DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

Macquarie–Castlereagh Long Term Water Plan

Part B: Macquarie–Castlereagh planning units

environment.nsw.gov.au

Cover photo: Great egret in breeding plumage in flight. Photo John Spencer/DPIE

Published by:

Environment, Energy and Science
Department of Planning, Industry and Environment
4 Parramatta Square, 12 Darcy Street, Parramatta NSW 2150
Phone: +61 2 9995 5000 (switchboard)
Phone: 1300 361 967 (Environment, Energy and Science enquiries)
TTY users: phone 133 677, then ask for 1300 361 967
Speak and listen users: phone 1300 555 727, then ask for 1300 361 967
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

Report pollution and environmental incidents
Environment Line: 131 555 (NSW only) or info@environment.nsw.gov.au
See also www.environment.nsw.gov.au

ISBN 978-1-925974-98-0
EES 2020/0087
July 2020

Find out more about your environment at:

www.environment.nsw.gov.au

Contents

Acknowledgement of Traditional Owners iv
Abbreviations vii
Glossary viii
1. Introduction 1
1.1 Planning units 1
1.2 Methods for determining flow rate thresholds 3
1.3 Information sources for ecological values occurring within priority environmental assets 4
1.4 Selection of recommended management strategies 5
2. Planning units that are regulated or affected by regulated water 8
2.1 Cudgegong Regulated River 8
2.2 Regulated Macquarie River – Burrendong Dam to Baroona 13
2.3 Regulated Macquarie River – Baroona to Warren Weir 18
2.4 Warren Weir to Macquarie Marshes 23
2.5 Macquarie Marshes 28
2.6 Lower Macquarie 41
2.7 Marra Creek 48
2.8 Lower Bogan River 51
2.9 Marthaguy Creek 59
3. Unregulated planning units 66
3.1 Macquarie system – Cudgegong headwaters 66
3.2 Macquarie system – Macquarie headwaters 71
3.3 Macquarie system – Upper Macquarie tributaries 76
3.4 Macquarie system – Upper Macquarie River above Burrendong 81
3.5 Macquarie system – Bell River and Molong Creek 84
3.6 Macquarie system – Little River 87
3.7 Macquarie system – Wambangalong, Whylandra, Maryvale & Geurie creeks 90
3.8 Macquarie system – Talbragar River 93
3.9 Macquarie system – Coolbaggie Creek 96
3.10 Macquarie system – Ewenmar Creek & Backwater Boggy Cowal 98
3.11 Upper Bogan system – Bogan River and headwaters (above Nyngan) 101
3.12 Castlereagh system – Castlereagh River above Binnaway 104
3.13 Castlereagh system – Binnaway to Gilgandra 107
3.14 Castlereagh system – Tooraweenah to Coonamble Tributaries 109
3.15 Castlereagh system – Castlereagh River Gilgandra to Coonamble 111
3.16 Castlereagh system – Lower Castlereagh tributaries 113
3.17 Castlereagh system – Castlereagh River below Coonamble 116

References 122

List of tables

Table 1 Key to hydrological alteration used in this document 3
Table 2 Recommended management strategies proposed for unregulated planning units 5
Table 3 LTWP EWRs for the regulated Cudgegong River as measured at Yamble Bridge (421019) 10
Table 4 LTWP EWRs for the Macquarie River between Burrendong and Baroona as measured at Dubbo (421001) (except where noted) 15
Table 5 LTWP EWRs for the Macquarie River between Baroona & Warren as measured at Warren Weir (421004) 20
Table 6 LTWP EWRs for the Macquarie River between Warren and the Macquarie Marshes measured as the combined flow at the Marebone Break and Macquarie River below Marebone Weir gauges (421088 + 421090) 25
Table 7 LTWP EWRs for the Macquarie Marshes PUs (southern, northern and eastern) 29
Table 8 LTWP EWRs for the Macquarie Marshes PUs (southern, northern and eastern) – Wetland inundation flows reliant on total event volume for whole-of-Marsh benefit. 33
Table 9 LTWP EWRs for the Lower Macquarie River as measured at Bells Bridge (Carinda) (421012) unless otherwise specified 44
Table 10 LTWP EWRs for the Lower Bogan River at Gongolgon Bridge (421023). 55
Table 11 LTWP EWRs for the Castlereagh below Coonamble at Gungalman Bridge (420020). 119

List of figures

Figure 1 Planning units in the Macquarie–Castlereagh catchment 2
Figure 2 Map of Cudgegong Regulated River PU. 8
Figure 3 Map of Regulated Macquarie River – Burrendong Dam to Baroona PU. 13
Figure 4 Map of Regulated Macquarie River – Burrendong Dam to Baroona PU. 18
Figure 5 Map of Warren Weir to Macquarie Marshes PU. 23

Figure 6	Map of Southern Macquarie Marshes PU.	35
Figure 7	Map of Northern Macquarie Marshes PU.	37
Figure 8	Map of Eastern Macquarie Marshes PU.	39
Figure 9	Map of Lower Macquarie PU.	41
Figure 10	Map of Marra Creek PU.	48
Figure 11	Map of Lower Bogan River PU.	52
Figure 12	Map of Marthaguy Creek PU.	59
Figure 13	Map of Macquarie system – Cudgegong headwaters PU.	67
Figure 14	Map of Macquarie system – Macquarie headwaters PU.	72
Figure 15	Map of Macquarie system – Upper Macquarie Tributaries PU.	77
Figure 16	Map of Macquarie system – Upper Macquarie River above Burrendong PU.	81
Figure 17	Map of Macquarie system – Bell River and Molong Creek PU.	84
Figure 18	Map of Macquarie system – Little River PU.	87
Figure 19	Map of Macquarie system – Wambangalong, Whylandra, Maryvale & Geurie creeks PU.	90
Figure 20	Map of Macquarie system – Talbragar River PU.	93
Figure 21	Map of Macquarie system – Coolbaggie Creek PU.	96
Figure 22	Map of Macquarie system – Ewenmar Creek & Backwater Boggy Cowal PU.	98
Figure 23	Map of Macquarie system – Bogan River and headwaters (above Nyngan) PU.	101
Figure 24	Map of Castlereagh system – Castlereagh River above Binnaway PU.	104
Figure 25	Map of Castlereagh system – Binnaway to Gilgandra PU.	107
Figure 26	Map of Castlereagh system – Tooraweenah to Coonamble Tributaries PU.	109
Figure 27	Map of Castlereagh system – Castlereagh River Gilgandra to Coonamble PU.	111
Figure 28	Map of Castlereagh system – Lower Castlereagh tributaries PU.	113
Figure 29	Map of Castlereagh system – Castlereagh River below Coonamble PU.	116

Acknowledgement of Traditional Owners

The NSW Department of Planning Industry and Environment pays its respect to the Traditional Owners and their Nations of the Murray-Darling Basin. The contributions of earlier generations, including the Elders, who have fought for their rights in natural resource management are valued and respected.

In relation to the Macquarie–Castlereagh Water Resource Plan Area, the NSW Department of Planning Industry and Environment pays its respects to the Traditional Owners—the Gomeroi/Kamilaroi, Ngemba, Ngiyampaa, Wailwan and Wiradjuri Nations—past, present and future. We look forward to building upon existing relationships to improve the health of our rivers, wetlands and floodplains including in recognition of their traditional and ongoing cultural and spiritual significance.

Abbreviations

AER	NSW DPIF Aquatic Ecosystems Research (database) of catch data
ARI	annual recurrence interval
Basin Plan	Murray–Darling Basin Plan
BPEOM	Basin Plan Environmental Outcome Monitoring
CAMBA	China – Australia Migratory Bird Agreement
CTF	commence-to-flow
DPI	NSW Department of Primary Industries
DPIE	NSW Department of Planning Industry and Environment
DPIE-BC	NSW Department of Planning, Industry and Environment – Biodiversity and Conservation Division
DPIE-Water	NSW Department of Planning Industry and Environment - Water
DPIF	NSW Department of Primary Industries Fisheries
EWA	environmental water allowance
EWR	environmental water requirement
ha	hectares
JAMBA	Japan – Australia Migratory Bird Agreement
LTWP	Long Term Water Plan
ML	megalitre
m/s	metres per second
NMBC	North Marsh Bypass Channel
NSW	New South Wales
OEH	NSW Office of Environment and Heritage (former government office, functions now done by DPIE-BC)
PCT	plant community type
PEW	planned environmental water
PU	planning unit
ROKAMBA	Republic of Korea – Australia Migratory Bird Agreement
UNSW	University of New South Wales
WRP	water resource plan
WRPA	water resource plan area
WSP	water sharing plan

Glossary

Alluvial	Comprised of material deposited by water.
Annual recurrence interval (ARI)	The expected frequency (in years) between exceedances of a given flow rate (in ML/d).
Bankfull flow	River flows at maximum channel capacity with little overflow to adjacent floodplains. Engages the riparian zone, anabranches and flood runners and wetlands located within the meander train. Inundates all in channel habitats including all benches, snags and backwaters.
Baseflow (BF)	Flows which inundate pools and riffle areas, providing sufficient depth for movement of small-bodied fish. Typically, baseflows are background flow levels within a river channel that are generally maintained by seepage from groundwater storage, but also by surface inflows. In watercourses with ephemeral or seasonal flows there may be extended periods without baseflows.
Basin Plan	The Basin Plan as developed by the Murray–Darling Basin Authority under the *Water Act 2007*.
Basin Plan Environmental Outcome Monitoring (BPEOM) zone	For the Basin Plan, DPIF has broken up the catchments of the Murray Darling Basin into smaller zones for the monitoring of environmental outcomes for fish. These zones are known as BPEOM zones.
Cease-to-flow (CTF)	The absence of flowing water in a river channel. Partial or total drying of the river channel. Streams contract to a series of isolated pools.
Cease-to-pump (access rule in WSP)	This is a low flow restriction on access to water for Works Approval Licences. Generally, licenced take is not permitted: • from in-channel pools and from natural off-river pools when the water level is lower than its full capacity • from pump sites when there is no visible flow. These rules typically apply unless there is a commence-to-pump access rule that specifies a higher flow rate that licence holders can begin pumping.
Cultural water-dependent asset	A place that has social, spiritual and cultural value based on its cultural significance to Aboriginal people and is reliant upon surface or groundwater supply for its values.
Cultural water-dependent value	An object, plant, animal, spiritual connection or use that is dependent on water and has value based on its cultural significance to Aboriginal people.
Ecological value	An object, plant or animal which has value based on ecological significance.
Ecosystem	A biological community of interacting organisms and their physical environment. It includes all the living things in that community, interacting with their non-living environment (weather, earth, sun, soil, climate and atmosphere) and with each other.
Environmental Water Allowance (EWA)	An allowance of water provided by the *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source* for environmental purposes.
Environmental water	Water for meeting the requirements of water-dependent ecosystems. It provides a multitude of benefits to not only the environment, but to communities, industry and society. It includes held environmental water and planned environmental water.
Environmental water requirement (EWR)	The water required to support the completion of all elements of a lifecycle of an organism or group of organisms (taxonomic or spatial), consistent with the objective/target, measured at the most appropriate gauge. Includes all water in the system including natural inflows, held environmental water (HEW) and planned environmental water (PEW).

Flow category	The type of flow in a waterway defined by its magnitude, season, shape and role (e.g. bankfull, spring fresh for native fish breeding).
Flow regime	The pattern of flows in a waterway or wetland over time that will influence the response and persistence of plants, animals and their ecosystems.
Freshes	Temporary in-channel flow pulse that typically happens in response to rainfall or release from water storages. Very important for a range of ecological values.
Groundwater	Water that is located below the earth's surface in soil pore spaces and in the fractures of rock formations. Groundwater is recharged from, and can eventually flow to, the surface naturally.
Held environmental water (HEW)	Water available under a water access right, a water delivery right, or an irrigation right for the purposes of achieving environmental outcomes (including water that is specified in a water access right to be for environmental use).
Hydrology	The study of the distribution and movement of water. For the purposes of this Plan, it relates to the size, duration, timing and frequency of flows.
Key ecological value	A species or community that is identified for its special conservation significance based on selected temporal and spatial criteria. Examples include Murray cod or river red gum woodlands.
Large fresh (LF)	A high-magnitude flow pulse that remains in-channel. May engage flood runners with the main channel and inundate low-lying wetlands. Connects most in channel habitats and provides partial longitudinal connectivity, as some low-level weirs and other in channel barriers may be drowned out. Highly important for aquatic ecosystems.
Lateral connectivity	Hydraulic link between river channels and the adjacent floodplain, wetlands and anabranch channels.
Long Term Water Plan (LTWP)	Plans required of Basin States by the Murray–Darling Basin Plan. Long term water plans give effect to the *Basin-wide Environmental Watering Strategy* relevant for each river system and will guide the management of water over the longer term. These plans will identify the environmental assets that are dependent on water for their persistence, and match that need to the water available to be managed for or delivered to them. The plan will set objectives, targets and watering requirements for key plants, waterbirds, fish and ecosystem functions. DPIE is responsible for the development of nine plans for river catchments across NSW, with objectives for five, 10 and 20-year timeframes.
Longitudinal connectivity	The flow link along the length of a watercourse.
Overbank flow (OB)	Flows that spill over the riverbank or extend to floodplain surface flows.
Planned environmental water (PEW)	Water that is committed by the Basin Plan, a water resource plan or another plan made under State water management law to specifically achieve environmental outcomes.
Planning Unit (PU)	A geographical division of a water resource plan area based on water requirements (in catchment areas in which water is actively managed), or a sub-catchment boundary (all other areas) for the purposes of this plan.
Priority environmental asset	In the context of this plan, is a place of particular ecological significance that contains values and functions that are water-dependent and can be influenced by environmental water.
Ramsar Convention	Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
Refuge (ecological)	An area which provides conditions to assist individuals within a population of plants or animals to survive through a period of decreased water availability.

Registered cultural asset	A cultural water-dependent asset that is registered in the NSW Aboriginal Heritage Information Management System (AHIMS).
Regulated river	A river that is gazetted under the NSW *Water Management Act 2000*. Flow is largely controlled by major dams, water storages and weirs. River regulation brings more reliability to water supplies but has interrupted the natural flow characteristics and regimes required by native fish and other plant and animal to breed, feed and grow.
Riparian	The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystems within them.
Small fresh (SF)	Low-magnitude in-channel flow pulse. Unlikely to drown out any significant barriers, but can provide limited connectivity and a biological trigger for animal movement.
Surface water	Water that exists above the ground in rivers, streams creeks, lakes and reservoirs. Although separate from groundwater, they are interrelated and over extraction of either will impact on the other.
Unregulated river	A waterway where flow is mostly uncontrolled by dams, weirs or other structures.
Very-low-flow (VLF)	Minimum flow in a channel that prevents a cease-to-flow. Provides limited connectivity between some pools and maintains water level in refuge pools.
Water resource plan (WRP)	A document prepared by State authorities and accredited by the Commonwealth under the Basin Plan. The document describes how water will be managed and shared between users in an area.
Water resource plan area (WRPA)	Catchment-based divisions of the Murray–Darling Basin defined by a water resource plan.
Water sharing plan (WSP)	A plan made under the NSW *Water Management Act 2000* that sets out specific rules for sharing and trading water between the various water users and the environment in a specified water management area. A water sharing plan will be a component of a water resource plan.
Water source	Under the WSPs for the unregulated water sources of the Macquarie-Bogan Rivers and of the Castlereagh River, the catchments have been divided into smaller areas called water sources. Each of these water sources has listed access and trading rules.
Water-dependent	A term used in the Basin Plan. In the context of this plan, an ecosystem, community or species that depends on periodic or sustained inundation, waterlogging or significant inputs of surface water for part or all of its lifecycle.

Definitions and explanatory text for EWRs

Flow category	Flows in rivers vary over time in response to rainfall, river regulation, extractions and other factors. The sequence of flows over time can be considered as a series of discrete events. These events can be placed into different flow categories (e.g. baseflows, freshes, bankfull, overbank and wetland flows) according to the magnitude of flow discharge or height within a watercourse, and the types of outcomes associated with the events (e.g. inundation of specific features such as channel benches, riparian zones or the floodplain). Flow categories used in LTWPs are illustrated and defined in Figure 9 and Table 7 in Part A of each LTWP.
Environmental water requirement (EWR)	An environmental water requirement (EWR, singular) describes the characteristics of a flow event (e.g. magnitude, duration, timing, frequency, and maximum dry period) within a particular flow category (e.g. small fresh), that are required for that event to achieve a specified ecological objective or set of objectives (e.g. to support fish spawning and in-channel vegetation). There may be multiple EWRs defined within a flow category, and numerous EWRs across multiple flow categories within a Planning Unit (PU). Achievement of each of the EWRs will be required to achieve the full set of ecological objectives for a PU.
EWR code	Each EWR is given a specific code that abbreviates the EWR name (e.g. SF1 for small fresh 1). This code is used to link ecological objectives and EWRs.
Gauge	The flow gauging station that best represents the flow within the PU, for the purpose of the respective EWR and associated ecological objective(s). To assess the achievement of the EWR, flow recorded at this gauge should be used.
Flow rate or flow volume	The flow rate (typically ML/d) or flow volume (typically GL over a defined period of time) that is required to achieve the relevant ecological objective(s) for the EWR. Most EWRs are defined using a flow rate, whilst flow volumes are used for EWRs that represent flows into some large wetland systems.
Timing	The required timing (or season, typically expressed as a range of months within the year) for a flow event to achieve the specified ecological objective(s) of the EWR. In some cases, a preferred timing is provided, along with a note that the event may occur at 'anytime'. This indicates that ecological objectives may be achieved outside the preferred timing window, but perhaps with sub-optimal outcomes. In these instances, for the purposes of managing and delivering environmental water, the preferred timing should be used to give greater confidence in achieving ecological objectives. Natural events may occur at other times and still achieve ecological objectives.
Duration	The duration for which flows must be above the specified flow rate for the flow event to achieve the specified ecological objective(s) of the EWR. Typically this is expressed as a minimum duration. Longer durations will often be desirable and deliver better ecological outcomes. Some species may suffer from extended durations of inundation, and where relevant a maximum duration may also be specified. Flows may persist on floodplains and within wetland systems after a flow event has passed. Where relevant a second duration may also be specified, representing the duration for which water should be retained within floodplain and wetland systems.

Frequency	The frequency at which the flow event should occur to achieve the ecological objective(s) associated with the EWR. Frequency is expressed as the number of years that the event should occur within a 10-year period. In most instances, more frequent events will deliver better outcomes, and maximum frequencies may also be specified, where relevant. Clustering of events over successive years can occur in response to climate patterns. Clustering can be ecologically desirable for the recovery and recruitment of native fish, vegetation and waterbirds populations, however extended dry periods between clustered events can be detrimental. Achieving ecological objectives will require a pattern of events over time that achieves both the frequency and maximum inter-flow period, and the two must be considered together when evaluating outcomes or managing systems. Where a range of frequencies is indicated (e.g. 3–5 years in 10), the range reflects factors including the natural variability in population requirements, uncertainty in the knowledge base, and variability in response during different climate sequences (e.g. maintenance of populations during dry climate sequences at the lower end of the range, and population improvement and recovery during wet climate sequences at the upper end of the range). The lower end of the frequency range (when applied over the long term) may not be sufficient to maintain populations and is unlikely to achieve any recovery or improvement targets. As such, when evaluating EWR achievement over the long-term through statistical analysis of modelled or observed flow records, the LTWP recommends using a minimum long-term average (LTA) target frequency that is at least the average of the recommended frequency range but may be higher than the average where required to achieve objectives. For example, for a recommended frequency range of 3-5 years in 10, the minimum LTA frequency should be at least 40% of years but may be up to 50% of years at sites where a higher frequency should be targeted over the long term to ensure recovery in certain species/populations. While these higher frequencies may exceed modelled natural event frequency in some cases, recovery in particularly degraded systems will be unlikely should lower (i.e. average) frequencies be targeted. Minimum LTA target frequencies in this LTWP are reported predominantly as the average of the recommended frequency range, however this may be refined during implementation of the LTWP and in future revisions of the LTWP based on the results of ongoing ecological monitoring.
Maximum inter-flow or inter-event period	The maximum time between flow events before a significant decline in the condition, survival or viability of a particular population is likely to occur, as relevant to the ecological objective(s) associated with the EWR. This period should not be exceeded wherever possible. *Annual planning of environmental water should consider placing priority on EWRs that are approaching (or have exceeded) the maximum inter-event period, for those EWRs that can be achieved or supported by the use of environmental water or management.*
Additional requirements and comments	Other conditions that should occur to assist ecological objectives to be met – for example rates of rise and fall in flows. Also comments regarding limitations on delivering environmental flows and achieving the EWR.

1. Introduction

To manage the complexity of the Macquarie–Castlereagh Water Resource Plan Area (WRPA), the Macquarie–Castlereagh Long Term Water Plan (LTWP) has been divided into 28 planning units (PUs) (Figure 1). This document, which forms Part B of the LTWP, provides the following local-scale information for each PU.

- The location of priority environmental assets identified as part of LTWP development.
- The ecological values, including native fish and waterbird species[1], native vegetation communities and cultural water-dependant assets[2] that occur within the PUs priority environmental assets.
- Objectives for native fish, showing relevant species. The objectives for each planning unit are outlined in Part A of the LTWP (Appendix A). Only native fish objectives are again shown here as these are highly species specific, so the species are listed with the objectives here.
- For 'key regulated PUs', environmental water requirements (EWRs) to support key ecological values and related LTWP objectives and targets that are presented for representative gauge/s in the planning unit.
- For PUs that are 'unregulated or have significant unregulated sections', an evaluation of the impact of water resource development on local hydrology and recommended management strategies for mitigating these changes to meet LTWP objectives and targets.

1.1 Planning units

The PU boundaries typically align with water source area boundaries in the *Macquarie–Castlereagh Water Resource Plan (WRP)*. However, some of these water sources have been amalgamated or split depending on how water management for the environment can be implemented. Where there are similarities between water sources they have been amalgamated; and where there are differences they have been split. When amalgamating and splitting, we have also aligned, where possible, PUs with the boundaries of the Basin Plan Environmental Outcomes Monitoring (BPEOM) zones of the NSW Department of Primary Industries - Fisheries (DPIF).

PUs may be regulated or unregulated, however the following have some overlap in terms of their management. These are fully or partly unregulated PUs that can be influenced by regulated deliveries from upstream.

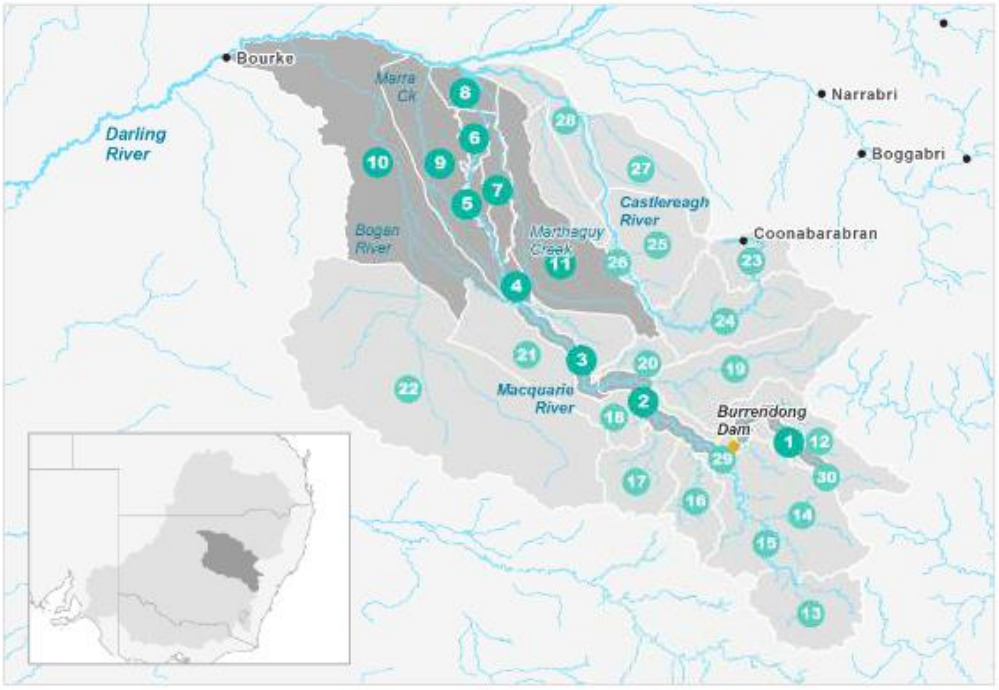
- The Macquarie Marshes PUs. Parts of these units are unregulated, but large areas of these areas can be influenced by regulated deliveries from the Macquarie River.
- The Lower Macquarie, which is unregulated. It can be influenced by deliveries from the regulated Macquarie through the Marshes.

[1] The waterbird species that are listed in each planning unit are primarily informed by spot records, which are influenced by inconsistent survey effort across the WRPA. Therefore, caution should be used in interpreting this information. Future work should focus on more rigorous monitoring or the development of models to predict species occurrence.

[2] The LTWP is currently limited to listing cultural assets that are registered in the Aboriginal Heritage Information Management System (AHIMS) database. It is acknowledged that Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered

- Marra Creek, which is unregulated, but receives stock and domestic replenishment flows and regulated deliveries can potentially be made at the top end (Profile gauge) from the regulated Macquarie.
- Marthaguy Creek, which is unregulated. It can be influenced downstream of the Terrigal Creek junction by deliveries from the regulated Macquarie/Marebone through the Eastern Marshes.
- The Lower Bogan PU. Parts of this PU are regulated (Gunningbar Creek, Duck Creek) and parts are unregulated. The unregulated areas can be influenced by water deliveries from the regulated Macquarie through the distributary creeks.

In regulated parts of the catchment, discretionary environmental water can be delivered to help meet the EWRs of priority environmental assets and functions. In unregulated areas, where there are no major upstream dams like Windamere or Burrendong and water cannot be delivered, the primary means of protecting environmentally important flows is through pumping access rules, restriction of trades into the water source and no creation of new entitlement.



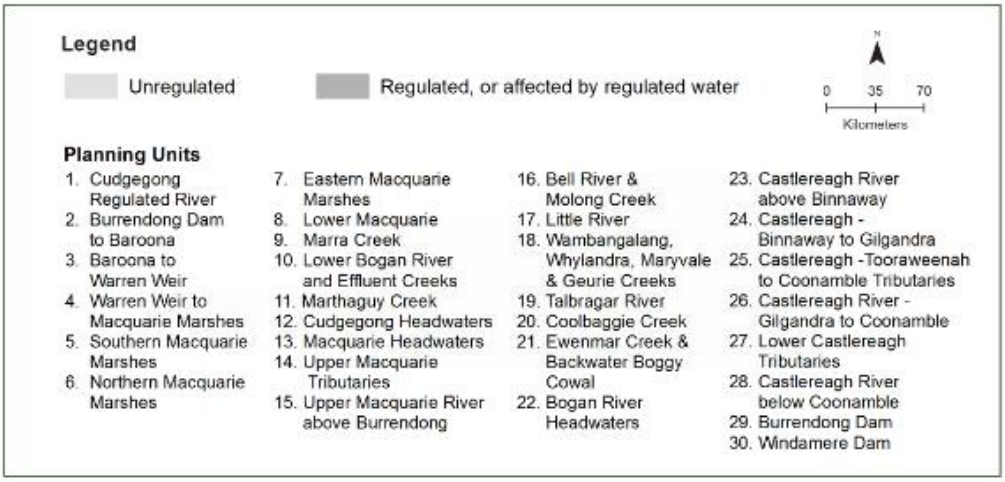


Figure 1 Planning units in the Macquarie–Castlereagh catchment

The PUs are presented in two sections in this document.

- Section 2 contains PUs 1–11, which are regulated or affected by regulated water.
- Section 3 contains PUs 12–28 that are unregulated and unable to be influenced by regulated water deliveries.

For the PUs in Section 2 that contain unregulated river reaches, the management of pumping access rules remains vital for protecting important flows. Recommended management strategies that could be implemented to ensure important flows are protected are outlined in Part A, Section 6.3 of the LTWP[3].

For each PU that is unregulated or has significant unregulated sections, information is presented on the hydrology[4] and the degree of alteration, as determined by DPIE–Water in their *Macquarie-Castlereagh Water Resource Plan Risk Assessment* (DPIE–W in prep), by comparing flows under modelled near natural conditions (with no dams or water extractions) and flows under modelled current conditions. Table 1 describes how the hydrology changes are presented for each PU.

Table 1 Key to hydrological alteration used in this document

Key from NSW DPIE–Water, in prep		
L = Low: less than 20% departure (+/-) from the base case for each hydrologic metric		
M = Medium: 20–50% departure (+/-); from the base case for each hydrologic metric		
H = High: greater than 50% departure (+/-) from the base case for each hydrologic metric		
N/A = no risk outcome or modelling available due to no hydrological data available		
[+] increase from near-natural condition	- decrease from near-natural condition	[0] no change from near-natural condition

1.2 Methods for determining flow rate thresholds

Flow rate thresholds for key regulated PUs are presented in Section 2. These thresholds were developed using multiple information sources.

- Expert opinion from regional water managers, DPIF staff and local landholders.
- Guidelines developed by DPIF (unpublished) for flow types including:
  - Very-low-flows: ideally velocity 0.03–0.05 m/s
  - Baseflows: ideally depth >0.3 m above commence-to-flow (CTF)
  - Small Freshes: ideally depth >0.5 m above CTF; flow 0.3–0.4 m/s
  - Large Freshes: ideally depth >2 m above CTF; flow >0.3 m/s.
- Flow percentiles described in Alluvium (2010):
  - the 20th percentile flow[5] as an indicator of the baseflow
  - the 40th percentile flow as an indicator the ‘low-flow-season fresh’, which may be taken as similar to our ‘small fresh’

[3] To improve the specificity of rule change recommendations, improved modelling, a better understanding of the actual total amount of take and the individual water access licence conditions is often required.

[4] The hydrology is presented as percentiles and ARIs as determined by pre-development modelling.

[5] That is 80th percentile exceedance. Other percentiles are similarly percentiles of occurrence rather than exceedance.

  - the 87th percentile flow as an indicator the 'high-flow-season fresh', which may be taken as similar to our 'large fresh'. We looked at both the 80th and 90th percentile.
- The approach used by the Stewardson and Guarino (2017) based on at-a-station hydraulic geometry equations (Stewardson 2005). They determined 'low freshes' as water levels at least one-eighth of the height of the bank above the baseflow level. They determined 'high freshes' as flow spells that raise water levels at least half of the height of the bank above the baseflow.
- Analysis of these flow rates to ensure they occurred under modelled or observed conditions. Analysis included checking against the required frequency of events and 95th percentile duration between events.

1.3 Information sources for ecological values occurring within priority environmental assets

Native fish species occurrence in PUs was determined from a range of sources including:

- the NSW Department of Primary Industries (DPI) Aquatic Ecosystem Research (AER) database (the database includes a range of site-specific catch data and information from various fish related projects in NSW from 1970 through to the present depending on the project and location)
- threatened and common species distribution models (Maxent 3.3.3)
- expert opinion from DPI Fisheries officers where applicable.

Water (flow)-dependant native vegetation communities were identified from a collated water (flow)-dependant vegetation map for the Macquarie–Castlereagh WRPA developed by DPIE as part of LTWP development. This collated map is based on best available vegetation mapping, including Plant Community Type (PCT) mapping for the Macquarie Marshes (2013) and mapping undertaken as part of the OEH Healthy Floodplains Program (2014).

Waterbird species records were collated from:

- NSW (Bionet – Atlas of NSW Wildlife) and Commonwealth (Australian Living Atlas) Government databases (1977-2015)
- University of New South Wales (UNSW) aerial survey datasets (1983-2015)
- NSW OEH aerial surveys (2008-2015) and ground surveys (2012-2015).

Significant Aboriginal cultural water dependent sites that are registered in the NSW Aboriginal Heritage Information Management System (AHIMS) were also included as water-dependent assets in the LTWP and are described for each PU. This includes areas such as Aboriginal ceremony and dreaming sites, fish traps, scar trees and waterholes.

1.4 Selection of recommended management strategies

Table 2 Recommended management strategies proposed for unregulated planning units

Management strategy	How chosen, purpose and description
Consider adding specific commence-to-pump rules in the Water Sharing Plan within five years to: • reduce the length of CTF periods • better protect low flows & baseflows	For consideration in PUs where: • DPIE-Water (in prep) have determined that CTF periods or low flows/baseflows have been moderately or highly impacted; and • DPIE-Water (in prep) has assessed the PU to be of moderate to very high environmental value or the LTWP has identified the PU for improvement in populations of key fish species (objectives NF7-9); and • the total entitlement in the water source exceeds 450 ML[6]; and • 20th percentile exceedance flow is greater than 5 ML/day[7] Changes considered may include raising the commence-to-pump flow level from the current 'visible flow' to a minimum flow rate at a nominated gauge. This would protect some base flows providing small-bodied fish enough water for limited movement along channels and improving the maintenance and replenishment of refuge pools. Cease-to-pump levels could potentially remain at the current level (often 'visible flow'), allowing extractors to access water at the tail end of a flow. By raising commence-to-pump levels the initial flows which break dry periods could be protected.
Consider rostering access during low flow months for unregulated river access (and, where relevant, special additional high flow access) licences.	For consideration in PUs where: • DPIE-Water (in prep) have determined that low flows/baseflows or freshes have moderately or highly decreased; and • DPIE-Water (in prep) has assessed the PU to be of moderate to very high environmental value or the LTWP has identified the PU for improvement in populations of key fish species (objectives NF7-9); and • the total entitlement in the water source exceeds 450 ML[6]; and • 20th percentile exceedance flow is greater than 5 ML/day[7]. Rostering take could involve an 'odds and evens' arrangement where a half of licence holders are able to access water on one day and the other half on the next. This is to reduce the daily extraction pressure on smaller flows where a significant proportion of the daily flow could be pumped if all pumps were activated simultaneously. Allowance would have to be made for travel times along longer systems.
Consider implementing a first flush rule to ensure periods between small freshes are not excessively prolonged and CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents	For consideration in PUs where: • DPIE-Water (in prep) has assessed the PU to be of moderate to very high environmental value or the LTWP has identified the PU for improvement in populations of key fish species (objectives NF7-9); and • For the breaking of CTF periods: DPIE-Water (in prep) have determined that CTF periods have been moderately or highly increased; and/or • For avoiding excessively prolonged periods between small freshes: DPIE-Water (in prep) have determined that freshes have been moderately or highly impacted; and • the total entitlement in the water source exceeds 450 ML[6]; and • 20th percentile exceedance flow is greater than 5 ML/day[7].

[6] Water sources with total entitlement less than 450 ML are in the lower quartile of all water sources in the WRPA.

[7] '20th percentile exceedance flow' means the flow that is met or exceeded on only 20% of days. Water sources with 20th percentile flows of less than 5 ML/day are in the lower quartile of all water sources in the WRPA.

Management strategy	How chosen, purpose and description
For the breaking of CTF periods, this will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.	The first flush rule would limit extraction following extended cease to flow events until a flushing flow of sufficient size has passed. This is aimed to ensure flows which break a cease-to-flow period are not reduced below the size required to replenish refuge pools and provide sufficient dilution quickly enough to avoid water quality problems associated with the destratification of refuge pools. The required event size would need to be determined for each identified PU and may vary depending on season. Where the first flush rule is implemented for avoiding excessively prolonged periods between small freshes, this is to allow the movement of larger-bodied fish species to prevent stranding and potentially to help trigger spawning. This will also help to protect the natural variability of flows. The size of the flow would be informed by the depth required for fish movement between refuges pools and potentially into other systems. In line with the EWRs in Part A of the LTWP (Section 4.3), the recommended maximum period between small freshes for fish movement ('small fresh 1') is 1 year.
Consider implementing total &/or individual daily extraction limits (IDELs & TDELs).	For consideration in PUs where: • DPIE-Water (in prep) have determined that low flows/baseflows, freshes or small overbanks (1.5 ARI flow) have moderately or highly decreased • DPIE-Water (in prep) has assessed the PU to be of moderate to very high environmental value or the LTWP has identified the PU for improvement in populations of key fish species (objectives NF7-9) • the total entitlement in the water source exceeds 450 ML[6]; and • 20th percentile exceedance flow is greater than 5 ML/day[7]. Individual daily extraction limits (IDELs) would limit the amount of water a licence holder could take on any one day. Total daily extraction limits (TDELs) would limit the daily take for the zone. These limits could be set at different levels for different flow sizes, so the proportion of any flow taken is able to be better managed and highly impacted and important flow types could be preserved.
Consider targeted water access licence purchases from willing sellers	For consideration in PUs where: • DPIE-Water (in prep) have determined that CTF, low flow/baseflow, freshes or small overbanks (ARI's of 1.5) have a high degree of hydrological change; and • DPIE-Water (in prep) has assessed the PU to be of very high environmental significance; and • The LTWP has identified the PU for improvement in populations of key fish species (objectives NF7-9 of the LTWP); and • The PU is either directly connected to or is within one PU of the Barwon (e.g. the Northern Marshes PU – which provides flow to the Lower Macquarie PU – which connects to the Barwon River); and • where the total entitlement in the water source exceeds 450 ML[6]; and • 20th percentile exceedance flow is greater than 5 ML/day[7]. Targeted purchases from willing sellers would help to protect flows in very high value PUs. They could be particularly useful in protecting flows that connect and provide flows to the Barwon River.
Ensure compliance with water access licence conditions including through metering of all licensed extraction	Applies to all PUs. To ensure all flows are protected from unauthorised extraction for the environment and other users.
Protect water for the environment that	Applies to all PUs which are downstream of regulated water sources where environmental water from held water entitlements or the EWA could be delivered.

