vulnerability are Border Rivers, Gwydir, Namoi and Macquarie–Castlereagh
- in the southern Basin, regions with very high, inherent community vulnerability are Lachlan, Murrumbidgee and Murray.

Communities in these areas combine higher sensitivity to diversion limit changes (i.e. very high dependence on water for agriculture and high agri-industry employment) with more limited levels of adaptive capacity (i.e. low levels of human capital, social capital and economic diversity) than other Basin areas. They are thus more likely to be affected by any major changes in diversion limits.

Taken together, these analyses show that there are many Basin communities, particularly smaller towns, which are likely to be vulnerable to a reduction in current diversion limits. These communities tend to have a high dependence on rice, cotton and other irrigated broadacre crops.

There are many potential policy implications arising from these conclusions, but it is clear that the implications for those people and communities most likely to be affected by the SDL proposals could be significantly mitigated if assistance were provided to adapt in a coordinated way.

Chapter 5 outlines some of the proposed transition arrangements for affected industries and communities for which MDBA is responsible, such as temporary diversion provisions and risk allocation.

Implications of government payments and assistance

The analysis presented above has assumed that no particular offsetting steps are taken by governments to mitigate the effects of the proposed SDLs. In reality, while there will be economic impacts, it can be expected that some of these will be offset by government payments to irrigators from either buybacks of water entitlements or through the risk allocation provisions of the proposed Basin Plan.

The extent to which spending of these payments can be expected to offset reduced irrigation sector economic activity depends on several factors. At a national level, the payments increase spending in the Basin that would otherwise have generated spending elsewhere (e.g. for health, infrastructure etc.). The net impact is forgone agricultural production, less the value of ecological outcomes and ecosystem services that result from improved environmental flows (Banerjee & Connor 2010).

In the Basin, the impact of any payments depends on whether the proceeds stay in the region. The study that most directly addresses this issue (Dixon, Rimmer & Wittwer 2009) has found that if all proceeds are spent locally, consumption from the payments exceeds what would have resulted from forgone irrigation. The net result is an increase in aggregate regional consumption. Survey data from irrigator recipients of the recent Australian Government water buyback support this finding. A significant portion of payments, though not all, is either invested locally or used to retire debt, thereby generating local consumption. Further work undertaken for MDBA by the Centre of Policy Studies at Monash University using its TERM-H2O model supports these findings. This study also notes that the precise effect on each individual may vary for a range of reasons, such as the way in which land and water prices tend to be affected by buybacks, and the degree of conversion of irrigated land to dryland (Wittwer 2010). It can also depend on the extent and location of individual land and water holdings, as the circumstances affecting the value of land and water across the Basin are quite diverse. However, despite this, towns with less than 1,000 inhabitants would still tend face the greatest adjustment costs since they usually have much less diversified economies and depend on agriculture to a greater degree than the larger regional centres (Banerjee & Connor 2010).

Implications for Aboriginal peoples

Aboriginal people stress the critical importance of the Basin's river systems to social, cultural and economic life and the need for balance in meeting the needs of all stakeholders. The desire for restoration of environmental systems and the relationships Aboriginal people have maintained with their countries is a key motivation behind ongoing engagement with water management issues; indeed, it is a compelling obligation in Aboriginal value systems and law.

There is a severe lack of quantitative data on Aboriginal water uses and values. Quantification, and development of methods for quantification, of such water use and the specification of Aboriginal water requirements lag behind other uses, inhibiting attempts to estimate the relative costs and benefits of water use and resolve tensions between competing allocations and environmental flows. Further work is needed to analyse and define appropriate Aboriginal water management institutions, such as the cultural flow concept (Jackson, Moggridge & Robinson 2010).

As part of the review undertaken for MDBA (Jackson, Moggridge & Robinson 2010), three case studies were made of representatives of the Nari Nari community at Hay, the Ngemba at Brewarrina and the Yorta Yorta at



Agnes (Dolly) Fox tells stories of the river to young members of the local community near Cunnamulla, Queensland

Barmah–Millewa Forest. The case studies reveal that Aboriginal people have diverse and multiple interests in water and demonstrate that Aboriginal water management aspirations, objectives and strategies vary as to their mix of conservation management, commercial water use and environmental water management activities.

There is a large degree of inter-dependence evident in the livelihood strategies being employed by the Aboriginal groups consulted. Although many communities give priority to environmental and cultural objectives in their land and water management strategies, Aboriginal people are also extracting some economic benefit from water use. In all three cases, Aboriginal organisations have a commercial entitlement and, in two of these cases, they are trading their water allocations to underwrite their social, cultural and environmental activities. It is highly likely that there are other Basin Aboriginal organisations pursuing a more singularly commercial approach to water use without any particular interest in environmental water management activities (Arthur 2010).

Some broad conclusions can be drawn about the likely impacts of changes in current diversion limits on the Aboriginal peoples of the Basin. These are that enhanced environmental flows are highly likely to generate positive impacts and, on the other hand, a reduction in current diversion limits could constrain Aboriginal economic development options.

Given the vision for a healthy Murray–Darling system articulated by many Aboriginal groups, general improvements to the environmental condition of the Basin will tend to be viewed very positively by Aboriginal people and will probably have benefits, particularly in terms of their social and cultural aspirations. This could include improving not only the ecological health of important cultural sites but also access to such sites and the relationships between Aboriginal people and other parties, including government (Jackson, Moggridge & Robinson 2010).

However, there is a risk that the full potential for increased environmental flows to substantially benefit Aboriginal people will not be realised if the determination of environmental flow requirements do not include Aboriginal values in assessment processes. Secondly, Aboriginal groups are concerned that environmental water management, no matter how adequately it meets ecological water requirements, does not currently recognise their resource governance systems, nor allow for co-management (Jackson, Moggridge & Robinson 2010).

With regard to economic interests, Aboriginal people own land in the agricultural districts of the Basin and some have formal entitlements to water. Aboriginal people are also employed in agricultural industries and the service sectors that support primary industries. Although economic dependence on water-based agriculture appears to be relatively low, the disadvantaged status of Aboriginal populations generally suggests that they are particularly vulnerable to any negative social and economic impacts on Basin regional economies and communities (Jackson, Moggridge & Robinson 2010).

The general disengagement of Aboriginal people from the irrigated agriculture sector may also mean they would be unlikely to derive much benefit from any adaptation assistance that may be offered to people and communities affected by the SDL proposals.

Aboriginal landowners may be adversely affected if their water entitlements are reduced and agricultural activity decreases as a result of the Basin Plan provisions. The severity of this impact will depend on the degree of Aboriginal people's access to improved irrigation efficiency, take-up of such efficiency measures by farmers leasing Aboriginal land, and the extent of Aboriginal-owned agriculturally viable land in the areas most vulnerable to reductions in diversion limits (Jackson, Moggridge & Robinson 2010).

The case-study evidence demonstrates that water is an asset of considerable value to some Aboriginal communities (e.g. the Nari Nari), allowing them to employ land management staff and run community organisations. It is also possible that direct impacts on Aboriginal wealth and labour force participation may adversely affect the customary sector because of interdependencies between the market, state and customary sectors (Altman 2004).

Reductions in the viability of the agricultural sector will narrow the options available to people to develop their land base and any new land that may be either claimed or purchased over coming years. Given the pattern of Aboriginal migration from more remote to more regional centres, structural economic changes may limit the extent to which Aboriginal people can return to their homelands after a period away in urban centres. There is, however, likely to be an increasing reliance on the Aboriginal community for labour and/or allied services, even with contraction of irrigated agricultural production (Cotter et al. 2006).

There is also considerable potential for structural change to open up new opportunities for Aboriginal people in emerging cultural and natural resource based industries, such as payment for environmental services, stewardship arrangements, small-scale bushfoods businesses and tourism.

Further research and analysis is required to develop the conceptual and empirical understanding of the means to meet Aboriginal water requirements and in doing so, fully involve Aboriginal people in any subsequent policy development and decision-making. Collaborative empirical research and further discussion with Aboriginal people through existing organisations will help provide the data, analysis and capacity necessary to address Aboriginal water access more comprehensively in the future (Jackson, Moggridge & Robinson 2010).

Likely benefits of the SDL proposals

MDBA recognises, as noted in Section 4.3, that the effects of reducing diversion limits will not be evenly distributed, with many of the costs expected to be borne disproportionately by specific local communities and



Midden found in the Narran Lakes Nature Reserve, New South Wales

many of the benefits accruing to a wide distribution of people, mainly in the nation's cities but also in those places where increases in river environmental flows will occur.

The analysis of the implications of the SDL proposals in this section, with the exception of the discussion of Aboriginal interests, has so far focused primarily on the anticipated costs to irrigated agriculture of reducing diversion limits and the flow-on effects for Basin regional economies and communities. This section considers some of the benefits.

The diversion limit scenarios would mean that the amount of water available for consumptive purposes will move from a long-term average of 13,700 GL/y to approximately 9,700–10,700 GL. This would result in improved environmental flow outcomes for a significant number of environmental assets and river ecosystem functions in many regions of the Basin. As a result, there are likely to be many environmental, economic, social and cultural benefits associated with the proposal. These, mainly public, benefits would comprise a mix of market and non-market goods and services. Some of these are described in terms of expected improvements in the ecological health of key environmental assets, ecosystem functioning of rivers and water quality in Chapter 6.

Quite apart from the anticipated environmental benefits, the range of other associated economic and social benefits that are likely to arise from the SDL proposals in many regions include recreation, tourism, human health and wellbeing, and primary production. For example, some of the indirect benefits likely to accrue from reducing current diversion limits include:

- economic benefits for downstream water users from greater water quantity or quality
- greater security of water for some users, particularly those downstream
- more secure town supply in some areas (particularly downstream), reducing the need for additional infrastructure or water restrictions.

The value of these and other benefits can be difficult to quantify, particularly across an area as large and diverse as the Basin. Because of this and the fact that many of the environmental and associated benefits provided by water-dependent ecosystems are broad, long-term and of a public nature, they have tended to receive less attention in decision-making than the more quantifiable market-based and shorter-term impacts on the private sector (Hamstead 2009). Nonetheless, these values can be significant and an indication of the nature and extent of some of these is provided below.

Economic valuation of environmental benefits

Environmental improvement can be valued because people use or expect to use environmental assets (e.g. for tourism or recreation purposes such as swimming, fishing and bird-watching). People can also value environmental assets without relating them to use; that is, the assets' existence or the options



Stone tools created as part of Traditional Knowledge project developed by North East Catchment Management Authority

they provide is valued. These are termed non-use values or benefits, and include the community's valuing of improved riverine health and assets such as healthy vegetation, native fish populations and waterbirds (Morrison & Hatton MacDonald 2010).

Increasingly, there is also recognition of the concept of ecosystem services as a means of understanding, categorising and valuing 'the benefits people obtain from ecosystems', including those mentioned above (Millennium Ecosystem Assessment 2005). In particular, the categories of regulating and supporting services derived from ecosystem functions (e.g. water regulation, purification and waste treatment, soil formation, primary production, nutrient cycling and water cycling) would appear to be relevant to any attempt to place a value on the maintenance of the productive base for agriculture in the long term.

In recent decades, changing social values have been reflected in increasing community preferences for delivering improved environmental outcomes and non-use values (Barr 2009). Passage of the *Water Act 2007* (Cwlth), with its emphasis on protecting and restoring key environmental assets and ecosystem functions, reflects this reality.

Despite the increasing clarity and understanding of concepts such as ecosystem services and the nature and range of environmental benefits, estimating the actual value the Australian community places on them, and in particular non-use values, is notoriously difficult. As noted in Section 4.3, while a number of techniques exist, assessing the economic value of the range of potential benefits is far from straightforward and many of the benefits are not readily quantifiable in dollar terms by reference to market-related data.

Nevertheless, estimates of the economic value of environmental benefits arising from reducing current diversion limits can be derived from the combination of an assessment of the likely extent of environmental change to be achieved and identification of the dollar values that people place on these incremental environmental changes.

Much work has been undertaken by MDBA to assess the amount of water required to protect and restore environmental assets and ecological functions, and also to understand the range of uncertainty and risk associated with achieving the desired environmental outcomes with these volumes of water. However, there are a number of scientific challenges in accurately estimating the incremental ecological responses of water-dependent ecosystems to increased watering events in most parts of the Basin. These include a lack of available scientific data and research to elicit specific empirical cause-effect relationships for many environmental assets, particularly given the highly variable climate and thus river-flow events in the Basin. While MDBA is confident that it has used the best available science, many knowledge gaps still remain, and are likely to do so for the foreseeable future. The sheer size of the Basin, coupled with the diversity of its environmental assets and the variability of its natural environment make any precise quantification a difficult task.

Given the expected benefits of the proposal for SDLs is largely driven by the anticipated ecological response to increased environmental flows, it is difficult to derive a precise economic estimate of value for the environmental benefits. Work undertaken for MDBA by Morrison and Hatton MacDonald (2010) nonetheless provides an indicative range of the likely benefits, as discussed in Section 4.3. For instance, they estimate that if there was a uniform 15% improvement Basin-wide in the health of native vegetation and a 10% increase in native fish populations, the total increase in non-use present value would be around \$2.9 billion. In addition, a two-year increase in the frequency of bird breeding events throughout the Basin is estimated to have a



*49th Annual Floodplain Conference by
Lake Hume, Victoria*

non-use value to the public of around \$1.1 billion, while in the Murray region alone, a three-unit increase in the number of waterbird species present is estimated to have a value to the community of around \$37 million.

It is important to note that most of the beneficiaries of these improved environmental outcomes live in the nation's cities and towns. The indicative assessment of economic values noted above relies to a substantial extent on the preferences of city-dwellers for delivering these outcomes.

There can be little doubt that environmental benefits are highly valued by the Australian community. However, it remains a key challenge to quantify in terms of economic value the extent of probable environmental changes caused by increased water flows.

MDBA has engaged the Centre for International Economics to conduct a social cost–benefit analysis, with the aim of further quantifying the environmental benefits that can be expected under the proposals for SDLs in terms of economic value. This analysis will draw on the range of studies commissioned by MDBA, which analyse various aspects of the expected costs and benefits associated with the SDL proposals.

Information derived from these studies should be considered as a valuable input to MDBA's decision-making processes; the studies will need to be interpreted with a degree of caution and considered alongside other information on ecological impacts and social equity.

Valuing water-quality benefits

It is anticipated that the measures outlined in the proposed Basin Plan will provide additional social and economic benefit to communities through improvements in water quality. As outlined in Chapter 6, the Water Quality and Salinity Management Plan will address a number of consequences of poor water quality. Among the anticipated benefits, improvements in water quality are expected to enhance aesthetic and amenity values of water and water bodies, minimise risks to human and animal health, enhance ecological and conservation outcomes, and minimise financial costs by reducing water filtration and purification treatments for both commercial and human consumption needs.

As with other improvements in environmental condition, these benefits are often difficult to quantify. However, the efforts made by Basin states and the Australian Government since 1988 to maintain salinity levels at Morgan on

the River Murray in South Australia have been recorded through a register of salinity debits and credits from land and water management outcomes. These have been applied by governments to maintain salinity levels at below 800 EC for 95% of the time. In 2009, these benefits were estimated at approximately \$17 million per year (MDBA 2010). In another study, Connor (2008) estimated that the reduction of salinity to a given target saved about \$350 million on the cost of treatment for food production and for drinking water for urban centres and industries in the lower Basin.

Many of these benefits are likely to accrue to water users who live by, or depend on, water from downstream parts of the River Murray. For example, residents of Adelaide, Port Pirie, Port Augusta and Whyalla outside the Basin, and Murray Bridge and other towns along the lower Murray, are likely to receive major benefits from improved water quality for drinking, domestic use and industry. While in normal years Adelaide draws about half its water supply from the River Murray, this can rise up to 90% in dry years (Mooney & Tan 2010).

Avoiding treatment costs and maintaining security of freshwater supplies is an important consideration in developing the proposed Basin Plan. It is expected that the Water Quality and Salinity Management Plan will deliver increased flushing flows to better maintain water quality standards, reduce in-stream salinity and tend to reduce the risk of blue-green algae outbreaks. However, the optimal flow regime for ecological health may not necessarily correspond fully with that desired for meeting water quality objectives, such as control of blue-green algae, so more research, modelling and analysis may be warranted to inform the optimal approach.

The proposed new arrangements for managing both water quality and salinity are discussed further in Chapter 6.

Potential implications for tourism

Tourism in the Basin is widespread and diverse and includes experiential and eco-tourism, boating and recreational fishing. Experiential tourism often relies on a vibrant food and wine sector, and as such has a close cultural association with irrigated agriculture. Activities such as boating, water sports and fishing depend to an extent on infrastructure developed to support the river regulation that maintains weir pools, while eco-tourism, boating, houseboating and fishing in some places also rely on the natural attraction of aquatic ecosystems and water for the environment.

Data from state tourism departments indicate that the total value of tourism associated with the River Murray alone was estimated in 2005 at \$1.6 billion (Howard 2008).

While tourism is undoubtedly an important activity in the Basin, there is little research into the nexus between water and tourism in the Australian context, particularly in a form that is relevant to policy (Cruse et al. 2010).

Nevertheless, benefits to the tourism industry from the SDL proposals can be expected to arise from improvements in the health of some aquatic assets, particularly those water bodies that offer a range of recreational opportunities including fishing, boating, camping and nature-based activities.

The potential importance of increased environmental flows to the tourism industry can be partly illustrated through the impacts of the recent drought. A destination visitor survey commissioned by Tourism Research Australia (2010) evaluated the impact of drought on the Murray region between 1999 and 2008. The region is a notable tourism destination in South Australia, representing 17% of direct regional tourism expenditure, while in Victoria

it is 12% and in New South Wales 3%. The research found that overnight visits to the entire Murray region, which were estimated to be 2.8 million in 2008, had fallen by more than 2% per year over the period. Had the drought not occurred, tourism expenditure would have been about 5%, or \$70 million, higher than actual levels in 2008. Over 1999–2008, there was an estimated fall in direct spending of \$350 million, leading to a reduction in gross regional product over the entire period of around \$460 million, and about 600 fewer full-time equivalent jobs. Further, it was reported that some 20% of respondents considered that the drought had affected their tourism patterns. Industry stakeholders were apparently concerned that visitors were avoiding the region because of perceptions that the drought was affecting the activities that could still be pursued (Tourism Research Australia 2010). This concern is supported by Mooney and Tan (2010), who report that perceptions of the river's declining amenity by the broader community was intensifying pressure on the industry.

The study by Mooney and Tan (2010) and the work of Marsden Jacob Associates et al. (2010) suggest that the recent economic impacts on the lower River Murray in South Australia due to a lack of flows and water levels have been significant for those communities.

While it is difficult to draw definitive conclusions about the likely effects of the SDL proposals, this research indicates that some of the costs incurred in recent times along the River Murray as a result of low flows may be overcome.

Benefits to primary industry: floodplain grazing

Some of the expected offsetting benefits for dryland agriculture arising from the impacts of diversion limit reductions on irrigated agriculture are discussed earlier in this chapter. It is anticipated there may also be benefits to floodplain graziers in some regions of the Basin.

Floodplain grazing is a practice which has existed for well over 100 years in many parts of the northern Basin. Graziers have argued that in recent decades, their industry and the floodplain environment have been negatively affected by the expansion of the irrigation industry and associated infrastructure. The construction of dams and structures upstream of the floodplains, and the subsequent lower frequency and volume of floods, are viewed as contributing factors to the diminished health of Basin floodplains and wetlands (Lewis 2006). In the Lower Balonne region, for instance, irrigation development and diversion has led to reduced flows, resulting in reduced fodder production in downstream grazing areas (Snowy Mountains Engineering Corporation 2006).

To date, little effort has been made to quantify the trade-offs between water consumption for irrigation and losses to the floodplain grazing industry (Arche Consulting 2010). Likewise, only cursory assessment has been made of the socioeconomic impacts associated with floodplain agriculture.

Recently, Arche Consulting (2010) undertook analysis to scope the socioeconomic effects of floodplain grazing. Using three case studies, an



Camping at Top Crossing Hut on the King River, Victoria

indication of the value of floodplain agriculture to the farmers who use this form of production was assessed. Three case-study farms with a combined area of 148,500 ha were examined, including an estimated floodplain area of 34,000 ha. The income from such enterprises is highly variable and peaks in flood years. Flooding has a very positive impact on the gross profit of such farms. For example, for the three studies, it was estimated that an additional 59% in gross profit was added to the standard enterprises compared to a without-flooding scenario.

While it is difficult to quantify the benefits to floodplain grazing from enhanced environmental flows, it is very likely that the floodplain grazing industry would benefit greatly from the reduction of current diversion limits and some reinstatement of natural flooding regimes. These benefits could be expected to modestly offset some of the costs associated with reductions in the value of irrigated agriculture, such as cotton production.

The Coorong, Lower Lakes and Murray Mouth



Ferry crossing the River Murray at Tailem Bend, South Australia

The Coorong, Lower Lakes and Murray Mouth are likely to be major net beneficiaries of any reductions in current diversion limits, since increased river flows will in turn improve their health.

The region is an example of the complex interaction of environmental, social and economic impacts, positive and negative, that could be expected to be seen from implementing the SDL proposals, although the outcomes here may well be less dramatic for other regions. The costs likely to be borne as a result of the proposal in the SA Murray region as a whole (i.e. including the Riverland) are

discussed earlier in this section, while the nature of many of the benefits are discussed above.

The area is recognised nationally and internationally for its environmental values, including through its Ramsar listing and status as one of six icon sites under the Living Murray program (MDBC 2007). In recent years, it has gained national coverage from its heightened state of degradation. Mean average annual flows reaching the Murray Mouth have fallen dramatically from a long-term average of around 12,000 GL (1900s to 1990s) to 1,006 GL over 2000–08 (Paton 2010). For example, hydrologic modelling indicates that a 3,500 GL reduction scenario would result in an annual average increase of 2,300 GL of flows through the Murray Mouth, producing an estimated long-term average flow of 7,400 GL/y, which is modelled to keep the mouth open about 91% of the time. Keeping it open is vital for exporting salt and nutrients from the Basin and maintaining the health of the Coorong; it is considered a critical indicator of the health of the entire Basin system.

Socioeconomic values associated with the region include Aboriginal and non-Aboriginal cultural values, tourism and recreation interests, fishing interests, and water sources for residential and domestic use and for primary industries.

Numerous studies have documented the many negative impacts incurred by the communities of the Lower Murray after a long period of low flows and a lower river level. For example, Mooney and Tan (2010) report that

the combination of low flows, reduced allocations and drought has had a 'devastating' impact on irrigated production of dairy, grapes, citrus and vegetables in the Lower Murray Swamps area, near Mypolonga.

Similarly, the problems associated with less fresh water, acid sulfate soils, rising salinity and species loss are already known to be affecting the social fabric of the region (SA Department for Environment and Heritage 2010). The fishing and irrigation industries, for example, have already been directly affected and many members of the community have expressed concerns over health issues, the future of local industries and associated effects on employment and their financial future.

A business-as-usual approach to current diversion limits would see a continuation of many of the impacts on these values, caused by low flows, low allocations and drought.

While these impacts have arisen as a result of a combination of effects, including various structural adjustment pressures that have been affecting primary industries for some years, the effect of low flows in this region would appear to be more disadvantageous than reductions in water allocations (Mooney & Tan 2010).

Apart from the non-use environmental values, some of the effects of low flows in the region have included:

- The imposition of significant management and remediation costs on local communities and the South Australian and Australian governments to maintain the health of the aquatic environment of the Lower Lakes and Coorong wetlands
- A range of costly management interventions that primarily aim to remediate or limit the environmental degradation of the wetland system, including:
 - dredging to keep the Murray Mouth open
 - building of barrages and weirs
 - controlling acid sulfate soils through various pumping and flow control measures
 - rehabilitation activities and improving or sourcing alternative water supplies for domestic consumption.
 - Kingsford et al. (2009) estimate the future costs of remedial engineering and infrastructure interventions in the Coorong and Lower Lakes to be in the order of \$2 billion.
- Impacts on tourism, which relies on the health of aquatic assets, particularly those dependent on the amenity values of the Lower Lakes and Coorong. For example, as a result of the drought and lower river levels in the Coorong and Lower Lakes region, overnight visits fell between 1999 and 2008 by an estimated 1.8% annually, duration of stay by 2.9% and direct expenditure by 5.1%, causing a loss of \$134 million in gross regional product (Tourism Research Australia 2010). The region accounts for 12% of direct regional tourism expenditure in South Australia and is a major destination for residents of Adelaide and other parts of South Australia, as well as interstate and international visitors. This translates into estimates of tourism expenditure forming over 6% of gross regional product and employment in the tourism sector, representing 7% of total regional employment (Mooney & Tan 2010). An estimated 80,000-plus nature-based tourists visit the Coorong and Lower Lakes annually (South Australian Tourist Commission 2007). Recreational use values of the Coorong were estimated to be worth \$57 million/y (Dyack et al. 2007). Tourism activity has plunged by 60–70% over concerns about water levels and quality. Low flows directly affect the navigability of the river

and lakes as well as access to berthing and on-shore facilities. Houseboat hire on the River Murray has suffered from this, as has the wider boating sector on the Lakes, based at Goolwa.

- Costs of around \$120 million for pipelines to secure water supplies for the townships, communities and irrigators who draw water from the Lower Lakes. Steps have also been taken to address the threats to the security and quality of water supplies for the residents of Adelaide and other major cities and towns inside and outside the Basin that depend on water from the Lower Murray for drinking and industry. In the past, Adelaide has drawn up to 90% of its supplies in extended dry times and has now built a \$1.3 billion desalination plant.
- Impacts on commercial and recreational fishing, which depends substantially on the maintenance of environmental flows to drive biological productivity. The sector once supported up to 32 enterprises with supporting processing and services. Lower lake levels affect water quality and the free passage of species in the lakes.
- Loss of Ngarrindjeri cultural, economic and environmental values associated with drinking water, fishing, collecting other food and materials, protection of cultural heritage, sites and knowledge (Mooney & Tan 2010).
- Psychological and other health impacts on community wellbeing arising from stress, feelings of spiritual and emotional loss, reduction of amenity, and the blowing of acid sulfate soils in strong winds (SA Department for Environment and Heritage 2009).

In terms of primary industries, the region has faced several challenges arising from low flows:

- Dairy farmers on the reclaimed Lower Murray Swamps, downstream from Mannum, have been prevented from gravity feeding water to properties.
- Viticulturalists at Langhorne and Currency Creek have been unable to access water from Lake Alexandrina and have survived due to the construction of a 110 km pipeline to supply water directly from the river at Jervois, south of Murray Bridge.
- Dairy farmers supplied from the Lower Lakes have been unable to access water due to low levels and raised salinity. Many have exited the industry and those who remain face raised costs and reduced yields if converting to dryland enterprises.
- Horticulturalists and viticulturalists between Lock 1 and Murray Bridge have suffered from low allocations and falling river levels.

In summary, quite apart from any valuation of the environmental benefits, these industries and the regional community would derive considerable benefits from increased flows down the Murray as a result of the SDL proposals and from the improved protection of the Coorong, Lower Lakes and Murray Mouth. The Lakes would be healthier, river salinity would be lower, tourism and boating would recover and urban development associated with water levels (e.g. marinas) would continue. Accessibility of water and the quality of that water for irrigation and other uses would improve as water levels rise (Marsden Jacob Associates et al. 2010).

Short-term implications and adjustment

Reducing current diversion limits will change the extent and pattern of diversion and therefore the use of water and other resources in the Basin. The Basin's irrigated agricultural industries and those businesses and

communities that rely directly and indirectly on the wealth created by such industries will be affected. As discussed in the above analysis, while good indications of the nature and extent of these implications can be provided, determining accurately their magnitude and distribution across an area as large and diverse as the Basin is extremely challenging. Predicting the future is fraught, as the extent of the change in any place is happening against a background of ongoing structural change in rural Australia and will depend on a complex array of climatic, market, demographic, technological, social and policy factors.

In considering the implications of the SDL proposals, it is important to recognise that some impacts will be in the short term, before those affected have fully adjusted to reduced diversion limits, and some will have long-term, ongoing implications. Most of the economic modelling results presented in this assessment have referred to the long-term outcomes; however, additional work done by ABARE–BRS (2010a) and the Centre of Policy Studies (Wittwer 2010), while conditional on water supply variability assumptions, suggest that the differences at a regional scale are small. Other aspects of the analysis have not particularly distinguished between long- and short-term implications.

Nevertheless, for those irrigation-dependent communities where the SDL proposals could result in substantial changes in economic output, MDBA recognises that the short-term adjustment effects may be significant. Given the SDL proposals, the extent of implications may be mitigated by several policy-related factors over which MDBA and Australian and state governments have some influence, including:

- The timing for implementation. While the Basin Plan is scheduled to be adopted in 2011, most state-based water resource plans will not come into effect until 2014 and, for Victoria, 2019. In addition, MDBA is proposing that SDLs be gradually implemented over a period of up to five years in many cases, through the temporary diversion provisions of the Water Act. Chapter 5 provides more information about these arrangements.
- The extent of structural adjustment assistance offered by governments to affected communities, such as the recovery of water through buybacks, irrigation infrastructure improvements and other measures under the Water for the Future initiative, including the Strengthening Basin Communities programs. The Australian Government its intention to bridge the gap between current diversions limits and SDLs. In addition, under the risk allocation provisions of the Water Act, MDBA must identify the Commonwealth's share of responsibility for any reduction in current diversion limits. See Chapter 5 for further information.
- The extent to which more efficient ways of achieving environmental objectives and targets for key environmental assets and ecosystem functions can be achieved, for example, through engineering and infrastructure works and measures such as those occurring under The Living Murray program.
- Improvements in the flexibility of water market mechanisms, such as the ability of participants to trade freely so as to adjust to changing circumstances. This also includes the way in which environmental water holders manage their assets and engage in water trading. In addition, the flexibility with which entitlement holders are able to manage their allocations, such as through carryover provisions, may provide opportunities for reducing planning uncertainty and increasing productivity. New water trading rules will be included in the Basin Plan, as outlined in Chapter 6.



Grapes not harvested due to lack of water, Bremer River, South Australia

- Provision of information to farmers, business, regional communities and other key stakeholders (such as financial institutions) to clarify proposed implementation arrangements. This could include information about the SDL proposals and other aspects of the proposed Basin Plan, transitional assistance measures, the respective roles of different state and federal government agencies in implementing the plan, and articulation of the proposed role of regional communities and stakeholders in this implementation.

For much of irrigated agriculture there is substantial capacity to adjust in the short term to changes in diversion limits. Given the interannual variability of rainfall and water supply across the Basin, dryland and irrigated agricultural farms are accustomed to responding to major changes in seasonal water availability. Notwithstanding this flexibility, it is likely that short-term impacts on farms, industries, businesses and communities will be greater than in the long term, since irrigated agriculture and associated industries are likely to achieve long-term productivity gains through, for example, enhancements in technology.

The success with which communities transition may be boosted by the continued provision of community services such as health, education, aged care and ongoing activities of community clubs, sporting clubs and other such connections. Sustaining the social fabric of communities will be in part determined by a combination of economic adjustments to the reduction in diversions, and the strength of each community's social capital and adaptive capacity.

Future work

MDBA is continuing to undertake further assessment of the social and economic implications of each diversion limit scenario. This includes a social cost–benefit analysis for each of the Basin's 19 regions and the Basin as a whole.

The range of social and economic assessments undertaken to date has highlighted a number of areas of uncertainty that may benefit from further research and analysis. Some of these relate to understanding the finer-scale implications for local communities.

In 2011, MDBA is required to provide advice to the Murray–Darling Basin Ministerial Council on the likely social and economic implications of the SDL scenarios in the proposed Basin Plan. In addition, a review of impacts of the Basin Plan is required five years after its adoption.

MDBA will consider its future work program in light of these considerations and the feedback it receives on the *Guide to the proposed Basin Plan*.



*Street scene in Albury,
New South Wales*

4.6 Critical human water needs

The drought experienced in the southern part of the Murray–Darling Basin in the early part of the 21st century has been the most severe in the past 114 years. Among other things, these unprecedented conditions revealed how challenging it can be to ensure ongoing supply to meet the basic human water needs of individuals and communities reliant on the rivers in the Basin.

While ensuring supply of domestic water is a state or territory government responsibility, in the southern connected Basin the recent experience emphasised the need for cooperative arrangements among states to ensure adequate supplies, as the water sharing rules in the Murray–Darling Basin Agreement did not contemplate such low water availability.

To build on the recent experience, the Basin Plan must take into account and provide for critical human water needs and associated monitoring and risk management. Critical human water needs are defined in the *Water Act 2007* (Cwlth) (s. 86A(2)) as the minimum amount of water, that can only reasonably be provided from Basin water resources, needed to meet core human requirements in urban and rural areas, and non-human consumption requirements for which a failure to meet would cause prohibitively high social, economic or national security costs.

It is expected that the circumstances in which water is available only to meet critical human water needs would be rare (occurring about once in every 100 years), but thorough preparation for such a scenario is still vital.

The Commonwealth and Basin states have agreed that water for critical human needs must be given the highest priority for the communities that are dependent on Basin water resources and that conveyance water will receive first priority in the River Murray system (see Figure 4.35). Water set aside and used for critical human needs will need to be taken from water available under the long-term average sustainable diversion limits (SDLs) for each region (see Section 4.4).

The proposed Basin Plan does not have to determine critical human water needs beyond the River Murray system, but to ensure that the plan takes into account the agreed priority of critical human water needs, the Murray–Darling Basin Authority (MDBA) has undertaken a comparison of estimated critical human water needs with the SDL proposals to ensure that the SDLs allow for critical human water needs to be met across the whole Basin.

For the Murray region, the Basin Plan will set out volumes that allow for basic individual requirements (e.g. drinking, food preparation and hygiene); water to cover community essentials under extreme circumstances (i.e. to keep hospitals, schools, emergency services and other key community services operating); and water to maintain, as far as possible, the social fabric of the community. However, decisions on what uses are ‘critical’ for specific communities are left to the states. It remains the responsibility of New South Wales, Victoria and South Australia to meet (i.e. set aside and deliver) the critical human water needs of their communities dependent on Basin water resources, to decide how water from its share is used (Water Act s. 86D(3) (b)) and to manage risks associated with the provision of critical human water needs.

Amount of water for critical human needs

The amount of water required for critical human needs has been derived with consideration of how communities function during periods of very low water availability. The aim is to provide sufficient water to maintain a satisfactory level of function within communities supported by the River Murray system. It has not, however, been set at a level that would sustain ‘normal’ function. How communities function during a period of low water availability will also be affected by how state authorities limit water use, and how each state manages the distribution of the critical needs water.

The approach to determine a bulk volume for critical human water needs from the River Murray system at a state level is based on:

- assumed average daily community use of 340 L per person in urban areas and 398 L per person in rural areas; these numbers include community services, commercial and industrial use and are based on an analysis of recent water use in Australian communities (including in the Basin) under high-level water restrictions
- an allowance for each state for extraordinary circumstances
- consideration of alternative water supplies that may supplement Basin water resources
- an allowance for distribution losses from the River Murray system to the point of supply.

Using this approach, the volumes of water required to meet the critical human water needs of the communities that are dependent on the River Murray system were determined (see Table 4.26).

The approach to determine the volumes is non-prescriptive; that is, it does not list which activities or uses of water are, or are not, included within the definition of critical human water needs, as it will be each state’s responsibility to manage the needs of its own communities.

Table 4.26 Volumes required to meet critical human water needs of Basin communities dependent on the River Murray system

State	Current (GL/y)	Proposed (GL/y)
New South Wales	75	61
Victoria	75	77
South Australia	201	204

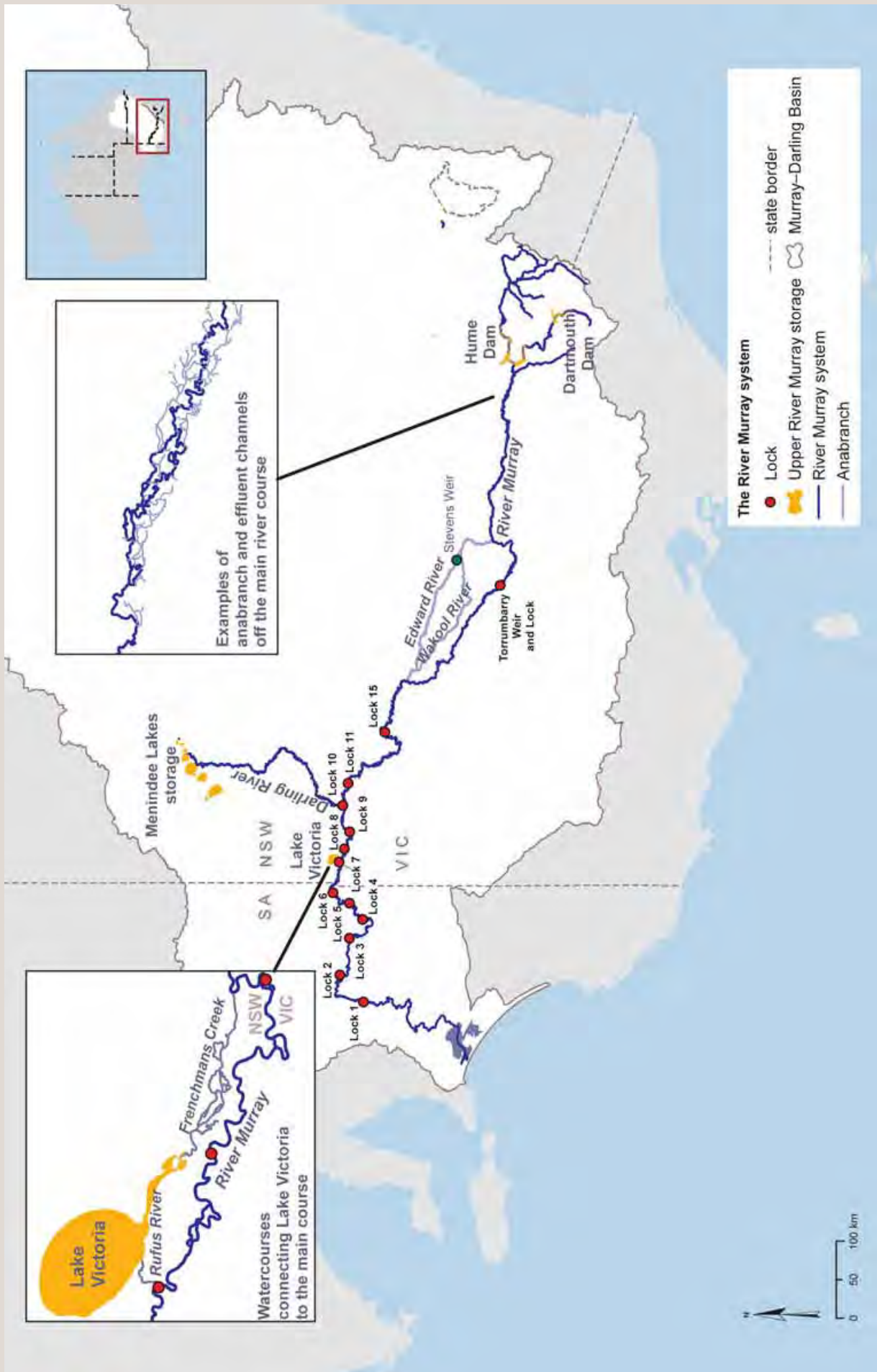


Figure 4.35 The River Murray system

Arrangements for carrying water over in storage from one year to another

States make their own arrangements to reserve water for critical human needs. For South Australia, this is facilitated by its right to store its entitlement to water, for the purposes of critical human water needs and private carryover, as provided for in clauses 91 and 130 of the Murray–Darling Basin Agreement and the proposed Schedule for South Australia’s Storage Right.

In addition, clause 130(7)(d) of the agreement provides that each state should be able to carry over (between one water year and the next, usually in dams) a volume of water equivalent to 150% (or 18 months supply) of its annual critical human water needs requirements.

Conveyance water

Conveyance water is the water required to ensure there is sufficient flow in the river to physically deliver the supply of water for other uses (in this case critical human needs) without it evaporating or seeping into the riverbed. Without allowing for conveyance water, much of the supply required to meet critical human needs would not reach the communities that rely on it. The conveyance water volume in the River Murray system has been estimated at 1,596 GL/y during periods of low water availability, when delivering water for critical human needs is most difficult. This is composed of three volumes:

- 150 GL/y for evaporation and seepage from the major storages. This estimate is based on observations during periods of below-average storage levels
- 750 GL/y for seepage and evaporation in the River Murray, between the major storages and the South Australian border. This estimate is based on observations during hot dry conditions
- 696 GL/y for dilution in the River Murray between the South Australian border and Wellington. This fixed volume is a requirement set out in clause 88(b) of the Murray–Darling Basin Agreement.

Conveyance reserve water

Under current arrangements there is no specific provision to reserve the volumes of conveyance water necessary to ensure that critical human water needs can be physically delivered. The Basin Plan will include conveyance reserve provisions intended to give protection for a potential worst-case scenario of extremely low inflows at a time when there is also very little water in storage. Depending on prior conditions, this is expected to provide coverage for a sequence of at least two exceptionally dry years.

Conveyance water is a joint responsibility that is managed by MDBA on behalf of the states in accordance with the Murray–Darling Basin Agreement, whereas setting aside critical human water needs is a state responsibility. Accordingly, the reserves policy in the proposed Basin Plan is focused on reserving sufficient conveyance water to deliver critical human water needs, rather than ensuring that sufficient water is available to meet such needs. In practice, the conveyance water and water for critical human needs should be considered as a package, as neither can provide a benefit without the other.

As the conveyance reserves policy may affect Basin state water sharing arrangements, the agreement of the Murray–Darling Basin Ministerial Council to the Basin Plan provisions is required in order for the provisions to take full effect (Water Act ss. 86G and 86H).



Lock 15 at Robinvale, Victoria, showing algae growth in foreground

Amount of conveyance reserve water

The required volume of conveyance water is about 1,600 GL/y. The conservative worst-case planning inflow sequence (the minimum expected inflows into the Murray system) is 980 GL/y. This is considered the most prudent inflow sequence to determine the volume of the conveyance reserve. Using the formula identified in the Water Act (s. 86D(2)), the annual volume of water required to be reserved to meet the shortfall in conveyance water is 620 GL. To support the development of the Schedule for Water Sharing, however, a detailed assessment is being undertaken of how to protect against shortfalls of conveyance water, which may show that a greater or smaller volume of conveyance reserve is required. This study will be taken into consideration once completed.

The worst-case planning inflow sequence includes minimum inflows from the Murrumbidgee, Darling and Goulburn rivers. These are therefore taken into account in developing the reserves policy. Such inputs can, however, be supplemented by increased inputs from these valleys, depending on the circumstances, either as part of normal operations in the water resource assessment process or in the form of contingency measures.

Water quality triggers for critical human water needs

The Basin Salinity Management Strategy and the Water Quality and Salinity Management Plan, combined with raw water treatment consistent with the *Australian drinking water guidelines* (NHMRC & NRMMR 2004), are considered to adequately address the risks associated with public health issues and impacts associated with drinking water from the River Murray system.

However, an emergency response would be triggered in the River Murray system should MDBA receive notification that either the salinity or water quality triggers had been exceeded, and a system level response was required. The salinity and water quality triggers are when:

- a salinity measurement of 840 mg/L total dissolved solids or greater is recorded, or
- a water quality characteristic is measured at a level significantly outside the manageable range for any parameter and a system-level emergency response is required. For example, had the recent occurrence of acid

sulfate soils led to a part of the system becoming highly acidic, a system-level emergency response would have been triggered.

The water quality trigger is most likely to be met at a time when a state notifies MDBA that water sourced from the River Murray system cannot be treated to an acceptable quality using existing treatment processes, and that a system-level emergency response is required (rather than a localised response) to manage the issue.

Tiered water sharing arrangements for the River Murray system

The Basin Plan will outline a graduated or tiered approach to sharing water in the River Murray system that is related to water availability. This allows additional water sharing rules and contingency measures to be invoked during periods of extremely low water availability. When critical human water needs cannot be met or delivered by the arrangements of the current tier, a change to a higher tier is triggered.

The tiers are:

- Tier 1 water sharing arrangements are considered ‘normal’ and operate from very wet to dry conditions when adequate water is available for critical human water needs and conveyance. They are set out in Part XII (Division 1), Part XIV and Schedule F to the Murray–Darling Basin Agreement (including special accounting). These arrangements have been in place in one form or another since the first Murray–Darling Basin Agreement was signed. The Water Act provides for the establishment of a reserve of conveyance water to improve the ability to manage the River Murray system under dry conditions. This conveyance reserve will be set aside during tier 1 water sharing.
- Tier 2 arrangements will apply during periods of very low water availability, when the ‘normal’ provisions will not ensure there is enough water to meet conveyance water requirements. The tier 2 arrangements will be set out in the Schedule for Water Sharing, described later in this section.
- Tier 3 arrangements deal with extreme and unprecedented conditions that could affect either the quality or quantity of water available for critical human needs, requiring an emergency response to be agreed by the Ministerial Council. These arrangements will also be included in the Schedule for Water Sharing.

Triggers for moving between the tiers

A key component of the tiered approach to sharing water is the triggers for moving between these tiers. The establishment and use of the conveyance reserve during the tier 1 water sharing arrangements will act as a buffer to reduce the likelihood of having to commence tier 2 water sharing arrangements.

The triggers for commencing tier 2 are:

- if it is 1 September to 31 May, tier 2 will commence operation if the worst-case planning water resource assessment predicts that the conveyance reserve cannot be set aside in full without the use of advances; or

- if it is 1 June to 31 August, tier 2 will commence operation if the worst-case planning water resource assessment predicts that the conveyance water requirements for the current year will not be met.

The trigger for ceasing tier 2 is as follows:

- At any time, tier 2 will cease to operate if the worst case planning water resource assessment predicts that the conveyance reserve can be set aside in full without the use of advances.

The triggers for commencing tier 3 are as follows:

- At any time, tier 3 will commence operation if the worst-case planning water resource assessment predicts that there will not be enough water to supply critical human water needs for the rest of the current water year; or
- At any time, tier 3 will commence operation if the worst-case planning water resource assessment predicts that conveyance cannot be supplied for the rest of the current water year, even with the use of tier 2 contingencies; or
- At any time, tier 3 will commence operation if there is a salinity or water quality measurement for any characteristic that is forecast to occur, in the raw surface water extracted from the River Murray system at any site, that does not meet, and cannot be treated to a standard that would meet the relevant health-related guideline value for human consumption purposes, and cannot be addressed at a local or state level.

The triggers for ceasing tier 3 are as follows:

- At any time, tier 3 will cease operation if the worst-case planning water resource assessment predicts that critical human water needs can be supplied in full for the rest of the current water year; or
- At any time, tier 3 will cease operation if the worst-case planning water resource assessment predicts that conveyance water requirements can be supplied in full for the rest of the current water year with the use of tier 2 contingencies; or
- At any time, tier 3 will cease to operate if the measurement for the salinity or water quality characteristic(s) of concern during a period of tier 3 water sharing arrangements has improved to a level such that it meets, or can be treated to a standard that would meet, the relevant health-related guideline value for human consumption purposes.

Monitoring and assessment

MDBA, on behalf of, and in conjunction with, the Commonwealth, New South Wales, Victorian and South Australian governments, assesses and mitigates risks to critical human water needs associated with inflow predictions through:

- monitoring the quantity and quality of inflows and forecasting the impacts of these throughout the River Murray system
- the reporting of inflows (and storage levels) as part of the water accounts
- the adoption of extremely conservative inflow sequences in the water resource assessments (the worst-case planning inflow sequence is currently used)
- predicting inflows on the basis of the best available information at a range of timescales

- regular reviews of trends in current and recent climate and inflow patterns and updating of forecasts
- operation of the River Murray system in coordination with anticipated inflows from the Snowy Mountains Scheme and tributaries
- use of river operations to mitigate issues where possible
- forecasts of water availability and use.

The Schedule for Water Sharing

The Schedule for Water Sharing is a new schedule to the Murray–Darling Basin Agreement (Part XII (Division 4)) that is being developed in parallel with the proposed Basin Plan provisions for critical human water needs. This new schedule will provide the necessary mechanism to set aside, deliver and account for water for critical human needs and a conveyance reserve.

While it is likely that the schedule will be agreed and in operation before the Basin Plan, there is no specific requirement for this and it will be subject to approval by the Ministerial Council.

The key points of the interaction between these two instruments are:

- If the schedule comes into effect before the plan, it must be reviewed for consistency with the proposed plan before the plan comes into effect (clause 152(1)(b) of the agreement).
- If the schedule comes into effect after the plan, it must be prepared having regard to the plan (clause 135(9)).
- While these provisions allow for either the plan or the schedule to come into effect first, the provisions in the plan may lack sufficient specific accounting mechanisms to set aside and manage the critical human water needs and associated conveyance reserve without further decisions. Therefore it may be difficult to implement the plan provisions before the schedule comes into effect.
- The critical human water needs and conveyance reserve arrangements set out in the proposed Basin Plan differ from the current accounting and water sharing arrangements in a number of ways. As such, the transition may result in a small step change in the various accounts. It is proposed that the simplest method is for the critical human water needs and associated conveyance reserve to be implemented from the first day of the first water year following the adoption of the Basin Plan by the Commonwealth Water Minister.
- The approval arrangements for the Basin Plan provisions and the Schedule for Water Sharing are quite different. The Basin Plan provisions are to be adopted by the Commonwealth Water Minister and the schedule is to be approved by the Ministerial Council.
- If the Basin Plan provisions relating to critical human water needs affect state water sharing arrangements, the application of those provisions is limited unless agreed by the Ministerial Council, or unless the Schedule for Water Sharing has not yet been agreed (Water Act ss. 86G(2) and 86H(4)).
- There are areas of overlap between the Basin Plan and the Schedule for Water Sharing that will require endorsement by both MDBA and the Ministerial Council.

Transitioning to the new arrangements



Chapter 5

The Basin Plan will establish new long-term average sustainable diversion limits (SDLs) for the Murray–Darling Basin’s water resources. While some parts of the Basin may be required to cut their historical levels of use by up to 35% of current diversion limits, recent experience of the drought has led to even more severe restrictions. Nevertheless, the social and economic effects of SDLs on some Basin communities and industries will be significant. As described in Chapter 4. However, Basin Plan mechanisms and government initiatives will help to mitigate the effects and soften the transition to the Basin’s new water sharing arrangements.

An important transition issue is the timing of the introduction of the SDLs. While the Basin Plan is due to be adopted in 2011, current water resource plans will generally continue to operate, despite any inconsistency with the Basin Plan, until they expire — that is, in most areas, no change will be made in the current levels of permitted extraction until the current water resource plans expire. Although two relatively small groundwater water resource plans in South Australia will expire near the end of 2012, it is not until 2014 that the majority of water resource plans in New South Wales, Queensland and South Australia will expire and then be subject to the SDLs. This means that water users and communities in these states will have up to three years to plan how to manage with less water. In Victoria the current water resource management arrangements expire in 2019. Provided current plans are recognised by regulation under the *Water Act 2007* (Cwlth) as transitional water resource plans, water entitlement holders and communities will have eight years to plan and adjust to the change before the SDLs will apply. Figure 5.1 shows an indicative timeline of the expiry of transitional and interim water resource plans, and the progressive percentages of water use managed under the Basin Plan.

In addition to the time available for communities to plan for the SDLs, new water trading rules will be included in the Basin Plan to improve the operation of the water market and enable market participants to trade more freely, thereby supporting adjustment to new water resource plans and SDLs.

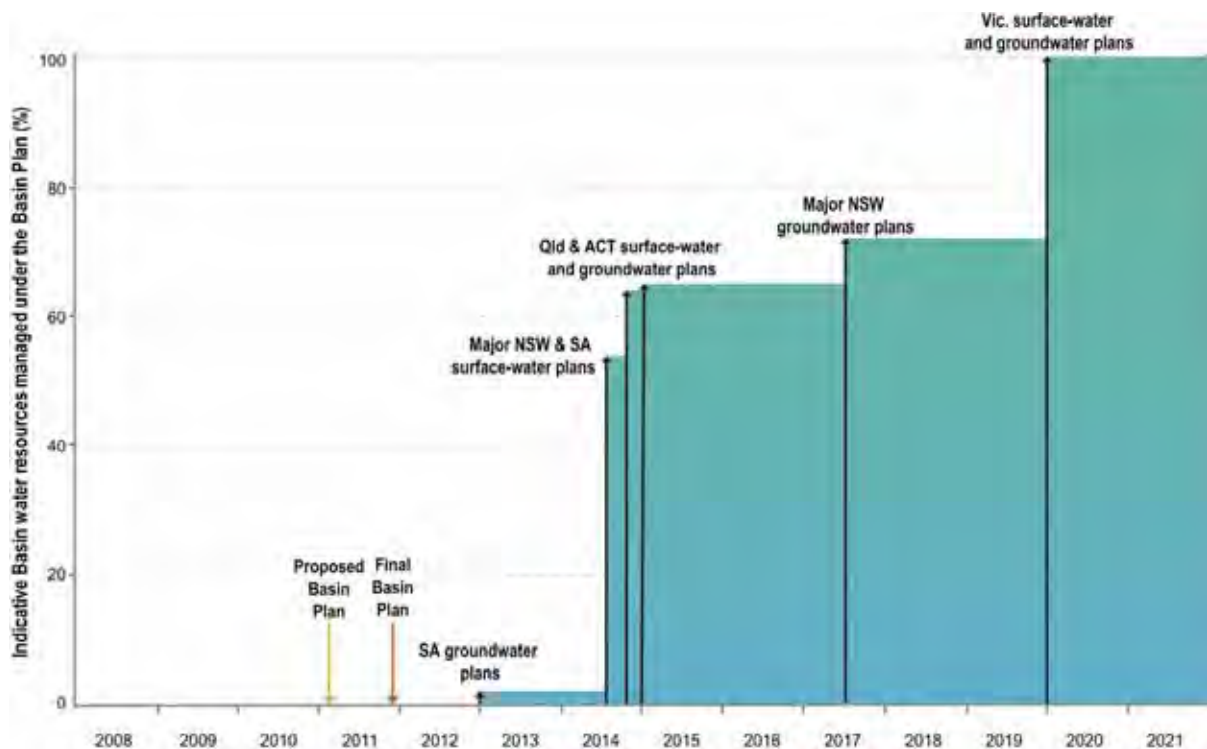


Figure 5.1 Indicative timing and percentages of Basin water resource use managed by the Basin Plan



Yarrawonga Weir on the River Murray over the town of Yarrawonga, Victoria

A range of existing and new government initiatives and Basin Plan provisions will help further with the transition. These include:

- the Australian Government’s Water for the Future initiative and related programs aimed at recovering water for the environment that will help to offset the effects of reductions in current diversion limits
- the risk allocation provisions of the Water Act, under which the Commonwealth will be responsible for managing its share of water availability reductions, as calculated by the Murray–Darling Basin Authority
- the Water Act’s temporary diversion provisions, which will allow for the gradual implementation of SDLs to assist social and economic effects.

