Australian Government

Commonwealth Environmental Water Office

Integrated planning for the use, carryover and trade of Commonwealth environmental water

# Macquarie River Valley

2015–16

Front cover image credit: Burra wetland, Macquarie Marshes Ramsar Site
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Back cover image credit: Buff-banded Rail in the Monkeygar wetland, Macquarie Marshes
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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.

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# Commonwealth environmental water portfolio management planning

## Purpose of the document

This document consists of two parts. Part I sets out the Commonwealth Environmental Water Office's (the Office) portfolio management planning for the 2015–16 water year and for the following two years. While focussed on the Macquarie River Valley, the identified use, carryover and trading intentions have been considered together with those for other catchments in a Murray-Darling Basin-wide analysis.

Part II of this document establishes the context for how the Office integrates management of the Commonwealth environmental water portfolio in the Macquarie River Valley and across the Murray-Darling Basin more broadly. It sets out the environmental demands that Commonwealth environmental water may contribute to in the Macquarie River Valley, as well as the long-term supply profile for Commonwealth environmental water. Part II also explains how these two factors are considered together to inform an overall purpose for portfolio management, as well as the most appropriate mix of portfolio management options to maximise the benefits that can be achieved across multiple years.

## Purpose of portfolio management planning

Efficient and effective management of the Commonwealth environmental water holdings requires the utilisation of all portfolio management options (use, carryover and trade). To support improved outcomes from water use over time, carryover provides the opportunity to optimise water use across water years and to improve water availability early in a water year, while trade provides further capacity to optimise use over the long-term as well as across catchments.

Through multi-year integrated planning, portfolio management tools such as use, carryover and trade can be strategically managed for maximising environmental outcomes. Integrated portfolio management planning will also support the Office in:

- meeting Basin Plan obligations and contributing to the long-term objectives of the environmental watering plan, the expected outcomes in the Basin-wide environmental watering strategy and Basin annual environmental watering priorities
- managing the Commonwealth environmental water portfolio in response to the demands identified by Basin States in long-term environmental watering plans, once available
- applying adaptive management (including the setting of objectives, evaluating outcomes and informing future decision-making)
- providing increased transparency in relation to the Commonwealth Environmental Water Holder's portfolio management (use, trade and carryover) behaviour
- coordinating water use with delivery partners, including developing long-term delivery arrangements.

## Scope of integrated portfolio management planning

The following portfolio management options have been determined to be in scope for integrated planning by the Office:

- use
- carryover
- trade of allocations including:
    - transfer of allocations between connected catchments
    - sale of allocations
    - purchase of allocations.

The Office's portfolio management planning seeks to consider long-term demands (i.e. flow regimes) and supply, covering at least the preceding three years and out to three years.

# Part I: Portfolio management planning in the Macquarie River Valley

# 1. Purpose and portfolio management for 2015–16

## 1.1. Overall purpose

Demand for environmental water

Hot and dry conditions have prevailed in the Macquarie catchment since spring 2012, with average to very much below average rainfall and above average to very much above average maximum temperatures across the region. These warmer and drier conditions have slowed the recovery of wetland vegetation that showed improvements during wetter conditions between 2010 and 2012, and has resulted in significant drying of the floodplains. A combination of NSW and Commonwealth environmental water has been delivered to the Macquarie River and Macquarie Marshes during these drier years, which has helped to support the inundation of core wetland areas. However, with reduced resource availability the environmental demands for water remain high.

Environmental water demands for environmental assets in the Macquarie catchment in 2015–16 are represented in Table 2 and are summarised below:

***Mid-Macquarie River (*Burrendong – Marebone Weir*):*** Low–High demand. Environmental demands in the mid-Macquarie River for 2015–16 vary in magnitude of flows required. The demand requiring water most urgently in 2015–16 is for small flows to maintain refugia for native fish and provide spawning opportunities for flow generalists. Flows of this type are required annually.

***Lower Macquarie River* (Marshes – Barwon River):** Moderate-High demand. With increasingly dry conditions over the past three years, there has been a reduction in connectivity between the Macquarie Marshes and the lower Macquarie River and the Barwon-Darling system. While there is uncertainty about the required frequency of flows and connectivity in the lower Macquarie, small flow events in2013 and 2014 have led to partial connectivity with the Barwon River, however, there have not been significant flows since early 2012. If adequate connectivity is not achieved in 2015–16, it is expected that the urgency for meeting this demand will increase to high in 2016–17.

***Macquarie Marshes (reed beds, lagoons, water couch)*:** High demand. Some species such as water couch were showing signs of improvement in 2013, but have not recovered to previously observed conditions and are being replaced by other species in some parts of the Marshes. Reeds are not recovering well. Wetting is required to sustain these communities, particularly in areas that were not inundated in 2014–15.

***Macquarie Marshes (reeds, water couch, mixed marsh, river red gum forest, river cooba)*:** High demand. With conditions continuing to dry since 2012–13, some areas have not been adequately watered, particularly in the North Marsh. Some species have maximum dry intervals of two to three years, so wetting is required to sustain these communities and prevent further loss.

***Macquarie Marshes (river red gum woodland, mixed marsh, river cooba)*:** Moderate demand. Some species such as river red gum woodland are not recovering well in parts of the Marshes, particularly in the South Marsh. These areas have not been inundated since 2012–13. River red gum woodlands in the North Marsh are showing signs of stress. Some vegetation species require water every three to four years and will require wetting in the next one to two years to maintain condition.

***Macquarie Marshes (outer river red gum forest, coolabah, myall)*:** Low-Moderate demand. These areas have not been sufficiently inundated since 2010–11, with only minor wetting in 2011–12 and 2012–13. There has been a decline in river red gum trees further away from watercourses. Some species require water every four to five years and will require wetting in the next one to two years to maintain condition.

***Effluent creeks*:** Low–High demand. Demands in the effluent creeks system are considered to only have been partially met over the last two years for some effluent creeks. Dry conditions and low water

availability has made it difficult to provide environmental water to these assets. Small to medium flows may be required in the next one to two years to effluent creeks such as Marra Creek to provide benefits for native fish and vegetation, and to provide connectivity with the Barwon-Darling system. Effluent creeks such as Gunningbar Creek and the regulated part of Crooked Creek have a lower demand for water as they are more continuously wet due to regulated water delivery and may require drying periods.

Supply

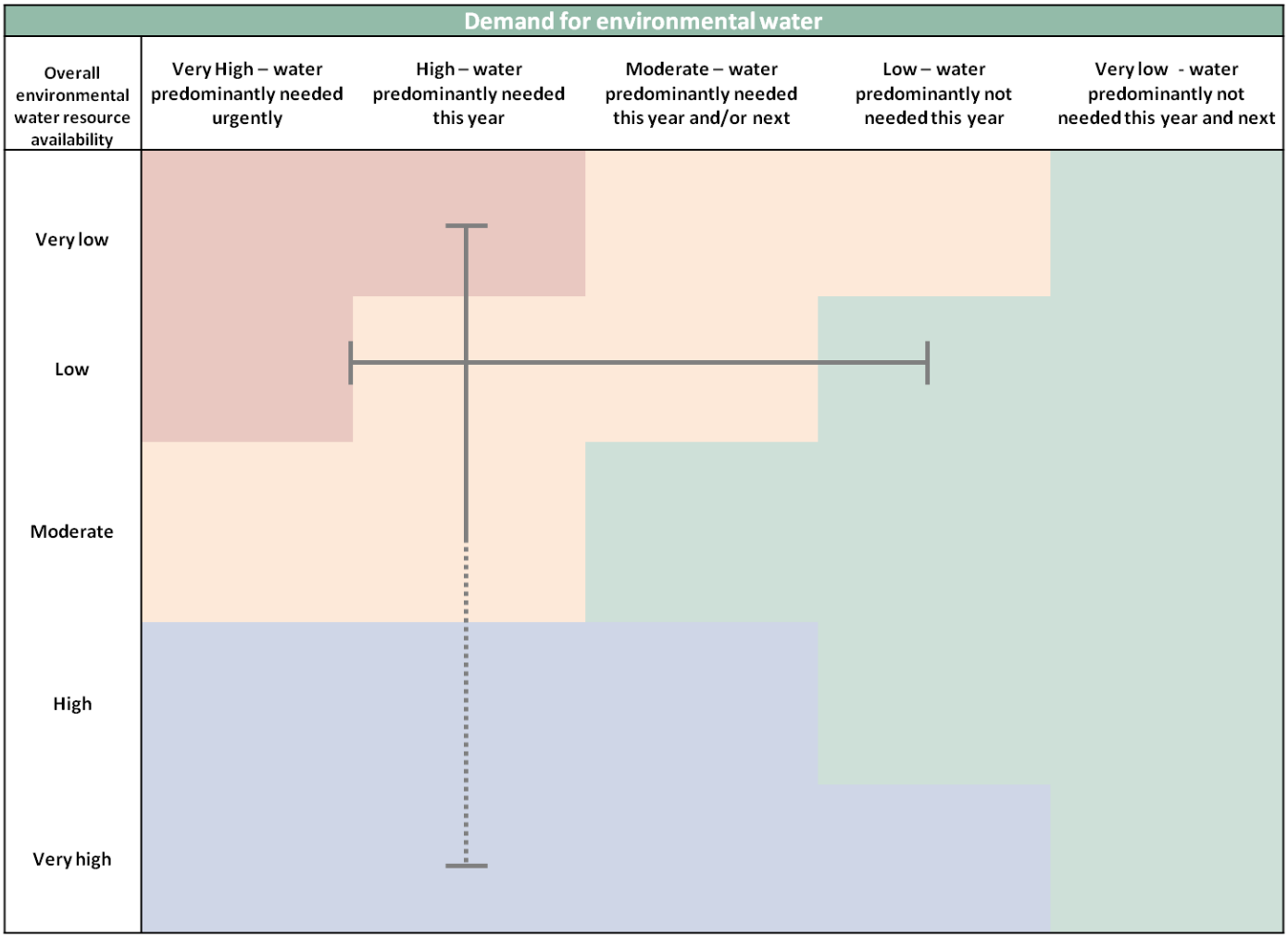
Water resource availability (supply) in the context of meeting environmental demands is made up of allocations against entitlements held for the environment by the Commonwealth Environmental Water Holder and New South Wales Office of Environment and Heritage, as well as natural and unregulated flows, and planned environmental water provisions. Further detail is provided in Part II, Section 4.

