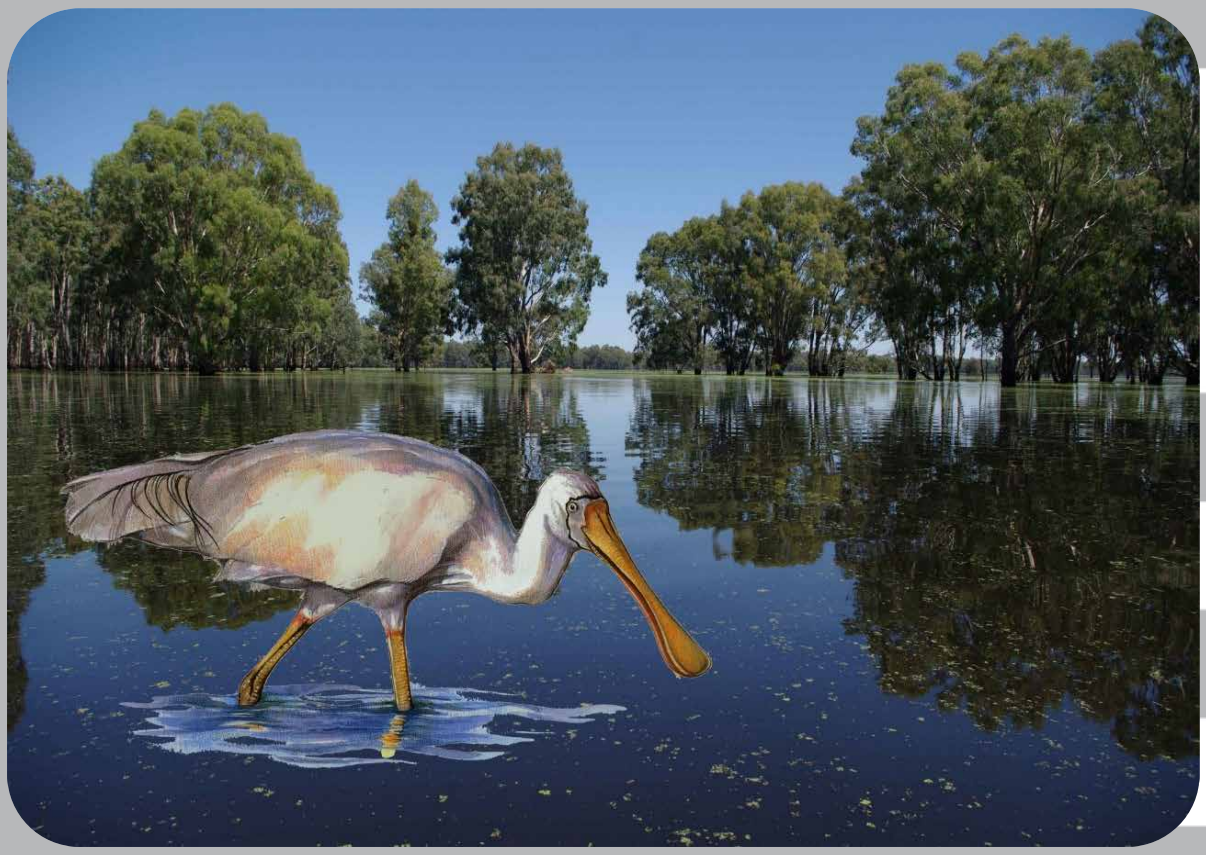
Australian Government

MURRAY–DARLING BASIN AUTHORITY

2015–16 Basin Annual Environmental Watering Priorities

Overview and technical summaries



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Postal Address: GPO Box 1801, Canberra ACT 2601
Telephone: (02) 6279 0100 international + 61 2 6279 0100
Facsimile: (02) 6248 8053 international + 61 2 6248 8053
Email: engagement@mdba.gov.au
Internet: http://www.mdba.gov.au

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Overview of the 2015–16 Basin annual environmental watering priorities

What are Basin annual environmental watering priorities

The Basin annual environmental watering priorities (the priorities) guide the annual planning and prioritisation of environmental watering across the Basin. This is done in order to achieve the most effective use of environmental water, promote better Basin-scale outcomes and coordinate environmental watering between environmental water holders and managers. All watering in the Murray–Darling Basin for environmental benefit, including watering that uses both held and planned environmental water, is to be undertaken having regard to the priorities.

The priorities are not an exhaustive list of all important environmental assets and functions throughout the Basin; and does not preclude other watering priorities identified by environmental water holders and managers at the regional level.

Basin-wide environmental watering strategy

The priorities are guided by the Basin-wide environmental watering strategy (the strategy) (MDBA 2014a) which was published in November 2014. The strategy quantifies the expected environmental outcomes for the Basin over the long term and proposes water management strategies and coordinated actions required to achieve them. The priorities represent annual steps to guide environmental watering to meet the long-term outcomes set out in the strategy.

Planning for the priorities

The priorities have regard to the Basin states annual environmental watering priorities in addition to the outcomes in the strategy. This ensures a bottom up and top down approach, taking into account both a whole-of-Basin and a regional perspective.

In March of each year the Murray–Darling Basin Authority (MDBA) releases a Basin environmental watering outlook (the outlook) as an early indication of the MDBA's thinking for watering opportunities in the coming water year. The outlook outlines past and present Basin-wide seasonal conditions and water storage, predicted rainfall and, environmental watering that has occurred over the past few years. The outlook provides an opportunity to obtain feedback from environmental water holders and managers on the potential watering opportunities.

The priorities have been framed in light of the forecasted Resource Availability Scenario, as outlined below, with realistic environmental watering goals for the coming water year. The priorities are flexible and can be implemented over a range of water Resource Availability Scenarios should there be a change in predicted condition.

Setting the scene for the 2015–16 priorities

Resource Availability Scenario

To ensure environmental water holders are prepared for the coming year it is important to identify the most likely Resource Availability Scenario (RAS) (refer Appendix 1) and the associated management objectives. The RAS is determined each year by considering conditions in the previous season, current water availability, long-term weather forecasts, antecedent conditions

and likely water availability. The RAS for the 2015–16 water year can be characterised as dry in the northern Basin and dry to moderate in the southern Basin based on the information summarised in the following sections.

Seasonal Conditions

Rainfall since November has been average to below average (Figure 1), while the average outlook for the next three months (June–August 2015) (Figure 2) is slightly above average. The Bureau of Meteorology climate outlook suggests that El Niño conditions will likely continue to strengthen into spring. El Niño is often associated with below-average rainfall across eastern Australia. Additionally, some climate models indicate an increased chance of a positive Indian Ocean Dipole developing later in 2015, which is associated with decreased winter and spring rainfall in southern Australia. The Bureau of Meteorology's rainfall outlook for the next three months indicates a slight chance of exceeding median rainfall in the Murray–Darling Basin (Figure 2).

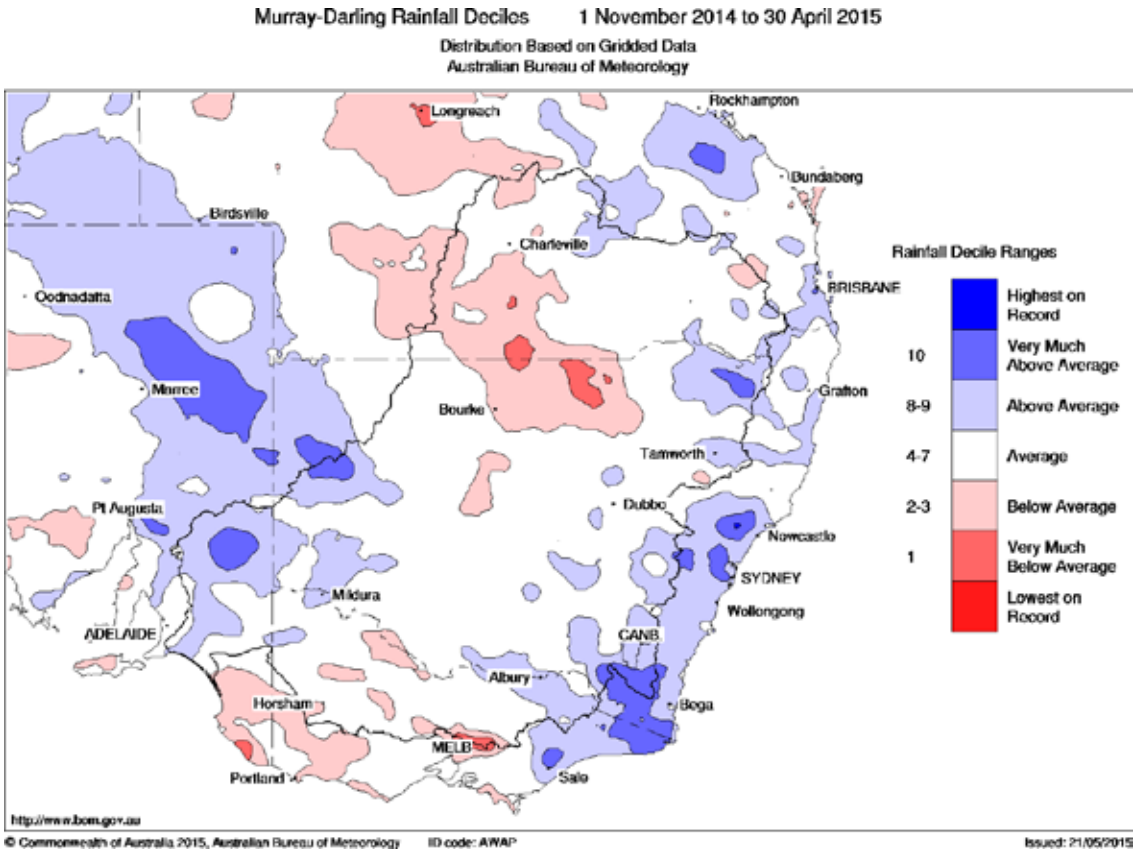

Figure 1: Rainfall across the Murray–Darling Basin in the past six months (1 November 2014 to 30 April 2015) (www.bom.gov.au).

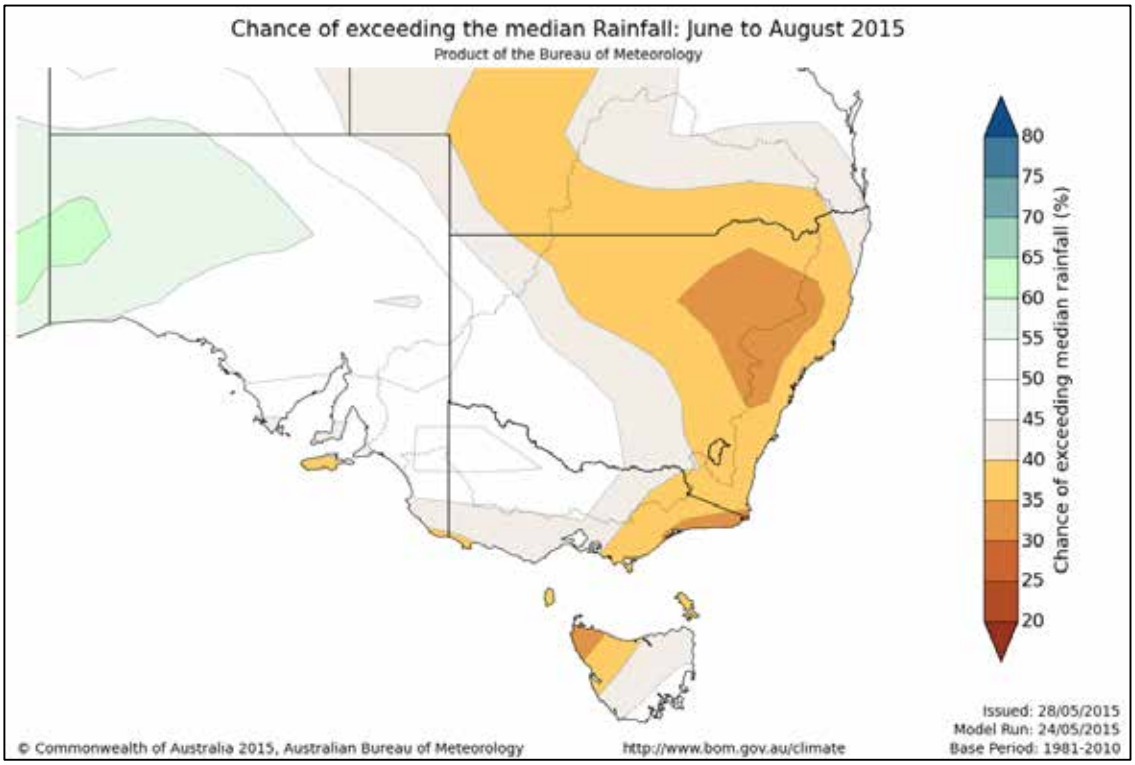

Figure 2: Chance of exceeding median rainfall in the Murray–Darling Basin: June to August 2015 (www.bom.gov.au).

Water availability

As of 21 May 2015 the combined storage levels (Figure 3) in the southern Basin are at 43% of capacity, with northern Basin storages at 22% capacity, and Lachlan storages at 35% capacity. These storage levels are below that of last years, which were 62% (southern Basin) and 31% (northern Basin including the Lachlan). Inflows into streams and storages are directly impacted by soil moisture. Upper layer soil moisture reflects short term rainfall and temperature events, whereas lower layer soil moisture is slower to respond to rainfall and temperature and reflects accumulated events over longer timeframes. Given that the lower soil moisture layer continued to display the effects of recent dry years in 2014, it is expected that system inflows in the 2015–16 water year will be low unless higher than average rainfall is received.