5.1 Water for the Future and related programs

The Water for the Future initiative and related government programs will help offset the effects of reduced water availability under the Basin Plan (Department of the Environment, Water, Heritage and the Arts 2010a). Under Water for the Future, the Australian Government is purchasing water entitlements in the Basin water market and also recovering water for the environment through investing with Basin states in more efficient irrigation infrastructure. All of the water recovered through these actions is held on behalf of the Commonwealth by the Commonwealth Environmental Water Holder.

The Commonwealth Environmental Water Holder’s holdings will not affect how a long-term average sustainable diversion limit (SDL) is set, but will offset the effects on individual entitlement holders by lessening the reduction in consumptive allocations required in a water resource plan area to meet the new SDL.

A 2010 report by the Australian Bureau of Agricultural and Resource Economics into the first phase of the buyback program found that the future impact of water purchases on water markets, regional economies and communities in the Murray–Darling Basin would have only modest economic and social effects because of regional communities’ broad economic bases. It also found that any effects would be dwarfed by other pressures (such as drought) on Basin communities (Hone et al. 2010). The study found that a small but sustained increase in productivity growth of 2.5% to 3% — the



Environmental watering event from The Living Murray environmental water portfolio is used at the Gunbower–Koondrook–Perricoota Forest in 2010

type of outcome sought from the Australian Government's investments in irrigation infrastructure — would be sufficient to completely offset any effect of the buyback on irrigated agricultural production (Hone et al. 2010).

In March 2010, the Productivity Commission reported that 'purchasing water from willing sellers (at appropriate prices) is a cost-effective way of meeting the Government's liability for policy-induced changes in water availability' (Productivity Commission 2010).

The Australian Government has committed \$3.1 billion to purchasing water in the Basin (Department of the Environment, Water, Heritage and the Arts 2010b). As at 30 June 2010, total environmental water available after all purchases, including those by the Commonwealth Environmental Water Holder and states, is 705 GL (see Table 5.1). In addition, close to \$3.7 billion has been committed in principle to irrigation infrastructure efficiency improvement projects in the Basin (Council of Australian Governments 2008). This includes, for example, contributions to the Northern Victorian Irrigation Renewal Project and funding for private irrigation infrastructure operators in New South Wales and South Australia.

It is estimated that, together, the water purchasing and infrastructure programs will recover in the order of 2,000 GL for the environment. That is, the overall effect of the SDLs on the Basin's entitlement holders is likely to be in the order of 2,000 GL less than it would have been without these programs.

Other water recovery programs exist, including the NSW RiverBank program. These programs will further add to the water available to meet the needs of the environment and consequently will help mitigate the reductions required of individual water access entitlement holders.

The \$200 million Strengthening Basin Communities program is helping local governments in the Murray–Darling Basin to plan for reduced water availability through grants for projects that reduce demand on potable water supplies (Department of the Environment, Water, Heritage and the Arts 2010f). A number of other Australian Government programs aim to provide a 'safety net' for irrigators. For example, the Exceptional Circumstances Exit Package provides an exit grant of up to \$150,000 for farmers who decide to leave the land. The package includes two additional grants of \$10,000 for retraining and \$10,000 for relocation costs for eligible farmers (Department

of Agriculture, Fisheries and Forestry 2010a). Similar benefits are available under the Climate Change Adjustment program (Department of Agriculture, Fisheries and Forestry 2010b).

It is also possible that further investment will be made in works and measures to improve the efficiency of environmental and agricultural watering. Any water recovered from such investments will be taken into account in Basin Plan revisions.

Table 5.1 Environmental water available for offset

Region	Held environmental water to offset reductions ^a at 30 June 2010 (GL/y)	Range of gap after water recovery ^{b, c} at 30 June 2010 (GL/y)
Paroo	0	0–0
Warrego	8	10–12
Condamine–Balonne	1	204–274
Moonie	1	11–14
Border Rivers	4	82–108
Gwydir	64	26–57
Namoi	6	66–88
Macquarie–Castlereagh	57	47–78
Barwon–Darling	32	12–25
Lower Darling	0	16–20
Lachlan	45	-1–24
Wimmera–Avoca	0	0–0
Ovens	0	10–11
Goulburn–Broken	107	341–492
Loddon	3	35–40
Campaspe	5	35–47
Murrumbidgee region	64	615–846
Murray	309	784–1,155
Eastern Mount Lofty Ranges	0	3–4
Murray–Darling Basin total	705	2,295–3,295

a Includes water held by Basin states and the Australian Government as at 30 June 2010 but does not include water held for The Living Murray initiative.

b The gap is the difference between the current diversion limit and the proposed SDL range for that region, less the held environmental water (previous column) as at 30 June 2010. It is possible that in some regions more water has been secured since 30 June 2010.

c Totals may not be the sum of the figures provided due to rounding.

Note: The held environmental water is the long-term Cap equivalent converted from secured water entitlements to allow direct comparison with SDLs.

5.2 Risk allocation

Risk allocation is about sharing the risks of any changes to the volume and reliability of entitlement holders' water between individual entitlement holders and governments, according to a formula that recognises climate change, new knowledge and policy change.

The risk allocation provisions in the *Water Act 2007* (Cwlth) stem from two intergovernmental agreements between the Commonwealth and Basin states:

- Under the Intergovernmental Agreement on a National Water Initiative 2004 (National Water Initiative), the Commonwealth, state and territory governments agreed to share with water entitlement holders the risks associated with future reductions in available water once known overallocation and overuse had been addressed. The Australian Government's commitment is legislated for in the *Water Act*.
- Under the Intergovernmental Agreement on Murray–Darling Basin Reform 2008, the Commonwealth agreed to assume Basin states' National Water Initiative responsibilities for risks associated with new knowledge, and to bring forward the Commonwealth's assumption of new knowledge risks to when transitional or interim water resource plans cease, provided that a Basin state legislated to implement the National Water Initiative's risk-sharing provisions. To date only New South Wales has passed such legislation and this is recognised in the *Water Act*.

Using the *Water Act*'s risk allocation provisions, the Murray–Darling Basin Authority (MDBA) must identify in the Basin Plan the Commonwealth's share of the water availability reductions. The Commonwealth is required to manage:

- all the reduction that results from changes in Australian Government policy
- some of the reduction that results from improvements in knowledge about the environmentally sustainable level of take.

New South Wales has legislated for the National Water Initiative risk-sharing provisions and water users bear the risk for reductions of up to 3% of the current diversion limit in relation to new knowledge and the Commonwealth bears all of the risk above 3%. Currently, in all other Basin states water users bear the first 3% of risk in relation to new knowledge, between 3% and 6% of the risk is shared between the relevant state or territory (one-third) and the Commonwealth (two-thirds), and beyond 6% the risk is shared equally between the two levels of government.

The Commonwealth is not responsible for any of the reduction that results from long-term changes in climate and periodic natural events such as bushfire or drought.

While MDBA is responsible for determining the Commonwealth's share of any reduction, it is the Commonwealth Water Minister, through the relevant Australian Government department, who will be responsible for managing the effect of the Commonwealth's share of the reduction. This may occur in two ways:

- Water recovery programs under the *Water for the Future* initiative, mentioned in Section 5.1, will contribute to managing the Commonwealth's share. As discussed, the water recovered under these programs will effectively offset impacts on many water entitlement holders.



Fishway and carp separation trap on the River Murray at Lock 1, Blanchetown, South Australia. Native fish can swim through, while carp are caught and processed for bait to be used in the fishing industry

- To the extent that water recovery efforts do not fully offset the Commonwealth's share of the water availability reduction as calculated by MDBA, the Water Act provides for payments to be made to affected entitlement holders. Any such payments would relate to reductions in the market value of eligible water entitlements.

Transitional and interim water resource plans

Transitional and interim water resource plans are existing water sharing arrangements that have been recognised under the Water Act. When a transitional or interim water resource plan is in effect, the water resource plan will prevail over the Basin Plan where the water resource plan and the Basin Plan are inconsistent with each other.

No transitional or interim plans are currently in place in Victoria, but Victoria has sought to have existing water sharing arrangements recognised as transitional water resource plans under the Water Act (s. 241) before the Basin Plan comes into effect.

MDBA has calculated the long-term average limit on the quantity of water that can be taken immediately before the transitional or interim plan ceases to have effect, so as to identify the reduction required to meet the new long-term average sustainable diversion limit (SDL) and hence identify the new Commonwealth policy component, the new knowledge component and the Commonwealth's share of any reduction.



Northern Macquarie Marshes Nature Reserve, New South Wales

Climate change

As indicated above, any reduction in the diversion limit attributed to climate change and periodic events such as bushfires and drought will not be considered part of the Commonwealth's share of risks. MDBA considers that the current diversion limits for surface water incorporate a 3% reduction due to climate change, and that the proposed groundwater SDLs do not incorporate any reduction due to climate change. The specific effect of the 3% climate change reduction on surface-water access entitlement holders will be dependent on how the reductions required to meet the SDLs are distributed within water resource plans. Further detail on considering climate change in developing SDLs can be found in Section 4.2.

Changes in Australian Government policy

Calculating the Commonwealth's liability in relation to 'changes to Commonwealth policy' is complex. There are two competing issues to take into account:

- the National Water Initiative (clauses 44 and 46) makes it clear that existing overallocation and overuse are to be disregarded when applying the risk assignment framework
- there is an argument that the Water Act is a change in Australian Government policy in that the Commonwealth, under the Water Act, now has the statutory policy role to set SDLs across the whole Basin and enforce state compliance, when previously the Commonwealth relied on the states to determine their own diversion limits.



Farmland in the Murrumbidgee region near Griffith, New South Wales

The National Water Initiative goals include the determination and implementation of environmentally sustainable levels of extraction in overallocated and overused systems, and explicit statutory specifications of environmental outcomes. Under the initiative, states and territories were responsible for determining environmental objectives and sustainable levels of extractions for the Murray–Darling Basin for water resource plans. The Commonwealth’s role was to encourage the states and territories to work towards determining and implementing environmental sustainability through the Council of Australian Governments process.

The Water Act specifies in detail the parameters the Commonwealth must consider when determining SDLs. One of the Commonwealth’s considerations is giving effect to relevant international agreements. This goes beyond what was a consideration under the National Water Initiative. The Water Act stipulates Basin-wide benefits that change the scale and emphasis of states individually determining sustainability for their jurisdictions.

MDBA accepts that, notwithstanding the Basin states’ requirements to meet their obligations under the National Water Initiative to address overallocation and overuse, the Commonwealth’s role under the Water Act is a change in Australian Government policy while pursuing the general overall goal of the initiative.

Improvements in knowledge

To quantify the effect of a change in knowledge about the sustainable level of take for a particular water resource on a reduction in a diversion limit, and hence calculate the improvements in knowledge component (as required under the Water Act s. 75(1)(c)), it is necessary to identify the baseline knowledge upon which current Basin state water plans were developed and to compare this with the information used for preparing the Basin Plan. MDBA examined the available information on current water plans and found it was not possible to make a valid comparison. MDBA also notes that relatively little new information on the watering requirements of aquatic ecosystems has come forward since existing state water plans were made.

Consequently, MDBA has concluded that none of the overall reduction can be attributed to the use of new knowledge.

Commonwealth's share of reductions due to SDLs

In summary, after taking into account the 3% reduction for climate change, MDBA proposes that the Commonwealth's share will be 100% of the remaining reduction due to changes in Australian Government policy.

Risks arising from other changes in the Basin Plan

Under the Water Act (ss. 80–86), if a change in the Basin Plan, apart from a reduction in diversion limits, results in a change in reliability of water allocations in a water resource plan area, MDBA will be required to determine the Commonwealth's share (if any) of risks arising from that change in reliability. Changes to the reliability of water allocations may be caused by the implementation of various elements of the proposed Basin Plan, in particular the specific requirements against which new water resource plans will be accredited. However, it will not be possible to specify the magnitude of any changes in reliability caused by the Basin Plan until after the development of Basin Plan-compliant water resource plans.

MDBA will therefore determine the Commonwealth's share of impacts arising from changes in the reliability of water allocations (if any) when new water resource plans are being accredited.

5.3 Temporary diversion provisions

The Murray–Darling Basin Authority (MDBA) is required to specify a temporary diversion provision (which can be zero) wherever a long-term average sustainable diversion limit (SDL) is specified in the Basin Plan. The provisions provide a transition period of up to five years for water users and communities to adjust to the SDLs. They are intended to apply where socioeconomic hardship may occur as a result of SDLs being introduced.

A temporary diversion provision that is not zero will be required to reduce to zero by the end of five years, but the rate at which a provision is reduced may vary over different years. For example, the provision could reduce by an equal volume each year over five years — similar to the method New South Wales has applied in reducing water use in overallocated groundwater systems — or it could remain stable for several years before a large change.

Factors that could be taken into account when considering whether a temporary diversion provision greater than zero will be necessary include:

- socioeconomic effects of the water availability reduction arising from the SDL
- the severity of the reduction
- potential adverse effects on key environmental assets
- time available to make the adjustment before the SDL takes effect
- environmental water recovery efforts by the Commonwealth and others.

The time already available for entitlement holders to adjust to a potentially lower SDL will vary for different water resource plan areas depending on when the relevant interim or transitional plan expires. For example, the surface-water resources of the Murray region shared by New South Wales, Victoria and South Australia are currently covered by water resource plans that expire by 2014 (New South Wales and South Australia) and 2019 in Victoria.



*Farmland near Moama,
New South Wales*

The Commonwealth Environmental Water Holder is purchasing existing entitlements for environmental use, which will reduce the gap between current diversions and the SDL, and will help water users with the transition. The scale of these environmental water purchases may reduce the need for any proposed temporary diversion provision. The difference between the reduction, after disregarding the reduction of 3% attributable to climate change, and any purchases can be considered the ‘residual adjustment’ component for which a temporary diversion provision will be considered.

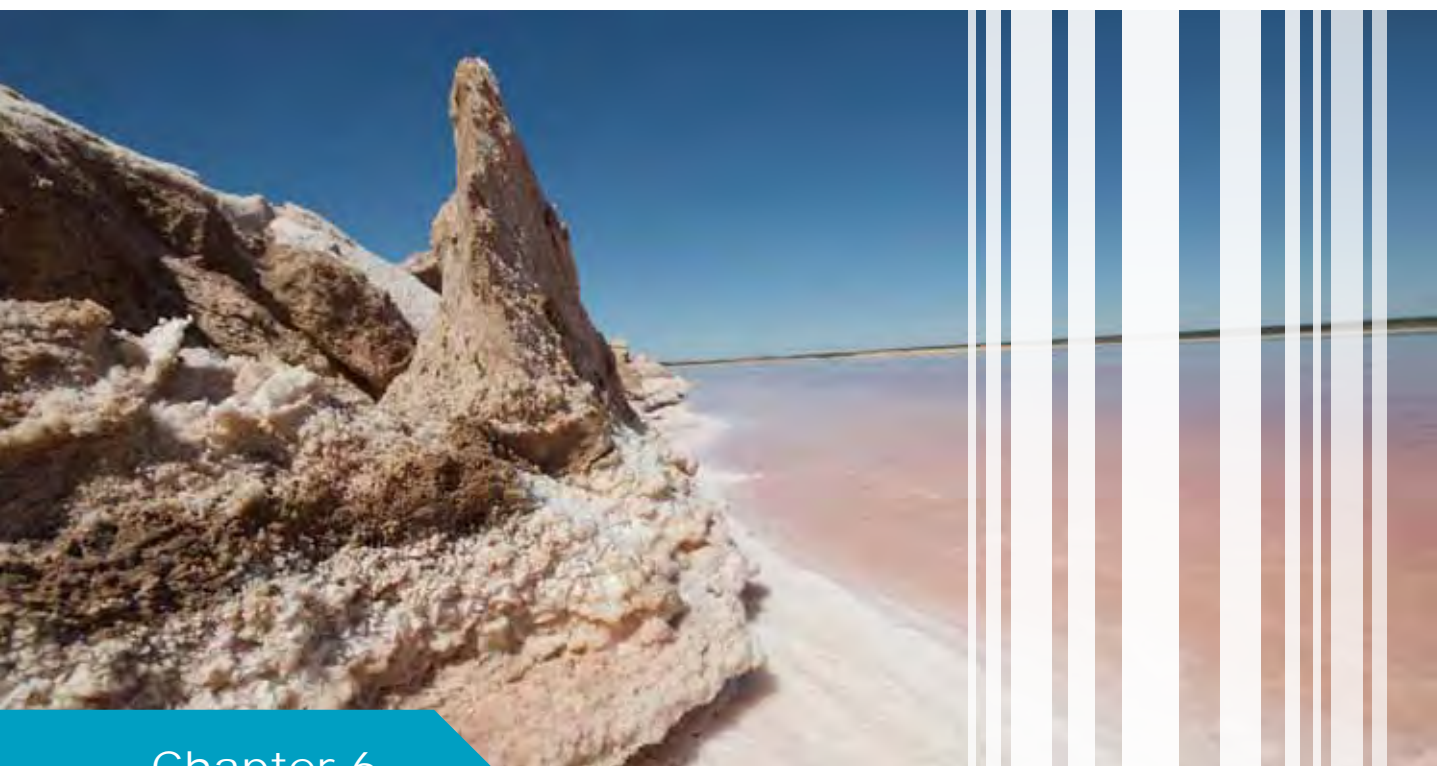
After considering the range of possible options for setting temporary diversion provisions, MDBA has determined that a principles-based approach will be used. These principles are:

- Where a new SDL does not come into operation in the first five years after the Basin Plan takes effect, the temporary diversion provision for the SDL area will be set at zero.
- Where a new SDL comes into operation within five years of the Basin Plan taking effect and, when the new water resource plan takes effect, the residual adjustment component is greater than 0% of the current diversion limit, then the temporary diversion provision will initially equal the residual amount and reduce to zero in five equal annual steps (see Table 5.2).

Table 5.2 Example of the application of the temporary diversion provision

	Current diversion limit	SDL	Reduction of 3% attributable to climate change	Commonwealth Environmental Water Holder	Residual adjustment	Year					
						1	2	3	4	5	6
Diversion (GL/y)	500	300	15	85	100	400	380	360	340	320	300
Temporary diversion provision (GL/y)						100	80	60	40	20	0

Implementing the new arrangements



Chapter 6

A suite of new arrangements will be required to translate the long-term average sustainable diversion limits (SDLs) identified in the Basin Plan into day-to-day water management. The *Water Act 2007* (Cwlth) requires the Basin Plan to include a number of mandatory content items to help drive the necessary changes to water management to deliver the objectives of the Water Act. These arrangements are described in this chapter.

Specifically, the Basin Plan is required to include:

- water resource plan accreditation
- water resource plan requirements
- an Environmental Watering Plan
- a Water Quality and Salinity Management Plan
- water trading rules.

The Murray–Darling Basin Authority (MDBA) plays a significant strategic role across the Basin. However, each state has the authority and responsibility to manage the use of its water resources within the framework set by the Basin Plan. A number of elements of the Basin Plan will be implemented through water resource plans consistent with the Basin Plan. For example, water resource plans will become the primary mechanism for achieving the SDLs.

These water resource plans will set out localised arrangements for the management of water resources. As such, these plans will determine how the SDLs will be achieved and therefore how individuals or groups of water users will ultimately be affected by the Basin Plan.

The Basin Plan also identifies water resource planning requirements that must be met for a plan to be accredited. The overarching requirement is that water resource plans must provide for the achievement of Basin Plan outcomes and targets for the relevant water resources and demonstrate clearly how this is achieved. Specific requirements will cover matters such as incorporation of SDLs, regulation of interception activities, consistency with targets set under the Water Quality and Salinity Management Plan, assessment of risks to water resources, metering and suspension of rules.

The Commonwealth Water Minister, on the advice of MDBA, will accredit water resource plans over the period 2012–19 as each of the current water sharing arrangements come to an end. The Water Act provides for transitional and interim water resource plans to operate until their expiry, even if they are inconsistent with the Basin Plan.

The Environmental Watering Plan is the primary mechanism to make the best use of water available to the environment. It builds on experience gained through The Living Murray program, the Commonwealth Environmental Water Holder and other environmental watering initiatives. To date these efforts have been limited to a small number of specific sites in the recent drought. The Environmental Watering Plan will operate across the key ecosystem functions and key environmental assets identified under the Basin Plan. The Environmental Watering Plan will also provide appropriate mechanisms to manage improvements in knowledge about environmental watering. The Environmental Watering Plan will provide a framework for adaptive management of watering activities rather than prescribing a watering regime or ‘recipe’ for sites.



Reedy Swamp in the Gunbower–Koondrook–Perricoota Forest, Victoria, after environmental watering, 2010

The Environmental Watering Plan is essentially a principles-based approach to environmental watering at Basin scale, supported by a planning and reporting framework. Basin states will be required to develop long-term and annual environmental watering plans for each surface-water resource plan area, showing how they will manage water to meet the requirements of the assets and functions in that area. Each year MDBA will call for advice on watering priorities and then publish a statement of the environmental watering priorities for the Basin.

Using this statement, holders of held environmental water will be able to make decisions about how to use their water. MDBA anticipates playing a significant coordination role in larger-scale watering events to ensure the best possible outcomes from the available water. This may include, for instance, watering events:

- that cross water resource plan areas
- with major downstream trade-offs or competing environmental water requirements.

At the end of each water year MDBA will publish a report of all watering events to increase transparency in watering activities and to help plan the environmental watering needs for the coming year.

The Water Quality and Salinity Management Plan builds on the National Water Quality Management Strategy and collaborative efforts under the Basin Salinity Management Strategy. Using these as a platform, the Water Quality and Salinity Management Plan sets targets in regard to aquatic ecosystems, raw drinking water, irrigation water and recreational water. Given the diversity of the Basin these targets are set at Basin, regional and site-specific scales.

Although the targets are not mandatory, the water resource plans will be obliged to include activities to meet the targets and objectives to, for example, control sources of contaminants, manage catchment activities that result in water quality issues or treat waste.

Of particular significance in the Water Quality and Salinity Management Plan is the setting of a salt load target for the mouth of the River Murray to ensure the export of salt from the Basin. The plan also incorporates operational or 'real time' salinity targets to complement the long-term salinity targets that already exist, and have been adopted by the plan, from the Basin Salinity Management Strategy.

A central tenet of water reforms in Australia over recent years has been the use of water markets to facilitate the movement of water to its most productive use. The water trading provisions of the proposed Basin Plan will be based on the advice of the Australian Competition and Consumer Commission.

The new arrangements give effect to the objects of the Water Act, one of which is to enable the Commonwealth, in conjunction with the Basin states, to manage the Basin water resources in the national interest. As a general rule, MDBA will provide a supplementary role for the new arrangements, meaning that, as a central authority, MDBA will only perform those tasks that cannot be performed at a more immediate or local level. Thus the new arrangements are designed to provide the overall structure, direction, standards and processes to deliver the Basin Plan while recognising the ongoing critical role of the Basin states in the management of water resources and allowing flexibility within that role.



Barmah Lake, Victoria, in 2009

6.1 Water resource plans

Water resource plan accreditation

Each Basin state has the authority and responsibility to manage the flow and use of its water resources and plans, and planning instruments are prepared for this purpose. The accreditation of state- and territory-developed water resource plans will ensure that those plans remain the primary tool for implementing water resource management in the Murray–Darling Basin. Accreditation will ensure that state and territory decisions regarding the level of water use and provision of water to the environment are made with regard to the national interest and Basin objectives. States will be free to optimise their water planning and management within a secure Basin-wide planning framework. Accredited water resource plans will implement many of the Basin Plan provisions needed to restore the balance between economic, ecological and social water use.

Water resource planning instruments recognised under the *Water Act 2007* (Cwlth) are transitional water resource plans. These plans are identified in Schedule 4 of the Water Act or prescribed in regulations. Recognition of the continuing effect of these plans is a commitment by the Australian Government to water users that water sharing arrangements would be respected for the life of the plans.

Water resource planning instruments made on or after 25 January 2007 and before the Basin Plan comes into effect are interim water resource plans. The purpose of recognising interim plans is to ensure that planning processes are not delayed until the Basin Plan comes into effect, but to require such planning processes to take account of advice from the Murray–Darling Basin Authority (MDBA) on whether the proposed water resource plans will provide for the sustainable management of Basin water resources. Interim plans are generally accorded a shorter lifespan than transitional water resource plans.

Transitional and interim water resource plans are deemed to have been accredited by the Commonwealth Water Minister under Subdivision D of Division 2 of Part 2 of the Water Act. This means that until the transitional or interim water resource plan expires, there will be no requirement for a Basin state to prepare a further plan for accreditation in relation to the water resource area covered by the plan.

The water resource plan accreditation process

Water resource plans will be the chief means of implementing management in each water resource plan area. MDBA will have the role of assessing Basin state water resource plans and management activity for compliance with requirements of the Basin Plan, and providing recommendations to the Commonwealth Water Minister about whether to accredit those plans.

Water resource plans may comprise one or more legal instruments, such as documents, legislative orders and maps, or specified parts of instruments that detail the principles, processes, rules, regulations, provisions and linkages of water management that the state intends to apply in the water resource plan area.

The sequence of events in achieving accreditation of water resource plans for water resource plan areas is:

- When the Basin Plan is first made, if transitional or interim resource plans are in place, new water resource plans will need to be prepared in time to come into effect when transitional or interim plans cease to have effect.
- The Basin state will prepare a proposed water resource plan that is consistent with the Basin Plan and addresses the accreditation requirements in a way that recognises the local situation. Proposed water resource plans will be submitted to MDBA for assessment.
- MDBA will advise the Commonwealth Water Minister as to whether the proposed water resource plan complies with the requirements of the Basin Plan and will make a recommendation to the minister as to whether the proposed plan should be accredited. A water resource plan will be considered by the minister and accredited if it is consistent with the relevant version of the Basin Plan.
- If a Basin state fails to put forward a water resource plan that is consistent with the Basin Plan, the minister may, after following a set procedure in the Water Act, 'step in' and request MDBA to prepare a plan for consideration instead.
- Once accredited, a water resource plan prepared by a Basin state will be in effect for 10 years, unless the plan ceases to operate earlier.
- A revised water resource plan will need to be prepared in time to come into effect when accreditation of the current water resource plan ends. The new plan must be consistent with the version of the Basin Plan that applied two years before the water resource plan is submitted.

It is likely that the Basin Plan will be amended during the period of accreditation, but this will have no effect on the accredited water resource plan.

Various individuals, organisations and governments will be required to comply with the obligations imposed by the Basin Plan and by the relevant water resource plan. The accreditation process is summarised in Figure 6.1.

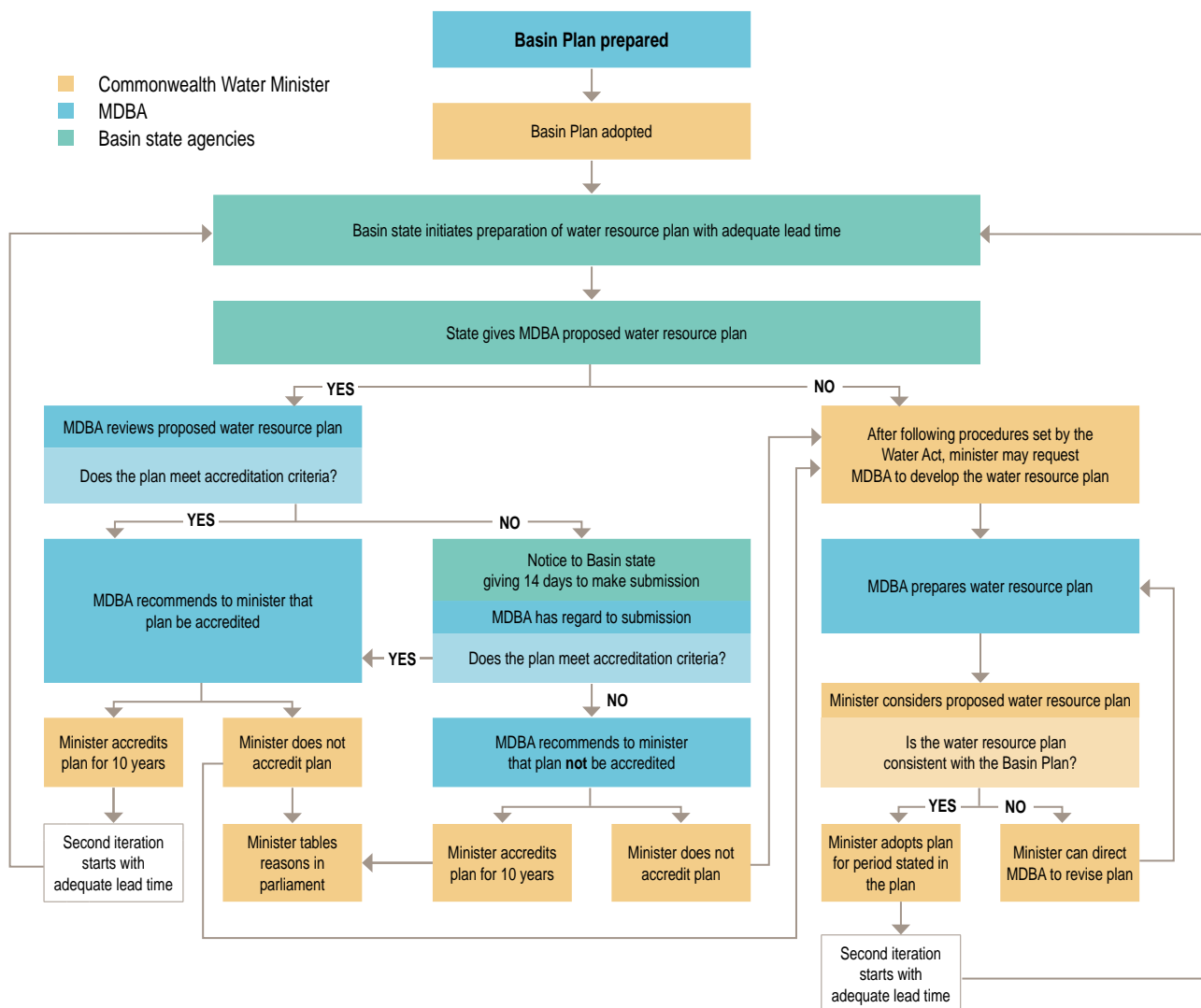


Figure 6.1 Steps in accreditation of water resource plans

Water resource plan requirements

Planning arrangements

The Water Act provides for the Basin Plan to set out the accreditation requirements for water resource plans (s. 22(1) item 11) and lists some specific topics that must be included (s. 22(3)).

Basin Plan requirements for water resource plans will not directly regulate land use or land-use planning, management of other natural resources, or control of pollution (Water Act s. 22(10)). However, the plans may impose certain requirements on the management of activities that intercept recharge or run-off.

One of the objects of the Water Act (s. 3(f)) is to ‘ensure that the management of the Basin water resources takes into account the broader management of natural resources in the Murray–Darling Basin’. With this in mind, it is important that the Basin Plan is not an isolated planning instrument but one that demonstrates an integrated approach to management of the Basin’s water resources.



*Landscape with box trees
between Broken Hill and Pooncarie,
New South Wales*

This section of the guide provides an overview of the proposed requirements with which water resource plans will need to comply to be accredited. Details of draft accreditation tests to be used by MDBA in its analysis of draft water resource plans are provided in Appendix E. These tests will provide the technical basis of MDBA's recommendation regarding accreditation as being consistent with the Basin Plan. The precise requirements will be included in the proposed Basin Plan.

General requirements for water resource plans

Water resource plans will govern many of the activities of governments and water users in the Basin. Water resource plans will be required to be consistent with the Basin Plan, clear about the obligations they impose and subject to periodic review to ensure that they remain effective.

The overarching requirement is that water resource plans provide for the achievement of Basin Plan outcomes and targets for the relevant water resources and demonstrate clearly how this will be achieved.

Water resource plans will be required to:

- set out obligations clearly and identify the people on whom the obligations are imposed
- set out objectively assessable criteria that can be used to determine whether particular conduct has taken place.

The following requirements (a)–(k) are mandatory under the Water Act (s. 22(3)). These are supplemented by additional requirements (l)–(o) identified as part of the proposed Basin Plan policy framework.

MDBA will require Basin states to provide supplementary information to allow it to assess whether water resource plans meet the accreditation requirements. This information will include the results of hydrologic model runs. A list of supplementary information needed to assist accreditation will be provided by MDBA.

Requirement (a) — defining the plan area

The Basin Plan incorporates 19 surface-water and 23 groundwater water resource plan areas (see Section 3.2, ‘Water resource plan areas’). Each water resource plan must identify the plan area and the water resources in the area to which it applies.

If a Basin state chooses to develop separate instruments for different water resources in the water resource plan area or to have separate planning instruments for specific purposes, such as for setting boundaries, managing salinity or allocating water, each instrument will be required to specify clearly which of the resources or requirements it applies to. The water resource plan will need to describe the links between the instruments and ensure that the planning arrangements are coordinated to achieve integrated water resource management.

Requirement (b) — incorporating and applying the long-term annual diversion limit

The Basin Plan will set enforceable long-term average sustainable diversion limits (SDLs) on the quantities of surface water and groundwater that can be taken from the Basin water resources. Methods for compliance with the SDL are described in detail in Chapter 7.2. Transitional limits may be set through adding a temporary diversion provision for a water resource. The temporary diversion provision and SDL for each water resource will together comprise the long-term annual diversion limit.

A description of the SDL and how it is developed can be found in Chapter 4.

Each water resource plan will be required to detail strategies and rules to limit the total volume of water taken from a resource to be no more than the long-term annual diversion limit. If the strategy for groundwater is to use the capacity of the groundwater system to buffer variations in annual extractions, the strategy will be required to address the sensitivity of the water resource to depletion and include quantitative limits, such as minimum water levels and relating annual allocations to water level, in order to protect the resource.

The Basin Plan may divide the long-term annual diversion limit into components reflecting different forms of take, such as diversions and interception. Where this is the case, water resource plans will be required to restrict volumes of the different forms of take to the components specified in the Basin Plan. However, a water resource plan may allow a particular form of take to exceed its component, provided there is a corresponding decrease in other forms of take. This is referred to as ‘offsetting components of take’ and is further explained in Section 4.4. In order to justify offsetting, the water resource plan will need to specify the access rights associated with each component.

Further requirements will be that there is no increase in the overall level of take, and the offsetting changes will not result in key environmental assets, key ecosystem functions, the productive base or key environmental outcomes being compromised (see Section 4.1).

Water resource plans will be required to set out:

- rules that govern rights to take water (e.g. under water access entitlements and allocations, or other types of water access rights)
- rules for determining what water is available and how much of it will be permitted to be taken by water users, including rules for allocating amounts to water access entitlements
- rules that will ensure that only the permitted amount is taken

- rules that ensure that transfers of entitlements are accounted for when working out how much water will be permitted to be taken.

Water resource plans will be required to specify the mechanisms for monitoring and reporting on each component of the long-term annual diversion limit in accordance with the requirements listed in Table 6.1.

Each water resource plan will be required to specify corrective actions and mechanisms that will be taken to ensure that long-term average annual diversions comply with the long-term annual diversion limit.

Water resource plan provisions will be required to be effective under the different long-term climate scenarios that were used in preparing the proposed Basin Plan. Proper incorporation of the diversion limits will have to be demonstrated at the time of plan submission for accreditation.

Information demonstrating that these requirements are satisfied by the arrangements in the water resource plan for relevant climate scenarios can be provided to MDBA when water resource plans are submitted for accreditation. This will include the consideration of wet and dry sequences and sharing of consumptive and environmental impacts under regional median 2030 climate conditions.

Table 6.1 Components for SDLs and methods used to determine actual take

SDL component	Method to determine actual take
Surface water access entitlements — measured take	Meter
Surface water access entitlements — estimated take	Multi-parameter method ^a
Harvesting floodplain surface water — measured take	Meter or other volumetric measurement (e.g. remote sensing/bathymetric)
Harvesting floodplain surface water — estimated take	Multi-parameter method, ^a modelling or regional method ^b
Take from watercourses under basic rights (stock and domestic rights, native title rights)	Meter, multi-parameter method ^a or regional method ^b
Interception by farm dams under basic rights (stock and domestic rights, native title rights and harvestable rights)	Remote sensing, multi-parameter method ^a or regional method ^b
Interception by farm dams (irrigation and other purposes, excluding floodplain harvesting) — measured take	Meter or other volumetric measurement (e.g. remote sensing/bathymetric)
Interception by farm dams (irrigation and other purposes, excluding floodplain harvesting) — estimated take	Multi-parameter method, ^a modelling or regional method ^b
Interception by forestry plantations (as it affects run-off)	Remote sensing, multi-parameter method ^a or regional method ^b
Groundwater access entitlements — measured take	Meter
Groundwater access entitlements — estimated take	Multi-parameter method ^a or regional method ^b
Groundwater take under basic rights (stock and domestic rights, native title rights)	Meter or multi-parameter method ^a or regional method ^b
Take by forestry plantations (as it affects aquifers)	Remote sensing, multi-parameter method ^a or regional method ^b
Interception by mining — measured take	Meter
Interception by mining — estimated take	Multi-parameter method, ^a modelling, regional method ^b or qualitative assessment ^c

a A multi-parameter method must determine the actual take by considering at least climate data and information related to how the water is being used (e.g. type of crop, crop area). This method must be calibrated using the most relevant data available, and regularly updated to include new information.

b MDBA must approve a regional method. The accuracy of the method must reflect the scale of the interception activity relative to other components of take.

c A qualitative estimate must be made by experienced diversions inspectors.

Requirement (c) — sustainable use and management of water

Whereas requirement (b) deals with the incorporation of SDLs, requirement (c) addresses the complementary management arrangements necessary to ensure sustainable water management within the SDLs. This requirement will ensure that the allocation arrangements, water flows and water resource conditions needed to protect the water resource and its uses are consistent with the sustainability requirements of the Basin Plan. For example, water resource plans will often set out rules to maintain particular flows in the dry season.

Water resource plans will be required to include arrangements and rules to ensure that any water resource condition limits, flow regimes or requirements that are specified in, or required by, the Basin Plan are met.

Water resource plans will also be required to include measures to ensure that taking water does not compromise the environmental watering needs of key environmental assets, key ecosystem functions, the environmental outcomes or the productive base of the water resource. The environmental assets and ecosystem functions, and their watering requirements, that require consideration in preparing a water resource plan, will be those identified by the Basin state using the methods set out in the Environmental Watering Plan (see Section 6.2).

Water resource plans will be required to include measures to ensure that there is no long-term progressive decline in groundwater levels, there is no threat to aquifer integrity, and confined aquifers will remain confined. An exception will apply for particular fossil groundwater resources.

Where local impacts are identified, or the Basin Plan requires, appropriate management arrangements will be required to be established to manage those impacts. This will require:

- local management zones around vulnerable features
- restrictions or prohibitions on extraction within the zone at particular times or at all times
- arrangements to protect and enhance water quality
- arrangements to protect water-dependent ecosystems.

Local management arrangements will be expected to be detailed in the water resource plan.

Where streams and aquifers are connected, water resource plans will be required to include measures to ensure that taking groundwater does not further affect the volume of stream flow.

Water resource plans will be required to describe the specific conditions under which entitlements will be granted for the operation of salt interception schemes and the obligations that will be placed on salt interception scheme operators. It is recognised that salt interception schemes are a form of beneficial use and existing operating criteria are to be preserved.

Requirement (d) — regulation of interception activities

This requirement will ensure that water resource plans address the need to manage activities that intercept water before it flows into rivers and aquifers.

Water resource plans will be required to ensure that there is no growth in interception by farm dams, forestry plantations or mining operations (including coal seam gas extraction) unless other use is reduced by an equivalent volume.

SDLs set out in the Basin Plan will limit take by interception to the best estimates of current interception, where the interception is thought to have a significant impact on Basin water resources and has been able to be measured to some degree. Particular measures are required to manage interception because the estimates of the level of take are relatively inaccurate.

Each water resource plan will be required to oblige new farm dams, forestry plantations and mining interception to acquire a water access right where the activity commences after the water resource plan commences. The water access rights will need to be (or be converted from) an existing entitlement. The effect will be that new farm dams, forestry plantations and mining interception will be permitted where the other take in the water resource plan area is reduced.



*Landscape near Dartmouth Dam,
north-eastern Victoria*

Water access rights need not be held for most dams for basic rights (including stock and domestic and NSW harvestable rights). However, new interception from these types of dams will be required to be accounted for in establishing compliance with the SDLs.

Water resource plans will be required to identify other interception activities that have the potential to significantly affect water resources, on an activity-by-activity basis or cumulatively. This includes coal seam gas mining in aquifers underlying or connected to those included in the water resource plan. The measures the Basin state will use to manage these activities will need to be described and the impacts of the activities accounted for in the water resource plan.

Requirement (e) — environmental watering provisions

This requirement will ensure that water resource plans are consistent with and support the implementation of the Environmental Watering Plan that is part of the Basin Plan.

Water resource plans will need to include obligations consistent with the objectives, principles, methods and requirements of the Environmental Watering Plan. Water resource plans will also ensure that environmental water delivery is coordinated, effective and protected. These obligations will apply regardless of whether the environmental water is applied in the same water resource plan area or Basin state. Most of the requirements relating to environmental watering are specified through the Environmental Watering Plan, and therefore will not be restated as a water resource plan requirement (refer to the Environmental Watering Plan, Section 6.2, for further details).

Requirement (f) — setting objectives for water quality and salinity

This requirement will ensure that water resource plans include strategies to sustain the quality of water resources and meet targets set out in the Basin Plan.

The Basin Plan will incorporate a Water Quality and Salinity Management Plan (see Section 6.3), which will include objectives for the Basin water resources that are consistent with the National Water Quality Management Strategy and the Basin Salinity Management Strategy. It will also incorporate

water quality and salinity targets and provide a management framework to help achieve these targets.

Water resource plans will be required to include a water quality and salinity management plan with measures and actions that will be implemented to achieve the water quality objectives and targets set out in the Basin Plan. The measures and actions are to be set at a spatial and temporal scale appropriate to the resource and consistent with targets in connected water resources.

Water resource plans will be required to:

- describe the current condition of the water quality characteristics for which targets have been set
- identify causes of degradation of water quality and salinity arising from water- and land-based activities
- set out management strategies to achieve proposed objectives and targets — the strategies may include management of flows and drainage, works, land conservation, operation of storages, restoration of vegetation or pollution controls
- set out accounting arrangements for salinity and water quality management that are consistent with the requirements of the Water Quality and Salinity Management Plan.

The authority responsible for each plan will be responsible for enforcing the implementation of the water resource plan's management strategies.

Consistency with the objectives and targets of the Water Quality and Salinity Management Plan may be demonstrated at the time of water resource plan submission through provision of information from models and methods.

Requirement (g) — water trading arrangements

The Basin Plan will set out the rules for trading (see Section 6.4), and water resource plan provisions will set out local arrangements; for example, the trading zones and any allowable restrictions.

The Basin Plan will include trading rules with which the Basin states must act consistently. Water resource plans should include a minimum of trading rules — only those necessary to tailor the Basin rules to a particular resource. Each water resource plan will be required to include provisions to identify any conditions, limitations or prohibitions on trading that apply only to the water resources managed under the water resource plan.

Trade may be restricted where there are physical, hydrologic and water supply considerations, or where there will be a significant environmental impact which will compromise Basin Plan objectives. Water resource plans will be required to specify any planned restrictions and justify their basis. Such restriction will be referred to as 'allowable constrains' to trade within accredited water resource plans (see Section 6.4).

Water resource plans will be required to include provisions for managing the effect of any trade in entitlements between environmental and consumptive water uses, in either direction, such that:

- for the long-term diversion limit, compliance is not breached
- trade is possible between SDL areas within the constraints of providing for local and Basin-wide environmental water requirements
- trade does not negatively affect the rights of any other water holders.

Requirement (h) — approach to managing risks to the Basin water resources

This requirement will ensure that water resource management arrangements address the risks to the local water resources. These risks might include dry climatic sequences, interception and increasing salinity. This requirement builds on the risk assessment (Section 3.3) and risk management (Section 3.4) elements of the Basin Plan.

Each water resource plan will be required to identify risks to the condition or continued availability of water resources to which the water resource plan applies, and the factors contributing to those risks. The plan will be required to assess and prioritise the risks and contributing factors following relevant Australian risk assessment standards. A Bayesian network probabilistic model developed by MDBA is available as a guide and represents MDBA's recommended approach.

The assessment will be required to be credible and evidence-based, using quantitative information where possible. It will need to consider and evaluate all risks to water resources, including the risk of:

- insufficient water for the environment
- inadequate water quality for primary industry, aquatic ecosystem protection, recreation and drinking water
- poor health of water-dependent ecosystems.

The analysis will be required to quantify risks and include estimates of uncertainties and the sensitivity of the analysis to the uncertainties.

The assessment will be required to categorise risks and their contributing factors as low, moderate or high, with any likelihood of 40% or more categorised as moderate or high, and any consequence with an impact greater than 40% graded as moderate or high. Risks and risk factors will need to be prioritised for treatment.

The assessment will be required to include risks to the continued availability of water to support ecosystem services and environmental outcomes. The assessment will need to cover the period during which the water resource plan will be in effect, address the design climate scenarios and be consistent with relevant Australian Standards.

Water resource plans will be required to establish strategies to manage or reduce the moderate- or high-level risks and, where possible, reduce risks to a tolerable level.

In addition to setting out strategies, each water resource plan will be required to detail how the strategies are to be implemented; for example, the actions that must be taken, who they must be taken by, and the timeframes within which they must be taken.

Requirement (i) — monitoring and metering

Monitoring associated with water resource plans must be linked to an adaptive process (see Chapter 7).

The Council of Australian Governments has agreed to a nationally consistent framework for water metering and measurement as part of the National Water Initiative (Council of Australian Governments 2004). The national framework for non-urban water metering policy paper came into effect on 1 July 2010 (Department of the Environment, Water, Heritage and the Arts 2009c). It is important to recognise that some components of take cannot be practically metered (although there may be other methods available to measure take — see Table 6.1). Nevertheless, there is considerable scope to improve the number of diversions and the volumes of take that are metered.

The Basin Plan will require water resource plans to include details of the number of diversion points and volumes of take that are metered (see Table 6.1) and a best estimate of the number and volumes that are not metered. The Basin Plan will also require each water resource plan to specify a program and time frames requiring improvement of the number and volumes metered and the quality of metering, consistent with the national framework for non-urban water metering policy paper and the standards it cites (Department of the Environment, Water, Heritage and the Arts 2009c).

Requirement (j) — plan review and amendment

Water resource plans will be reviewed or made anew every 10 years and provided to the Commonwealth Water Minister for accreditation as being consistent with the relevant version of the Basin Plan. This requirement will ensure that the water resource planning arrangements are reviewed periodically to ensure that the arrangements are not outdated or ineffective. Water resource plans are intended to provide security for long-term investment in consumptive and environmental water use. Water resource plans should be as adaptive as possible within the context of provision of water-use security for 10 years.

Review and amendment requirements are needed to support active adaptive management of the plan in response to new knowledge and information becoming available. A balance between flexibility and security needs to be struck. These review requirements should be considered a minimum provision supporting adaptive management rather than a restriction to it. Review provisions in the water resource plan must be consistent with the Basin Plan's Monitoring and Evaluation Program (see Section 7.2).

Water resource plans will be required to provide for a mid-term review of the plan's effectiveness within the life of the plan. This will require consideration of whether the models and methods used to set the allocations or the management and delivery arrangements, or to determine annual quantities of water take, require amendment to give effect to the long-term annual diversion limit.

Although water resource plans will be accredited for 10 years, they may be amended at any time during their operation on the initiative of the Basin state. Amendments can be prepared and submitted to MDBA for assessment against the prevailing Basin Plan requirements. The amendments may then be accredited by the Commonwealth Water Minister and will have effect under the Water Act.

Requirement (k) — supporting scientific information and modelling

The intention of this requirement is to ensure that the analysis and management of the water processes and water use incorporates the outcomes of research in all areas, including climate, hydrology, salinity and ecological processes.

Water resource plans will be required to be based on the best available scientific knowledge, including climate, run-off, river, groundwater and salinity processes. As knowledge, analysis and modelling improves, the planning arrangements will, over time, need to reflect the benefit of these improvements.

The consistency of each water resource plan with the requirements of the Basin Plan must be demonstrated at the time of plan submission through modelling or analysis of the water resource plan's effect.

Each water resource plan will be required to document the scientific information and models on which it is based and against which its outcomes have been assessed, including socioeconomic, ecological, environmental and hydrologic information and models.

The water resource hydrologic models used to determine and audit the water resource management arrangements must adequately simulate river and groundwater flows and salt transport. Documentation will be required to include a description of the modelled:

- access rules, allocation processes and accounting arrangements
- development and extractive demand assumptions
- environmental water requirements
- flow and salt-load relationships
- climate scenarios
- flow regime from the water resource plan area.

The environmental watering models or methods that are used will be required to address key parameters and processes, particularly the water resource flows and condition, the effects of climate change, the taking of water and any risks identified in the risk assessment.

The models and methods used to determine the permitted take and estimate the actual take will be required to simulate or analyse key processes, including the monitoring and measurement, allocation, delivery, taking and return of water.

The information, analyses and models used to develop water resource plans will need to be calibrated, verified and peer reviewed. In particular, the proposed local management arrangements will be required to be independently verified if key groundwater-dependent environmental assets have a high or moderate sensitivity to the taking of groundwater.

The knowledge and information will be required to be classified using MDBA's Knowledge and Information Directory quality ranking system or another best-practice science classification tool approved by MDBA.

Except where the Basin state and MDBA agree otherwise, the data and models used in the preparation of a water resource plan will be provided under a Creative Commons Attribution (by) licence. The intention of this licence is to enable the public to have unrestricted access to, and use of, the data and models.

Requirement (l) — suspension of rules during extreme or unprecedented events

Planning for dry sequences and unusual conditions will assist water users to understand the scope of risks and improve planning for their own activities. In the hydrologic context ‘unprecedented’ is taken to mean any extreme event that has not occurred in the past 114 years of water management history and record keeping in the Basin. It is the range of experience that is built into the historical climatic baseline. The definition does not change to reflect new extremes that occur during the water resource planning period. Water resource plans will need to include provisions for at least the full range of situations experienced under baseline conditions. This means any situations generating past suspensions of management plan rules should be included within the scope of the new water resource plans so that the situation does not trigger suspension.

The National Water Initiative (2004, p. 8) states:

Plans should [be] robust to a range of future climate scenarios and allow for the possibility that water availability may occur outside the planned range. In these cases, plans should include clear rules or processes to describe how such unprecedented or unplanned situations will be managed. This will allow water users to understand and manage their own risk profiles.

Under current state statutory arrangements, each Basin state has the authority to switch off water resource management arrangements in accordance with conditions specified in plans or laws, such as in times of extreme drought. It is important that such conditions are identified so that water resource plans can, wherever practical, address all situations that may arise.

Such events may include extreme water quality problems and infrastructure failures. Roles and responsibilities associated with managing such events need to be clearly specified in water resource plans as well as the different actions that will be implemented to deal with such events.

In addition, it may be appropriate to incorporate alternative rules to manage unprecedented events. However, a range of indicators must be in place to determine when those rules should be adopted.

In the case of the River Murray system, water resource plans will need to have provisions in place to ensure that unprecedented events can be managed consistently with the water sharing arrangements established under the Murray–Darling Basin Agreement (Schedule 1 to the Water Act) and the Basin Plan for critical human water needs (see Section 4.6).

Each water resource plan will be required to recognise events from the relevant climate scenarios that are more extreme than those recorded historically, and identify responses to such situations should they arise during the 10-year life of the water resource plan.

Requirement (m) — Aboriginal values

MDBA considers that the importance of water resources to Aboriginal culture should be recognised in water resource planning arrangements in keeping with the principles of the National Water Initiative.

Aboriginal water values do not pertain just to consumptive water use but also encompass access to a water resource for cultural purposes and water rights under native title.

The CSIRO (2009b) *Background paper on Indigenous participation in water resource planning* provides an overview of Aboriginal water access provisions

and how these have been addressed by the Basin states. It was recognised that the state and territory governments are in the early stages of formally recognising Aboriginal water values and it may be appropriate to look at alternatives to the exclusive 'environmental flow' focus. Specific cultural flows may need to be adopted.

For the purpose of accrediting a water resource plan it is critical that Aboriginal interests in water are recognised and that Aboriginal knowledge be included in water resource assessments. This is in line with the intent of the relevant provisions of the Water Act (s. 22(1) item 1(b) and s. 21(4)(c)(v)).

Water resource plans will be required to identify Aboriginal water values and uses and the relationships between the water regime and cultural values. Plans will be required to include an assessment of the risks to those values and uses, and implement strategies to protect them. These provisions will need to be set out specifically and separately in each water resource plan.

Requirement (n) — the making of water resource plans

MDBA considers that the Basin states should ensure that water resource plans are prepared in a consultative way and that the Basin Plan requirements are implemented in a way that optimises social, economic and environmental outcomes.

Water resource plans will be prepared under the Basin states' legislative arrangements, insofar as these are consistent with the Water Act. For example, it should be noted that the Water Act requires a water resource plan to be prepared in consultation with an adjacent Basin state if the water resource plan area is adjacent to a water resource plan area in that other Basin state (s. 63(2)).

The Basin Plan will require that the social and economic impacts of each water resource plan be analysed.

Requirement (o) — integration with natural resource management plans

Water resource planning is an integral part of catchment and landscape management. The quantity, quality and patterns of water flow are significantly influenced by vegetation cover and soil management. Conversely, access to water strongly influences the nature of land use, agriculturally or for other business enterprises. Further, the presence of natural waterways has major impacts on social and cultural activities. This makes it appropriate that state planners have regard to the broader regional natural resource management planning context. Water resource plans will be required to:

- identify regional natural resource management plans for the same area and time as is covered by the water resource plan
- state the extent to which the water resource plan integrates with the relevant natural resource management plans.



*Playing the didgeridoo on the
riverbank in Mildura, Victoria*



Douglas Swamp, Barmah–Millewa Forest, Victoria, showing early response to environmental watering

6.2 Environmental Watering Plan

The *Water Act 2007* (Cwlth) (s. 22(1) item 9) requires the Murray–Darling Basin Authority (MDBA) to include an Environmental Watering Plan in the Basin Plan. The Environmental Watering Plan will provide new arrangements to manage the environmental water set aside by the long-term average sustainable diversion limits (SDLs) to achieve environmental outcomes. For the first time, these new arrangements will prioritise environmental watering activities to achieve Basin-scale environmental outcomes through applying a coordinated and transparent planning and reporting framework across the Basin.

The arrangements provide a foundation for an adaptive approach to the management of environmental water rather than prescribing a strict flow regime. This approach to the Environmental Watering Plan allows for advances in knowledge and provides a way to deal with variations in climate from season to season and from year to year.