Considering the relatively small carryover of Commonwealth environmental allocations from 2014–15 to 2015–16 and the range of potential opening allocations for 2015–16, along with the full range of potential stream flows, all resource availability scenarios from very low to high are potentially in scope for 2015–16 (with moderate to high resource availability only possible if conditions become wet).

This resource availability scenario takes into account the significant storage deficit in the Macquarie River Valley that is required be made up to meet essential needs prior to any new allocation announcements being made. As at May 2015 this storage deficit was 40 gigalitres but this volume is subject to review by the NSW Office of Water as conditions change. As at May 2015, Windamere and Burrendong dams were at 43.4 per cent and 13.6 per cent of capacity respectively. The last General Security water allocation announcement in the Macquarie River Valley was a two per cent allocation made in August 2014.

Purpose

Figure 1 shows how these two factors are considered together. The overall 'purpose' for managing the Commonwealth's water portfolio in the Macquarie River Valley for 2015–16 is to **avoid damage** and **protect** core areas of the Macquarie Marshes, and assets in the Macquarie River and effluent creeks, to ensure ecological capacity for recovery. If water availability becomes high to very high, there may be scope to **maintain** or **improve** the health and resilience of aquatic ecosystems in the Macquarie River Valley.




**Avoid damage:** Avoid damage to environmental assets

**Protect:** Ensure ecological capacity for recovery

**Maintain:** Maintain ecological health and resilience

**Improve:** Improve the health and resilience of aquatic ecosystems / Build future capacity to support ecological health and resilience

**Figure 1:** Determining a broad purpose for portfolio management in the Macquarie River Valley for 2015–16. Note: grey lines represent potential range in demand and resource availability

## 1.2. Water Use

Consistent with the demands and purpose described above, the Office is considering supplying environmental water to the following watering actions for 2015–16. Table 1 summarises which of these actions are relevant to which resource availability scenarios in 2015–16, with further detail and rationale established in Table 2, including implications for future years based on assumed use behavior for 2015–16. Table 1 also identifies the 2015–16 Basin annual environmental watering priorities (published by the Murray-Darling Basin Authority) that the various watering actions may contribute to meeting.

**Table 1:** Potential Commonwealth watering actions and applicable resource availability scenarios for the Macquarie River Valley in 2015–16

| **Watering action** | **2015–16 Basin annual environmental watering priority(s)** [1] | **Resource availability scenarios action is likely to be pursued under** | | |
|---|---|---|---|---|
| | | **Low – very low** | **Moderate** | **High – very high** |
| Mid-Macquarie River (baseflows and freshes) | • Basin-wide flow variability and longitudinal connectivity<br>• Basin-wide native fish habitat and movement<br>• Northern Basin fish refuges | Yes (limited freshes under low/very low availability) | Yes | Yes |
| Lower Macquarie River (connectivity) | • Basin-wide flow variability and longitudinal connectivity<br>• Basin-wide native fish habitat and movement<br>• Northern Basin fish refuges | No (although depending on watering in the Macquarie Marshes some connectivity may be achieved) | Yes | Yes |
| Macquarie Marshes (wetland inundation) | • Basin-wide flow variability and longitudinal connectivity<br>• Basin-wide in-stream and riparian vegetation<br>• Macquarie Marshes<br>• Basin-wide waterbird habitat and future population recovery<br>• Basin-wide native fish habitat and movement<br>• Northern Basin fish refuges | Yes | Yes | Yes |
| Effluent creeks (baseflows and freshes) | • Basin-wide flow variability and longitudinal connectivity<br>• Basin-wide native fish habitat and movement | No | Possible (unregulated creeks, such as Mara Creek) | Possible (Demand may be satisfied by unregulated flows) |

[1] For full details on the Basin annual environmental watering priorities refer to the MDBA website at http://www.mdba.gov.au/what-we-do/environmental-water/environmental-watering-priorities

**Mid-Macquarie River (baseflows and freshes)**

Summary: Contributing to baseflows and freshes to provide habitat for native fish (all guilds), provide spawning opportunities for flow generalists, and/or support the maintenance and conditioning of native fish populations.

Timing: Winter (July to mid-August – maintenance/conditioning flow), and/or spring (October to November) depending on the availability of water. Delivering flows between mid-August and October should be avoided to prevent increasing opportunities for carp breeding.

Operational considerations and feasibility:

- The low water availability in the Macquarie Valley storages may result in no or low increases in General Security allocations in the first quarter of the season, which may limit the capacity to contribute environmental water in the mid-Macquarie River. Flows in the mid-Macquarie River may only be feasible as part of an action to deliver environmental water to the Macquarie Marshes.
- Watering actions will preferably be in response to natural tributary flows and water temperatures to maximise benefits of native fish.
- Watering in July to mid-August may be more feasible than spring watering in 2015–16 should dry conditions continue.
- No variations from the standard operational considerations are expected (see actions 2 and 3 in Part II, Section 3.6).

**Macquarie Marshes (wetland inundation)**

Summary: Contributing to flows to the Macquarie Marshes to inundate semi-permanent wetland vegetation in the inundation zone covering up to 19 000 ha of reeds, water couch and mixed marsh, river red gum forest and river cooba. Flows are also expected to provide habitat and recruitment opportunities for waterbirds, fish and frogs.

Timing: July to November.

Operational considerations and feasibility:

- Low storage levels may result in no or low increases in General Security allocations early in the season, which may limit the capacity to contribute environmental water to the Macquarie Marshes in 2015–16.
- Under a very low to low resource availability scenario, not all of the inundation zone can be watered. Consequently, specific areas (e.g. 4 000 to 12 000 ha) of the Marshes within that inundation zone will be targeted for environmental watering in 2015–16. Those areas will be selected depending on how urgently it is considered that water is required to meet the needs of key semi-permanent vegetation.
- This action can be scaled depending on conditions and water availability to target different inundation zones/vegetation.
- No variations from the standard operational considerations are expected (see action 7 in Part II, Section 3.6).

**Lower Macquarie River (connectivity)**

Summary: Contributing to flows (freshes) to provide connectivity to the lower Macquarie River and through to the Barwon-Darling system (including possible connection via Marthaguy Creek), maintain aquatic ecosystems and riparian vegetation, and provide opportunities for native fish. The action would help support inner floodplain vegetation assets along the Lower Macquarie River during periods of higher water resource availability.

Timing: July to November.

Operational considerations and feasibility:

- Targeting flows to the lower Macquarie River in 2015–16 would likely need an increase in water resource availability. However, some connectivity may be achieved depending on the volumes and timing of water delivered to the Macquarie Marshes, and conditions in the system at the time.

- No variations from the standard operational considerations are expected (see action 6 in Part II, Section 3.6).

**Effluent creeks (baseflows and freshes)**

Summary: Contributing to small and medium sized flows (baseflows and freshes) in one or more of the effluent creeks, to support hydrological connectivity, vegetation and native fish populations.

Timing: Any time during the year, however, most likely to occur during winter and spring.

Operational considerations and feasibility:

- Targeting flows to the effluent creeks system in 2015–16 would not be considered under a very low or low water resource availability scenario, Water delivery under a moderate scenario may be considered, but only after an assessment of priorities and demands across the catchment, predominant conditions, and available water. Under a very high water resource availability scenario it would be considered that natural flows would meet environmental demands in these systems.

- Unregulated effluent creeks such as Marra Creek would be the most likely priority for delivery of environmental water.

- No variations from the standard operational considerations are expected (see action 9 in Part II, Section 3.6).

**Stakeholder feedback:**

The Macquarie-Cudgegong Environmental Flows Reference Group (EFRG) has recommended that environmental water delivery in 2015–16 should target the inundation of semi-permanent wetland vegetation (reeds, water couch, mixed marsh, river red gum forest and river cooba). The EFRG advised that the reed beds and fringing river red gums in the North Marsh have not been fully inundated since 2012–13, and some species require water one (1) in 1–2 years. Targeting these species and communities in the North Marsh would provide a number of benefits in the South Marsh as well.

Some stakeholders raised concerns about watering regulated effluent creeks, which receive more water under a regulated water regime than they would have in the absence of regulation and that these creeks require implementation of a more natural wetting/drying regime. The Office notes that the priority for environmental water would be in unregulated creeks, such as Marra Creek. However, this does not preclude environmental; water being used in other effluent creeks at times, depending on need.

Feedback will be sought on an ongoing basis as planning transitions to implementation phase (see Section 1.5).

## 1.3. Carryover

A moderate proportion of allocations available in 2014–15 were carried over to 2015–16. Given the low levels of holdings and the relatively high environmental demands in the Macquarie for 2015–16 a very low proportion of the Commonwealth's available allocations for 2015–16 are expected to be carried over to 2016–17. If water resource availability improves a low to moderate proportion of the Commonwealth's available allocations for 2015–16 may be carried over to support environmental demands in 2016–17. The level of available allocations to be carried over to 2017–18 will depend on resource availability and demand.

## 1.4. Trade

At this time there is no plan to buy or sell allocations in the Macquarie catchment in 2015–16. While supplementing supplies (through the purchase of regulated or supplementary allocation) may assist in meeting environmental demands, there is currently limited market opportunity for allocation purchase to be pursued. The moderate to high demands for environmental water that may extend to 2016–17 mean that the trade of allocations will be considered based on ongoing assessments of environmental demands within the Macquarie and across the Basin over the next two years (Table 2). The types of scenarios where the need to adjust the availability of Commonwealth allocations is most likely to arise in coming years include:

- If environmental demands have been met and it is determined that there is sufficient forecast allocation to meet future demands across the Macquarie catchment, the market will be assessed to determine if there are opportunities to sell surplus water and secure proceeds to improve the Commonwealth Environmental Water Holder's capacity to meet current or future environmental demands across the Murray Darling Basin

- If a Basin-scale analysis identifies urgent environmental demands within a particular catchment and allocation purchase provides an opportunity to meet those demands using proceeds from the sale of water in a catchment with less urgent demands

- If conditions were to become wet while environmental demands remain high, market conditions might provide a favourable opportunity to purchase allocations to assist in meeting demands and augmenting natural flows

Refer to the Commonwealth environmental water Trading Framework, which includes operating rules, procedures, and protocols, for further information.