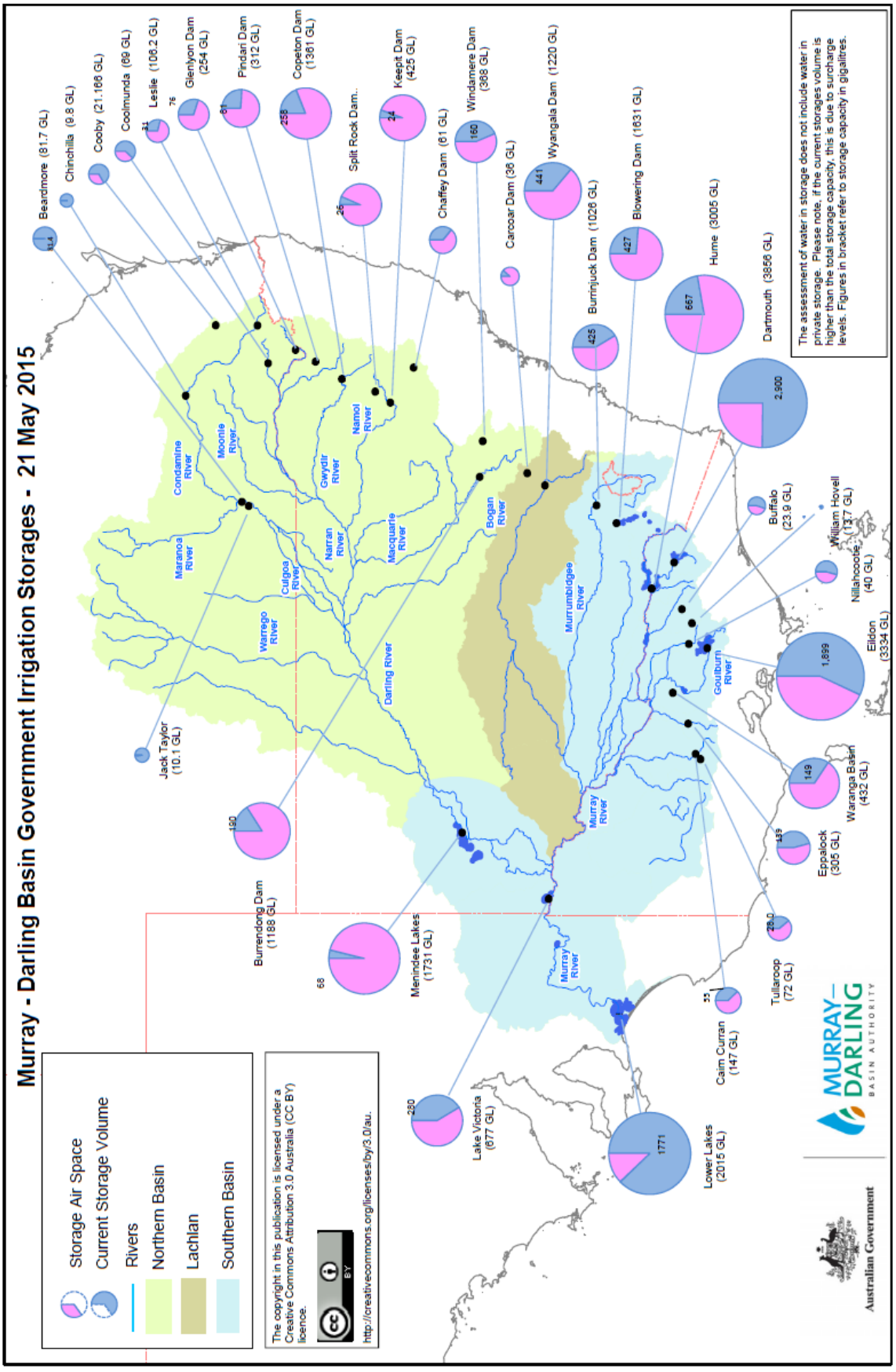

Figure 3: Murray–Darling Basin storage volumes as at 21 May 2015 (www.mdba.gov.au).

The 2014–15 Basin annual environmental watering priorities

The 2014–15 priorities focused around three themes; connecting rivers and floodplains, supporting in-stream functions and enhancing and protecting refuge habitat. Seven priorities were identified in order to achieve environmental benefits at multiple ecological sites and functions under dry to moderate conditions:

- Gwydir Wetlands: *Improve the condition and maintain the extent of wetland vegetation communities in the Gwydir Wetlands (including Ramsar sites) by restoring hydrological connectivity and a flow regime that meets ecological requirements.*
- Mid-Murrumbidgee wetlands: *Improve the condition of wetland vegetation communities in the mid-Murrumbidgee wetlands through a winter or spring fresh.*
- Macquarie River: *Improve native fish habitat within the Macquarie River below Burrendong Dam, by restoring a more natural flow regime and managing cold water pollution.*
- Connectivity in the River Murray system**:** *Improve riparian, littoral and aquatic vegetation (e.g. Ruppia tuberosa) and native fish populations, by increasing ecosystem connectivity through coordinating water delivery in the River Murray system.*
- Winter flows for fish in the southern Basin: *Improve survival, recruitment and condition of native fish populations, by providing winter flows to tributaries and creeks of the River Murray and through the barrages to the Coorong.*
- Native fish in the northern Basin**:** *Improve survival of native fish populations by enhancing and protecting dry period refuge habitat in the northern Basin.*
- Waterbird refuge**:** *Maintain waterbird habitat, including refuge sites and food sources, to support waterbird populations across the Murray–Darling Basin. Support waterbird breeding where feasible.*

Based on water availability and natural rainfall events in 2014–15, environmental watering in line with the 2014–15 priorities occurred in the following locations:

- **Gwydir Wetlands:** Water was delivered to the wetlands from September until mid-October, suspended for a month while crops were harvested, and began again in mid-November. Although the break in flows was not optimal from an environmental perspective, a full watering of the Gingham and lower Gwydir wetlands was nevertheless achieved, including Ramsar sites. A flow was also provided for fish in the Mehi River and water was delivered to Mallowa Creek.
- **Murrumbidgee River:** Although the flow trigger required for a 'piggyback' event was not reached, Yarradda Lagoon — a nationally significant wetland in the mid-Murrumbidgee — received water via pumping. This contributed to the recovery of aquatic vegetation. Brolgas (*Grus rubicunda*) and the very rare Australasian bittern (*Botaurus poiciloptilus*) were recorded in the wetlands. While this small scale watering was successful and supported some recovery of the wetlands, the majority of mid-Murrumbidgee wetlands still have not received water and their condition continues to decline. The mid-Murrumbidgee wetlands have therefore been relisted as a 2015–16 priority.
- **Macquarie River:** Environmental water was released in the Macquarie River to take advantage of new temperature control curtain infrastructure. Early reports from the

region indicate that opportunities for native fish migration and spawning were provided. The Macquarie Marshes also received about 30 GL of environmental water sustaining some semi-permanent wetland communities. The Macquarie Marshes have been listed as a 2015–16 priority due to drying conditions. Water will be required to maintain semi-permanent vegetation and core drought refuges.

- **River Murray:** Watering occurred at several environmental sites down the length of the River Murray, including Gunbower Forest, Hattah Lakes, Koondrook–Perricoota Forest, Mulcra Island and the Chowilla floodplain. These flows provided connectivity in the River Murray system, improved vegetation and native fish populations and, provided carbon and nutrient cycling between the floodplain and the river.
- **Native fish:** Two spring 'freshes' were provided in the Goulburn River that triggered spawning and migration of golden perch (*Macquaria ambigua*). Silver perch (*Bidyanus bidyanus*) also spawned, which was a significant outcome for this threatened species. Additionally, large volumes of environmental water were delivered to Gunbower Forest in winter and spring 2014, promoting river red gum (*Eucalyptus camaldulensis*) health, and triggering a significant breeding opportunity for small-bodied native fish. Watering in the Gwydir wetlands and Macquarie River also contributed to enhancing and protecting fish refuges under dry conditions.
- **Waterbird refuge:** Watering in the Macquarie Marshes, Gwydir Wetlands, Lower Lakes, Coorong, and the lower and mid-Murrumbidgee contributed to maintaining waterbird habitat, refuge sites and food sources.

The priorities for 2015–16

The 2015–16 priorities have been written to accommodate a range in conditions across both the dry and moderate Resource Availability Scenarios. These are aimed at maintaining ecological health and ecosystem resilience throughout the Basin. The 2015–16 priorities are focussed around four themes for which the strategy identifies quantified environmental outcomes, these are river flows and connectivity, native vegetation, waterbirds and native fish.

All priorities are supported by a rationale outlining the expected benefits, links to the Basin-wide environmental watering strategy, and watering implementation. The priorities have not attempted to prioritise the watering needs of all the ecological assets and functions throughout the Murray–Darling Basin. Rather, the priorities reflect those considered to be of Basin significance, noting that environmental watering is already occurring successfully throughout much of the Basin at the local and regional scale; and that state priorities will guide watering for each water resource plan area. Figure 4 (page 10) provides a geographic representation of the 2015–16 priorities in the Murray–Darling Basin. Due to the variable nature of climate and river flow across the Basin, real-time management of environmental water will be undertaken according to specific conditions in each catchment.

River flows and connectivity theme

The 2015–16 priorities will provide longitudinal connectivity and provide variability in flow patterns for improved water quality and ecological benefit.

Maintaining longitudinal hydrological connectivity is vital to protect, restore and enhance the health of in-stream and end-of-system aquatic ecosystem functions, linking aquatic habitats and species and communities along the length of the rivers. Given the moderate to dry predictions for water availability in the 2015–16 water year longitudinal connectivity will assist in protecting refuge areas and maintaining the condition of these areas such that they can persist during dry conditions. Providing lateral connectivity to refuge areas and other priority sites will also be important, but are unlikely to be widespread given the forecast water availability.

The 2015–16 priorities that focus on river flows and connectivity are:

- **Basin-wide flow variability and longitudinal connectivity:** *Provide flow variability and longitudinal connectivity within rivers to support refuge habitats.*
- **River Murray weir pool variation:** *Ensure a variable flow pattern and lateral connectivity through coordinated weir pool management in the River Murray from Euston to Blanchetown.*
- **Coorong, Lower Lakes and Murray Mouth:** *Improve water quality, fringing vegetation and native fish movement by varying the water levels in Lakes Alexandrina and Albert to maintain flows into the Coorong and Murray Mouth.*

Native vegetation theme

Several sites have been identified as priorities for watering in the 2015–16 water year where the aim is to maintain and improve water-dependent native vegetation. Given the moderate to dry predictions for water availability, the following priorities focus on the condition of in-stream and riparian vegetation that fringe the rivers of the Basin. This will build resilience in these areas through improving condition and replenishing the seedbank for native vegetation.

If implemented these priorities will also result in improved outcomes for waterbirds and native fish, as they will improve or maintain the condition and extent of wetland habitats and drought refuges throughout the Basin. This is of particular importance for waterbird populations, which have experienced a decline in both abundance and breeding in 2013 and 2014.

The 2015–16 priorities that focus on meeting the long-term expected outcomes for native vegetation are:

- **Basin-wide in-stream and riparian vegetation:** *Maintain and where possible improve the condition of in-stream riparian vegetation, through in-channel freshes.*
- **Mid-Murrumbidgee Wetlands:** *Improve the condition of wetland vegetation communities in the mid-Murrumbidgee wetlands*.
- **Macquarie Marshes:** *Maintain semi-permanent wetland vegetation in core refuge areas in the Macquarie Marshes.*
- **Moira grass:** *Maintain the condition and range of Moira grass in Barmah–Millewa Forest by supplementing a natural event and extending the duration of inundation.*

Waterbirds theme

The waterbird priority for 2015–16 focusses on protecting significant waterbird sites across the Basin by improving vegetation structure and condition. This is linked to the priorities for native vegetation outlined above, as each of these will also improve conditions for waterbird habitat and drought refuge.

Preceding dry conditions throughout the Basin mean there are fewer wetlands for waterbirds to congregate. Given the moderate to dry predictions for water availability in the 2015–16 water year, seasonally appropriate pulsed flows will be required to ensure that the quality of habitats and drought refuges across the Basin are maintained or improved for waterbirds.

While the 2015–16 focus is not on managing water in order to initiate a breeding response, should such an event be triggered by natural flows, environmental water should be managed in harmony with biological cues in order to optimise outcomes for waterbirds.

The 2015–16 priority that focusses on the long-term expected outcomes for waterbirds is:

- **Basin-wide waterbird habitat and future population recovery:** *Improve the complexity and health of priority waterbird habitat to maintain species richness and aid future population recovery.*

Native fish theme

The native fish priorities for the 2015–16 water year focus on protecting, and where possible enhancing, current populations and their habitats in order to achieve a diverse native fish community with resilient populations. Given the moderate to dry predictions for water availability, actions for protecting populations focus on protecting drought refuges in the northern Basin and promoting connectivity for breeding, foraging, growth and movement of fish in the southern Basin.

The long-term recovery of silver perch has been identified as a priority that will require planning and actions over several years to build population resilience. The MDBA encourages managers to consider how improved outcomes for silver perch can be achieved in 2015–16 and beyond.

The 2015–16 priorities that focus on the long-term expected outcomes for native fish are:

- **Basin-wide native fish habitat and movement:** *Maintain native fish populations by protecting and improving the condition of fish habitat and providing opportunities for movement.*
- **Northern Basin fish refuges:** *Protect native fish populations and in-stream habitats, particularly drought refuges, in the northern Basin.*
- **Silver perch:** *Contribute to the long-term recovery of silver perch by maintaining key populations, supporting recruitment and facilitating movement and dispersal.*

Outcomes of particular importance to Aboriginal people

Aboriginal environmental outcomes are not cultural flows or cultural water. Cultural flows/water are water entitlements which are owned by Aboriginal Nations and which may also have a commercial benefit where any revenue accrued goes to Aboriginal people. Involvement with the management of environmental flows provides an opportunity for Aboriginal people to sustain and strengthen their connection with rivers and improve the condition of Country.

Environmental watering will be undertaken in order to achieve environmental outcomes (as set out in the Basin Plan). At the same time, environmental watering can contribute to some outcomes sought by Aboriginal peoples. The term “Aboriginal environmental outcomes” is being used to describe and communicate the benefits to Aboriginal people that can be derived from healthier rivers and wetlands produced by environmental watering. Examples of Aboriginal environmental outcomes are improved fish populations, more reeds or increased bird breeding events, all of which can be harvested and used by Aboriginal people.

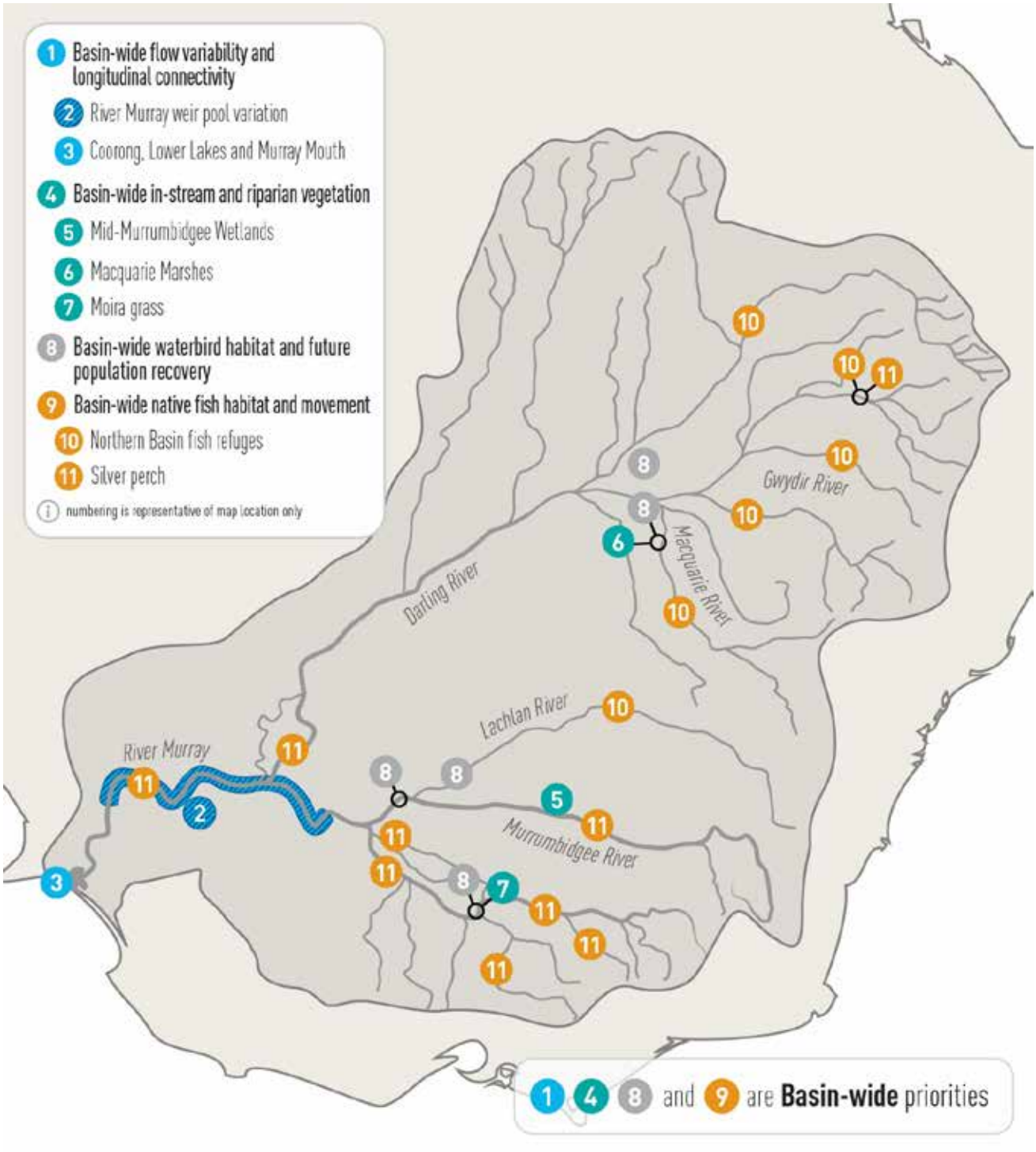

Figure 4: Geographic representation of the 2015–16 priorities in the Murray–Darling Basin

Basin-wide flow variability and longitudinal connectivity

Basin annual environmental watering priority

Provide flow variability and longitudinal connectivity within rivers to support refuge habitats.