The Environmental Watering Plan includes:

- overall environmental objectives for the Basin’s water-dependent ecosystems — to protect and restore key environmental assets and key ecosystem functions and enhance ecosystem resilience to risks and threats
- an environmental management framework that describes new roles for MDBA and relevant parties — the framework will enable a strategic and Basin-wide approach to manage environmental water in a coordinated, consistent and adaptive manner
- a method to identify key environmental assets and key ecosystem functions that require environmental watering — consistent with the method used to determine the environmentally sustainable level of take (see Section 4.1)
- principles to be applied, and methods to be used, to determine the priorities for applying environmental water
- principles to be applied in environmental watering
- targets by which to measure progress towards the overall environmental objectives.

The Environmental Watering Plan will have important links to the environmentally sustainable level of take (see Section 4.1). Two important links are that:

- the methods to identify key environmental assets and key ecosystem functions for the environmentally sustainable level of take are closely aligned with those that must be used for the Environmental Watering Plan
- reporting against targets to measure progress towards meeting the overall objectives for water-dependent ecosystems will be supported by assessment of whether the water requirements identified in the environmentally sustainable level of take are being met.

The water requirements of the Basin's water-dependent key environmental assets and key ecosystem functions will be met by 'planned' and 'held' environmental water.

Environmental Watering Plan objectives and purposes

The Water Act (s. 28) requires the Environmental Watering Plan to specify overall environmental objectives for the Murray–Darling Basin's water-dependent ecosystems.

These objectives are:

1. Protect and restore the key water-dependent ecosystems of the Murray–Darling Basin.
2. Protect and restore the ecosystem functions of key water-dependent ecosystems.
3. Enhance the resilience of the key water-dependent ecosystems to risks and threats.

Further detail with regard to these objectives is provided in Table 6.2.

The purposes of the Environmental Watering Plan are to:

- safeguard existing environmental water
- plan for the recovery of additional environmental water
- coordinate the effective management of this environmental water.

Environmental management framework — overview

The Environmental Watering Plan's environmental management framework sets out how the Basin's environmental water will be planned, coordinated and managed to protect and restore wetlands and other environmental assets, to protect biodiversity, and to achieve other environmental outcomes (Water Act s. 28(1)(d)–(e)).

The framework will place obligations on Basin states to undertake long-term and annual environmental water planning and management consistent with methods and principles set out in the Environmental Watering Plan. Publication of long-term environmental watering plans for each water resource plan area, and of annual priorities by MDBA, will increase the consistency and transparency of decision making. The environmental management framework is also designed to continually build on environmental watering knowledge to improve environmental watering management and outcomes within the Murray–Darling Basin.

Planned and held environmental water

The Water Act's (s. 6) broad definition of planned environmental water includes 'rules-based' environmental water. Planned environmental water can be delivered when flows are released from storages for environmental purposes. It can also be managed through water take restrictions.

An example is the Barmah–Millewa Environmental Water Allocation, a rules-based allocation that was established in 1993. It comprises a high security environmental water entitlement of 100 GL/y and a low security allocation of 50 GL/y which are provided equally by Victoria and New South Wales. These volumes can be banked up across years, are only available in line with broader allocation announcements and are delivered according to certain rules and triggers. These features differentiate this water from a standard entitlement such that the environmental water allocation is more in line with planned environmental water.

Held environmental water (defined in the Water Act (s. 4)) includes water available under an access, delivery or irrigation right that is held to achieve environmental outcomes.

An example of held environmental water is the 3.63 GL high reliability entitlement held by the Victorian environment minister for use under the Living Murray Initiative. Of the water allocated against this entitlement in the 2009–10 water year, 2 GL was delivered to Reedy Lagoon in the Gunbower Forest to maintain drought refuge, and to contribute to the maintenance of bird breeding and foraging habitat.

Table 6.2 Detailed descriptions of the overall environmental objectives for the Murray–Darling Basin’s water-dependent ecosystems

Objective	Detailed description
<p>1 Protect and restore the key water-dependent ecosystems of the Murray–Darling Basin</p>	<p>1.1 A comprehensive, adequate and representative subset of all Basin water-dependent ecosystems are protected and restored.</p> <ul style="list-style-type: none"> • Declared Ramsar wetlands that depend on Basin water resources maintain their ecological character. • Water-dependent ecosystems that depend on Basin water resources and support the life cycles of species listed under the Bonn Convention or the China–Australia, Japan–Australia or Republic of Korea–Australia migratory bird agreements are protected and restored to such a condition that they continue to support the species listed. • Water-dependent ecosystems are able to support episodically high ecological productivity and its ecological dispersal. <p>1.2 Biodiversity dependent on Basin water resources is protected and restored.</p> <ul style="list-style-type: none"> • Water-dependent ecosystems that depend on Basin water resources and support the life cycles of listed threatened species or listed threatened ecological communities are protected and, if necessary, restored so that they continue to support those life cycles. • Viable populations and communities of endemic biota are protected and restored.
<p>2 Protect and restore the ecosystem functions of key water-dependent ecosystems</p>	<p>2.1 Connectivity within and between water-dependent ecosystems that depend on Basin water resources is protected and restored.</p> <ul style="list-style-type: none"> • The diversity, dynamics and distribution of geomorphic structures, water-dependent ecosystems, habitats, species, and genes are protected and restored. • Ecological processes dependent on hydrologic connectivity along the rivers and laterally between rivers and floodplains (and associated wetlands) are protected and restored. • The Basin remains open and therefore 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 Basin to the ocean. • The Murray Mouth remains open at frequencies and for durations that ensure tidal exchanges maintain the Coorong’s water quality, in particular salinity levels, within the tolerance of the ecosystem’s resilience. • Barriers to the natural passage of biological resources through the Basin, including to biota, carbon and nutrients, are overcome or minimised. <p>2.2 The natural balance of erosion and deposition is maintained as far as possible at a range of scales, including slack water, river reach and across floodplains.</p> <ul style="list-style-type: none"> • As far as possible natural processes that protect landforms, such as the formation and maintenance of soils, are protected and restored. <p>2.3 Habitat diversity is provided for biota at a range of scales, including at Basin, riverine landscape, river reach and asset class scales.</p> <p>2.4 Food webs that sustain water-dependent ecosystems and that are dependent on Basin water resources are maintained.</p> <ul style="list-style-type: none"> • Energy, carbon and nutrient dynamics, including primary production and respiration, are protected and restored. <p>2.5 Ecosystem functions that maintain populations, such as reproduction, regeneration, dispersal, immigration and emigration, are protected and restored.</p> <ul style="list-style-type: none"> • Flow sequences and inundation and recession events occur consistent with ecological requirements such as cues for migration, germination and breeding, where possible. • Habitat diversity that supports the biota of water-dependent ecosystems, such as habitats that protect juveniles from predation, is maintained. <p>2.6 Community structure and species interactions are protected and restored.</p> <p>2.7 Basin water resources are of a quality that does not negatively affect water-dependent ecosystems and is consistent with the Water Quality and Salinity Management Plan.</p>
<p>3 Enhance the resilience of key water-dependent ecosystems to future risks and threats</p>	<p>3.1 Water-dependent ecosystems are resilient to climate change and other disturbances such as drought.</p> <p>3.2 Refuges are protected to support long-term survival and resilience of the populations dependent on them during drought and allow for their subsequent recolonisation.</p> <p>3.3 Wet/dry cycles do not extend the ecologically relevant wetting/inundation interval beyond the tolerance of ecosystem resilience or the threshold of irreversible change.</p> <p>3.4 Anthropogenic-related threats, such as the impact of introduced species, algal blooms, and degraded water quality, are mitigated.</p> <p>3.5 Habitat fragmentation is minimised to maximise ecosystem resilience.</p>

Figure 6.2 provides an overview of the environmental management framework for coordinated environmental water planning and environmental watering. The key elements of the environmental management framework are summarised below; more detail is supplied later in this section.

- Long-term environmental water planning is required for each surface-water water resource plan area. Basin state environmental watering plans will outline how the state intends to manage the water available to the environment; identify key environmental assets and key ecosystem functions using a set method; outline the water requirements to support the assets and functions and the long-term environmental watering priorities within that area. The information in the long-term environmental watering plans will provide the basis for determining Basin annual environmental watering priorities.
- Annual water planning (based on the 1 July to 30 June water year) will propose the annual watering priorities for each of the water resource plan areas to inform a Basin-scale prioritisation process (see next point). Once the Basin-scale priorities are identified by MDBA, all managers of planned environmental water and holders of held environmental water will be required to have regard to the priorities in managing their water.
- Environmental watering prioritisation processes will coordinate Basin-scale environmental watering priorities using a set method, in accordance with principles outlined in the Environmental Watering Plan and considering the advice of an Environmental Watering Advisory Committee. The prioritisation method will actively consider the forecast water availability and the management outcomes being sought. This process will facilitate delivery of environmental water to where it is most needed in the Basin.
- Environmental water delivery will remain the responsibility of the Basin states and/or current river operators at the request of the environmental water holder(s) and/or managers.
- Monitoring, evaluation and compliance reporting will allow assessment of whether the Basin-scale outcomes are being achieved (see Section 7.3).

The Water Act (ss. 34 and 35) sets out the effect of the Basin Plan, and therefore the Environmental Watering Plan, on MDBA, on other Commonwealth agencies, Basin states and other parties. MDBA and other Commonwealth agencies will be required to perform functions and exercise powers in a manner that gives effect to the framework (as part of the Environmental Watering Plan). In particular, the Water Act (s. 105) requires the Commonwealth Environmental Water Holder to manage its holdings in accordance with the Environmental Watering Plan. Similarly, the Basin Officials Committee, Basin state agencies, operating authorities, infrastructure operators and water rights holders will be required to act consistently with the framework.

Implementation of the environmental management framework will start immediately when the Basin Plan takes effect, except where existing interim or transitional water resource plans are inconsistent with the framework, for example where they stipulate an environmental watering arrangement (see Section 6.1).

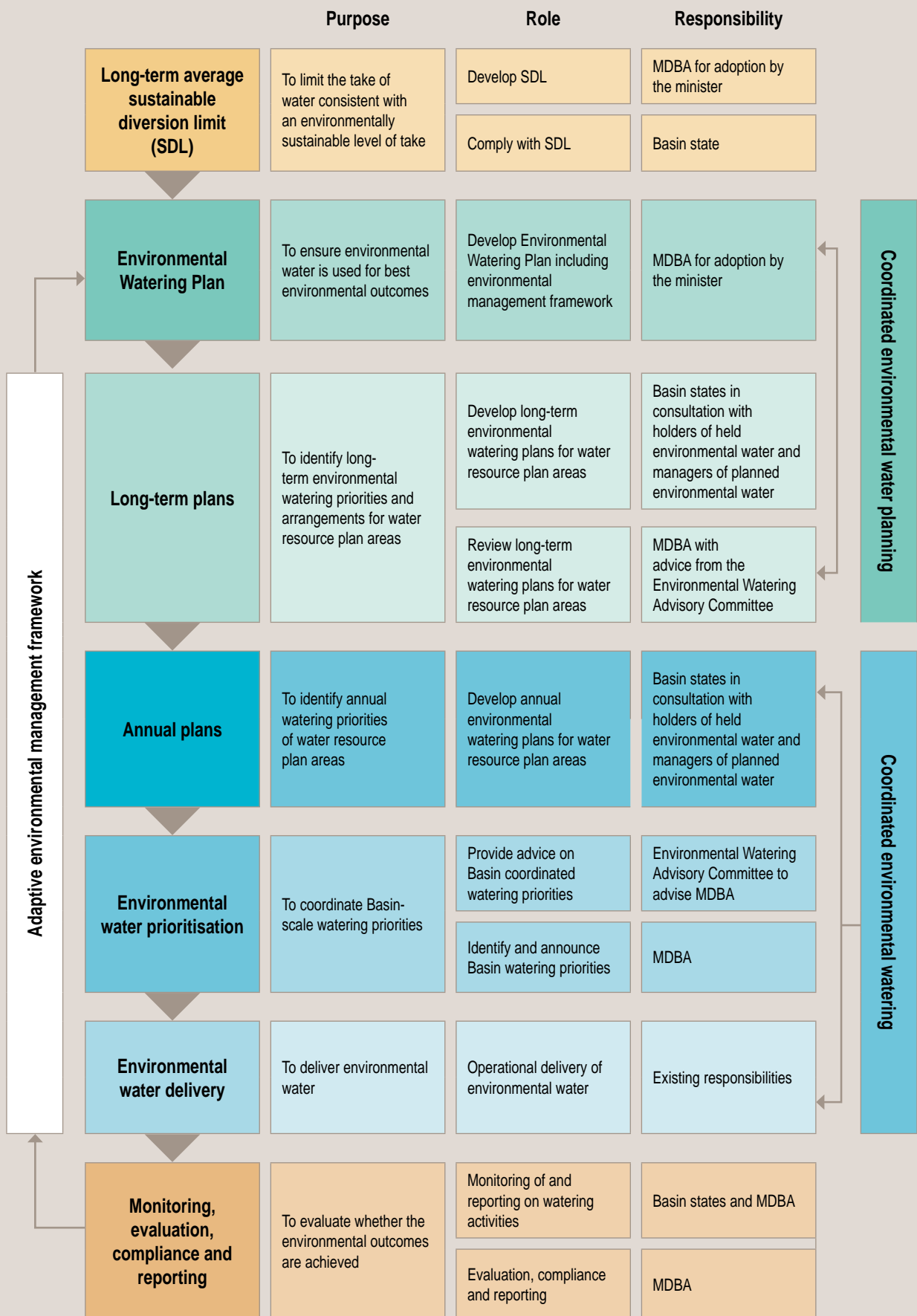


Figure 6.2 The adaptive environmental management framework

Environmental management framework — the Murray–Darling Basin Authority’s role

MDBA will review the Basin Plan’s Environmental Watering Plan every five years, as required by the Water Act (s. 22(1) item 13).

To ensure planning and watering are consistent with the Environmental Watering Plan, MDBA will:

- review Basin states’ long-term environmental watering plans (developed in consultation with holders of held environmental water and managers of planned environmental water) to ensure consistency with the Environmental Watering Plan
- maintain a Basin-wide database of key environmental assets and key ecosystem functions that require environmental watering
- identify Basin-scale watering priorities for the forthcoming annual and/or seasonal period, drawing on Basin state and other stakeholder inputs
- establish an Environmental Watering Advisory Committee to advise MDBA on Basin-scale environmental watering priorities
- coordinate environmental watering where required (see below)
- monitor and report on environmental watering in the Basin
- lead the coordination and resolution of Basin-scale environmental water planning policy matters.

MDBA’s coordination role will be more significant during large-scale watering events, to ensure the best possible environmental outcomes, and is most likely to occur where:

- environmental watering priorities are across state or territory borders or water resource plan areas
- there are multiple sources of environmental water and competing watering priorities
- there are Basin-scale environmental water planning policy matters that need resolution
- it is necessary to achieve Basin-scale outcomes.

MDBA’s annual planning role will start immediately after the Basin Plan takes effect. MDBA will:

- review Basin states’ annual environmental watering plans to determine their consistency with the Environmental Watering Plan
- seek advice from the Environmental Watering Advisory Committee before the start of the watering year on key environmental assets and key ecosystem functions that should be considered a priority for coordinated watering
- develop annual watering priorities for key environmental assets and key ecosystem functions that require watering at the Basin scale by June for the forthcoming watering year, and review and update them as required
- align coordinated environmental watering with appropriate monitoring to determine the condition of the Basin’s key environmental assets and key ecosystem functions
- identify and account for the Basin’s held environmental water (Water Act s. 32)
- report on environmental water use and, where appropriate, environmental outcomes achieved against Basin Plan objectives.



Kulcurna area on the Chowilla Floodplain after environmental watering, 2010, South Australia



*Black Creek, in the
Gunbower–Koondrook–Perricoota
forests, Victoria, 2009, after
environmental watering*

In coordinating environmental watering and delivery of environmental water, MDBA:

- will consider targets outlined in the Water Quality and Salinity Management Plan (see Section 6.3) when determining priorities for coordinated environmental watering
- may engage individual scientists, a scientific advisory committee, or other relevant parties as required to provide advice on Basin-scale environmental watering priorities and their water requirements
- will endeavour to collaboratively develop environmental watering schedules for coordinated environmental watering.

Environmental Watering Advisory Committee

MDBA anticipates playing a significant coordination role in larger-scale watering events to ensure the best possible outcomes from the available water. This may include, for instance, watering events that cross water resource plan areas and those with major downstream trade-offs. As the objectives at some sites will be achievable only through the coordination of environmental water between water resource plan areas, the Basin states, managers of planned environmental water and holders of held environmental water will need to work cooperatively to maximise the Basin's overall environmental benefits.

To this end, MDBA will establish an Environmental Watering Advisory Committee under the Water Act (s. 203) within three months of the Basin Plan taking effect. A representative from MDBA will chair the committee, which will comprise senior representatives from Basin states and significant holders of held environmental water. The committee will advise on Basin-scale environmental watering priorities and work to resolve operational and strategic issues to enable the effective management and coordination of environmental water.

Environmental management framework — the role of Basin states

Basin states will be required to submit long-term environmental watering plans to MDBA no later than 12 months after the Basin Plan takes effect. Basin states will be required to update these plans at least every five years or when either the Environmental Watering Plan or a water resource plan is updated. Any changes to long-term plans will need to be submitted to MDBA.

Basin states' long-term environmental watering plans will be developed on the scale of water resource plan area, and will be required to contain at least the following:

- a description of the nature of the environmental water held in the water resource plan area, including the volumes/characteristics of held and planned environmental water
- a list of environmental assets and ecosystem functions, developed by applying the method to identify environmental assets and ecosystem functions that will require environmental watering
- site-specific objectives and targets for environmental assets or ecosystem functions that are consistent with the overall objectives for water-dependent ecosystems in the Murray–Darling Basin
- environmental watering priorities and water management arrangements consistent with the principles and method for prioritising and managing environmental watering
- proposed cooperative arrangements with neighbouring water resource plan areas and Basin states, holders of held environmental water and managers of planned environmental water (these can be formalised further as a schedule to the Environmental Watering Plan on the agreement of relevant parties)
- water delivery arrangements for each water resource plan area to ensure environmental water is used effectively
- potential risks and how these will be managed
- a monitoring, evaluation and reporting program, consistent with the Basin Plan and its Monitoring and Evaluation Program
- evidence of consultation with holders of held environmental water and managers of planned environmental water and affected parties as appropriate.

The first March after the Basin Plan takes effect and each March thereafter, Basin states will be required to submit annual environmental watering plans for the next water year to MDBA. Annual plans will be required to specify regional watering priorities developed in consultation with owners of held environmental water, managers of planned environmental water and other affected parties.

Basin states' annual environmental watering plans will be developed on the scale of water resource plan area to provide consistency with water resource planning, and will be required to contain at least the following:

- regional environmental watering priorities and water management arrangements that have been developed by applying the principles and method for prioritising and managing environmental watering
- the contribution that held environmental water will make towards meeting environmental water requirements
- proposed cooperative arrangements with neighbouring water resource plan areas and Basin states, other holders of held environmental water and managers of planned environmental water
- water delivery arrangements for each water resource plan area to ensure environmental water is used effectively, including shepherding of environmental flows and identification of risk management strategies (subject to other statutory requirements)
- evidence of consultation with holders of held environmental water and managers of planned environmental water and affected parties as appropriate.

The Environmental Watering Plan will place an obligation on all managers of planned environmental water and holders of held environmental water such that, once the annual Basin-scale priorities are identified by MDBA, they will need to have regard to the priorities in managing their water.

Role of holders of held environmental water and managers of planned environmental water

Holders of held environmental water will be required to advise the relevant Basin state on their water holdings to help states prepare long-term environmental watering plans. Holders will also need to report to MDBA, to allow MDBA to account for held environmental water in accordance with the Water Act (s. 32).

Holders of held environmental water will also be required to advise the relevant Basin state on their water holdings and priorities annually to help Basin states prepare annual environmental watering plans.

Managers of planned environmental water will be required to advise the agency responsible for environmental water planning on the legislative and operational management of, and priorities for, their water. This will help Basin states prepare long-term and annual environmental watering plans. This will also apply where planned environmental water may be used in more than one region.

Role of water managers and river and infrastructure operators

Historically, the management of rivers, streams and infrastructure has focused on supplying water for consumptive use. Often this has been to the detriment of environmental assets and particularly the ecosystem functions of the Basin.

Ecological sustainability and the protection of ecological assets and functions should be one of the primary objectives of management of all water, not only environmental water. Accordingly, as far as possible within obligations to capture, store and deliver water for consumptive purposes, all water managers will give effect to the overall objectives for water-dependent ecosystems by having regard to the principles for prioritising and managing environmental water set out in the Environmental Watering Plan, consistent with the Water Act (ss. 34 and 35).

Ecological sustainability can be enhanced by actions of water managers and river and infrastructure operators. First, actions should, wherever possible, be consistent with the needs of the environment. This might include, for example, pulsing the delivery of consumptive water or coordinating the delivery of consumptive water with environmental water where synergistic benefits can be obtained. Second, routine management actions should not undermine or otherwise limit the effectiveness of environmental watering. An example of this would be managing dams to ensure that bank slumping and drowning of bank vegetation is avoided.

To achieve these outcomes, water managers will need to review current river operations and management to ensure that rivers can be operated to achieve multiple objectives, including the overall environmental objectives for the Murray–Darling Basin’s water-dependent ecosystems. This review should include a review of Basin state policies and procedures to ensure that water management can accommodate the delivery of environmental water.

Other examples of ways that water management can be improved to deliver additional benefits include:

- increasing the release capacity from large storages
- reducing cold-water pollution effects
- building fishways at weirs and other instream structures
- screening town and irrigation water supply pumps to prevent entrainment of larval and juvenile fish
- reducing floodplain flow fragmentation by addressing barrier impacts.

Many of these will require significant time and investment to implement, but planning for them should be given priority.

The Environmental Watering Plan will not seek to manage the taking of water for consumption (or for other purposes not related to environmental watering), or to direct land or water infrastructure management and water delivery.

Environmental watering schedules

For Environmental Watering Plan implementation purposes, the Water Act (s. 29) requires MDBA to consult environmental water holders and managers, and environmental asset owners, with a view to agreeing on environmental watering schedules.

Schedules will be consensual agreements that maximise environmental watering benefits. Their priorities will be required to be consistent with the Environmental Watering Plan. It is anticipated that schedules may need to be agreed for large environmental assets where a Basin state is seeking to secure the use of held environmental water in a consistent pattern towards meeting environmental outcomes, for example, the current agreement on rules to secure watering of the Barmah–Millewa Forest (although this will not automatically become a schedule).

For environmental management framework purposes, an environmental watering schedule means an agreement:

- that coordinates environmental water use to maximise environmental watering benefits, either Basin-wide or in a specified part of the Basin
- to which some or all of the following are parties;
 - holders of held environmental water (including the Commonwealth)
 - owners of environmental assets
 - managers of planned environmental water
- that relates to held environmental water in the Basin and to which MDBA is a party.

MDBA will consult all relevant parties in developing schedules.



Little Reedy Lagoon near Shepparton in Victoria, after receiving an environmental water allocation in 2009

Identifying environmental assets and ecosystem functions

The Environmental Watering Plan will specify a method to be used to determine environmental assets and ecosystem functions in the Basin that will require watering, along with their watering needs. The method is outlined in the box below.

Identifying key environmental assets and key ecosystem functions and their water requirements

Key environmental assets

Criteria have been developed to identify assets that require environmental watering based on the requirements of the Water Act. The criteria are broadly aligned with the *National framework and guidance for describing the ecological character of Australian Ramsar wetlands* (Department of the Environment, Water, Heritage and the Arts 2008b) and the draft criteria for identifying high-conservation-value aquatic ecosystems (diversity, distinctiveness, vital habitat, evolutionary history, naturalness and representativeness). A key environmental asset will require watering if it satisfies the assessment indicators for any (one or more) of these criteria. This data will be required by MDBA.

The five criteria are:

Criterion 1 The water-dependent ecosystem is formally recognised in, and/or is capable of supporting species listed in, relevant international agreements.

Criterion 2 The water-dependent ecosystem is natural or near-natural, rare or unique.

Criterion 3 The water-dependent ecosystem provides vital habitat.

Criterion 4 The water-dependent ecosystem supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities.

Criterion 5 The water-dependent ecosystem supports or is capable of supporting significant biodiversity.

The criteria will be applied at the scales relevant to the assessment indicator. Where assets extend into multiple water resource plan areas, their portions will need to be recorded in all relevant areas with reference made to the asset as a whole.

Water requirements and flow regimes will have to be identified consistent with the overall environmental objectives.

The flow regimes are composed of multiple flow events, which individually relate to one or more site-specific ecological objectives and targets. The water requirements are to be specified (where applicable) in terms of:

- either a flow threshold or total flow volume
- the required duration for that flow threshold, or duration over which the volume should be delivered
- the required timing (seasonality) of the event (if important)
- the required frequency
- a maximum period between events
- inundation depth
- degree of groundwater dependence.

Key ecosystem functions

Criteria have been developed to identify functions that require environmental watering based on the requirements of the Water Act. The method to identify key ecosystem functions follows a similar approach to the ecological limits of hydrologic alteration framework (Poff et al. 2010). Variation from the framework is typically in response to data limitations or to maintain a more direct link to the Water Act. The development of this method for the Basin Plan is described in more detail in Alluvium (2010).

The four criteria are:

Criterion 1 The water-dependent ecosystem supports the creation and maintenance of habitats for use by plants and animals.

Criterion 2 The water-dependent ecosystem supports the transportation and dilution of nutrients, organic matter and sediment.

Criterion 3 The water-dependent ecosystem provides connections along the river for migration and recolonisation by plants and animals.

Criterion 4 The water-dependent ecosystem provides connections across floodplains, adjacent wetlands and billabongs for foraging, migration and recolonisation by plants and animals.

Each criterion will be applied at the scale relevant to the assessment indicators for each criterion.

Water requirements and flow regimes will be required to be specified consistent with the overall environmental objectives. MDBA will require the data used to identify the water requirements and flow regimes.

The key environmental assets and key ecosystem functions method is aligned with that used to determine the environmentally sustainable level of take (and thus the SDLs) (see Section 4.1).

The method will provide a consistent Basin-wide approach to determining the key environmental assets and key ecosystem functions that require environmental watering. The process for the relevant parties to apply the method is to:

- consider the principles outlined in Table 6.3
- identify the relevant key environmental assets and key ecosystem functions derived from those to be published by MDBA
- identify any potential changes to key environmental assets and key ecosystem functions
- for any changes to key environmental assets or key ecosystem functions, collate relevant supporting data consistent with MDBA data requirements
- provide the data to MDBA.

The resulting set of assets and functions must be included in Basin states' long-term environmental watering plans. Basin states will be required to update the plans when either the Environmental Watering Plan or a relevant water resource plan is updated, or at least every five years. At this time any changes in key environmental assets, key ecosystem functions and water requirements can also be updated.



River Murray downstream of Wangaratta, Victoria

In addition to identifying the assets and functions, long-term environmental watering plans must identify the environmental water and/or flow regime requirements for the key environmental assets and key ecosystem functions and document the basis for these. Environmental watering requirements should include assessment of groundwater, salinity and water quality targets where relevant. In determining the requirements, any targets must be consistent with the Water Quality and Salinity Management Plan.

Prioritising and managing environmental watering

The Water Act requires the Environmental Watering Plan to identify principles and a method to be used to determine priorities for applying environmental water across the Basin and, more broadly, principles to be applied during environmental watering. Table 6.3 outlines the principles that satisfy both of these requirements. These principles, and the Environmental Watering Plan overall, build on and are consistent with the environmental watering provisions of the National Water Initiative water reform framework and outcomes.

Prioritisation of environmental watering will need to occur at both water resource plan area and Basin scales in the development and implementation of long-term and annual planning by MDBA and Basin states.

The method to prioritise and manage environmental watering is:

- Step 1 Determine the management outcomes appropriate to the likely resource availability scenarios (management outcomes for various resource availability scenarios are set out in Table 6.4 and guidance on identifying appropriate resource scenarios is in Table 6.5).
- Step 2 For the various resource availability scenarios and aligned management outcomes, determine priorities for environmental watering through the application of the principles (as set out in Table 6.3) and apply ranking criteria.
- Step 3 Manage environmental watering to deliver these priorities consistent with the principles (as set out in Table 6.3).

Table 6.3 Principles for prioritising and managing environmental watering

Principle	Description
Maximise environmental outcomes consistent with Environmental Watering Plan objectives	<p>The prioritisation and management of environmental watering will deliver the best environmental outcome and give effect to the Environmental Watering Plan's overall objectives for water-dependent ecosystems.</p> <p>Environmental watering will be undertaken in a way that:</p> <ul style="list-style-type: none"> • has regard to the Basin annual watering priorities prepared by MDBA • maximises environmental benefits (this may include ensuring the water achieves the best environmental outcomes in a delivery system (including natural watercourses) en route to an intended environmental asset) • maximises Basin-wide outcomes wherever possible • maximises its benefits and effectiveness, e.g. by coordinating watering between environmental water managers and by coordinating its delivery with other flows • makes a substantial contribution to protecting or restoring the asset's ecological significance • takes into consideration best available science (biophysical, social and economic) to achieve the environmental outcome, e.g. mitigating or avoiding seasonal flow inversions • incorporates strategies to deal with drought and climate variability. <p>Consideration may be given to Aboriginal cultural values where these align with or enhance environmental outcomes.</p>
Implement adaptive management	Environmental watering will be consistent with adaptive management. This will improve knowledge of the system and inform policy, planning and management.
Consider asset sustainability	The asset's contribution to the long-term sustainability of the Basin Plan's goals and objectives should be considered. This may include the importance and viability of an individual site, the degree to which it is part of the connected system and the long-term prospect of watering the assets such that its values can be maintained.
Effectiveness	<p>The environmental watering prioritisation process will seek to ensure that the management of all environmental water types is coordinated between holders and managers of environmental water to meet site-specific and overall environmental objectives.</p> <p>Watering priorities will take account of the likely effectiveness of applying environmental water, based on:</p> <ul style="list-style-type: none"> • the amount of water and resources needed to achieve objectives, relative to other options • the extent and effectiveness of integration with existing complementary natural resource management plans • the likely response to watering based on previous experience or best available knowledge • the opportunity to take advantage of other water flows to realise benefits (e.g. piggybacking with natural events, conjunctive delivery with other water).
Assess and manage risks	<p>Watering priorities will take account of environmental water's potential risks, including the likelihood and significance of:</p> <ul style="list-style-type: none"> • negative outcomes of its application (including fish kills, the spread of weeds and pests or undesirable flooding) and water quality and salinity impacts, and measures that may be taken to minimise these • the effect on the water-dependent ecosystems if environmental water is not provided, including the risk of not meeting the intended long-term objectives of the Basin Plan • the ecological opportunity costs of using water for a particular purpose (i.e. identification of water-dependent ecosystems that will not receive water as a result of a particular course of action) • risks that may cause a water delivery failure, including extraction or interception risks.
Ensure robust and transparent decisions	Watering priorities will be made using robust, transparent and documented decision-making processes consistent with the environmental management framework including the relevant long-term plan and annual planning. Consideration should be given to communities and stakeholders affected by environmental water management.
Apply the precautionary principle	Environmental watering will be consistent with the Water Act (s. 4(2)(b)). That is, if there are threats of serious or irreversible environmental damage, lack of full scientific certainty cannot be used as a reason for postponing measures to prevent environmental degradation.
Consider downstream obligation and Basin benefit	Given that the SDL in each catchment is set to meet a combination of within-water-resource-plan-area and downstream needs, environmental watering will need to be undertaken in a way that considers downstream obligations and trade-offs with the capacity to meet environmental objectives at other sites.

Table 6.4 Management outcomes sought under different resource availability scenarios

	Very dry	Dry	Moderate	Wet	Very wet
General outcomes sought from watering activities	Avoid irretrievable loss of, or damage to, priority environmental assets	Ensure priority assets maintain their basic functions and resilience	Maintain ecological health and resilience	Improve the health and resilience of aquatic ecosystems	Improve the health and resilience of aquatic ecosystems
Specific outcomes/ watering objectives, including to identify and reduce emerging threats to key environmental assets and key ecosystem functions	Avoid critical loss of species, communities and ecosystems Maintain key refuges Avoid irretrievable damage or catastrophic events Relieve severe, unnaturally prolonged dry periods	Support the survival and viability of threatened species and communities Maintain priority assets Maintain priority ecosystem functions Maintain priority refuges	Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna Promote low-lying floodplain–river connectivity Support medium-flow river and floodplain functions	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna Promote higher floodplain–river connectivity Support high-flow river and floodplain functions	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna Promote higher floodplain–river connectivity Support high-flow river and floodplain functions
Examples of management actions	Water priority assets, especially refuges for key species and communities Undertake emergency watering of specific assets Use carryover water to meet critical needs	Water refuges supporting threatened species and communities Provide low flows and freshes in sites and reaches of priority assets Use carryover water to maintain critical needs	Prolong flood/high-flow duration at priority assets Contribute to the full range of in-channel flows Use carryover water if required to meet objectives Carry over water where possible to provide for subsequent years	Increase flood/high-flow duration and extent across priority assets Contribute to the full range of flows, including overbank Carry over water where possible to provide for subsequent years	Increase flood/high-flow duration and extent across priority assets Contribute to the full range of flows, including overbank Carryover water to provide for subsequent years

Note: given the Basin's ecosystem and climate diversity, multiple resource availability scenarios are likely to exist, including within water resource plan areas, depending on asset or function scale. Part of the Environmental Watering Advisory Committee's task will be to integrate and prioritise these scenarios to achieve the best environmental outcomes with available water.

Source: based on versions from the Victorian Department of Sustainability and Environment, the NSW Department of Environment, Climate Change and Water, the federal Department of the Environment, Water, Heritage and the Arts, and The Living Murray program.

Table 6.5 Guidance for use of antecedent and forecast conditions of water availability relative to flow duration curves to determine categories of resource availability^a

Forecast one-year water availability percentile	Water availability percentile (previous five years)				
	0–20	21–40	41–60	61–80	81–100
0–20	very dry	very dry	dry	moderate	moderate
21–40	very dry	dry	dry	moderate	wet
41–60	dry	dry	moderate	moderate	wet
61–80	dry	moderate	moderate	wet	very wet
81–100 ^b	moderate	moderate	wet	very wet	very wet

Note: uses state utility forecasts

a This is a guide only; conditions will vary in different plan areas.

b As water availability increases (very wet years) antecedent hydrologic conditions have less influence on those in the current year, especially ecological conditions.



Lake Pamamaroo, Menindee, New South Wales, 2010, filled as a result of floods in Queensland

Targets by which to measure progress

Under the Water Act, the Environmental Watering Plan is required to include targets to measure progress towards meeting the overall environmental objectives for the Murray–Darling Basin’s water-dependent ecosystems. The targets are only intended to measure progress towards meeting objectives. The Environmental Watering Plan will not oblige any party to achieve these targets.

These targets can be summarised as:

- no loss or degradation of ecosystem response outcomes within 5 years of the Basin Plan commencing
- improvements in ecosystem response outcomes within 5–20 years of the Basin Plan commencing.

The ecosystem response outcomes constitute a range of outcomes as specified in Table 7.1, which are aligned with the overall objectives for water-dependent ecosystems. These indicators essentially measure the health of the Murray–Darling Basin’s water-dependent ecosystems in a scientifically robust way.

The monitoring to measure these indicators will be undertaken as part of the Monitoring and Evaluation Program (see next section and Chapter 7).

The above targets for the Environmental Watering Plan will be supplemented by reporting on two additional items:

- the site-specific objectives and targets that were used to derive the environmental water requirements as input to the environmentally sustainable level of take for the Basin Plan; this will enable progress against initial expectations from the Basin Plan to be measured and evaluated
- the site-specific objectives and targets for environmental assets and ecosystem functions that are required within the long-term environmental water plans for each water resource plan area.

Monitoring and reporting

The Environmental Watering Plan monitoring and reporting requirements will be implemented through the Monitoring and Evaluation Program (further details are in Chapter 7). The Monitoring and Evaluation Program will provide the mechanism to measure and evaluate the effectiveness of

achieving the overall environmental objectives for the water-dependent ecosystems of the Murray–Darling Basin and the targets by which to measure progress.

MDBA will collaborate with Basin states and Commonwealth agencies to implement an integrated, focused and cost-effective Monitoring and Evaluation Program. The details of the monitoring, including selection of indicator and monitoring sites, will be finalised after Basin state consultation and further technical development.

MDBA and Basin states will be required to report on activities and outcomes as part of annual environmental water planning and the Environmental Watering Plan’s five-yearly review.

Review and improvement

The Monitoring and Evaluation Program proposes an adaptive management framework to ensure that new knowledge generated through monitoring activities and outcomes is incorporated into management (see Chapter 7). Important aspects that will drive improvement to the Environmental Watering Plan over time include:

- implementation of the environmental management framework that provides a key platform for adaptive management via the planning, prioritisation and reporting processes
- the 5-yearly review of the Environmental Watering Plan
- planning for the recovery of additional environmental water where required through hydrologic modelling of the water resources — recovery of additional environmental water will become more refined as the Basin Plan and new water sharing arrangements are implemented in the water resource plan areas
- the Basin Plan 10-year review, which will be informed by all of the above.

Safeguarding existing environmental water

Under the Water Act (s. 28(1)(a)), one of the Environmental Watering Plan’s purposes is to safeguard existing environmental water. ‘Safeguarding’ is not defined in the Water Act and so takes its ordinary meaning from the Macquarie Dictionary: ‘to guard, protect, secure’ existing planned and held environmental water.

The coordinated and transparent planning and reporting framework provided by the Environmental Watering Plan will assist with safeguarding existing environmental water. This will complement other mechanisms provided throughout the Basin Plan, notably SDLs and water resource plan requirements, thus:

- The Basin Plan will set and enforce SDLs to ensure there is no net reduction in planned environmental water protection from that provided for by a Basin state water management law immediately before the Basin Plan takes effect (Water Act s. 21(5)).
- The Basin Plan will require that water resource plans include rules to:
 - ensure there will be no reduction in planned environmental water protection over the water resource plan’s life
 - document the contribution that environmental water makes towards meeting environmental water requirements in the water resource plan area to ensure that SDLs are not exceeded.



*The Royal spoonbill, Moira Lake,
New South Wales*

6.3 Water Quality and Salinity Management Plan

The *Water Act 2007* (Cwlth) (s. 22(1) item 10) requires the Basin Plan to include a water quality and salinity management plan. Under the *Water Act* (s. 25(1)), this plan must:

- (a) identify the key causes of water quality degradation in the Murray–Darling Basin; and
- (b) include water quality and salinity objectives and targets for the Basin water resources.

The overarching objective of the Water Quality and Salinity Management Plan is to maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin. This objective complements the general management objectives and outcomes for the Basin’s water resources, objectives for environmental watering and long-term average sustainable diversion limits (SDLs). Implementation of the plan will contribute to maintaining the productive base of the Basin’s water resources. A summary of objectives and targets for the Water Quality and Salinity Management Plan is provided in Table 6.8 at the end of this section.

The Water Quality and Salinity Management Plan will address a number of the consequences of poor water quality, including:

- adverse social consequences — by reducing the cultural values of water, by detracting from the aesthetic value of water and water bodies, and by creating risks to human and animal health through consumption and contact through recreational pursuits
- adverse ecological consequences — by affecting the variety and abundance of plants, fish and other animal life, in rivers, wetlands and estuaries
- adverse economic consequences — by increasing the risk of financial losses in irrigated agriculture and livestock production, by affecting tourism and by making water less suitable for domestic and commercial use or increasing the cost of treating water for these purposes.

The Water Quality and Salinity Management Plan builds on the existing intergovernmental water quality and salinity frameworks: the National Water Quality Management Strategy and the Basin Salinity Management Strategy. The National Water Quality Management Strategy identified a number of possible environmental values (beneficial uses) of water. The environmental values that have greatest relevance for the management of the Basin's water resources are:

- aquatic ecosystems
- raw water for drinking supplies
- irrigation use
- recreational water.

Principles

The Water Quality and Salinity Management Plan will incorporate the following principles:

- Targets will be set across the Murray–Darling Basin, using the best available science. These targets will give effect to the policy intent of the plan and seek to manage water quality to protect the assets of the Basin.
- The Water Quality and Salinity Management Plan supports many of the overall environmental objectives of the Environmental Watering Plan (see Table 6.2); in particular:
 - declared Ramsar wetlands that depend on Basin water resources maintain their ecological character (Objective 1.1)
 - viable populations and communities of endemic biota are protected and restored (Objective 1.2)
 - energy, carbon and nutrient dynamics, including primary production and respiration, are protected and restored (Objective 2.4).

Thus, water quality targets for the Water Quality and Salinity Management Plan focus on physical and chemical stressors; that is, they will seek to ensure water quality is not the limiting factor in achieving the overall objectives. Broader water resource health targets in support of the overall environmental objectives will be found in the Environmental Watering Plan.

- The Water Quality and Salinity Management Plan will recognise the contribution of groundwater to instream salinity levels, but will not set groundwater quality or salinity targets. Groundwater SDLs have been formulated in recognition of the dynamics of the spread of unfavourable water quality parameters (primarily salinity) through aquifers.
- Targets have been set to be realistically achievable over time; however, they will not be used directly for enforcement purposes. That is, the fact that a target is exceeded will not lead directly to enforcement action.
- Targets will be set for each characteristic at the level of application (scale) appropriate for the environmental value of the water. If more than one target applies at a given location, achieving the most stringent target will ensure that all environmental values are met.
- Targets in the proposed Basin Plan have been specified taking into account the cumulative or downstream concentration effects of conservative characteristics such as salt.

- The National Water Quality Management Strategy identifies the following principle as part of its management framework: wherever possible, ambient water quality should not be allowed to degrade to the levels prescribed by the water quality objectives; that is, where the existing water quality is better than the target value, the overriding management requirement is to not allow any deterioration. The Water Quality and Salinity Management Plan encapsulates this as the ‘no deterioration’ principle. A similar policy position was adopted by the Murray–Darling Basin Ministerial Council at Meeting 9, 31 August 1990.
- The Water Quality and Salinity Management Plan will be prepared in the context of the constraints of the Water Act (s. 22(10)); that is, it cannot directly regulate land use or land-use planning, the management of natural resources (other than water) or the control of pollution.

Types of water quality degradation and their key causes

Land management and land-use actions undertaken within catchments, and water management activities such as diversions (which have reduced flow levels), have been the key causes that have allowed water quality to deteriorate. The dominant indicators of water quality degradation in the Murray–Darling Basin identified by the Water Quality and Salinity Management Plan are salinity, blue-green algal toxins, water temperature, dissolved oxygen, suspended matter, toxicants, nutrients and pH.

Salinity

Australia’s dry climate and ancient weathered landscape result in naturally high stores of salt in surface water and groundwater. Since the early 20th century, land clearing on a large scale and the progressive introduction of irrigation in agriculture have altered the water balance in catchments and the Basin as a whole, increasing the discharge of salt from the landscape to the river systems. Mobilisation of salt from saline aquifers to the rivers is a major water quality concern, particularly in the lower River Murray. Salt and saline water accumulate progressively down through the system to the Lower Lakes and Murray Mouth.

Flow is critical in maintaining the Basin’s salt balance. If the future is drier, increasingly lower flows under current levels of diversion will lead to higher salinity levels in the river system.

High levels of salinity can cause changes in aquatic communities and a significant loss of diversity. Salinity can inhibit or prevent the growth of many aquatic plants, causing the loss of important microhabitats. It affects riparian vegetation, further reducing habitat and increasing the potential for bank erosion (Watson et al. 2008). Salinity levels can be highly variable and, while much floodplain and instream life is adapted to this variability, the frequency and duration of high-salinity events can affect the resilience and sustainability of aquatic ecosystems. It also reduces the suitability of water for drinking purposes, irrigation and industrial use; contributes to the loss of productive land; and adversely affects public and private infrastructure.



Lake Charm near Kerang, Victoria, in 2007, so consumed by salt that the salt can be harvested commercially

Blue-green algal toxins

Blue-green algae (more correctly cyanobacteria), under favourable conditions, reproduce at very high rates to form blooms — sudden increases in growth that dominate the aquatic environment, forming unpleasant and sometimes toxic scums. Although blooms were recorded as long ago as 1878, there is a view they are worsening in frequency and intensity.

A series of factors interact to favour blooms of blue-green algae, including:

- Stable water columns — for blue-green algae to bloom, a water body needs to have little or no flow, calm weather with little or no wind, and hot, sunny days. These factors allow the water column to stratify, where a layer of warm surface water remains unmixed with the cooler, deeper water below it.
- Nutrients — sufficient levels of nitrogen and phosphorus need to be present in a form available to the algae. Phosphorus is usually present in sufficient quantities in the sediment of water bodies and can become available to algae when water stratifies, causing oxygen levels to fall and the associated release of phosphorus from the sediment by microbial activity. Adequate nitrogen is generally available to algae.

River regulation has led to an overall reduction in flow volume and duration (both of which previously reduced stratification), and so may increase the likelihood of development of algal blooms. During severe droughts, the reduction or cessation of river flow, combined with additional nutrients from eroded soils and waste discharges means intense blooms are more likely.

The growth of blue-green algae may also be favoured by impounding water in artificial storages in a hot and dry climate, and water releases from storages may ‘seed’ downstream blooms.

Algal toxins can cause serious health problems for humans and livestock. If ingested, the toxins microcystin and cylindrospermopsin can damage the liver and other organs, and the lymphatic system. The presence of blooms increases the water treatment costs for affected Basin communities. As skin contact can result in rashes and skin disorders, recreation may be restricted during a bloom.

Temperature

Human activities in the Murray–Darling Basin have led to changes in water temperature.

Reduction in temperature

In the warmer months (spring to autumn), large storages almost invariably stratify, with the result that the lower layer can be many degrees cooler than the natural seasonal temperature. To maximise water yield, many storages have their off-takes as close as possible to the bottom. Large releases in summer from such storages can reduce stream temperatures for hundreds of kilometres downstream.

A study examined 102 water regulation structures and found 29 with a high potential to cause abrupt changes in temperature (Ryan & Preece 2003).

Cold-water pollution affects a wide spectrum of organisms, including fish and macroinvertebrates. The effect on native fish spawning and recruitment is particularly concerning. Fish life cycles are finely tuned to natural daily and seasonal variations in temperature. Cold-water pollution reduces the growth and survival of native fish, reduces their spawning opportunities, delays egg hatching and promotes invasion by introduced species.



Bottle Bend, near Mildura, affected by salinity and acid sulfate soils

Addressing cold-water pollution will help to improve the recreational and tourism value of inland rivers, bringing associated social and economic benefits to the communities living along those rivers. Conversely, the Goulburn River downstream of Eildon Dam, for example, is an important trout fishery that is no doubt assisted by cold-water releases; returning to a more natural temperature regime may affect this fishery.

Increase in temperature

Storage of water and its subsequent release in winter can elevate stream temperatures. Additionally, clearing riparian vegetation can cause a rise in stream temperature. It is also possible that climate change may contribute to increased stream water temperatures, by causing an increase in the ambient air temperature and by causing reductions in water flow and stream depth in catchments where rainfall and run-off decrease. Release of water over a previously hot dry stream bed may also lead to high water temperatures.

As well as causing direct stress on aquatic species and ecosystems, increases in water temperature cause many secondary effects. For example, warmer water can stimulate the growth of algal blooms and, because it holds less dissolved oxygen, can exacerbate problems caused by blackwater (see 'Dissolved oxygen').

Dissolved oxygen

Dissolved oxygen levels can vary greatly. Major environmental problems can result from reduced levels of dissolved oxygen.

Decreased dissolved oxygen has a number of causes, including inputs of organic matter. As microorganisms in the water consume the organic matter, they use up oxygen in the water, often at a rate faster than it can be replenished. This can come about as a result of, for example, discharge of organic matter from sewage treatment plants or the flushing of organic material from the floodplain. Because water rich in organic matter from the floodplain can be a dark 'tea' colour, these events are termed 'blackwater'. Managed watering events need to be carefully monitored to ensure that blackwater impacts are minimised.

Reduced dissolved oxygen levels may also result from bottom release from stratified storage or from overturn within the storage or other stratified water bodies. Exposure and oxidation of acid sulfate soils may also cause reduced dissolved oxygen in water bodies.

Reduced dissolved oxygen levels are a common cause of the death of fish and other aquatic animals. Large daily variation in dissolved oxygen will also cause stress to many aquatic biota.



Algal bloom (brighter green areas) on the River Murray

Suspended matter

Suspended matter (i.e. matter that is not dissolved) increases a water body's turbidity. While the transport of suspended matter by rivers is a natural process and an important driver of diversity in geomorphology and habitat, current rates are much greater than natural rates. Turbidity is primarily caused by the erosion of soils in catchments and the subsequent transport of soil particles in catchment run-off to waterways. Land use and changes in land use that increase the exposure of unprotected soil increase the risk of catchment erosion and the subsequent increase in suspended matter in streams. Land-management practices that include inappropriate frequency and timing of cultivation, inadequate use of contour banks, overgrazing and poor soil conservation actions contribute to the risk of increased soil erosion. Failure to capture sediments by interception in the catchment, including by riparian buffer strips and vegetation cover, also contributes to increased sediment loads in waterways.



Old bridge over Warrego River near Augathella, Queensland

Soil erosion rates have increased since European settlement in the Basin. Extensive modelling of the Basin (Moran et al. 2005) indicates that two thirds of the Basin's rivers and streams have experienced a greater than 20-fold increase in sediment loads since European settlement, while 20% of waterways have experienced a more than a hundredfold increase.

Elevated turbidity can also be caused by water-management practices. For example, rapid drawdown of a storage or change in river level can lead to bank collapse, and bank and bed erosion can be caused by releases from storage, either because of the volume

of water released or the nature of its release. Wave wash from speedboats and stock grazing on floodplains and riverbanks also increase rates of erosion. Very low water levels may result in high and unstable banks that are prone to collapse, which is currently a problem in the River Murray below Lock 1.

High turbidity and consequent sedimentation in watercourses can significantly alter the physical habitat of instream environments by making pools shallower and covering coarse sediments on the bottom of the pools with finer material. In turn, this leads to:

- loss of fish species that depend on gravel beds for habitat and spawning sites
- inhibition of plant growth resulting in the replacement of a macrophyte-dominated water body with algae
- loss of fine habitat for macroinvertebrates because of infilling of coarse instream sediments.

High turbidity and suspended sediments can also:

- make it harder for some visually oriented predators to find prey
- act as a carrier for nutrients and pesticides originating from agricultural activities
- reduce recreational opportunities such as fishing, aquaculture and tourism
- increase the cost of treating water for industrial and domestic use
- lead to sedimentation of reservoirs and other water stores.

Toxicants

Pesticides

Pesticides are chemicals, generally artificial, used for insect, disease and pest plant control. They are widely used in agriculture and to a lesser extent in urban areas.

Pesticides are mobile and not all applied pesticide may remain in a target site. When best management practices are not followed, there is a risk that these chemicals may enter waterways through spray drift, surface-water run-off, leaching, soil erosion or other pathways. Because of the level and extent of agricultural activity in the catchment, sources of pesticide chemicals are widespread. Studies in the northern Basin identified the pesticides chlorpyrifos, endosulfan and profenofos as posing high hazards to aquatic organisms (Muschal & Warne 2003). In rice-growing areas, the herbicide molinate is causing concern (Christen, Chung & Quayle 2005).

Fish kills as a result of pesticide contamination have been regularly reported, especially in the cotton-growing areas in the northern Basin. There are undoubtedly also longer-term chronic impacts on aquatic ecosystems. Pesticides may also contaminate drinking water supplies.

Metals

A recent detailed study of metals in the River Murray concluded that there was no indication of widespread contamination in the river (Murray–Darling Basin Authority 2010d). Consequently, metals are not further considered in the Water Quality and Salinity Management Plan. There may, however, be significant local impacts from mining operations or exposure of acid sulfate soils (see the section ‘pH’, below).

Nutrients

Excessive nutrient levels (primarily of phosphorus and nitrogen) are a major surface-water-quality issue affecting most of the Murray–Darling Basin.

Both nitrogen and phosphorus are derived from a range of diffuse and point sources. They can be derived from natural sources (soil, organic matter and rainfall) and land-use sources, such as domestic animal waste, soil erosion, fertilisers, stormwater run-off, sewage and industrial discharges. Catchment erosion is a predominant cause of not only elevated suspended matter, but also nutrients.

Point sources of nutrients include sewage outfalls. Elevated levels of nutrients can also be released downstream from storages that have a bottom release and where water is stratified.

Surface-water nutrients are essential for aquatic ecosystem food chains. However, excessive nutrient levels lead to a number of adverse affects, such as:

- Accelerated eutrophication — high levels of nutrients that promote excessive aquatic plant and algal growth, which can result in oxygen depletion, especially at night, as a result of plant respiration. Eutrophication can also result in more broadscale oxygen depletion and, in some cases, in fish kills caused by decomposing organic matter.
- Blue-green algae blooms — promoted by increased nutrient levels in surface waters (and by cycling of nutrients from sediments), these blooms contain compounds toxic to humans and stock, making water unsafe for drinking and recreation.



Monitoring salinity and the water table at Punkah Creek on the Chowilla Floodplain, South Australia

The ecological impacts of excessive nutrient levels can cause a loss of biodiversity within affected aquatic ecosystems. Social and economic impacts include increased costs of water treatment, risks to public health, loss of amenity values (fishing, swimming, boating and aesthetics), reduced productivity of fisheries and declines in tourist numbers.

pH

The major pH problem in the Murray–Darling Basin arises as a result of exposure to the air of acid sulfate soils.

The term ‘acid sulfate soils’ refers to soils affected by iron sulfide minerals. When exposed to the air, the sulfides react with oxygen to form sulfuric acid (i.e. sulfuric materials with pH <4), which can result in significant amounts of acidity released into the water. A related property of water, ‘alkalinity’ reflects the ability of water to resist a reduction in pH. An early warning sign of an emerging problem from acid sulfate soils is a reduction in alkalinity.

Sulfidic materials form and build up in inland acid sulfate soils under freshwater conditions when two conditions are met:

- local watertables rise because of changes in catchment water balances, which induce the discharge of saline–sulfatic groundwater and cause the significant accumulation of sulfidic material in subaqueous and margin soils
- subaqueous and margin soils in wetlands and drainage disposal ponds remain inundated or saturated, because of higher weir pool levels or other water controls.

There may be other minor causes of changes in pH, including mine discharge, as well as diurnal variation as a result of eutrophication. Increase in soil acidification as a result of agricultural practices may also affect the water’s pH. This is an area that has been little investigated.

pH can have direct toxic impacts on aquatic organisms. Additionally, the oxidation of pyrite and associated rise in acidity also causes trace elements and metal ions (such as Fe³⁺ and Al³⁺) to be released. The released acid, metals (mainly aluminium), metalloids and non-metals can potentially leach into waterways, killing fish, other aquatic organisms and vegetation, and even corroding concrete and steel pipes and structures to the point of failure.

