Barmah Forest

Seasonal Watering Proposal 2013 - 2014

GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

Goulburn Broken Catchment Management Authority

Publication details

Published by:
Goulburn Broken Catchment Management Authority,
PO Box 1752, Shepparton 3632
(April 2013)

Please cite this document as:
GB CMA (2013). Barmah Forest Seasonal Watering Proposal 2013-2014. Goulburn Broken Catchment Management Authority, Shepparton.

ISBN

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Front cover image: Moira Grass (*Pseudoraphis spinescens*) plain community at Little Rushy Swamp, Barmah Forest 27/10/2012 (photo by Keith Ward).

Contents

Glossary and acronyms

Bank full - carrying capacity of the stream before spilling out onto adjacent land

BM OAG – Barmah-Millewa Operational Advisory Group

Catchment management authority – statutory authorities established to manage regional and catchment planning, waterways, floodplains, salinity and water quality

CEW - commonwealth environmental water

Channel - that part of a river where water flows at some time and includes the bed and banks, taken to mean the whole of the depression in which the water flows before it rises sufficiently to spill over onto adjacent lands as flood water

Commonwealth Environmental Water Holder (CEWH) – (part of the Department of Sustainability, Environment, Water, Populations and Communities) holds and manages the water entitlements purchased through the Restoring the Balance water recovery program

Confluence - where two streams meet.

Environmental flow regime – the timing, frequency, duration and magnitude of flows for the environment

Environmental flow study – a scientific study of the flow requirements of a particular basin's river and wetlands systems used to inform decisions on the management and allocation of water resources

Environmental water entitlement – an entitlement to water to achieve environmental objectives in waterways (could be an environmental entitlement, environmental bulk entitlement, water share, section 51 licence or supply agreement)

Flow - movement downstream of water confined in the channel. The term **lotic** applies to flowing or moving water

Flow component – components of a river system's flow regime that can be described by timing, seasonality, frequency and duration (for example, cease to flow and overbank flows)

Flow regime - pattern of seasonal flow variations in any one year, usually consisting of periods of low flow during summer-autumn then high flows during winter-spring

Freshes - flows that produce a substantial rise in river height for a short period, but do not overtop the river bank. Freshes help maintain water quality and serve as life-cycle cues for fish

GB CMA - Goulburn Broken Catchment Management Authority

Geomorphology - the physical interaction of flowing water and the natural channels of rivers including erosion and sedimentation

Gigalitre (GL) – one billion (1,000,000,000) litres

High flows - high flow within channel capacity. High flows allow full connection between all habitats in the river, which is important to fish passage during migration

High-reliability entitlement – legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected in most years)

Instream - refers to that area of a waterway below the surface of the water

Low-reliability entitlement – legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected only in some years)

Macroinvertebrates - animals without backbones, generally visible with the naked eye and associated with freshwater systems

Macrophytes – an aquatic plant that grows in or near water and is either emergent, submergent, or floating

Megalitre (ML) – one million (1,000,000) litres

MDBA – Murray-Darling Basin Authority

Passing flow – water released out of storages to operate river and distribution systems (to deliver water to end users), provide for riparian rights and maintain environmental values and other community benefits

Planktonic algae – floating microscopic plants that are an important food source for aquatic fauna

POE – Percentage of exceedance

Pool - a significantly deeper area in a river

Reach - a visible length of river extending away from or adjacent to the observer, also a length of river with various water types such as pools and riffles

Riparian vegetation - vegetation growing on the water line, up the bank or along the very top of the bank. It is the vegetation which has the most direct affect on instream biota.

RMUF – River Murray unregulated flow

Seasonal allocation – the volume of water allocated to a water share in a given season, expressed as a percentage of total entitlement volume

The Living Murray – an intergovernmental program, which holds an average of 500,000 ML of environmental water per year, for use at six icon sites along the River Murray

Unregulated entitlement – an entitlement to water declared during periods of unregulated flow in a river system, that is, flows that are unable to be captured in storages

Victorian Environmental Flow Monitoring and Assessment Program – assesses the effectiveness of environmental flows in delivering ecological outcomes

Victorian Environmental Water Holder – an independent statutory body responsible for holding and managing Victorian environmental water entitlements and allocations (Victorian Water Holdings)

Water entitlement – the right to a volume of water that can (usually) be stored in reservoirs and taken and used under specific conditions

Water Holdings – environmental water entitlements held by the Victorian Environmental Water Holder

WMA – water management area. Internal sub-catchment that can have water management occur semi-independently to adjoining WMAs

Waterway manager – agency responsible for the environmental management of waterways (includes catchment management authorities and Melbourne Water)

Waterways – can include rivers, wetlands, creeks, floodplains and estuaries

1. Summary

The use of environmental water plays a critical role in the management of the Barmah-Millewa Forest ecosystem. River regulation has altered the timing, frequency and duration of flooding. Winter and spring flows are captured in upstream storages and released for consumptive use to prolong steady-state higher flows through late-spring, summer and into autumn. Environmental water is utilised primarily in spring to increase or prolong desired flows, and occasionally create inundation of part of the floodplain in-line with achieving a suite of ecological objectives for the forest.

The Barmah-Millewa Forest has seen prolonged flooding from July 2010 to March 2012 on the back of a decade of drought. The recent floods have rejuvenated some sections of the forest ecosystem, stimulating a mostly positive response from native flora and fauna species. Uncharacteristically, the summer and autumn months of 2011 and 2012 have seen natural flooding continue in the forest, resulting in the low-laying wetlands being inundated continuously for 18-21 months which exceeds nearly all previous flow records and known tolerance limits of some vegetation species. A brief drying regime in late-autumn and early-winter was broken by a return to flooding in mid-winter that existed until mid-spring. This occurred a time when colonial waterbirds (predominantly White and Straw-necked Ibis, but also some Royal Spoonbill) where nesting, requiring some supplementary EWA to be supplied to one wetland until nesting successfully concluded in January 2013. The broader floodplain has now experienced a strong dry regime in summer and autumn 2013.

Concerns currently exist for an alarming decrease in the extent and cover of Moira Grass (*Pseudoraphis spinescens*), a floodplain specialist species that used to dominate the treeless floodplain of Barmah Forest and serve as a major waterbird feeding ground on which Ramsar status has been bestowed on the reserve. The current low amount of Moira Grass (recently mapped to exist at approximately 5% of the area that existed 70 years ago, is expected to benefit with the recent dry regime but only if followed by a return to deep winter-spring floods.

The 2013/14 watering proposal for Barmah Forest therefore retains the primary objective of returning a more natural annual wet-dry cycle to the floodplain. Given the recent strong drying regime having been experienced, combined with a strong chance of natural flooding occurring in winter-spring due to relatively full upstream reservoirs and seasonal rainfall outlooks, then ensuring deep and continuous seasonal flooding throughout spring is to be targeted. Opportunity to participate in a Multi-Site Watering Trial (MSWT), pending NPWS and Parks Victoria works program having been complete by June 2013, could greatly enhance to achievement of this target for the Barmah Forest, in addition to assisting the MSWT via passing water through the forest for downstream environmental use.

Ecological objectives for fauna may be achieved, depending on spring flows. Providing suitable conditions for native fish spawning (flood pulses) could again be provided in late-spring, while colonial waterbird breeding targets could be managed for but only if natural flows induce a significant breeding event in terms of numbers, location or conservation status of the species (rarer species having priority management). An exception may be to stimulate and maintain breeding in Boals Deadwoods with a small targeted water release where a remote camera and potential experiment is to occur, with low level water management in that particular wetland known not to affect adjoining wetlands.

There are various risks associated with environmental water, although such risks are rated no higher than medium under this watering proposal. Increasing natural peaks would be targeted for early- to mid-spring to flush the floodplain during cooler conditions which will reduce the likelihood of a blackwater event. Another relevant risk is having insufficient flows, environmental water volume or delivery channel capacity to meet the ecological target for vegetation.

Estimating required volumes of environmental water is inherently difficult for Barmah Forest, as so much depends on natural flow events and the operation of the Murray River. With the proposed use of environmental water, the minimum requirements to meet vegetation targets are flows (downstream of Yarrawonga Weir) of 18,000 ML/day for 120 days for Moira Grass (*Pseudoraphis spinescens*) plains and flows up to 20,000 ML/day (MDBA imposed limit for managed water releases) for 30 days for Red Gum forest objectives. Up to 95% of water diverted into Barmah Forest returns directly to the Murray River downstream of the Barmah Choke (although a greater percentage loss will be accepted under the Basin Officials Committee acknowledgement).

2. Introduction

2.1 Background

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. The reserve includes minimum river flows, unregulated flows and specific environmental entitlements.

Environmental entitlements can be called out of storage when needed and delivered to streams or wetlands to protect or enhance their environmental values and health. Environmental entitlements are held by the Victorian Environmental Water Holder (VEWH), the Commonwealth Environmental Water Holder (CEWH), and the Murray-Darling Basin Authority (MDBA). Catchment Management Authorities (CMAs) are responsible for determining the environmental water requirements of streams and wetlands, developing and submitting seasonal watering proposals to the VEWH for consideration, and managing the delivery of environmental water in accordance with the VEWH's Seasonal Watering Plan.

The VEWH prepares seasonal watering plans for rivers and wetlands as separate plans based on each of the CMA's seasonal watering proposals. The plans describe the desired environmental water use for rivers and wetlands across Victoria in the coming year. To help facilitate the desired environmental water use outlined in the plans, the VEWH negotiates access to environmental water managed by the CEWH and the MDBA. The VEWH then prepares seasonal watering statements that authorises CMA's to undertake the agreed watering activities, including the use of CEWH and MDBA water. As more environmental water becomes available during the season the VEWH may prepare additional seasonal watering statements. Where possible, the VEWH, CEWH and the MDBA seek to coordinate the delivery and management of environmental water to maximise ecological benefits.

2.2 Purpose

The purpose of this Barmah Forest Seasonal Watering Proposal is to:

- identify the environmental water requirements of Barmah Forest (below Hume Reservoir) in the coming year under a range of climatic and flow scenarios to protect or improve its environmental values and health; and
- inform the development of environmental water priorities in the VEWH's seasonal watering plan.

The proposal is informed by scientific studies and reports that identify the flow regimes required to meet the ecological objectives of the site. The proposal was prepared in consultation with key stakeholders and partners, and was approved by the GB CMA Board. The GB CMA has also prepared seasonal watering proposals for the Goulburn River, lower Broken Creek and priority wetlands.

3. System overview

3.1 System overview

Barmah Forest forms approximately one half of the Barmah-Millewa Forest Icon Site which covers 66,600 ha and straddles the Murray and Edwards Rivers between the townships of Tocumwal, Deniliquin and Echuca (Figure 1). The site is a contiguous forest and wetland system that is reserved as the Barmah National Park and Murray River Park in Victoria, and as part of the Murray Valley National Park in New South Wales.

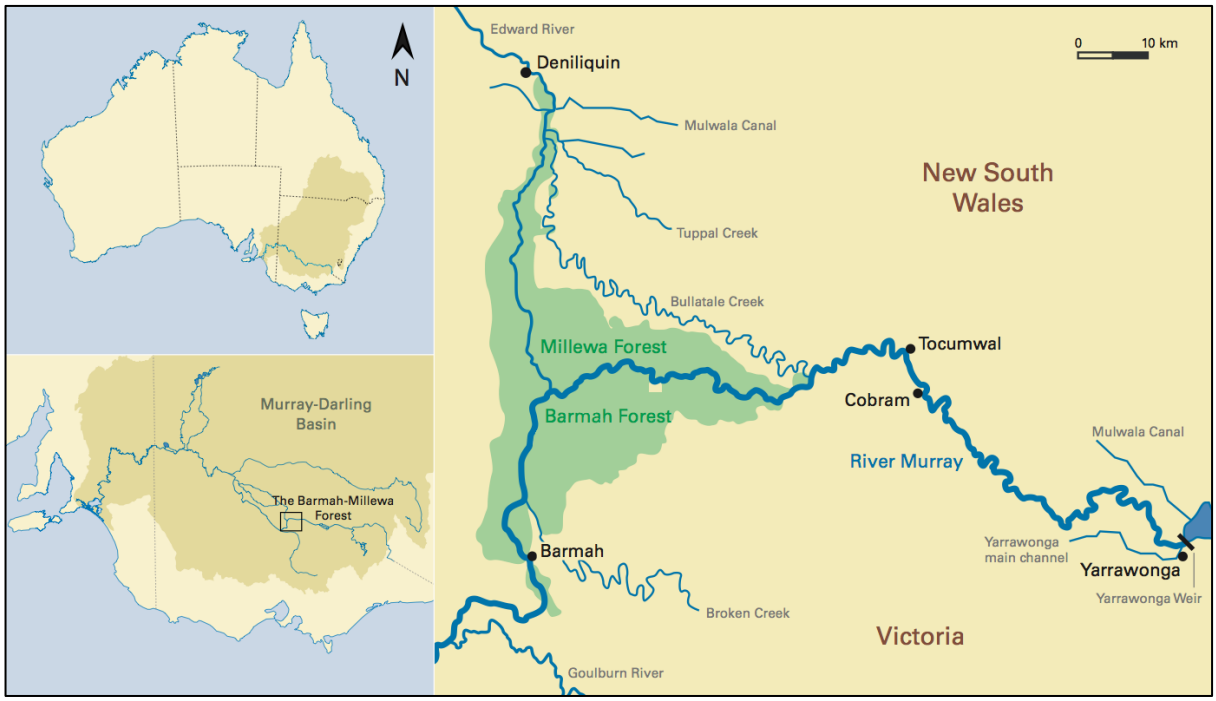


Figure 1: Location of the Barmah-Millewa Icon Site (modified from MDBA).

3.2.1 Flow Regime

Water regulation of the Murray River has caused significant alterations to flow patterns now affecting the floodplain environment. Barmah Forest, being located in the semi-arid Murray River system where inflows are usually greatest in winter/spring and lowest in summer/autumn, has had its flow regime altered by river regulation storing the winter and spring flows for release in later spring through to autumn (Figure 2). Although spring flooding still frequently occurs, it is often of reduced extent and duration compared to natural conditions, and summer flooding is now substantially more frequent (Table 1).

The effect of regulation at six flow thresholds on frequency, duration, variability and start time is shown below (Table 1). Greatly decreased means when Current/Natural *100 is less than 60%, and greatly increased means when Current/Natural *100 is more than 150%.

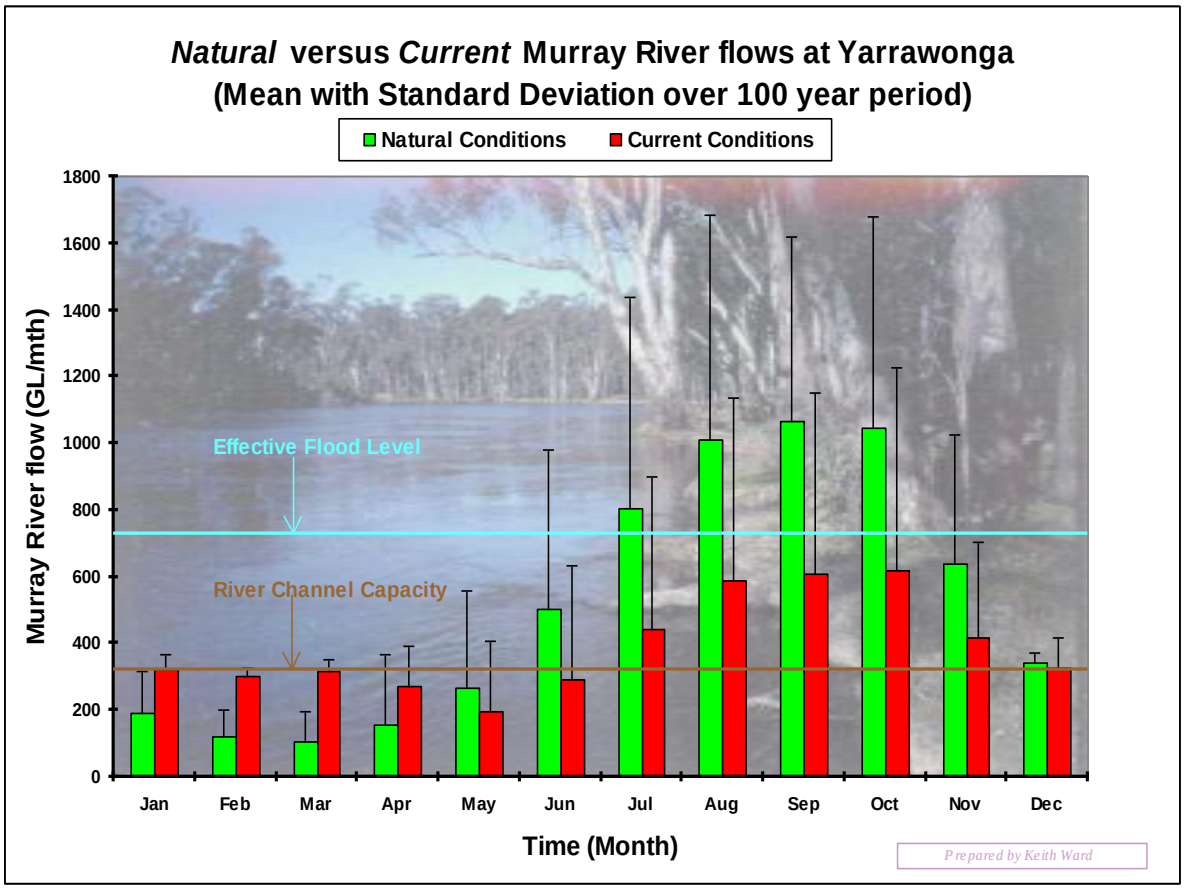


Figure 2: Natural and current monthly Murray River flow release from downstream Yarrawonga Weir.

Table 1: Summary of effects of regulation: Current v Natural for six flow thresholds (Roberts 2006).

	Flow thresholds at Tocumwal, ML/d					
	=>12,000	=>15,000	=>20,000	=>30,000	=>40,000	=>50,000
Frequency	Increased	Similar	Decreased	Decreased	Decreased	Decreased
Length (mean duration)	Decreased	Decreased	Decreased	Similar	Similar	Similar
Variation (CV)	Increased	Increased	Increased	Similar	Increased	Increased
Small v large events (Skew)	Increased	Increased	Increased	Similar	Similar	Decreased
Number of floods starting in May-June	Decreased	Decreased	Decreased	Greatly Decreased	Greatly Decreased	Decreased
Number of floods starting in Sept-Nov	Greatly Increased	Greatly Increased	Decreased	Decreased	Decreased	Decreased

Figure 3 demonstrates a cross-section of the forest showing key vegetation communities and their water requirements, while Figure 4 shows the 'commence-to-flow' river discharges required to achieve flooding of the main vegetation types and the area of forest inundated by those thresholds. 'Effective flooding' (i.e. with a minimum required depth of water) of these communities occurs at higher discharges.

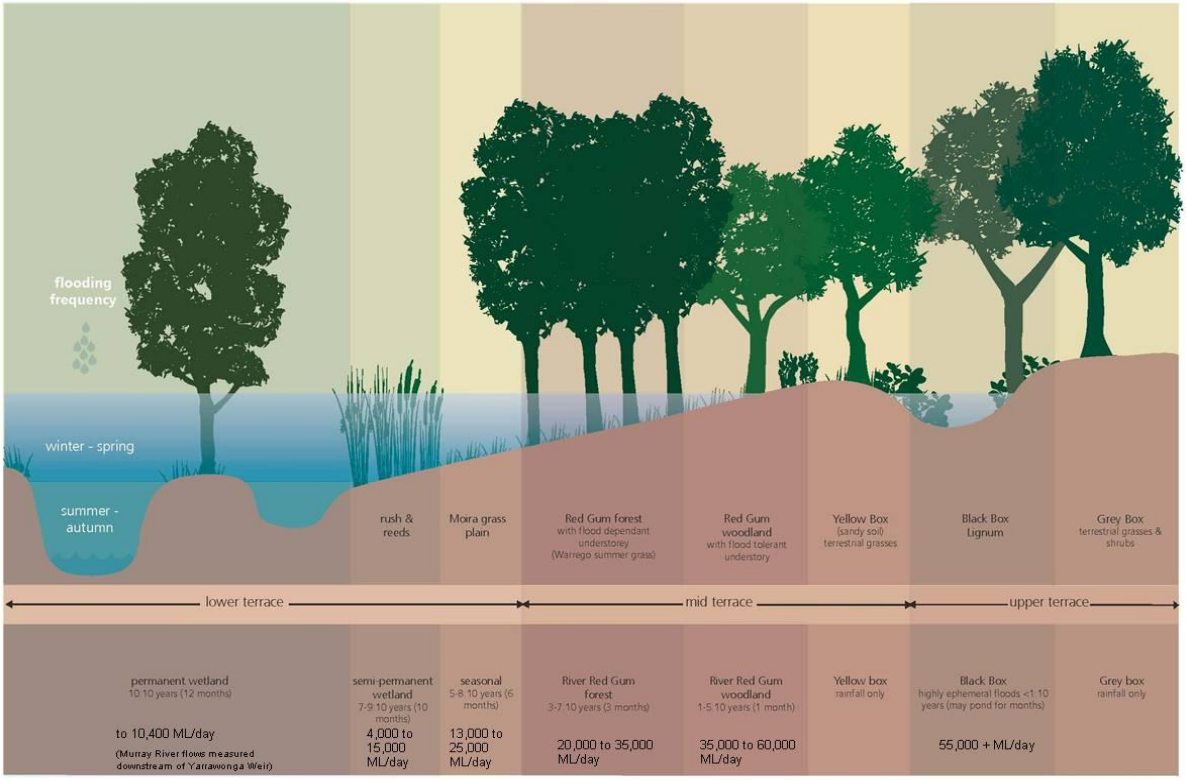


Figure 3: Diagrammatic cross-section of the Barmah-Millewa floodplain showing key vegetation communities and their water requirements and corresponding river level commence-to-flow thresholds (as measured in the Murray River downstream of Yarrawonga).

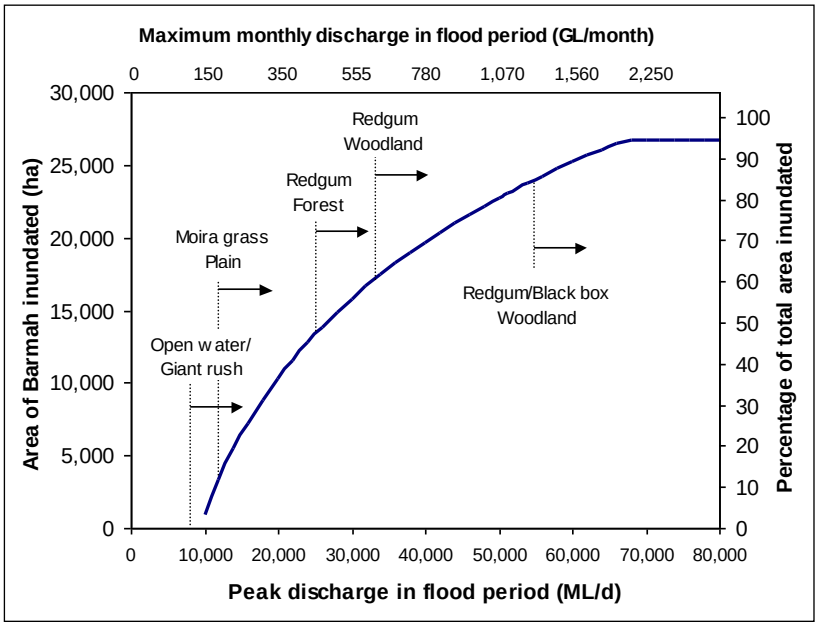


Figure 4: Area of Barmah Forest inundated as a function of River Murray flood peak and at Tocumwal (instantaneous peak discharge, ML/d) and Yarrawonga (monthly total discharge, GL/month) (Bren *et al.* 1987 and Bren *et al.* 1988).