Management strategy	How chosen, purpose and description
originates from held water entitlements & the EWA.	To protect all flow sizes and provide connectivity downstream of watered areas. Environmental water releases may trigger responses such as fish spawning and productivity increases, which makes the protection of this water downstream more valuable.
Maintain existing rules in the WSP to maintain priority environmental assets	Applies to all PUs. These rules include trade rules and extraction rules. This strategy is to ensure no reduction in protection. Changes may be made where recommended to increase protection.
Consider restrictions to take in water sources bordering the Barwon River when embargoes on take exist in the Barwon River	For consideration in PUs: • where the total entitlement in the water source exceeds 450 ML[6]; and • 20th percentile exceedance flow is greater than 5 ML/day[7]; and • which connect directly or almost directly to the Barwon (that is, the lower part of the Marthaguy Creek PU - which connects to the Lower Macquarie near junction with the Barwon – is included). There are periods when extended low or nil flows in the Barwon River are considered so extreme that embargoes are placed on take there. Currently flows in the Macquarie-Castlereagh WRPA may be extracted without consideration of the needs of the downstream system. To help alleviate periods of extreme water shortage in the Barwon impacting critical drought refuges, consideration should be given to the protection of flows during embargoes in the Barwon-Darling WRPA.
Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes	Applies to all PUs. Patterns of usage and demand may change with changing crop choices and practices. This may alter the seasonality and volume of take and have differing impacts on different flows.
Review conditions on larger in-stream storages. This should include consideration of the need for environmental releases.	For consideration in PUs where: • there is a storage of 1000 ML or greater; and • DPIE-Water (in prep) has assessed the PU to be of high or very high environmental significance; or the LTWP has identified the PU for improvement in populations of key fish species (objectives NF7-9 of the LTWP); and • DPIE-Water (in prep) have determined that CTFs, low flows/baseflows, freshes or small overbanks have been moderately or highly impacted. This review would determine if the impacts on flows downstream of dams could be mitigated and the potential costs and benefits of any changes.
Improve the gauging network to better indicate flow distribution	For consideration in PUs where: • there is limited or no flow data; and • DPIE-Water (in prep) has assessed the PU to be of very high environmental significance; and the LTWP has identified the PU for improvement in populations of key fish species (objectives NF7-9 of the LTWP); and • the total entitlement in the water source exceeds 450 ML[6]; and • 20th percentile exceedance flow is greater than 5 ML/day[7], **or** in PUs: • which connect directly to the Barwon River or almost directly connect to the Barwon (that is, the lower part of the Marthaguy Creek PU - which connects to the Lower Macquarie near junction with the Barwon – is included); and • which have extraction below the current most downstream gauge; and • where the total entitlement in the water source exceeds 450 ML[6]; and • 20th percentile exceedance flow is greater than 5 ML/day[7].

2. Planning units that are regulated or affected by regulated water

2.1 Cudgegong Regulated River

The regulated section of the Cudgegong River flows west from Windamere Dam near Mudgee to Burrendong Dam. Three major tributaries flow into the Cudgegong River between Windamere and Burrendong dams; Lawsons, Wyaldra and Meroo creeks. In the upper reaches, the Cudgegong River flows through narrow valleys that broaden into a wider alluvial floodplain below Mudgee (Green et al. 2011).

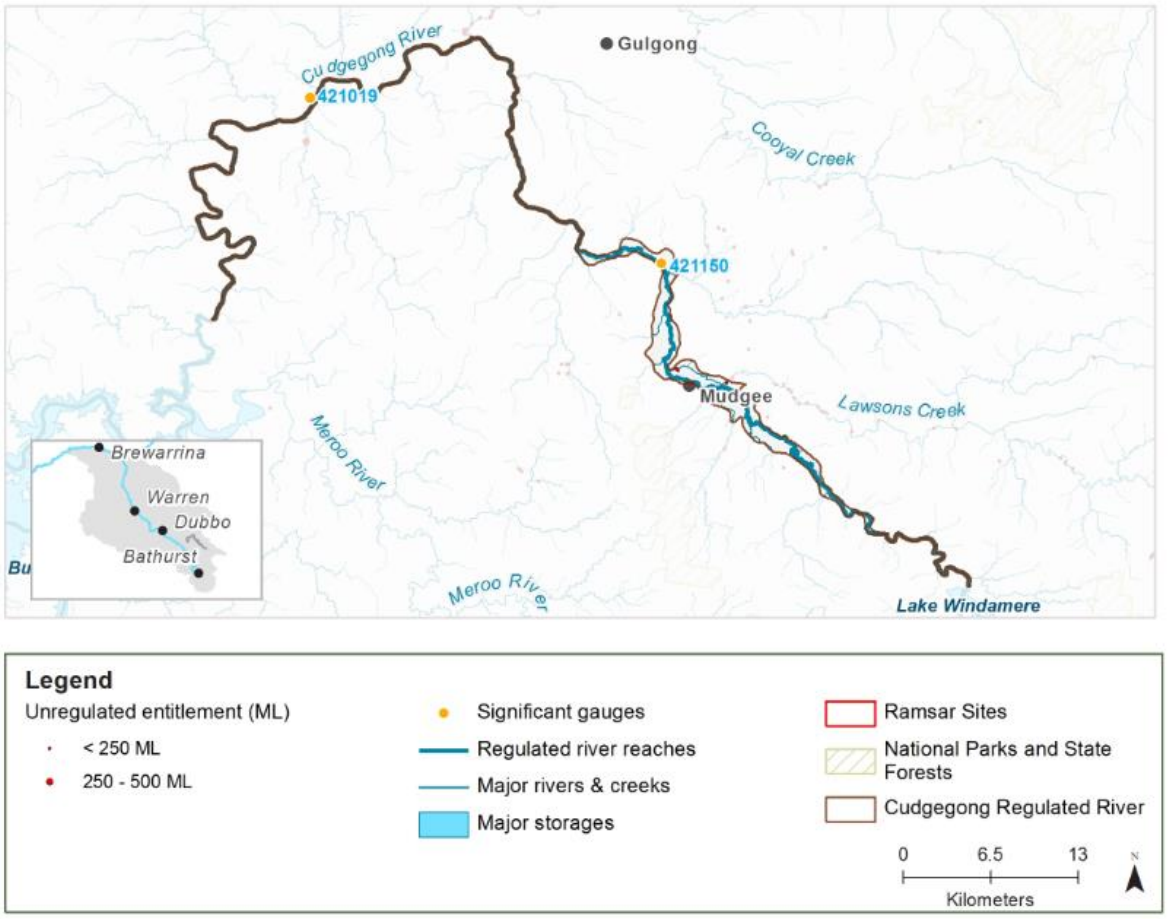


Figure 2 **Map of Cudgegong Regulated River PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Cudgegong River @ Yamble Bridge (421019) and Cudgegong River at Wilbertree Road (421150).

Named priority environmental assets
• Cudgegong River channel & riparian zone • Cudgegong River floodplain and Wetlands: Putta Bucca • Cudgegong River unregulated tributaries: Lawsons Creek

Key ecological values CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.		
Native fish	Australian smelt [X + Y] carp gudgeon [X + Y] dwarf flat-headed gudgeon [X] eel-tailed catfish (E) [X + Y] flat-headed gudgeon [X + Y]	golden perch [X + Y] mountain galaxias [X + Y] Murray cod (V) [X + Y] purple-spotted gudgeon (E) [Y]
Waterbirds	29 species recorded	
Native vegetation	800 ha of river red gum, & river oak riparian forest & woodland	
Registered water-dependent cultural assets	No water-dependent cultural assets identified in known site data. It is acknowledged that Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, flat-headed gudgeon, dwarf flat-headed gudgeon, mountain galaxias
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch
NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod, eel-tailed catfish, purple-spotted gudgeon
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Table 3 LTWP EWRs for the regulated Cudgegong River as measured at Yamble Bridge (421019)

Flow category and EWR code[8]		Flow volume[8]	Timing[8]	Duration[8]	Frequency (LTA frequency)[8]	Maximum inter-event period[8]	Additional requirements and comments[8]
Cease-to-flow	CTF	0 ML/d	CTF events no longer occur in this river reach. Due to the changed conditions that fish & other plant & animal communities may currently depend on, CTF events should be avoided in this reach.				
Very-low-flow	VLF	5 ML/d	Any time	No less than natural	No less than natural	No greater than natural	Flow of 5 ML/d at this gauge is estimated to be sufficient to maintain a flow to end of planning unit
Baseflow	BF1	>40 ML/d	Anytime	In moderate years, 223 days per year. In very dry years, at least 97 days per year[9]	Annually	1984–2017 observations did not exceed 47 days in 95% of years	
	BF2	>40 ML/d	Sep–Mar	In moderate years, 127 days per season. In very dry years, at least 103 days per season[9]	5–10 years in 10 75% of years)	2 years	
	BF3	>40 ML/d[10]	As required to avoid stratification during periods of identified high risk where a hypoxic bottom layer is likely to develop to an extent that it could produce hypoxic conditions in the entire water column should subsequent mixing occur. Requirement more likely during periods of extreme heat and low flow.				As these flows are to maintain water quality, weir level management (where relevant), natural flows, operational water and non-discretionary environmental water should be used in the first instance before considering

[8] Refer to Glossary for definitions of terms and explanatory text for EWRs

[9] This is based on 1984–2017 observations, which show the baseflow threshold being exceeded more often than pre-development levels. As the system has been altered, it is a risk to revert to lower baseflows unless there is evidence to suggest otherwise. Duration for 'moderate years' is based on the number of days of flow in the median year. Duration for 'very dry years' is based on the 95th percentile year. BF2 'very dry year' duration is based on the 25th percentile as this flow is only required every 5–10 years.

[10] Where threshold estimates are given these are provisional. Further work is required to confirm thresholds. See action on 'tools for preventing fish deaths due to stratification' in Table 22 of Part A.

Flow category and EWR code[8]		Flow volume[8]	Timing[8]	Duration[8]	Frequency (LTA frequency)[8]	Maximum inter-event period[8]	Additional requirements and comments[8]
			This flow would also help reduce the risk of fish mortality due to extremely high water temperatures. Further work (see Table 22 of Part A) is required to provide tools to develop flow requirements.				the use of discretionary environmental water. DSF flow must be provided in a manner which considers potential impacts from turning over refuge pools and initial water temperature increases from flows travelling over hot, dry river beds. Consult NSW DPI-Fisheries on interim flow protocols and in developing detailed future requirements (see recommended further work, Table 22 of Part A).
De-stratifying flow	DSF	TBD[10]	As required to destratify refuge pools during periods of identified high risk where a hypoxic bottom layer has developed and could produce hypoxic conditions in the entire water column when mixed. Requirement more likely during periods of extreme heat and low flow. Further work (see Table 22 of Part A) is required to better identify risk periods and provide tools to develop flow requirements.				
Small fresh	SF1	>200 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10) (100% of years)	1 year	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 40% per day for 'pre-development' observed flows from 1939–1960 (e.g. 200ML-120ML-70ML-40ML).
	SF2	200–1,000 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	
	SF3	Not applicable. This is for PUs connecting to Barwon River					
Large fresh	LF1	>1,000 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 40% per day for 'pre-development' observed flows from 1939–1960 (e.g. 1000ML- 600ML- 360ML -200ML)
	LF2	>1,000 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	
Overbank/ Wetland flow	OB/ WS1	Not applicable. This is for core wetland areas, which are not a feature of this PU					
	OB/ WS2	Not applicable to this PU as no flows greater than overbank have a duration of 10 days. Floodplain specialist fish unlikely to spawn here.					

Flow category and EWR code[8]		Flow volume[8]	Timing[8]	Duration[8]	Frequency (LTA frequency)[8]	Maximum inter-event period[8]	Additional requirements and comments[8]
small[11] *	OB/ WS3	>12,000 ML/d	Anytime (ideally Sep–Feb)	2 days (based on median duration of pre-development modelled & observed)	2–3 years in 10 (25% of years)	5 years	The objective for fish dispersal/condition is not fully satisfied as flows of 12,000 ML/d only occurred for the required 5-day duration in 3% of years under pre-development conditions. Hence this flow focuses on requirements for river red gum, which has a shorter duration of 2 days in this PU. There may also be benefit in longer duration flows (5 days) that are smaller (e.g. a flow of 3,000 ML/d may extend overbank in some sections of this PU).
	OB/ WS4	Not applicable as this PU does not have large areas of non-woody vegetation on the floodplain					
Overbank/ Wetland flow medium[11] *	OB/ WM	Not applicable as this PU does not have large areas of floodplain woodlands outside the riparian corridor					
Overbank/ Wetland flow large[11] *	OB/ WL	Not applicable as this PU does not have large areas of floodplain woodlands outside the riparian corridor					

[11] Grey shading (and * in 1st column of row) denotes that flows of this size are not able to be delivered. They are dependent on natural events but may be impacted by water policy, including flood mitigation zone management

2.2 Regulated Macquarie River – Burrendong Dam to Baroona

This section of the Macquarie River is regulated by Burrendong Dam and receives unregulated inflows from tributary streams including the Bell, Little and Talbragar rivers.

Water delivery to this section of the river is dominated by regulated releases from Burrendong Dam during spring and summer. These releases are primarily for irrigation and environmental orders. As a result, there is a degree of seasonal flow reversal compared to the natural hydrology of the system (Barma et al. 2011).

The lowest flows generally occur in autumn to winter to meet town and stock and domestic needs, which are continuous. These flows provide water for the lower portion of the river channel and habitats such pools (including weir pools).

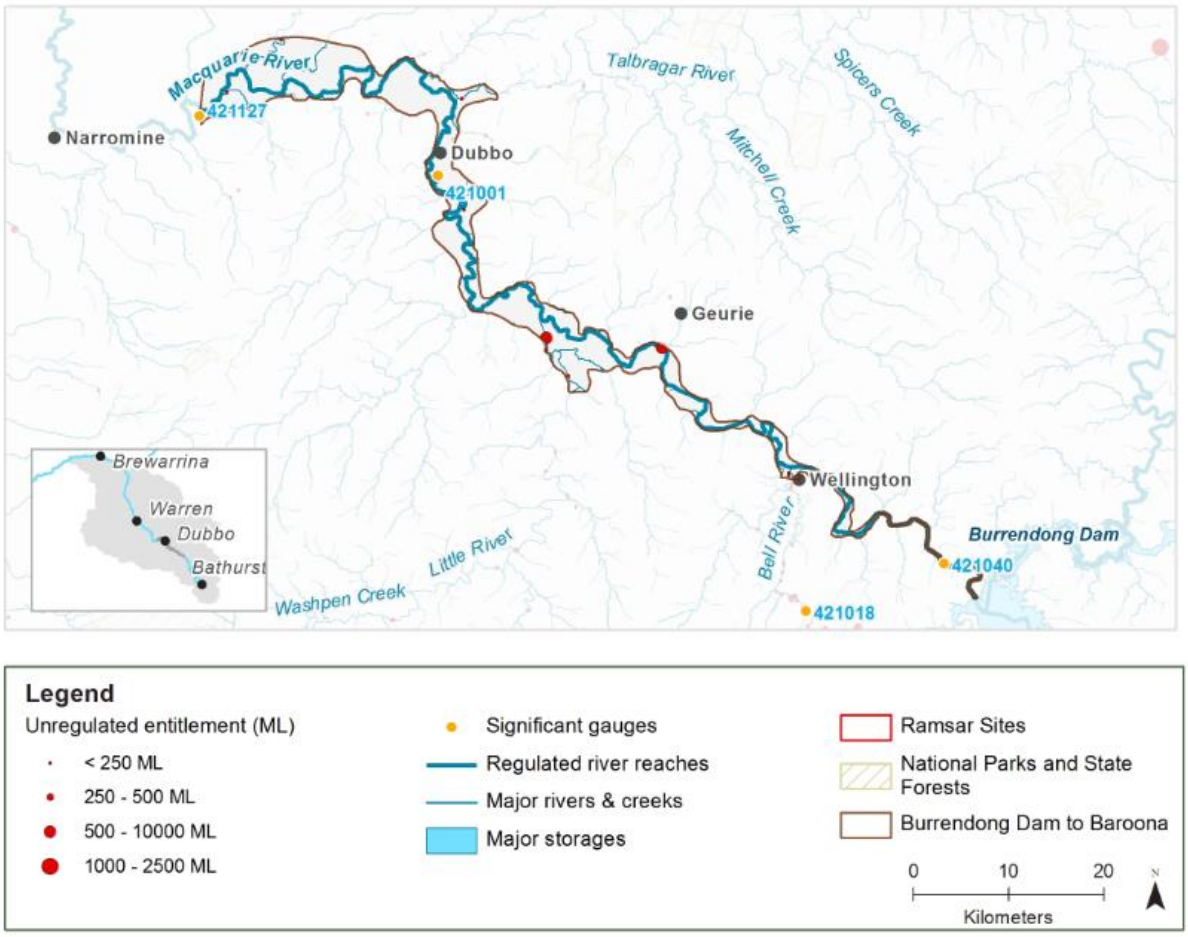


Figure 3 **Map of Regulated Macquarie River – Burrendong Dam to Baroona PU.** Area outside of PU has been faded. Significant gauges relevant to the PU are Macquarie River @ Baroona (421127), Macquarie River @ Dubbo (421001), Macquarie River @ D/S Burrendong Dam (421040).

Named priority environmental assets

- Macquarie River channel & riparian zone
- Macquarie River unregulated tributaries: Deep Creek, Bell River, Maryvale-Geurie, Talbragar River, Galwadgerie Gully, Spring Gully, Bushrangers Creek
- Floodplain wetlands: Brocklehurst overflow

Key ecological values

CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.

Native fish	Australian smelt [X + Y] bony herring [X + Y] carp gudgeon [X + Y] dwarf flat-headed gudgeon [Y] eel-tailed catfish (E) [X + Y] flat-headed gudgeon golden perch [X + Y] mountain galaxias [X]	Murray cod (V) [X + Y] Murray–Darling rainbowfish [X + Y] olive perchlet [Y] purple-spotted gudgeon (E) [Y] silver perch (V) [X + Y] trout cod (E) [X + Y] un-specked hardyhead [X + Y]
Waterbirds	47 species recorded, including: Australian painted snipe (E), blue-billed duck (V), magpie goose (V), marsh sandpiper (C,J,R) & sharp-tailed sandpiper (C,J,R)	
Native vegetation	3356 ha of water-dependent native vegetation communities, including 2100 ha of riparian river red gum & 1200 ha of floodplain/riverine river red gum forests & woodlands	
Registered water-dependent cultural assets	Camp sites, carved trees & scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp-gudgeon, dwarf flat-headed gudgeon, flat-headed gudgeon, mountain galaxias, Murray-Darling rainbowfish, & un-specked hardyhead

NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish (E), Murray cod (V), trout cod (E), purple-spotted gudgeon (E)

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch, Murray cod (V)

NF8 Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range): Eel-tailed catfish

Table 4 LTWP EWRs for the Macquarie River between Burrendong and Baroona as measured at Dubbo (421001) (except where noted)

Flow category and EWR code[12]		Flow volume[12]	Timing[12]	Duration[12]	Frequency (LTA frequency)[12]	Maximum inter-event period[12]	Additional requirements and comments [12]
Cease-to-flow	CTF	0 ML/d	CTF events no longer occur in this river reach. Due to the changed conditions, which fish & other plant & animal communities may currently depend on, CTF events should be avoided in this reach.				
Very-low-flow	VLF	1 ML/d at Baroona	Any time	No less than natural	No less than natural	No greater than natural	As measured at Baroona gauge (421127)
Baseflow	BF1	> 200 ML/d	Anytime	In moderate years, 223 days per year. In very dry years, at least 97 days per year[13]	Annually	1984–2017 observations did not exceed 47 days in 95% of years	
	BF2	> 200 ML/d	Sep–Mar	In moderate years, 127 days per season. In very dry years, at least 103 days per season[13]	5–10 years in 10 (75% of years)	2 years	
	BF3	> 200 ML/d[14]	As required to avoid stratification during periods of identified high risk where a hypoxic bottom layer is likely to develop to an extent that it could produce hypoxic conditions in the entire water column should				As these flows are to maintain water quality, weir level management (where relevant), natural flows, operational water and non-discretionary

[12] Refer to Glossary for definitions of terms and explanatory text for EWRs

[13] This is based on 1984–2017 observations, which show the baseflow threshold being exceeded more often than pre-development levels. As the system has altered, it is a risk to revert to lower baseflows unless there is evidence to suggest otherwise. Duration for 'moderate years' is based on the number of days of flow in the median year. Duration for 'very dry years' is based on the 95th percentile year. BF2 'very dry year' duration is based on the 25th percentile as this flow is only required every 5–10 years.

[14] Where threshold estimates are given, these are provisional. Further work is required to confirm thresholds. See action on 'tools for preventing fish deaths due to stratification' in Table 22 of Part A. Initial estimate for BF3 may need to be greater to accommodate slower flows in weir pools – e.g. a flow of 0.03 m/s at Dubbo weir pool is achieved at 400ML/day

Flow category and EWR code[12]		Flow volume[12]	Timing[12]	Duration[12]	Frequency (LTA frequency)[12]	Maximum inter-event period[12]	Additional requirements and comments [12]
			subsequent mixing occur. Requirement more likely during periods of extreme heat and low flow. This flow would also help reduce the risk of fish mortality due to extremely high water temperatures. Further work (see Table 22 of Part A) is required to provide tools to develop flow requirements.				environmental water should be used in the first instance before considering the use of discretionary environmental water. DSF flow must be provided in a manner which considers potential impacts from turning over refuge pools and initial water temperature increases from flows travelling over hot, dry river beds. Consult NSW DPI-Fisheries on interim flow protocols and in developing detailed future requirements (see recommended further work, Table 22 of Part A).
De-stratifying flow	DSF	TBD[14]	As required to destratify refuge pools during periods of identified high risk where a hypoxic bottom layer has developed and could produce hypoxic conditions in the entire water column when mixed. Requirement more likely during periods of extreme heat and low flow. Further work (see Table 22 of Part A) is required to better identify risk periods and provide tools to develop flow requirements.				
Small fresh	SF1	> 500 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10)	1 year	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 30% per day for 'pre-development' observed flows from 1912-1960 (e.g. 500ML – 350ML – 200ML).
	SF2	>500–6,000 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	
	SF3	Not applicable. This is for PUs connecting to Barwon River					
Large fresh	LF1	> 6,000 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 35% per day for 'pre-development' observed flows from 1912–1960 (e.g. 6000ML – 4000ML – 2500ML).
	LF2	> 6,000 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	
Overbank/ Wetland flow	OB/ WS1	Not applicable. This is for core wetland areas, which are not a feature of this PU					
	OB/ WS2	Not applicable to this planning unit – no flows have a duration of 10 days. DPIF note olive perchlet are likely to be supported in this PU. Hence, an objective for floodplain specialist fish (NF3) exists in this PU. Although the 10-day overbank flow did not occur					

Flow category and EWR code[12]		Flow volume[12]	Timing[12]	Duration[12]	Frequency (LTA frequency)[12]	Maximum inter-event period[12]	Additional requirements and comments [12]
Small[15] *		historically, and regular breeding is not likely in this PU, the habitat is considered suitable for fish that have bred downstream. Other flows (shorter overbank flows and freshes) are important for dispersal and productivity and some of these larger flows will contribute to overbanks in downstream planning units (where the channel is smaller) which may provide breeding opportunities for this fish guild.					
	OB/ WS3	> 65,000 ML/d	Anytime (ideally Sep–Feb)	2 days (based on median duration of pre-development modelled & observed)	2–3 years in 10 (25% of years)	5 years	The objective for fish dispersal/condition is not fully satisfied as flows of 65,000 ML/d only occurred for the required 5-day duration in 6% of years under pre-development conditions. Hence this flow focuses on requirements for river red gum, which has a shorter duration of 2 days in this PU.
	OB/ WS4	Not applicable. This is for non-woody wetland vegetation, which is not an extensive feature of the floodplain this PU					
Overbank/ Wetland flow Medium[15] *	OB/ WM	Not assessed. Non-riparian river red gum forests & woodlands are less extensive in this PU					
Overbank/ Wetland flow Large[15] *	OB/ WL	Not applicable as extensive areas of floodplain woodlands outside the riparian corridor are not a feature of this PU					

[15] Grey shading (and * in 1st column of row) denotes that flows of this size are not able to be delivered. They are dependent on natural events but may be impacted by water policy.

2.3 Regulated Macquarie River – Baroona to Warren Weir

The Macquarie River becomes a distributary system downstream from Narromine. From here, the river channel starts to lose integrity with a broader floodplain and distributary creeks develop.

Water delivery to this section of the Macquarie River is dominated by regulated releases from Burrendong Dam for town water supply, stock and domestic needs, irrigation orders and environmental requirements (largely targeted at the Macquarie Marshes). The lowest flows generally occur in the late autumn to winter period. Higher flows occur in spring to late summer for irrigation orders and environmental water releases. This has created a degree of seasonal flow reversal compared to the natural hydrology of the system (Barma et al. 2011).

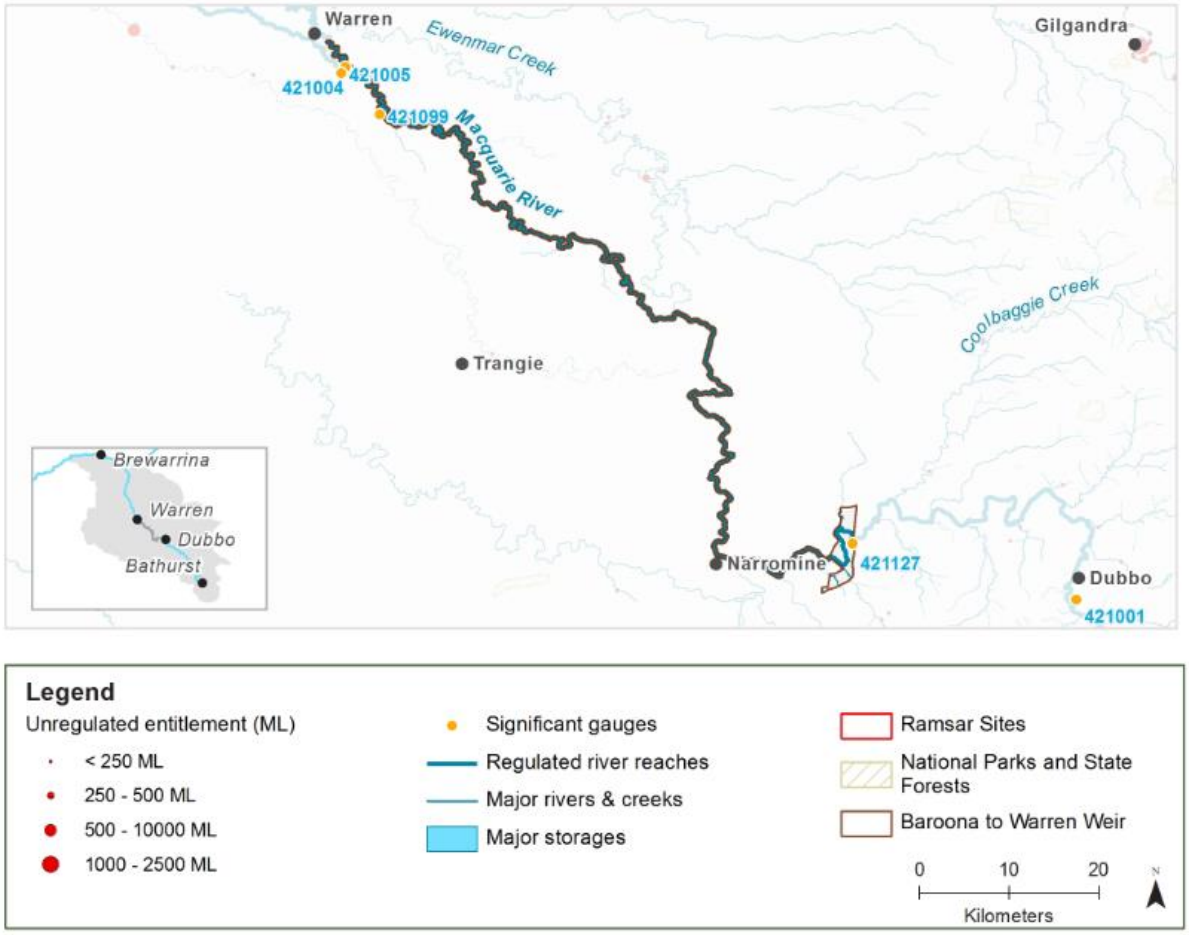


Figure 4 **Map of Regulated Macquarie River – Burrendong Dam to Baroona PU.** Area outside of PU has been faded. Significant gauges relevant to the PU are Macquarie River @ Baroona (421127), Macquarie River @ Dubbo (421001), Macquarie River @ D/S Burrendong Dam (421040).

Named priority environmental assets

- Macquarie River channel & riparian zone
- Macquarie River Distributaries: Redinville break, Gunningbar Creek, Balaringar creek
- Macquarie River Floodplain and Wetlands

Key ecological values

CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.

Native fish	Australian smelt [X + Y] bony herring [X + Y] carp-gudgeon [X + Y] dwarf flat-headed gudgeon [Y] eel-tailed catfish (E) [X + Y] flat-headed gudgeon [X + Y] golden perch [X + Y] mountain galaxias [X]	Murray cod (V) [X + Y] Murray-Darling rainbowfish [X + Y] olive perchlet [Y] purple-spotted gudgeon (E) [Y] silver perch (V) [X + Y] spangled perch [X] trout cod (E) [Y] un-specked hardyhead [X + Y]
Waterbirds	15 species recorded	
Native vegetation	3,083 ha of water-dependent native vegetation communities, including: river red gum (2765 ha), coolibah (4 ha), black box (9 ha), lignum (15 ha) & non-woody wetland vegetation (20 ha)	
Registered water-dependent cultural assets	Carved trees, scarred trees & camp sites It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp-gudgeon, dwarf flat-headed gudgeon, flat-headed gudgeon, mountain galaxias, Murray-Darling rainbowfish, & un-specked hardyhead

NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch, spangled perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish (E), Murray cod (V), trout cod (E), purple-spotted gudgeon (E)

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch, Murray cod (V)

NF8 Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range): Eel-tailed catfish

Table 5 LTWP EWRs for the Macquarie River between Baroona & Warren as measured at Warren Weir (421004)

Flow category and EWR code[16]		Flow volume[16]	Timing[16]	Duration[16]	Frequency (LTA frequency)[16]	Maximum inter-event period[16]	Additional requirements and comments[16]
Cease-to-flow	CTF	0 ML/d	CTF events occurred in around 50% of years under the natural system but now only occur rarely. Due to the changed conditions that fish & other plant & animal communities may currently depend on, CTF events should be avoided in this reach.				
Very-low-flow	VLF	1 ML/d	Any time	No less than natural	No less than natural	No greater than natural	
Baseflow	BF1	>200 ML/d	Anytime	In moderate years, 271 days per year. In very dry years, at least 152 days per year[17]	Annually	1984–2017 observations did not exceed 37 days in 95% of years	
	BF2	>200 ML/d	Sep–Mar	In moderate years, 190 days per season. In very dry years, at least 161 days per season[17].	5–10 years in 10 (75% of years)	2 years	
	BF3	>200 ML/d[18]	As required to avoid stratification during periods of identified high risk where a hypoxic bottom layer is likely to develop to an extent that it could produce hypoxic conditions in the entire water column should subsequent mixing occur. Requirement more likely during periods of extreme heat and low flow.				As this flow is to maintain water quality, weir level management (where relevant), natural flows, operational water and non-discretionary environmental water should be used in the first instance before considering

[16] See Table 1 for definitions and explanatory text for EWRs

[17] This is based on 1984–2017 observations, which show the baseflow threshold being exceeded more often than pre-development levels. As the system has altered, it is a risk to revert to lower baseflows unless there is evidence to suggest otherwise. Duration for 'moderate years' is based on the number of days of flow in the median year. Duration for 'very dry years' is based on the 95th percentile year. BF2 'very dry year' duration is based on the 25th percentile as this flow is only required every 5–10 years.

[18] Where threshold estimates are given, these are provisional. Further work is required to confirm thresholds. See action on 'tools for preventing fish deaths due to stratification' in Table 22 of Part A. Initial flow estimate for BF3 may need to be greater to accommodate slower flows in weir pools – e.g. a flow of 0.03 m/s at Dubbo weir pool is achieved at 400ML/day, and this may be similar at Gin Gin Weir and Warren Weir.

Flow category and EWR code[16]		Flow volume[16]	Timing[16]	Duration[16]	Frequency (LTA frequency)[16]	Maximum inter-event period[16]	Additional requirements and comments[16]
			This flow would also help reduce the risk of fish mortality due to extremely high water temperatures. Further work (see Table 22 of Part A) is required to provide tools to develop flow requirements.				the use of discretionary environmental water. DSF flow must be provided in a manner which considers potential impacts from turning over refuge pools and initial water temperature increases from flows travelling over hot, dry river beds. Consult NSW DPI-Fisheries on interim flow protocols and in developing detailed future requirements (see recommended further work, Table 22 of Part A).
De-stratifying flow	DSF	TBD[18]	As required to destratify refuge pools during periods of identified high risk where a hypoxic bottom layer has developed and could produce hypoxic conditions in the entire water column when mixed. Requirement more likely during periods of extreme heat and low flow. Further work (see Table 22 of Part A) is required to better identify risk periods and provide tools to develop flow requirements.				
Small fresh	SF1	>450 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10)	1 year	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 20% per day for 'pre-development' observed flows from 1902–1960 (e.g. 450ML - 360ML - 280ML)
	SF2	450–4,000 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	
	SF3	Not applicable. This is for PUs connecting to Barwon River					
Large fresh	LF1	>4,000 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 25% per day for 'pre-development' observed flows from 1902–1960 (e.g. 4000ML - 3000ML - 2250ML).
	LF2	>4,000 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	
Overbank/ Wetland flow	OB/ WS1	Not applicable. This is for core wetland areas, which are not a feature of this PU					
	OB/ WS2	Not applicable to this planning unit – flows of 10 days duration occur only rarely in ideal season (13% of years under modelled natural conditions). DPIF note olive perchlet are likely to be supported in this PU. Hence, an objective for floodplain specialist fish (NF3) exists in this PU. Note that although the 10-day overbank flow only occurred infrequently, and regular breeding is not likely in					

Flow category and EWR code[16]		Flow volume[16]	Timing[16]	Duration[16]	Frequency (LTA frequency)[16]	Maximum inter-event period[16]	Additional requirements and comments[16]
Small[19] *		this PU, the habitat is considered suitable for fish that have bred downstream. Other flows (shorter overbank flows and freshes) are important for dispersal and productivity and some of these larger flows will contribute to overbanks in downstream planning units (where the channel is smaller) which may provide breeding opportunities for this fish guild.					
	OB/ WS3	>12,000 ML/d	Anytime (ideally Sep– Feb)	5 days for fish dispersal/condition. 3 days for riparian river red gum	2–3 years in 10 (25% of years)	5 years	
	OB/ WS4	Not applicable as non-woody vegetation is not a prominent feature on the floodplain of this PU. Non-woody vegetation that is in this PU is considered covered by medium overbank.					
Overbank/ Wetland flow Medium[19] *	OB/ WM	>16,000 ML/d	Anytime (ideally Aug–Mar)	Persistence of water 3 months for wetland depressions. Flow of 3 days (median natural duration) required to fill depressions & soil profile	5 years in 10 (50% of years)	5 years	
Overbank/ Wetland flow Large[19] *	OB/ WL	>18,000 ML/d	Anytime (ideally Aug– Mar)	Persistence of water. 3 months for wetland depressions. Flow of 3 days (median natural duration) required to fill depressions & soil profile.	2–3 years in 10 (25% of years)	5–10 years	Black box & coolibah are not a prominent feature of this PU.

[19] Grey shading (and * in 1st column of row) denotes that flows of this size are not able to be delivered. They are dependent on natural events but may be impacted by water policy including floodplain harvesting and flood mitigation zone management.

2.4 Warren Weir to Macquarie Marshes

This PU includes the Macquarie River and tributaries, including Ewenmar Creek. The Macquarie River flows north for approximately 100 km, from the township of Warren to Marebone Weir. This PU encompasses the 'Macquarie River at Warren Weir' water source area of the unregulated and alluvial WSP and the lower section of the Ewenmar Creek water source area, in line with the Macquarie River Corridor water management area boundary of Thomas *et al.* (2010).

