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MURRAY–DARLING BASIN AUTHORITY

Basin environmental watering priorities

Overview and technical summaries

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GPO Box 1801, Canberra ACT 2601
engagement@mdba.gov.au
1800 230 067
mdba.gov.au

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin
The Murray−Darling Basin Authority pays respect to the Traditional Owners and their Nations of the Murray−Darling Basin. We acknowledge their deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

The guidance and support received from the Murray Lower Darling Rivers Indigenous Nations, the Northern Basin Aboriginal Nations and our many Traditional Owner friends and colleagues is very much valued and appreciated.

Aboriginal people should be aware that this publication may contain images, names or quotations of deceased persons.

Contents

Executive summary

The Murray–Darling Basin Authority has developed environmental watering priorities to guide the annual planning of environmental watering across the Basin. The priorities are the actions needed to help achieve the Basin Plan's long-term objectives of protecting and restoring the Basin's rivers, wetlands and floodplains.

Since the Basin Plan took effect, 2,106 gigalitres (GL) of water has been recovered for the environment that sustains Basin communities and benefits the nation. Environmental water managers have developed innovative ways to use this water effectively and efficiently, including making the best use of other water in the system to enhance the benefits for the Basin's water-dependent ecosystems.

The first assessment of progress, the 2017 Basin Plan Evaluation (the Evaluation), showed that there are early signs of improvement in the condition of some of the Basin's rivers and wetlands. Where environmental water has been delivered, local improvements are evident. However, the MDBA's report on key ecological sites along the River Murray, released in April 2018, concluded that while sites had responded to environmental watering, water alone is not enough to achieve the scale of improvements needed.

Overall, the Evaluation found site and reach-scale improvement in the environmental condition of the Basin's rivers, but achieving broad system-scale improvements will require many more years of careful management.

Policy and operational impediments continue to limit the ability of environmental water managers to restore some parts of the flow regime in the Basin. Without improvement in the timing (seasonality) and volume of flows, the condition and recovery of native fish populations, native vegetation communities and waterbirds will fall short of the long-term ecological outcomes envisioned by the Basin Plan.

The scale of the task is immense; Basin-scale improvements will take many years to become evident. This is recognised in the Basin-wide environmental watering strategy which sets the long-term outcomes we are working to achieve.

The first of the targets in the strategy and the Basin Plan to measure progress towards the overall environmental objectives for water-dependent ecosystems is that there is *no loss or degradation* by 30 June 2019. This is followed by *improvements* in subsequent years. We have set priorities for 2018–19 that reflect this 2019 target and the learnings from the Evaluation. This includes for the first time a priority to improve flows along the rivers (longitudinal connectivity) out to the floodplains (lateral connectivity) and to the end of the Murray–Darling river system.

Opportunities to use water recovered for the environment under the Basin Plan are influenced by prevailing climatic conditions. For much of the period between 2012 and 2017, dry conditions dominated the Basin climate. After relatively wet conditions for large parts of the Basin in 2016 and early 2017, the Basin has experienced a drying trend over the past 12 months.

For the forthcoming water year, the MDBA is planning in anticipation of dry conditions in the northern Basin and moderate conditions in the southern Basin. In 2018–19, the focus is on opportunities to maintain, and in some cases improve, key elements of the Basin's river system where water is available. The Barwon–Darling and the Lower Lakes, Coorong and Murray Mouth are a particular focus for the coming water year given their current condition.

In drier areas, the focus is on avoiding irreversible impacts on species, vegetation communities and important sites, and managing the risks to water quality to protect ecological functions and critical human water needs.

However, the Australian climate is sometimes subject to relatively rapid and extreme change, as evidenced by the reversal from dry-moderate conditions to extreme wet conditions in mid-2016. For this reason, this report includes recommendations for a range of water availability scenarios. Should climatic conditions change significantly over coming months, the MDBA will issue an update to this report to recognise the changed opportunities for environmental water managers.

A key theme of this report, and of the wider environmental management framework that sits under the Basin Plan, is that Basin-scale outcomes require Basin-scale solutions. Environmental water use is most effective when it spans state and catchment borders — both the northern and southern Basins have benefited from coordinated cross-government water use in recent years. This cooperative principle is especially important given that dry-to-moderate conditions are anticipated to continue for many months. Basin governments and environmental water holders are encouraged to build upon established cooperative arrangements to maximise environmental outcomes over the coming year.

Overview of the Basin environmental watering priorities

The Basin annual environmental watering priorities (the priorities) guide the annual planning and prioritisation of environmental watering across the Murray–Darling Basin. They represent annual steps toward the long-term outcomes in the *Basin-wide environmental watering strategy* and are prepared to help deliver the Basin Plan's objectives of protecting and restoring the Basin's rivers, wetlands and floodplains.

This report has been produced principally for managers of environmental water (the Commonwealth Environmental Water Holder (CEWH) and Basin states), who will be guided by the Basin-wide priorities outlined in this report when they undertake environmental watering.

The MDBA has prepared this report in accordance with the requirements in Chapter 8 of the Basin Plan, including consultation with members of the Environmental Watering Working Group representing Basin governments, and with river operators.

This document lists environmental watering priorities by four themes: river flows and connectivity, native vegetation, waterbirds, and native fish. Basin-scale priorities include:

- delivering flows in the northern and southern Basin with particular attention on the Barwon–Darling to reduce cease-to-flow events and benefit native fish, and the Lower Lakes, Coorong and Murray Mouth to support native fish, vegetation and shorebirds
- delivering water, where possible, to important sites for waterbirds which need watering to improve habitat
- supporting threatened native fish species to expand range and establish new populations.

As part of our continuous improvement and adaptation to the evolving practice of environmental water management, the MDBA has moved to develop watering priorities that span multiple years and differing water resource availability scenarios. These are the 'rolling, multi-year priorities'. This approach recognises that an annual prioritisation process is more effective when it connects to both longer and shorter time frames.

Rolling, multi-year priorities are medium-term outcomes that are guided by the MDBA's long-term Basin-wide environmental watering strategy. The rolling, multi-year priorities guide environmental watering over the medium term (i.e. the next 3–5 years) to achieve the expected environmental outcomes identified in the Basin-wide environmental watering strategy.

To assist in achieving the multi-year priorities, Basin annual environmental watering priorities have been developed for each of the resource availability scenarios. The annual watering priorities for any given time are dictated by the current best estimate of the resource availability scenario over the next year.

This framework provides for annual watering priorities to be adaptable to prevailing climatic conditions over the next water year recognising that water managers often need to adapt their

watering strategies in response to significant changes in water resource availability. The framework also provides insight to the likely annual watering priorities in the forthcoming water years to assist in future planning.

The outcomes sought through these Basin-scale priorities are complemented by outcomes targeted at local and regional scales through the work of the Commonwealth Environmental Water Holder and Basin states managing water for the environment.

Climate context for 2018–19

The MDBA assesses seasonal conditions for the upcoming water year (the resource availability scenario) in each Basin catchment based on the past year's climate conditions (rainfall, runoff and soil moisture) and surface water availability in public dams in regulated catchments. We also consider the Bureau of Meteorology's climate outlook and El Niño–Southern Oscillation wrap up. In addition, we consult with environmental water managers.

The objectives sought from providing water for the environment are influenced by seasonal conditions. This means not all priorities are relevant each water year. Identifying which priorities to use will depend on the resource availability scenario and the condition of the area in question.

The assessment of the current resource availability scenario for Basin catchments, updated since the MDBA published the *Basin environmental watering outlook 2018–19* (the Outlook), is as follows:

- Warrego, Paroo and Lower Darling as 'very dry'
- Gwydir, Namoi, Macquarie–Castlereagh, Barwon–Darling, Condamine–Balonne, Moonie, Loddon, Campaspe, Wimmera–Avoca, Eastern Mt Lofty Ranges and Ovens as 'dry'
- Border Rivers, Lachlan, Goulburn–Broken, Murrumbidgee and Murray as 'moderate'.

For the forthcoming water year, the MDBA is planning in anticipation of dry conditions in the northern Basin and moderate conditions in the southern Basin. More information on the assessment of the water resource availability scenarios in the Basin is provided in Appendix 1.

Influence of climate forecasts

While seasonal and longer-term climate forecasting are not included in the assessment of water resource availability in the Basin, the MDBA uses this contextual information to provide an indication of changes in water resource availability that may emerge over the months ahead.

At the time this report was being prepared, the seasonal forecast for rainfall in the Basin from May to July 2018 is for generally average conditions, tending slightly towards lower than average rainfall in southwestern parts of the Basin. Daytime temperatures are likely to be warmer than average for southern and eastern parts of the Basin.

The Bureau of Meteorology announced on 13 March 2018 that the weak La Niña event over summer 2017–18 had ended with the El Niño–Southern Oscillation (ENSO) indicator returning to neutral. Most climate models are now indicating the most likely scenario is for the ENSO indicator to remain

neutral through autumn and winter. The Indian Ocean Dipole (IOD) is also currently neutral. However, three of the six international climate models indicate a negative IOD is possible during winter. During negative IOD events, southern Australia typically experiences a wetter than average winter-spring.

Climate model outlooks for both the ENSO and IOD have lower accuracy during autumn than at other times of the year. This means current model outlooks of these climate drivers should be viewed with caution.

Current conditions

Overall, climate conditions across the Basin over the year to 30 April 2018 were predominately warm and dry. The dry conditions over the 2017–18 water year are in strong contrast with the previous year which experienced record rainfall for May to September 2016.

In 2017, mean annual temperatures were well above average across the Basin for the fifth consecutive year, with many regions experiencing record-breaking temperatures. Warmer than average temperatures persisted into autumn 2018, with many regions of the Basin recording the hottest April on record.

Rainfall was predominantly below average across the Basin with patches of very much below average rainfall, particularly in the northern Basin. While a number of significant rainfall events occurred in the southern and northern basins over the 2017–18 water year, these events were not sufficient to fill the rainfall deficits that had emerged in winter and spring 2017.

The southern Basin experienced a dry winter and spring followed by warm temperatures in summer that increased evaporation. Low inflows were boosted by summer rain and in some catchments, water is available in storage. The northern Basin experienced generally warmer and drier conditions from winter through to summer. Inflows were low and cease-to-flow conditions occurred along sections of a number of major tributaries and rivers including the Barwon Darling, Namoi and Gwydir. Heavy rain in late summer and early autumn in Queensland increased flows in the Moonie, Warrego and Culgoa rivers, delivering modest inflows to the Barwon–Darling through April and May 2018. However, the flows were insufficient to fully replenish drought refuge waterholes, or substantially improve connectivity between waterholes.

In response, the Commonwealth Environmental Water Holder partnered with the NSW Office of Environment and Heritage in approving up to 31 gigalitres of environmental water to build on the natural flows and provide for connectivity across multiple river systems in the northern Basin.