3.2.2 Priority reaches and measuring points

The Murray River between Hume Reservoir to Yarrawonga (Reach 1), and Yarrawonga to Barmah Forest (Reach 2), contains intrinsic in-stream habitat values and relatively high terraced floodplain wetlands. Only once flows reach the Barmah-Millewa floodplain does widespread flooding and relatively low flow thresholds commence to occur, and it is here that the region's greatest environmental values occur.

The Barmah-Millewa reserve has been arbitrarily divided into Water Management Areas (WMA) based on internal sub-catchments that can have water management occur semi-independently to adjoining WMAs (Figure 5). Often a single WMA will contain a number of identified wetlands, which collectively form a semi-discrete wetland system within the broader floodplain reserve, although all WMAs progressively join by flooding with increasing river flows. For the purposes of this report, priority reaches for environmental water management will relate to Barmah Forest WMAs (A to H4).

Measuring points for environmental water delivery at Barmah Forest have recently been investigated by Hydro Environmental (2010). They determined that the measurement option selected will depend on the flood event being measured, given that a lot of the proposed in-forest measuring sites will be drowned out if overbank flow on the creeks occurs upstream, particularly if the River overtops its banks.

As with previous EWA releases to the Barmah-Millewa Forest, the 2013/14 event will be gravity diverted from the Murray River into the forest at approximate rates through waterway regulating structures as guided by specific rating curves that exist for those structures, and will be periodically check by flow measurement by a qualified contractor. River Murray Water will also undertake mass balance of river flow between their existing gauged stations upstream and downstream of the forest.

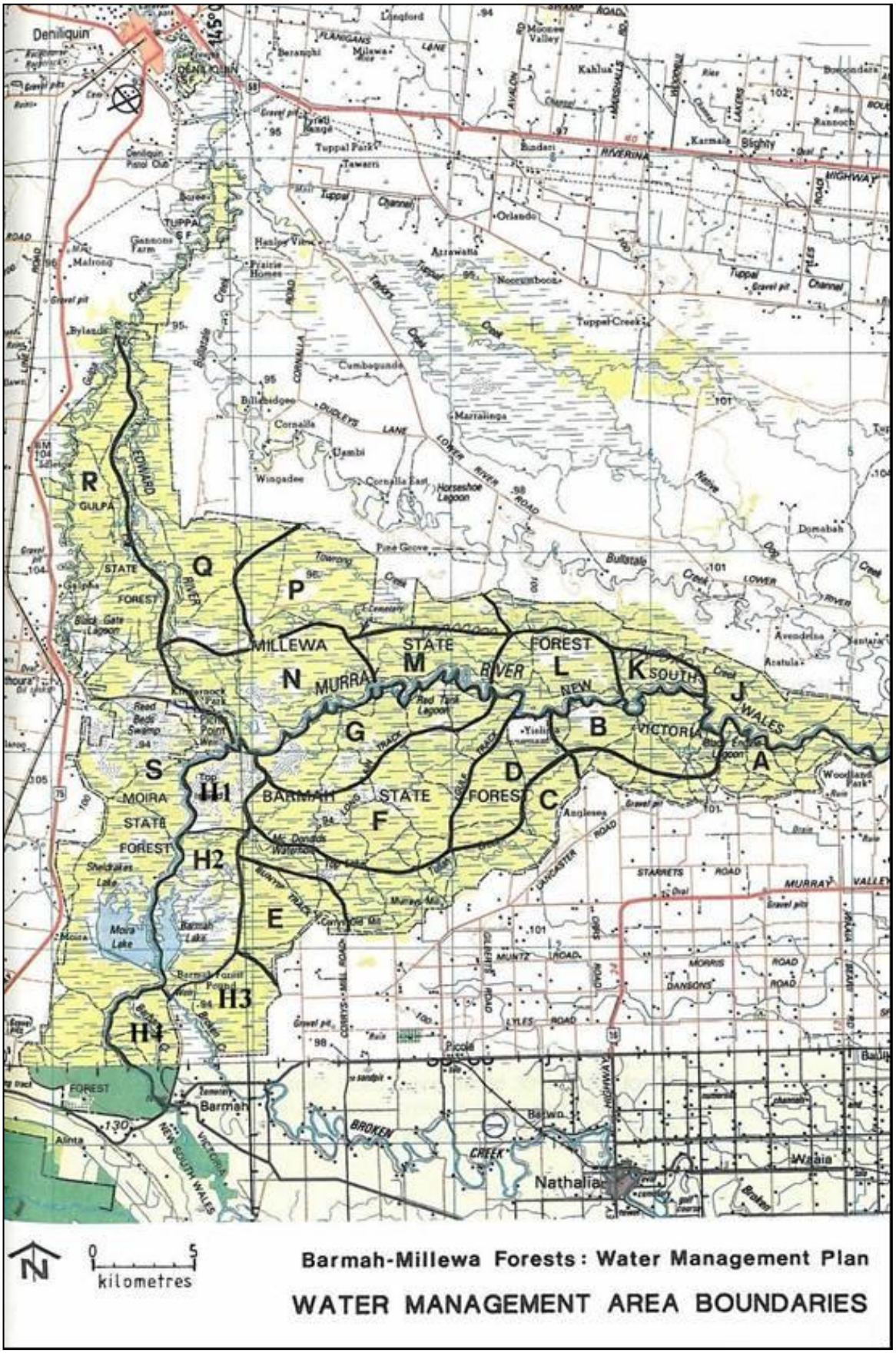


Figure 5: Barmah-Millewa Water Management Area Boundaries (Modified from Maunsell Australia Pty Ltd 1992).

3.2.3 Delivery constraints

Delivery of environmental water down the Murray River from Hume Reservoir to Barmah Forest is primarily constrained by the risk of flooding private and public assets. For Reach 1 (Hume to Yarrawonga), channel capacity is deemed to be 25,000 ML/d, whereas for Reach 2 (Yarrawonga to Barmah Forest), channel capacity is 10,400ML/d. Flows exceeding channel capacity in Reach 1 increasingly commence to affect private land, whereas exceeding channel capacity in Reach 2 only influences the targeted floodplain and other crown floodplain until approximately 20,000ML/d* (although 35,000ML/d has to date been the largest managed river release for the Barmah-Millewa environment). [*Note: The 20,000 ML/d is a recently imposed limit by MDBA until an issue of flows affecting private land in NSW is determined. The actual flow is expected to be higher].

The 20,000 ML/d downstream of Yarrawonga (Reach 2) limit by MDBA will therefore constrain the size of environmental water delivery in 2013/14.

3.2.4 Water sources

Environmental water available for use at Barmah Forest includes:

- Barmah-Millewa Forest Entitlement (*DSE is responsible for the Barmah component of the entitlement, although release is approved in conjunction with the NSW Office of Water and the MDBA. A total annual allocation of 100,000 ML is high reliability and 50,000 ML is low reliability. The allocation can be accrued up 700,000 ML*);
- The Living Murray Environmental Entitlement held by MDBA (*has been used in the past to supply water to Barmah Forest*);
- Victorian River Murray Flora and Fauna Bulk Entitlement held by VEWH (*has been used in the past to supply water to Barmah Forest*);
- NVIRP water savings to be held by VEWH (*33% of approved NVIRP water savings will be awarded for environmental use*);
- Other environmental entitlements held by the VEWH;
- Environmental entitlements held by the CEWH;
- Unregulated flows (*surplus Murray River flows under the Murray-Darling Agreement have been used in the past to supply water to Barmah Forest*).
- Influence of other environmental water released by NSW authorities for Millewa Forest.

4. Long-term objectives and flow recommendations

This section outlines the environmental flow objectives established for Barmah Forest, and the corresponding flow recommendations including the volume (ML/day), timing, duration and frequency of flow components.

The social and economic values of healthy wetlands have been variously reviewed by Stone (1991), DSE (1992), Young & Mues (1999), Chong (2003), Chong & Ladson (2003), Abel et al. (2006), Howard (2008) and VEAC (2008) to show healthy wetlands are highly valued for their cultural heritage, recreation, tourism and economic values. Stone (1991) used contingent valuation survey to find Victorians' willingness to pay once to keep Barmah Forest as it was in 1991 at between $139M and 176M (converted to 2012 values). More in-depth economic investigation into water management is intended to be undertaken by PhD candidate Mr Simon Hone from La Trobe University's School of Applied Economics, Wodonga, under Professor Lin Chase. Social constraints have been discussed in Section 1.3.3 (delivery constraints) above.

4.1 Environmental flow objectives

Environmental flow objectives for Barmah Forest have been detailed in the site's Environmental Water Management Plan (EWMP) (MDBA 2012a). The development of all TLM Icon Site EWMPs was coordinated by MDBA in consultation with the Environmental Watering Group (which includes state representation) to ensure a consistent approach to planning and management across the icon sites. This Barmah-Millewa EWMP builds on previous iterations of the EWMP (previously known as Environmental Management Plans) and incorporates consultation, research into icon site key species, learning's from flood behaviour modelling and outcomes from previous environmental watering events.

Based on an understanding of the icon site's characteristics and ecological requirements, the Barmah-Millewa EWMP's ecological objectives are to:

- Promote healthy and diverse vegetation communities, with an emphasis on restoring natural extent and distribution of Giant Rush, Moira Grass, River Red Gum forest and River Red Gum woodland in at least 55% of the area of Barmah-Millewa Icon Site.
- Facilitate healthy and diverse vegetation to provide suitable, breeding and foraging habitat for a diverse range of waterbirds and bush birds.
- Promote and/or sustain successful breeding events of multiple thousands of colonial and migratory waterbirds in at least three years in ten, by inundating selected floodplain and wetland areas to provide suitable nesting and feeding habitat.
- Promote successful recruitment of native fish species by improving flow variability in spring and early summer to replicate natural cues, and by inundation of floodplain and wetland areas to provide breeding and nursery habitat.
- Facilitate successful breeding and feeding opportunities for native frog species by seasonal inundation of selected floodplain and wetland areas for appropriate season and duration as required for each species.
- Facilitate successful breeding of native turtle species by inundation of selected floodplains and wetland areas to provide suitable breeding and nursery habitat.
- Facilitate appropriate management to ensure the sustainability of Crayfish populations.
- Facilitate appropriate management measures to control the abundance and spread of invasive aquatic species.
- Facilitate appropriate geomorphology management in selected waterways.

The water regimes to achieve these objectives have been determined on the basis of the ecology of key species, forest hydrology and observed responses to natural and managed floods. The operating regime that contributes to the broader ecological objectives in Barmah Forest is outlined in Table 2.

Table 2: Operating regime that contributes to the ecological objectives.

Ecological objective	Vegetation community (Area inundated in hectares)	Mechanism to meet objective (average min. river flows)	Frequency (years in 10)	Duration (days)
Preferred operating scenario				
Healthy vegetation in at least 55% of the area of the forest	Low-lying creeks and wetlands (1000)	11 GL/day	9	30
	Wetlands and Moira Grass plains (7000-10,000)	18 GL/day	7	120
	Red Gum forest (17,000)	35 GL/day	5	90
	Red Gum woodland (24,000)	60 GL/day	3	30
Successful breeding events of thousands of colonial waterbirds in at least three years in ten	Creeks, wetlands, Moira grass plains, Red Gum forest and woodland (24,000)	30 GL/day	3	90 days
		18 GL/day		30 days
Minimum operating strategy				
Healthy vegetation in at least 55% of the area of the forest	Low-lying creeks and wetlands (1000)	11 GL/day	5	30
	Wetlands and Moira Grass plains (7000-10,000)	18 GL/day	3	120
	Red Gum forest (15,000)	35 GL/day	2	30
Successful breeding events of thousands of colonial and migratory waterbirds in at least three years in ten	Creeks, wetlands, Moira grass plains, Red Gum forest and woodland (15,000)	35+ GL/day	2	90 days
		18+ GL/day		30 days

4.2 Flow components delivered

The key flow components for the Barmah Forest include:

- Periodic base flows to maintain refuge pools in the major waterways of the reserve to maintain native fish and turtle habitat and passage.
- Freshes to maintain water quality and habitat for macro-invertebrates; and provide cues for native fish migration and spawning.
- Overbank flows to increase the extent and diversity of floodplain and wetland vegetation; exchange of food and organic material; and increase breeding and feeding opportunities for native fish, waterbirds and amphibians.

These key flow components and their ecological objective under various inflow scenarios are outlined in Table 3.

Table 3: Approximate flow component values and their ecological objective under various inflow scenarios for Barmah Forest (Murray River flows downstream of Yarrawonga - ML/day).

	Extreme Dry	Dry	Median	Wet
Ecological Watering Objectives	**Avoid damage to key environmental assets**	**Ensure ecological capacity for recovery**	**Maintain ecological health and resilience**	**Improve and extend healthy and resilient aquatic ecosystems**
Watercourse Objectives (4,000 to 15,000 ML/d)	Maintain flow in creeks and refuge pools in winter and spring to: - maintain fish populations - maintain water quality in watercourses and refuge pools - provide lateral transfer of water into adjacent groundwater aquifers to maintain health of large riparian River Red Gums	Provide and freshes flow in creeks and refuge pools in winter and spring : - maintain fish populations - stimulate fish breeding - inundate riparian River Red Gums - inundate organic debris and reduce summer blackwater risks - provide lateral transfer of water into adjacent groundwater aquifers to maintain health of large riparian River Red Gums	Provide sustained flow with multiple peaks in winter and spring to: - achieve multiple fish spawning events - inundate organic debris, reduce summer blackwater risks and export organic matter to River Murray (including the Gulpa Creek and Edward-Wakool systems) - waterbird nesting in riparian trees (i.e. maintain nesting and foraging habitat for colonial nesting waterbird species such as the Great Egret, herons and cormorants)	Provide sustained flows with connections to inundated floodplain habitat. Process and export organic matter and support fish breeding. Waterbird nesting in riparian trees (i.e. maintain nesting and foraging habitat for colonial nesting waterbird species such as the Great Egret, herons and cormorants)

Giant Rush Wetland Objectives **(4,000 to 15,000 ML/d)**	Flood Giant Rush wetlands such as Boals Deadwoods and Top Island.	Inundate Giant Rush wetlands to: - maintain vegetation health - provide adequate water depth and flood frequency to restrict invasion of Giant Rush and River Red Gums into open areas of water - provide feeding habitat for waterfowl - provide breeding habitat for some waterfowl species - provide habitat diversity and dispersal opportunities for fish, turtles and yabbies	Inundate Giant Rush wetlands to: - support breeding by a variety of waterbirds such as ibis, swans, spoonbills, bitterns - provide additional habitat for fish, frogs, yabbies and turtles - maintain a mosaic of open water and rush/reed beds	Inundate Giant Rush wetlands to: - support breeding by a variety of waterbirds such as ibis, swans, spoonbills, bitterns - provide additional habitat for fish, frogs, yabbies and turtles - maintain a mosaic of open water and rush/reed beds. Attempt to submerge Giant Rush in wetlands where invading to reduce colonisation ability.
Moira Grass Plain Objectives **(13,000 to 25,000 ML/d)**	None	Inundate Moira Grass Plains to: - maintain Moira Grass growth - provide adequate water depth and flood frequency to restrict invasion of Giant Rush and River Red Gums into Moira Grass Plains	Inundate Moira Grass Plains to: - maintain Moira Grass growth and asexual reproduction - provide nesting and foraging habitat for waterbirds such as egrets, herons, grebes, terns. - provide adequate water depth and flood frequency to restrict invasion of Giant Rush and River Red Gums into Moira Grass Plains Allow fish to return to permanent habitat on the flood recession	Inundate Moira Grass Plains to: - maintain Moira Grass growth and flowering/seeding - provide nesting and foraging habitat for waterbirds such as egrets, herons, grebes, terns. - provide adequate water depth and flood frequency to restrict invasion of Giant Rush and River Red Gums into Moira Grass Plains Allow fish to return to permanent habitat on the flood recession

Red Gum Forest Objectives **(20,000 to 35,000 ML/d)** **(additional flows increase floodplain inundation extent up to 60,000 to 70,000ML/d if occurs for over one month, which achieves broader forest values)**	None	None	Inundate Red Gum Forest to: - maintain Red Gum growth - inundate organic debris, reduce summer blackwater risks and export organic matter to River Murray Allow fish to return to permanent habitat on the flood recession	Inundate Red Gum to: - maintain Red Gum growth and reproduction - inundate associated Terete Culm Sedge understorey - provide feeding locations for waterbirds - inundate organic debris, reduce summer blackwater risks and export organic matter to River Murray Allow fish to return to permanent habitat on the flood recession

5. Current situation

5.1 Flood History since 1998

The flood history of each Barmah-Millewa WMA over the past 15 years is provided in Table 4. It includes a flood scoring system established within the Barmah-Millewa Forum (Maunsell McIntyre 1999) that attempts to recognize that different WMAs of the forest flood to different extents and also possess different flood requirements. The departure of the sum of the flood scores from the ideal total flood score for that site highlights the longer-term flood deficit for that area, and hence allows for some geographic prioritization for water delivery.

Using this system, and adjusting the departure score above originally proposed because of extreme drought deficits affecting all WMAs, it is readily apparent that most WMAs remain in severe flood deficit from ideal flood requirements despite recent years of extensive flooding. Unfortunately such a system that summarizes a given year's flood peak to characterize that year without recognition to timing, quality or duration, reduces the effectiveness of the system to rely on as a sole tool for prioritizing watering sites. Furthermore, correcting more recent prolonged flooding, by analyzing only a more recent series of years rather than the past 14 years of data, will yield differing prioritization. Nevertheless, it is a tool that is presented as a component of overall water planning considerations.

Table 4: Barmah-Millewa Forest flood prioritisation based on the past 15 year flood history and scored against ideal flood scenarios scores (Maunsell McIntyre 1999).

Water Management Area	Observed flooding score															Ideal average annual flood score #	Accumulated score 1998-2012	Ideal score	Departure from ideal flood score	Watering priority for 2013	Ranking
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012						
Kynmer Creek (A)	1	1	2	0	1	0	0	1	0	0	0	0	3	2	2	1.3	11	18.2	-7.2	Priority	14
Tongalong Creek (B)	1	1	3	0	1	1	1	2	0	0	0	0	3	3	3	1.5	16	21.0	-5.0	Priority	18
Smiths Creek (C)	3	1	3	0	1	0	0	2	0	0	0	0	3	2	2	1.5	15	21.0	-6.0	Priority	16
Yielima (D)	2	1	3	0	0	0	0	2	0	0	0	1	3	2	2	1.5	13	21.0	-8.0	Priority	13
Black Swamp (E)	2	1	3	0	0	0	0	1	0	0	0	0	3	2	2	1.6	12	22.4	-10.4	Priority	6
Gulf Creek (F)	2	1	3	0	2	1	1	3	0	0	1	1	3	3	3	1.9	20	26.6	-6.6	Priority	15
Boals Deadwood (G)	2	1	2	0	1	1	1	3	0	0	0	1	3	3	3	1.9	18	26.6	-8.6	Priority	11
Top Island (H1)	2	1	3	0	1	1	1	3	0	0	0	0	3	2	2	1.9	17	26.6	-9.6	Priority	9
Steamer/War Plain (H2)	2	1	3	0	2	2	2	3	1	0	0	1	3	3	3	2.0	23	28.0	-5.0	Priority	17
Goose Swamp (H3)	1	1	3	0	1	1	0	0	0	0	0	0	3	2	2	1.6	12	21.7	-9.7	Priority	8
Barmah Island (H4)	2	1	3	0	2	2	2	1	0	0	0	0	3	2	2	2.0	18	28.0	-10.0	Priority	7
Aratula Creek (J)	3	0	3	0	0	0	0	1	0	0	0	0	3	2	2	1.5	12	21.0	-9.0	Priority	10
Plantation (L)	2	0	3	0	0	1	0	1	0	0	0	0	3	2	2	2.0	12	28.0	-16.0	Priority	1
Mary Ada (M)	3	0	3	0	0	1	1	2	0	0	0	0	3	3	3	1.9	16	26.6	-10.6	Priority	5
Edward River (N)	3	1	3	0	0	1	1	2	0	0	0	0	3	3	3	2.3	17	32.2	-15.2	Priority	2
Towrong Creek (P)	3	0	3	0	0	0	1	2	0	0	0	2	3	2	2	1.4	16	19.6	-3.6	-	19
St Helena Swamp (Q)	2	1	3	0	0	1	1	2	0	0	0	0	3	3	3	2.2	16	30.8	-14.8	Priority	4
Gulpa Creek (R)	2	1	3	0	0	1	2	1	0	0	0	0	3	3	3	2.2	16	30.8	-14.8	Priority	3
Moira Lake (S)	2	1	3	0	2	1	2	2	1	0	0	0	3	3	3	2.0	20	28.0	-8.0	Priority	12

Notes:

Flood scores:

0 "no flooding the WMA"

1 "some flooding the WMA"

2 "lot of flooding"

3 "completely flooded"

Notes:

Based on the proportion of wetlands, SQI, SQII, SQIII in each WMA and desirable flooding frequencies of 10 years out of 10 for wetlands, 8 years, 5 years and 3 years out of 10 for SQI, SQII and SQIII.

NB: excludes Barmah & Moira Lakes, Edward & Gulpa Rivers and unregulated creeks of Little Budgee Creek and Budgee Creek in Barmah Forest.

5.2 Historical watering actions

The following information summarises the watering actions, and provides an estimate of the area inundated, for the previous five years at Barmah Forest.

2008/09

- Drought conditions prevailed with flows not exceeding channel capacity.
- 0.3 GL of The Living Murray environmental water was delivered to Gulf Creek in November 2008. The objective was to provide drought refuge for the last known populations in Barmah forest of Southern Pygmy Perch (*Nannoperca australis*) and Dwarf Flat-headed Gudgeon (*Philypnodon macrostomus*) and refill refuge pools for turtles and other fauna. Vandalism to regulators in January/February resulted in minor flooding of Boals Deadwoods and Gulf Creek.
- An estimated 10% of the Barmah Forest floodplain was inundated, including Barmah Lake from at-channel capacity flows.

2009/10

- Drought conditions prevailed with flows not exceeding channel capacity.
- 2.01 GL of environmental water was used in Barmah Forest, 1.76 GL from the Murray Flora and Fauna Bulk Entitlement and 0.25 GL from The Living Murray. The objectives were to reconnect drought refuge pools through Gulf Creek and Smiths Creek (~45km of creek-line), as well as reinvigorating wetland plants with shallow flooding in Top Island and Boals Deadwoods, both key colonial waterbird breeding sites.
- An estimated 15% of the Barmah Forest floodplain was inundated, including Barmah Lake from at-channel capacity flows.

2010/11

- Natural major flooding returned with peaks in excess of 100,000 ML/day (10 times the capacity of the Barmah Choke) occurring in September and December of 2010. Unusually, the flooding persisted for the entire year over much of the floodplain with significant late summer / early autumn flooding.
- 428 GL of environmental water was delivered to Barmah-Millewa Forest. The environmental water was delivered to maintain flows at or above channel capacity, preventing the draining of wetlands and the potential for nest abandonment by colonially nesting waterbirds, as well as maintaining ideal flood depth and duration for wetland vegetation such as Moria Grass.
- An estimated 90+% of the floodplain was inundated (basically, as flooded as it gets).

2011/12

- Late winter and early spring natural flood events peaking at 50,000ML/d in August were followed by a slightly drier than forecast conditions for the remainder of spring. Following the completion of colonial waterbird breeding, wetlands were entering a desirable drying cycle, before a highly unusual March flood event re-flooded the majority of the floodplain after sharply peaking at 57,000ML/d downstream of Yarrawonga.
- A total of 428.1 GL of environmental water was delivered to maintain flows at or above channel capacity between natural flood peaks in spring and summer. This was to maintain water under colonially nesting waterbirds (preventing nest abandonment). A pulse was delivered in late November – early December for native fish spawning, before regulated flows were delivered to specific waterbird colonies over summer to ensure fledging success.
- An estimated 65% of the floodplain was inundated in 2011/12.

