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Executive summary

This document provides an early indication of the likely Basin environmental watering priorities for 2019–20 to work towards achieving the long-term expected outcomes for the Murray–Darling Basin’s rivers and floodplains.

The Murray–Darling Basin Authority’s (MDBA) focus is at the Basin-scale and complements the Basin states’ focus on regional and local water for the environment.

Under the Basin Plan, approximately 2,118 gigalitres (GL) has been recovered (as at 30 November 2018) for the environment to help reverse the decline of the Basin’s rivers and floodplains. Water managers have used annual allocations against this entitlement, along with other parcels of water for the environment and water available in the river system, to improve the condition of the Basin’s rivers and floodplains. Innovative approaches and increasingly intricate methods of delivering water are being used, making the most of all the water available. Improvements have been recorded at local scales but challenges remain to achieving Basin-scale improvements.

Many of the Basin’s rivers, wetlands and floodplains have not recovered from the millennium drought. Above-average rainfall and high flows in 2010 and 2011 that broke that drought were followed by a return to dry conditions for several years. High natural flows in 2016 created opportunities to improve the condition of the Basin’s water-dependent ecosystems but dry and warm conditions returned in most parts of the Basin in 2017–18. This trend has continued into the current water year. For example, the Basin as a whole recorded its seventh driest year on record in 2018 while parts of New South Wales (NSW) and Queensland experienced record dry winters. Some parts of the northern Basin have had two years of extremely dry conditions. Inflows for the Murray system in 2018 totalled 2,740 GL against the long-term average of 9,030 GL. In the north, there were record low flows along the Barwon-Darling; flow at Bourke was the lowest on record at 1.3% of the long-term average. Maximum and minimum temperatures in the Basin continue to be higher than average and large parts of Queensland and NSW are in drought.

As a result of above-average temperatures and low inflows over successive years, some important wetlands and floodplain forests have not received water for long periods, this includes key sites for waterbirds. The condition of the Coorong South Lagoon is deteriorating, as noted at the Ministerial Council meeting in December 2018. The Barwon-Darling has experienced more frequent and longer periods without flows. Fish kills in the lower Darling and other Basin catchments in the past few months are a graphic demonstration of the stress the system is under and the work that remains to be done to restore the river to health.

Environmental water allocations are like all other equivalent water allocations, this means that with widespread dry-to-very-dry conditions and substantial inflows unlikely in the remainder of 2018–19, environmental water allocations will likely be low across most of the Basin. As a result, opportunities for improving the Basin’s rivers and floodplains are likely to be limited in the forthcoming water year. In 2019–20, we anticipate that the key focus for environmental water managers in dry catchments will be maintaining the condition of species and habitat where water is available. In very dry catchments, the focus will be on avoiding irretrievable loss of species and habitat, and providing drought refuges. However, in southern Basin catchments where environmental water allocations
have been higher and reasonable carryover volumes are likely, opportunities might arise to improve condition in some catchments.

Those priorities identified for the 2018–19 water year are likely to remain the focus for Basin-scale environmental watering in 2019–20, noting that water managers will need to respond to any change in conditions should more water become available in the forthcoming water year.

New sustainable limits on water diversion take effect across the Basin on 30 June 2019. Other work that will complement the increased flow volumes for the environment will take longer to complete. This includes environmental works and measures, addressing physical constraints and changing some of the ways the river is managed, including strengthening protection of water for the environment. The MDBA is working with Basin governments to address physical, policy and operational constraints and to finalise the recovery of water for the environment.

The MDBA and the Commonwealth Environmental Water Holder (CEWH) are also working with Northern Basin Aboriginal Nations (NBAN) and Murray Lower Darling Rivers Indigenous Nations (MLDRIN) to develop First Nations environmental watering guidance. This work will provide a platform for MLDRIN, NBAN, and Aboriginal Nations across the Basin to provide strategic advice on the objectives and outcomes First Nations would like environmental watering to achieve on Country. The MDBA will incorporate this information into the development of the 2020–21 Basin-wide environmental watering priorities.

Introduction

Each water year the MDBA prepares Basin-wide environmental watering priorities for the Murray–Darling Basin (the priorities). The priorities guide environmental water management across the Basin to achieve Basin-scale outcomes for flows and connectivity, native vegetation, waterbirds and native fish. Water for the environment to meet these outcomes will also support essential ecosystem processes and functions, such as nutrient cycling and food production.

The Basin environmental watering outlook (outlook) summarises the prevailing and forecast environmental conditions (ecological, climatic and hydrological) as at 1 December 2018. The assessment is informed by information collected by the Bureau of Meteorology (rainfall, runoff, soil moisture, storage volumes, the El Niño Southern Oscillation Index and the Indian Ocean Dipole).

Understanding the prevailing and forecast environmental conditions helps us to characterise the Basin on a spectrum from very dry to very wet. We call this the resource availability scenario. Appropriate management outcomes are selected and environmental watering is prioritised to achieve these outcomes.

This outlook includes a summary assessment of the overall ecological condition of river flows and connectivity, waterbirds, native vegetation and native fish, where information is available, and foreshadows some of the important environmental watering needs over coming years.

We prepare the outlook to seek feedback on the likely Basin-scale environmental watering priorities for the forthcoming water year and to assist Basin states and the CEWH as they plan environmental watering for 2019–20.

In June, the MDBA will publish the priorities. They guide the annual planning and prioritisation of environmental watering across the Basin, and are consistent with the Basin-wide environmental watering strategy. The Basin-wide priorities complement regional and state environmental watering priorities.

The MDBA welcomes community feedback on the watering opportunities in this outlook. Comments can be provided by email to engagement@mdba.gov.au or by phoning 1800 230 067.
Environmental watering outcomes
2017–18 and 2018–19

2017–18

The 2017–18 water year was hot and dry in the Basin. Rainfall was lower than average throughout the year, with falls in September 2017 the lowest on record. Mean temperatures were also above average across the Basin, with daytime temperature records broken in April.

Basin states, the CEWH and the MDBA worked together to provide about 3,130 GL\(^1\) of water for the environment during 2017–18. This included water that was delivered to multiple sites using return flows. In the northern Basin there were a number of targeted deliveries of water for the environment, including the northern Basin connectivity event. See text box 1 for details.

A lower Darling River watering event that occurred across November and December 2017 delivered 26 GL that aimed to support Murray cod spawning and survival of juveniles, including those that spawned in the previous year. It also aimed to support golden perch that spawned in the previous year. Monitoring in winter 2018 showed that Murray cod that spawned in 2016 and 2017 made up 28% of the overall cod population in the lower Darling. Similarly, golden perch that spawned in 2016 made up more than 30% of the lower Darling perch population.

Approximately 135 GL of environmental water in two different flow events was provided to the Macquarie Marshes between July and December 2017. Water managers noted the first flow delivered between July and August 2017 primed the system, improving water efficiency and boosting standing water in the channels and shallow groundwater systems. The second larger flow delivered to the Marshes between August and November 2017 inundated semi-permanent wetland vegetation communities. A small waterbird breeding event was also observed and the flow supported conditioning, breeding and dispersal of native fish, including Murray cod and golden perch in the mid-Macquarie River and lower Macquarie River channels. The lower Macquarie River received approximately 22 GL of outflow below the Marshes and it is estimated about 4.5 GL entered the Barwon River.

The Gwydir catchment and floodplain experienced a mostly dry 2017–18. With little rainfall received, water was held in reserve and used to target habitat health and provide a more natural flow pattern. NSW Office of Environment and Heritage (NSW OEH) and CEWH worked together to manage the delivery of 47 GL of water for the environment. Environmental water increased the health of the local aquatic environment, contributed to the large-scale northern Basin connectivity event and benefited the Gingham and Lower Gwydir Wetlands and Whittaker’s Lagoon. Triggered by inflows into Copeton Dam, NSW OEH and the CEWH released an ‘early season stimulus flow’ of 10 GL to prime the system and restore a pattern of small pulses to the river to benefit native fish.