Emerging threats

Threats to the Basin’s water quality continue to emerge. The discharge of endocrine-disrupting compounds from sewage treatment facilities and other sources is a recognised water quality threat in some river systems overseas. The extent of any similar threat in the Murray–Darling Basin is yet to be determined and will require new research into local impacts and risks. The discharge of highly saline water into the Basin’s streams as a result of groundwater dewatering, particularly for coal seam gas mining, is emerging as another potential threat.

Water quality objectives and targets for identified environmental values

Aquatic ecosystems

The development of water quality management objectives and targets for the protection of aquatic ecosystems for key environmental assets will be considered at two levels of protection:

- sites with high national ecological significance
- water-dependent ecosystems (regional scale).

This approach aligns with the purpose of the Basin Plan (Water Act s. 20) by giving special attention to key environmental assets of high ecological significance that are recognised in international agreements (e.g. Ramsar-listed sites).

Variability in the tolerance of aquatic biota across the Basin is such that no single set of conditions can be applied. Therefore, a resource condition limit of 500 mg/L total dissolved solids is proposed for aquatic ecosystems, in line with the development of salinity operational targets (see the section 'Salinity operational targets' later in this chapter).

Sites with high national ecological significance

The water quality management objectives and targets will be applied to sites identified and mapped as being of high ecological significance. These will cover Ramsar wetlands and will be expanded in the future to include other 'high conservation value aquatic ecosystem' sites of importance identified by Murray–Darling Basin Authority (MDBA).



Southern Macquarie Marshes, private land, New South Wales

Relevant water quality characteristics will be those identified in the ecological character description of specific sites as 'critical components' or those that are identified as being vulnerable to an 'actual or likely threat or threatening activities' (Department of the Environment, Water, Heritage and the Arts 2008b).

The water quality management objective is to ensure that the quality of water is sufficient to maintain the ecological character of declared Ramsar sites, consistent with their ecological character description as published by the Department of Sustainability, Environment, Water, Population and Communities.

For a particular site, the water quality 'limits of acceptable change' as described in the ecological character description will be adopted as water quality targets for the purpose of the Water Quality and Salinity Management Plan.



Reed Beds Swamp in the Barmah–Millewa Forest, watered under The Living Murray program in November 2009

Water-dependent ecosystems (regional scale)

Relevant water quality characteristics include salinity, nutrients, dissolved oxygen, pH, turbidity, toxicants and temperature.

The water quality management objectives for regional-scale water-dependent ecosystems are to ensure valley-wide water quality is sufficient to:

- protect and restore viable populations and communities of endemic biota
- protect and restore critical ecosystem functions such as energy, carbon and nutrient dynamics, including primary production and respiration.

The overall water quality target values that will be adopted are those for 'slightly to moderately disturbed' systems (ANZECC & ARMCANZ 2000).

The guideline values as presented in the Australian and New Zealand Environment Conservation Council (ANZECC) water quality guidelines for 'slightly to moderately disturbed' systems (ANZECC & ARMCANZ 2000, Table 3.4.1) will be adopted for the purposes of the Water Quality and Salinity Management Plan. These will apply throughout the Basin.

For pesticides, a target will be considered to be exceeded if any sample does not meet the target.

The water temperature should be maintained within 2 °C of the estimated natural monthly temperature.

Targets for other relevant water quality characteristics have been developed for different water quality zones (based on the Sustainable Rivers Audit valleys; Davies et al. 2008) throughout the Murray–Darling Basin. The method, following the ANZECC guidelines, was based on the evaluation of water quality data in reference condition from each of the water quality zones. A map providing an overview of the water quality zones is in Figure 6.3 with the detailed numerical targets in Table 6.6.

Raw water for drinking supplies

Targets for raw water for drinking supplies will be largely those sourced from the *Australian drinking water guidelines* (NHMRC & NRMMC 2004), which are currently being revised. For some water quality characteristics where there is no existing quantitative information, the draft 2010 guidelines have been used. These values are summarised in Table 6.8. If the revision is finalised before the Basin Plan comes into effect, these figures will be updated to reflect the new values.

The drinking water guidelines apply at the point of use; however, to minimise the economic costs of treatment and to ensure suitability for small communities with limited treatment capacity, a limited subsection of the guidelines is generally applied to the raw water supply. That is, for the Water Quality and Salinity Management Plan the targets will not include microbial contaminants or suspended solids that are removed by conventional water treatment processes.

The targets will be applicable at sites in the Murray–Darling Basin where Basin water is extracted by water supply authorities for treatment and supply for human consumption (potable) purposes. The targets will not apply to some groundwater and surface-water systems used for potable purposes where the natural composition of the water is such that the aesthetic target for salinity is exceeded, but a local decision has been made to accept water of poorer quality, or to undertake additional treatment.

Relevant water quality characteristics to be considered for the Water Quality and Salinity Management Plan will be:

- microcystin and cylindrospermopsin (blue-green algal toxins)
- geosmin and 2-methylisoborneol (major odour compounds)
- total dissolved solids
- sodium
- chloride
- pesticides (where a risk can be demonstrated).

The water quality management objectives are:

- health-related — to ensure that the quality of water supplied for treatment for human consumption does not result in adverse human health effects
- aesthetic value-related — to maintain the palatability rating of water supplied for treatment for human consumption at ‘good’ (NHMRC & NRMMC 2004), and to ensure that the odour of drinking water is not offensive to most consumers.

The salinity level (total dissolved solids) at which water becomes unsuitable to meet critical human water needs is that defined as ‘poor’ to ‘unsuitable’ in the *Australian drinking water guidelines* (NHMRC & NRMMC 2004).



Taking measurements at the sedimentation and flocculation tanks, Bathurst Water Treatment Plant, New South Wales

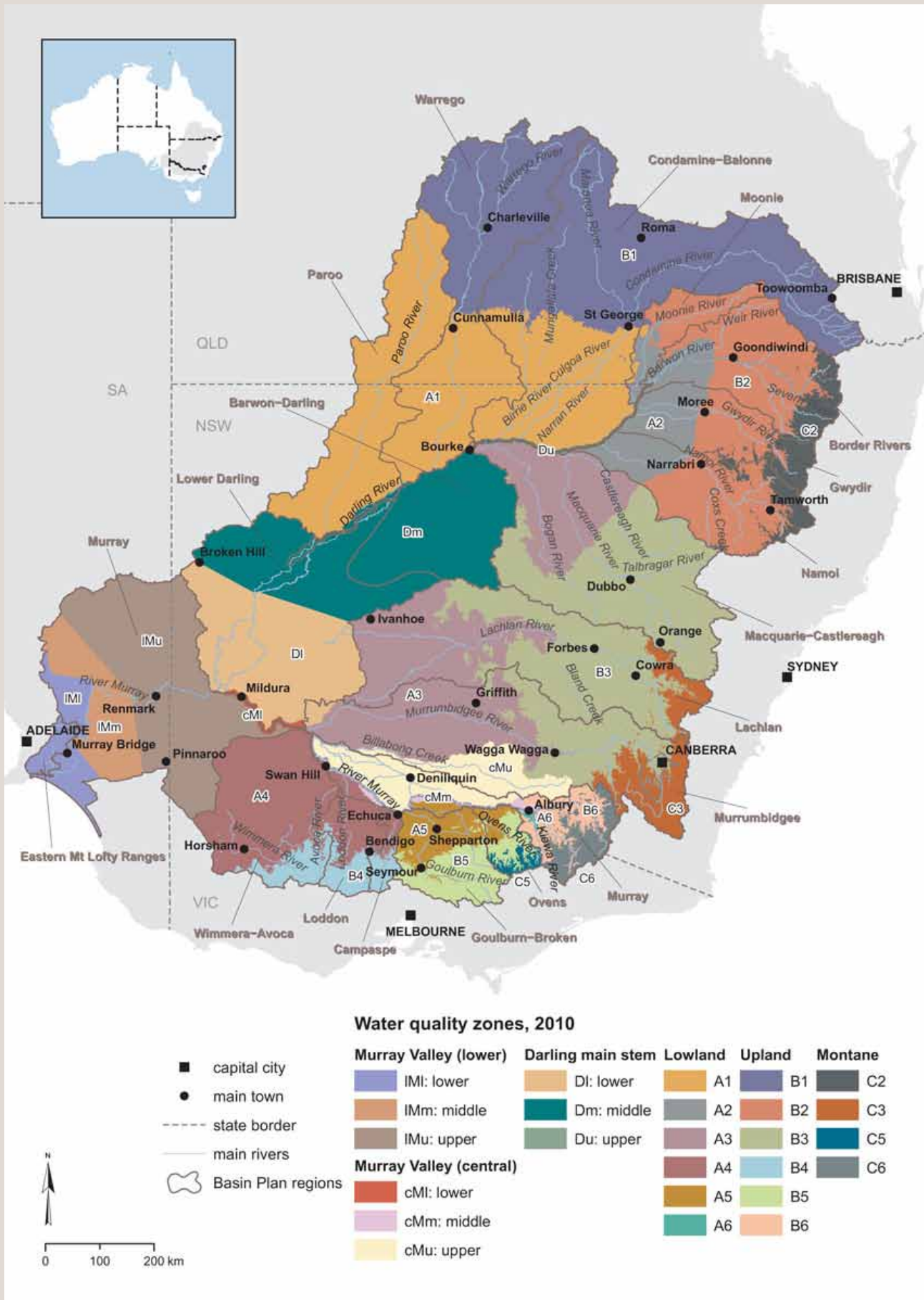


Figure 6.3 Water quality zones: Murray–Darling Basin

Table 6.6 Summary of targets for water quality zones: Murray–Darling Basin

Water quality zone ^a		pH	Dissolved oxygen (mg/L, % saturation minimum and/or maximum)	Turbidity NTU (nephelometric turbidity units)	Total phosphorus (µg/L)	Total nitrogen (µg/L)
A: Lowland (<200 m)	A1	6.5–8.0	>5 mg/L or 60–110% saturation	700	300	1,000
	A2	7.0–8.3	>5 mg/L or 65–110% saturation	200	200	1,000
	A3	6.5–8.0	>7 mg/L or 80–110% saturation	35	50	600
	A4	6.5–8.3	80–110% saturation	30	45	900
	A5	6.4–7.7	>7.5 mg/L or 85–110% saturation	30	45	600
	A6	6.4–7.7	>7.5 mg/L or 85–110% saturation	10	45	600
B: Upland (200 m – 700 m)	B1	7.0–8.5	<110% saturation	270	450	2,000
	B2	7.5–8.5	<110% saturation	30	80	750
	B3	7.0–8.0	>8.0 mg/L or 90–110% saturation	20	35	600
	B4	6.5–8.3	80–110% saturation	10	25	600
	B5	6.4–7.7	>8.0 mg/L or 90–110% saturation	10	30	600
	B6	6.4–7.7	>8.5 mg/L or 85–110% saturation	5	30	350
C: Montane (>700 m)	C2	6.5–7.5	90–110% saturation	25	20	250
	C3	6.5–7.5	>8.5 mg/L or 90–110% saturation	10	20	250
	C5	6.4–7.7	95–110% saturation	5	25	150
	C6	6.4–7.7	>9.0 mg/L or 95–110% saturation	5	25	150
Darling main stem	Du: Upper	7.0–8.1	>7.0 mg/L or 80–110% saturation	230	250	900
	Dm: Middle	6.5–8.0	85–110% saturation	50	50	500
	DL: Lower	6.5–8.0	85–110% saturation	50	50	500
Murray Valley (lower)	IMu: Upper	6.5–9.0	85–110% saturation	50	100	1,000
	IMm: Middle	6.5–9.0	85–110% saturation	50	100	1,000
	IMl: Lower	6.5–9.0	85–110% saturation	50	100	1,000
	IMml: Mt Lofty zone	6.5–9.0	85–110% saturation	50	100	1,000
Murray Valley (central)	cMu: Upper	6.5–7.5	>7.7 mg/L or 90–110% saturation	15	40	500
	cMm: Middle					
	cMl: Lower	6.8–8.0	>8.0 mg/L or 90–110% saturation	35	80	700

^a The water quality zones are based on Sustainable Rivers Audit (Davies et al. 2008) valleys and zones with some valleys combined, and slopes and upland zones combined and referred to as 'upland'.

Irrigation water

The National Water Quality Management Strategy guideline (ANZECC & ARMCANZ 2000), supplemented by more recent studies such as the Basin Salinity Management Strategy cost-function review (Rendell and McGuckian Consulting Group 2009), has been used in developing water quality objectives and targets for irrigation. The targets can be considered as a guideline value below which no water-quality-related restriction on the use of the water should apply.

The relevant water quality characteristics for irrigation water are salinity (impact on water absorption), toxicity (chemical impact on plants) and sodicity (impact on soil structure).

The water quality management objective for irrigation water is to maintain water quality at current levels or better, suitable for a range of crops typically grown across the Murray–Darling Basin.



Yarrawonga Weir on the River Murray in flood, 2010

As the salinity tolerance of crops varies, rather than setting targets for irrigation, MDBA has identified guideline values based on resource condition limits. When using water with values less than those shown for ‘no restriction on use’ (as per Ayers & Westcot 1985), no soil or cropping problems should be experienced. With increasing salinity, increasing care is required in selecting crop and management alternatives if full yield potential is to be achieved. At higher salinity levels, the water user is likely to experience soil and cropping problems or reduced yields.

Values calculated using the framework and data published in

Ayers and Westcot (1985) have been modified for Murray–Darling Basin use by the MDBA and SKM (2010) to include consideration of ecologically sustainable development principles. On that basis, the guideline values in Table 6.8 are framed as resource condition limits, beyond which there will be a decline in the environmental value (i.e. a loss of productivity). That is, the resource condition limits provide a guide to the suitability of water for irrigation in any location and have been developed from the available information.

The guideline values assume there is best management practice for:

- water supply to farms
- on-farm irrigation management, including minimising unused water
- minimising drainage (leaching fractions)
- any drainage water.

Recreational water quality and aesthetics

The water quality value will apply to water bodies throughout the Basin, for both primary contact with water (e.g. through swimming) and secondary contact (e.g. when people are splashed while engaging in activities such as fishing).

The water quality characteristics relevant to recreational water are microbial quality, cyanobacteria and algae, and algal toxins.

The water quality management objective is to protect the health of humans from water quality threats posed during recreational use of the rivers and lakes of the Murray–Darling Basin.

Water quality target values will be set at the guideline values provided in the *Guidelines for managing risks in recreational water* (NHMRC 2008) for microbial quality and algal toxins.

Whole-of-Basin salinity

Salinity is a conservative water quality characteristic at the concentrations experienced in the rivers of the Basin — that is, once salt is added to water, it will remain in solution. In addition, the salinity level or concentration of rivers generally increases from the headwaters to the lower reaches, due to the progressive intrusion of higher salinity surface waters and groundwaters. Other contaminants may be precipitated, or converted to biomass, and the concentration of these contaminants can vary over time.

The achievement of salinity targets for all environmental values of water at downstream locations, therefore, requires the setting of lower target values at upstream locations. Setting targets in this manner will generally define the expected salinity regime in each river reach and will allow water users to make informed decisions about the suitability of water for particular purposes. Managing salinity will require export of salt to the ocean.

Water Quality and Salinity Management Plan targets have been developed with reference to the Basin Salinity Management Strategy processes and procedures, including the integration of existing accountability arrangements, but with more contemporary targets that reflect real-time salinity outcomes. Accordingly, a Basin salt export target, and salinity planning and salinity operational targets are proposed.

Basin salt export

The rivers of the Basin, particularly the River Murray, are the conduit for the export of salt into the Southern Ocean. Managing salt accumulation in rivers and floodplains is best achieved by providing for average salt-load exports necessary to balance imports from the landscape and upstream. Salt export could be undertaken under appropriate timing and conditions for travel to the ocean.

The salt-load target will apply at the barrages on Lake Alexandrina for a salt load to the Southern Ocean. The target is a minimum of 2 million tonnes per year on a 10-year rolling average; that is, 20 million tonnes in any 10-year period. This is based on the Basin Salinity Management Strategy target tonnage of 1.8 million tonnes per year with a 10% allowance for salt intrusion between Morgan and the barrages.

Salinity planning targets

Salinity planning targets are for Basin and end-of-valley long-term river salinity planning and evaluation, and for catchment management purposes.

Evaluation of salinity levels within, or at the end of, catchments assesses instream salinity outcomes arising from accountable actions across the Basin. This assessment provides the basis for measuring the extent to which accountable actions in a catchment contribute to achieving acceptable levels of salinity for the Basin as a whole.



Salt covering a dried-out wetland near Wellington, South Australia

Morgan, South Australia, is the point of expression in the river system for the long-term quantum of Basin-wide management actions and their impacts, as well as the expression of salinity from the landscape, groundwater and river system.

The Basin salinity planning target site at Morgan measures whether long-term management strategies:

- protect key assets and values across the Basin
- maintain water quality in the Basin's rivers
- reduce risks to water quality.

The following target values apply:

- Basin-level: under the Water Act (s. 7(1) of Schedule B in Schedule 1), the Basin salinity planning target is to maintain the average daily salinity at Morgan at a simulated level of less than 800 electrical conductivity units (500 mg/L) for at least 95% of the time during the benchmark period.
- Valley-level: end-of-valley salinity planning targets (and the Basin-level target) are provided in Appendix 1 of Schedule B in Schedule 1 of the Water Act.

Salinity operational targets

Salinity operational targets are for event-based or 'real-time' planning to support shorter-term river management.

The salinity operational targets are derived from the lowest target value (the most sensitive) adopted for environmental water values at that location. This is generally the target value for aquatic ecosystems and/or for drinking water, which can often be lower than the resource condition limit for irrigated crops. Where the current salinity level in the water resource is lower than the target value, the current value becomes the relevant salinity operational target value for that river or valley (the 'no deterioration' principle; see 'Principles' at the beginning of this section).

Salinity operational targets for specific regions have been established by:

- assessing the target value against actual river or valley salinity upper and lower bounds, over the period of time that salinity data is available for that water resource
- determining the likelihood of the upper bound being exceeded
- establishing the lowest value of either the target value or the upper bound 95th percentile salinity outcome for the river or valley.

This approach will support the inclusion of salinity levels in short-term decision making for river operations. The use of an upper bound recognises that where a target value is not under threat, the 'no deterioration' principle comes into force. Salinity operational targets are summarised in Table 6.7.

Table 6.7 Summary of salinity operational targets: Murray–Darling Basin

Valley	Valley reporting site ^a	Australian Water Resources Council site number	Proposed target (mg/L)
South Australian border	Flow to South Australia	426200	310
Lock 6 to Berri	River Murray at Lock 4 (flow)	426514	390
	Berri Pumping Station (salinity)	426537	
Murray–Darling Basin	River Murray at Morgan (salinity)	426554	500 ^g
Below Morgan	River Murray at Murray Bridge	426522	500 ^g
Murrumbidgee	Murrumbidgee River downstream of Berembed Weir	410023	160
Lachlan	Lachlan River at Forbes (Cottons Weir)	412004	500 ^g
Macquarie	Macquarie River at Dubbo	421001	320
Namoi	Namoi River at Narrabri	419002	500 ^g
Gwydir	Gwydir River at Pallamallawa	418001	360
Barwon–Darling	Darling River at Wilcannia Main Channel	425008	500
Darling	Darling River downstream of Menindee lakes at Burtundy	425007	500 ^g
Border Rivers	Barwon River at Mungindi	416001	250
Loddon ^b	Loddon River at Serpentine Weir ^c	407229	500 ^g
Campaspe	Campaspe River at Campaspe Weir	406218	500 ^g
Goulburn	Goulburn River at Goulburn Weir	405259	200
Mallee	River Murray at Red Cliffs	414204	350
Mallee	River Murray at Swan Hill	409204	270
Riverine Plains	River Murray at Torrumbarry	409207 ^d	120
Riverine Plains	River Murray at Yarrawonga Weir	409216 ^e	60
Condamine–Balonne	Ballandool River at Hebel–Bollon Road	422207A	200 ^h
Condamine–Balonne	Narran River at New Angledool ^f	422012	320 ^h

^a Targets are not set for all valleys (e.g. Kiewa, Ovens, Moonie, Warrego, Paroo).

^b Sensitivity analysis indicates that more accurate predictions of Loddon River salinities would be achieved through improved modelling (SKM 2010).

^c Additional operational site

^d Statistics use monitoring data from gauge 409207 (from 2000 onwards) but modelled data (pre-2000) from 409219.

^e Statistics are limited to modelled data from gauge 409025 as no continuous monitoring data was available from 2000 to 2010.

^f This site is operated by New South Wales on behalf of Queensland.

^g At these sites, if natural levels of salinity exceed target values, local objectives and targets may be developed in the water management plans.

^h At these sites, statistics use data from Queensland Basin Salinity Management Strategy baseline conditions.

Implementation

Principles of water quality management

The principles of waste management provide a useful framework for water quality management for the Murray–Darling Basin:

- good planning to prevent inappropriate land use
- preventing the generation of the contaminant by controlling the source
- treating the waste at the source
- managing the symptoms by other methods, such as dilution flows (which may be used to manage water quality both as a symptom and at the source)
- temporarily managing the symptoms of water quality degradation until the full impact of source controls is realised.

Water quality and salinity management will be addressed as appropriate in either or both the proposed Basin Plan and water resource plans for water resource plan areas.

Basin-level management

Implementation of the Basin Plan — particularly the Environmental Watering Plan and the SDLs — will be closely linked to water quality issues. More water flowing in a river system is likely to reduce the risk of exceeding water quality targets; however, some outcomes will need to be managed adaptively on a case-by-case basis, optimising for multiple objectives that may be inconsistent. For example, flushing to reduce the risk of blue-green algal blooms may require water at sub-optimal times for environmental flow or water supply.



Students sample for macroinvertebrates, Ovens River, Victoria

When making operational water supply decisions related to flow, river managers and water infrastructure operators will need to plan, coordinate and implement operations in consideration of both Basin and regional-level water quality targets. Generally, management actions will relate to flow management and infrastructure construction and operation.

If the effect of an operational decision is that targets are not achieved, operating authorities will be required to show that mitigation options were considered in the decision-making process and that opportunities for mitigation, such as the provision of dilution flows, were evaluated. The operating authority will also be required to investigate and report on the impact on environmental values of an operational decision that caused the target not to be met.

Water quality and salinity targets at a Basin level will be implemented through state management and accountability arrangements, including through existing strategies. Water quality best managed at the Basin level will have one or more of four attributes:

- is conservative in nature and remains in the stream
- is of a magnitude that requires coordinated action of an operational nature
- already has shared management responsibilities
- reflects the need for shorter-term operational decision making.

The water quality characteristics to be managed in this fashion are salinity and blue-green algae.

Salinity management

Salinity operational targets are relevant for event-based ('real-time') planning to support shorter-term river management. The mid-term review of the Basin Salinity Management Strategy (MDBC 2008b) recommended the development of operational salinity targets. Actions to meet salinity operational targets set for the Murray–Darling Basin could include:

- discharge from storages in such a way as to achieve salinity operational targets
- water release requirements in regulated resources, including for irrigation or environmental watering, coordinated through MDBA
- mitigation strategies, including provision of dilution flow, floodplain salinity reduction and post-flood salinity concentration risk reduction through saline groundwater extraction and salt disposal at times of low river salinity or low salinity impact risk
- evaluation for improved management through reporting of measured river salinity against salinity operational targets.

Blue-green algae management

Blue-green algal blooms are of increasing concern in the Murray–Darling Basin; in many cases, alleviating these blooms requires coordinated management action.

The Algal Management Strategy (Murray–Darling Basin Ministerial Council 1994) identified a number of key actions critical for blue-green algae management, including two of relevance to the Basin Plan: nutrient reduction and flow management.

Nutrient reduction actions will be addressed through water resource plan requirements (Section 6.1), while the flow management aspects will be delivered in making operational water supply decisions related to flow as described earlier.

Regional-level management — water resource plan accreditation

Some water quality issues are managed more appropriately at local or regional levels and should be addressed in water resource plans under the Water Act (s. 22(3)). Accredited water resource plans will include water quality management plans that reflect the content identified in the water resource plan requirements.

Broadly, it will be necessary for Basin states to develop water quality management plans at an appropriate scale (their specific nature will vary in accordance with the particular legislation, policies, strategies, programs and plans of individual states). Useful models for these plans are water quality improvement plans created as part of a Department of the Environment, Water, Heritage and the Arts framework for protecting marine and estuarine water quality (2002). These plans are being used, and are proving useful, in many sensitive coastal environments.

Development of water quality management plans should include:

- following the principles of water quality management, consideration of the adoption of a range of management mechanisms, including regulatory and other government approaches, market approaches, provision of information, training and education and support for voluntary actions (Marsden Jacob Associates 2010)
- provision of a broad-based approach to protecting water quality and demonstration of an ability to meet the targets
- adaptive management, including refinement of water quality targets and management strategies
- use of a collaborative approach for state, territory, regional and local natural resource management bodies
- allowance for the maintenance and protection of any relevant Ramsar sites or high conservation value aquatic ecosystems, in accordance with the relevant ecological character description.

A number of other well-established arrangements should continue, with ongoing collaboration and support for implementation and regular review of the *Australian drinking water guidelines* (NHMRC & NRMCC 2004) and the *Guidelines for managing risks in recreational water* (NHMRC 2008).

Salinity management

The Basin Salinity Management Strategy 2001–2015 provides a framework for communities and government to work together to control salinity and to protect water quality, environmental values, regional infrastructure and productive agricultural land. Under the Water Quality and Salinity Management Plan, salinity management will be implemented through existing arrangements under Schedule B to the Murray–Darling Basin Agreement (Water Act Schedule 1) or, where appropriate, through accredited water resource plans. The Water Act provides for a review of the schedules to the Murray–Darling Basin Agreement, prior to the adoption of the Basin Plan. This process will incorporate any adjustment of Schedule B to align with the Water Quality and Salinity Management Plan.



Diversion channel used to take water to Buckinbah Weir, Queensland

Table 6.8 Summary of Water Quality and Salinity Management Plan objectives and targets: Murray–Darling Basin

Water Quality and Salinity Management Plan overarching objective — to maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin				
Water quality environmental value	Objective	Target		
Aquatic ecosystems High conservation (Ramsar and other sites identified by MDBA)	To ensure that the quality of water is sufficient to maintain the ecological character of declared Ramsar sites, consistent with their ecological character description as published by the Department of Sustainability, Environment, Water, Population and Communities	For a particular site, the water quality 'limits of acceptable change' as described in the ecological character description will be adopted as water quality targets for the purpose of the Water Quality and Salinity Management Plan		
Aquatic ecosystems Regional	To ensure valley-wide water quality is sufficient to protect and restore viable populations and communities of endemic biota To ensure valley-wide water quality is sufficient to protect and restore critical ecosystem functions such as energy, carbon and nutrient dynamics, including primary production and respiration	As described in detail in the section on 'Water-dependent ecosystems (regional scale)'		
Raw drinking water	Health-related — to ensure that the quality of water supplied for treatment for human consumption does not affect human health Aesthetic value-related — to maintain the palatability rating of water supplied for treatment for human consumption at 'good' (NHMRC & NRMMC 2004), and to ensure that the odour of drinking water is not offensive to most consumers	Values		
		Algal toxins	Microcystin Cylindrospermopsin	1.3 µg/L 1 µg/L (proposed in draft 2010 guidelines)
		Total dissolved solids	–	500 mg/L
		Taste and odour compounds	Total geosmin and/or 2-methylisoborneol	20 ng/L (proposed in draft 2010 guidelines, as the levels above which additional testing post-treatment should occur)
		All other relevant values (see list above)	See <i>Australian drinking water guidelines</i> (NHMRC & NRMMC 2004)	
Irrigation water	To maintain water quality at current levels or better, suitable for a range of crops typically grown across the Murray–Darling Basin ^a	Basin catchment/area	Typical crop	Salinity guideline values (mg/L)
		Murray Bridge–Yarrowonga (Murray River)	Grapes, pasture, cereals and other cut crops	410–420
		Loddon, Campaspe, Goulburn (Southern Basin)	Apples, grapes, pasture, cereals and other cut crops	300–480
		Murrumbidgee, Lachlan, Macquarie, Namoi (Central Basin)	Grapes, cotton	600–670
		Condamine–Balonne (Northern Basin)	Sorghum, cotton	2,080 ^b
Recreational water	To protect the health of humans from water quality threats posed during recreational use of the rivers and lakes of the Murray–Darling Basin	Target values will be set at the guideline values provided in the <i>Guidelines for managing risks in recreational water</i> (NHMRC 2008) for microbial quality and algal toxins		
Basin-wide salinity	To maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin	Operational targets	see Table 6.7 Summary of salinity operational targets	
		Planning targets	Basin-level: under the Water Act (s. 7(1) of Schedule B in Schedule 1), the Basin salinity planning target is to maintain the average daily salinity at Morgan at a simulated level of less than 800 electrical conductivity units (500 mg/L) for at least 95% of the time during the benchmark period Valley-level: end-of-valley salinity planning targets (and the Basin-level target) are provided in the Water Act (Appendix 1 of Schedule B in Schedule 1)	
		Salt export target	a minimum of 2 million tonnes per year on a 10-year rolling average	

a Guideline values — see the section on 'Irrigation water'.

b Little data on crop impact is available for the northern Basin and this figure is based on the best available information.

6.4 Water trading rules

Under the *Water Act 2007* (Cwlth) (s. 22(1) item 12), the Basin Plan must include rules for the trading or transfer of tradeable water rights. These rules must contribute to achieving the Basin water market and trading objectives and principles set out in Schedule 3 of the Water Act. The water trading rules complement the water market and water charge rules, which are made by the Commonwealth Water Minister under the Water Act, separately from the Basin Plan.

The water trading rules under the Basin Plan will aim to ensure that water will reach its highest value use through the development of efficient water-trading regimes that optimise economic, social and environmental outcomes within the Murray–Darling Basin.

The water trading arrangements for the Murray–Darling Basin will develop efficient water markets by removing barriers to trade and creating greater transparency for market participants, with the aim to:

- increase the efficiency of water markets and opportunities for trade and transfer within and between Basin states, where water supply considerations permit water trading
- minimise transaction costs on water trading through good information flows and making entitlement, registry, regulatory and other arrangements compatible across states
- enable development of an appropriate mix of water products based on water access entitlements
- recognise and protect the needs of the environment
- provide appropriate protection of third-party interests.

Water trading rules will also address the terms and processes for the trading and transfer of water rights, the manner in which trade is conducted, and the provision of information to enable trading to occur.

Process for developing water trading rules

Under the Water Act, the role of the Murray–Darling Basin Authority (MDBA) includes developing, implementing, monitoring compliance with, and enforcing the water trading rules.

Under the Water Act (s. 42(2)), MDBA must seek and have regard to advice from the Australian Competition and Consumer Commission when developing the Basin Plan water trading rules. Having sought stakeholder views, the Australian Competition and Consumer Commission provided its *Water trading rules: final advice* to MDBA in March 2010 (available through acc.gov.au). This advice addresses reducing barriers to trade, ensuring equal access to information, minimising transaction costs, and provide appropriate protection to third parties. Having considered the advice of the Australian Competition and Consumer Commission, MDBA made some minor modifications, which are outlined here in the discussion of the relevant rules.

Scope of water trading rules

The scope of the matters that the Basin Plan water trading rules may cover is laid out in the Water Act (s. 26). The Basin Plan water trading rules will apply to all water resources within or beneath the Murray–Darling Basin, except for groundwater that forms part of the Great Artesian Basin, or other water resources prescribed by regulations (Water Act s. 4).



Drip irrigated table grapes in the Merbein Irrigation District, Victoria

Basin Plan water trading rules will affect all entities wishing to buy or sell water in the Basin. All water access right holders and administrators of water (including Basin state agencies and irrigation infrastructure operators) will be required to comply. This will ensure that water markets across the Basin function consistently and transparently.

Currently, rules associated with the trading and transfer of tradeable water rights within the Basin are found in state and territory legislation and the policies and procedures of irrigation infrastructure operators, and are administered by the states or by infrastructure operators. Because water trade policy has generally been set by the states and the Australian Capital Territory, rules about water trading vary. Water trading rules under the Basin Plan will create consistent water trading rules for all Basin water resources, except potentially during the period where transitional and interim water resource plans are provided for under the Water Act.

Water trading rules and water resource plans

Water resource plans developed or amended by the Basin states after the Basin Plan first takes effect will only be accredited by the Commonwealth Water Minister if they are consistent with the relevant Basin Plan water trading rules. Further, under the Water Act (s. 22(3)(g)), the Basin Plan must include requirements for water resource plans relating to the circumstances in which tradeable water rights may be traded or transferred, and the conditions applicable to such trades or transfers. For more information about water resource plan requirements, see Section 6.1.

Proposed water trading rules

The following provides an overview of each of the proposed water trading rules. The proposed rules are set out in boxes beneath the relevant text, and for the purpose of the rules it should be noted that ‘trade’ includes ‘transfer’, and ‘restriction’, in relation to trade, includes ‘barrier’. These rules are indicative of the final version of the water trading rules to be included in the proposed Basin Plan. Words from the rules that are set in square brackets are still under active consideration.

Rules in relation to water access rights

Water access rights can relate to different types of water resources — for example, surface-water resources in regulated or unregulated systems, or groundwater resources. It is a broad term that includes the following types of rights: water access entitlements, water allocations, stock and domestic rights, riparian rights, and any other right in relation to the taking or use of water prescribed by regulations.

The water trading rules will deal with matters relating to the trade of water access rights, including restrictions on trade. This section outlines the scope of the proposed water trading rules in relation to:

- volumetric limits
- ownership restrictions
- intended use of water
- unbundled water rights
- trade into and out of the Murray–Darling Basin
- overallocation and overuse
- carryover.

Tradeable water rights

The water trading rules under the Basin Plan apply to different types of tradeable water rights within the Murray–Darling Basin, including water access rights (such as entitlements and allocations), irrigation rights and water delivery rights. Terminology used to describe these water rights varies between jurisdictions. The Water Act (s. 4) defines the term ‘tradeable water rights’ as referring to:

- water access rights: any right conferred by, or under a law of, a state or territory to hold and/or take water from a water resource, including a water access entitlement, a water allocation, riparian rights, stock and domestic rights, as well as any other right in relation to the taking or use of water as prescribed by regulations
- water delivery rights: a right to have water delivered by an infrastructure operator
- irrigation rights: a right that a person has against an irrigation infrastructure operator to receive water that is not a water access right or a water delivery right.

Trade not to be subject to volumetric limits

The Basin Plan water trading rules will provide that a person may trade a water access right free of any volumetric limit, unless the volumetric limit is permitted or required under the Basin Plan. A volumetric limit means a limit that has the purpose or effect of capping the total volume that may be traded out of an area, for example, the 4% limit.

Trade not to be subject to volumetric limits

- (1) A person may trade a water access right free of any volumetric limit, [unless the volumetric limit is permitted or required by or under the Plan].
- (2) In this section 'volumetric limit' means a limit whose purpose or effect is to cap the total volume of water that may be traded out of an area.

Ownership restrictions

The Basin Plan water trading rules will provide that a person may trade a water access right free of any restriction that is based on whether a party to the trade is a member of a particular class of entity. This includes entities such as:

- non-landholders (unless use has not been unbundled from water access rights)
- environmental water holders
- urban water authorities
- foreign entities (except to the extent of the operation of the *Foreign Acquisitions and Takeovers Act 1975* (Cwlth)).

Class of persons

A person may trade a water access right free of any condition as to the person being, or not being, a member of a particular class of persons.

Note: For example, a person seeking to trade a water access right must not be discriminated against on the basis that a person is an environmental water holder or urban user.

Restrictions allowable for breaches of state water management law

Nothing in the water trading rules is to be taken to have the effect that a person may trade a water access right free of a restriction imposed under state water management law because the person has:

- (a) committed an offence; or
- (b) failed to pay fees and charges.

Note: see section 4 of the Water Act for the meaning of state water management law.

Intended use of water

The Basin Plan water trading rules will provide that, in the case of water access rights other than stock and domestic rights:

- a person may trade a water access right free of any condition based on the purpose for which the water has been, or will be, used
- a person is free to use water under a water access right free of any restriction arising from the fact that the water access right has been traded (this will allow water use on land to be addressed separately through use approvals).



Flood irrigated pasture in the Goulburn Valley region, Victoria

Purpose for which water is used

- (1) A person may trade a water access right free of any condition as to the purpose for which the water relating to that right has been, or will be, used.
- (2) This section does not apply to a water access right that is a stock and domestic right.

Take and use of water after a trade

A person may take and use water under a water access right free of any restriction arising from the fact that the water access right has been traded.

Unbundled water rights

Where water rights or approvals are governed through separate instruments or processes, a person may trade a water access right free of a condition relating to the person holding, obtaining, trading or terminating:

- a water delivery right
- a works approval, or
- a water use approval.

Separate rights

- (1) If a water access right is held separately from a location-related right, a person may trade the water access right, free of any condition as to the holding, buying, selling, obtaining, accepting, or terminating of a location-related right of that kind.
- (2) The kinds of 'location-related right' referred to in subsection (1) are any of the following:
 - (a) water delivery right
 - (b) works approval
 - (c) water use approval.

Use outside the Murray–Darling Basin

Water access rights trade will not be restricted on the basis that the water may be used outside the Basin.

Use outside Murray–Darling Basin

A person may trade a water access right free of any restriction arising from the fact that water extracted under the right may be transported or used outside the Murray–Darling Basin.

Overallocation and overuse

The Basin Plan water trading rules will provide that a person may trade a water access right free of any restriction arising from the overallocation of a water resource.

The Basin Plan water trading rules will also provide that a person may trade a water access right free of any restriction arising from:

- the historical level of use of the water access right
- an anticipated increase in use of the water access right.

Overallocation

A person may trade a water access right free of any restriction based on the overallocation of a water resource.

Level of use of water access right

A person may trade a water access right free of any restriction based on:

- (a) the historical level of use of the water access right, or
- (b) an anticipated increase in the use of the water access right by the person to whom it is traded.

Carryover

The Basin Plan water trading rules will provide that a person may trade a water allocation free of any restriction arising from the fact that the water allocation was carried over (once it has been deemed accessible for use).

The Basin Plan water trading rules will also provide that a person may participate in a carryover arrangement free of any restriction arising from the fact that the water access right has been traded (assuming other criteria, such as possession of a water access entitlement, are met).

Trade of water allocation which has been carried over

- (1) A person may trade a water allocation free of any restriction arising from the fact that the water allocation was carried over from the previous water accounting period under a carryover arrangement.
- (2) Subsection (1) applies only to a water allocation that has been the subject of a carryover announcement.

Access to carryover for traded water access rights

- (1) A person may participate in a carryover arrangement free of any restriction arising from the fact that the water access right to which the arrangement applies has been traded.
- (2) Despite subsection (1), if:
 - (a) the trade of a water access right results in a change of the water resource to which the right relates, and
 - (b) the carryover arrangement for the destination water resource is different from that of the origin water resource,the carryover arrangement for the destination water resource may be applied to the water access right.

Note: See sections regarding exchange rates.

'Carryover announcement' means an announcement made by an agency of a state as to when a water allocation covered by a carryover arrangement may be taken or traded.

'Carryover arrangement' means an arrangement that allows a water access entitlement holder to retain water allocation not taken in a water accounting period for possible take or trade in the next water accounting period.

Rules in relation to water delivery rights

The Water Act (s. 4) defines a water delivery right as 'a right to have water delivered by an infrastructure operator'. Given this definition, water delivery rights exist within the irrigation networks of some irrigation infrastructure operators and, more generally, in areas serviced by the water service infrastructure of an infrastructure operator. Water delivery rights could also potentially include implied delivery rights for private diverters within a river system and between surface-water resources.

Specific and separate water delivery rights

The Basin Plan water trading rules will require irrigation infrastructure operators to specify, in writing, for each member or customer who holds a water delivery right against them:

- the volume or unit share of the member's or customer's access to the irrigation network under the water delivery right
- where the water delivery right relates to a specific part or parts of the irrigation infrastructure operator's network, the parts of the irrigation network to which the water delivery right relates
- details of the contractual terms and conditions between the irrigation infrastructure operator and the member or customer, applicable to the water delivery right.

Obligation on irrigation infrastructure operator to specify water delivery rights and give notice

- (1) An irrigation infrastructure operator must, for each person who holds a water delivery right against that irrigation infrastructure operator, make a decision as to:
 - (a) the volume or unit share of the person's water delivery right,
 - (b) the units applicable to the water delivery right,
 - (c) if the water delivery right relates to a specific part of the irrigation infrastructure operator's irrigation network, the part of the irrigation network to which the water delivery right relates.

Note: The units applicable to the water delivery right may be expressed, for example, as ML, ML/time, percentage or fraction of available capacity.

- (2) An irrigation infrastructure operator must provide written notice to the person of:
 - (a) the decision,
 - (b) the reasons for the decision,within six months after the commencement of this plan.
- (3) The irrigation infrastructure operator must provide written notice to the person of the terms and conditions of the contract between the irrigation infrastructure operator and the person which are applicable to the water delivery right.
- (4) This section does not apply if:
 - (a) the irrigation infrastructure operator has given such notice before the commencement of the plan,
 - (b) the notice is accurate at the commencement of the plan.

Where the determination of a person's volume or unit share of water delivery right is subsequently altered by the irrigation infrastructure operator (other than as a result of trade), the Basin Plan water trading rules will provide that the irrigation infrastructure operator must, as soon as practical, but no later than one month after the change:

- provide a written notice of the change to the volume or unit share of water delivery right for each affected water delivery right holder
- provide each affected water delivery right holder with written details to support the change of the volume or unit share of water delivery right.

Obligation on irrigation infrastructure operator to give notice if water delivery right is changed

If a person's volume or unit share of water delivery right changes as a result of a decision by the irrigation infrastructure operator, other than as a result of trade or termination by the person, the irrigation infrastructure operator must provide written notice to the person of:

- (a) the change to the volume or unit share, and
- (b) the reasons for the change to the volume or unit share,

as soon as practicable, but in any case within one month after the change.

Note: see section 25D of the *Acts Interpretation Act 1901* (Cwlth) for content required in a statement of reasons.

Irrigation infrastructure operators will be prevented from requiring a person to obtain, terminate or vary the volume of a water delivery right as a result of, or condition for approval of, a trade of a water access right or an irrigation right.

Trade must not be made conditional on water delivery right

An irrigation infrastructure operator must not require a person to hold, buy, sell, obtain, accept, terminate or vary the volume or unit share of a water delivery right:

- (a) as a condition of; or
 - (b) as the result of;
- the trade of a water access right or irrigation right.

Trade of water delivery rights

The Basin Plan water trading rules will provide that an irrigation infrastructure operator cannot unreasonably refuse, prevent, deter or delay the trade of water delivery rights (in part or in full) between people who own or occupy land in an area serviced by the operator's irrigation network. Factors that may inform whether a trade has been unreasonably prevented, deterred or delayed include, but are not limited to:

- overall capacity in the network
- capacity in the parts of the network to which the water delivery rights would potentially be traded
- reconfiguration or decommissioning work in the parts of the network to which the water delivery rights would potentially be traded
- connectivity between specific parts of the network relevant to the proposed trade
- payment of previous water access fees or other relevant charges
- the amount of water delivery rights reasonably required to irrigate a person's property for both current and expected future water use
- whether the necessary administrative arrangements are in place to assess and give effect to a trade in water delivery rights.

Where an irrigation infrastructure operator does not agree to the trade of water delivery rights (in part or in full) between people who own or occupy land in an area that is serviced by the irrigation infrastructure operator's network, the irrigation infrastructure operator must give reasons for their decision to both parties of the proposed trade.

No unreasonable restriction of trade of water delivery rights

- (1) An irrigation infrastructure operator must not unreasonably restrict the trade of:
 - (a) a water delivery right, or
 - (b) part of the entitlement to delivery under a water delivery right, between persons who own or occupy land in the area serviced by the irrigation infrastructure operator's irrigation network.
- (2) Without limiting subsection (1), an irrigation infrastructure operator is taken to restrict trade if it refuses, prevents, deters or delays trade.

When restriction of trade is unreasonable

- (1) For the purpose of the above section, factors to be taken into account in deciding whether a restriction is reasonable include, but are not limited to:
 - (a) overall capacity in the irrigation infrastructure operator's irrigation network,
 - (b) capacity in the parts of the irrigation infrastructure operator's irrigation network to which water would potentially be delivered under the traded water delivery right,
 - (c) reconfiguration or decommissioning work in the parts of the irrigation infrastructure operator's irrigation network to which water would potentially be delivered under the traded water delivery right,
 - (d) connectivity between specific parts of the irrigation infrastructure operator's irrigation network relevant to the proposed trade;
 - (e) payment of fees or charges of the type described in S. 91(1)(a) of the Water Act,
 - (f) the volume of a water delivery right reasonably required to irrigate a person's property for both current and expected future water use,
 - (g) the existence of necessary administrative arrangements needed to assess and give effect to a trade in water delivery rights.
- (2) In this section, 'reconfiguration or decommissioning work' means activities whereby irrigation networks are upgraded, closed, rationalised, or otherwise changed, in order to change their capacity or efficiency.

Irrigation infrastructure operator must give reasons for refusing trade of water delivery right

- (1) If an irrigation infrastructure operator refuses the trade of:
 - (a) a water delivery right, or
 - (b) part of the entitlement to delivery under a water delivery right, between persons who own or occupy land in the area serviced by the irrigation infrastructure operator's irrigation network, the irrigation infrastructure operator must give written reasons for its decision to both persons.
- (2) The irrigation infrastructure operator must provide the written reasons as soon as practicable, but in any case within one month after the refusal.

Rules in relation to irrigation rights

Under the Water Act (ss. 26(1)(h) and 26(2)), the Basin Plan water trading rules may impose or remove restrictions on, or barriers to, the trade or transfer of tradeable water rights, and may deal with the availability of information to enable trading and transfer of tradeable water rights. Irrigation rights are included in the definition of a tradeable water right (Water Act s. 4).



Irrigation pump station on the River Murray near Berri, South Australia

Specifying the volume/unit share of irrigation rights

For each person who holds an irrigation right against an irrigation infrastructure operator, the operator must make a determination of that person's entitlement to water under their irrigation right, expressed as either a volume of water (denoted in megalitres) or a unit share of the irrigation infrastructure operator's water access entitlements, and provide a written notice of this determination to that person.

Where a determination of a person's entitlement to water under their irrigation right is subsequently altered by the irrigation infrastructure operator (other than as a result of trade), the Basin Plan water trading rules will provide that the operator must as soon as practical, but no later than one month after the change:

- provide a written notice of the change to the volume or unit share of the irrigation right for each affected irrigation right holder
- provide each affected holder with written details to support the change of the volume or unit share of their entitlement to water under an irrigation right.

To facilitate negotiations in the event of a dispute between the irrigation infrastructure operator and irrigation right holders, the operator must provide to each holder written details to support the determination of the volume of water or unit share of their entitlement to water under an irrigation right.

The application of the above rules for specifying the volume/unit share of irrigation rights should not apply to an irrigation infrastructure operator that has given a written notice to each person who holds an irrigation right against that operator, specifying that person's entitlement to water under their irrigation right, expressed as either a volume of water (in megalitres) or as a unit share of the operator's water access entitlements.

Obligation on irrigation infrastructure operator to specify irrigation rights and give notice

- (1) An irrigation infrastructure operator must, for each person who holds an irrigation right against that irrigation infrastructure operator, make a decision in relation to the person's entitlement to water under their irrigation right, expressed as either:
 - (a) a number of megalitres, or
 - (b) a unit share of the irrigation infrastructure operator's water access entitlement.
- (2) An irrigation infrastructure operator must provide written notice to the person of:
 - (a) the decision,
 - (b) the reasons for the decision,within six months after the commencement of the plan.
- (3) This section does not apply if:
 - (a) an irrigation infrastructure operator has given such notice to each person who holds an irrigation right against that irrigation infrastructure operator before the commencement of the plan,
 - (b) the notice is accurate at the commencement of the plan.

Obligation on irrigation infrastructure operator to give notice if irrigation right is changed

If a person's entitlement to water under an irrigation right changes as a result of a decision by the irrigation infrastructure operator, other than as a result of trade or transformation by the person, the irrigation infrastructure operator must provide written notice to the person of:

- (a) the change to the entitlement,
- (b) the reasons for the change to the entitlement,

as soon as practicable, but in any case within one month after the change.

Rules in relation to location matters (hydrologic and environmental constraints)

Water systems can be classified based on the type of water resource and the degree to which system operators can control flows. There are four water systems within and between which trading rules will apply:

- trade in regulated surface-water systems
- trade in unregulated surface-water systems
- trade in groundwater systems
- trade between groundwater and surface water.

A number of common concepts apply to the trade of water access rights in various types of systems. For example, trade of water access rights often involves changes in extraction location, which opens up a wide range of trade-related issues, such as losses and connectivity.

For the purpose of rules in relation to location matters, a reference to the trade of a water access right to or between places (e.g. trading zones, locations, resources or systems) is a reference to:

- (a) a trade that results in a change of location at which the water to which the right relates may be taken, or
- (b) a trade that results in a change of the water resource or part of the resource to which the right relates.

Allowable restrictions for water trading in all water systems

The Basin Plan water trading rules will provide that trade of water rights between and within water resource systems may be restricted where there are physical constraints, environmental constraints, hydrologic connections and water supply considerations, low hydraulic connectivity, or a combination of any of the restrictions. While the existence of a Basin state border may necessitate different trading zones, it should not (in isolation) limit trade between these two zones.

The Australian Competition and Consumer Commission advised that trade between regulated system trading zones only be restricted due to physical constraints, environmental constraints, hydrological connections and water supply considerations. MDBA has adopted this approach, but also clarified that these allowable restrictions apply more generally to all types of water systems (i.e. also in unregulated systems and groundwater systems).

Restrictions allowable for physical or environmental reasons

- (1) A restriction on the trade of a water access right has effect if the restriction is reasonably required due to any of the following:
 - (a) a physical constraint,
 - (b) an environmental constraint,
 - (c) the need to address hydrologic connections and water supply considerations,
 - (d) low hydraulic connectivity,
 - (e) a combination of the above.

'Environmental constraint' means a restriction on the trade of a tradeable water right:

- (a) arising from an environmental consideration,
- (b) imposed by or under a water resource plan, interim water resource plan or transitional water resource plan.

'Hydrologic connections and water supply considerations', in relation to a water access right, means any of the following:

- (a) the amount of transmission loss that may be incurred through evaporation, seepage, or other means,
- (b) the potential impact, as a result of trade, on water availability in relation to a water access right held by a third party,
- (c) the ability to:
 - (i) deliver water from the same storage from which it is currently delivered, or
 - (ii) adjust valley accounts to facilitate trade, for example by way of a back trade.

Note: see clause 3 of Schedule D to Schedule 1 of the Water Act for the meaning of 'valley account'.

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'Back trade' means a trade that can only occur up to the volume that has previously been traded in the opposite direction.

'Hydraulic connectivity' means the ease with which, or the rate at which, groundwater moves:

- (a) within aquifers, or
- (b) between aquifers, or
- (c) between aquifers and the adjacent or overlying surface-water system.

'Physical constraints' means a natural formation or a physical structure (such as a pipe or channel) that limits the volume of water that can pass a given location.

Trade in regulated surface-water systems

The proposed Basin Plan will ensure that water access rights in a regulated system may generally be traded. It will allow limited restrictions to this in the case of:

- physical constraints
- environmental constraints
- hydrologic connection and water supply considerations
- a combination of the above.

Free trade in a regulated system

(1) This section applies in addition to [rules under heading 'Rules in relation to water access rights' and the rule titled 'Restrictions allowable for physical or environmental reasons'].

(2) If trading zones are in place, a person may trade a water access right between two trading zones in:

- (a) a regulated system, or
- (b) different regulated systems,

free of any restriction on the trade, unless the restriction is permitted or required by or under this plan.

Note: see clause 1 of Schedule 3 to the Water Act for the meaning of 'trading zones'.

(3) If trading zones are not in place, a person may trade a water access right between two locations in:

- (a) a regulated system, or
- (b) different regulated systems,

free of any restriction on the trade, unless the restriction is permitted or required by or under this plan.

Note: see also the sections titled 'restrictions allowable for physical or environmental reasons' and 'restrictions allowable for breaches of State water management law'.

Exchange rates

The Basin Plan water trading rules will provide that exchange rates will not be used to manage the trade of water access entitlements between trading zones in regulated systems. An exemption will be included for cases where an exchange rate is being used to reverse the impact of past exchange rate trades (up to the historical volume previously traded out using exchange rates).

Exchange rates not to be used

A water access entitlement must not be traded in a regulated system or between regulated systems if an exchange rate is applied to the water access entitlement.

Note 1: see clause 1 of Schedule 3 to the Water Act for the meaning of 'exchange rate'.

Note 2: see the section below for an exception to this section.

Authority may permit exchange rates in limited circumstance

- (1) Despite the above section, a water access entitlement to which an exchange rate is applied may be traded from one location (location A) to another (location B) if:
 - (a) the Authority has made a declaration under this section; and
 - (b) the water access entitlement is to be traded between the two locations specified in the declaration.
- (2) The Authority may make a declaration permitting the application of an exchange rate to trades between two specified locations under this section if it is satisfied that:
 - (a) the purpose of the exchange rate is to redress the impact of previous exchange rate trades from location B to location A,
 - (b) the total volume of water access entitlements to be traded from location A to location B using the exchange rate would not exceed the total volume of water access entitlements previously traded from location B to location A using exchange rates.

The declaration must be in writing and must be published on the Authority's website.

Tagging

The Basin Plan water trading rules will provide that restrictions on the ability to trade water allocation between two locations apply equally to the delivery of water allocations pursuant to a tag between the same two locations, at the time when delivery is requested (i.e. when water is ordered against the tag).

A water trading rule giving effect to the advice of the Australian Competition and Consumer Commission on tagged entitlements may change the delivery conditions of a tagged entitlement. A transition path will be included in the proposed Basin Plan, giving owners of established tagged entitlements time to adjust to possible changes in delivery conditions upon implementation of the Basin Plan.

The Basin Plan water trading rule on tagging will incorporate a clause that allows for tags established before the Basin Plan commences to be managed in accordance with the tagging system by which they were established, until the tag is cancelled or phased out.