2012/13

- An early winter natural flood event extended through to mid-October, briefly peaking at 53,000ML/d in July and 41,000ML/d in August, but was then followed by a drier than average conditions for the remainder of spring. The lower floodplain region experienced a desirable dry phase after largely being inundated for the previous 2.5 years, although completion of waterbird breeding required some targeted release of EWA.
- 0.3 GL of The Living Murray environmental water was delivered to Boals Deadwoods wetland between 17 November 2012 to 14 January 2013. This water successfully maintained shallow flooding beneath colonially nesting waterbirds (White Ibis, Straw-necked Ibis and Royal Spoonbill), successfully preventing nest abandonment.
- An estimated 60% of the floodplain was inundated in 2012/13.

5.3 2012-2013 season review

Widespread flooding conditions have occurred in Barmah Forest throughout 2011-12 (Figure), influencing all WMAs in the reserve (Figure 7) and continues near-continuous flooding that had initiated in July 2010. For many low-laying Barmah Forest wetlands, flooding has essentially been continuous for 28 months (due to ponding between renewed periods of overbank flows). Monitoring had shown approximately 500 nests of Ibis occurred at Boals Deadwoods wetland and an additional 600 nests at Keyes Point wetland in spring 2012, although substantially lower than in spring of the previous two flood years (2010 and 2011). The Moira Grass plain wetland community continues to displaying only a patchy positive response to the prolonged flooding (Ward 2011,

2012), with recent mapping by CSIRO indicating that it presently occupies only 154ha, representing a 96% decline in extent over the past 83 years when compared to Chesterfield (1986) estimates of extent in 1930 (Figure 8).

The current drying regime that is being experienced through autumn is expected to continue until early-winter 2013. This is desirable for Moira Grass as part of its preferred strong wet/dry seasonal flooding requirement. The need for a return of later-winter and spring flood exceeding 0.5m deep (Ward 1994) is now required to re-invigorate Moira Grass and hopefully re-expand its distribution on the remaining plains. The chance of natural flooding in spring is relatively high, however the need to augment this with additional water releases is likely to be required to maintain flood depth during spring.

The premise for release of EWA in 2013/14 is that a natural flood peak will occur in late-winter, breaking the drying regime of the wetlands to encourage Moira Grass to grow and fish and waterbird feeding interest on the wetlands in spring 2013. Moira Grass requires 3.5 to 4 months of continuous flooding to flower and set seed, which is a similar time for waterbirds to complete nesting and fledging young, although often waterbird breeding occurs later and at different locations within the forest. Environmental water planning can often cater for the two separate flood regime requirements by differential delivery of EWA spatially and temporally according to need.

Figure 6: Murray River flow downstream from Yarrawonga in 2012/13
(data from MDBC 2012b; data current to 16/04/2013).

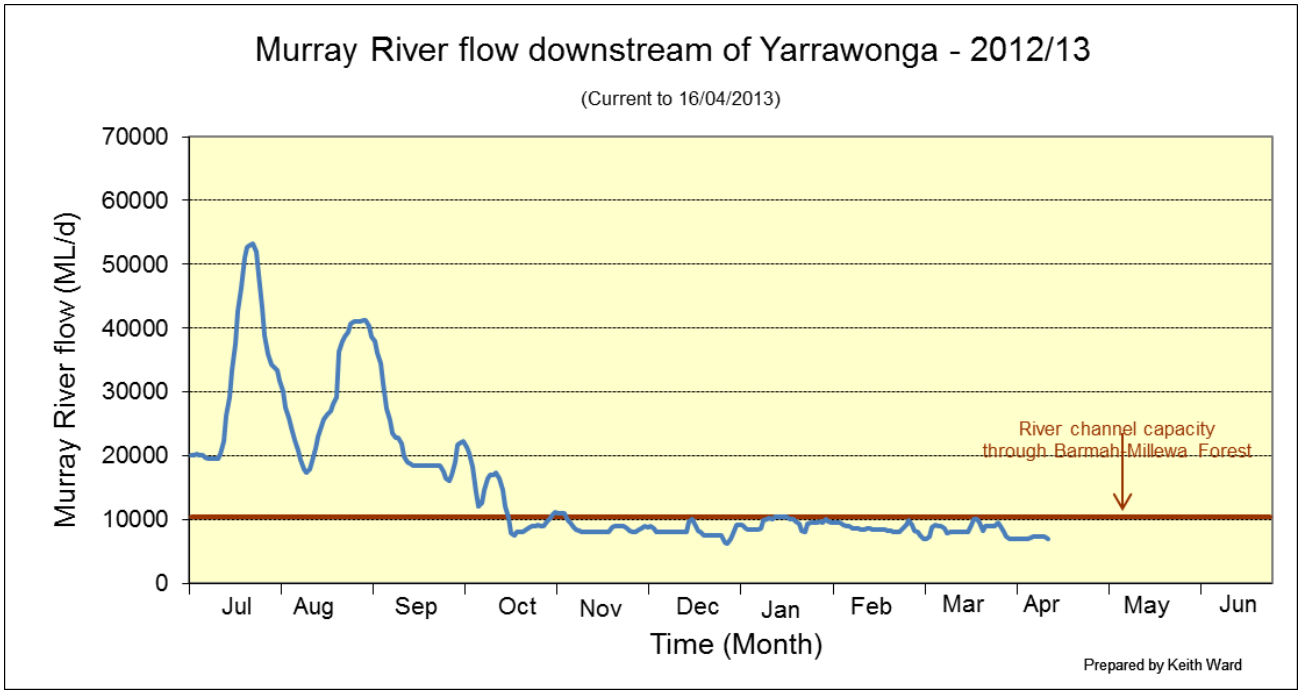
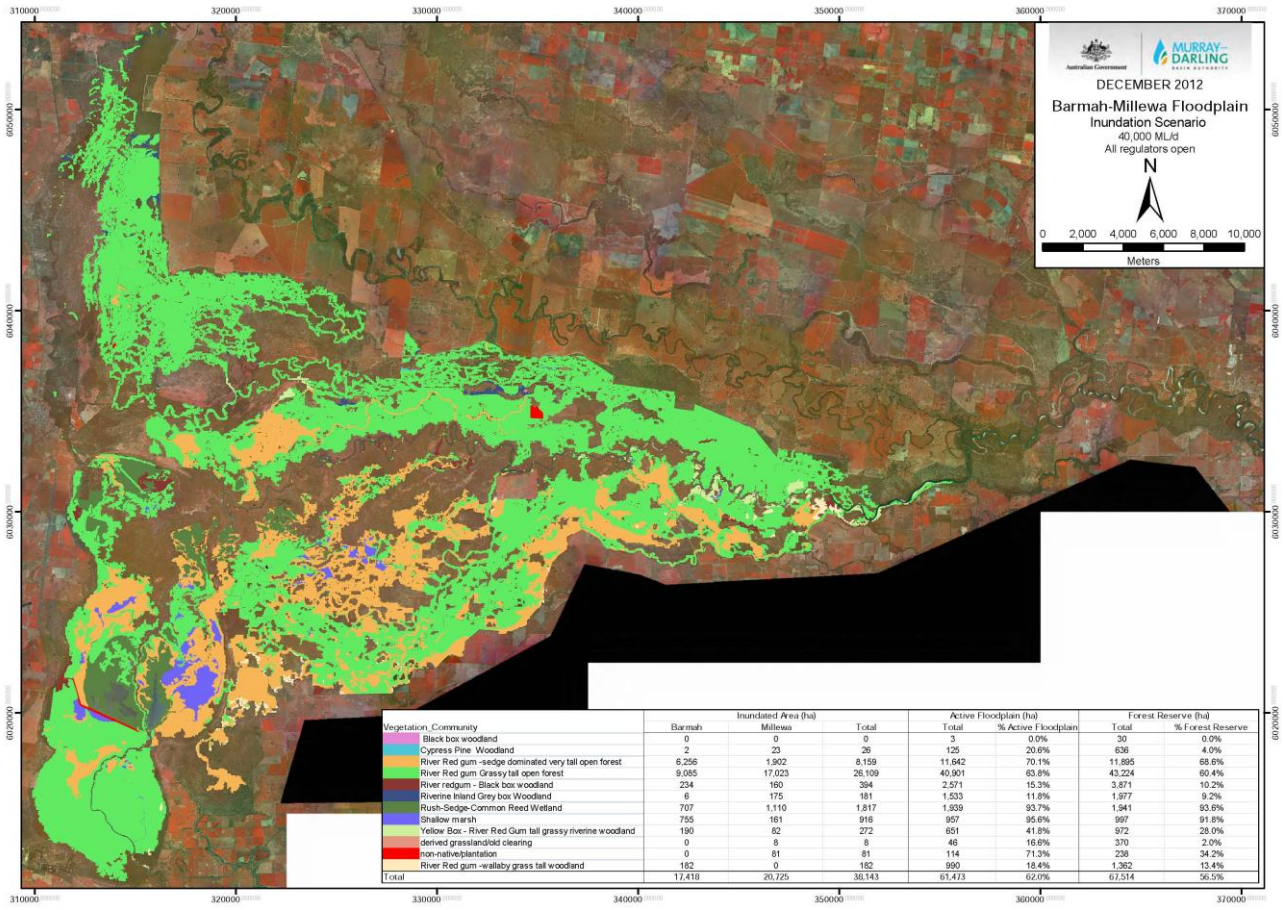
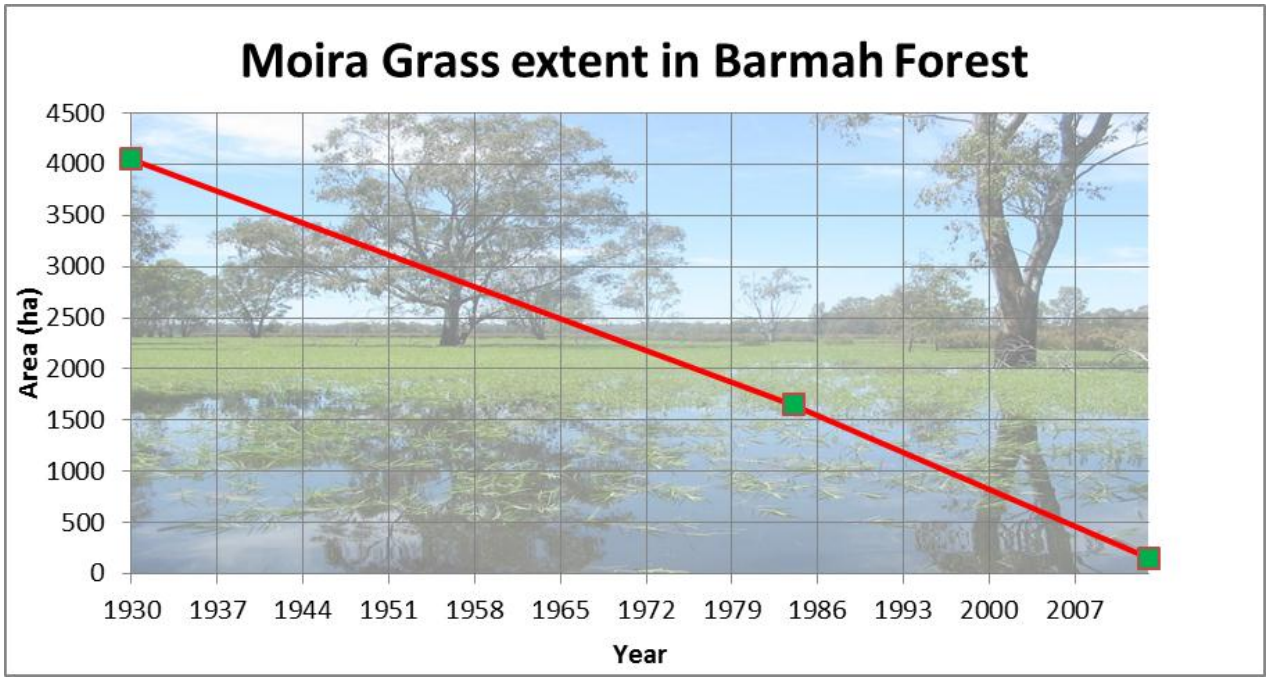


Figure 7: Approximate flood distribution on the Barmah-Millewa Forest floodplain in 2012/13 (hydrodynamic model map of 40GL/mth downstream of Yarrawonga from MDBC 2012c)



Vegetation_Community	Inundated Area (ha)			Active Floodplain (ha)		Forest Reserve (ha)	
	Barmah	Millewa	Total	Total	% Active Floodplain	Total	% Forest Reserve
Black box woodland	0	0	0	3	0.0%	30	0.0%
Cypress Pine Woodland	2	23	26	125	20.6%	636	4.0%
River Red gum -sedge dominated very tall open forest	6,256	1,902	8,159	11,642	70.1%	11,895	68.6%
River Red gum Grassy tall open forest	9,085	17,023	26,109	40,901	63.8%	43,224	60.4%
River redgum - Black box woodland	234	160	394	2,571	15.3%	3,871	10.2%
Riverine Inland Grey box Woodland	6	175	181	1,533	11.8%	1,977	9.2%
Rush-Sedge-Common Reed Wetland	707	1,110	1,817	1,939	93.7%	1,941	93.6%
Shallow marsh	755	161	916	957	95.6%	997	91.8%
Yellow Box - River Red Gum tall grassy riverine woodland	190	82	272	651	41.8%	972	28.0%
derived grassland/old clearing	0	8	8	46	16.6%	370	2.0%
non-native/plantation	0	81	81	114	71.3%	238	34.2%
River Red gum -wallaby grass tall woodland	182	0	182	990	18.4%	1,362	13.4%
Total	17,418	20,725	38,143	61,473	62.0%	67,514	56.5%

Figure 8: Trend in decline of Moira Grass extent in Barmah Forest (data from Chesterfield 1986 and Vivian *et al.* in prep.).



5.4 Current ecological conditions

The floods and freshes experienced from July 2010 to October 2012 provided water to a system that was strongly exhibiting drought stress and declining health. The floods also provided input of nutrients, carbon and organic matter to the river and an exchange of sediments and biota between the channel, floodplain and wetlands. The floods and freshes connected regions of the Barmah floodplain not inundated for 10 years, and greatly enhanced wetland vegetation health (Ward 2011, 2012), stimulated the largest waterbird breeding event (numbers of species and individuals) for 40-60 years (depending on the species) (Chalmers & Ward 2012), and promoted some native fish breeding (King *et al.* 2011).

However, the relative poor response of Moira Grass to the recent flooding remains a key concern. The lack of an annual wet-dry regime is likely to be a strong contributing factor, although the duration of the poor conditions created by drought and continued grazing pressure from feral horses may also have weakened the species ability to respond.

Furthermore, the blackwater event in December 2010 that resulted in a substantial fish and crayfish death incident in the Murray River downstream of Barmah Forest (King *et al.* 2011), appears to have resulted in complete loss of crayfish downstream of the forest while some of the more mobile fish species have returned to the area (Raymond *et al.* 2012). The strong recruitment of Common Carp (*Cyprinus carpio*) and Eastern Gambusia (*Gambusia holbrooki*) in the Barmah Forest wetlands in 2010/11 (Raymond *et al.* 2011) was reduced by 60% in 2011/12, possibly as a result of no hypoxic blackwater occurring in 2011/12 giving these exotic species a competitive advantage (Raymond *et al.* 2012).

On a positive side, the strong prolonged flooding of the past three years appears to have reversed some encroachment of species such as Giant Rush and River Red Gum onto the Moira Grass Plains and from areas of open water, especially Barmah Lake.

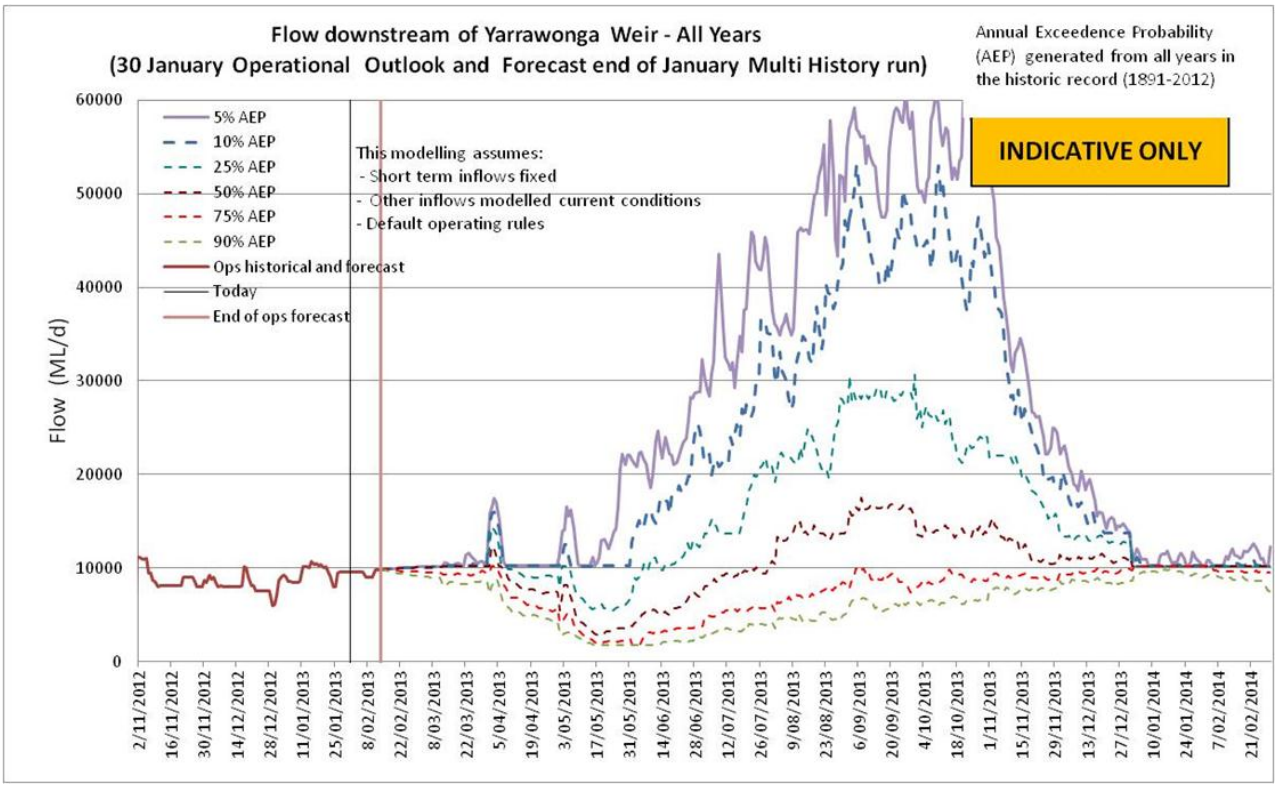
The need for annual to near annual floodplain inundation to reduce the accumulation of organic compounds that lead to blackwater development is therefore highlighted. However, the timing of flood inundation and return flows is critical (avoiding warmer months of summer and early autumn), as too is the requirement for a drying regime on the floodplain during summer to early winter.

5.5 Climatic outlook for 2013-2014

According to the latest weather outlook information from the Bureau of Meteorology (BoM 2013), the Murray Catchment has a 45-55% chance of receiving median rainfall from April to June 2013 and a 60-70% chance of exceeding the median maximum temperature. Dartmouth Reservoir and Hume Reservoirs are currently 94% and 50% full respectively (as of 27 March 2013; MDBA 2012c), and hence there is a possibility that they could spill to create natural flooding of the Barmah-Millewa floodplain in spring.

MDBAs modelling (current to 30 January 2013) has indicated that the 50% annual exceedence probability (AEP) of the Murray River flow downstream of Yarrawonga in 2013 is approximately 15,000 ML/d between August to November, while a wet scenario having a 25% AEP is a flow exceeding 20,000 between July to November peaking up to 30,000 ML/d in September/October (Figure 9).

Figure 9: MDBA seasonal forecast model run for Murray River flows downstream of Yarrawonga in 2013 (current as of 30/01/2013) under various annual exceedence probabilities (AEP).



6. Priority watering actions

6.1 2013-14 watering outlook

The broad strategy for 2013/14 is essentially to maintain flood duration following initiation by a natural flood event given that a summer-autumn drying regime has now been experienced by the seasonal wetlands within the forest. However, because there exists a high probability that the forest will experience at least some natural flooding in spring (based on high Hume Reservoir and Dartmouth Dam storage levels and BoM forecasts of 'average' spring rainfall which usually results in some floodplain inundation), then the strategy will be to build on flood peaks to re-inundate the broadest floodplain extent that is manageable (given that the Moira Grass plains will already be wet from the smaller natural flood event).

Re-boosting the health and extent of Moira Grass on the plains is now the primary ecological target for 2013/14, consistent under the following strategic aim;

- Promote healthy and diverse vegetation communities, with an emphasis on restoring natural extent and distribution of Giant Rush, Moira Grass, River Red Gum forest and River Red Gum woodland in at least 55% of the area of Barmah-Millewa Icon Site (MDBA 2012a).

An adaptive management approach will need to be applied as 2012/13 unfolds, specifically in relation to natural flooding, the availability of environmental water and the ability to achieve ecological targets. Given the high probability of natural flooding in spring, ecological targets for native fish spawning and recruitment and waterbird nesting are also expected to be achievable.

6.2 Summary of 2013/14 watering priorities

The following priorities are largely ordered by increasing water demand, until Priority 6 which is assisting with the proposed Multi-Site Watering Trial and Priority 7 which is related to implementing a natural dry regime in summer-autumn. Note: Achieving Priority 5 is likely to also achieve the preceding priorities, while Priority 6 could act as a useful enabling tool to ensure maximum water use.

Priority 1: River fish: Provide preferred flow conditions for native fish recruitment through appropriately timed variable pulses in the main river channel, rather than constant low-level flows. [Achieved via pulsing flows if no natural pulses occur during the water delivery period in spring]. [Figure 9]

Priority 2: Creek flow: Ensure a period of some flow into all main forest waterways to re-improve water quality, provide connectivity and maintain drought refuge for fish and turtles. [Achieved via diversion of some Murray River flows through major forest regulators. Volumes and river flow thresholds are variable, but can be readily achieved for most sites at river flows >7,000 ML/d downstream of Yarrawonga]. [Figure 10]

Priority 3: Boals waterbirds: Achieve successful breeding of Ibis and Spoonbills, and potentially facilitate a proposed experiment to investigate the relationship between open water, Giant Rush and Ibis nesting at Boals Deadwoods wetland. [Achievable with passing 100 ML/d for 3.5 months through Boals Creek Regulator in mid-spring to early summer]. [Figure 11]

Priority 4: Broader forest waterbirds: Maintain appropriate flood depth and duration to wetlands supporting a significant colonial waterbird breeding event, if this initiates. [Depth and location will depend on the waterbird species and their realised breeding location.]Provide ideal conditions for native fish recruitment through appropriately timed variable flows (pulses) in the main river channel, rather than constant flows]. [Figure 12]

Priority 5: Moira Grass & Red Gum Forest: Increase and extend natural spring flooding to maximise benefit for Moira Grass Plains and River Red Gum Forest. [NB: Moira Grass has exhibited a significant decline in abundance and extent over the past few years as a result of drought followed by unusually extended flooding. The recent dry regime of the species' distribution on the floodplain during summer-autumn 2012/13 is expected to have been beneficial to the species, while deep (>0.5m) and continuous (4 months) flooding is now required in late-winter to the end of spring]. [Figure 13]

Priority 6: Bypass Choke for MSWT: Assist water deliver to downstream Icon Sites as part of the proposed Multi-Site Watering Trial by bypassing channel capacity constraints of the Barmah Choke via re-routing water through Barmah Forest during winter-spring. [Given that flow will pass into Barmah Forest above the Barmah Choke and return to the Murray River below the Barmah Choke]. [Figure 14]

Priority 7: Seasonal dry: Implement a drying regime to the floodplain in summer-autumn 2013/14. [Achieved by maintaining Murray River levels at or below normal regulated capacity of 10,400 ML/d downstream of Yarrawonga, and having all forest regulators closed to prevent river flows from passing into the forest's waterways]. [Figure 15]

The following table in Section 5: Scenario Planning further outlines potential management activities under different scenarios, including charts of hypothetic flows and subsequent EWA management response.