Basin environmental watering priorities

The priorities in this report are essential steps to support the achievement of the expected environmental outcomes set out in the Basin-wide environmental watering strategy and through them, the Basin Plan ecological objectives and targets.

The priorities are set out as rolling, multi-year priority frameworks that cover each resource availability scenario. Basin annual environmental watering priorities are listed within these frameworks for each resource availability scenario.

If conditions change across catchments within the year, the annual priorities also change. This allows environmental water managers to change strategy in response to changes in conditions in specific catchments.

Annual guidance has also been provided to assist water managers to implement the annual priorities in the coming water year, based on anticipated seasonal conditions and emerging issues that need to be supported or ameliorated with environmental water.

The rolling, multi-year priorities are:

- Support lateral and longitudinal connectivity.
- Freshwater connectivity through the Coorong, Lower Lakes and Murray Mouth.
- Maintain and improve the condition and promote recruitment of forests and woodlands.
- Improve the condition and extent of lignum shrublands.
- Improve the condition and extent of Moira grass in Barmah–Millewa Forest.
- Expand the extent and improve resilience of *Ruppia tuberosa* in the southern Coorong.
- Improve the abundance and maintain the diversity of the Basin's waterbird population.
- Maintain the abundance of key migratory shorebird species in the Coorong and Lower Lakes.
- Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
- Improve flow regimes and connectivity to maximise the ecological function of the Barwon–Darling river system for native fish.
- Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.

While implementation of actions to contribute to these priorities should be straightforward, it will require careful application by water managers. The MDBA's recommended approach is that water managers first have regard to the annual guidance, since it is specific in nature, and second have regard to the multi-year priority frameworks, as these are general in nature. With respect to the latter, these priorities encompass the full range of seasonal conditions (i.e. the resource availability scenario from very dry to very wet) and managers should implement the relevant scenario for their catchment. The MDBA has identified the current resource availability scenario and will advise if it changes substantially.

Implementing the priorities will require effective use of *all* water, including consumptive water on route to users. Any watering decision made to meet these priorities will need to consider current constraints and include consultation with stakeholders.

The MDBA is planning in anticipation of continuing dry conditions, noting that water storages in the southern Basin are at moderate levels and it may be possible to improve the Basin environment.

Providing water to the environment in dry times is critical to restoring the long-term condition of the Basin's rivers, wetlands and floodplains, and improving the health and abundance of native fish, waterbirds and native vegetation that rely on a healthy river system. In dry conditions, the focus of delivering water for the environment is on mitigating irreversible impacts and protecting the viability of threatened species and communities, for example by providing drought refuges to support survival.

In 2018–19, the MDBA anticipates the focus for water managers will be:

- in drier catchments, on in-channel events, areas of the floodplains close to the main rivers, providing drought refuges and supporting critical habitats and ecological processes
- -iIn catchments that are wetter, to further consolidate the improvements of the past two seasons, improving the condition of rivers and floodplains so they can support future breeding and recruitment, and be better prepared to survive drier times.

Environmental water managers should also be ready to respond if conditions change, to maximise the benefits of wetter conditions or shift focus if drier conditions develop.

Annual guidance for 2018–19

River flows, connectivity and end-of-basin flows

- Support opportunities for lateral connectivity between the river and adjacent low-lying floodplains and wetlands to reinstate natural nutrient and carbon cycling processes
- Coordinate replenishment flows across multiple tributaries to maintain habitat condition and regulate water quality, carbon and nutrients in refuges along the Barwon–Darling watercourse
- Maintain seasonally appropriate water levels and support a suitable salinity gradient in the Coorong; provide regular flows for fish movement and salt export though the barrages

Native vegetation

- Enable growth and maintain the condition of lignum shrublands
- Maintain Ruppia tuberosa extent in the southern Coorong

Waterbirds

- Provide flows to improve habitat and support waterbird breeding
- Maximise availability of productive foraging habitat for shorebirds

Native fish

- Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin
- Improve flow regimes and connectivity to maximise the ecological function of the Barwon–Darling river system for native fish
- Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations

State priorities

The Basin states are required to provide the MDBA with annual environmental watering priorities in each water resource plan area by 31 May each year. The MDBA has received annual priorities from New South Wales, Victoria, South Australia and Queensland that list priorities at a regional scale. The MDBA had regard to these regional priorities as it finalised the Basin-wide priorities.

The 2018–19 Basin state priorities generally complement the Basin-wide priorities in this report. This is the result of consultation on the needs and opportunities for environmental watering within the framework provided by the Basin Plan and the Basin-wide environmental watering strategy. An example of Basin state priorities and Basin priorities complementing one another is maintaining foraging habitat for waterbirds in the Macquarie Marshes, Gwydir wetland and the Lowbidgee floodplain.

The MDBA and Basin states have different but complementary roles in planning environmental watering. This means that the Basin priorities are not an exclusive list — state priorities may be more

detailed at the regional scale. Additionally, many regional priorities will support and contribute to the expected environmental outcomes outlined in the Basin-wide environmental watering strategy.

Aboriginal environmental outcomes

An important aspect of the MDBA's role, and of the Basin Plan, is to foster *connection* across the Basin. This includes the physical connections between rivers and floodplains, or the upstream-to-downstream flow connection to support a healthy river system. But it also includes the promotion of social and cultural connection across the Basin – supporting water management and policy development that crosses state and catchment borders, and includes the voices of all people who rely on a healthy working Basin.

Statement of Commitment: Incorporating Aboriginal environmental values and outcomes into Basin environmental watering priorities

The MDBA recognises that Aboriginal peoples' knowledge of Country can contribute to better environmental water planning. Inclusion of Aboriginal cultural objectives in water planning will also support cultural continuity, contribute to Aboriginal communities, and build capacity for managing and accessing water into the future. The MDBA is committed to incorporating Traditional Owner knowledge into environmental watering planning and management.

Independent, culturally authoritative and strategic input from Aboriginal people into environmental water planning can improve environmental watering decisions. Managing environmental water in ways that incorporate Aboriginal people's objectives for healthier rivers and wetlands will improve wellbeing and cultural resilience. Considering the local knowledge of Aboriginal communities in environmental water planning decisions will also help to improve outcomes of environmental watering and the health of Country.

The Murray Lower Darling Rivers Indigenous Nations (MLDRIN) and the Northern Basin Aboriginal Nations (NBAN) are working with the MDBA on ways to integrate Aboriginal people's perspectives into annual and long-term environmental water planning, including the incorporation of Aboriginal environmental outcomes.

Aboriginal environmental outcomes describe tangible physical benefits that can be derived from environmental watering for Aboriginal people, such as improved populations of culturally significant fish species or improved health of important cultural landscapes. Last year the MDBA published two case studies (*MLDRIN Aboriginal environmental outcomes in Gunbower Forest* and *NBAN Aboriginal environmental outcomes in the Macquarie Marshes)* that described where Aboriginal environmental outcomes have occurred locally from past environmental watering events.

When responsive to Traditional Owner objectives, environmental watering can provide complementary cultural benefits, but it is not able to provide all of the outcomes that cultural flows could provide. Cultural flows are water entitlements that are legally and beneficially owned by

Aboriginal Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, natural, environmental, social and economic conditions of those Nations.

This year the MDBA will progress the inclusion of Traditional Owner objectives in environmental water planning by partnering with NBAN and MLDRIN to develop Aboriginal environmental values and outcomes guidance. This work will provide a platform for MLDRIN, NBAN, and Aboriginal Nations across the Basin to provide long-term strategic advice on Aboriginal environmental values and outcomes at the Basin scale.

The MDBA will incorporate this information into the development of the 2019–20 priorities. This guidance will outline Aboriginal Nations' cultural objectives across the Basin and the outcomes they would like environmental watering to achieve on Country. In addition, we will also begin to develop a framework that will meaningfully and transparently incorporate Traditional Owner input into our policy.

The first step is to collaborate with NBAN, MLDRIN, environmental water holders and Basin government agencies to identify and consolidate information that provides guidance on the condition of Country and Aboriginal peoples' values of, and desired outcomes for, environments across the Basin.

Working in partnership with NBAN and MLDRIN will facilitate knowledge sharing between Aboriginal peoples and water planners. In addition, the MDBA will work with emerging Aboriginal natural resource managers from NBAN and MLDRIN to develop their skills in environmental water planning and management.

Technical summaries of the Basin environmental watering priorities

River flows and connectivity

Irrigated agriculture has intensely modified the natural flow regime in many of the Basin's rivers, to the detriment of water-dependent ecosystems and risking the sustainability of the river system. To arrest further decline, and restore the river system to health, the Basin Plan has returned more water to the river, securing the benefits of a healthy Basin for future generations of Australians.

Returning parts of the natural flow pattern is a central element of river restoration and a concept adopted by the Basin Plan to restore and protect environmental assets and functions. To achieve this, the Basin-wide environmental watering strategy sets objectives for river flow regimes, the connectivity of rivers and their floodplains, and the condition of the environment at the end of the Basin. For more information about the current condition of river flow and connectivity in the Basin, see the Basin environmental watering outlook 2018–19 (the Outlook).

Rolling, multi-year priorities for river flows and connectivity

Building towards these objectives, this is the first time the MDBA has included specific priorities for lateral and longitudinal connectivity and end-of-basin flows. These priorities aim to return river flows to a more natural pattern (flow regimes) and re-establish connections along the river, and between the river and its floodplains and estuary (connectivity).

The rolling, multi-year priorities for river flows and connectivity are to:

- Support lateral and longitudinal connectivity along the river systems.
- Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.

Support lateral and longitudinal connectivity along the river systems

Many plants and animals in the Basin rely on river flows for water, food and habitat, as well as to support the cycle of wetting and drying that underpins various stages of their life cycle. The connection between rivers and their anabranches, wetlands and floodplains is referred to as *lateral connectivity*, which is associated with in-channel pulses, bankfull and overbank flow events. These events support a range of ecosystem functions including providing habitat, cycling nutrients and carbon, and providing a natural cue for feeding, breeding and movement – which underpin the food web for native fish, waterbirds and native vegetation.

The connection along a river and between a river and its tributaries is referred to as *longitudinal connectivity.* These flows are usually described in volumetric terms with objectives focused on maintaining sufficient flow volumes to sustain ecosystem functions that maintain water quality, support movement, import nutrients and export salt and pollutants.