Restrictions on delivery of water under a tagged water access entitlement

- (1) If:
 - (a) a restriction referred to in the section titled 'Restrictions allowable for physical or environmental reasons' has an effect on the trade of water allocation between two trading zones, and
 - (b) a tagged water access entitlement exists in relation to those two trading zones, and
 - (c) an order for water is made under the tagged water access entitlement,the order for water under the tagged water access entitlement is subject to the same restriction.
- (2) This section does not apply to a tagged water access entitlement which is [established before the release of the *Guide to the proposed Basin Plan: technical background*].
- (3) During the first five years after the commencement of the plan, this section does not apply to a tagged water access entitlement which is [established after the release of the *Guide to the proposed Basin Plan: technical background*] and before the commencement of the Plan.
- (4) For the purpose of this section, a tagged water access entitlement is 'established' once the tag has been approved by all relevant approval authorities.
- (5) In this section 'tagged water access entitlement' means a water access entitlement:
 - (a) which is registered on a water register in relation to one trading zone,
 - (b) under which water allocation is extracted in a different trading zone (which is tagged on the register),pursuant to an arrangement for water access entitlement tagging.
- (6) If trading zones are not in place, a reference in this section to a 'trading zone' is taken to be a reference to a location.

Trade of groundwater

These sections are still under active consideration. During development of the proposed Basin Plan, several technical issues regarding the trade of water within and between groundwater long-term average sustainable diversion limit (SDL) areas and also between groundwater and surface-water SDL areas were identified.

MDBA engaged a consultant to assist it to resolve these issues and, as a result, the proposed water trading rules will instead set out a range of requirements that must be met before such trades should be permitted to occur. These requirements are similar to the recommendations of the Australian Competition and Consumer Commission for water resource plan requirements.

Trade in groundwater systems

The Basin Plan water trading rules will provide that trade should only be allowed within a groundwater long-term average SDL area when:

- there is a level of connectivity between the two locations and that connectivity is well understood
- local resource condition limits are not exceeded as a result of the trade



Bore water used for cattle on Old Dromana Station near Moree, New South Wales

- the water access rights in the two resources have substantially similar characteristics, or an approach is in place to ensure the characteristics (the nominal volume, timing and reliability) of the original product are maintained
- it can be demonstrated that third-party interests have been considered and appropriately protected.

The Basin Plan water trading rules will also provide that trade of water rights should not be allowed between groundwater SDL areas, unless the boundary between the SDL areas is based solely on a state boundary.

These sections are still under active consideration:

Trade within a groundwater SDL resource unit

The trade of a water access right between two locations within a groundwater SDL resource unit is prohibited, unless all the following conditions are met:

- (a) there is a [level of connectivity] between the two locations,
- (b) the level of connectivity is [well understood],
- (c) [resource condition limits] are not exceeded as a result of the trade,
- (d) either:
 - (i) the water access rights in the two [locations] have substantially similar characteristics of timing, reliability and nominal volume, or
 - (ii) an approach is in place to ensure that those characteristics of the water access right [which is the subject of the trade] are maintained,
- (e) third party interests [have been considered] and appropriately protected.

Trade between groundwater SDL resource units

- (1) The trade of a water access right between two groundwater SDL resource units is prohibited.
- (2) However, if the boundary between two groundwater SDL resource units is based solely on the border between two Basin states, this section does not apply [and the above applies as if the trade of the water access right were between two locations within a groundwater SDL resource unit].

Trade between groundwater and surface-water systems

The Basin Plan water trading rules will provide that trade should not be allowed between groundwater and surface-water systems unless it can be demonstrated that:

- there is a level of connectivity between the two resources and that connectivity is well understood
- accounting and adjustment meeting the compliance requirements between the two SDLs can occur
- the water access rights in the two resources have substantially similar characteristics, or an approach is in place to ensure the characteristics (the nominal volume, timing and reliability) of the original product are maintained
- third-party interests have been considered and appropriately protected.

This section is still under active consideration:

Trade between groundwater and surface-water resources

The trade of a water access right between a groundwater resource and a surface-water resource is prohibited, unless all the following conditions are met:

- (a) there is a [level of connectivity] between the two locations,
- (b) the level of connectivity is [well understood],
- (c) [accounting and adjustment can occur in a way which meets the requirements of Chapter 9 Part 2],(d) either:
 - (i) the water access rights relating to the two resources have substantially similar characteristics of timing, reliability and nominal volume, or
 - (ii) an approach is in place to ensure that the characteristics of the [water access right which is the subject of the trade] are maintained,
- (e) third party interests [have been considered] and appropriately protected.

Rules in relation to approval authorities

Each Basin state administers its own trading rules and processes for the trade of water access rights within its borders. Although there are similarities between the processes of each state, there are also significant differences.

In general, a trade requires the involved parties (or an intermediary acting on their behalf, such as a broker) to apply to the relevant approval authority or authorities by completing the relevant application forms. The approval authority or authorities decide whether the trade can be approved according to relevant trading rules, which are set out in water resource plans or other statutory instruments. Approval may also be contingent on other matters — for example, for a water allocation trade, the seller's approval authority must also assess whether the seller has sufficient water in their account for the transaction to proceed.

To reduce transaction costs for market participants and ensure the ongoing transparency of approval authorities, the water trading rules outlined here will address matters relating to:

- approving applications to trade
- other activities of approval authorities.

In relation to the proposed trade of a water access right, 'approval authority' means a person whose approval is required under State water management law for the trade to proceed.

Approving applications to trade

The Australian Competition and Consumer Commission has advised that approval authorities should be required to provide for the electronic lodgement of water allocation trading applications. MDBA considers that the water trading rules are not the appropriate mechanism to provide for electronic lodgement of water allocation trading applications. As a result, no such water trading rule is being pursued at this time. Consideration is being given to pursuing this option by other means.

Other activities of approval authorities

Disclosure of interest to other parties involved in the potential trade

The Basin Plan water trading rules will provide that an approval authority must not approve an application to trade a water access right unless it has first informed all other parties to the trade of any interest (and if so, the nature of that interest) that it or a related party has in:

- that water access right
- a water market intermediary that brokered or facilitated the trade in return for a commission or fee.

Where an approval authority rejects a proposed trade of a water access right, the approval authority will be required to notify the parties to the proposed trade in writing of the reason(s) why it rejected the proposed trade.

Approval authority must disclose interest before trade occurs

- (1) An approval authority must disclose to each party to a proposed trade submitted to it for approval:
 - (a) the nature of any legal or equitable interest it, or a related party, has in a water access right which is the subject of the proposed trade,
 - (b) the nature of any commercial interest it, or a related party, has in the activities of any water market intermediary involved in the proposed trade.
- (2) A disclosure in subsection (1) must be made:
 - (a) as soon as practicable,
 - (b) before the approval authority approves or rejects the trade.
- (3) Subsection (1) does not require an approval authority to disclose the nature of an interest if that interest arises solely from the fact that the approval authority is an agency of a state.

'Related party', in relation to an approval authority, means:

- (a) an [entity] in which the approval authority has a controlling interest, or
- (b) a natural person who is acting on behalf of the approval authority in return for a commission or fee.

'Water market intermediary' means any of the following:

- (a) a person who trades tradeable water rights on behalf of another person in exchange for a commission or fee,
- (b) a person who investigates tradeable water right trading possibilities on behalf of potential water market participants for a commission or fee,
- (c) a person who organises or fills in documents necessary for a tradeable water right trade on behalf of potential water market participants for a commission or fee,
- (d) a person who provides a trading platform or water exchange for tradeable water rights.

Approval authority to give reasons for rejecting trade

If an approval authority has rejected a proposed trade of a water access right, the approval authority must notify the parties to the proposed trade in writing of its reasons for rejecting the trade as soon as practicable, but in any case within one month of the refusal.

Note: see S. 25D of the *Acts Interpretation Act 1901* (Cwlth) for content required in a statement of reasons.

Disclosure of trades by trade approval authorities

Approval authorities will be required to inform the market of any trade of a water access right to which they have been a buyer, seller, lessee or lessor. This disclosure should be made as soon as practical after the trade has been completed, and placed on the approval authority's website.

Approval authority must disclose if it has been a party to a trade

If:

- (a) an approval authority has approved the trade of a water access right,
- (b) the approval authority, or a related party of the approval authority, was a party to the trade (e.g. a buyer, seller, lessee or lessor),

the approval authority must publish those facts (including details of the type of water access right and volume) on its website as soon as practicable after the trade has been approved.



Kangaroo in the Nocolche Nature Reserve, New South Wales

Rules on reporting and availability of information

Access to timely and accurate information is critical for a well-functioning water market, as it allows market participants to make informed decisions about managing their water needs with no advantage or disadvantage given to other users. A lack of information can inhibit trade and raise transaction costs for market participants.

Consistency of the format of the information is just as important as the information itself. Although market participants may be familiar with the terminology in their own area, they may lack this information for other areas. While relevant information is generally available at present, there may be issues about its accessibility, timeliness and, in some cases, accuracy and clarity.

Water trading is inhibited when market participants do not have access to, or a general understanding of, the water products for sale or the procedures to conduct a trade. Requiring information on water access rights (other than water allocations) to be provided in a consistent format will allow comparison across products and geographic regions, helping water users to make more informed decisions.

To ensure that consistent, useful information is provided to the market, with an aim to reduce transaction costs and increase market transparency, Basin Plan water trading rules will address:

- information about tradeable water right characteristics
- information about trading rules and processes
- information about trading prices
- allocation and policy announcements.

Publication of information

The Authority must:

- (a) publish information provided to it under [rules applying to reporting and availability]
- (b) update the information from time to time.

Information about tradeable water right characteristics

The Basin Plan water trading rules will require that state and territory government agencies provide information about the different licensed water access rights (but not water allocations) available under the water management regime in their jurisdiction.

The information should be provided to MDBA, which will publish it at a central location. Where more than one agency holds the required information, it will be sufficient for one agency (per jurisdiction) to provide it.

Information about water access rights to be made available

- (1) An agency of a Basin state that holds information listed in the section below must provide the information to the Authority. The agency must provide the information in relation to all current water access rights, other than water allocation, issued by the State.
- (2) If more than one agency of the state holds the information, it is sufficient for one agency to provide the information on behalf of the State.
- (3) If the information is changed, an agency of the state must notify the Authority of the change.
- (4) The information must be provided in the form prescribed by the Authority from time to time.
- (5) The information must be provided within the time periods prescribed by the Authority from time to time.

Types of information about water access rights

- (1) The information about water access rights which must be provided under the section above is as follows:
 - (a) location (water resource name),
 - (b) water resource type (regulated, unregulated, groundwater),
 - (c) priority or reliability class, if applicable,
 - (d) total volume of water access right on issue of that kind,
 - (e) reliability profile (both long-term and more recent),
 - (f) fees and charges payable by the holder of the water access right to infrastructure operators and agencies of the State,
 - (g) applicable carryover policy, if any,
 - (h) dates of allocation announcements, method for announcing allocation and any other applicable regular policy announcements (e.g. a link to the appropriate allocation determination website), if applicable,
 - (i) information on how allocation levels are determined, if applicable,
 - (j) [links] to applicable trading rules and rules relevant to the water resource or trading zones within the water resource (e.g. minimum flow requirements),
 - (k) areas (including any trading zones) to which the water access right (and any water allocated under that water access right) may be traded (by way of water access entitlement tagging or otherwise),
 - (l) areas (including any trading zones) from which water access rights can be traded to the [water resource location].
- (2) In this section 'fees and charges' means fees and charges that are payable because the water access right is held for example, bulk water charges and water planning and management charges — (rather than fees and charges imposed for other reasons, such as a fine for a breach of state water management law).

Information about trading rules and processes

Basin state governments providing trading rules to a central information point

The Basin Plan water trading rules will require that Basin state governments provide, to MDBA, all applicable rules, as changed from time to time, regulating the trade of water access rights. The rules should be provided in a compiled form, but may use cross-references to other documents. Where cross-references are used, the document will be required to explain the context in which the linked document relates to rules contained in the compilation.

An agency of a state must provide trading rules

- (1) An agency of a Basin state with responsibility for rules regulating the trade of water access rights in its jurisdiction must provide a copy of the rules to the Authority:
 - (a) within 90 days after the commencement of the plan,
 - (b) if the rules change — as soon as practicable, but in any case within one month of the change.
- (2) Subsection (1) does not apply to the following rules:
 - (a) the Basin plan water trading rules,
 - (b) rules of a kind referred to in the section titled 'An irrigation infrastructure operator must provide trading rules'.
- (3) The rules must be provided in a consolidated form.
- (4) If the rules include material by way of a reference to another document:
 - (a) the rules must explain how the referenced document relates to the rules,
 - (b) the referenced documents must be publicly available online.

Irrigation infrastructure operators providing trading rules

The Basin Plan water trading rules will require that irrigation infrastructure operators provide their trading rules, as changed from time to time, for trade within, into, or out of the irrigation infrastructure operator's irrigation network.

Their trading rules will have to be provided:

- to MDBA, for those irrigation infrastructure operators entitled under water access entitlements to at least 10 GL
- on request, for all irrigation infrastructure operators
- on their website, for those irrigation infrastructure operators that have a website.

Irrigation infrastructure operators' trading rules should be provided in a compiled form, but may use cross-references to other documents. Where cross-references are used, the document will need to explain the context in which the linked document relates to rules contained in the compilation.



River red gum and lignum at Clear Lake, part of the Narran Lakes Nature Reserve, New South Wales, 2008

An irrigation infrastructure operator must provide trading rules

- (1) An irrigation infrastructure operator must provide a copy of any rules made by it which govern the trade of tradeable water rights within, into, or out of the irrigation infrastructure operator's irrigation network upon request to the Authority:
 - (a) within three months after the commencement of the plan,
 - (b) if the rules change — as soon as practicable, but in any case within one month of the change.
- (2) If the irrigation infrastructure operator has a website, it must publish the rules on the website:
 - (a) within three months after the commencement of the plan,
 - (b) if the rules change — as soon as practicable, but in any case within one month of the change.
- (3) If the sum of the volume of water to which the irrigation infrastructure operator is entitled under water access entitlements held by the irrigation infrastructure operator is at least 10 GL, the irrigation infrastructure operator must also provide a copy of the rules to the Authority.
- (4) The rules must be provided in a consolidated form.
- (5) If the rules include material by way of a reference to another document:
 - (a) the rules must explain how the referenced document relates to the rules,
 - (b) the referenced documents must be publicly available online.

Note: see S. 4 of the Water Act for the meaning of 'irrigation infrastructure operator'.

Information about trading volumes and prices

The Basin Plan water trading rules will provide that an approval authority must not approve a trade unless the seller has reported the agreed price to the approval authority.

The above requirement will not preclude a Basin state from otherwise collecting price information.

The Basin Plan water trading rules do not need to contain obligations concerning subsequent publishing of price and volume information. This is because, under existing legislation (*Water Regulations 2008* [Cwlth]), approval authorities must report any price and volume information they collect to the Bureau of Meteorology. This will facilitate reporting to the National Water Market System.

MDBA assessed the Australian Competition and Consumer Commission advice and it was considered appropriate that price information be collected as part of the trade approval process. Consequently, the water trading rules will seek to ensure that water access right holders provide this information before a trade is approved.

Price to be reported as a condition of approval of trade

- (1) If the trade of a water access right requires the approval of an approval authority, the seller of a water access right must notify the approval authority in writing of the price agreed for the trade. The notice must be given either at, or before, the time the approval is sought.
- (2) If the trade of a water access right does not require the approval of an approval authority but does require registration, the seller must notify the registration authority of the price agreed for the trade. The notice must be given either at, or before, the time the registration is sought.

Allocation and policy announcements

Standards for making allocation announcements

Governments (or their delegates) making allocation announcements, or announcing policy changes or information that would have a material effect on the price or value of water access rights (such as changes to carryover conditions, changes in the ability to trade between trading zones, or amendments to previous announcements), should make those announcements to the entire market at the same time.

The trading rules will provide that the information must be made 'generally available', such that any interested member of the public could find out the information.

Meaning of 'water announcements' and 'material effect'

- (1) 'Water announcement' means a public announcement of either of the following kinds:
 - (a) an allocation announcement, or
 - (b) an announcement of a policy change, or of information that would have a material effect on the price or value of water access rights, including but not limited to:
 - (i) changes to carryover conditions, or
 - (ii) changes in the ability to trade between trading zones, or
 - (iii) amendments to previous announcements.
- (2) An announcement of a policy change or information is taken to have a 'material effect' on the price or value of water access rights if the information would, or would be reasonably likely to, influence a person in deciding whether to acquire or dispose of such rights.

'Allocation announcement' means an announcement specifying the volume of water allocated to water access entitlements.

Note: an announcement could increase or decrease the volume of water allocated.

Water announcements must be made generally available

- (1) A person must ensure that a water announcement made by [it] is made in such a manner as to be generally available.
- (2) Information is 'generally available' if:
 - (a) it has been published in a manner that would, or would be likely to, bring it to the attention of interested members of the public, and
 - (b) since it was published, a reasonable period for it to reach such persons has elapsed.

Parties working with allocation announcements

Parties privy to allocation announcements and announcements of policy changes or information that would have a material effect on the price or value of water access rights will be prohibited from trading any water access right that is the subject of the relevant announcement, or whose price or value would be materially affected by the relevant announcement, until the announcement is made to the entire market and is generally available.

Person not to trade if aware of water announcement before it is made generally available

A person who is aware of a water announcement before it is made generally available must not trade any water access right that is:

- (a) the subject of the water announcement, or
- (b) whose price or value would be materially affected by the water announcement,

until the water announcement is made generally available.



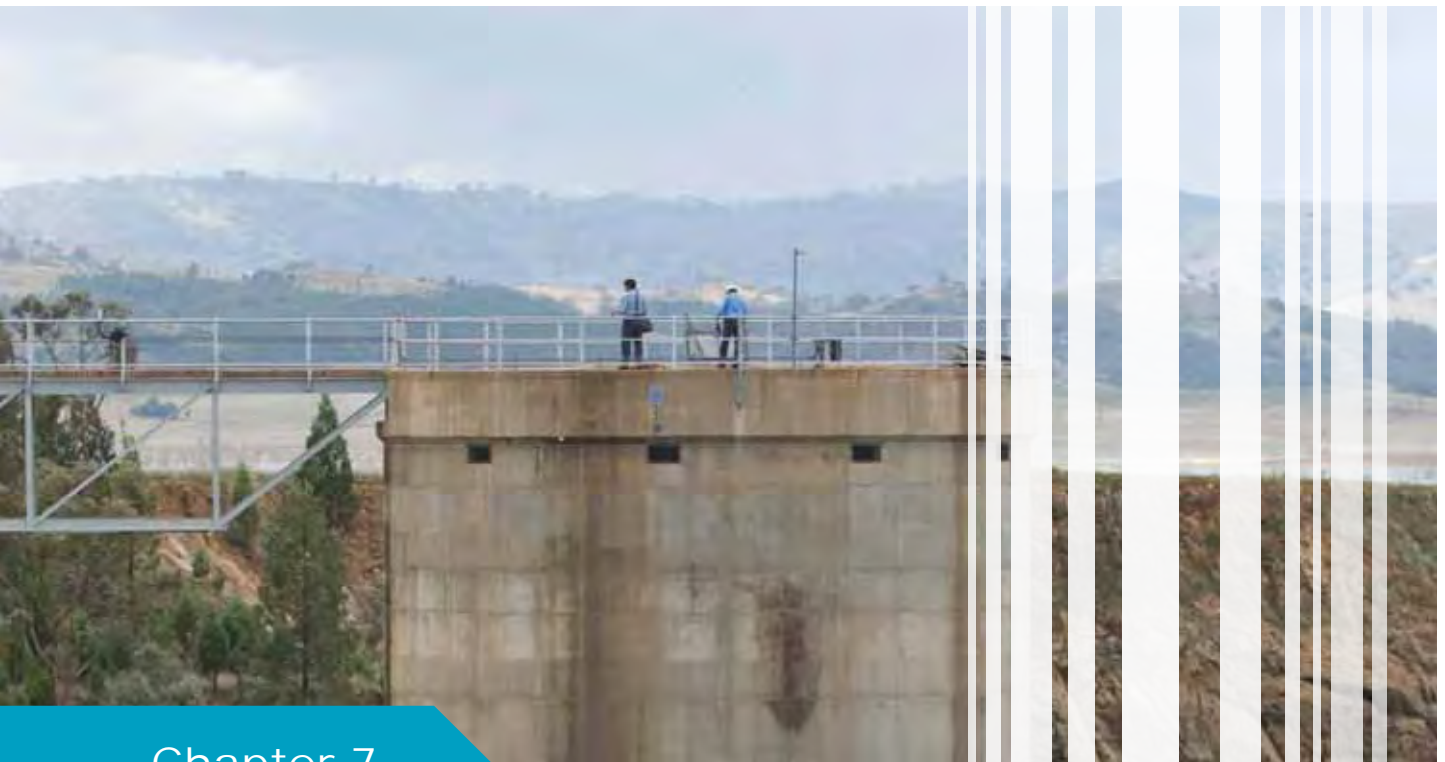
Pelican in flight over Lake Alexandrina, South Australia

Impact of water trading rules

Water access rights will be more freely tradeable within the market and between users within different locations and purposes. Water entitlements will be tradeable between irrigators and non-irrigators, towns and cities, sole traders and holding companies, and environmental managers and recreational users. All entitlement holders will be treated equally. People will be able to make their own decisions about their portfolio of assets, their drought management strategies and their cash-flow strategies.

Restrictions on trade will be confined solely to environmental and physical constraints, hydrologic connection and water supply considerations, low hydraulic connectivity, or any combination of these in relation to a Basin water resource. Apart from these, the water trading rules will effectively give a person the right to trade free of any volumetric restrictions. Access to information will be improved by making sure that all state, territory and irrigation infrastructure operator trading rules are made readily available. Allocation announcements, which are fundamental to the trading system, will be more transparent, leading to greater certainty in transactions and driving down transaction costs.

Tracking success



Chapter 7

The *Water Act 2007* (Cwlth) provides for the integrated and sustainable management of the Murray–Darling Basin’s water resources under the Basin Plan, and establishes a governance framework to ensure the plan’s successful implementation. The framework will include measures to assess the appropriateness, effectiveness and efficiency of the plan, promote compliance with the plan’s requirements, and provide for its adaptive management and improvement. These measures will include:

- promoting and enforcing compliance with the plan’s provisions by all regulated parties
- monitoring and evaluating change in ecological, social and economic terms
- ensuring transparent reporting
- reviewing the plan’s provisions.

The Water Act establishes a range of obligations relating to the Basin Plan’s provisions and water resource plans (Part 2) and provision of information to the Murray–Darling Basin Authority (MDBA) (ss. 238–239). MDBA is the enforcement agency for these provisions and will promote compliance by regulated parties by:

- helping them to understand and meet their obligations through education, communication, incentives and audit
- enforcing compliance with obligations where necessary through transparent, consistent and accountable use of enforcement powers, supported by powers to investigate and gather information and evidence, available under the Water Act.

The Basin Plan must set out the principles and framework to monitor and evaluate its effectiveness in achieving its purpose, objectives and outcomes. The monitoring and evaluation framework will be required to include reporting requirements for the Commonwealth and Basin states, and five-yearly reviews of the targets in the Water Quality and Salinity Management Plan and the Environmental Watering Plan. As well as being a legislative requirement, monitoring and evaluation will provide a rigorous process for the plan’s adaptive management and continuous improvement using the best available science (biophysical, social and economic).

By the end of 2014, the Water Act’s operation must be reviewed — in particular whether the Basin Plan’s management objectives and outcomes are being met. This review will be required to consider the extent to which the water market is operating effectively and efficiently, and whether long-term average sustainable diversion limits (SDLs) are being met. The National Water Commission will periodically report on the plan’s implementation, while MDBA will continue to monitor and evaluate the impact of plan provisions. The plan must be reviewed after 10 years or at the request of the Commonwealth Water Minister or all of the Basin states.

7.1 Compliance and enforcement

The *Water Act 2007* (Cwlth) sets out a new role for the Commonwealth in water resource regulation, compliance and enforcement, operating in parallel with Basin state legislation. When the Basin Plan takes effect, existing transitional and interim Basin state water resource plans will take precedence, to the extent that they include provisions inconsistent with the Basin Plan. New water resource plans, however, must be submitted to the Commonwealth Water Minister for accreditation on the advice of the Murray–Darling Basin Authority (MDBA).

MDBA is the appropriate enforcement agency for contraventions of the Water Act in relation to the Basin Plan and water resource plans (Part 2) and provision of information to MDBA (ss. 238–239). Basin states will continue to implement water resource plan compliance and enforcement under Basin state water legislation. MDBA will collaborate with Basin states regarding the concurrent regulation of water users under state, territory and Commonwealth water legislation.

The Basin Plan will clearly and unambiguously indicate:

- what obligations apply
- to whom the obligations apply
- whether the obligations are imposed by the Basin Plan or whether the plan requires water resource plans to impose the obligations.

The Basin Plan’s features will enable the regulated entities to identify their obligations, and enable MDBA to enforce them.

It is expected that enforcement of water resource plans by Basin states will be the primary means of compliance with water resource plan rules. While this will be the responsibility of Basin states, it is expected that MDBA will collaborate to help the Basin states through the application of consistent principles, a risk-based approach, training and support systems, and the provision of information. Where Basin Plan or water resource plan obligations are contravened, a range of enforcement powers are available to MDBA (Water Act Part 8), supported by powers to investigate and gather information and evidence (ss. 238–239).

This section sets out the framework that will be used to give the Basin Plan legal and practical effect, and to achieve compliance by the Commonwealth, Basin states and other regulated entities. This framework is presented in Figure 7.1. More specific and detailed arrangements are set out for the diversion limit compliance method (see Section 7.2), as required by the Water Act (s. 22(1) item 8).

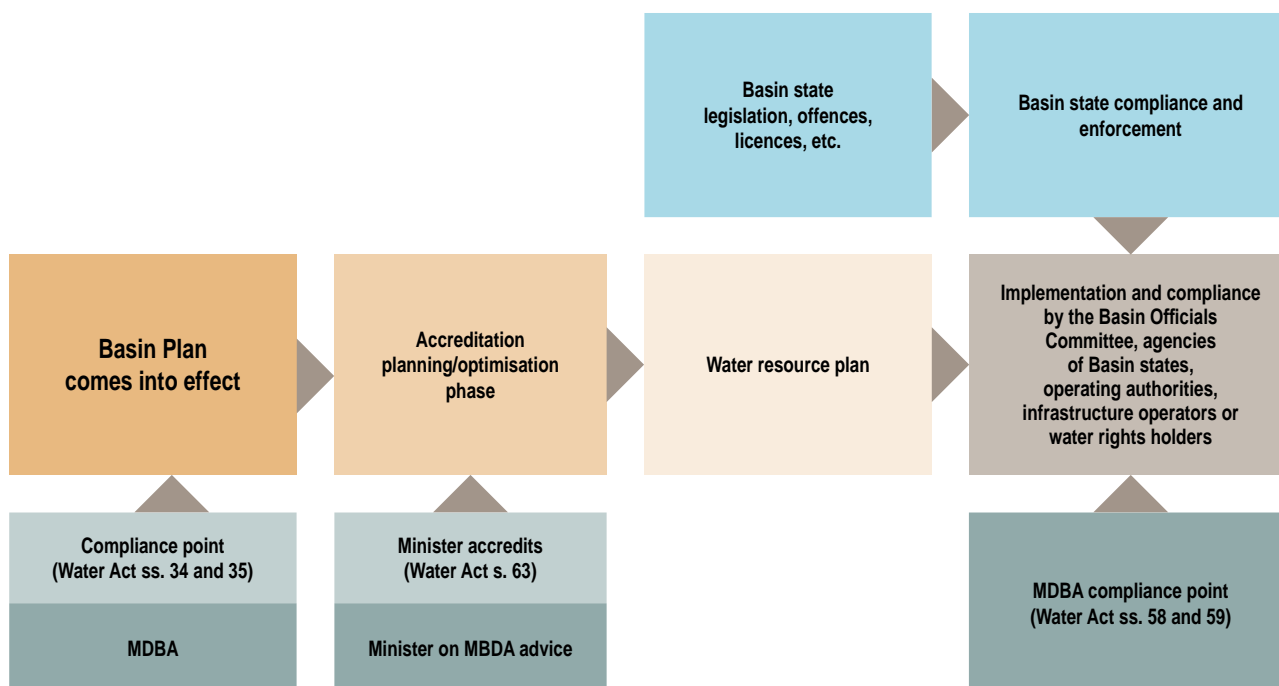


Figure 7.1 The compliance framework as provided for in the Water Act

Direct Basin Plan compliance and enforcement

The Basin Plan will directly impose obligations (enforceable via the Water Act ss. 34–35) where the same or a similar obligation is not required to be imposed by water resource plan requirements (Water Act s. 39). MDBA will enforce obligations imposed directly by the Basin Plan. The Basin states will not have an enforcement role in this regard.

The Basin Plan will directly impose obligations concerning the following items, provided similar obligations are not imposed via water resource plan requirements:

- the Environmental Watering Plan will require Basin states to develop long-term and annual environmental watering plans in consultation with managers of held and planned environmental water, consistent with the Environmental Watering Plan's objectives and framework
- the Monitoring and Evaluation Program reporting requirements will oblige the Commonwealth and Basin states to report data and information
- the water trading and transfer rules will apply directly via the Basin Plan to Basin states and water rights holders
- the Water Quality and Salinity Management Plan will oblige operating and infrastructure authorities to apply certain principles in the management of water flows.

Obligations imposed by the Basin Plan can apply from when the plan takes effect (from 2011), but transitional or interim water resource plans take precedence over the Basin Plan, to the extent of any inconsistency.

Compliance through water resource plan rules

The Basin Plan's principal items to be enforced through water resource plans (Water Act ss. 58–59) are the long-term annual diversion limits, as determined by applying the method for deciding whether there has been compliance with that diversion limit (Water Act s. 22(1) item 8, s. 22(3)(b)(c) (d)), including those water resource plan rules that implement the diversion limit. This includes rules for allocation, management and delivery of water, as well as rules to ensure compliance with the diversion limit.

Obligations required to be imposed by water resource plans will not apply until the water resource plan is accredited. These obligations will generally be enforced by Basin states through state and territory water legislation. Under certain circumstances MDBA will enforce water resource plan obligations under the Water Act, particularly compliance with those obligations by Basin states and the Commonwealth.

Water resource plan requirements

The Basin Plan will require water resource plans to specify clearly what obligations apply and to whom, so MDBA can enforce those obligations and regulated entities can identify the nature of their obligations against the Water Act (ss. 58–59).

MDBA will apply this requirement when considering its accreditation advice to the Commonwealth Water Minister to ensure it can enforce water resource plans.



*Lock 9 on the Murray River
downstream of Wentworth, Victoria*

For example, it may be necessary to require the following kinds of provisions in a water resource plan to provide certainty and a clear obligation under the Water Act:

- a water rights holder must not take more water than allocated
- a water rights holder must not take water in contravention of access rules
- a Basin state must apply water resource plan rules to achieve compliance with the long-term diversion limit, consistent with the method to determine compliance.

Enforcement of water resource plans by MDBA

MDBA will primarily regulate Basin state and Commonwealth agencies' compliance with water resource plan rules. This will be key to ensuring the Basin Plan's outcomes are achieved, and will involve:

- Basin states designing water resource plan rules that meet outcomes specified in the Basin Plan (through accreditation requirements)
- Basin states being obliged to implement those water resource plan rules
- MDBA regulating state compliance with those water resource plan rules.

MDBA can take enforcement action in relation to all contraventions relating to management of Basin water resources (ss. 19–86), including contraventions by water rights holders. In general, MDBA will lead enforcement action on water rights holders' compliance with water resource plan rules where:

- a contravention involves a Basin state or Commonwealth agency
- a contravention involves an interstate matter
- the Basin state and MDBA agree that MDBA leads the matter (for example, where the evidence and circumstances favour successful action under Commonwealth legislation but are unlikely to do so under state or territory legislation)
- the Basin state fails to take action and the matter is demonstrably relevant to Commonwealth powers (for example, relevant to international treaty obligations).

Basin states will continue to enforce compliance by water rights holders, operating authorities and infrastructure authorities, under state and territory water legislation.

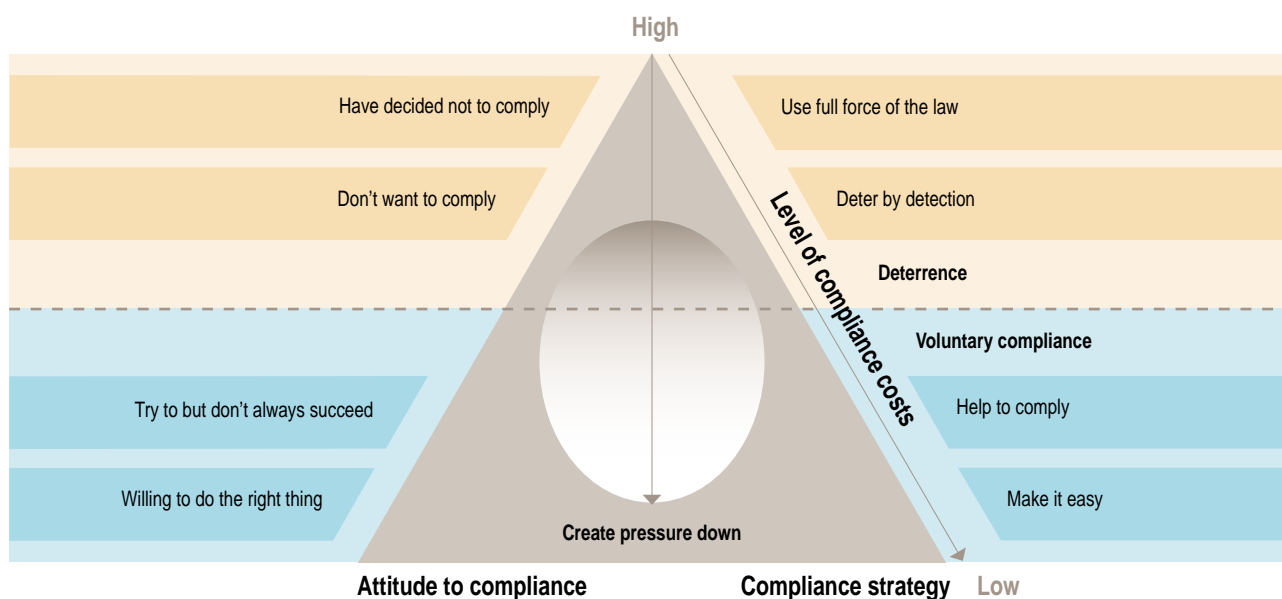


Figure 7.2 Compliance model pyramid

Source: Australian Fisheries Management Authority (2010)

Compliance approach

A range of measures will be available to MDBA to achieve compliance with the Basin Plan's provisions (the measures may also be known as the regulatory toolbox, pyramid or spectrum as shown in Figure 7.2). Measures will range from helping regulated parties to understand their obligations, to employing the full force of the Water Act to ensure compliance.

In the first instance, MDBA will help regulated parties to understand and voluntarily meet their obligations through a mix of:

- education and training — MDBA may choose to implement education and training programs with the regulated community, including the Commonwealth, Basin state water agencies, infrastructure operators and water rights holders
- engagement and negotiation — MDBA may engage with regulated entities to address compliance issues by discussion, negotiation and (non-statutory) written agreement
- incentives — MDBA (potentially in conjunction with other Commonwealth entities such as the Department of Sustainability, Environment, Water, Population and Communities) may choose to offer funding incentives to demonstrate best practice, help with adjustment to compliant or best-practice behaviour, or as tied conditional funding for Basin Plan implementation (e.g. the Water for the Future program buybacks, infrastructure and other investments)
- public affairs and communications — delivery of key messages through the media, stakeholder forums and publications has been shown to be successful as part of a regulatory strategy
- industry behaviour change — many other mechanisms can be applied to promote behaviour change in a community or industry
- audit — a key tool in a successful compliance strategy, allowing identification of non-compliance without necessarily leading to enforcement, providing the problem is addressed; both internal audit by the regulated entities and audit by the regulator (using powers if necessary) can be part of this strategy.

Where these methods do not produce compliance, MDBA will enforce it through the transparent, consistent and accountable use of enforcement powers available under the Water Act (ss. 136–170, 216–239), including:

- requiring information to be provided to MDBA
- entering property for monitoring purposes
- applying to a magistrate to enter property for compliance monitoring purposes and to gather evidence
- applying for a court injunction
- applying to a court for a declaration that a person is in contravention
- issuing enforcement notices
- entering into enforceable undertakings
- applying to a court for civil penalties for certain contraventions.

Before Basin Plan implementation, MDBA will develop a compliance and enforcement strategy. The Council of Australian Governments is developing a national framework for water legislation compliance and enforcement, including a proposal to agree and implement a common set of best practice principles.

MDBA will work with the Basin states to implement effective compliance through a compatible approach, aligned with Council of Australian Governments agreements.

Water resource plans

As stated, compliance and enforcement with water resource plan rules by water rights holders and infrastructure operators and operating authorities will be principally administered by Basin states through state and territory water legislation. MDBA will work cooperatively with Basin state compliance and enforcement agencies.

MDBA's principal focus for water resource plan compliance and enforcement will be on Basin state compliance with water resource plan rules. In particular, this is a key element of the diversion limit compliance method and framework. MDBA's compliance and enforcement effort will be targeted by the diversion limit compliance audit process and by other risk-based assessments.

Environmental Watering Plan

The Environmental Watering Plan will ensure that water 'outside' (i.e. not limited by) the long-term average sustainable diversion limits (SDLs) is used for the best Basin-scale environmental outcomes. It will provide new frameworks for the management and coordination of environmental watering. MDBA's role will be to coordinate planning and watering activities at the Basin scale. The Basin states' role in environmental watering will be ongoing, but will be required to be carried out consistently with the Environmental Watering Plan. MDBA will cooperate with Basin states, working in the context of clear roles, responsibilities and obligations.

The Basin Plan will require Basin states to consider the Environmental Watering Plan, including priorities and any schedules for environmental watering. While the approach will be founded on cooperation, MDBA will implement a robust compliance regime for planned and held environmental water, consistent with the approach for consumptive water.

Water Quality and Salinity Management Plan

Water resource plan rule accreditation will be a key component of water quality and salinity target implementation. Some water quality matters directly related to water management may operate directly through the Basin Plan. Section 22 of the Water Act prevents direct regulation by the Basin Plan of matters related to land use or planning and management of natural resources, or pollution control.



Landscape in Hattah–Kulkyne National Park, Victoria



*River Murray at Swan Reach,
South Australia*

Monitoring and Evaluation Program

The Monitoring and Evaluation Program's obligations are the reporting requirements. These will apply to Basin states and the Commonwealth. The requirements are set in such a way as to avoid embedding prescriptive technical detail in the Basin Plan, but are specific enough to ensure that critical data will be available to evaluate the plan's effectiveness.

MDBA will publish technical guidelines to help the Commonwealth and Basin states comply with the reporting requirements. MDBA will consult Commonwealth agencies and Basin states on the content of these guidelines.

Trading rules

The Basin Plan will specify trading rule obligations to be enforced by MDBA. The Australian Competition and Consumer Commission advises on Basin Plan trading rules, but will not enforce them as its enforcement role is limited to market and water charge rules.

MDBA proposes to undertake an awareness program before the water trading rules take effect, and to publicise the specific obligations that the trading rules impose. As the Basin Plan takes effect, MDBA will conduct auditing and training to highlight early non-compliance. It will also consider publicising instances of non-compliance to drive behavioural change before tougher enforcement options are pursued. MDBA envisages that it would seek negotiation with non-compliant entities in an attempt to reach a resolution before taking stronger action.

MDBA will audit trading rule compliance and identify information requirements necessary to detect potential contraventions.

7.2 Diversion limit compliance method and framework

The *Water Act 2007* (Cwlth)(s. 22(1) item 8) requires that the Basin Plan include a method to determine compliance with a long-term annual diversion limit (which is the sum of the long-term average sustainable diversion limit (SDL) and the temporary diversion provision for a particular SDL area). In addition, the *Water Act* (s. 71) obliges Basin states to report to the Murray–Darling Basin Authority (MDBA) within four months of the end of a water

accounting period on compliance with the limit in each SDL area, using the Basin Plan's method. The report must also include the quantity of water available, the quantity permitted to be taken, the quantity actually taken and various other relevant details. For most surface-water SDL areas, the quantity of water permitted to be taken will vary from year to year as climate and inflows vary.

The diversion limit compliance method will be written into the Basin Plan. It will also set out the contextual policy, regulatory and implementation arrangements that will give effect to the method, but is not required to be drafted in the Basin Plan. The compliance framework will provide particular details on how compliance with SDLs under the Basin Plan will be enforced. For the diversion limit compliance framework and method, the overall policy objectives are to:

- allow for climate variability, water resource availability, environmental requirements and entitlement water security
- provide objective rules by which water will be made available for diversion, which are clear to all regulated entities at the start of the water year and which provide certainty and security to water rights holders and the environment (within the reliability profiles of different entitlements)
- provide a clear, transparent, unambiguous and enforceable method to determine compliance
- ensure accountability for non-compliance with the diversion limit
- provide the ability to apply the limit from year one of the water resource plan
- focus effort on significant non-compliance by minimising the triggering of false non-compliance reports that are probably due to model error
- support transparent and thorough water accounting
- provide a clear policy signal to allocation authorities, the water market and the broader community, including a trigger to promptly manage any growth in diversions above the limit
- protect environmental water requirements.

The diversion limit compliance method proposed is similar to, but not the same as, that applied under the Murray–Darling Basin Cap. The method builds on the Cap's strengths and MDBA's experience with its implementation. The key differences of the diversion limit compliance method are that:

- its benchmark levels reflect environmentally sustainable levels of take, not 1993–94 diversions and rules
- governance arrangements and management decisions are administered by a regulatory authority to which the Basin states submit reports, rather than an independent auditing process and consensus decisions by partner governments
- groundwater is included
- there are legal consequences for non-compliance directly linked to water resource plan rule obligations and MDBA's civil enforcement powers, rather than reporting of non-compliance at the Ministerial Council.

Terminology used in this section:

- diversion limit compliance method — the method to determine compliance with a long-term annual diversion limit, required by the Water Act (s. 22(1) item 8) as mandatory content of the Basin Plan
- diversion limit compliance framework — MDBA's broader implementation framework for the method, not required by the Water Act to be included in the Basin Plan, but included in the *Guide to the proposed Basin Plan* for clarity and transparency
- permitted take — the maximum quantity of water permitted to be taken in a water accounting period in an SDL area, varying from year to year according to the interaction of climate, inflows and water resource plan rules (e.g. allocation rules, access rules)
- actual take — the total quantity of water actually extracted from the water resources of an SDL area during a water accounting period
- excess take — the quantity of water actually extracted from the water resources of an SDL area during a water accounting period that exceeds permitted take
- long-term average sustainable diversion limit (SDL) — the maximum long-term annual average quantity of water that can be taken on a sustainable basis from a particular water resource and reflects the environmentally sustainable level of take (Water Act s. 22(1) item 6 and s. 23)
- long-term annual diversion limit — the sum of the SDL and the temporary diversion provision for a particular water resource (Water Act s. 22(1) item 7).

Diversion limit compliance method

Water accounting period for diversion limit compliance

The primary water accounting period for diversion limit compliance reporting will be annual, over the period from 1 July to 30 June. However, there is provision for secondary tiers of the diversion limit compliance method to allow averaging over multiple years to reduce the risk of model error leading to false reporting of non-compliance, and to allow variability where appropriate.

Key variable for determining compliance — volumetric

The method for determining diversion limit compliance will be against a volumetric annual permitted take that varies according to climatic conditions and relevant triggers in water resource plan rules.

Central role of water resource plan rules

Under the Basin Plan, the annual determination of diversion limit compliance will depend on the combination of accredited water resource plan rules and climate and other triggers that occur in each water year.

Under the Basin Plan, the approach to diversion limit compliance will be:

- the Basin Plan identifies SDLs (Water Act s. 22(1) item 6)
- the Basin state then optimises the rules in the proposed water resource plan to achieve a diversion up to the SDL and other requirements, as specified in the water resource plan requirements (Water Act s. 22(1) item 11)
- the Basin state submits the water resource plan for accreditation and MDBA advises the Commonwealth Water Minister whether the water resource plan can be accredited as consistent with the Basin Plan
- once the water resource plan is made (under Basin state legislation) and accredited (under Commonwealth law), its rules are binding on the Basin state and other regulated entities
- determination of annual diversion limit compliance depends on the combination of accredited water resource plan rules and the climate and other triggers that occur each water year
- the diversion limit compliance method is outlined in the Basin Plan, but the actual volumetric limit in each year is not provided in the plan because this will vary with the climate and other triggers in the water resource plan rules
- diversion limit compliance will be enforced through the water resource plan, rather than directly through the Basin Plan (i.e. through the Water Act ss. 58–59, not through ss. 34–35)
- for this reason, Basin Plan requirements are specific on which water resource plan rules must be addressed in order to achieve accreditation.

If the actual take has exceeded the permitted take due to non-compliance with the water resource plan rules, MDBA can take action against the Basin state and/or other regulated entities (Water Act ss. 58, 59, 136–170). Depending on the circumstances, this may result in the use of a range of measures to ensure compliance with water resource plan rules.

The Basin Plan Monitoring and Evaluation Program will require Basin states to report annually to MDBA on compliance with water resource plan rules.



Hume Dam, on the River Murray in New South Wales and Victoria, at 3% capacity in May 2007

Long-term versus annual compliance assessment

The assessment of diversion limit compliance will take place on an annual basis, against a variable annual permitted take. While the SDL itself is a long-term average, it is essential that compliance is determined annually, so that unsustainable growth in diversions, or unauthorised take, can be addressed promptly. Permitted take will vary annually to reflect the climate-driven variability in:

- total available water
- environmental water needs
- allocations made to water rights holders.

This approach will help to protect environmental water requirements and underpin water rights through early detection of non-compliance.

To determine compliance with the long-term annual diversion limit at the end of any particular water accounting year, the Basin state will be required to determine that the actual take is less than or equal to the permitted take, using models and methods that meet the water resource plan requirements for accreditation.

If the actual take is greater than the permitted take for a water year, the Basin state will report non-compliance unless certain conditions apply (see the 'Use of models/methods (surface water)' and 'Credits and debits to address model uncertainty' sections of this chapter).

Definition of permitted take

A clear definition of permitted take is essential to underpin the diversion limit compliance method and to safeguard environmental water requirements and water rights.

Permitted take is defined as the maximum quantity of water permitted to be taken in a water accounting period in an SDL area, varying from year to year according to the interaction of climate, inflows and water resource plan rules (e.g. allocation rules, access rules). In most cases, for large, complex and regulated river systems, permitted take will be calculated at the end of every water year, using the same hydrologic model used to derive and accredit water resource plan rules.

For groundwater, permitted take is defined in the 'Groundwater diversion limit compliance method' section later in this chapter.

Forms of permitted take that cannot be modelled will be estimated using a method defined in the water resource plan, which satisfies accreditation requirements. See the 'Different forms of take' section later in this chapter.

The permitted take will exclude:

- the volume of water under the above categories that was identified as held environmental water before or at the time of water resource plan accreditation
- planned environmental water
- water rights traded out of the water resource plan area.

Permitted take is therefore not the same as the total volume of water rights or the total of allocations to water rights in a given year (see Figure 7.3).

The water resource plans will be required to detail how the method for determining compliance with the diversion limit will be applied, including how permitted take will be determined for each of the components of take



*Lock 4 on the River Murray at Berri,
South Australia*

listed above. The water resource plan requirements will specify how issues of rigour, accuracy, precision and consistency should be addressed to support the annual process of determining permitted take for that year. The long-term average of the permitted take for each water accounting period (over a model run of many years) will be required to be shown, at the time of water resource plan accreditation, to be equal to or less than the SDL (but with the addition of temporary diversion provisions where these apply in the transition period).

Definition of actual take

The actual take will indicate the performance of a Basin state in applying the water resource plan rules. It must be defined in a robust manner to ensure it will reflect the volume of water extracted and the volume made available to the environment.

The actual take is defined as the total quantity of water actually extracted from the water resources of an SDL area during a water accounting period. It will be determined according to the diversion limit method and the water resource plan.

To be consistent with the permitted take calculation, the actual take includes the same forms of take as those listed under 'Definition of permitted take'. These will be required to be measured or estimated using the best available method, as specified in water resource plan accreditation requirements (see Section 6.1, 'Water resource plans').

Use of models/methods (surface water)

In principle, the diversion limit compliance method is not a modelling exercise. The compliance method will compare annual actual take to annual permitted take.

In practice, hydrologic computer models will be needed to determine the permitted take volume. This will capture the effects of water resource plan rules (allocation, management and delivery of water) in relation to variability in available water, environmental watering requirements and the water security of different water entitlements. Permitted take will be determined using the models and methods provided to support water resource plan accreditation.

The use of hydrologic computer models raises various issues when applied to a compliance method.

Credits and debits to address model uncertainty

It is recognised that there are uncertainties involved in assessing the permitted take using computer simulation models, which will be the case for most of the water resource plan areas. Some of these issues are:

- carryover — the full complexity of carryover arrangements will need to be incorporated in the determination of permitted take
- behavioural changes — where people use water differently from the use assumed in the model, there will be cases where the water resource plan rules have been met but the permitted take is still exceeded
- extreme conditions — there will be greater uncertainty under extreme climatic conditions because of the limited data available against which to calibrate the models
- model error — there will be cases where the model does not accurately simulate system behaviour; this can be due to a range of causes such as the interaction between different attributes being poorly understood (e.g. surface-water and groundwater interactions) or there not being enough information available to sufficiently calibrate the model.

The diversion limit method will accommodate these issues and uncertainties by applying a debits and credits regime. This method builds on experience with the current Murray–Darling Basin Cap on surface-water diversions. Ongoing improvements to models will reduce these uncertainties over time.

To assess diversion limit compliance, the Basin state will be required to determine that actual take is less than or equal to permitted take for that water year.

If actual take is greater than permitted take, the Basin state will be required to report non-compliance unless the following conditions apply:

- the cumulative debit, within the period of effect of an accredited water resource plan, is less than 20% of the SDL (i.e. actual take does not exceed permitted take by more than 20% of the SDL)
- cumulative credits from previous water accounting periods are used to offset excess take, subject to:
 - cumulative credits can accumulate to a maximum of 30% of the SDL
 - cumulative credits used to offset excess take in any one water accounting period are limited to 10% of the SDL (i.e. to prevent adverse environmental outcomes, a cumulative credit of 30% cannot all be used in a single year to offset a debit).

This proposed credits and debits approach is intended to reduce false reports of non-compliance that are in fact due to model error and uncertainty. This will enable Basin states and MDBA to focus resources on those SDL areas where actual take is demonstrably growing beyond permitted take.

Full public disclosure of models, calculations, actual take and compliance assessment will be provided, subject to any lawful exceptions (*Privacy Act 1988* (Cwlth), evidentiary or enforcement matters).

When an accredited water resource plan is implemented, it is proposed there will be no importing of existing debits or credits from the current Cap on surface-water diversions because the basis of the limit, its governance and the regulatory legal context are substantively different. In addition, there are other mechanisms to help with transition, including Water for the Future investment, temporary diversion provisions and risk allocation (see Chapter 5 of this volume). However, MDBA will give further consideration to ensuring

the integrity of both the Cap and the SDL in the transition period to full implementation of the Basin Plan and water resource plans.

Different forms of take

The method for determining compliance will apply to all diversions in the water resource plan area, but some forms of take can be measured and their compliance determined with greater accuracy than others. It is important that the difficulties in accurately determining some forms of take (e.g. interception by farm dams) will not undermine provision of a clear limit for those forms of take for which compliance can be more accurately determined (e.g. metered water access entitlements).

The diversion limit for surface water will include components for the following forms of take:

- surface-water access entitlements — metered and included in hydrologic models
- surface-water access entitlements — estimated using an approved method
- harvesting floodplain surface water — included in hydrologic models
- harvesting floodplain surface water — estimated using an approved method
- take from watercourses under basic rights (stock and domestic rights, native title rights)
- interception by farm dams under basic rights (stock and domestic rights, native title rights and harvestable rights)
- interception by farm dams (irrigation and other purposes, excluding floodplain harvesting) — measured take
- interception by farm dams (irrigation and other purposes, excluding floodplain harvesting) — estimated using an approved method
- interception by forestry plantations (as it affects run-off).

The diversion limit for groundwater will include the following forms of take:

- groundwater access entitlements — measured take
- groundwater access entitlements — estimated using an approved method
- groundwater take under basic rights (stock and domestic, native title rights)
- take by forestry plantations (as it affects aquifers)
- interception by mining — measured take
- interception by mining — estimated using an approved model or method.

For more detail about the forms and components of take, see Tables 4.13 and 6.1.

Accounting for trade

Currently, trade in entitlements between water resource plan areas is generally accounted for in the water resource plan area of origin, because that is from where the characteristics of the entitlement are derived. However, this is not intuitive or transparent and does not reflect the physical location of extraction. It also conflicts with national water accounting standards and the method for accounting trade in the Cap.

Traded water will be accounted for in the calculation of both actual and permitted take. The volume traded will be kept on the water account in



The River Murray at Boundary Bend, Victoria

the water resource plan area where the water was extracted to be consistent with the national water account, reflect the physical reality and provide transparency. To ensure the traded water is not double-counted, the following adjustments need to be performed on the permitted and actual take:

- the permitted take in the origin water resource plan area must be reduced by the volume traded
- the permitted take in the destination water resource plan area must be increased by the volume traded
- the actual volume extracted must be included in the actual take of the destination water resource plan area.

These requirements have been put in place to ensure that trade is not restricted by the new diversion limit arrangements.

Trading rules are detailed in Section 6.4 ‘Water trading rules’. They include rules to ensure environmental outcomes are not affected by trade.

Accounting for held and planned environmental water

The use of water for the purpose of achieving environmental watering outcomes consistently with the Environmental Watering Plan is not limited by diversion limits. This means that take for such uses will not be counted as ‘actual take’ when permitted take and actual take are being compared to determine diversion limit compliance at the end of a water year.

Water available for environmental watering outcomes consistent with the Environmental Watering Plan may be water that has been made available under a water access entitlement or other water access right for achieving environmental outcomes (held environmental water). Alternatively, it may be planned environmental water that is set aside by a water resource plan for achieving environmental outcomes, for example through flow rules.

MDBA will account for the volumes of held environmental water used each year under the Water Act (s. 32). Basin states will be required to report to MDBA annually on volumes of planned environmental water and held environmental water used each year under the Basin Plan Monitoring and Evaluation Program.

Mechanisms to deal with change in purpose for which water rights are used — impacts on diversion limit compliance and water security

Both planned environmental water and held environmental water contribute to meeting environmental water requirements, and to ensuring that the SDL is not exceeded (see Figure 7.3). As shown in the figure, the total pool of water access rights is a different total from the SDL. The quantity of environmental water is to some extent determined by how much held environmental water is available.

The holders of water rights generally have the discretion to determine the purpose for which they will use their right from year to year — whether or not it is held environmental water. However, to assist Basin states in ensuring diversion limit compliance and providing third-party certainty, water resource plans will be required to identify water rights that Basin states understand will be used for environmental purposes. This will help Basin states to determine the water resource plan rules necessary to allocate water in a manner that supports compliance with the SDL.