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\(^1\) All environmental water volumes contained in this report include held environmental water and planned environmental water.
Early season stimulus flows in conjunction with stable fish flows, support fish populations in the Gwydir system.

In the southern Basin, the focus of watering for 2017–18 was on consolidating the gains from the wet year of 2016 and building system-scale resilience. While natural river flows were low in 2017–18, water managers used carryover holdings to deliver over 2,880 GL of water for the environment. This focused on helping fish to spawn, grow and move through the system; supporting waterbird feeding and breeding; and supporting floodplain vegetation. Water managers also continued to strengthen coordination and reuse of water for the environment, maximising the benefits of what water was available.

Watering events in the southern Basin included more than 270 GL to reconnect numerous wetlands to the river in the Murrumbidgee, a Basin-scale watering priority for several years. The delivery of this water was a co-operative effort involving NSW OEH, WaterNSW, the CEWH, Murrumbidgee Irrigation Limited, Coleambally Irrigation, DPI Water and landholders along the Murrumbidgee River system. A significant golden perch breeding event occurred in response to the watering.

Around 112 GL of water was delivered to Hattah Lakes between July and October 2017 for black box trees that had not been flooded since 1993. The watering supported further germination and growth of the trees. Monitoring in 2018 found that the tree canopy increased in areas that received water.

Two natural floods occurred in Barmah Forest in August and December 2017. Around 290 GL of water for the environment along with operational water was used between the two peaks to flow through the forest in October and November. The water triggered growth in Moira grass and river swamp wallaby grass, and waterbird breeding. The flows also provided connectivity and increased food for fish and other animals in the river.

Up to 210 GL of water for the environment was delivered to wetlands along the River Murray in South Australia. There were notable improvements for native fish and some native vegetation as well as connectivity from 1157 GL of water for the environment delivered to the Lower Lakes, Coorong and Murray Mouth. Return flows of around 666 GL from the Goulburn, Murrumbidgee and River Murray provided continuous releases over the barrages that supported winter fish migration between the river and the sea, fish breeding in warmer months, and flows to improve salinity levels and remove salt from the system. Black bream had their most successful breeding in the Coorong since the millennium drought.

2018–19

The year-to-date has been exceptionally dry for NSW, Victoria, eastern South Australia and the southern half of Queensland. Conditions at the start of the 2018–19 water year were warmer and drier than the previous year. A dry winter was followed by a dry spring, with record warm weather and low rainfall. The Basin recorded its seventh-lowest rainfall for the period January to November 2018 since 1900, coupled with higher-than-average temperatures.

Water storages in the south had fallen by end of January, with Dartmouth Reservoir at 67% and Hume Reservoir at 33% capacity. In these conditions, the focus of delivering water for the environment has been on maintaining condition and supporting critical environmental needs.
The CEWH delivered 5.5 GL in the Namoi River downstream of Wee Waa following a cease-to-flow event that started in August 2018. The reconnection flow, which started in early November, was planned to be high to refresh waterholes and then reduce to allow fish movement between habitats for several weeks after the peak. An update on monitoring in late November indicated that fish species diversity was reasonable but the number of fish was low.

The Gwydir and Mallowa Creek wetlands received 73 GL between July 2018 and the end of January 2019. The watering events went through the Lower Gwydir and Gingham watercourses filling near wetlands and enhancing habitat and foraging resources for a large number of waterbird species. Flows also made their way through the Mallowa system and upper parts of the Mehi system, filling waterholes and refuges, as well as inundating some shallow, adjacent wetlands. During NSW OEH’s annual spring waterbird survey, 47 waterbird species were observed within all survey sites. The flows also supported native fish, frogs and turtles. NSW OEH survey staff noted the good condition of wetland areas receiving water for the environment.

A watering event in the Macquarie River and Marshes between July and December 2018 delivered 126.4 GL from Burrendong Dam. The water for the environment made its way through the Marshes, along the lower Macquarie River and connected to the Barwon River. The delivery aimed to maintain stable flow rates in October to cover nesting sites for Murray cod in the mid-Macquarie River and create conditions to promote growth of wetland vegetation. Before the flows, the Barwon River had ceased to flow downstream of Walgett. The flows from the Macquarie improved water quality by reducing salinity levels, topped up 175 pools along a stretch of the Barwon River, provided refuge for native fish in dry periods, supported important habitat and provided food for a range of waterbirds. A total of 40 different waterbird species were recorded in the Marshes in spring 2018. However, both species diversity and abundance were slightly lower than average since the survey commenced in 2012, which is to be expected in a dry year.

With little water for the environment available in the northern Basin, the focus of environmental water planning and delivery for the remainder of 2018–19 includes protecting drought refuge sites and avoiding further losses.

In the southern connected Basin, there were a number of successful early season watering actions delivered by the CEWH and Basin states during winter and spring of 2018. The larger and more significant watering actions included:

- An in-channel rise operation of the Chowilla regulator along with a small weir raising at Lock 6, weir raising at Locks 2 and 5 and pumping to key wetlands to increase productivity in the river and maintain condition of fringing vegetation and wetlands.
- Opening the Barmah-Millewa Forest regulators early in the water year to provide a more natural inflow to the creeks in the forest for fish and other aquatic animals to access important breeding and feeding habitat.
- Providing winter and spring freshes in the Goulburn River to improve the condition of bank vegetation, water quality and habitat access. These pulses were protected through to the end of the Basin river system, including to cue lamprey to migrate upstream from the Coorong.
- Watering the Gunbower floodplain to maintain the condition of the river red gum forest and key wetlands.
• Delivering water to refuge sites in the Murrumbidgee River system, including Lake Yanga where it is estimated that over 500,000 juvenile golden perch are located after the Murrumbidgee River reconnection environmental water release in 2017–18 (see above). Once water availability conditions allow, the lake will be reconnected through natural flooding or managed environmental flows to allow the juvenile golden perch to disperse back into the river system.

• Return flows from upstream environmental watering activities maintained connectivity in the Lower Lakes, Coorong and Murray Mouth. A winter fresh in the Goulburn system contributed to elevated barrage flows to support fish movement and reproduction. Hot and dry conditions have made it difficult to deliver additional water for the environment in 2018–19, however, where possible, additional water orders are in place over the warmer months to support continuous flows to the Coorong over summer, to support habitat for a range of migratory waders and fish species.

Delivering environmental water in the current climate brings challenges to water managers. For example, dry conditions and channel capacity constraints became challenging for all involved in river management in the southern connected Basin at the start of September 2018. Plans to coordinate delivery of environmental water from Hume Dam with a fresh for the Goulburn River to provide a river-scale in-channel pulse to the sea to cue fish to move, breed and have access to more food, could not proceed. This was due to competing demands on the river channel. Sustained use of the Goulburn catchment for inter-valley water trade during 2017–18 and 2018–19 has affected channels and fringing vegetation in the lower Goulburn. These higher flow rates were needed to set the system up to meet downstream irrigation and environmental demands over summer. This situation illustrates that sometimes there can be trade-offs between meeting system water requirements and local water needs.

Channel capacity opened up in the Murray to allow a small amount of water for the environment to be delivered from Hume Dam in November and December 2018. Governments are working together to resolve some of these channel sharing and constraint challenges to meet future demands of all users, including the environment.

