Australian Government

MURRAY–DARLING BASIN AUTHORITY

MURRAY-DARLING BASIN AUTHORITY

Barmah–Millewa Forest

Environmental Water Management Plan

February 2012

Barmah–Millewa Forest

Environmental Water Management Plan

February 2012

© Copyright Murray–Darling Basin Authority (MDBA), on behalf of the Commonwealth of Australia 2012.

This work is copyright. With the exception of photographs, any logo or emblem, and any trademarks, the work may be stored, retrieved and reproduced in whole or in part, provided that it is not sold or used in any way for commercial benefit, and that the source and author of any material used is acknowledged.

Apart from any use permitted under the *Copyright Act 1968* or above, no part of this work may be reproduced by any process without prior written permission from the Commonwealth. Requests and inquiries concerning reproduction and rights should be addressed to the Commonwealth Copyright Administration, Attorney General's Department, National Circuit, Barton ACT 2600 or posted at http://www.ag.gov.au/cca.

The views, opinions and conclusions expressed by the authors in this publication are not necessarily those of the MDBA or the Commonwealth. To the extent permitted by law, the MDBA and the Commonwealth excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this report (in part or in whole) and any information or material contained within it.

Australian Government Departments and Agencies are required by the *Disability Discrimination Act 1992* (Cth) to ensure that information and services can be accessed by people with disabilities. If you encounter accessibility difficulties or the information you require is in a format that you cannot access, please contact us.

Murray–Darling Basin Authority

Postal Address: GPO Box 1801, Canberra ACT 2601

Office location: Level 4, 51 Allara Street, Canberra City, Australian Capital Territory

Tel: (02) 6279 0100, international + 61 2 6279 0100
Fax: (02) 6248 8053, international + 61 2 6248 8053

E-mail: info@mdba.gov.au
Website: ←www.mdba.gov.au→

For further information contact the Murray-Darling Basin Authority office on (02) 6279 0100

Cover image: Flood marks on giant rush at Barmah Lake showing flood levels.

Photographer: Keith Ward, Goulburn Broken CMA

This report may be cited as: Barmah–Millewa Forest: Environmental Water Management Plan 2012

MDBA Publication No. 219/11
ISBN (on-line) 978-1-921914-74-4
ISBN (print) 978-1-921914-75-1

Contents

About this plan 1

Summary 2

Barmah–Millewa Forest 2

1. The Living Murray 3

The Living Murray icon site environmental water management plans 4

Planning context and legislation framework 4

Agreements 4

National legislation 5

Victorian legislation 6

New South Wales legislation 7

Victorian planning strategies 8

New South Wales planning strategies 9

Governance and planning arrangements 10

Joint management 10

Integrated Coordinating Committee 10

2. Icon site description 13

Description of key ecological assets of the icon site 13

Values of the icon site 14

3. Ecological objectives and water requirements 16

The Living Murray First Step icon site objectives 16

Water requirements 17

Climate and rainfall in the Murray–Darling Basin 20

Antecedent hydrological conditions 20

Past management actions and activities 20

4. Water delivery 21

Prioritising water requirements 21

The Living Murray works and water modelling 23

Water accounting and measurement 26

Water use 26

Sources of environmental water 27

Barmah–Millewa Environmental Water Allocation 27

Annual 'alternating' arrangements 28

Consumptive water en route 28

State-based environmental entitlements 28

Evaluation and management of potential risks 29

5. Environmental monitoring 30

River Murray system-scale monitoring 30

Icon site condition monitoring 30

6. Community consultation and communication 31

7. Indigenous engagement 32

8. Adaptive management and reporting 33

Adaptive management 33

Appendix A: State governance arrangements 35
Appendix B: List of significant flora in Barmah–Millewa Forest 38
Appendix C: List of significant fauna in Barmah–Millewa Forest 40
Appendix D: Commence-to-flow thresholds for Barmah–Millewa waterways 42
Appendix E: Hydraulic model outputs 43
Appendix F: Operating rules for the Barmah–Millewa Forest Environmental Water Allocation 48
Appendix G: Barmah Ramsar site ecosystems services — risk assessment 55
Schedules 58
Schedule 1 Condition Monitoring Plan 58
Schedule 2 Operating strategy 58
Schedule 3 Communications plan 58
List of figures and tables 59
Figures 59
Tables 59
Abbreviations and acronyms 60
Glossary 61
References 63