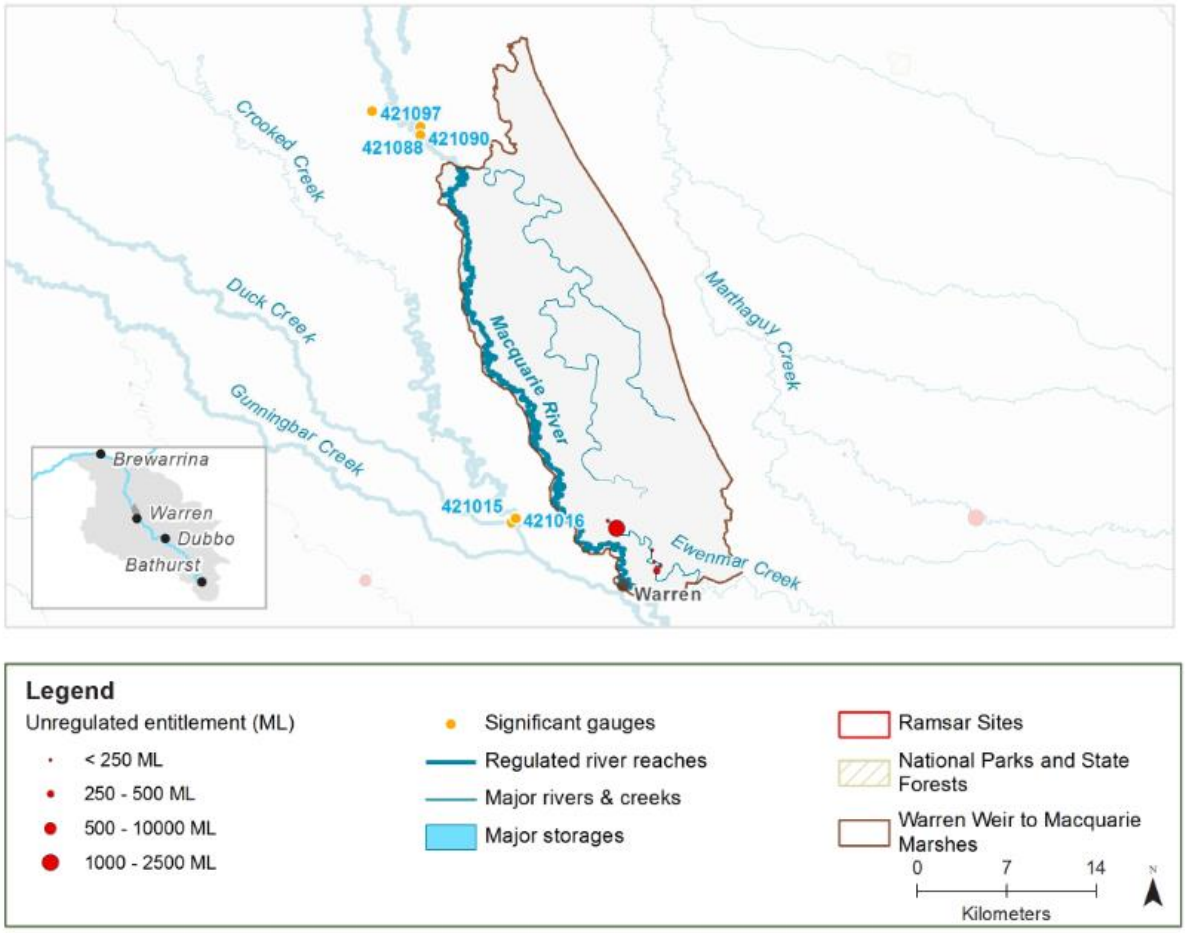


Figure 5 **Map of Warren Weir to Macquarie Marshes PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Marebone Break @ D/S Marebone Regulator (421088) and Macquarie River @ D/S Marebone Weir (421090)

Named priority environmental assets

- Macquarie River channel, anabranches & riparian zone
- Floodplain Wetlands
- Distributary Creeks
- Five Mile Cowal
- Lower Ewenmar Creek
- Junction Creek
- Umangla Cowal

Key ecological values CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.		
Native fish	Australian smelt X + Y bony herring X + Y carp-gudgeon X + Y eel-tailed catfish (E) X + Y flat-headed gudgeon X + Y golden perch X + Y	Murray cod (V) X + Y Murray–Darling rainbowfish X + Y olive perchlet Y silver perch (V) X + Y spangled perch X + Y un-specked hardyhead X + Y
Waterbirds	48 species recorded, including: Australasian bittern (E), cotton pygmy-goose (E) & magpie goose (V)	
Native vegetation	16,534 ha of water-dependent native vegetation communities, including: river red gum (7373 ha), coolibah (250 ha), black box (890 ha), lignum (43 ha) & non-woody wetland vegetation (638 ha)	
Registered water-dependent cultural assets	Scarred trees, ceremony & dreaming sites. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring (V), carp gudgeon, flat-headed gudgeon, Murray–Darling rainbowfish & un-specked hardyhead
NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch, spangled perch
NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish (E), Murray cod (V)
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch, Murray cod (V)

Table 6 LTWP EWRs for the Macquarie River between Warren and the Macquarie Marshes measured as the combined flow at the Marebone Break and Macquarie River below Marebone Weir gauges (421088 + 421090)

Flow category and EWR code[20]		Flow volume[20]	Timing[20]	Duration[20]	Frequency (LTA frequency)[20]	Maximum inter-event period[20]	Additional requirement and comments[20]
Cease-to-flow	CTF	0 ML/d	CTF events occurred in around 60% of years under the natural system but now only occur rarely. Due to the changed conditions that fish & other plant & animal communities may currently depend on, CTF events should be avoided in this reach.				
Very-low-flow	VLF	1 ML/d	Any time	No less than natural	No less than natural	No greater than natural	A flow of 1 ML/d to come from upstream flow not adjustment of weir gates as the VLF is to maintain a trickle flow into in-channel fish refuge pools in PU
Baseflow	BF1	>100 ML/d	Anytime	In moderate years, 318 days per year. In very dry years, at least 150 days per year[21]	Annually	1986–2017 observations did not exceed 60 days in 95% of years	
	BF2	>100 ML/d	Sep–Mar	In moderate years, 201 days per season. In very dry years, at least 181 days per season[21]	5–10 years in 10 (75% of years)	2 years	
	BF3	>30 ML/d[22]	As required to avoid stratification during periods of identified high risk where a hypoxic bottom layer is likely to develop to an extent that it could produce hypoxic conditions in the entire water column should subsequent mixing occur. Requirement more likely during periods of extreme heat and low flow				As these flows are to maintain water quality, weir level management (where relevant), natural flows, operational

[20] Refer to Glossary for definitions of terms and explanatory text for EWRs

[21] This is based on 1986–2017 observations, which show the very-low-flow and baseflow threshold being exceeded more often that pre-development levels. As the system has altered, it is a risk to revert to less frequent flows unless there is evidence to suggest otherwise. Duration for 'moderate years' is based on the number of days of flow in the median year. Duration for 'very dry years' is based on the 95th percentile year. BF2 'very dry year' duration is based on the 25th percentile as this flow is only required every 5-10 years.

[22] Where threshold estimates are given, these are provisional. Further work is required to confirm thresholds. See action on 'tools for preventing fish deaths due to stratification' in Table 22 of Part A. Initial estimates for BF3 may need to be greater to accommodate slower flows in weir pools – e.g. Marebone Weir

Flow category and EWR code[20]		Flow volume[20]	Timing[20]	Duration[20]	Frequency (LTA frequency)[20]	Maximum inter-event period[20]	Additional requirement and comments[20]
			This flow would also help reduce the risk of fish mortality due to extremely high water temperatures. Further work (see Table 22 of Part A) is required to provide tools to develop flow requirements.				water and non-discretionary environmental water should be used in the first instance before considering the use of discretionary environmental water. DSF flow must be provided in a manner which considers potential impacts from turning over refuge pools and initial water temperature increases from flows travelling over hot, dry river beds. Consult NSW DPI-Fisheries on interim flow protocols and in developing detailed future requirements (see recommended further work, Table 22 of Part A).
De-stratifying flow	DSF	TBD[22]	As required to destratify refuge pools during periods of identified high risk where a hypoxic bottom layer has developed and could produce hypoxic conditions in the entire water column when mixed. Requirement more likely during periods of extreme heat and low flow. Further work (see Table 22 of Part A) is required to better identify risk periods and provide tools to develop flow requirements.				
Small fresh	SF1	>350 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10)	1 year	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 30% per day for 'without-development' modelled flows (e.g. 350ML-245ML-70ML)
	SF2	350–2,500 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	
	SF3	Not applicable. This is for PUs connecting to Barwon River					
Large fresh	LF1	>2,500 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates

Flow category and EWR code[20]		Flow volume[20]	Timing[20]	Duration[20]	Frequency (LTA frequency)[20]	Maximum inter-event period[20]	Additional requirement and comments[20]
	LF2	>2,500 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	of fall) was 35% per day for 'without-development' modelled flows (e.g. 2500ML-1625ML-1060ML).
Overbank/ Wetland flow Small [23] *	OB/ WS1	Not applicable. This is for core wetland areas, which are not a feature of this PU					
	OB/ WS2	>4,000 ML/d	Oct–Apr	10 days	5–10 years in 10 (75% of years)	4 years	
	OB/ WS3	>4,000 ML/d	Anytime (ideally Sep–Feb)	5 days (is also the median duration of flows of this size, so 5 days is also used for riparian river red gum requirements)	2–3 years in 10 (25% of years)	5 years	
	OB/ WS4	>4,000 ML/d	Anytime (ideally Aug–Mar)	Persistence of water 3 months. Flow of 5 days (median natural duration) required to fill depressions & soil profile.	8–9 years in 10 (85% of years)	2 years	
Overbank/ Wetland flow Medium23[23] *	OB/ WM	> 5,500 ML/d	Anytime (ideally Aug–Mar)	Persistence of water 3 months for wetland depressions. Flow of 3 days (median natural duration) required to fill depressions & soil profile	5 years in 10 (50% of years)	5 years	
Overbank/ Wetland flow Large[23] *	OB/ WL	Not assessed	Not analysed. Flows over 5,500 ML/d may cover this requirement.				

[23] Grey shading (and * in 1st column of row) denotes that flows of this size are not able to be delivered. They are dependent on natural events but may be impacted by water policy including floodplain harvesting and flood mitigation zone management.

2.5 Macquarie Marshes

2.5.1 Macquarie Marshes – items relevant to all planning units (southern, northern and eastern Marshes)

The Macquarie Marshes are partly in the 'Lower Macquarie River' water source area of the unregulated and alluvial WSP.

Relevant management rules for the unregulated sections of the Marshes PUs (southern, northern & eastern)				
Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	H-	M-	M-	H-/M-
The Lower Macquarie Water Source has the largest volume of unregulated water entitlement in the WRPA, at 51,888 ML. Part of this water source is covered by the Lower Macquarie PU. Around 30,000 ML of entitlement is in the area covered by the Macquarie Marshes planning units. This area includes at least 3 large licences (>2,500 ML) and around 20 licences of greater than 500 ML/day within the Marshes. One of these is a 'high flow' licence (around 1,500 ML of entitlement) for which take is only permitted when flow at the Bells Bridge (Carinda) gauge exceeds 245 ML/day. As assessed by the Macquarie-Castlereagh WRPA Risk Assessment (DPIE-Water, in prep) the Lower Macquarie Water Source has experienced a reduction in CTF events, but a moderate to high decrease in low and baseflows, freshes and overbank events compared to near-natural conditions.				
Gum Cowal management zone	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: permitted in a downstream direction only. No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.			
Lower Macquarie River upstream management zone	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: permitted in a downstream direction only. Access rules from rivers & creeks: cease to pump when the flow at Macquarie River at Oxley (421022) ≤500 ML/d For natural off-river pools: No pool drawdown For pump sites not within a natural pool, cease to pump rule when no visible flow.			
Recommended management strategies for the unregulated sections of the Marshes PUs (southern, northern & eastern)				
• Consider rostering landholder water access during low flow months • Consider implementing total &/or individual daily extraction limits (IDELS & TDELS) • Consider targeted water access licence purchases from willing sellers *(Note licence purchase may not reduce extraction of events in dry periods – water normally taken by the purchased licence may be taken by downstream licences. In such cases purchases may need to target the most downstream licences)* • Consider implementing a first flush rule to ensure periods between small freshes are not excessively prolonged • Ensure compliance with water access licence conditions including through metering of all licensed extraction • Protect water for the environment that originates from held water entitlements (HEW) & the EWA. • Maintain existing rules in the WSP to maintain priority environmental assets • Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes				

Table 7 LTWP EWRs for the Macquarie Marshes PUs (southern, northern and eastern)

Flows are to be met at both the gauge on the Macquarie River downstream Marebone (421090) and at Oxley Station (421022) unless otherwise stated.

Flow category and EWR code[24]		Flow volume[24]	Timing[24]	Duration[24]	Frequency (LTA frequency)[24]	Maximum inter-event period[24]	Additional requirements and comments[24]
Cease-to-flow	CTF	0 ML/d	In line with natural. Typically occurs Nov–Jun	Maximum duration: In moderate years, events should not persist for more than 5 days on the Macquarie at Marebone or at Oxley. In very dry years, events should not persist for more than 30 days at Marebone or Oxley[25]	Should not occur in more than 20% of years[25]		This is to maintain a trickle flow into in-channel fish refuge pools in the Southern Marsh PU
Very-low-flow	VLF	10 ML/d @ Marebone (421090) 5 ML/d @ Oxley (421022)	Anytime	In moderate years, 359 days per year at Marebone & Oxley. In very dry years, at least 259 days per year at Marebone & 238 at Oxley[26]	No less than natural (Annually)	1986–2017 observations did not exceed 21 days at Marebone or 33 days at Oxley in 95% of years	This is to maintain a trickle flow into in-channel fish refuge pools (particularly Oxley Waterhole) in the Southern Marsh PU
Baseflow	BF1	>65 ML/d	Anytime	In moderate years, 280 days per year at Marebone & Oxley. In very dry years, at least 90 days per year at Marebone & Oxley[27]	Annually	1986–2017 observations did not exceed 55 days in 95% of years	

[24] Refer to Glossary for definitions of terms and explanatory text for EWRs

[25] This is based on 1986–2017 observations for the Macquarie River at Marebone and 1984–2017 observations at Oxley. There has been some rounding and averaging between the two gauges. These show CTF events occur less often than pre-development levels. Because the system has altered it is a risk to revert to less frequent flows unless there is evidence to suggest otherwise. Oxley Waterhole is an important fish refuge and in this PU. Duration for 'moderate years' is based on the number of days of flow in the median year. Duration for 'very dry years' is based on the 95th percentile year.

[26] This is based on 1986–2017 observations for the Macquarie River at Marebone and 1984–2017 observations at Oxley. Duration for 'moderate years' is based on the duration of the median year. Duration for 'very dry years' is based on the 95th percentile year.

[27] Uses Marebone 1986–2017 observations (with some rounding). These are higher than the Oxley results (though lower than the modelled pre-development results for both gauges). Because of the importance of Oxley Waterhole, the higher figure from Marebone is used. Duration for 'moderate years' is based on the number of days of flow in the

Flow category and EWR code[24]		Flow volume[24]	Timing[24]	Duration[24]	Frequency (LTA frequency)[24]	Maximum inter-event period[24]	Additional requirements and comments[24]
	BF2	>65 ML/d	Sep–Mar	In moderate years, 180 days per season at Marebone & Oxley. In very dry years, at least 125 days per season at Marebone & Oxley[27]	5–10 years in 10 (75% of years)	2 years	
	BF3	>30 ML/d @ Marebone (421090) >20 ML/d @ Oxley (421022)[28]	As required to avoid stratification during periods of identified high risk where a hypoxic bottom layer is likely to develop to an extent that it could produce hypoxic conditions in the entire water column should subsequent mixing occur. Requirement more likely during periods of extreme heat and low flow. This flow would also help reduce the risk of fish mortality due to extremely high water temperatures. Further work (see Table 22 of Part A) is required to provide tools to develop flow requirements.				As this flow is to maintain water quality, weir level management (where relevant), natural flows, operational water and non-discretionary environmental water should be used in the first instance before considering the use of discretionary environmental water. The DSF flow must be provided in a manner which considers potential impacts from turning over refuge pools and initial water temperature increases from flows travelling over hot, dry
De-stratifying flow	DSF	TBD[28]	As required to destratify refuge pools during periods of identified high risk where a hypoxic bottom layer has developed and could produce hypoxic conditions in the entire water column when mixed. Requirement more likely during periods of extreme heat and low flow. Further work (see Table 22 of Part A) is required to better identify risk periods and provide tools to develop flow requirements.				

median year. Duration for ‘very dry years’ is based on the 95th percentile year. BF2 ‘very dry year’ duration based on the 25th percentile because this flow is only required every 5–10 years.

[28] Where threshold estimates are given, these are provisional. Further work is required to confirm thresholds. See action on ‘tools for preventing fish deaths due to stratification’ in Table 22 of Part A.

Flow category and EWR code[24]		Flow volume[24]	Timing[24]	Duration[24]	Frequency (LTA frequency)[24]	Maximum inter-event period[24]	Additional requirements and comments[24]
							river beds. Consult NSW DPI-Fisheries on interim flow protocols and in developing detailed future requirements (see recommended further work, Table 22 of Part A).
Small fresh	SF1	>300 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10)	1 year	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 30% per day for 'pre-development' observed flows at Oxley from 1943–1960 (e.g. 300ML - 210ML - 150ML)
	SF2	>300–1,000 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	
	SF3	Not applicable. This is for PUs connecting to Barwon River					
Large fresh	LF1	>1,000 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 20% per day for 'pre-development' observed flows at Oxley from 1943–1960 (e.g. 1000ML - 700ML - 550ML)
	LF2	>1,000 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	

Flow category and EWR code[24]		Flow volume[24]	Timing[24]	Duration[24]	Frequency (LTA frequency)[24]	Maximum inter-event period[24]	Additional requirements and comments[24]
Overbank/ Wetland flow Small	OB/ WS1	See Table 8					
	OB/ WS2	>2,900 ML/d at Marebone, >2,600 ML/d at Oxley	Oct–Apr	10 days	5–10 years in 10 (75% of years)	4 years	
	OB/ WS3	>2,900 ML/d at Marebone, >2,600 ML/d at Oxley	Anytime (ideally Sep–Feb)	5 days	2–3 years in 10 (25% of years)	5 years	
	OB/ WS4	See Table 8					
Overbank/ Wetland flow Medium	OB/ WM	See Table 8					
Overbank/ Wetland flow Large[29] *	OB/ WL	See Table 8					

[29] Grey shading (and * in 1st column of row) denotes that flows of this size are unable to be delivered with discretionary environmental water (although some water can be delivered to extend events). Flows of this size are dependent on natural events but may be impacted by water policy, including floodplain harvesting and flood mitigation zone management.

Table 8 LTWP EWRs for the Macquarie Marshes PUs (southern, northern and eastern[30]) – Wetland inundation flows reliant on total event volume for whole-of-Marsh benefit.

Flow category and EWR code[31]		Flow volume[31]	Timing[31]	Duration (retention of standing water)[31]	Frequency (LTA frequency)[31]	Maximum inter-event period[31]
Overbank/ Wetland flow Small	OB/ WS1	60,000 ML within 90 days at combined River & Marebone Break gauges downstream of Marebone[32]	Anytime (ideally Aug–Mar)	3 months	9–10 years in 10 (95% of years)	18 months
	OB/ WS4	100,000 ML within 90 days at combined River & Marebone Break gauges downstream of Marebone[32]	Anytime (ideally Aug–Mar)	3 months	8–9 years in 10 (85% of years)	2 years
Overbank/ Wetland flow Medium	OB/ WM	Northern and southern Marshes: 250,000 ML within 120 days at combined River & Marebone Break gauges downstream of Marebone[32]	Anytime (ideally Aug–Mar)	3 months	5 years in 10 (50% of years)	4 years
		Eastern Marshes: 8000 ML[33] at 400 ML/day or above at 'Gum Cowal at bifurcation' within 40 days[32]				

[30] The eastern Marshes are not targeted for small overbank/wetland flows. For medium overbank/wetland flows a specific flow requirement is included for the eastern Marshes (measured at Gum Cowal). For large overbank/wetland flows no specific eastern Marshes flow requirement it stated as it is assumed the larger flow volume will provide wetting to all three Marshes planning units, including the eastern Marshes.

[31] Refer to Glossary for definitions of terms and explanatory text for EWRs

[32] Volume required will vary between years depending on antecedent conditions

[33] Only flow on days with 400ML/day or above are counted towards the 8,000 ML total. Flow does not have to happen on consecutive days but is to happen within 40 days

Flow category and EWR code[31]		Flow volume[31]	Timing[31]	Duration (retention of standing water)[31]	Frequency (LTA frequency)[31]	Maximum inter-event period[31]
Overbank/ Wetland flow Large[34] *	OB/WL	440,000 ML within 150 days at combined River & Marebone Break gauges downstream of Marebone[32]	Anytime (ideally Aug–Mar)	3 months	2–3 years in 10 (25% of years)	5 years (up to 10 years for outer coolibah/black box areas)

[34] Grey shading (and * in 1st column of row) denotes that flows of this size are unable to be delivered with discretionary environmental water (although some water can be delivered to extend events). Flows of this size are dependent on natural events but may be impacted by water policy, including floodplain harvesting and flood mitigation zone management.

2.5.2 Southern Macquarie Marshes

The southern Marshes includes the Mole Marsh, Monkeygar Swamp, Southern Macquarie Marshes Nature Reserve, Monkey Swamp, Buckiinguy Swamp, Harper's Creek, Mundooie Floodplain, Pillicawarrina Floodplain (South), the 'Old Macquarie River' and the Marebone area.

The southern Marshes contains extensive reedbeds, water couch meadows, mixed marsh wetland, river red gum woodlands, lignum and open-water lagoons that support important colonial nesting waterbird breeding sites and feeding habitat. The Macquarie River, Bulgeraga Creek and Monkeygar Creek provide important riparian habitats between Marebone Weir and the northern Marshes.

The southern Marshes is upstream of the northern Marshes and acts as a natural sediment filter and buffer zone. The southern area of the Macquarie Marshes has undergone, and continues to undergo, significant channel changes and associated degradation of floodplain wetlands due to sediment accumulation and river regulation (OEH, 2010).

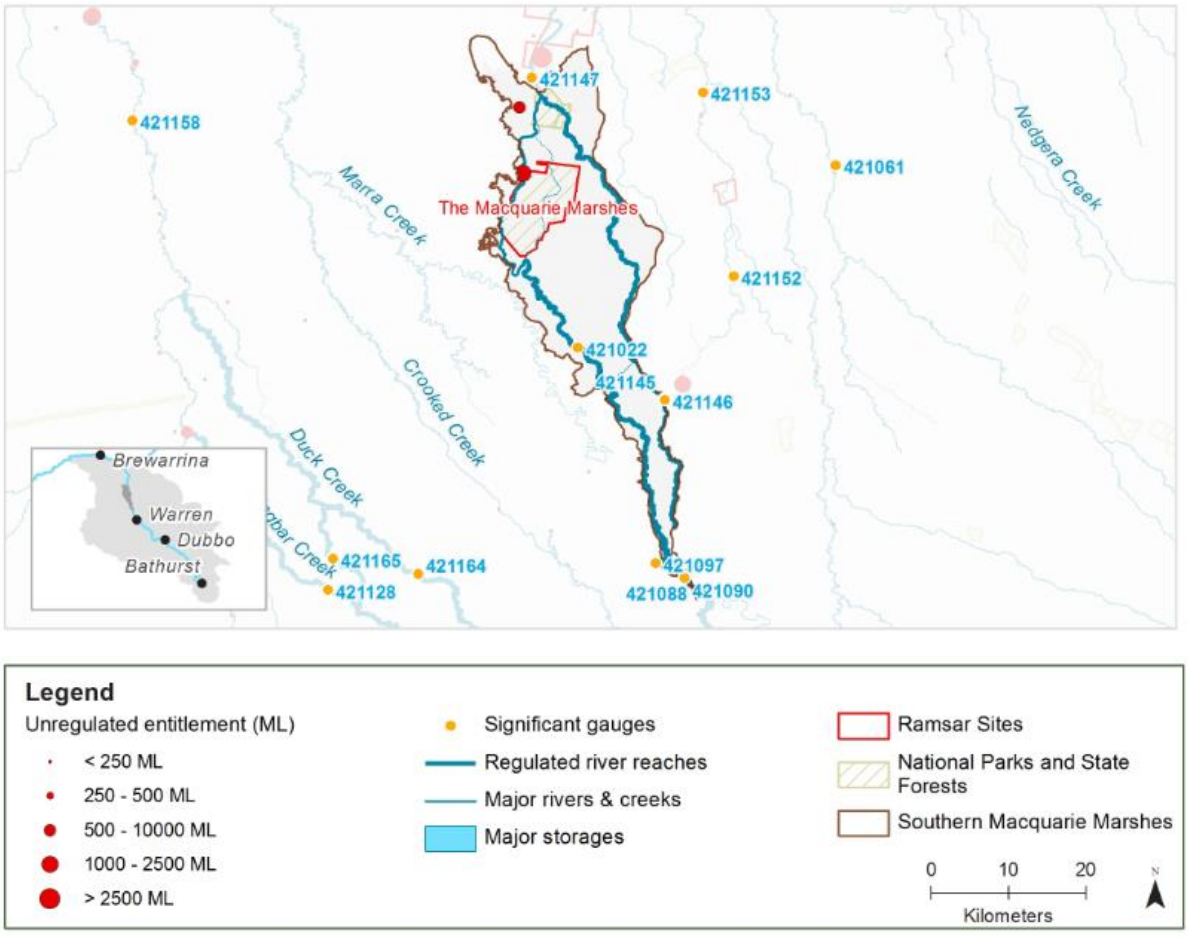


Figure 6 **Map of Southern Macquarie Marshes PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Macquarie River @ Oxley Station (421022), Macquarie River @ D/S Marebone Weir (421090) and Bulgeraga Creek @ Bifurcation (421145).

Named priority environmental assets
Macquarie River channel & floodplain, Buckiinguy Swamp, Harpers Creek, Monkey Swamp, Old Macquarie River Channel and Floodplains, Southern Macquarie Marshes Nature Reserve, South Marsh Reedbed, Monkeygar Creek, Monkeygar Swamp, Stinky Hollow, Willancorah Swamp, Mole Marsh, U-Block, Pillicawarrina Floodplain (South), Mundooie Floodplain, Bulgeraga Creek Channel, Oxley Break, Government Channel, Milmiland Creek

Key ecological values CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.		
Native fish	Australian smelt [X + Y] bony herring (V) [X + Y] carp gudgeon [X + Y] eel tailed catfish (E) [Y] flat-headed gudgeon [X] golden perch [X + Y]	Murray cod (V) [X + Y] Murray–Darling rainbowfish [X + Y] olive perchlet [Y] silver perch (V) [Y] spangled perch [X + Y] un-specked hardyhead [Y]
Waterbirds	66 species recorded, including: Australasian bittern (E), Australian painted snipe (E), black-necked stork (E), blue-billed duck (V), brolga (V), Caspian tern (C,J), common greenshank (C,J,R), common sandpiper (C,J,R), cotton pygmy goose (E), curlew sandpiper (CE; C,J,R), freckled duck (V), Latham's snipe (C,J,R), magpie goose (V), marsh sandpiper (C,J,R), red-necked stint (C,J,R) & sharp-tailed sandpiper (C,J,R)	
Native vegetation	45,771 ha of water-dependent native vegetation communities, including: river red gum (10,671 ha), coolibah (1814 ha), black box (1113 ha), lignum (2088 ha) & non-woody wetland vegetation (10,251 ha)	
Registered water-dependent cultural assets	Carved trees, ceremonial ring, scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring (V), carp gudgeon, flat-headed gudgeon, Murray–Darling rainbowfish & un-specked hardyhead
NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch, spangled perch
NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish (E), Murray cod (V)
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch, Murray cod (V)

Relevant management rules for unregulated sections and recommended management strategies
See above for whole of Marshes (Section 2.5.1)

LTWP EWRs
See above for whole of Marshes (Section 2.5.1)

2.5.3 Northern Macquarie Marshes

The northern Marshes includes the Bora Channel, Ginghet Creek, River Paddock, Pillicawarrina Floodplain, Zoo Paddock, Louden's Lagoon, Hunt's Woodland, Duck Swamp, North Marsh Reedbed, Mullin's Swamp, the confluence of Monkeygar and Bulgeraga creeks, the Macquarie River and the Macquarie Marshes Nature Reserve (North).

The northern Marshes contains large areas of river red gum woodlands, lignum, reedbeds and water couch meadows that support important colonial nesting waterbird breeding sites and feeding habitat for . The northern Marshes also includes the northern section of the Macquarie Marshes Nature Reserve, which is part of the Macquarie Marshes Ramsar site (OEH, 2010).

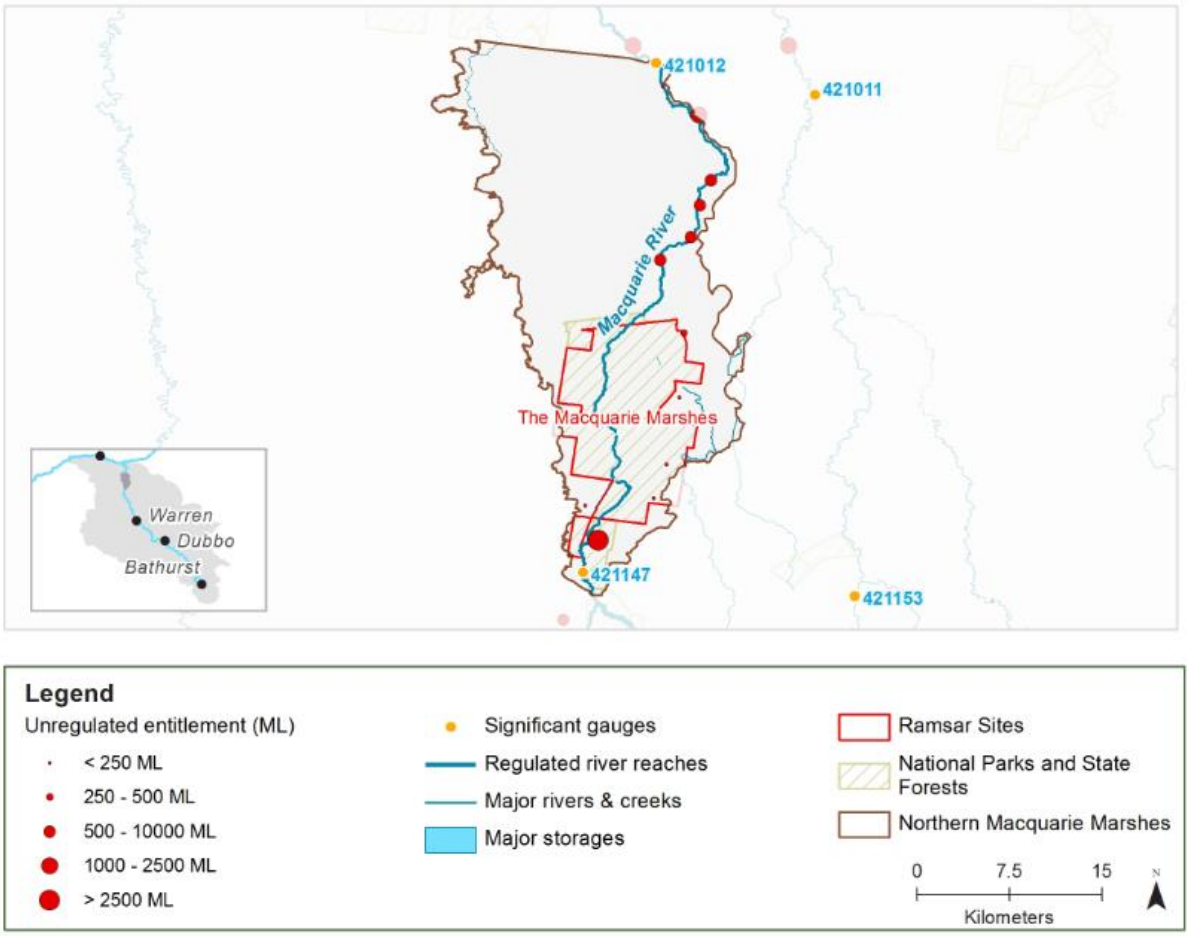


Figure 7 **Map of Northern Macquarie Marshes PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Macquarie River @ Carinda (Bells Bridge) (421012) And Macquarie River @ Pillicawarrina (421147).

Named priority environmental assets
Macquarie River channel & wetlands, Macquarie Marshes Nature Reserve, Pillicawarrina Floodplain (North), North Marsh reedbed, The Bora Creek System, Ginghet Creek, Lower Macquarie Lagoons, Duck Swamp, Hunt's Woodland, Zoo Paddock

Key ecological values CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.		
Native fish	Australian smelt [X + Y] bony herring [X + Y] carp gudgeon [X + Y] golden perch [X + Y] Hyrtl's tandan	Murray cod (V) [Y] Murray–Darling rainbowfish [Y] olive perchlet [Y] silver perch (V) [Y] spangled perch [X + Y]
Waterbirds	70 species recorded, including: Australasian bittern (E), Australian painted snipe (E), bar-tailed godwit (C,J,R), bar-tailed godwit (V,C,J,R), black-necked stork (E), blue-billed duck (V), brolga (V), Caspian tern (C,J), common greenshank (C,J,R), common sandpiper (C,J,R), curlew sandpiper (CE; C,J,R), freckled duck (V), gull-billed tern (C), Latham's snipe (C,J,R), magpie goose (V), marsh sandpiper (C,J,R), sharp-tailed sandpiper (C,J,R) & wood sandpiper (C,J,R)	
Native vegetation	43,281 ha of water-dependent native vegetation communities, including: river red gum (13,648 ha), coolibah (8651 ha), black box (3310 ha), lignum (4732 ha) & non-woody wetland vegetation (7181 ha)	
Registered water-dependent cultural assets	Modified trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp-gudgeon, Murray–Darling rainbowfish
NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, Hyrtl's tandan, spangled perch & silver perch
NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch, Murray cod
NF9 Increase the prevalence and/or expand the population of key moderate to long-lived flow pulse specialists native fish species into new areas (within historical range): Hyrtl's tandan

Relevant management rules for unregulated sections and recommended management strategies
See above for whole of Marshes (Section 2.5.1)

LTWP EWRs
See above for whole of Marshes (Section 2.5.1)

2.5.4 Eastern Macquarie Marshes

The eastern Marsh includes Gum Cowal–Terrigal Creek, Lower Marthaguy Creek Floodplains, Long Plain Cowal and Dusty Swamp, Terrigal Creek Wetlands, Wilgara Wetland, Gum Cowal Lagoons and Floodplain, Gradgery Floodplain and the Jungle & Back Swamp.

The eastern Marsh has open water lagoons, river red gum woodlands, lignum and water couch meadows that support important colonial nesting waterbird breeding sites and feeding habitat. The eastern Marsh includes the Wilgara Wetlands portion of the Macquarie Marshes Ramsar site.

Parts of the area, such as the Long Plain Cowal and Dusty Swamp are inundated only in medium to large floods that are beyond the scope of most managed environmental flows (under current conditions). Marthaguy Creek is unregulated, flowing independently from the east, joining Terrigal Creek upstream of the “Ninia” section of the Macquarie Marshes Nature Reserve. Terrigal Creek flows north through the “Wilgara” Ramsar site before joining Marthaguy Creek.

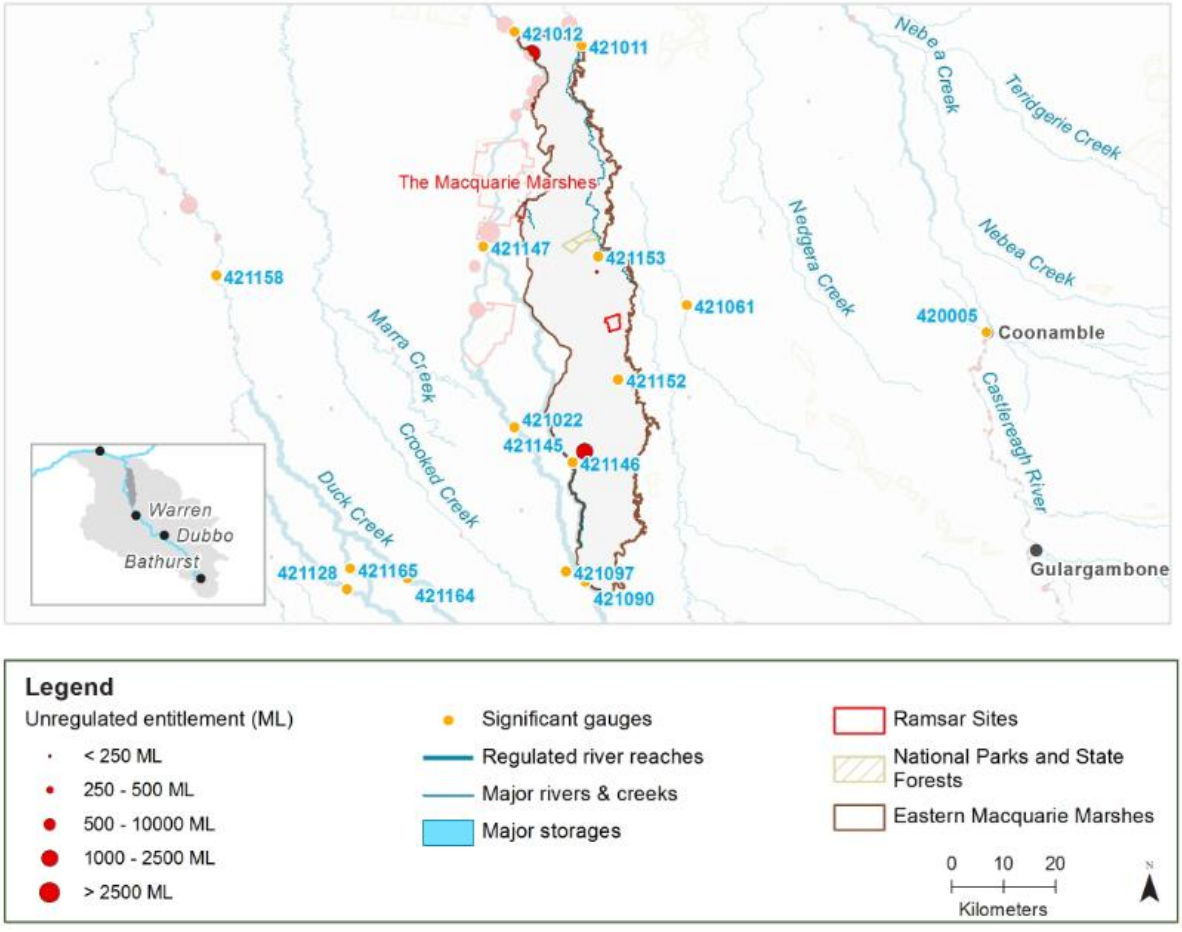


Figure 8 **Map of Eastern Macquarie Marshes PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Marebone Break @ D/S Marebone Regulator (421088), Gum Cowal @ Bifurcation (421146), Gum Cowal @ Oxley (421152), Terrigal Creek @ U/S Marthaguy Creek (421153), Marthaguy Creek @ Carinda (421011).

Named priority environmental assets		
Gum Cowal lagoons & floodplains, Gum Cowal Terrigal, Terrigal Creek and wetlands, Wilgara Wetland, Long Plain Cowal, Dusty Swamp/Cowal, Dusty Creek, Back swamp, Marthaguy Creek, Merri Merri creek		
Key ecological values CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.		
Native fish	Australian smelt X + Y bony herring X + Y carp-gudgeon X + Y golden perch X + Y Hyrtl's tandan Murray cod (V) X + Y	Murray–Darling rainbowfish X + Y olive perchlet X + Y spangled perch X + Y silver perch (V) X + Y un-specked hardyhead X + Y
Waterbirds	66 species recorded, including: Australasian bittern (E), Australian painted snipe (E), black-necked stork (E), blue-billed duck (V), brolga (V), Caspian tern (C,J), common greenshank (C,J,R), common sandpiper (C,J,R), curlew sandpiper (CE; C,J,R), freckled duck (V), gull-billed tern (C), Latham's snipe (C,J,R), magpie goose (V), marsh sandpiper (C,J,R) sharp-tailed sandpiper (C,J,R) & wood sandpiper (C,J,R)	
Native vegetation	90,468 ha of water-dependent native vegetation communities, including: river red gum (16,011 ha), coolibah (10,268 ha), black box (17,678 ha), lignum (15,446 ha) & non-woody wetland vegetation (1452 ha)	
Registered water-dependent cultural assets	Resource & gathering, scarred trees & modified trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp-gudgeon, Murray–Darling rainbowfish & un-specked hardyhead
NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, Hyrtl's tandan, spangled perch & silver perch (V)
NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod (V)
NF6 A 25% increase in abundance of mature (harvestable sized): Murray cod (V) & golden perch
NF9 Increase the prevalence and/or expand the population of key moderate to long-lived flow pulse specialists native fish species into new areas (within historical range): Hyrtl's tandan

Relevant management rules for unregulated sections and recommended management strategies
See above for whole of Marshes (Section 2.5.1)

LTWP EWRs
See above for whole of Marshes (Section 2.5.1)

2.6 Lower Macquarie

The Lower Macquarie River, as defined locally, commences downstream of the northern Macquarie Marshes where the river channel re-forms. It extends approximately 80km to the confluence with the Barwon River. This PU commences at the Carinda (Bells Bridge) gauge and extends downstream to the Barwon River.