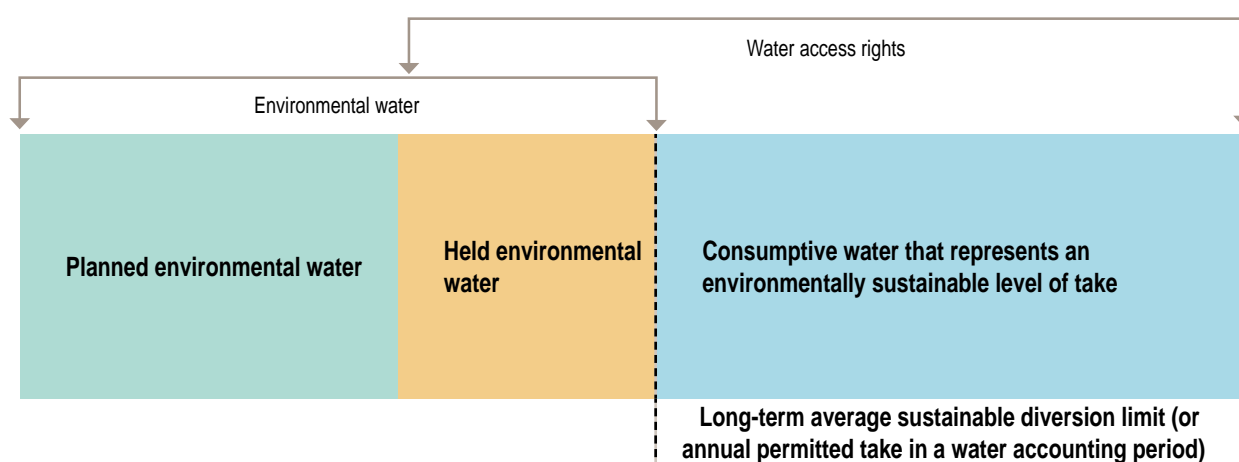


Figure 7.3 Hypothetical balance of planned and held environmental water contributions to meet environmental water requirements for a water resource plan area that ensures the SDL is not exceeded

Note: This figure is a conceptual representation of the long-term average water balance, as well as the balance for a water accounting period, which varies from year to year. The figure is not to scale and the proportions will vary between SDL areas and between water accounting periods.

In this diagram the terms planned environmental water, held environmental water and SDL have the same meaning as in the Environmental Watering Plan. Take of consumptive water is limited by the SDLs. An environmentally sustainable level of take reflects environmental water requirements.

The proposed Basin Plan will not prohibit the purpose of a water right being changed during the 10-year term of a water resource plan. Where the purpose of a water right changes from environmental purposes consistent with the Environmental Watering Plan to ‘take’ that is limited by the diversion limit, this presents a risk of exceeding the diversion limit. Where the purpose of a water right changes from ‘take’ limited by the diversion limit to purposes consistent with the Environmental Watering Plan, it is important that the overall allocations do not change, in order not to diminish the benefit of the new held environmental water.

The Basin Plan will require Basin states, when preparing water resource plans for accreditation, to provide mechanisms that ensure a change in purpose

for which water is used, does not diminish the environmental benefit of held environmental water and does not cause diversion limits to be exceeded. The Basin Plan will also require Basin states to consider the impacts of these mechanisms on water security for all uses of Basin water resources (including consumptive use). The mechanisms may, for example, involve the water resource plan requiring annual declarations about the intentions of holders of held environmental water and/or issuing entitlements with particular caveats (i.e. water is only to be used for a certain environmental purpose for a period of time).

This will mean that, if a consumptive entitlement is secured during the water resource plan accreditation period for environmental purposes, allocations will continue to be made to the entitlement as if its purpose had not changed. This will ensure that the purchase actually has a beneficial environmental effect. It will mean that the Basin state will not be able to increase allocations on the basis that there are fewer consumptive entitlement holders whose take is limited by the SDL.

The Basin Plan will require that each water resource plan includes rules to ensure there will be no reduction in planned environmental water protection over the life of the water resource plan. The Basin Plan will also require each water resource plan to document the contribution that environmental water makes towards meeting environmental water requirements in the water resource plan area to ensure that SDLs are not exceeded.

Groundwater diversion limit compliance method

Diversion limit compliance for groundwater requires slightly different arrangements to surface water because of the different nature of the resource (slower response time to rainfall and difficulty in measuring the volume of the resource in real time), and the different water management arrangements. However, the groundwater diversion limit compliance method will share the same fundamental construct of actual take assessed against permitted take.

For groundwater, SDLs will be set separately for different SDL areas. Diversion limit compliance will therefore be determined by SDL area. Actual diversions must be less than or equal to permitted diversions for the water accounting period (1 July to 30 June) for compliance to be reported, unless certain other conditions are satisfied.

The method for determining diversion limit compliance for groundwater systems will be against annual volumetric limits that reflect the assessed risk to the groundwater system from short-term extraction above the diversion limit.

MDBA has developed a method to determine the take temporarily permitted above the SDL for each SDL area, according to the assessed risk of compromising the environmentally sustainable level of take characteristics. The risk classification is based on the Recharge Risk Assessment Method.



Stock watering point between Booligal and Hay, New South Wales. Water is channelled in from the Lachlan River.

A Basin state can report diversion limit compliance where:

- the actual take for a water accounting period for each SDL area does not exceed the SDL by more than 5% for high-risk, 20% for medium-risk and 30% for low-risk SDL areas
- the average annual actual take over the past five water accounting periods is less than or equal to the SDL.

Diversion limit compliance framework

This section outlines MDBA's intended diversion limit compliance framework to provide context, clarity and transparency as to how MDBA intends to implement the diversion limit compliance method.

A detailed description of the framework is provided in Figure 7.4 and consists of these key elements:

- a method to determine compliance with the diversion limit (Water Act s. 22(1) item 8) by determining whether actual take in a water accounting period is less than or equal to the permitted take
- annual reporting obligations that require Basin states to determine their compliance with the diversion limit in accordance with the method and report this to MDBA
- MDBA verification to ensure that the compliance method is being accurately applied and to determine the causes of any non-compliance
- compliance assessment with water resource plan rules and obligations, and MDBA investigation where non-compliance is verified
- ensuring compliance, including by mechanisms such as a negotiated process or by MDBA enforcement.

This new compliance framework will come into effect once a water resource plan is accredited. The Cap arrangements will continue under the existing water planning arrangements and in accordance with the Murray–Darling Basin Agreement until this is the case, and include the period after the Basin Plan is in place but before a water resource plan has been accredited. However, it should be noted that the Cap is not enforceable under the Basin Plan.

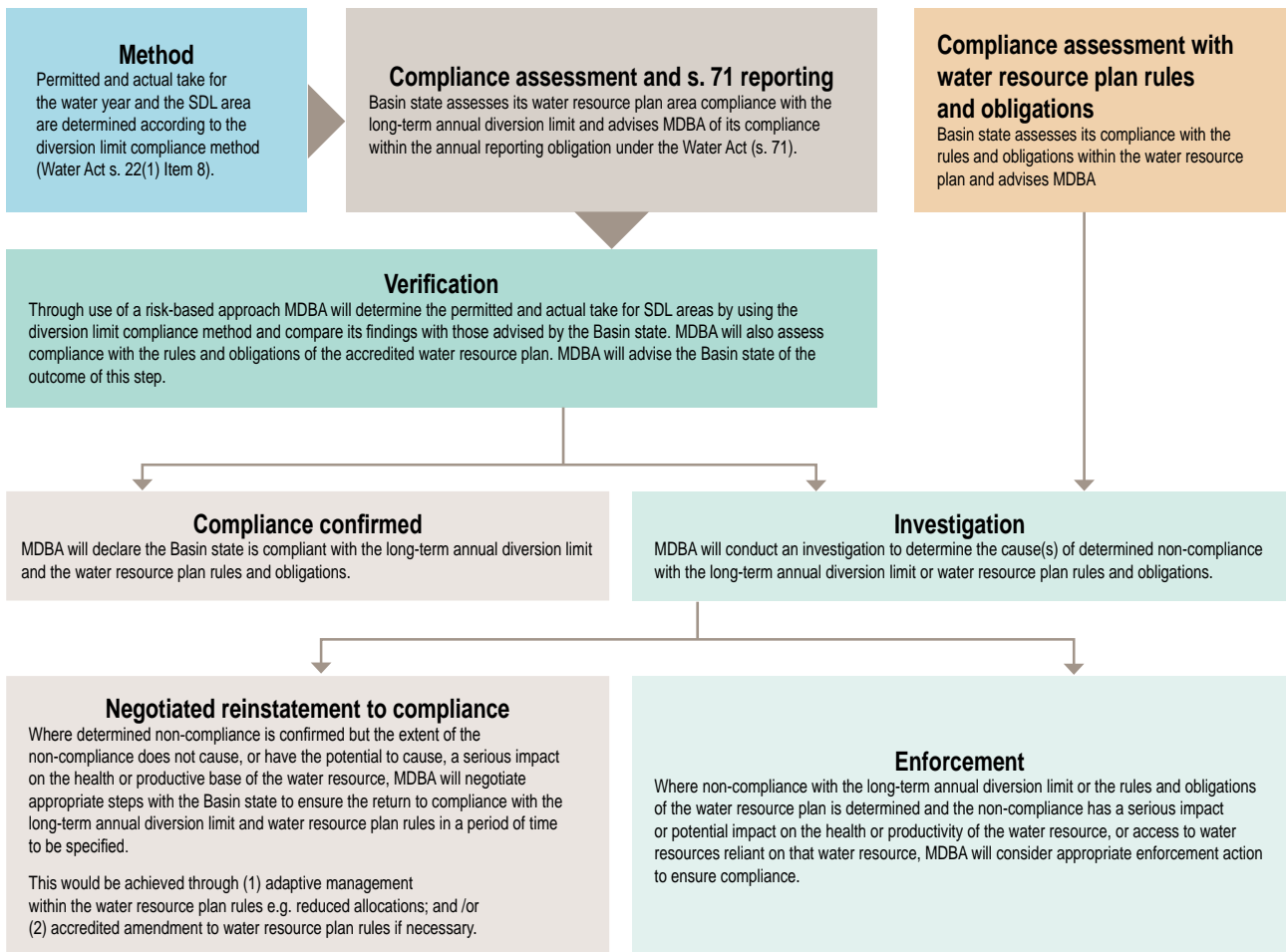


Figure 7.4 The diversion limit compliance framework

Reporting obligations and guidelines

Under the Water Act (s. 71), the reporting obligations provide the framework for annual reporting of compliance by the Basin states, against the diversion limit compliance method. MDBA may issue guidelines on how it interprets these reporting obligations and will consult the Basin states on the content of such guidelines.

Verification and investigation

Upon receipt of Basin state reports, MDBA will conduct verification procedures to assess whether the actual and permitted diversions have been determined correctly in accordance with the method and whether errors are present in the data or analysis.

Where the report and/or verification determines non-compliance (or where risks and drivers of future non-compliance are identified) MDBA will investigate to determine the cause of non-compliance. First, it will assess whether the water resource plan rules have been implemented and complied with and, if this is the case, whether the assumptions embedded in the model and water resource plan rules no longer apply.

Where non-compliance with the diversion limit or the water resource plan rules is identified, MDBA will conduct an investigation to determine the cause and the regulated entity at fault.

Ensuring compliance

Compliance will be achieved through the broader architecture of the Basin Plan and water resource plan requirements, as well as the overall Basin Plan compliance framework.

Ensuring compliance will rely on a number of mechanisms:

- water resource plans, including rules that allow allocations or other rules to be adjusted to bring diversions within permitted take, in response to non-compliance (or risk of non-compliance) with the diversion limit
- review of water resource plan rules
- where it is found that the water resource plan rules do not support diversion limit compliance, the Basin state must propose an amendment to the water resource plan for accreditation
- investigation where non-compliance with water resource plan rules is identified
- application of a range of measures by MDBA including enforcement mechanisms where required.

MDBA will publish guidelines or policy on its considerations for enforcement power decisions. This will ensure accountable decision-making and provide transparency for the regulated community.

Non-compliance with permitted take only

Where the permitted take has not been achieved, but the audit has found that water resource plan rules have been adhered to, the non-compliance will probably be due to a growth in diversions associated with changed behaviour by water rights holders or through other forms of take (e.g. from conservative to risky). Similarly, trade between water resource plan areas can lead to different behaviours by the seller and the buyer, in full compliance with water resource plan rules. Water resource plan access rules are mostly determined using a computer model that assumes a certain proportion of the allocated water is used. This is quite often based on historical behaviour. If this behaviour changes and a greater proportion of the allocation is being used, this may lead to non-compliance with the permitted take, even though there is compliance with the water resource plan access rules.

To remedy this, the model will be upgraded to better reflect the changed behaviour for each form of take. The upgraded model would need to be re-run to confirm that water resource plan rules support compliance with the diversion limit. Any proposed change to water resource plan rules, including use of the upgraded model to determine permitted take, would need to be submitted for accreditation as amendments to the water resource plan.

7.3 Monitoring and evaluation

The Basin Plan must set out a program to monitor and evaluate its effectiveness (*Water Act 2007* (Cwlth) (s. 22)). The Monitoring and Evaluation Program must include the principles to be applied and the framework to be used in evaluation, reporting requirements for the Commonwealth and Basin states, and five-yearly reviews of the Water Quality and Salinity Management Plan targets and the Environmental Watering Plan (*Water Act* s. 22). As well as being a legislative requirement, monitoring and evaluation will provide a rigorous process for adaptive management and continuous improvement of the Basin Plan using the best available science (biophysical, social and economic).



Inverell Public School students monitoring water pollution at Lake Inverell, New South Wales

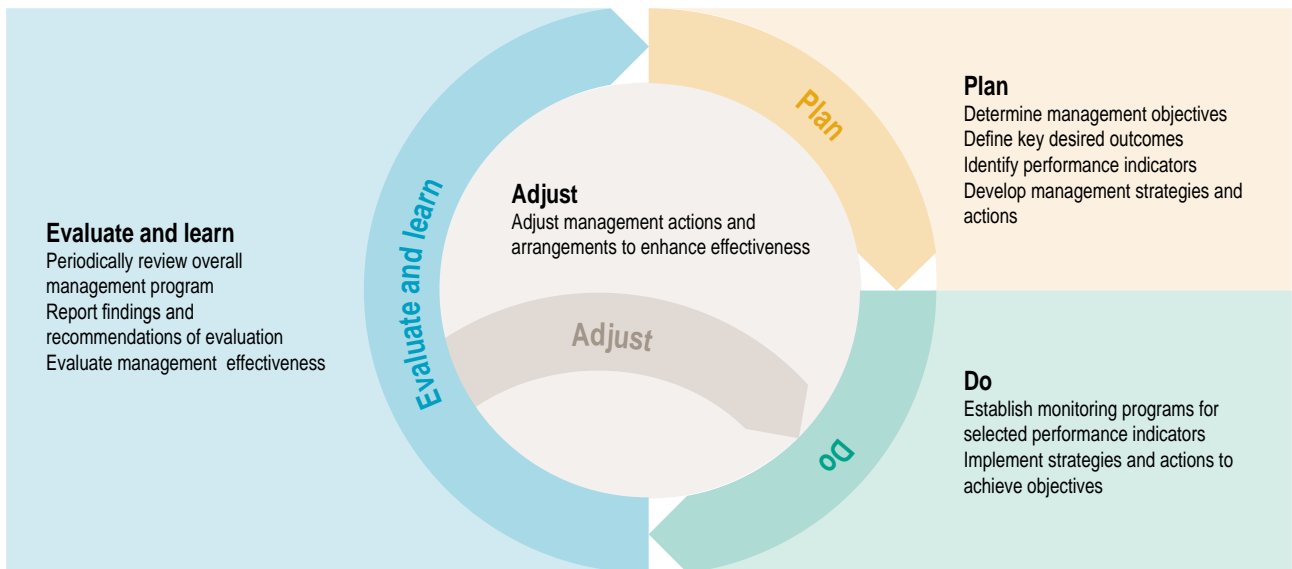


Figure 7.5 The planning cycle

Source: Jones (2005)

The monitoring and evaluation cycle (Figure 7.5) comprises four interrelated components:

- monitoring — the regular collection and analysis of information to assist timely decision-making, ensuring accountability and providing the basis for evaluation and learning
- evaluation — periodic assessment of impact, appropriateness, effectiveness and efficiency
- reporting — the publication of data and findings from the evaluation process
- reviewing and improving — the use of the evaluation findings to inform decision-making about whether and where adjustments might be made to ensure achievement of objectives and outcomes.

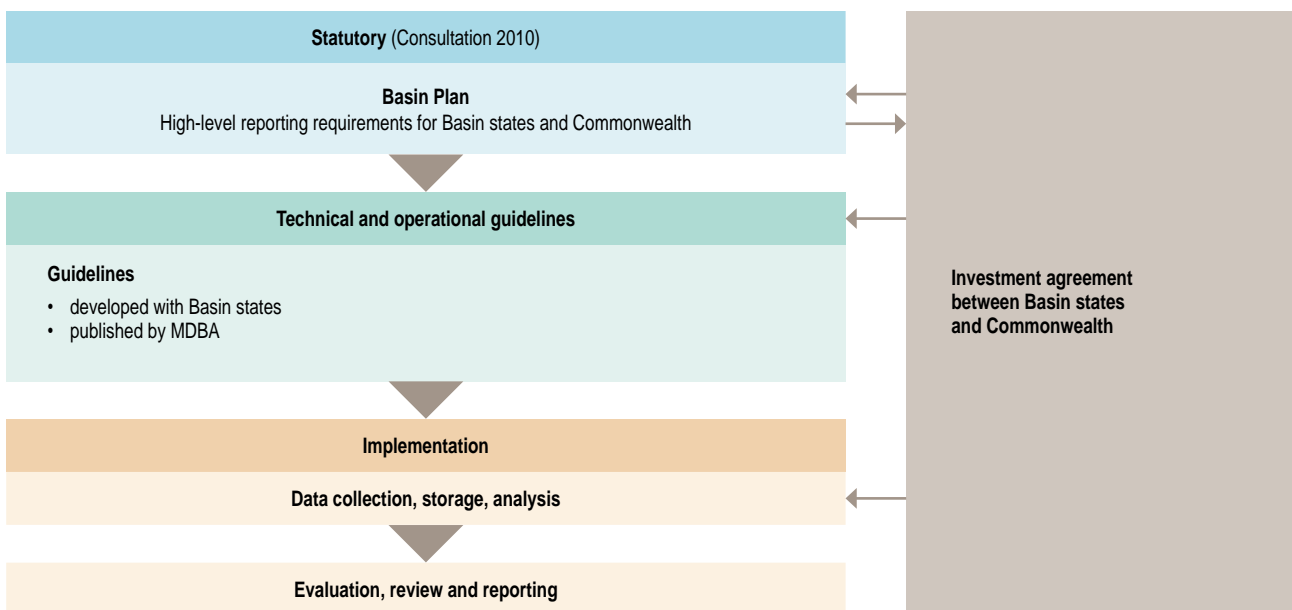


Figure 7.6 Relationship between the Monitoring and Evaluation Program, guidelines, implementation and investment

The structure for implementing the Monitoring and Evaluation Program is presented in Figure 7.6. The program will:

- provide the framework for collection and analysis of the critical information needed to determine whether and how the Basin Plan is meeting its purpose, objectives and targets
- guide and facilitate data and information provision for annual reporting, and 5-yearly and 10-yearly reviews of the Basin Plan
- ensure through reporting of outcomes that Basin Plan activities meet Australian Government requirements for accountability and transparency, to enable learning, improvement and accountability
- provide the principal mechanism to reinforce, review and refine activities as part of an ongoing adaptive management process.

Principles

Nine principles have been used in the development of the Monitoring and Evaluation Program and will guide its implementation:

- effective partnerships are established between the Australian Government and Basin states by defining clear responsibilities and obligations for Basin Plan monitoring and evaluation activities
- program logic is the key tool for evaluating Basin Plan performance by establishing causal links between program activities and outcomes; conceptual frameworks and models are the basis for establishing causal links and for testing underlying assumptions
- best available scientific knowledge (biophysical, social and economic), evidence and analysis are used in the Monitoring and Evaluation Program's application to ensure credibility, transparency and usefulness of evaluation findings
- multiple lines and levels of evidence, taking into account quantitative and qualitative data, are used in evaluating progress towards achievement of Basin Plan targets and objectives
- adaptive management through continuous learning is used to refine Basin Plan initiatives where required, and leads to adjustments in the plan programs, activities and targets
- cost-effectiveness of monitoring and evaluation activities is achieved by ensuring that benefits outweigh costs; existing monitoring programs and associated data are reviewed and used where appropriate to avoid duplication
- time and space scales are recognised and accounted for in evaluating Basin Plan performance
- consistent collection, collation and reporting systems are adopted by the Australian Government and Basin states
- stakeholder involvement in design and implementation of the program is encouraged.



Measuring water seepage at Burrinjuck Dam, New South Wales

What is the framework?

The monitoring and evaluation program will establish the information needed to evaluate effectiveness, by using the approach of the Australian Government's framework for natural resource monitoring, evaluating, reporting and improvement (MERI).

The purpose of this framework is to provide over-arching principles and guidance to the development of monitoring, evaluation and reporting processes within the natural resource management field. The MERI Framework incorporates four important concepts, which are relevant to this framework:

- an integrated approach to investment and program design, the planning process, evaluation and adaptive program management
- an asset-based approach to evaluation that promotes target setting for the key asset classes that contribute to sustainable natural resource management
- monitoring program performance in addition to the state of and change over time in the condition of assets
- reporting with an emphasis on outcomes and impacts, including at an intermediate outcome stage.

The MERI Framework has been adopted to frame the Basin Plan monitoring and evaluation program, with some customisation. The monitoring component of this framework will be addressed in the overall monitoring framework; the evaluation component will be addressed in the key evaluation questions; the reporting is addressed in the reporting requirements of the Basin states and Commonwealth; while the improvement component will be addressed in the adaptive management section.

Monitoring framework

Six key Basin Plan elements will be addressed in the Monitoring and Evaluation Program's monitoring framework:

- ecosystem outcomes from the implementation of long-term average sustainable diversion limits (SDLs) and the Environmental Watering Plan
- the Water Quality and Salinity Management Plan
- critical human water needs
- risks to the condition and availability of Basin water resources
- water trading and transfer rules
- socioeconomic impacts.

The conceptual framework for design of Monitoring and Evaluation Program elements is described in a program logic (Figures 7.7–7.16 and Table 7.1). The program logic identifies expected immediate, intermediate and longer-term program outcomes and impacts and provides a foundation for determining which strategies are effective. The Monitoring and Evaluation Program will operate at a range of scales and time frames:

- longer-term outcomes (11+ years)
 - the desired improvements across the Basin as a result of the Basin Plan; they may be measurable (although difficult and complex to measure at Basin scale) but may be difficult to attribute solely to the plan's water management inputs and activities
- intermediate outcomes (6–10 years)
 - the expected outcomes at the point where the Basin Plan's strategies have been applied
 - often protection or management outcomes
 - they are measurable (although with possible difficulty in measuring at the Basin scale) and significantly attributable to the Basin Plan's inputs and activities

- immediate outcomes (1–5 years)
 - the immediate consequences of each input and activity; these are generally easily identifiable and measurable
- foundational activities
 - the inputs and activities used to develop and implement the Basin Plan
 - inputs include the component parts of the Basin Plan such as the SDLs, the Environmental Watering Plan and the Water Quality and Salinity Management Plan.

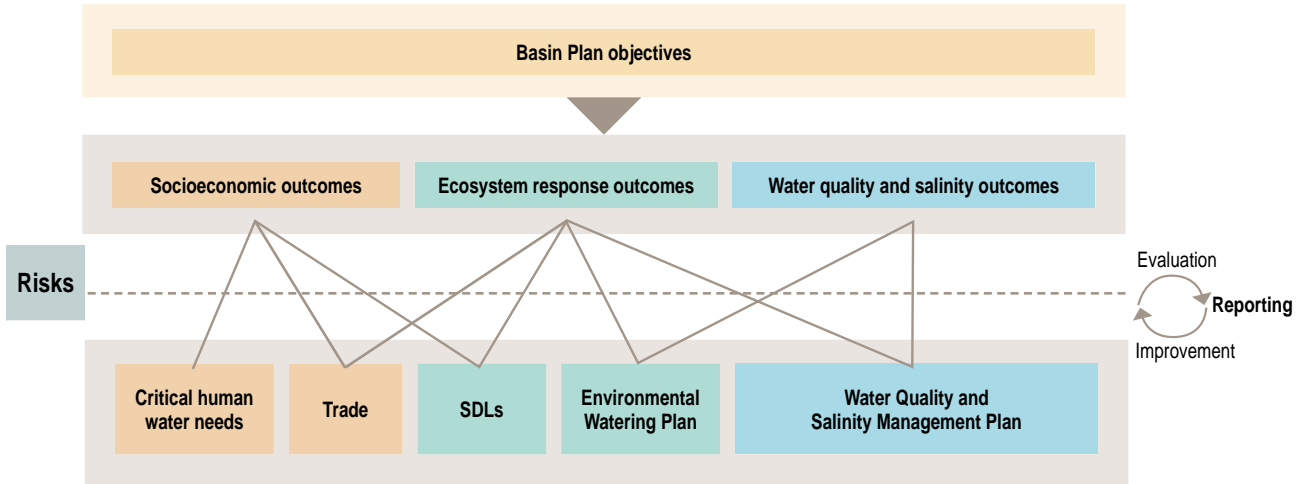


Figure 7.7 Program logic for the Monitoring and Evaluation Program

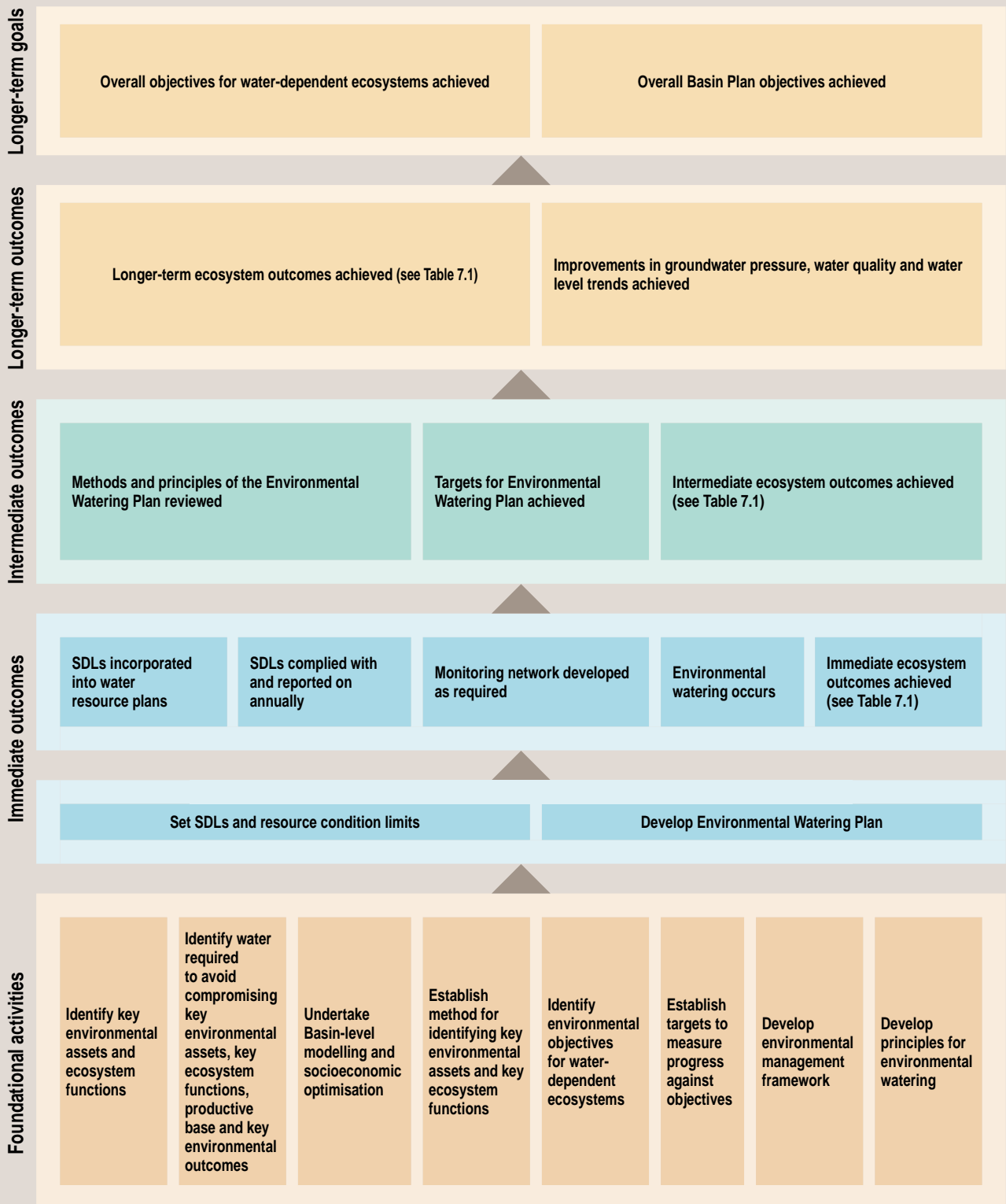
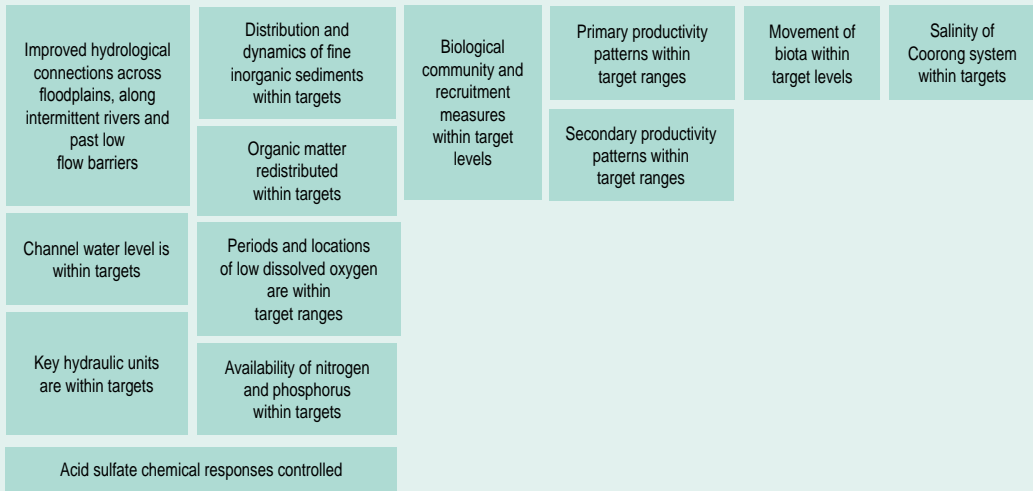


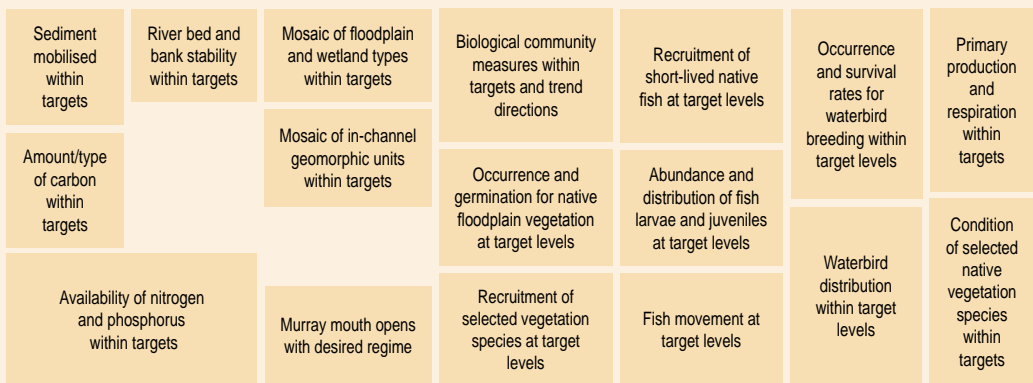
Figure 7.8 Program logic for the SDLs and Environmental Watering Plan

Actions under Basin Plan and water resource plans

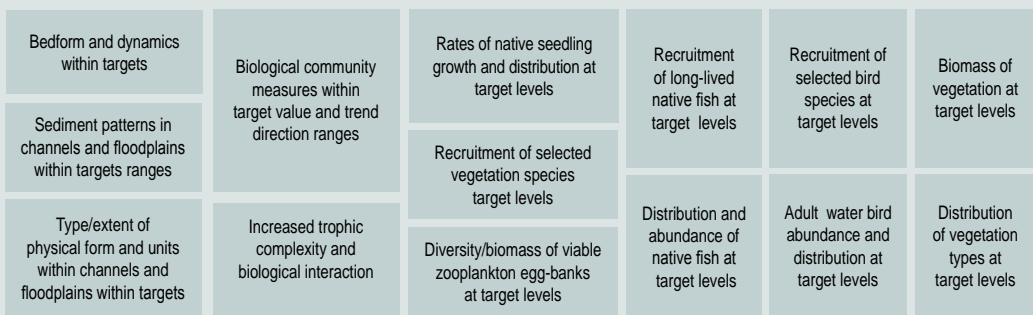
Ecosystem outcomes observed within 1 year



Ecosystem outcomes observed over 1 to 5 years



Ecosystem outcomes observed over 5 to 20 years



Ecosystem outcomes observed after 20 years

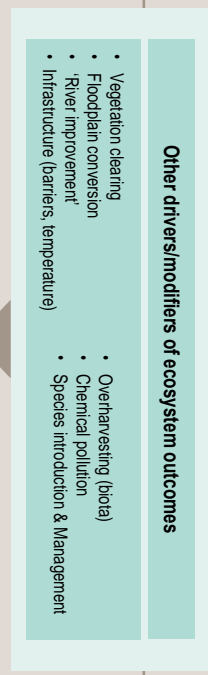
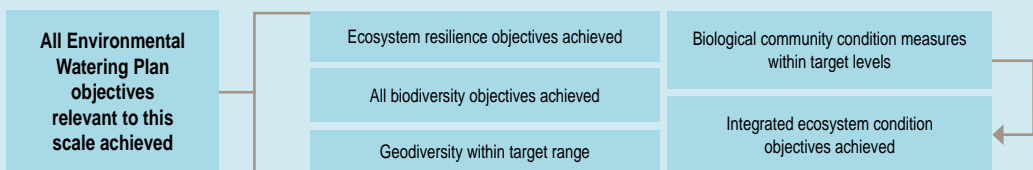


Figure 7.9 Ecosystem monitoring and evaluation conceptual framework: local scale

Source: Davies et al. (2008)

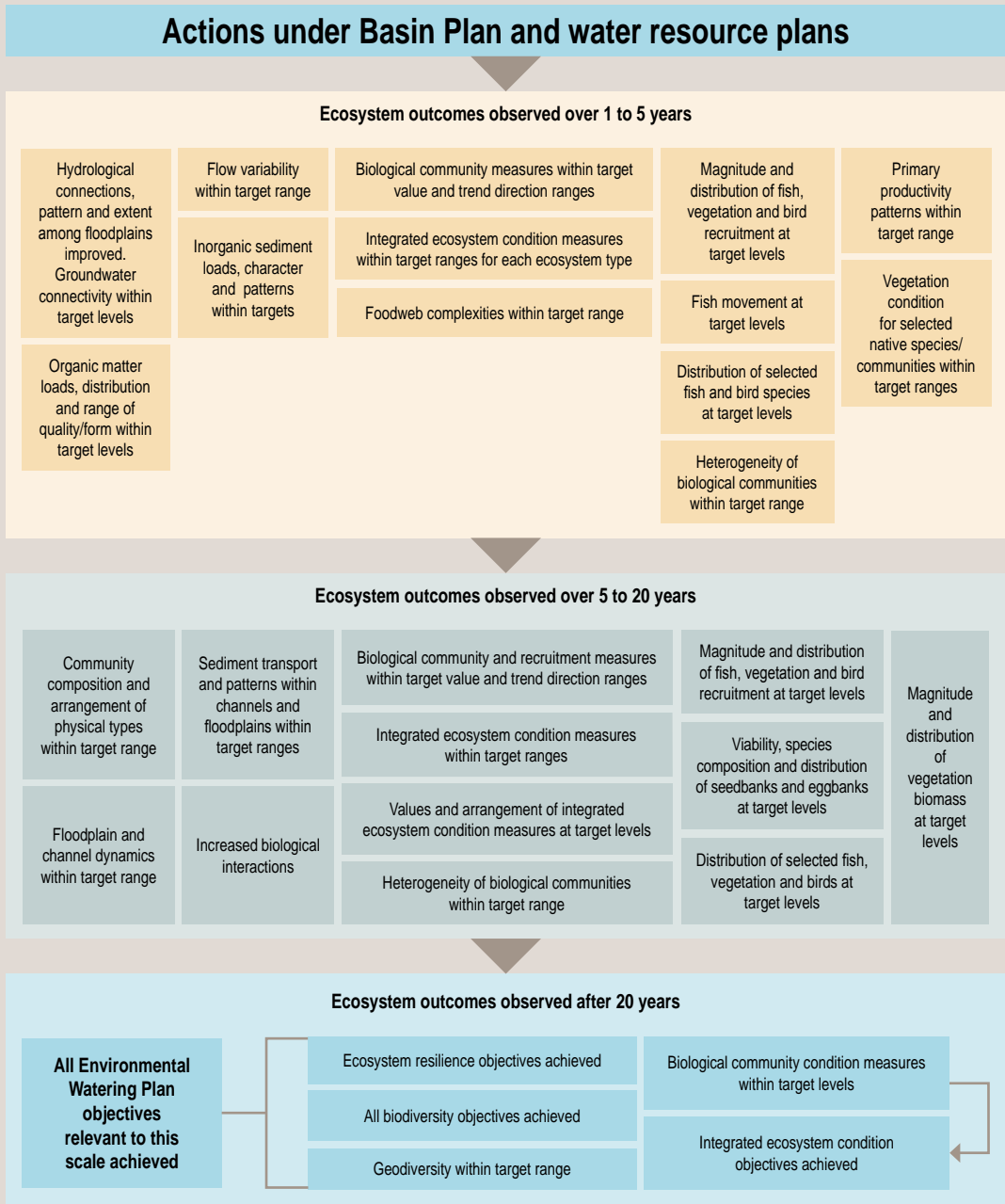


Figure 7.10 Ecosystem monitoring and evaluation conceptual framework: Basin scale

Source: Davies et al. (2008)

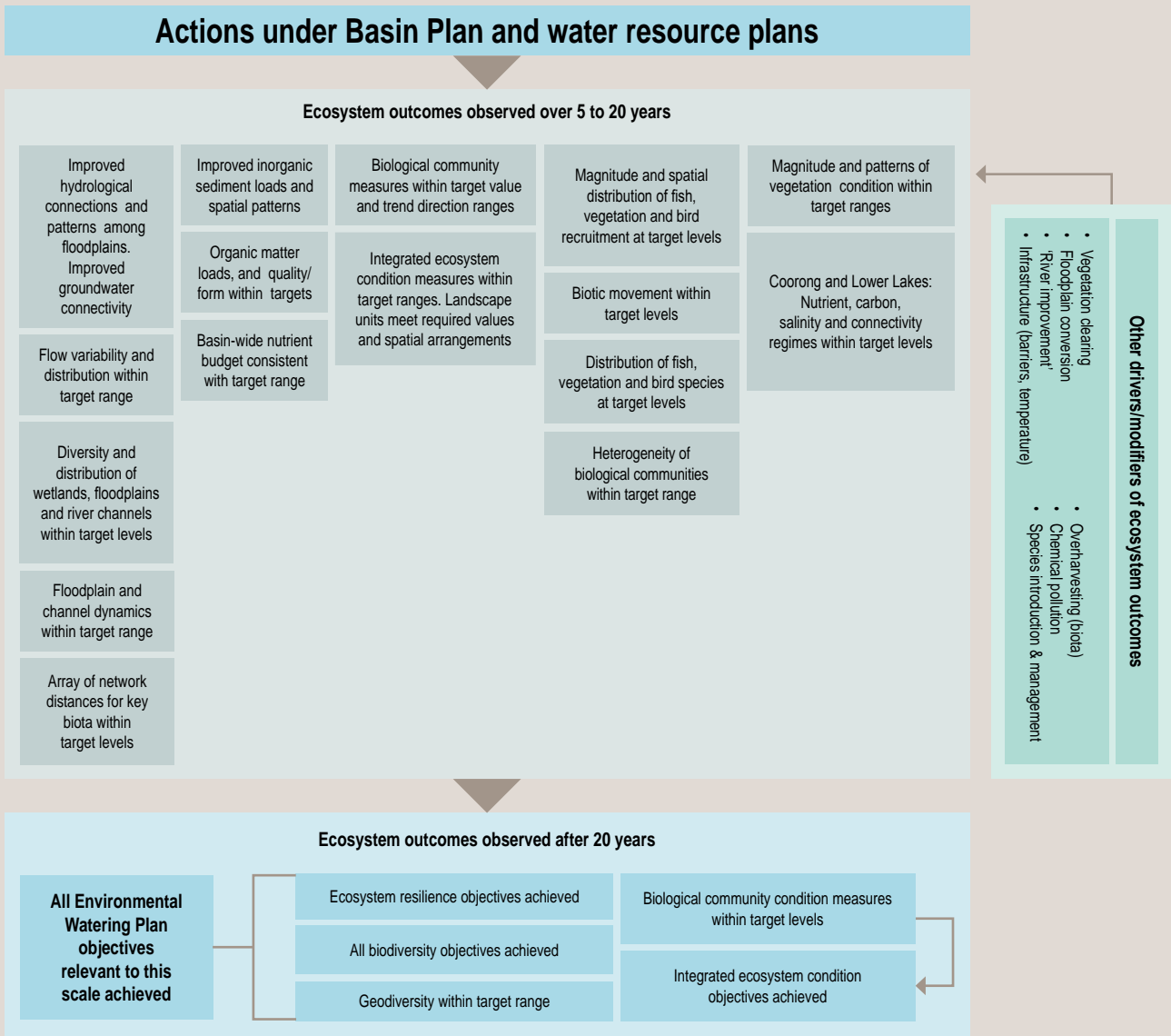


Figure 7.11 Ecosystem monitoring and evaluation conceptual framework: valley scale

Source: Davies et al. (2008)

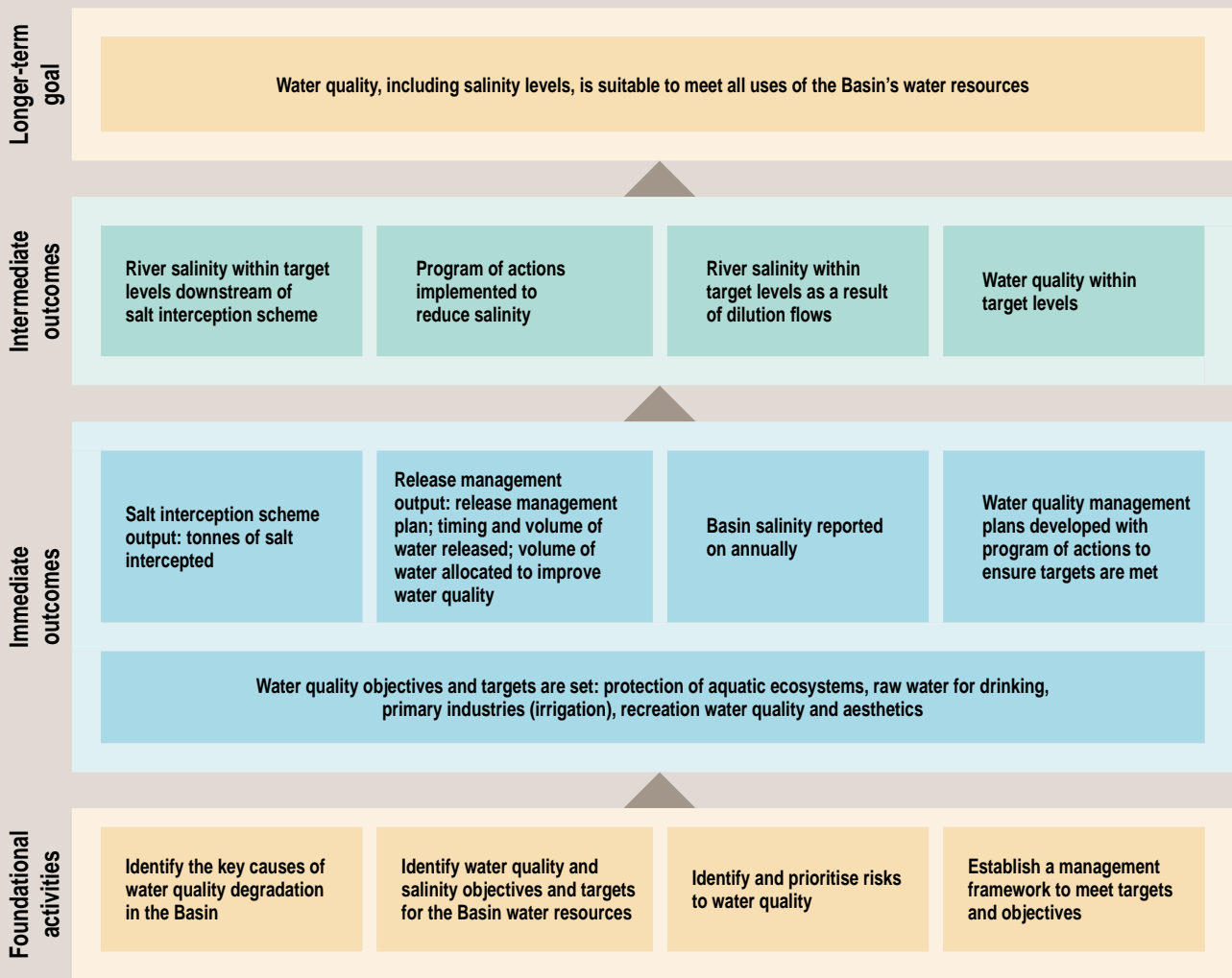


Figure 7.12 Program logic for the Water Quality and Salinity Management Plan

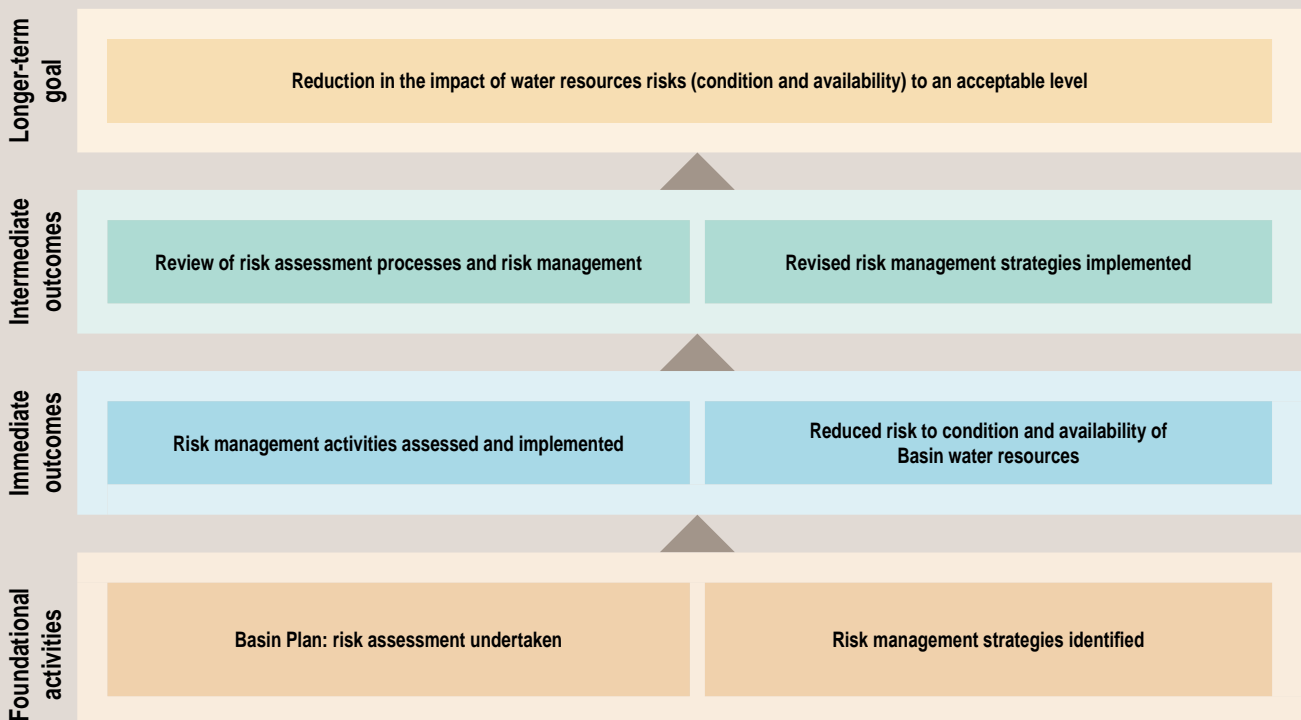


Figure 7.13 Program logic for risk assessment and risk management

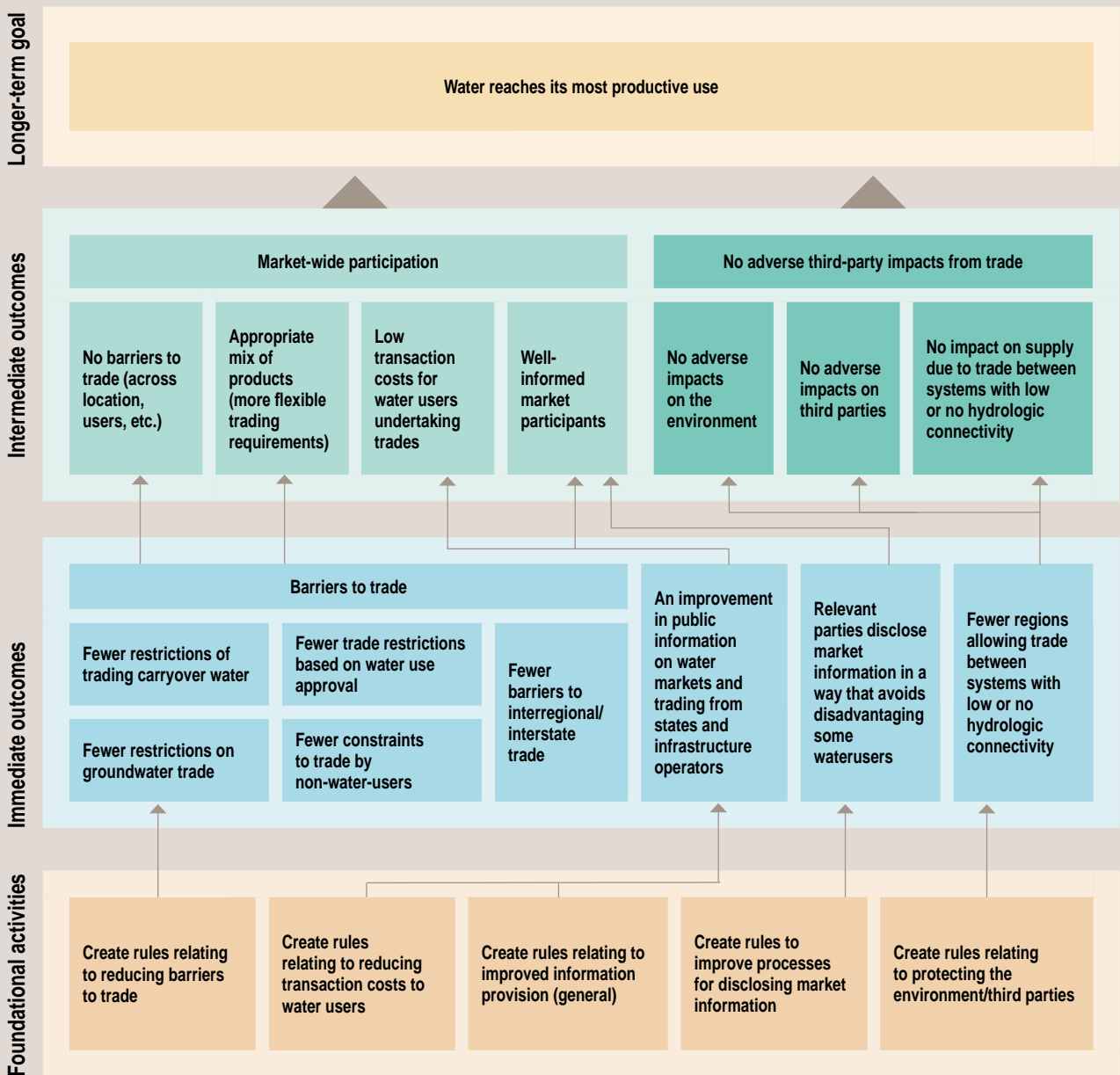


Figure 7.14 Program logic for water trade

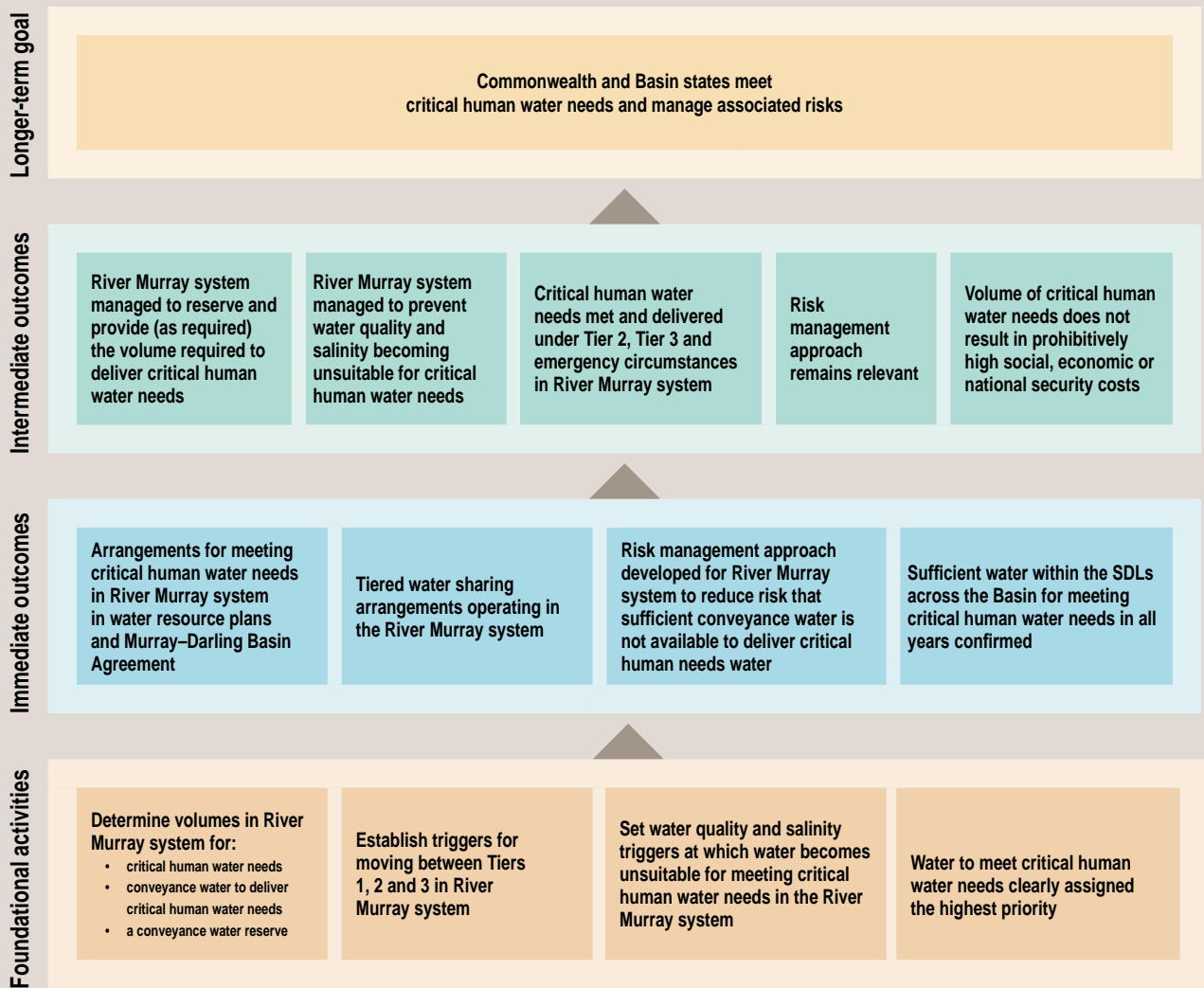


Figure 7.15 Program logic for critical human water needs

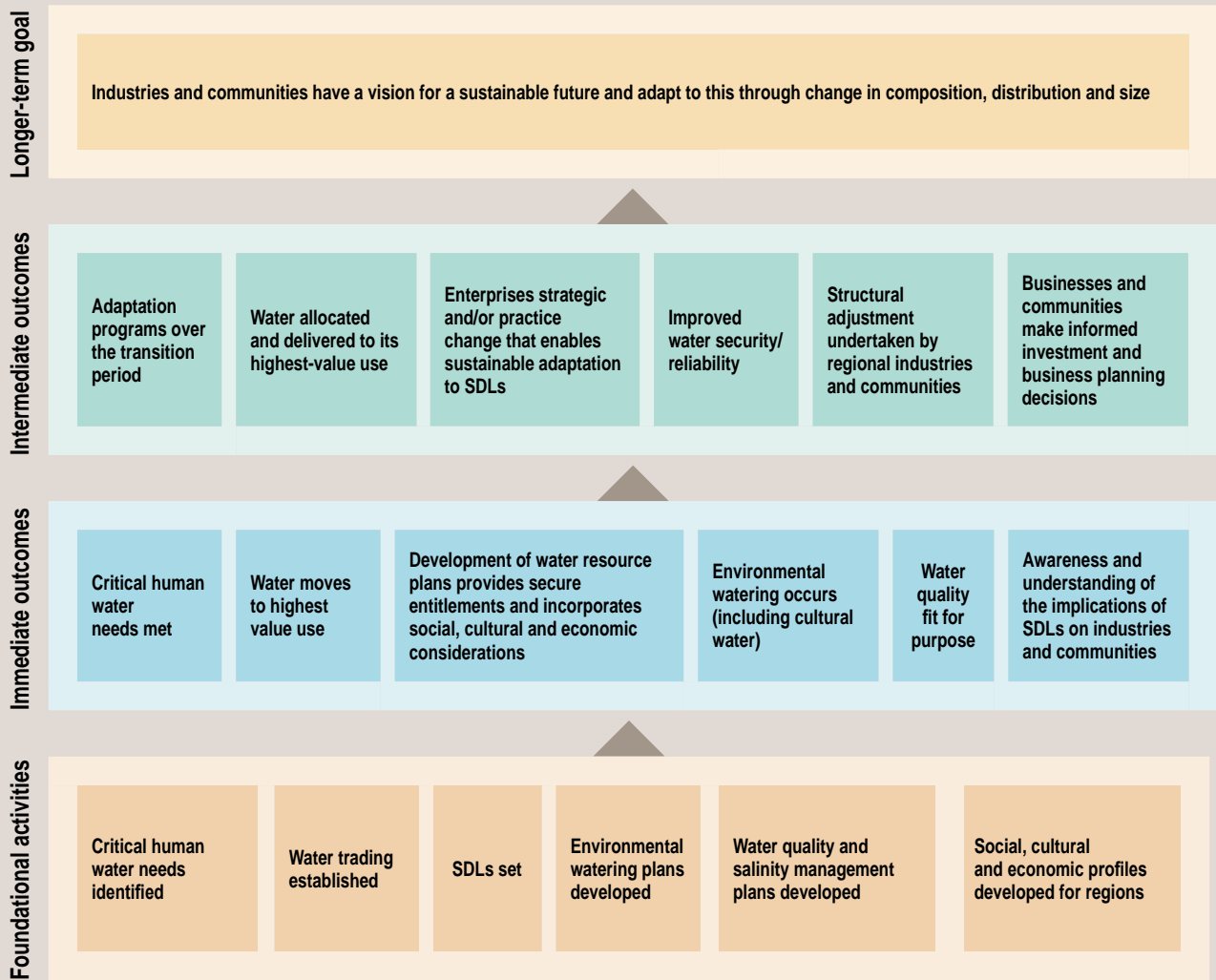


Figure 7.16 Program logic for social and economic outcomes

Table 7.1 The relationship between the Environmental Watering Plan's overall objectives for water-dependent ecosystems and the ecosystem response outcomes^a

