Australian Government
Commonwealth Environmental Water Office

Commonwealth Environmental Water

Portfolio Management Plan

Macquarie River Valley

2019–20

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Acknowledgement of the traditional owners of the Murray–Darling Basin

The Commonwealth Environmental Water Office respectfully acknowledges the traditional owners, their Elders past and present, their Nations of the Murray–Darling Basin, and their cultural, social, environmental, spiritual and economic connection to their lands and waters.

The Macquarie River Valley is within the traditional lands of the Wiradjuri, Wailwan, Ngemba, Ngiyampaa and Kamilaroi people, and holds significant value for them.

This report should be attributed as 'Commonwealth Environmental Water Portfolio Management Plan: Macquarie River Valley 2019–20, Commonwealth of Australia, 2019'.

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Commonwealth environmental water portfolio management planning

Commonwealth Environmental Water Holder

The Commonwealth Environmental Water Holder is a statutory position established under the *Water Act 2007* and is responsible for managing the Commonwealth's environmental water holdings. This water must be managed to protect and restore the rivers, wetlands and floodplains (and the native animals and plants they support) of the Murray–Darling Basin. Ms Jody Swirepik is the current Commonwealth Environmental Water Holder. She is supported by staff of the Commonwealth Environmental Water Office, which employs six local engagement officers who live and work in regional centres across the Murray–Darling Basin.

Commonwealth environmental water

Commonwealth environmental water holdings are water entitlements that have been acquired by the Australian Government through investments in water-saving infrastructure and purchases on the water market. The holdings are a mix of entitlement types held across 19 catchments. The rules governing the entitlements vary across states and across catchments. Commonwealth environmental water entitlements are subject to the same fees, allocations, carryover and other rules as equivalent entitlements held by other water users.

There are broadly three options for managing Commonwealth environmental water:

- delivering water to a river or wetland to meet an identified environmental demand
- leaving water in storage and carrying it over for use in the next water year (referred to as 'carryover')
- trading water, that is, selling water and using the proceeds to buy water in another catchment or in a future year, or investing in complementary 'environmental activities'.

Purpose of the document

This document sets out the plans for managing the Commonwealth environmental water portfolio in the Macquarie River Valley for 2019–20. Efficient and effective management of Commonwealth environmental water requires the utilisation of all portfolio management options. By taking a multi-year approach to planning, portfolio management tools such as use, carryover and trade can be managed for maximising environmental outcomes.

The portfolio management plans support transparent, coordinated and adaptive management of Commonwealth environmental water, consistent with the Basin-wide environmental watering strategy and having regard to the Basin annual environmental watering priorities.

To learn more about the planning approach see *Portfolio Management Planning: Approach to planning for the use, carryover and trade of Commonwealth environmental water, 2019–20* (available at: http://www.environment.gov.au/water/cewo/publications under 'Planning approach').

Delivery partners

Commonwealth environmental water is managed in conjunction with and delivered by a range of partners. This portfolio management plan has been developed in consultation with our delivery partners, including the NSW Office of Environment and Heritage (OEH), the Department of Primary Industries (DPI) – Fisheries, WaterNSW, and the Macquarie Cudgegong Environmental Flows Reference Group (the Macquarie Cudgegong EFRG), who provide advice to water managers on priorities for water use.

Your input

The management of Commonwealth environmental water relies on considerable advice and assistance from others. Individuals and groups within the Murray–Darling Basin community are encouraged to submit suggestions for the management of Commonwealth environmental water. Please contact the Commonwealth Environmental Water Office via: ewater@environment.gov.au.

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1. Environmental watering in Macquarie River Valley

1.1. The Macquarie River Valley

Macquarie River flows are heavily influenced by large rainfall events in the upper catchment and flows in tributary systems. The river is formed when the Campbells and Fish rivers join above Bathurst in Central Western New South Wales, followed by tributary flows from the Winburndale River, Turon River and Pyramul Creek. The Macquarie River then flows into Burrendong Dam, south east of Wellington (Figure 1). Below the dam, tributary flows are provided by the Bell River, which enters at Wellington; Little River and Wambangalong Creek, which enter upstream of Dubbo; and the Talbragar River and Coolbaggie Creek, which enter just downstream of Dubbo. Subsequently, as the land flattens further west of Dubbo, the Macquarie River provides flows to distributary creeks, wetlands and rich alluvial river flats associated with braided channels. At this point, water flows are slow resulting mainly from extensive silt deposits and high attenuation, and can connect with the Barwon-Darling River.

Two major storages, Windamere Dam (capacity 368 gigalitres (GL) on the Cudgegong River, and Burrendong Dam on the Macquarie River (storage capacity of 1 188 GL, with additional storage capacity of 489 GL in the flood mitigation zone), regulate catchment water supplies. Commonwealth environmental water delivery is gravity fed from Burrendong Dam into the Macquarie River to downstream environmental assets such as the Macquarie Marshes and distributary creeks. Regulating structures are utilised to manage the diversion of water into distributary creeks at lower rates. At higher flow rates, water may flow overbank or via flood runners onto floodplains and wetlands.

The catchment includes the Macquarie Marshes complex on the lower reaches of the Macquarie River, of which, parts of the northern, southern and eastern Marshes are listed as a Wetland of International Importance under the Ramsar Convention. The Macquarie Marshes were recognised under the Ramsar Convention for being a unique example of a wetland type in the region in terms of their size and their diversity of wetland types, supporting species of conservation significance and biological diversity, providing refuge during adverse conditions, and regularly supporting large numbers of waterbirds. This includes those listed under international migratory agreements (JAMBA, ROKAMBA, CAMBA). The Ramsar site contains a range of habitats including core areas of semi-permanent wetlands, including forests and woodlands, reed beds, marshes, rushlands and open lagoons. These vegetation types have been identified as critical components of the Ramsar site, and provide habitat for migratory bird species and large numbers of waterbirds, including colonial nesting birds.

Other assets in the catchment include the Macquarie River channel, the unregulated component of the lower Macquarie River downstream of Warren Town Weir and the distributary creek system to the west of the Marshes.

The rivers and wetlands of the Macquarie Valley hold significant spiritual and cultural importance for Aboriginal people. In the upper and middle Macquarie catchment, the Aboriginal people are the Wiradjuri, while on the plains the Bogan River forms the boundary between the Ngemba and Ngiyampaa Nations to the west and the Wailwan Nation to the east. Wailwan country includes most of the Castlereagh catchment, except the north-east corner, which is the traditional land of the Kamilaroi.

The Macquarie Marshes and Macquarie River support a number of species listed as endangered or vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*, for example, the Australian painted snipe, Australasian bittern, Murray cod, trout cod and spike rush. The aquatic community of the Macquarie also forms part of the *Lowland Darling River aquatic ecological community*, which is listed as endangered under the *NSW Fisheries Management Act 1994*. This community includes 21 native fish species and hundreds of native invertebrate species that are found within the Darling River and its associated streams, wetlands and anabranches within NSW.

The *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source (2016)* provides for planned environmental water (refer to Attachment C) and stock and domestic (replenishment) flows. The NSW Government also manages licenced water for the environment. These other water sources offer opportunities to align Commonwealth environmental water deliveries to increase the potential for environmental objectives to be achieved jointly and assist with delivery efficiency and effectiveness.

A number of the rivers and creeks in the Macquarie Valley may contribute water to the Barwon-Darling at various times. The Barwon-Darling connects rivers, lakes and wetlands across the northern Basin, providing critical drought refuge, a movement corridor for fish and waterbirds, and habitat for other aquatic species including turtles, mussels, and shrimp. Flows that connect the Barwon-Darling and the northern tributaries may help to support healthy and diverse populations of native fish and other fauna, including in the Macquarie River. More information about the Barwon-Darling is described in the *Commonwealth Environmental Water Portfolio Management Plan: Barwon-Darling 2019–20.*

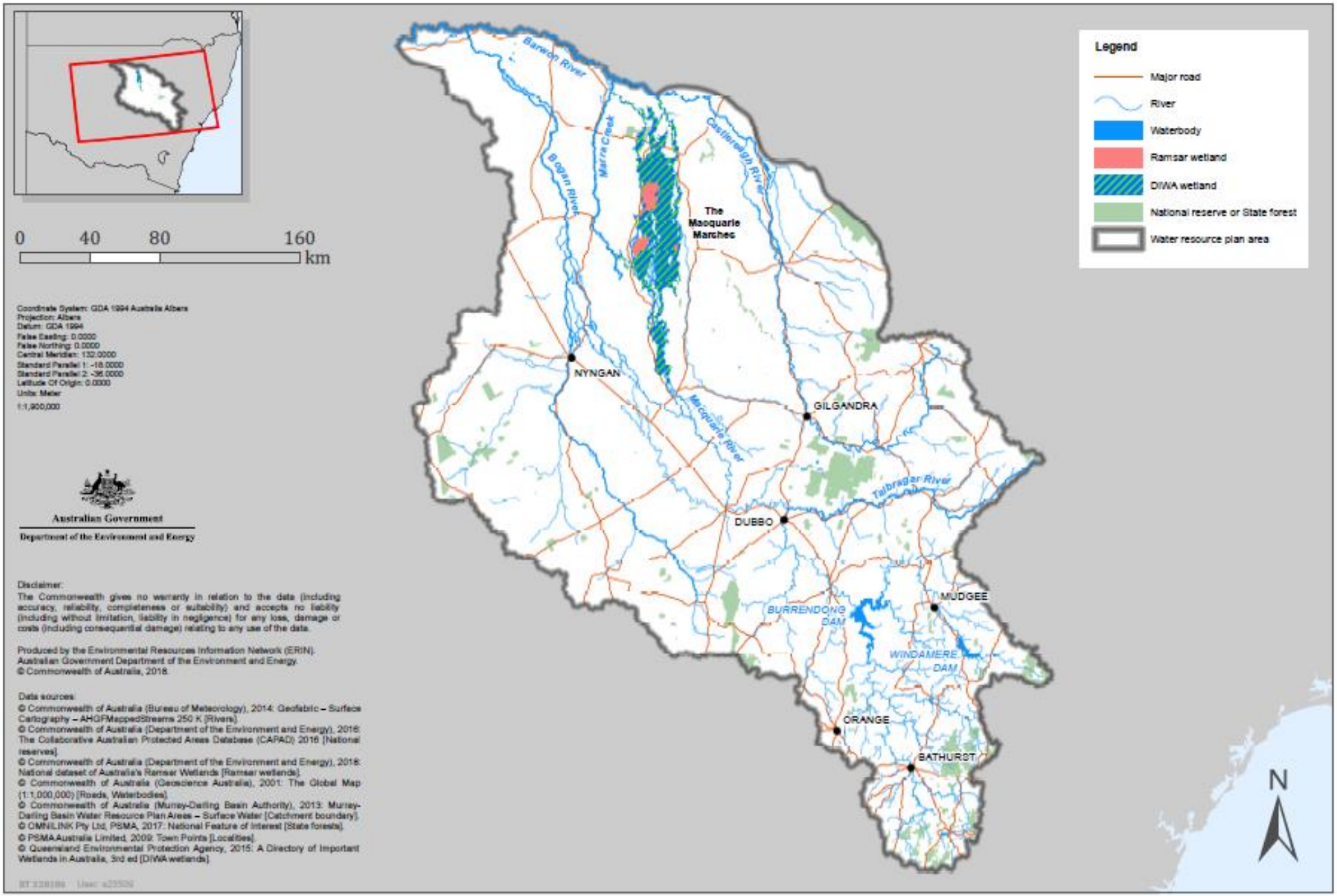
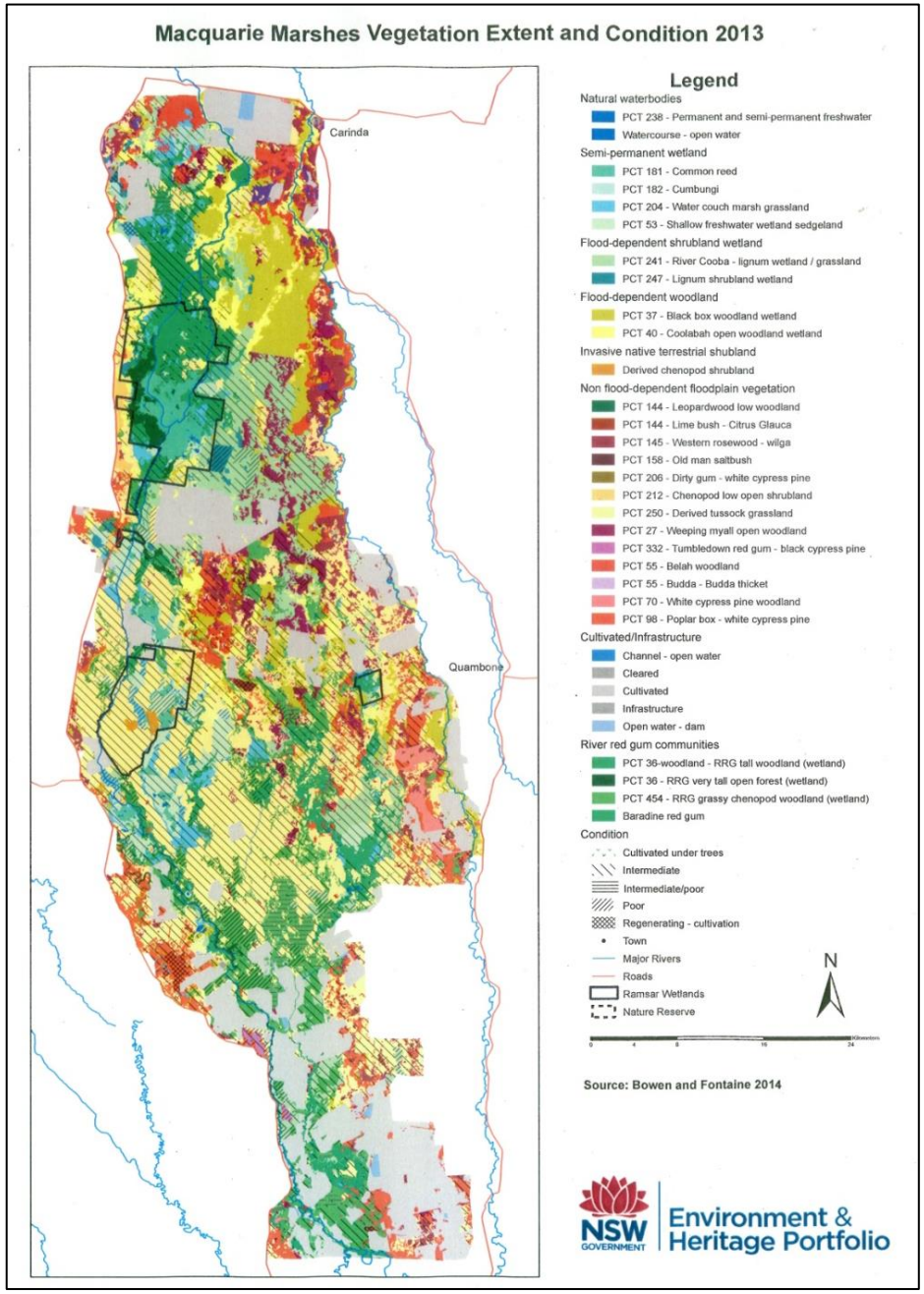