Flows into the lower Macquarie generally come via the northern Marshes, either from the Bora system, northern Marshes reedbed or the North Marsh Bypass Channel – sometimes a combination of all three. The lower Macquarie River is joined by the lower Marthaguy Creek and Castlereagh River just upstream of its confluence with the Barwon River (Torrible et. al, 2011).

The Lower Macquarie Planning Unit includes the lower sections of the lower Macquarie River water source area and the Marthaguy Creek water source area.

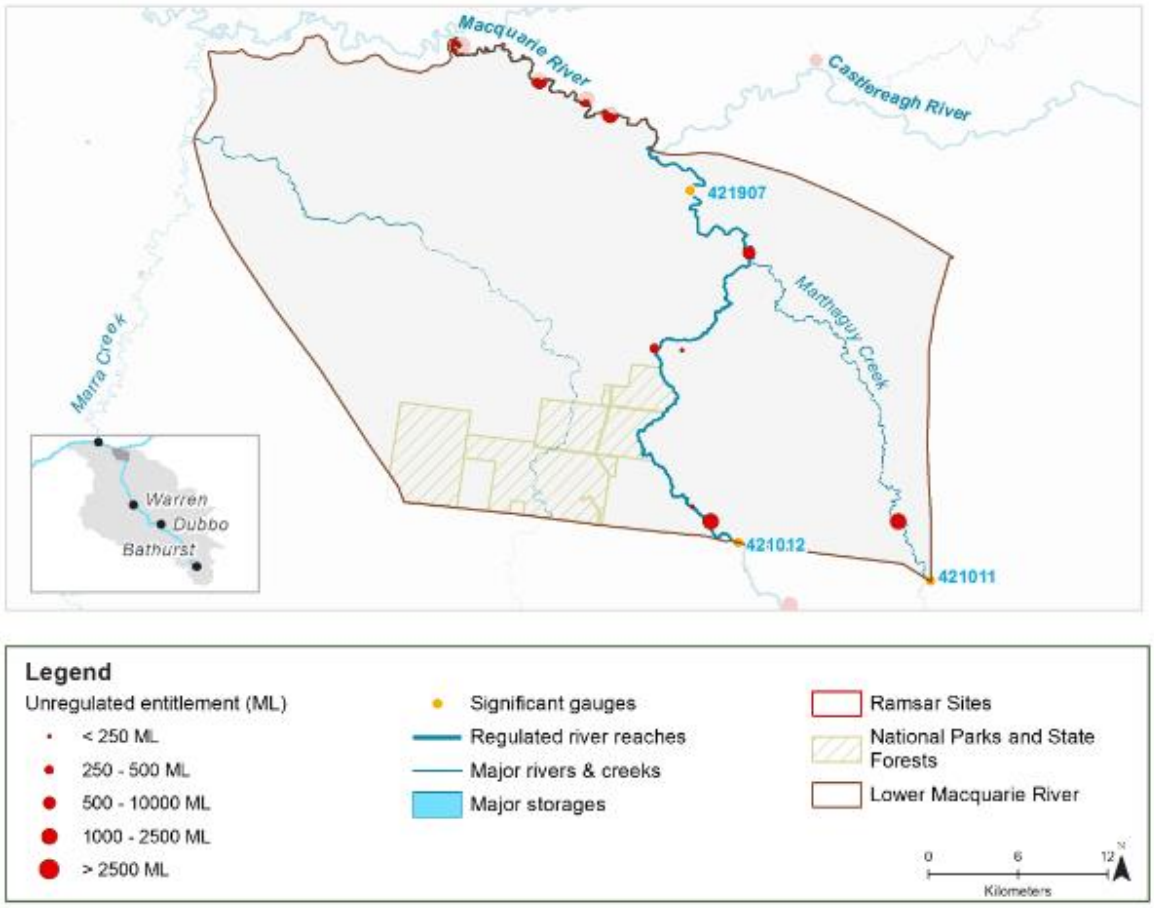


Figure 9 **Map of Lower Macquarie PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Macquarie River @ Brewon Bridge (421907), Marthaguy Creek @ Carinda (421011) and Macquarie River @ Carinda (Bells Bridge) (421012).

Named priority environmental assets

- Lower Macquarie River channel & floodplains
- Mullins Swamp
- Ginghet Creek
- Briery Anabranch
- Lower Marthaguy Creek
- Floodplain Wetlands

Key ecological values

CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.

Native fish	Australian smelt [Y] bony herring [X + Y] carp gudgeon [X + Y] golden perch [X + Y] Hyrtl's tandan	Murray cod (V) [X + Y] Murray-Darling rainbowfish [Y] olive perchlet [Y] silver perch (V) [Y] spangled perch [X + Y]
Waterbirds	35 species recorded, including: freckled duck (V)	
Native vegetation	54,772 ha of water-dependent native vegetation communities, including: river red gum (325 ha), coolibah (17,672 ha), black box (17,672 ha), lignum (580 ha) & non-woody wetland vegetation (2436 ha)	
Registered water-dependent cultural assets	Ceremony & dreaming & scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, Murray-Darling rainbowfish

NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, Hyrtl's tandan, silver perch & spangled perch

NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch, Murray cod

NF7 Increase the prevalence and/or expand the population of key short to moderate-lived floodplain specialist native fish species into new areas (within historical range): olive perchlet

NF9 Increase the prevalence and/or expand the population of key moderate to long-lived flow pulse specialists native fish species into new areas (within historical range): silver perch, Hyrtl’s tandan

Hydrology (DPIE Water, in prep)

The Lower Macquarie Water Source Area has experienced a moderate to high degree of hydrological alteration. As assessed by the Macquarie-Castlereagh WRPA Risk Assessment, cease-to-flow, low flow & baseflows, freshes and overbanks have all decreased compared to modelled near-natural conditions.

The Lower Macquarie water source area (which also includes areas of the Macquarie Marshes PUs) has 51,888 ML of entitlement. The section covered by this PU (downstream of Bells Bridge) contains 10 licences totalling just over 19,000 ML of entitlements, with one of these licences (of around 1,600 ML) being a 'special high flow' entitlement requiring 245 ML/day at the Bells Bridge (Carinda) gauge before take is permitted. The licences are spread along the length of the river in this PU, with one licence within 1 km of the junction with the Barwon.

Hydrological alteration See Table 1 for key	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
	H-	M-	M-	H-/M-
Relevant rules from WSP	**Trade INTO** water source: permitted in from the Marthaguy Creek water source, the Gum Cowal management zone & the Lower Macquarie River Upstream management zone only, subject to the higher access rule of 50ML/d on Macquarie River @ Bells Bridge (Carinda). Trades in of unregulated river (special additional high flow) licences not permitted. **Trade WITHIN** water source: Permitted, subject to assessment No pool drawdown For pump sites not within a natural pool, cease to pump rule when no visible flow. For licences traded in pumping is not permitted when Macquarie River @ Bells Bridge (Carinda) gauge is ≤50 ML/d			

Recommended management strategies

- Consider adding specific commence-to-pump rules in the WSP within five years to:
  - better protect low flows & baseflows
  - *investigate increasing commence-to-pump to 65 ML/d at Bells Bridge (Carinda) (421012).*
- Consider rostering landholder water access during low flow months
- Consider implementing total &/or individual daily extraction limits (IDELS & TDELS)
- Consider implementing a first flush rule to ensure periods between small freshes are not excessively prolonged
- Consider targeted water access licence purchases from willing sellers *(Note licence purchase may not reduce extraction of events in dry periods – water normally taken by the purchased licence may be taken by downstream licences. In such cases purchases may need to target the most downstream licences)*
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Protect water for the environment that originates from held water entitlements & the EWA.
- Maintain existing rules in the WSP to maintain priority environmental assets
- Consider restrictions to take in water sources bordering the Barwon River when embargoes on take exist in the Barwon River
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes
- Improve the gauging network to better indicate flow distribution and take, particularly for the gauging of flow below the most downstream extraction point.

Table 9 LTWP EWRs for the Lower Macquarie River as measured at Bells Bridge (Carinda) (421012) unless otherwise specified

Flow category and EWR code[35]		Flow volume[35]	Timing[35]	Duration[35]	Frequency (LTA frequency)[35]	Maximum inter-event period[35]	Additional requirements and comments[35]
Cease-to-flow	CTF	0 ML/d	In line with natural. Typically occurs Nov–June	Maximum duration: In moderate years persist for 27 days & do not persist for more than 138 days[36]	Should not occur more than 69% of years[36]		
Very-low-flow[37#]	VLF	Evidence of flow to confluence with Barwon, nominally >10 ML/d at Bells Bridge[38]	Anytime	In moderate years, 267 days per year. In very dry years, at least 34 days per year[36]	Days with >10 ML/day of flow occurred in at least 96% of years pre 1966[36]	450 days[36]	No fish refuge pools greater than 2m deep identified; however, there would still be benefits in protecting this flow for other objectives within this PU.

[35] Refer to Glossary for definitions of terms and explanatory text for EWRs

[36] Based on 1938–1966 observations, except for CTF, which is likely to have been heavily impacted by development prior to 1966. CTF is based on 1984–2017 observations. Maximum durations (for CTF) and maximum inter-event periods and 'very dry year' durations (for other flows) are based on 95th percentiles. BF2 'very dry year' duration based on the 25th percentile as this flow is only required every 5–10 years. Duration for 'moderate years' is based on the number of days of flow in the median year. Maximum inter-event period for VLF and BF1 have been rounded from 492 days (for VLF) and 432 days (for BF1) to avoid the counterintuitive result caused by the greater number of smaller breaks in the BF1 results calculating a lower number for it.

[37] Orange shading (and # in the 1st column of row) denotes that these flows are not a priority for delivery of discretionary water as there are no identified fish refuge pools in this planning unit. However, the LTWP acknowledges the importance of protecting these flows for other ecological objectives (e.g. Native vegetation NV1, NV3; Ecosystem functions EF1, EF2, EF6 etc.)

[38] Actual flow required at Bells Bridge to provide trickle flow to the Barwon will vary depending on antecedent and seasonal conditions. Flow of 10 ML/day at Bells Bridge used to provide initial analysis for historical frequencies and durations. Flow at Brewon gauge (421907), which is closer to the confluence with the Barwon will assist in determining if flow is likely to reach the Barwon.

Flow category and EWR code[35]		Flow volume[35]	Timing[35]	Duration[35]	Frequency (LTA frequency)[35]	Maximum inter-event period[35]	Additional requirements and comments[35]
Baseflow[39]	BF1	>100 ML/d	Anytime	In moderate years, 208 days per year. In very dry years, at least 13 days per year[39]	Days with >100 ML/day of flow occurred in at least 96% of years pre 1966[36]	450 days[36]	
	BF2	>100 ML/d	Sep–Mar	In moderate years, 128 days per season. In very dry years, at least 42 days per season[39]	5–10 years in 10 (75% of years)	2 years	
	BF3	N/A	N/A No fish refuge pools greater than 2 metres deep identified in this planning unit				
De-stratifying flow	DSF	N/A	N/A No fish refuge pools greater than 2 metres deep identified in this planning unit				
Small fresh	SF1	>140 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10)	1 year	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 15% per day for 'pre-development' observed flows from 1938–1960 (e.g. 140ML-120ML-100ML)
	SF2	140–700 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	

[39] Baseflows in this planning unit have markedly reduced in frequency. Due to limited availability of water the targets are not currently likely to be achieved. However, they remain to highlight the degree of impact on flows in this reach, which is important for fish connectivity between the Barwon and Macquarie systems.

Flow category and EWR code[35]		Flow volume[35]	Timing[35]	Duration[35]	Frequency (LTA frequency)[35]	Maximum inter-event period[35]	Additional requirements and comments[35]
	SF3	>140 ML/d	Anytime (ideally July–Sep for initial flow & Oct–Apr for subsequent flow)	28 days	5 years in 10 (50% of years)	4 years	For movement of fish recruits from Barwon River
Large fresh[40]*	LF1	>700 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 10% per day for 'pre-development' observed flows from 1938–1960 (e.g. 700ML-630ML-570ML).
	LF2	>700 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	
Overbank/ Wetland flow Small[40]*	OB/ WS1	Not applicable. For core wetland areas, which are not a feature of this PU					
	OB/ WS2	>1,900 ML/d	Oct–Apr (but for this northernmost river section, anytime is considered acceptable)	10 days	5–10 years in 10 (75% of years)	4 years	This flow is not as high a priority as in other PUs because there are fewer off-channel wetlands that would provide lasting habitat

[40] Grey shading (and * in 1st column of row) denotes that flows of this size are not able to be delivered with discretionary environmental water (although deliveries to the Marshes assist in achieving these flows). Flows of this size are dependent on natural events but may be impacted by water policy including floodplain harvesting and flood mitigation zone management.

Flow category and EWR code[35]		Flow volume[35]	Timing[35]	Duration[35]	Frequency (LTA frequency)[35]	Maximum inter-event period[35]	Additional requirements and comments[35]
	OB/ WS3	>1,900 ML/d	Anytime (ideally Sep–Feb)	5 days (the median duration of flows is greater than 5 days. 5 days is also used for riparian river red gum requirements)	2–3 years in 10 (25% of years)	5 years	For both fish dispersal/condition & riparian river red gum
	OB/ WS4	>1,900 ML/d	Anytime (ideally Aug–Mar)	Persistence of water 3 months. Flow of 5 days estimated as required to fill depressions & soil profile.	3–10 years in 10 (65% of years)	5 years	Lower frequency required in this PU because the main non-woody vegetation is rats tail couch.
Overbank/ Wetland flow Medium[41] *	OB/ WM	Not determined	Anytime (ideally Aug–Mar)	Persistence of water. 3 months for wetland depressions.	5 years in 10 (50% of years)	5 years	
Overbank/ Wetland flow Large[41] *	OB/ WL	Not determined	Anytime (ideally Aug –Mar)	Persistence of water 3 months for wetland depressions.	2–3 years in 10 (25% of years)	5–10 years	

[41] Grey shading (and * in 1st column of row) denotes that flows of this size are not able to be delivered with discretionary environmental water (although deliveries to the Marshes assist in achieving these flows). Flows of this size are dependent on natural events but may be impacted by water policy including floodplain harvesting and flood mitigation zone management.

2.7 Marra Creek

The Marra Creek PU encompasses Marra Creek and Crooked Creek (upper and Lower). Marra Creek is an unregulated stream over 250 km long and reaches the Barwon River upstream of Brewarrina. Marra Creek receives water from three sources:

- local rainfall
- the Marra cutting (a constructed channel from the Marebone Weir pool to Marra Creek with a channel capacity of 250 ML/d)
- the creek's natural off-take channel, which starts upstream of Marebone Weir and has a commence-to-flow of about 3,200 ML/d at Marebone Weir (combined gauged flows).

Under the *Macquarie Cudgegong Water Regulated Sharing Plan*, Marra Creek can receive an annual stock and domestic replenishment flow of up to 15,000 ML (Torrible et al. 2011).

Crooked Creek commences as an offtake of Gunningbar Creek. Flows are controlled by a regulator and can eventually reach Marra Creek. Regulated water supplies are provided to the upper Crooked Creek for limited irrigation and stock and domestic use as far as the "Mumblebone" Weir. Downstream of Mumblebone" Weir the lower Crooked Creek is unregulated (Torrible et al. 2011).

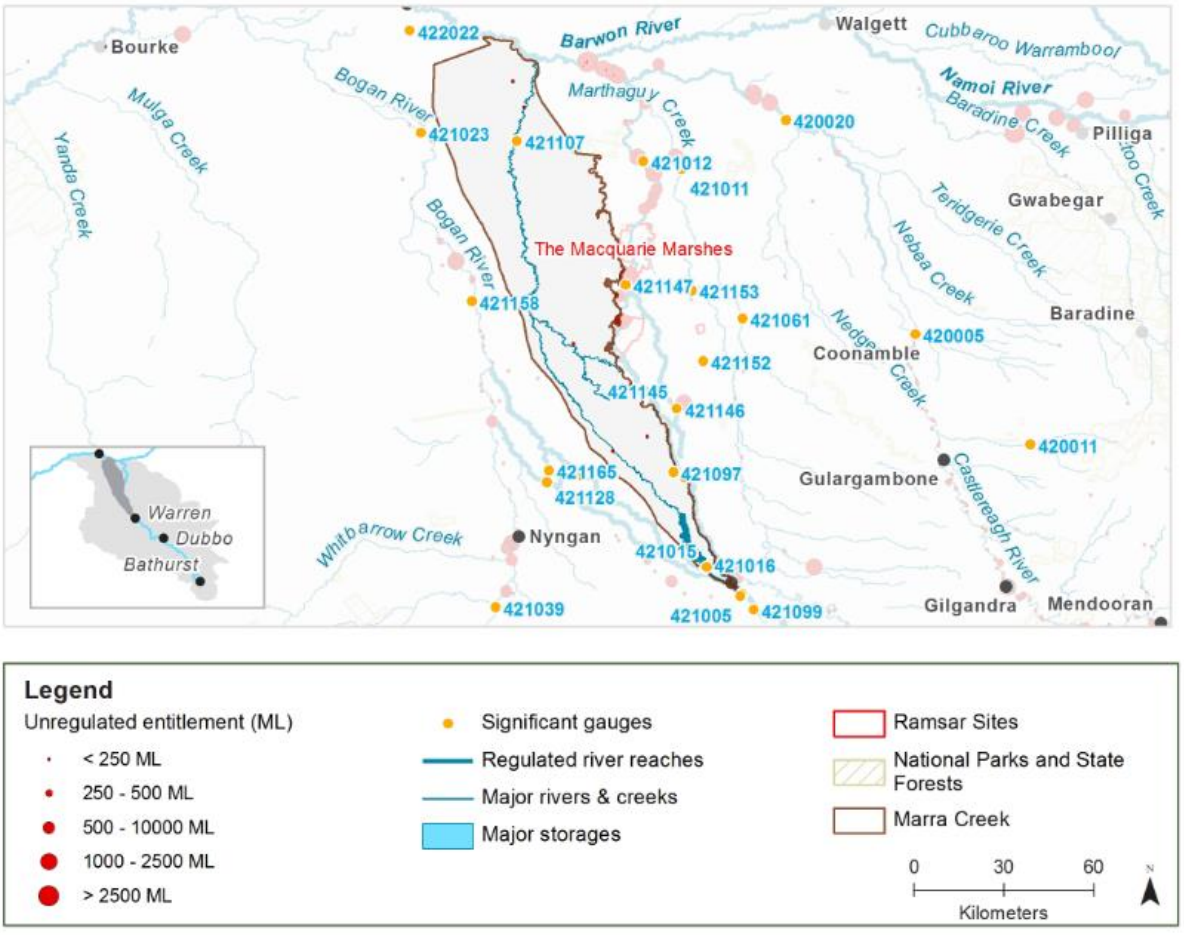


Figure 10 **Map of Marra Creek PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Marra Creek @ Billybingbone Bridge (421107), Marra Creek @ Carinda Road (421097) and Crooked Creek @ Profile (421016)

Named priority environmental assets		
Marra Creek channel & riparian zone, Marra Creek Flooplain Wetlands, Crooked Creek, Bulla Bulla Creek, Milmiland Creek, Middle Creek, Sandy Cowal, The Big Lagoon, Womby Cowa, Briery Creek, Tarrion Creek, Burlong Creek, Bread and Cheese Creek, McClures Creek		
Key ecological values CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.		
Native fish	Australian smelt [X + Y] bony herring [X + Y] carp-gudgeon [X + Y] eel-tailed catfish (E) [X + Y] flat-headed gudgeon [X + Y] golden perch [Y]	Murray cod (V) [Y] Murray–Darling rainbowfish [X + Y] olive perchlet [Y] silver perch (V) [Y] spangled perch [X + Y] un-specked hardyhead [Y]
Waterbirds	55 species recorded, including: Australasian bittern (E), Australian painted snipe (E), bar-tailed godwit (C,J,R), black-necked stork (E), blue-billed duck (V), brolga (V), common greenshank (C,J,R), Latham's snipe (C,J,R), magpie goose (V), marsh sandpiper (C,J,R) & sharp-tailed sandpiper (C,J,R)	
Native vegetation	202,430 ha of water-dependent native vegetation communities, including: river red gum (15,652 ha), coolibah (20,130 ha), black box (26,481 ha), black box/coolibah (11,551 ha), lignum (1145 ha) & non-woody wetland vegetation (7079 ha)	
Registered water-dependent cultural assets	Carved trees & scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp-gudgeon, flat-headed gudgeon, Murray–Darling rainbowfish, & un-specked hardyhead
NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch, spangled perch
NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish, Murray cod
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE Water, in prep)

The Marra Creek Water Source Area has experienced a moderate to high degree of hydrological alteration. As assessed by the Macquarie-Castlereagh WRPA Risk Assessment, low flow & baseflows and freshes have increased compared to modelled near-natural conditions. Overbank events have experienced a moderate to high decrease compared to modelled near-natural conditions. There are 5 water access licences with entitlements of >250 ML distributed throughout the water source. The total volume of entitlements for the water source is 311 ML.

Hydrological alteration	CTF	Low flow & baseflow	Freshes	Overbanks
See Table 1 for key	L+	H+	H+	H-/M-
Relevant rules from WSP	**Trade INTO** water source: Not permitted **Trade WITHIN** water source: Permitted, subject to assessment No pool drawdown For pump sites not within a natural pool, cease to pump rule when no visible flow.			

Recommended management strategies

- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Protect water for the environment that originates from held water entitlements & the EWA.
- Maintain existing rules in the WSP to maintain priority environmental assets
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

Further work

- Sections 4.6 and 7.2 in Part A of the LTWP identify that further work would be beneficial to improve flow and asset information in Marra Creek. They also identified the need for further work determining the feasibility of delivering water to the Talga Wetland/overflow of lower Crooked Creek

2.8 Lower Bogan River

The Lower Bogan commences directly downstream of the Nyngan Weir pool and flows north to reach the Barwon River downstream of Brewarrina. The Lower Bogan is unregulated but receives regulated flow from the Macquarie River at Nyngan via the Albert Priest channel and can also receive flows via the regulated Gunningbar and Duck Creeks. The Nyngan weir pool provides water supply to Nyngan and Cobar, and some water supply for local irrigation. The Lower Bogan provides water supply to a number of grazing and irrigation businesses and residences along the section, and to the village of Gongolgon and Brewarrina Correction Facility.

Gunningbar Creek is a distributary creek which flows to the northwest and is provided regulated water from the Warren Weir pool (a regulator controls creek flows from the weir pool). It joins the Bogan River downstream of Nyngan. Gunningbar Creek is regulated and used to provide regulated water supplies for irrigation, mining and stock and domestic use. A stock and domestic replenishment of up to 1,000 ML is provided between Nyngan and the Gunningbar junction and 15,000 ML is provided from Gunningbar Creek for the lower Bogan to the Barwon River junction (Barma, 2011). The main operational constraint for regulated water delivery is a 150-200 ML/d limit at Fairview Dam on Gunningbar Creek. Some of the flow above this level escapes into Bena Billa Creek and then into Duck Creek (Barma, 2011). River regulation has substantially altered the flow regime of Gunningbar Creek as it no longer dries out as it would have under pre-development conditions (Torrible et al. 2011).

Duck Creek is regulated for limited irrigation and stock and domestic use to its junction with the Bogan River downstream of Nyngan and the Gunningbar junction. Duck Creek is also connected to the regulated Upper Crooked Creek and to Bena Billa Creek. Duck Creek now receives continuous low flows which have resulted in significant degradation of its natural ecological values (Barma, 2011), although it does now provide refugia for native fish species.

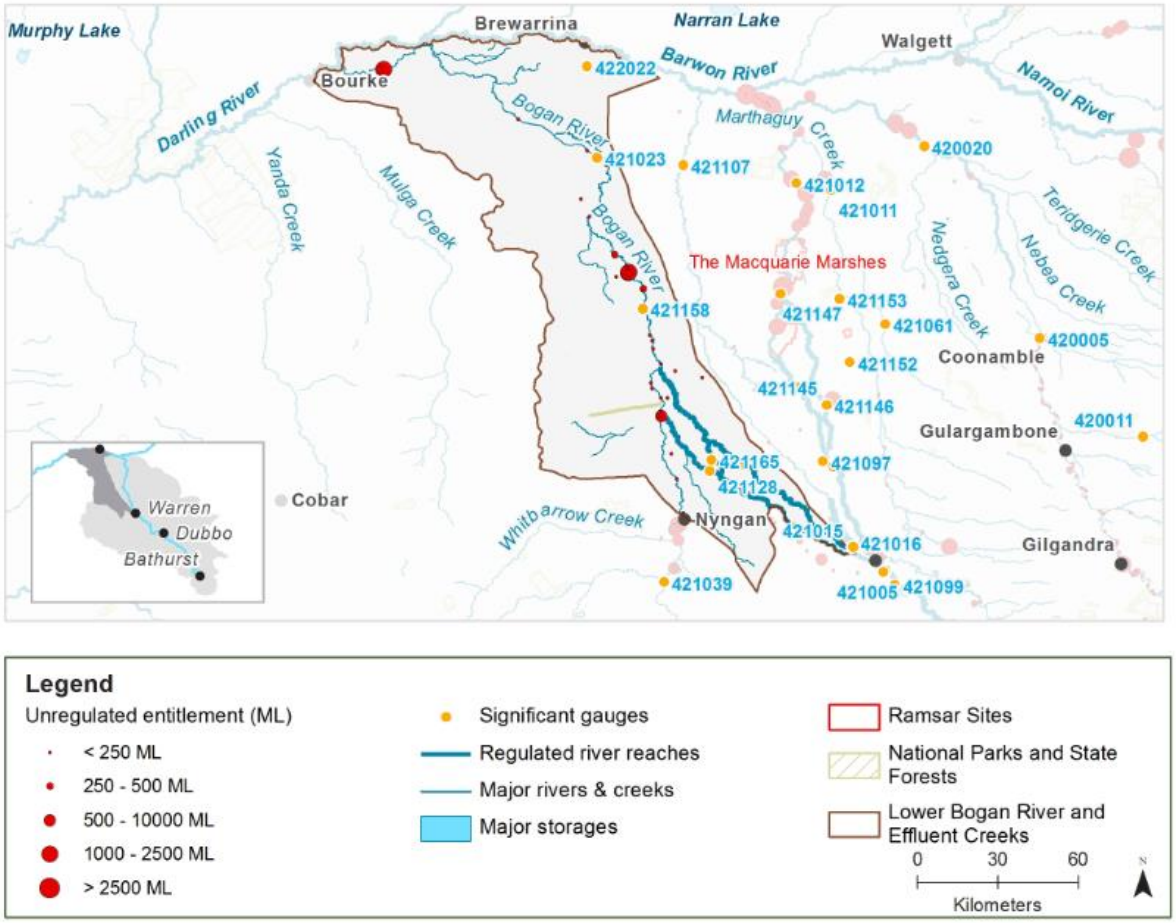


Figure 11 **Map of Lower Bogan River PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Duck Creek @ Offtake (421015), Gunningbar Creek @ Box Culverts (421128), Beni Billa Creek @ Downstream Canonba Road (421165), Bogan River @ Monkey Bridge (421158), Bogan River @ Gongolgon (421023)

Named priority environmental assets

Bogan River channel & floodplain, Gunningbar Creek, Rigleys Cowal, Doyles Creek, Box Cowal, Moonagee Cowal, Belar Creek, Yongee Creek, Merungle Creek, Goldbiddie Cowal, Bugwah Cowal, Turners Creek, Yangunyah Cowal, Keerugulla Lake, Tarrion Creek, Kellys Cowal, Piano Creek, Little Bogan River, Bena Billa Creek, Nyangi Bogan Cowal, Duck Creek, Goldbiddie Cowal, Boomi Creek, The Duckholes, Finneys Cowal, Floodplain wetlands

Key ecological values

CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling.

Native fish	Australian smelt [X + Y]	Hyrtl's tandan [X + Y]
	bony herring [X + Y]	Murray cod (V) [X + Y]
	carp-gudgeon [X + Y]	Murray–Darling rainbowfish [X + Y]
	flat-headed gudgeon [X]	olive perchlet [X + Y]
	flathead galaxias (CE) [Y]	spangled perch [X + Y]
	eel-tailed catfish (E) [X + Y]	silver perch (V) [Y]
	golden perch [X + Y]	un-specked hardyhead [X + Y]

Waterbirds	53 species recorded, including: Australasian bittern (E), Australian painted snipe (E), black-tailed godwit (V), blue-billed duck (V), brolga (V), common greenshank (C,J,R), Latham's snipe (C,J,R), marsh sandpiper (C,J,R) & sharp-tailed sandpiper (C,J,R)
Native vegetation	233,541 ha of water-dependent native vegetation communities, including: river red gum (7664 ha), coolibah (17,185 ha), black box (47,746 ha), black box/coolibah (21,107 ha), lignum (5068 ha) & non-woody wetland vegetation (10,883 ha)
Registered water-dependent cultural assets	Camp sites & scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, flat-headed gudgeon, bony herring, Murray–Darling rainbowfish, un-specked hardyhead

NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet & flathead galaxias

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch, Hyrtl's tandan & spangled perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish & Murray cod

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

NF7 Increase the prevalence &/or expand the population of key moderate to long-lived riverine specialists into new areas (within historical range): olive perchlet

NF9 Increase the prevalence &/or expand the population of key moderate to long-lived flow pulse specialists into new areas (within historical range): Hyrtl's tandan

Hydrology (DPIE Water, in prep)

The Lower Bogan Water Source Area has experienced a moderate to high degree of hydrological alteration. As assessed by the Macquarie-Castlereagh WRPA Risk Assessment, cease-to-flow events, freshes and overbank events have all decreased compared to near-natural conditions. Low flow and baseflow events have experienced a high increase compared to modelled near-natural conditions. There are 27 water access licences within the water source (>250 ML X 20, 250-500 ML X 3, 1000-2500 ML X 2 and > 2500 ML X 2). The total volume of unregulated entitlements for the water source is 41,374 ML, 39,029 ML of which is in four 'special additional high flow' licences. These require flows of 160 ML/day at Gongolgon Weir before take is allowed.

Hydrological alteration (Bogan at Gongolgon (421023)) See Table 1 for key	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
	H-	H+	M-	M-/H-

Relevant rules from WSP	**Trade INTO** water source: permitted from the Upper Bogan River & Bulbodney Grahway Creek water sources. Trades in unregulated river (special additional high flow) licences are not permitted into this water source **Trade WITHIN** water source: Permitted, subject to assessment No pool drawdown For pump sites not within a natural pool, cease to pump rule when no visible flow.

Recommended management strategies

- Consider rostering landholder water access during low flow months.
- Consider implementing total &/or individual daily extraction limits (IDELS & TDELS)
- Improve the gauging network to better indicate flow distribution and take, particularly for the gauging of flow below the most downstream extraction point.
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Consider implementing a first flush rule to ensure periods between small freshes are not excessively prolonged
- Protect water for the environment that originates from held water entitlements & the EWA.
- Maintain existing rules in the WSP to maintain priority environmental assets
- Consider restrictions to take in water sources bordering the Barwon River when embargoes on take exist in the Barwon River
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

Further work

Sections 4.6 and 7.2 in Part A of the LTWP identify a number of issues with the distributary (effluent) creeks in this PU. These relate to:

- investigating possible ways to improve flow variability in some distributary creeks
- improving flow and asset information in the distributary (effluent) creeks.

Further work to determine the importance of non-woody wetlands near Doyle's Creek would also be beneficial. If deemed of conservation value, further work would then be required to determine the flow regime required and the feasibility of protecting flows or providing flows to the area.

Table 10 LTWP EWRs for the Lower Bogan River at Gongolgon Bridge (421023).

As the Lower Bogan River at Gongolgon Bridge is unregulated42, the values provide an indication of the flow sizes and frequencies which should ideally be protected. All information should be considered preliminary based on the limited data available (modelled data is provisional and gauge information is from weirs – making determination of baseflow levels difficult)

Flow category and EWR code[43]		Flow volume[43]	Timing[43]	Duration[43]	Frequency (LTA frequency)[43]	Maximum inter-event period[43]	Additional requirements and comments[43]
Cease-to-flow	CTF	0 ML/d					Not analysed due to poor data set and difficulty in analysing low flows
Very low flow	VLF	Not determined	Anytime				Not analysed due to poor data set and difficulty in analysing low flows
Baseflow	BF1	>100 ML/d (provisional estimate)	Anytime				Not analysed due to poor data set and difficulty in analysing low flows
	BF2	>100 ML/d (provisional estimate)	Sep–Mar				Not analysed due to poor data set and difficulty in analysing low flows
	BF3	To be determined[44]	As required to avoid stratification during periods of identified high risk where a hypoxic bottom layer is likely to develop to an extent that it could produce hypoxic conditions in the entire water column should subsequent mixing occur. Requirement more likely during periods of extreme heat and low flow. This flow would also help reduce the risk of fish mortality due to extremely high water temperatures.				As these flows are to maintain water quality, weir level management (where relevant), natural flows, operational water and non-discretionary environmental

[42] Regulated flows via Gunningbar Creek could contribute to smaller flows at Gongolgon Bridge, but due to delivery capacities and on-route ‘loses’ this may not often be practical or the most effective use of available water.

[43] Refer to Glossary for definitions of terms and explanatory text for EWRs

[44] Further work is required to confirm thresholds. See action on ‘tools for preventing fish deaths due to stratification’ in Table 22 of Part A.

Flow category and EWR code[43]		Flow volume[43]	Timing[43]	Duration[43]	Frequency (LTA frequency)[43]	Maximum inter-event period[43]	Additional requirements and comments[43]
			Further work (see Table 22 of Part A) is required to provide tools to develop flow requirements.				water should be used in the first instance before considering the use of discretionary environmental water.
Destratifying flow	DSF	To be determined[44]	As required to destratify refuge pools during periods of identified high risk where a hypoxic bottom layer has developed and could produce hypoxic conditions in the entire water column when mixed. Requirement more likely during periods of extreme heat and low flow. Further work (see Table 22 of Part A) is required to better identify risk periods and provide tools to develop flow requirements.				The DSF flow must be provided in a manner which considers potential impacts from turning over refuge pools and initial water temperature increases from flows travelling over hot, dry river beds. Consult NSW DPI-Fisheries on interim flow protocols and in developing detailed future requirements (see recommended further work, Table 22 of Part A).
Small fresh	SF1	>400 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10)	1 year	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 30% per day for 'pre-development' observed flows from 1947–1960 (e.g. 400ML-280ML-200ML).
	SF2	400–1,500 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	
	SF3	>400 ML/d	Anytime (ideally July–Sep for initial flow & Oct–Apr for subsequent flow)	28 days	5 years in 10 (50% of years)	4 years	For movement of fish recruits from Barwon River
Large fresh	LF1	>1,500 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural

Flow category and EWR code[43]		Flow volume[43]	Timing[43]	Duration[43]	Frequency (LTA frequency)[43]	Maximum inter-event period[43]	Additional requirements and comments[43]
	LF2	>1,500 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 35% per day for 'pre-development' observed flows from 1947-1960 (e.g. 1500ML-975ML-635ML).
Overbank/ Wetland flow Small	OB/ WS1	Not applicable. This flow is for core wetland areas, which are not a feature of this PU					
	OB/ WS2	>4,500 ML/d	Oct–Apr (but for this northern river section, anytime is considered acceptable)	10 days	Ideally 4–10 years in 10 (70% of years), but this may only be achieved in wetter sequences- see 'additional information' column))	4 years	There are objectives to support the floodplain specialist native fish, the olive perchlet, in this planning unit. Analysis shows small overbanks of 10 days duration only occur in 37% of years (when assessed for pre-development observed flows as any time of year). Therefore, this species may only be supported in wetter sequences of years or in off-channel wetlands that are filled at below bankfull levels. Following dry sequences recruits may come from the Barwon, but this requires further research to be confirmed.
	OB/ WS3	>4,500 ML/d	Anytime (ideally Sep–Feb)	5 days (the median duration of flows is greater than 5 days. 5 days is also used for riparian river red gum requirements)	2–3 years in 10 (25% of years)	5 years	For both fish dispersal/condition & riparian river red gum

Flow category and EWR code[43]		Flow volume[43]	Timing[43]	Duration[43]	Frequency (LTA frequency)[43]	Maximum inter-event period[43]	Additional requirements and comments[43]
	OB/ WS4	>4,500 ML/d	Vegetation mapping in the planning unit shows some areas of non-woody vegetation exist, particularly around Doyle's Creek and this is predominantly water couch. Further work on that creek system to determine the conservation value of the non-woody vegetation there would be beneficial. If considered of conservation value, then further work would be required to determine the viability of protecting or providing flows to it. In terms of the Lower Bogan system as a whole, because there is an absence of substantial areas of non-woody veg associated with main river channels and because of the relatively low frequency of overbanks, no planning unit wide flow for non-woody wetland vegetation is proposed.				
Overbank/ Wetland flow Medium	OB/ WM	Not determined	Anytime (ideally Aug–Mar)	Persistence of water. 3 months for wetland depressions.	5 years in 10 (50% of years)	5 years	
Overbank/ Wetland flow Large	OB/ WL	Not determined	Anytime (ideally Aug –Mar)	Persistence of water 3 months for wetland depressions.	2–3 years in 10 (25% of years)	5–10 years	

2.9 Marthaguy Creek

Marthaguy Creek has its source near Gilgandra and flows north. It is part of a complex of creeks that drain the area between the Castlereagh and Macquarie Rivers into the Macquarie Marshes complex. The lower section of this creek (below Terrigal Creek junction) can be affected by regulated environmental water deliveries via the streams of the eastern Macquarie Marshes.