## 1.5. Your input

The management of Commonwealth environmental water relies on considerable advice and assistance from local organisations, state governments and 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 Office via: ewater@environment.gov.au.

**Table 2a:** Environmental demands, potential watering in 2015–16 and outlook for coming years in the Macquarie River Valley – **VERY LOW / LOW WATER RESOURCE AVAILABILITY IN 2015–16**

| Environmental assets | *Physical and process assets* | Indicative demand (for all sources of water in the system) | Required frequency (maximum dry interval) | Watering history (from all sources of water) [6] | | | 2015–16 | | | Implications for future demands | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2012–13 (moderate) | 2013–14 (drying) | 2014–15 (dry) | Predominant urgency of environmental demand for water | Purpose under very low / low resource availability | Potential Commonwealth environmental water contribution? | Likely urgency of demand in 2016–17 if watering occurred as planned in 2015-16 | 2017–18 Range of likely demand: Met in 2016–17 / Not met in 2016–17 |
| **Mid-Macquarie River (Burrendong – Marebone Weir)** [1] | Fish refuge – all guilds<br>Fish spawning opportunity – flow generalists | Small flows up to 1 000 ML/day at Wellington between spring (October to November) and autumn; and/or conditioning/maintenance flow in winter (July to mid-August) | Annually | | | Met in spring but not winter | HIGH<br>Respond to natural tributary flows and water temperature.<br>Minimum baseflows required if releases from Burrendong cease in extreme dry | **Avoid damage** / Protect | Possible use subject to tributary flows and sufficient water availability to maintain refugia. | High | Moderate to High / High |
| | Flow specialists (golden and silver perch) | Medium flow of 6 000–7 000 ML/day at Wellington, during spring (October to November) | 1 in 3 years (ideally twice per year, but reinstate several events per decade) | Possibly | | | MODERATE<br>Respond to natural tributary flows and water temperature, and significant river rises that will cue movement and spawning of flow specialists. | Protect | Insufficient water under a very low or low water availability scenario unless delivery is coordinated with an unregulated event. | High | Low / Critical |
| | Fish<br>In stream + riparian vegetation | Large flow of 10 000–20 000 ML/day (to drown out weirs) | 1–2 in 10 years | | | | LOW<br>Based on flows at Dubbo, these flow volumes have been achieved on 5 occasions since March 2005. Barriers were drowned out for several days in 2011–12 and 2010–11 | Protect / Maintain | Insufficient water under a very low or low water availability scenario to contribute to this demand. unless delivery is coordinated with major unregulated event. | Low | Low / Low to Moderate |
| **Lower Macquarie River (Marshes – Barwon River)** [2] | Connectivity<br>Aquatic ecosystems<br>Riparian vegetation<br>Fish | Instream flows in the lower Macquarie River with connectivity to the Barwon-Darling (including possible connection via Marthaguy Creek) | Unknown | | Some connection | Very minor connection | MODERATE-HIGH<br>Limited connectivity achieved since 2012–13. However, there is a uncertainty around the frequency and volume required for connectivity | Protect | Insufficient water under a very low or low water availability scenario to contribute to this demand. | High | Low / High |
| **Macquarie Marshes** [3,4] **(Refer to Figure 2 for inundation map)** | Blue and Purple inundation zones (4 000 to 9 000 ha) | 30-60 GL at Marebone over 5 months between June and April to inundate reed beds (require water annually, but could survive if watered every 2 years), lagoons and water couch (requires water every 1–2 years) | Annually (2 years) | | | Met in South and East Marshes, but not North Marsh | HIGH<br>Antecedent conditions have increased requirement for water, with low rainfall and high evaporation. | **Avoid damage** / Protect | A lower volume would be required if only a specific area/s of the Marshes are targeted. | High (depending on whether demand met in all areas of the Marshes or not) | Moderate / Critical |
| | Pink inundation zone (19 ,000 ha) | 100 GL at Marebone over 5 months between June and April to inundate reeds, water couch, mixed marsh, river red gum forest, river cooba. Some species have maximum dry interval of 2–3 years. | 1 in 1–2 years (2–7 years) | | Mostly inundated | Minor inundation only | HIGH<br>Demand last met in 2012–13, with some areas not being watered adequately since, particularly in the northern parts of the Marshes. | **Avoid damage** / Protect | Will only be able to partially contribute to this demand under very low–low water resource availability.<br>A lower volume would be required if only targeting a specific area/s of the Marshes. | Moderate to High (depending on whether demand met in all areas of the Marshes or not) | Moderate / High to Critical |

| Environmental assets | *Physical and process assets* | Indicative demand (for <u>all sources of water</u> in the system) | Required frequency (maximum dry interval) | Watering history (from all sources of water) [6] | | | 2015–16 | | | Implications for future demands | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2012–13 (moderate) | 2013–14 (drying) | 2014–15 (dry) | Predominant urgency of environmental demand for water | Purpose under <u>very low</u> / <u>low</u> resource availability | Potential Commonwealth environmental water contribution? | Likely urgency of demand in 2016–17 if watering occurred as planned in 2015-16 | 2017–18 Range of likely demand: Met in 2016–17 / Not met in 2016–17 |
| | Red inundation zone (50 000 ha) | 250 GL at Marebone over 5 months between June and April to inundate river red gum woodland, mixed marsh, river cooba | 1 in 3–4 years (4–7 years) | | | | MODERATE<br>Last inundated in 2012–13. Will require water in 2016–17. | Protect | Insufficient water under a very low or low water availability scenario to contribute to this demand | High | Low / High to Critical |
| | 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 forest, coolabah, myall and black box | 1 in 4–8 years (4–20 years) | Minor inundation | | | LOW-MODERATE<br>Last inundated in 2010–11, with some minor inundation in some areas in 2011–12 and 2012–13. May require water in next 1–2 years | Protect | Insufficient water under a very low or low water availability scenario to contribute to this demand | Moderate | Very Low / High |
| **Effluent creeks** [5] | Fish<br>In channel and riparian vegetation<br>Connectivity | Baseflows and freshes targeting fish, vegetation and connectivity with the Barwon-Darling River.<br>Volumes required dependent on which creeks are targeted. | Required frequency unknown (1 in 1–3 years based on key vegetation) | | | | MODERATE-HIGH<br>Some effluent creeks, such as Marra Creek, may require baseflows and small freshes to increase resilience. | Protect | Insufficient water under a very low or low water availability scenario to contribute to this demand. | High for Marra Creek | Low |
| | | | | | | | LOW-MODERATE<br>for regulated effluent creeks. | | | Low to Moderate | High |
| | | | | | | | | **Carryover potential** | Low proportion of allocations carried into 2016–17. | Low to moderate proportion of allocations may be carried over to 2017–18, but will depend upon resource availability and demands. | Level of carryover will depend on environmental demands and resource availability. |
| | | | | | | | | **Trade potential** | High need to augment available allocations. Therefore should market conditions improve there is likely to be a desire to purchase allocation to assist in meeting high demands. Sale of allocations unlikely considering moderate and high demands and low availability of water to meet them. | High expected need to augment available allocations, therefore should market conditions improve there is likely to be a desire to purchase allocation or supplementary flow access to assist in meeting high demands. Sale of allocations unlikely considering a number of moderate and high demands expected. | Potential to trade will depend on environmental demands and resource availability. |

1. Sourced from information and advice provided by NSW DPI Fisheries (Sam Davis, pers. comm.)
2. Sourced from Barma Water Resources et al. (2011)
3. Sourced from advice from NSW Office of Environment and Heritage (Tim Hosking and Debbie Love, pers. comm.), and MDBA (2012)
4. Based on inundation zones as mapped by Thomas, R.F (in press).
5. Sourced from Torrible et al. (2011)
6. All watering history sourced from advice from NSW Office of Environment and Heritage (Tim Hosking and Debbie Love, pers. comm.) and data from the following gauges (Water NSW 2015):
   - 421090: Macquarie River at d/s Marebone Weir
   - 421040: Macquarie River d/s Burrendong Dam (in the absence of available data at Wellington)
   - 421001: Macquarie River at Dubbo
   - 421107: Marra Creek at Billybongbone Bridge
   - 421166: Gunningbar Creek at Fairview Dam
   - 421164: Duck Creek at Napali
   - 421012: Macquarie River at Carinda (Bells Bridge)

**Key - events in previous years**

- means demand was met, by Commonwealth environmental water or any other source
- means demand was partially met, by Commonwealth environmental water or any other source (may be used to indicate infrastructure assisted delivery)
- means water did not contribute to meeting demands.

