



Australian Government

Commonwealth Environmental Water Office

Commonwealth Environmental Water Office

Water Management Plan

Chapter 3.3 – Warrego and Moonie rivers

2020–21



This document represents a sub-chapter of 'Commonwealth Environmental Water Office Water Management Plan 2020-21, Commonwealth of Australia, 2020'.

Please visit: <https://www.environment.gov.au/water/cewo/publications/water-management-plan-2020-21> for links to the main document.

Acknowledgement of the Traditional Owners of the Murray–Darling Basin

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3.3 Warrego and Moonie rivers

3.3.1 Region overview

(a) River valleys

The Warrego and Moonie rivers are characterised by highly variable rainfall and ephemeral (intermittent) stream flows (**Figure 1**). Significant flow events generally result from heavy rainfall in elevated headwater areas. These northern unregulated systems are highly intermittent, and no flow periods of several months are common, extending to several years during prolonged dry conditions.

The flat landscape, low local runoff and intermittent flow conditions have led to the evolution of distinctive ecology in lowland river reaches. Aquatic and floodplain species are adapted to high flow variability and ‘boom and bust’ cycles. This is characterised by episodes of intense reproduction and high productivity by opportunistic plants and animals—the boom—associated with periods of flooding, followed by periods of stress and reduced production—the bust.

The Moonie River is a predominantly unregulated system and has no water major storages. A weir was built over the river at Thallon in 1959 to supply town water. Almost all irrigation in the Moonie depends on surface water. However, these diversions are small, accounting for only 0.2% of surface water diverted for irrigation in the Basin. Small to medium weirs are dispersed along the Moonie river for irrigation purposes, predominantly for cotton. The majority of water stored is harvested through capture of overland flows and the diversion of floodwater during episodic flow events. Water is stored in large shallow floodplain storages known as ring tanks or turkey nest dams.

The Warrego River is largely unregulated, other than the State-owned Allan Tannock Weir at Cunnamulla. Only a small volume of surface water in the Warrego catchment is diverted for irrigation and urban use. Some water is also taken from the river by diversion of flow or overland flows into private off-channel storages.

Water use and planning information on the Condamine–Balonne and Barwon–Darling are provided in separate sub-chapters.

(b) Traditional Owners

The lands and waters of the Warrego and Moonie catchments hold significant spiritual and cultural importance for Aboriginal people. Many Aboriginal nations retain a connection with the region and their history, culture and livelihoods are closely intertwined with its river systems. The Warrego catchment takes in (or closely borders) the traditional lands of the Yuwaalaraay/Euahlayi, Bidjara, Gwamu/Kooma, Gunggari/Kungari, Kunja, Mandandanji, Mardigan, Githabul and Murrawarri nations. The Moonie catchment includes the traditional lands of the Bigambul, Gomeroi/Kamilaroi and Mandandanji nations.