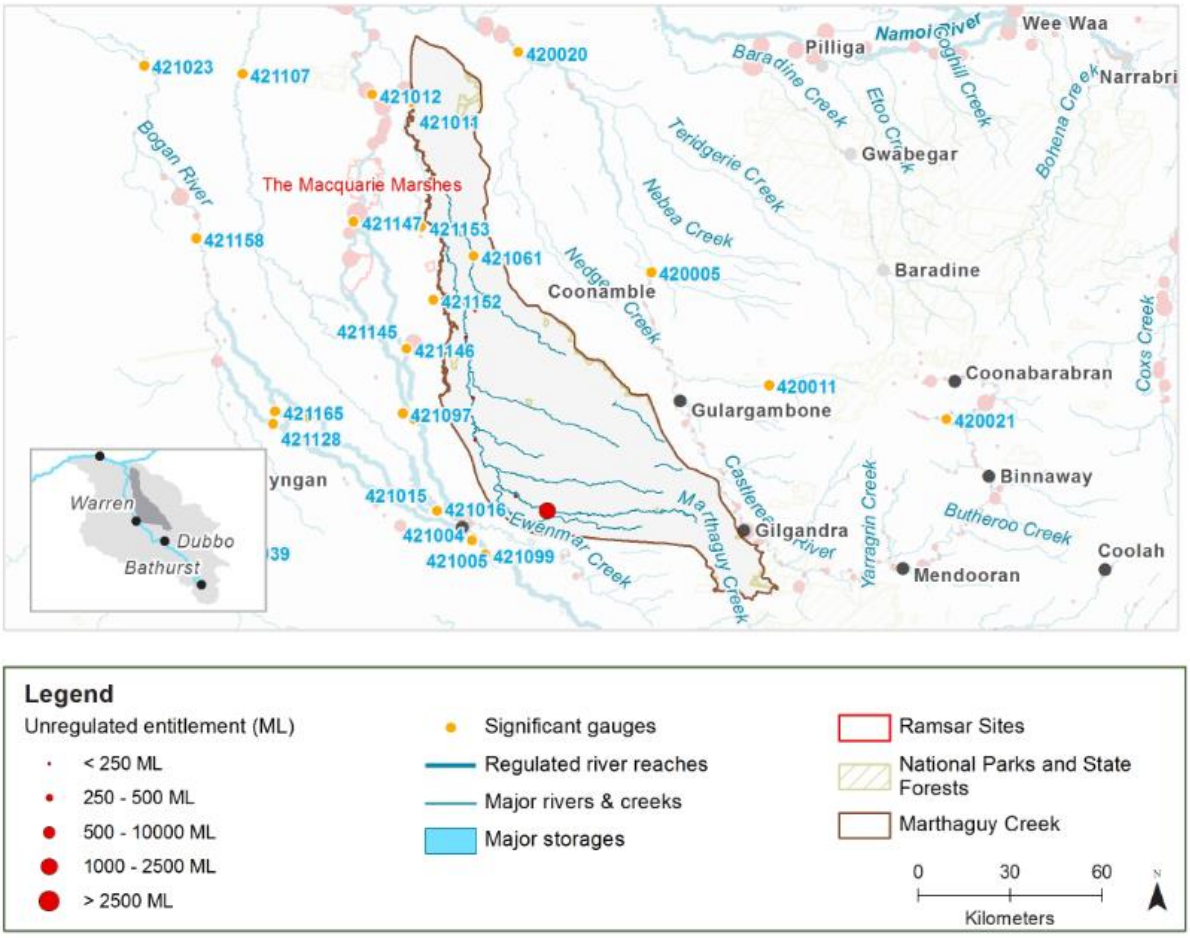


Figure 12 **Map of Marthaguy Creek PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Merri Merri Creek @ Quambone (421061), Marthaguy Creek @ Carinda (421011).

Named priority environmental assets		
Marthaguy Creek channel & riparian zone, Merri Merri Creek, Back Creek, Little Merri Merri Creek, Bullagreen Creek, Wemabung Creek, Merrigal Creek, Boothaguy Creek, Quandong Cowal, Meryon Cowal		
Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt [X + Y] bony herring [Y] carp-gudgeon [X + Y] dwarf flat-headed gudgeon [Y] eel-tailed catfish (E) [Y] flat-headed gudgeon [Y]	golden perch [X] Hyrtl's Tandan Murray–Darling rainbowfish [Y] spangled perch [X + Y] un-specked hardyhead [Y]
Waterbirds	48 species recorded, including: Australian painted snipe (E), black-necked stork (E), blue-billed duck (V), Brolga (V), Latham's snipe (C,J,R) & magpie goose (V)	
Native vegetation	185,361 ha of water-dependent native vegetation communities, including: river red gum (5032 ha), coolibah (12,067 ha), black box (34,889 ha), lignum (685 ha) & non-woody wetland vegetation (4390 ha)	
Registered water-dependent cultural assets	Carved trees & scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, flat-headed gudgeon, dwarf flat-headed gudgeon, bony herring, Murray–Darling rainbowfish & un-specked hardyhead
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, Hyrtl's tandan & spangled perch
NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch
NF9 Increase the prevalence &/or expand the population of key moderate to long-lived flow pulse specialists into new areas (within historical range): Hyrtl's tandan

Hydrology (DPIE Water, in prep)		
80th percentile: 0 ML/d	**50th percentile**: 0 ML/d	**20th percentile**: 5 ML/d
1.5 ARI: 1400 ML/d	**2.5 ARI**: 2800 ML/d	**5 ARI**: 5100 ML/d

The Marthaguy Creek Water Source Area has experienced a moderate to high degree of hydrological alteration. As assessed by the Macquarie-Castlereagh WRPA Risk Assessment, cease-to-flow events have increased moderately, and overbank events have decreased moderately compared to modelled near-natural conditions. Although freshes & baseflows appear to have increased, this is most likely due to inflows at the end of the system from regulated deliveries into the Gum Cowal-Terrigal system. Flows into Marthaguy Creek above the junction of the Terrigal are likely to have reduced.

There are 6 water access licences within the water source, 4 with entitlements of >250 ML, and 2 of 1000-2500 ML. The total volume of entitlements for the water source is 4342 ML.

Hydrological alteration See Table 1 for key	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
	M+	H+	H+	M-/L-
Relevant rules from WSP	**Trade INTO** water source: permitted only from Gum Cowal management zone & Lower Macquarie downstream management zone within the Lower Macquarie River water source. **Trade WITHIN** water source: Permitted, subject to assessment No pool drawdown For pump sites not within a natural pool, cease to pump when no visible flow.			

Recommended management strategies

- Consider adding specific commence-to-pump rules in the WSP within five years to:
  - reduce the length of CTF periods
  - *investigate increasing commence-to-pump to 20 ML/d on the Marthaguy at Carinda (421012).*
- Consider implementing a first flush rule to ensure CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents.
  - *This will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.*
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Protect water for the environment that originates from held water entitlements & the EWA.
- Maintain existing rules in the WSP to maintain priority environmental assets
- Consider restrictions to take in water sources bordering the Barwon River when embargoes on take exist in the Barwon River. This is relevant to the lower part of Marthaguy Creek (below the junction of Terrigal Creek), as although it does not border directly on the Barwon, it joins the Lower Macquarie River just upstream of its junction with the Barwon River.
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes
- Improve the gauging network to better indicate flow distribution and take, particularly to give flows above the junction with Terrigal Creek and below the most downstream extraction point.

Table 11 LTWP EWRs for Lower Marthaguy Creek as measured Carinda (421011)

Flow category and EWR code[45]		Flow volume[45]	Timing[45]	Duration[45]	Frequency (LTA frequency)[45]	Maximum inter-event period[45]	Additional requirements and comments[45]
Cease-to-flow	CTF	0 ML/d	In line with natural. Typically occurs Nov–Jun	Maximum duration: In moderate years persist for 25 days & should not persist for more than 244 days[46]	Should not occur in more than 97% of years[49]		
Very-low-flow[47#]	VLF	Observed flow at confluence with the Macquarie[48]	Any time	No less than natural	No less than natural	No greater than natural	No fish refuge pools greater than 2m deep identified; however, there would still be benefits in protecting this flow for other objectives.
Baseflow	BF1	>20 ML/d	Anytime	In moderate years, 115 days per year. In very dry years, there may be no days with flow[49]	Days with >20 ML/day of flow occurred in at least 96% of years pre 1966[49]	426 days[49]	
	BF2	>20 ML/d	Sep–Mar	In moderate years, 76 days per season. In very dry years, at least 12 days per season[49]	5–10 years in 10 (75% of years)	2 years	

[45] Refer to Glossary for definitions of terms and explanatory text for EWRs

[46] This is based on 1986–2017 observations. Maximum durations (for CTF) are based on 95th percentiles.

[47] Orange shading (and # in the 1st column of row) denotes that these flows are a lower priority for delivery of discretionary water as there are no identified fish refuge pools in this planning unit. However, the LTWP acknowledges the importance of protecting these flows for other ecological objectives (e.g. Native vegetation NV1, NV3; Ecosystem functions, EF1, EF2, EF6 etc.)

[48] There is no end of system gauge for the Marthaguy. Flow at Carinda required to provide a flow to the Macquarie will vary depending on how dry channel is and seasonal conditions. Flows at Macquarie @Brewon gauge (421907) may assist in determining if flows from the Marthaguy have reached the Macquarie.

[49] Based on 1944–1966 observations. Maximum inter-event periods and 'very dry years' durations (for other flows) are based on 95th percentiles. BF2 'very dry years' duration based on the 25th percentile as this flow is only required every 5–10 years. Duration for 'moderate years' are based on number of days of flow in median years.

Flow category and EWR code[45]		Flow volume[45]	Timing[45]	Duration[45]	Frequency (LTA frequency)[45]	Maximum inter-event period[45]	Additional requirements and comments[45]
	BF3	To be determined[50]	As required to avoid stratification during periods of identified high risk where a hypoxic bottom layer is likely to develop to an extent that it could produce hypoxic conditions in the entire water column should subsequent mixing occur. Requirement more likely during periods of extreme heat and low flow. This flow would also help reduce the risk of fish mortality due to extremely high water temperatures. Further work (see Table 22 of Part A) is required to provide tools to develop flow requirements.				As these flows are to maintain water quality, weir level management (where relevant), natural flows, operational water and non-discretionary environmental water should be used in the first instance before considering the use of discretionary environmental water. There are weir pools in the Marthaguy that are known to be refuges for golden perch and eel-tailed catfish (Sam Davis. DPI-Fisheries, pers. comm. 2019). The DSF flow must be provided in a manner which considers potential impacts from turning over refuge pools and initial water temperature increases from flows travelling over hot, dry river beds. Consult NSW DPI-Fisheries on interim flow protocols and in developing detailed future requirements (see recommended further work, Table 22 of Part A).
De-stratifying flow	DSF	To be determined[50]	As required to destratify refuge pools during periods of identified high risk where a hypoxic bottom layer has developed and could produce hypoxic conditions in the entire water column when mixed. Requirement more likely during periods of extreme heat and low flow. Further work (see Table 22 of Part A) is required to better identify risk periods and provide tools to develop flow requirements.				
Small fresh	SF1	>70 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10)	1 year	Maintain the maximum rate of event recession within natural range: As a guide, the 5th

[50] Further work is required to confirm thresholds. See action on 'tools for preventing fish deaths due to stratification' in Table 22 of Part A. Delivery options to the Marthaguy are limited and the feasibility of delivery at required rates will need to be further investigated. Protection of adequate flows from extraction may be the only feasible management tool in many cases.

Flow category and EWR code[45]		Flow volume[45]	Timing[45]	Duration[45]	Frequency (LTA frequency)[45]	Maximum inter-event period[45]	Additional requirements and comments[45]
							percentile (fastest 5% of rates of fall) was 30% per day for 'pre-development' observed flows from 1944–1960 (e.g. 70ML-50ML-35ML).
	SF2	70–800 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 30% per day for 'pre-development' observed flows from 1944–1960 (e.g. 70ML-50ML-35ML).
	SF3	>70 ML/d	Anytime (ideally July–Sep for initial flow & Oct–Apr for subsequent flow.	28 days	5 years in 10 (50% of years)	4 years	
Large fresh*	LF1	>800 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 20% per day for 'pre-development' observed flows from 1944–1960 (e.g. 700ML-660ML-530ML).
	LF2	>800 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	Maintain the maximum rate of event recession within natural range: As a guide, the 5th percentile (fastest 5% of rates of fall) was 20% per day for 'pre-development' observed flows from 1944–1960 (e.g. 700ML-660ML-530ML).

Flow category and EWR code[45]		Flow volume[45]	Timing[45]	Duration[45]	Frequency (LTA frequency)[45]	Maximum inter-event period[45]	Additional requirements and comments[45]
Overbank/ Wetland flow Small [51]	OB/ WS1	Not applicable. For core wetland areas, which are not a feature of this PU					
	OB/ WS2	Not applicable. Overbank flows of 10 days duration do not occur with the required frequency of 50% of years					
	OB/ WS3	>2,900 ML/d	Anytime (ideally Sep–Feb)	5 days	2–3 years in 10 (25% of years)	5 years	
	OB/ WS4	>2,900 ML/d	Anytime (ideally Aug–Mar)	Persistence of water 3 months. Flow of 5 days (median natural duration) required to fill depressions & soil profile.	3–10 years in 10 (65% of years)	5 years	Lower frequency required in this PU because the main non-woody vegetation is likely to be more drought tolerant
Overbank/ Wetland flow Medium [51] *	OB/ WM	Not determined	Anytime (ideally Aug–Mar)	Persistence of water. 3 months for wetland depressions	5 years in 10 (50% of years)	5 years	
Overbank/ Wetland flow Large [51]*	OB/ WL	Not determined	Anytime (ideally Aug–Mar)	Persistence of water 3 months for wetland depressions.	2–3 years in 10 (25% of years)	5–10 years	

[51] Grey shading (and * in 1st column of row) denotes that flows of this size are not able to be delivered with discretionary environmental water (although deliveries to the Marshes assist in achieving these flows). Flows of this size are dependent on natural events but may be impacted by water policy including floodplain harvesting, extraction and flood mitigation zone management.

3. Unregulated planning units

3.1 Macquarie system – Cudgegong headwaters

This PU consists of the following water sources:

- Upper Cudgegong River Water Source
- Lawsons Creek Water Source
- Cooyal Wialdra Creek Water Source
- Piambong Creek Water Source
- Goolma Creek Water Source
- Pipeclay Creek Water Source

These water sources were amalgamated to align with the DPIF BPEOM zone of the same name, however several differences remain. DPIF have split the Burrendong Dam Tributaries Water Source and placed the north–eastern section (Meroo River/Creek) in their 'Cudgegong Headwaters' monitoring zone, and the remainder in 'Upper Macquarie Tributaries'. To avoid splitting the Burrendong Dam Tributaries Water Source Unit we have put the whole of this water source into Upper Macquarie Tributaries PU.

The rivers of the upper Macquarie catchment flow within well-defined channels and have only limited floodplains (Green et al. 2011). Storages in this PU include Rylstone Dam (3320 ML storage capacity) and Redbank Creek Dam (180 ML storage capacity) in Mudgee. This PU excludes Windermere and Burrendong dams and the regulated Cudgegong River.

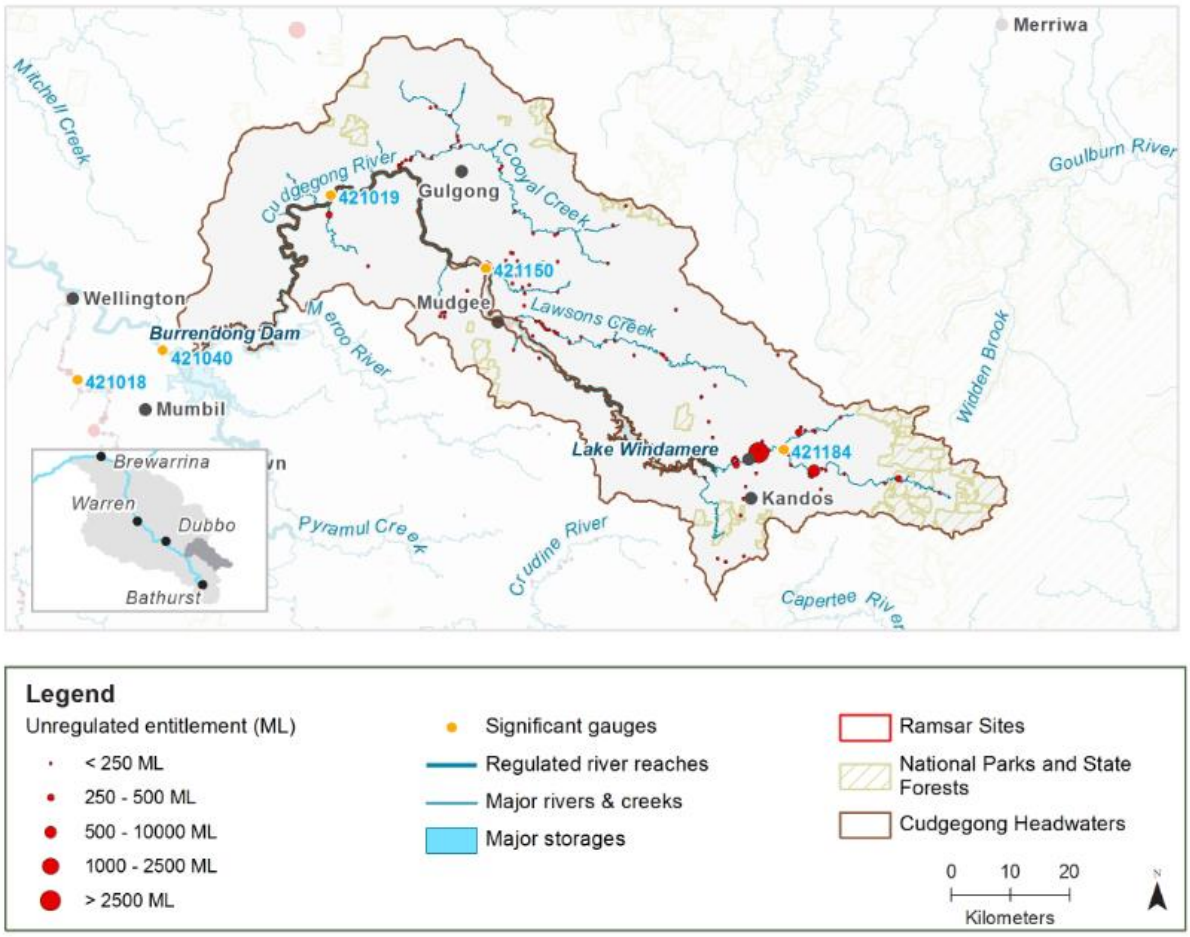


Figure 13 **Map of Macquarie system – Cudgegong headwaters PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Cudgegong River @ Upstream Rylestone (421184), Cudgegong River @ Wilbertree Road (421150), Cudgegong River @ Yamble Bridge (421019), 421038 Cudgegong River at Rylstone Bridge, Wyaldra Creek at Gulgong (421058), Meroo Creek at Yarrabin No.2 (421073).

Named priority environmental assets

- Upper unregulated Cudgegong River
- Cudgegong River tributaries including Davis Creek, Swampy Creek, Coxs Creek, Towinhingy Creek, Lawsons Creek, Cooyal Wialdra Creek, Piambong Creek, Goolma Creek, Pipeclay Creek channel & riparian zone
- Lawsons Creek tributaries including Bara Creek, Long Gully, Wet Swamp Creek, Reedy Creek
- Cooyal Creek tributaries including Spring Creek, Stony Creek, Back Creek, Chainman's Creek
- Wialdra Creek tributaries including Slapdash Creek
- Piambong Creek tributaries including Fromes Creek, Crowirs Creek, Californian Gully & Baylys Creek
- Goolma Creek tributaries
- Pipeclay Creek tributaries including Woonambula Creek, Fords Creek & Pig & Whistle Creek

Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt X + Y carp gudgeon X + Y dwarf flat-headed gudgeon X eel-tailed catfish (E) X + Y flat-headed gudgeon X + Y	golden perch X + Y Murray cod (V) X + Y mountain galaxias X + Y northern river blackfish X + Y purple-spotted gudgeon (E) Y
Waterbirds	47 species recorded, including black-necked stork (E), brolga (V), Caspian tern (C, J), cattle egret (C, J), common greenshank (C,J,R), black-necked stork (E).glossy ibis (C) & Latham's snipe (C,J,R)	
Native vegetation	1100 ha of water-dependent native vegetation communities including 370 ha of river red gum	
Registered water-dependent cultural assets	No registered water-dependent cultural assets were found in the known site data* *It is acknowledged that unregistered Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, dwarf flat-headed gudgeon, flat-headed gudgeon, mountain galaxias
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch
NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod, eel-tailed catfish, northern river blackfish, purple-spotted gudgeon
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)		
Upper Cudgegong River Water Source: *Simulated inflows*		
80th percentile: 4 ML/d	**50th percentile**: 29 ML/d	**20th percentile**: 121 ML/d
1.5 ARI: 4800 ML/d	**2.5 ARI**: 7400 ML/d	**5 ARI**: 12700 ML/d
Cease-to-flow periods and low flows are highly altered (>50% departure from base case), and freshes and overbank flows are moderately altered (20-50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows, freshes and overbank flows occur less frequently compared to the 'without development' model scenario. Thirty-four small water access licences (<500-250 ML) are distributed across the planning unit. In addition, two larger licences (1000-2500 ML) are located on the Cudgegong River. The total volume of unregulated entitlements for the water source is 6451 ML.		
Lawsons Creek Water Source Gauge: 421038 *Cudgegong River at Rylstone Bridge*		
80th percentile: 3 ML/d	**50th percentile**: 17 ML/d	**20th percentile**: 52 ML/d
1.5 ARI: 1100 ML/d	**2.5 ARI**: 2000 ML/d	**5 ARI**: 5200 ML/d
Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. Several small water access licences are distributed across the planning unit, many of them occurring along the lower end of Lawsons Creek. The total volume of unregulated entitlements for the water source is 1496 ML.		

Cooyal Wialdra Creek Water Source Gauge: 421058 *Wyaldra Creek at Gulgong*		
80th percentile: 0 ML/d	**50th percentile**: 2 ML/d	**20th percentile**: 19 ML/d
1.5 ARI: 3800 ML/d	**2.5 ARI**: 6900 ML/d	**5 ARI**: 10,600 ML/d

Cease-to-flow periods, low flows and freshes are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows and freshes occur less frequently compared to the 'without development' model scenario. Several small water access licences are distributed across the planning unit, with a small group of licences clustered on Wialdra Creek near the confluence of the Cudgegong River. The total volume of unregulated entitlements for the water source is 741 ML.

Piambong Creek Water Source Gauge: 421073 *Meroo Creek at Yarrabin No.2*		
80th percentile: 0 ML/d	**50th percentile**: 4 ML/d	**20th percentile**: 38 ML/d
1.5 ARI: 3100 ML/d	**2.5 ARI**: 4900 ML/d	**5 ARI**: 6600 ML/d

Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. Several small and a few medium sized water access licences are distributed across the planning unit. The total volume of unregulated entitlements for the water source is 925 ML.

Pipeclay Creek Water Source Gauge: 421058 *Wyaldra Creek at Gulgong*		
80th percentile: 0 ML/d	**50th percentile**: 0.4 ML/d	**20th percentile**: 4 ML/d
1.5 ARI: 700 ML/d	**2.5 ARI**: 1400 ML/d	**5 ARI**: 2100 ML/d

Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. Several small water access licences are distributed across the planning unit. The total volume of unregulated entitlements for the water source is 446 ML.

Goolma Creek Water Source: no model, no licences		
80th percentile: N/A	**50th percentile**: N/A	**20th percentile**: N/A
1.5 ARI: N/A	**2.5 ARI**: N/A	**5 ARI**: N/A

Flows do not seem to be altered by more than 20% compared to the 'without development' model scenario as assessed by the Macquarie Castlereagh WRPA Risk Assessment. There are no extraction licences in this planning unit.

	CTF		**Low flow & baseflow**		**Freshes**		**Overbanks**	
Hydrological alteration See Table 1 for key	H+	Upper Cudgegong Lawsons Creek Cooyal Wialdra Piambong Creek Pipeclay Creek	H-	Upper Cudgegong Lawsons Creek Cooyal Wialdra Piambong Creek Pipeclay Creek	M-/H-	Upper Cudgegong Cooyal Wialdra	M-	Upper Cudgegong
	L^0	Goolma Creek	L^0	Goolma Creek	L^0/L-	Lawsons Creek Piambong Creek	L^0/L-	Lawsons Creek Cooyal Wialdra

						Goolma Creek Pipeclay Creek		Piambong Creek Pipeclay Creek Goolma Creek
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment within water source, but not permitted into the pool created by Rylstone Dam **Access**: No pool drawdown For pump sites not within a natural pool, cease to pump rule when no visible flow.							

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Consider adding specific commence-to-pump rules in the Water Sharing Plan for the Upper Cudgegong above Windamere Water Source within five years to:
  - reduce the length of CTF periods
  - better protect low flows & baseflows
  - *investigate increasing commence-to-pump to 20 ML/d at 'upstream Rylstone' gauge (421184)*
- Consider rostering landholder access during low flow months for the Upper Cudgegong above Windamere Water Source
- Consider implementing in the Upper Cudgegong above Windamere Water Source a first flush rule to ensure periods between small freshes are not excessively prolonged and CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents.
  - *For the breaking of CTF periods, this will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.*
- Consider implementing in the Upper Cudgegong above Windamere Water Source total &/or individual daily extraction limits (IDELS & TDELS)
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes.

3.2 Macquarie system – Macquarie headwaters

This PU consists of the following water sources:

- Queen Charlottes Vale Evans Plains Creek Water Source
- Campbells River Water Source
- Fish River Water Source.

These water sources were amalgamated to align with the DPIF BPEOM zone of the same name.

The Macquarie River rises in the Great Dividing Range near Oberon and is formed by the junction of the Fish River and Campbells River upstream of Bathurst. Major tributaries include Queen Charlottes Vale Creek. The rivers of the upper Macquarie catchment flow within well-defined channels and have only limited floodplains (Green et al. 2011).

The Fish River rises on the plateau south east of Oberon and flows generally to the north–west into the Macquarie River just east of Bathurst. Storages in this PU include Rydal Dam (370 ML storage capacity), which regulates water eastwards over the divide via the Fish River Scheme, Oberon Dam (45,420 ML storage capacity), and Chifley Dam (30,800 ML storage capacity).

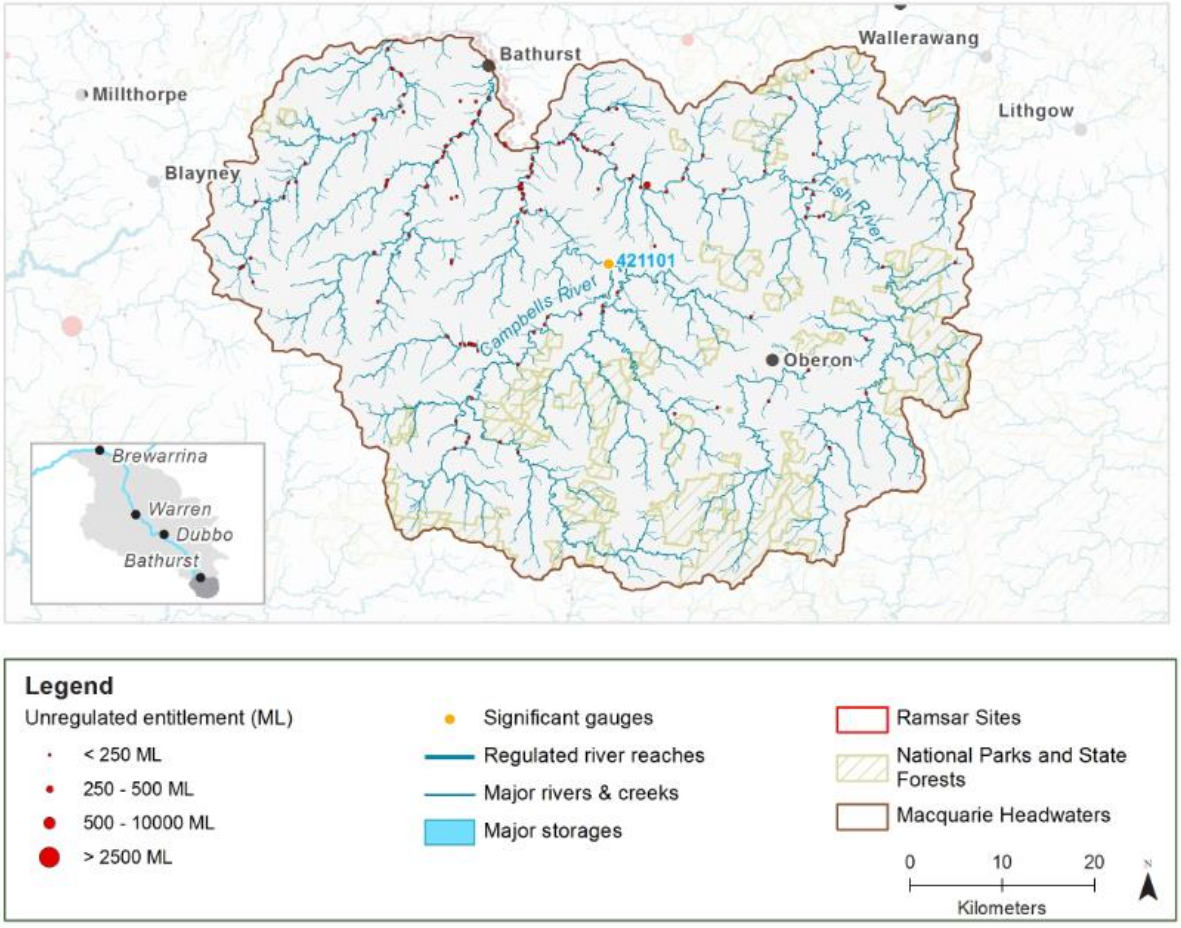


Figure 14 **Map of Macquarie system – Macquarie headwaters PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Campbells River @ U/S Ben Chifley Dam (421101), Queen Charlottes Creek at Georges Plains (421053).

Named priority environmental assets

- Queen Charlottes Creek, Evans Plains Creek, Campbell River and Fish River channel and riparian zone
- Macquarie headwaters tributaries including: Ryans Creek, Mountain Run Creek, Summer Hill Creek, Caloola Creek, Georges Plains Creek, Sandy Creek, Mcleans Creek, Collins Creek, Dicks Creek, Spring Creek, Rocks Creek, The Lagoon, Davys Creek, Deep Creek, Wisemans Creek, Sheltons Gully, Little Wisemans Creek, Middle Creek, Brisbane Valley Creek, Sewells Creek, Native Dog Creek, Thompsons Gully, Chain Of Ponds Creek, Wild Cat Creek, Spring Creek, Triangle Creek, Shinglers Creek, Arkell Creek, Gum Flat Creek, O'Briens Creek, Gilmandyke Creek, Judds Creek, Poison Creek, Walbrook Creek, Racecourse Creek, Boiler Creek, Parlour Creek, Yellow Waterhole Creek, Gilmandyke Creek, Captain Kings Creek, Peppers Creek, Jumpers Flat Creek, Fosters Valley, King George Gully, Stony Creek, Alicks Creek, Salt Water Creek, Frying Pan Creek, Raineville Creek, Middle Creek, Duckmaloi River, Scotts Creek, Eusdale Creek, Mount Tannas Creek, Blossom Hill Creek, Badger Creek

Key water-dependent values

(CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)

Native fish	Australian smelt [X]	Murray cod (V) [Y]
	carp gudgeon [Y]	northern river blackfish [Y]

	golden perch [X + Y] Macquarie perch (E) [Y] mountain galaxias [X + Y]	purple-spotted gudgeon (E) [Y] un-specked hardyhead [Y]
Waterbirds	53 species recorded, including Australasian bittern (E), Australian painted snipe (E), blue-billed duck (V), freckled duck (V), Latham's snipe (C,J,R), magpie goose (V), marsh sandpiper (C,J,R) & sharp-tailed sandpiper (C,J,R)	
Native vegetation	340 ha of water-dependent native vegetation communities recorded, all of which is riparian river oak	
Registered water-dependent cultural assets	No water-dependent cultural assets were found in the known site data*	
	*It is acknowledged that unregistered Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, mountain galaxias

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch

NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod, Macquarie perch, northern river blackfish, purple-spotted gudgeon

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

NF8 Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range): Macquarie perch

Hydrology (DPIE-Water, in prep)

Queen Charlottes Vale Evans Plains Creek Water Source Gauge: 421053 *Queen Charlottes Creek at Georges Plains*

80th percentile: 7 ML/d	**50th percentile**: 34 ML/d	**20th percentile**: 100 ML/d
1.5 ARI: 3400 ML/d	**2.5 ARI**: 4800 ML/d	**5 ARI**: 5800 ML/d

Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. Many small water access licences are distributed across the planning unit. The total volume of unregulated entitlements for the water source is 1935 ML.

Campbells River Water Source Gauge: 421101 *Campbells River upstream Ben Chifley Dam*

80th percentile: 12 ML/d	**50th percentile**: 55 ML/d	**20th percentile**: 200 ML/d
1.5 ARI: 3900 ML/d	**2.5 ARI**: 5500 ML/d	**5 ARI**: 8700 ML/d

Campbells River Water Source: Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. Several small water access licences are distributed across the planning unit, with a small group of licences clustered on Peppers Creek and on the the lower Campbells River near the confluence of the Fish River. The total volume of unregulated entitlements for the water source is 2106 ML

Fish River Water Source: IQQM Modelled		
80th percentile: 0 ML/d	**50th percentile**: 0 ML/d	**20th percentile**: 136 ML/d
1.5 ARI: 6100 ML/d	**2.5 ARI**: 10,000 ML/d	**5 ARI**: 18,900 ML/d

Cease-to-flow, freshes and overbank flows are highly altered (>50% departure from base case), and low flows are moderately altered (20-50% departure from base case), as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows, freshes and overbanks occur less frequently compared to the 'without development' model scenario. One large (2500 ML) and 43 small (250-500 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 18,071 ML

<table>
<tr><th rowspan="2"></th><th colspan="2">CTF</th><th colspan="2">Low flow & baseflow</th><th>Freshes</th><th colspan="2">Overbanks</th></tr>
<tr><td rowspan="2">Hydrological alteration
See Table 1 for key</td><td>H+</td><td>Queen Charlottes
Campbells River</td><td rowspan="2">M-/H-</td><td rowspan="2">All water sources</td><td>H-</td><td>H-/M-</td><td>Fish River</td></tr>
<tr><td>H-</td><td>Fish River</td><td>L-</td><td>L0/L-</td><td>Queen Charlottes
Campbells River</td></tr>
<tr><td>Relevant rules from WSP</td><td colspan="7">Queen Charlottes Vale Evans Plain Creek
Trade INTO water source:
Queen Charlottes Vale Evans Plains Creek downstream: Not permitted.
Queen Charlottes Vale Evans Plains Creek tributaries: Trades are permitted in from the downstream management zone, as long as the trade is within the catchment of Evans Plains Creek or within the catchment of Queen Charlottes Vale Creek, but not between these catchments.
Trade WITHIN management zone:
Queen Charlottes Vale Evans Plains Creek downstream: Trades are permitted within the catchment of Evans Plains Creek & within the catchment of Queen Charlottes Vale Creek, but not between these catchments.
Queen Charlottes Vale Evans Plains Creek tributaries: Trades are permitted within the catchment of Evans Plains Creek & within the catchment of Queen Charlottes Vale Creek, but not between these catchments.
Access:
Queen Charlottes Vale Evans Plains Creek downstream: Extraction of water is not permitted in association with an excavation with a depth greater than 1 metre or base area greater than 4 square metres.
Queen Charlottes Vale Evans Plains Creek tributaries: No pool drawdown
For pump sites not within a natural pool, cease to pump rule when no visible flow.

Campbells River
Trade INTO water source: Campbells River downstream: Trades are permitted in from the Macquarie River above Bathurst management zone in the Macquarie River above Burrendong water source only. Campbells River tributaries MZ: Not permitted.
Trade WITHIN management zone: Permitted, subject to assessment
Access: Campbells River downstream MZ: Pumping is not permitted when Ben Chifley Dam is equal to or less than 22% capacity, which equates to the water level being approximately 700 m (Australian height datum) at the storage gauge.</td></tr>
</table>

	Campbells River tributaries MZ: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow. **Fish River** **Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.

Recommended management strategies

- Consider adding specific commence-to-pump rules in the Water Sharing Plan within five years to:
  - reduce the length of CTF periods in Campbells River Water Source
  - better protect low flows & baseflows in Campbells River and Fish River Water Source Areas
  - *investigate increasing commence-to-pump to 30 ML/d @ 421101 'Campbells River upstream Ben Chifley Dam' gauge*
- Consider rostering landholder water access during low flow months in Fish River and Campbells River Water Source Areas
- Consider implementing a first flush rule to ensure CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents in Fish River and Campbells River Water Source Areas.
  - *This will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.*
- Consider implementing a first flush rule in the Fish River Water Source Area to ensure periods between small freshes are not excessively prolonged
- Consider implementing total &/or individual daily extraction limits (IDELS & TDELS) in Fish River and Campbells River Water Source Areas
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Maintain existing rules in the WSP to maintain priority environmental assets
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes
- Review conditions on larger in-stream storages, such as Oberon Dam and Ben Chifley Dam. This should include consideration of the need for environmental releases or the enhancement of any existing releases.

3.3 Macquarie system – Upper Macquarie tributaries

This PU consists of the following water sources, which have been amalgamated to align with the DPIF BPEOM zone of the same name:

- Winburndale Rivulet Water Source
- Macquarie River above Burrendong Water Source
- Turon Crudine River Water Source
- Burrendong Dam Tributaries Water Source
- Summerhill Creek Water Source

The Macquarie River rises in the Great Dividing Range near Oberon and is formed by the junction of the Fish River and Campbells River upstream of Bathurst. From here it flows north–west before entering Burrendong Dam upstream of Wellington. Major tributaries of the Macquarie River include the Turon and Crudine Rivers and Winburndale Rivulet. The rivers of the upper catchment flow within well-defined channels and have only limited floodplains (Green et al. 2011). Storages in this PU include Suma Park Dam (18,080 ML storage capacity), Gosling Creek Dam (645 ML storage capacity), and Spring Creek Dam (4680 ML storage capacity). Additionally, Blackman's Swamp Creek Stormwater Harvesting can divert up to 900 ML annually into Gosling Creek Dam and Ploughman's Creek Stormwater Harvesting can divert 700-800 ML annually into Suma Park Dam.

Note that this consists only of the tributaries of the Macquarie River and Burrendong Dam. The unregulated Macquarie River itself is a separate unit (see Section 3.4). This is because the DPIF BPEOM program separated tributaries from the river and we have aligned areas.

There is a difference between the boundaries of the PU and DPIF BPEOM zone. We have kept the entire Burrendong Dam Tributaries Water Source Unit in this PU. DPIF has put the Meroo River/Creek section of this in their 'Cudgegong Headwaters' BPEOM zone.