With dry conditions expected to continue in coming months, the focus for the remainder of the 2018–19 water year will be ensuring that high priority needs can be met to protect ecosystems. This includes:

• Working with river operators to maximise opportunities to deliver water to the Lower Lakes and Coorong to support critical environmental needs, including maintaining connectivity through the barrages (where possible) to support habitat for migratory waders in the Coorong North Lagoon, and Lower Lakes water levels to support fringing wetland habitat for threatened native fish species. There is an inherent trade-off — particularly under dry conditions — between maintaining connectivity through the barrages and supporting fringing wetlands, which means it is difficult to fully achieve both objectives.

• Under drier conditions, continued connectivity between the lakes and the Coorong should be maintained where possible.
• Delivering environmental water in the River Murray in autumn and winter following the irrigation season to maintain baseflows to support and improve threatened native fish populations.

• Undertaking a number of smaller watering actions with either operational or environmental water in Lower Broken Creek, Gunbower Creek, Campaspe and Loddon rivers and other numerous individual wetlands to achieve environmental outcomes including fish recruitment and maintenance of refuges.

• Supporting variable flows along the river to boost productivity, diversity of habitat for native fish and more variable inundation conditions to promote better condition and diversity of vegetation can be created by manipulating weir pools, including between Locks 7 to 9. Reinstating wetting and drying regimes on the banks of weir pools can increase moisture availability for fringing vegetation and promote growth of different plant types that grow at different times through the wetting and drying cycle.

In response to the death of around 2,000 native fish near Redbank Weir in late January 2019, water managers started a release of up to 26 GL in the lower Murrumbidgee upstream of Balranald. The flows, which are planned to continue through to April, are designed to improve oxygen levels in the river, provide refuges for native fish and promote movement of fish and other aquatic animals to those refuge sites. Multiple water holders are contributing to the delivery, including the CEWH, the joint government managed Living Murray (coordinated by the MDBA) and NSW OEH. Returns flows are anticipated through to the River Murray in South Australia.

Similar issues have emerged in the lower Darling. While there has not been water available to provide to the environment, Basin governments are looking at other strategies to help prevent further fish deaths.
Northern Basin connectivity event

The pattern of flows in the Barwon-Darling river system that connects the northern and southern basins has always been variable, shifting from floods to cease-to-flow periods when all that remains are pools cut off from one another. These pools are vital to keep species alive in drier periods.

Since the year 2000, cease-to-flow periods have become more frequent and last longer, while the floods that follow them have been smaller. These changes are having significant impacts on the river system and the plants and animals it supports.

By January 2018, more than 1,000 km of the Barwon-Darling downstream of Brewarrina had ceased to flow. As water quality deteriorated into stagnant waterholes, blue-green algae alerts increased and native fish and other instream life were put under significant stress. Riverside communities were concerned about the river condition and a number of Shires voiced their concern.

In response to the worsening river conditions, State and Commonwealth agencies worked together to deliver water for the environment in the northern Basin from April to June 2018. Support from irrigators, local governments and communities was an important part of the co-ordination effort.

The northern Basin connectivity event, as it became known, provided 23 GL of water managed by the CEWH and NSW OEH from Glenlyon and Copeton dams in the Border Rivers and Gwydir catchments. The water travelled 2,000 km along the Barwon-Darling to reach Menindee Lakes. The flow was able to build upon a previous unregulated flow.

To ensure the flow was protected on its way downstream, the NSW government restricted access using a temporary embargo provision for the first time while the MDBA commissioned the use of the latest satellite technology to ensure water was not diverted for unauthorised use.

While the main purpose of the northern Basin connectivity event was to support native fish in line with the Basin-wide annual environmental watering priorities, it was a multi-purpose, large-scale event which provided a number of environmental, social and cultural benefits.

The flow managed to flush blue-green algae from the rivers, improving water quality and providing food and habitat for plants, fish and birds. It also allowed native fish to move between habitats by providing connectivity across multiple river systems.

The northern Basin connectivity event created a great sense of relief and excitement for communities. Community events were organised to help celebrate and view the flow. Community feedback suggests there was strong support for this complex watering action and four shire councils gratefully acknowledged the positive community response to the flow event.

The northern Basin connectivity event highlights that under the Basin Plan positive outcomes for communities and the environment can be achieved through collaborative management and goodwill. However, the recent fish kills in the lower Darling and other Basin catchments are a clear demonstration that there is still a long way to go to return the Basin to health.
Current condition

River flows and connectivity

Regulation and use of the Basin’s rivers to secure water supplies for growing towns, industries and agriculture has dramatically altered the natural flow regime. Overall flow volumes have decreased, flow variability has declined, the natural timing of flows has been altered and the river and its anabranches, wetlands and floodplains are connected less frequently. These changes have caused a significant decline in health for many important and rare water-dependent ecosystems across the Basin.

The 2017 evaluation of the Basin Plan found that the recovery of water for the environment over recent years had improved river flow regimes in many parts of the Basin. Longitudinal connectivity (along the river) was most improved in the southern Basin where environmental watering activities in multiple tributaries had increased flow volumes in the River Murray. However, with much of the 2012–18 period dominated by dry conditions, River Murray flows and flows into the Coorong and Lower Lakes generally remained below their long-term average. Ecological condition would have been significantly worse without the ongoing delivery of water for the environment. The regular provision of environmental flows within the southern Basin following full implementation of the Basin Plan, including relaxing constraints, will support the recovery and restoration of environmental assets and functions in the years to come.

In the northern Basin water for the environment has also increased flow volumes and improved the flow regime in several rivers (such as the northern Basin connectivity event in 2018). Environmental water managers will need to continue to explore alternative ways to provide water to important environmental assets, such as trading or temporary purchase of allocations where feasible, particularly if drying conditions persist into 2019–20.

Inflows in the Murray system in 2018 totalled 2,740 GL, well down from the long-term average of 9,030 GL. The majority of streamflow forecasts for the Basin are predicting low inflows for the remainder of 2018–19, although near-median inflows are possible for south-eastern Australia. Water available in storages has been decreasing in 2018–19. With water availability generally reducing over the past 12 months, managers of held environmental water will need to monitor emerging environmental threats, and where feasible, respond swiftly to mitigate the environmental impacts of ongoing dry and hot conditions. Increased temperatures, such as those experienced in 2018 where mean temperatures across the Basin were in the top 10% of records, have the potential to exacerbate risks of reduced water availability. When rainfall occurs, managers will also need to take advantage of any opportunities to improve lateral and longitudinal connectivity by supplementing unregulated flows.
Barwon-Darling and lower Darling

Flow into the lower Darling system is determined by inflow patterns in the northern Basin through the Barwon-Darling, and the rules by which Menindee Lakes are operated as a storage.

The Barwon-Darling itself experiences very little runoff and only a fraction of the water that flows into the northern Basin rivers will reach Menindee Lakes. Almost all of the rain that falls in this catchment either evaporates or is absorbed by local waterholes and vegetation — very little runs into the river itself. For this reason, flow through the Barwon-Darling River is almost entirely dependent on inflows from upstream catchments across southern Queensland and northern NSW. Some of these northern rivers contribute more water to the Barwon-Darling than others, determined partly by prevailing climatic conditions, but also by the combined effects of the natural and human development-related features of the system. Prior to significant human development, around 75% of northern Basin flows would have been consumed through natural processes such as evaporation, seepage into the groundwater system, and supporting the natural ecosystem — only around one quarter of northern Basin inflows would have reached Menindee Lakes. Importantly, some of the northern rivers, such as the Condamine-Balonne, Gwydir and Macquarie-Castlereagh, contain large floodplain and wetland systems that absorb significant volumes of water just upstream from the junction with the Barwon-Darling River. Human development to capture water in storage or use by local communities and agriculture has further decreased the amount of water flowing into the Barwon-Darling and ultimately through to Menindee Lakes. The construction of storages and extraction for consumptive use means that less water is available for the environment and only 16% of northern river inflows will reach Menindee Lakes. This is a long-term value, during dry years (such as 2018) the proportion is far less.