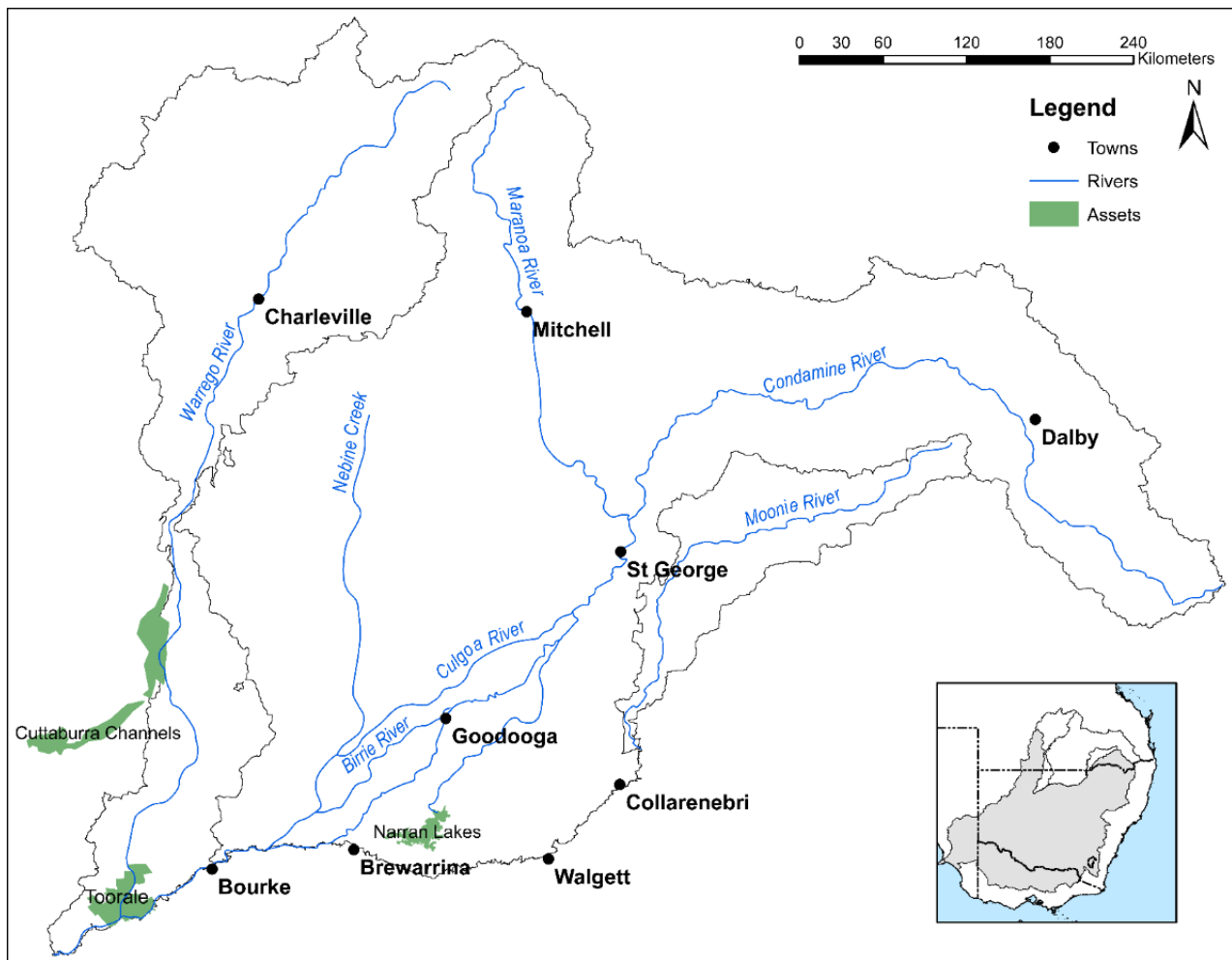


Figure 1: Map of the Warrego and Moonie rivers.

(c) *Important sites and values*

There are many environmental assets in the Warrego and Moonie catchments including species and communities of fish, waterbirds and vegetation and important habitats such as wetlands and drought refuges.

There are over more than 100 wetlands along the Moonie River floodplain. Even though the wetlands are not recognised as nationally or internationally important, they provide significant waterbird habitat within the Basin, including for the threatened Australian painted snipe and the freckled duck. They also support threatened and endangered plant species and three endangered vegetation communities.

The Warrego catchment supports large areas of wetlands. The Cuttaburra Channels and nationally significant Yantabulla Swamp (a mosaic of channels, floodways and wetlands) consistently support large numbers and a high diversity of waterbirds and provides breeding sites for ducks and colonial waterbirds when flooded. Waterholes along the Warrego near Charleville are an important breeding area for native fish including Murray cod and silver perch. Toorale's Western Floodplain is also an ecologically important floodplain wetland, providing important feeding and breeding habitat for a range of water dependent species in wet conditions. These ecological populations and habitats are connected to the Barwon–Darling River, providing a critical drought refuge and movement corridor for fish and waterbirds.

Native vegetation in the Warrego and Moonie rivers includes important riparian and floodplain communities in the dryland catchment areas such as lignum, river red gum, river cooba, black box and coolibah. There is a high proportion of remnant vegetation in good condition in some areas including the floodplains of the Warrego, such as stands of coolibah, black box and lignum. The Western Floodplain also supports 'tiny teeth' (*Dentella minutissima*) a plant species listed as threatened under NSW legislation.

The Warrego and Moonie rivers support several species listed as endangered or vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*, for example, Murray cod, silver perch, Australian painted snipe, Australasian bittern, and examples of the threatened ecological community of coolibah-blackbox woodland. Additionally, these rivers support important remnant populations of olive perchlet, purple spotted gudgeon, and freshwater catfish that are less prevalent or no longer present in the southern Basin.

In between boom periods, channels typically dry to a series of disconnected waterholes, which are drought refuges that are reconnected by the next significant flow event. Semi-permanent and permanent waterholes in the main river channels and distributary creeks and anabranched systems are critical to ensuring the survival of species between boom periods and their capacity to recolonise the system in subsequent flow periods. Much of the riverine fauna (e.g. fish, turtles, invertebrates) of the Warrego and Moonie rivers is dependent upon the persistence of a network of refugial waterholes during frequent and often prolonged no flow periods.

(d) Stakeholder engagement

In the Warrego and Moonie rivers, planning, management, and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders in the Warrego and Moonie include the Queensland Departments of Natural Resources, Mines and Energy (DNRME), Environment and Science (DES), and Agriculture and Fisheries (DAF), NSW Department of Planning, Industry and Environment (DPIE), NSW Department of Primary Industries (DPI) – Fisheries, NSW National Parks and Wildlife Service and the Toorale Joint Management Committee.

Local Engagement Officers from the Commonwealth Environmental Water Office (CEWO) also work with different stakeholders as part a broader program of engagement around the management of the Commonwealth's portfolio of environmental water entitlements. As part of this work, the CEWO's Local Engagement Officers have been engaging directly with members of the local Aboriginal community. This work has focused on aligning priorities for water use with Aboriginal community objectives for sites, values and species significant to the all Nations in the Warrego and Moonie catchments.

3.3.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, state long-term watering plans, site management plans, and best available knowledge, the following objectives are relevant for environmental watering in the Warrego and Moonie rivers. These objectives will continue to be revised as part of the CEWO's commitment to adaptive management.

Vegetation: Maintain and improve the condition, growth and survival of riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Maintain foraging, roosting and breeding habitats at targeted sites on the floodplain to support waterbirds.

Native fish: Improve habitat condition, and support different life stages (migration, spawning, recruitment and refuge), natural flow variability, and connectivity between river channels, wetlands, anabranches and floodplains.

Invertebrates: Maintain and improve the micro and macroinvertebrate communities by providing a variety of habitat and flow conditions.

Other vertebrates: Support survival and recruitment of other native aquatic species, including frogs and turtles.

Connectivity: Support longitudinal connectivity, including with the Barwon River, and lateral connectivity with between the river(s), wetlands and floodplain.

Processes/water quality/resilience: Support key ecosystem functions, biotic dispersal, and promote productivity; maintain water quality in channels and pools and support more natural water temperatures and processes to provide water quality benefits; and maintain drought refuge habitat.