Note that not all demands require water every year, drying phases are important for floodplains and temporary wetlands or streams

**Key - potential watering in 2015-16**

- means a high priority for Commonwealth environmental watering (subject to seasonal and operational considerations)
- means a secondary priority for Commonwealth environmental watering, or a partial contribution may be made
- means a low priority for Commonwealth environmental watering

**Key - urgency of environmental demands**

- means critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- means high demand for water i.e. needed in that particular year
- means moderate demand for water i.e. water needed that particular year and/or next
- means low demand for water i.e. water generally not needed that particular year
- means 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 specifc requirements that are more or less urgent within the flow regime

**Table 2b:** Environmental demands, potential for watering in 2015–16 and outlook for coming years in the Macquarie River Valley – **MODERATE WATER RESOURCE AVAILABILITY IN 2015–16**

| Environmental assets | *Physical and process assets* | Indicative demand (for all sources of water in the system) | Required frequency (maximum dry interval) | Watering history (from all sources of water) [6] | | | 2015–16 | | | Implications for future demands | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2012–13 (moderate) | 2013–14 (drying) | 2014–15 (dry) | Predominant urgency of environmental demand for water | Purpose under a moderate resource availability | Potential Commonwealth environmental water contribution? | Likely urgency of demand in 2016–17 if watering occurred as planned in 2015-16 | 2017–18 Range of likely demand: Met in 2016–17 / Not met in 2016–17 |
| **Mid-Macquarie River (Burrendong – Marebone Weir)** [1] | Fish refuge – all guilds<br>Fish spawning opportunity – flow generalists | Small flows up to 1 000 ML/day at Wellington between spring (October to November) and autumn; and/or conditioning/maintenance flow in winter (July to mid-August) | Annually | | | Met in spring but not winter | HIGH<br>Respond to natural tributary flows and water temperature.<br>Minimum baseflows required if releases from Burrendong cease in extreme dry | Protect | High potential for use subject to tributary flows and sufficient water availability to maintain refugia. | Moderate to High | Moderate to High / High |
| | Flow specialists (golden and silver perch) | Medium flow of 6 000–7 000 ML/day at Wellington, during spring (October to November) | 1 in 3 years (ideally twice per year, but reinstate several events per decade) | Possibly | | | MODERATE<br>Respond to natural tributary flows and water temperature, and significant river rises that will cue movement and spawning of flow specialists. | Maintain | Insufficient water under a very low or low water availability scenario unless delivery is coordinated with an unregulated event. | High | Low / Critical |
| | Fish<br>In stream + riparian vegetation | Large flow of 10 000–20 000 ML/day (to drown out weirs) | 1–2 in 10 years | | | | LOW<br>Based on flows at Dubbo, these flow volumes have been achieved on 5 occasions since March 2005. Barriers were drowned out for several days in 2011–12 and 2010–11 | Maintain | Insufficient water under a very low or low water availability scenario to contribute to this demand unless delivery is coordinated with major unregulated event. | Low | Low / Low to Moderate |
| **Lower Macquarie River (Marshes – Barwon River)** [2] | Connectivity<br>Aquatic ecosystems<br>Riparian vegetation<br>Fish | Instream flows in the lower Macquarie River with connectivity to the Barwon-Darling (including possible connection via Marthaguy Creek) | Unknown | | Some connection | Very minor connection | MODERATE<br>Limited connectivity achieved since 2012–13. However, there is a uncertainty around the frequency and volume required for connectivity | Protect | Possible use depending on water available, antecedent conditions and watering in the Macquarie Marshes. | Moderate | Low / High |
| **Macquarie Marshes** [3,4] **(Refer to Figure 2 for inundation map)** | Blue and Purple inundation zones (4 000 to 9 000 ha) | 30-60 GL at Marebone over 5 months between June and April to inundate reed beds (require water annually, but could survive if watered every 2 years), lagoons and water couch (requires water every 1–2 years) | Annually (2 years) | | | Met in South and East Marshes, but not North Marsh | HIGH<br>Antecedent conditions have increased requirement for water, with low rainfall and high evaporation. | Protect | A lower volume would be required if only a specific area/s of the Marshes are targeted. | High (depending on whether demand met in all areas of the Marshes or not) | Moderate / Critical |
| | Pink inundation zone (19 000 ha) | 100 GL at Marebone over 5 months between June and April to inundate reeds, water couch, mixed marsh, river red gum forest, river cooba. Some species have maximum dry interval of 2–3 years. | 1 in 1–2 years (2–7 years) | | Mostly inundated | Minor inundation only | HIGH<br>Demand last met in 2012–13, with some areas not being watered adequately since, particularly in the northern parts of the Marshes. | Protect | High potential for watering in 2015–16.<br>A lower volume would be required if only a specific area/s of the Marshes are targeted. | Moderate to High (depending on whether demand met in all areas of the Marshes or not) | Moderate / High to Critical |

| Environmental assets | *Physical and process assets* | Indicative demand (for <u>all sources of water</u> in the system) | Required frequency (maximum dry interval) | Watering history (from all sources of water) [6] | | | 2015–16 | | | Implications for future demands | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2012–13 (moderate) | 2013–14 (drying) | 2014–15 (dry) | Predominant urgency of environmental demand for water | Purpose under a <u>moderate</u> resource availability | Potential Commonwealth environmental water contribution? | Likely urgency of demand in 2016–17 if watering occurred as planned in 2015-16 | 2017–18 Range of likely demand: Met in 2016–17 / Not met in 2016–17 |
| | Red inundation zone (50 000 ha) | 250 GL at Marebone over 5 months between June and April to inundate river red gum woodland, mixed marsh, river cooba | 1 in 3–4 years (4–7 years) | | | | MODERATE<br>Last inundated in 2012–13. Will require water in 2016–17. | Protect | Insufficient water under a moderate water availability scenario to contribute to this demand | High | Met: Low<br>Not met: High to Critical |
| | Orange and green inundation zones (8 000 – 145 000 ha) | 400 to 700 GL at Marebone over 5 months between June and April to inundate outer river red gum forest, coolabah, myall and black box | 1 in 4–8 years (4–20 years) | Minor inundation | | | LOW-MODERATE<br>Last inundated in 2010–11, with some minor inundation in some areas in 2011–12 and 2012–13. May require water in next 1–2 years | Protect | Insufficient water under a moderate water availability scenario to contribute to this demand | Moderate | Met: Very Low<br>Not met: High |
| **Effluent creeks** [5] | Fish<br>In channel and riparian vegetation | Baseflows and freshes targeting fish, vegetation and connectivity with the Barwon-Darling River | Required frequency unknown (1 in 1–3 years based on key vegetation) | | | | MODERATE-HIGH<br>Some effluent creeks, such as Marra Creek, may require baseflows and small freshes to increase resilience.<br>LOW-MODERATE<br>for regulated effluent creeks. | Protect | Possible use, depending on water available and recent watering in the Macquarie Marshes.<br>Volumes required dependent on which creeks are targeted. | Moderate for Marra Creek<br>Low to Moderate | Met: Low<br>Not met: High |
| See references at Table 2a | | | | | | | | **Carryover potential** | Low to moderate proportion of allocations carried into 2016–17. | Low to moderate proportion of allocations may be carried over to 2017–18, but will depend upon resource availability and demands. | Level of carryover will depend on environmental demands and resource availability. |
| | | | | | | | | **Trade potential** | Moderate to high need to augment available allocations given recent dry conditions. Therefore should market conditions improve there is likely to be a desire to purchase allocation or supplementary flow access to assist in meeting high demands. Sale of allocations unlikely considering moderate and high demands. | Moderate to high expected need to augment available allocations, therefore should market conditions improve there is likely to be a desire to purchase allocation or supplementary flow access to assist in meeting high demands.. Sale of allocations unlikely considering a number of moderate and high demands expected. | Potential to trade will depend on environmental demands and resource availability. |

**Key - events in previous years**

- means demand was met, by Commonwealth environmental water or any other source
- means demand was partially met, by Commonwealth environmental water or any other source (may be used to indicate infrastructure assisted delivery)
- means water did not contribute to meeting demands.

Note that not all demands require water every year, drying phases are important for floodplains and temporary wetlands or streams

**Key - potential watering in 2015-16**

- means a high priority for Commonwealth environmental watering (subject to seasonal and operational considerations)
- means a secondary priority for Commonwealth environmental watering, or a partial contribution may be made
- means a low priority for Commonwealth environmental watering

**Key - urgency of environmental demands**

- means critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- means high demand for water i.e. needed in that particular year
- means moderate demand for water i.e. water needed that particular year and/or next
- means low demand for water i.e. water generally not needed that particular year
- means 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 specifc requirements that are more or less urgent within the flow regime

**Table 2c:** Environmental demands, potential watering in 2015–16 and outlook for coming years in the Macquarie River Valley – **HIGH WATER RESOURCE AVAILABILITY IN 2015–16**

| Environmental assets | *Physical and process assets* | Indicative demand (for all sources of water in the system) | Required frequency (maximum dry interval) | Watering history (from all sources of water) [6] | | | 2015–16 | | | Implications for future demands | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2012–13 (moderate) | 2013–14 (drying) | 2014–15 (dry) | Predominant urgency of environmental demand for water | Purpose under high / very high resource availability | Potential Commonwealth environmental water contribution? | Likely urgency of demand in 2016–17 if watering occurred as planned in 2015-16 | 2017–18 Range of likely demand: Met in 2016–17 / Not met in 2016–17 |
| **Mid-Macquarie River (Burrendong – Marebone Weir)** [1] | Fish refuge – all guilds<br>Fish spawning opportunity – flow generalists. | Small flows up to 1 000 ML/day at Wellington between spring (October to November) and autumn; and/or conditioning/maintenance flow in winter (July to mid-August) | Annually | | | Met in spring but not winter | HIGH<br>Respond to natural tributary flows and water temperature.<br>Minimum baseflows required if releases from Burrendong cease in extreme dry | Improve | Watering that contributes to the medium and large flow demands may also contribute to meeting this demand. | Moderate to High | Moderate to High / High |
| | Flow specialists (golden and silver perch) | Medium flow of 6 000–7 000 ML/day at Wellington, during spring (October to November) | 1 in 3 years<br>(ideally twice per year, but reinstate several events per decade) | Possibly | | | MODERATE<br>Respond to natural tributary flows and water temperature, and significant river rises that will cue movement and spawning of flow specialists. | Improve | Possible use depending on available water and other higher urgency demands having been met.<br>Subject to an unregulated event. | Low | Low / Moderate |
| | Fish<br>In stream + riparian vegetation | Large flow of 10 000–20 000 ML/day (to drown out weirs) | 1–2 in 10 years | | | | LOW<br>Based on flows at Dubbo, these flow volumes have been achieved on 5 occasions since March 2005. Barriers were drowned out for several days in 2011–12 and 2010–11 | Maintain / Improve | Possible use depending on available water.<br>Subject to a major unregulated event. | Low | Low / Low to Moderate |
| **Lower Macquarie River (Marshes – Barwon River)** [2] | Connectivity<br>Aquatic ecosystems<br>Riparian vegetation<br>Fish | Instream flows in the lower Macquarie River with connectivity to the Barwon-Darling (including possible connection via Marthaguy Creek) | Unknown | | Some connection | Very minor connection | MODERATE<br>Limited connectivity achieved since 2012–13. However, there is a uncertainty around the frequency and volume required for connectivity | Improve | Watering that contributes to demands in the Macquarie Marshes may contribute to meeting this demand. | Low | Low / Moderate |
| **Macquarie Marshes** [3,4] **(Refer to Figure 2 for inundation map)** | Blue and Purple inundation zones (4 000 to 9 000 ha) | 30-60 GL at Marebone over 5 months between June and April to inundate reed beds (require water annually, but could survive if watered every 2 years), lagoons and water couch (requires water every 1–2 years) | Annually<br>(2 years) | | | Met in South and East Marshes, but not North Marsh | HIGH<br>Antecedent conditions have increased requirement for water, with low rainfall and high evaporation. | Improve | High potential for watering in 2015–16. | Moderate | Moderate / High |
| | Pink inundation zone (19,000 ha) | 100 GL at Marebone over 5 months between June and April to inundate reeds, water couch, mixed marsh, river red gum forest, river cooba. Some species have maximum dry interval of 2–3 years. | 1 in 1–2 years<br>(2–7 years) | | Mostly inundated | Minor inundation only | HIGH<br>Demand last met in 2012–13, with some areas not being watered adequately since, particularly in the northern parts of the Marshes. | Improve | High potential for watering in 2015–16. | Moderate to High | Moderate / High to Critical |
| | Red inundation zone (50,000 ha) | 250 GL at Marebone over 5 months between June and April to inundate river red gum woodland, mixed marsh, river cooba | 1 in 3–4 years<br>(4–7 years) | | | | MODERATE<br>Last inundated in 2012–13. Will require water in 2016–17. | Improve | Possible use depending on available water and other higher urgency demands having been met. | Low | Low / Moderate |