7. Scenario planning

As natural flood events and flows are critical to determining what ecological objectives may be achieved for Barmah Forest in any given year, various scenarios are described to cover a variety of events.

The benefit of describing various scenarios is for actual environmental water use and outcomes to be linked to planning strategies, regardless of what conditions actually occur. For 2013/14, planning is based around average to slightly wetter than average conditions.

Table 5: Water management strategies and activities targeted under different inflow scenarios:

Water Resource Scenario	Objective targeted	Hydraulic target*	Optimal Delivery		Alternate Delivery		Trigger Flow or Trigger Event (i.e. bird breeding, unregulated flow periods)	Target Flow Required			Vol Required (GL)	Vol Returned (GL)	Area Inundated	
			Date	Duration	Date	Duration		ML/d	Duration	location			ha	Duration
Extreme Dry	1 (river fish) [Figure 9]	<10,400	Late Nov	2 weeks	Early Dec	1 week	Stable river during Nov.	1,500	2 weeks	Main river channel	21	20	negligible	2 weeks
	2 (creek flow) [Figure 10]	<10,400	Oct to Nov	2 months	Sum mer	2 weeks	No period of regulators being opened in 2013	500	2 months	Gulf, Big Woodcutter, Boals	30	15	YTBD (est. ~500)	9-12 months (due to ponding)
Dry	3 (Boals birds) [Figure 11]	>8,500 (or >5,500 if willow removal works have been completed)	Sep to Dec	3.5 months	Oct to Jan	3.5 months	Natural initiation of a colonial bird breeding event requiring maintenance	100	3.5 months	Boals	10	3 (broad estimate)	100	4 to 5 months (due to some ponding
	4 (other birds) [Figure 12]	>15,000 (prefer 18,000+)	Aug to Nov	3.5 months	Nov / Dec		If significant** bird breeding event initiates	Variable depending on location	Variable depending on location and stage of nesting	Dependant on where waterbird event initiates	Variable depending on location	Variable depending on location	Variable depending on location	Variable depending on location

Water Resource Scenario	Objective targeted	Hydraulic target*	Optimal Delivery		Alternate Delivery		Trigger Flow or Trigger Event (ie bird breeding, unregulated flow periods)	Target Flow Required			Vol Required (GL)	Vol Returned (GL)	Area Inundated	
			Date	Duration	Date	Duration		ML/d	Duration	location			ha	Duration
Median	5 (Moira Grass & Red Gum Forest) [Figure 13]	>18,000 (prefer 25,000+, but 20,000 = MDBA imposed temporary release limit).	Aug to Nov	4 months	Jul / Dec	3 months	Coincident with natural flood pulse between 15,000 to 20,000 (latter = MDBA imposed temporary release limit).	8,000 (average)	4 mths	All regulator opened	970	680 (= 70% return as per BOC agreement), or 875 (>90% returns as measured in 2005).	21,000 (10,000 Barmah + 11,000 Millewa)	4.5 months (ponding is limited on shedding floodplain; longer in lower regions)
	6 (bypass Choke for MSWT) [Figure 14]	Variable (dependent upon downstream Icon Site demands)	Aug to Nov	4 months	Jul / Dec	3 months	Variable (dependent upon downstream Icon Site demands)	Variable (dependent upon downstream Icon Site demands)	Variable (dependent upon downstream Icon Site demands)	Gulf, Big Woodcutter, Boals (and potentially all others depending upon flow required downstream)	Variable (dependent upon downstream Icon Site demands)	Variable (dependent upon region of forest flow is diverted and antecedent flood conditions)	Variable (dependent upon region of forest flow is diverted and antecedent flood conditions)	Variable (dependent upon region of forest flow is diverted)
Wet	7 (seasonal dry) [Figure 15]	<10,400	Jan to May	6 months	Feb to May	4 months	10,400 to 15,000 (2013/14 = MF turn for unseasonal flow management ***)	0	4 days (typical rain-rejection event)	Regulators in WMAG (i.e., those that avoid MG Plains)	0 (flows are unwanted)	Variable depending on location, duration and size of rain-rejection event, and antecedent	Variable depending on location, duration and size of rain-rejection event, and	Variable depending on location, duration and size of rain-rejection event, and antecedent flood

												flood conditions in the forest. Likely to be less than 40%	antecedent flood conditions in the forest.	conditions in the forest.

* = Murray River flow (ML/d) downstream of Yarrawonga.

** = significant bird breeding event is defined as a high percentage of common species population or any wetland-dependant VRoT species where water management can realistically target.

*** = An arrangement exists for Barmah Forest and Millewa Forest to alternate, on an annual basis, the management of all unseasonal flows solely on Vic or NSW side of the river in attempt to permit the other side achieve a satisfactory dry regime on their Moira Grass plains (i.e., rather than share any unseasonal flooding that would result in both forests' Moira Grass plains having their natural drying cycle broken by very shallow flooding, then the arrangement allows for deeper flooding on some Moira Grass plains to permit others to remain dry in recognition that the following year reciprocal management occurs). The 20013/14 year is Millewa Forest turn to accept the unseasonal flows.

Figure 9: Hypothetical flow scenario 1 (Extreme Dry) with riverine fish target

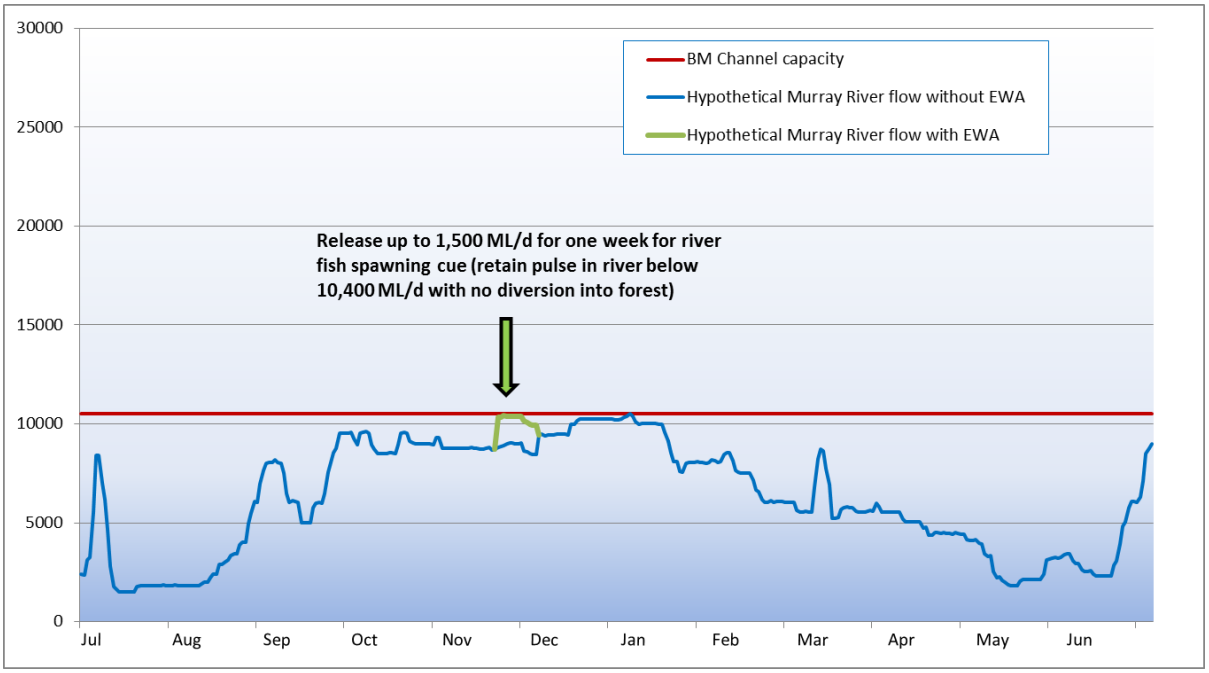


Figure 10: Hypothetical flow scenario 1 (Extreme Dry) with forest creek target

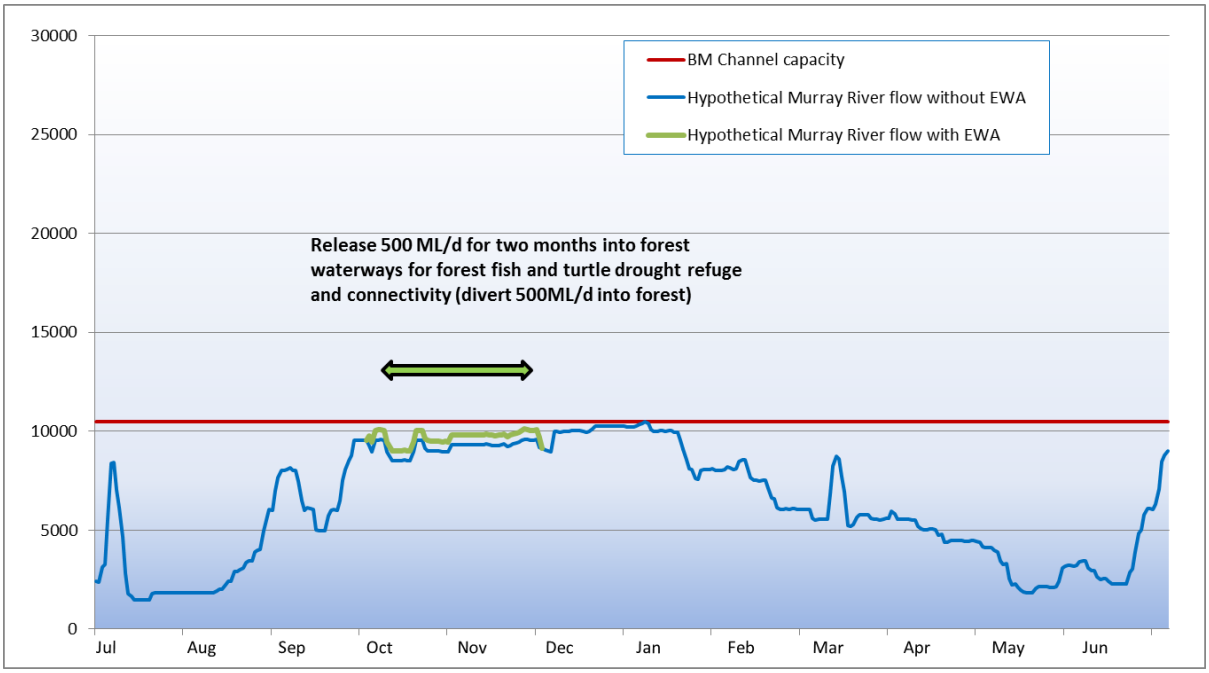


Figure 11: Hypothetical flow scenario 2 (Dry) with Boals waterbird target

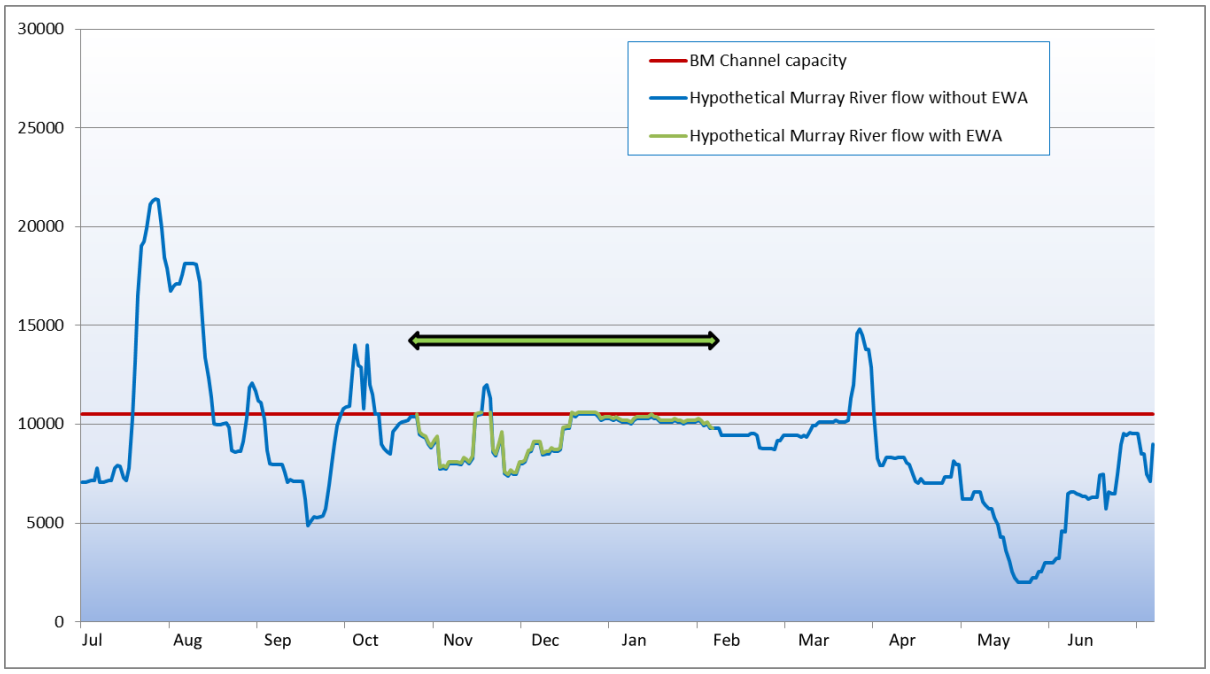


Figure 12: Hypothetical flow scenario 2 (Dry) with other forest waterbird target

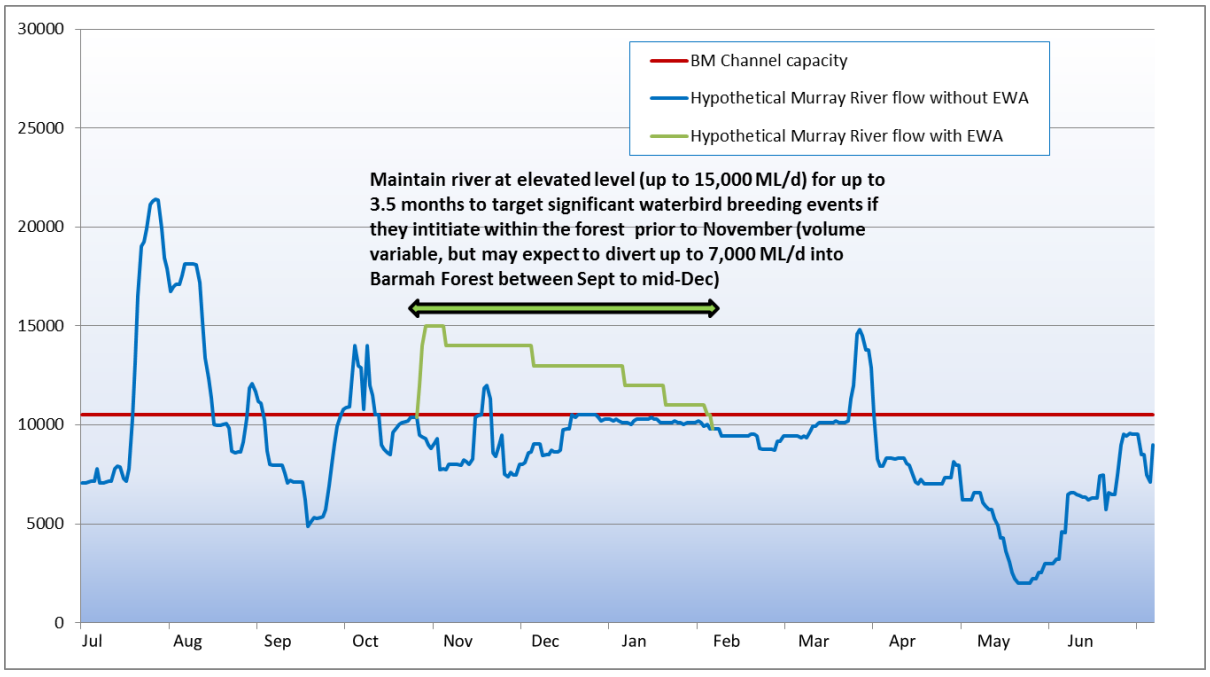


Figure 13: Hypothetical flow scenario 3 (Median) with Moira Grass & RG forest target

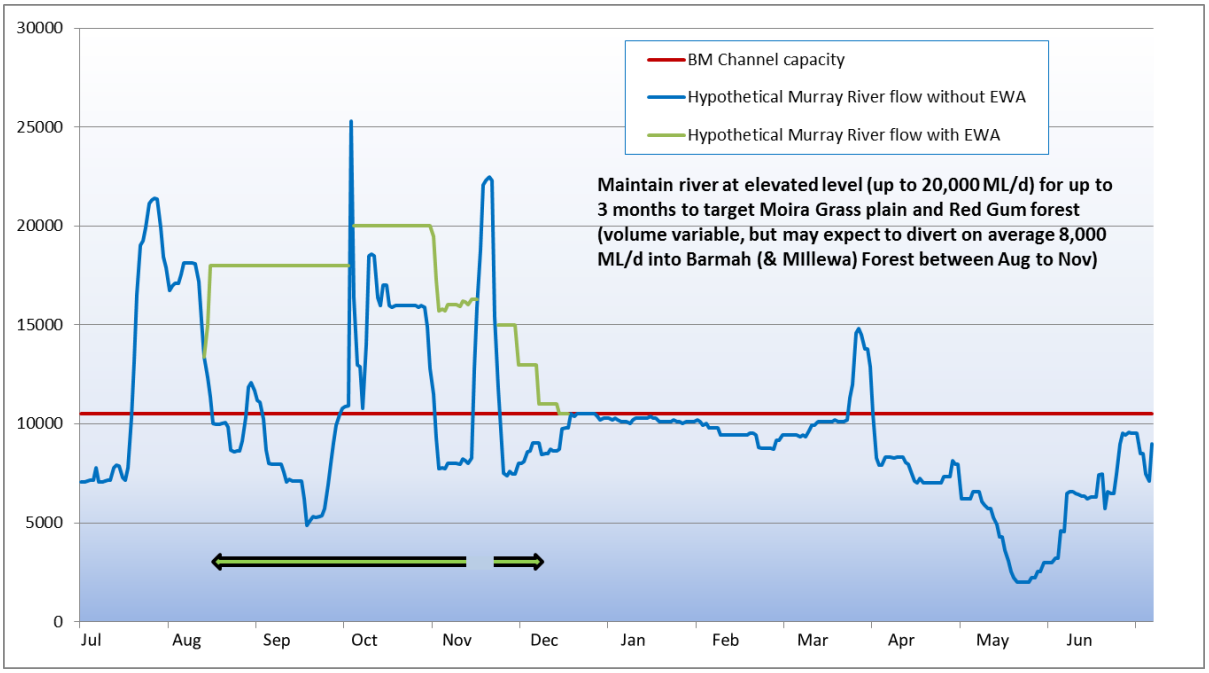


Figure 14: Hypothetical flow scenario 3 (Median) with Multi-Site Watering Trial target

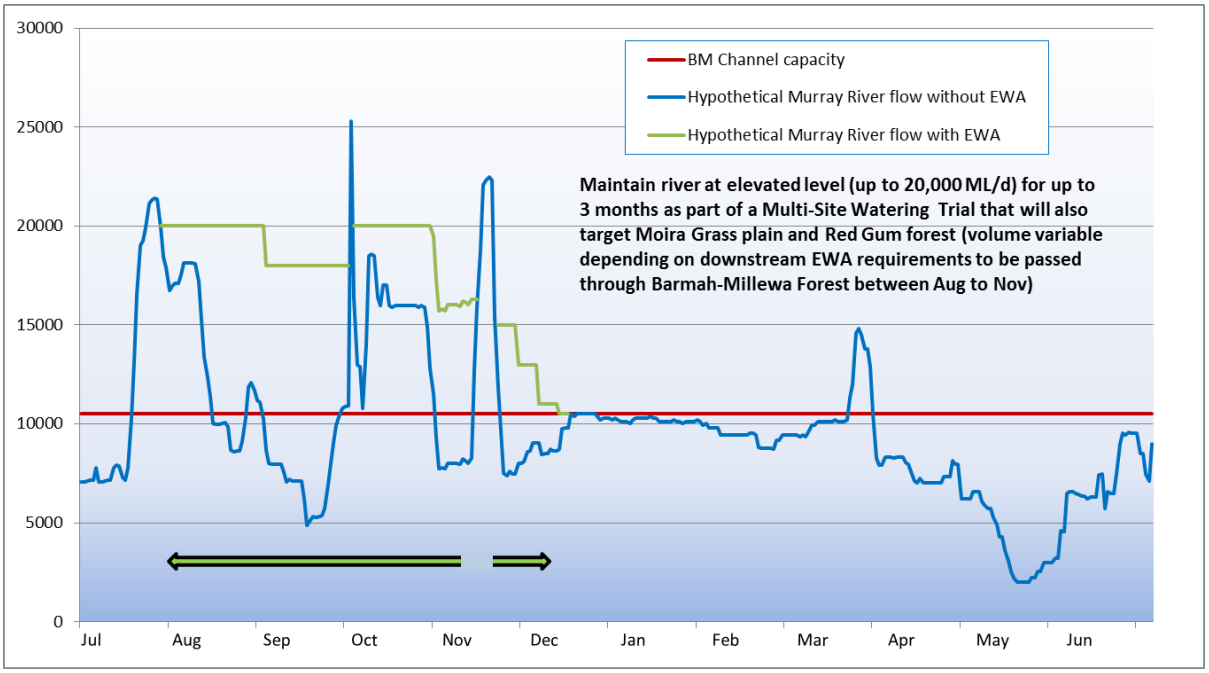
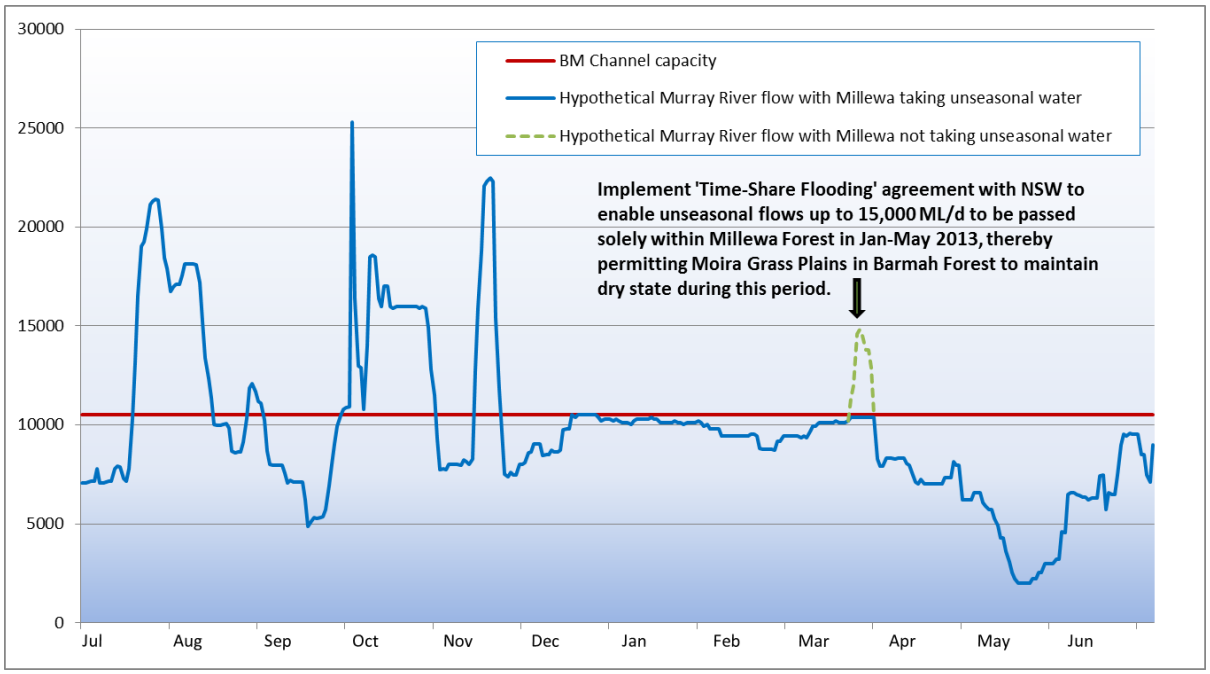


Figure 15: Hypothetical flow scenario 4 (Wet) with Time-Share Flooding implementation



An adaptive approach is critical in managing water dependant ecosystems so both land managers and policy makers can learn and change strategies based on the outcomes of research and watering actions. It is also known as 'learning by doing' through designing, implementing, monitoring, reporting and evaluating our work. Adaptive management informs the on-going refinement and implementation of the Barmah-Millewa Environmental Water Management Plan (EWMP) by incorporating outcomes from environmental delivery, ecological monitoring, operation of works at each site, modelling and community consultation.