Given that rainfall was well-below average across the northern Basin in 2018, and temperatures were well-above average, very little of the rain that fell in the upper-catchments made its way to the lower Darling. The long distances and travel times along the Barwon-Darling further intensify the reduction of flow from evaporation and seepage.

The Basin Plan is seeking to increase the amount of water within the Barwon-Darling River by recovering water for the environment, delivering it towards important environmental outcomes, and ensuring it is protected from extraction as it passes through the river. However, during dry periods (such as 2017–18) it is difficult to pass major flows through the river system. There is little water available for all users, including the environment, and any water that is released for environmental purposes will pass through a series of near-dry river channels and high transmission losses. The Barwon-Darling stretches 1,600 km river and during dry periods transforms into a series of disconnected pools. Restarting the river system (i.e. reconnecting it from the top of the river to Menindee Lakes) requires large volumes of water.

By January 2018, more than 1,000 km of the Barwon-Darling were in cease-to-flow condition, with significant implications for the environment and communities (see text box above). In response to these conditions, Commonwealth and NSW water for the environment was made available for delivery — the northern Basin connectivity event. This was an unprecedented event in which two environmental water holders coordinated releases from two storages in the northern Basin to pass water through the Border Rivers and Gwydir catchments into and through the Barwon-Darling River.
The purpose of the event was to benefit native fish by improving longitudinal connectivity, but there were also a number of important social benefits from this water delivery. The NSW minister agreed to protect this flow from pumping for irrigation. Coordinating an environmental flow and associated activities (including monitoring of flows and ecology, and engagement) was a complex task over 2,000 km of river over a period of several months.

The event was a success, and shows the progression of Basin river management towards a ‘one-system’ approach, as envisioned by the Basin Plan. The event was able to provide longitudinal connectivity and refresh drought refuges in the Barwon-Darling and some northern tributaries, but only a small proportion made its way to Menindee Lakes. It was not enough to connect all waterholes, provide effective connection with the lower Darling or restore the system. Achieving wholesale reconnection of the northern and southern Basins requires substantial rainfall and natural flows that could be complemented by environmental water releases to enhance the connectivity benefits.

The hydrology in this area has changed in recent years. The number and length of cease-to-flow periods in the Barwon-Darling have increased significantly in the past 18 years, an effect which can be tied to both the volume of water extracted from the river and climate across the northern Basin. This trend has also affected water availability in Menindee Lakes and the flow characteristics downstream through the lower Darling.

For flows measured at Weir 32 on the lower Darling, for the period of 1982 through to 2000 there were no cease-to-flow days (flow below 5ML/d). In the following 18 years, from 2000 to 2018, there were 499 cease-to-flow days; 219 of these fell in the last few years, including the cease-to-flow period starting in late 2018 (Figure 1).

![Figure 1 - observed flows at U/S Weir 32 from 1982–2018, showing cease-to-flow periods (of less than 5ML/d)](image-url)

In 2018, Menindee Lakes only had enough water to provide local water needs with few natural flows coming down the Darling. Flows into the lower Darling have been well below the smallest environmental water requirement identified by the MDBA for the lower Darling during Basin Plan development (7,000ML/d for 10 days in 70–90% of years). This particular flow threshold and duration
has not been met for six years, which is an indicator of the high potential risk of poor instream habitat in the lower Darling (Figure 2). It is however important to note that these environmental water requirements were not developed with the intention of stipulating future environmental water use. As well, knowledge of environmental water requirements is constantly evolving with work being undertaken by Basin states to develop region-specific, long-term environmental watering plans capturing recent advances in understanding of flow-ecology relationships. In practice, environmental watering managers make decisions on how to use available environmental water during any given year, based on the natural eco-hydrologic cues and the best available information on outcomes that can be achieved with environmental watering actions.

Figure 2: Flow at Weir 32 for 2016–2018 compared to the lower Darling environmental water requirements

Without significant replenishment flows, water quality degradation becomes a serious issue. January 2019 has been characterised by blue-green algae red alerts at locations extending from Louth down to Tolarno (south of Menindee) as well as Wentworth and Mildura weirs on the Murray. It is suspected that the large fish deaths in early January was caused by low oxygen levels triggered by a sudden drop in temperature that de-stratified and deoxygenated the water. This was a large-scale event, affecting approximately 45km of the Darling River below the Menindee main weir. Additional flows are needed to improve water quality and keep weir pools mixed. These flows have to be managed carefully to avoid exacerbating the situation. With little prospect of substantial flows in the coming months, Basin governments are considering options to mitigate water quality to avoid further environmental damage.
Native vegetation

The 2017 evaluation of the Basin Plan found that in areas where water for the environment can be delivered, there are positive signs of native vegetation responding. These benefits have been achieved by extending flow durations and protecting flow peaks (by limiting extractions), and by creating lateral connectivity between the main river channel and the adjacent wetlands and floodplains including through the use of infrastructure. Water for the environment has buffered many of the Basin’s water-dependent vegetation communities from the effects of the current drought, particularly in wetland areas of the Gwydir, Macquarie-Castlereagh, Lachlan and Murrumbidgee catchments.

The dry conditions experienced during 2018 resulted in a decline in condition of some wetland and floodplain vegetation communities across the Basin, particularly those located higher on the floodplain or in unregulated systems. These dry conditions, combined with the effects other stressors such as salinity and feral animals, have resulted in declining vegetation cover and changes in plant community composition. This has been particularly evident in northern Basin vegetation communities in the Narran, Barwon-Darling and the Warrego catchments.

During 2018, water for the environment was often used to create in-channel or small overbank events, which supported vegetation species on river banks and in low-lying wetlands. Monitoring shows that targeted riparian and low-lying wetland vegetation communities are responding well. For example, in the Gwydir River system and the Chowilla anabranch, water for the environment supported in-stream and riparian vegetation, including the recruitment of saplings, and watering events in Hattah have contributed to an improvement in Lignum condition.

Non-woody vegetation on river banks and low-lying wetlands also benefited from delivery of water for the environment in the Barwon-Darling, Macquarie Marshes, Gwydir and the Lachlan catchments throughout the 2017–18 water year. In the Barmah-Millewa Forest, Moira grass has responded well to watering, particularly where combined with complementary management actions (e.g. fencing to keep out feral horses and pigs). However, the overall contraction of the Moira grass plains remains of concern given there has been no major increase in the presence of the species at sites where it previously existed.

Although *Ruppia tuberosa* (*R. tuberosa*) extent has remained relatively stable from summer 2016 to summer 2018, the overall abundance of *R. tuberosa* in the southern Coorong in summer 2018 was lower than in the previous summer. Reproduction and seed set of the species was hampered by falling water levels in the southern Coorong over spring and the presence of filamentous algae. Seed density in sediments remains low, putting the species’ survival at risk.

Waterbirds

The 2017 evaluation of the Basin Plan also found that there are positive signs that water for the environment contributes to the long-term health of the Basin’s waterbird population. The rate of decline in waterbird abundance has slowed and species richness has remained steady. However, migratory shorebird numbers have declined over time, likely driven by habitat degradation in Australia and overseas, and waterbird abundance has not yet increased to a sustainable level.
Since the 2017 evaluation, the Basin’s waterbird population has been surveyed for another two years, by the South-East Australian Aerial Waterbird Survey and the Aerial Survey of Basin Environmental Assets. While the 2017 South-East Australian Waterbird survey showed an improvement in waterbird numbers from the previous year, the 2018 survey showed a decline, from around 70,000 in 2017 to 55,000 in 2018. As can be seen in Figure 3, abundances for the last six years are similar to those seen during the millennium drought.