About this plan

This environmental water management plan consists of:

i. A long-term strategic plan, (per Clause 117 of the TLM Business Plan), which outlines the icon site's environmental water requirements and how to broadly achieve them with a combination of environmental water and works and measures.

ii. Schedules detailing operational information about the icon site such as Operating, Condition Monitoring, Risk Management and Communication Plans. These Schedules will be added to the environmental water management plan as they become available and updated to reflect learnings from the operation of works, the results of environmental waterings and the latest science.

The environmental water management plans provide context for an icon site's water planning, delivery, monitoring and consultation processes. While the environmental water management plans include proposed operating strategies, annual water planning and implementation will be responsive to changing water resource conditions, opportunities and environmental priorities throughout the season and from year to year.

This environmental water management plan and associated schedules have been prepared by TLM partner governments in consultation with the relevant stakeholders. The MDBA would like to acknowledge the significant contribution of all those involved in the development of the environmental water management plans.

Summary

The Living Murray (TLM) Initiative is one of Australia's most significant river restoration programs. The program is delivered by six partner governments as outlined in the Murray–Darling Basin Intergovernmental Agreement (2004), which is facilitated through a formal governance framework coordinated by the Murray–Darling Basin Authority (MDBA) and ultimately overseen by the Murray–Darling Basin Ministerial Council. This overarching framework is underpinned by state-based governance arrangements.

Almost 500 GL long-term Cap equivalent (LTCE) has now been recovered through TLM. This water will be used at six icon sites to improve environmental outcomes: Barmah–Millewa Forest; Gunbower–Koondrook–Perricoota Forest; Hattah Lakes; Chowilla Floodplain and Lindsay–Wallpolla Islands; Lower Lakes, Coorong and Murray Mouth; and the River Murray Channel.

Barmah–Millewa Forest

The Barmah–Millewa Forest icon site supports the largest river red gum forest (*Eucalyptus camaldulensis*) in Australia and forms the largest and most intact freshwater floodplain system along the River Murray. The Barmah–Millewa Forest provides habitat for numerous plant and animal species (including birds, fish and reptiles), and supports colonies of breeding waterbirds during appropriate seasonal conditions. The Barmah–Millewa Forest is listed on the Register of the National Estate in recognition of its importance as part of Australia's heritage and its outstanding natural values. Indigenous and the broader Australian community have significant connections to the Barmah–Millewa Forest. Consequently, the cultural landscape within the icon site reflects both Indigenous Australian and European activities.

Environmental watering management plans have been produced for all six icon sites, with the aim of describing TLM ecological objectives and targets and the site-specific watering regimes, works and water delivery arrangements. This icon site plan supersedes the Barmah–Millewa Forest Environmental Management Plan 2006–07.

Investigations at Barmah–Millewa Forest, including development of a hydraulic model for the icon site, have shown that achieving the ecological objectives for the forest would require sustained high river flows. Unlike other TLM icon sites, large-scale works could not be used to create large-scale flooding within Barmah–Millewa Forest. A suite of small-scale works to improve water management within the forest has been developed; these works will include fishways and the construction or refurbishment of regulators.

The aim of the proposed operating strategy for the Barmah–Millewa Forest icon site is to achieve ecological objectives set for the forests by providing the water requirements for key vegetation communities, including wetlands, moira grass (*Pseudoraphis spinescens*) plains and river red gum communities. The operating strategy also includes specific flow recommendations to provide habitat for native fish and support the breeding events of waterbirds, including colonial and non-colonial nesters.

Annual monitoring, primarily through the icon site's condition monitoring program, will determine progress towards achieving the ecological objectives for the icon site. Additional monitoring will also be undertaken during and following watering events, while monitoring of specific risks associated with environmental water delivery will occur as required.