Figure 1: Map of the Macquarie River Valley (produced by the Department of the Environment and Energy, June 2018)

a)



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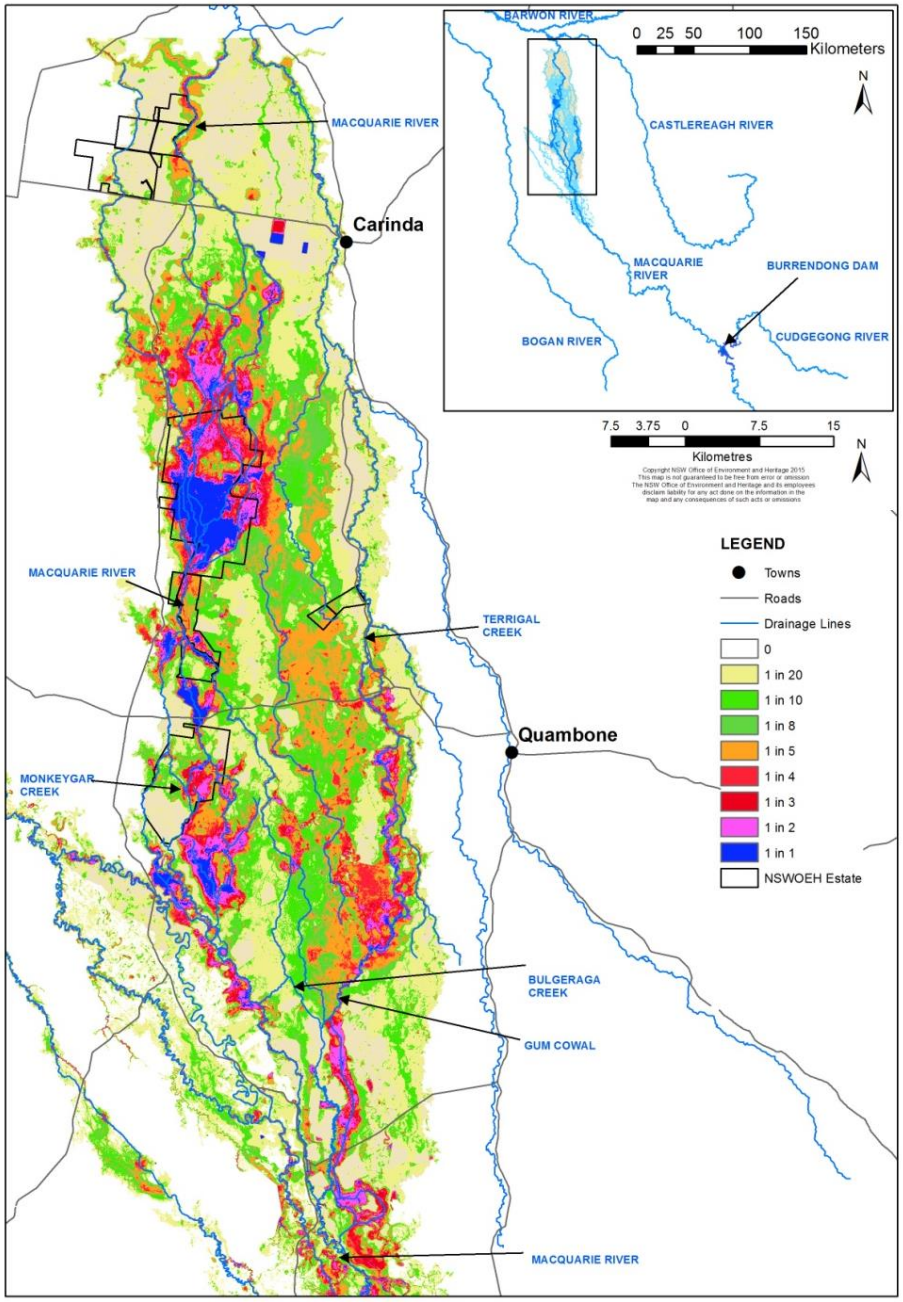

Figure 2: a) Macquarie Marshes vegetation mapping (Bowen & Fontaine 2014); b) Inundation frequencies: Macquarie Marshes 1988–2008 (Thomas et al. 2015)

1.2. Environmental objectives in the Macquarie River Valley

The long-term environmental objectives for the Murray–Darling Basin are described in the Basin Plan's environmental watering plan and the Basin-wide environmental watering strategy, which includes 'quantified environmental expected outcomes' at both a Basin-scale and for each catchment. The expected outcomes relevant for the Macquarie River Valley are summarised in Table 1 and described in detail in Attachment A.

Basin state governments are also developing long-term watering plans for each catchment. These plans will identify the priority environmental assets and ecosystem functions in the catchment, the objectives and targets for these assets and functions, and their watering requirements. Once developed, these plans will provide the key information on the long-term environmental water demands in the catchment. Before the development of long-term watering plans, the Commonwealth Environmental Water Office will continue to draw on existing documentation on environmental water demands developed by state governments, local natural resource management agencies and the Murray–Darling Basin Authority.

Based on these strategies and plans, and in response to best available knowledge drawing on the results of environmental watering monitoring programs, the objectives for environmental watering in the Macquarie River Valley are summarised in Table 1 below. The objectives for water-dependent ecosystems will continue to be revised as part of the Commonwealth Environmental Water Office's commitment to adaptive management.

Table 1: Summary of objectives being targeted by environmental watering in the Macquarie-Castlereagh Water Resource Plan Area.

<table>
<tr><th rowspan="3">BASIN-WIDE MATTERS
(Matters in red link to the Basin-wide Environmental Watering Strategy)</th><th colspan="3">OBJECTIVES FOR MACQUARIE ASSETS</th></tr>
<tr><th colspan="2">IN-CHANNEL ASSETS</th><th>OFF-CHANNEL ASSETS</th></tr>
<tr><th>Macquarie River</th><th>Macquarie Marshes</th><th>Distributary creeks</th></tr>
<tr><td>VEGETATION</td><td>Maintain riparian and in-channel vegetation condition, growth and survival (extent) by providing in-channel freshes</td><td>Maintain, and in some cases improve, floodplain and wetland vegetation condition, growth and recruitment, including for non-woody vegetation, river red gum, black box and coolibah, by contributing to in-channel freshes, bankfull and small overbank flows</td><td>Support the condition, growth and survival of riparian and in-channel vegetation by providing in-channel freshes</td></tr>
<tr><td>WATERBIRDS</td><td></td><td>Support naturally triggered breeding events, increase connectivity, and provide suitable habitat (including drought refuge), to increase waterbird abundance and reproduction, and maintain current species diversity</td><td></td></tr>
<tr><td>FISH</td><td colspan="2">Provide baseflows and freshes to support opportunities for the movement and increased distribution, reproduction and recruitment of native fish, including freshwater catfish, Murray cod, golden perch, silver perch and trout cod, to prevent the loss of native species, and improve the population structure and distribution of key species</td><td>Support the movement and habitat requirements of native fish by providing baseflows and freshes</td></tr>
<tr><td>MACROINVERTEBRATES</td><td colspan="3">Support recruitment and maintain macroinvertebrate diversity and habitat</td></tr>
<tr><td>OTHER VERTEBRATES</td><td colspan="2">Support opportunities for the reproduction and recruitment of other native aquatic species, including frogs and turtles</td><td>Support the reproduction of other native aquatic species including frogs</td></tr>
</table>

BASIN-WIDE MATTERS (Matters in red link to the Basin-wide Environmental Watering Strategy)	OBJECTIVES FOR MACQUARIE ASSETS		
	IN-CHANNEL ASSETS	OFF-CHANNEL ASSETS	
	Macquarie River	Macquarie Marshes	Distributary creeks
CONNECTIVITY	Support longitudinal connectivity, including increasing connectivity with the Barwon River, by providing low flows, baseflows and small freshes	Support connectivity, particularly lateral between the river and floodplain by contributing to freshes and bankfull flows	Support connectivity, particularly with the lower Macquarie River and Barwon River by providing baseflows and small freshes
PROCESSES	Support key ecosystem functions and promote productivity, including on the floodplain		
WATER QUALITY	Maintain water quality within channels and pools		
RESILIENCE	Maintain drought refuge habitat (fish, birds and other biota)		

Information sourced from: Murray–Darling Basin Authority (2012); Murray–Darling Basin Authority (2014); Barma Water Resources in association with IRPEC Pty Ltd and Paul Wettin (2011); Torrible et al. (2011); Commonwealth Environmental Water Office (2014); and Jenkins et al. (2012).

1.3. Environmental flow requirements

While environmental water plays an important role in supporting wetlands and rivers, not all environmental demands can and will be met through the use of held environmental water. In the Macquarie Valley, some demands are met by regulated water deliveries for consumptive purposes, while others are met by tributary flows or large unregulated/natural flow events, dam spills or flood mitigation releases. Some environmental demands are beyond what can be delivered within operational constraints.

Figure 3 shows the broad environmental demands that are in scope for Commonwealth environmental water. Importantly, these are broad, indicative demands and individual watering events may contribute to particular opportunities, such as using infrastructure to deliver water to individual wetlands that would otherwise not be possible because of constraints. There may be opportunities for Basin state governments to remove or modify constraints, which will improve the efficiency and/or effectiveness of environmental watering. Further information on operational delivery including constraints is described in Attachment B.

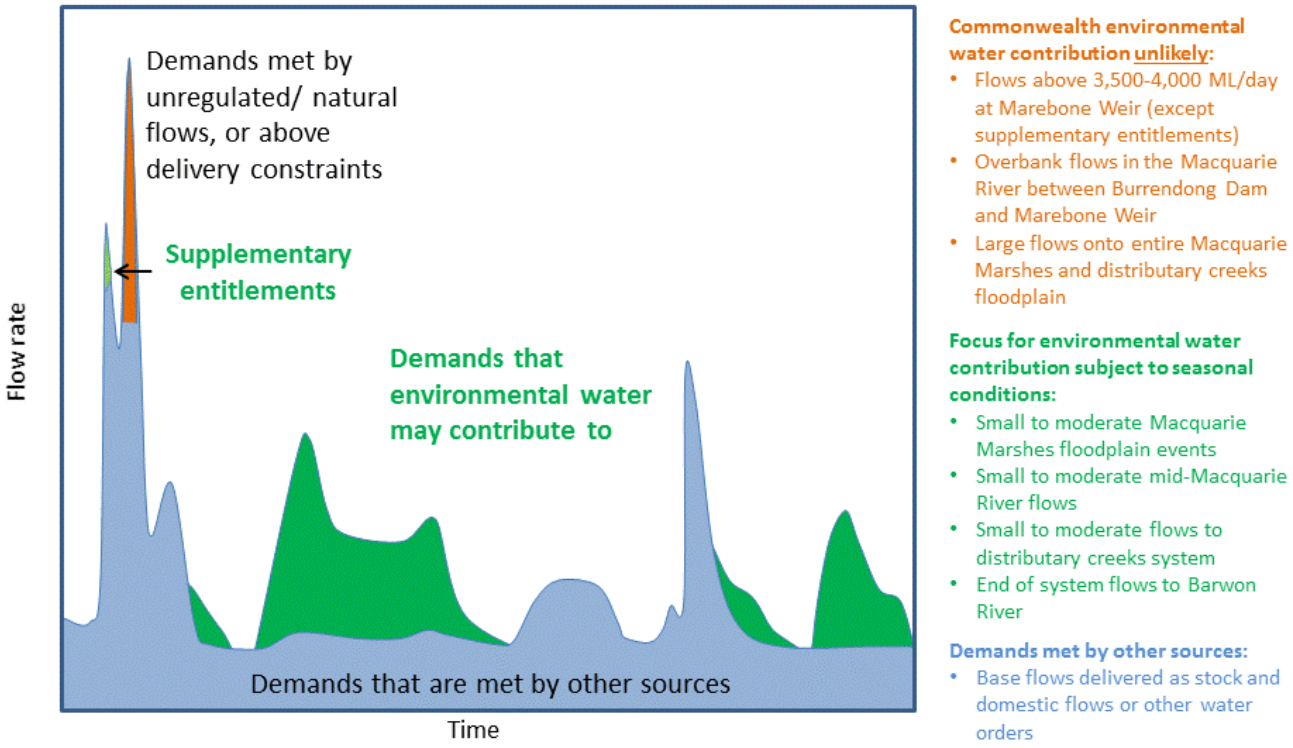

Figure 3: Scope of demands that environmental water may contribute to in the Macquarie River Valley.