The EWMP promotes an adaptive management approach through 'learning by doing'. Ecological information collected during and after environmental watering events will be incorporated into the icon site operating strategy to ensure it remains relevant and effective (MDBA 2012a).

Management of environmental water delivery at Barmah-Millewa Forest will occur adaptively in-line with the adaptive management cycle as detailed in Figure 16.

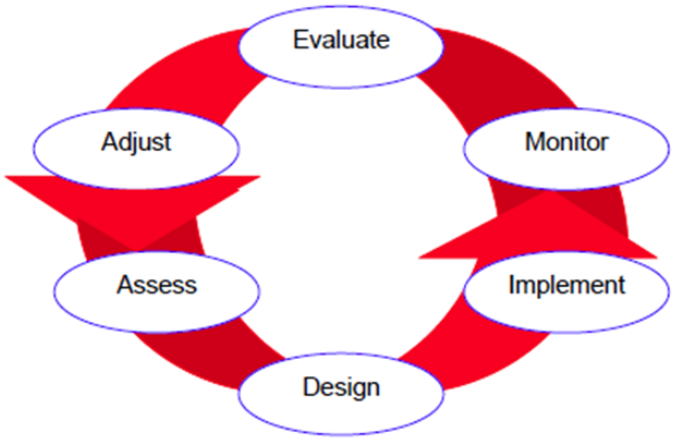


Figure 16: An adaptive management cycle (MDBA 2012a).

Water management activities will be closely monitored (as outlined in Section 9), while weekly teleconferences of the Barmah-Millewa Operations Committee will ensure consideration of all required information is made available for refined water planning and management (as outlined in Section 10).

The various scenarios will be adopted in response to the existing conditions. The following points are examples of events that may trigger the adoption of changing targets;

- Lengthy natural spring flooding (flows around 15,000 ML/day) would trigger a move away from maintaining a drying regime to managing spring flooding to maximise the benefit for Moira Grass plains and River Red Gum forest.
- Significant natural spring flooding (moving towards a 20,000 ML/day monthly average flow) may trigger maintaining a higher minimum flow with environmental water.
- River flows (natural or environmental water) in late spring could be manipulated to provide variable flows (pulses) to support native fish spawning.
- Observed mass colonial waterbird nesting may be supported through to fledging by environmental water. Small numbers of threatened species nesting (e.g.. Egret species or Brolga) may trigger environmental water delivery to complete the nesting event. This could be achievable during regulated flows within channel capacity, or the periodic pulsing of flows to recharge ponded water levels, depending on the location or requirement of the nesting activity.

More in-depth consideration of monitoring and strategy will remain with the existing TLM Icon Site Committees (ICC, CRG, IPP and TAC).

8. Triggers for actions

The following water management targets are associated with various hydrological, biological and physical triggers for environmental water management. As discussed in Section 4 (above), the priorities are largely nested depending upon antecedent river flows, available environmental water, environmental response, potential links with downstream EWA demand, and channel capacity constraints (Figure 17).

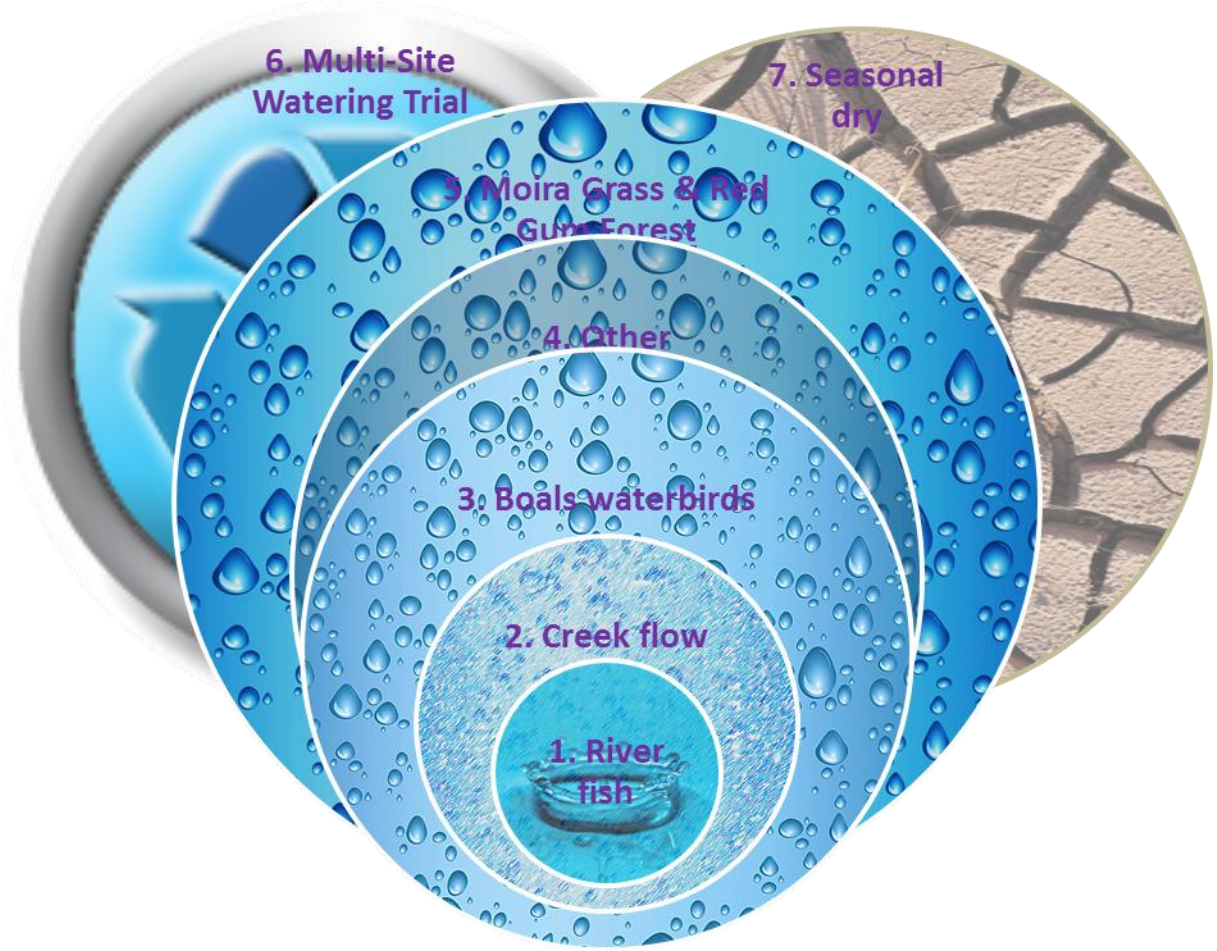


Figure 17: Diagrammatic representation of water management proposals for Barmah Forest in 2013/14, displaying nested water volumes and environmental targets of the five proposed EWA volumes, plus the addition of the Multi-Site Watering Trial and a seasonal dry in summer-autumn as complimentary actions.

Table 5 (above) included triggers for the priority water management targets under various water resource scenarios, but these have been expanded with corresponding action in Table 6:

Table 6: Triggers for water management actions in Barmah Forest in 2013/14.

NB: All flows are Murray River flows downstream of Yarrawonga unless otherwise indicated.

Trigger	Action	Target
Stable river <10,400 ML/d during November.	Create a pulse in river flows by releasing up to 1,500 ML/d for 2 weeks. Ensure peak does not exceed 10,400 ML/d.	River fish breeding cue. Refer to Figure 9.
No period of regulators being opened in 2013 prior to end of November.	Release 500 ML/d into main Barmah Forest regulators for up to 2 months (min 2 weeks). Regulator selection will be based on degree of refuge pool drying and their commence-to-flow thresholds.	Drought refuge in forest waterways for fish and turtles. Longer duration permits connectivity to permit movement and dispersal. Shorter duration permits only refreshing in-stream pools. Refer to Figure 10.
Natural initiation of colonial waterbird breeding in Boals Deadwoods wetland prior to end of November.	Release 100 ML/d for the duration of maintaining the event through to successful completion (up to 3.5 months)	Significant numbers of Australian White Ibis, Straw-necked Ibis and Royal Spoonbill (whilst recognising that Bitterns, Crakes and Rails are also likely to breed within the wetland but not be observed nesting duet to their cryptic habit). Refer to Figure 11.
Natural initiation of a significant waterbird breeding event elsewhere in the forest (which could be small numbers of threatened species or large numbers of common species) prior to end of November.	Determine flow threshold required to maintain adequate flooding of the breeding site, and consider if available water resource exists to maintain flooding for the duration of the breeding event (possibly up to 3.5 months). Release water in accordance to requirements if water resources and constraints (channel capacity or minimal-impact on other targets) permit.	Significant bird breeding event is defined as a high percentage of common species population or any wetland-dependant VRoT species where water management can realistically target. Refer to Figure 12.
Natural flood pulse between 15,000 to 20,000 ML/d occurring within August to November.	Maintain flooding between 15,000 to 20,000 ML/d for up to 4 months by building on river flows up to 20,000 ML/d (MDBA imposed temporary release limit) by release up to 8,000 ML/d, ensuring flooding does not exceed December (and contingent upon NPWS & PV prior works completion).	Moira Grass & Red Gum Forest. Refer to Figure 13.
Multi-Site Watering Trial initiates (trigger yet to be agreed by other Icon Sites in conjunction with BMF Icon Site).	Variable release rates and duration depending upon downstream Icon Site demands associated with the MSWT (although higher flows will be restricted largely between August to November).	Assist Multi-Site Watering Trial bypass Barmah Choke and attain Barmah Forest watering targets. Refer to Figure 14.
10,400 to 15,000 ML/d river flow between January to May.	Enact unseasonal flow management agreement* with Millewa Forest whose turn it is to take all unseasonal flows between 10,400 ML/d and 15,000ML/d in 2013/14 year. Flows exceeding 15,000 ML/d will need to be diverted into Barmah Forest, but will preferentially be via regulators in Water Management Area G (i.e., those that avoid Moira Grass plains in WMA C, G & H1; refer to Figure 5)..	Maintain Moira Grass plains in seasonal dry phase (January to May) in Barmah Forest. Refer to Figure 15.

* = An arrangement exists for Barmah Forest and Millewa Forest to alternate, on an annual basis, the management of all unseasonal flows solely on Vic or NSW side of the river in attempt to permit the other side achieve a satisfactory dry regime on their Moira Grass plains (i.e., rather than share any unseasonal flooding that would result in both forests' Moira Grass plains having their natural drying cycle broken by very shallow flooding, then the arrangement allows for deeper flooding on some Moira Grass plains to permit others to remain dry in recognition that the following year reciprocal management occurs). The 20013/14 year is Millewa Forest turn to accept the unseasonal flows.

9. Implementation arrangements

9.1 Notice and time required

Environmental water delivery is usually undertaken via a stakeholder teleconference, the Barmah-Millewa Operational Advisory Group (BM OAG), which remains in operation during the period of environmental water delivery to the forest. The BM OAG is a multi-agency committee of managers and practitioners who contribute to timely decision making processes concerning water management requirements in Barmah-Millewa Forest. Participants of the BM OAG include agency environmental water holders (CEWH, VEWH, MDBA), water delivery (G-MW, NSW Office of Water, RMW), on-ground ecological monitoring and/or strategic planning (GB CMA, Murray CMA, NSW NPWS, MDFRC, DSE/ARI) and land management (NSW NPWS, PV, YYNAC), including roles of representative groups often being multi-purpose. BM OAG teleconferences are chaired by the MDBA and only convened during times where active water management considerations are required for Barmah-Millewa Forest (especially when EWA releases are being made) (GB CMA 2012).

The BM OAG is an example where active partnerships between relevant authorities can rapidly co-manage active water management events, under direction of water management operating plans previously considered by exiting TLM structures. Weekly teleconferences permit ready participation where ecological advice and on-ground reports can be incorporated into timely consideration for management of environmental flows and hence embrace active adaptive management outcomes..

River Operations staff from RMW participate in these teleconferences, and often modifications to water releases can been achieved within the day. However, normally a notice period of one to two days minimum and preferably four days is required for environmental water orders from Murray system storages. If constraints in making environmental water available are foreseen by RMW, the Environmental Water Manager will be advised accordingly. Releases from Hume Reservoir take approximately 7 days to reach the first of the Barmah Forest regulators (including the 3.5 days transmission time for releases from Yarrawonga Weir (Lake Mulwala) to reach the forest). However this can be influenced by existing conditions in the river channel and seasonal conditions. Inflows to Yarrawonga Weir from the Ovens River also serve as an important additional source of water.

9.2 Costs

The Environmental Water Manager does not have to make any payment for headwork's costs relating to the environmental entitlements or the Murray water entitlements. If chargeable, these costs are met by the entitlement holders. There are no water delivery costs to supply Barmah Forest given supply is via the natural river system and gravity diverted into the forest.

10. Risk assessment and management

10.1 Determining Risk

Risk assessments have been prepared for each season in 2013/14. The scenario used is based on a spring environmental water allocation release. Table shows the flow components applied in the scenario, while Table 8 and Table 6 show the level of risk for each flow component per season against the risk categories and types.

The Barmah Forest watering strategy for 2013/14 scores a low to medium level of risk, depending on the type of risk being considered. This is a result of a relatively conservative approach to the use of environmental water to meet ecological targets, while remaining within channel capacity constraints downstream of Yarrawonga imposed by MDBA.

Table 7: Barmah-Millewa Forest watering proposal risk assessment – flow components.

	Year	2013/14
	Generic flow component	**Components identified in proposal**
Winter	Cease-to-flow	**0**
	Low flow	**0**
	Fresh	**1**
	High flow	**1**
	Bankfull flows	**1**
	Overbank flow	**1**
Spring	Cease-to-flow	**0**
	Low flow	**0**
	Fresh	**1**
	High flow	**1**
	Bankfull flows	**1**
	Overbank flow	**1**
Summer	Cease-to-flow	**0**
	Low flow	**0**
	Fresh	**1**
	High flow	**0**
	Bankfull flows	**0**
	Overbank flow	**0**
Autumn	Cease-to-flow	**0**
	Low flow	**0**
	Fresh	**1**
	High flow	**0**
	Bankfull flows	**0**
	Overbank flow	**0**

Text	Value
No	0
Yes	1

Table 8: Barmah-Millewa Forest watering proposal risk assessment (winter and spring 2013).

Note: shaded columns indicate 2013/14 watering strategy. High flows are considered to be bank-full flows for Barmah Forest

Risk Category	Risk #	Risk Type	Winter						Spring					
			Cease-to-flow	Low flow	Fresh	High flow	Bankfull flows	Overbank flow	Cease-to-flow	Low flow	Fresh	High flow	Bankfull flows	Overbank flow
Quality issues lead to no achievement of objectives	1.0	Release volume is insufficient in meeting required flow at target point	Low	Low	Low	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium
	1.1	Current recommendations on environmental flow inaccurate	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	1.2	Storage Operator maintenance works affect ability to deliver water	Low	Low	Low	Low	Low	Low	Low	Low	Low	low	Low	Low
	1.3	Resource Manager cannot deliver required volume or flow rate (outlet/capacity constraints, insufficient storage volume)	low	low	low	low	low	low	low	low	Medium	Medium	Medium	Medium
Time	2.0	Limited CMA resource to deliver environmental release	low	low	low	low	low	low	low	low	low	low	low	low
Cost	3.0	Cost of delivery exceeds available funding	low	low	low	low	low	low	low	low	low	low	low	low
Human	4.0	Environmental release cause personal injury to river user	low	low	low	low	low	low	low	low	low	low	low	low
Environmental	5.1	Releases cause water quality issues (eg blackwater, low DO, mobilisation of saline pools, acid-sulphate soils)	low	low	low	low	low	low	Low	low	Low	Low	low	Low
	5.2	Improved conditions for non-native species (eg carp)	low	low	low	low	low	low	Low	Low	Medium	Low	Low	Medium
Compliance	6.0	Environmental water account is overdrawn	low	low	low	low	low	low	low	low	Low	Low	Low	Medium
	6.1	Environmental releases causes flooding of private land	low	low	low	low	low	low	low	low	low	low	low	Medium
	6.2	Environmental release cause flooding to public infrastructure	low	low	low	low	low	low	low	low	low	low	low	low
	6.3	Environmental releases causes flooding of Crown land	low	low	low	low	low	low	low	low	low	low	low	Medium
Reputation	7.0	Unable to provide evidence in meeting ecological objective	High	High	High	High	High	High	High	High	High	High	High	High
	7.1	Key stakeholders not supportive of environmental water release	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low

Table 6: Barmah-Millewa Forest watering proposal risk assessment (summer and autumn 2014).

Note: shaded columns indicate 2013/14 watering strategy

Risk Category	Risk #	Risk Type	Summer						Autumn					
			Cease-to-flow	Low flow	Fresh	High flow	Bankfull flows	Overbank flow	Cease-to-flow	Low flow	Fresh	High flow	Bankfull flows	Overbank flow
Quality issues lead to no achievement of objectives	1.0	Release volume is insufficient in meeting required flow at target point	low	low	Medium	low	low	low	low	low	Medium	low	low	low
	1.1	Current recommendations on environmental flow inaccurate	Low	Low	Low	Low	low	Low	Low	Low	Low	Low	low	Low
	1.2	Storage Operator maintenance works affect ability to deliver water	low	low	low	low	low	low	low	low	low	low	low	low
	1.3	Resource Manager cannot deliver required volume or flow rate (outlet/capacity constraints, insufficient storage volume)	low	low	low	low	low	low	low	low	low	low	low	low
Time	2.0	Limited CMA resource to deliver environmental release	low	low	low	low	low	low	low	low	low	low	low	low
Cost	3.0	Cost of delivery exceeds available funding	low	low	low	low	low	low	low	low	low	low	low	low
Human	4.0	Environmental release cause personal injury to river user	low	low	low	low	low	low	low	low	low	low	low	low
Environmental	5.1	Releases cause water quality issues (eg blackwater, low DO, mobilisation of saline pools, acid-sulphate soils)	Low	Low	Low	Low	low	Low	Low	Low	Low	Low	low	Low
	5.2	Improved conditions for non-native species (eg carp)	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low	Low
Compliance	6.0	Environmental water account is overdrawn	low	low	low	low	low	low	low	low	low	low	low	low
	6.1	Environmental releases causes flooding of private land	low	low	low	low	low	low	low	low	low	low	low	low
	6.2	Environmental release cause flooding to public infrastructure	low	low	low	low	low	low	low	low	low	low	low	low
	6.3	Environmental releases causes flooding of Crown land	low	low	low	low	low	low	low	low	low	low	low	low
Reputation	7.0	Unable to provide evidence in meeting ecological objective	High	High	High	High	High	High	High	High	High	High	High	High
	7.1	Key stakeholders not supportive of environmental water release	low	low	low	low	low	low	low	low	low	low	low	low

10.2 Risk mitigation strategies

Risk mitigation strategies are required for medium or high risks. As some medium and high risks exist for the 2013/14 Barmah Forest watering strategy, mitigation measures are outlined below (Table 7).