Expected benefits

It is anticipated that delivering environmental water in 2015–16 in accordance with this priority will:

- maintain drought refuges, particularly for native fish and waterbirds
- enable fish movement
- increase in-channel habitat diversity (e.g. still water, fast and slow flowing water)
- reinstate a natural wetting and drying regime
- maintain and improve water quality
- support vegetation communities within or closely fringing the river channel as well as some low lying areas of the floodplain

Why is this a Basin watering priority?

River regulation and water resource development has significantly impacted river flows and connectivity. A reduction of small to medium flood events has resulted in limited lateral connectivity between rivers and floodplains and less longitudinal connectivity. River regulation has also reduced hydrodynamic diversity (i.e. flow variability) and disrupts seasonal flow patterns.

Should dry conditions continue in northern areas of the Murray–Darling Basin (current forecasts predict an El Niño developing later in the year) protecting and improving the condition of refuges will become extremely important. In addition, given the limited water available for use, maximising ecological outcomes through the way we manage all water will also be critically important. All water, both consumptive and environmental, can be managed to provide a variety of different flows (e.g. still water, fast and slow flowing water) and still meet the needs of all users. This will maximise the outcomes possible with only limited amount of environmental water.

Opportunities to enhance longitudinal connectivity will be important throughout the Basin but particularly in the northern Basin given the preceding and forecasted dry Resource Availability Scenario (RAS). Longitudinal connectivity will assist in providing refuge for fish by providing in-channel connectivity between pools, rivers and to the ocean, as well as maintaining in-stream habitats and enabling native fish movement.

Providing lateral connectivity between the main channel and priority off-channel refuge areas will also be important but unlikely to be widespread given the forecast of limited water availability. The upcoming season may be more of an opportunity to allow for drying to occur consistent with natural wetting-drying cycles. The priority sites for providing limited lateral connectivity would be where wetlands are in poor condition or provide important refuge.

This priority will contribute, within the bounds of the RAS, to meeting the expected environmental outcomes identified in the Basin-wide environmental watering strategy (the strategy) (MDBA 2014a). There are multiple relevant outcomes in the strategy including:

- keeping base flows of at least 60% of the natural level
- 30 to 60% increase in the frequency of freshes, bank-full and lowland floodplain flows in the Murray, Murrumbidgee, Goulburn–Broken and Condamine Balonne catchments
- barrage flows of greater than 2,000 GL/year on a three-year rolling average basis for 95% of the time, with a two year minimum of 600 GL at any time.

Implementation

Water management strategies to achieve this priority will vary spatially and temporally across the Murray–Darling Basin, depending on conditions. The strategy identifies a range of water management strategies that could be adopted to meet this priority and contribute towards meeting the expected environmental outcomes. Some relevant strategies suited to the current and forecast conditions in the Murray–Darling Basin are identified below, with further detail provided in the other specific priorities.

Contributing to and protecting base flows will be important to ensure longitudinal connectivity. While base flows are generally maintained by seeping groundwater, small regulated releases of surface water may also be needed, to provide longitudinal connectivity throughout the Basin. This will protect in-stream drought refuges, particularly in the northern Basin (refer Northern Basin fish refuges priority) and provide flows through the barrages in South Australia (refer Coorong, Lower Lakes and Murray Mouth priority).

Pulsing flows and increasing variability in the rate of delivery of all water (consumptive and environmental) should be considered. In-channel freshes provide water to closely fringing vegetation, including black box (*Eucalyptus largiflorens*) and river red gum and assists in maintaining or improving their health (refer Basin-wide in-stream and riparian vegetation priority). Increasing variability will facilitate a more natural flow pattern, provide for natural wetting and drying of low lying wetlands, and improve diversity of in channel habitats (refer River Murray weir pool variation and Silver perch priorities).

Providing lateral connectivity within low lying areas will not be possible everywhere. In some areas of the Murray–Darling Basin it will be possible to inundate priority low lying areas with the current anticipated water availability or through the use and/or commissioning of environmental works (e.g. regulating structures). Those areas identified as being a priority include: Moira grass in Barmah–Millewa Forest (refer Moira grass priority), semi aquatic vegetation in the Mid-Murrumbidgee wetlands (refer Mid-Murrumbidgee wetlands priority), semi-permanent wetland vegetation in the Macquarie Marshes (refer Macquarie Marshes priority), and waterbird refuge sites (refer to Basin-wide waterbird habitat and future population recovery priority). Where appropriate, drying phases should be maintained at wetlands higher on the floodplain, in line with their natural wetting and drying regime.

River Murray weir pool variation

Basin annual environmental watering priority

Ensure a variable flow pattern and lateral connectivity through coordinated weir pool management in the River Murray from Euston to Blanchetown.

Expected benefits

Ensuring a natural in-stream flow pattern through coordinated weir pool management in 2015–16 will:

- inundate and expose emergent aquatic vegetation and shallow water habitats by varying water levels
- improve operational flexibility and allow for efficient water management
- connect the River Murray to ephemeral wetlands and floodplains
- transport organic matter, stimulate seed germination, enhance riparian vegetation diversity and improve river and wetland productivity
- create a range of in channel habitats for native fish by increasing hydrodynamic diversity (i.e. fast and slow flowing water)

Why is this a Basin watering priority?

The River Murray provides important habitat for numerous native fish species (e.g. Murray cod (*Maccullochella peelii*), trout cod (*Maccullochella macquariensis*), golden perch and silver perch) that spend the majority of their life in the main channel, connected anabranches and billabongs (Lintermans 2007). The River Murray and adjacent wetlands, floodplains, anabranches and creeks support a significant number of internationally and nationally listed waterbirds, important native fish and vegetation communities.

The construction and management of the 12 locks and weirs from Euston in New South Wales to Blanchetown in South Australia (stretching over 1,100 river km) have altered the natural flow of the River Murray. These structures create a series of stable pools which reduce the variability and frequency of high and low flows for some distance upstream of the weir (Figure 5) (Walker 1985; Koehn et al. 2014). Modification of the natural flow of the River Murray has in turn limited key ecosystem functions, such as sediment and nutrient transport (Schiller & Harris 2001), permanently inundated some connected ephemeral wetlands (Walker 1985) and negatively impacted riparian vegetation.

This priority will help achieve multiple environmental benefits through the coordinated operation of weirs across state boundaries in the River Murray system, between governments, environmental water holders and managers. The priority will contribute to the quantified environmental outcomes in the Basin-wide environmental watering strategy (the strategy) that can be achieved now and into the future by encouraging fish to use fish passages and maintaining the current extent of non-woody vegetation (MDBA 2014a).

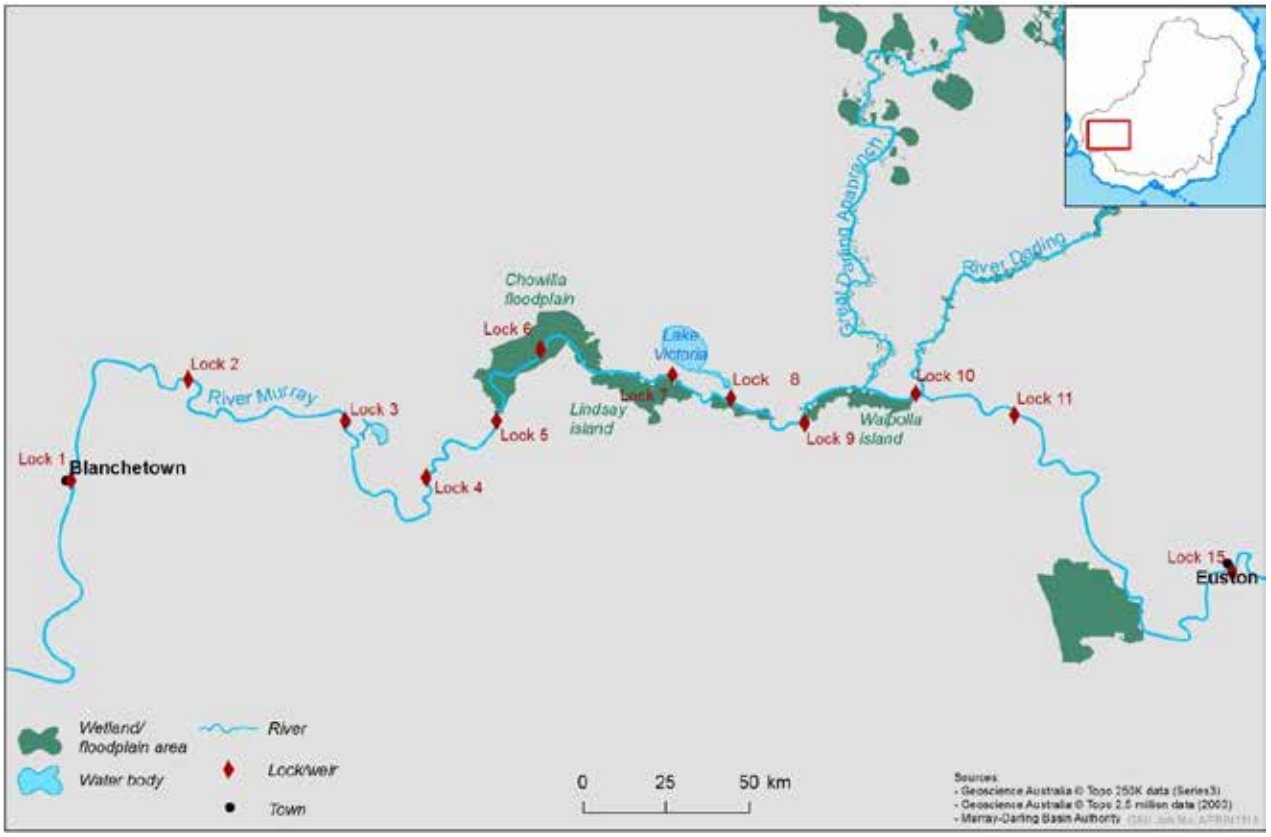

Figure 5: Map of the River Murray with locks and weirs.

Implementation

Coordinated weir pool management can improve operational flexibility, allow for more efficient water management and improve ecological outcomes in highly regulated systems. This priority entails encouraging a more active management regime by manipulating weir pools to raise and lower water levels to mimic naturally variable flows. This will help achieve the above stated outcomes.

The Resource Availability Scenario for 2015–16 is forecasted to range from moderate to dry in the River Murray system, however, this priority can be achieved in all Resource Availability Scenarios (very dry to very wet) using consumptive and environmental water. Weir pools can be raised to inundate low-lying wetlands and floodplains, flood runners and tributaries that are influenced by the locks and weirs and lowered to create additional stream variability. For example, at Lock 15 the weir is raised during winter and spring, then lowered in summer and autumn to promote a more complex riparian plant community and increase wetland productivity by ensuring connection and disconnection occurs at the appropriate time.

The following are examples of water management strategies specific to vegetation and native fish outcomes in the strategy (MDBA 2014a) that can be implemented to achieve this priority:

- cooperative arrangements for the management of weir pool achieves vegetation outcomes in lower River Murray
- delivering in-channel freshes to support vegetation fringing rivers and low-lying wetlands
- operating rivers to improve and/or reinstate slow and faster flowing water habitats for native fish

When implementing this priority water managers and holders need to be aware of and manage risks, including increased bank erosion, opportunities for the dispersal and breeding of pest species, impacts on affected landholders and boat operators (Government of South Australia 2014).

Implementing this priority will create a variety of flow generated habitats required for fish at different stages of their lifecycle. For example, slow flowing backwaters provide shelter and feeding sites for larval or juvenile fish. In addition this priority will promote carbon and nutrient cycling, natural wetting and drying periods in off-stream habitats, sediment transport and salinity dilution. This priority should be implemented in line with the Basin-wide flow variability and longitudinal connectivity, Basin-wide native fish habitat and movement, Basin-wide in-stream and riparian vegetation and Coorong, Murray Mouth and Lower Lakes priorities.

Coordinated management

New South Wales, Victorian and South Australian governments are investigating ways to enhance operational decision making and address barriers to weir pool manipulation. Water managers in all states have experimented with the manipulation of weir pool levels in an attempt to introduce more variable inundation patterns. A trial in the lower River Murray in 2005–06 resulted in successful spawning and recruitment of golden perch (Ye, Cheshire & Fleer 2008). In 2014–15 Locks 7, 8 and 9 were lowered to promote the drying of backwaters and building on this in 2015–16 Locks 7, 8 and 9 are proposed to be manipulated to trial a way to achieve fast flowing habitats for native fish recruitment.

The Victorian and New South Wales governments developed a coordinated management plan to manage the reach between Lock 8 and 9 for environmental benefit (Ecological Associates 2013). In 2014, they extended this work to include Lock 6 to Lock 10 and Lock 15. The plans identify ecological objectives and outline hydrological regimes to achieve the objectives, including opportunities and constraints in each reach. To oversee the implementation of these plans the states established the Weir Implementation Group comprised of river operators and water managers representing Commonwealth, Victorian, New South Wales and South Australian government agencies. South Australia has also commenced preliminary investigations into managing the reach between Lock 1 and 5. This would result in coordinated management from Lock 1 to 10 and Lock 15 for ecological benefits. The Authority encourages a cross border management approach for Lock 1 to Lock 10 and Lock 15 for environmental benefit.