3.3.3 First Nations environmental objectives

The First Nations peoples of the Warrego and Moonie catchments have identified environmental objectives for their country for 2020–21. These objectives have been determined based two processes: one through the First Nations Environmental Guidance project with the Northern Basin Aboriginal Nations (NBAN); and the second through direct engagement with members of the local Aboriginal community*. These processes have identified objectives (Table 1) across a range of sites, issues and values.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or species is not well understood.

The CEWO is committed to working with local First Nations groups to better understand their objectives. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder’s statutory responsibility of protecting and restoring environmental assets in the Basin.

Table 1: First Nations environmental objectives for the Warrego and Moonie rivers for 2020–21

<p>River flows and Connectivity</p> <p><i>NBAN Priority Sites:</i> The Warrego River to flow into the Paroo River, during flood times.</p> <p><i>NBAN other flows and connectivity:</i> Annual flood periods that will be the stimuli for breeding seasons, which can occur 3 – 6 months after an inundation.</p> <p><i>Local Aboriginal community objectives:</i> Water is life and connects all things, and all things are interconnected; rivers and wetlands need water, need flows; need to care for Country in a physical and spiritual sense; need to look after country and to fulfil cultural obligations; need to look after own mob and for downstream mobs</p>
<p>Native Vegetation</p> <p><i>NBAN indicator species:</i> River redgum, coolabah, gidgee, and water reed.</p> <p><i>Local Aboriginal community indicator species:</i> Vegetation species that are resources growing in and along rivers and in wetlands and billabongs, and on floodplains – bush tucker, medicines and cultural practices.</p>
<p>Native Birds</p> <p><i>NBAN indicator species:</i> Water hen, wood duck, pelican, galahⁱ, cockatooⁱ and pigeonⁱ.</p> <p><i>Local Aboriginal community indicator species:</i> Species of special importance or are important resources including: brolga, ducks, magpie geese.</p>
<p>Native Animals</p> <p><i>NBAN indicator species:</i> Yellowbelly, black bream (silver perch), mussel, goannaⁱ, emuⁱ, echidnaⁱ, wedge-tail eagleⁱ.</p> <p><i>Local Aboriginal community indicator species:</i> Look after native fish, both own importance and resource for community; Look after the critters, everything needs water, make sure things can survive and live; need to look after critters, care for all as part of whole picture, and to look after totem species and significant species.</p>

* Objectives determined through recent and past engagement activities by local engagement officers from the CEWO as well as through reports completed based on input from local Aboriginal community members.

Connecting with Country

NBAN: Nation gathering and teaching. Camping and fishing.

Local Aboriginal community objectives: Sharing stories and knowledge are important to the Northern Intersecting Streams people and the following assist in doing this: Being able to go out on Country to reconnect and share knowledge about landscape and resources, about spiritual and creation stories, and educate the younger generation, Connecting to and Caring for Country – opportunities to go out on Country, and obligations to care for Country.

ⁱ Water for the environment targeting other environmental outcomes may influence this species or objective

3.3.4 Recent conditions and seasonal outlook

(a) *Recent conditions and environmental water use*

Unregulated entitlements in both the Warrego and Moonie rivers were triggered in 2019–20. The Commonwealth’s entitlements in the Moonie were activated from the end of January to April 2020, with an estimated Commonwealth water for the environment contribution of 4.5 gigalitres.

The Commonwealth’s Toorale licences on the Warrego River were also activated in March 2020. The CEWO accessed 200 per cent of the share component of these river licences, contributing 16.2 gigalitres of the 45 gigalitres that flowed from the Warrego River into the Darling River, helping meet downstream environmental demands. Over 11 000 hectares of the Western Floodplain at and around Toorale National Park was also inundated, with flows connecting with the Darling from the floodplain via the Talowla channel for the first time since 2010.

Unregulated flows from the NSW parts of the Moonie and Warrego rivers, along with other northern Barwon–Darling tributary systems in NSW were protected from irrigation extraction using temporary protection orders in early 2020.

Vegetation on the Western Floodplain in the Warrego catchment has responded to the flows, with lignum flowering and showing new growth. Native fish including golden perch are also expected to have benefited from the flows. However, dry periods before flows in early 2020 have limited the abundance and diversity of waterbirds and frogs.

Details of previous Commonwealth environmental water use in the Warrego and Moonie rivers are available at: <http://www.environment.gov.au/water/cewo/catchment/northern-unregulated-rivers/history>.

(b) *Seasonal outlook*

According to the Bureau of Meteorology outlook on 2 July 2020, above median rainfall is forecast for the Warrego and Moonie catchments in August to October. While this forecast suggests that the recent severe dry conditions may ease somewhat, several months of above average rainfall are needed to see a recovery from the current severe drought. Stream flows may be less than expected during the recovery. However, wetter conditions can return suddenly in the northern Basin. Maximum temperatures are also forecast to remain above average over the coming months.

(c) Water availability

The Warrego and Moonie rivers have fewer regulating structures than other areas of the Murray–Darling Basin, which limits options for the managed delivery of water for the environment at a predetermined volume and time. Rather, Commonwealth water for the environment in the Warrego and Moonie rivers can generally only be sourced as a share of an unregulated flow event or in some cases targeted management within an event. Most Commonwealth unregulated entitlements are left in-stream to provide environmental benefits by restoring flows that were formerly extracted and improving flow variability.