Table 1 Rolling, multi-year priority framework for lateral and longitudinal connectivity

Rolling, multi-year priority	**Support lateral and longitudinal connectivity along the river systems**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Coordinate environmental watering to increase longitudinal connectivity in connected catchments. Mitigate irreversible impacts associated with extended drought. Prevent dry spell durations exceeding refuge tolerances.	Maintain natural cycles of wetting and drying. Where possible, maintain base flow volumes at 60% of natural levels. Provide replenishment flows to maintain habitat condition and regulate water quality, carbon and nutrients. Use works infrastructure to connect floodplain-wetland ecosystems and manage associated risks.	Coordinate regulated releases with tributary flows (regulated and unregulated) to increase longitudinal connectivity in the Barwon–Darling and Murray rivers. Coordinate regulated releases with timing of tributary flow events to increase flow variability and the frequency of in-channel pulses and bankfull flow events. Extend the duration and magnitude of natural events to promote the movement of biota nutrients, sediments and salt.	Manage water in harmony with natural cues to maximise connectivity and flow variability to reinstate key elements of the flow regime. Provide flow regimes that allow opportunities for high ecological productivity. Supplement unregulated flow events to promote hydraulic diversity and facilitate natural geomorphic processes and groundwater replenishment.	Maximise ecological responses by adaptively managing the recession of high-flow events. Maximise the export of sediments, pollutants and salt. Mitigate water quality impacts associated with natural flood events.

End-of-basin flows

The Lower Lakes (Albert and Alexandrina), Coorong and Murray Mouth region support freshwater, estuarine and marine ecosystems which provide vital habitat for many unique, rare and threatened species. The area is Ramsar listed in recognition of the wetlands international importance.

As for many of the Basin's rivers, the flow regime at the end of the system has been modified as a result of development. Building and managing the barrages, and the cumulative impacts of water regulation and extraction upstream have altered the volume, timing and quality of the water reaching the Lower Lakes, Coorong and Murray Mouth.

The Basin Plan provides for environmental water planning and delivery to achieve end-of-basin outcomes, provide conditions to protect and restore the health of water-dependent ecosystems and ensure they are resilient by reinstating important parts of its natural flow regime.

The expected environmental outcomes in the Basin Plan and Basin-wide environmental watering strategy aim to maintain suitable water and salinity levels in the Lower Lakes and provide sufficient flows through the barrages to facilitate freshwater exchange to the Coorong Estuary and Murray Mouth. Continued fresh water flow through the barrages supports migration of diadromous fish, reduces salinity levels in the Coorong, assists flushing of sediments, maintains an open Murray Mouth, and provides suitable habitat for native fish, vegetation, waterbirds and macroinvertebrates.

Environmental water managers and planners should consider the interactions with priorities for native vegetation, waterbirds and native fish, and obligations to maintain the ecological character of this Ramsar wetland when working to achieve these end-of-basin priorities.

Table 2 Rolling, multi-year priority framework for end-of-basin flows

Rolling, multi-year priority	**Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Where possible, mitigate adverse environmental impacts associated with extended dry and drought conditions through the following priorities. Assist the maintenance of Lower Lake levels above sea level (0m AHD). Support the maintenance of suitable estuarine conditions around the barrages by managing balance between lake levels and barrage outflows (supporting by additional freshwater inflows where possible). Manage water quality in the Lower Lakes with additional freshwater inflows, having regard to	Continuously connect the Lower Lakes, Coorong and Southern Ocean via the Murray Mouth. Coordinate the management of environmental water with barrage operation to apportion environmental water between sites above and below the barrages. Improve water quality in the Lower Lakes with additional freshwater inflows, having regard to the Basin Plan salinity targets. Assist the maintenance of Lower Lake levels above 0.4m. Manage estuarine conditions around the	Continuously connect the Lower Lakes, Coorong and Southern Ocean via the Murray Mouth. Coordinate the management of environmental water with barrage operation to increase the resilience of end- of-basin ecosystems. Supplement barrage flow events to enhance salt export and maintain estuarine water quality in the Coorong's North Lagoon. Provide seasonal water level variability within the Lower Lakes, and cues for migratory fish movement via flows through the barrages.	Continuously connect the Lower Lakes, Coorong and Southern Ocean via the Murray Mouth. Supplement unregulated barrage flow events to export salt from the Murray–Darling Basin and scour sediments from the Murray Mouth. Assist the maintenance and variability of Lower Lake levels to maximise ecological productivity. Provide seasonal flow variability within the Lower Lakes, and cues for migratory fish movement via flows through the barrages. Where possible, coordinate additional barrage flows to provide	Continuously connect the Lower Lakes, Coorong and Southern Ocean via the Murray Mouth. Increase barrage flow volumes to maximise salt export and the scouring of sediment from the Murray Mouth and provision of cues for migratory fish movement. Harmonise barrage releases to provide conditions conducive to high ecological productivity in the Coorong.

Rolling, multi-year priority	Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth				
	the Basin Plan salinity targets. Where possible, provide flows to Coorong to avoid water quality exceeding tolerances of listed or threatened species.	barrages and in the Coorong's North Lagoon. Facilitate migratory fish movement via barrage fishways.		a suitable salinity gradient between the North and South lagoons.	

Guidance to achieve flows and connectivity priorities in 2018–19

The Evaluation found environmental water delivery has had immediate and positive impact on river flow regimes and connectivity, supporting a number of ecosystem functions. These changes were most evident in the southern Basin, where large regulated water releases improved connectivity between the Goulburn, Murray and Murrumbidgee rivers. The resulting increase in flows to South Australia supported the life cycle needs of instream biota, and maintained nutrient cycles between ecosystems and exported salt from the Basin.

Regular connection with the floodplain improves floodplain health and also provides a wide range of benefits for the broader river system. For example, leaf litter transported into the river provides a valuable source of carbon for aquatic food webs.

Support opportunities for lateral connectivity between the river and adjacent low-lying floodplains and wetlands to reinstate natural nutrient and carbon cycling processes

Regular connection between the river and adjacent floodplains and wetlands is critical to maintain and improve floodplain and river health, transport leaf litter into the river and provide a valuable source of carbon for aquatic food webs.

The Evaluation highlighted the challenge posed by physical and policy constraints that are restricting the achievement of lateral connectivity outcomes sought by the Basin Plan. Full implementation of the Basin Plan, including implementation of the constraints management strategy, is required for improvements to the lateral connectivity between rivers and floodplains to be realised.

Therefore, in 2018–19 it is important to create and support lateral connections across the Murray–Darling Basin where possible within existing constraints and where resource availability is sufficient. In drier resource availability scenarios, environmental water managers should seek opportunities to maximise benefits through the use of environmental works in the southern connected system to create and enhance these connections.

Coordinate replenishment flows across multiple tributaries to maintain habitat condition and regulate water quality, carbon and nutrients in refuges along the Barwon–Darling watercourse

The Barwon–Darling river system plays a vital role in the function of the Basin. It links the northern and southern basins and is particularly important for native fish communities.

The Barwon–Darling river system has a highly variable flow regime. However, a study by the MDBA demonstrated that cease-to-flow events have become more frequent, and flows and patterns between these events have also changed, no longer providing the scale of benefits they once did. During the past two years there have been prolonged cease-to-flow conditions.

The Evaluation identified only small improvements in connectivity in the northern Basin, due to the generally dry to very dry climatic conditions. The Northern Basin Review found that flows and longitudinal connectivity outcomes in the Darling River will be maximised if environmental watering (and associated flow protection) is coordinated and timed between the Darling River and its tributaries.

In April–May 2018, the Commonwealth Environmental Water Office and New South Wales government coordinated the delivery of environmental water into the Barwon–Darling river system to mitigate a cease-to-flow event. This was the first event of this type to be actively managed through environmental releases and environmental flow protection. If dry conditions prevail over the coming months, it will be important to repeat these replenishment flow events to maintain the integrity of refuge habitats, subject to environmental water availability.

Maintain seasonally appropriate water levels and support a suitable salinity gradient in the Coorong, provide regular flows for fish movement and salt export though the barrages

Freshwater inflows are critical for maintaining the ecological character of the Lower Lakes, Coorong and Murray Mouth. The Evaluation found that more than 600 GL of additional environmental water has reached the Lower Lakes every year since 2014–15, helping to maintain lake levels within the preferred seasonal operating envelopes. However, the Coorong and Murray Mouth ecosystem remains in relatively poor condition. Large volumes of delivered environmental water, combined with unregulated flows, since 2014–15 have not markedly improved eco-hydrological conditions for an ecosystem that is still recovering from the millennium drought. Therefore, the MDBA provides the following guidance to achieve the priorities for end-of-basin condition in 2018–19.

During 2018–19 a focus for end-of-basin outcomes is coordination between environmental water planners and managers to deliver and maintain seasonally appropriate water levels in the Coorong to support a range of vital ecological species and functions and maintain/improve the ecological character of the Ramsar wetland. Where possible, environmental water managers should prioritise flows through the barrages. This will require working with relevant agencies to ensure barrage operation allows additional environmental water inflows to the Lower Lakes to pass through to the Coorong to provide connectivity between the lakes, Coorong and Southern Ocean via the Murray Mouth. In turn, this will support and complement the 2018–19 Basin annual priorities specified for key ecological outcomes relating to *Ruppia tuberosa*, diadromous fish species and migratory shorebird species.

Native vegetation

The Basin supports a diverse range of vegetation community types and hundreds of native plant species. The Basin-wide environmental watering strategy includes objectives for water-dependent vegetation in the Basin, which are plant species that require inundation for at least part of their life cycle. The goal is to maintain and improve these vegetation communities, many of which are ecologically important components in significant areas such as Ramsar wetlands (i.e. Moira grass in Barmah Forest).

It is important to maintain a diverse range of vegetation types and ensure plant populations across the Basin remain healthy. Plants provide shelter, habitat, food and shade for a range of animals. They are vital for nutrient cycling, improving water quality and stabilising soil and riverbanks. Different vegetation communities support unique species and ecosystem functions.

Healthy floodplain forests, woodlands and wetlands rely on periods of wetting and drying to thrive. Most vegetation communities have different water requirements and require flooding at specific times throughout the year to maintain the health of the community.

Water resource management has changed the wetting and drying cycles that would have occurred naturally. This affects the type, diversity and health of vegetation communities along the rivers and in floodplains of the Basin.

For more information about the current condition of the Basin's water-dependent native vegetation species and communities, see the Outlook.

Rolling, multi-year priorities for native vegetation

The native vegetation rolling, multi-year priorities focus on opportunities to improve the condition and extent of native vegetation. These address the expected environmental outcomes for native vegetation in the Basin-wide environmental watering strategy and are described below.

The rolling, multi-year priorities for native vegetation are to:

- Maintain and improve the condition and promote recruitment of forests and woodlands.
- Improve the condition and extent of lignum shrublands.
- Improve the condition and extent of Moira grass in Barmah–Millewa Forest.
- Expand the extent and improve resilience of Ruppia tuberosa in the southern Coorong.