The Environmental Water Management Plan for Barmah–Millewa will promote an adaptive management approach through 'learning by doing'. Ecological information collected during and after environmental watering events will be incorporated into the icon site's operating strategy to ensure that it remains relevant and effective.

The plan recognises the importance of ongoing community consultation and communication in delivery of the plan's components. The Barmah–Millewa Community Reference Group was established to provide advice on consulting with regional and local groups with interests in managing the Barmah–Millewa Forest icon site.

The Indigenous Reference Group includes representatives from the Yorta Yorta nation and New South Wales Aboriginal land councils. This group and the community reference group will support the Integrated Coordinating Committee regarding consultation and communication with Indigenous stakeholders. The Integrated Coordinating Committee's main role is to coordinate environmental watering and other TLM activities across the Barmah–Millewa icon site.

1. The Living Murray

The Living Murray (TLM) Initiative is one of Australia's most significant river restoration programs. Established in 2002, TLM is a partnership of the Australian Government and the governments of New South Wales, Victoria, South Australia and the Australian Capital Territory; it is coordinated by the Murray–Darling Basin Authority (MDBA). The long-term goal of this program is to achieve a healthy working River Murray system for the benefit of all Australians.

The Living Murray aims to improve the environmental health of six icon sites chosen for their significant ecological, cultural, recreational, heritage and economic values (see **Figure 1.1**):

- Barmah–Millewa Forest
- Gunbower–Koondrook–Perricoota Forest
- Hattah Lakes
- Chowilla Floodplain and Lindsay–Wallpolla Islands (including Mulcra Island)
- River Murray Channel
- Lower Lakes, Coorong and Murray Mouth.

Through its First Step water recovery initiative, TLM has acquired a water portfolio consisting of environmental water entitlements. As of May 2011, there was 478.97 gigalitres long-term Cap equivalent (LTCE)[1], with another 7.1 GL to be recovered in 2011–12. The actual volume of water available against these entitlements depends on the allocations. This portfolio will be used to achieve environmental objectives at the icon sites. Regulating structures, water delivery channels and fishways, known as works and measures, will deliver and manage the environmental water at the icon sites. On-ground works for each icon site will be progressively constructed from 2010 to 2012. The success of the environmental watering against the objectives will be monitored using fish, birds and vegetation as an overall indicator of the icon site's health.

The Living Murray will seek to align itself to the requirements of the Basin Plan Environmental Watering Plan, once finalised.

Further information on TLM is available on the MDBA website at ←www.mdba.gov.au/programs/tlm.→

1 The long-term Cap equivalent is a type of average and takes into account different characteristics of water entitlements in New South Wales, Victoria and South Australia and their reliability. The measure of water recovery creates a common unit on measure, thus allowing equitable comparison of a broad range of water recovery measures.

Figure 1.1: Location of The Living Murray icon sites

The Living Murray icon site environmental water management plans

The Barmah–Millewa Forest Environmental Water Management Plan establishes priorities for the use of TLM water within the icon site. It identifies environmental objectives and targets (where appropriate), water delivery options and regimes for the site that can use TLM water portfolio.

Development of the Environmental Water Management Plan has been coordinated by the MDBA in consultation with the Environmental Watering Group to ensure a consistent approach to planning and management across the icon sites.

This revision builds on previous iterations of the Barmah–Millewa Environmental Water Management Plan (previously known as 'environmental management plans') and incorporates consultation, research into icon site key species, learning from water behaviour modelling and outcomes from previous environmental watering. The Barmah–Millewa Environmental Water Management Plan reflects the larger volume now held in TLM water portfolio, and uses TLM works and measures (as construction is completed) and monitoring information gathered at the icon site.

Planning context and legislation framework

The Australian Government and the jurisdictions of Victoria, New South Wales and South Australia have comprehensive legislative frameworks addressing natural resource and environmental management. For activities associated with management of TLM icon sites, including construction of works under TLM, the principal pieces of legislation and planning strategies are detailed below.