Water availability depends on the flow events that occur. Unregulated entitlements provide opportunistic access to unregulated river flows and overland flows when a flow event reaches levels specified in entitlement conditions and/or water resource plan triggers at which a period of access may be announced are met. Each entitlement will contribute to restoring in-stream flows reflecting its particular flow access windows, take rates and location. Daily, instantaneous, annual or multi-year limits cap overall diversions in any given year or flow event, and likewise the in-stream contributions that can be attributed to unregulated Commonwealth entitlements.

There is some capacity to direct flows at the junction of the Warrego and Darling rivers through infrastructure on the Toorale site (managed by the NSW National Parks and Wildlife Service in consultation with the Toorale Joint Management Committee). However, this is limited by the nature of the Commonwealth’s entitlements in the Warrego and Darling rivers and day to day operations of the Toorale infrastructure. Upgrades and changed management of the Toorale structures is underway through the Toorale Infrastructure Project.

(d) Environmental demands

Considering the ongoing drought, the potential for further hot and dry conditions in the Warrego and Moonie rivers, and the need to avoid further damage to key assets, there are a number of environmental demands that require water urgently in 2020–21.

The environmental water demands for assets in the Moonie and Warrego rivers are represented in Table 2. Note that the capacity to contribute to these environmental demands is contingent on the occurrence of rainfall and unregulated flow events in the catchment that enable access to flows.

Table 2: Environmental demands and priorities for 2020–21

Environmental assets	Physical and process assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history (from all sources of water)	2020–21		Implications for future demands Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
		Flow/volume	Required frequency (maximum interval)		Environmental demands for water	Potential Commonwealth environmental water contribution?	
Moonie (at Gundablouie)	Native fish dispersal and condition Native fish spawning and recruitment Native vegetation Aquatic ecosystem function	Very low flow (VLF) (>30 ML/day) Timing in line with natural (anytime). Minimum duration: typically 60 days/year exceed VLF threshold but not less than 9 days/yr.	At least 96% of years. (Max. interval 70 days (but not more than 283 days))	Met in all years since 2010–11 excluding in 2018–19. Required annually therefore a high demand for water in 2020–21.	High	Possible use of CEW to contribute to an unregulated flow event.	High
		Small fresh 1: >314 ML/day any time (ideally Oct–April). Minimum duration 10 days	3–8 years in 10 (55%). (Max. interval 4.5 years)	Met 2010–11, 2011–12, 2012–13, partially met 2014–15, not met 2015–16, met 2016–17, not met 2017–18, not met 2018–19, met 2019–20. Moderate environmental demand for water in 2020–21, moving to low if watering proceeds as planned.	Moderate		Low
		Small fresh 2: >314 ML/day (Sept–April) duration 14 days	2–6 years in 10 (40%). (Max. interval 6.5 years)	Met between 2010–11 and 2012–13, not met between 2013–14 and 2015–16, met 2016–17, not met 2017–18 or 2018–19, and met 2019–20.	Moderate	Low	
		Large fresh 1: >3 909 ML/day (any time) duration 5 days	2–6 years in 10 (45%). (Max. interval 6.5 years)	Met between 2010–11 and 2012–13, not met between 2013–14 and 2015–16, met 2016–17, not met 2017–18 or 2018–19, and partially met 2019–20.	Moderate	Possible use of CEW to contribute to an unregulated flow event.	Moderate
		Large fresh 2: >3 909 ML/day (Oct–April) duration 5 days.	2–5 years in 10 (35%). (Max. interval 6.5 years)	Met between 2010–11 and 2012–13, not met between 2013–14 and 2015–16, met 2016–17, not met 2017–18 or 2018–19, partially met 2019–20.	Moderate		Moderate
		Large fresh 3: 5 100–18 787 ML/day (any time) duration 7 days	2–5 years in 10 (40%). (Max. interval 6.5 years)	Met in 2010–11, 2011–12, 2012–13, partially met 2013–14. Not met since then.	High	Moderate	
		Overbank: >18 787 ML/day (any time) duration 1 day.	0–3 years in 10 (15%). (Max. interval 20 years)	Met 2010–11, 2011–12, 2013–14. Not met since 2013–14.	Moderate	Low	
		In-channel flows: Up to 600 ML/day for minimum 10 days to enable fish passage and movement.	Ideally 5–10 in 10 years (Max. interval 2 years)	Met in all years since 2010–11 excluding 2012–13.	Low	A high priority for CEW under all water resource availability scenarios.	Low