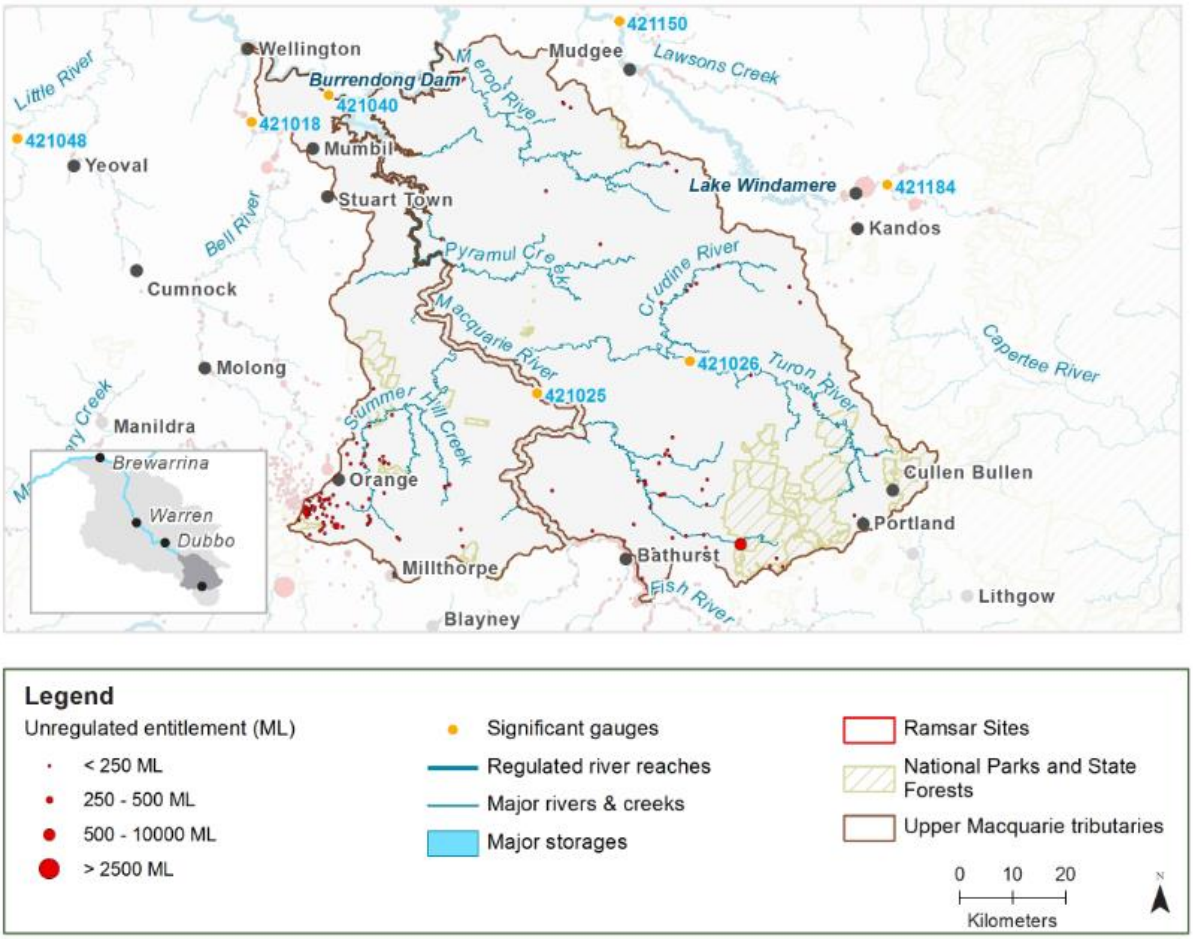


Figure 15 **Map of Macquarie system – Upper Macquarie Tributaries PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Winburndale Rivulet at Howards Bridge (421072), Macquarie River at Dixons Long Point (421080), Turon River at Sofala (421026), Meroo Creek at Yarrabin No.2 (421073), Lewis Ponds Creek at Ophir (421052).

Named priority environmental assets

- Macquarie River, Turon River, Winburndale Rivulet and Summer Hill Creek channel & riparian zone
- Winburndale Rivulet tributaries including Cheshire Creek, Rovers Creek, Clear Creek & Gulf Stream
- Macquarie River tributaries including Sawpit Creek, Raglan Creek & Jordan Creek
- Turon River tributaries including Green Gully, Coolamigal Creek & Jews Creek
- Burrendong Dam tributaries, including Meroo Creek, Wollerang Creek, Pyramul Creek, Green Valley Creek, Triamble Creek, Merinda Creek, Grattai Creek, Guigong Creek
- Burrendong Dam tributaries floodplain wetlands
- Summer Hill Creek tributaries including Gosling Creek, Brandy Creek, Spring Creek, Dairy Creek, Emu Swamp Creek, Licking Hole Creek & Blackmans Swamp Creek

Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt [X + Y] carp gudgeon [X + Y] dwarf flat-headed gudgeon [X] eel-tailed catfish (E) [X + Y] flat-headed gudgeon [X + Y] golden perch [X + Y] Macquarie perch (E) [Y] mountain galaxias [X + Y]	Murray cod (V) [X + Y] eel-tailed catfish (E) [X + Y] mountain galaxias [X + Y] Murray cod (V) [X + Y] Murray–Darling rainbowfish [Y] northern river blackfish [X + Y] purple-spotted gudgeon (E) [Y] un-specked hardyhead [Y]
Waterbirds	55 species recorded, including Australian painted snipe (E), blue-billed duck (V), Caspian tern (C,J), common sandpiper (C,J,R), curlew sandpiper (E, C,J,R), freckled duck (V), Latham's snipe (C,J,R), magpie goose (V), sharp-tailed sandpiper (C,J,R) & red-necked stint (C,J,R)	
Native vegetation	2800 ha of water-dependent native vegetation communities including riparian river red gum & river oak	
Registered water-dependent cultural assets	Carved trees, ceremony & dreaming sites. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, flat-headed gudgeon, un-specked hardyhead, northern river blackfish & Murray–Darling rainbowfish
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch & silver perch
NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod & eel-tailed catfish
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)		
Winburndale Rivulet Water Source Gauge: 421072 *Winburndale Rivulet at Howards Bridge*		
80th percentile: 3 ML/d	**50th percentile**: 29 ML/d	**20th percentile**: 142 ML/d
1.5 ARI: 4500 ML/d	**2.5 ARI**: 9200 ML/d	**5 ARI**: 15,800 ML/d
Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. One medium (<1000 ML) and 25 small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 1635 ML.		

Macquarie River above Burrendong Water Source Gauge: 421080 *Macquarie River at Dixons Long Point*		
80th percentile: 76 ML/d	**50th percentile**: 349 ML/d	**20th percentile**: 1570 ML/d
1.5 ARI: 31,600 ML/d	**2.5 ARI**: 54,100 ML/d	**5 ARI**: 100,900 ML/d

Low flows are highly altered (>50% departure from base case) and cease-to-flows have a high-risk rating as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Low flows occur less frequently compared to the 'without development' model scenario. One large (2500 ML), 3 medium (500-1000 ML) and 72 small (<250 ML) water access licences are distributed across the water source, most of which are clustered near the top of the water source. The total volume of unregulated entitlements for the water source is 25,586 ML.

Turon Crudine River Water Source Gauge: 421026 *Turon River at Sofala*		
80th percentile: 14 ML/d	**50th percentile**: 79 ML/d	**20th percentile**: 342 ML/d
1.5 ARI: 13,500 ML/d	**2.5 ARI**: 23,400 ML/d	**5 ARI**: 35,800 ML/d

Cease-to-flow periods are highly altered (>50% departure from base case), and low flows are moderately altered (20-50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. 16 small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 328 ML.

Burrendong Dam Tributaries Water Source Gauge: 421073 *Meroo Creek at Yarrabin No.2*		
80th percentile: 0 ML/d	**50th percentile**: 13 ML/d	**20th percentile**: 112 ML/d
1.5 ARI: 7400 ML/d	**2.5 ARI**: 14,000 ML/d	**5 ARI**: 22,000 ML/d

Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. 11 small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 584 ML.

Summerhill Creek Water Source Gauge: 421052 *Lewis Ponds Creek at Ophir*		
80th percentile: 7 ML/d	**50th percentile**: 35 ML/d	**20th percentile**: 169 ML/d
1.5 ARI: 6100 ML/d	**2.5 ARI**: 13,000 ML/d	**5 ARI**: 21,500 ML/d

Cease-to-flow periods and low flows are highly altered (>50% departure from base case), and freshes are moderately altered (20-50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows and freshes occur less frequently compared to the 'without development' model scenario. One large (2500 ML), two medium (500-1000 ML) and 84 small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 11,765 ML.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	H+	M-/H-	L-/M-	L^0/L-

Relevant rules from WSP	**All water sources excluding Macquarie River above Burrendong** **Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow. **Macquarie River above Burrendong Water Source** **Trade INTO** water source: Macquarie River above Bathurst MZ: Trades are permitted in from the Campbells River downstream management zone in the Campbells River Water Source. Macquarie River between Bathurst & Evans Plains Creek MZ: Trades are permitted in from the Campbells River, Fish River, Queen Charlottes Vale Evans Plains Creek, Summerhill Creek, Turon Crudine River & Winburndale Rivulet water sources, & the Macquarie River above Bathurst & the Macquarie River tributaries management zones. Macquarie River tributaries management zone MZ: Trades are permitted in from the Campbells River, Fish River, Queen Charlottes Vale Evans Plains Creek, Summerhill Creek, Turon Crudine River, & Winburndale Rivulet water sources, & the Macquarie River above Bathurst & the Macquarie River between Bathurst & Evans Plains Creek management zones. **Trade WITHIN** management zone**:** Permitted, subject to assessment (all management zones) **Access**: Macquarie River above Bathurst MZ: Pumping is not permitted when Ben Chifley Dam is equal to or less than 22% capacity, which equates to the water level being approximately 700 m at the storage gauge. Macquarie River between Bathurst & Evans Plains Creek MZ: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow. Macquarie River tributaries MZ: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.

Recommended management strategies

- Consider adding specific commence-to-pump rules in the Water Sharing Plan within five years to:
    - reduce the length of CTF periods in Winburndale Rivulet Water Source Area
    - better protect low flows & baseflows Winburndale Rivulet Water Source Area
    - *investigate increasing commence-to-pump to 25 ML/d @ 421072 'Winburndale Rivulet at Howards Bridge' gauge*
- Consider rostering landholder water access during low flow months in Winburndale Rivulet Water Source Area
- Consider implementing a first flush rule to ensure CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents in Winburndale Rivulet Water Source Area.
    - *This will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.*
- Consider implementing total &/or individual daily extraction limits (IDELS & TDELS) in Winburndale Rivulet Water Source Area
- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.4 Macquarie system – Upper Macquarie River above Burrendong

This PU has been split from the Upper Macquarie tributaries PU (Section 3.3) to align with the DPIF BPEOM zone that created the river as a separate zone.

The Macquarie River rises in the Great Dividing Range near Oberon and is formed by the junction of the Fish River and Campbells River upstream of Bathurst. From here it flows north–west before entering Burrendong Dam upstream of Wellington.

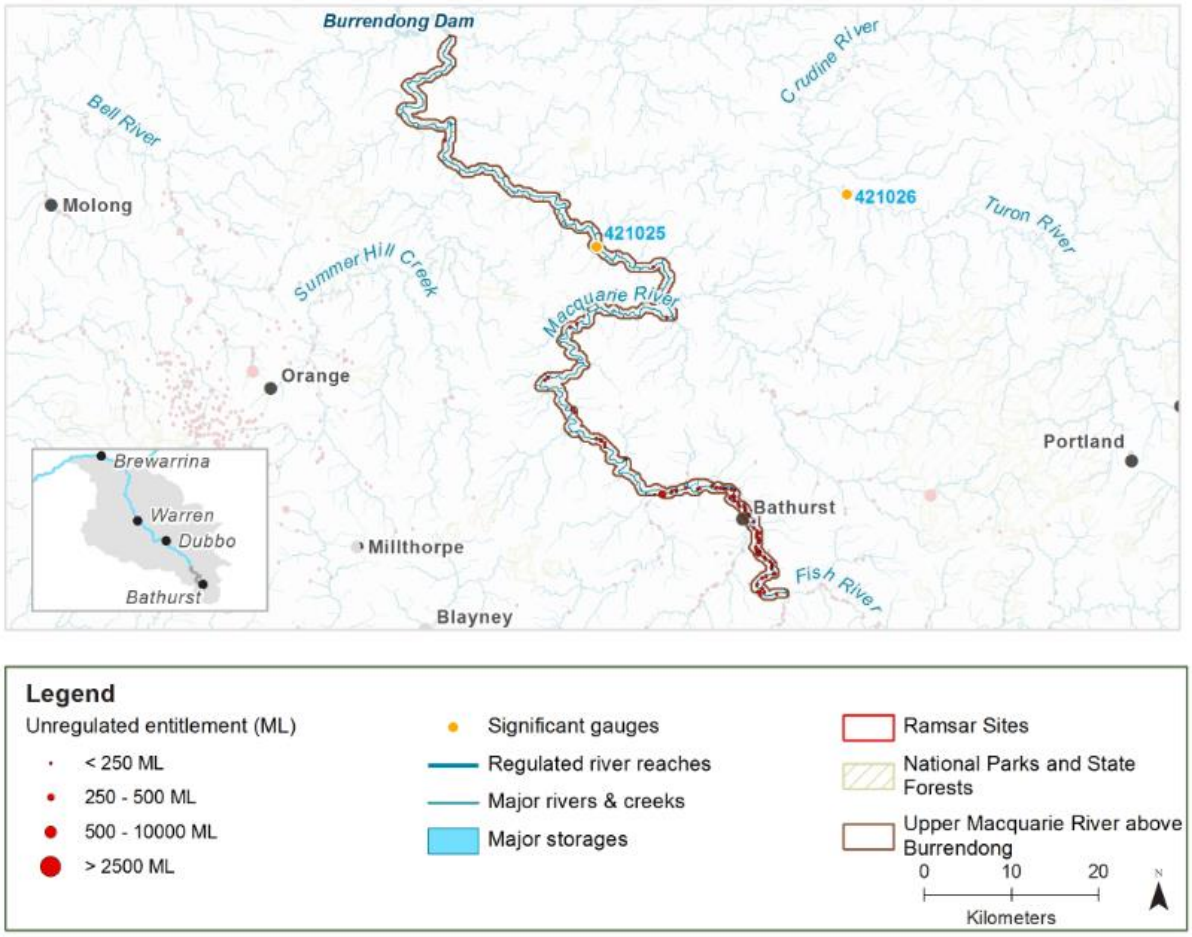


Figure 16 **Map of Macquarie system – Upper Macquarie River above Burrendong PU.** Area outside of PU has been faded. Significant gauges relevant to the PU are Macquarie River at Dixons Long Point (421080).

Named priority environmental assets		
Macquarie River channel & riparian zone		
Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt [X + Y] carp gudgeon [X + Y] eel-tailed catfish (E) [X + Y] flat-headed gudgeon [X + Y] golden perch [X + Y] Macquarie perch (E) [Y] mountain galaxias [X + Y]	Murray cod (V) [X + Y] Murray–Darling rainbowfish [Y] northern river blackfish [Y] purple-spotted gudgeon (E) [Y] silver perch (V) [X + Y] trout cod (E) [X] un-specked hardyhead [Y]
Waterbirds	41 species recorded, including curlew sandpiper (E,C,J,R), Latham's snipe (C,J,R), magpie goose (V) & sharp-tailed sandpiper (C,J,R)	
Native vegetation	220 ha of water-dependent native vegetation communities including riparian river red gum & river oak	
Registered water-dependent cultural assets	Carved trees, ceremony & dreaming sites. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, flat-headed gudgeon, mountain galaxias, Murray-darling rainbowfish, un-specked hardyhead
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch
NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish, Macquarie perch, Murray cod, northern river blackfish, purple-spotted gudgeon, trout cod
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)		
Gauge: 421080 *Macquarie River at Dixons Long Point*		
80th percentile: 76 ML/d	**50th percentile**: 349 ML/d	**20th percentile**: 1570 ML/d
1.5 ARI: 31,600 ML/d	**2.5 ARI**: 54,100 ML/d	**5 ARI**: 100,900 ML/d

Cease-to-flow events and Low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Low flows occur less frequently and cease to flow events occur more frequently compared to the 'without development' model scenario.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	H+	H-	L-	L-
Relevant rules from WSP	**Trade INTO** water source:			

	Macquarie River above Bathurst MZ: Trades are permitted in from the Campbells River downstream management zone in the Campbells River Water Source. Macquarie River between Bathurst & Evans Plains Creek MZ: Trades are permitted in from the Campbells River, Fish River, Queen Charlottes Vale Evans Plains Creek, Summerhill Creek, Turon Crudine River, & Winburndale Rivulet water sources, & the Macquarie River above Bathurst & the Macquarie River tributaries management zones. Macquarie River tributaries management zone MZ: Trades are permitted in from the Campbells River, Fish River, Queen Charlottes Vale Evans Plains Creek, Summerhill Creek, Turon Crudine River, & Winburndale Rivulet water sources, & the Macquarie River above Bathurst & the Macquarie River between Bathurst & Evans Plains Creek management zones. **Trade WITHIN** management zone: Permitted, subject to assessment (all management zones) **Access**: Macquarie River above Bathurst MZ: Pumping is not permitted when Ben Chifley Dam is equal to or less than 22% capacity, which equates to the water level being approximately 700 m at the storage gauge. Macquarie River between Bathurst & Evans Plains Creek MZ: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow. Macquarie River tributaries MZ: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.

Recommended management strategies

- Consider adding specific commence-to-pump rules in the Water Sharing Plan within five years to:
    - reduce the length of CTF periods
    - better protect low flows & baseflows
    - *investigate increasing commence-to-pump to 70 ML/d @ 'Macquarie River at downstream Long Point' gauge (421192)*
- Consider rostering landholder water access during low flow months
- Consider implementing a first flush rule to ensure CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents.
    - *This will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.*
- Consider implementing total &/or individual daily extraction limits (IDELS & TDELS)
- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.5 Macquarie system – Bell River and Molong Creek

This PU consists of the following water sources:

- Bell River Water Source
- Molong Creek Water Source

These water sources were amalgamated due to their connection and because they are not treated separately in the DPIF BPEOM zone for the area. The DPIF zone, 'Mid-Macquarie tributaries' is actually larger than this PU and includes the Little, Talbragar, Coolbaggie, Wambangalang Whylandra creeks and Maryvale Geurie Creek water sources.

The Bell River rises in the hills north–west of Orange and flows generally north past the town of Molong. The Bell River joins the Macquarie River at Wellington. The rivers of the upper catchment flow within well-defined channels and have only limited floodplains (Green et al. 2011). Storages in this planning unit include Molong Creek Dam (1GL storage capacity), Lake Canobolas (680 ML), and Borenore Dam.

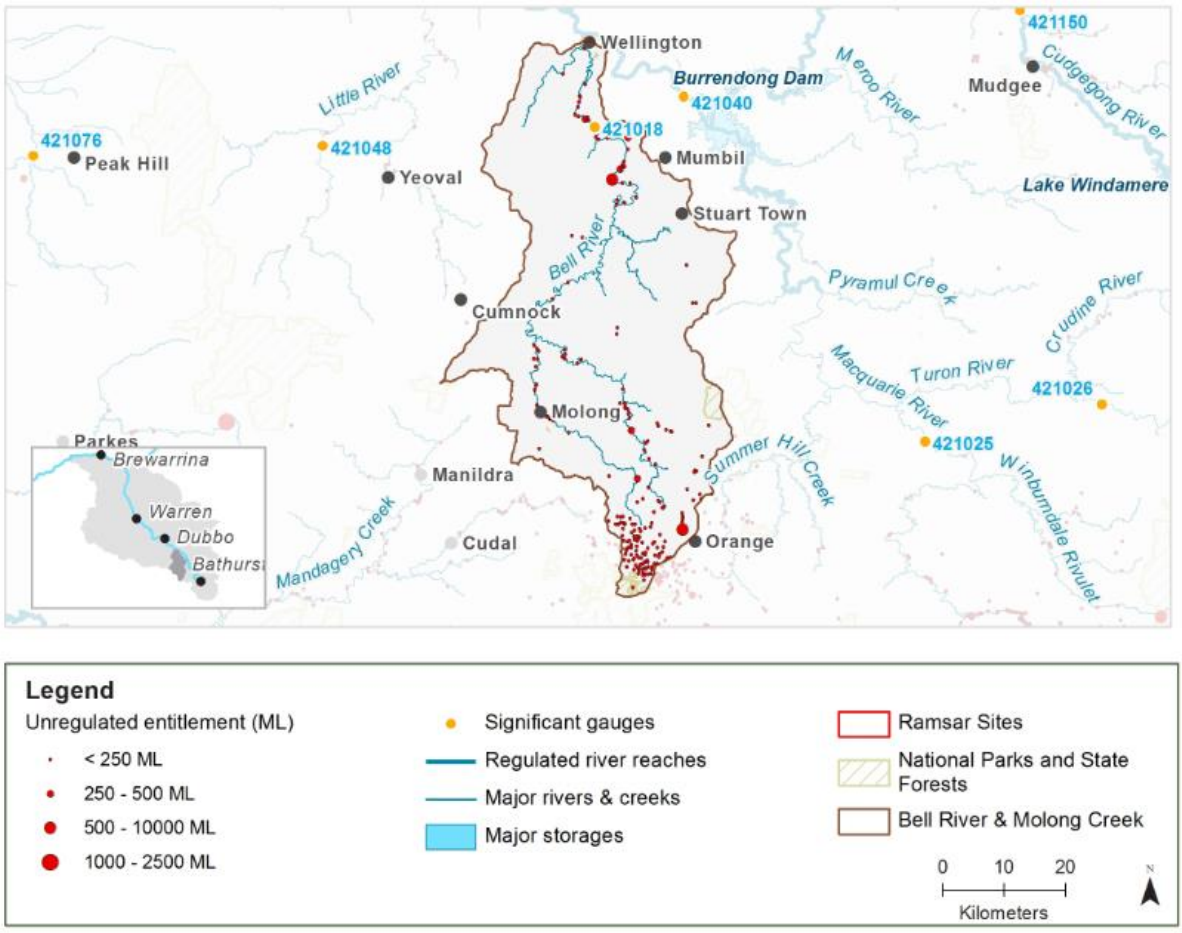


Figure 17 **Map of Macquarie system – Bell River and Molong Creek PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Bell River @ Newrea (421018) and Molong River at Molong (421049).

Named priority environmental assets

- Bell River and Molong Creek channel & riparian zone
- Bell River tributaries including Ploughmans Creek, Curra Creek & Golding Creek
- Molong Creek tributaries including Towac Creek, Colemans Creek & Wattle Flat Gully

Key water-dependent values

(CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)

Native fish	Australian smelt [X + Y] carp gudgeon [X + Y] eel-tailed catfish (E) [Y] flat-headed gudgeon [Y] golden perch [X + Y]	mountain galaxias [X + Y] Murray cod (V) [Y] northern river blackfish [X + Y] purple-spotted gudgeon (E) [Y]
Waterbirds	57 species recorded, including Australasian bittern (E), blue-billed duck (V), freckled duck (V), Caspian tern (C,J), Latham's snipe (C,J,R), red-necked stint (C,J,R), sharp-tailed sandpiper (C,J,R), common greenshank (C,J,R) & marsh sandpiper (C,J,R)	
Native vegetation	1060 ha of water-dependent native vegetation communities, including 900 ha of river red gum forest & woodland	
Registered water-dependent cultural assets	A scarred tree, carved tree & ceremonial sites. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, flat-headed gudgeon, & mountain galaxias

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish, Murray cod, northern river blackfish, purple-spotted gudgeon

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)

Bell River Water Source Gauge: 421018 *Bell River at Newrea*

80th percentile: 11 ML/d	**50th percentile**: 65 ML/d	**20th percentile**: 282 ML/d
1.5 ARI: 7600 ML/d	**2.5 ARI**: 14,000 ML/d	**5 ARI**: 26,300 ML/d

Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. Two large (1000-2500 ML), three medium (500-1000 ML), 90 small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 8157 ML.

Molong Creek Water Source Gauge: 421049 *Molong River at Molong*

80th percentile: 3 ML/d	**50th percentile**: 16 ML/d	**20th percentile**: 77 ML/d
1.5 ARI: 1900 ML/d	**2.5 ARI**: 4600 ML/d	**5 ARI**: 7000 ML/d

Cease-to-flow periods and low flows are highly altered (>50% departure from base case), and freshes are moderately altered (20-50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows and freshes occur less frequently compared to the 'without development' model scenario. One medium (500 ML) and 117 small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 5641 ML.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	H+	H-	L-/M-	L^0/L-
Relevant rules from WSP	**Bell River** **Trade INTO** water source: Trades are permitted in from the Molong Creek Water Source only if the new work is located downstream of the confluence of Molong Creek & Bell River. **Trade WITHIN** water source: Trades are not permitted from downstream of the confluence of Molong Creek & Bell River to upstream of the confluence of Molong Creek & Bell River. Other trades permitted within water source, subject to assessment **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow. **Molong Creek** **Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Trades are not permitted from downstream of the confluence of Molong Creek & Borenore Creek to upstream of the confluence of Molong Creek & Borenore Creek. Other trades permitted within water source, subject to assessment. **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.6 Macquarie system – Little River

This PU includes the Little River and its tributaries and consists of the Little River Water Source. The DPIF BPEOM zone, 'Mid-Macquarie tributaries', which encompasses this PU is larger and includes the Little, Bell, Molong, Talbragar, Coolbaggie, Wambangalang and Whylandra creeks and Maryvale Geurie Creek water sources.

Little River rises in Curumbeyenya Range within Goobang National Park, west of Molong and flows 122 km generally north north–east, joined by three minor tributaries, before reaching its confluence with the Macquarie River west of Geurie. Little River flows within well-defined channels and has only limited floodplains (Green et al. 2011).

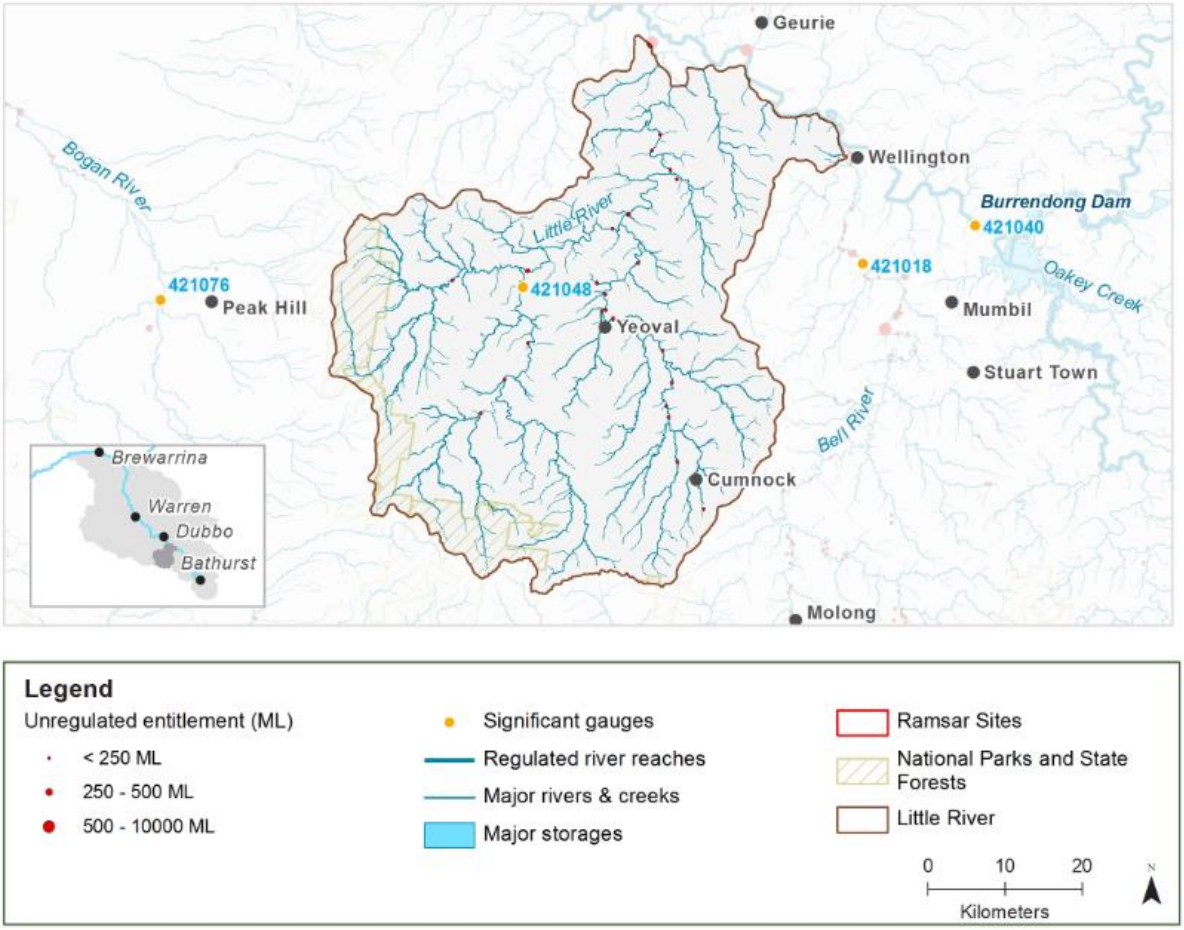


Figure 18 **Map of Macquarie system – Little River PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Little River at Arthurville No. 2 (421176).

Named priority environmental assets

- Little River channel & riparian zone
- Little River tributaries including: Washpen Creek, Budgebegambil Creek, Greenbah Creek, Oaks Creek, Pipeclay Creek, Wandawandong Creek, Sandy Creek, Wandabadgery Creek, Tuckwells Creek, Balrudgery Creek

Key water-dependent values
(CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)

Native fish	Australian smelt [X + Y]	mountain galaxias [Y]
	carp gudgeon [X + Y]	Murray cod (V) [X + Y]
	eel-tailed catfish (E) [X + Y]	Murray-Darling rainbowfish [Y]
	flat-headed gudgeon [Y]	purple-spotted gudgeon (E) [Y]
	golden perch [X + Y]	un-specked hardyhead [Y]

Waterbirds	34 species recorded, including Australian painted snipe (E)
Native vegetation	1274 ha of water-dependent native vegetation communities, including 1200 ha of river red gum forest & woodland
Registered water-dependent cultural assets	Scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, flat-headed gudgeon, mountain galaxias, Murray–Darling rainbowfish & un-specked hardyhead

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish, Murray cod & purple-spotted gudgeon

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)

Little River Water Source Gauge: 421176 *Little River at Arthurville No. 2*

80th percentile: 0 ML/d	**50th percentile**: 11 ML/d	**20th percentile**: 32 ML/d
1.5 ARI: 1800 ML/d	**2.5 ARI**: 3000 ML/d	**5 ARI**: 8700 ML/d

Low flows are highly altered (>50% departure from base case), and cease-to-flow periods are moderately altered (20-50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario.

One large (1,000 ML) and 30 small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 2272 ML.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	M+	H-	L-	L^0
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Consider adding specific commence-to-pump rules in the Water Sharing Plan within five years to:
  - reduce the length of CTF periods
  - better protect low flows & baseflows
  - *investigate increasing commence-to-pump to 25 ML/d @ 'Little River at Obley no.2' gauge (421048)*
- Consider rostering landholder water access during low flow months.

- Consider implementing a first flush rule to ensure CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents.
    - *This will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.*
- Consider implementing total &/or individual daily extraction limits (IDELS & TDELS).
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes
- There is one large licence (>1000 ML/day) at the very end of the creek. Its location reduces the impact on creek flows. If trading of this licence upstream is sought, then this should only be considered in conjunction with pumping restrictions such as a commence-to-pump threshold equivalent to a small fresh level (estimated at 80 ML/day at Obley no.2 gauge).

3.7 Macquarie system – Wambangalong, Whylandra, Maryvale & Geurie creeks

This PU consists of the following water sources:

- Wambangalong and Whylandra Creek Water Source
- Maryvale and Geurie Creek Water Source

These water sources were amalgamated due to their small size, proximity and because they are not treated separately in the DPIF BPEOM zone for the area. The DPIF BPEOM zone, 'Mid-Macquarie tributaries' is actually larger than this PU and includes Little, Talbragar, Coolbaggie, Wambangalong, Whylandra creeks and Maryvale Geurie Creek water sources.

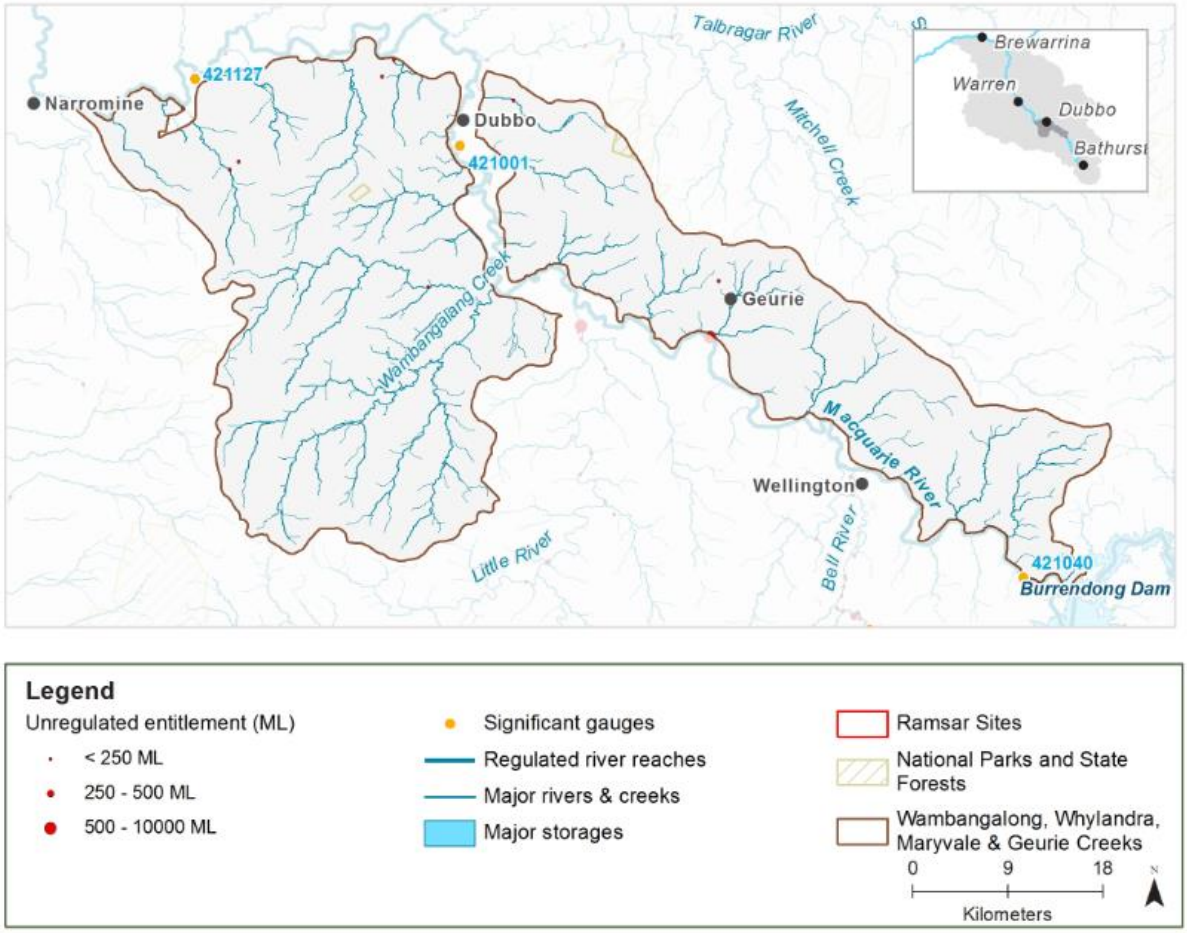


Figure 19 **Map of Macquarie system – Wambangalong, Whylandra, Maryvale & Geurie creeks PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Coolbaggie Creek at Rawsonville (421055).

Named priority environmental assets

- Wambangalong, Whylandra, Maryvale and Geurie Creek channel & riparian zone
- Wambangalong Creek tributaries including Glennie Creek, Emmagool Creek & Belowrie Creek
- Whylandra Creek tributaries
- Maryvale Creek tributaries including Bodangora Creek
- Geurie Creek channel & tributaries including Limestone Creek
- Tributaries including Troy Creek, Eulomogo Creek, Forest Creek & Deep Creek

Key water-dependent values
(CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)

Native fish	Australian smelt [X + Y] bony herring [X] carp gudgeon [X + Y] dwarf flat-headed gudgeon [Y] eel-tailed catfish (E) [X + Y] flat-headed gudgeon [X + Y] golden perch [X + Y]	mountain galaxias [Y] Murray cod (V) [X + Y] Murray–Darling rainbowfish [X + Y] purple-spotted gudgeon (E) [X + Y] silver perch (V) [X] un-specked hardyhead [X + Y]
Waterbirds	52 species recorded, including blue-billed duck (V), magpie goose (V), marsh sandpiper (C,J,R), ruff (C,J,R), Latham's snipe (C,J,R), red-necked stint (C,J,R), ruff (C,J,R) & sharp-tailed sandpiper (C,J,R)	
Native vegetation	1975 ha of water-dependent native vegetation communities, including: river red gum (1788 ha) & non-woody wetland vegetation (2 ha)	
Registered water-dependent cultural assets	Camp sites, scarred trees & carved trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, dwarf flat-headed gudgeon, flat-headed gudgeon, mountain galaxias, Murray-Darling rainbowfish & un-specked hardyhead

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch & silver perch

NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod, eel-tailed catfish & purple-spotted gudgeon

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

NF8 Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range): purple-spotted gudgeon

Hydrology (DPIE-Water, in prep)

Wambangalong Whylandra Creek Water Source Gauge: 421055 *Coolbaggie Creek at Rawsonville*

80th percentile: 0 ML/d	**50th percentile**: 0 ML/d	**20th percentile**: 0 ML/d
1.5 ARI: 400 ML/d	**2.5 ARI**: 600 ML/d	**5 ARI**: 800 ML/d

Flows do not seem to be altered by more than 20% compared to the 'without development' model scenario as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Five small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 169 ML.

Maryvale Geurie Creek Water Source Gauge: 421055 *Coolbaggie Creek at Rawsonville*

80th percentile: 0 ML/d	**50th percentile**: 0 ML/d	**20th percentile**: 0 ML/d
1.5 ARI: 400 ML/d	**2.5 ARI**: 700 ML/d	**5 ARI**: 1000 ML/d

Low flow & Baseflow periods are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Low flow & Baseflow periods currently occur less frequently compared to the 'without development' model scenario.

Three small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 639 ML.