Overall environmental objectives for water-dependent ecosystems	Ecosystem response outcomes (and ecosystem reporting requirements)	Scale and timeframe of expected ecosystem response outcomes ^b	
<p>1. To protect and restore the water-dependent ecosystems that depend on Basin water resources</p> <p>Targets by which to measure progress towards this objective^c:</p> <ul style="list-style-type: none"> no loss or degradation of ecosystem response outcomes within 5 years of the Basin Plan commencing improvements in ecosystem response outcomes within 5–20 years of the Basin Plan commencing. 	Hydrologic outcomes		
	Hydrologic connectivity at local scale	Local, short term	
	Hydrologic connectivity at valley scale, hydrologic connectivity at Basin scale	Valley, short term Basin, long term	
	Physicochemical outcomes		
	Carbon dynamics	Valley, short term	
	Floodplain and wetland hydrological types	Local, short term	
	Riverine landscape units	Basin, long term	
	Biological outcomes		
	Vegetation physiological condition	Local, valley, Basin, short term	
	Biomass/standing crop of riverine vegetation	Local, long term	
	Recruitment of fish, riverine vegetation and birds	Valley, short term	
	Waterbird breeding	Local, short term	
	Recruitment of selected riverine vegetation	Local, long term	
	Array of network distances for riverine biota	Basin, long term	
	Riverine vegetation type, composition and pattern	Valley, short term, Basin, long term	
	Biological community metrics (including riverine vegetation, macroinvertebrates, fish and birds)	Valley, short term	
	<p>2. To protect and restore the ecosystem functions of water-dependent ecosystems that depend on Basin water resources</p> <p>Targets by which to measure progress towards this objective^c:</p> <ul style="list-style-type: none"> no loss or degradation of ecosystem response outcomes within 5 years of the Basin Plan commencing improvements in ecosystem response outcomes within 5–20 years of the Basin Plan commencing. 	Hydrologic outcomes	
		Flow regimes at valley scale	Valley, short term
		Flow regimes at Basin scale	Basin, long term
Hydrologic connectivity at local scale		Local, short term	
Hydrologic connectivity at valley scale, Hydrological connectivity at Basin scale		Valley, short term Basin, long term	
Physicochemical outcomes			
Carbon dynamics		Valley, short term	
Water quality		Local, short term	
Floodplain and wetland hydrological types		Local, short term	
Acid sulfate chemical response		Local, short term	
Condition of Coorong and Lower Lakes ecosystems and Murray Mouth opening regime		Local, short term	
Biological outcomes			
Vegetation physiological condition		Local, valley, Basin, short term	
Biomass/standing crop of riverine vegetation		Local, long term	
Recruitment of fish, riverine vegetation and birds		Valley, short term	
Waterbird breeding		Local, short term	
Recruitment of selected riverine vegetation		Local, long term	
Array of network distances for riverine biota		Basin, long term	
Riverine vegetation type, composition and pattern		Valley, short term Basin, long term	
Biological community metrics (including riverine vegetation, macroinvertebrates, fish and birds)	Valley, short term		

a Each ecosystem response outcome may relate to more than one objective.

b 'Local' scale will usually equate to environmental assets and 'valley' scale will usually equate to SDL area, but this may not always be the case.

c Under the Water Act, the Environmental Watering Plan is required to include targets to measure progress towards meeting the overall environmental objectives for the Murray–Darling Basin's water-dependent ecosystems. The targets are only intended to measure progress towards meeting objectives. The Environmental Watering Plan will not oblige any party to reach these targets.

... continued

Table 7.1 The relationship between the Environmental Watering Plan’s overall objectives for water-dependent ecosystems and the ecosystem response outcomes^a (continued)

Overall environmental objectives for water-dependent ecosystems	Ecosystem response outcomes (and ecosystem reporting requirements)	Scale and timeframe of expected ecosystem response outcomes ^b
<p>3. To ensure that water-dependent ecosystems that depend on Basin water resources are resilient to risks and threats</p> <p>Targets by which to measure progress towards this objective^c:</p> <ul style="list-style-type: none"> no loss or degradation of ecosystem response outcomes within 5 years of the Basin Plan commencing improvements in ecosystem response outcomes within 5–20 years of the Basin Plan commencing. 	Hydrologic outcomes	
	Flow regimes at valley scale	Valley, short term
	Flow regimes at Basin scale	Basin, long term
	Hydrologic connectivity at valley scale, hydrological connectivity at Basin scale	Valley, short term Basin, long term
	Physicochemical outcomes	
	Water quality	Local, short term
	Acid sulfate chemical response	Local, short term
Long-term indicators — ecosystem condition/health (applies to all the above objectives)	Integrated riverine ecosystem condition measures	Valley, long term Basin, long term

a Each ecosystem response outcome may relate to more than one objective.

b ‘Local’ scale will usually equate to environmental assets and ‘valley’ scale will usually equate to SDL area, but this may not always be the case.

c Under the Water Act, the Environmental Watering Plan is required to include targets to measure progress towards meeting the overall environmental objectives for the Murray–Darling Basin’s water-dependent ecosystems. The targets are only intended to measure progress towards meeting objectives. The Environmental Watering Plan will not oblige any party to reach these targets.



Beehives placed next to fields of rockmelons near St George, Queensland

Evaluation framework

The Water Act (s. 22) provides for the periodic assessment of the Basin Plan's effectiveness and promotes learning and adaptive management through a continuous cycle of monitoring, evaluation and review. The Monitoring and Evaluation Program's evaluation framework seeks to explain:

- why a particular outcome has occurred
- how well a program or activity was undertaken
- whether it was appropriate to undertake it
- what will be done in light of the evaluation findings in terms of Basin Plan refinement and implementation.

The evaluation framework addresses seven key elements of the Basin Plan:

- the Basin Plan itself
- ecosystem outcomes from the implementation of SDLs and the Environmental Watering Plan
- the Water Quality and Salinity Management Plan
- critical human water needs
- risks to the condition and availability of Basin water resources
- water trading and transfer rules
- socioeconomic impacts.

The evaluation framework is based on the key evaluation questions for each element of the Basin Plan described in Tables 7.2–7.8. MDBA will use the evaluation questions to inform its evaluation of the effectiveness of the Basin Plan in meeting the immediate outcomes, intermediate outcomes and long-term outcomes for each of the Basin Plan elements.

Table 7.2 Key evaluation questions for the Basin Plan

- What is the progress towards meeting the Basin Plan's purposes? (effectiveness)
- To what extent do the Basin Plan objectives and targets align with the Basin Plan's purpose? (appropriateness)
- To what extent have Basin Plan objectives, targets and outcomes been achieved? How do these results compare to what was intended or planned? (effectiveness)
- To what extent has the Basin Plan contributed (either directly or indirectly) to changes in condition? (impact)
- What, if any, unanticipated positive or negative outcomes have resulted from Basin Plan programs and activities? (impact)
- How could Basin Plan programs and activities be delivered more efficiently? (efficiency)
- What could be improved to maximise the impact of Basin Plan programs and activities? (efficiency)

Table 7.3 Key evaluation questions for SDLs and the Environmental Watering Plan

Immediate activities and outcomes
<ul style="list-style-type: none">• To what extent do the activities align with the Environmental Watering Plan and SDL targets and objectives? (appropriateness)• What results (immediate outcomes) have the activities delivered? How do these results compare to those intended? (effectiveness)• To what extent are the changes directly or indirectly a result of the activities? (impact)• How could activities have been delivered more productively and efficiently? (efficiency)
Intermediate outcomes
<ul style="list-style-type: none">• What is the progress towards targets? (effectiveness)• To what extent are the SDLs and resource condition limits methods based on best practice? (appropriateness)• To what extent are the following based on best practice? (appropriateness)<ul style="list-style-type: none">– the method to identify environmental assets that require environmental watering– the principles and methods for determining the priorities for applying environmental water• Have the SDLs and resource condition limits been effective in meeting the Basin Plan objectives? (effectiveness)• Have the SDLs been effective in meeting the environmental objectives for water-dependent ecosystems? (effectiveness)• What, if any, unanticipated outcomes have resulted from the Environmental Watering Plan, SDLs and resource condition limits? (impact)• What alternative or complementary (adaptive) actions could improve progress?
Longer-term outcomes
<ul style="list-style-type: none">• What is the progress towards targets? (effectiveness)• To what extent have the SDLs and Environmental Watering Plan contributed to this progress? (effectiveness)• What is the current status with respect to achieving Basin Plan targets? (impact)• What, if any, unanticipated outcomes have resulted from the Environmental Watering Plan? (impact)

Table 7.4 Key evaluation questions for the Water Quality and Salinity Management Plan

Immediate activities and outcomes
<ul style="list-style-type: none">• To what extent do the water quality and salinity management activities align with other Basin activities?• To what extent have the water quality and salinity management actions been implemented?
Intermediate outcomes
<ul style="list-style-type: none">• To what extent have the activities reduced threats to water quality?• What, if any, unanticipated changes or other outcomes (positive or negative) have resulted?• To what extent were the changes in water quality directly or indirectly produced by the program actions?
Longer-term outcomes
<ul style="list-style-type: none">• In what ways and to what extent has the Water Quality and Salinity Management Plan contributed to improving water quality, management practices and institutions?

Table 7.5 Key evaluation questions for the risks to Basin water resources

Immediate activities and outcomes
<ul style="list-style-type: none"> To what extent is the risk management process based on best practice? Are the proposed risk management strategies being implemented? What results (immediate outcomes) have the projects/programs/activities delivered? How do these results compare to those intended? (effectiveness)
Intermediate outcomes
<ul style="list-style-type: none"> Are risks decreasing to acceptable levels? To what extent are changes in risk directly or indirectly a result of the projects/programs/activities? (impact)
Longer-term outcomes
<ul style="list-style-type: none"> To what extent has the risks program ensured that the condition and availability of water resources is not significantly compromised by risks? In what ways and to what extent has the risks strategy contributed to improvements in water resources? In what ways and to what extent has the risks to water resources program contributed to changing management practices and institutions?

Table 7.6 Key evaluation questions for water trade

Immediate activities and outcomes
<ul style="list-style-type: none"> What are the patterns of compliance across the Basin?
Intermediate outcomes
<ul style="list-style-type: none"> Have the water trading rules had a discernible effect on water market functions? (i.e. no barriers to trade, low transaction costs, an appropriate mix of products, well-informed participants, and no adverse impacts on the environment or third parties) (effectiveness) Is there evidence of water users using 'work-around' arrangements to reduce the cost of trade restrictions? Are the key rules identified in each area (e.g. barriers to trade) still the most significant? Have some rules/issues become more important?
Longer-term outcomes
<ul style="list-style-type: none"> In what ways and to what extent have water trading rules contributed to a more efficient water market? (effectiveness) Are the water trading rules (and water market and trading objectives) aligned with improving overall market efficiency? (appropriateness) Are there any trade-offs between the water market and trading objectives that could undermine overall efficiency?

Table 7.7 Key evaluation questions for critical human water needs

Immediate activities and outcomes
<ul style="list-style-type: none"> Did the volumes supplied for critical human water needs avoid prohibitively high social, economic or national security costs? Are sufficient volumes being reserved in the River Murray system to deliver critical human water needs? Have the Basin states prepared water sharing arrangements that make critical human water needs the highest priority? Are the tiered water sharing arrangement triggers and other emergency response processes appropriate to address water scarcity or breaches of water quality and salinity trigger points?
Intermediate outcomes
<ul style="list-style-type: none"> Do communities reliant on the River Murray system have their critical human water needs met under all tiers of the tiered water sharing arrangements? Was the River Murray managed to prevent water being unsuitable for critical human water needs? What is the impact of meeting critical human water needs on other elements of the Basin Plan?
Longer-term outcomes
<ul style="list-style-type: none"> How effective is the Basin Plan in ensuring that all communities dependent on the Basin water resources have critical human water needs met and how can it be improved?

Table 7.8 Key evaluation questions for socioeconomic outcomes

Immediate activities and outcomes
<ul style="list-style-type: none"> What are the social, cultural and economic circumstances of the Basin communities? What are the other external impacts on social, cultural and economic conditions?
Intermediate outcomes
<ul style="list-style-type: none"> To what extent have industries and communities adapted to lower water availability as a result of the Basin Plan? To what extent have enterprises adapted to lower water availability as a result of the Basin Plan?
Long-term outcomes
<ul style="list-style-type: none"> How effective is the Basin Plan in meeting its social and economic objectives and outcomes? What are the social, cultural and economic effects of meeting the Basin Plan environmental objectives?

Table 7.9 Reporting requirements for sustainable diversion limits and the Environmental Watering Plan

Immediate outcomes
(a) the environmental watering plan is implemented so as to facilitate the delivery of environmental water
(b) during each water accounting period: <ul style="list-style-type: none">(i) held environmental water and planned environmental water is used in accordance with the rules of the water resource plan area(ii) water released or otherwise made available to achieve environmental outcomes is assessed, including the volumes, timing (frequency and duration), location and flow rates of that water(iii) the hydrologic effects of the water that is released or otherwise made available is assessed, including whether the watering has met the watering requirements and flow regime requirements of the environmental assets and ecosystem functions.
(c) the degree to which the delivery of environmental water achieves the management outcomes relevant to the water accounting period as assessed
(d) long-term average sustainable diversion limits are incorporated into water resource plans
(e) compliance with the water resource plan rules give effect to the long-term average sustainable diversion limits and there is a reduction in unauthorised take
(f) for the first five water accounting periods after the commencement of the Basin Plan, there is no loss of, or degradation in, the following: <ul style="list-style-type: none">(i) flow regimes(ii) hydrologic connectivity(iii) nutrients(iv) carbon dynamics(v) acid sulfate chemical response.
(g) after the end of the 5th water accounting period there are improvement in the matters listed in (f) (i)–(v).
Intermediate outcomes
(h) the degree to which the delivery of environmental water achieves the site-specific ecological objectives and targets identified in the long-term watering plans as assessed
(i) five-yearly reviews of the environmental watering plan are undertaken
(j) for the first 10 water accounting periods after the commencement of the Basin Plan there is no loss of, or degradation in, the following: <ul style="list-style-type: none">(i) flow regimes(ii) hydrologic connectivity(iii) riverine landscape units(iv) condition of Coorong and Lower Lakes ecosystems and Murray Mouth opening regime(v) vegetation physiological condition(vi) riverine vegetation type, composition and pattern(vii) recruitment of riverine vegetation, fish and birds(viii) waterbird breeding(ix) biological community metrics (including riverine vegetation, macroinvertebrates, fish and birds).
(k) after the 10th water accounting period after the commencement of the Basin Plan there is improvement in the matters listed in (j) (i)–(ix).
Longer-term outcomes
(l) there are improvements in groundwater pressure, water quality and water levels
(m) there are improvements in the following: <ul style="list-style-type: none">(i) riverine landscape units<ul style="list-style-type: none">(ii) biomass and standing crop of riverine vegetation(iii) recruitment of selected riverine vegetation species(iv) array of network distances for riverine biota(v) integrated riverine ecosystem condition measures.

Table 7.10 Reporting requirements for the Water Quality and Salinity Management Plan

Immediate outcomes
(a) water quality and salinity objectives and targets are effectively met by salt interception schemes
(b) water resource plans incorporate water quality and salinity management plans with actions to ensure water quality and salinity targets are met
(c) water resource plans incorporate release management and flow manipulation rules that deal with the key causes of water quality degradation identified in the water quality and salinity management plan
Intermediate outcomes
(d) there are decreases in salinity levels in rivers downstream of salt interception schemes
(e) nutrients, turbidity, toxicants and algal blooms are within target levels
(f) dissolved oxygen is within target levels
(g) water temperatures is within target levels
(h) there are decreases in the levels of river salinity as a consequence of adequate dilution flows
(i) there are reductions in irrigation-induced river salinity levels
Note: Target levels are set out in the water quality and salinity management plan.
Longer-term outcomes
(j) water quality and salinity levels are suitable to meet all uses of Basin water resources identified in the water quality and salinity management plan
(k) water quality and salinity management plan objectives and targets are achieved.

Table 7.11 Reporting requirements for the risks to Basin water resources

Immediate outcomes
(a) risk management strategies are assessed at the water resource plan level and Basin level
(b) risk management strategies are implemented at the water resource plan level and Basin level
(c) there is a reduction in risk to the condition, and continued availability, of the Basin water resources
Intermediate outcomes
(d) risk assessment is reviewed and improved as required
(e) risks and implementation of risk management strategies in water resource plans are revised
Longer-term outcome
(f) the condition and availability of water resources are not significantly compromised by risks.

Table 7.12 Reporting requirements for water trade

Immediate outcomes
(a) there is a reduction in the number and severity of trade barriers in the Murray–Darling Basin
(b) there is an improvement in public information on water markets and trading
(c) relevant parties disclose market information in a way that ensures that water users do not suffer economic or social disadvantage
(d) fewer areas allowing trade between systems with low hydrologic connectivity
Intermediate outcomes
(e) there is an increase in water trade among water users and regions previously affected by trade restrictions
(f) there are more flexible trading arrangements
(g) there is a decrease in overall transactions costs from trading water
(h) there are well-informed market participants
(i) there are no adverse impacts on third parties who are not directly involved in the water trade transaction
(j) there are no adverse impacts on the environment due to trade
Longer-term outcome
(k) water markets allocate water to its most productive use.

Table 7.13 Reporting requirements for critical human water needs

Immediate outcomes
(a) arrangements for meeting critical human water needs in River Murray system in water resource plans and Murray–Darling Basin Agreement
(b) tiered water sharing arrangements operating in the River Murray system
(c) risk management approach developed for River Murray system to reduce risk that sufficient conveyance water is not available to deliver critical human needs water
(d) sufficient water within the SDLs across the Basin for meeting critical human water needs in all years confirmed
Intermediate outcomes
(e) river Murray system managed to reserve and provide (as required) the volume required to deliver critical human water needs
(f) river Murray system managed to prevent water quality and salinity becoming unsuitable for critical human water needs
(g) critical human water needs met and delivered under Tier 2, Tier 3 and emergency circumstances in River Murray system
(h) volume of critical human water needs does not result in prohibitively high social, economic or national security costs
(i) the risk management approach continues to be suitable
Longer-term outcome
(j) the Commonwealth and Basin states meet critical human water needs and manage associated risks.

Table 7.14 Reporting requirements for socioeconomic outcomes

Immediate outcomes
(a) water resource plans are developed having regard to social, cultural and economic profiles
(b) levels of awareness and understanding of the implication of the long-term average sustainable diversion limit on industries and communities have increased
Intermediate outcomes
(c) enterprise strategic or practice change occurs that enables sustainable adaptation to a water-reduced future, including technological and agronomic changes, business restructuring and lifestyle changes.
(d) structural adjustment occurs in regional industries and communities in response to any reductions in the long-term average sustainable diversion limits
(e) businesses and communities make informed investment and business planning decisions to produce the most productive outcomes
(f) there is improved water security/reliability
(g) water is allocated and delivered for its most productive use
(h) the uptake of adaptation programs addresses social, cultural and economic impacts
(i) cultural well-being of Indigenous communities relating to cultural flows is not adversely affected.
Longer-term outcomes
(j) Industries and communities have a vision for a sustainable future and adapt to this through change in composition, distribution and size.



Gwydir Wetlands, north-west of Moree, New South Wales

7.4 Reporting requirements

The reporting requirements are central to the implementation of the Monitoring and Evaluation Program (see Figure 7.6). The program must include reporting requirements for the Commonwealth and Basin states and five-yearly reviews of the Water Quality and Salinity Management Plan targets and the Environmental Watering Plan (*Water Act 2007* (Cwlth) (s. 22)). The Water Act (ss. 34, 35) requires the Murray–Darling Basin Authority (MDBA), Commonwealth and Basin state agencies to act consistently with the Basin Plan.

They are required to report on core activities and outcomes under the Monitoring and Evaluation Program as listed in tables 7.9–7.14. These reporting requirements have been derived from the element program logics in Figures 7.8–7.16 and from the ecosystem response outcomes listed in Table 7.1.

At the Commonwealth level:

- the Bureau of Meteorology is only required to report on core activities and outcomes that relate specifically to water information (this arrangement may change under any amendments to current regulations as a reflection of Basin Plan monitoring requirements)
- the Commonwealth Environmental Water Holder is only required to report on activities and outcomes that relate to aquatic ecosystems.

In addition to a written report, Commonwealth and Basin states will be required to provide raw data collected for each activity and outcome. This requirement will not apply where the data has been provided to the Bureau of Meteorology. MDBA will be responsible for ensuring that monitoring and evaluation is coordinated and consistent. The Monitoring and Evaluation Program's operating and technical guidelines will address issues of design, scale and implementation of the environmental monitoring program. Collection and analysis of data that underpins the reports will be required to be consistent with the Basin Plan Monitoring and Evaluation Program, and technical and operational guidelines published on the MDBA website.

MDBA must prepare an annual report, including an analysis of the Basin Plan's effectiveness (*Water Act* s. 214), and publish an account of environmental water in the Basin each financial year (*Water Act* s. 32). The Water Act (ss. 101–103) provides for the establishment of a

Murray–Darling Basin Water Rights Information Service by MDBA, which may hold some or all of the information included in the registers of water rights kept by a Basin state, an infrastructure operator or any other person prescribed by the regulations. It may also hold other information about water rights in these registers.

A range of parties specified in the Water Regulations 2008, including MDBA and Commonwealth and Basin state agencies, must provide the Bureau of Meteorology with water information (Water Act s. 126) and the Director of Meteorology must publish annual national water accounts (Water Act s. 122). The Commonwealth Environmental Water Holder is required to publish an annual report including achievements against the Environmental Watering Plan's objectives (Water Act s. 114). Basin states are required to provide a written report, within four months of the end of a water accounting period, on the availability and management of water resources in each water resource plan area in the Basin state (Water Act s. 71). The Australian Competition and Consumer Commission must monitor transformation arrangements and compliance with the water market rules and give the Commonwealth Water Minister a report on the results of such monitoring (Water Act s. 99).

7.5 Water accounting

In recent years, water accounting has been shown to provide a transparent mechanism for identifying, measuring, recording and reporting water-related information to users and decision makers in a consistent and structured manner. The concept of water accounting also includes the more detailed management accounts that are required by water agencies to manage and report on water resources.

Under the *Water Act 2007* (Cwlth), the Bureau of Meteorology (among its other functions) has the responsibility for:

- collecting, holding, managing, interpreting and disseminating Australia's water information
- compiling and maintaining water accounts for Australia, including a set of water accounts to be known as the National Water Account.

In implementing the various mandatory components of the Basin Plan, water accounting will be used as a central mechanism by which Basin water resources will be measured, recorded and reported to stakeholders in a consistent and transparent way. This use of water accounting in relation to Basin water resources will be implemented in a collaborative approach with the Bureau of Meteorology and other agencies.

Murray–Darling Basin water accounts

On an annual basis MDBA will prepare a set of Murray–Darling Basin accounts that will display the volumes of water available for environmental use, consumptive use or extraction within the various water resource systems of the Murray–Darling Basin. In general the type of information to be identified in Basin water accounts may include:

- water resource final allocation announcements
- carryover brought forward
- water resource system losses
- extraction/usage (consumptive and environmental).



Sprinkler irrigation on a farm near Moree, New South Wales

It is proposed that these annual Basin accounts will be publicly available and relate to the Bureau of Meteorology's National Water Account, which will be published annually. It is anticipated that both the Murray–Darling Basin water account and the Bureau of Meteorology's National Water Account will be based on the same water information, but each will provide a different level of detail in relation to Basin water resources. As part of the process of preparing the proposed Basin Plan, 19 regional water accounts across the Basin have been prepared. These water accounts are located at Appendix F in this volume. They cover the 2006–07 and 2007–08 water years. The Bureau of Meteorology's Pilot National Water Account is available on the Bureau of Meteorology's website (www.bom.gov.au/water/nwa).

Environmental water reporting

MDBA proposes to develop specific environmental water accounts for the Murray–Darling Basin that explain how water (both held environmental water and planned environmental water) has been made available for environmental benefit within the Basin. They will provide the volumes of water that were potentially available for environmental use, the volumes actually used and where possible the location of that use. These accounts may also display information including, but not limited to:

- trading of held environmental water (between different users)
- carryover and other management of environmental water
- recovery of water (e.g. water savings through infrastructure)
- associated administrative information.

The information contained within these specific accounts would complement the Basin-wide water accounts.

Accounts for planned environmental water and held environmental water will draw on both data provided through the reporting requirements in the Basin Plan Monitoring and Evaluation Program and the information acquired through water information systems outlined below.

Diversion limit reporting

Specific accounts will be developed that report the water that was permitted to be taken in accordance with the diversion limit within a given water year, and the water that was actually taken. These will complement the Basin-wide water accounts. Preparation of these accounts will consider the method to determine compliance with the diversion limit (see Section 7.2), including water trading, allocations made and other relevant matters. This specific account will draw on information from Basin states provided under the Water Act (s. 71), complemented by other water information where relevant.

Water information systems

Under the Water Act, MDBA may provide an information service that allows access to water rights information specific to the Murray–Darling Basin. This service would integrate with the National Water Market System and with water information systems established by the Bureau of Meteorology. The National Water Market System is being developed cooperatively with Basin states by the Department of Sustainability, Environment, Water, Population and Communities.

The data stored in these integrated information systems will contribute to the preparation of reports on the status of Basin water resources such as Murray–Darling Basin water accounts, environmental water accounts and diversion

limit accounts. It is also anticipated that by using these integrated systems to prepare reports on Murray–Darling Basin water resources, information across the Basin will become more consistent, transparent and standardised over time, which will empower users to make more informed decisions about the management of water-related assets either on a specific or general basis.

7.6 Review

The *Water Act 2007* (Cwlth) explicitly provides for the adaptive management of water resources in the Murray–Darling Basin through the review of the Basin Plan and legislation. The Commonwealth Water Minister must initiate a review of the Water Act's operation before the end of 2014 (Water Act s. 253) and the Murray–Darling Basin Authority (MDBA) must report to the Murray–Darling Basin Ministerial Council on the impacts of the Basin Plan after five years (Water Act s. 49A). The Basin Plan must be reviewed in its tenth year or when the minister — or all Basin states — request MDBA to conduct a review. The Water Act also stipulates five-yearly reviews of the Environmental Watering Plan and the Water Quality and Salinity Management Plan targets.

MDBA will analyse the information provided by the Basin states and the Commonwealth and evaluate the Basin Plan's effectiveness at appropriate intervals. These reviews will inform improvements to the Basin Plan or adjustments to its implementation. The evaluation and review process will consider:

- refinement of targets
- improvement of causal relationships to ensure strong ties between management actions and outcomes
- effective use of knowledge
- identification of the practical effectiveness and impact of Basin Plan provisions, including unanticipated and unintended outcomes, and provision of more meaningful progress reporting to the community to assist public awareness.

The reviews may result in minor refinements, such as changes to the combination or order of actions, or significant alterations such as to targets or in strategic direction.

A deliberative, cooperative and transparent review process will result in better decision-making for the Basin Plan and, while the Water Act provides the regulatory infrastructure, there is a need for interactive learning and feedback to all participants through the review process.

Next steps

This volume is one of a suite of documents that comprise:

- Volume 1: *Guide to the proposed Basin Plan: overview*
- Volume 2: *Guide to the proposed Basin Plan: technical background*
- Volumes 3–21: regional guides to outline how the provisions of the proposed Basin Plan will affect the 19 regions of the Basin.

With the release of these guides, interested parties will have the opportunity to provide the Murray–Darling Basin Authority (MDBA) with feedback ahead of the release of the proposed Basin Plan.

In the coming months, MDBA will continue preparing the proposed Basin Plan (i.e. the legislative instrument) for release. Once it is released, together with a plain English summary of the instrument, the formal 16-week consultation period required under the *Water Act 2007* (Cwlth) will commence. Submissions on the proposed plan will be sought from all sectors of the community.

Submissions received during the formal 16-week consultation period will be published on the MDBA website. When the public comment period has finished, a summary of the submissions received will be produced, together with information on any resulting amendments to the plan.

When MDBA has taken comments into account and finalised the Basin Plan, the Murray–Darling Basin Ministerial Council will consider it, together with MDBA's assessment of the socioeconomic implications of each SDL scenario. MDBA will then present the Basin Plan to the Commonwealth Water Minister for adoption and it will become law when the minister tables it in the Australian Parliament, which is expected to happen in 2011.

Where to find more detail

For more information, contact MDBA:

- on the web: www.mdba.gov.au
- by phone: 1800 230 067
- by email: engagement@mdba.gov.au
- by mail: GPO Box 3001, Canberra, ACT 2601.

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Glossary

ABARE

The Australian Bureau of Agricultural and Resource Economics (ABARE) is an Australian Government economic research agency. On 1 July 2010, the Department of Agriculture, Fisheries and Forestry merged two bureaus within its portfolio — the Australian Bureau of Agriculture and Resource Economics and the Bureau of Rural Sciences — to form the Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences (ABARE–BRS).

Aboriginal nations (Indigenous nations)

Term used by Aboriginal communities in the Murray–Darling Basin to describe traditional owner groups. Aboriginal nations, Indigenous nations or traditional owner groups are Aboriginal people whose territories are determined through interpretation of customs and traditions, and who have rights and responsibilities for lands and waters under those customs and traditions.

Aboriginal water values

The traditional and contemporary cultural importance of water regarding identity, customs and beliefs of Aboriginal peoples.

Aboriginal water values can relate to resources, places, features and oral traditions, and include (but not be limited to) spiritual, ecological, educational, social, ceremonial, economical, cultural and natural entities. Aboriginal water values are interconnected and holistic.

ABS

The Australian Bureau of Statistics (ABS) is the Australian statistical agency that assists and encourages informed decision-making, research and discussion within government and the community.

Abstraction

The removal of water from its natural source.

ACCC

The Australian Competition and Consumer Commission (ACCC) promotes competition and fair trade in the marketplace to benefit consumers, businesses and the community. It also regulates national infrastructure services. Its primary responsibility is to ensure that individuals and businesses comply with the Commonwealth competition, fair trading and consumer protection laws. It has a role in enforcing the Water Market Rules 2009 and the Water Charge (Termination Fees) Rules 2009. In this, the ACCC intends to use a cooperative approach, including working with irrigation infrastructure operators to achieve compliance. However, when necessary, it is prepared to use remedies available to it under the *Water Act 2007* (Cwlth).

Acid sulfate soils

Soils formed naturally when sulfate-rich water (e.g. saline groundwater or seawater) mixes with sediments containing iron oxides and organic matter. Under waterlogged, anaerobic (oxygen-free) conditions, bacteria convert sulfates to sulfides, which can form sulfidic sediments. When these sediments are exposed to oxygen, such as under drought conditions, chemical reactions may lead to the generation of sulfuric acid.

Acidification

The process of change or conversion into an acid.

Actual take

The total quantity of water actually extracted from the water resources of a water resource plan area during a water accounting period (see also 'permitted take').

Adaptive management

A structured, iterative process to improve decision-making when knowledge is uncertain. Adaptive management aims to reduce uncertainty over time by incorporating new knowledge and learning into decision-making, such as from system monitoring.

Afforestation

Conversion of bare or cultivated land into forest.

AHD

Australian Height Datum, which approximates mean sea level and was determined by monitoring tide gauges around the Australian coastline.

Algal bloom

A sudden increase in the number of algae in a water body, to levels that cause visible discolouration of the water.

Algal Management Strategy

Developed by the Murray–Darling Basin Commission and agreed by the Murray–Darling Basin Ministerial Council in 1994, to provide coordinated action to reduce the frequency and intensity of algal blooms.

Alkalinity

The chemical property of water that enables it to resist a reduction in pH. The 'p' stands for potential, the 'H' for hydrogen. The pH of distilled water is 7, which is neutral. Any solution with a pH below 7 is an acid; any solution with a pH above 7 is an alkali.

Allocation

The water to which the holder of an access licence is entitled from time to time under licence, as recorded in the water allocation account for the licence. In New South Wales, under the *Water Management Act 2000* (NSW), water allocations are called 'available water determinations'.

Alluvial groundwater system

Groundwater in sand, gravel, silt and clay particles, usually deposited by rivers.

Anabranch

A branch of a river that leaves the main stream and rejoins it downstream.

ANAO

The Australian National Audit Office (ANAO) is a specialist public sector practice, providing a full range of audit services to the Parliament and Commonwealth public sector agencies and statutory bodies.

ANCOLD Inc

The Australian National Committee on Large Dams Incorporated (ANCOLD Inc) is an incorporated voluntary association of organisations and individual professionals with an interest in dams in Australia. ANCOLD Inc technical working groups produce, for example, guidelines on design, management and risk assessment of dams.

Anthropogenic

Caused by human beings.

Approval authority

An entity authorised to approve or register water trades, usually held by a state or territory government department, or delegated to an infrastructure operator.

AquaBAMM

The aquatic biodiversity assessment and mapping (AquaBAMM) method is a tool used to assess conservation values for wetlands.

Aquatic ecosystem

An ecosystem that is in or depends on water.

Aquifer

An underground water-bearing geological formation from which groundwater can be extracted.

Aquitard

A geological formation that may contain groundwater, but is not capable of transmitting significant quantities under normal hydrologic gradients. An aquitard may function as a confining bed.

Artesian

Water that comes to the surface under natural pressure when tapped by a bore.

AusRegion model

ABARE's general equilibrium economic model used to estimate implications for economic activity in response to shocks to the Murray–Darling Basin economy. As a general equilibrium model, AusRegion incorporates direct and indirect impacts of shocks to the economy, including feedback from regions. This is in contrast to partial equilibrium models that restrict analysis of impacts to a particular industry or region.

Australian Bureau of Agricultural and Resource Economics

The Australian Bureau of Agricultural and Resource Economics (ABARE) is an Australian Government economic research agency. On 1 July 2010, the Department of Agriculture, Fisheries and Forestry merged two bureaus within its portfolio — the Australian Bureau of Agriculture and Resource Economics and the Bureau of Rural Sciences — to form the Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences (ABARE–BRS).

Australian Bureau of Statistics

The Australian Bureau of Statistics (ABS) is the Australian statistical agency that assists and encourages informed decision-making, research and discussion within government and the community.

Australian Competition and Consumer Commission

The Australian Competition and Consumer Commission (ACCC) promotes competition and fair trade in the marketplace to benefit consumers, businesses and the community. It also regulates national infrastructure services. Its primary responsibility is to ensure that individuals and businesses comply with the Commonwealth competition, fair trading and consumer protection laws. It has a role in enforcing the Water Market Rules 2009 and the Water Charge (Termination Fees) Rules 2009. In this, the ACCC intends to use a cooperative approach, including working with irrigation infrastructure operators to achieve compliance. However, when necessary, it is prepared to use remedies available to it under the *Water Act 2007* (Cwlth).

Australian Drinking Water Guidelines

Guidelines prepared by the National Health and Medical Research Council (NHMRC) to provide the Australian community and the water supply industry with direction on quality drinking water.

AWRIS

The Australian Water Resources Information System (AWRIS) is a publicly accessible online information tool, <www.water.gov.au/default.aspx>, and is the official repository for water data and reporting in Australia. AWRIS integrates and adds value to extensive measurements of river flows, groundwater levels, reservoir storage volumes, water quality, use, entitlements and trades. AWRIS is being developed by the Bureau of Meteorology, in line with the requirements of the *Water Act 2007* (Cwlth).

Bank slumping

A mass failure of riverbank material resulting in partial or complete collapse.

Bankfull

The maximum amount of discharge that a stream channel can carry without overflowing. Bankfull flows are an important trigger for fish breeding in the Murray–Darling Basin.

Barmah Choke

A narrow section of the River Murray that constrains the volume of water that can pass during major floods. During floods, large volumes of water are temporarily banked up behind the Barmah Choke, which floods the Barmah–Millewa Forest wetland system.

Barrages

Five low, wide weirs built at the Murray Mouth in South Australia to reduce the amount of seawater flowing in and out of the mouth due to tidal movement. The barrages also help to control the water level in the Lower Lakes and River Murray below Lock 1.

Baseline

Conditions regarded as a reference point for the purpose of comparison. In the Basin Plan, baseline is defined by elements including the time under consideration; climate characteristics; each jurisdiction's policies, water management rules, entitlement systems and operating rules; the configuration and specification of water resource models; and the mix and location of various water uses and water sources.

Basic rights

Basic rights cover three types of water rights that do not require a licence: stock and domestic rights, native title rights and harvestable rights.

Basin Community Committee

The Basin Community Committee advises the Murray–Darling Basin Authority (MDBA) about the performance of its functions, including engaging the community in the preparation of each draft Basin Plan, community matters relating to the Basin water resources, and matters referred to the committee by MDBA.

Basin Officials Committee

A committee set up to facilitate cooperation and coordination between the Commonwealth, the Murray–Darling Basin Authority and the Basin states in funding works and managing the Basin's water and other natural resources.

Basin Plan

A plan for the integrated management of the water resources of the Murray–Darling Basin, to be adopted by the minister under s. 44 of the *Water Act 2007* (Cwlth).

Basin Salinity Management Strategy

A 15-year plan for communities and governments in cooperating to control salinity in the Murray–Darling Basin. The strategy establishes targets for the river salinity in each major tributary valley and across the Murray–Darling system. The strategy was agreed by the Murray–Darling Basin Ministerial Council on 17 September 2001.

Basin state agencies

Under the *Water Act 2007* (Cwlth), a person or entity appointed or established by or on behalf of a Basin state.

Basin states

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

Basin water resources

According to s. 4 of the *Water Act 2007* (Cwlth), Basin water resources are within or beneath the Murray–Darling Basin, but do not include water resources within or beneath the Murray–Darling Basin that are prescribed by the regulations or groundwater that forms part of the Great Artesian Basin.

Bayesian network

A method for understanding and managing the complex linkages between risk factors in a system, and of transparently considering both qualitative and quantitative information from a variety of sources.

Bifurcate

To divide into two branches — a split in the flow of water.

Biodiversity

The variety of species of plants, animals and microorganisms, their genes and the ecosystems they comprise, often considered in relation to a particular area.

Bioregion

An identifiable regional habitat in terms of living organisms.

Bioremediation

The use of living organisms and their by-products as a means of returning the chemistry of a contaminated environment to an uncontaminated state.

Biosphere

In a broad sense, the entire planetary ecosystem, including all living organisms and those parts of the earth and its atmosphere in which living organisms exist or are capable of supporting life.

Biota

The plant and animal life of a region or ecosystem, as in a stream or other body of water.

Bird-breeding flooding

Flooding that attracts large numbers of flocking birds to breed and feed.

Blackwater

Water with a dark colour due to a high level of organic compounds.

Block bank

A bank that is used to block, move, intercept, hold or harvest water, and for the protection of agricultural development.

Blue-green algae (cyanobacteria)

A group of photosynthetic bacteria more correctly referred to as *cyanobacteria*.

BOM

Under the *Water Act 2007* (Cwlth) the Bureau of Meteorology (BOM) has a water information role — compiling and delivering Australia's water information — to accurately monitor, assess and forecast water availability, condition and use.

Bonn Convention

Also known as the Convention on the Conservation of Migratory Species of Wild Animals (or CMS), the Bonn Convention was signed in 1979 and entered into force in 1983.

Borefield

A deep hole of small diameter bored to the aquifer of an artesian basin, through which water rises under hydrostatic pressure.

BRS

The Bureau of Rural Sciences (BRS) provides scientific advice to government, rural industries and communities on agriculture, fisheries and forestry. On 1 July 2010, the Department of Agriculture, Fisheries and Forestry merged two bureaus within its portfolio — the Australian Bureau of Agriculture and Resource Economics and the Bureau of Rural Sciences — to form the Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences (ABARE–BRS).

Bureau of Meteorology

Under the *Water Act 2007* (Cwlth), the Bureau of Meteorology (BOM) has a water information role — compiling and delivering Australia's water information — to accurately monitor, assess and forecast water availability, condition and use.

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CAC Act

Commonwealth Authorities and Companies Act 1997 (Cwlth).

Calibration process

The process of optimising the input parameters of a numerical model by matching the model to measured data.

Canopy

Overhanging cover formed by vegetation, or the cover of branches and foliage formed by the crowns of trees and shrubs.

Cap (the Murray–Darling Basin Cap on diversions)

A limit, implemented in 1997, on the volume of surface water that can be diverted from rivers for consumptive use. Under the Basin Plan, the Cap will be replaced by long-term average sustainable diversion limits (SDLs).

Caring for our Country

An Australian Government funding program for projects that improve biodiversity and sustainable farm practices. The funding can support regional natural resource management groups, local, state and territory governments, Aboriginal groups, industry bodies, land managers, farmers, Landcare groups and communities.

Carryover

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

Catchment

The area of land drained by a river and its tributaries.

Cease-to-flow

A period of no discernible flow in a river, which can lead to total or partial drying of the river channel, depending on the specifics of the system.

Channel

Of a watercourse, a natural or artificial streamflow with definite bed and banks to confine and conduct water.

Of a landform, the bed of a watercourse that commonly is barren of vegetation and is formed of modern alluvium (deposited during relatively recent geologic time).

Channel capacity

The volume of water that can pass along a channel at a certain point without spilling over the bank.

Channel flow

The flow of water that is conveyed through natural or artificial open water conveyance carriers (as opposed to piped conveyance), expressed in megalitres per day (ML/d) or in another appropriate unit.

Channelled floods

Floods that flow in channels, or between levees or block banks.

Chenopods

Salt-tolerant shrubs resistant to drought.

Climate change

A significant and long-term change in usual climatic conditions beyond natural climate variability, especially where such changes are thought to be caused by global warming (see also 'global warming').

Climate Change Adjustment Program

An Australian Government program to provide assistance, farm business and management advice to primary producers to manage the impacts of climate change.

Climate change buffer

A water planning contingency or policy position to address the direct effects of climate change on rainfall over the next 10–20 years. The buffer is based on scientific forecasts of the rate and magnitude of changes in long-term average runoff across the Basin.

Climate scenario

A description of the weather characteristics predicted to occur over a century or more if known causes of change are stable. Usually expressed in terms of statistics or variability in annual rainfall or runoff for a climate with a fixed level of greenhouse gases.

Coefficient of variation

A measure of the deviation of individual values compared to the mean value of a series of data.

Cold water pollution

Release of cold water from the bottom of a water storage that has a layer of warm surface water and a layer of cooler, deeper water below it. The water temperature at depth can be many degrees cooler and can have serious environmental impacts when it is released.

Colonial nesting waterbirds

Species of seabirds and wading birds that rely on water bodies for food (fish and aquatic invertebrates) and tend to gather in large colonies during the nesting season.

Commonwealth buyback

An Australian Government program to purchase water in the Murray–Darling Basin to return it to the environment. Each year, water purchasing tenders are conducted across the Basin by the Department of the Environment, Water, Heritage and the Arts.

Commonwealth Environmental Water Holder

The *Water Act 2007* (Cwlth) establishes the Commonwealth Environmental Water Holder to manage water entitlements that the Commonwealth acquires. Under the Act, this official has the responsibility for using these entitlements to protect and restore the environmental assets of the Murray–Darling Basin, or assets outside of the Basin where water is held by the Australian Government for that area.

Commonwealth Scientific and Industrial Research Organisation

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's national science agency. Water for a Healthy Country is one of CSIRO's national research flagships and its Land and Water Division takes part in a wide range of research relevant to the Murray–Darling Basin.

Community Advisory Committee

The role of the committee is to advise the Murray–Darling Basin Ministerial Council from a community viewpoint on critical natural resource management issues within the Basin.

Confined aquifer

An aquifer that has a confining layer (aquitard) between it and the land surface. Groundwater contained in confined aquifers is usually under natural pressure and the confining layer is at least partially saturated.

Connectivity

Connections between natural habitats, such as a river channel and adjacent wetland areas. Connectivity is a measure or indicator of whether a water body (e.g. river, wetland, floodplain) has water connections or flow connections to another body (see also 'environmental connectivity', 'groundwater connectivity', 'hydrologic connectivity').

Conservative characteristic (referring to salt)

Once salt is added to water, it remains in solution. This means that the level of salt will only change by dilution or as a result of additional input (it is not subject to any biological or chemical transformation).

Consumptive use

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

Convention on the Conservation of Migratory Species of Wild Animals

See 'Bonn Convention'.

Convention on Wetlands of International Importance

See 'Ramsar Convention'.

Conveyance reserve

The reserve required under s. 86D(1)(c) of the *Water Act 2007* (Cwlth); water required to be reserved to meet the shortfall in conveyance water.

Conveyance water

The water required to ensure sufficient flow in a river to physically deliver water for critical human water needs without evaporation or seepage into the riverbed. The *Water Act 2007* (Cwlth) terms conveyance water as water in the River Murray system required to deliver water to meet critical human water needs as far downstream as Wellington in South Australia.

Cooperative research centres

Cooperative research centres (CRCs) are key bodies for Australian scientific research across a range of sectors to enhance Australia's industrial, commercial and economic growth.

Critical human water needs

Under s. 86A(2) of the *Water Act 2007* (Cwlth), the core water requirements of communities dependent on Basin water resources. The definition also includes non-human requirements that if not met would cause prohibitively high social, economic or national security costs.

CSIRO

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's national science agency. Water for a Healthy Country is one of CSIRO's national research flagships and its Land and Water Division takes part in a wide range of research relevant to the Murray–Darling Basin.

CSIRO Murray–Darling Sustainable Yields Project

On 7 November 2006, the Prime Minister of Australia, the premiers of New South Wales, Victoria and South Australia and the Acting Premier of Queensland commissioned a progressive report by the end of 2007 on sustainable yields of surface-water and groundwater systems within the Murray–Darling Basin. The Murray–Darling Basin Sustainable Yields Project was undertaken by CSIRO as a major research project on current and future water availability in the Murray–Darling Basin. It included an overall Basin report as well as 18 regional analyses.

Council of Australian Governments

The peak intergovernmental forum in Australia, which initiates, develops and monitors the implementation of policy reforms that are of national significance and that require cooperative action by all levels of Australian government.

Cultural flows (or cultural water flows)

Both the Murray Lower Darling Rivers Indigenous Nations (a confederation of 10 Aboriginal nations in the southern part of the Basin) and the Northern Murray–Darling Basin Aboriginal Nations (a confederation of 21 Aboriginal nations in the northern part of the Basin) have developed their own definition of cultural flows: 'Water entitlements that are legally and beneficially owned by the Aboriginal nations and are of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Aboriginal nations. This is our inherent right.'

Current-arrangements flow conditions

Modelled flow that reflects the effects of water management infrastructure and consumptive water use (see also 'without-development flow conditions').

Current diversion limit

Long-term average diversions allowable under existing state and territory water resource management plans, or the Cap on diversions where no plan exists, or the current level of development where neither a plan nor the Cap exists.

Cut-off loop

Another term for abandoned meander bends which are bends in the river channel that have been short-circuited by the main river flow. Cut-off loops commonly form billabongs and ox-bow lakes adjacent to the main river channel.

Cyanobacteria (blue-green algae)

A group of photosynthetic bacteria.

Debits and credits regime

A system for water accounting, whereby excess take (more than the permitted take) is recorded as a 'debit' and take that is below the permitted take is recorded as a 'credit'. Debits may be accrued up to a limit and can be offset against credits, subject to certain restrictions.

Defined variable climate

An observed climatic sequence over the benchmark period (1 May 1975 to 30 April 2000) that is used consistently as a basis for simulating catchment responses (such as groundwater movements and river behaviour) at other dates.

Delivery water

Water of a specified quantity and quality, with defined timing and user, but undefined purpose.

Demographics

Attributes or characteristics of a population or section of a population. Demographics are described using indicators or statistics intended to characterise the population under study. Demographic descriptors include the size, growth, density, distribution, mortality and birth rates, sex and age profile of a group of people.

Deoxygenation

The removal of oxygen.

Depauperate

Stunted (growth); having limited biodiversity.

Desalination

The removal of salt and other dissolved minerals from saline waters, including seawater, to produce low salinity water suitable for human consumption.

Dewatering

Lowering of the groundwater level at a particular location as the result of groundwater extraction.

DEWHA

The Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA).

Diffuse dryland recharge

Groundwater recharge that is sourced from rainfall, as opposed to streamflow recharge or recharge from irrigation leakage.

Dilution flow

The flow required to meet certain water quality standards by mixing a contaminated flow with a better quality flow.

Direct economic impact

The first-round impact of a shock or a policy change that is directly related to a shock. For example, changes in water availability have a direct effect on economic activity in irrigated agriculture (see also 'indirect economic impact').

Discharge

Flow of groundwater from a saturated zone to the earth's surface; flow of surface water out of a defined catchment.

Dissolved oxygen level

The amount of oxygen dissolved in water.

Distributary stream

A diverging stream that does not return to the main stream, but discharges into another stream or into the ocean; it also refers to conduits that take water from a main canal for delivery to a farm.

Diurnal

Any pattern that recurs daily, such as a cycle of daily temperature change or oxygen levels in water.

Diversion

A structure in a river or canal that diverts water to another watercourse; a turning aside or alteration of the natural course of a flow of water; the transfer of water from a water source by a canal, pipe, well, or other conduit to a watercourse or to the land (as in an irrigation system).