Environmental assets	Physical and process assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history (from all sources of water)	2020–21		Implications for future demands
		Flow/volume	Required frequency (maximum interval)		Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Cuttaburra Creek (at Turra)	Native fish dispersal and condition Native fish spawning and recruitment Native vegetation Aquatic ecosystem function	Small fresh 1: <1 000 ML/d for 23 days (anytime)	4 years in 10	Met in 2010–11 and 2011–12. Not met in 2012–13 or 2013–14. Met in 2014–15, 2015–16, 2016–17. Not met in 2017–18. Met in 2018–19 and 2019–20.	Moderate	Possible use of CEW to contribute to an unregulated flow event.	Low
		Large fresh 1: Up to 3 000 ML/d for 45 days (anytime)	2.5 years in 10	Met in 2010–11. Not met in the last 10 years. Nearly met in 2011–12 (43 days).	Critical	Possible use of CEW to contribute to an unregulated flow event.	Low
	<20% wetland inundation Provides feeding and foraging habitat	Wetland inundation 1: 82 000 ML in 60 days (anytime)	1–2 years in 10	Met in 2010–11 and 2011–12. Not met in 2012–13, 2013–14, 2014–15 or 2015–16. Met in 2016–17. Not met in 2017–18. Met in 2018–19 and 2019–20.	Low	Possible use of CEW to contribute to an unregulated flow event.	Low
	50% wetland inundation Small breeding of non-colonial species	Wetland inundation 2: 166 000 ML in 90 days	1–2 years in 10	Met in 2010–11, 2011–12 and 2019–20.	Low	Low priority for use of CEW. Benefit of contributing additional water would be negligible.	Low
	100% wetland inundation Large scale colonial waterbird breeding	Wetland inundation 3: 724 000 ML in 90 days	1–2 years in 10	Not met in the last 10 years.	Critical	Low priority for use of CEW. Benefit of contributing additional water would be negligible.	High
Warrego River (at Barringun)	Native fish dispersal and condition Native fish spawning and recruitment Native vegetation Support refuge habitat (frogs, fish, waterbirds) Aquatic ecosystem function	Small fresh (SF): SF1: >217 ML/d for at least 10 days in the Warrego Barringun in Oct–Apr (but can occur at any time) (native fish condition and dispersal). SF2: >217 ML/d for at least 14 days in the Warrego Barringun, in Sept–Apr (spawning of in-channel specialists and generalists)	SF1: Annually (Max. interval: 1 year) SF2: 5–10 in 10 years (Max. interval 2 years)	Met in 2010–11 and 2011–12. Not met in 2012–13 or in 2013–14. Met in 2014–15. Partially met in 2015–16. Met in 2016–17. Partially met in 2017–18. Met in 2018–19 and 2019–20.	Moderate to High	Possible use of CEW to contribute to an unregulated flow event.	Moderate to High
		Large fresh (LF): LF1: >2 242 ML/d for at least 5 days in the Warrego Barringun, in Jul–Sept (but can occur at any time) (native fish condition and dispersal). LF2: >2 242ML/d for at least 5 days in the Warrego Barringun, in Oct–Apr (spawning flow specialists).	LF1: 5–10 years in 10 (Max. interval: 2 years) LF2: 3–5 years in 10 (Max. interval: 4 years)	Met in 2010–11 and 2011–2012. Not met in 2012–13, 2013–14, 2014–15 and 2015–16. Met in 2016–17. Not met in 2017–18 and 2018–19. Met in 2019–20.	High	Possible use of CEW to contribute to an unregulated flow event.	High

Environmental assets	Physical and process assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history (from all sources of water)	2020–21		Implications for future demands Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
		Flow/volume	Required frequency (maximum interval)		Environmental demands for water	Potential Commonwealth environmental water contribution?	
Warrego River (Boera Dam to Darling) ¹	Refuge habitat (waterbirds, frogs, fish) Instream aquatic ecosystems Riparian vegetation	Flows to replenish refuges and connect to the Darling.	Annually (Max. interval: 1 year)	Met every year except 2012–13.	High	A high priority for use of CEW under all water resource availability scenarios.	High
	In-stream aquatic ecosystems Fish connectivity and movement Riparian vegetation	In-channel flows: Up to 600 ML/day for minimum 10 days to enable fish passage and movement ¹ .	Ideally: 5–10 in 10 years (Max. interval: 2 years)	Met every year except 2012–13.	Moderate	A high priority for use of CEW under all water resource availability scenarios.	Moderate
Toorale Western Floodplain Wetland and floodplain vegetation Threatened species (<i>Atriplex infrequens</i> , <i>Dentella minutissima</i> , and <i>Osteocarpum scleropterum</i>) and ecological communities such as coolibah-blackbox woodland Migratory birds (e.g. Eastern great egret; glossy ibis; oriental pranticole; rainbow bee-eater) Native fish nursery and frog habitat	Minor inundation Northern and Central parts of the floodplain (2 420 ha)	7 GL to the Western Floodplain within 30 days to inundate vegetation such as lignum, coolibah, river cooba, chenopod, forbs.	Preferably: 1 to 1.5 years (lignum); 1 to 3–5 years (river cooba, river red gum, black box); 7–15 years (Coolibah). 5–10 years in 10 (Max interval: 2 years)	Met in 2010–11, 2011–12, 2016–17, 2018–19 and 2019–20.	High	A high priority for use of CEW under all water resource availability scenarios.	Moderate
	Inundation of around half the floodplain (4 459 ha)	16 GL to the Western Floodplain within 30 days to inundate vegetation such as lignum, coolibah, river cooba, chenopod, forbs.	Anytime Ideally: 4–8 in 10 years (Max interval: 3 years)	Met in 2010–11 and 2011–12. Partially met in 2016–17 (over a period of more than 30 days), 2018–19 and 2019–20.	Moderate	A high priority for use of CEW under all water resource availability scenarios.	Moderate
	Inundation of entire Western Floodplain (7 104 ha)	33 GL to the Western Floodplain within 30 days to inundate vegetation such as lignum, coolibah, river cooba, chenopod, forbs.	Any time Ideally: 3–6 years in 10 (Max interval: 6 years)	Met 2010–11, 2011–12 and 2019–20.	Moderate	Possible use of CEW to contribute to an unregulated flow event.	Moderate
	Boom inundation of more than entire Western Floodplain, Uteara lake, reconnections to Darling and return flows to the Warrego. Darling may backup to provide greater inundation. (11 847 ha)	75 GL/year to the Western Floodplain to inundate vegetation such as lignum, coolibah, river cooba, chenopod, forbs.	Any time Ideally: 1–3 years in 10 (Max interval: 10 years)	Met in 2011–12 and 2019–20.	Moderate	Possible use of CEW to contribute to an unregulated flow event.	Moderate

¹ Currently some fish movement may occur via secondary channels including the Western Bywash around Booka Dam and breaches in embankments when flows are large enough to activate these channels.