Table 7: Watering proposal risk mitigation strategies for 2013/14

Season	Risk Type	Risk Score	Risk Mitigation
Winter	1.0 Release volume is insufficient in meeting required flow at target point	Medium	The risk of having insufficient water to achieve the target is considered a possibility depending upon the target and the timing of trigger occurring. However, water resource availability is to be secured prior to actioning water release if a trigger is met to ensure adequate water reserve exists to achieve the target in the event that no further natural inflows occur. Potential use of Multi-Site Watering Trial, TLM and CEWH water holdings ought to be sufficient for the various watering scenarios proposed for 2013/14.
	7.0 Unable to provide evidence in meeting ecological objective	High	Budget cuts to Condition and Intervention monitoring in 2013/14 will cause most, if not all, monitoring programs to cease, resulting in no data to support the attainment of environmental targets. Anecdotal observations of vegetation response and waterbird use are intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.
Spring	1.0 Release volume is insufficient in meeting required flow at target point	Medium	The risk of having insufficient water to achieve the target is considered a possibility depending upon the target and the timing of trigger occurring. However, water resource availability is to be secured prior to actioning water release if a trigger is met to ensure adequate water reserve exists to achieve the target in the event that no further natural inflows occur. Potential use of Multi-Site Watering Trial, TLM and CEWH water holdings ought to be sufficient for the various watering scenarios proposed for 2013/14.
	1.3 Resource Manager cannot deliver required volume or flow rate (outlet/capacity constraints, insufficient storage volume)	Medium	Environmental water is planned to be used to primarily fill in gaps between natural flood events. Available volumes of environmental water are considered and continuously reviewed along with weather forecasts when implementing a particular scenario and determining the likely success. Consequence of specific volume and duration of water is lower for the vegetation target because a periodic drop in desired water level ought not to unduly cause disruption to life cycle (assuming that at least some water depth remains), but has greater consequence for waterbird nesting outcomes as the result could be abandonment of chicks if water levels prematurely recede.
	5.2 Improved conditions for non-native species (e.g. carp)	Medium	Flooding of wetlands in spring coincides with most breeding strategies for native flora and fauna, and can reduce pest plant invasion, and hence is of advantage. However, Carp have the ability to breed over a broader range of season and water temperatures than many native fish species that only breed in spring/early summer. Proposed flood strategies in spring are to create a pulse in the river if stable in-channel flows occur, which is aimed to benefit native Perch species, or otherwise re-fresh in-forest refuge pools at low level to benefit all fish but avoid low-flooding of grass plains where carp are known to benefit. The high flow strategy proposed for spring is to maintain high flows if they naturally occur, which are expected to benefit all fish species (recognising that there exist some native low-flow specialists). .
	6.0 Environmental water account is overdrawn	Medium	The Barmah-Millewa Operations Advisory Group will be active for the duration of any environmental watering event, enabling agencies to continuously monitor environmental water availability versus the forecast requirements and relate this to the watering strategy objectives. Overdraw of environmental water accounts are therefore expected to be minimised.
	6.1 Environmental releases causes flooding of private land	Medium	Proposed watering actions take heed of a recent MDBA restriction on release rates downstream of Yarrawonga by conforming to the limit of 20,000 ML/d to avoid flooding private land in the Bullatale Creek system in NSW until further studies define the actual flow level responsible for flooding the private floodplain areas. Although a buffer exists within this imposed limit, a large rainfall event could occur during the period of managed water release to have the potential to exceed the overall flow limit downstream of Yarrawonga. Mitigation measure

			will be via close communication with River Murray Water within the Barmah-Millewa Advisory Group and directly as required to ensure river management and rainfall forecasts are considered for potential rapid reduction or cessation to the managed releases.
	6.3 Environmental releases causes flooding of Crown land	Medium	The higher flow releases proposed for spring to achieve Objectives 5 & 6 are likely to cause inflow into three wetlands on Crown land between Yarrawonga and Tocumwal (Quinns Island wetland and Horseshoe Lagoon at Cobram each have a CTF of ~17,000 ML/d, while Wetland 9 near the Newell Hwy south of Tocumwal has a CTF of 18,200 ML/d). Flooding of these wetlands in spring is of benefit, and hence the consequence of their flooding is positive. No other Crown land is expected to be inundated at the proposed releases.
	7.0 Unable to provide evidence in meeting ecological objective	High	Budget cuts to Condition and Intervention monitoring in 2013/14 will cause most, if not all, monitoring programs to cease, resulting in no data to support the attainment of environmental targets. Anecdotal observations of vegetation response and waterbird use are intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.
Summer	1.0 Release volume is insufficient in meeting required flow at target point	Medium	The risk of having a summer fresh or rain-rejection event occurring is high, but this is mitigated to medium or even low via the intended implementation of the "unseasonal flood arrangement" with NSW where Millewa Forest will accept flows in excess of 10,400 to 15,000 ML/d river flows. No environmental water is required. If flows exceed 15,000 Ml/d in summer, then the excess will need to be diverted into Barmah Forest preferentially via regulators in Water Management Area G (i.e., those that avoid Moira Grass plains in WMA C, G & H1; refer to Figure 5).
	5.2 Improved conditions for non-native species (e.g. carp)	Medium	Flooding of wetlands in summer is not desirable for a range of ecological reasons and hence will be avoided where possible. Most native fish have passed their breeding season while Carp continue to have the ability to breed well into summer. Proposed flood strategies in summer are to implement a drying regime on the floodplain or restrict flooding to colonial waterbird breeding locations, and hence Carp breeding will be discouraged through drying preferred spawning habitat. .
	7.0 Unable to provide evidence in meeting ecological objective	High	Budget cuts to Condition and Intervention monitoring in 2013/14 will cause most, if not all, monitoring programs to cease, resulting in no data to support the attainment of environmental targets. Anecdotal observations of vegetation response and waterbird use are intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.
Autumn	1.0 Release volume is insufficient in meeting required flow at target point	Medium	The risk of having an autumn fresh or rain-rejection event occurring is high, but this is mitigated to medium or even low via the intended implementation of the "unseasonal flood arrangement" with NSW where Millewa Forest will accept flows in excess of 10,400 to 15,000 ML/d river flows. No environmental water is required. If flows exceed 15,000 Ml/d in autumn, then the excess will need to be diverted into Barmah Forest preferentially via regulators in Water Management Area G (i.e., those that avoid Moira Grass plains in WMA C, G & H1; refer to Figure 5).
	5.2 Improved conditions for non-native species (e.g. carp)	Medium	Flooding of wetlands in autumn is not desirable for a range of ecological reasons and hence will be avoided where possible. The intended dry regime of the floodplain is anticipated to benefit native vegetation over exotic species, and will not provide spawning habitat to exotic fish (which most have passed their breeding period by autumn anyway). Feral pig and fox activity can increase on drawdown and dry out of floodplains, but these remain subject of pest control program by Parks Victoria as the land manager. .
	7.0 Unable to provide evidence in meeting ecological objective	High	Budget cuts to Condition and Intervention monitoring in 2013/14 will cause most, if not all, monitoring programs to cease, resulting in no data to support the attainment of environmental targets. Anecdotal observations of vegetation response and waterbird use are intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at

			that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.

11 Monitoring and reporting

11.1 Current monitoring programs

The following tables (Table 8 & Table 9) outline the monitoring projects being undertaken in 2012/13, their funding source and their related ecological targets.

Table 8: The Living Murray funded monitoring projects conducted in Barmah-Millewa Forest during 2012/13.

Project	Lead Agency	Ecological Target
Understorey vegetation monitoring	NSW NPWS (undertaken by a consultant)	Vegetation – provides ongoing data to assess the species diversity, % cover and flowering at sentinel sites in wetland and adjacent forest
Stand condition	NSW NPWS	Vegetation – provides ongoing data to assess the health and change over time of overstorey vegetation
Waterbirds	NSW NPWS	Colonial waterbirds – provides ongoing data to assess species diversity and populations and change over time
Terrestrial birds	NSW NPWS	Terrestrial birds - provides ongoing data to assess species diversity and populations and change over time and is a reflection of vegetation health
Fish condition – drift	DSE - Arthur Rylah Institute (ARI)	Fish – provides ongoing data to assess spawning and recruitment, measures change over time and comparison between flow conditions
Fish condition – wetlands	DSE - ARI	Fish – provides ongoing data to assess spawning and recruitment, measures change over time and comparison between flow conditions
Fish condition – river	DSE - ARI	Fish – provides ongoing data to assess spawning and recruitment, measures change over time and comparison between flow conditions
Water quality	NSW NPWS	Various – relates to multiple ecological objectives, particularly aquatic fauna
*Flood compliance monitoring	NSW NPWS & GB CMA (intervention monitoring)	Various – provides information on vegetation and waterbirds in particular, as well as water related data (observations including depth, flow, areas inundated etc as well as spot water quality measurements)
*Remote camera (DSE / GB CMA)	GB CMA (intervention monitoring)	Various –provides visual observation of waterbird breeding in addition to vegetation and water levels at selected sites where the cameras have been installed (which are remote and inaccessible sites)
**Turtle monitoring	ARI & Yorta Yorta Nations Aboriginal Corporation (YYNAC)	Turtles – GPS tracking providing information on movements and potential nesting locations.

* Projects funded under '2012/13 Intervention Monitoring' funding.
** Project funded under '2012/13 Indigenous Partnership' funding.

Table 9: Non TLM funded monitoring projects conducted in Barmah-Millewa Forest during 2012/13.

Non-TLM funded	Lead Agency	Ecological Target
Giant Rush/Moira Grass	CSIRO - Water for a Healthy Country project	Vegetation – investigating the interaction between Giant Rush and Moira Grass on the declining Moira Grass plains.
Understorey vegetation monitoring (biomass)	Parks Victoria	Vegetation – measurements of ground cover biomass at sentinel sites
White-bellied Sea-eagle	Parks Victoria	Waterbirds – collation of field reports of nest location, recruitment and persistence of this indicator species
Aerial waterbird survey (coordinated with annual eastern Australian waterbird survey	NSW Office of Environment and Heritage	Waterbirds – annual survey collecting waterbird population and location data
Fish otolith identification (from middens)	YYNAC & Charles Sturt University	Fish – investigating species and age of fish traditionally used by the Yorta Yorta people
Sustainability Audit – indigenous use of plants	YYNAC	Vegetation – investigating the plant species utilised by traditional owners, including species location and populations
Hydrograph recorders	MDBA / RMW / contractor	Flooding

11.2 Monitoring 2013-2014 environmental flow outcomes

Unfortunately, all Condition and Intervention monitoring projects are likely cease at the end of 2012/13 due to expected TLM funding withdrawal for monitoring in 2013/14. The consequence of this will be result in no data being collected to determine whether environmental targets have been attained, in addition to reducing the strength of otherwise developing long-term datasets that are rare yet highly valuable commodity.

Anecdotal observations of vegetation response and waterbird use are therefore intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.

Encouragement will also be given to existing non-TLM funded monitoring programs to continue, in addition to seeking new opportunities.

11.3 Reporting

Various established reporting channels exist for activities related to Barmah Forest, including;

- Icon Site Manager milestone reports provided to the Department of Sustainability and Environment, which in turn contribute to reporting to the Living Murray Environmental Watering Group.
- Event related weekly teleconferences facilitated by the MDBA in relation to environmental watering events (Barmah-Millewa Operations Advisory Group) and blackwater events if they should occur (basin or event scale).
- Reporting to Barmah-Millewa icon site committees, including the B-M Integrated Coordinating Committee, B-M Technical Advisory Committee, B-M Consultation Reference Group and B-M Indigenous Reference Group (currently the B-M Indigenous Partnership Project).
- Updates to the Barmah Forest page on GB CMA website, including latest remote camera images.
- Completion of the Barmah-Millewa Annual Report.
- Planning for a third Barmah-Millewa Research and Monitoring Conference to share findings with NRM managers related to Barmah-Millewa Forest was planned for 2013/14, although may no longer be possible if no new research or monitoring work is to be undertaken in 2013/14..

12. Knowledge gaps and limitations

The following are items where our knowledge can be improved for Barmah-Millewa Forest through specific or long-term monitoring programs:

- Bird movements - particularly for colonial nesting species. This includes migration (when and where) and what cues stimulate nesting in Barmah-Millewa Forest. Could include experiment on habitat modification within a reed-bed site to determine nesting selection preference (based on theory that the nesting colony nucleus may commence near open water in dense reed-beds that are surrounded by water or have some distance of reed-beds between the nesting site and the edge of the wetland. The ramifications are potential habitat modification to improve nesting suitability and water management efficiency).
- Fish movements – cues responsible for accessing the main river, creeks and wetlands, breeding, migration and movement response to water quality.
- Frogs – species, numbers, breeding locations and cues, and recruitment outcomes.
- Murray Crayfish –population, movement and the impacts of blackwater events.
- Turtle movements – continue GPS transmitter tracking of a sample of turtles of all three species to determine movements in relation to water management and nesting locations (which also has ramifications for pest animal control programs).
- Macro invertebrates – very little is known of their significance or water requirements in Barmah-Millewa Forest.
- Carbon cycling.
- Erosion and sedimentation rates (main river channel and other waterways). Particular value would be obtained from re-surveying existing erosion monitoring transect sites in Barmah Forest that have previously survey data from 1998, 1999, 2002 and 2006.
- Water quality monitoring – maintain basic water quality monitoring to herald any issues before severe impact occurs.
- Rare or threatened species – undertake targeted surveys to determine location for potential water management.

However, expected budget cuts in 2013/14 will cease current monitoring programs, and hence their continuation could now also be seen as future knowledge gap and limitation to target management and reporting.

13. Stakeholder engagement

There are two key audiences for communications under the proposal. The primary audience is the agencies involved in delivering the proposed flow management and include River Murray Water / MDBA, the Victorian Environmental Water Holder and the Commonwealth Environmental Water Holder.

River Murray Water is the key flow delivery agency for watering in the Murray River. When the final proposal for 2013/14 is agreed, communications with River Murray Water are aimed at making clear what the intended environmental flow release plans are and their intended purpose. Then, throughout the season, there will be regular communications, primarily via the established Operating Committee teleconferences to understand unregulated flows, River Murray Water planned consumptive use releases, and to organise environmental flow releases.

The Victorian Environmental Water Holder will use the proposal as the basis (in whole or part) in developing the Seasonal Watering Plan. Water allocated is to be delivered in accordance with the plan and the plan is used to seek agreement from other water holders for the use of their water. Routine communication (phone, email) will report on deployment of water under the plan, and seek to modify release plans to align with downstream site needs as the year unfolds.

Commonwealth Environmental Water Holder may have allocated water to the Seasonal Watering Plan which is based on this proposal, and are responsible for achieving further benefits from the water at downstream environmental sites. Routine communication will be via the Victorian Environmental Water Holder.

The secondary audience is those potentially affected by or interested in environmental flows and/or the health of the river environment. This includes NSW National Parks & Wildlife Service, Parks Victoria, Yorta Yorta Nation Aboriginal Corporation and Department of Sustainability and Environment (public land managers), water users along the river (Goulburn-Murray Water diversion licence holders), campers and recreation users, local government, environment groups and the general public. As the effect of the proposal on these groups is expected to be minimal, the communication objective is to provide information about the decision to provide environmental flows and what it is trying to achieve. A secondary objective is to build a public understanding of the reasons for specific water management activities. These communications will be through media articles, information to the Barmah Heritage Centre and potentially talks directly with special interest groups.

Table 10 outlines the consultation process the Goulburn Broken Catchment Management Authority has undertaken during the development of this seasonal water proposal and the consultation process that will be implemented following its assessment.

Table 10: Stakeholder consultation.

Stakeholder	Purpose	Engagement type	Method	Timing
Proposal development				
Yorta Yorta Nation Aboriginal Corporation	Seek information on Yorta Yorta environmental aspirations and plan water strategies	Involve/consult	Personal discussion with key staff (TLM Indigenous Facilitation Officer)	Throughout 2013/14
NSW National Parks & Wildlife Service	Seek information on NPWS environmental aspirations, on-ground constraints and plan water strategies	Involve/consult	Personal discussion with key staff (Manager Adaptive Management Unit and Regional Ecologist)	Throughout 2013/14
Parks Victoria	Seek information on PV environmental aspirations, on-ground constraints and plan water strategies	Involve/consult	Personal discussion with key staff (Regional Ecologist, Ranger-in-Charge, local project officers)	Throughout 2013/14
River Murray Water	Seek information on water system outlooks and river management, and feasibility of proposal	Consult	Personal discussion with key staff (River Operations Group) via Operations Committee and other planning meetings	Periodic as required throughout 2013/14
DSE	Advise of seasonal plans in accordance with Environmental Water	Consult	Icon Site Manager's reports and personal discussion with key staff	Monthly

Stakeholder	Purpose	Engagement type	Method	Timing
	Management Plan		(Office of Water)	
VEWH	Seek information on water availability in relation to other state priorities, and feasibility of proposal	Consult	Personal discussion with key staff and special planning meetings as required.	Periodic as required throughout 2013/14
CEWH	Seek information on water availability in relation to other state priorities, and feasibility of proposal	Consult	Involvement with VEWH during special planning meetings as required.	Periodic as required throughout 2013/14
TLM (MDBA)	Advise of seasonal plans and monitoring activities in accordance with Environmental Water Management Plan	Consult	Icon Site Manager's reports and personal discussion with key staff (TLM program)	Periodic as required throughout 2013/14
TLM committees	Seek information on each agency's environmental aspirations and plan water strategies	Involve/consult	Formal ICC, CRG, IPP and TAC meetings	Periodic as required throughout 2013/14 (generally 3-4 times per year)
CMA Board	Approval of the proposal	Approve	Board Meeting Paper/Presentation	26 April 2013
Proposal implementation				
Yorta Yorta Nation Aboriginal Corporation	To keep updated on progress and outcomes, and explore requirement for strategy re-adjustment	Involve/consult	Personal discussion with key staff (TLM Indigenous Facilitation Officer)	Throughout 2013/14
NSW National Parks & Wildlife Service	To keep updated on progress and outcomes, and explore requirement for strategy re-adjustment	Involve/consult	Personal discussion with key staff (Manager Adaptive Management Unit and Regional Ecologist)	Throughout 2013/14
Parks Victoria	To keep updated on progress and outcomes, and explore requirement for strategy re-adjustment	Involve/consult	Personal discussion with key staff (Regional Ecologist, Ranger-in-Charge, local project officers)	Throughout 2013/14
River Murray Water	Seek information on water system outlooks and river management, and potential re-adjustment of proposal	Consult	Personal discussion with key staff (River Operations Group) via Operations Committee and other planning meetings	As required throughout 2013/14
DSE	To keep updated on progress and outcomes	Consult	Icon Site Manager's reports and personal discussion with key staff (Office of Water)	Monthly
VEWH	To keep updated on progress and outcomes	Consult	Personal discussion with key staff and special planning meetings as required.	Periodic as required throughout 2013/14
CEWH	To keep updated on progress and outcomes	Consult	Involvement with VEWH during special planning meetings as required.	Periodic as required throughout 2013/14
TLM (MDBA)	To keep updated on progress and outcomes	Consult	Icon Site Manager's reports and personal discussion with key staff (TLM program)	Periodic as required throughout 2013/14
CMA Board	To keep updated on progress and outcomes	Consult	Inclusion of update in Board papers	Monthly
Public	To keep updated on progress and outcomes and need for water management interventions	Inform	Media releases, website, Barmah Heritage Centre, presentations to special interest groups	Periodic as required throughout 2013/14

14. Communications

Communication activities for the Barmah-Millewa icon site are currently guided by the *Barmah-Millewa Icon Site Engagement Strategy 2012/13*, which outlines communication and consultation activities, stakeholders and target audiences, communication tools as well as preferred key messages. The engagement strategy is primarily managed by the Barmah-Millewa Consultation Reference Group, an advisory group under the Barmah-Millewa Integrated Coordinating Committee.

Specific issues can arise that benefit from communication through the media to inform the public of events associated with the Barmah-Millewa Forest. A selection of issues that generate strong media interest in the Barmah-Millewa forest include;

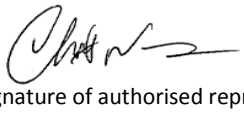
- Flooding (natural), particularly resulting in colonial waterbird breeding events and/or the inundation of surrounding/upstream private land,
- The use of environmental water on the floodplain and associated ecological objectives,
- The end of an environmental water delivery to support a colonial waterbird breeding event (particularly where the potential exists for end of colony nest abandonment, such as 2010/11 with continuous and repeated nesting behaviour),
- Blackwater events, particularly with fish deaths and crayfish emerging at the edge of waterways,
- Understorey vegetation growth (often related to perceived fire risk and/or the historical practice of grazing cattle),
- The ecological thinning of River Red Gums (often associated with the historical practice of commercial timber harvesting).

The Barmah-Millewa Operations Advisory Group (see Section 7) provides an ideal opportunity for stakeholders to be made aware of current issues in a timely manner during environmental watering events and liaise about communication activities to ensure a coordinated approach. Communications and media protocols exist for the VEWH and TLM and will be applied as required.

15. Approval and endorsement

I, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Barmah Forest system 2013-14.

SIGNED FOR AND ON BEHALF OF Goulburn Broken Catchment Management Authority



Signature of authorised representative

CHRIS NORMAN
Name of authorised representative

Date: 30 April 2013

ENDORSEMENT

We, the authorised representatives of the agencies shown below, endorse the Seasonal Watering Proposal for the Barmah Forest system 2013-14.

SIGNED FOR AND ON BEHALF OF storage operator

Signature of authorised representative

Name of authorised representative

Date:

SIGNED FOR AND ON BEHALF OF land manager

Signature of authorised representative

Name of authorised representative

Date:

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Appendix 1: Summary template

System name	Barmah Forest

Waterway manager	Goulburn Broken CMA
Storage operator/s	River Murray Water (MDBA)
Land manager/s	Parks Victoria and Yorta Yorta Nations Aboriginal Corporation

System summary
Barmah Forest is part of the Barmah-Millewa Icon Site located on the mid-Murray floodplain. The site is a National Park with Ramsar status, and forms part of the largest River Red Gum reserve in Australia (and therefore the world). Approximately 85% of Barmah Forest is active floodplain, depending on frequent flood flows from the Murray River for sustaining the wetland flora, fauna and function. The site is also recognized habitat for a range of threatened flora and fauna species, many of which are wetland dependent (such as Wavy Marshwort, Murray Cod, Broad-shelled Turtle, Great Egret, Intermediate Egret, Little Egret, Royal Spoonbill, Australasian Bittern, Little Bittern and Brolga). River regulation has altered the natural flow regime, and a decrease in floodplain inundation return frequency, depth and duration now exist along with a corresponding decrease in the extent of healthy native vegetation and populations of breeding waterbirds and fish.

Summary of planned environmental water use in 2013-14
The long-term ecological objectives of promoting native fish, bird and vegetation values, as outlined in the Barmah-Millewa Water Management Strategy (MDBA 2012a), are the focus for the intended re-introduction of strong seasonal flooding in winter-spring as core to the 2013/14 Barmah Forest watering proposal. A nested design of watering priorities, based on water resource availability and flow triggers, is proposed. Involvement with a broader Murray River Multi-Site Watering Trial is also given. A summer-autumn dry period will then be facilitated by enacting the "unseasonal watering sharing agreement" with NSW where rain-rejection events will be managed through Millewa Forest in 2013/14. *The nested flow proposals are 1) River fish – providing a pulse flow of up to 1,500 ML/d for two weeks if river levels have otherwise been stable during November, ensuring bankfull capacity is not exceeded; 2) Creek drought refuge – providing drought refuge in forest waterways by proving top-up flows of 500 ML/d for a minimum of 2 weeks in the event that no other in-flows have occurred prior to November 2013; 3) Boals Waterbirds – maintaining bird breeding in Boals Deadwoods wetland at 100 ML/d for up to 3.5 months; 4) Other Waterbirds – providing flows if threatened waterbird species or significant numbers of common waterbird species breed elsewhere in the forest; 5) Moira Grass and Red Gum – Maintaining 15,000 to 20,000 ML/d flow downstream of Yarrawonga for up to 4 months to bridge natural flood peaks.*

System overview

Barmah Forest forms approximately one half of the Barmah-Millewa Forest Icon Site which covers 66,600 ha and straddles the Murray and Edwards Rivers between the townships of Tocumwal, Deniliquin and Echuca (Figure 1).

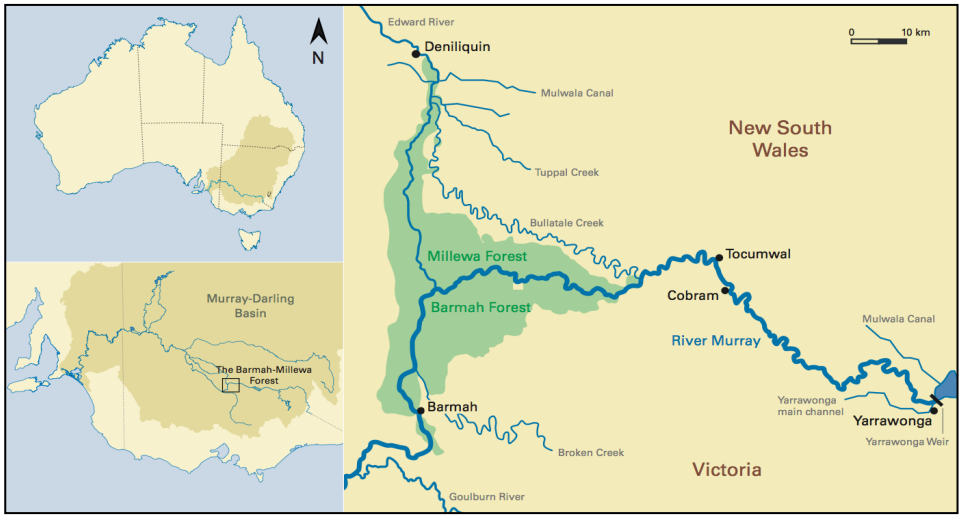


Figure 6: Location of the Barmah-Millewa Icon Site (modified from MDBA)

Hume and Dartmouth Reservoirs are located in the upper catchment to Barmah Forest. This has caused Barmah Forest, being located in the semi-arid mid-Murray River system where inflows are usually greatest in winter/spring and lowest in summer/autumn, to have its flow regime altered by river regulation where winter and spring flows are now largely stored for release in later spring through to autumn (Figure 2).