Data from the 2018 Aerial Survey of Basin Environmental Assets (undertaken in October to November 2018) is pending. However, observations from the survey team found that in the northern Basin, many of the wetlands were dry, and bird counts correspondingly low, with little breeding activity.

The Narran Lakes was one of these dry wetlands. No waterbirds were observed at the Narran Lakes, and as at January 2019, the lakes had not received any significant flows in more than two years. A significant colonial breeding event has not occurred since 2011–12. Wetlands in the northern Basin which had some water during the survey period (October to November 2018), such as the Macquarie Marshes, Menindee Lakes and the Gwydir wetlands, supported low to moderate numbers of waterbirds, with little to no breeding.

In the southern Basin (including the Lachlan catchment) during the survey period, most sites were partially wet and supported low numbers and diversity of waterbirds, with little to no breeding. The exceptions were: Lake Cowal in the Lachlan catchment, which supported moderately high...
numbers and diversity of waterbirds; Lake Cullen (part of the Kerang wetlands) which supported about 10,000 waterbirds; and the Coorong, Lower Lakes and Murray Mouth where waterbirds were relatively abundant, species diversity was high and there were several moderately large breeding colonies of ibis, pelican and cormorants on the lakes and South Lagoon.

Shorebird numbers in the Coorong and Lower Lakes increased in January 2018 from the previous year (Figure 4), which is not unexpected given in January 2017 (when monitoring is conducted) there was very little habitat in the Coorong to support shorebirds. In summer 2016–17, substantial releases of flood waters through the barrages inundated the Coorong mudflats making feeding habitat unfavourable for migratory waders. Lower barrage flows in summer 2017–18 resulted in lower water levels and more favourable feeding conditions. Red-necked stint, curlew sandpiper and sharp-tailed sandpiper numbers were up in the Coorong from 2017, while common greenshank numbers were down (refer Figure 4). Although there were more shorebirds present in the Coorong in January 2018 than in January 2017, their abundances generally remained low and some well below their long-term median abundances.

![Figure 4: Abundance of four shorebird species (Curlew sandpiper, Common Greenshank, Red-necked Stint and Sharp-tailed Sandpiper) and Coorong water level at Coorong over the period of 2000 to 2018.](image)

**Native fish**

The 2017 evaluation of the Basin Plan found that overall, the condition of native fish in the Basin remains poor. Many of the short-lived species listed in the Basin-wide environmental watering strategy were not regularly found in Basin-wide surveys, and were not widespread.

In the northern Basin, drought conditions are severe. Many wetlands are disconnected and drying rapidly; many are highly likely to have dried over the summer of 2018–19. Consequently, there are
good populations of a number of important short-lived native fish species that are at risk of being lost.

Last year the drought refuge waterhole below Cunnamulla weir dried for the first time in living memory. Native fish were lost from the Warrego River for a distance below Cunnamulla weir, and did not return on the February to March 2018 flows. Reports on the Narran system indicate that of more than 30 refuge waterholes in that system, water remains in only three.

The northern Basin connectivity event helped maintain drought refuge waterholes and habitats, and provided some opportunities for native fish movement.

In the Lachlan River, ongoing monitoring has identified a number of accumulations of native fish below the Gin Gin and Jemalong weirs. Strong spawning of Murray cod has been detected in some areas, with strong cohorts of small Murray cod coming through. However, the numbers of Murray cod in the legal size range for angling are low. Pressure from fishing in the Lachlan system is high, particularly for golden perch and silver perch at the sites where accumulations occur, and for Murray cod more broadly.

Conditions in Victorian valleys are variable. Populations of Murray cod are doing well in anabranch systems of the River Murray that receive suitable flows (both environmental and operational) such as Gunbower Creek and Mullaroo Creek. However, in other systems such as the Wimmera and lower Loddon, pygmy perch, river blackfish and galaxias are under threat from dry conditions. In the Goulburn and Campaspe systems there is a risk that bulk operational transfers of water may impact on rainbow fish and the recruitment of Murray cod.

Coordinated flows targeting juvenile fish movement into suitable habitats is showing promise in the southern Basin. Delivery of water through the Murrumbidgee River and into Lake Yanga in 2017–18 resulted in an estimated 500,000 juvenile golden perch being observed, potentially benefiting from suitable nursery habitat that the lake provides. However, delivering flows needed to disperse fish remains a challenge in the lower Darling and in the River Murray.

In the Coorong and estuary, a single shortheaded lamprey was detected at a fishway on Goolwa barrage in October 2018. This is the first time the species has been detected in the Basin since winter 2011. Several pouchied lamprey were also captured and tagged in winter 2018, with some subsequently detected moving upstream through the lower River Murray fishways.

Abundances of upstream migrating common galaxias and congolli at the Murray barrages remained high in spring/summer 2018–19, reflecting continuous fishway operation and connectivity during the preceding period when adults migrated downstream to spawn in winter 2017. Ongoing monitoring of these species in spring/summer 2018–19 has detected ‘moderate’ abundances compared to previous years.

Recruitment of black bream was detected in the Coorong in autumn 2018 resulting from spawning that occurred between December 2017 and February 2018 following a low-volume peak in discharge from the barrages, supported by water for the environment.
In the Lower Lakes, intensive sampling has been undertaken in known Yarra pygmy perch habitat and likely suitable habitat. Despite this effort, no Yarra pygmy perch have been detected, leading to serious concerns about their status in the Basin. Further analysis is being conducted.

During the 2018–19 summer, there have been a number of major fish kills. In the lower Darling River, downstream of Menindee, many thousands of large-bodied species (Murray cod, golden perch) and possibly millions of small-bodied fish (including bony bream) have been lost due to poor water quality resulting from low/zero flows. Fish kills have also occurred in other Basin catchments. The implications of these fish kills are yet to be understood, however it will take many years of good conditions for the populations in the lower Darling, in particular, to recover. In January 2019, the Australian Government appointed an independent panel to assess the fish deaths in the lower Darling. The panel will review the cause of the event and make recommendations to government to improve future management.
Seasonal conditions

Overall, despite a number of significant rainfall events across the Basin in 2018, warm and dry conditions have prevailed from late 2016. For the 12 months to 31 December 2018, rainfall was below average to very much below average across the entire Basin, with widespread regions experiencing rainfall in the lowest 10% of years over the historical record (Figure 5).

In combination with temperatures that were either well above average or record-breaking across the Basin, the rainfall deficiencies in the northern Basin over 2018 resulted in low flow and cease-to-flow conditions in many major tributaries, while in the southern Basin inflows into the River Murray were around one third of the long-term average, or in the lowest 10% of years over the historical record since 1891.

2018 was the third warmest year on record for Australia since 1900. Mean temperatures across the Basin were in the top 10% of records, with areas in northwest NSW experiencing record-breaking temperatures.

The generally high temperatures throughout the year contributed to record rates of evaporation for winter and spring in NSW and Queensland. Evaporation for June to August 2018 was the highest on record for the Murray–Darling Basin. The high evaporation rates have exacerbated drought conditions across the Basin. In irrigation areas, this has meant higher demand for water over the growing season.

Surface water availability

The warm and dry conditions in the Basin over 2018 have resulted in lower public water storages in comparison with the corresponding period last year. Water storage for the Basin on 2 January 2019 was at 9,442 GL, or 42%, compared to 72% of capacity at the corresponding time last year. As for last
year, storage levels are quite variable across the Basin and the majority of this water is held in the southern Basin, particularly in the upper River Murray storages of Lake Hume and Lake Dartmouth. Storage levels in the northern Basin in early January were at 935 GL, or 20%, in comparison with storage levels of 7,969 GL, or 49% in the southern Basin. The Menindee Lakes storage was at 67 GL, or 4% of capacity, with Menindee Lake dry since 6 February 2018 and Lake Cawndilla also being dry. The Menindee Lakes are currently on red alert for blue-green algae.