Coorong, Lower Lakes and Murray Mouth

Basin annual environmental watering priority

Improve water quality, fringing vegetation and native fish movement by varying the water levels in Lakes Alexandrina and Albert and maintain flows into the Coorong and Murray Mouth.

Expected benefits

Managing and delivering water in both the Lower Lakes and the Coorong in 2015–16 in accordance with this priority will:

- provide hydrological and physical connectivity between the River Murray, the Lower Lakes, the Coorong estuary and through to the Southern Ocean via an open Murray Mouth
- improve flow cues for spawning and recruitment of diadromous fish
- support nationally-listed and state-listed threatened and endangered species
- create temporal variability of water levels in Lake Alexandrina and Lake Albert to benefit fringing and aquatic vegetation and stabilise banks
- improve long term water quality for *Ruppia tuberosa*, a key indicator species for the health of the Coorong
- improve habitat conditions within the Coorong (especially the North Coorong lagoon) to support the survival, condition and recruitment of native fish
- encourage coordination between governments and environmental water holders and managers.

Why is this a Basin watering priority?

The Coorong and Lakes Alexandrina and Albert comprise one of Australia's largest wetland systems (Brookes et al. 2009) totalling 142,500 hectares (Figure 6) and are listed under the Convention on Wetlands of International Importance (the Ramsar Convention). Collectively, the Coorong, Lower Lakes and Murray Mouth meet eight of the nine criteria listed in the Ramsar Convention (Lester et al. 2011) and contain 23 Ramsar wetland types. The area provides important feeding habitat for waterbirds that migrate internationally, provides for the export of salt and sediment through the Murray Mouth and allows for native fish movement between marine, estuarine and freshwater environments.

Fringing emergent vegetation on the lake's edge provide important nesting and breeding areas, and shelter for native fish, frogs, migratory and non-migratory waterbirds and macro-invertebrates (Roberts & Marston 2000). They also provide an important source of organic matter in the food web.

Figure 6: Coorong, Lower Lakes and Murray Mouth, South Australia

Connectivity between freshwater, estuarine and marine environments enable native fish to move and migrate which is important for the resilience of populations. Connectivity is particularly important for diadromous fish (i.e. congolli (*Pseudaphritis urvillii*), common galaxias (*Galaxias maculatus*), short-headed lamprey (*Mordacia mordax*) and pouched lamprey (*Geotria australis*)), that move between these environments to complete lifecycles. However, whilst the barrages prevent saline water in the Coorong and Murray Mouth from entering the Lower Lakes and River Murray (MDBC 2006; Phillips & Muller 2006), they significantly limit fish movement. Creating a salinity gradient (i.e. a gradual change from freshwater to hyper-saline water within the Coorong) positively influences fish populations (Elliot & Whitfield 2011), distribution, species richness and spawning and recruitment success (Zampatti et al. 2010; Bice et al. 2012).

Salinity levels in the Coorong can be reduced with water flow through the barrages and via the Upper South East Drainage Scheme into the Coorong's South Lagoon. The salinity of the Coorong generally increases with distance from the Murray Mouth, but varies over time, mainly in response to freshwater inflows over the barrages. The maintenance of connectivity with the Lower Lakes, tidal exchange through the Murray and a salinity gradient along the Coorong is critical to maintaining diversity and population health of estuarine species.

The salinity levels, water depth and turbidity drives the distribution of *Ruppia tuberosa* (Carruthers et al. 1999). *Ruppia tuberosa* provides abundant food resources for local and migratory herbivorous waterbirds (Paton et al. 2001; Nicol 2005; Whipp 2010) and habitat for native fish and macroinvertebrates (Paton & Rogers 2009). *Ruppia tuberosa* drives primary productivity of the Coorong and Murray Mouth ecosystem (Paton & Rogers 2009). It is a key indicator species for the health of the Coorong (Lamontagne et al. 2012; MDBA 2012b). The

distribution and abundance of *R. tuberosa* in the South Lagoon has been greatly reduced as a result of the low water levels and associated extreme salinity during the Millennium Drought (Paton & Rogers 2009; Lamontagne et al., 2012).

Due to the more stable water levels, the distribution and diversity of aquatic and fringing vegetation around the Lower Lakes has greatly reduced (MDBA 2014b).

This priority builds on priorities listed by the Murray–Darling Basin Authority in 2013–14 and 2014–15 and contributes to achieving many of the quantified environmental outcomes in the Basin-wide environmental watering strategy (the strategy) (MDBA 2014a), for example:

- maintaining water levels in the Lower Lakes above 0.4m Australian Height Datum (AHD) for 95% of the time, as far as practicable, to allow for barrage releases
- achieving barrage flows greater than 2,000 GL/year on a three-year rolling average basis for 95% of the time (with a two year minimum of 600 GL at any time)
- a sustained and adequate population of *R. tuberosa* in the south lagoon of the Coorong by ensuring *R. tuberosa* occurs in at least 80% of sites across at least a 50 km extent by 2019
- salinity in the Coorong remains below 100 grams per litre 95% of the time for key flora and fauna.

Implementation

The importance of increased availability of environmental water for outcomes within the Coorong, Lower Lakes and Murray Mouth has been well recognised within the *Basin Plan 2012* and the strategy (MDBA 2014a). However, there is an increasing recognition of the importance of having complementary and seasonally appropriate operating strategies to maximise priority environmental outcomes.

The Environmental Water Requirements recommend managing the water levels in Lake Alexandrina and Albert between 0.7m AHD and 0.35m AHD every year and between 0.8m AHD and 0.5m AHD once every three years (MDBA 2014b). Since 2011, lake levels have fluctuated within and above these Environmental Water Requirements (Figure 7). Achieving both the low and high lake levels will benefit the lake's fringing vegetation, and provide flows into the Coorong and Murray Mouth which will improve water quality and facilitate fish movement. It is therefore recommended that the Lower Lakes are managed closer in line with the Environmental Water Requirements and the quantified environmental objective in the strategy (MDBA 2014a) which is to maintain lake levels above 0.4m AHD for 95% of the time (as far as practicable).

When the Lower Lakes are managed within a lower water level envelope, the additional water allocated to achieving environmental benefit for the system is able to flow through the barrages into the Coorong and through the Murray Mouth to maintain tidal exchange. This will lower salinity levels in the North Lagoon and northern end of the Southern Lagoon of the Coorong, connect freshwater and estuarine environments, facilitate bi-directional connectivity, and allow upstream and downstream movement of fish. This will also improve the fringing vegetation around the Lower Lakes by providing it with the appropriate water regime (MDBA 2014b).

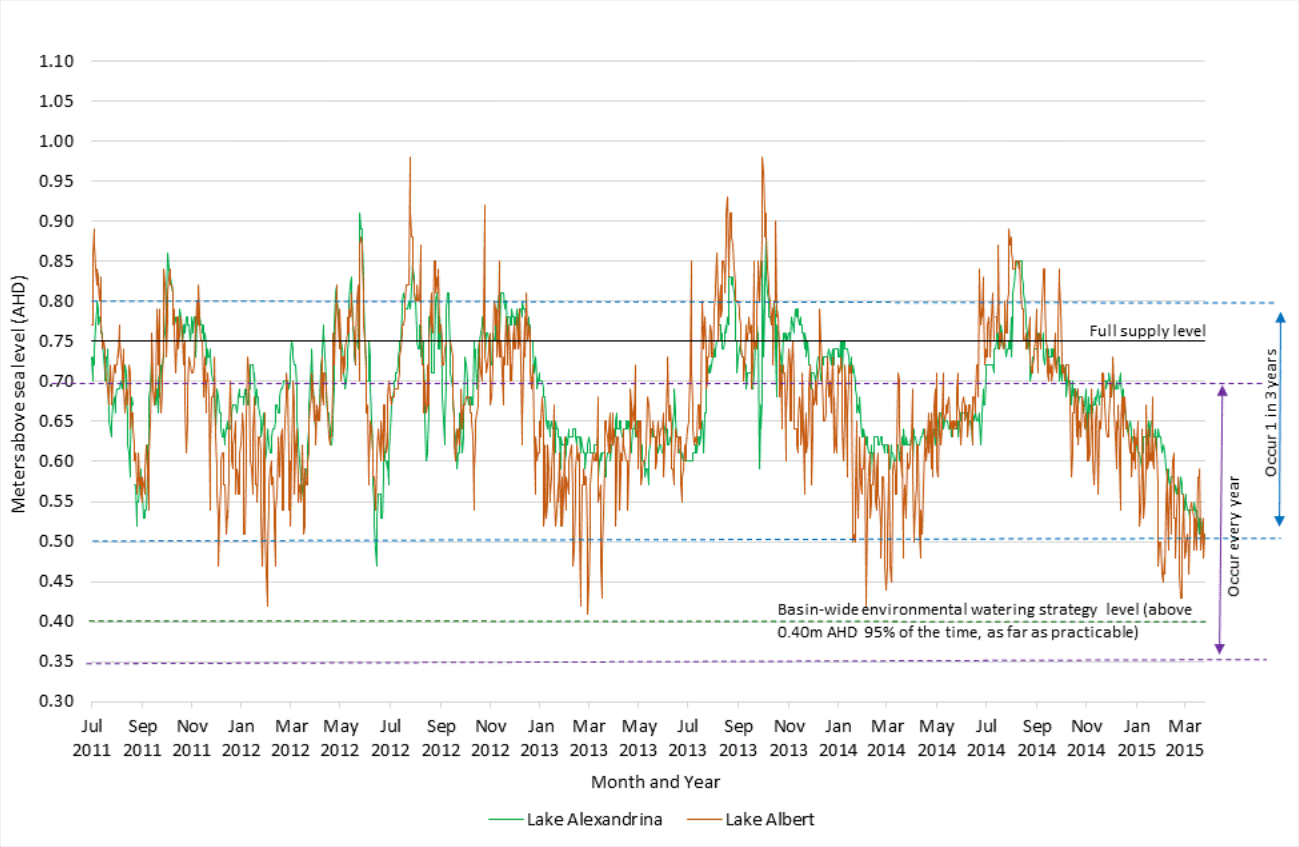

Figure 7: Water levels in Lake Alexandrina and Lake Albert from July 2011 to March 2015 and the associated Environmental Water Requirements to achieve icon site ecological target levels (MDBA 2014b) and levels articulated in the strategy (MDBA 2014a).

This priority can be implemented in all Resource Availability Scenarios, except in very dry scenarios. The forecast Resource Availability Scenario is likely to be moderate to dry. Therefore environmental water holders and managers should consider using both unregulated and managed water delivery events across the southern connected system to achieve the environmental benefits in the Lower Lakes, Coorong and Murray Mouth. The appropriateness of managing to lower lake water levels will require adequate operational planning and consideration of forecast river conditions and water availability. Any watering decisions to meet this priority will need to include consultation with relevant stakeholders to manage third party impacts.

The implementation of this priority complements the water management strategies outlined in the strategy (MDBA 2014a). These water management strategies include:

- augmenting and coordinating tributary flows in regulated parts of the Basin (particularly those which naturally contribute large flows downstream) to help in meeting downstream environmental outcomes
- watering requirements that support recruitment events and improve condition, including requirements for drying periods
- maintaining a salinity gradient in the estuary, whilst ensuring that the spatial extent of the gradient varies
- considering the spawning and recruitment outcomes for all native fish species, especially where flow affects critical parts of their life-cycles (such as movement and dispersal).

This priority should be implemented in line with the Basin-wide flow variability and longitudinal connectivity, Basin-wide native fish habitat and movement, Basin-wide in-stream and riparian vegetation and River Murray weir pool variation priorities.

Basin-wide in-stream and riparian vegetation

Basin annual environmental watering priority

Maintain and where possible improve the condition of in-stream and riparian vegetation through in-channel freshes.

Expected benefits

It is anticipated that delivering environmental water to in-stream and closely fringing vegetation communities in 2015–16 will:

- improve the condition of emergent, submergent, semi-permanent wetland vegetation and riparian vegetation communities
- maintain vegetation corridors along rivers
- replenish seedbank, improving resilience
- provide important areas of refuge in the event of further drying conditions
- provide longitudinal connectivity and to some degree lateral connectivity and associated outcomes (i.e. fish migrations, carbon inputs etc).

Why is this a Basin watering priority?

In-stream and riparian vegetation within and closely fringing the rivers throughout the Murray–Darling Basin are vital to the functioning of riverine ecosystems, providing important inputs into the river such as woody debris for fish habitat, food sources macroinvertebrates and habitat for birds and frogs. Riparian vegetation also provides corridors for movement of species and has high amenity values.

Rivers and low lying wetlands are important areas of refuge during dry times, which is currently important for 2015–16 given the antecedent conditions and low water availability across much of the Murray–Darling Basin. Building resilience, through improving condition and replenishing the seedbank, will be potentially important in the coming years in these refuge areas.

As detailed in the Basin-wide environmental watering strategy (the strategy) (MDBA 2014a) the condition of water dependent vegetation in the Murray–Darling Basin has declined in response to water resource development (water abstraction and river regulation). The decline in vegetation condition has often occurred in conjunction with a decline in extent. This is evident in areas such as the Barmah–Millewa Forest where areas of non-woody vegetation (such as Moira Grass) is reducing with subsequent encroachment of river red gums (refer Moira grass priority). The semi-permanent wetland vegetation communities in the Gwydir have also suffered significant loss of extent.

The implementation of this priority will improve growth of vegetation communities that fringe or occur within the main river corridors, including some areas of low lying wetlands. This will help meet the long-term outcomes detailed within the strategy. The strategy also lists additional regionally significant sites where the delivery of water for water-dependent vegetation should be targeted.

Implementation

Water management strategies to achieve this priority will vary spatially and temporally across the Murray–Darling Basin depending on conditions. The strategy identifies a range of water

management strategies that could be adopted to meet this priority and contribute towards meeting the quantified environmental outcomes. Relevant water management strategies suited to the current and forecast conditions in the Murray–Darling Basin include:

- providing in-channel freshes to support emergent and submergent vegetation communities and refresh soil water available to vegetation closely fringing rivers, helping to maintain or improve their condition (MDBA 2014a).
- delivery and management of all water (consumptive and environmental) in a way that provides in-channel freshes.
- providing low to moderate flows of extended duration to assist in watering end of river low lying wetlands. This priority will assist in maintaining condition of core wetland areas which will provide important refuge should dry conditions continue. For further details on implementation refer to the priority for the Macquarie Marshes. These flows can also be delivered via a flow pulse, providing an in-channel fresh which could achieve additional outcomes en route.
- providing in-channel high flows which fill closely fringing, low lying wetlands. Where possible natural cues should be supplemented to deliver high flows which build upon natural events. Mid-Murrumbidgee and Barmah–Millewa Forest have been identified as priority low lying areas requiring watering. Refer to the priorities for the Mid-Murrumbidgee Wetlands, River Murray weir pool variation and Moira grass priorities for further detail on implementation at these sites.
- maintaining a drying regime consistent with a natural wetting and drying cycle will be important in some areas and can contribute to the health of vegetation (e.g. shoreline vegetation such as sedges and rushes). For example, the Gwydir wetlands could tolerate a dry period in 2015–16 in a dry scenario, as it received water in 2014–15. However, in the instance of rainfall or other biological cues, watering of the Gwydir wetlands in 2015–16 will still be desirable to build resilience and to provide an important refuge in the Basin.