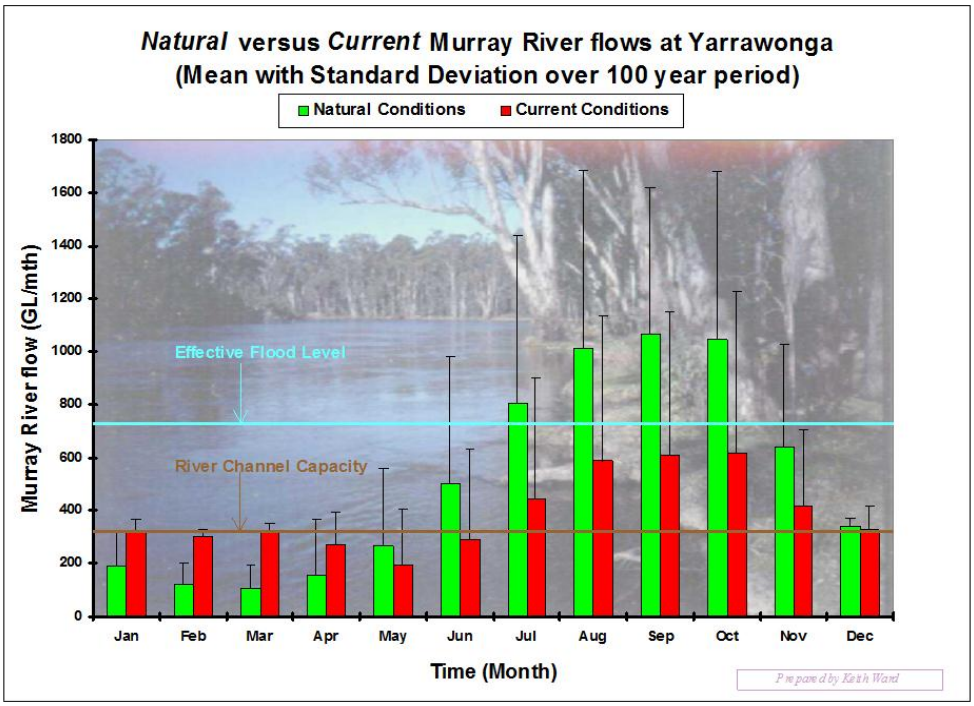


Figure 2: Natural and current monthly Murray River flow release from downstream Yarrawonga Weir.

The Murray River between Hume Reservoir to Yarrawonga (Reach 1), and Yarrawonga to Barmah Forest (Reach 2), contains intrinsic in-stream habitat values and relatively high terraced floodplain wetlands. Only once flows reach the Barmah-Millewa floodplain does widespread flooding and relatively low flow thresholds commence to occur, and it is here that the region's greatest environmental values occur. For Reach 1, channel capacity is deemed to be 25,000 ML/d, whereas for Reach 2, channel capacity is 10,400ML/d. However, flows exceeding channel capacity in Reach 1 increasingly commence to affect private land, whereas exceeding channel capacity in Reach 2 only influences the targeted floodplain and other crown floodplain until approximately 20,000 ML/d [which is a recently imposed limit by MDBA until an issue of flows affecting private land in NSW is determined. The actual flow is expected to be higher].

As with previous EWA releases to the Barmah-Millewa Forest, the 2013/14 event will be gravity diverted from the Murray River into the forest at approximate rates through waterway regulating structures as guided by specific rating curves that exist for those structures, and will be periodically check by flow measurement by a qualified contractor. River Murray Water will also undertake mass balance of river flow between their existing gauged stations upstream and downstream of the forest. The aim of the releases will be to fill in missing components of the natural hydrograph where an environmental imperative is known to exist. Watering priorities for native fish, birds, vegetation and turtles have been identified, along with triggers upon which to release the water.

Current situation

The Millenium Drought between 2001 and 2009 had caused severe drought conditions in Barmah Forest, particularly between 2006 to 2009 where permanent water courses in the forest dried for the first time in 105 years of recorded history. A return of extensive flooding in 2010 to 2012 has therefore be of welcome relief to many wetland flora and fauna species, however for some, such as Moira Grass, the flooding may have come too late and then persisted for too long. A return to dry conditions between October 2012 to current (April 2013) has been welcome after 2.5 years of near continuous flooding for the low laying wetlands.

Watering actions last financial year achieved successful outcome for colonial waterbirds in a confined wetland whilst encouraging a drying regime in most other wetlands of the forest to predominantly cater for Moira Grass. However, numbers of nesting waterbirds have continued to decline in most of the past 50 years, and recent mapping of the extent of Moira Grass by CSIRO shows that the species currently only occupies 4% of its former distribution in the forest compared to 80 years ago. Furthermore, fisheries surveys are no longer finding Spiny Crayfish for a considerable distance in the Murray River downstream of Barmah Lake following a severe Blackwater event in 2010 (caused by a large summer storm event that inundated and flushed accumulated organic material off a drought affected floodplain resulting in anoxic water conditions unsuitable for fish and crayfish to breathe).

On a positive side, the strong prolonged flooding of the past three years has reversed some encroachment of species such as Giant Rush and River Red Gum onto the Moira Grass Plains and from areas of open water, especially Barmah Lake.

Environmental objectives

Re-flooding in winter/spring 2013 after the recent summer/autumn dry period would be reflective of the main natural flood regime, and hence is expected to be of greatest benefit to the native floodplain flora and fauna. The use of environmental water, triggered by a variety of natural hydrological and biological cues, is therefore proposed in winter/spring 2013 to nurse specific elements of the ecosystem back to health. A strong drying regime in the ensuing summer/autumn is then to be attempted, akin to the natural hydrological regime for that period of the year. Native fish, birds, vegetation and turtles will be the target of water management depending upon EWA reserves and natural cues..

Priority watering actions

The water management priorities for Barmah Forest in 2013/14 are largely nested depending upon antecedent river flows, available environmental water, environmental response, potential links with downstream EWA demand, and channel capacity constraints (Figure 3). This means, for example, that attaining a Creek flow target could potentially also may incorporate the river fish target, but would unlikely achieve, say, the Boals Deadwoods waterbird target. But if the Moira Grass and Red Gum target was to be achieved, then it is likely that the waterbird targets, creek flow and river fish targets could also be achieved. The Multi-site Watering Trial is a periphaeral action that could assist with attaining all Barmah Forest targets and those of downstream Icon Sites via efficient water re-use, while the seasonal drying regime implemented in summer/autumn is part of the annual hydrological cycle that needs to be incorporated regardless of the watering options implemented in the previous winter/spring.

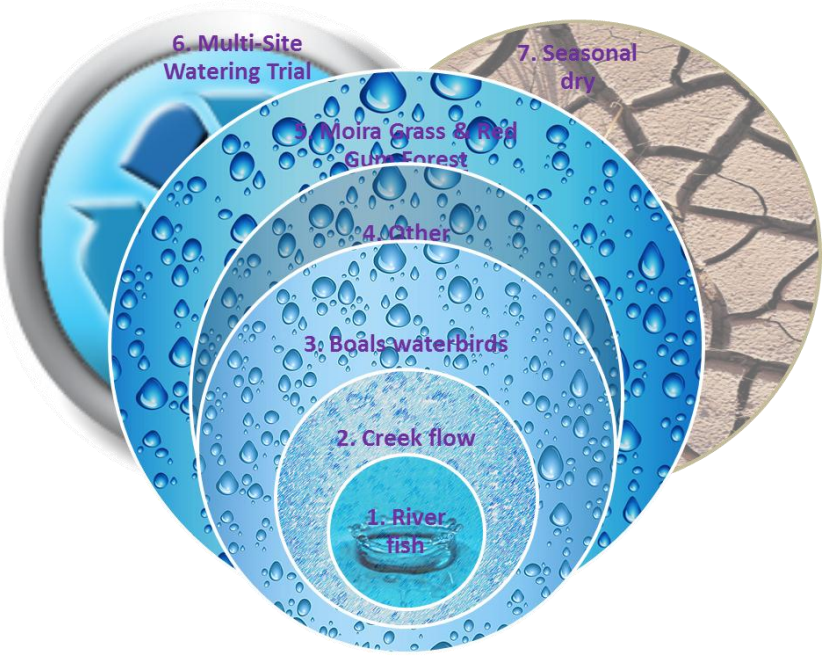


***Figure 3*: Diagrammatic representation of water management proposals for Barmah Forest in 2013/14, displaying nested water volumes and environmental targets of the five proposed EWA volumes, plus the addition of the Multi-Site Watering Trial and a seasonal dry in summer-autumn as complimentary actions.**

As natural flood events and flows are critical to determining what ecological objectives may be achieved for Barmah Forest in any given year, various scenarios are described to cover a variety of events (1). The benefit of describing various scenarios is for actual environmental water use and outcomes to be linked to planning strategies, regardless of what conditions actually occur. For 2013/14, planning is based around average to slightly wetter than average conditions.

Table 1: Water management strategies and activities targeted under different inflow scenarios.

Water Resource Scenario	Objective targeted	Hydraulic target*	Optimal Delivery		Alternate Delivery		Trigger Flow or Trigger Event (i.e. bird breeding, unregulated flow periods)	Target Flow Required			Vol Required (GL)	Vol Returned (GL)	Area Inundated	
			Date	Duration	Date	Duration		ML/d	Duration	location			ha	Duration
Extreme Dry	1 (river fish) [Figure 4]	<10,400	Late Nov	2 weeks	Early Dec	1 week	Stable river during Nov.	1,500	2 weeks	Main river channel	21	20	negligible	2 weeks
	2 (creek flow) [Figure 5]	<10,400	Oct to Nov	2 months	Sum mer	2 weeks	No period of regulators being opened in 2013	500	2 months	Gulf, Big Woodcutter, Boals	30	15	YTBD (est. ~500)	9-12 months (due to ponding)
Dry	3 (Boals birds) [Figure 6]	>8,500 (or >5,500 if willow removal works have been completed)	Sep to Dec	3.5 months	Oct to Jan	3.5 months	Natural initiation of a colonial bird breeding event requiring maintenance	100	3.5 months	Boals	10	3 (broad estimate)	100	4 to 5 months (due to some ponding
	4 (other birds) [Figure 7]	>15,000 (prefer 18,000+)	Aug to Nov	3.5 months	Nov / Dec		If significant** bird breeding event initiates	Variable depending on location	Variable depending on location and stage of nesting	Dependant on where waterbird event initiates	Variable depending on location	Variable depending on location	Variable depending on location	Variable depending on location

Median	5 (Moira Grass & Red Gum Forest) [Figure 8]	>18,000 (prefer 25,000+, but 20,000 = MDBA imposed temporary release limit).	Aug to Nov	4 months	Jul / Dec	3 months	Coincident with natural flood pulse between 15,000 to 20,000 (latter = MDBA imposed temporary release limit).	8,000 (average)	4 mths	All regulator opened	970	680 (= 70% return as per BOC agreement), or 875 (>90% returns as measured in 2005).	21,000 (10,000 Barmah + 11,000 Millewa)	4.5 months (ponding is limited on shedding floodplain; longer in lower regions)
	6 (bypass Choke for MSWT) [Figure 9]	Variable (dependent upon downstream Icon Site demands)	Aug to Nov	4 months	Jul / Dec	3 months	Variable (dependent upon downstream Icon Site demands)	Variable (dependent upon downstream Icon Site demands)	Variable (dependent upon downstream Icon Site demands)	Gulf, Big Woodcutter, Boals (and potentially all others depending upon flow required downstream)	Variable (dependent upon downstream Icon Site demands)	Variable (dependent upon region of forest flow is diverted and antecedent flood conditions)	Variable (dependent upon region of forest flow is diverted and antecedent flood conditions)	Variable (dependent upon region of forest flow is diverted)
Wet	7 (seasonal dry) [Figure 10]	<10,400	Jan to May	6 months	Feb to May	4 months	10,400 to 15,000 (2013/14 = MF turn for unseasonal flow management ***)	0	4 days (typical rain-rejection event)	Regulators in WMAG (i.e., those that avoid MG Plains)	0 (flows are unwanted)	Variable depending on location, duration and size of rain-rejection event, and antecedent flood conditions in the forest. Likely to be < 40%	Variable depending on location, duration and size of rain-rejection event, and antecedent flood conditions in the forest.	Variable depending on location, duration and size of rain-rejection event, and antecedent flood conditions in the forest.

** = Murray River flow (ML/d) downstream of Yarrawonga.*

*** = significant bird breeding event is defined as a high percentage of common species population or any wetland-dependant VRoT species where water management can realistically target.*

**** = An arrangement exists for Barmah Forest and Millewa Forest to alternate, on an annual basis, the management of all unseasonal flows solely on Vic or NSW side of the river in attempt to permit the other side achieve a satisfactory dry regime on their Moira Grass plains (i.e., rather than share any unseasonal flooding that would result in both forests' Moira Grass plains having their natural drying cycle broken by very shallow flooding, then the arrangement allows for deeper flooding on some Moira Grass plains to permit others to remain dry in recognition that the following year reciprocal management occurs). The 20013/14 year is Millewa Forest turn to accept the unseasonal flows.*

Triggers for the priority water management targets under various water resource scenarios are outlined in Table 2, whilst hypothetical hydrographs (Figures 4 – 10) are provided to illustrate the adoption of the various priority water management targets.

Table 2: Triggers for water management actions in Barmah Forest in 2013/14. NB: All flows are Murray River flows downstream of Yarrawonga unless otherwise indicated.

Trigger	Action	Target
Stable river <10,400 ML/d during November.	Create a pulse in river flows by releasing up to 1,500 ML/d for 2 weeks. Ensure peak does not exceed 10,400 ML/d.	River fish breeding cue. Refer to Figure 4.
No period of regulators being opened in 2013 prior to end of November.	Release 500 ML/d into main Barmah Forest regulators for up to 2 months (min 2 weeks). Regulator selection will be based on degree of refuge pool drying and their commence-to-flow thresholds.	Drought refuge in forest waterways for fish and turtles. Longer duration permits connectivity to permit movement and dispersal. Shorter duration permits only refreshing in-stream pools. Refer to Figure 5.
Natural initiation of colonial waterbird breeding in Boals Deadwoods wetland prior to end of November.	Release 100 ML/d for the duration of maintaining the event through to successful completion (up to 3.5 months)	Significant numbers of Australian White Ibis, Straw-necked Ibis and Royal Spoonbill (whilst recognising that Bitterns, Crakes and Rails are also likely to breed within the wetland but not be observed nesting duet to their cryptic habit). Refer to Figure 6.
Natural initiation of a significant waterbird breeding event elsewhere in the forest (which could be small numbers of threatened species or large numbers of common species) prior to end of November.	Determine flow threshold required to maintain adequate flooding of the breeding site, and consider if available water resource exists to maintain flooding for the duration of the breeding event (possibly up to 3.5 months). Release water in accordance to requirements if water resources and constraints (channel capacity or minimal-impact on other targets) permit.	Significant bird breeding event is defined as a high percentage of common species population or any wetland-dependent VRoT species where water management can realistically target. Refer to Figure 7.

Natural flood pulse between 15,000 to 20,000 ML/d occurring within August to November.	Maintain flooding between 15,000 to 20,000 ML/d for up to 4 months by building on river flows up to 20,000 ML/d (MDBA imposed temporary release limit) by release up to 8,000 ML/d, ensuring flooding does not exceed December (and contingent upon NPWS & PV prior works completion).	Moira Grass & Red Gum Forest. Refer to Figure 8.
Multi-Site Watering Trial initiates (trigger yet to be agreed by other Icon Sites in conjunction with BMF Icon Site).	Variable release rates and duration depending upon downstream Icon Site demands associated with the MSWT (although higher flows will be restricted largely between August to November).	Assist Multi-Site Watering Trial bypass Barmah Choke and attain Barmah Forest watering targets. Refer to Figure 9.
10,400 to 15,000 ML/d river flow between January to May.	Enact unseasonal flow management agreement* with Millewa Forest whose turn it is to take all unseasonal flows between 10,400 ML/d and 15,000ML/d in 2013/14 year. Flows exceeding 15,000 ML/d will need to be diverted into Barmah Forest, but will preferentially be via regulators in Water Management Area G (i.e., those that avoid Moira Grass plains in WMA C, G & H1; refer to Figure 5)..	Maintain Moira Grass plains in seasonal dry phase (January to May) in Barmah Forest. Refer to Figure 10.

** = An arrangement exists for Barmah Forest and Millewa Forest to alternate, on an annual basis, the management of all unseasonal flows solely on Vic or NSW side of the river in attempt to permit the other side achieve a satisfactory dry regime on their Moira Grass plains (i.e., rather than share any unseasonal flooding that would result in both forests' Moira Grass plains having their natural drying cycle broken by very shallow flooding, then the arrangement allows for deeper flooding on some Moira Grass plains to permit others to remain dry in recognition that the following year reciprocal management occurs). The 20013/14 year is Millewa Forest turn to accept the unseasonal flows.*

Figure 4: Hypothetical flow scenario 1 (Extreme Dry) with riverine fish target

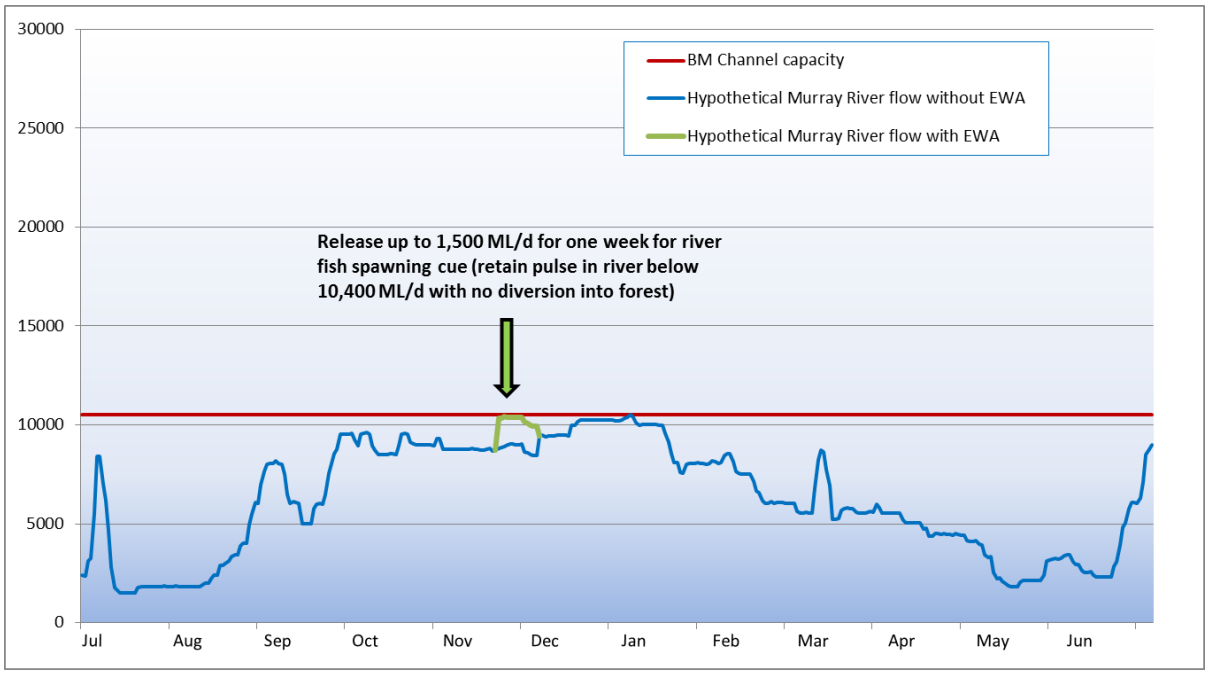


Figure 5: Hypothetical flow scenario 1 (Extreme Dry) with forest creek target

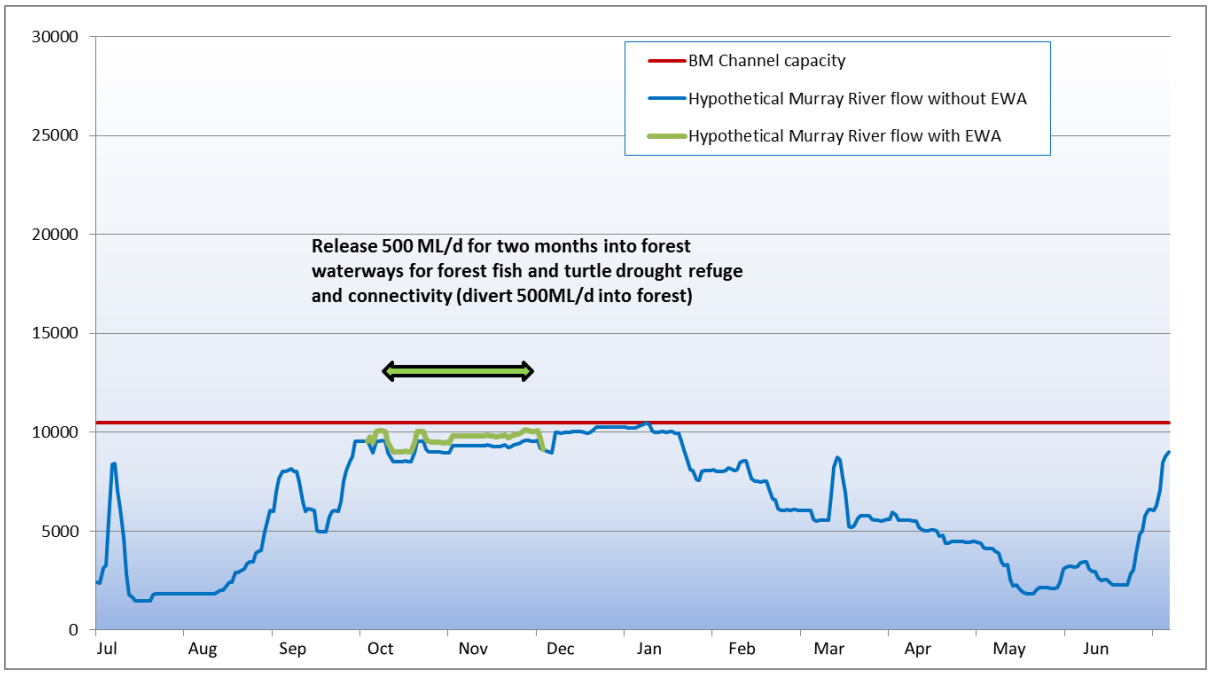


Figure 6: Hypothetical flow scenario 2 (Dry) with Boals waterbird target

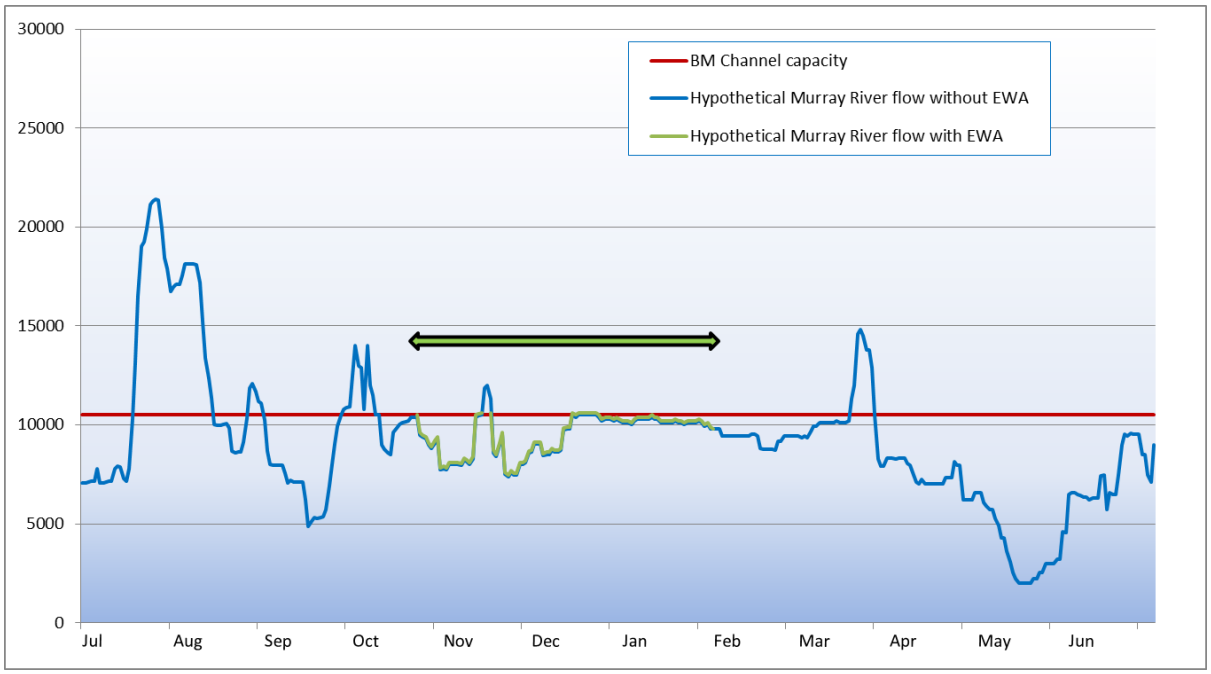


Figure 7: Hypothetical flow scenario 2 (Dry) with other forest waterbird target

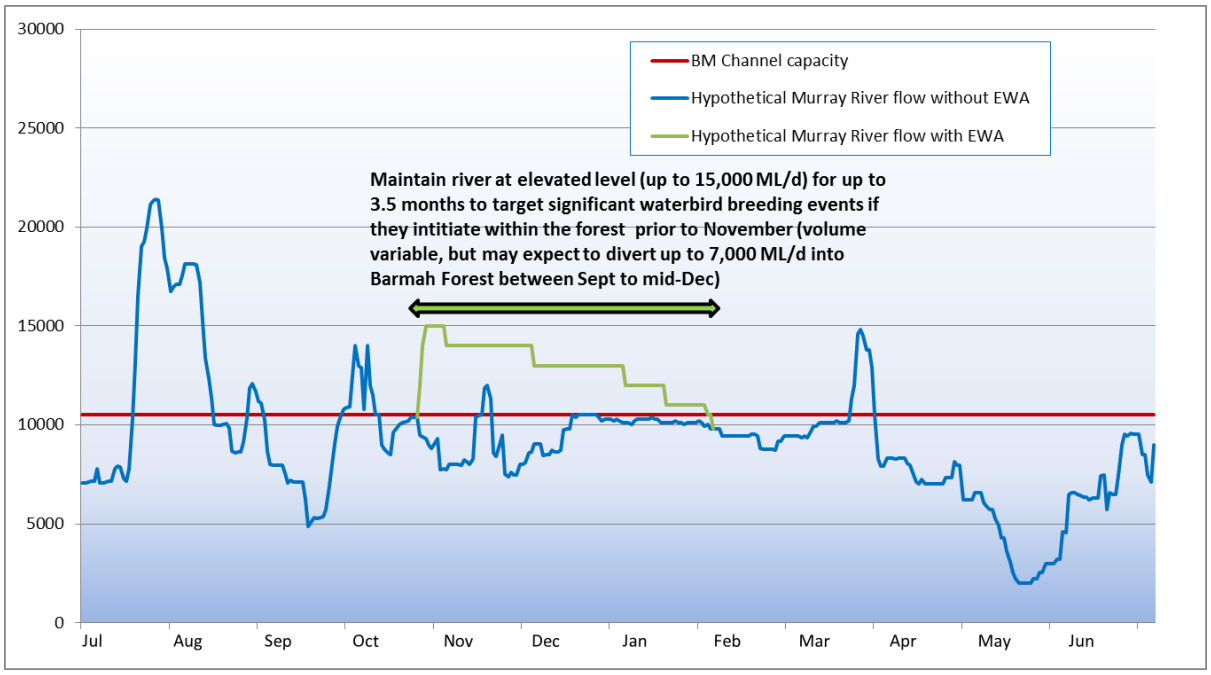


Figure 8: Hypothetical flow scenario 3 (Median) with Moira Grass & RG forest target