The results of a comparison of public water storage levels of regulated systems across the Basin as at 1 December 2018 with the historical record, are reported in Table 1 of Appendix 1. Overall, the results were as follows: the Namoi and lower Darling were well below average; the Gwydir, Macquarie Castlereagh, Lachlan, Murrumbidgee, Murray, Loddon, Campaspe and Goulburn-Broken were below average; and the Border Rivers was above average.

Resource availability scenario for 2019–20

The resource availability scenario helps water managers plan the delivery of water for the environment. Determining the resource availability scenario involves analysis of rainfall, soil moisture and runoff (indicators of antecedent conditions) over the previous year and current surface water availability based on public water storage levels in regulated systems. The analysis includes a comparison of these conditions with the historic record.

The MDBA also takes account of the Bureau of Meteorology’s seasonal and longer-term forecasts; these provide an indication of potential changes in water resource availability over the months ahead.

The current water resource availability scenario has been assessed as being dry to very dry across the Basin (Appendix 1) with the results for catchments as follows:

- the Warrego, Border Rivers, Lachlan, Murrumbidgee, Goulburn-Broken and, Campaspe were assessed as ‘dry’; and
- the Condamine-Balonne, Moonie, Paroo, Gwydir, Namoi, Macquarie-Castlereagh, Barwon-Darling, Lower Darling, Murray, Ovens, Loddon, Wimmera-Avoca and Eastern Mount Lofty Ranges were assessed as ‘very dry’.

The method to calculate the resource availability scenario does not fully reflect all environmental water holdings that might be available due to carryover provisions. The MDBA and Bureau of Meteorology are working on refining the method. Carryover holdings are anticipated in some parts of the southern Basin, which may provide opportunities to improve environmental condition in some catchments.

Rainfall and flow conditions in 2019–20 are difficult to predict with any precision this far out. As such, the water resource availability could range from very dry to very wet conditions. Environmental water managers need to plan for all scenarios.
Implications of climate forecasts

Climate conditions over the months ahead will influence water resource availability. The seasonal outlook for rainfall from January to March 2019 is that conditions are likely to be drier than average for many catchments across the Basin, with the chance of drier than average conditions being highest in the northern Basin. For the southern Basin, January to March is historically a low rainfall period and given the Bureau of Meteorology’s outlook, significant inflows to the Murray are not likely between now and March. Both daytime and night time temperatures are likely to be warmer than average over January to March.

The latest El Niño Southern Oscillation Index (ENSO) Wrap-Up issued by the Bureau of Meteorology, on 8 January 2018 advised that tropical Pacific Ocean surface waters had returned to ENSO-neutral temperatures after exceeding El Niño levels in November and early December. The Bureau’s ENSO Outlook remains on El Niño ALERT.

Most models are currently indicating sea surface temperatures in the tropical Pacific are likely to remain near El Niño levels at least until early autumn 2019. If sea surface temperatures do maintain their anomalous warmth through summer, it increases the chance of El Niño emerging in 2019.

The positive Indian Ocean Dipole (IOD) event ended at the start of December 2018, and the IOD is currently neutral. The IOD typically has little influence on Australian climate from December to April, particularly when in a neutral phase.

Overall, and according to the latest seasonal forecast from the Bureau, climate conditions over the months ahead are likely to be mostly warmer and drier than average across the Basin.

The MDBA will update the resource availability scenario when it publishes the priorities in June to take into consideration any changes in seasonal conditions.
Environmental watering opportunities in 2019–20 to support Basin-scale outcomes

Basin catchments have dried out significantly since early 2018. Within this context, where water was provided for the environment during 2018 it has made a difference. Water for the environment has improved flows and connected rivers and wetlands, supported waterbirds and native fish recruitment and improved the condition of native vegetation in some places.

Given declining storages in the Basin and the outlook for continuing drier and warmer than average conditions in coming months, opportunities to deliver water for the environment in the coming water year are likely to be limited. In the northern Basin the MDBA anticipates that the focus for water managers will be to provide drought refuges and avoid irreversible loss of species. In some southern Basin catchments, carryover volumes may provide opportunities to maintain and to avoid decline in the condition of critical wetlands refuges, supporting native vegetation, waterbirds and native fish.

While this document anticipates a very-dry-to-dry outlook for 2019–20, the Basin environmental watering priorities to be published in June 2019 will provide guidance for all scenarios. This includes the rolling-multi-year priorities, which the MDBA further developed for the 2018–19 water year. The rolling, multi-year priorities include all resource availability scenarios and provide guidance for water managers to respond to changing conditions and adjust the outcomes sought for the river system accordingly. Conditions can change rapidly, as occurred in 2016, and rolling, multi-year priorities support water managers to adjust their water planning and delivery in response.

While environmental flows are important, there are other non-flow factors and risks that affect ecological communities. These include feral animals and land management practices. Managers should work together to achieve outcomes at multiple scales by being responsive to local conditions as well as natural climate signals.

River flows and connectivity

The long-term outcomes for flows and connectivity are to return river flows to a more natural pattern (flow regimes) and to re-establish connections along the river, and between the river and its floodplains and estuary (connectivity).

River flows and connectivity for the Barwon–Darling and lower Darling

Since the early 2000s the frequency and length of dry spells in the Barwon–Darling have been increasing, an effect which can be tied to both extraction and climate across the northern Basin. This trend has also affected water availability in Menindee Lakes and the flow characteristics downstream through the lower Darling.
The northern Basin connectivity event (see above) provided some relief to the upstream Barwon-Darling system by replenishing drought refuges and improving water quality, however minimal flow made its way to the Menindee Lakes (Lake Wetherell) and there was no measurable effect on lower Darling flows.

The Menindee Lakes storage was at 2% of capacity at 6 February 2019 and WaterNSW ceased releases from Menindee in mid-February. Block banks have been installed through the lower Darling, providing temporary local water storage. However, throughout both the Barwon-Darling and lower Darling rivers, drought refuges are stratifying and the need for fresh water to avoid anoxic conditions is important. Recent blue-green algae alerts and large fish kills highlight the deteriorating water quality in this area.

Dry conditions are continuing across the northern Basin and based on current environmental water availability, there is limited capacity to provide a flow through to Menindee Lakes. If the opportunity arises in response to rainfall, environmental water managers, managers of planned environmental water and water access right holders should coordinate flows to improve connectivity of the tributaries to the Barwon-Darling and, if possible, through to Menindee Lakes. Any first flush events will need to be carefully managed to ensure the flows are large enough to dilute the existing water or small enough to not disturb the stratification. Care should be taken to avoid the mixing of stratified layers without enough water to dilute and provide acceptable dissolved oxygen levels for fish in the waterholes.

Similarly, for the lower Darling, in response to any inflows, water managers should seek opportunities to supplement operational releases from Menindee Lakes to increase connectivity and enhance environmental outcomes.

**River flows and connectivity for the Narran Lakes**

Narran Lakes is a Ramsar-listed wetland of almost 8,500 ha that provides valuable breeding and feeding habitat for waterbirds. There has been almost no flow into the lakes since April 2017 and it is a priority for receiving water. Analysis of achievement of environmental water requirements for Narran Lakes developed by the MDBA has shown that none of these specific flow requirements have been met since 2012 (however 2016 came close to meeting the 25 GL indicator which will have provided partial outcomes for some parts of the ecosystem). As these water requirements are key known inundation thresholds to achieve functional requirements and outcomes for the Narran Lakes, they are an indicator of the high risk to the high environmental values of the site (see above for context on environmental water requirements).