Delivery of consumptive water could contribute to meeting this priority, however in some situations the timing and volume of consumptive water delivery will not coincide with environmental requirements.

Mid-Murrumbidgee Wetlands

Basin annual environmental watering priority

Improve the condition of wetland vegetation communities in the mid-Murrumbidgee wetlands.

Expected benefits

It is anticipated that a winter spring fresh in the mid-Murrumbidgee in 2015–16 will:

- maintain and improve the health of inundation dependent vegetation communities in the mid-Murrumbidgee wetlands by providing opportunities for growth and recruitment
- support watering of adjacent low-lying wetlands promoting mobilisation, transport and dispersal of biotic and abiotic material (e.g. sediment, nutrients and organic matter)
- discourage the establishment of terrestrial vegetation into the wetlands
- support recovery of native vegetation communities from drought
- increase habitat for fish, frogs, birds and turtles
- maintain and improve the condition of downstream ecosystems.

Why is this a Basin watering priority?

This priority will contribute to meeting the Basin scale outcomes identified within the Basin-wide environmental watering strategy (MDBA 2014a). Achieving this priority will directly contribute to meeting targets for river red gum and non-woody vegetation and will also contribute to outcomes for waterbirds, native fish and river flows and connectivity. This priority also relates directly to the Basin-wide in-stream and riparian vegetation priority.

The mid-Murrumbidgee wetlands (between Wagga and Carrathool) (Figure 8) have been listed as a Basin annual environmental watering priority in 2013–14 and 2014–15. Achieving this priority through a co-ordinated environmental flow event has proven difficult in the past. Despite a small number of individual watering actions being conducted at selected wetlands, at a system level the condition of vegetation, particularly semi-aquatic vegetation, in the mid-Murrumbidgee wetlands continues to decline due to a lack of inundation. Given the condition of the vegetation, watering of the wetlands may be required in successive years to enable full recovery.

The mid-Murrumbidgee wetlands support rare and threatened fauna species including the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) listed endangered trout cod, the vulnerable southern bell frog (*Litoria raniformis*) and numerous bird species. The wetlands also support internationally listed migratory species such as the cattle egret (*Ardea ibis*), eastern great egret (*Ardea modesta*), glossy ibis (*Plegadis falcinellus*), latham's snipe (*Gallinago hardwickii*) and the white-bellied sea-eagle (*Haliaeetus leucogaster*) (MDBA 2012a).

The mid-Murrumbidgee wetlands are good examples of inland river and lagoon wetlands of which a selection is listed in the Directory of Important Wetlands of Australia (Environment Australia 2001). These wetlands support the functioning of the middle and lower reaches of the Murrumbidgee River, one of the longest rivers in the Murray–Darling Basin, by providing an important input of carbon and nutrients to the river as well as being a key habitat for fish, frogs, turtles and birds.

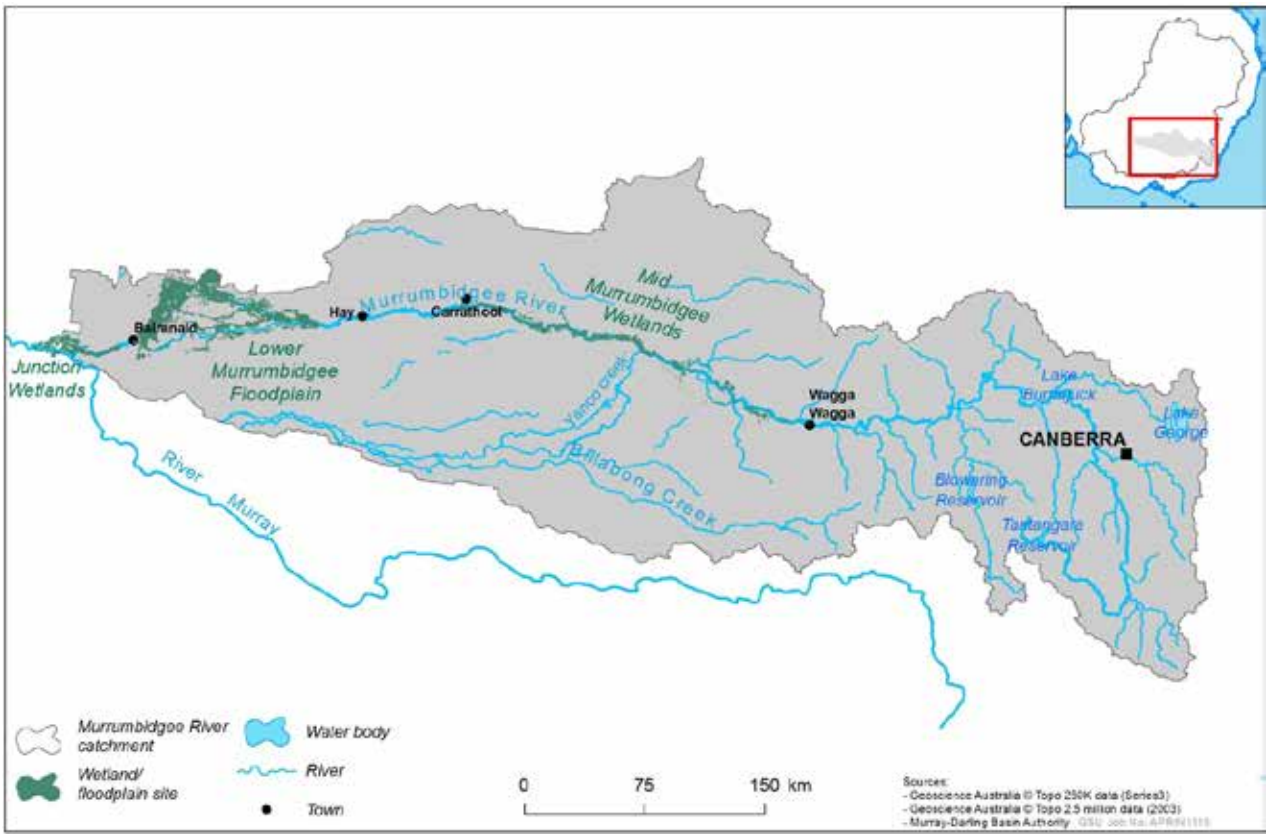

Figure 8: Map of the Murrumbidgee Catchment

Implementation

Prevailing conditions throughout the water year will determine the extent to which this priority can be achieved and how it is achieved. At the time of preparing the priority, the Resource Availability Scenario (RAS) outlook for 2015–16 range from moderate to dry for the Murrumbidgee River system, with a potential drying trend.

Under a dry scenario there is likely to be reduced occurrence of natural higher flows and fewer opportunities to build on a natural flow event to achieve or extend inundation. There will also be reduced water availability, and potentially reduced outlet capacity with lower water levels in Burrinjuck Dam. In the event that a trigger flow does not occur in winter or spring (the preferred timing), consideration should be given to seeking opportunities later in the season (i.e. autumn) to inundate the mid-Murrumbidgee wetlands. While a flow in autumn may not be ideal in terms of timing there would still be benefits in reconnecting the wetlands to the main channel at this time. If a large natural flow event does not occur, consideration should be given to building on a smaller event to assist in improving condition of the lower lying wetlands should an extended dry sequence occur.

Should wetter conditions occur (i.e. a moderate to wet scenario) there may be more opportunities to build on natural flow events and this will increase the likelihood of achieving this priority. This scenario will also result in increased water availability and greater outlet capacity with higher water levels in Burrinjuck Dam.

There are multiple constraints to delivering higher managed flows in the Murrumbidgee Valley. The delivery of environmental water needs to be consistent with the rules outlined in the Water Sharing Plan for the Murrumbidgee Regulated River Water Source. Continued planning and stakeholder consultation should facilitate the implementation of this priority in 2015–16.

Meeting multiple objectives

Implementation of this priority should, where possible, aim to achieve outcomes beyond this specific priority. Consideration should also be given to:

- coordinating flows to the Junction Wetlands. The Junction Wetlands are a group of creeks and wetlands located on the western side of the Murrumbidgee River at its confluence with the River Murray (Figure 8). Watering of the Junction Wetlands requires concurrent high flows in both the Murray (flows of 10,000 ML/day at Barham) and Murrumbidgee (flows of 5,000 ML/day downstream of Balranald weir) rivers (SKM 2011). While there is relatively little known about the Junction Wetlands they are known to support a number of rare and threatened species (SKM 2011). The Junction Wetlands have experienced similar conditions to the mid-Murrumbidgee, having undergone a long drying period between 2000 and 2010. While the wetlands and creeks received subsequent flows during 2010–12 they are still recovering and require continued support.
- providing freshes during the spring period and throughout the length of the system (in-line with the Basin-wide flow variability and longitudinal connectivity priority) to support recruitment opportunities for a range of native aquatic species including fish (refer to the Silver perch priority) and support key ecosystem functions, particularly those related to longitudinal connectivity and transport of sediment, nutrients and carbon.
- providing water down the Yanco creek system. This would contribute towards the Basin-wide in-stream and riparian vegetation priority to maintain fringing woody vegetation and non-woody wetland vegetation.

Macquarie Marshes

Basin annual environmental watering priority

Maintain semi-permanent wetland vegetation in core refuge areas in the Macquarie Marshes.

Expected benefits

It is anticipated that delivering environmental water to core refuge areas of the Macquarie Marshes in 2015–16 will:

- enable semi-permanent vegetation to be maintained in core refuge areas
- enable core refuge sites to function in continuing dry conditions
- discourage the establishment of terrestrial vegetation
- support the absorption, recycling and release of biotic and abiotic material by connecting the river channel to the Macquarie Marshes
- provide refuge for native fish and waterbirds in a drying scenario.

Why is this a Basin watering priority?

The Macquarie Marshes are located in the lower floodplain of the Macquarie River in central northern New South Wales (Figure 10). The Macquarie Marshes are considered to be of Basin-scale significance. It is one of the largest freshwater wetlands in the Murray–Darling Basin (approximately 200,000 hectares) and contains a variety of wetland types including wetland grasslands and reed-beds, semi-permanent river red gum forests, to less frequently watered areas of coolabah (*Eucalyptus coolabah)* and black box woodland. The Marshes are one of the Murray–Darling Basin's most biologically diverse wetland systems that support some of the largest waterbird breeding events in Australia (Marchant & Higgins 1990; Kingsford & Auld 2005). The Macquarie Marshes are recognised under the Ramsar Convention, and a number of the bird species are listed under international migratory bird agreements.

The Marshes filter water from the Macquarie River. This is a critical ecosystem service of absorbing, recycling and releasing nutrients. This provides conditions suitable for some of the highest densities of microinvertebrates reported in wetlands anywhere in the world (OEH 2012) which provides the foundation for a food web that supports many larger fauna (Jenkins & Wolfenden 2006).

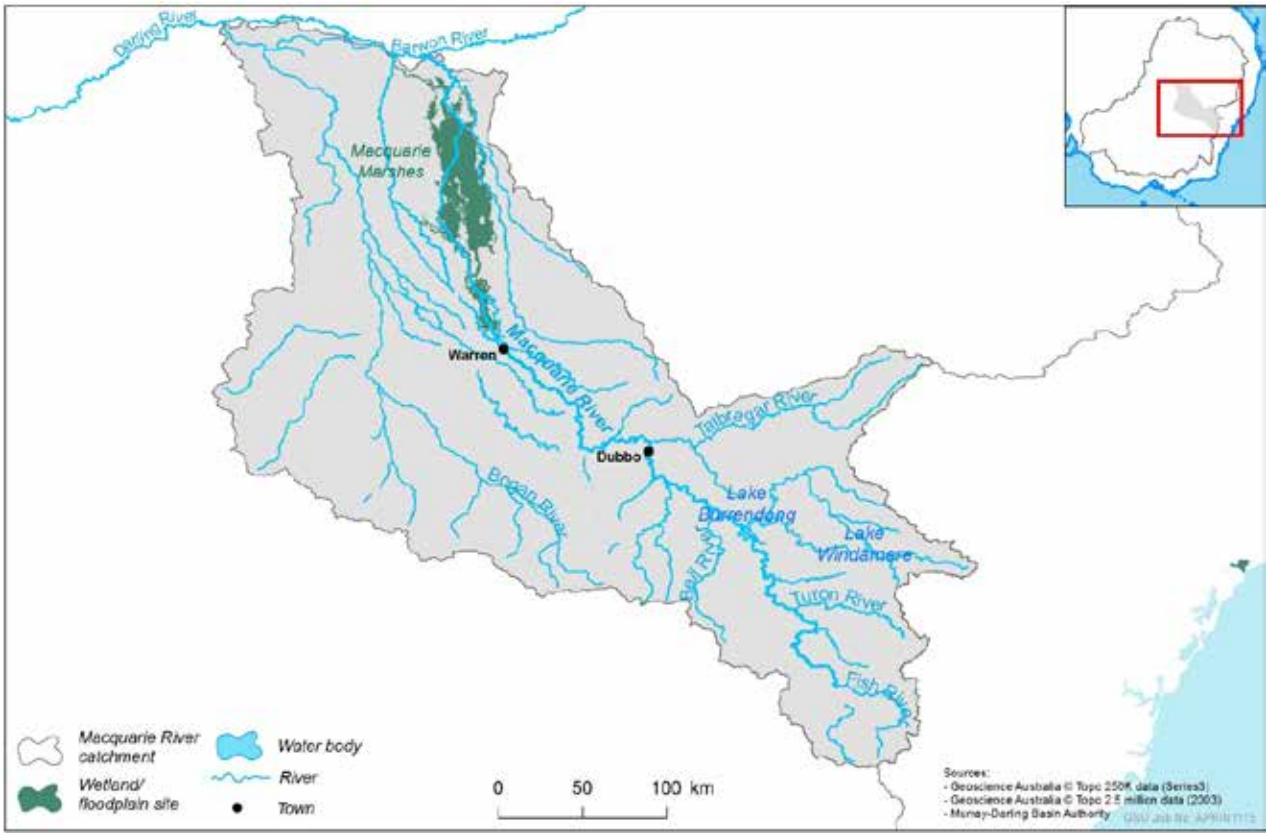

Figure 9: Macquarie catchment and the Macquarie Marshes

The Macquarie Marshes experienced significant decline in condition during the Millennium Drought and it is estimated that 50 years of water regulation and extraction from the Macquarie River have contributed to a 40–50% reduction in the size of the Macquarie Marshes (Kingsford & Thomas 1995). The Marshes recovered some condition during the wet years from 2010 to 2012 and follow up watering from environmental water accounts in 2013–14 and 2014–15. However indications of drying are becoming evident and in some areas terrestrial vegetation is invading.