| Environmental assets | *Physical and process assets* | Indicative demand (for <u>all sources of water</u> in the system) | Required frequency (maximum dry interval) | Watering history (from all sources of water) [6] | | | 2015–16 | | | Implications for future demands | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2012–13 (moderate) | 2013–14 (drying) | 2014–15 (dry) | Predominant urgency of environmental demand for water | Purpose <u>under high / very high</u> resource availability | Potential Commonwealth environmental water contribution? | Likely urgency of demand in 2016–17 if watering occurred as planned in 2015-16 | 2017–18 Range of likely demand: Met in 2016–17 / Not met in 2016–17 |
| | Orange and green inundation zones (81 000 – 145 000 ha) | 400–700 GL at Marebone over 5 months between June and April to inundate outer river red gum forest, coolabah, myall and black box | 1 in 4–8 years (4–20 years) | Minor inundation | | | LOW-MODERATE<br>Last inundated in 2010–11, with some minor inundation in some areas in 2011–12 and 2012–13. May require water in next 1–2 years | Improve | Possible use depending on available water and other higher urgency demands having been met.<br>May be provided on the tail of an unregulated flow depending on flow rates and duration of flows | Low | Very Low / Very Low |
| **Effluent creeks** [5] | Fish<br>In channel and riparian vegetation | Baseflows and freshes targeting fish, vegetation and hydrological connectivity. | Required frequency unknown<br>(1 in 1–3 years based on key vegetation) | | | | MODERATE-HIGH<br>Some effluent creeks, such as Marra Creek, may require baseflows and small freshes to increase resilience.<br>LOW<br>for regulated effluent creeks | Improve | Possible use depending on available water and other higher urgency demands having been met.<br>May be met by unregulated flow | Low | Low / Moderate |
| | | | | | | | | **Carryover potential** | Low to moderate proportion of allocations carried into 2016–17. | Low to moderate proportion of allocations may be carried over to 2017–18, but will depend upon resource availability and demands. | Level of carryover will depend on environmental demands and resource availability. |
| | | | | | | | | **Trade potential** | Moderate need to augment available allocations given recent dry conditions. Therefore should market conditions improve there is likely to be a desire to purchase allocation or supplementary flow access to assist in meeting high demands. Sale of allocations unlikely considering moderate and high demands. | Low expected need to augment available allocations, therefore limited requirement for allocation purchase. Sale of allocations may be considered, although there is expected to still be some demands with a moderate to high urgency requiring water. | Potential to trade will depend on environmental demands and resource availability. |

See references at Table 2a

**Key - events in previous years**

means demand was met, by Commonwealth environmental water or any other source

means demand was partially met, by Commonwealth environmental water or any other source (may be used to indicate infrastructure assisted delivery)

means water did not contribute to meeting demands.

Note that not all demands require water every year, drying phases are important for floodplains and temporary wetlands or streams

**Key - potential watering in 2015-16**

means a high priority for Commonwealth environmental watering (subject to seasonal and operational considerations)

means a secondary priority for Commonwealth environmental watering, or a partial contribution may be made

means a low priority for Commonwealth environmental watering

**Key - urgency of environmental demands**

means critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage

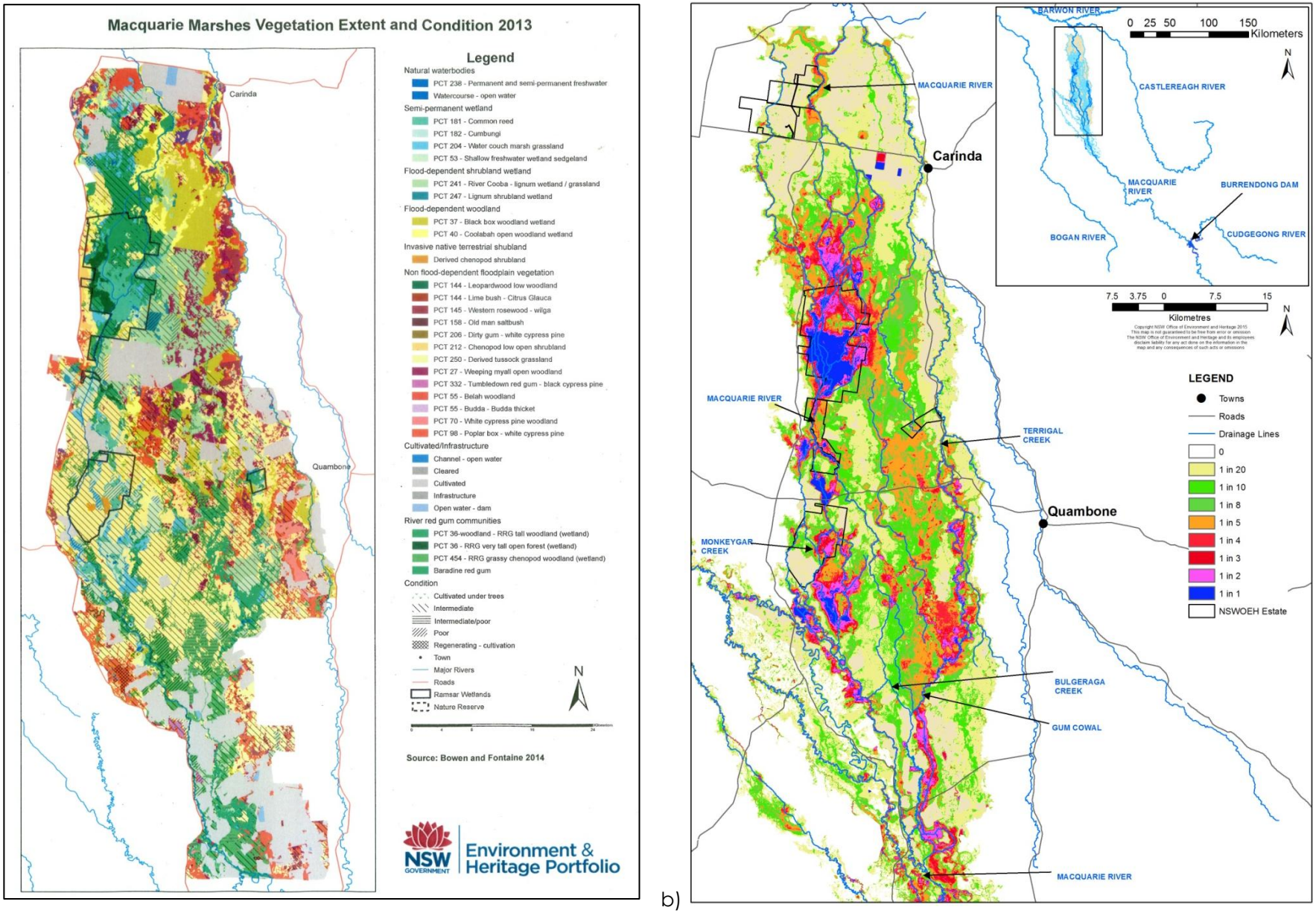
means high demand for water i.e. needed in that particular year

means moderate demand for water i.e. water needed that particular year and/or next

means low demand for water i.e. water generally not needed that particular year

means 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 specifc requirements that are more or less urgent within the flow regime




a) b)

**Figure 2:** a) Vegetation mapping of the Macquarie Marshes (Bowen and Fontane in press) and b) Inundation mapping of the Macquarie Marshes 1988-2008 (Thomas, R.F in press).)

# Part II: Commonwealth environmental water portfolio management planning

# 2. Background

## 2.1. Commonwealth environmental water

The Commonwealth Environmental Water Holder is an independent statutory position established by the *Water Act 2007* (the Water Act) to manage the Commonwealth environmental water holdings. The Commonwealth Environmental Water Holder leads and is supported by the Commonwealth Environmental Water Office (the Office), a division of the Australian Government Department of the Environment.

Under the Water Act, Commonwealth environmental water must be managed to protect or restore environmental assets, so as to give effect to relevant international agreements. The Water Act also requires that the Commonwealth Environmental Water Holder perform its functions and exercise its powers consistently with and in a manner that gives effect to the Basin Plan and that Commonwealth environmental water is managed in accordance with the Basin Plan's environmental watering plan.