Diversion channel

An artificial channel constructed around a point of high potential flood damage (e.g. a town) to divert floodwater; a channel carrying water from a diversion dam.

Diversion limit compliance framework

A broad implementation framework for the Murray–Darling Basin Authority's diversion limit compliance method. The framework is not required by the *Water Act 2007* (Cwlth) to be included in the Basin Plan, but it has been included in the *Guide to the proposed Basin Plan* for clarity and transparency.

Diversion limit compliance method

The method to determine compliance with a long-term annual diversion limit, required by the *Water Act 2007* (Cwlth) (s. 22(1), item 8), as mandatory content of the Basin Plan.

Drawdown

The lowering of the water level in a weir pool.

Dredging

The mechanical removal of mud and other material to deepen a waterway.

Drought refuge

An area that a species can retreat to during times of drought; for example, a permanent pool that remains when a river dries out during drought.

Dry extreme 2030 climate

When high or low estimates on how much greenhouse gas will be in the atmosphere by 2030 are put into models, they generate different outcomes as to how wet or dry it will be in the Basin. The dry extreme 2030 climate is the future climate scenario predicted using the driest model run from the model that predicts drier conditions for the Basin (see also 'wet extreme 2030 climate' and 'median 2030 climate').

Drying off

A strategy used by some perennial horticultural enterprises, generally during periods of water scarcity, of withholding water from less profitable plantings (depending on commodity price and water price) so that water can be directed to more profitable uses within a farm business.

Dryland farming

Non-irrigated crop farming; crop production in semi-arid regions, usually using moisture-conserving farming techniques; also referred to as 'dry farming'.

Dryland river

In the Murray–Darling Basin, generally refers to rivers in the dry north and west of the region, such as the mid and lower Darling.

Dynamic equilibrium

In groundwater systems, when the groundwater levels cease to be drawn down and instead reach a steady state.

Easement

The legal right granted by a property owner to another party to enter on the land, usually to maintain a pipeline or cable, or to cross the land to gain access to another property.

Ecologically sustainable development

Using, conserving and enhancing the community's resources so that ecological processes on which life depend are maintained and the total quality of life, now and in future, can be increased.

Ecology

The study of the interrelationships of living things to one another and to the environment.

Ecoregion

A continuous geographic area over which the macroclimate is sufficiently uniform to permit the development of similar ecosystems on sites with similar geophysical properties. Ecoregions contain a variety of landscapes with different spatial patterns of ecosystems.

Ecosystem

A dynamic complex of plant, animal and microorganism communities, and the non-living environment, all interacting as a functional unit.

Ecosystem response outcomes

The way in which ecosystems — living plants and animals, and the environment in which they live — respond to changing circumstances.

Effluent

An outflowing substance, especially a stream flowing out of a body of water.

In terms of water quality, discharged wastewater, such as treated wastes from municipal sewage plants.

Effluent seepage

Diffuse discharge of groundwater to the ground surface.

Electrical conductivity

A unit commonly used to indicate water salinity. One unit of electrical conductivity equals 1 microsiemen per centimetre, measured at 25 °C.

Endemic biota

Animal and plant life native to a country or locality, either collectively or interdependently.

Endocrine-disrupting compounds

Compounds that interfere with the endocrine systems of organisms, especially compounds such as steroidal hormones, surfactants (wetting agents that lower the surface tension of a liquid); plasticisers (additives that increase the plasticity or fluidity of the material to which they are added); pesticides; and organometals (chemical compounds containing bonds between carbon and a metal).

End-of-valley targets

Under the Basin Salinity Management Strategy, a water quality target set for a point in the lower reach of each catchment.

Entitlement (or water entitlement)

The volume of water authorised to be taken and used by an irrigator or water authority, including bulk entitlements, environmental entitlements, water rights, sales water and surface-water and groundwater licences.

Entitlement holder

An irrigator or water authority.

Environmental asset

A key environmental asset for the purposes of the Basin Plan is a water-dependent ecosystem that meets one or more of the criteria under the *Water Act 2007* (Cwlth). Environmental assets include water-dependent ecosystems, ecosystem services and sites of ecological significance.

Environmental connectivity

Environmental connectivity consists of links between water-dependent ecosystems that allow migration, colonisation and reproduction of species. These connections also enable nutrients and carbon to be transported throughout the system to support the healthy functioning and biodiversity of rivers, floodplains and wetlands. Hydrologic and ecological links are between upstream and downstream sections of river (longitudinal connectivity) and between rivers and their floodplains (lateral connectivity).

Environmental flow

Any river-flow pattern that is provided with the intention of maintaining or improving river health.

Environmental outcome

An outcome (usually of a project) that benefits the ecological health of the river system.

Environmental water

Water used to achieve environmental outcomes, including benefits to ecosystem functions, biodiversity, water quality and water resource health.

Environmental water requirements

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

Environmental Water Scientific Advisory Committee

A committee comprising prominent scientists and experts in fields such as hydrology, limnology, river operations management, river and floodplain ecology, and the management of aquatic ecosystems, appointed to advise the Commonwealth Environmental Water Holder on the use of environmental water.

Environmental Watering Plan

A plan to restore and sustain the wetlands and other environmental assets of the Basin and to protect biodiversity dependent on the Basin water resources.

Environmental Works and Measures Program

A scheme to deliver works and measures to improve the health of the River Murray system by making the best use of available water, optimising the benefits of any water recovered in the future, and considering other policy interventions.

Environmentally sustainable level of take

The level of water extraction from a particular system which, if exceeded, would compromise key environmental assets or ecosystem functions and the productive base of the resource.

Ephemeral river system

An ephemeral river system that does not flow constantly and may be dry for months or years at a time.

Ephemeral stream

A stream that flows only in direct response to precipitation, usually for a short time, and stops flowing during dry seasons. Most dry washes in more arid regions may be classified as ephemeral streams.

Estuarine

The area of a river near its mouth that is tidal — where the river flow meets the sea tides. One of the classification systems under the wetlands and deepwater habitats classification system (see also ‘wetlands’).

Estuarine waters

Deepwater tidal habitats and tidal wetlands that are usually enclosed by land, but that connect with the ocean and are at least occasionally diluted by freshwater runoff from the land (e.g. bays, mouths of rivers, salt marshes, lagoons).

Estuarine zone

The area near the coastline that consists of estuaries and coastal saltwater wetlands.

Estuary

An area where fresh-water meets salt-water (e.g. bays, mouths of rivers, salt marshes, lagoons). The area of a river flow influenced by the tide of the body of water into which it flows (e.g. a bay or mouth of a river), where the tide meets the river flow; an area where fresh and marine waters mix.

Eutrophication

In water bodies, such as lakes or slow-moving streams, excess nutrients that stimulate plant overgrowth (e.g. algal blooms).

Evaporation

Water converting into a gaseous state or vapour from open water surfaces. This includes water evaporating from wet vegetation and water evaporating from the soil surface. Potential evaporation is an estimate of the evaporation as a function of predicted or measured weather parameters, such as temperature, humidity and wind.

Evapotranspiration

The transfer of water as vapour from near the earth’s surface to the air; includes evaporation from water surfaces, transpiration from plants and transfer of water vapour directly from the soil surface.

Excess take

The amount of water extracted from the water resources of a water resource plan area during a water accounting period that exceeds permitted take.

Exotic species

A species that is not native to an area; plants or animals either intentionally or inadvertently introduced from another state or country.

Extracted water

Water extracted for consumptive use (see also 'nonextracted water').

Extreme and unprecedented circumstances

In terms of water availability or water quality, conditions for worst-case planning purposes — see s. 86E of the *Water Act 2007* (Cwlth). Conditions, either actual or predicted, where the critical human water needs of communities dependent on the River Murray system cannot be met over the planning period. This is a situation that cannot be managed without invoking Tier 3 water-sharing arrangements and/or an emergency response.

Farm dam

Small dams (usually less than 5 ML storage capacity) designed to capture runoff from rainfall events. While most farm dams are located on farms, the term includes dams on other types of properties, such as public or urban land.

Fish kill

A localised die-off of aquatic life due to a variety of causes, including industrial pollution.

Fish passage

The capacity for fish to travel up and downstream; for example, weirs and dams obstruct the passage of fish within streams, and structures such as fishways are built to restore fish passage by enabling fish to pass.

Fishway

A structure that provides fish with passage past an obstruction in a stream.

Flash

In waterways, to fill suddenly with water.

Flashiness

The frequency and rapidity of short-term changes in streamflow, especially during runoff events. Flashiness is an important component of a stream's hydrologic regime. A variety of land use and land management changes may lead to increased or decreased flashiness, often to the detriment of aquatic life.

Flood-dependent ecosystem

An ecosystem that depends on flooding from rivers.

Floodplain

Any normally dryland area that is susceptible to inundation by water from any natural source.

Floodplain harvesting

The collection, extraction or impoundment of water flowing across floodplains.

Flood runner watercourse

A stream that carries water in high flows or floods, generally running from (and sometimes back to) the main channel.

Flow data

Information about the quantity and rate of water carried through channels, rivers, pipelines and any other means of water conveyance.

Flow event

A single event of flow in a river; sometimes required to achieve one or more environmental targets. A series of flow events comprises a flow history.

Flow hydrograph

A graphic representation or plot of changes in the flow of water or in the elevation of water level, plotted against time.

Flow indicator

Characterisation of a part of the flow regime that is biologically relevant and important in shaping ecological processes in streams.

Flow regime

The characteristic pattern of a river's flow quantity, timing and variability.

Flow variability

When applied to the Murray–Darling Basin, refers to the combined variability of the magnitude (size in height and volume), the duration (the time the flow lasts) and the frequency (how often a flow occurs).

Flux estimates

Measurement of the approximate rate of flow of water through a groundwater system.

Food chain

The transfer of energy from primary producers (green plants) through a series of organisms that eat and are eaten. At each stage, much energy is lost as heat, a fact that usually limits the number of steps (trophic levels) in the chain to four or five.

Food web

A complex of interrelated food chains in an ecological community.

Forestry plantation

Used throughout this guide to mean the planting of woody perennial plants for commercial purposes. Although most plantations are established to grow timber products, the term also includes plantations established for other commercial purposes (e.g. carbon sequestration or for biofuel).

Fossil groundwater

A non-renewable supply of water trapped underground in aquifers. A body of groundwater that was recharged under previous hydrogeological conditions, but is not recharged under current hydrogeological conditions.

Fractured rock aquifer

Groundwater that exists in the fractures, joints, bedding planes and cavities of a rock mass.

Freshes

Small or short-duration peak flow events. Freshes exceed the base flow for at least several days, contributing to the variability of flow regimes and providing short pulses in flow.

Fringing vegetation

Vegetation on the edge of a water body, generally in relation to wetlands and floodplains.

Future climate scenario

Daily rainfall and potential evapotranspiration projections of a future where the global average surface air temperature is higher (e.g. in 2030 relative to 1990). Data is available on historical climate, and modelling of future climate scenarios is based on this data with scaling up or down for extreme dry, median and extreme wet scenarios.

Geomorphology

A branch of physiography and geology that deals with the form of the earth, the general configuration of its surface, and the changes that take place in the evolution of landforms; the geological aspect of the visible landscape.

Geoscience Australia

Geoscience Australia is an Australian Government agency that provides geoscientific information to facilitate informed decisions on the exploitation of resources, environmental management and safety of critical infrastructure.

Gigalitre (GL)

One billion (1,000,000,000) litres; or 1 km² of water 1 metre deep.

Global warming

The increase in the average temperature of earth's air and oceans, particularly over the past century and projected into the future, believed to be initiated largely by increases in the atmospheric concentration of heat-retaining gases (such as carbon dioxide, nitrous oxide, and methane and, as a secondary effect, water vapour).

Goldfields Superpipe

A 133 km pipeline in north-central Victoria, built to improve water security for Bendigo, Ballarat and surrounding towns. It carries Goulburn River water from the Waranga Western Channel to Lake Eppalock (stage 1) and then to White Swan Reservoir (stage 2).

Great Artesian Basin

A series of aquifers that extends from under the northern part of New South Wales and South Australia, the south-eastern part of the Northern Territory through Queensland to the Gulf of Carpentaria. It underlies part of the Murray–Darling Basin in northern New South Wales and southern Queensland. It is a multilayered aquifer system consisting mainly of sandstones alternating with impermeable siltstones and mudstones. Murray–Darling Basin Plan water resources do not include Great Artesian Basin groundwater.

Groundwater

Water occurring naturally below ground level (in an aquifer or otherwise).

Groundwater connectivity

Surface-water and groundwater systems are not separate resources but components of one system. Their connectivity is a dynamic relationship that fluctuates both seasonally and over the long term in response to climatic variations and the delayed impact of groundwater extractions. Where the connection is strong, groundwater extraction may directly affect surface-water streamflow by inducing leakage to groundwater, or intercepting stream base flow over short and long time frames. Similarly, surface-water extraction and management regimes may affect the availability of groundwater.

Groundwater-dependent environmental asset

An environmental asset that depends on groundwater for part or all of its survival. Also referred to as a groundwater-dependent ecosystem.

Groundwater discharge

Water released from a groundwater system to wetlands, lakes, streams and springs.

Guidelines for managing risk in recreational water

Guidelines prepared by the National Health and Medical Research Council (NHMRC) to ensure that recreational water environments are managed as safely as possible.

Gwydir Raft

An accumulation of timber, debris and sediment into a logjam, deposited over many decades, which extends for about 35 km along the Gwydir River downstream of Moree.

Ha

Hectare or hectares

Habitat

The natural environment or place where living things exist and grow.

Harvestable right

The right under New South Wales law that allows landholders to collect up to 10% of the average regional rainwater runoff on their property and use this water in a farm dam. Dams for this purpose can only be constructed on minor streams that are not permanently flowing, or on hillsides and gullies.

Held environmental water

Water available under an access, delivery or irrigation right that is held to achieve environmental outcomes.

High flow

A persistent increase in seasonal base flow that remains within the channel; high flows do not fill the channel to 'bankfull'.

Historical climate scenario

A scenario for climate projections that is based on 114 years of measured annual runoff statistics for the Basin, from when record keeping began.

Human capital

Refers to the stock of attributes of a person or group that is relevant to economic activity, including the innate and acquired personal abilities and aptitudes, skills, health and knowledge of individuals who contribute to their productivity. An individual's human capital can be increased through personal investment in education, training and health care, and can increase the stock of capital in a region or country.

Hydric

Characterised by, relating to, or requiring an abundance of moisture; a habitat of wet or moist conditions.

Hydrodynamic force

The force exerted by moving water.

Hydrodynamics

Science that deals with the dynamics of fluids, especially incompressible fluids in motion.

Hydrograph

A graphic representation of changes in the flow of water or in the elevation of water level, plotted against time; the trace of stage (height) or discharge of a stream over time, sometimes restricted to the short period during storm flow.

Hydrographic area

In a general sense, refers to a defined geographic area, subregion, sub-basin, basin, region or watershed encompassing the drainage area or catchment area of a stream, its tributaries, or a portion thereof. A hydrographic area is typically defined as a study area for analysis or planning purposes in which the land or undersea contours result in surface-water flows or measures of elevation draining to a single point.

Hydrologic connectivity

Hydrologic connectivity is the physical ability for water at one location to be available at another, and includes the effect of the losses and constraints on flow along the way.

Hydrologic indicator site

A key site used to determine the environmentally sustainable level of take in the Murray–Darling Basin.

Hydrologic loading

The level of impact of water on the environment. This can be the result of irrigation, rainfall or pumping, and is an indication of the stress the environment may be under. It may be used to indicate overextraction in certain catchments, irrigation systems or river sections.

Hydrologic model

Generally a computer model, but can be any model, simulating the hydrologic cycle of rainfall, infiltration and evapotranspiration to predict runoff, water use, and a range of other qualitative and quantitative indicators of environmental health.

Hydrologic monitoring site

Areas of hydrologic features (e.g. rivers and streams) where measures of flow, such as volume, variability, extreme flow events and seasonality are measured (e.g. using a gauge).

Hydrologic regime

A flow regime that organises, drives and defines physical and ecological processes in a river. Flows can be described broadly at three scales: flow pulses (single events, their influence generally lasts for less than a year), flow history (a sequence of flow pulses with an influence that lasts between one and 100 years) and flow regime (a long-term statistical generalisation of flows with an influence that lasts for hundreds of years).

Hydrology

The study of the distribution and movement of water.

Hydrophytic (vegetation)

Plants that grow in water or in saturated soils that are periodically deficient in oxygen as a result of high water content (e.g. cattails, sedge, rushes).

Hypersaline

Waters with salinity greater than 40 parts per thousand, due to land-derived salts.

Icon sites

Six locations chosen for The Living Murray program due to their regional, national and international ecological value, and the concurrence that they are at risk and require improved water-flow regimes. The sites are Barmah–Millewa Forest; Gunbower–Koonrook–Perricoota Forest; Hattah Lakes; Chowilla Floodplain and Lindsay–Wallpolla Islands; Murray Mouth, Coorong and Lower Lakes; and the River Murray Channel.

Impact assessment framework

The conceptual framework that was used to structure the analysis of the potential social and economic impacts of the Basin Plan.

In-channel

Within the banks of a watercourse; usually refers to flows or impediments, such as weirs and block banks.

Independent Sustainable Rivers Audit Group

The group of ecological scientists that oversees and reports on the Sustainable Rivers Audit.

Indicator vegetation communities

Communities of plants used by scientists to reveal something about a characteristic of interest. For example, river red gum forests and woodlands (and other plants found in semipermanent wetlands) can be used as indicator communities for water stress.

Indirect economic impact

The second and subsequent round impacts of shocks or policy changes that follow on from the first round impacts of a shock. For example, changes in water availability are estimated to directly affect economic activity in irrigated agriculture (as a first round impact) — a second round impact would be on agricultural supply industries that would be expected to experience a reduction in the purchases of seed, fertiliser and other inputs when primary production declines (see also ‘direct economic impact’).

Infiltration

Flow of fluid into a substance through pores or small openings; commonly used to denote the flow of water into soil.

Inflow

The source of the water that flows into a specific body of water; for a lake, inflow could be a stream or river, and inflow for a stream or river could be rain.

Inland floodplain wetland

A wetland on a floodplain of an inland river. All the rivers of the Murray–Darling Basin are inland rivers. Therefore, all wetlands on the floodplains of these rivers are inland floodplain wetlands.

Instream connections

Water connections between a river, its floodplains and wetlands through which transfer of energy, nutrients and wildlife takes place. Often migration paths in the life cycles of many plants and animals.

Instream flow

Typically, non-consumptive uses of water that do not require water to be diverted from its natural watercourse (e.g. for fish and other aquatic life, recreation, navigation, aesthetics, scenic enjoyment).

Instream structures

Structures located in a watercourse, such as weirs, locks, dams and block banks.

Interception activity

The interception of surface water or groundwater — that is, a Basin water resource under s. 4 of the *Water Act 2007* (Cwlth) — that would otherwise flow, directly or indirectly into a watercourse, lake, wetland, aquifer, dam or reservoir.

Intergovernmental Agreement on Murray–Darling Basin Reform

Signed in July 2008 by the Council of Australian Governments, this agreement provides for the establishment of cooperative, efficient, and effective planning and management arrangements for the Basin’s water and other natural resources, and enables the social, environmental and economic values of the Murray–Darling Basin to be protected into the future.

Interim water resource plan

Under the *Water Act 2007* (Cwlth), a plan for the management of the water resources of the Murray–Darling Basin made under state water management law of a Basin state on or after 25 January 2007, and before the Basin Plan first has effect. An interim water resource plan ceases to have effect on 31 December 2014 or five years after the plan is made, whichever is later.

Irrigation accession

The process of obtaining water artificially from natural and artificial water sources.

Jurisdictional expert panel

A panel for each Basin state, made up of groundwater experts from that jurisdiction and from the Murray–Darling Basin Authority.

Key environmental asset

An environmental feature deemed ‘key’ for the purposes of the Basin Plan because it meets at least one of five criteria set by the Murray–Darling Basin Authority.

Keystone species

A species that plays a critical role in maintaining the structure of an ecological community and whose impact on the community is greater than would be expected, based on its relative abundance or total biomass.

Lacustrine

Of or relating to a lake.

Leaching

The removal of soluble salts from soil by the action of downward percolation of water.

Lignum shrublands

Highly productive habitats of lignum (a perennial shrub) that support bird foraging and breeding after flood events.

Limnology

The study of freshwater (nonmarine) systems, including rivers, lakes and wetlands.

Listed species

Species specifically identified in legislation related to migratory birds or threatened species.

Living Murray Initiative, The

A partnership of the Basin state governments aimed at achieving a healthy, working River Murray system.

Lock

A rectangular chamber with gates at either end, allowing vessels to move from one water level to another.

Longitudinal profile

A graphic presentation of elevation versus distance. In channel hydrologics, a plot of water surface elevation against upstream-to-downstream distance.

Long-term annual diversion limit

For a particular water resource, the sum of the long-term average sustainable diversion limit and the temporary diversion provision — *Water Act 2007* (Cwlth) s. 22(1), item 7.

Long-term average sustainable diversion limit (SDL)

For particular water resources, the maximum long-term annual average quantity of water that can be taken on a sustainable basis; reflects the environmentally sustainable level of take — *Water Act 2007* (Cwlth) s. 22(1), item 6 and s. 23.

Long-term Cap equivalent

An average that takes into account the different characteristics of water entitlements and allocations in New South Wales, Victoria and South Australia, and their reliability. This creates a common unit of measure, allowing equitable comparison of a broad range of water recovery measures.

Loss

Water lost from a river system that is not available to other users; for example, due to evaporation and seepage.

Low flow

A continuous flow through a water channel that either maintains the flow above a cease-to-flow condition or provides habitat as a change from high flow.

Lowland catchment

A catchment in the lower part of a river basin.

Lowland flooding

Inundation of the very lowest portions of floodplain areas (near a river, stream or lake) that are normally subject to frequent flooding.

Lunette

A broad, low-lying, typically crescent-shaped mound of sandy or loamy matter formed by the wind, especially along the windward side of a lake basin.

Macroinvertebrate

An animal without a backbone that is large enough to be seen without magnification.

Macrophyte

A macroscopic plant in an aquatic environment. The most common macrophytes are rooted vascular plants usually arranged in zones in aquatic ecosystems.

Maireana

A genus of perennial shrubs and herbs endemic to Australia.

Managed aquifer recharge

The process of adding water to aquifers under controlled conditions for withdrawal at a later date. Can also be used to manage the flow of saltwater or other contaminants within an aquifer.

Marsh

An area of soft, wet, low-lying land characterised by grassy vegetation that does not accumulate appreciable peat deposits, often forming a transition zone between water and land; a tract of wet or periodically inundated treeless land.

MDBA

In December 2008, the Murray–Darling Basin Authority (MDBA) assumed responsibility for all functions of the former Murray–Darling Basin Commission to manage the Basin’s water resources in the national interest. The MDBA is made up of six members supported by an office of around 300 staff. Main roles and responsibilities include preparing the Basin Plan for adoption by the Australian Water Minister; implementing and enforcing the Basin Plan; advising the minister on the accreditation of state water resource plans; developing a water rights information service that facilitates water trading across the Murray–Darling Basin; measuring and monitoring water resources in the Basin; gathering information and undertaking research; and educating and engaging the community in the management of the Basin’s resources.

MDBC

The Murray–Darling Basin Commission (MDBC) was the executive arm of the Murray–Darling Basin Ministerial Council, set up under the Murray–Darling Basin Agreement in 1992. The functions of the MDBC were subsumed by the Murray–Darling Basin Authority in 2008.

MDBMC

The Murray–Darling Basin Ministerial Council (MDBMC) has an advisory role in the preparation of the Basin Plan, and policy and decision-making roles for matters such as state water shares, critical human water needs, and the funding and delivery of natural resource management programs. The MDBMC is chaired by the Commonwealth Water Minister and comprises one minister from each of the Basin states.

MDFRC

Murray–Darling Freshwater Research Centre

Mean annual flood

The average of all annual flood stages or discharges of record; may be estimated by regionalisation, correlation or any other process that can furnish an estimate of the long-term average from observed data.

Mean annual flow

The annual flows in a river, added together and divided by the number of years.

Median

The single middle value in a range of values ordered from lowest to highest. If there is an even number of values (and therefore two middle values), the median is the average of the two middle values.

Median 2030 climate

When high or low estimates on how much greenhouse gas will be in the atmosphere by 2030 are put into models, they generate different outcomes as to how wet or dry it will be in the Basin. The median 2030 climate is the annual rainfall patterns predicted using the model runs that predict both the driest and the wettest conditions for the Basin (see also ‘dry extreme 2030 climate’ and ‘wet extreme 2030 climate’).

Microcystin cylindrospermopsin

Chemicals produced by some *cyanobacteria* that can be very toxic to plants and animals, including humans.

Mitigation strategy

Actions by governments and other external parties to mitigate (i.e. alleviate) the potential impacts of the Basin Plan.

ML

Megalitre; 1 million (1,000,000) litres

ML/d

Megalitres per day

MLDRIN

Murray Lower Darling Rivers Indigenous Nations (MLDRIN) is a confederation of 10 Aboriginal nations in the southern part of the Basin, comprising representatives of the Wiradjuri, Yorta Yorta, Taungurung, Wamba Wamba, Wadi Wadi, Mutti Mutti, Latji Latji, Ngarrindjeri, Barapa Barapa and Wergaia peoples.

Model integration framework

A computer framework set up to link, in this case, all individual computer models of Murray–Darling Basin Authority regions so that they can exchange information up and down the river system.

Modelling

The application of a mathematical process or simulation framework (e.g. a mathematical or econometric model) to describe various phenomena and analyse the effects of changes to some characteristics on others. For example, a rainfall runoff model can be used to estimate flow in river based on rainfall and other climate data. Such a model embodies a mathematical representation of catchment processes, such as seepage of water into ground, evaporation and use by plants, and excess water flowing over the land surface into channels and ultimately into a river system.

MODFLOW

Computer software that resolves an equation for modelling to simulate the flow of groundwater through aquifers.

Monitoring and evaluation cycle

A cycle of monitoring and evaluation of the outcomes of the Basin Plan, undertaken at least every five and 10 years, to inform review and adaptive management.

Monitoring and Evaluation Program

A program to monitor and evaluate the effectiveness of the Basin Plan as required by the *Water Act 2007* (Cwlth). This program must set out the principles to be applied and the framework to be used for monitoring and evaluation, including the requirements for reporting.

Morphology

The science of the structure of organisms; also the external structure form and arrangement of rocks in relation to the development of landforms. River morphology deals with the science of analysing the structural make-up of rivers and streams. Geomorphology deals with the shape of the earth's surface.

Multiple wellpoint borefield

More than one groundwater extraction bore linked together to extract water.

Murray Lower Darling Rivers Indigenous Nations

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Murray–Darling Basin

The entire tract of land drained by the Murray and Darling rivers, covering parts of Queensland, New South Wales, Victoria and South Australia, and the whole of the Australian Capital Territory.

Murray–Darling Basin Authority

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National Action Plan for Salinity and Water Quality

The Australian, state and territory governments adopted this plan in 2000, to tackle salinity and water quality problems in key catchments and regions. The plan ceased on 30 June 2008.

National Land and Water Resources Audit

A national audit to develop information to support the assessment of change in natural resources as a result of government programs. In the first phase (1997–2002), the audit made a series of recommendations about the improved management of Australia’s natural resources. The second phase of the audit (2002–2008) was a collaborative program between all states and territories and the Australian Government, to provide data, information, and nationwide assessments of Australia’s natural resources.

National Water Commission

The National Water Commission (NWC) is responsible for driving progress towards the sustainable management and use of Australia’s water resources under the National Water Initiative.

National Water Initiative

The National Water Initiative (NWI) is an intergovernmental agreement between the Australian, state and territory governments to improve the management of the nation's water resources and provide greater certainty for future investment. The NWI was signed by the Australian Government and all state and territory governments in 2004 (other than Tasmania, which signed the agreement in 2005, and Western Australia, which signed in April 2006). The NWI builds on the previous Council of Australian Governments framework for water reform that was signed by all governments in 1994.

Native Fish Strategy

Aims to ensure that the Murray–Darling Basin sustains viable fish populations and communities throughout its rivers, by rehabilitating native fish communities to 60% of their estimated pre–European settlement levels within 50 years of implementation.

Native title right

Aboriginal native title holders in New South Wales can take water in the exercise of native title rights for a range of personal, domestic and non-commercial communal purposes. Native title holders are as determined under the *Native Title Act 1993* (Cwlth).

Natural flow

Water movement past a specified point on a natural stream from a drainage area for which there have been no effects caused by stream diversion, storage, import, export, return flow or change in consumptive use caused by human-controlled modification to land use.

Natural resource management

The management of natural resources such as land, water, soil, plants and animals, with a particular focus on how management affects the quality of life for both present and future generations.

Natural Resource Management Ministerial Council

Consists of Australian, state, territory and New Zealand government ministers responsible for primary industries, natural resources, environment and water. The peak government forum for consultation, coordination and, where appropriate, integration of action by governments on natural resource management issues.

No deterioration principle

From the National Water Quality Management Strategy, wherever possible, ambient water quality should not be allowed to degrade to the levels prescribed by water quality objectives or targets.

Nonextracted water

Water remaining in the catchment after extractions have occurred (see also 'extracted water').

Northern Basin Aboriginal Nations

A shortened term sometimes used for Northern Murray–Darling Basin Aboriginal Nations (NBAN), a confederation of Aboriginal nations in the northern part of the Basin. NBAN recognises 21 nations eligible to be members. These include Barkindji (Paakantyi), Barunggam, Bidjara, Bigambul, Budjiti, Euahlayi, Gamilaroi, Githabul, Gunggari, Jarowair, Gwamu, Kunja, Kwiambul, Malangapa, Mandandanji, Mardigan, Murrawarri, Ngemba, Ngiyampaa, Wailwan and Wakka Wakka peoples.

Northern Region Sustainable Water Strategy

Released in 2009, the strategy discusses threats to water quantity and quality over a 50-year planning horizon and sets out actions to manage the impacts of future prolonged droughts and the uncertainty of climate change. The strategy area covers the Ovens, Goulburn–Broken, Campaspe and Loddon catchments and the Victorian River Murray.

Northern Victoria Irrigation Renewal Project

A two-stage project to modernise and rationalise irrigation infrastructure in the Goulburn–Murray Irrigation District of northern Victoria, to deliver improved water efficiency, better service delivery and increased on-farm productivity. The project's resulting water savings are to be shared between irrigators, the environment and supply to Melbourne.

Numerical groundwater model (or groundwater flow model)

A mathematical model used to simulate groundwater flow systems and test sustainable diversion limit scenarios (see also 'MODFLOW').

Nutrient

An element or compound that is essential to life and sustains individual organisms and ecosystems; the portion of any element or compound in the soil that can be readily absorbed and assimilated to nourish growing plants.

Nutrient pollution

Contamination of water resources by excessive inputs of nutrients. In surface waters, this can result in excess algal production. Although natural sources of nutrients exist, major sources are typically anthropogenic (human-made), including municipal sewage-treatment plants, industrial outflows, commercial fertilisers, animal waste and combustion emissions.

NWC

The National Water Commission (NWC) is responsible for driving progress towards the sustainable management and use of Australia's water resources under the National Water Initiative.

NWI

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Offtake

A location where water is diverted from an open water supply system for consumptive use.

Outer floodplain vegetation

Vegetation on the edges of floodplains.

Overallocation

Occurs when the total volume of water that can be extracted by the holders of access rights at a given time exceeds the environmentally sustainable level of take for those water resources.

Overbank flows

Flows greater than bankfull, resulting in inundation of the adjacent floodplain habitats. Overbank flows are critical for a range of ecological factors, including floodplain productivity.

Overextraction

The take of water from a water resource above what is sustainable.

Overland flow

Surface runoff; the flow of rainwater or melted snow over the land surface toward stream channels; the discharge of wastewater in such a way that it flows over a defined land area prior to entering a receiving stream. The movement over vegetated land fosters the removal of plant nutrients from the wastewater and constitutes a form of tertiary wastewater treatment.

Overuse

When the total volume of water taken for consumptive use from the water resources of the area at a given time exceeds the environmentally sustainable level of take for those water resources. An overuse may arise for a water resource plan area if the area is overallocated or if the planned allocation for the area is exceeded due to inadequate monitoring or accounting.

Permitted take

The total quantity of water permitted to be taken during a water accounting period in a water resource plan area, varying from year to year according to the interaction of climate, inflows and water resource plan rules (e.g. allocation rules, access rules). The long-term average of the permitted take for each water accounting period (over a model run of many years) must be shown at the time of water resource plan accreditation to be equal to or less than the long-term average sustainable diversion limit (but with the addition of temporary diversion provisions, where these apply in the transition period).

Pesticides

Chemicals, generally artificial, used for invertebrate, disease and pest plant control; substances or mixture of substances used to kill unwanted species of plants or animals.

Planned environmental water

Water committed by legislation to achieve environmental outcomes or other environmental purposes specified in the legislation. Planned environmental water can be delivered when flows are released from storages for environmental purposes or can be managed through water-take restrictions.

Porous rock aquifer

Groundwater in the interconnected pore spaces of the rock mass.

Potable water

Water suitable for drinking or culinary purposes, on the basis of both health and aesthetic considerations.

Precautionary principle

Principle that can be applied to prevent degradation of the environment where there are threats of serious or irreversible environmental damage, even if there is a lack of full scientific certainty.

Productive base

Of a water resource, the capacity to supply water suitable for various uses by virtue of its intrinsic characteristics, such as salinity within a range suitable for irrigation; algal counts suitable for primary recreation contact without treatment; or groundwater standing water levels that facilitate economic pumping. The productive base includes the services provided by ecosystems and is distinct from the actual use of water for any particular activity, including for consumption.

Program logic

A diagram or other method to set out the steps in a program (or project, organisation, policy or sector) starting from inputs (e.g. activities and policy implementation) and illustrating their consequences as immediate outcomes, intermediate outcomes and longer term (or higher order) outcomes. These steps also illustrate support of policy objectives.

Rain rejection

When water ordered from a dam by an irrigator is not taken from the river or is returned to the river because it has rained in the meantime.

Ramsar Convention

The Convention on Wetlands of International Importance is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Ramsar listing

The inclusion of a wetland area on the Ramsar List of Wetlands of International Importance, an inventory prescribed by the Convention on Wetlands of International Importance (generally known as the Ramsar Convention). Australia has designated 65 sites for this list.

Recession event

Receding floodwaters; opposite of an inundation.

Recharge

The process of replenishing an aquifer, usually from rainfall or losses from surface-water bodies, such as rivers and lakes.

Reedbeds

Large monocultures of a wetland plant known as phragmites (the common reed).

Reference condition

The condition of a river, as assessed by an audit, relative to how it would have been had it not been changed.

Reference group

A committee with a range of expertise to advise on and review projects and findings.

Refuge

In the context of the Murray–Darling Basin, a refuge is either a regulated flow, flow regulation or a controlled flow rate, resulting from the influence of a regulating structure, such as a dam or weir.

Refugia site

A place where animals and plants can survive when times are hard. One of the values of semipermanent or core wetlands is that they provide refuge for plants and animals when they cannot survive in other parts of the landscape.

Regimen of a stream

A stream's habits with respect to velocity and volume, form and changes in channel, capacity to transport sediment, and amount of material supplied for transportation. The term is also applied to a stream that has reached an equilibrium between corrosion and deposition — a graded stream.

Regulated

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

Regulated flow

A controlled flow rate resulting from the influence of a regulating structure, such as a dam or weir.

Regulation

The artificial manipulation of the flow of a body of water.

Reserves policy

Policy defined in s. 86D(1)(c) of the *Water Act 2007* (Cwlth) to meet the shortfall in conveyance water, varying between years and taking into account the potential inputs.

Resnagging

A program to reinstate snags or instream woody habitats used by native fish, such as the Murray cod. These habitats are used as shelter from currents and predators, feeding and spawning sites, and nurseries for juvenile fish.

Resource condition limit

The threshold water quality value below which the highest possible environmental values will be achieved.

Riffle

A shallow area where rocks break up the flow of water.

Riparian

Of, inhabiting, or situated on the bank or floodplain of a river.

Risk allocation

When there are reductions to the volume or change to the reliability of an entitlement holder's water allocation from the Basin Plan, the risks are shared between individual entitlement holders and governments, according to a formula in the *Water Act 2007* (Cwlth) that recognises climate change and other natural events, new knowledge and changes in government policy.

River health

Status of a river system based on water quality, ecology and biodiversity.

River Murray Waters Agreement

The River Murray Waters Agreement (later changed to the Murray–Darling Basin Agreement) was ratified in 1915 by the Commonwealth and state governments and proclaimed on 31 January 1917 by the Australian Government. The agreement specified construction works, including storages on the upper Murray and at Lake Victoria, and set up the River Murray Commission — later to become the Murray–Darling Basin Commission — which was replaced by the Murray–Darling Basin Authority under the *Water Act 2007* (Cwlth).

RiverBank program

An environmental fund set up by the New South Wales Government to buy water for the state's most stressed and valued inland rivers and wetlands for five years until 2011.

Riverine

Relating to, formed by, or resembling a river including tributaries, streams, brooks and the like; pertaining to or formed by a river; situated or living along the banks of a river.

Riverine systems

Open-water habitats, typically including all open-water areas within a defined channel of a stream, as well as along perennial and intermittent stretches of streams and some major dry washes. The riverine system is often referred to as riparian habitat.

River Murray increased flows

Water recovered under investment in the Snowy Joint Government Enterprise and managed under The Living Murray program.

River red gum

The most widely distributed eucalyptus species in Australia, growing along watercourses throughout the country — it lines the River Murray for most of its length.

Runoff

Flow of surface water from a given area resulting from the effects of rainwater.

Rural water corporation

Victorian organisations that provide a combination of irrigation services, domestic and stock services, and some bulk water-supply services, namely Goulburn–Murray Water, Grampians Wimmera Mallee Water, Lower Murray Water and Southern Rural Water.

Saline

Water that contains a significant concentration of dissolved salts, predominantly sodium chloride.

Salinisation

The build-up of salts in soils as the result of capillary flow of saline groundwater towards the land surface.

Salinity

The concentration of dissolved salts in groundwater or river water, usually expressed in electrical conductivity units or milligrams of dissolved solids per litre.

Salinity register

A salinity-based accounting system underpinning the Basin Salinity Management Strategy, providing an accounting record of state and territory actions that affect river salinity.

Salt interception schemes

Large-scale groundwater pumping and drainage projects that intercept saline groundwater flowing into rivers, and dispose of the saline waters by evaporation and aquifer storage at more distant locations.

Salt load

Amount of salt carried in rivers, streams, groundwater or surface run-off in a given time.

Salt-load target

The load of dissolved salt carried in water, expressed as a numerical value, which can be carried from the Basin to the ocean through the mouth of the River Murray.

Salt management basin

Basins that receive and hold the salt extracted by salt interception schemes.

Salt mobilisation

Processes by which salts held in one part of the landscape become mobile and can adversely impact other parts of a landscape.

Schedule for Water Sharing

Water-sharing arrangements that replace the 'normal' arrangements of the agreement to deliver water to meet critical human water needs when water availability is so low that the normal arrangements cease to be appropriate. The schedule sets out how state and territory water entitlements are determined, delivered and accounted for during tiers 2 and 3 — see s. 135(6) (a) of the Murray–Darling Basin Agreement — and during the transition periods moving to and from tiers 2 and 3.

Scroll swale

Refers to the landform pattern that results from a river channel migrating laterally across its floodplain over long time periods. This landform consists of higher ridges (scroll bars, or scrolls) separated by topographic lows called swales.

Sediment

Soil particles that have been transported by wind or water action; particles of sand, soil and minerals that are washed from the land and settle on the bottom of wetlands and other aquatic habitats. This material is in suspension in water or recently deposited from suspension.

Sedimentation

Deposition or accumulation of matter at the bottom of a water body.

Sediment load

The amount of sediment carried by a water body.

Semipermanent or 'core' wetlands

The wetlands at the heart of a system, usually referring to the parts that dry out last and become wet first.

SIL0

A source of meteorological and agricultural data provided by the Bureau of Meteorology (<www.bom.gov.au/silo>) and is of particular interest to anyone involved in the agricultural arena.

Sinclair Knight Merz

Sinclair Knight Merz (SKM) is an engineering, sciences and project delivery firm consulting in civil, mechanical, electrical and environmental engineering.

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Slack water

Still, slow, sluggish water.

Slough

Soft muddy ground as in a march or swamp

Snowy Water Licence

The licence issued under the *Snowy Hydro Corporatisation Act 1997* (NSW) to operate the Snowy Scheme. The licence is currently issued to Snowy Hydro Limited.

Sodicity

A measure of the amount of sodium in a soil.

Southern connected Basin

The upper River Murray, the River Murray in South Australia, and regulated reaches of the Goulburn, Campaspe, Loddon and Murrumbidgee river systems.

Spatial

Usually refers to area or distance.

Spatial data

Any data that can be mapped.

Spatial data source

Original data or spatial database, which is a structured collection of spatial data and its related attribute data, organised for efficient storage and retrieval.

Species diversity

The number of species within an area.

Spray drift

Aerial movement of a pesticide from its site of application (e.g. as a result of prevailing winds).

Stock and domestic right

Allows rural landholders to extract water for domestic household and stock watering purposes, without an access licence.

Storage-to-recharge ratio

The volume of water stored in a groundwater system relative to the volume of recharge. Provides an indication of the intrinsic nature of the aquifer, particularly in terms of its sensitivity to short-term overextraction.

Stratification (of the water column)

Where a layer of warm surface water remains unmixed with the cooler, deeper water below it. Due to the density gradient between cooler, deeper water and warmer, upper layers, which can develop during spring and summer months, stratification is common in deep, still water bodies.

Streamflow management plan

Plans developed under Victorian law for stressed or highly used unregulated surface waterways that are declared as water-supply protection areas. The plans set out detailed water-sharing arrangements to balance the rights of diverters and the needs of the environment, as well as other matters such as monitoring and metering programs.

Stressor

A physical, chemical or biological characteristic that can cause an adverse effect in an aquatic ecosystem.

Subaqueous

Soils that form in sediment found in shallow permanently flooded environments.

Subartesian water

Groundwater that does not come to the surface under natural pressure when tapped by bores.

Substrate

The physical surface upon which an organism lives; the natural or artificial surface upon which an organism grows or to which it is attached; the layer of material beneath the surface soil.

Succession planning

Succession is the right, act or process by which one person succeeds to the office, rank, estate or the like of another person. In this case, the successor is usually a family member who will take on the ownership and day-to-day management of a farming business. Succession planning is the strategy employed to ensure that the process occurs smoothly, and typically involves planning around the timing, personnel and financial aspects of the arrangement.

Supplementary access

A type of licence issued in New South Wales that allows water to be taken when uncontrolled flows exceed any immediate water needs and any specific environmental requirements as set out in environmental flow rules.

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.

Surface-water delivery efficiency

The ratio of water used beneficially at the final point of use over the amount of water originally diverted from the water source. Various definitions may be used, depending on the scale of the assessment (e.g. on-farm, river reach, irrigation system, river system, whole-of-catchment).

Surface-water diversion

Changing the natural flow of surface water to another location by artificial means, such as dams or pipelines.

Suspended matter

Matter that is not dissolved.

Sustainable diversion limit (SDL)

Long-term average sustainable diversion limits, or SDLs, set the maximum long-term annual average quantities of water that can be taken on a sustainable basis from the Basin water resources as a whole, and from the water resources or particular parts of the water resources of each water resource plan area.

Sustainable Rivers Audit

A program designed to determine the ecological condition and health of river valleys in the Murray–Darling Basin, to give a better insight into the variability of river health indicators over time, and to trigger changes to natural resource management.

Swale

A slight depression, sometimes swampy, in the midst of generally level land; shallow depression in an undulating ground moraine due to uneven glacial deposition; long, narrow, generally shallow, troughlike depression between tow beach ridges, and aligned roughly parallel to the coastline; a piece of meadow, often a slight depression or valley, as in a plain or moor, marshy and rank with vegetation. Swales usually carry flows only during or immediately after rainfall or snowmelt events. Swales vary in size from small conveyances providing drainage along roadways and behind or between buildings to larger waterways.

Swamp

Wet, spongy land; low saturated ground and ground covered intermittently with standing water, sometimes inundated and characteristically dominated by trees or shrubs, but without appreciable peat deposits. Swamps may be freshwater or saltwater, tidal or non-tidal. A swamp differs from a bog in not having an acid substratum.

Take

The removal of water from a water resource; the reduction in flow of water in or into a water resource.

Target value

Numerical values that relate to a water quality characteristic, which, if exceeded, indicate an unacceptable risk of harmful environmental effects.

Taxonomic diversity

Species richness.

Technical reference panel

A forum set up by the Murray–Darling Basin Authority comprising one representative from each Basin state and Murray–Darling Basin Authority representatives to discuss technical groundwater issues throughout the Murray–Darling Basin.

Temporary diversion provision

If the Basin Plan sets a long-term average sustainable diversion limit that is lower than the long-term average volume of water that has been taken (before the Basin Plan), a temporary diversion provision provides for a transitional period of up to five years to mitigate any significant social and economic impacts on entitlement holders and communities.

Terminal lake

A lake with no outlet.

Threat abatement plan

A plan that provides for the research, management, and any other actions necessary to reduce the impact of a listed key threatening process (e.g. predation by a feral animal species) on native species and ecological communities.

Threatened species (also listed-threatened)

Species or ecological communities considered threatened with extinction as defined by the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) or relevant jurisdictional legislation.

Tiered water-sharing arrangements (tiers 1, 2 and 3)

These arrangements set out the sharing of water in the River Murray system — see s. 86 of the *Water Act 2007* (Cwlth) — and are to be included in the Basin Plan and the Schedule for Water Sharing, to manage the risks to critical human water needs due to water availability and/or water quality. The arrangements include a reserves policy to set aside water to meet conveyance water requirements.

Time-lag effect

The time taken for groundwater extraction to influence hydraulically connected streamflow or to influence pressure levels within an aquifer remote from the point of extraction.

Total dissolved solids

A measure of the total amount of material dissolved in water.

Trading zones

Zones established to simplify administration of water trade by setting out the known supply source or management arrangements, and the physical realities of relevant supply systems within a zone so that trade can occur within and between zones without first having to investigate and establish the details and rules of the system in each zone.

Transitional water resource plan

Transitional and interim water resource plans are existing water-sharing arrangements recognised under the *Water Act 2007* (Cwlth).

Transmission loss

Water losses incurred in natural waterways (both regulated and unregulated) and engineered water-supply systems during delivery of water from water-supply sources to end users.

Transpiration

The amount of water evaporated (used) by vegetation through leaves for growth. As with evaporation, this is estimated, based on weather data, plant variety and other indicators. When evaporation is combined with transpiration, it is referred to as evapotranspiration.

Turbidity

A measure of water clarity and an indicator of the presence of suspended material, such as silt and clay, in water sources.

Unassigned water (groundwater)

A volume of groundwater that may be taken sustainably from an unincorporated area for which groundwater resources are relatively undeveloped.

Underdeveloped

Where current groundwater use is less than the long-term average sustainable diversion limit in a groundwater system, resulting in unassigned water.

Understorey vegetation

An underlying layer of vegetation, especially the plants that grow beneath a forest's canopy.

Unincorporated area

Of groundwater, an area not covered by an existing groundwater plan or a groundwater management area.

Unprecedented hydrologic event

Any extreme climatologic, hydrologic or water quality event that has not occurred in the past 114 years of water management history and record keeping in the Basin.

Unregulated

A water system that is not a regulated system.

Unregulated use

Use of water from an unregulated system.

Vegetation response

The way in which plants respond to conditions. For example, wetland, riverbank or floodplain plants (vegetation) often respond to floods or flows of water by germinating, growing new leaves, flowering and setting seeds.

Volumetric annual permitted take

The maximum quantity of water permitted to be taken in a water accounting period in a water resource plan area, varying from year to year according to the interaction of climate, inflows and water resource plan rules (e.g. allocation rules, access rules).

Water access entitlement

A perpetual or ongoing entitlement, by or under a law of a state or territory, to exclusive access to a share of the water resources of a water resource plan area.

Water access entitlement tagging

An accounting approach allowing a water access entitlement traded from one jurisdiction or trading zone to another to retain its original characteristics, rather than being converted into a form issued in the new jurisdiction or trading zone.

Water accounting

A systematic process of identifying, recognising, quantifying, reporting and assuring information about water, the rights or other claims to water, and the obligations against water. Water accounting applies Australian water accounting standards.

Water accounting period

The period for which a water accounting report is prepared.

Water allocation

The specific volume allocated to the holders of water entitlements in a given season, 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.

Water balance

An account of all the water in a specific system (e.g. groundwater) with all inflows, outflows and change in water held in storage accounted for.

Water column

A concept that imagines a column of water taken from the surface to the bottom sediments. This concept is used for evaluating the stratification or mixing (e.g. by wind-induced currents) of the thermal or chemically stratified layers in a lake or stream.

Water-dependent ecological communities

Ecological communities that depend on periodic or sustained inundation, waterlogging or significant inputs of surface water or groundwater for their ecological integrity.

Water-dependent species

Species dependent on habitat with periodic or sustained inundation, waterlogging or significant inputs of surface water or groundwater for their ecological integrity.

Water entitlement

Water users in the Basin hold legal entitlement, or licence, to a share of the available water. The entitlement usually specifies size (or volume) of the share, the source of the water (e.g. the river, catchment or aquifer) and the category (which can be a combination of priority and purpose).

Water forfeiture

The proportion of announced allocation that is not used at the end of the water accounting period and, subject to the rules of the water resource plan, cannot be carried forward for use in the following water accounting period.

Water for Rivers program

A program established by the Australian Government and the governments of New South Wales and Victorian to recover 282 GL of water for the Snowy River and River Murray. This volume of water savings is aimed at being achieved through investment in water-efficiency infrastructure projects, innovation and technology, and — where appropriate — by acquisition of water entitlements.

Water for the Future program

An initiative to prepare Australia for a future with less water. It has four key priorities: taking action on climate change, using water wisely, securing water supplies, and supporting healthy rivers and wetlands.

Water licence

A licence issued under Basin state laws that authorises holders to take, use or hold water, subject to conditions.

Water market

A framework for the buying, selling and transfer of tradeable water rights.

Water market rules

Rules that apply to irrigation infrastructure operators who hold a group water entitlement on behalf of its members, designed to ensure that members can separate their portion of the group-held entitlement into a separate entitlement held by the individual. Water market rules are required under the *Water Act 2007* (Cwlth), but are not within the Basin Plan. These rules are made by the Commonwealth Water Minister.

Water plan

A statutory plan for surface-water or groundwater systems, consistent with regional natural resource management plans, developed in consultation with all relevant stakeholders on the basis of best scientific and socioeconomic assessment, to provide secure ecological outcomes and resource security for users.

Water quality

The condition of water and its suitability for different purposes. Water quality refers to a combination of physical, chemical and biological characteristics of water in the context of the value or use for which the water body is being recognised.

Water Quality and Salinity Management Plan

To be included in the Basin Plan, a plan to protect and enhance water quality in the Basin for environmental, social, economic and cultural uses.

Water quality zone

A geographic region within the Basin where a number of water quality targets are identical.

Water recovery

Implementation of measures that result in water being made available under The Living Murray environmental watering plan.

Water recovery registers

Water recovery measures are approved and monitored using a system of staged registers: the developmental register, the eligible measures register and the environmental water register.

Water-regulating structure

An object such as a bar or gate, fitted to regulate water flow or depth.

Water resource

Of groundwater, water that occurs naturally beneath the ground level (whether in an aquifer or otherwise, or water that has been pumped, diverted or released to an aquifer for the purpose of being stored there). Basin groundwater resources exclude groundwater in the Great Artesian Basin.

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

Water resource allocation

Process used by the Murray–Darling Basin Authority to distribute the water identified by the water resource assessment method.

Water resource plans

Statutory management plans — recognised under provisions of the *Water Act 2007* (Cwlth) — 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).

Water share

In Victoria, a water entitlement held by a water authority or individual. Legislation enables all water rights and licences to be converted into water shares.

Water sharing plan (and water-sharing arrangement)

In New South Wales, a legal document prepared under the *Water Management Act 2000* (NSW) that establishes rules for sharing water between the environmental needs of the river or aquifer, water users and the different types of water users, such as town supply, rural domestic supply, stock watering, industry and irrigation.

Water stress

A potentially fatal condition of wetland, riverbank and floodplain plants that are starved of water.

Watertable

The level below the ground surface, under which all void spaces are fully saturated.

Water trade model

The Australian Bureau of Agricultural and Resource Economics' economic model of land and water use in the agricultural sectors of the Murray–Darling Basin. The model incorporates irrigated agricultural activities and models water trade.

Water trade program

An MDBA program that has developed the proposed Basin Plan water trading rules, and coordinates implementation and administration of interstate water trade within the southern connected Basin.

Water trading rules

A set of overarching consistent rules enabling market participants to buy, sell and transfer tradeable water rights.

Water year (or hydrologic year)

A continuous 12-month period starting from July (or any other month as prescribed under the water regulation or a resource operations plan, usually selected to begin and end during a relatively dry season). The water year is used as a basis for processing streamflow and other hydrologic data.

Water yield

Amount of water leaving a watershed, as measured at a weir. Expressed in units of height per area.

WAVES

A soil-vegetation-atmosphere model that uses Basin-wide datasets and a historical climate dataset based on SILO to produce groundwater recharge estimates (see also 'SILO').

Weir

A dam in a river to stop and raise the water (e.g. to form a fishpond or similar).

Weir pool

A body of water stored behind a weir.

Wet extreme 2030 climate

When high or low estimates on how much greenhouse gas will be in the atmosphere by 2030 are put into models, they generate different outcomes as to how wet or dry it will be in the Basin. The wet extreme 2030 climate is the model run that generates the highest long-term average rainfall for the Basin (see also 'dry extreme 2030 climate' and 'median 2030 climate').

Wetlands

Areas of marsh, fen, peatland or water — whether natural or artificial, permanent or temporary — with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which does not exceed six metres at low tide. An area that is periodically inundated or saturated by surface water or groundwater on an annual or seasonal basis, displays hydric soils, and typically supports or is capable of supporting hydrophytic vegetation.

Without-development flow conditions

Modelled flow that reflects conditions without the effects of water management infrastructure and consumptive water use; an approximation of natural flow in rivers (see also ‘current-arrangements flow conditions’).

Woodland

Any land used primarily for growing trees and shrubs, including — in addition to what is ordinarily termed ‘forest’ or ‘forest plantations’ — shelterbelts, windbreaks, wide hedgerows containing woodland species for wildlife food or cover, stream and other banks with woodland cover, and so on. Also includes farmland and other lands on which woody vegetation is to be established and maintained. An area or biotic community dominated by widely spaced trees of short stature growing on warm, dry sites.

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