Environmental assets	Physical and process assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history (from all sources of water)	2020–21		Implications for future demands Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
		Flow/volume	Required frequency (maximum interval)		Environmental demands for water	Potential Commonwealth environmental water contribution?	
Darling River (downstream of the junction with the Warrego)² Native fish habitat, movement, refuge and spawning In-stream aquatic ecosystems and riparian vegetation Provides connectivity and movement between Darling and Warrego catchments Support refuge habitat Frog and waterbird habitat and refuge Improve water quality	Drought refuge Fish refuge: all guilds Aquatic ecosystems	Darling River is considered a priority (above all other priorities) when conditions in the Darling River at Louth exceed one or more environmental water requirements from <i>the Barwon Darling LTWP</i> : 1. When cease to flow conditions have occurred for more than 110 days; 2. There has been more than 135 days of flow less than 450 ML/d, or; 3. It has been more than one year since a small fresh of at least 1 500 ML/d occurred for at least 10 days as measures at the Louth gauge.	Annual	Refer to Barwon–Darling Plan 2020–21 for a detailed watering history.	High	A high priority for use of CEW under dry to moderate conditions.	High

Note: contributions to meet Barwon–Darling environmental requirements may be considered subject to water availability, antecedent conditions, and environmental demands. Refer to CEWO's Water Management Plan 2020-21: Chapter 3.7 Barwon–Darling.

Key - potential watering in 2020-21

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

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
 - High demand for water i.e. needed in that particular year
 - Moderate demand for water i.e. water needed that particular year and/or next
 - Low demand for water i.e. water generally not needed that particular year
 - Very low demand for water i.e. water generally not needed that particular year or the following year
- Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

² Demands in the Darling which flows from the Warrego may contribute to downstream of Louth. Other environmental demands in the Darling are described in the *Barwon–Darling Long Term Watering Plan*.

3.3.5 Water delivery in 2020–21

Unregulated entitlements provide opportunistic access to unregulated river flows when a flow event reaches levels specified in entitlement conditions and/or water resource plan triggers at which a period of access may be announced are met. Each entitlement will contribute to restoring in-stream flows reflecting its particular flow access windows, take rates and location.

Management of the Commonwealth's unregulated holdings on the Warrego River at Toorale are managed in accordance with the management strategy for use of these entitlements at Boera Dam (**Figure 2**) to meet environmental demands outlined in Table 2. The CEWO does not have access to the Toorale Warrego River licences in 2020–21 having already accounted for 300 per cent of the share component for these licences between 2018–19 and 2019–20. Operations of the Toorale infrastructure will continue to be managed by the NSW National Parks and Wildlife Service and DPIE, in consultation with the Toorale Joint Management Committee and the CEWO.

Further information on environmental demands in the Barwon–Darling is provided in the CEWO Water Management Plan 2020-21: Chapter 3.7 Barwon–Darling.

3.3.6 Monitoring and Lessons learned

(a) *Monitoring*

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

In the Warrego Valley, the five-year Long-Term Intervention Monitoring (LTIM) Project (2013–2014 to 2018–19) included the junction of the Warrego and Darling Rivers as a focus area. It aimed to understand the environmental response from Commonwealth environmental watering with respect to the targeted objectives by carrying out monitoring of site condition over many years.

This monitoring is being continued under the CEWO Monitoring, Evaluation and Research three-year program from 2019–20 onwards. Details of monitoring activities funded by the CEWO in the Junction of the Warrego and Darling Rivers can be found at:

<http://www.environment.gov.au/water/cewo/catchment/northern-unregulated-rivers/monitoring>.

(b) *Lessons learned*

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed. Key findings from Long Term Intervention Monitoring at the Junction of the Warrego and Darling Rivers³, The Warrego-Darling Monitoring, Evaluation and Reporting (MER) selected area project⁴ and relevant other monitoring⁵ is summarised in Table 3.

³ Eco Logical Australia (2019b)

⁴ UNE unpublished

⁵ CEWO 2020

Table 3: Key lessons learned in the Warrego and Moonie rivers

Theme	Lesson learned
Native fish	<ul style="list-style-type: none"> • Flows in the Warrego, including environmental water, support breeding and recruitment in many fish species. During ‘wetter’ times, multiple species have been observed to breed, recruit and maintain their population structure, e.g. golden perch, spangled perch, bony herring, Hyrtl’s tandan. • Golden perch spawn on river rises in the Warrego, and recruits from the catchment are likely to be contributing to the wider Darling Basin golden perch population. • The fish community in the Warrego River are highly resilient and can survive over highly variable flow conditions, including drying down. Fish communities were able to recolonise and recruit following larger flow events. Golden perch, spangled perch and bony herring have demonstrated an ability to move, colonise and opportunistically recruit in the Warrego in response to increased flows. • Retaining water at all times in at least some of the five main waterholes on the Warrego River will ensure that when the system is reconnected, there are founder populations present that can distribute and recolonise across the lower sections of the Warrego. This will help prepare native fish populations for the next drying phase. • The Moonie has relatively long and deep waterholes that have been shown to be critical refugia for sustaining native fish populations in the often-long periods between flows in the system. Species including golden perch, bony bream, eel tailed catfish and smelt moved significant distances (up to 70 kilometres) in response to waterhole reconnecting flows, enabling recolonisation of the system and genetic mixing.
Frogs	<ul style="list-style-type: none"> • Inundation of the Western Floodplain, including with environmental water, supports increased frog abundance and richness. This is because greater areas of highly productive habitat is created, which is capable of supporting breeding and larger frog populations. • The more permanent sites in the Warrego River provide more stable habitat for local frog populations. • Frog monitoring under the MER project in late 2019 and early 2020 found relatively low numbers and diversity of frog species (likely because of dry conditions). Species detected included plains froglet, Peron’s tree frog, desert tree frog, barking marsh frog, painted marsh frog, plains froglet and green tree frog. Frog species are expected to recover following further rainfall in the Warrego catchment.
Waterbirds	<ul style="list-style-type: none"> • When inundated, the Western Floodplain supports diverse and abundant waterbird populations and can support waterbird breeding. • The Warrego River waterholes appear to provide longer-term refugia that support more stable populations of waterbirds. Boera Dam consistently had the greatest richness and diversity of waterbirds.
Connectivity	<ul style="list-style-type: none"> • Environmental water has been observed to successfully increase longitudinal connectivity between the Warrego and Darling rivers, and laterally, with parts of the Western Floodplain. By increasing connectivity, water for the environment improves water quality, increases available habitat and productivity, and supports native fish movement between rivers. The resulting productivity booms can also generate an increase in the abundance and diversity of invertebrates, frogs and waterbirds on the floodplain. • Environmental water can successfully increase the size of flows through the Warrego system, increasing connectivity between the Warrego and Darling rivers.