Maintain and improve the condition and promote recruitment of forests and woodlands

River red gum, black box and coolibah forests grow on riverbanks and floodplains, and many of these areas are Ramsar sites and national or state parks. These forests provide habitat and resources for aquatic, amphibious and terrestrial animals. They also assist with nutrient cycling within the Basin's ecosystems by contributing dissolved organic carbon into the nearby rivers. Roots and branches of the forest's trees can provide shelter and habitat for fish and help moderate water temperature by providing shade.

Inundation requirements are different across river red gum, black box and coolibah forests. River red gum forests and woodlands growing near rivers, creeks, wetlands and lakes are widespread throughout the Basin and regular flooding is vital to maintain them. Black box is a common drought-tolerant and flood-responsive vegetation community that grows throughout the Basin. Black box generally occurs higher on the floodplain than river red gums and can source water from rainfall, floods, rivers and groundwater. Coolibah grows in the northern part of the Basin in riverine habitats and on floodplains, sourcing its water from rainfall, floods and groundwater.

This priority aims to provide water to promote river red gum, black box and coolibah recruitment and improve the condition of woody vegetation and understorey vegetation (e.g. shrubs and grasses) in forests and woodlands.

It is important to achieve this priority within the managed floodplain areas where environmental water managers want recruitment of these species to occur and not in areas where forest vegetation has encroached onto wetlands and river beds.

Table 3 Rolling, multi-year priority framework for water-dependent forests and woodlands

Rolling, multi-year priority	**Maintain and improve the condition and promote recruitment of forests and woodlands**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Identify critical river red gum, black box and coolibah communities to maintain condition or where saplings require water to survive. Where possible, manage or deliver water to these areas. The necessity of this priority is dependent on the target species and is more critical the longer the preceding dry spell. Where appropriate, operate environmental regulators, works or use pumps to deliver environmental water and sustain inundation.	Identify important river red gum, black box and coolibah communities to maintain condition or where saplings require water to survive. Where possible, manage or deliver water to these areas. The necessity of this priority is dependent on the target species and the condition of new recruits and is more critical the longer the preceding dry spell. Where appropriate, operate environmental regulators, works or use pumps to deliver environmental water and sustain inundation.	If river red gum, black box or coolibah recruitment has occurred at desired locations (i.e. do not encourage river red encroachment into wetlands or into river beds) promote growth and improve condition if/where possible to ensure their survival. Target low lying river red gum, black box and coolibah forests adjacent to rivers where water can be delivered to promote growth and improve condition. Where appropriate, operate environmental regulators or works to deliver environmental	Improve river red gum, black box and coolibah recruitment success at desired locations (i.e. do not encourage river red encroachment into wetlands or into river beds) and condition by providing inundation in line with optimal duration, timing and depth. Improve river red gum, black box and coolibah condition in desired locations by providing inundation in line with optimal duration, timing and depth. Added benefits of achieving the priority are the improved condition and resilience of larger trees and supporting the	Improve river red gum, black box and coolibah recruitment success at desired locations (i.e. do not encourage river red encroachment into wetlands or into river beds) and condition by providing inundation in line with optimal duration, timing and depth. Improve river red gum, black box and coolibah condition in desired locations by providing inundation in line with optimal duration, timing and depth. Added benefits of achieving the priority are the improved condition and resilience of larger trees and supporting the

Rolling, multi-year priority	**Maintain and improve the condition and promote recruitment of forests and woodlands**				
			water and sustain inundation.	growth and condition of water- dependent understorey species.	growth and condition of water- dependent understory species.
Basin significant sites	The MDBA may identify locations/regions based on state annual environmental watering priorities, state long-term environmental watering plans, vegetation monitoring outcomes, Basin-wide environmental watering strategy and the Stand Condition Assessment Tool, to name a few. The MDBA may stipulate Environmental Water Requirements for these locations using information from long-term environmental watering plans, published scientific or other government reports.				

Improve the condition and extent of lignum shrublands

Lignum grows along riverbanks, on floodplains and in wetlands across the Basin and can grow in woodlands under trees or as the dominant overstorey species in shrublands. Lignum shrublands provide important habitat and resources for a range of animal species, with dense, tall shrublands acting as ideal nesting and nursery habitat for many waterbird species during both wet and dry times.

Lignum requires periodic flooding to maintain good condition, promote growth and support reproduction. Lignum is found in a range of habitats which means that the lignum shrublands across the Basin experience a variety of inundation frequencies. For example, lignum growing in low-lying wetlands will often be inundated more frequently than those shrublands growing on higher areas of the floodplain.

Inundation frequency directly influences the size and condition of lignum shrublands. They can withstand extended periods without inundation, but inundation over sequential years will improve condition and growth, and facilitate recruitment.

Table 4 Rolling, multi-year priority framework for water-dependent lignum shrublands

Rolling, multi-year priority	**Improve the condition and extent of lignum shrublands**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Where lignum shrublands have received environmental water in previous years, they are likely to be in a reasonable condition to withstand a dry period. The necessity of this priority is more critical the longer the preceding dry spell. Where possible, limit any loss or a decline in condition of lignum shrublands by providing some inundation.	Where lignum shrublands have received environmental water in previous years, they are likely to be in a reasonable condition to withstand a dry period. The necessity of this priority is more critical the longer the preceding dry spell. Where possible, limit any loss or a decline in condition of lignum shrublands by providing some inundation.	Maintain the condition of lignum shrublands by providing inundation in line with the optimal duration, timing and depth. The necessity of this priority is more critical the longer the preceding dry spell. Where lignum shrublands have been inundated in previous years, they are likely to be in a reasonable condition to withstand a dry period.	Improve the condition of lignum shrublands by providing inundation in line with the optimal duration, timing and depth. Where lignum shrublands have been inundated in previous years, they are likely to be in a reasonable condition to withstand a dry period. The necessity of this priority is more critical the longer the preceding dry spell.	Improve the condition of lignum shrublands by providing inundation in line with the optimal duration, timing and depth. Where lignum shrublands have been inundated in previous years, they are likely to be in a reasonable condition to withstand a dry period. The necessity of this priority is more critical the longer the preceding dry spell.

Rolling, multi-year priority	Improve the condition and extent of lignum shrublands
Basin significant sites	Environmental water managers and planners should prioritise lignum shrublands located within the regions listed in the Basin-wide environmental watering strategy, which are: the Lower Lachlan; Lower Murrumbidgee; Lower Darling; Lower Condamine–Balonne (including Narran Lakes); Lower Gwydir; Macquarie Marshes; Lower Border Rivers; and the River Murray from the junction of Wakool River to downstream of Lock 3 (including Chowilla and Hattah Lakes). The MDBA may identify locations/regions based on state annual environmental watering priorities, state long-term environmental watering plans, vegetation monitoring outcomes and the Basin-wide environmental watering strategy, to name a few.

Improve the condition and extent of Moira grass in Barmah–Millewa Forest

Moira grass is a rapidly growing, semi-aquatic grass that thrives in wetlands and floodplains. The Barmah–Millewa Forest has one of the largest inland plains of Moira grass in Australia.

These floodplain marshes act as a drought refuge in an otherwise arid to semi-arid region and support threatened species of plants and animals. The Moira grass marshes are an important part of the Barmah Forest Ramsar Convention listing and bilateral migratory bird agreements including JAMBA, CAMBA, ROKAMBA, and the Bonn Convention on Migratory Species.

Moira grass requires flooding across winter and spring to promote growth. River regulation has caused a decline in the depth and duration of flooding across Barmah–Millewa Forest. Environmental flows are often used to mimic the natural flood regime to better meet the flow requirements of Moira grass.

There has been a continual decline in Moira grass extent; only 182 hectares of Moira grass in the floodplain marshes in Barmah Forest was recorded in early 2014. This is about 12% of the amount recorded at the time of its Ramsar listing in 1982. Recent studies have also indicated that the Moira grass seedbank in Barmah–Millewa Forest is declining and is not self-sustaining. New research has shown that Moira grass may rely on the preservation and maintenance of existing rootstock and stem fragments to re-establish its population under an appropriate watering regime.

Any expansion in Moira grass extent is likely to take several years. The current trajectory of decline indicates that without an appropriate watering regime, Moira grass plains could be locally extinct in a matter of years.

It should be noted that there are a number of other threats to Moira grass in Barmah–Millewa Forest, including grazing pressures (e.g. pigs, kangaroos and horses) and encroachment of river red gum and giant rush.

Table 5 Rolling, multi-year priority framework for Moira grass in Barmah–Millewa Forest

Rolling, multi-year priority	**Improve the condition and extent of Moira grass in Barmah–Millewa Forest**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Where possible, limit any loss of Moira grass extent through the operation of forest regulators. The necessity of this action will become more critical the longer the preceding dry spell.	Maintain the condition and extent of Moira grass through the operation of forest regulators. Where possible, aim to improve condition of Moira grass. This action will be more likely in a Dry RAS following Moderate to Very Wet RAS years.	Improve the condition and maintain the extent of Moira grass by providing an opportunity for growth of existing plants. Where possible, aim to improve the extent by providing inundation in line with optimal duration and flooding.	Improve the condition and extent of Moira grass by providing inundation in line with optimal duration and timing. If a flowering event occurred in the previous water year, promote seed germination if/where possible. If seed germination occurred in the previous water year, support the consolidation of growth of new plants.	Improve the condition and extent of Moira grass by providing inundation in line with optimal duration and timing. If a flowering event occurred in the previous water year, promote seed germination if/where possible. If seed germination occurred in the previous water year, support the consolidation of growth of new plants.

Expand the extent and improve resilience of Ruppia tuberosa in the southern Coorong

The Lower Lakes and Coorong is one of Australia's largest wetland systems. It has 23 wetland types, covers 142,500 hectares and meets eight of nine criteria listed in the Ramsar Convention. *Ruppia tuberosa,* a submerged aquatic plant that was once widespread along the length of the southern Coorong, is a key indicator of the health of the Coorong and a defining component of the ecosystem's ecological character. Many species in the Coorong, such as waterfowl and migratory waders, rely on the plant as a food resource. *Ruppia tuberosa* also provides habitat for other species in the southern Coorong, such as Murray hardyhead and chironomid larvae.

Ruppia tuberosa's water requirements vary between each stage of its life history (refer MDBA website). By late summer, *Ruppia tuberosa* persists as seeds and turions on the ephemeral mudflats on the shores of the southern Coorong. These seeds and turions germinate or sprout when the water levels rise during late autumn, and the plants continue to grow through winter. If the water levels in the southern Coorong remain adequate, the plant reproduces sexually (producing seeds) and asexually (producing turions) during spring and early summer.

The condition and extent of *Ruppia tuberosa* is influenced by a range of factors, such as water levels, water quality and the presence of filamentous algae within the Coorong. The millennium drought had a significant impact on the condition of the species, with *Ruppia tuberosa* disappearing from the southern Coorong. Although the species is showing signs of recovery, providing suitable habitat conditions and flow regimes for *Ruppia tuberosa* is essential to maintain this species that underpins the ecology of the ecosystem.