The combination of environmental water use and drying conditions has resulted in low volumes of environmental water remaining in accounts. Further, dam storage volumes are low and unless there are significant inflows to the dam, water allocations are likely to be low for 2015–16. The Resource Availability Scenarios (RAS) outlook for 2015–16 in the Macquarie River system is identified as dry. The climate forecast, low storage volume and antecedent condition have elevated the need to protect core refuge areas in the Macquarie Marshes in 2015–16. This priority builds upon watering undertaken in 2013–14 and 2014–15 and further enhance the resilience of core wetland areas.

This priority will contribute to achieving quantified environmental outcomes in the Basin-wide environmental watering strategy (the strategy) (MDBA 2014a). The strategy states that maintaining the extent and condition of water dependent vegetation near river channels and on low-lying areas of the floodplain is an important outcome. The strategy requires an increase in periods of growth for communities that form extensive stands within wetlands of the Macquarie Marshes (including water couch (*Paspalum distichum*)) by 2024. The strategy also identifies the importance of the Macquarie Marshes to achieve outcomes for waterbirds.

Implementation

The RAS has a significant influence on the extent to which this priority can be achieved. If conditions are dry and storage volumes do not increase significantly there will be limited opportunity to water the full range of semi-permanent wetland vegetation in the Macquarie Marshes. However, critical core refuge areas could still be targeted with the limited volume of available environmental water.

If wetter conditions ensue, there will be a greater capacity to combine held environmental water with an unregulated event, which will increase the opportunity for water managers to target a broader range of wetland communities and achieve multiple outcomes. Achieving this priority will also contribute to achieving other priorities including the Northern Basin fish refuges priority, the Basin-wide in-stream and riparian vegetation priority, and the Basin-wide flow variability and longitudinal connectivity priority.

This priority is consistent with the water management strategies outlined in the strategy (MDBA 2014a) to achieve outcomes for vegetation and waterbirds. It will deliver long-term watering requirements for regionally significant sites of water-dependent vegetation. In addition it will provide appropriate flow regimes that support water-dependent vegetation on the floodplain, including creating and augmenting lateral connectivity by increasing bank-full and over-bank events, extending flow durations and protecting flow peaks.

Moira grass

Basin annual environmental watering priority

Maintain the condition and range of Moira grass in Barmah–Millewa Forest by supplementing a natural event and extending the duration of inundation.

Expected benefits

It is anticipated that delivering environmental water to the Barmah–Millewa Forest Moira grass plains in 2015–16 will:

- support the recovery of Moira grass from drought and maintain extent and condition by providing an opportunity for growth and recruitment
- limit river red gum and giant rush (*Juncus ingens*) encroachment
- provide food and habitat for fish, frogs, birds, turtles and macroinvertebrates
- promote the mobilisation, transport and dispersal of biotic and abiotic material (e.g. sediment, nutrients and organic matter) by delivering water to adjacent low-lying wetlands.

Why is this a Basin watering priority?

Moira grass (*Pseudoraphis spinescens*) is a rapidly growing, semi-aquatic grass that occurs on wetlands and floodplains. The Barmah–Millewa Forest Moira grass plains comprise the largest inland extent of Moira grass in New South Wales and Victoria (Colloff et al 2014).

Barmah–Millewa Forest's floodplain marshes are formally recognised as capable of supporting species listed in bilateral migratory bird agreements with Japan, China and the Republic of Korea as well as the Bonn Convention on Migratory Species (Ramsar Sites Information Service 2015). It supports flora and fauna listed as threatened under Commonwealth and state legislation, and acts as a drought refuge in an otherwise arid to semi-arid region (Colloff et al 2014; MDBA 2012c).

Barmah–Millewa Forest is located along the River Murray across both New South Wales and Victoria between the towns of Tocumwal, Deniliquin and Echuca (Figure 11). Both forests are listed as internationally significant under the Ramsar Convention (Ramsar Sites Information Service 2015), and together are a The Living Murray icon site.

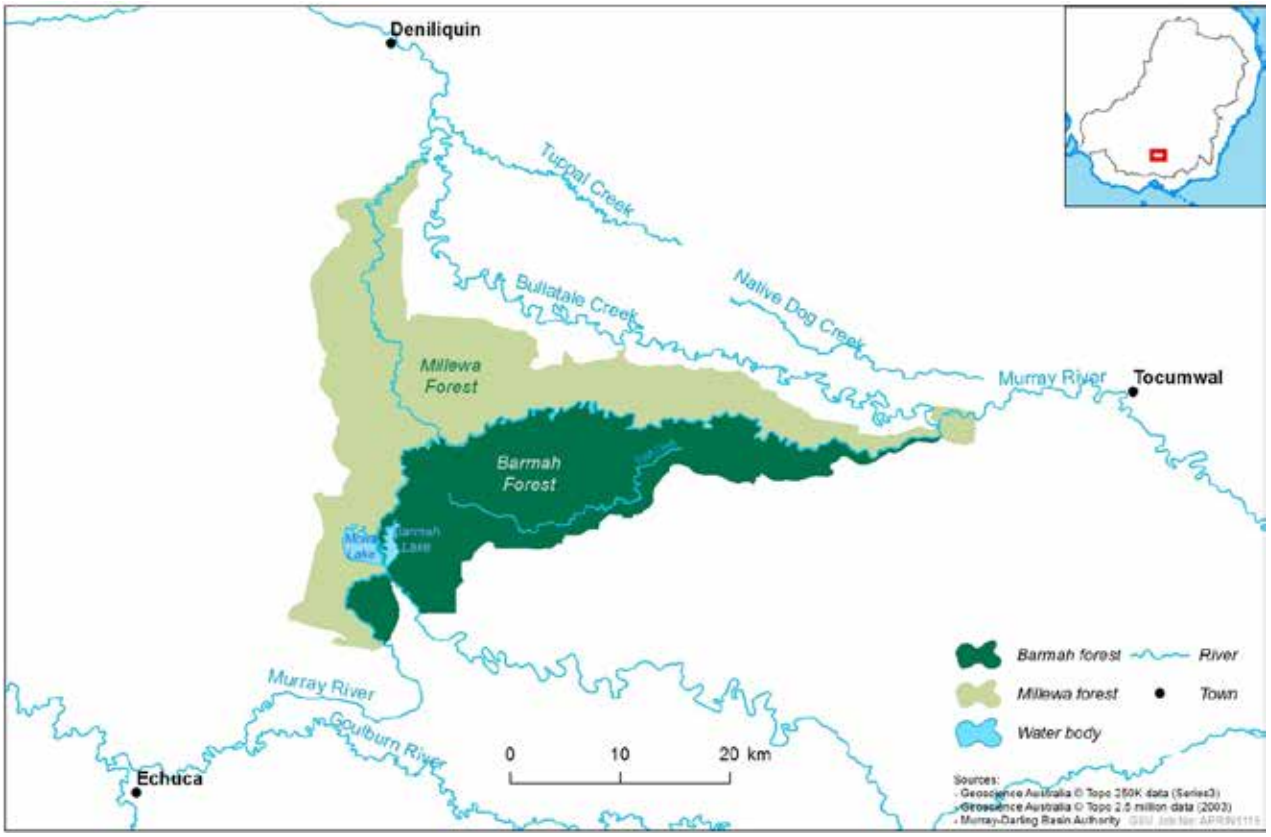

Figure 10: Barmah–Millewa Forest

It is thought that the combined effects of river regulation and climate change could contribute to a rapid decline in the extent and condition of Moira grass in Barmah–Millewa forest. Current conditions indicate that the limits of acceptable change for the Moira grass marshlands are at risk of being exceeded due to the altered hydrological regime and encroachment by river red gums (P Childs 2015, pers. comm., 7 May). Moira grass in Barmah Forest is also under threat of giant rush encroachment; it has been identified that the limits of acceptable change for this vegetation community may already have been exceeded as a result (Hale & Butcher 2011).

Changes in the seasonality, inter-annual variability and duration of flow have been found to be important factors impacting the growth and condition of Moira grass (Vivian et al 2014). This decline was further exacerbated by the Millennium Drought, which destroyed much of the Moira grass turf layer and seedbank, allowing for encroachment by river red gum saplings and giant rush. Additionally, altered flooding conditions currently favour the establishment of river red gum and giant rush (MDBA 2012c; Vivian et al 2014).

For optimal vegetative growth and flowering Moira grass requires flooding of at least 0.5 metres from July through to December, followed by a drying period through summer and autumn (Colloff et al 2014). Improving the condition and range of Moira grass, in particular the thick turf layer and seedbank, will assist in preventing encroachment and establishment of species that threaten the ecological character of the wetlands.

This priority will contribute to the quantified environmental outcomes that can be achieved beyond 2019 by maintaining the current extent of non-woody communities near or in wetlands, streams and on low-lying floodplains (MDBA 2014a).

Implementation

This priority complements the strategies to achieve vegetation, waterbird and native fish outcomes outlined in the Basin-wide environmental watering strategy (the strategy) (MDBA 2014a), including:

- providing appropriate flow regimes that support the character of water-dependent vegetation on the managed floodplain,
- supporting a network of waterbird sites across the Basin
- improving native fish habitat and maintaining drought refuge habitats.

Additionally, this priority complements the 2015–16 priorities for: Basin-wide flow variability and longitudinal connectivity, Basin-wide in-stream and riparian vegetation, Basin-wide waterbird habitat and future population recovery, and Basin-wide native fish habitat and movement. For example, The Living Murray's 2013–14 environmental water delivery to the floodplain marshes in Barmah Forest aimed to promote successful growth and flowering of Moira grass (MDBA 2014d). In doing so it also improved the health of other floodplain vegetation, as well as fish, turtle and waterbird populations, and resulted in the only egret breeding event in Victoria.

Prevailing conditions throughout the water year will determine the extent to which this priority can be achieved and how it is achieved. At the time of preparing the priority, the Resource Availability Scenarios for 2015–16 range from dry to moderate for the River Murray system. A dry scenario may reduce the extent or duration of inundation. In this instance environmental watering in line with this priority will help avoid critical loss and support survival and viability of threatened species, communities and ecosystems. Under a moderate scenario environmental watering could assist in restoring and maintaining vegetation condition and supporting growth and possible recruitment of native fauna. A wet scenario would further assist in improving vegetation condition and supporting growth and recruitment.

Under any scenario, this priority is contingent on a flow trigger downstream of Yarrawonga Weir. If a flow event occurs that generates high flows in the River Murray, it may be possible to extend this inundation with environmental water.

Environmental water would only make up a relatively small proportion of any watering event in Barmah–Millewa Forest. Any environmental watering would only be able to extend the duration of natural inflows in an attempt to mimic a larger natural flooding event. Any environmental water releases would need to be made as the natural flow event recedes, thereby extending the duration of the event.

Implementation of this priority may be limited by current constraints. High river levels downstream of Yarrawonga Weir can limit access to private property. This restricts the amount of environmental water that can be delivered. Additionally, there are natural resource management matters within Barmah Forest that need to be resolved in order to fully meet this priority (e.g. feral horses). Any watering decisions to meet this priority will therefore need to include consultation with relevant stakeholders.

Basin-wide waterbird habitat and future population recovery

Basin annual environmental watering priority

Improve the complexity and health of priority waterbird habitat to maintain species richness and aid future population recovery.

Expected benefits

It is anticipated that delivering environmental water in 2015–16 in accordance with this priority will:

- maintain the current population of waterbirds by improving vegetation structure and condition at Basin significant sites
- provide foraging opportunities for a range of species by maintaining a diverse network of habitat for waterbirds
- maintain waterbird drought refuges so that populations can disperse and recover when conditions improve
- extend natural flow events to improve the success of breeding and recruitment.

Why is this a Basin watering priority?

Waterbirds depend on rivers and wetlands to provide breeding, roosting and feeding habitat, as well as food and protection from predators. They span the full range of freshwater and estuarine environments found within the Murray–Darling Basin, with different functional groups (e.g. fish-eating waterbirds, large wading birds) using different parts of the ecosystem. This diversity of habitat use provides a good indicator of potential improvements resulting from environmental water.

In 2014 waterbird abundance was low across the Murray–Darling Basin (Figure 12), with wetlands in QLD, NSW and central and western Victoria being mostly dry at the time of the survey (Porter et al. 2014). Waterbird abundance has been lower than the average baseline abundance for 10 of the last 11 years (Figure 12), with high abundance in 2012 only. While waterbird numbers are expected to be low when the Murray–Darling Basin is experiencing dry conditions, analysis suggests that such low abundances (e.g. 2013 and 2014) should be rare and occur (on average) no more than once or twice a century.

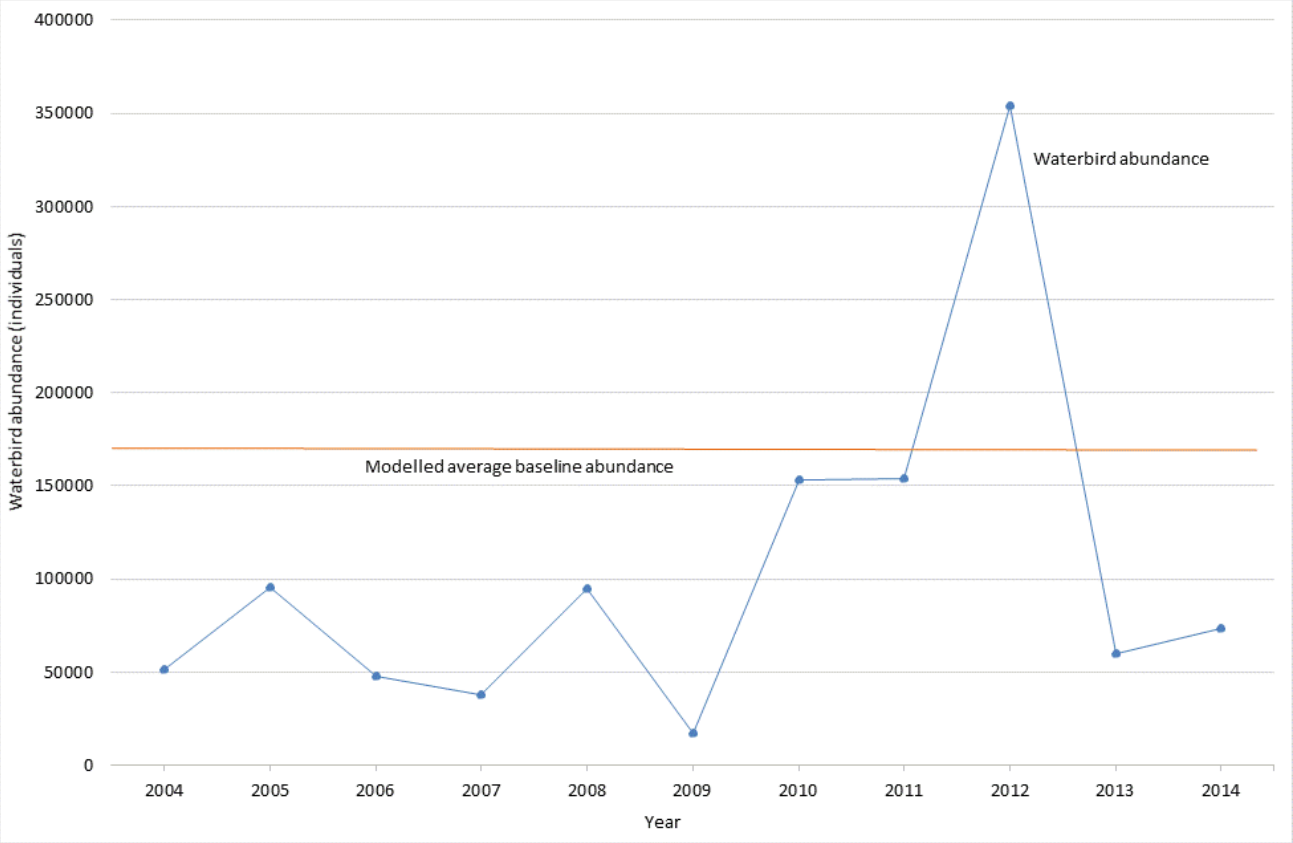

Figure 11: Waterbird abundance as measured by aerial survey in the Murray–Darling Basin 2004 – 14 and modelled average baseline abundance.