Should the opportunity arise to get water down the system to the Narran Lakes, an event-based mechanism could be used whereby trade or temporary purchase of allocations could protect an unregulated event. Typically, a medium flood at St George is needed to trigger the 25 GL inflow action for Narran Lakes. This would provide for full connectivity along the Narran, triggering fish migration and enhancing water delivery into the Narran site, inundating core waterbird breeding habitat. However, in the absence of sufficient inflows, which is likely given the current forecast, efforts should focus on filling waterholes in the Narran River system and, if possible, enhancing a medium to large fresh to trigger fish migration and connectivity to Narran Lakes.
River flows and connectivity in Koondrook-Perricoota
The absence of larger floodplain watering (natural or using environmental water) between 2012 and 2016 in Koondrook-Perricoota Forest has meant the benefits of natural flooding in 2010–11 and 2011–12 have not been sustained. The works at this site have been operated only once, in 2014–15 when 26 GL was delivered to test them. As a result, most of the indicators of condition at Koondrook-Perricoota are poor or showing signs of decline.

It is particularly important to achieve lateral connectivity at the site to inundate permanent and semi-permanent wetlands, floodplain understorey and river red gum sites. All other icon sites in the Upper Murray are generally improving as a result of natural flooding and subsequent watering using regulators installed at the sites. Therefore, if seasonal conditions are appropriate and the opportunity arises within the context of the water resources available, getting water into Koondrook-Perricoota and overcoming constraints that limit effective use of the works with water delivery is seen as a priority.

River flows and connectivity in the Coorong
Being at the end of the system, the Coorong, Lower Lakes and Murray Mouth complex is one part of the Basin that has been most affected by decades of reduced flow. Improving conditions in the Coorong requires a long-term approach as many of the key species and ecological processes within the system require specific flow regimes over multiple years. Although high flows in 2016 benefited this Ramsar area, it remains a watering priority.

Restoring connectivity by increasing flows along the River Murray and its tributaries to the sea supports vital ecosystem functions. These include moving salt, nutrients and sediment through the Murray Mouth and allowing native fish to move between marine, estuarine and freshwater environments. Without sufficient flows, salinity increases and connectivity between the ecosystems declines.

Achieving river flows and connectivity in the Coorong are dependent on a range of factors. Any opportunities to coordinate watering events from the tributaries to the River Murray should be used to help build flow events for the Coorong. Where possible, and subject to discussion with potentially affected landholders, the delivery of flows up to 18,000 ML day downstream of Yarrawonga should be sought. This should be complemented by appropriate policy and operational procedures such as return flow provisions and seasonally appropriate operation of the Lower Lakes to allow flows to pass through the barrages.

This environmental watering opportunity for 2019–20 builds on priorities from previous years with the aim of maintaining minimum hydrological connectivity between the freshwater, estuarine and marine environments in the Coorong. There is an inherent trade-off, particularly under dry conditions, between maintaining connectivity through the barrages and supporting Lower Lakes fringing wetlands which means it is difficult to fully achieve both objectives. Under drier conditions, continued connectivity between the lakes and Coorong should be maintained where possible.
Native vegetation

The long-term outcomes sought for native vegetation within the managed floodplain are to maintain the extent, improve condition and promote recruitment (where appropriate).

Watering opportunities for native vegetation in 2019–20 are likely to be influenced by drought conditions and very dry resource availability scenario across much of the Basin. While these conditions have affected many of the Basin’s water-dependent vegetation communities, some areas that received follow-up watering after widespread rainfall in 2016 have maintained condition.

Some river red gum and lignum communities that received targeted deliveries of water for the environment in 2017–18 and 2018–19, and riparian communities supported by consumptive deliveries, are unlikely to require targeted watering in 2019–20. Opportunities to support higher floodplain river red gum and lignum communities that have not been inundated since the 2016 flood event will help to build resilience to protect against forecast low water availability.

Many black box and coolibah communities may be harder to reach with available environmental water in 2019–20 under a very dry resource availability scenario. Complementary measures may provide opportunity to support these vegetation communities through the current dry period.

Maintaining core wetland areas is likely to be a key priority in the coming water year to protect vulnerable non-woody wetland vegetation, and also maintain critical refuge habitat in the drying landscape.

Signs of ongoing decline in the resilience of *Ruppia tuberosa* in the Coorong indicate the Coorong is likely to remain a watering priority into 2019–20.

Waterbirds

The long-term outcomes sought for waterbirds are to increase abundance and maintain species diversity. Achieving these objectives for the Basin’s waterbird population under dry conditions is quite limited. In catchments with a very dry resource availability scenario, the appropriate annual strategy will be to avoid loss of foraging and roosting habitat at refuge locations, which includes the Corop wetlands, Fivebough Swamp, Lowbidgee floodplain, Pyap Lagoon, River Murray and Euston Lakes and upper Darling River.

In those catchments with a dry resource availability scenario, the appropriate annual strategies will be to maintain foraging and roosting habitat at refuge locations (refer site list above) and where possible support breeding events at important breeding sites. These include Barmah-Millewa Forest, Booligal wetlands, Lower Lakes Coorong and Murray Mouth, Great Cumbung Swamp, Gunbower-Koondrook-Perricoota, Gwydir wetlands, Hattah Lakes, Kerang wetlands, Lake Brewster, Macquarie Marshes and Narran Lakes. Not all sites may be applicable in 2019–20.

Providing roosting and foraging habitat at refuge sites will be important for waterbirds during the dry conditions to ensure that waterbird numbers are sustained and that individuals are healthy enough to breed when climatic conditions improve. This is particularly important given waterbird numbers in the Basin have been low for the last six years and there has been limited breeding.
Strategies to maintain the abundance of shorebirds in the Coorong and Lower Lakes under dry conditions are similar to those mentioned above (providing for foraging and roosting habitats) but also include managing water quality issues and algal blooms at key foraging sites such as the Coorong.

Should conditions improve and watering opportunities arise, there are a number of sites which need watering to support waterbirds. Of particular importance are:

- Narran Lakes, which has been identified as an important Basin environmental asset for waterbird abundance and diversity, colonial waterbird breeding and shorebird abundance, and urgently needs environmental water to maintain waterbird breeding and foraging habitat. As mentioned above, with the exception of a small flow event in spring 2016 of around 25 GL, the last significant inflow into Narran Lakes was in April 2013. The MDBA encourages innovative approaches to enhance inflows into Narran Lakes, such as event-based mechanisms for the protection of environmental flows, to improve the condition of waterbird breeding and foraging habitat, thus helping the wetland to support colonial waterbird breeding events into the future.

- Koondrook-Perricoota Forest, which has been identified as an important Basin environmental asset for colonial waterbird breeding, urgently needs watering to avoid loss and maintain waterbird habitat. The habitat on the lower to mid-floodplain received some natural flows in 2012 and 2016–17, however monitoring of vegetation suggests that it is still in poor condition. Importantly, the habitat on higher elevations in the forest, which is required to support large scale breeding events, is also in poor condition.

- The Coorong and Lower Lakes, identified as an important Basin environmental asset for waterbird abundance and diversity, colonial waterbird breeding and shorebird abundance, supported the largest area of breeding in 2018. If conditions allow, watering to support juvenile waterbirds should be done to build upon limited breeding that occurred in 2018, helping to increase the abundance of waterbirds in the Basin. The Coorong is also a critical site for shorebirds, and the 2018 survey demonstrated a small increase in shorebirds from the 2017 surveys, where numbers had dropped to their lowest on record. A watering opportunity in 2019–20 will be to actively manage water levels and other threats to improve foraging opportunities for shorebirds in the Coorong.

**Native fish**

The long-term outcomes sought for native fish are to support Basin-scale population recovery by reinstating flows that promote key ecological processes across local, regional and system scales. This will be vital to assist in the recovery of native fish populations affected by the numerous fish kills that occurred during the summer of 2018–19.