Table 6 Rolling, multi-year priority framework for Ruppia tuberosa in the southern Coorong

Rolling, multi-year priority	**Expand the extent and improve resilience of *Ruppia tuberosa* in the southern Coorong**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Where possible, limit loss of *Ruppia tuberosa* extent through the delivery of freshwater through barrages. Where possible, improve water quality to maintain *Ruppia tuberosa* habitat conditions and mitigate risks to population health. The necessity of this action will become more critical the longer the preceding dry spell.	Maintain the extent of *Ruppia tuberosa* through the delivery of freshwater through barrages. Where possible, improve water quality to maintain *Ruppia tuberosa* habitat conditions and mitigate risks to population health. The necessity of this action will become more critical the longer the flows across the barrages are at lower volumes.	Maintain the extent of *Ruppia tuberosa* by providing opportunities for growth and support the completion of the plants life cycle. Where possible, promote *Ruppia tuberosa* sexual and asexual reproduction by providing inundation in line with optimal duration, timing and depth of flooding. Where possible, improve habitat conditions and salinity gradient in the Coorong to maintain *Ruppia tuberosa* condition and mitigate risks to population health. This includes considering options to manage the flow regime within the end-of-basin system to reduce the chance of filamentous	Improve the extent and support the reproduction of *Ruppia tuberosa* by providing inundation in line with optimal duration, timing and depth of flooding. This includes: Increasing inundation of mudflats over early spring. Reaching peak inundation over late spring/early summer months. Easing drawdown of water during mid-late summer. Where possible, operate barrages to enhance optimal *Ruppia tuberosa* inundation, including slowing the rate at which water levels drop over late spring and early summer. Improve habitat conditions and salinity gradient in the Coorong to maintain	Improve the extent and support the reproduction of *Ruppia tuberosa* by providing inundation in line with optimal duration, timing and depth of flooding. Where possible, operate barrages to enhance optimal *Ruppia tuberosa* inundation, including slowing the rate at which water levels drop over late spring and early summer. Where possible, improve habitat conditions and salinity gradient in the Coorong to maintain *Ruppia tuberosa* condition and mitigate risks to population health. This includes

Rolling, multi-year priority	Expand the extent and improve resilience of *Ruppia tuberosa* in the southern Coorong				
			algae outbreaks in the southern Coorong.	*Ruppia tuberosa* condition and mitigate risks to population health. This includes considering options to manage the flow regime within the end –of-basin system to reduce the chance of filamentous algae outbreaks in the southern Coorong.	considering options to manage the flow regime within the end-of-basin system to reduce the chance of filamentous algae outbreaks in the southern Coorong.

Guidance to achieve native vegetation priorities in 2018–19

The Evaluation found that some areas of lignum shrublands have declined in condition. It also found that the extent of *Ruppia tuberosa* needs to be stabilised and that the seedbank is still depleted from the millennium drought. Therefore, the MDBA provides the following guidance to achieve the priorities for native vegetation in 2018–19.

Enable growth and maintain the condition of lignum shrublands

Lignum shrublands often require several subsequent waterings to improve condition. The Evaluation found that the lignum shrublands described in the Basin-wide environmental watering strategy have improved in condition in response to environmental water. In areas that did not receive adequate water, the condition of lignum shrublands are likely to have declined. Environmental water managers and planners are encouraged to limit loss or decline and maintain condition of lignum shrublands in areas where they have declined, where water is available within the current resource availability scenario and current constraints. In line with the areas described in the Basin-wide environmental watering strategy and the findings from the Evaluation, these areas include wetlands along the River Murray from Wakool Junction to downstream of Lock 3, Lower Lachlan, Narran Lakes and Lower Border Rivers.

Maintain Ruppia tuberosa extent in the southern Coorong

The Basin-wide environmental watering strategy expected environmental outcomes state that *Ruppia tuberosa* should occur in at least 80% of sites across at least a 50km extent by 2019. Long-term monitoring of the extent of *Ruppia tuberosa* in the Coorong shows that its area of occupation has increased, with the 2016–17 monitoring period being the first time since the summer monitoring program began in 2007 that *Ruppia tuberosa* occurred in at least 80% of sites across at least 50 km of the southern Coorong. However, it is important to note that this progress is not guaranteed to continue into the future if threats such as insufficient water levels in the southern Coorong at key times in the species' life cycle and the presence of filamentous algae are not mitigated.

Having regard to the 2019 target and the requirement to maintain extent in subsequent years, it is important that environmental water managers consider managing flows within the end-of-basin system to ensure the extent of the species does not decline.

Meeting this outcome each year relies on coordination between water managers to maintain appropriate water and salinity levels in the Coorong through each stage of the species' life cycle when possible. It is also important to undertake further research into identifying the influence and management options for external influences on *Ruppia tuberosa* extent and reproduction – for example, filamentous algae can smother the plant, thereby limiting growth and preventing recruitment.

Waterbirds

Waterbirds depend on rivers and wetlands to provide foraging, breeding, roosting and nesting habitat, as well as protection from predators. Waterbirds are highly mobile and can move from catchment to catchment in search of suitable conditions.

The Basin contains nearly half of all wetlands where colonial nesting waterbirds (birds that nest in large colonies) breed in Australia. The spectacular colonies and high concentrations of waterbirds on many of the Basin's wetlands were the catalyst for their nomination as wetlands of international importance under the Ramsar Convention.

Many colonial nesting waterbirds require wetlands to be flooded to initiate and complete breeding. Managers can use small environmental watering events to maintain the distribution, structure and health of wetland vegetation; thus ensuring that the wetland is in 'event ready' condition when larger flows arrive. As a result of river regulation, floods have become smaller and less frequent, with wetlands experiencing longer dry spells as much of the water is used for other purposes and captured in dams. Long-term surveys have shown a decline of more than 70% in the total population of waterbirds since 1983. Surveys conducted in 2016 recorded the second lowest numbers on record, as highlighted in the Evaluation.

Shorebird numbers fluctuate from year to year. These species rely on multiple international 'staging' sites during their annual migration and are highly specialised foragers, requiring exposed tidal flats for feeding opportunities. Observed long-term declines in these species' abundance could also be a result of river regulation or degradation at other international 'staging' sites, which may affect counts in the Coorong, regardless of conditions there.

For more information about the current condition of the Basin's waterbirds, see the Outlook.

Rolling, multi-year priorities for waterbirds

The rolling, multi-year priorities for waterbirds are to:

- Improve the abundance and maintain the diversity of the Basin's waterbird population.
- Maintain the abundance of key shorebird species in the Lower Lakes and Coorong.

These priorities address the expected environmental outcomes for waterbirds in the Basin-wide environmental watering strategy.

Improve the abundance and maintain the diversity of the Basin's waterbird population

Environmental water managers should have regard to the annual priorities at Basin-significant sites identified in Table 7. Since it is difficult to predict where waterbirds will accumulate each year, how the priorities are implemented at each site will depend on how waterbirds respond to conditions. Water managers should also have regard to the 'Guidance to achieve waterbird priorities in 2018–19' section below for additional guidance to achieving these Basin annual watering priorities.

Table 7 Rolling, multi-year priority framework for waterbirds

Rolling, multi-year priority	**Improve the abundance and maintain the diversity of the Basin's waterbird population**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Avoid loss of foraging and roosting habitat at refuge locations.	Maintain foraging and roosting habitat at refuge locations. Support breeding where naturally triggered.	Maintain waterbird breeding habitat in 'event ready' condition. Trigger and provide on-going support for small-scale breeding across functional groups. Support breeding where naturally triggered. Create mosaic of wetland habitats suitable for functional feeding groups.	Support breeding where naturally triggered. Create mosaic of wetland habitats suitable for functional feeding groups. Trigger and provide on-going support for small to moderate-scale breeding across functional groups.	Support breeding where naturally triggered. Create mosaic of wetland habitats suitable for functional feeding groups. Improve the opportunities for large-scale breeding for colonial nesting waterbird species.
Basin significant sites that can be managed with environmental water	Corop wetlands Fivebough Swamp* Lowbidgee floodplain Pyap Lagoon River Murray & Euston Lakes Upper Darling River	Barmah–Millewa* Booligal wetlands Lower Lakes, Coorong & Murray Mouth* Corop wetlands (refuge) Fivebough Swamp* (refuge) Great Cumbung Swamp	Barmah–Millewa* Booligal wetlands Lower Lakes, Coorong & Murray Mouth* Corop wetlands Great Cumbung Swamp Gunbower–Koondrook–Perricoota*	Barmah–Millewa* Booligal wetlands Lower Lakes, Coorong & Murray Mouth* Corop wetlands Darling Anabranch Fivebough Swamp* Great Cumbung Swamp	Barmah–Millewa* Booligal wetlands Lower Lakes, Coorong & Murray Mouth* Corop wetlands Darling Anabranch Fivebough Swamp* Great Cumbung Swamp

Rolling, multi-year priority	Improve the abundance and maintain the diversity of the Basin's waterbird population				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
		Gunbower–Koondrook–Perricoota* Gwydir wetlands* Hattah Lakes* Kerang wetlands* Lake Brewster Lowbidgee floodplain (refuge) Macquarie Marshes* Narran Lakes* Pyap Lagoon (refuge) River Murray & Euston Lakes (refuge) Upper Darling River (refuge)	Gwydir wetlands* Hattah Lakes* Kerang wetlands* Lake Brewster Lowbidgee floodplain Macquarie Marshes* Narran Lakes* Pyap Lagoon	Gunbower-Koondrook-Perricoota* Gwydir wetlands* Hattah Lakes* Kerang wetlands* Lake Brewster Lake Buloke Lindsay-Walpolla-Chowilla* Lowbidgee floodplain Macquarie Marshes* Narran Lakes* Pyap Lagoon River Murray & Euston Lakes	Gunbower–Koondrook–Perricoota* Gwydir wetlands* Hattah Lakes* Kerang wetlands* Lake Brewster Lake Buloke Lindsay–Walpolla–Chowilla* Lowbidgee floodplain Macquarie Marshes* Narran Lakes* Pyap Lagoon River Murray & Euston Lakes

*Denotes basin significant waterbird sites that can be managed for environmental outcomes which are also classified as Ramsar sites.

Maintain the abundance of key shorebird species in the Lower Lakes and Coorong

This rolling, multi-year priority addresses the expected environmental outcome for migratory shorebirds in the Basin-wide environmental watering strategy. The Evaluation, in assessing progress towards this outcome, concluded that while it was 'too early to tell' if the expected outcome would be achieved, there are signs that it is at risk of *not* being achieved.