Under the Basin-wide environmental watering strategy, the long-term expected outcome (2024 onwards) is to maintain current species diversity, increase abundance over the baseline scenario by 20-25% and improve breeding success (MDBA 2014a). Given reduced waterbird populations observed across the Murray–Darling Basin over much of the decade, a range of actions will be required to ensure their persistence (see below).

Watering in accordance with this priority provides the optimum chance of contributing to the strategy's expected environmental outcomes for waterbirds.

Implementation

Preceding conditions and the forecasted dry Resource Availability Scenario (RAS) for the Murray–Darling Basin in 2015–16 may mean there are few wetlands in which waterbirds are able to congregate and only small volumes of environmental water available to maintain habitat or support breeding. Despite the limitations in resource availability the strategy provides water management strategies which could be implemented to help achieve this priority, including:

- identifying and delivering long-term watering requirements for priority environmental assets that will maintain a diversity of habitats and protect drought refuges, including sites considered to be of Basin significance (MDBA 2014a, Appendix 4)
- supporting breeding events by responding to natural cues and ensuring that environmental water is provided at seasonally appropriate times.

Watering actions which improve vegetation structure and condition in the core areas of Basin significant sites may help maintain the waterbird population. Environmental watering should therefore focus on protecting drought refuges and creating or supporting small inundation events so that the waterbird population does not further decline. This is consistent with the Basin-wide in-stream and riparian vegetation priority. It is also reflective of current practice that waterbird habitat should be maintained in the best "event ready" state for when wetter conditions return. In this way, watering in dry years can aid future population recovery.

Waterbirds rely on lateral connectivity to create suitable habitat by inundating wetlands adjacent to the main river channel. Analysis of the flows required for colonial waterbird breeding indicates that many sites are not being inundated at the desired volume or frequency. Barmah–Millewa forest, lower Murrumbidgee floodplain, Lachlan Swamp and Macquarie Marshes are some of these sites.

However, given the predicted dry RAS for 2015–16, there may not be sufficient environmental water to initiate and sustain successful colonial waterbird breeding events. Instead environmental watering should follow the water management strategies outlined in the Basin-wide environmental watering strategy (the strategy), such as managing water in harmony with biological cues (MDBA 2014a).

Where high rainfall does occur in the Murray–Darling Basin and a breeding response is initiated, management actions should aim to complete the breeding event by supplementing these natural inundation events, provided that there is sufficient environmental water held in storage. In parts of the Murray–Darling Basin where stored environmental water is limited and projected system inflows remain low, water trading may be considered as a way of supporting breeding and achieving this priority. An example of such a scenario occurred in the Narran Lakes in 2008 (Brandis et al. 2011). This may be required in the Narran Lakes during 2015–16 to maintain waterbird populations.

Basin states have, in preparing their own annual environmental watering priorities, identified sites where environmental watering may produce resting, nesting and feeding habitat for waterbirds. Amongst these sites are Broken wetlands; Kerang wetlands; Coorong, Lower Lakes and Murray Mouth; Lindsay–Wallpolla–Mulcra Islands; River Murray Channel; Cuba Dam; and Currawinya Lakes & Paroo overflow lakes.

Some of these sites are of Basin significance (MDBA 2014a, Appendix 4) while others may have regional significance. The Authority supports environmental watering at all of these sites but emphasises that environmental water should be delivered to Basin significant sites as first priority.

Basin-wide native fish habitat and movement

Basin annual environmental watering priority

Maintain native fish populations by protecting and improving the condition of fish habitat and providing opportunities for movement.

Expected benefits

Protecting and improving the condition of fish habitat and providing opportunities for movement in 2015–16 will:

- provide a greater diversity of in-channel fish habitats such as fast and slow flowing habitats, to support native fish species through different life stages
- provide opportunities for movement and dispersal of fish between sites to improve access to habitat and food
- enhance recruitment by supporting biological cues for spawning followed by appropriate habitat conditions to maximise egg, larval and juvenile survival
- stimulate seasonal food production that enhances growth, body condition and survival of fish, particularly in early life stages.

Why is this a Basin watering priority?

Native fish populations were once widely distributed in the Murray–Darling Basin. However river regulation has resulted in changes to the natural flow regime, with reduced connectivity and hydrodynamic complexity across the Basin. This has resulted in a significant decline in native fish abundance and has reduced the resilience of fish populations to change (MDBA 2014a).

Both longitudinal and lateral connectivity is vital to support movement of species, transport nutrients and sediments and promote productivity throughout the system. Movement is a key ecological process for many native fish species across many of their life stages. For example, upstream and downstream spawning migrations of adults are important, with larvae drifting downstream in the water column as they develop in spring and summer. Juveniles colonise new habitat and move in and out of productive off-channel habitats such as wetlands.

Diverse flow regimes are important in providing a range of habitats suitable for different species at regional and local scales. Flows allow access to habitats, and maintain the health of in-stream and emergent vegetation. In addition reinstating hydrodynamic diversity (ensuring a range of flows from still water through to slow and fast-flowing areas) can be crucial to the lifecycle of many native fish species. River regulation has converted many areas of slow-flowing and fast-flowing habitats into still water habitats, reducing native fish diversity (Bunn & Arthington 2002). Loss of faster-flowing water has particularly impacted species that rely on these habitats such as silver perch, Murray cod, trout cod and macquarie perch.

Ongoing annual watering actions will be required to ensure the recovery of native fish populations. In the long-term, appropriate water management will contribute to a diverse native fish community with sustainable populations occupying a greater proportion of their historic distribution.

Given the moderate to dry Resource Availability Scenario (RAS), the priority aims to achieve the native fish outcomes by implementing actions to improve movement and protect key fish habitats in the basin to help ensure no further loss in fish populations (MDBA 2014a).

Implementation

Prevailing conditions throughout the water year will determine the extent to which this priority can be achieved and how it is achieved. However, regardless of the Resource Availability Scenario (RAS) actions can be implemented to achieve outcomes for all three fish communities recognised in the strategy: estuarine, southern and northern fish communities (MDBA 2014a). At the time of preparing this priority the RAS outlook for 2015–16 was dry in the northern Basin and moderate in the southern Basin.

In the northern Basin, should prolonged dry conditions continue, flow regimes should focus on the protection of in-stream habitat, particularly drought refuges. Strategies to achieve this are limited but could include improving longitudinal connectivity and protecting longitudinal flow integrity. Additional strategies to achieve fish outcomes in the northern Basin are detailed in the Northern Basin fish refuges priority.

The moderate RAS in the southern Basin provides greater scope to improve fish populations and habitats in 2015–16. This can be achieved by providing opportunities to promote connectivity for breeding, foraging, growth and movement of fish, including estuarine species. Providing outcomes for fish in the southern Basin will also be complemented through the achievement of the River Murray weir pool variation, Silver perch, Mid-Murrumbidgee Wetlands and Coorong, Lower Lakes and Murray Mouth priorities.

The implementation of this priority should be consistent with the broad water management strategies outlined in the Basin-wide environmental watering strategy (the strategy) for fish - to support the needs of the whole fish community and protect and improve existing populations of threatened species (MDBA 2014a). This can be done through targeted actions including:

- providing flows to inundate benches to increase food resources
- managing the recession tail of flows to allow fish to exit off-stream habitats
- maintaining flow integrity and increasing the extent or duration of slow and fast-flowing habitats, including riffle maintenance flows to scour spawning locations for some species
- inundating key in-stream and off-stream habitats (primarily low-lying areas where commence-to-flow can be achieved by in-channel flows)
- maintaining water quality
- improving macrophyte condition for fish habitat
- maintaining a salinity gradient in the estuary
- improve fish passage through in-channel flows over low-level barriers; provide flows through fishways and barrages for seasonal bi-directional movement of diadromous species
- reinstate winter flows in the southern Basin.

Basin states have, in preparing their own annual environmental watering priorities, identified sites where environmental watering may produce outcomes for native fish. Many proposed actions will benefit native fish communities in general and actions planned at a number of sites will support the needs of specific species including golden perch, Murray cod, river blackfish (*Gadopsis*

marmoratus), freshwater catfish (*Tandanus tandanus*), Murray hardyhead (*Craterocephalus fluviatilis*) and southern pygmy perch (*Nannoperca australis*). Some of these sites are of Basin significance (MDBA 2014a, Appendix 7) while others have regional significance. The Authority supports these initiatives as they will contribute to outcomes for native fish across the Basin.

Northern Basin fish refuges

Basin annual environmental watering priority

Protect native fish populations and in-stream habitats, particularly drought refuges, in the northern Basin.

Expected benefits

On-going protection of fish populations and in-stream habitats in the northern Murray–Darling Basin in 2015–16 will:

- increase persistence of critical refuge habitats to ensure no loss of species
- provide short-term, in-channel connectivity between pools that maintain in-stream habitats and facilitate native fish movement
- support small-scale recruitment, particularly for short-lived species
- sustain native fish populations such that recruitment and colonisation of habitats can occur when wetter conditions return.

Why is this a Basin watering priority?

Fish communities in the northern Basin are important to the overall biodiversity of native fish in the Murray–Darling Basin. There are national and state-listed threatened species, important remnant populations of fish, and native fish that are restricted to the northern Basin (MDBA 2014a).

The long-term persistence of native fish in the northern Basin is dependent on the survival of populations through dry phases (Balcombe et al. 2006; Lobegeiger 2011). This survival in turn depends on access to appropriate drought refuges such as permanent and semi-permanent waterholes, and core wetland refuge (Arthington & Balcombe 2011; Leigh et al. 2010; Lobegeiger 2011; McNeil et al. 2013).

This priority builds on the 2014–15 priority Enhance and protect refuge habitat: Native fish in the northern Basin (MDBA 2014b). Protection of northern Basin fish populations and in-stream habitats in 2015–16 will contribute to achieving the long-term outcomes for fish in the Basin-wide environmental watering strategy (the strategy) (MDBA 2014a) namely, no loss of species and maintenance of critical populations. This is vital, particularly if dry conditions persist beyond 2015–16. The above outcomes will ensure that the diversity, resilience, and population structure of native fish populations in the northern Basin are retained in the long-term.

Implementation

Should dry conditions continue throughout much of the northern Basin, this priority requires actions that improve access to, and quality of, drought refuge habitat and links to the 2014–15 priority *Enhance and protect refuge habitat: Native fish in the northern Basin* (MDBA 2014c). The implementation of this priority links with water management strategies outlined for fish in the strategy (MDBA 2014a) including:

- prioritising and protecting natural inflows, especially those that coincide with naturally high periods of in-stream productivity
- following natural hydrographs as much as possible when water levels need to change

- maintenance of longitudinal connectivity between refuges and protecting small inflows during dry conditions.

Achievement of this priority in 2015–16 will be driven by local conditions and the availability of regulated and unregulated water. Key locations for implementing this priority (Figure 13) include the Namoi River, Macquarie River, Lachlan River, Gwydir River, the Condamine–Balonne catchment (including lower Balonne) and the Border Rivers. For 2015–16, actions outlined in the Macquarie Marshes priority can also contribute to achieving fish outcomes in the northern Basin.

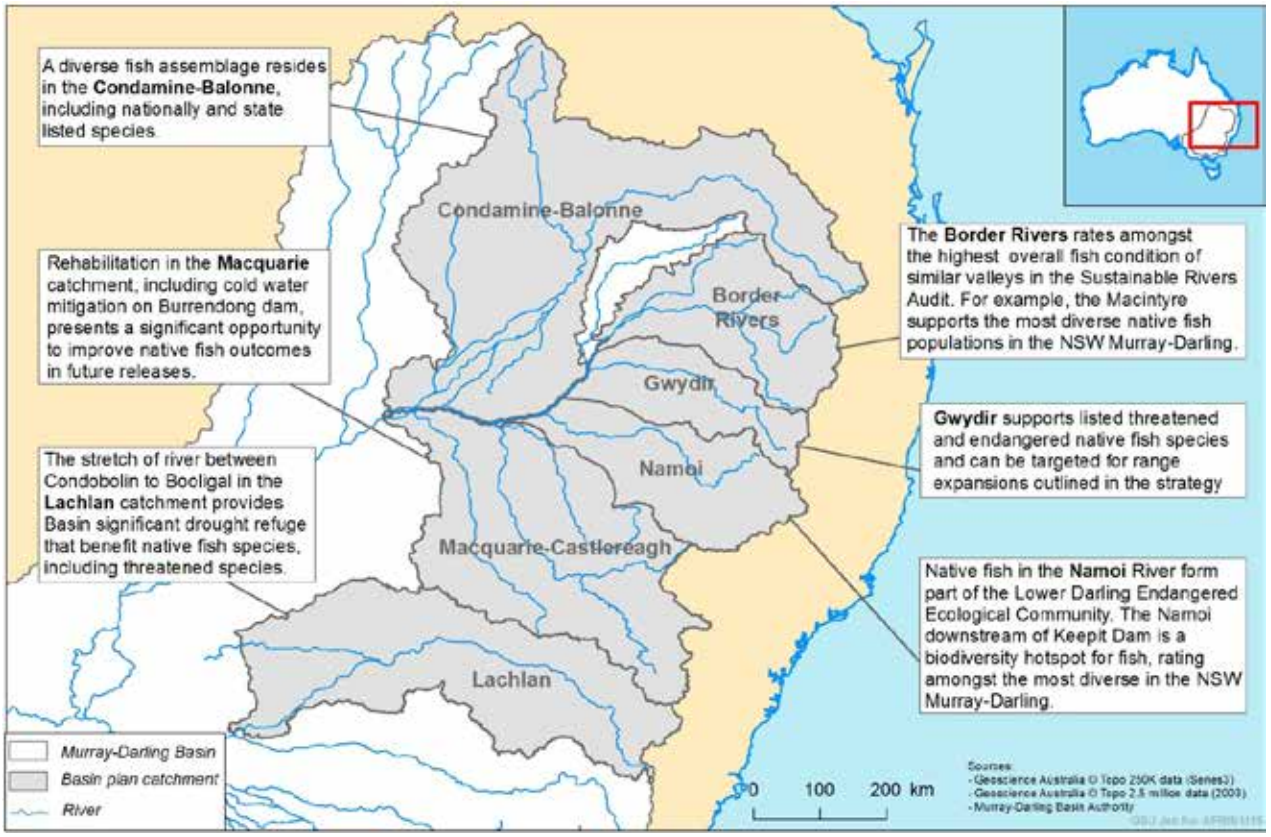

Figure 12: Key locations for fish in the northern Basin

The current dry Resource Availability Scenario and limited water held in northern Basin storages may constrain options for implementing this priority in 2015–16. Base flows and low flows will maintain refuges and combining regulated and unregulated events in main channels will inundate refuges across greater lengths of the river. Maximising outcomes from the use of all water can also contribute to this priority. For example, consumptive water delivered in regulated catchments can help maintain in-stream refuges.