Based on the above objectives and delivery constraints, specific watering requirements (flow magnitude, duration, timing and frequency) have been identified as being in scope for Commonwealth environmental water. These water requirements are described in Table 3. As with the objectives, the environmental water requirements will continue to be reviewed and revised in response to new knowledge.

2. Portfolio management in 2019–20

In planning for the management of Commonwealth environmental water, the Commonwealth Environmental Water Office aims to maximise the outcomes achieved from the available water. This includes consideration of the urgency of demands (based on targeted objectives and watering requirements, watering history and asset condition) and the available supply under different resource scenarios. Plans for water delivery, trade and carryover are then made in a multi-year context, with an assessment also undertaken of need for water in future years.

This planning process is outlined in full in Table 3 below and summarised in the sections below.

2.1. Lessons from previous years

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth environmental water. These learnings are incorporated into the way environmental water is managed.

The Commonwealth Environmental Water Office works with the Murray–Darling Basin Authority, state agencies, research organisations, local groups and others, such as landholders, to collect monitoring information and evaluation results, to ensure we adaptively manage and change our practices where needed. This continual review of information and outcomes is helping to build knowledge about the best way to get positive outcomes on a larger scale, based on what works and what doesn't work. Key findings and recommendations from fish (Stocks et al. 2015, Davis et al. 2017), flow (WaterNSW 2017), frog (NSW OEH 2017, Ocock and Spencer 2017, NSW OEH 2019a)) and waterbird (Spencer et al. 2016, McGinness et al. 2017, Brandis 2017, NSW OEH 2019b) monitoring include:

- Spring/early summer deliveries of environmental water in the Macquarie River have been associated with peaks in hatch date frequencies of some small-bodied opportunistic fish species such as Australian smelt, un-specked hardyhead and Murray-Darling rainbowfish, particularly on the receding tail of flows or during sustained periods of increased flow.

- Environmental water delivered in spring and early summer is likely to support native fish recruitment for species such as Murray cod and freshwater catfish, by increasing flows and boosting in-stream productivity in the Macquarie River.

- Local weather conditions influence the activity of some frog species, as well as inundation extent. Increased inundation extent is associated with an increase in the number of sites with good breeding conditions, resulting in greater numbers of calling flow-responsive species breeding. Flooding events are very important for increasing the overall abundance of flow-responsive frog species, by supporting breeding and enabling frogs to move between wetlands, thus connecting isolated populations.

- Longer durations of environmental water delivery are important to provide habitat and help maintain inundation to complete frog metamorphosis. Maintaining water levels in the Marshes into late November increases frog recruitment, with higher recruitment corresponding with years when wetland water levels were maintained for a longer duration (i.e. 2016 and 2018).

- Delivery of environmental water over the winter-spring months can provide suitable wetland habitat for nationally threatened and internationally recognised migratory species of waterbirds. Late winter and early spring delivery (maintained into summer if possible) will coincide with warmer temperatures and the peak activity of most waterbird species and their food supplies. A slow, steady contraction of inundated area is preferable, particularly for wading species.

- Delivery of environmental water to inundate parts of the Macquarie Marshes during dry conditions can support a diverse range of waterbirds, and provide important feeding and refuge habitat

- Connectivity between the lower Macquarie River (downstream of the Macquarie Marshes) and the Barwon River is important for allowing the movement of native fish between rivers for spawning, movement and recruitment (e.g. for bony bream, golden perch, spangled perch).

- Connectivity between the lower Macquarie and Barwon rivers can be successfully achieved using environmental water, particularly in synchrony with flow events occurring in the Barwon River. Further connectivity events between the Macquarie and Barwon rivers should be considered in the future by environmental water managers.

- Identified and potential barriers to fish movement within the mid-lower Macquarie River and Marshes need to be investigated and remedied, and adequate protection of environmental flow events in the Macquarie catchment is required.

- Long-term flow monitoring in the lower Macquarie River would result in a more accurate understanding of the amount of environmental water that is delivered through this system and into the Barwon River.

The outcomes from these monitoring activities are used to inform portfolio management planning and adaptive management decision-making.

2.2. Antecedent and current catchment conditions and the demand for environmental water in 2019–20

Following a period of very hot and dry conditions between spring 2012 and autumn 2016, conditions began to change in May 2016, with highest on record rainfall across parts of the catchment during winter and spring. Burrendong Dam filled to 100 per cent of capacity on 4 September 2016 (up from 11 per cent of capacity in early May). Good rainfall, tributary flows and releases under airspace operations of the Flood Mitigation Zone (FMZ) in Burrendong Dam in late 2016 and early 2017 contributed to widespread inundation in the Macquarie Marshes. All areas of river red gum woodland in the Marshes were inundated, improving the condition of wetland vegetation. Flooding triggered large-scale colonial and general waterbird breeding, with at least 21 colonies recorded in the Marshes. Managed environmental water (a mix of NSW and Commonwealth water sources) was delivered immediately following the cessation of Flood Mitigation Zone flows to maintain water levels in key colonial waterbird colonies and foraging areas.

Although conditions began to dry again over summer 2016–17, good rainfall occurred in March 2017 across the catchment. Environmental water (Commonwealth and NSW) was delivered in April and May 2017 as part of two watering actions to support native fish in response to natural tributary flows. Environmental water was used to: support the post spawning dispersal of native fish in the mid-Macquarie River and Marshes; and to provide connectivity between the lower Macquarie and Barwon rivers, providing opportunities for the movement of native fish between the catchments.

Rainfall was variable during 2017–18, but was well below average during the year. Temperatures were warm, particularly during winter, with highest on record temperatures recorded. Environmental water (Commonwealth and NSW) was delivered between July and November 2017, to support wetland vegetation, waterbirds and native fish in the Macquarie River and Marshes.

The 2018–19 water year has been very hot and dry, with a return to severe drought conditions in the Macquarie River Valley. Rainfall has been well below average in parts of the catchment, with highest on record temperatures occurring in January 2019. Inflows to Burrendong Dam during this period have been extremely low, with the lowest inflows on record – between August 2017 and the end of April 2019 inflows have been ~88 GL, which is only 36 per cent of the previous record low inflow of ~246 GL for the 21 months ending in April.

The new drought of record in the Macquarie River Valley resulted in access to general security and planned environmental water accounts being restricted to 70 per cent of the 1 July 2018 carryover balance. This limited the volume of environmental water that could be delivered in 2018–19. A smaller than planned volume of NSW and Commonwealth water was delivered to the Macquarie River and parts of the Marshes in winter and spring, to support wetland vegetation and native fish. Providing this environmental water was particularly important to help protect ecological assets and to continue building resilience so the system could withstand the ongoing dry conditions.

With the potential for further dry and hot conditions in the Macquarie catchment in future, and the need to avoid damage to key assets in the system, there are a number of environmental demands that require water in 2019–20. Note that the capacity to contribute to these environmental demands is contingent on a substantial improvement in water availability in the catchment.

Environmental water demands for environmental assets in the Macquarie catchment in 2019–20 are represented in Table 3 and summarised below:

***Mid-Macquarie River (*Burrendong – Marebone Weir):** The level of demand is related to the flow rate. Small flows to maintain refugia for native fish remain a high demand as they are required continuously to avoid damage to fish populations. While these flows are often met by other sources of water, they may not be met in 2019–20 should drought conditions remain. There is a moderate demand for water in 2019–20 to contribute to small freshes that will support the movement and breeding of native fish flow generalists (e.g. Australian smelt, Murray-Darling rainbow fish), in-channel specialists (e.g. Murray cod, freshwater catfish). There is a high to critical demand for flows to support the breeding of native fish flow specialists (e.g. golden and silver perch), with the maximum frequency interval for these flows having now been exceeded. The demand for large freshes and bankfull flows to drown out weirs and allow for

the movement of native fish is considered to be low (required approximately twice in ten years), after being met by high flows in spring 2016.

***Macquarie Marshes 1:1 to 2:3* year inundation zones (reed beds, lagoons, mixed marsh, water couch)*:** High demand. Ideally, annual wetting is required to maintain these communities, which are also identified as critical components of the Ramsar site. There have been positive responses in these vegetation communities following good inundation in 2016–17, 2017–18 and 2018–19. For example, water couch and mixed marsh vegetation responded well in 2018–19 in the Southern Marshes, and there was strong growth and expansion of reedbeds in 2017–18. However, with very dry conditions continuing, groundcover in autumn 2019 was observed to be in poor condition and low abundance over a large area of the Marshes. Watering in 2019–20 is required for these vegetation communities to avoid damage and continue building resilience to protect the capacity to recover from further dry years.

***Macquarie Marshes 1:2 to 2:5 year inundation zones (reeds, water couch, mixed marsh, river red gum forest, river cooba)*:** High demand. These areas of the Marshes were well inundated in 2016–17, and they were the target of environmental water delivered in 2017–18 and 2018–19. A positive response was observed in the condition of wetland vegetation which was watered again in 2018–19. In particular, river red gums in the Northern Marshes displayed healthy canopies, fresh growth and flowering. However, conditions were dry between 2013–14 and 2015–16, with demands only being partially or not met during that time, and very dry conditions returned in 2017–18 and 2018–19. These vegetation communities ideally require water eight in ten years, with some species having a maximum dry interval of two to three years. Reeds, water couch, mixed marsh and river red gum are also critical components of the Ramsar site. Wetting is required again in 2019–20 to build on the benefits of previous inundation, maintain soil moisture and groundwater levels, support vegetation recruitment, and to build resilience and capacity to recover from dry conditions, to help sustain these communities in the longer term.

***Macquarie Marshes 1:3 to 1:4 year inundation zones (river red gum woodland, river cooba, inner coolibah woodland)*:** Moderate demand. These areas were sufficiently watered in 2012–13 and again in 2016–17. These communities are ideally inundated one in three years, with some species requiring water every three to four years. Some of these communities had been showing signs of stress before being inundated in 2016 (e.g. river red gum woodland in the Northern Marshes). Improvements in tree condition were observed in autumn 2017 and 2018. River red gum woodland and coolibah woodland are both critical components of the Ramsar site. Water will be required again in the next one to two years to maintain condition.

***Macquarie Marshes 1:5 to 1:10 year inundation zones (outer river red gum woodland, coolibah and black box)*:** Low demand. Much of this area was inundated in 2016–17 with the approximate 1:8 year inundation event. Before that time this zone had not been inundated since 2010–11. Some species require water every four to five years and the condition of river red gum trees further away from watercourses had declined during those dry years. Wetting may be required again in the next 2–3 years to maintain condition. These vegetation communities are identified as critical components of the Ramsar site, however, these areas are difficult to reach with environmental water alone.

* For example, 1:1 – inundation required every year; 2:3 – inundation required two years in three; and so on.

***Lower Macquarie River* (Marshes – Barwon River):** The level of demand is related to the flow rate. There is a high demand for water in 2019–20 to provide small in-channel flows and a moderate to high demand for a fish connection flow in the lower Macquarie River. This demand was met in 2016–17, however, it was not met between 2012–13 and 2015–16, and was only partially met in 2017–18 and 2018–19. Small in-channel flows are ideally provided annually. Connectivity through the system is important for all native fish, which need to move as part of their life cycle to feed, find shelter, and maintain good body condition. The capacity to support connection between the lower Macquarie River and the Barwon River is contingent on suitable conditions in both these systems, water availability and operational feasibility. Following good flows and connectivity in 2016–17, there is a moderate demand in 2019–20 to provide water to inundate the floodplain in the lower Macquarie River, which is likely required one in every three years. However, the lower Macquarie floodplain areas are difficult to reach with environmental water.

***Distributary creeks*:** Moderate to high demand. Demands in the distributary creeks are considered to have been met in 2016–17, although they were only partially or not met (depending on the creek) in the preceding three years, which were particularly dry, or in 2017–18 and 2018–19. Although the required watering frequencies are not well known for the distributary creeks, they may require further water in the next one to two years to provide benefits for native vegetation and to provide connectivity with the Barwon-Darling system.

Critical refuge habitat: High to Critical demand (should extreme dry conditions persist). Demands at key refuge sites are considered to have been met in all but extreme dry conditions. In 2018–19, environmental water was delivered to two sites in 2018–19 to maintain refuge habitat: at the Lower Nyngan Weir Pool on the Bogan River, and at Methalibar Reserve on Ewenmar Creek. Water may be required to support prioritised refuge habitat in 2019–20 if conditions remain very dry, to avoid damage and irretrievable loss. Should climatic conditions improve, this demand will reduce and is expected to be met by other water sources.