Numbers of two key shorebirds species, red-necked stints and sharp-tailed sandpipers, were at their lowest on record in 2017. While international development may be driving some decline, other studies have found that reduced shorebird numbers in the Lower Lakes and Coorong surpasses population reductions seen elsewhere in Australia and that threats are intensifying at sites. For example, in 2016–17 it was not only water levels which diminished foraging habitat for waterbirds; there was also a widespread outbreak of filamentous algae in the southern Coorong, limiting food resources for shorebirds.

In seeking to achieve this outcome, which is due by 30 June 2019, environmental water managers should have regard to the annual priorities for the Lower Lakes and Coorong identified in Table 8. Water managers should also have regard to the 'Achieving waterbird priorities in 2018–19' section below for additional guidance to achieving these Basin annual watering priorities for migratory shorebirds.

Table 8 Rolling, multi-year priority framework for key shorebird species in the Lower Lakes and Coorong

Rolling, multi-year priority	**Maintain the abundance of key shorebird species in the Lower Lakes and Coorong**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Avoid loss of foraging and roosting habitat at key refuge locations. Where possible manage algal blooms and water quality at key foraging sites.	Maintain foraging and roosting habitat at refuge locations. Support breeding of resident shorebirds where naturally triggered (i.e. maintain isolation from predators). Manage algal blooms and water quality at key foraging sites.	Build productivity of foraging habitat for summer. Support breeding of resident shorebirds where naturally triggered (i.e. maintain isolation from predators). Manage algal blooms and water quality at key foraging sites.	Build productivity of foraging habitat for summer. Actively maximise shorebird access to foraging habitat during summer. Support breeding of resident shorebirds where naturally triggered (i.e. maintain isolation from predators). Create mosaic of wetland habitats suitable for shorebirds.	Where possible actively maximise shorebird access to foraging habitat during summer. Support breeding of resident shorebirds where naturally triggered (i.e. maintain isolation from predators). Create a mosaic of wetland habitats suitable for shorebirds.

Guidance to achieve waterbird priorities in 2018–19

The MDBA provides the following guidance to achieve the priorities for waterbirds in 2018–19.

Provide flows to improve habitat and support waterbird breeding

Water managers should be aware that three of the Basin-significant sites listed in Table 7 have been identified as being in urgent need of environmental water for the 2018–19 water year based on the environmental watering requirements to support waterbirds.

Narran Lakes: Narran Lakes has not been adequately watered since 2012–13. This habitat is critical in supporting large-scale waterbird breeding events and generally requires water every 1 to 1.7 years. The MDBA encourages innovative approaches to enhance inflows and improve the condition of this habitat.

Gunbower–Koondrook–Perricoota Forest: Analysis of environmental watering requirement indicators suggests that some flow targets for waterbird habitat are overdue for watering. The smaller flow indicators which contribute to waterbird habitat outcomes on the mid to lower floodplain elevations were met through natural flows in 2012 and 2016–17. In Gunbower Forest, these natural flows were supplemented by the use of regulators, contributing further to these outcomes. However, in Koondrook–Perricoota natural flows have only been supplemented by the use of regulators once, in 2014. Monitoring suggests vegetation is still in poor condition, indicating that further watering is needed. The larger flows indicators which support outcomes for waterbird habitat on higher elevations and large-scale waterbird breeding have not been met or come close to being met by a natural flow for a long time. Given this analysis and information reported on vegetation condition, the watering of the waterbird habitat on high elevations and to support any large-scale breeding events are important in Gunbower–Koondrook–Perricoota forests. Koondrook–Perricoota Forest also requires additional watering to support waterbird habitat on the mid to lower floodplain.

Lindsay–Walpolla Islands and Chowilla Floodplain: Analysis of environmental watering requirement indicators suggest that all of the moderate to high flow indicators have not been fully met through natural flows for a very long time (1993 in many cases). However, use of infrastructure, combined with natural flows in late 2016, provided extensive inundation of wetland and floodplain vegetation communities and sustained areas conducive to waterbird breeding. While there was not a large response in either waterbird breeding or improvement in habitat, nesting and foraging habitat has not declined and in some cases condition has improved. Further watering of parts of the floodplain using infrastructure in 2017 elicited a strong response, with hundreds of waterbirds using Lake Wallawalla as feeding habitat. Follow-up watering to build upon these results and improve habitat for waterbirds is important.

Maximise availability of productive foraging habitat for shorebirds

To help achieve the Basin annual watering priorities for shorebirds outlined in Table 8, water managers should also aim to maximise the availability of productive foraging habitat for shorebirds not only at the Lower Lakes and Coorong but also across the Basin.

In addition to the Lower Lakes and Coorong, there are four Basin-significant sites known to be important for shorebirds:

- Fivebough and Tuckerbill swamps
- Narran Lakes
- Macquarie Marshes
- Lowbidgee floodplain.

Watering actions at these five sites and any other regionally significant sites for shorebirds should aim to ensure key foraging habitats, such as mudflats and sand flats, are available with water depths shallow enough for shorebird foraging (less than 20 mm). This priority is most relevant during summer, when migratory species are building body condition in preparation for their northward migration. Water levels should be managed carefully prior to these months to build the abundance and diversity of macroinvertebrates at key migratory shorebird foraging sites and maintain foraging sites for resident shorebirds. Environmental water managers should aim to ensure there are times when different areas are inundated so that shorebirds are able to continuously forage and macroinvertebrate abundance can be maintained.

To achieve outcomes in the Lower Lakes and Coorong, watering actions need to take into account other Basin annual environmental watering priorities particularly for *Ruppia tuberosa* and end-of-basin condition.

Native fish

The Basin has more than 60 species of native fish, including freshwater, estuarine, marine and migratory fish. Many of these freshwater species are unique to Australia, with a number living only in the Basin. Native fish can also be part of the ecological character of Basin Ramsar sites.

The Evaluation found that overall, condition of native fish in the Basin remains poor. However, it also recognised that where environmental water had been delivered it benefitted 20 of the 25 key species listed in the Basin-wide environmental watering strategy, including silver perch, golden perch and Murray cod.

For more information about the current condition of the Basin's native fish, see the Outlook.

To achieve the expected environmental outcomes for native fish in the Basin-wide environmental watering strategy, flows that improve fish habitats and allow fish to complete their life cycles are needed.

Rolling, multi-year priorities for native fish

The rolling, multi-year priorities for native fish identify flow needs based on new information on fish habitat, recruitment and movement. Outcomes can be achieved using consumptive and operational water as well as environmental water. Coordinated management actions can help to address the needs of native fish across catchment boundaries.

The rolling, multi-year priorities for native fish are to:

- Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
- Improve flow regimes and connectivity to maximise the ecological function of the Barwon–Darling river system for native fish.
- Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.

Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin

This priority focuses on providing a suitable flow regime by coordinating and linking flows in different rivers for species that live, and respond to flows, in river channels and anabranches. Flows that support recruitment processes in spring, summer and autumn will also provide food and habitat, and connectivity between habitats. This will restore recruitment processes that promote population recovery of silver perch, golden perch, Murray cod and lamprey.

The following four ecologically-significant flow components are the focus of this priority:

- end-of-system flows through the barrage fishways and the barrages
- winter flows for food, habitat, and connectivity between habitats within channels
- flows that support breeding activity in spring
- flows that support dispersal movements in spring, summer and autumn.

To achieve population recovery, each of the target fish species has specific recruitment objectives and flow needs, as outlined in Table 9. For more information on the specific flow needs, refer to Appendix 2.

Table 9 Species-specific objectives and flow needs to achieve the multi-year priority for the southern connected Basin

Species	Recruitment Objectives	Flow needs
Murray cod	Support local recruitment in the main channel of the River Murray and lower Darling River, and regulated anabranches and tributaries.	Perennial base flows in anabranches and tributaries Spring rise in anabranches and tributaries Reduced unnatural variability and maintaining levels in anabranches and tributaries
Silver perch and golden perch	Support annual system-scale recruitment in the mid-Murray. Support local recruitment in the lower River Murray, lower Darling River, tributaries and anabranches. Promote movement and dispersal, particularly of juveniles, into tributaries and anabranches.	Perennial base flows in anabranches and tributaries Spring rise in main river channels Variable flow in main river channels Flow integrity for egg and larvae drift in spring and summer Flows to off stream nursery habitat In-channel dispersal flows in spring, summer and autumn throughout the system Flow integrity in the lower Murray
Golden perch	Capitalise on episodic system-scale recruitment from the Darling River.	Flow integrity in the Barwon–Darling system In-channel dispersal flows from Menindee Lakes into the lower Darling and River Murray system
Short-headed and pouched lamprey	Support system-scale migrations of lamprey from the ocean, through the estuary and into the River Murray to upstream breeding grounds.	End-of-system flows Flow integrity in the lower Murray In-channel dispersal flows throughout the system

Improve flow regimes and connectivity to maximise the ecological function of the Barwon–Darling river system for native fish

This priority aims to improve the Barwon–Darling River's ecological health by providing suitable flow regimes and increasing connectivity in the Barwon–Darling river system. This will improve recruitment, spawning and dispersal of native fish in the Barwon–Darling and into the connected northern and southern catchments.

The flow regime of the Barwon–Darling is variable but recently this variability has considerably diminished. An analysis of flows in the Barwon-Darling shows an increasing number of cease-to-flow events and corresponding shorter periods when flow occurs.

The analysis also found a high number of cease-to-flow events in recent years. In addition, flow events that break cease-to-flow conditions historically had multiple flow peaks (typically a small fresh followed closely by a large fresh). More recently, events that break cease-to-flow conditions have had lower total volume and continue to reduce in volume further downstream as water is adsorbed by the dry river bed, making these events less effective for the environment.

The changes to the historic flow regime are a contributing factor in the decline of the ecological health of the Barwon–Darling and resulting degradation of native fish communities. The Barwon–Darling is largely unregulated, limiting the ability to actively manage and deliver water. This makes protecting environmental flows an important management tool.

This priority has three key focus areas, outlined below.

Increase the frequency of flows and improve flow variability in the Barwon–Darling to support native fish

Recent analysis suggests that management actions that limit the occurrence of cease-to-flow events over 80 days at Bourke and 150 days at Wilcannia need to be pursued. Flows in the Barwon–Darling system should occur at a frequency that avoids breaching these limits.

Each flow type (e.g. low flows, freshes) provides a range of functions and benefits for native fish communities. These different flows can maintain water quality, increase movement opportunities and improve access to in-channel habitats like snags. Freshes that inundate river benches and backwaters enable regular inputs of nutrients, supporting productivity and food webs. Higher flows provide energy boosts that drive the ecology of the Barwon–Darling.

Ensuring Barwon–Darling River flows are sufficient to maintain adequate water quality and water levels, particularly in the lower Darling River and Menindee Lakes, will also boost young fish survival and growth. Once developed, dispersal of young fish from this region into the southern connected Basin and northern catchments can occur under the right conditions.