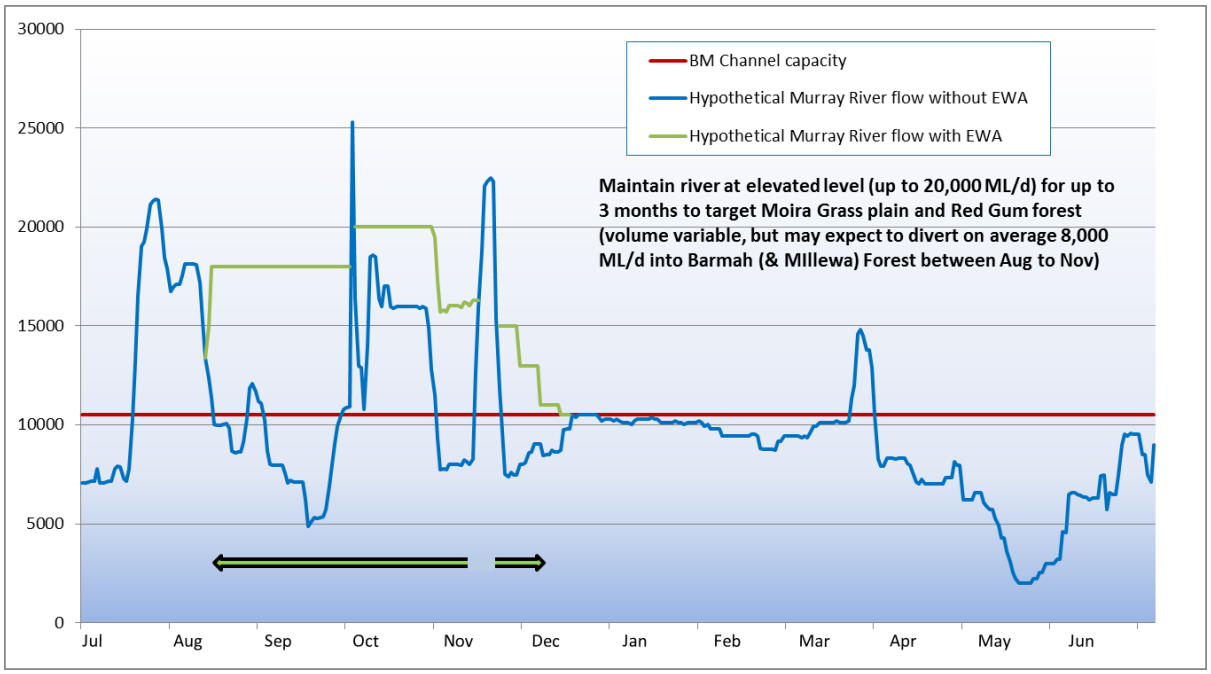


Figure 9: Hypothetical flow scenario 3 (Median) with Multi-Site Watering Trial target

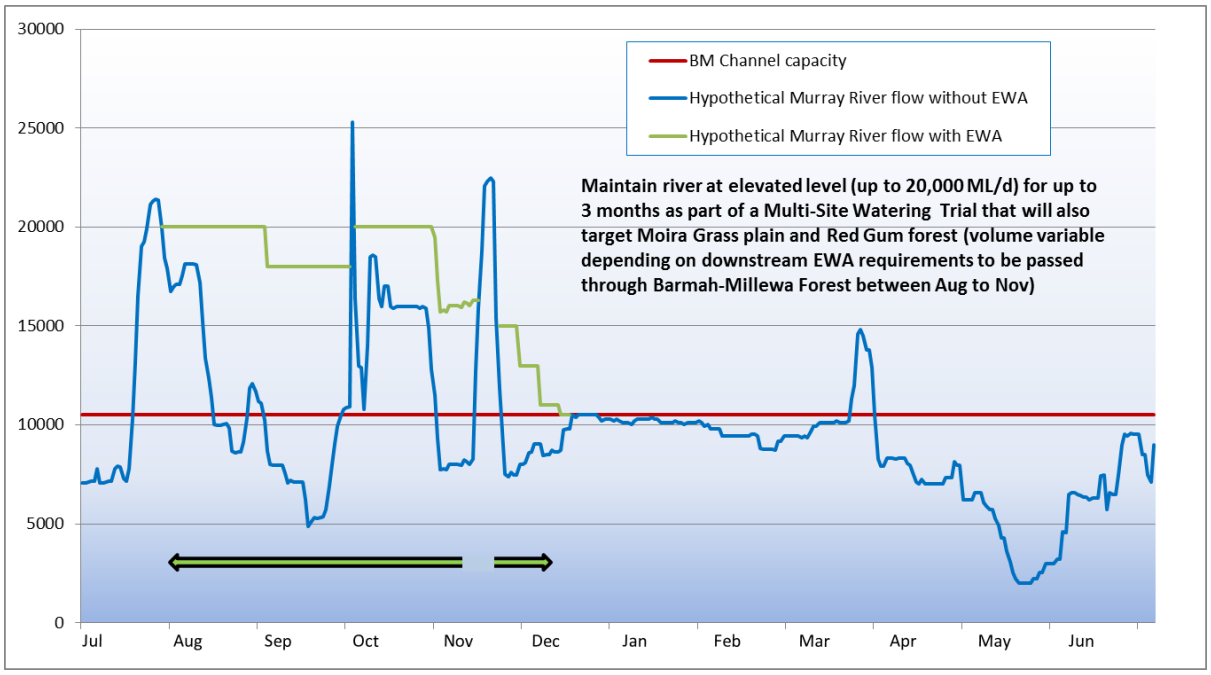
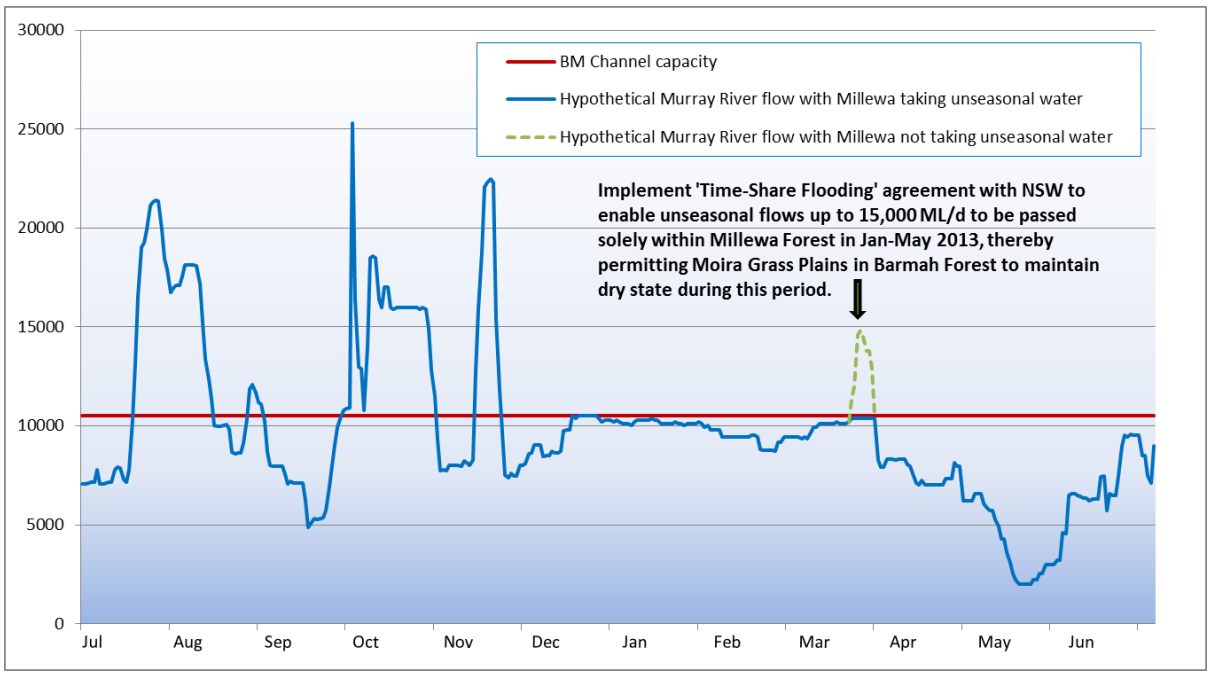


Figure 10: Hypothetical flow scenario 4 (Wet) with Time-Share Flooding implementation



Risk assessment and management
Risk assessments showing the level of risk for each flow component per season in 2013/14 are presented in Table 3 and Table 4. The associated risk mitigation strategies for medium or high risks are outlined in Table 5. .

Table 3: Barmah-Millewa Forest watering proposal risk assessment (winter and spring 2013).

Note: shaded columns indicate 2013/14 watering strategy. High flows are considered to be bank-full flows for Barmah Forest

Risk Category	Risk #	Risk Type	Winter						Spring					
			Cease-to-flow	Low flow	Fresh	High flow	Bankfull flows	Overbank flow	Cease-to-flow	Low flow	Fresh	High flow	Bankfull flows	Overbank flow
Quality issues lead to no achievement of objectives	1.0	Release volume is insufficient in meeting required flow at target point	Low	Low	Low	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium
	1.1	Current recommendations on environmental flow inaccurate	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	1.2	Storage Operator maintenance works affect ability to deliver water	Low	Low	Low	Low	Low	Low	Low	Low	Low	low	Low	Low
	1.3	Resource Manager cannot deliver required volume or flow rate (outlet/capacity constraints, insufficient storage volume)	low	low	low	low	low	low	low	low	Medium	Medium	Medium	Medium
Time	2.0	Limited CMA resource to deliver environmental release	low	low	low	low	low	low	low	low	low	low	low	low
Cost	3.0	Cost of delivery exceeds available funding	low	low	low	low	low	low	low	low	low	low	low	low
Human	4.0	Environmental release cause personal injury to river user	low	low	low	low	low	low	low	low	low	low	low	low
Environmental	5.1	Releases cause water quality issues (eg blackwater, low DO, mobilisation of saline pools, acid-sulphate soils)	low	low	low	low	low	low	Low	low	Low	Low	low	Low
	5.2	Improved conditions for non-native species (eg carp)	low	low	low	low	low	low	Low	Low	Medium	Low	Low	Medium
Compliance	6.0	Environmental water account is overdrawn	low	low	low	low	low	low	low	low	Low	Low	Low	Medium
	6.1	Environmental releases causes flooding of private land	low	low	low	low	low	low	low	low	low	low	low	Medium
	6.2	Environmental release cause flooding to public infrastructure	low	low	low	low	low	low	low	low	low	low	low	low
	6.3	Environmental releases causes flooding of Crown land	low	low	low	low	low	low	low	low	low	low	low	Medium
Reputation	7.0	Unable to provide evidence in meeting ecological objective	High	High	High	High	High	High	High	High	High	High	High	High
	7.1	Key stakeholders not supportive of environmental water release	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low

Table 4: Barmah-Millewa Forest watering proposal risk assessment (summer and autumn 2014).

Note: shaded columns indicate 2013/14 watering strategy

Risk Category	Risk #	Risk Type	Summer						Autumn					
			Cease-to-flow	Low flow	Fresh	High flow	Bankfull flows	Overbank flow	Cease-to-flow	Low flow	Fresh	High flow	Bankfull flows	Overbank flow
Quality issues lead to no achievement of objectives	1.0	Release volume is insufficient in meeting required flow at target point	low	low	Medium	low	low	low	low	low	Medium	low	low	low
	1.1	Current recommendations on environmental flow inaccurate	Low	Low	Low	Low	low	Low	Low	Low	Low	Low	low	Low
	1.2	Storage Operator maintenance works affect ability to deliver water	low	low	low	low	low	low	low	low	low	low	low	low
	1.3	Resource Manager cannot deliver required volume or flow rate (outlet/capacity constraints, insufficient storage volume)	low	low	low	low	low	low	low	low	low	low	low	low
Time	2.0	Limited CMA resource to deliver environmental release	low	low	low	low	low	low	low	low	low	low	low	low
Cost	3.0	Cost of delivery exceeds available funding	low	low	low	low	low	low	low	low	low	low	low	low
Human	4.0	Environmental release cause personal injury to river user	low	low	low	low	low	low	low	low	low	low	low	low
Environmental	5.1	Releases cause water quality issues (eg blackwater, low DO, mobilisation of saline pools, acid-sulphate soils)	Low	Low	Low	Low	low	Low	Low	Low	Low	Low	low	Low
	5.2	Improved conditions for non-native species (eg carp)	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low	Low
Compliance	6.0	Environmental water account is overdrawn	low	low	low	low	low	low	low	low	low	low	low	low
	6.1	Environmental releases causes flooding of private land	low	low	low	low	low	low	low	low	low	low	low	low
	6.2	Environmental release cause flooding to public infrastructure	low	low	low	low	low	low	low	low	low	low	low	low
	6.3	Environmental releases causes flooding of Crown land	low	low	low	low	low	low	low	low	low	low	low	low
Reputation	7.0	Unable to provide evidence in meeting ecological objective	High	High	High	High	High	High	High	High	High	High	High	High
	7.1	Key stakeholders not supportive of environmental water release	low	low	low	low	low	low	low	low	low	low	low	low

***Table 5*: Watering proposal risk mitigation strategies for 2013/14**

Season	Risk Type	Risk Score	Risk Mitigation
Winter	*1.0 Release volume is insufficient in meeting required flow at target point*	*Medium*	*The risk of having insufficient water to achieve the target is considered a possibility depending upon the target and the timing of trigger occurring. However, water resource availability is to be secured prior to actioning water release if a trigger is met to ensure adequate water reserve exists to achieve the target in the event that no further natural inflows occur. Potential use of Multi-Site Watering Trial, TLM and CEWH water holdings ought to be sufficient for the various watering scenarios proposed for 2013/14.*
	7.0 Unable to provide evidence in meeting ecological objective	*High*	*Budget cuts to Condition and Intervention monitoring in 2013/14 will cause most, if not all, monitoring programs to cease, resulting in no data to support the attainment of environmental targets. Anecdotal observations of vegetation response and waterbird use are intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.*
Spring	*1.0 Release volume is insufficient in meeting required flow at target point*	*Medium*	*The risk of having insufficient water to achieve the target is considered a possibility depending upon the target and the timing of trigger occurring. However, water resource availability is to be secured prior to actioning water release if a trigger is met to ensure adequate water reserve exists to achieve the target in the event that no further natural inflows occur. Potential use of Multi-Site Watering Trial, TLM and CEWH water holdings ought to be sufficient for the various watering scenarios proposed for 2013/14.*
	1.3 Resource Manager cannot deliver required volume or flow rate (outlet/capacity constraints, insufficient storage volume)	*Medium*	*Environmental water is planned to be used to primarily fill in gaps between natural flood events. Available volumes of environmental water are considered and continuously reviewed along with weather forecasts when implementing a particular scenario and determining the likely success. Consequence of specific volume and duration of water is lower for the vegetation target because a periodic drop in desired water level ought not to unduly cause disruption to life cycle (assuming that at least some water depth remains), but has*

		greater consequence for waterbird nesting outcomes as the result could be abandonment of chicks if water levels prematurely recede.
5.2 Improved conditions for non-native species (e.g. carp)	*Medium*	*Flooding of wetlands in spring coincides with most breeding strategies for native flora and fauna, and can reduce pest plant invasion, and hence is of advantage. However, Carp have the ability to breed over a broader range of season and water temperatures than many native fish species that only breed in spring/early summer. Proposed flood strategies in spring are to create a pulse in the river if stable in-channel flows occur, which is aimed to benefit native Perch species, or otherwise re-fresh in-forest refuge pools at low level to benefit all fish but avoid low-flooding of grass plains where carp are known to benefit. The high flow strategy proposed for spring is to maintain high flows if they naturally occur, which are expected to benefit all fish species (recognising that there exist some native low-flow specialists). .*
6.0 Environmental water account is overdrawn	*Medium*	*The Barmah-Millewa Operations Advisory Group will be active for the duration of any environmental watering event, enabling agencies to continuously monitor environmental water availability versus the forecast requirements and relate this to the watering strategy objectives. Overdraw of environmental water accounts are therefore expected to be minimised.*
6.1 Environmental releases causes flooding of private land	*Medium*	*Proposed watering actions take heed of a recent MDBA restriction on release rates downstream of Yarrawonga by conforming to the limit of 20,000 ML/d to avoid flooding private land in the Bullatale Creek system in NSW until further studies define the actual flow level responsible for flooding the private floodplain areas. Although a buffer exists within this imposed limit, a large rainfall event could occur during the period of managed water release to have the potential to exceed the overall flow limit downstream of Yarrawonga. Mitigation measure will be via close communication with River Murray Water within the Barmah-Millewa Advisory Group and directly as required to ensure river management and rainfall forecasts are considered for potential rapid reduction or cessation to the managed releases.*

	6.3 Environmental releases causes flooding of Crown land	*Medium*	*The higher flow releases proposed for spring to achieve Objectives 5 & 6 are likely to cause inflow into three wetlands on Crown land between Yarrawonga and Tocumwal (Quinns Island wetland and Horseshoe Lagoon at Cobram each have a CTF of ~17,000 ML/d, while Wetland 9 near the Newell Hwy south of Tocumwal has a CTF of 18,200 ML/d). Flooding of these wetlands in spring is of benefit, and hence the consequence of their flooding is positive. No other Crown land is expected to be inundated at the proposed releases.*
	7.0 Unable to provide evidence in meeting ecological objective	*High*	*Budget cuts to Condition and Intervention monitoring in 2013/14 will cause most, if not all, monitoring programs to cease, resulting in no data to support the attainment of environmental targets. Anecdotal observations of vegetation response and waterbird use are intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.*
Summer	*1.0 Release volume is insufficient in meeting required flow at target point*	*Medium*	*The risk of having a summer fresh or rain-rejection event occurring is high, but this is mitigated to medium or even low via the intended implementation of the "unseasonal flood arrangement" with NSW where Millewa Forest will accept flows in excess of 10,400 to 15,000 ML/d river flows. No environmental water is required. If flows exceed 15,000 Ml/d in summer, then the excess will need to be diverted into Barmah Forest preferentially via regulators in Water Management Area G (i.e., those that avoid Moira Grass plains in WMA C, G & H1; refer to Figure 5).*
	5.2 Improved conditions for non-native species (e.g. carp)	*Medium*	*Flooding of wetlands in summer is not desirable for a range of ecological reasons and hence will be avoided where possible. Most native fish have passed their breeding season while Carp continue to have the ability to breed well into summer. Proposed flood strategies in summer are to implement a drying regime on the floodplain or restrict flooding to colonial waterbird breeding locations, and hence Carp breeding will be discouraged through drying preferred spawning habitat.*

	7.0 Unable to provide evidence in meeting ecological objective	*High*	*Budget cuts to Condition and Intervention monitoring in 2013/14 will cause most, if not all, monitoring programs to cease, resulting in no data to support the attainment of environmental targets. Anecdotal observations of vegetation response and waterbird use are intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.*
Autumn	*1.0 Release volume is insufficient in meeting required flow at target point*	*Medium*	*The risk of having an autumn fresh or rain-rejection event occurring is high, but this is mitigated to medium or even low via the intended implementation of the "unseasonal flood arrangement" with NSW where Millewa Forest will accept flows in excess of 10,400 to 15,000 ML/d river flows. No environmental water is required. If flows exceed 15,000 Ml/d in autumn, then the excess will need to be diverted into Barmah Forest preferentially via regulators in Water Management Area G (i.e., those that avoid Moira Grass plains in WMA C, G & H1; refer to Figure 5).*
	5.2 Improved conditions for non-native species (e.g. carp)	*Medium*	*Flooding of wetlands in autumn is not desirable for a range of ecological reasons and hence will be avoided where possible. The intended dry regime of the floodplain is anticipated to benefit native vegetation over exotic species, and will not provide spawning habitat to exotic fish (which most have passed their breeding period by autumn anyway). Feral pig and fox activity can increase on drawdown and dry out of floodplains, but these remain subject of pest control program by Parks Victoria as the land manager..*
	7.0 Unable to provide evidence in meeting ecological objective	*High*	*Budget cuts to Condition and Intervention monitoring in 2013/14 will cause most, if not all, monitoring programs to cease, resulting in no data to support the attainment of environmental targets. Anecdotal observations of vegetation response and waterbird use are intended to occur within the Environmental Delivery program associated with Icon Site Manager role. Waterbird nesting at Boals Deadwoods wetland will occur using existing remote cameras installed at that wetland. Attainment of fish targets will be unable to be determined without specific monitoring.*