Agreements

Ramsar Convention on Wetlands of International Importance

The Ramsar Convention on Wetlands of International Importance (the Ramsar Convention) is an international treaty with the broad aim of halting the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. For wetlands to be listed as Ramsar wetlands, they need to be representative, rare or unique in terms of their ecological, botanical, zoological, limnological or hydrological importance. Ramsar-listed wetlands can be natural, artificial, permanent or temporary swamps, marshes, billabongs, lakes, salt marshes or mudflats classified as wetlands.

Signatories to the Ramsar Convention, including Australia, are required to formulate and implement their planning so as to promote the conservation of wetlands included in the Ramsar list, and as far as possible the wise use of all wetlands in their territory. Ramsar wetlands in Australia are protected under the *Environment Protection and Biodiversity Conservation Act 1999* as a matter of national environmental significance (Department of Sustainability, Environment, Water, Population and Communities 2011a).

Bilateral migratory bird agreements

Over the past 30 years Australia has signed three bilateral migratory bird agreements in an effort to conserve migratory birds in the east Asian and Australian regions: China–Australia Migratory Bird Agreement (signed in 1986); Japan–Australia Migratory Bird Agreement (signed in 1974); and the Republic of Korea – Australia Migratory Bird Agreement (came into effect in 2007).

These agreements protect terrestrial, water and shorebird species that migrate from Australia to Japan or China. The Japan–Australia Migratory Bird Agreement also provides for cooperation on the conservation of threatened birds, while the Republic of Korea – Australia Migratory Bird Agreement ensures conservation of migratory birds and collaboration on the protection of migratory shorebirds and their habitat (Department of Sustainability, Environment, Water, Population and Communities 2011b).

Murray–Darling Basin agreements

The Murray–Darling Basin Ministerial Council established TLM in 2002. In 2004, the Australian Government and the governments of New South Wales, Victoria, South Australia and the Australian Capital Territory signed the Intergovernmental Agreement on Addressing Water Over-allocation and Achieving Environmental Objectives in the Murray–Darling Basin, which gave effect to a funding commitment (made in 2003) of $500 million over five years for TLM. The Living Murray program's First Step aimed to recover 500 GL of water for the River Murray and focused on improving the environment at the six icon sites. A supplementary Intergovernmental Agreement was signed in 2006 which provided increased funding of $200 million to The Living Murray.

The role of the Intergovernmental Agreement on Murray–Darling Basin Reform, signed by the Council of Australian Governments, is to:

- promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of the water and other natural resources of the Murray–Darling Basin (Council of Australian Governments 2008).

This Agreement was the foundation for the Water Act 2007, which established the MDBA whose role is to manage the Basin's water resources through the development of a Basin plan.

National legislation

Water Act 2007

The Intergovernmental Agreement on Murray–Darling Basin Reform was the foundation for the federal *Water Act 2007*, which established the MDBA, whose role is to manage the water resources of the Murray–Darling Basin in an integrated, consistent and sustainable manner. The Water Act requires the MDBA to prepare and oversee a Basin Plan, which will be a legally enforceable document that provides for the integrated and sustainable management of water resources in the Basin.

The Basin Plan's Environmental Watering Plan will provide a strategic framework for coordinated environmental water planning and environmental watering throughout the Murray–Darling Basin. In the future, TLM will align the Environmental Watering Plan with the development of Basin states' annual and long-term environmental watering plans through the annual environmental water prioritisation processes.

Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places (including natural, historic or Indigenous places)—defined in the EPBC Act as matters of national environmental significance. There are eight matters of national environmental significance to which the EPBC Act applies.

The EPBC Act aims to balance the protection of these crucial environmental and cultural values with our society's economic and social needs by creating a legal framework and decision-making process based on the guiding principles of ecologically sustainable development.

Native Title Act 1993

Section 24KA of the *Native Title Act 1993* requires that native title claimants are notified of any future act consisting of the grant of a lease, licence, permit or authority under legislation that relates to the management or regulation of surface or subterranean water.

Victorian legislation

The principal Acts listed in this section operate in conjunction with other state legislation that deals with the management and conservation of Victoria's natural resources and outlines obligations relating to obtaining approvals for structural works within TLM icon sites.