## 2.2. 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 (NSW) followed by tributary flows from the Winburndale River, Turon River and Pyrmul Creek. The River then drains into Burrendong Dam, south east of Wellington (Figure 3). 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, 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.

Two major storages, Windamere Dam (capacity 368 GL) on the Cudgegong River and Burrendong Dam (storage capacity of 1 188 GL, with additional storage capacity of 489 GL in the flood mitigation zone) on the Macquarie River, 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 effluent creeks. Regulating structures are utilised to manage the diversion of water into distributary creeks at lower rates or overbank at high flow rates onto floodplains and wetlands.

The primary environmental asset in the catchment is the Macquarie Marshes complex on the lower reaches of the Macquarie River. 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 effluent creek system to the west of the Marshes.

The *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source (2003)* provides for planned environmental water and stock and domestic (replenishment) flows. Such releases offer opportunities to align Commonwealth environmental water deliveries to increase the potential for environmental objectives to be achieved and assist with delivery efficiency.

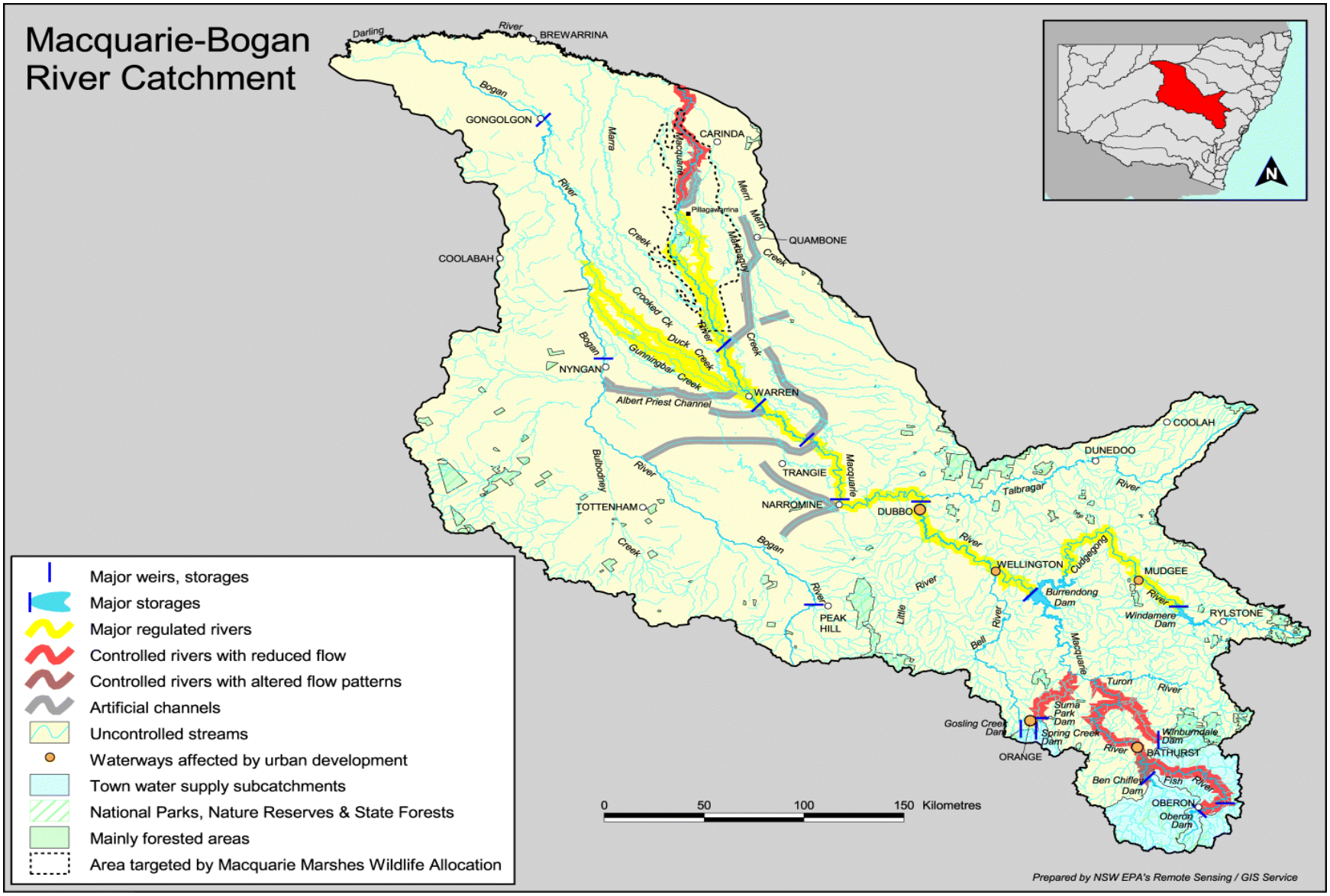



**Figure 3:** Map of the Macquarie River Valley (produced by the NSW Office of Environment and Heritage).

# 3. Long-term environmental water demands in the Macquarie River Valley

## 3.1. Basin-wide environmental watering strategy

The Murray-Darling Basin Authority has published the first Basin-wide environmental watering strategy (the Strategy, MDBA 2014). Building on Basin Plan's environmental objectives, the Strategy sets out the Authority's best assessment of the expected environmental outcomes over the next decade as a result of implementing the Basin Plan and associated water reforms. The Strategy focuses on four components: river flows and connectivity; vegetation; waterbirds; and native fish. The expected outcomes for each component are summarised below, with more specific quantified outcomes provided in Attachment A.

**River flows and connectivity:** Improve connections along rivers and between rivers and their floodplains

**Vegetation:** Maintain extent and improve the condition

**Waterbirds:** Maintain current species diversity, improve breeding success and numbers

**Native Fish:** Maintain current species diversity, extend distributions, improve breeding success and numbers

## 3.2. Long-term watering plans

State governments are developing long-term watering plans for each catchment in the Basin. These plans will identify:

- the priority environmental assets and ecosystem functions in the catchment
- the objectives and targets for these assets and functions
- their watering requirements.

In developing these plans, state governments will be consulting with environmental water holders and local communities.

Once developed, these plans will provide the key information on the long-term environmental water demands in the catchment and the Office's planning for the Macquarie River Valley will be reviewed so that this information can be incorporated.

Prior to the development of long-term watering plans, the 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.

Key documentation includes:

- Assessment of environmental water requirements for the proposed Basin Plan: Macquarie Marshes (MDBA 2012)
- Post flood assessment and determination of environmental water requirements for Gunningbar Creek, Lower Crooked Creek, Marra Creek and the lower Macquarie River (Torrible at al. 2011)
- Environmental water delivery: Macquarie River (prepared for the Commonwealth Environmental Water Office by Barma Water Resources et al. (2011) – unpublished)
- A range of scientific literature and on-ground knowledge (e.g. Roberts and Marston 2011; NSW Office of Environment and Heritage, NSW Department of Primary Industries – Fisheries, and Water NSW officers).

The below section represents the Office's summary of the long-term environmental water demands, based on these documents. The objectives and expected outcomes for water-

dependent ecosystems will continue to be revised and refined in response to best available knowledge, including drawing on the results of environmental watering monitoring programmes.

## 3.3. Expected outcomes in the Macquarie River Valley

The expected outcomes from environmental watering in the Macquarie River Valley are described below in Table 3 and how these contribute to Basin-wide outcomes. These outcomes will be refined and/or revised once the long-term watering plan for the catchment has been developed.

**Table 3:** Summary of long-term expected outcomes from environmental watering in the Macquarie River Valley

<table>
<tr><th>BASIN-WIDE OUTCOMES<br>(Outcomes in red link to the Basin-wide Environmental Watering Strategy)</th><th colspan="3">EXPECTED OUTCOMES FOR MACQUARIE ASSETS</th></tr>
<tr><th rowspan="2">ECOSYSTEMS</th><th>IN-CHANNEL ASSETS</th><th colspan="2">OFF-CHANNEL ASSETS</th></tr>
<tr><th>Macquarie River</th><th>Macquarie Marshes</th><th>Effluent creeks</th></tr>
<tr><td>VEGETATION</td><td>Maintain riparian and in-channel vegetation condition, growth and survival (extent)</td><td>Maintain, and in some cases improve, floodplain and wetland vegetation condition, growth and survival</td><td>Support the condition, growth and survival of riparian and in-channel vegetation</td></tr>
<tr><td>WATERBIRDS</td><td></td><td>Provide suitable habitat to increase waterbird abundance and reproduction, and maintain current species diversity</td><td></td></tr>
<tr><td>FISH</td><td colspan="2">Support opportunities for the movement and increased distribution, reproduction and recruitment of native fish</td><td>Support the movement and habitat requirements of native fish</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 frogs</td></tr>
<tr><td>CONNECTIVITY</td><td>Support longitudinal connectivity, in particular increase connectivity with the Barwon-Darling</td><td>Support connectivity, particularly lateral between the river and floodplain</td><td>Support connectivity, particularly with the lower Macquarie River and Barwon River</td></tr>
<tr><td>PROCESSES</td><td colspan="3">Support key ecosystem functions, and promote productivity, including on the floodplain</td></tr>
<tr><td>WATER QUALITY</td><td colspan="3">Maintain water quality within channels and pools</td></tr>
<tr><td>RESILIENCE</td><td colspan="3">Provide drought refuge habitat (particularly for fish)</td></tr>
</table>

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).

## 3.4. Flows in scope for Commonwealth environmental watering

Not all environmental demands can and will be met through the use of held environmental water. Some demands are met by regulated water deliveries for consumptive purposes, while others are met by large unregulated/natural flows events or are beyond what can be delivered within operational constraints. Figure 4 shows the broad environmental demands that are in scope for the Office to focus on contributing to in the Macquarie River Valley. 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 due to constraints. Also, there may be opportunities for Basin State governments to remove or modify constraints, which will improve the efficiency and/or effectiveness of environmental watering.