Theme	Lesson learned
	<p>This is important for improving water quality, increasing productivity and allowing the movement of native fish between rivers for spawning, dispersal and recruitment.</p> <ul style="list-style-type: none"> • Environmental water can also increase connectivity and inundation of parts of the Western Floodplain. The resulting booms in productivity have supported the highest abundance and diversity of invertebrates, frogs and waterbirds compared to the Warrego and Darling sites.
Water Quality	<ul style="list-style-type: none"> • Water for the environment delivered through the Warrego consistently helps improve the quality of Darling River water downstream of the confluence. Observed improvements include, reduced pH, conductivity, turbidity and algal productivity, and increased nutrient cycling and habitat when compared with periods without environmental water.
Productivity/ food webs	<ul style="list-style-type: none"> • Environmental water that contributes to connection for a long duration (>6 months) stimulates a boom in productivity, which provides food for higher order predators such as waterbirds. • The Western Floodplain is important for highly dense and species rich invertebrate communities. More diverse macroinvertebrate communities may offer a wider range of feeding opportunities for higher level consumers such as frogs, fish, waterbirds and other aquatic vertebrates. • The Warrego and Western Floodplain are productive systems, species such as shrimps and tadpoles responded quickly to inundation. Species such as fairy and shield shrimps are known to rely on an egg bank that is desiccation resistant, which may help survival and responsiveness. • Using environmental water to inundate channel and floodplain habitats during warmer periods can maximise the diversity and density of invertebrates and frogs by increasing the range of food and habitat available. Inundating in-channel habitat features such as snags, benches and anabranches promotes the transfer of nutrients and organic material, which drives the food webs of the river.
Vegetation	<ul style="list-style-type: none"> • The condition of vegetation communities on the Western Floodplain is driven by inundation, which has been enhanced by Commonwealth environmental water. Flooding of the Western Floodplain increased the cover and richness of vegetation communities, including annual herbaceous ground cover species. • Lignum condition improved when inundated more frequently. Extended dry periods (greater than 2.5 years) on the floodplain resulted in declines in vegetation cover and condition. However, lignum condition improved again in response to inundation in 2019 and early 2020. • Grazing and competition for resources are likely to impact on tree recruitment more than inundation alone.
Refuge	<ul style="list-style-type: none"> • Warrego River waterholes act as longer term refuges for native fish, waterbirds, turtles and frogs, supporting more consistent ecological communities over time. Boera and Booka dams provide the most persistent refuges. Environmental water can help replenish and re-connect refuge habitat in the Warrego River and the Darling River near Toorale.