Barwon-Darling

There is a growing awareness of the importance of connecting flows across the northern Basin, to support habitat, water quality, native fish and other aquatic species in the Barwon-Darling and its tributary systems, including the Macquarie River. Subject to antecedent conditions, water availability, and urgency of environmental demands, there may be opportunities to coordinate releases across multiple rivers in the northern Basin to meet broader environmental demands. The environmental demands in the Barwon-Darling are described in the *Commonwealth Environmental Water Portfolio Management Plan: Barwon-Darling 2019–20*.

Murray–Darling Basin-wide environmental watering strategy and 2019–20 annual priorities

The Murray–Darling Basin Authority publish the Basin annual environmental watering priorities each year and have published multi-year priorities since 2017–18. There are no specific 2019–20 Basin annual environmental watering priorities relevant to the Macquarie River Valley, however, the rolling annual priorities are applicable.

Rolling, multi-year priorities

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

- Support lateral and longitudinal connectivity along the river systems.

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

- Maintain the extent, improve the condition and promote recruitment of forests and woodlands.
- Maintain the extent and improve the condition of lignum shrublands.

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

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

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

- Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales.
- Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.

2.3. Water availability in 2019–20

Forecasts of Commonwealth water allocations

The volume of Commonwealth environmental water likely to be carried over in the Macquarie River Valley for use in 2019–20 is estimated to be 23 GL. This volume is likely to be unavailable for use under current drought restrictions until resource availability significantly improves.

Allocations against Commonwealth water entitlements in the Macquarie River Valley are determined by state governments and will vary depending on inflows. The following forecasts in Table 2 are based on the best available information including State forecasts and historical inflow scenarios.

Table 2: Forecasts of Commonwealth water allocations (including carryover) in 2019–20 in the Macquarie River Valley as at 31 May 2019.

Entitlement type	Forecasts of Commonwealth water allocations (including carryover) in 2019–20 (GL)					
	Very dry ← → Very wet					
	95 percentile	90 percentile	75 percentile	50 percentile	25 percentile	10 percentile
Macquarie (general security)	23	23	23	23	34	34
Macquarie (supplementary)	Up to 8 GL	Up to 8 GL	Up to 8 GL	Up to 8 GL	Up to 8 GL	Up to 8 GL

Notes:
1. Forecasts for regulated catchments are given to the nearest whole gigalitre.
2. Allocation rate scenarios are based on long term average allocation rates.
3. Allocation in Commonwealth accounts is unavailable for use under current drought restrictions. This will not change until resource availability significantly improves.

Information on allocations to Commonwealth environmental water holdings can be found at http://www.environment.gov.au/water/cewo/portfolio-mgt/holdings-catchment and is updated monthly.

Water resource availability scenarios

Commonwealth environmental water is not managed in isolation. When considering the available resources to meet environmental demands, it is necessary to also factor in the resources managed by other entities and available to contribute to environmental objectives. Relevant resources include held environmental water managed by state government agencies, planned environmental water, natural and unregulated flows, conveyance water and consumptive water. Further detail on sources of environmental water in the Macquarie River Valley is provided in Attachment C.

By combining the forecasts of water held by the Commonwealth with streamflow forecasts, as well as taking into account operational considerations, water resource availability scenarios can be developed ranging from very low to very high. Based on available information, very low to moderate resource availability scenarios are in scope for 2019–20.

Note that these scenarios are only possible if conditions become wetter and water from the drought sub-account becomes available. Should conditions remain dry, no environmental water will be available for use in 2019–20. Furthermore, as of April 2019, an estimated 260 GL of inflows are required into Burrendong Dam before any increase in available allocations can be made.

2.4. Overall purpose of managing environmental water based on supply and demand

Environmental water needs (demand) and water availability (supply) both influence the overall purpose of Commonwealth environmental water management. Under different combinations, the management purpose can range from 'avoiding damage' to the environment to 'improving' ecological health. This in turn informs the mix of portfolio management options that are suitable for maximising outcomes.

Figure 4 shows how current demands and forecasted supply are considered together.

The overall 'purpose' for managing the Commonwealth's water portfolio in the Macquarie River Valley for 2019–20 is to avoid damage and protect the health and resilience of aquatic ecosystems in the Macquarie River and Macquarie Marshes, and other important sites in the valley as required.

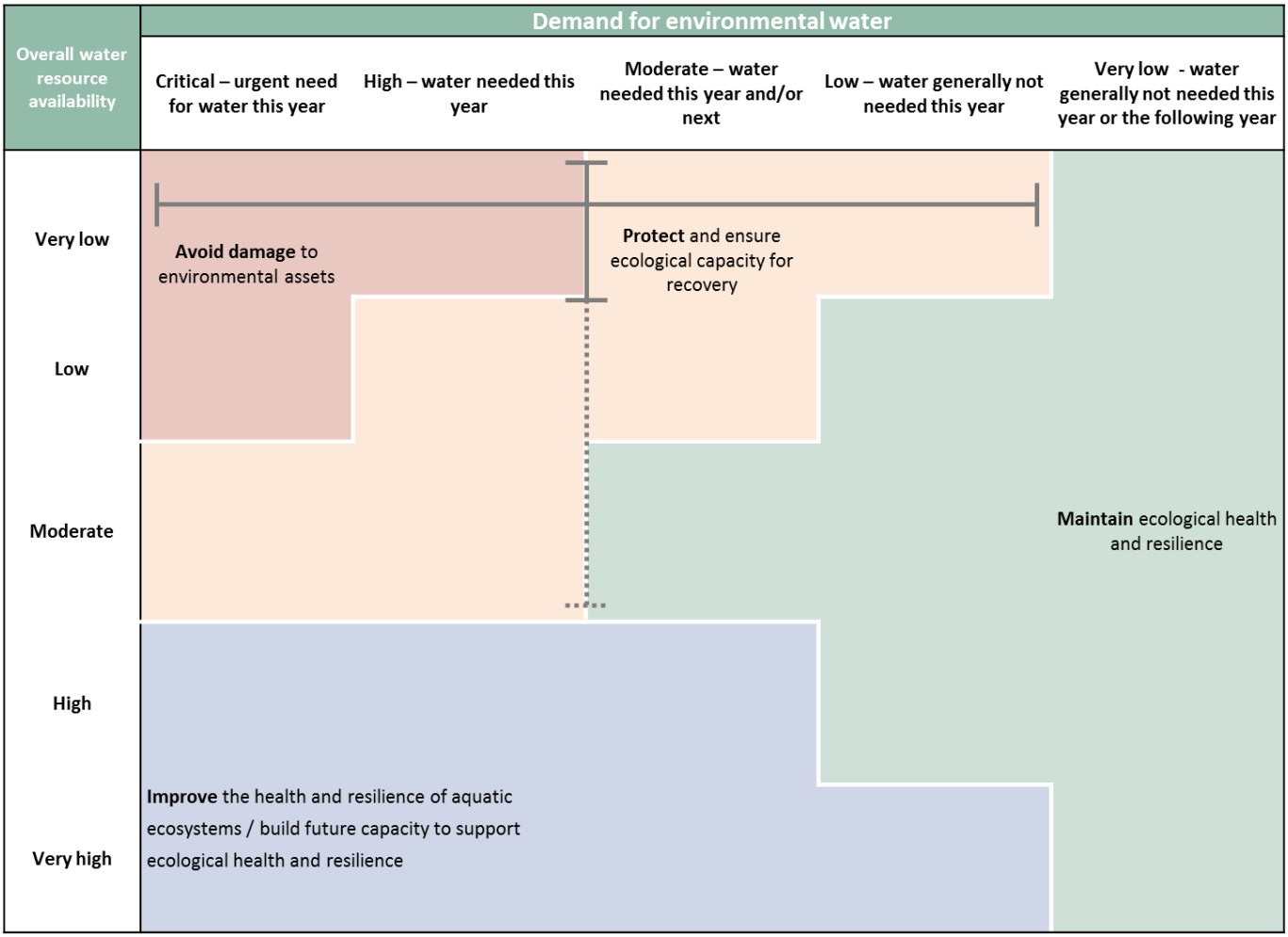

Figure 4: Determining a broad purpose for portfolio management in the Macquarie River Valley for 2019–20. Note: grey lines represent potential range in demand and water resource availability.

Further detail on how the overall purpose for portfolio management changes under different supply and demand scenarios is provided in *Portfolio Management Planning: Approach to planning for the use, carryover and trade of Commonwealth environmental water, 2019–20* (available at: http://www.environment.gov.au/water/cewo/publications).

2.5. Water Delivery in 2019–20

Consistent with the demands and purpose described in section 2.4, the Commonwealth Environmental Water Office is considering supplying environmental water to the following watering actions for 2019–20 (see also Table 3 for supporting information regarding the basis for determining these watering intentions).

The delivery of environmental water as described below is contingent on water being made available from the drought sub-account, and assumes that there will be sufficient reserves in Burrendong Dam to resume normal river operations and provide continuous flow to the end of the regulated reaches.

There is a high to critical demand to protect refuge pools downstream of Warren on the Macquarie River. However, based on current conditions, no environmental water will be available for delivery to support refuge pools as of 1 July 2019. When water is made available again it is expected that river operations will meet this demand.

As environmental water (NSW and Commonwealth) becomes available again during 2019–20, deliver water to the Macquarie Marshes (Action 6 – Appendix 3) to target the inundation of 4 000–9 000 ha (blue and purple inundation zones – Figure 2) of wetland vegetation (reeds, water couch, lagoons and mixed marsh), to avoid irretrievable loss or damage, and to support ecosystem resilience and native fish.

Depending on the volume of water available, delivering environmental water to the Macquarie Marshes may also:

- meet baseflow requirements in the mid-Macquarie River (Action 1 – Appendix 3)
- support native fish condition, movement and spawning opportunities in the mid-Macquarie River by managing the hydrograph to provide suitable flows (Actions 2 and 3 – Appendix 3)
- support values of the Ramsar site within the Marshes, such as maintaining core areas of semi-permanent wetlands (including reeds, water couch and red gum forest), providing habitat for migratory waterbirds and native fish, and promoting biological diversity.

The delivery of Commonwealth and NSW environmental water to support the Macquarie Marshes is scalable, depending on the volume of water available and catchment conditions (Action 6 – Appendix 3). The volume of water required to meet the demands described may also vary, depending on antecedent conditions. Should conditions and water availability improve, and new allocations are made available for use, there may be opportunities to meet other demands in the catchment, for example, up to 19,000 ha (pink inundation zone), or to provide freshes to support native fish. Following increased water availability, the Commonwealth Environmental Water Office would consult with delivery partners and the EFRG to determine priorities for use.

Under wetter conditions, delivering environmental water to the Macquarie Marshes may also contribute to meeting environmental demands for small in-channel flows in the lower Macquarie River (Action 8 – Appendix 3). Additional water could also be used to build adequate water supplies to meet environmental demands in future years.

Despite the high to critical demand for water in 2019–20, it is unlikely to be feasible to target the spawning of native fish flow specialists in the Macquarie River using environmental water. Irrespective of the lack of water available for delivery, the flow rates required to target native fish flow specialists become particularly difficult to operationalise during dry conditions without contributions from tributary inflows. Additionally, monitoring over a number of years has not found evidence that flow specialist fish species have spawned, so there is still uncertainty about whether this group spawns in the Macquarie. However, providing connection to source populations like the Barwon River is important, and large freshes improve productivity and provide opportunities for movement (and can be a trigger for spawning if temperatures are right).

When available, supplementary entitlements (Commonwealth and NSW) may be used to contribute to meeting environmental demands and to build on the benefits of naturally triggered flow events in the Macquarie system.

Any watering actions in the Macquarie Marshes would contribute to maintaining waterbird habitat and may support breeding under suitable conditions. This would also benefit waterbird populations more broadly (e.g. via waterbird flyways across the Lachlan, Murrumbidgee, mid-Murray, Gwydir, Namoi and Border Rivers catchments).

As in previous years, the use of Commonwealth and NSW environmental water in the Macquarie River Valley will be adaptively managed together throughout 2019–20, in response to changing water resource availability and environmental conditions and demands.

Stakeholder Feedback

The Macquarie Cudgegong EFRG has provided valuable advice that has informed planning for the management of Commonwealth environmental water in the catchment. NSW OEH and NSW DPI – Fisheries have provided additional advice in the development of this plan.

In recognition of the particularly dry antecedent conditions, forecast water availability and environmental demands, the EFRG has advised that:

- When available, environmental water be used with other water sources to deliver a flow of up to 110 GL to inundate the blue and purple inundation zones (Figure 2) in the Macquarie Marshes (4 000–9 000 ha). This flow would help to avoid irretrievable loss of wetland vegetation in the core areas of the Marshes, including reeds, water couch, mixed marsh and lagoons. It would also provide refuge habitat for waterbirds, fish and frogs, and support ecosystem resilience.

- Should some of the 110 GL of environmental water currently being held in the drought sub-account be made available, environmental water may contribute to a minimum 10 GL (all water sources) watering action. The release pattern of environmental water would be determined by antecedent conditions and timing of water made available.

- If more than 30 GL of environmental water is made available from the drought sub-account, a small fresh for 10 days could be incorporated into the delivery to support native fish (e.g. in-channel specialists and flow generalists). This would ideally occur after October when water temperatures are warmer.