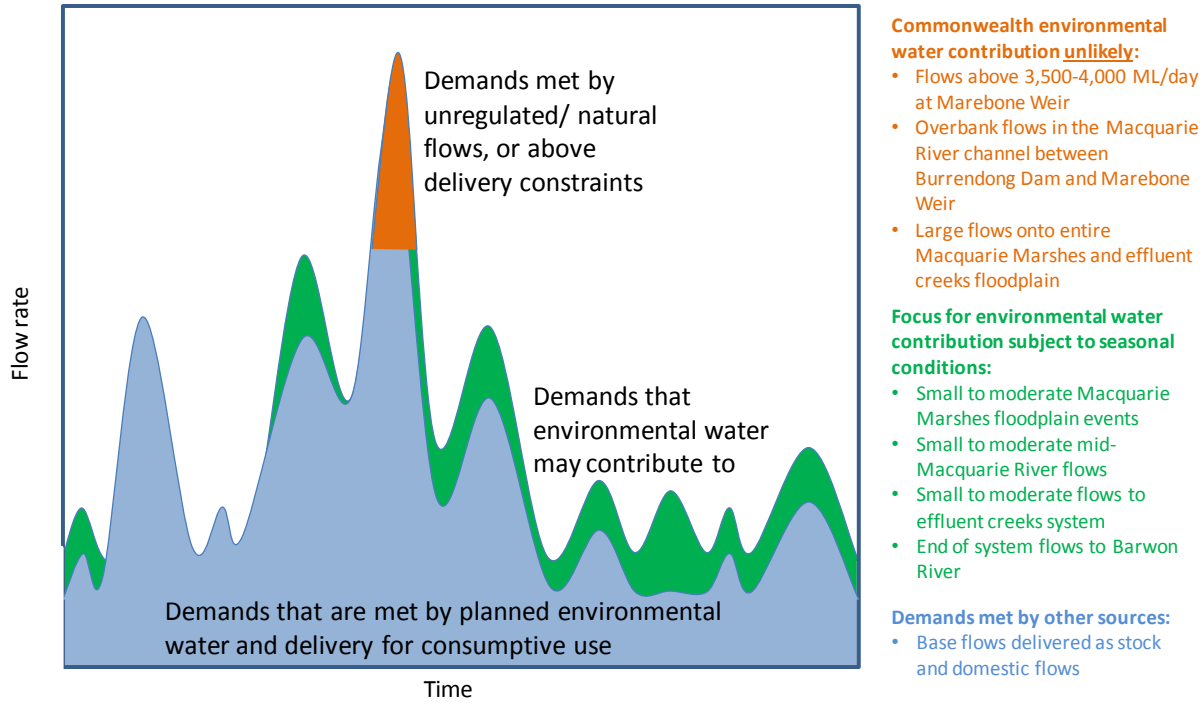



**Figure 4:** Scope of demands that environmental water may contribute to in the Macquarie River Valley.

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 and outlet capacity of 8 200 ML/day (Water NSW 2015)
- 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 Marshes.

Adaptive environmental water and discretionary planned environmental water, managed by the New South Wales Office of Environment and Heritage (NSW OEH), may also be used in order to undertake complementary environmental watering actions with Commonwealth environmental water.

Operational considerations such as delivery methods, opportunities, constraints and risks will differ depending on the inflow scenario and are summarised in Table 4. Throughout the year seasonal, operational and management considerations will be addressed as decisions are taken to make water available for use and as these decisions are implemented. This will include refining the ecological objectives, assessing operational feasibility and potential risks and the ongoing monitoring of the seasonal outlook and river conditions.

**Table 4:** Current constraints on environmental watering for the Macquarie River Valley

| Inflow scenario | Very low | Low | Moderate | High | Very high |
|---|---|---|---|---|---|
| **Constraints** | | | | | |
| Environmental water delivery is limited by high flows, which reduce channel capacity and limits the use of infrastructure and additional releases from storages. | | | | | |
| High irrigation demand may constrain environmental water delivery by limiting available channel capacity. | | | | | |
| Flow thresholds to avoid third party impacts, such as inundation of crossings, which restricts access to land. | | | | | |
| Release capacities of storages will constrain the magnitude of flow augmentation. | | | | | |
| Flow thresholds for existing river and floodplains works may constrain the delivery of environmental water, particularly targeted peak flow rates. | | | | | |
| The level of inundation possible throughout the Macquarie Marshes is constrained by in channel and floodplain structures. | | | | | |

Constraints as they relate to specific watering actions are described in the standard operating considerations listed in section 3.5 below.

Based on the above outcomes sought and delivery constraints, Table 5 identifies flows that are in scope for Commonwealth environmental watering. Some specific watering requirements (flow magnitude, duration, timing and frequency) have also been listed, drawn from existing resources. The watering requirements for the Macquarie River Valley will be developed in full by the state government as part of their long-term watering plan and will be reflected in future planning documents by the Commonwealth Environmental Water Office.

**Table 5:** Long-term indicative elements of a flow regime in scope for Commonwealth environmental watering in the Macquarie River Valley

| Asset/Function | Indicative demands / events | Frequency (Maximum dry interval) |
|---|---|---|
| Mid-Macquarie River<br>(native fish refuge, spawning opportunities for flow generalists and specialists) | Small flows up to 1 000 ML/day at Wellington between spring (Oct–Nov) and autumn; and/or winter (July to mid-August) | Annually |
| | Medium flow of 6 000–7 000 ML/day at Wellington during spring (Oct–Nov) | 1 in 3 years |
| | Large flows of 10 000–20 000 ML/day to drown out weirs | 1–2 in 10 years |
| Lower Macquarie River<br>(hydrological connectivity, aquatic ecosystems, riparian vegetation, fish) | Instream flows in the lower Macquarie River with connectivity to the Barwon-Darling (including possible connection via Marthaguy Creek) | Unknown |
| Macquarie Marshes<br>(inundate reed beds, lagoons and water couch) | 60 GL at Marebone over 5 months between June and April | Annually<br>(2 years) |
| Macquarie Marshes<br>(inundate reeds, water couch, mixed marsh, river red gum forest, river cooba) | 100 GL at Marebone over 5 months between June and April | 1 in 1–2 years<br>(2–7 years) |
| Macquarie Marshes<br>(inundate river red gum woodland, mixed marsh, river cooba) | 250 GL at Marebone over 5 months between June and April | 1 in 3–4 years<br>(4–7 years) |
| Macquarie Marshes<br>(inundate outer river red gum forest, coolabah, myall, black box) | 400–700 GL at Marebone over 5 months between June and April | 1 in 4–8 years<br>(4–20 years) |
| Effluent creeks<br>(Native fish, vegetation, hydrological connectivity) | Baseflows and freshes | Unknown |

Information sourced from Barma Water Resources et al. (2011), MDBA (2012), Torrible et al. (2011), NSW DPI Fisheries (pers. comm.), NSW OEH (pers. comm).

## 3.5. 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 6 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 6:** Summary of potential watering actions for the Macquarie River Valley

| Broad Asset | Indicative demand | Applicable level(s) of resource availability | | | | |
|---|---|---|---|---|---|---|
| | | **Very Low** | **Low** | **Moderate** | **High** | **Very High** |
| **Mid-Macquarie River** | **Small flows up to 1 000 ML/day at Wellington between spring (October to November) and autumn; and/or conditioning/ maintenance flow in winter (July to mid August** | *1. Minimum baseflows*: contribute to flows to maintain connectivity during extreme dry conditions to provide native fish refuge if regulated flows cease | | | | |
| | | *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) (July to mid-August)* | | | | |
| | | *3. Native fish flow (flow generalists)*: 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 (spring)* | | | | |
| | **Medium flow of 6 000–7 000 ML/day at Wellington, during spring (October to November)** | | | *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* | | |
| | **Large flow of 10 000–20 000 ML/day (to drown out weirs)** | | | | *5. Native fish passage flow*: contribute to river flows (freshes) in the mid-Macquarie River to drown weirs and provide spawning and movement opportunities for flow specialists and support recruitment of flow generalists and specialists * | |
| **Lower Macquarie River** | **Provide instream flows in the lower Macquarie River with connectivity to the Barwon-Darling (including possible connection via Marthaguy Creek)** | | 6. Contribute to flows (freshes) to provide connectivity to the lower Macquarie River and through to the Barwon-Darling, maintain aquatic ecosystems and riparian vegetation, and provide opportunities for native fish* | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Macquarie Marshes** | **Flows between 60 and 700 GL at Marebone over five months between June and April**<br>(wetland inundation action scalable depending on water resource availability scenario and target extent – see Section 3.6) | *7. Wetland inundation:* Contribute to flows to the Macquarie Marshes to inundate wetland vegetation and provide habitat and recruitment opportunities for waterbirds, fish and frogs | | | |
| | | | *8. 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 | | |
| **Effluent creeks** | **Baseflows and freshes targeting fish, vegetation and connectivity with the Barwon River** | | | 9. *Restoring natural flow variability:* Contribute to flows (baseflows and freshes) in one or more of the effluent creeks to support hydrological connectivity, vegetation and native fish populations | |

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 East Marsh.

## 3.6. Potential watering actions – standard operational considerations

Table 6 above identifies the range of potential watering actions in the Macquarie River Valley that give effect to the long-term demands and flow regime identified as being in scope for the Office to contribute environmental water to in any given year. The standard considerations associated with these actions are set out below.

**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 flows cease.

*Standard operational considerations:* Target flow rates would be dependent on conditions in the system, the voulme 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 downstream of Warren.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and Fisheries) before implementing this action.

**2. Native fish maintenance flow**

*Watering action:* Contribute to flows (baseflows and freshes) in the mid-Macquarie River for the maintenance and conditioning of native fish (flow generalists) (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. Flows should be delivered before mid-August to avoid favouring carp and providing a competitive advantage over native fish species
- 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 appopriate timing and volumes.

*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 (Water NSW, OEH and Fisheries) before implementing this action.

**3. Native fish flow (flow generalists)**

*Watering action:* 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.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir
- 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 appopriate timing and volumes.

*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 (Water NSW, OEH and Fisheries) before implementing this 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

- 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. A flow rise of of approximately 2 metres may be required.

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

*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 (Water NSW, OEH and Fisheries) before implementing this action.