<table>
<tr><th rowspan="3">Hydrological alteration
See Table 1 for key</th><th>CTF</th><th colspan="2">Low flow & Baseflow</th><th>Freshes</th><th>Overbanks</th></tr>
<tr><td>L+</td><td>L^0</td><td>Wambangalong
Whylandra</td><td rowspan="2">L^0/L-</td><td rowspan="2">L^0</td></tr>
<tr><td>L+</td><td>H-</td><td>Maryvale Geurie</td></tr>
<tr><td>Relevant rules from WSP</td><td colspan="5">Trade INTO water source: Not permitted.
Trade WITHIN water source: Permitted, subject to assessment
Access: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.</td></tr>
</table>

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.8 Macquarie system – Talbragar River

This PU consists of the following water sources:

- Lower Talbragar River Water Source
- Upper Talbragar River Water Source

These water sources were amalgamated due to their small size, proximity and because they are not treated separately in the DPIF BPEOM zone for the area. The BPEOM zone, 'Mid-Macquarie tributaries' is actually larger than this PU and includes the Little, Talbragar, Coolbaggie, Wambangalong – Whylandra Creek and Maryvale Geurie Creek water sources.

The Talbragar River rises on the western side of the Liverpool Range, north of Cassilis and flows generally south west for approximately 277 kilometres. The Talbragar River is joined by fifteen tributaries, including the Coolaburragundy River. The river reaches its confluence with the Macquarie River near Dubbo.

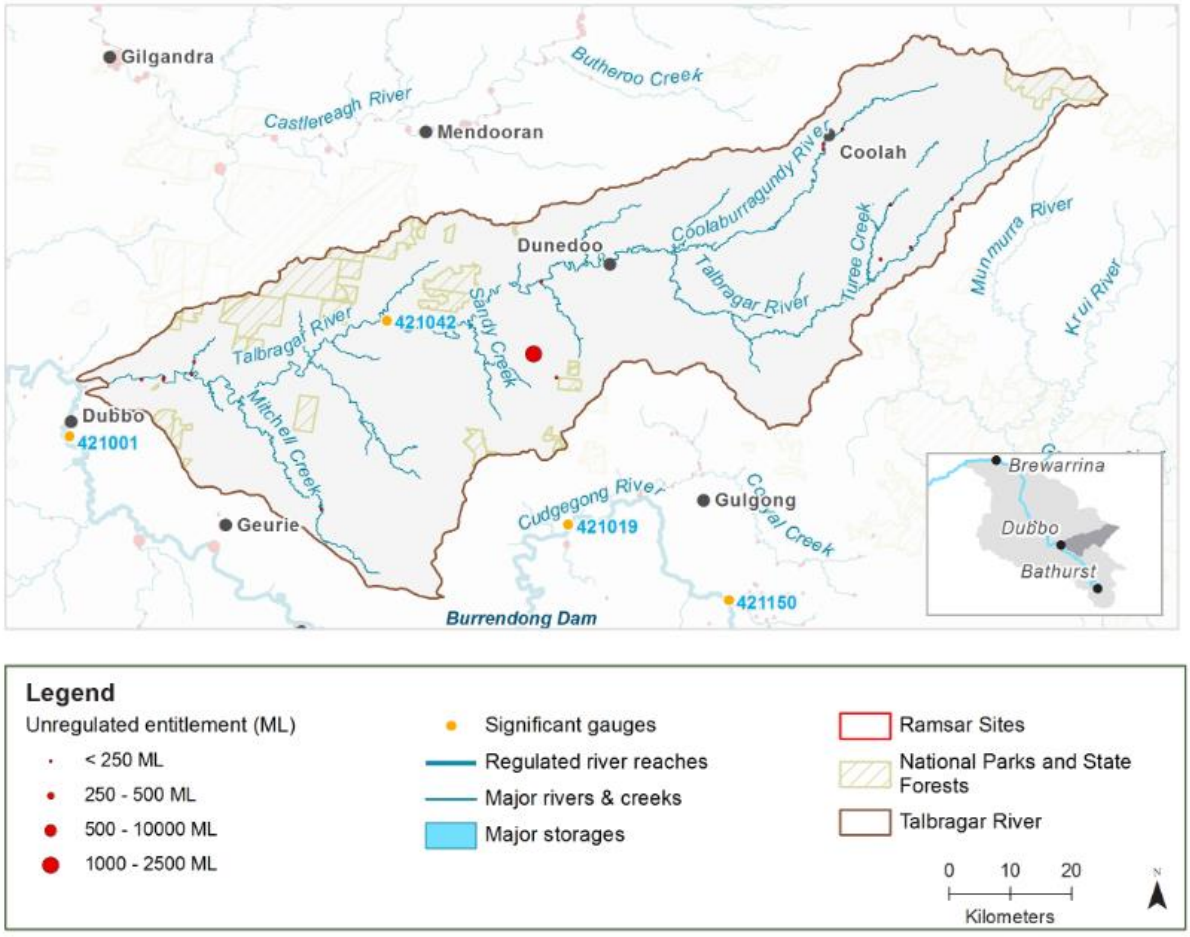


Figure 20 **Map of Macquarie system – Talbragar River PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Talbragar River at Emanon (421163), Coolaburragundy River at Coolah (421056).

Named priority environmental assets

- Talbragar River channel & riparian zone
- Talbragar River tributaries including Goan Creek, Scrubby Creek, Peters Creek, Rocky Creek

Key water-dependent values

(CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)

Native fish	Australian smelt [X + Y] bony herring [Y] carp gudgeon [X + Y] dwarf flat-headed gudgeon [Y] eel-tailed catfish (E) [X + Y] golden perch [X + Y]	mountain galaxias [Y] Murray cod (V) [Y] northern river blackfish [Y] purple-spotted gudgeon (E) [Y] un-specked hardyhead [Y]
Waterbirds	45 species recorded, including blue-billed duck (V), glossy ibis (C), sharp-tailed sandpiper (C,J,R), common greenshank (C,J,R) & Latham's Snipe (C,J,R)	
Native vegetation	4700 ha of water-dependent native vegetation communities, including: river red gum (3840 ha) & river oak (715 ha)	
Registered water-dependent cultural assets	Camp sites, scarred trees, waterhole/wells & fish traps. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, dwarf flat-headed gudgeon, mountain galaxias & un-specked hardyhead

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish, Murray cod, northern river blackfish, purple-spotted gudgeon

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

NF8 Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range): Eel-tailed catfish

Hydrology (DPIE-Water, in prep)

Lower Talbragar Water Source Gauge: 421163 *Talbragar River at Emanon*

80th percentile: 0 ML/d	**50th percentile**: 7 ML/d	**20th percentile**: 82 ML/d
1.5 ARI: 3300 ML/d	**2.5 ARI**: 6200 ML/d	**5 ARI**: 9900 ML/d

Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. One large (1000-2500 ML) and nine small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 2251 ML. Note the large licence is on a tributary, not the main creek.

Upper Talbragar Water Source Gauge: 421056 *Coolaburragundy River at Coolah*

80th percentile: 18 ML/d	**50th percentile**: 64 ML/d	**20th percentile**: 197 ML/d
1.5 ARI: 10600 ML/d	**2.5 ARI**: 16900 ML/d	**5 ARI**: 25000 ML/d

Cease-to-flow periods are highly altered (>50% departure from base case), and low flows are moderately altered (20-50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario. Seven small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 376 ML.

Hydrological alteration See Table 1 for key	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
	H+	M-/H-	L-	L^0
Relevant rules from WSP	**Trade INTO** Upper Talbragar water source: Not permitted. **Trade INTO** Lower Talbragar water source permitted in from the Upper Talbragar River water source to the main trunk of the Talbragar River only. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Consider adding specific commence-to-pump rules in the Water Sharing Plan within five years to:
  - reduce the length of CTF periods
  - better protect low flows & baseflows
  - *investigate increasing commence-to-pump to 10 ML/d @ 'Talbragar River at Elong Elong' gauge (421042)*
- Consider implementing a first flush rule to ensure CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents.
  - *This will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.*
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.9 Macquarie system – Coolbaggie Creek

This PU consists of the Coolbaggie Creek Water Source. Coolbaggie Creek runs to the south–west where it enters the Macquarie River approximately 25 kilometres downstream of Dubbo.

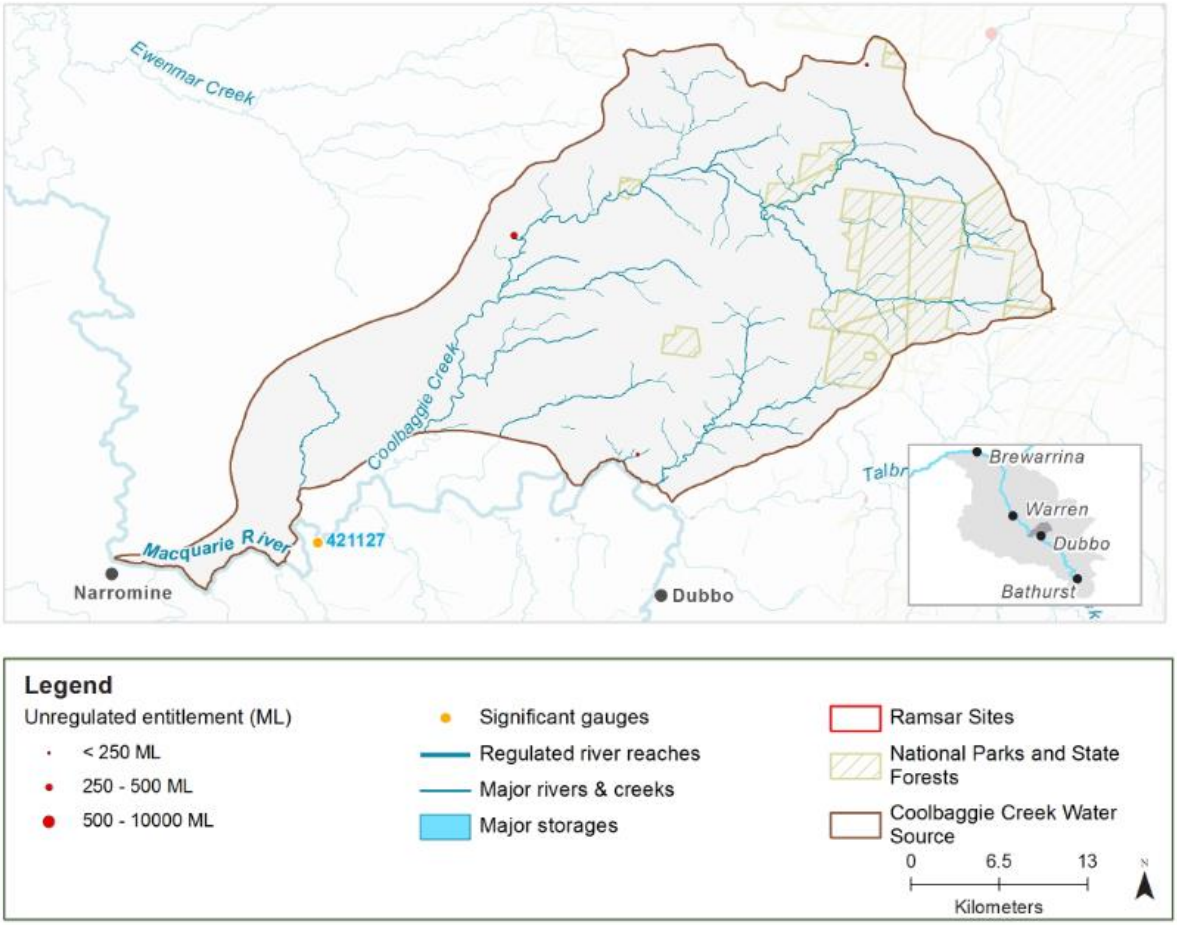


Figure 21 **Map of Macquarie system – Coolbaggie Creek PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Coolbaggie Creek at Rawsonville (421055).

Named priority environmental assets		
• Coolbaggie Creek channel & riparian zone • Coolbaggie Creek tributaries including: Goondy Creek, Drillwarrina Creek, Branch Creek, Yellow Creek, Caledonia Creek, Sandy Creek, Red Creek, Goondy Creek • Old Harbour Lagoon		
Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt [X + Y] bony herring [Y] carp gudgeon [X + Y] dwarf flat-headed gudgeon [Y] eel-tailed catfish [X] flat-headed gudgeon [X + Y]	golden perch [X + Y] Murray cod (V) [X + Y] Murray–Darling rainbowfish [X + Y] purple-spotted gudgeon (E) [Y] un-specked hardyhead [Y]

Waterbirds	28 species recorded, including the Australian painted snipe (E)
Native vegetation	2,169 ha of water-dependent native vegetation communities, including: river red gum (1,431 ha)
Registered water-dependent cultural assets	Scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, dwarf flat-headed gudgeon, flat-headed gudgeon, Murray–Darling rainbowfish & un-specked hardyhead

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish, Murray cod, purple-spotted gudgeon

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)

Gauge: 421055 *Coolbaggie Creek at Rawsonville*

80th percentile: 0 ML/d	**50th percentile**: 0 ML/d	**20th percentile**: 3 ML/d
1.5 ARI: 4300 ML/d	**2.5 ARI**: 7200 ML/d	**5 ARI**: 9700 ML/d

Low flow periods have experienced a high decrease compared to near-natural conditions, as assessed by the Macquarie-Castlereagh WRPA Risk Assessment.

There are 4 water access licences distributed throughout the Planning Unit with entitlements of < 250 – 500 ML. The total volume of unregulated entitlements for the water source is 466 ML.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	L^0	H-	L-	L^0
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.10 Macquarie system – Ewenmar Creek & Backwater Boggy Cowal

This PU consists of the following unregulated water sources:

- Ewenmar Creek Water Source (upper Ewenmar Creek)
- Backwater Boggy Cowal Water Source

It excludes the regulated Macquarie River which dissects this PU.

These unregulated water sources were amalgamated due to their ephemeral nature, their proximity and because they are not treated separately in the DPIF BPEOM zone for the area. The BPEOM zone, 'Mid-Macquarie anabranches and cowals' is actually larger than this PU and includes the Ewenmar Creek, Backwater Boggy Cowal water sources, and some of the anabranches in the Lower Bogan Water Source near the distributary (effluent) creeks.

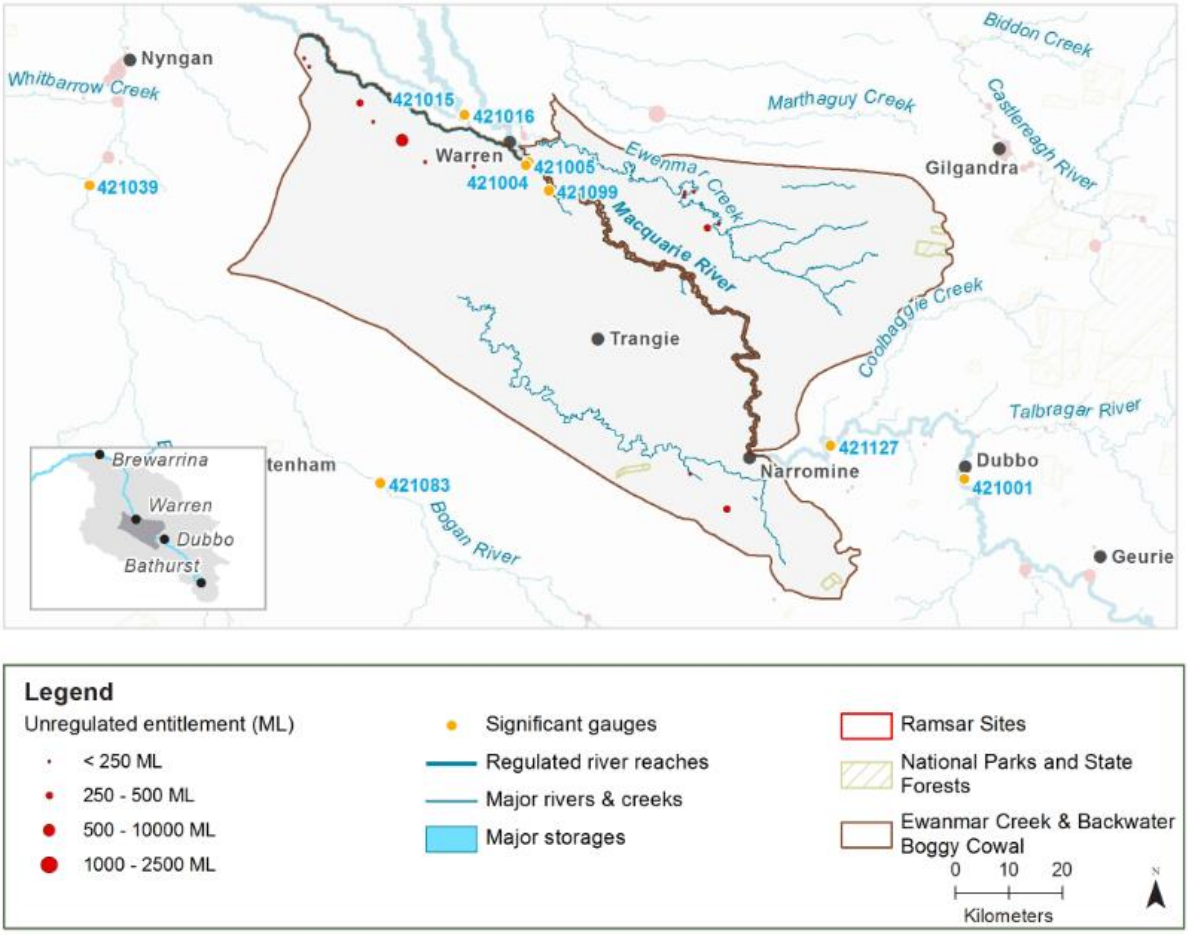


Figure 22 **Map of Macquarie system – Ewenmar Creek & Backwater Boggy Cowal PU.** Area outside of PU has been faded.

Named priority environmental assets

- Ewenmar Creek and Boggy Cowal channel & riparian zone
- Ewenmar Creek tributaries including Birchells Plain Creek, Macquarie River, Greenhide Creek, Crooked Creek
- Wetlands adjacent to and within the Boggy Cowal, Trangie Cowal, Greenhide Creek, Birchells Plain Creek, Ewenmar Creek, Crooked Creek & Macquarie River
- Boggy Cowal distributary streams

- Beleringar Creek

Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt X + Y bony herring X + Y carp gudgeon X + Y dwarf flat-headed gudgeon Y eel-tailed catfish (E) X + Y flat-headed gudgeon Y flathead galaxias (CE) Y	golden perch X + Y Murray cod (V) X + Y Murray–Darling rainbowfish X + Y olive perchlet Y silver perch (V) Y spangled perch Y un-specked hardyhead X + Y
Waterbirds	58 species recorded, including Australian painted snipe (E), black-necked stork (E), blue-billed duck (V), common greenshank (C,J,R), freckled duck (V), Latham's snipe (C,J,R), magpie goose (V), red-necked stint (C,J,R), sanderling (V) & sharp-tailed sandpiper (C,J,R)	
Native vegetation	99,000 ha of water-dependent native vegetation communities, including: river red gum (8700 ha), coolibah (6200 ha), black box (3600 ha), lignum (400 ha) & non-woody wetland vegetation (4600 ha)	
Registered water-dependent cultural assets	Scarred trees, carved trees & camp sites. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, dwarf flat-headed gudgeon, flat-headed gudgeon, Murray–Darling rainbowfish & un-specked hardyhead

NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: flat-headed galaxias & olive perchlet

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch & spangled perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish & Murray cod

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)

Ewenmar Creek Water Source: No Model

Overbank flows are highly altered (>50% departure from base case), and the 1 year in 5 overbank flows are moderately altered (20-50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Larger flows occur less frequently compared to the 'without development' model scenario.

One medium (500 ML) and three small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 1289 ML.

Backwater Boggy Cowal Water Source: No Model

Overbank flows are highly altered (>50% departure from base case), and the 1 year in 5 overbank flows are moderately altered (20-50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Larger flows occur less frequently compared to the 'without development' model scenario.

One large (1,000 ML), Two medium (<500 ML), and seven small (<250 ML) water access licences are distributed across the water source, with the majority clustered at the bottom end of Beleringar Creek. The total volume of unregulated entitlements for the water source is 2631 ML.

Hydrological alteration	CTF	Low flow & baseflow	Freshes	Overbanks
See Table 1 for key	N/A	N/A	N/A	H-
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access:** For Backwater Boggy Cowal Water Source: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow. For Ewenmar Creek Water Source: Pumping is not permitted when there is no visible flow at Ewenmar Creek at Oxley Highway bridge.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.11 Upper Bogan system – Bogan River and headwaters (above Nyngan)

This PU consists of the following water sources:

- Upper Bogan Water Source
- Bulbodney Grahway Water Source

These water sources were amalgamated due to their proximity and because they are not treated separately in the DPIF BPEOM zone for the area. DPIF has separated this zone, 'Bogan Headwaters' from the river channel itself, but this has not been done for the LTWP.

The Bogan River starts in the Hervey Range near Peak Hill and flows north–west to Nyngan. The western side of the catchment is drained by four major tributaries: Bullock, Bulbodney, Pangee and Whitbarrow creeks. The eastern catchment between the Bogan and Macquarie rivers is ill-defined. The total catchment area of the Bogan River upstream of Nyngan is approximately 18,000 km^2.

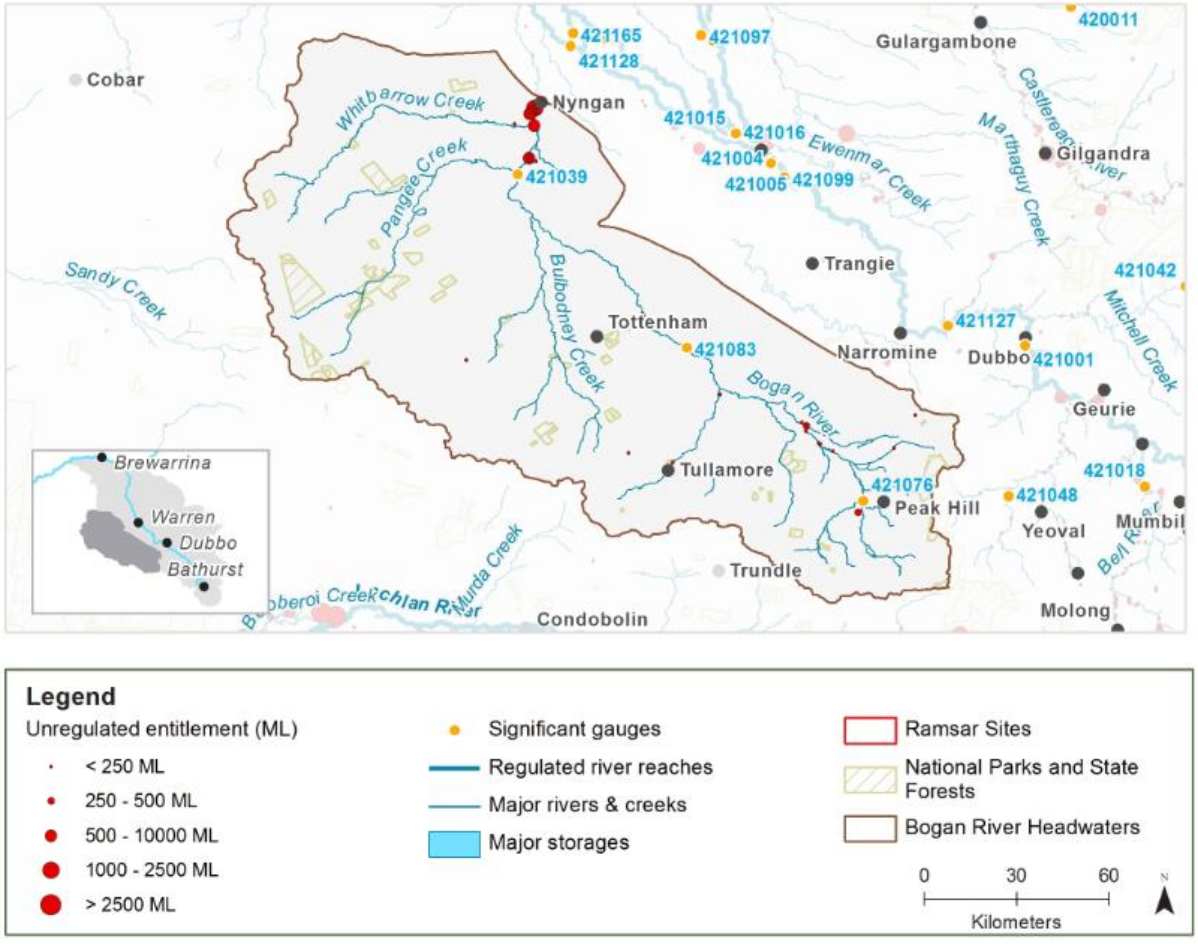


Figure 23 **Map of Macquarie system – Bogan River and headwaters (above Nyngan) PU.** Area outside of PU has been faded. Significant gauges relevant to the PU are Bogan River @ Dandaloo (421083).

Named priority environmental assets
Bogan River and Bulbodney Grahway Creek channel & riparian zone Tributaries: Sandy Creek, Bullock Creek, Bradys Cowal, Genaren Creek, Burrill Creek, Gundong Creek, Tomingley Creek, Bulldog Creek, Barrabadeen Creek, Ten Mile Creek, Burrandong Creek, Bay of Biscay Swamp, Genaren Creek, Pangee Creek, Whitbarrow Creek, Moore Creek, Tigers Creek

Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt [X + Y] bony herring [X + Y] carp gudgeon [X + Y] dwarf flat-headed galaxias [Y] flathead galaxias [Y] eel-tailed catfish (E) [X + Y] golden perch [X + Y] mountain galaxias [Y]	Murray cod (V) [X + Y] Murray-darling rainbowfish [Y] olive perchlet [X + Y] purple-spotted gudgeon (E) [Y] silver perch (V) [X] spangled perch [X + Y] un-specked hardyhead [X + Y]
Waterbirds	53 species recorded, including Australasian bittern (E), black-necked stork (E), brolga (V), Caspian tern (C,J), freckled duck (V) & gull-billed tern (C)	
Native vegetation	133,000 ha of water-dependent native vegetation communities, including: river red gum (13,000 ha), coolibah (10,000 ha), black box (19,000 ha), lignum (700 ha) & non-woody wetland vegetation (6700 ha)	
Registered water-dependent cultural assets	Ceremony & dreaming sites, carved trees & scarred trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, carp gudgeon, dwarf flat-headed gudgeon, bony herring, mountain galaxias, Murray–Darling rainbowfish & un-specked hardyhead
NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet & flathead galaxias
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch & spangled perch
NF5 Improve population structure for moderate to long-lived riverine specialists: purple-spotted gudgeon, eel-tailed catfish & Murray cod
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod
NF7 Increase the prevalence &/or expand the population of key moderate to long-lived riverine specialists into new areas (within historical range): olive perchlet
NF8 Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range): Eel-tailed catfish

Hydrology (DPIE-Water, in prep)

Bulbodney Grahway Water Source Gauge: 421083 *Bogan River at Dandaloo*

80th percentile: 0 ML/d	**50th percentile**: 0 ML/d	**20th percentile**: 3 ML/d
1.5 ARI: 4300 ML/d	**2.5 ARI**: 7200 ML/d	**5 ARI**: 9700 ML/d

Several water access licence entitlements (< 250 – 2500 ML) are distributed throughout the Bulbodney Grahway Water Source Area. The total volume of unregulated entitlements for the water source is 8123 ML. Two of these licences, with entitlement totalling 1,312 ML, are high flow licences, with pumping permitted only when the flow on the Bogan River at Neurie Plains gauge exceeds 635 ML/day. As Assessed by the Macquarie-Castlereagh WRPA Risk Assessment the Bulbodney Grahway Water Source Area has experienced a high decrease in Low flow and baseflows compared to modelled near-natural conditions. CTF, Freshes and Overbank events have experienced low hydrological alteration compared to near-natural conditions.

Upper Bogan River Water Source Gauge: 421083 *Bogan River at Dandaloo*

80th percentile: 0 ML/d	**50th percentile**: 0 ML/d	**20th percentile**: 2 ML/d
1.5 ARI: 2500 ML/d	**2.5 ARI**: 6700 ML/d	**5 ARI**: 17,200 ML/d

11 small (<250 ML) and two medium (<1000 ML) water access licence entitlements are distributed throughout the Upper Bogan Water Source Area. The total volume of unregulated entitlements for the water source is 1735 ML. Two of these licences, with entitlement totalling 1082 ML, are high flow licences, with pumping permitted only when the flow on the Bogan River at Neurie Plains gauge exceeds 635 ML/day. As assessed by the Macquarie-Castlereagh WRPA Risk Assessment the Upper Bogan Water Source Area has experienced a high degree of hydrological alteration compared to near-natural conditions, including:

- High increase in CTF events
- High decrease in Low flow and baseflow
- High decrease in freshes
- Moderate decrease in overbank events

Hydrological alteration
See Table 1 for key

CTF		Low flow & baseflow		Freshes		Overbanks	
H+	Upper Bogan	H-	All water sources	H-	Upper Bogan	M-	Upper Bogan
L+	Bulbodney Grahway			L-	Bulbodney Grahway	L^0	Bulbodney Grahway

Relevant rules from WSP

Upper Bogan

Trade INTO water source: Trades are permitted in from the Lower Bogan River or Bulbodney Grahway Creek water sources only. Trades in unregulated river (special additional high flow) licences are not permitted into this water source.

Trade WITHIN water source: Permitted, subject to assessment

No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.

Bulbodney Grahway

Trade INTO water source**:**

Bulbodney Grahway: Trades are permitted in from the Lower Bogan River & Upper Bogan River water sources & the Upper Nyngan Weir Pool & Lower Nyngan Weir Pool management zones. Trades in unregulated river (special additional high flow) licences are not permitted into this management zone.

Lower Nyngan Weir Pool: Trades are permitted in from the Upper Nyngan Weir Pool management zone. Trades in unregulated river (special additional high flow) licences are not permitted into this management zone.

Upper Nyngan Weir Pool: Trades are permitted in from the Lower Nyngan Weir Pool management zone. Trades in unregulated river (special additional high flow) licences are not permitted into this management zone.

Trade WITHIN water source: Permitted, subject to assessment.

Access:

Bulbodney Grahway: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.

Lower Nyngan Weir Pool: Pumping is not permitted when the water level in the Lower Nyngan weir pool is lower than 50 per cent of its full capacity.

Upper Nyngan Weir Pool: Pumping is not permitted when the water level in the Upper Nyngan weir pool is 70 centimetres or more below the concrete sill of the weir.

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.12 Castlereagh system – Castlereagh River above Binnaway

This PU consists of the Castlereagh River above Binnaway Water Source. The DPIF BPEOM zone, 'Castlereagh headwaters' encompasses this PU, but also includes tributaries of the Castlereagh River (but not the river itself) in the Binnaway to Gilgandra and Tooraweenah to Coonamble Tributaries water sources.

The Castlereagh River rises approximately 20 km west of Coonabarabran in the Warrumbungles and flows south to Binnaway. The Castlereagh and its tributaries are unregulated, except for the effects of Timor Dam (1,140 ML storage capacity), which is operated for Coonabarabran water supply.

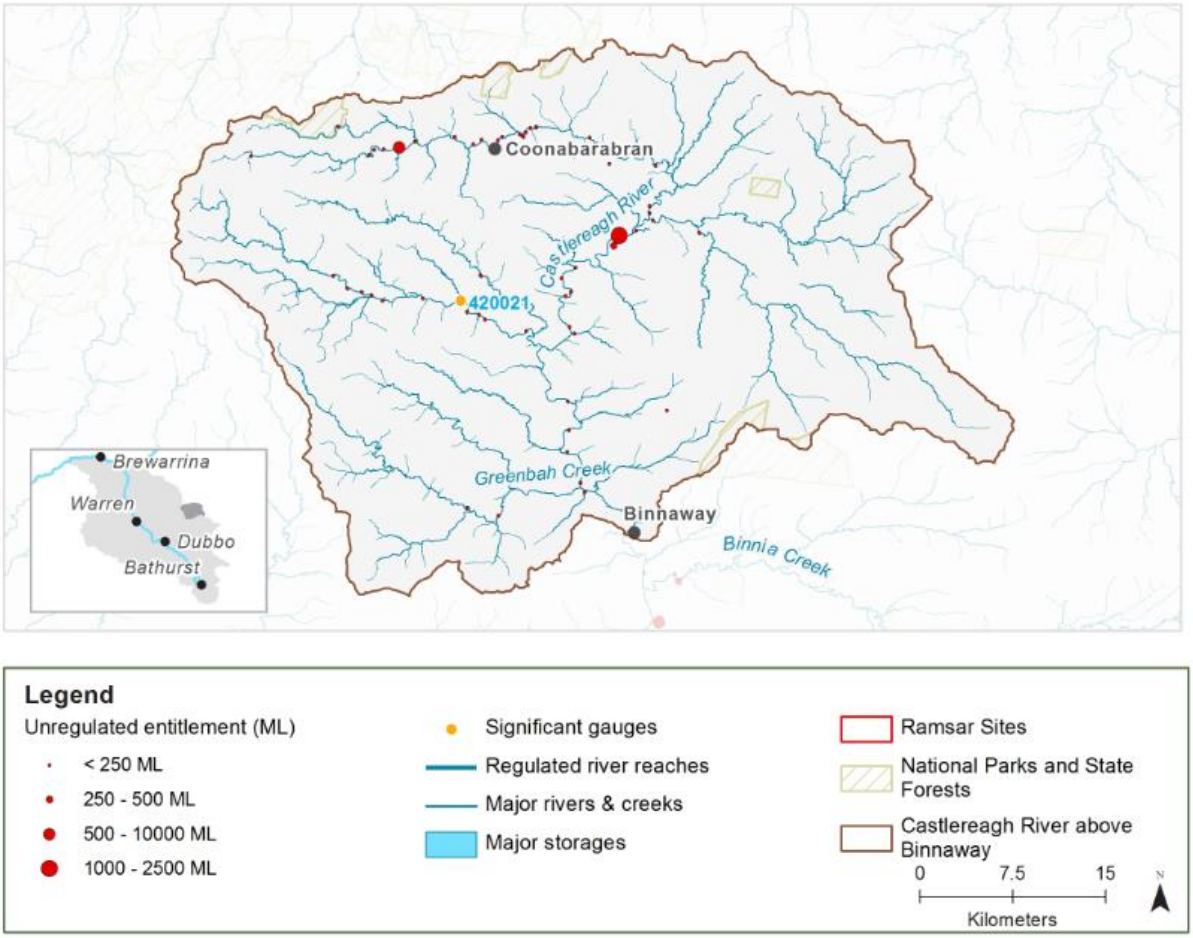


Figure 24 **Map of Castlereagh system – Castlereagh River above Binnaway PU.** Area outside of PU has been faded. Significant gauges relevant to the PU are Castlereagh River at Binnaway (420007).

Named priority environmental assets
Castlereagh River channel & riparian zone
Castlereagh above Binnaway tributaries: Shawns Creek, Jews Gully, Baby Creek, Guntahaba Creek, Dog Trap Creek, Mountain Creek, Front Creek, Fox Creek, Deadmans Gully, Back Belar Creek, Woolshed Creek, Box Ridge Creek, Pipeclay Creek, Tenandra Creek, Cutlers Camp Creek, Belar Creek, Urabrible Creek, Billy Kings Creek, Nandi Creek, Flaggy Creek, Mobara Creek, Colwells Gully, Gundi Creek, Jack Halls Creek

Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt [X + Y] bony herring [X] carp gudgeon [X + Y] dwarf flat-headed gudgeon [Y] eel-tailed catfish (E) [X + Y] golden perch [X + Y]	mountain galaxias [X + Y] Murray cod (V) [Y] northern river blackfish [X + Y] purple-spotted gudgeon (E) [X + Y] spangled perch [X + Y]
Waterbirds	32 species recorded	
Native vegetation	1,618 ha of water-dependent native vegetation communities, including 57 ha of river red gum forest & woodland	
Registered water-dependent cultural assets	Fish traps & carved trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, dwarf flat-headed gudgeon
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch & spangled perch
NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod, eel-tailed catfish, northern river blackfish & purple-spotted gudgeon
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)		
Gauge: 420007 *Castlereagh River at Binnaway*		
80th percentile: 4 ML/d	**50th percentile**: 20 ML/d	**20th percentile**: 75 ML/d
1.5 ARI: 4000 ML/d	**2.5 ARI**: 10,000 ML/d	**5 ARI**: 27,000 ML/d

Low flow periods have decreased moderately compared to near-natural condition as assessed by the Macquarie-Castlereagh WRPA Risk Assessment.

There are a large number of water access licences (~50) with entitlements ranging between < 250 – 2500 ML, distributed throughout the Planning Unit, with the majority occurring along the Castlereagh river. The total volume of unregulated entitlements for the water source is 5722 ML.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	L^0	M-	L-	L^0
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Consider adding specific commence-to-pump rules in the Water Sharing Plan within five years to:
  - better protect low flows & baseflows in the Castlereagh River above Binnaway Water Source Area
  - *investigate increasing commence-to-pump to 15 ML/d @ 420007 'Castlereagh River at Binnaway' gauge*
- Consider rostering landholder water access during low flow months
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes
- Review conditions on larger in-stream storages, such as Timor Dam. This should include consideration of the need for environmental releases or the enhancement of any existing releases.

3.13 Castlereagh system – Binnaway to Gilgandra

This PU consists of only the Castlereagh Binnaway to Gilgandra Water Source. The DPIF BPEOM zone, 'Castlereagh headwaters' encompasses this PU, but also includes the Castlereagh River above Binnaway Water Source and tributaries of the Castlereagh River (but not the river itself) in the Tooraweenah to Coonamble Tributaries Water Source.

The Castlereagh River flows south–south west to the small town of Mendooran then flows westerly/north–westerly towards the town of Gilgandra.