- Should new allocations become available, the EFRG would reconvene to advise on the best use of this water. This will provide greater certainty about how it can be used most effectively, based on a clearer understanding of conditions and environmental demands at the time.

- Until Commonwealth and NSW environmental water is made available from the drought sub-account, no active delivery of environmental water will be possible. However, the EFRG recommended that during this time the priority for use of any surplus water should be to maintain and protect refuge pools downstream of Warren on the Macquarie River, to avoid loss of species or irretrievable damage to these ecosystems.

2.6. Trading water in 2019–20

The Water Act 2007, requires the Commonwealth Environmental Water Holder to trade for the purpose of protecting and restoring the environment. In addition to the obligations of the *Water Act 2007*, the Commonwealth Environmental Water Holder and Commonwealth Environmental Water Office staff are required to comply with a wide range of existing legislative requirements. This includes: financial management arrangements for Commonwealth agencies; freedom of information; and policies relating to information management, auditing, employee conduct and accountability.

Planning on water trade considers supply and demand within the catchment and across the Basin. As part of the planning process, the Commonwealth Environmental Water Office undertakes a Basin-wide analysis to identify opportunities to use allocation trade to better match differing demands across catchments. Consideration is given to the water available to meet both current and future environmental needs. Additionally these decisions are influenced by current climatic conditions, as well as implications of trade for commercial outcomes in communities.

Large parts of the northern Basin are currently experiencing pressures from water scarcity, with low storage levels and rainfall deficiencies evident in most northern catchments. It is likely that insufficient water resources will be a major constraint on achieving proposed actions however acquisition to meet environmental needs is unlikely to be feasible until water availability improves. Significant rainfall is required to break the drought and large shortfalls in reserves need to be captured in storage before new allocations can be made.

No specific trade of water in the Macquarie Valley has been identified for 2019-20. Trade opportunities will be reviewed in the valley throughout the water year and as conditions change. Further information will be provided to the market ahead of any trade of Commonwealth environmental water at: http://www.environment.gov.au/water/cewo/trade

For more information on the rules and procedures governing the trade of Commonwealth environmental water, see the *Commonwealth environmental water Trading Framework* available at: http://www.environment.gov.au/water/cewo/publications/water-trading-framework-nov2016

2.7. Carrying over water for use in 2020–21

The volume of water carried over for use in 2020–21 will depend upon resource availability and demand throughout the year. As the 2019–20 water year progresses, a carryover target will be determined for the Macquarie catchment, sufficient to meet early season requirements, subject to water availability. As documented in Table 3 below, potential demands in 2020–21 include:

- Wetland watering between June and April to the Macquarie Marshes to inundate up to 19 000 ha of the wetlands, which includes the blue/purple and pink inundation zones (reeds, lagoons, water couch, mixed marsh – Figure 2).

- Flows in the mid-Macquarie River, targeting native fish movement and breeding.

Carryover volumes will be adjusted throughout the year as the season unfolds in response to both current and future demands and the water available to meet these demands. These decisions will be based upon best information available at the time.

More information on how the Commonwealth makes decisions on carryover is here: http://www.environment.gov.au/water/cewo/portfolio-mgt/carryover

2.8. Identifying Investment Opportunities

Under the *Water Act 2007*, the Commonwealth Environmental Water Holder has the flexibility to use the proceeds from the sale of water allocations to fund environmental activities in the Basin.

'Environmental activities' must be consistent with the Commonwealth Environmental Water Holder's obligation to exercise their function to protect and restore environmental assets. Environmental activities must also improve the capacity of the Commonwealth Environmental Water Holder to meet the objectives of the Basin Plan environmental watering plan, and be directly linked to current or future delivery of water for the environment.

The option of investing the proceeds in environmental activities will be considered alongside other available water management options, such as purchasing water at another time or place. The Commonwealth Environmental Water Holder is finalising an Investment Framework and an Annual Investment Plan to inform future investment in environmental activities.

Table 3: Environmental demands, priority for watering in 2019–20 and outlook for coming year in the Macquarie River Valley.

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)[6]		Watering history[7]	2019–20		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2020–21 if watering occurred as planned in 2019–20
Mid-Macquarie River (Burrendong – Marebone Weir) [1] • Native fish habitat and spawning including threatened species such as Murray cod, freshwater catfish • In-stream aquatic ecosystems • Riparian vegetation	Fish refuge: all guilds Aquatic ecosystems	**Baseflows†:** small (>200 ML/d), very regular flows through to end of system, wetting holes and in-stream storages. Ideally depth >0.3 m above commence to flow level, to allow some movement and prevent pool stratification.	Ideally: continuous flow (Max interval: continuous flow)	Minimum baseflows have been achieved, even during drier years between 2013–14 and 2015–16. However, these are ideally required continuously to maintain in-stream habitat, and will be required again in 2019–20. Therefore, the environmental demand has been assessed as high.	High	Expected to be met by essential regulated supplies. However, there is a risk in 2019–20 that baseflows won't be met by this water under a very low water availability scenario. Potential use of CEW under very low water availability scenario, subject to environmental water being available for delivery.	High
	Fish spawning–flow generalists (e.g. Australian smelt, carp gudgeon) + in-channel specialists (e.g. Murray cod, freshwater catfish)	**Small freshes:** Small fresh 1(SF1) >500 ML/d anytime (but ideally Oct–Apr) for 10 days. Small fresh 2 (SF2) >500–6 000 ML/day for at least 14 days at Baroona in Sep–Apr (Sep–Dec for Murray cod spawning); and conditioning flow in winter (July to mid-August).	Ideally: SF1: annually (Max interval: 3 years for large-bodied generalists; 5 years in-channel specialists; 1 year for small-bodied) SF2: 5–10 years in 10	Small freshes have been achieved since 2015–16. These flows are ideally provided annually, so are required again in 2019–20, preferably timed with tributary flows. Therefore, the environmental demand has been assessed as moderate.	Moderate	Potential use under very low to high water resource availability scenarios, subject to natural tributary flows and water temperature.	Moderate
	Flow specialists guild movement and breeding‡	**Priming flow:** >5 000 ML total flows at Baroona over 3 days with approx. 7 day recession (tributary pulse). **Spawning pulse:** initial peak ≥ 5 000 ML/day at Baroona for >2 days with event lasting for >7 days. (35–40 day total event) **Dispersal flow:** Initial pulse >3 000 ML total flows over 3 days at Baroona. Second pulse min. 2 000ML/day peak with recession. Approx 10d duration total events. (Oct–March) Water temperature for all pulses ≥19°C.	Ideally: 3–5 years in 10 (up to twice per year) (Max interval: 4 years)	Flows for native fish flow specialists were likely last fully met in 2012–13 (Nov–Jan). Flows in spring 2016 were likely sufficient to meet the flow targets for a spawning pulse, however, the temperatures at the time were not appropriate throughout the river system for native fish spawning. No spawning of golden or silver perch has been detected. While targets for dispersal flows have been met in at least the last three years, in the absence of adequate priming and spawning flows, the environmental demand has been assessed as high to critical.	High to Critical	Although the demand for water is very high, water available to meet this demand is insufficient under a very dry scenario. The capacity to target spawning pulses using regulated environmental water is also limited in most years. Possible use of CEW (e.g. supplementary) under moderate to high water resource availability scenarios to augment freshes and support movement. Subject to natural tributary flows, water temperature, and significant river rises that will cue movement and possibly spawning of flow specialists.	Critical
	Fish movement In stream + riparian vegetation	**Large freshes and bankfull:** 10 000–20 000 ML/day at Baroona for a minimum of 3 days (to drown out key weirs).	Ideally: 2 in 10 years (Max interval: 2–4 years)	Large freshes were last achieved in 2016–17, when flows >10 000 ML/day were achieved at Baroona on three occasions, for 6, 3 and 28 days respectively in Sept-Oct 2016. Before this, it was last met in 2011–12 and 2010–11, meeting the desired frequency of 2 in 10 years. Therefore, the environmental demand has been assessed as low.	Low	A low priority for CEW in 2019–20 and only able to contribute to this demand when coordinated with major tributary flow event.	Low

† Very low flows in the mid-Macquarie River have the same flow rate and requirements as baseflows (>200 ML/day). Cease to flow events should be avoided because they no longer occur, and fish, plant and animal communities are dependent on regular flows.

‡ There are still knowledge gaps related to spawning requirements and hotspots in the Macquarie catchment for flow specialists.

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)[6]		Watering history[7]	2019–20		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2020–21 if watering occurred as planned in 2019–20
Macquarie Marshes [3,4§] • Includes areas of Ramsar listed wetlands[**] • Nationally significant wetlands • Waterbird breeding and habitat • Habitat and breeding ground for frogs • Native fish habitat	Blue and Purple inundation zones (4 000 to 9 000 ha)	30–60 GL at Marebone over 3 months between June and April to inundate reed beds, lagoons, mixed marsh, and water couch.	Ideally: annually (Max interval: 2 years)	Demand has been met in past 7 years in all areas of the Marshes except the Northern Marshes in 2014–15, and the Eastern Marshes in 2015–16. Partially met in the Eastern Marshes in 2018–19. Watering is required to maintain wetland vegetation with annual watering requirements, building on benefits of previous inundation, and to provide drought refuge for a range of aquatic species.	High	A high priority for CEW under very low to high water resource availability scenarios. Unlikely to have sufficient water to target this demand, unless there is a substantial improvement in water availability.	High
	Pink inundation zone (19 000 ha)	100 GL at Marebone over 3 months between June and April to inundate reeds, water couch, mixed marsh, river red gum forest, river cooba.	Ideally: 8 in 10 years (Max interval: Groundcover – 2 years; trees 4–7 years)	Demand met in 2012–13, 2016–17 and again in 2017–18 in all areas of the Marshes, excluding the Eastern Marshes in 2017–18, which was not inundated for the target duration. Demand either partially met or not met in years in between, including in 2018–19, when the target extent and duration were not achieved. In 2018–19 a total of 57% per cent of the area targeted in the pink zone was inundated. This included 65% of the target zone in the Northern Marshes, 64% in the Southern Marshes, and 23% in the Eastern Marshes[††]). Requires water again in 2019–20 to contribute to 8 in 10 year frequency, and to build resilience and avoid damage, including in Ramsar sites. Therefore, the environmental demand has been assessed as high. If this demand is not met in 2019–20, it will increase to critical in 2020–2021.	High	A high priority for CEW under low to high water resource availability scenarios. Unlikely to have sufficient water to target this demand, unless there is a substantial improvement in water availability.	High
	Red inundation zone (50 000 ha)	250 GL at Marebone over 3– 5 months between June and April to inundate river red gum woodland, river cooba, inner coolibah woodland	Ideally: 1 in 3 years (Max interval: 4–7 years)	Demand met in 2016–17 and 2012–13 in all areas of the Marshes. Based on having been met once in the last three years, the demand is considered moderate for 2019–20, and will require water in the next 1–2 years.	Moderate	Possible use under high or very high water resource availability scenarios. Would require other water sources to meet.	Moderate to High
	Orange and green inundation zones (81 000 to 145 000 ha)	400 to 700 GL at Marebone over 5 months between June and April to inundate outer river red gum (RRG) woodland, coolibah, and black box	Ideally: 1 in 4 years (RRG), or 1 in 8 years (other veg) (Max interval: 7 years (RRG) 20 years (other veg))	Demand last met in 2016–17 in all areas of the Marshes. Before that this demand was met in 2010–11, although some minor inundation occurred in 2011–12 and 2012–13. Demand is considered low for 2019–20, but may require water in the next 2–3 years.	Low	Low priority for CEW in 2019–20.	Moderate

§ Volume required to meet demands may vary depending on antecedent conditions.

** Vegetation types/communities that are identified as critical components of the Ramsar site include water couch, river red gum forest and woodland, reed beds, cumbungi, mixed marsh, coolibah and blackbox woodland. By maintaining this wetland vegetation, other critical components of the Ramsar site may be supported, including frogs, fish, waterbird breeding and foraging habitat.

†† Note that inundation of some areas of the pink zone in the Eastern Marshes require flow rates that are not deliverable using managed flows (e.g. Back Swamp).