**5. Native fish passage flow**

*Watering action:* Contribute to river flows (freshes) in the mid-Macquarie River to drown weirs and provide spawning and movement opportunities for flow specialists and support recruitment of flow generalists and specialists.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir

- 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 appopriate timing and volumes.

*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.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and Fisheries) before implementing this action.

**6. Lower Macquarie River connectivity and aquatic ecosystems**

*Watering action:* Contribute to flows (baseflows and freshes) to provide connectivity to the lower Macquarie River and Barwon-Darling, maintain aquatic ecosystems and riparian vegetation, and provide opportunities for native fish. The 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 voulme of water available to be delivered and operational considerations.
- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appopriate timing and volumes.

*Typical extent:* This watering action would be targeted at contributing flows to the lower Macquarie River downstream of the Macquarie Marshes. If water is being provided to the East Marsh 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. This action would provide addtional benefits to the mid-Macquarie River and Marshes en route to the lower Macquarie.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and Fisheries) before implementing this action.

**7. 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
- 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.

*Typical extent:*

- Depending on water availability, specific areas of the Marshes system may be targeted (e.g. within the North, South and/or East Marsh) rather than the entire inundation zone.
- The extent targeted varies across demands and water resource availability scenarios:
    - Contribute to inundating up to 9 000 ha of reed beds, lagoons and water couch in the Macquarie Marshes (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: Low – High scenario).
    - Contribute to inundating between 81 000 and 145 000 ha of outer river red gum forest, coolabah, myall and black box in the Macquarie Marshes (400–700 GL: Moderate to High scenario).

*Approvals:* Consult with NSW agencies (Water NSW, OEH and Fisheries) before implementing this action.

**8. Waterbird breeding contingency**

*Watering action:* Contribute to flows to the Macquarie Marshes to maintain inundation in key waterbird reproduction 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 agencices that catchment conditions and short term future flows into the Marshes will not be sufficient to maintain the conditions required to complete a successful 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) 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.

*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 (Water NSW, OEH and Fisheries) before implementing this action. In particular, to determined whether environmental water can be delivered to the precise location of the bird breeding event.

**9. Restoring natural flow variability**

*Watering action:* Contribute to flows (baseflows and freshes) in one or more of the effluent creeks 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 effluent creeks system.
- Commonwealth environmental water could be provided to the effluent 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, and depending on conditions.
- Delivery tothe lower Crooked Creek is constrained by the capacity of the Crooked Creek channel, regulator and Mumblebone Weir.

*Typical extent:* The likely target of this action would be the unregulated parts of the effluent creeks such as Marra Creek. Other effluent creeks such as Crooked Creek, Duck Creek and Gunningbar Creek may be targeted pending further investigation and consultation. Flows may also contribute to achieving connectivity with the Bogan River and/or Barwon-Darling.

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

# 4. Long-term water availability

## 4.1. 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.

## 4.2. 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 (New South Wales Office of Environment and Heritage)
- Supplementary (New South Wales Office of Environment and Heritage)

## 4.3. Planned environmental water

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

The Macquarie Water Sharing Plan allocates 160 GL of planned environmental water for use in the Macquarie River Valley. To date, this allocation has largely been used to provide flows to the Macquarie Marshes in conjunction with environmental water entitlements held by the Commonwealth Environmental Water Holder and NSW Riverbank. A further 'environmental translucency' allocation of 10 GL is stored in the Windamere Dam for the Cudgegong system.

# 5. Next steps

## 5.1. From planning to decision making

It is important to distinguish between planning and operational decision making. As shown in Figure 5, planning allows the 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, constraints to water delivery and market conditions.

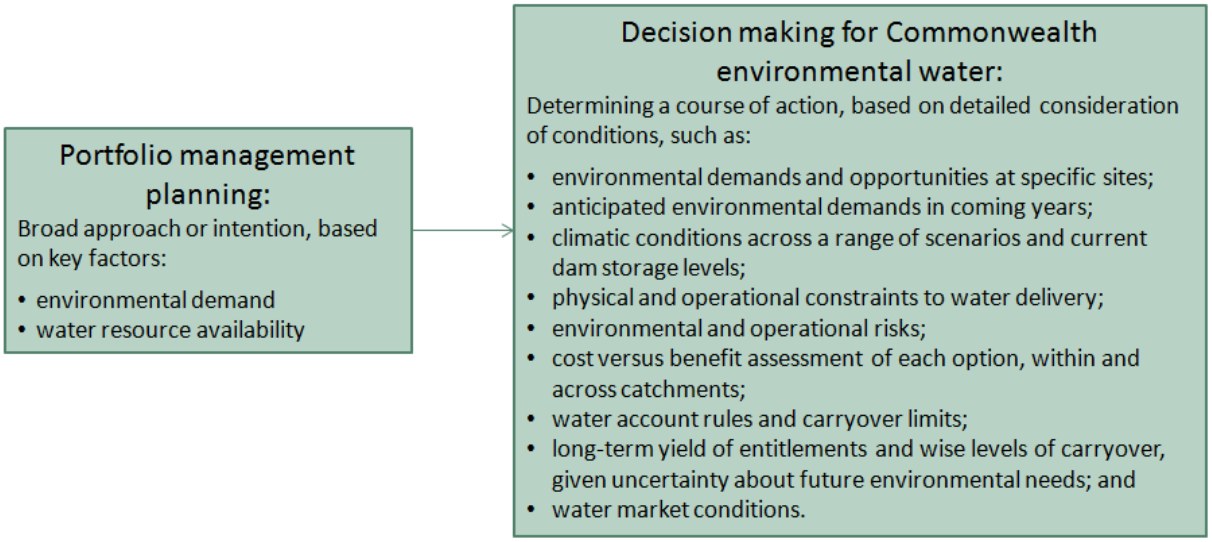



**Figure 5:** Planning and decision-making for Commonwealth environmental water use.

## 5.2. Further information

For further information on how the Office plans for water use, carryover and trade, please visit our web site www.environment.gov.au/topics/water/commonwealth-environmental-water-office

- 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: *Discussion Paper – Trade of Commonwealth Environmental Water* and *Commonwealth Environmental Water Trading Framework:* http://www.environment.gov.au/water/cewo/trade/trading-framework

# 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 C'th e-watering |
|---|---|---|---|---|---|
| Macquarie Marshes | 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 C'th 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 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 | No |
| 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 C'th 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 |

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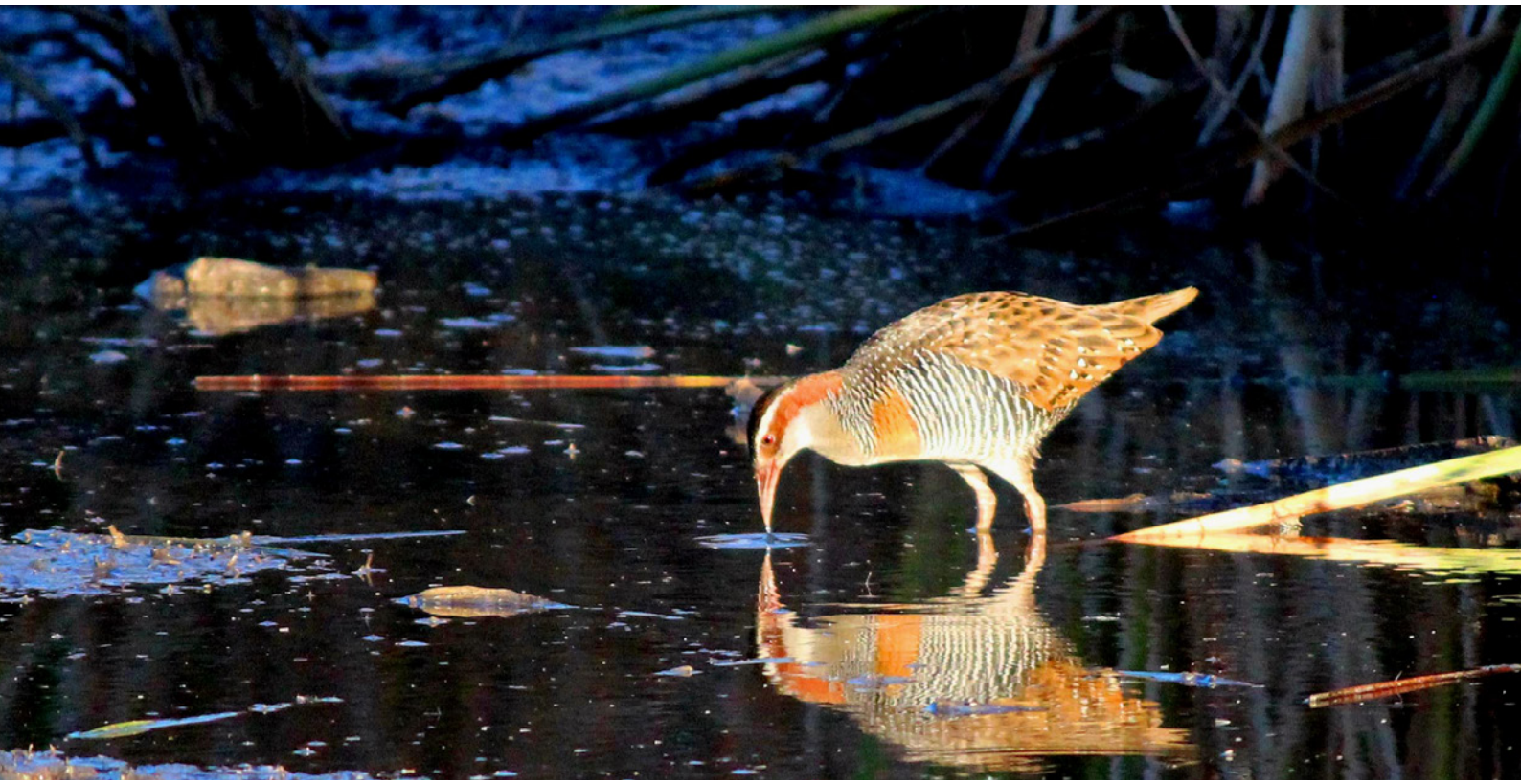

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