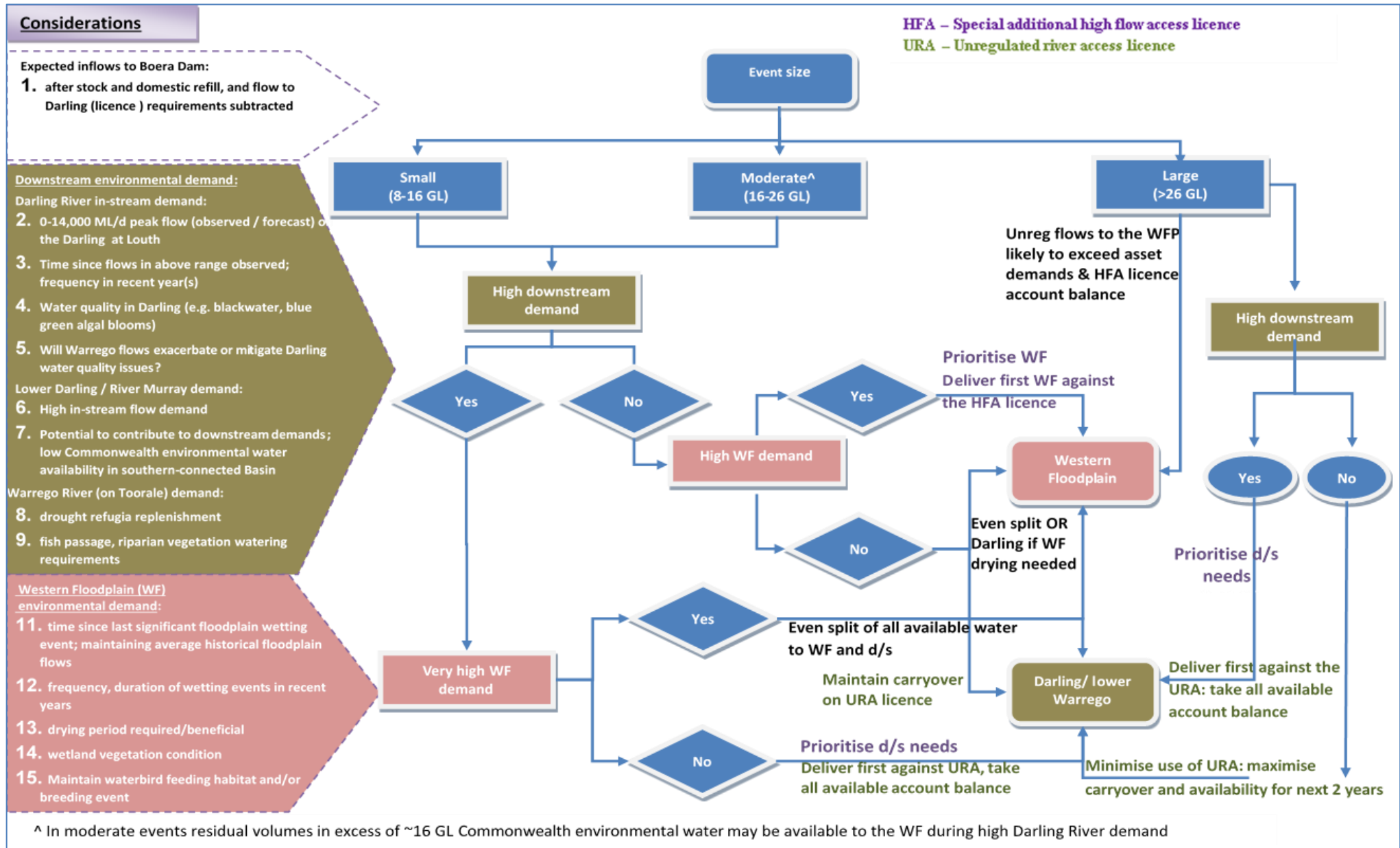


Figure 2: Management strategy for Commonwealth environmental water at Toorale (Subject to change as new information becomes available)

3.3.7 Bibliography

- Arthington A., and Balcombe S. (2011). Extreme flow variability and the boom and bust ecology of fish in arid-zone floodplain rivers: a case history with implications for environmental flows, conservation and management. *Ecohydrology*, 4, 708–720.
- Balcombe, S. Arthington, A. Foster, N. Thoms, M. Wilson, G. Bunn, S. (2006). Fish assemblages of an Australian dryland river: abundance, assemblage structure and recruitment in the Warrego River, Murray-Darling Basin. *Marine and Freshwater Research*, 57, 619-633.
- Bureau of Meteorology (2020). *Rainfall—The chance of above median for July to September 2020*. <http://www.bom.gov.au/climate/outlooks/#/rainfall/median/seasonal/0>
- Bureau of Meteorology (2020). *Rainfall—The chance of above median for August to October 2020*. <http://www.bom.gov.au/climate/outlooks/#/rainfall/median/seasonal/1>
- Bureau of Meteorology (2020). *Temperature—The chance of above median maximum temperature for June to August 2020*. <http://www.bom.gov.au/climate/outlooks/#/temperature/maximum/median/seasonal/0>
- Bureau of Meteorology (2020). *Temperature—The chance of above median maximum temperature for July to September 2020*. <http://www.bom.gov.au/climate/outlooks/#/temperature/maximum/median/seasonal/1>
- Department of Planning, Industry and Environment (2019a). *Barwon Darling Long Term Watering Plan. Draft for Exhibition*. State of NSW and Department of Planning, Industry and Environment
- Department of Planning, Industry and Environment (2019b). *Intersecting Streams Long Term Water Plan Parts A and B. Draft for Exhibition*. State of NSW and Department of Planning, Industry and Environment
- Eco Logical Australia (2019a). *Toorale Water Infrastructure Project (Phase 2) Review of Environmental Factors*. Prepared for NSW Department of Planning, Industry and Environment.
- Eco Logical Australia (2019b) *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area – Five Year Evaluation Report*, Commonwealth of Australia 2019
- Kingsford R., Bedward M. and Porter J. (1994). Waterbirds and Wetlands in Northwestern New South Wales. National Parks and Wildlife Service Occasional Paper No 19. NSW National Parks and Wildlife Service, Hurstville.
- Kingsford R.T, Thomas R.F and Wong P.S. (1997). Significant wetlands for waterbirds in the Murray- Darling Basin. NSW National Parks and Wildlife Service, Hurstville.
- Marshall J., Menke N., Crook D., Lobegeiger J., Balcombe S., Huey J., Fawcett J., Bond N., Starkey A. and Sternberg D. (2016). Go with the flow: the movement behaviour of fish from isolated waterhole refugia during connecting flow events in an intermittent dryland river. *Freshwater Biology* 61, 1242-1258 <https://doi.org/10.1111/fwb.12707>
- Northern Basin Aboriginal Nations (NBAN) (2020) *First Nations Environmental Watering Guidance Report*. Provided to the CEWO.
- Sheldon F., Bunn S., Hughes J., Arthington A., Balcombe S. and Fellows C. (2010). 'Ecological roles and threats to aquatic refugia in arid landscapes: dryland river waterholes'. *Marine and Freshwater Research*, 61, 885–89