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)[6]		Watering history[7]	2019–20		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2020–21 if watering occurred as planned in 2019–20
Lower Macquarie River (Marshes – Barwon River)[1,2] • Native fish habitat and dispersal • Provides connectivity between Macquarie and Barwon catchments • In-stream aquatic ecosystems and floodplain vegetation	In-stream aquatic ecosystems Fish Connectivity	**In-channel flows:** Minimum 20 ML/day at Bells Bridge for 45 days.	Ideally: annually (Max interval: 1–2 years)	Small in-channel flows were met in the lower Macquarie in each year between 2016–17 and 2018–19 (usually between Aug and Dec/Jan). These flows ideally occur annually and are required again in 2019–20. Therefore, the environmental demand has been assessed as high.	High	Possible use under low to moderate water resource availability scenarios, subject to tributary flows. Needs may be partially met by other flows.	Moderate
	Fish Connectivity	**System connectivity between the Macquarie and Barwon catchments:** † for example in-channel flow targeting minimum rates of 140 ML/day at Bells Bridge (minimum depth of 50 cm) to connect the lower Macquarie River and the Barwon River for a minimum of 28 days.	Opportunistic (Max interval: 4 years)	Based on flows at Bells Bridge, suitable connection was achieved in spring 2016, autumn 2017, and again in spring/summer 2017. Note that these flows in 2016–17 occurred during wetter conditions and the autumn flow was specifically targeting connectivity to the Barwon River. However, flows in 2017–18 occurred in drier conditions and were likely subject to extraction downstream of Bells Bridge, meaning suitable connection may not have been achieved. This demand was also partially met in 2018–19, with environmental water providing a low flow connection to the Barwon River during spring 2018. Therefore, the environmental demand has been assessed as moderate to high.	Moderate to High	Unlikely to be a priority under continuing very dry conditions. Possible use under moderate to very high water resource availability scenarios only, subject to suitable conditions and operational feasibility.	Moderate to High
	Floodplain vegetation Connectivity	15–30 GL at Bells Bridge to inundate floodplain and lower reach of Macquarie River.	Ideally: 1 in 3 years (Max interval: 7 years)	Good connectivity was achieved with the lower reach and floodplain of the Macquarie River in 2016–17 and previously in 2012–13. ~15.3 GL of flow also passed Bells Bridge between July and mid-Dec 2017. However, this water was likely subject to unregulated flow extraction in the lower Macquarie, so this demand may not have been fully met since 2016–17. Therefore, the environmental demand has been assessed as low to moderate.	Moderate	A low priority for CEW in 2019–20.	Moderate to High
Unregulated Distributary creeks[5] Marra Creek Lower Crooked Creek[‡‡] • Native fish habitat • In-channel and riparian habitat • Connectivity with Barwon-Darling catchment	Fish In channel and riparian vegetation Increased frequency and duration of connectivity to Barwon-Darling	Baseflows and freshes to Marra Creek and/or the lower Crooked Creek. Volumes required dependent on which creeks are targeted. Some connectivity may be provided by replenishment flows.	Required frequency unknown (1 in 1–3 years based on key vegetation)	Demand met in 2016–17 and 2012–13, with stock and domestic replenishment flows partially contributing to demand in some creeks in years in between. Therefore, the environmental demand has been assessed as moderate to high.	Moderate to High	Possible use under moderate to very high water resource availability scenarios, subject to suitable water availability and operational feasibility.	Moderate to High
Prioritised critical refuge habitat – various locations as required in exceptional circumstances	Fish (all guilds) and other aquatic dependent biota refuge Aquatic ecosystems	Baseflows to replenish significant refuge pools at high risk of drying down in exceptionally dry circumstances. Volumes required are likely to be relatively small, but	As required only during extremely dry conditions	Demand expected to be met by essential regulated supplies in all but the most extreme dry years. Environmental water was provided to two important refuge pools in 2018–19 (Lower Nyngan Weir Pool and at Methalibar Reserve on Ewenmar Creek) to help prevent them from drying out.	High to Critical (should extreme dry conditions continue – if conditions improve, the demand for	Expected to be met by essential regulated supplies. However, there is a risk in 2019–20 that some critical refuge habitat may be at risk if sections of the Macquarie River are shut down. Potential use under very low water availability scenario, subject to	Variable depending on climatic conditions: If extreme dry conditions persist, demand may be Critical; Should conditions become significantly

‡‡ Broader system connectivity may be achieved by other flows in the system and operational management of environmental/other water (e.g. via the Bogan River, Gunningbar Creek, the Castlereagh River, and Marthaguy Creek (including through the Gum Cowal)).

Environmental assets	Target values	Indicative demand (for all sources of water in the system)[6]		Watering history[7]	2019–20		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2020–21 if watering occurred as planned in 2019–20
• Refuge habitat • Native fish (e.g. olive perchlet), water rat and tortoise survival • Water quality		dependent on which refuge pools are targeted.		Should extreme dry conditions continue in 2019–20, the demand for water to maintain critical refuge habitat will be high to critical.	water will reduce)	environmental water being available for delivery.	wetter, demand may reduce to Low or Very Low
					Carryover potential	The volume of Commonwealth environmental water likely to be carried over in the Macquarie River Valley for use in 2019–20 is estimated to be 23 GL	A low proportion of available allocations may be carried over to 2020–21
					Trade potential	No specific commercial trade of water has been identified for 2019–20. Trade opportunities will be reviewed in the valley throughout the water year and as conditions change.	Potential to trade will depend on environmental demands, resource availability and market conditions.

Note: contributions to meet Barwon-Darling environmental requirements may be considered subject to water availability, antecedent conditions, and environmental demands. Refer to Commonwealth Environmental Water Portfolio Management Plan: Barwon-Darling 2019–20.

References:

1. Sourced from information and advice provided by NSW DPI Fisheries (Sam Davis, pers. comm. 2015– 2019)
2. Sourced from Barma Water Resources et al. (2011)
3. Sourced from advice from NSW Office of Environment and Heritage (Tim Hosking, Paul Keyte and Debbie Love, pers. comm. 2015–2019), NSW Department of Environment, Climate Change and Water (2010), and MDBA (2012)
4. Based on inundation zones as mapped by Thomas et al. (2015).
5. Sourced from Torrible et al. (2011)
6. All watering history sourced from advice from NSW Office of Environment and Heritage (Tim Hosking, Paul Keyte and Debbie Love, pers. comm. 2015–2019), NSW OEH Statement of annual environmental watering priorities, WaterNSW Water Balance Reports, and data from the following gauges (WaterNSW 2019):

- 421090: Macquarie River at d/s Marebone Weir
- 421001: Macquarie River at Dubbo (in the absence of available data at Wellington)
- 421147: Macquarie River at Pillicawarrina
- 421088: Marebone Break at d/s regulator
- 421107: Marra Creek at Billybongbone Bridge
- 421097: Marra Creek at Carinda Road
- 421146: Gum Cowal at Bifurcation
- 421907: Macquarie at Brewon
- 421127: Macquarie River at Baroona
- 421016: Crooked Creek at Profile
- 421012: Macquarie River at Carinda (Bells Bridge)
- 421022: Macquarie River at Oxley Station
- 421152: Gum Cowal at Oxley

Key - potential watering in 2019–20

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate – high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high – very high water resource availability)
- Unable to provide Commonwealth water due to constraints

Key - environmental demands

- critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- high demand for water i.e. needed in that particular year
- moderate demand for water i.e. water needed that particular year and/or next
- low demand for water i.e. water generally not needed that particular year
- very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3. Next steps

3.1. From planning to decision making

It is important to distinguish between planning and operational decision making. As shown in Figure 5, planning allows the Commonwealth Environmental Water Office to manage the environmental water portfolio in a holistic manner and is an exercise in developing a broad approach or intention, based on the key drivers (demand and supply).

Decision making throughout each year builds on the intention by considering in more detail the specific prevailing factors and additional factors such as costs, risks, and constraints to water delivery and market conditions.

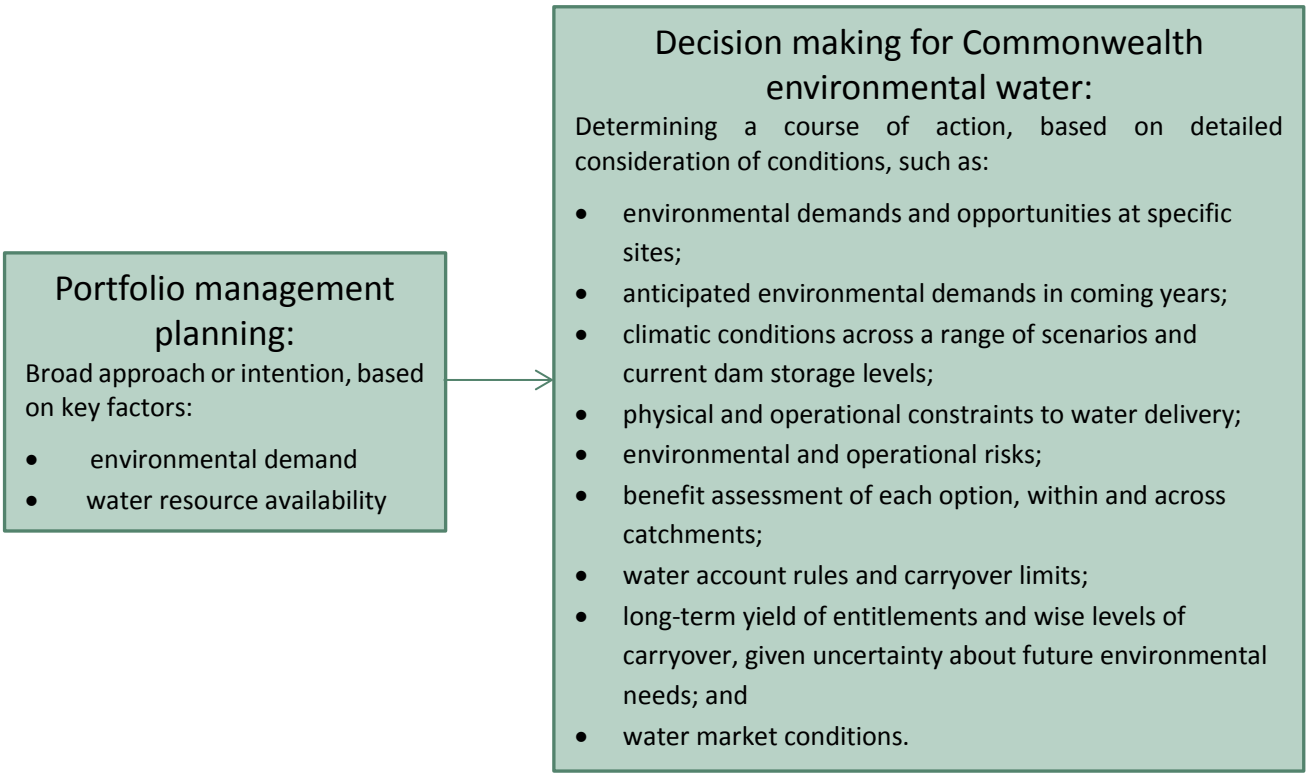

Figure 5: Planning and decision making for Commonwealth environmental water use

3.2. Monitoring

Operational monitoring is undertaken for all Commonwealth environmental watering actions and involves collecting on-ground data with regard to environmental water delivery such as volumes delivered, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes.

In the Macquarie-Castlereagh catchment, this is primarily achieved by the collaborative efforts and resources of NSW agencies and the Commonwealth Environmental Water Office, and includes:

- prioritised environmental monitoring of vegetation, waterbirds and frogs by NSW OEH and native fish by NSW DPI – Fisheries
- hydrology (online flow gauging) and flow delivery data by WaterNSW
- short-term intervention monitoring funded by the Commonwealth Environmental Water Office in the Macquarie catchment in 2014–15 (native fish) and 2016–17 (waterbird colonies and native

fish). This monitoring aimed to understand the environmental responses to different watering actions, with respect to targeted objectives and expected outcomes.

- operational surveillance of flow events by staff from the Commonwealth Environmental Water Office, NSW OEH and WaterNSW

- other aspects such as shallow groundwater and processes/functions by various others including researchers, landholders and agencies.

Information on the monitoring activities is available at http://www.environment.gov.au/water/cewo/catchment/macquarie/monitoring. Monitoring information is also provided by state governments.

3.3. Further information

For further information on how the Commonwealth Environmental Water Office plans for water use, carryover and trade, please visit our web site: http://www.environment.gov.au/water/cewo

or the sites below:

- Water use: www.environment.gov.au/topics/water/commonwealth-environmental-water-office/assessment-framework

- Carryover: http://www.environment.gov.au/topics/water/commonwealth-environmental-water-office/portfolio-management/carryover

- Trade: http://www.environment.gov.au/water/cewo/trade/trading-framework

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Attachment A – Expected outcomes from the Basin-wide environmental watering strategy

Expected outcomes from the Basin-wide environmental watering strategy (MDBA 2014) that are relevant to the Macquarie River Valley are described below.

RIVER FLOWS AND CONNECTIVITY

Baseflows are at least 60 per cent of the natural level

Contributing to a 10 per cent overall increase in flows in the Barwon-Darling

A 10–20 per cent increase in the frequency of freshes and bankfull flows

VEGETATION

Maintain the current extent of water-dependent vegetation near river channels and on low-lying areas of the floodplain.

No decline in the condition of river red gum, black box and coolibah across the Basin

Improved recruitment of trees within black box, river red gum and coolibah communities

Improve condition of lignum shrublands in the Macquarie Marshes

Increased periods of growth for non-woody vegetation communities that closely fringe or occur within the river and creek channels, and for common reed and cumbungi in the Macquarie Marshes.