To maintain and improve native fish populations in the Basin, environmental watering opportunities that improve habitat, increase ecological function and promote recruitment processes including dispersal and movement, should be taken. The opportunities may be local, regional or system-wide,
however all actions will contribute to a diverse native fish community and improve population sustainability.

In the coming years it will be important to support the survival of threatened species and communities, maintain drought refuges during dry conditions, and enable growth, reproduction and recruitment for a range of species as conditions improve or when opportunities arise.

In the current dry conditions, the focus of environmental water across the Basin should be on maintaining adequate water quality and sufficient habitat to allow existing populations of native fish to survive. At the Basin-scale, base flows, low flows and small freshes in rivers will help support fish survival. These types of flows will also provide opportunities for local scale recruitment, particularly of short-lived species.

The main focus should be on actions that protect refuges and in-stream habitats, maintain river connectivity and secure water supply to key populations. Flows can be provided to ensure that essential functions for these populations can be met as well as allowing small-scale movements to occur. For example, if the opportunity arises, flows should be provided to support valuable populations (e.g. in the Barwon-Darling) to support native fish repopulation and recovery.

In the River Murray system, where there are opportunities to use water for the environment in-channel, actions should aim to provide suitable flowing habitat, maintain or improve fish condition and improve recruitment outcomes. This can include supplementing operational flows at important times during the recruitment cycle, such as creating pulses to promote migration and spawning in spring and/or pulses that promote dispersal of young fish into new areas throughout the system. Providing suitable flows in anabranch systems throughout the year will also be important for native fish species that use those habitats to live, feed and breed. Connections between tributaries and major rivers, especially between the River Murray and the lower Darling River (if conditions allow), will enhance long-term population resilience and recovery. Flows that provide connections with off-channel nursery habitats containing young fish, such as Yanga Lake in the Murrumbidgee, are also important to improving Basin-wide populations.

Flows through the barrage fishways in winter and early spring will allow estuarine and diadromous fish to move between fresh and saline water as required to complete their recruitment. The connectivity between the estuary and freshwater is critical to maintain a functional fish community at the end of the river system. If conditions allow, barrage flows in late spring/early summer can support movement of young congolli and galaxias from the estuary into suitable habitat in the Lower Lakes.

Environmental water delivery to maintain off-channel habitats that support critical populations of threatened fish will also be important in the dry conditions. Many of the Basin’s threatened species live in floodplain and wetland habitats, which are most vulnerable to dry conditions. Many off-channel habitats require large freshes or overbank flooding to replenish them, and may not have received natural flooding for many years. Active management, such as use of floodplain infrastructure or pumping of water, may be required to maintain or replenish these sites and keep important populations alive until conditions improve.
If conditions improve, or when opportunities arise, the use of environmental water to support recruitment and distribution of important fish species should be considered to help recover populations affected by fish kills and low flow conditions. In the northern Basin, environmental water managers should take opportunities to support, or provide, flows that improve connectivity and access to habitat throughout the river system. This includes replenishing waterholes that provide drought refuges.
Figure 6: Resource Availability Scenario as at 1 December 2018

1. This figure has been produced on the results of the RAS calculation presented in Table 1. Where the RAS is expressed as a range in Table 1 (e.g. ‘wet-to-very-wet’), the lower value (i.e. ‘wet’, in this example) has been used in the production of the figure. Where the RAS in Table 1 spans three values, the middle value is used in the production of the map (e.g. if the results in Table 1 span ‘dry-to-wet’ then, the RAS used in the production of the map would be ‘moderate’).
Table 1: Antecedent climate conditions and water storage levels for the catchments of the Murray–Darling Basin for the year to 1 December 2018

<table>
<thead>
<tr>
<th>Catchment (Regulated = R; Unregulated = Unreg)</th>
<th>Precipitation</th>
<th>Root zone soil moisture</th>
<th>Runoff</th>
<th>Antecedent percentile range</th>
<th>Surface water percentile</th>
<th>Resource Availability Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Rivers (R)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>61-85%</td>
<td>Dry</td>
</tr>
<tr>
<td>Gwydir (R)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>16-45%</td>
<td>Very dry</td>
</tr>
<tr>
<td>Namoi (R)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>Very dry</td>
</tr>
<tr>
<td>Macquarie–Castlereagh (R)</td>
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<td>0-15%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>16-45%</td>
<td>Very dry</td>
</tr>
<tr>
<td>Lachlan (R)</td>
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<td>0-15%</td>
<td>46-60%</td>
<td>0-15% to 46-60%</td>
<td>16-45%</td>
<td>Dry</td>
</tr>
<tr>
<td>Murrumbidgee (R)</td>
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<td>0-15%</td>
<td>46-60%</td>
<td>0-15% to 46-60%</td>
<td>16-45%</td>
<td>Dry</td>
</tr>
<tr>
<td>Lower Darling (R)</td>
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<td>61-85%</td>
<td>0-15% to 61-85%</td>
<td>0-15%</td>
<td>Very dry</td>
</tr>
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<td>Murray (R)</td>
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<td>0-15%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>16-45%</td>
<td>Very dry</td>
</tr>
<tr>
<td>Loddon (R)</td>
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<td>16-45%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>16-45%</td>
<td>Very dry</td>
</tr>
<tr>
<td>Campaspe (R)</td>
<td>16-45%</td>
<td>16-45%</td>
<td>16-45%</td>
<td>16-45%</td>
<td>16-45%</td>
<td>Dry</td>
</tr>
<tr>
<td>Goulburn–Broken (R)</td>
<td>16-45%</td>
<td>16-45%</td>
<td>16-45%</td>
<td>16-45%</td>
<td>16-45%</td>
<td>Dry</td>
</tr>
<tr>
<td>Wimmera-Avoca (UnReg)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>N/A</td>
<td>Very dry</td>
</tr>
</tbody>
</table>
## Basin Environmental Watering Outlook for 2019–20

### Resource Availability Scenario

<table>
<thead>
<tr>
<th>Catchment2 (Regulated = R; Unregulated = Unreg3)</th>
<th>Precipitation</th>
<th>Root zone soil moisture</th>
<th>Runoff</th>
<th>Antecedent percentile range</th>
<th>Surface water percentile</th>
<th>Resource Availability Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moonie (Unreg)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>N/A</td>
<td>Very dry</td>
</tr>
<tr>
<td>Barwon–Darling4 (Unreg)</td>
<td>16-45%</td>
<td>0-15%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>N/A</td>
<td>Very dry</td>
</tr>
<tr>
<td>Condamine–Balonne (Unreg)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>N/A</td>
<td>Very dry</td>
</tr>
<tr>
<td>Paroo (Unreg)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>0-15%</td>
<td>N/A</td>
<td>Very dry</td>
</tr>
<tr>
<td>Warrego (Unreg)</td>
<td>16-45%</td>
<td>16-45%</td>
<td>16-45%</td>
<td>16-45%</td>
<td>N/A</td>
<td>Dry</td>
</tr>
<tr>
<td>Ovens (Unreg)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>N/A</td>
<td>Very dry</td>
</tr>
<tr>
<td>Eastern Mt Lofty Ranges (Unreg)</td>
<td>0-15%</td>
<td>0-15%</td>
<td>16-45%</td>
<td>0-15% to 16-45%</td>
<td>N/A</td>
<td>Very dry</td>
</tr>
</tbody>
</table>

2. Based on the best quality data available at the time of writing for public water storages in the Basin. Private water storages have not been included in calculation of the RAS.
3. For unregulated catchments only antecedent climate conditions can be applied to determine the RAS given these catchments either do not have public water storages or have only small water storages that are unlikely to play a role in environmental watering.
Office locations
Adelaide
Albury–Wodonga
Canberra
Goondiwindi
Toowoomba

mdba.gov.au 1800 230 067 engagement@mdba.gov.au