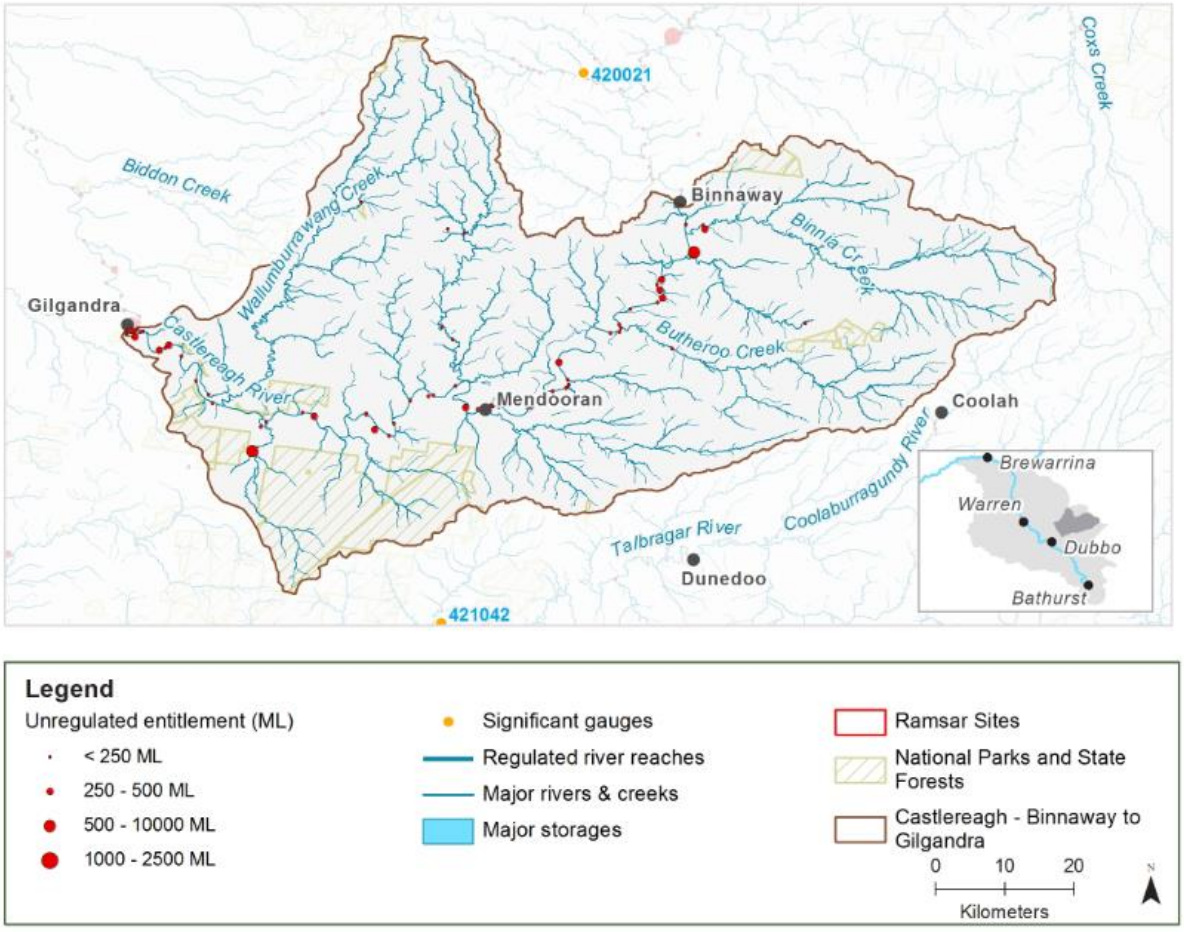


Figure 25 **Map of Castlereagh system – Binnaway to Gilgandra PU.**
Area outside of PU has been faded. Significant gauges relevant to the PU are Castlereagh River at Mendooran (420004)

Named priority environmental assets

Castlereagh River channel & riparian zone

Castlereagh River Binnaway to Gilgandra tributaries: Apple Tree Creek, Breelong Creek, Sallabalah Creek, Denmire Creek, Gum Creek, Dead Man's Creek, Quart Pot Creek, Bellymeyer Creek, Wallumburrawang Creek, Kirban Creek

Key water-dependent values

(CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)

Native fish	Australian smelt [X + Y]	mountain galaxias [Y]
	Bony herring [X + Y]	Murray cod (V) [Y]
	carp gudgeon [X + Y]	northern river blackfish [Y]

	dwarf flat-headed gudgeon [Y] eel-tailed catfish (E) [Y] golden perch [X + Y]	purple-spotted gudgeon (E) [Y] spangled perch [X + Y] un-specked hardyhead [Y]
Waterbirds	38 species recorded, including the Australasian bittern (E)	
Native vegetation	4637 ha of water-dependent native vegetation communities, including: river red gum (2158 ha) & river oak - rough-barked apple - red gum - box riparian tall woodland (1805 ha)	
Registered water-dependent cultural assets	Modified trees, waterhole / wells, ceremony & dreaming sites. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring carp gudgeon, dwarf flat-headed gudgeon, mountain galaxias, un-specked hardyhead

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch & spangled perch

NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod, eel-tailed catfish, purple-spotted gudgeon & northern river blackfish

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch and Murray cod

Hydrology (DPIE-Water, in prep).

Gauge: 420004 *Castlereagh River at Mendooran*

80th percentile: 0 ML/d	**50th percentile**: 0 ML/d	**20th percentile**: 4 ML/d
1.5 ARI: 6900 ML/d	**2.5 ARI**: 26,900 ML/d	**5 ARI**: 45,200 ML/d

Cease-to-flow periods and low flows have been highly altered compared to near-natural conditions as assessed by the Macquarie-Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario.

There are a large number (~50) of water access licences with entitlements ranging between < 250 – 1000 ML, distributed along the length of the Castlereagh river and some tributaries. The total volume of unregulated entitlements for the water source is 7979 ML.

Hydrological alteration See Table 1 for key	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
	H+	H-	L-	L^0
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access:** No pool drawdown. Pumping only permitted when a flow is visible			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.14 Castlereagh system – Tooraweenah to Coonamble Tributaries

This PU consists of only the Tooraweenah to Coonamble Tributaries Water Source. The DPIF BPEOM zone, 'Castlereagh headwaters' encompasses this PU, but also includes the Castlereagh River above Binnaway Water Source and tributaries of the Castlereagh River (but not the river itself) in the Binnaway to Gilgandra Water Source.

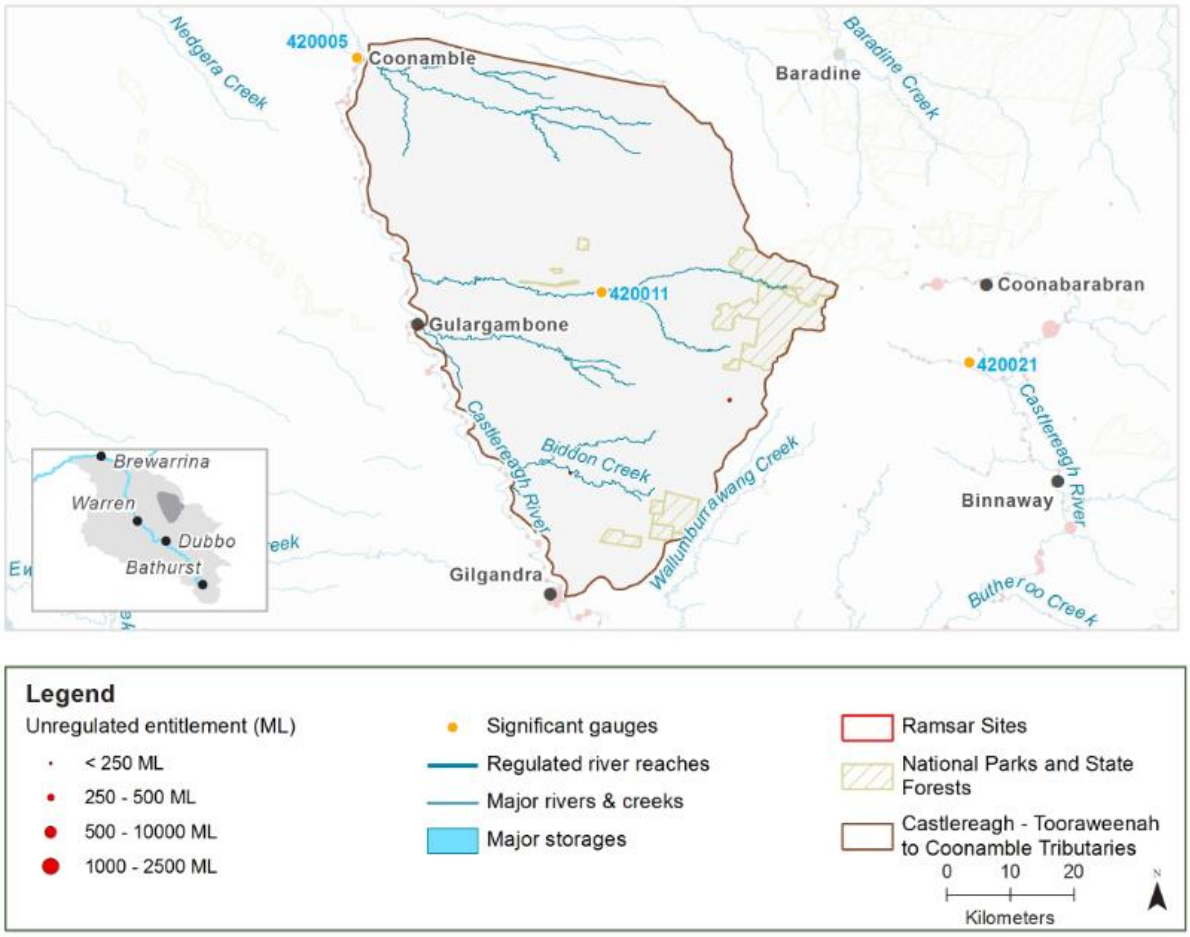


Figure 26 **Map of Castlereagh system – Tooraweenah to Coonamble Tributaries PU.** Area outside of PU has been faded.

Named priority environmental assets		
Tooraweenah to Coonamble tributaries channel & riparian zone including Coonamble Creek, Gulargambone Creek, Quanda Quanda Creek, Baronne Creek, Biddon Creek, Wambelong Creek, Magometon Creek		
Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt [Y] bony herring [X + Y] carp gudgeon [X + Y] eel-tailed catfish (E) [Y] golden perch [X] mountain galaxias [Y] Murray cod (V) [Y]	Murray–Darling rainbowfish [Y] northern river blackfish [X] olive perchlet [Y] purple-spotted gudgeon (E) [Y] spangled perch [X + Y] un-specked hardyhead [Y]

Waterbirds	39 species recorded, including brolga (V) & Australasian bittern (E)
Native vegetation	67,766 ha of water-dependent native vegetation communities, including: river red gum (3754 ha), coolibah (1028 ha), black box (7 ha) & non-woody wetland vegetation (125 ha)
Registered water-dependent cultural assets	Scarred trees, carved trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, mountain galaxias, Murray–Darling rainbowfish & un-specked hardyhead

NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet

NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch & spangled perch

NF5 Improve population structure for moderate to long-lived riverine specialists: eel-tailed catfish, Murray cod, northern river blackfish & purple-spotted gudgeon

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch and Murray cod

Hydrology (DPIE-Water, in prep)

There are 2 small water access licences with entitlements of <250 ML located in this planning unit. The total volume of unregulated entitlements for the water source is 114 ML.

Macquarie Castlereagh WRPA Risk Assessment modelled flows indicated alteration by less than 20% compared to the 'without development' model scenario.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	L+	L^0	L^0	L^0
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access:** No pool drawdown. In rivers and creeks: cease to pump rule when no visible flow.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.15 Castlereagh system – Castlereagh River Gilgandra to Coonamble

This PU consists of the Castlereagh River Gilgandra to Coonamble Water Source of the unregulated Castlereagh River WSP. This aligns with the DPIF BPEOM zone 'Castlereagh River (Middle)'. The Castlereagh River flows north–westerly across the plains through Gulargambone and Coonamble.

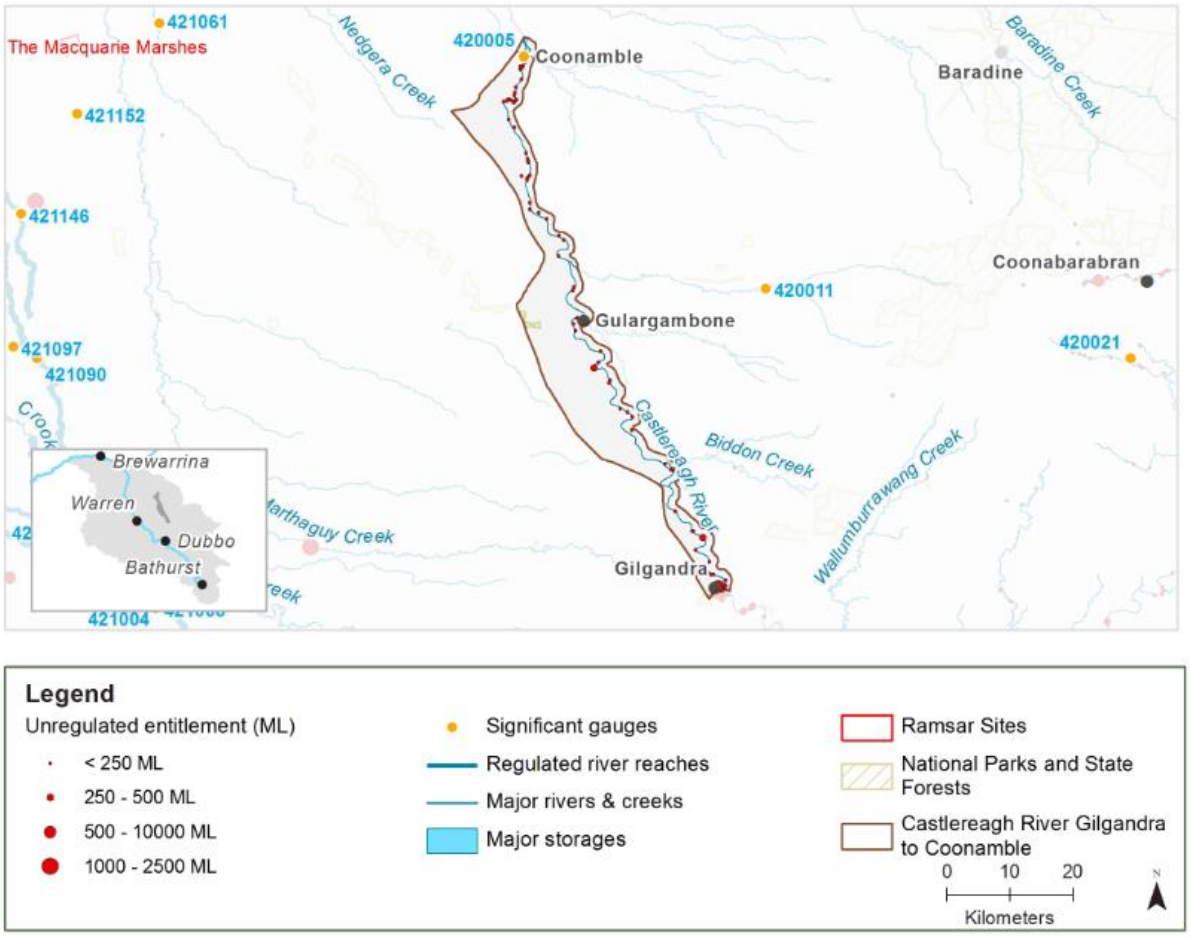


Figure 27 **Map of Castlereagh system – Castlereagh River Gilgandra to Coonamble PU.** Area outside of PU has been faded. Significant gauges relevant to the PU are River at Coonamble Castlereagh (420005)

Named priority environmental assets		
Castlereagh River channel & riparian zone Castlereagh River tributaries including Amareb Gully, Warrana Creek, Baronne Creek		
Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt X + Y bony herring X + Y carp-gudgeon X + Y eel-tailed catfish (E) Y golden perch X + Y	Murray cod (V) Y Murray–Darling rainbowfish Y olive perchlet Y spangled perch X + Y un-specked hardyhead Y

Waterbirds	39 species recorded, including black-necked stork (E) & brolga (V)
Native vegetation	11,283 ha of water-dependent native vegetation communities, including: river red gum (2,895 ha), coolibah (109 ha), black box (222 ha) & non-woody wetland vegetation (1 ha)
Registered Water-dependent cultural assets	Scarred trees, carved trees, habitation structures. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.

Native fish objectives

NF1 No loss of native fish species

NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, Murray–Darling rainbowfish & un-specked hardyhead

NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet

NF4 Improve population structure for moderate to long-lived flow pulse specialists: spangled perch & golden perch

NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod & eel-tailed catfish

NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod

Hydrology (DPIE-Water, in prep)

Gauge: 420005 *Castlereagh River at Coonamble*

80th percentile: 0 ML/d	**50th percentile**: 11 ML/d	**20th percentile**: 132 ML/d
1.5 ARI: 3200 ML/d	**2.5 ARI**: 7500 ML/d	**5 ARI**: 12,100 ML/d

Cease-to-flow periods and low flows have been highly altered compared to near-natural condition as assessed by the Macquarie-Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario.

There are approximately 70 water access licences in this PUdistributed evenly along the length of the Castlereagh River. In the upper part of the PU there is an entitlement of around 1500 ML and another of around 500 ML. The remaining licences are smaller, with only 5 being greater than 100 ML. The total volume of unregulated entitlements for the water source is 4861 ML.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	H+	H-	L-	L-
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites not within a natural pool, cease to pump rule when no visible flow.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.16 Castlereagh system – Lower Castlereagh tributaries

This PU consists of the following water sources:

- Teridgerie Creek Water Source
- Nedgera Creek Water Source

These water sources were amalgamated due to their proximity and because they align with the DPIF BPEOM zone of the same name. Nedgera Creek and Mowlma Creeks support the largest remaining areas of floodplain woodland and wetlands in the Castlereagh (DPIE–W in prep).

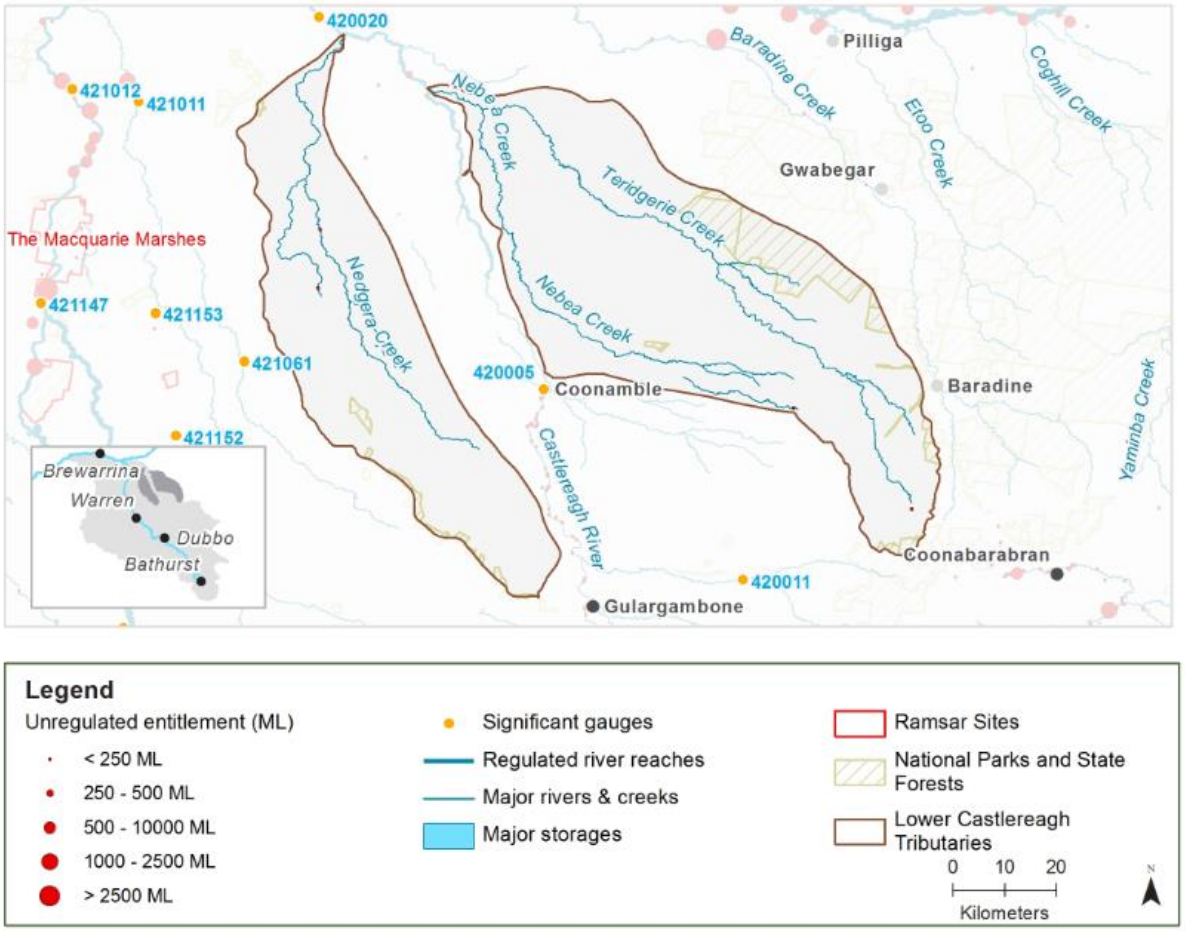


Figure 28 **Map of Castlereagh system – Lower Castlereagh tributaries PU.**
Area outside of PU has been faded.

Named priority environmental assets

- Teridgerie Creek and Nedgera Creek channel & riparian zone
- Teridgerie Creek tributaries including: Nebea Creek, Tititiree Creek, Gidgerygah Creek, Urawilkie Creek, Weetaliba Creek, Ironbark Creek, Six Mile Creek, Murrumbah Creek, Tititiree Creek, Bucklanbah Creek, Milchomi Creek, Small Creek, Duck Holes Creek
- Nedgera Creek tributaries including: Garriwilla Watercourse, Tallegar Swamp Creek, Brooklyn Creek

Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)		
Native fish	Australian smelt [Y] bony herring [X + Y] carp gudgeon [X + Y] eel-tailed catfish (E) [Y] flathead galaxias (CE) [Y] golden perch [Y]	Murray cod (V) [Y] Murray–Darling rainbowfish [Y] olive perchlet [Y] purple -spotted gudgeon [Y] spangled perch [X + Y] un-specked hardyhead [Y]
Waterbirds	52 species recorded, including Australian painted snipe (E), black-necked stork (E), brolga (V), Caspian tern (C,J), Latham's snipe (C,J,R), sharp-tailed sandpiper (C,J,R) & marsh sandpiper (C,J,R)	
Native vegetation	144,000 ha of water-dependent native vegetation communities, including: river red gum (2000 ha), coolibah (22,000 ha), black box (11,000 ha), lignum (160 ha) & non-woody wetland vegetation (4000 ha)	
Registered water-dependent cultural assets	Carved trees. It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.	

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, Murray–Darling rainbowfish & unspecked hardyhead
NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet & flat-headed galaxias
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch & spangled perch
NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod, purple-spotted gudgeon & eel-tailed catfish
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch and Murray cod

Hydrology (DPIE–Water, in prep)

Nedgera Creek Water Source

Flows do not seem to be altered by more than 20% compared to the 'without development' model scenario as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Two small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 12 ML.

Teridgerie Creek Water Source

Flows do not seem to be altered by more than 20% compared to the 'without development' model scenario as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Two small (<250 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 62 ML.

Hydrological alteration	**CTF**	**Low flow & baseflow**	**Freshes**	**Overbanks**
See Table 1 for key	L^0/L+	L^0	L^0	L^0

Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites on rivers and creeks, cease to pump when no visible flow.

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes

3.17 Castlereagh system – Castlereagh River below Coonamble

This PU includes the Castlereagh River and tributaries from Coonamble to its confluence with the Lower Macquarie River. This PU consists of only the Castlereagh River below Coonamble Water Source. This aligns with the DPIF BPEOM zone, 'Castlereagh River (Lower)'.

Downstream of Coonamble the Castlereagh River flows across a broad flat plain towards its junction with the lower Macquarie River. Several creek systems contribute flows to the river after localised rainfall. Nebea and Teridgerie are the largest of these creeks on the eastern side, and Mowlma and Nedgera creeks on the western side. The Castlereagh River enters the Macquarie River approximately 20 km upstream of its confluence with the Barwon River.

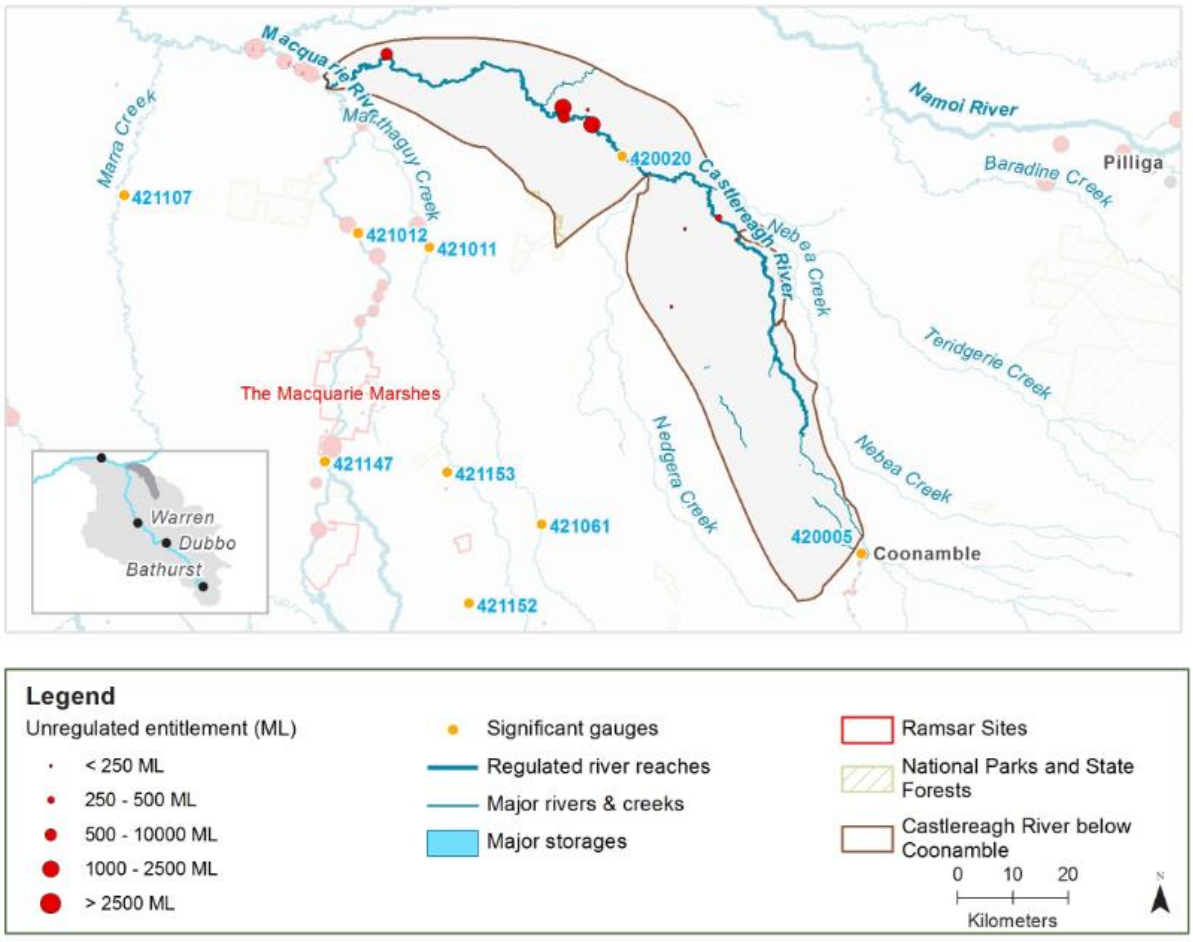


Figure 29 **Map of Castlereagh system – Castlereagh River below Coonamble PU.** Area outside of PU has been faded. Significant gauges relevant to the PU are Castlereagh River @ Gungalman (420020).

Named priority environmental assets	
Castlereagh River, riparian zone & floodplain	
Key water-dependent values (CE = Critically Endangered, E = Endangered, V = Vulnerable, C = CAMBA, J = JAMBA, R = ROKAMBA, X = species recorded in this planning unit via catch records and or Australian Museum Records where they exist, Y = species expected to occur based on MaxEnt modelling)	
Native fish	Australian smelt [X + Y] bony herring [X + Y] carp gudgeon [X + Y] eel-tailed catfish (E) [Y] golden perch [X + Y] Hyrtl's tandan Murray cod (V) [Y] Murray-Darling rainbowfish [Y] olive perchlet [Y] purple-spotted gudgeon (E) [Y] silver perch (V) [Y] spangled perch [X + Y] un-specked hardyhead [Y]
Waterbirds	41 species recorded, including magpie goose (V), Caspian tern (C,J) & red-necked stint (C,J,R)
Native vegetation	104,733 ha of water-dependent native vegetation communities, including: river red gum (1638 ha), coolibah (33,888 ha), black box (26,442 ha) & non-woody wetland vegetation (6769 ha)
Registered water-dependent cultural assets	Scarred trees It is acknowledged that other Aboriginal values such as sites, objects, landscapes, resources & beliefs that are important to Aboriginal people as part of their continuing culture may be present but not registered.

Native fish objectives
NF1 No loss of native fish species
NF2 Increase the distribution & abundance of short to moderate-lived generalists: Australian smelt, bony herring, carp gudgeon, Murray–Darling rainbowfish & un-specked hardyhead
NF3 Increase the distribution & abundance of short to moderate-lived floodplain specialists: olive perchlet
NF4 Improve population structure for moderate to long-lived flow pulse specialists: golden perch, silver perch, spangled perch & Hyrtl's tandan
NF5 Improve population structure for moderate to long-lived riverine specialists: Murray cod, eel-tailed catfish & purple-spotted gudgeon
NF6 A 25% increase in abundance of mature (harvestable sized) golden perch & Murray cod
NF7 Increase the prevalence &/or expand the population of key short to moderate-lived floodplain specialists into new areas (within historical range): olive perchlet
NF9 Increase the prevalence and/or expand the population of key moderate to long-lived flow pulse specialists native fish species into new areas (within historical range): Hyrtl's tandan

Hydrology (DPIE–Water, in prep)

Gauge: 420020 *Castlereagh River at Gungalman*

Cease-to-flow periods and low flows are highly altered (>50% departure from base case) as assessed by the Macquarie Castlereagh WRPA Risk Assessment. Cease-to-flow periods currently occur more frequently, and low flows occur less frequently compared to the 'without development' model scenario.

Four small (<250 ML), one medium (500 ML), and four large (1,000-2500 ML) water access licences are distributed across the water source. The total volume of unregulated entitlements for the water source is 4868 ML. Two of the licences, totalling 3330 ML of entitlement, are high flow licences.

Hydrological alteration	CTF	Low flow & baseflow	Freshes	Overbanks
See Table 1 for key	H+	H-	L-	L-
Relevant rules from WSP	**Trade INTO** water source: Not permitted. **Trade WITHIN** water source: Permitted, subject to assessment **Access**: No pool drawdown. For pump sites on rivers and creeks, cease to pump when no visible flow.			

Recommended management strategies

- Maintain existing rules in the WSP to maintain priority environmental assets
- Consider adding specific commence-to-pump rules in the WSP within five years to:
  - reduce the length of CTF periods
  - better protect low flows & baseflows
  - *investigate increasing commence-to-pump to 30 ML/d @ 420020 'Castlereagh River at Gungalman' gauge*
- Consider rostering landholder water access during low flow months
- Consider implementing a first flush rule to ensure CTF periods are broken at ecologically relevant times by events of sufficient magnitude to avoid adverse water quality incidents.
  - *This will require work to identify refuge pools, estimate the flow requirements to replenish these pools and provide sufficient dilution, and water quality monitoring to help establish and confirm these estimates.*
- Consider implementing total &/or individual daily extraction limits (IDELS & TDELS)
- Improve the gauging network to better indicate flow distribution and take, particularly for the gauging of flow below the most downstream extraction point.
- Ensure compliance with water access licence conditions including through metering of all licensed extraction
- Monitor for changes in water demand & review access rules if usage increases or if the pattern of use changes
- Consider restrictions to take in water sources bordering the Barwon River when embargoes on take exist in the Barwon River. This is relevant to this PU, as although the main Castlereagh channel not directly join the Barwon, it joins the Lower Macquarie River just upstream of its junction with the Barwon River.

Table 12 LTWP EWRs for the Castlereagh below Coonamble at Gungalman Bridge (420020).

As the Castlereagh River is unregulated, the values provide an indication of the flow sizes and frequencies which should ideally be protected. All information should be considered preliminary based on the limited dataset available (recording at this gauge began in 2001, available modelled data is provisional)

Flow category and EWR code		Flow volume	Timing	Duration	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements and comments
Cease-to-flow	CTF	0 ML/d					Not analysed due to poor data set and difficulty in analysing low flows
Very-low-flow	VLF	Evidence of flow to confluence with Macquarie[52]	Anytime				Not analysed due to poor data set and difficulty in analysing low flows
Baseflow	BF1	>30 ML/d	Anytime				Not analysed due to poor data set and difficulty in analysing low flows
	BF2	>30 ML/d	Sep–Mar				Not analysed due to poor data set and difficulty in analysing low flows
	BF3	TBD[53]	As required to avoid stratification during periods of identified high risk where a hypoxic bottom layer is likely to develop to an extent that it could produce hypoxic conditions in the entire water column should subsequent mixing occur. Requirement more likely during periods of extreme heat and low flow. This flow would also help reduce the risk of fish mortality due to extremely high water temperatures. Further work (see Table 22 of Part A) is required to provide tools to develop flow requirements.				

[52] Actual flow required at Gungalman Bridge to provide trickle flow through to the Macquarie will vary depending on antecedent and seasonal conditions.

[53] To be determined. Further work is required to confirm thresholds. See action on ‘tools for preventing fish deaths due to stratification’ in Table 22 of Part A.

Flow category and EWR code		Flow volume	Timing	Duration	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements and comments
De-stratifying flow	DSF	TBD[53]	As required to destratify refuge pools during periods of identified high risk where a hypoxic bottom layer has developed and could produce hypoxic conditions in the entire water column when mixed. Requirement more likely during periods of extreme heat and low flow. Further work (see Table 22 of Part A) is required to better identify risk periods and provide tools to develop flow requirements.				
Small fresh	SF1	>100 ML/d	Anytime (ideally Oct–Apr)	10 days	Annually (10 years in 10)	1 year	
	SF2	100–850 ML/d	Sep–Apr (Sep–Dec for Murray cod spawning)	14 days	5–10 years in 10 (75% of years)	2 years	
	SF3	>100 ML/d	Anytime (ideally July–Sep for initial flow & Oct–Apr for subsequent flow)	28 days	5 years in 10 (50% of years)	4 years	For movement of fish recruits from Barwon River
Large fresh	LF1	>850 ML/d	Anytime (ideally Jul–Sep)	5 days	5–10 years in 10 (75% of years)	2 years	
	LF2	>850 ML/d	Oct–Apr	5 days	3–5 years in 10 (40% of years)	4 years	
Overbank/ Wetland flow Small	OB/ WS1	Not applicable. This flow is for core wetland areas, which are not a feature of this PU					
	OB/ WS2	>3,000 ML/d	Oct–Apr (but for this northern river section, anytime is considered acceptable)	10 days	Ideally 4–10 years in 10, but this may only be achieved in wetter sequences- see 'additional information' column))	4 years	There are objectives to support the floodplain specialist native fish, the olive perchlet, in this planning unit. Analysis shows small overbanks of 10 days duration only occur in 33% of years (when assessed as any time of

Flow category and EWR code		Flow volume	Timing	Duration	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements and comments
							year for post 2001 observed flows). Therefore, this species may only be supported in wetter sequences of years or in off-channel wetlands that are filled at below bankfull levels. Following dry sequences recruits may come from the Barwon, but this requires further research to be confirmed.
	OB/ WS3	>3,000 ML/d	Anytime (ideally Sep–Feb)	5 days (the median duration of flows is greater than 5 days. 5 days is also used for riparian river red gum requirements)	2–3 years in 10 (25% of years)	5 years	For both fish dispersal/condition & riparian river red gum
	OB/ WS4	>3,000 ML/d	Anytime (ideally Aug–Mar)	Persistence of water 3 months. Flow of 5 days estimated as required to fill depressions & soil profile.	3–5 years in 10 (40% of years)	5 years	Lower frequency required in this PU because the main non-woody vegetation is rats tail couch and other relatively dry-tolerant species.
Overbank/ Wetland flow Medium	OB/ WM	Not determined	Anytime (ideally Aug–Mar)	Persistence of water. 3 months for wetland depressions.	5 years in 10 (50% of years)	5 years	
Overbank/ Wetland flow Large	OB/ WL	Not determined	Anytime (ideally Aug –Mar)	Persistence of water 3 months for wetland depressions.	2–3 years in 10 (25% of years)	5–10 years	

References

Alluvium 2010, *Key ecosystem functions and their environmental water requirements*, Report by Alluvium for Murray–Darling Basin Authority, Canberra.

Barma Water Resources, IRPEC Pty Ltd & Wettin P 2011, *Environmental Water Delivery: Macquarie River*, Prepared for Commonwealth Environmental Water Office, Department of Sustainability, Environment, Water, Population and Communities, Canberra.

DPIE–Water in prep, Risk Assessment for the Macquarie–Castlereagh Water Resource Plan Area (SW11), NSW Department of Industry–Water.

Green D, Petrovic J, Moss P and Burrell M 2011, *Water resources and management overview: Macquarie–Bogan catchment*, NSW Office of Water, Sydney.

Morris S, Pollard D, Gehrke P & Pogonoski J 2001, *Threatened and potentially threatened freshwater fishes of coastal New South Wales and the Murray–Darling Basin*. NSW Fisheries, Sydney.

NSW Department of Primary Industries (DPI) 2015, *NSW Fish Community Status Project*. Final report prepared for the Commonwealth Government. NSW Department of Primary Industries, Wollongbar.

NSW Department of Primary Industries–Fisheries (DPIF) unpublished. Fish and flows in water planning activities. NSW Department of Primary Industries, Tamworth.

NSW Office of Environment and Heritage (OEH) 2010, *Macquarie Marshes Adaptive Environmental Management Plan*, NSW Office of Environment and Heritage.

Stewardson MJ & Guarino F 2017, *2015–16 Basin scale evaluation of Commonwealth environmental water–Hydrology*, Final report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 142/2017, October, 45pp plus annex.

Stewardson MJ 2005, Hydraulic geometry of stream reaches, *Journal of Hydrology* 306(1), 97–111.

Thomas RF, Cox S & Love, D 2013, *Macquarie Marshes Wetland Region and Water Management Area Boundaries Version 6*. NSW Office of Environment and Heritage, Sydney.

Torrible L, Wettin P, Barma D, Wilson G, Hobcroft D and O'Cock, J 2011. *Post Flood Assessment and Determination of Environmental Water Requirements for Gunningbar Creek, Lower Crooked Creek, Marra Creek and the Lower Macquarie River*. Prepared by IRPEC Pty or BWR on behalf of The Australian Government Department of Sustainability, Environment, Water, Population and Communities.