If opportunities arise, other actions may also be considered such as freshes and higher in-channel flows. Such flows could enhance native fish outcomes by inundating important in-stream habitats, stimulating food production, supporting recruitment and improving longitudinal connectivity.

Follow-up flows to sites that received water in previous water years should also be considered, focusing on maintaining habitat to increase survival of recruits and contribute to long-term improvement of native fish populations. For example, it may be possible in the Lachlan, Gwydir

and lower Balonne to build on native fish outcomes achieved in previous water years. In the lower Balonne, protecting natural inflows (e.g. by temporary purchases) may help to improve outcomes for fish in this region. Where possible, protecting biologically important unregulated events is important, such as dry spell breaking flows and the first post-winter flows, to maintain key periods of native fish movement, spawning and recruitment, as outlined in the strategy (MDBA 2014a).

Where a dry Resource Availability Scenario is expected to persist, managers may consider watering key refuges only and retaining the bulk of held environmental water as insurance against dry conditions potentially continuing into future watering years.

Silver perch

Basin annual environmental watering priority

Contribute to the long-term recovery of silver perch by maintaining key populations, supporting recruitment and facilitating movement and dispersal.

Expected benefits

Providing an appropriate flow regime in 2015–16 to maintain key populations, support recruitment and facilitate movement to support long-term recovery will:

- provide opportunity for silver perch to complete spawning and subsequent development of egg and larval life stages
- increase dispersal and colonisation of habitat by promoting seasonal movement
- improve the growth, survival and body condition of larval, juvenile and adult fish by increasing food resources
- meet outcomes for silver perch alongside other objectives (e.g. for golden perch, Murray cod and other biota)

Why is this a Basin watering priority?

Silver perch is a long-ranging, flow-cued species endemic to the Murray–Darling Basin. Historically, silver perch were a dominant large-bodied fish species in the River Murray (Mallen-Cooper & Brand 2007) and were widely distributed through the Murray–Darling Basin. However, severe declines in silver perch have resulted in a national listing as a threatened species, accepted as critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999* in 2013. Given its dependence on flow, river regulation and water diversion are key threats to silver perch. Reduced movement and dispersal has fragmented populations and increased the risk of localised extinction events (Department of the Environment 2013). Consequently, improved flow management is a key action that will contribute to the recovery of this species.

Spawning of silver perch can be stimulated by increasing in-channel flows during the breeding season and recruitment (i.e. survival of early life stages) is enhanced by floods and overbank flows (Mallen-Cooper & Stuart 2003; King et al. 2008). However, successful completion of egg/larval stages is much more difficult to achieve than spawning for many native fish (Humphries & King 2002). Silver perch eggs and larvae drift downstream in the water column as they develop. Successful development is temperature-dependent (typically spring/summer) (Clunie & Koehn 2001) and larval survival also depends on ready access to food resources. Strong recruitment events require long sections of uninterrupted faster-flowing habitat to complete early stages of their lifecycle (Clunie & Koehn 2001, Mallen-Cooper & Stuart 2003). In-stream barriers, loss of flow (i.e. still water), undershot weirs and water extraction can all contribute to increased mortality of larval perch (Clunie & Koehn 2001; Baumgartner et al. 2006, 2009; Jones & Stuart 2008).

Silver perch are a highly mobile species, with extensive movement occurring across life stages (Mallen-Cooper et al. 1995; Mallen-Cooper & Stuart 2003). Given they recruit and disperse over large distances, recovery of silver perch requires a system-scale approach with sustained

improvements over a long-time. As a long-lived species, it may also be several seasons before recovery becomes apparent.

The Murray–Darling Basin Authority has prioritised silver perch due to the widespread and severe decline of its populations across many areas of the Basin (Department of the Environment 2013). There is limited evidence of recovery of silver perch populations (Department of the Environment 2013), and in the Sustainable Rivers Audit 2008–10 it was the only native fish to show no evidence of recruitment (Davies et al. 2012). The middle-Murray population is the only region to demonstrate some recovery of silver Perch populations with relatively good numbers (Department of the Environment 2013). Therefore it is vital that environmental watering actions sustain this critical population.

Recently, golden perch and Murray cod have benefitted from targeted environmental watering actions to meet their needs. Many of these actions may have had benefits for silver perch; however, the Murray–Darling Basin Authority considers more targeted environmental watering actions for silver perch will be important to ensure its long-term survival and to help rebuild sustainable populations over the longer term.

In 2015–16, this priority will directly contribute to improved movement, recruitment and distribution outcomes for silver perch in the Basin-wide environmental watering strategy (the strategy) (MDBA 2014a). Many actions to improve silver perch are compatible with flow objectives for golden perch and Murray cod. Therefore, this priority will also contribute to outcomes for these native fish outlined in the strategy (MDBA 2014a).

The Murray–Darling Basin Authority encourages managers to consider water requirements and management to improve silver perch across a range of sites and regions across the Basin. This will require planning and actions over several years to build populations through increased movement and dispersal and improved recruitment. Therefore, it is anticipated that this priority will be required over multiple years.

Implementation

Prevailing conditions throughout the water year will determine the extent to which this priority can be achieved. Given the forecasted dry Resource Availability Scenario (RAS) in 2015–16 for the northern Basin, actions to improve silver perch outcomes may be limited. Positive outcomes are more likely in the southern Basin given the moderate RAS forecasted. Should RAS conditions improve there may be greater opportunities to achieve more significant outcomes for silver perch.

Flows to improve conditions for silver perch can be achieved by the water management strategies for native fish outlined in the strategy (MDBA 2014a). These include:

- aligning protection of environmental flows and environmental water delivery with natural productivity, seasonality and timing of fish growth, movement and reproduction
- reinstating in-channel flow variation, including at in-channel habitats with regulated stable water levels
- providing for delivery arrangements that reinstate hydrodynamic diversity and improved in-stream habitats
- focusing on opportunities to maximise longitudinal and lateral fish movement.

Locations where these strategies may be implemented to maintain silver perch populations in 2015–16 include the Edward–Wakool system, lower River Murray, mid-Murray, Goulburn River, lower Broken River, Ovens River, Murrumbidgee River, Darling River and Border Rivers.

Actions should particularly focus on areas and timing of flows (including a flow pulse in spring/summer) which support silver perch recruitment. The uninterrupted, flowing-water habitats between Mulwala weir and Torrumbarry weir and between Torrumbarry weir and Euston weir, supports one of the largest self-sustaining populations of silver perch and this mid-Murray region is vital for recruitment (Department of the Environment 2013) (Figure 13). Similarly, uninterrupted stretches of flowing-water habitat down the length of the Darling River could be prioritised for silver perch recruitment this year, or in subsequent years, if sufficient water is available.

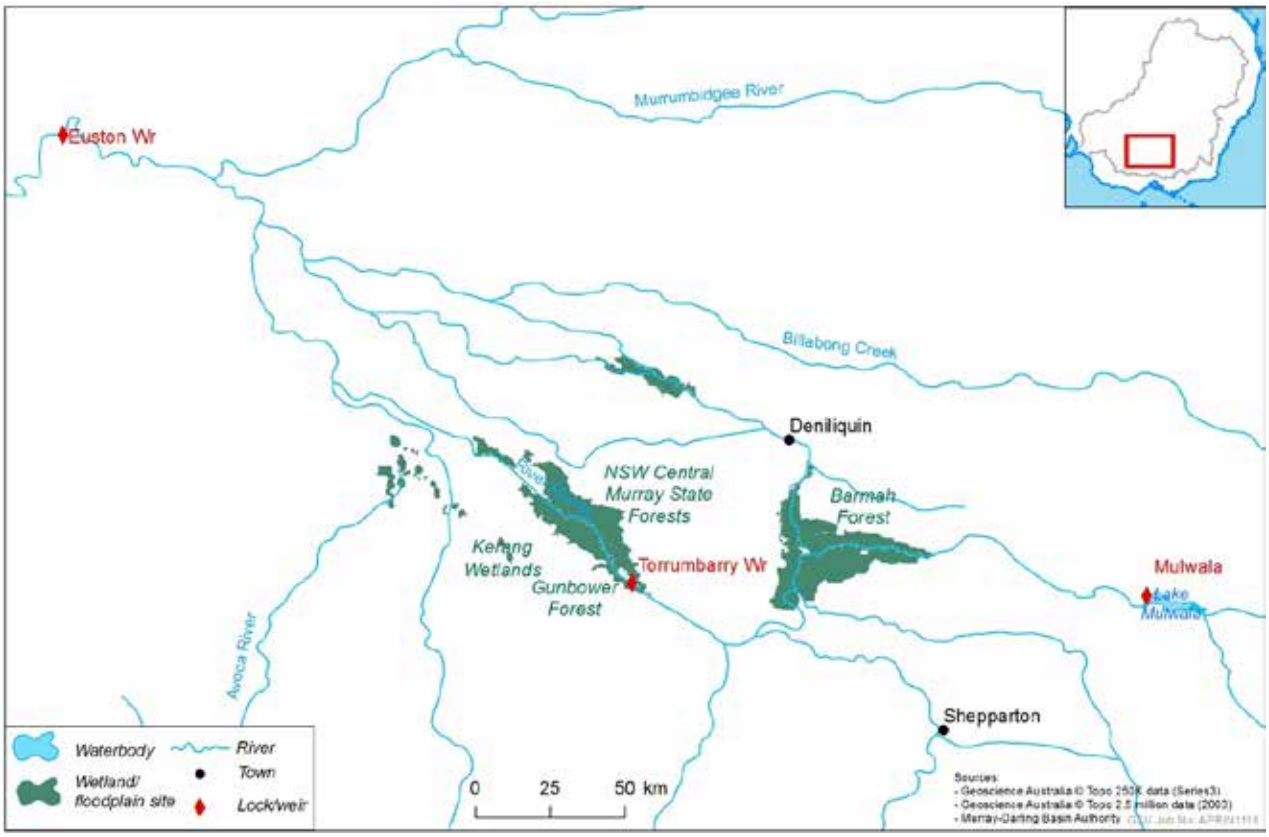

Figure 13: Location of largest self-sustaining population of silver perch in the Basin

Water management strategies that improve flow integrity will also contribute to outcomes for silver perch. Flow integrity is the uninterrupted movement of water through a system to maintain or reinstate the natural flow patterns rather than re-regulating the flow (Koehn et al. 2014). It is important to maintain the integrity of flow peaks as they move downstream to preserve important biological cues (such as rising and falling water levels). Actions to reinstate hydrodynamic diversity (see the Basin-wide native fish habitat and movement priority) will also improve outcomes for silver perch. Hydrodynamic diversity means that areas of fast-flowing, slow-flowing and still water habitats occur across local to landscape scales (MDBA 2014a). Weir pools have increased still water habitats in the River Murray which have negatively impacted the diversity and distribution of fish and other aquatic biota (Bunn & Arthington 2002). Therefore actions to reinstate greater extent and duration of slow-flowing and fast-flowing habitats through the River Murray weir pool variation priority will benefit silver perch.

An improved understanding of the large-scale processes and interactions between regions and recruitment requirements for silver Perch will assist in the refinement of strategies to improve silver perch populations in subsequent years. Complementary rehabilitation measures are critical to enhance silver perch populations across the Murray–Darling Basin. For example, the Sea to Hume fishways have restored connectivity throughout a large part of the River Murray. This will complement flow management actions aimed at improving dispersal of silver perch. Further measures to reduce the effect of other barriers, improve water quality (including temperature), reinstate important habitats, and mitigate the impact of alien species will also enhance outcomes that can be achieved with flow restoration.

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Appendix 1: Resource Availability Scenarios

Table 1: Resource availability scenarios, management outcomes and strategies to achieve them (from the Basin-wide environmental watering strategy, 2014)

	Scenario: Very dry	Scenario: Dry	Scenario: Moderate	Scenario: Wet to very wet
Management objectives:	**Avoid irretrievable loss of or damage to, environmental assets:**	**Ensure environmental assets maintain their basic functions and resilience:**	**Maintain ecological health and resilience:**	**Improve the health and resilience of water-dependent ecosystems:**
Management outcomes:	Avoid critical loss of species, communities, and ecosystems. Maintain critical refuges. Avoid irretrievable damage or catastrophic events.	Support the survival and viability of threatened species and communities. Maintain environmental assets and ecosystem functions, including by allowing drying to occur consistent with natural wetting–drying cycles. Maintain refuges.	Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna. Promote low-lying floodplain–river connectivity. Support medium-flow river and floodplain functions.	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna. Promote higher floodplain–river connectivity. Support high-flow river and floodplain functions.
Annual strategies to achieve outcomes will include:	Allow drying to occur but relieve severe unnaturally prolonged dry periods. Prioritise watering where possible for: · water-dependent vegetation sites identified as critical refuges for other species · waterbird drought refuges, particularly those identified in Appendix 4 in the strategy · identified dry period native fish refuges, particularly for threatened species identified in Appendix 7 in the strategy. Manage unnaturally low flow levels to mitigate water quality issues, particularly in the lower Basin, that are likely to cause irretrievable damage.	Allow drying to occur consistent with natural wetting–drying cycles to support maintenance of vegetation condition where possible. Prioritise watering where possible for: · water-dependent vegetation sites identified as critical as refuges for other species · waterbird drought refuges, particularly those identified in Appendix 4 in the Strategy · identified dry period native fish refuges, particularly for threatened species identified in Appendix 7 in the strategy, and including opportunities to maintain refuge habitat (e.g. scouring flows). Prioritise discharges through barrages, where possible.	Undertake follow-up watering events to promote longitudinal and lateral connectivity (where possible) to: · support successful recruitment or to assist in restoring and maintaining vegetation condition in floodplain communities near river wetlands and anabranches · support growth, reproduction and recruitment for waterbirds (particularly at sites listed in Appendix 4 in the strategy) including low-lying floodplain–river connectivity for foraging opportunities · promote in-stream flows and low-lying floodplain–river connectivity for fish breeding, foraging, growth and movement; including for estuarine species.	Build on natural events to maximise longitudinal and lateral connectivity to: · support maintenance and improvement in vegetation condition and large-scale recruitment events, on a broader extent of the lower floodplain · support growth, reproduction and large-scale recruitment for waterbirds, including the episodic productivity of large wetlands that are supporting waterbird breeding and foraging · support growth, reproduction and large-scale recruitment and movement for native fish.