Vegetation extent

Area of river red gum (ha)	Area of black box (ha)	Area of coolibah (ha)	Shrublands	Non–woody water dependent vegetation
58 200	57 100	32 200	Lignum in the Macquarie Marshes	Closely fringing or occurring within the Bogan, Castlereagh, Macquarie and Talbragar rivers; and common reed, cumbungi and water couch in the Macquarie Marshes

WATERBIRDS

Maintain current species diversity

Increase Basin-wide abundance of waterbirds by 20–25 per cent by 2024

A 30–40 per cent increase in nests and broods (Basin-wide) for other waterbirds

Up to 50 per cent more breeding events (Basin-wide) for colonial nesting waterbird species

Important Basin environmental assets for waterbirds in the Macquarie

Environmental asset	Total abundance and diversity	Drought refuge	Colonial waterbird breeding	Shorebird abundance	In scope for Cth e-watering
Macquarie Marshes	Yes	Yes	Yes	Yes	Yes

FISH

No loss of native species

Improved population structure of key species through regular recruitment, including:

- Short-lived species with distribution and abundance at pre-2007 levels and breeding success every one to two years
- Moderate to long-lived with a spread of age classes and annual recruitment in at least 80 per cent of years

Increased movements of key species

Expanded distribution of key species and populations

Key species for the Macquarie include:

Species	Specific outcomes	In-scope for Cth e-water in the Macquarie?
Flathead galaxias (*Galaxias rostratus*)	Considered extinct. Reintroduction using southern populations may be an option in the longer term, with the Macquarie a potential candidate site.	Possibly (Once widespread. Current extent unknown in Macquarie. Potential for re-introduction)
Freshwater catfish (*Tandanus tandanus*)	Expand the core range of existing populations in the Macquarie	Yes
Golden Perch (*Macquaria ambigua*)	A 10–15 per cent increase of mature fish (of legal take size) in key populations	Yes
Murray cod (*Maccullochella peelii*)	A 10–15 per cent increase of mature fish (of legal take size) in key populations	Yes
Olive perchlet (*Ambassis agassizii*)	Establish additional populations in the Macquarie	Possibly (Once widespread. Current extent unknown in Macquarie. Potential for re-introduction)
Silver perch (*Bidyanus bidyanus*)	Expand the core range in the Macquarie catchments	Yes
Southern purple-spotted gudgeon (*Mogurnda adspersa*)	Expand the range (or core range) of populations in the Macquarie. Establish additional populations	Yes
Trout cod (*Maccullochella macquariensis*)	The distribution of trout cod in the Northern Basin is limited to the Macquarie catchment downstream of Burrendong Dam. Range expansion of the current population is a priority. Establish additional populations	Yes

Important Basin environmental assets for native fish in the Macquarie

Environmental asset	Key movement corridors	High Biodiversity	Site of other Significance	Key site of hydrodynamic diversity	Threatened species	Dry period / drought refuge	In-scope for Cth e-water
Macquarie River – below Burrendong Dam to Warren	Yes	Yes			Yes	Yes	Yes
Macquarie Marshes to Barwon, including lateral connectivity at the Marshes	Yes				Yes	Yes	Yes
Lower Bogan River to junction with the Darling River	Yes				Yes	Yes	Yes

Attachment B – Operational details for watering

Operational considerations in the Macquarie River Valley

The delivery of environmental water in the Macquarie River Valley is currently constrained by the release capacities from storages, channel capacities, and system constraints.

Watering actions will be developed in consideration of the following constraints:

- Burrendong Dam storage capacity of 1 188 000 ML with additional storage capacity of 489 GL in the flood mitigation zone and outlet capacity of 8 200 ML/day (WaterNSW 2018; Department of Infrastructure, Planning and Natural Resources 2004)
- South Dubbo weir drown out at > 14 385 ML/day
- Marebone Choke – third party impact at prolonged flows > 4 000 ML/day
- Crooked Creek off take capacity of 100 ML/day
- structures such as banks, weirs, regulators and diversion channels in the Macquarie Marshes.

The Commonwealth Environmental Water Office will develop watering options within existing water delivery and channel capacity constraints unless the agreement of all affected parties has been obtained for an alternative delivery approach.

Potential watering actions under different levels of water resource availability

Under certain levels of water resource availability, watering actions may not be pursued for a variety of reasons, including that environmental demand may be met by unregulated flows and that constraints and/or risks may limit the ability to deliver environmental water. Table 4 identifies the range of potential watering actions in the Macquarie River Valley and the levels of water resource availability that relate to these actions.

Table 4: Summary of potential watering actions for the Macquarie River Valley

<table>
<tr><th rowspan="2">Broad Asset</th><th rowspan="2">Indicative demand</th><th colspan="5">Applicable level(s) of resource availability</th></tr>
<tr><th>Very Low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very High</th></tr>
<tr><td rowspan="3">Mid-Macquarie River</td><td>Baseflows: small (>200 ML/day), very regular flows through to end of system, wetting holes and in-stream storages. Ideally depth >0.3m above commence to flow to allow movement and prevent pool stratification.</td><td colspan="2">1. Minimum baseflows: contribute to flows to maintain connectivity during extreme dry conditions to provide native fish refuge if regulated flows cease</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Small freshes: small fresh 1 >500 ML/day anytime (ideally Oct–April); small fresh 2 >500–6 000 ML/day for at least 14 days at Baroona in Sept–April (Sept–Dec for Murray cod spawning); and conditioning flow in winter (July to mid-August).</td><td colspan="4">2. Native fish maintenance flow: contribute to flows (baseflows and freshes) in the mid-Macquarie River for the maintenance and conditioning of native fish (flow generalists and in-channel specialists) (July to mid-August)*</td><td></td></tr>
<tr><td colspan="4">3. Native fish flow (flow generalists + in-channel specialists): contribute to river flows (baseflows and freshes) in the mid-Macquarie River to provide habitat for native fish (all guilds) and to provide spawning opportunities for flow generalists and in-channel specialists (spring)*</td><td></td></tr>
<tr><td>Priming flow: >5 000 ML total flows at Baroona over 3 days with approx. 7 day recession (tributary pulse).
Spawning pulse: initial peak ≥ 5 000 ML/day at Baroona for >2 days with event lasting for >7 days. (35–40 day total pulse)
Dispersal flow: Initial pulse >3 000 ML total flows over 3 days at Baroona.</td><td></td><td></td><td>4. Native fish flow (flow specialists): contribute to river flows (freshes) in the mid-Macquarie River to support native fish populations (flow specialists), including movement, reproduction and recruitment*</td><td></td><td></td></tr>
</table>

<table>
<tr><th rowspan="2">Broad Asset</th><th rowspan="2">Indicative demand</th><th colspan="5">Applicable level(s) of resource availability</th></tr>
<tr><th>Very Low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very High</th></tr>
<tr><td></td><td>Second pulse min. 2 000 ML/day peak with recession. Approx. 10d duration total events.
(Oct–March)
Water temperature for all pulses ≥19 ◦C.</td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td>Large freshes and bankfull: 10 000–20 000 ML/day at Baroona for a minimum of 3 days (to drown out key weirs).</td><td></td><td></td><td></td><td colspan="2">5. Native fish passage flow: contribute to river flows (freshes) in the mid-Macquarie River to drown key weirs and provide movement, spawning and recruitment opportunities for flow specialists and generalists*</td></tr>
<tr><td rowspan="2">Macquarie Marshes</td><td rowspan="2">Flows between 30 and 700 GL at Marebone over three–five months between June and April
(wetland inundation action scalable depending on water resource availability scenario and target extent)</td><td colspan="5">6. Wetland inundation: contribute to flows to the Macquarie Marshes to inundate wetland vegetation and provide habitat and recruitment opportunities for waterbirds, fish and frogs</td></tr>
<tr><td></td><td></td><td colspan="3">7. Waterbird breeding contingency: contribute to flows to the Macquarie Marshes to maintain inundation in key waterbird reproduction areas to support a naturally triggered breeding event</td></tr>
<tr><td rowspan="2">Lower Macquarie River</td><td>Small in-channel flows
Minimum 20 ML/day at Bells Bridge for 45 days.</td><td></td><td colspan="2">8. Lower Macquarie small in-channel flows: contribute to flows to provide connectivity to the lower Macquarie River and through to the Barwon-Darling, maintain aquatic ecosystems, and provide opportunities for native fish*#</td><td></td><td></td></tr>
<tr><td>System connectivity between Macquarie and Barwon catchments: minimum 140 ML/day at Bells Bridge (minimum depth of 50 cm) to</td><td></td><td></td><td colspan="3">9. Native fish system connection flow: contribute to river flows in the lower Macquarie River system to provide connection with the Barwon River, allowing opportunities for the movement of native fish*#</td></tr>
</table>

Broad Asset	Indicative demand	Applicable level(s) of resource availability				
		Very Low	Low	Moderate	High	Very High
	connect the lower Macquarie and Barwon rivers for a minimum of 28 days					
	15–30 GL at Bells Bridge to inundate floodplain and lower reach of Macquarie River				*10. Lower Macquarie floodplain inundation:* contribute to flows to inundate floodplain and the lower reach of the lower Macquarie River through to the Barwon-Darling, provide connectivity, and support floodplain vegetation*	
Distributary creeks	Baseflows and freshes targeting fish, vegetation and connectivity with the Barwon River			*11. Restoring natural flow variability:* contribute to flows (baseflows and freshes) in Marra Creek and/or lower Crooked Creek to support hydrological connectivity, vegetation and native fish populations		
Prioritised critical refuge habitat	Baseflows to replenish significant refuge pools at high risk of drying down in exceptionally dry circumstances, to support native fish survival	*12. Maintaining critical fish refuge:* provide baseflows to prioritised refuge sites to maintain water quality and levels, and to support native fish survival in exceptionally dry conditions.				

Note: Under certain resource availabilities, options may not be pursued for a variety of reasons including that environmental demand may be met by unregulated flows and that constraints and/or risks may limit the ability the deliver environmental water.

* Could be coordinated with environmental water delivery to the Macquarie Marshes, depending on timing and/or volumes. Providing connectivity via Marthaguy Creek may be achieved by coordinating with water delivered to the Eastern Marshes.

Targeted connection to the Barwon may be subject to conditions such as fish spawning/recruitment in the Barwon, tributary inflows, water availability and protection of environmental water.

Potential watering actions – standard operating arrangements

Table 4 identifies the range of potential watering actions in the Macquarie River Valley in the Murray–Darling Basin that give effect to the long-term demands and flow regime identified as being in scope for the contribution of Commonwealth environmental water in any given year. The standard considerations associated with these actions are set out below.

Watering Action 1: Mid-Macquarie River minimum baseflows

Watering action: Contribute to flows to maintain connectivity during extreme dry conditions to provide native fish refuge if regulated flow releases from Burrendong Dam cease.

Standard operational considerations: Target flow rates would be dependent on conditions in the system, the volume of water available to be delivered and operational considerations.

Typical extent: This watering action would contribute flows to the mid-Macquarie River downstream of Burrendong Dam to Marebone.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action.

Watering Action 2: Native fish maintenance flow

Watering action: Contribute to flows (small freshes) in the mid-Macquarie River for the maintenance and conditioning of native fish (flow generalists and in-channel specialists) (July to mid-August).

Standard operational considerations:

- The flow limit for this action is 4 000 ML/day at Marebone Weir
- The timing of the flow is very important. Conditioning flows would ideally be delivered before mid-August to avoid favouring carp and providing a competitive advantage over native fish species. However, late winter pulses may be beneficial for movement of species such as Murray cod.
- This action could take advantage of in-stream flows by supplementing tributary flows and/or consumptive orders to create the desired flow increase and recession.
- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appropriate timing and volumes.
- All Macquarie River fishways are required to be open and functioning for this action.

Typical extent: This watering action would be targeted at contributing flows to the mid-Macquarie River downstream of Burrendong Dam, but would also provide flows into the Macquarie Marshes.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action.

Watering Action 3: Native fish flow (flow generalists and in-channel specialists)

Watering action: Contribute to river flows (small freshes) in the mid-Macquarie River to provide habitat for native fish (all guilds) and to provide spawning opportunities for flow generalists and in-channel specialists.

Standard operational considerations:

- The flow limit for this action is 4 000 ML/day at Marebone Weir (excluding supplementary water).

- This action would take advantage of in-stream flows by supplementing tributary flows and/or consumptive orders to create the desired flow increase and recession.

- All Macquarie River fishways are required to be open and functioning for this action.

- Commonwealth supplementary entitlements could contribute to meeting this demand.

- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appropriate timing and volumes.

- If a small to medium sized fresh is moving through Marthaguy Creek, environmental water could be directed down Gum Cowal and the Eastern Marshes to support connectivity (targeting 5–7 days of connection of at least 0.5 m depth, with the Gum Cowal regulator fully open to ensure fish passage). Flows in the unregulated Gum/Cowal and Marthaguy systems may be at risk of extraction.

- If Marthaguy Creek is not flowing, environmental water could be directed down the mainstem Macquarie River into the Macquarie Marshes to benefit and maintain other downstream assets. Flows in the unregulated lower Macquarie system may be at risk of extraction.

- All Macquarie River fishways are required to be open and functioning for this action.

Typical extent: This watering action would be targeted at contributing flows to the mid-Macquarie River downstream of Burrendong Dam, but would also provide flows into the Macquarie Marshes. Additional areas may be targeted in the Marshes and Marthaguy Creek depending on conditions to support connectivity.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action.

Watering Action 4: Native fish flow (flow specialists)

Watering action: Contribute to river flows (freshes) in the mid-Macquarie River to support native fish populations (flow specialists), including movement, reproduction and recruitment.

Standard operational considerations:

- The flow limit for this action is 4 000 ML/day at Marebone Weir (excluding supplementary water).

- Triggers are based on tributary inputs, flow rates at Baroona and water temperatures of at least 19 degrees celsius.

- Two pulses consisting of a priming flow and then a spawning pulse may be required. This action would take advantage of in-stream flows by supplementing tributary flows and other water in the system to create the desired flow pulses and recessions.

- This action may include a dispersal/recruitment flow consisting of an initial pulse from tributary flows meeting required triggers, followed by a second peak with an appropriate recession.

- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appropriate timing and volumes.

- All Macquarie River fishways are required to be open and functioning for this action.

- Commonwealth supplementary entitlements could contribute to meeting this demand by protecting some of the flow pulse.

Typical extent: This watering action would be targeted at contributing flows to the mid-Macquarie River downstream of Burrendong Dam, but would also provide flows into the Macquarie Marshes.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action.

Watering Action 5: Native fish passage flow

Watering action: Contribute to river flows (large freshes and bankfull) in the mid-Macquarie River to drown out key weirs and provide movement, spawning and recruitment opportunities for flow specialists and generalists.

Standard operational considerations:

- The flow limit for this action is 4 000 ML/day at Marebone Weir (excluding supplementary water).
- A total of 15 000 ML/day at Dubbo is required to drown out weirs on the Macquarie River at Dubbo and Narromine.
- This action would take advantage of in-stream flows by supplementing tributary flows and/or consumptive orders to create the desired flow increase and recession .
- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appropriate timing and volumes.
- All Macquarie River fishways are required to be open and functioning for this action.
- Commonwealth supplementary entitlements could contribute to meeting this demand.

Typical extent: This watering action would be targeted at contributing flows to the mid-Macquarie River downstream of Burrendong Dam, particularly at major weirs at Dubbo and Narromine to enable fish passage. The action would also provide flows into the Macquarie Marshes and possibly downstream to the lower Macquarie River.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action.

Watering Action 6: Wetland inundation

Watering action: Contribute to flows to the Macquarie Marshes to inundate wetland vegetation, and provide habitat and recruitment opportunities for waterbirds, fish and frogs.

Standard operational considerations:

- The flow limit for this action is 4 000 ML/day at Marebone Weir (excluding supplementary water).
- Commonwealth environmental water would be delivered via river flows from Burrendong Dam to Marebone Weir (accounting point), taking up to 11 days to reach the weir.
- Commonwealth supplementary entitlements could contribute to meeting this demand.
- Use of particular channels (e.g. Bulgeraga, Gum Cowal) will depend on assets and outcomes being targeted.
- All Macquarie River fishways are required to be open and functioning for this action.

Typical extent:

- Depending on water availability, specific areas of the Marshes system may be targeted (e.g. within the Northern, Southern and/or Eastern Marshes) rather than the entire inundation zone.

- The extent targeted varies across demands and water resource availability scenarios and will vary depending on delivery design and flow rates. Approximate inundation extents are provided below:
    - Contribute to inundating up to 9 000 ha of reed beds, lagoons and water couch in the Macquarie Marshes (30–60 GL: Very Low to Low scenario).
    - Contribute to inundating up to 19 000 ha of reeds, water couch, mixed marsh, river red gum forest and river cooba in the Macquarie Marshes (≥100 GL: Very Low to Moderate scenario).
    - Contribute to inundating up to 50 000 ha of river red gum woodland, mixed marsh and river cooba in the Macquarie Marshes (250 GL: Moderate to High scenario).
    - Contribute to inundating between 81 000 and 145 000 ha of outer river red gum forest, coolibah, myall and black box in the Macquarie Marshes (400–700 GL: Moderate to High scenario). These areas may be difficult to reach with environmental water alone.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action.

Watering Action 7: Waterbird breeding contingency

Watering action: Contribute to flows to the Macquarie Marshes to maintain inundation in key waterbird reproduction areas or foraging areas to support a naturally triggered breeding event.

Standard operational considerations:

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- Delivery of Commonwealth environmental water will be triggered by a shared recognition with NSW OEH and other key agencies that catchment conditions and short term future flows into the Marshes will be insufficient to maintain the conditions required to successfully complete a bird breeding event.
- Delivery of Commonwealth environmental water will be adaptively managed to maintain inundation at an appopriate depth and duration, and to avoid a rapid flow recession in known breeding areas.
- This action may not be operationalised if other flows (e.g. irrigation, unregulated, replenishment flows, flood mitigation zone releases) are deemed sufficient to support the breeding event to completion.
- Commonwealth environmental water would be delivered via rivers flows from Burrendong Dam to Marebone Weir (accounting point), taking up to 11 days to reach the weir.
- All fishways and regulators are required to be open and functioning for this action.

Typical extent: Key waterbird breeding sites across the Macquarie Marshes. Specific sites will depend on where the waterbird breeding event takes place at that time.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action. In particular, to determine whether environmental water can be delivered to the precise location of the bird breeding event.

Watering Action 8: Lower Macquarie River small in-channel flows

Watering action: Contribute to small flows to provide connectivity to the lower Macquarie River and Barwon-Darling, maintain aquatic ecosystems and riparian vegetation, and provide opportunities for native fish. This action would help support floodplain vegetation along the lower Macquarie River during periods of higher resource availability.

Standard operational considerations:

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- Target flow rates would be dependent on conditions in the system, the volume of water available to be delivered and operational considerations.
- This action could be coordinated with environmental water delivery to the Macquarie Marshes or other flows, depending on appropriate timing and volumes.
- Flows in the unregulated lower Macquarie system may be at risk of extraction.
- All Macquarie River fishways are required to be open and functioning for this action.

Typical extent: This watering action would be targeted at contributing to flows to the lower Macquarie River downstream of the Macquarie Marshes and the Barwon-Darling. It is expected that this action would provide connectivity to the Barwon-Darling system. This action would provide additional benefits to the mid-Macquarie River and Marshes en route to the lower Macquarie.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action. This action may require close collaboration with relevant landholders. Environmental flow protection mechanisms would require consultation with WaterNSW and NSW DOI.

Watering Action 9: Native fish system connection flow

Watering action: Contribute to river flows in the lower Macquarie River system to provide connection with the Barwon River, allowing opportunities for the movement of native fish. The action would also provide secondary benefits to the mid-Macquarie and Macquarie Marshes.

System connectivity flows to the Barwon River may be opportunisitic and subject to the following considerations:

- Potential for a fresh flow in the Barwon River of flows greater than 1 000 ML/day upstream of the confluence with the Macquarie River (contributed from any water source).
- Coordination of travel times between the Barwon and Macquarie flow pulses.
- Would ideally build on tributary pulses in the Macquarie to increase productivity and provide cues from the catchment, however, this is not critical.
- Lack of barriers for fish movement in the lower Macquarie River.
- Ideally, Brewarrina fishway should be open (flow trigger for opening is 120 ML/day and rising at Geera, and 75 ML/day and rising at Boorooma on the Barwon River).
- All Macquarie River fishways are required to be open and functioning for this action.
- Flows should be delivered down routes with the fewest fish barriers to maximise the environmental outcomes. The use of Bulgeraga Creek should be limited until fish passage is addressed at the dropbox regulator at the Gum Cowal bifurcation. The Northern Bypass Channel should be used only to prime the system quickly if flows need to catch up through the Northern Marshes.
- Flows would need to be delivered at a rate that does not cause high flow velocities at the Miralwyn pipe culverts, to a depth of at least 0.5 m. Connection with the Barwon River would be targeted for a minimum of 28 days at a minimum flow of 140 ML/day.
- Flows in the unregulated systems (e.g. Lower Macquarie, Gum Cowal/Marthaguy) may be at risk of extraction.

- Water availability and antecedent conditions in the Macquarie River system. The action may be more likely to occur during wetter conditions or when larger actions have been undertaken beforehand. Providing connection to the Barwon at a minimum depth of 0.5 m for a minimum of 28 days is unlikely to be feasible during periods of low water availability and dry conditions.

Typical extent: This watering action would be targeted at contributing flows to the lower Macquarie River downstream of the Macquarie Marshes, with benefits provided to the whole Macquarie River downstream of Burrendong Dam, and the Macquarie Marshes. If water is being provided to the Eastern Marshes it may also be possible to deliver additional water to the lower Macquarie River via Marthaguy Creek. Depending on water availability, this action would also provide flows to the Barwon-Darling system.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action. The flow would need to be protected in the unregulated systems, which would require consultation with WaterNSW and NSW DOI.

Watering Action 10: Lower Macquarie floodplain inundation

Watering action: Contribute to flows to inundate floodplain and the lower reach of the lower Macquarie River through to the Barwon-Darling, provide connectivity, and support floodplain vegetation.

Standard operational considerations:

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- Target flow rates would be dependent on conditions in the system, the volume of water available to be delivered and operational considerations. These areas may be difficult to target with environmental water alone.
- This action could be coordinated with environmental water deliveries to the Macquarie Marshes or other flows, depending on appropriate timing and volumes.
- Flows above 50 ML/day at Carinda may be at risk of extraction, so consideration is required as to how environmental water would be protected to the end of system.
- All Macquarie River fishways are required to be open and functioning for this action.
- Risk of third party impacts would need to be considered.

Typical extent: This watering action would be targeted at contributing to flows to the lower Macquarie River and floodplain downstream of the Macquarie Marshes. It is expected that this action would provide connectivity to the Barwon-Darling system. This action would provide additional benefits to the mid-Macquarie River and Marshes en route to the lower Macquarie.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action. This action would also require close collaboration with relevant landholders to manage any potential third party impacts. The flow would need to be protected in the lower Macquarie, which would require consultation with WaterNSW and NSW DOI.

Watering Action 11: Restoring natural flow variability

Watering action: Contribute to flows (baseflows and freshes) in Marra Creek and/or lower Crooked Creek to support hydrological connectivity, vegetation and native fish populations.

Standard operational considerations:

- Target flow rates will be dependent on prevailing flow conditions, target assets and operational considerations.

- Commonwealth environmental water would be delivered as in-stream flows, which are gravity fed from Burrendong Dam and diverted from the Macquarie River channel into the distributary creeks system.

- Commonwealth environmental water could be provided to the distributary creeks using either General Security or Supplementary entitlements, depending on conditions and water availability. Flows may be provided in addition to replenishment or unregulated flows, depending on conditions.

- Delivery to the lower Crooked Creek is constrained by the capacity of the Crooked Creek channel, regulator and Mumblebone Weir.

- Commonwealth Supplementary entitlements could contribute to meeting this demand.

Typical extent: The likely target of this action would be the unregulated parts of the distributary creeks system such as Marra Creek and the lower Crooked Creek. Flows may also contribute to achieving connectivity with the Bogan River and/or Barwon-Darling. Other distributary creeks such as Duck and Gunningbar creeks are not likely to be targeted for the delivery of Commonwealth environmental water. Further investigation and consultation regarding the regulated distributary creeks may be undertaken in the future.

Approvals: Close collaboration with landholders in the distributary creeks system would be required to deliver environmental water to the system. Consultation with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) would be required before implementing this action.

Watering action 12: Maintaining prioritised critical fish refuge

Watering action: under exceptional circumstances, provide baseflows to prioritised refuge sites to maintain water quality and levels, and to support native fish survival, in exceptionally dry conditions.

Standard operational considerations:

- Target flow rates and volumes required will be dependent on antecedent conditions, the sites targeted for watering, and operational considerations.

- Depending on the locations targeted, Commonwealth environmental water may be delivered as in-stream flows, through irrigation or town water supply channels, and/or via pumping.

- Commonwealth environmental water could be provided to key refuge habitat sites using General Security entitlements, depending on conditions and water availability. The availability and deliverability of allocations may affect the capacity to meet requirements in some circumstances.

- Specific operational requirements for different sites may need to be investigated and agreed in consultation with relevant stakeholders before water delivery commences. Agreements for the delivery of environmental water may be developed by NSW OEH, for example with landholders, local council, and/or irrigation schemes.

Typical extent: The extent of watering for native fish refuge would depend on which sites are targeted. Priority sites may be identified by local community members during dry conditions. Further investigation regarding critical refuge habitats in the Macquarie River Valley may be undertaken in the future.

Approvals: Consult with NSW agencies (WaterNSW, NSW OEH and NSW DPI – Fisheries) before implementing this action. This action would also require close collaboration with other relevant parties, including landholders, irrigation system operators, local councils etc, to manage the delivery of environmental water.

Attachment C – Long-term water availability

Commonwealth environmental water holdings

The Commonwealth holds the following entitlements in the Macquarie River Valley:

- General Security
- Supplementary

The full list of Commonwealth environmental water holdings can be found at www.environment.gov.au/topics/water/commonwealth-environmental-water-office/about-commonwealth-environmental-water/how-much and is updated monthly.

Other sources of environmental water

Other potential sources of held environmental water that may be used to complement Commonwealth environmental water delivery in the Macquarie River Valley include:

- General Security (NSW Office of Environment and Heritage)
- Supplementary (NSW of Environment and Heritage)

Planned environmental water

In addition to water entitlements held by environmental water holders, environmental demands may also be met via water provided for the environment under rules in state water plans (referred to as 'planned environmental water').

There are many sources of Planned Environmental water in the catchment including:

1) a 160 GL General Security Allowance ('Environmental Water Allowance' – EWA) that is partly active and partly translucent, explicitly targeted in the Water Sharing Plan to the Macquarie Marshes.

2) other protected flow components, such as triggers on supplementary event declarations and the 'first 500 ML/day rule' for translucent releases under the EWA.

3) a translucent allocation of 10 GL is stored in the Windamere Dam for the Cudgegong system, available only when dam inflow triggers are reached and dam storage levels are above a minimum level.

4) a variety of other non-extracted water that is not easily accounted for, including surplus flows, tributary flows, rainfall irrigation rejections, local rainfall effects, conveyance water and base flows.