Protect natural recruitment flows through the Barwon–Darling to boost native fish populations

Large flow events are crucial for native fish in the Barwon–Darling. These flows can originate in the upper parts of the system, for example the Border Rivers, and then flow through the Barwon–Darling River. These types of flow events can over-top weirs, providing greater opportunities for fish to move, and can lead to large recruitment events.

The integrity of these larger flows along the Barwon–Darling should be maintained. This would promote uninterrupted development of eggs, larvae and juvenile fish down the Barwon–Darling and dispersal into nursery habitat in the lower Darling and Menindee Lakes system.

Increase flow connections between the Barwon–Darling and its tributaries

There are benefits for native fish by connecting the Barwon–Darling and its tributaries on a smaller scale. Connected river flows promote the exchange of fish, other biota and nutrients between systems. Connecting tributaries promotes the movement of native fish, particularly of juvenile and

sub-adult golden perch, Murray cod and silver perch into tributary habitats, boosting resident populations.

For more information on the timing and ecological outcomes of each flow type, refer to Appendix 2.

Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations

This priority seeks to improve the long-term viability of threatened native fish in the Basin. Actions will be needed over several years, complemented by non-flow measures, to maximise opportunities for threatened species. Achieving this priority will help to meet the long-term outcome sought for threatened fish in the Basin-wide environmental watering strategy.

The focus for managing threatened species is to first protect remaining populations and then increase the areas they occupy. This will reduce the risk of populations going extinct. Boosting threatened fish numbers and increasing the number of locations in which they occur during moderate to wet times builds resilience against potential losses in dry or very dry conditions.

The long-term goal for many threatened fish is to reinstate a network of populations that can connect with each other through flows, and disperse and colonise habitat more regularly. Over time, increased ranges will allow river flows to reconnect populations in the Basin more regularly, building more resilient populations.

To increase the area that threatened species occupy and to build fish populations, a number of steps can be taken in a process that spans multiple years:

- Protect and boost key source populations.
- Support surrogate sites and populations that can start new permanent populations.
- Identify and prepare sites to establish permanent populations.
- Support fish stocked into reintroduction sites and secure their long-term future.

In dry or very dry conditions, the main focus should be on actions that protect refuges and instream habitats, maintain river connectivity and secure water supply to key populations isolated from river channels. Flows can be provided to ensure that essential functions for populations can be met as well as allowing localised movements to occur.

Some breeding opportunities can also be supported under drier conditions. Short-lived species are particularly vulnerable because of their short lifespans and need for regular (in some cases annual) spawning and recruitment. They are a high priority, particularly under very dry or dry conditions. Opportunities to expand populations or establish new populations are less likely under drier conditions but some opportunities may arise. Establishing and maintaining surrogate populations will also be necessary under very dry conditions.

Moderate and wet to very wet conditions enable more actions to be taken for a greater range of species and sites. This includes more opportunities to provide and protect suitable flow conditions for expanding species' range and establishing new populations. Greater movement opportunities arise under these conditions including promoting long-distance movements, migration and dispersal.

Lateral connectivity, including follow-up connections to allow fish to exit off-channel habitats and for dispersal of offspring, is also a key action under these scenarios.

Table 10 Rolling, multi-year priority framework for native fish

Rolling, multi-year priorities	**Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin** **Improve flow regimes and connectivity to maximise the ecological function of the Barwon–Darling river system for native fish** **Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Support system-scale migrations of golden perch, silver perch and lamprey Maintain the integrity of spawning flow pulses through the system to allow eggs and larvae to drift uninterrupted Provide opportunities for young golden perch and silver perch to disperse following episodic system-scale recruitment events Increase flow connections between major rivers and their tributaries and anabranches to promote movement and dispersal Provide flows that protect ecologically important populations of native fish				
	Provide base flows, low flows and small freshes. Provide flows through barrage fishways in winter and spring. Provide flows to protect critical populations of	Provide low flows and small freshes; and medium freshes with peak. Provide flows through barrage fishways all year round. Provide flows through barrages when possible. Provide flows that maintain existing	Provide medium freshes with peak; large freshes; and hydrological connectivity between systems. Provide flows through barrage fishways all year round. Provide flows through barrages during spring.	Provide medium freshes with peak; large freshes; and hydrological connectivity between systems. Provide flows through barrage fishways all year round.	Provide overbank flows (expected rather than targeted); and hydrological connection between systems. Provide flows through barrages year round. Provide flows that assist in the dispersal of

Rolling, multi-year priorities	**Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin** **Improve flow regimes and connectivity to maximise the ecological function of the Barwon–Darling river system for native fish** **Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
	threatened small-bodied fish.	populations of threatened small-bodied fish.	Provide flows that expand existing populations of threatened small-bodied fish; and prepare new reintroduction sites.	Provide flows through barrages through spring to autumn. Provide flows that expand existing populations of threatened small-bodied fish; and create new reintroduction sites.	threatened small-bodied fish into new habitats.

Guidance to achieve native fish priorities in 2018–19

The MDBA provides the following guidance to achieve the priorities for native fish in 2018–19.

Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin

Conditions in 2016–17 resulted in large-scale recruitment and subsequent dispersal of golden perch from the Menindee Lakes into the lower Darling River, Darling Anabranch and River Murray. These fish remain in pockets of habitat in the Euston to Chowilla region awaiting flow cues to continue their dispersal migrations.

Complementary flow actions in the mid-Murray and Victorian tributaries in 2016–17 and, to a lesser extent 2017–18, helped juvenile silver perch move from the River Murray into the tributaries. Flows that support annual silver perch recruitment and dispersal are necessary to recover this threatened species, which has been shown to have a significantly shorter life-span in the River Murray than previously thought.

Conditions in 2016–17 also resulted in large-scale breeding of Murray cod in the lower Darling River. However, low flows in the lower Darling River, which reflect flow conditions in the Barwon–Darling system upstream of Menindee Lakes, since that time have put this important Murray cod population at risk.

The status of these important large-bodied fish species demonstrate that there are opportunities upon which to build, regardless of the resource availability scenario. To support recruitment of these important species in 2018–19, water managers should look to:

- support system-scale migrations of golden perch and silver perch
- provide opportunities for young golden perch and silver perch to disperse
- provide flows that protect these ecologically-important populations
- support system-scale migrations of lamprey via the barrages.

Improve flow regimes and connectivity to maximise the ecological function of the Barwon–Darling river system for native fish

In 2017–18 drier conditions have prevailed in the Barwon–Darling River and in many of its tributaries, resulting in reduced flows and extended cease-to-flow conditions. The Barwon–Darling River at Bourke ceased to flow in mid-February 2018 and subsequently, deteriorating water quality had negative impacts on fish condition, particularly in disconnected pools downstream of Wilcannia.

No-flow conditions in some parts of the Barwon–Darling were alleviated by low flows during late March to June 2018. Initially, these low flows were the result of rainfall events in Queensland, providing minor natural tributary inflows from the Moonie, Culgoa and Warrego rivers. Subsequently, environmental flows were released in mid-April from regulated tributaries – the

Border Rivers (sourced from Glen Lyon Dam in Queensland) and the Gwydir River (sourced from Copeton Dam in NSW).

These environmental flows, dubbed the northern connectivity event, were the result of joint Commonwealth/NSW environmental water releases. Also, the NSW government initiated temporary access restrictions to ensure these flows were protected as they moved downstream, maximising the resulting social, cultural and environmental outcomes. These temporary restrictions are an important step towards enduring arrangements that protect environmental water in the northern Basin. This event also emphasises the long-term environmental benefits that can be gained through coordinated and cooperative water management between Basin governments.

As of 25 May, flows at Brewarrina had reached ~1,000ML/d for the first time in 12 months and flows had reached Bourke – approximately 500ML/d – and were expected to rise further. The flow event has benefitted over 1,000km of river channel with flows continuing to move downstream of Bourke as this document is finalised.

Downstream of Wilcannia, cease-to-flow conditions persisted into June. The initial flow event, generated from rainfall in Queensland and protected for town water supplies, did reach Wilcannia but not much further. The northern connectivity event is expected to replenish waterholes downstream of Wilcannia to the Menindee Lakes but will not provide long periods of connectivity.

Therefore, in 2018–19, key outcomes being sought in the Barwon–Darling include:

- whole-of-river flow connectivity, building upon the northern connectivity event
- flushing flows
    - for spawning and migration of fish
    - for nutrient cycling and salt movement
- protection of held environmental water.

Managed environmental flows may again be required (subject to water availability) if cease-to-flow conditions return to critical levels in 2018–19, particularly if current flows are insufficient to break the extended cease-to-flow event below Wilcannia.

Natural flow events in the Barwon–Darling system, including the tributaries, can rapidly change conditions. Flow planning and management should look to build upon opportunities for recruitment and subsequent dispersal of native species as outlined above.

Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations

Almost half of the native fish species in the Murray–Darling Basin are of conservation concern. The Evaluation highlighted that several threatened fish species were either not detected or detected in low numbers. This includes: purple-spotted gudgeon; flathead galaxias; Yarra pygmy perch; olive perchlet; and Rendahl's tandan. Environmental watering, alongside other measures, is a key action to improve outcomes for threatened fish.

Positive outcomes can be achieved for threatened fish under all resource availability scenarios. However, the anticipated resource availability scenarios across the majority of catchments means

that the highest priority for water managers to is to focus on protecting and maintaining existing populations.

Water managers can support a range of actions, alongside non-flow measures, to maintain and improve existing populations of threatened fish. This can be done by protecting or providing flows that:

- drive ecosystem processes that underpin populations, such as food production and maintain suitable water quality
- maintain and enhance instream habitats and refuges
- create connectivity between key areas to maintain existing populations
- provide conditions for successful recruitment of annual species where they occur
- maintain populations and support successful recruitment of threatened fish in unregulated systems.

Appendix 1: Seasonal conditions

One of the key steps in developing the environmental watering priorities is determining the water resource availability scenario (RAS). The MDBA calculates the RAS using the *Guidelines for the method to determine priorities for applying environmental water.* The calculation is based on indicators of antecedent climate conditions over the previous year (rainfall, runoff and soil moisture) and surface water availability in public dams of regulated systems.

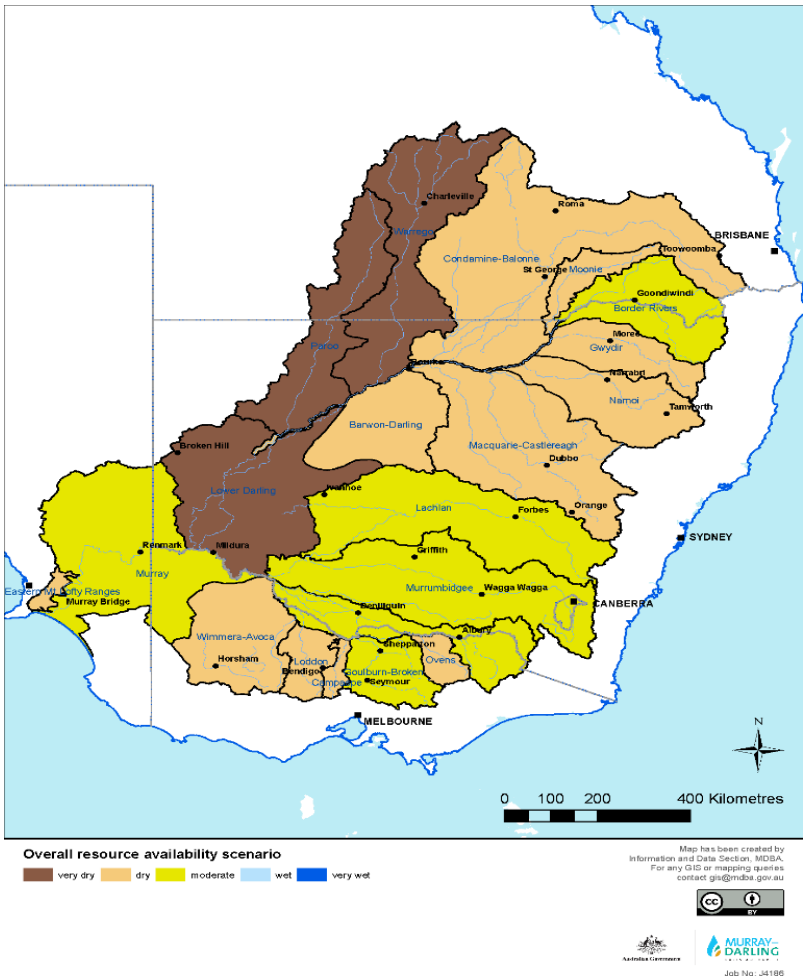

Figure 1 Resource availability scenario as at 1 March 2018[1]

[1] This figure has been produced using the results of the RAS calculation presented in Table 11/Appendix 1. Where the RAS is expressed as a range in Table 11/Appendix 1 (eg 'wet to very wet'), the lower value (ie 'wet', in this example) has been used in the production of this figure. Where the RAS in Table 1 spans three values, the middle value is used in the production of the map (eg if the results in Table one span 'dry to wet' then, the RAS used in the production of the map would be 'moderate'.

Table 11 Antecedent climate conditions and water storage levels for the catchments of the Murray–Darling Basin for the year to 1 March 2018[2]

Catchment[3] (Regulated = R; Unregulated = Unreg[4])	Precipitation	Root zone soil moisture	Runoff	Antecedent percentile range	Surface water percentile (as at 28 February 2018)	Resource Availability Scenario
Border Rivers (R)	46-60%	16-45%	46-60%	16-45% to 46-60%	61-85%	Moderate to Wet
Gwydir (R)	16-45%	16-45%	16-45%	16-45%	46-60%	Dry
Namoi (R)	16-45%	16-45%	16-45%	16-45%	16-45%	Dry
Macquarie–Castlereagh (R)	16-45%	0-15%	16-45%	0-15% to 16-45%	46-60%	Dry
Lachlan (R)	16-45%	16-45%	61-85%	16-45% to 61-85%	46-60%	Dry to Wet (Moderate overall)
Murrumbidgee (R)	46-60%	16-45%	61-85%	16-45% to 61-85%	46-60%	Moderate to Wet
Lower Darling (R)	16-45%	16-45%	61-85%	16-45% to 61-85%	0-15%	Very dry to Dry
Murray (R)	16-45%	16-45%	46-60%	16-45% to 46-60%	61-85%	Moderate to Wet
Loddon (R)	16-45%	16-45%	46-60%	16-45% to 46-60%	46-60%	Dry to Moderate
Campaspe (R)	46-60%	46-60%	16-45%	16-45% to 46-60%	46-60%	Dry to Moderate
Goulburn–Broken (R)	16-45%	16-45%	16-45%	16-45%	61-85%	Moderate

[2] The method for calculating the water resource availability scenario (RAS) is set out in the *Guidelines for the method to determine priorities for applying environmental water* (MDBA 2012): https://www.legislation.gov.au/Details/F2012L02240/4fdd68b4-f6f1-4fed-978d-29e06bb8b525

[3] 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.

[4] 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.

Catchment[3] (Regulated = R; Unregulated = Unreg[4])	Precipitation	Root zone soil moisture	Runoff	Antecedent percentile range	Surface water percentile (as at 28 February 2018)	Resource Availability Scenario
Wimmera-Avoca (R)	16-45%	16-45%	46-60%	16-45% to 46-60%	N/A	Dry to Moderate
Moonie (UnReg)	46-60%	16-45%	16-45%	16-45% to 46-60%	N/A	Dry to Moderate
Barwon–Darling (UnReg)	16-45%	16-45%	16-45%	16-45%	N/A	Dry
Condamine–Balonne (UnReg)	16-45%	16-45%	16-45%	16-45%	N/A	Dry
Paroo (UnReg)	16-45%	0-15%	16-45%	0-15% to 16-45%	N/A	Very dry to Dry
Warrego (UnReg)	0-15%	0-15%	16-45%	0-15% to 16-45%	N/A	Very dry to Dry
Ovens (UnReg)	16-45%	16-45%	16-45%	16-45%	N/A	Dry
Eastern Mt Lofty Ranges (UnReg)	16-45%	16-45%	46-60%	16-45% to 46-60%	N/A	Dry to moderate

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Appendix 2: Flow outcomes that maximise recruitment of target native fish species in the southern connected Basin

Flow outcome	Description
End-of-system flows	End-of-system flows through the barrage fishways and the barrages during June to September to support spawning migrations of short-headed and pouched lamprey.
Flow integrity in the lower Murray	Flow integrity throughout the lower River Murray in winter and spring to cue short-headed and pouched lamprey to migrate upstream and provide movement and recruitment benefits for other fish species.
Base flows in anabranches and tributaries	Sufficient base flows in anabranches and tributaries over winter and early spring for sufficient habitat for adult and young Murray cod, golden perch, silver perch and trout cod to co-exist.
Spring rise in anabranches and tributaries	Late-winter-early spring rise in anabranches and minor tributaries to encourage Murray cod and trout cod nesting.
Reducing unnatural variability and maintaining levels in anabranches and tributaries	Maintaining river levels that inundate nesting habitat (e.g. hollow logs and snags) throughout the breeding season to avoid nest abandonment and improve recruitment of Murray cod and trout cod. Applies to anabranches and minor tributaries between October and February.
Spring rise in main river channels	In main river channels, a late-winter-early spring rise to cue adult spawning migrations of golden perch and silver perch.
Variable flow in main river channels	Following the spring rise, a rising, variable flow in the main river channels in November and December to stimulate golden perch and silver perch spawning.
Flow integrity for egg and larvae drift	Maintaining the integrity of the spawning flow pulses through the system, particularly through weir pools, to allow eggs and larvae to drift uninterrupted to suitable nursery habitats.
Flow integrity in the Barwon–Darling system	Flows through the Barwon–Darling river system and into the lower Darling River and River Murray to cue golden perch spawning and allow eggs and larvae to drift into the Menindee Lakes and other nursery habitats.
Flows to offstream nursery habitat	Flows to deposit eggs and larvae into offstream nursery habitats, maintain water levels and, when young fish are suitably developed, provide flows to re-connect to the main river channel to stimulate fish to disperse.
In-channel dispersal flows throughout the system	In-channel dispersal flow pulses in late summer and autumn, firstly from major tributaries and then conveying the pulse downstream, to connect recruitment hotspots to areas that have the potential to host new populations.

Appendix 3: Flow types to improve native fish outcomes in the Barwon–Darling

Flow type	Frequency and timing	Ecological outcomes sought
Base flows	In almost all years, preferably at least throughout spring, summer and autumn.	Sustain in-channel habitat, maintain dry season/drought refuges (water quality and volume) for native fish. The key objective is to prevent contraction of the Barwon–Darling to pools in warmer seasons and resultant poor water quality due to increased stratification.
Low flows	In almost all years, preferably between September and April.	Longitudinal connectivity between instream barriers – may achieve shorter fish movements. Enhance fish access to instream habitats – inundating some snags and benches outside of weir pools. Support ecosystem functions including nutrient cycling. May trigger spawning or recruitment in some species. Maintain water quality in-channel and refuge pools. Example: Bourke flows at 500ML/day for 50 days (with a minimum peak of 1,500ML/day for 14 days) would result in inundation of 30–40% of snags between Walgett and Wilcannia.
Small freshes	In almost all years.	Longitudinal connectivity that may achieve short to moderate fish movements. Improved habitat availability – inundating a larger proportion of snags and benches. Support ecosystem functions including nutrient cycling. Aimed at maintenance and condition of native fish but may result in recruitment flows for some species. Example: Bourke flows at 6,000ML/day for at least 14 days would drown out a number of low barriers and result in inundation of 47–59% of snags between Brewarrina to Bourke and 76–88% of benches between Walgett to Brewarrina.
Medium freshes	In almost all years, preferably between August and May.	Larger-scale movement outcomes from drown-out of most major weirs. Inundation of large areas of instream habitat (snags and benches). Food production. Recruitment outcomes for some key species. Example: Bourke flows (approx 10,000ML/day) of at least 25 days duration will connect with the Menindee Lakes and allow fish movement over 1,100km between Walgett and Menindee and inundate between 68–90% of snags and 96–99% of benches between Brewarrina and Bourke.
Medium fresh with a peak	In some years, preferably between September and April.	As above, but in addition targeting spawning and recruitment outcomes for golden perch and silver perch by including a flow peak. Example: At Bourke, adding a flow peak to a medium fresh, with the peak constituting a minimum of 15,000 ML/day for at least five days.
Large freshes	In some years, preferably between September and April.	Major recruitment outcomes. Large-scale fish movements, including dispersal of young with large areas of instream habitat (snags and benches). Food production. Example: Flows at Wilcannia of at least 20,000ML/day will connect with the Menindee Lakes, inundate between 75% of snags between Wilcannia and Tilpa, and 100% of benches between Wilcannia and Brewarrina.

Flow type	Frequency and timing	Ecological outcomes sought
		Note: Likely to result mostly from natural flow events.
Overbank flows		Note: Natural flooding – not a target for water managers. May require some management to ensure integrity of flow transit downstream. Natural flooding provides significant increases in food production, habitat and movement cues, resulting in major recruitment outcomes.

Office locations
Adelaide
Albury-Wodonga
Canberra
Toowoomba

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