Aboriginal Heritage Act 2006

The *Aboriginal Heritage Act 2006* provides for the protection of Indigenous cultural heritage in Victoria. The Act also provides for the introduction and management of a system of Registered Aboriginal Parties that allows Indigenous groups with connection to country and others to be involved in decision-making processes around cultural heritage. Regulations enabled under the Aboriginal Heritage Act require a cultural heritage management plan to be prepared when undertaking high-impact activities in culturally sensitive landscapes.

Environmental Effects Act 1978

The *Environmental Effects Act 1978* aims to ensure that development occurs in an ecologically sustainable manner and provides for assessment of any project or development that could have significant effects on the environment. The Environmental Effects Act enables the Victorian Minister for Planning to decide whether an environmental effects statement should be undertaken for proposed projects. Projects should be referred to the minister if they meet any referral criteria, as set out in ministerial guidelines (Victorian Department of Sustainability and Environment 2006). A project can be referred by the proponent, a statutory authority or any minister.

Flora and Fauna Guarantee Act 1988

The aim of the *Flora and Fauna Guarantee Act 1988* is to conserve threatened flora and fauna species and communities, and to manage potentially threatening processes. The Flora and Fauna Guarantee Act provides for the establishment and maintenance of lists of threatened species, potentially threatening processes and excluded species, which are those not to be conserved because they constitute a serious threat to human welfare (i.e. human disease organisms).

The Act directs that action statements (brief management plans) are to be prepared for listed species to track the progress of management actions, and recovery plans are to be prepared for species also listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

Forests Act 1958

The *Forests Act 1958* governs forest management in Victoria. This Act and associated regulations are supported by Victoria's five regional forest agreements. Under the Act's provisions, detailed forest management plans are developed for each area following a complex assessment process that considers all forest values. These management plans provide for the control, maintenance, protection and taking of forest produce and fire management in state forests.

Planning and Environment Act 1987

The *Planning and Environment Act 1987* establishes a framework for planning the use, development and protection of land in Victoria in the present and long-term interests of all Victorians. Local planning schemes are enabled under this Act.

The Planning and Environment Act enables the Gannawarra and Campaspe planning schemes. Under these schemes, planning permits are required for proposed TLM works in these areas, with applications prepared and submitted to the relevant councils.

Murray–Darling Basin Act 1993

The *Murray–Darling Basin Act 1993* enables the Murray–Darling Basin Agreement 2008, which was entered into by the Australian Government and the governments of New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory with regard to the water, land and other environmental resources of the Murray–Darling Basin. This Act provides for the referral of selected powers under the Victorian Constitution that enable the Australian Government to manage specific aspects of water resource management with the Basin.

National Parks Act 1975 and Parks Victoria Act 1998

In Victoria, national parks are managed by Parks Victoria. Under the *Parks Victoria Act 1998*, Parks Victoria's responsibilities are to provide services to the state and its agencies for the management of parks, reserves and other public land. Under s. 27 of the *National Parks Act 1975*, works by a public authority within a park reserved and managed under the provisions of the Act are subject to consent by the minister. A condition of this consent is that the proposed works comply with the management objectives and strategies for the park.

Water Act 1989

The *Water Act 1989* governs the way water entitlements are issued and allocated in Victoria. The Act defines water entitlements and establishes the mechanisms for managing Victoria's water resources. Part 10 of the Water Act (Vic.) establishes waterway management and general river health management as the responsibility of catchment management authorities and Melbourne Water (where applicable). For TLM works, s. 67 of the Water Act (Vic.) identifies catchment management authorities as the responsible authorities for issuing licences for conducting works in a designated waterway.

New South Wales legislation

National Parks and Wildlife Act 1974

The conservation status of Millewa Forest also has recently been transferred to that of National Park by the New South Wales Government. It is part of the new Murray Valley National Park, proclaimed on 1 July 2010.

Under the *National Parks and Wildlife Act 1974*, the Director-General of the National Parks and Wildlife Service is responsible for the care, control and management of all national parks. Under this legislation, the Director-General is also responsible for the protection and care of native fauna and flora, and Indigenous places and objects throughout New South Wales.

Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* provides legal status for biota of conservation significance in New South Wales. The Act aims to conserve biological diversity and promote ecologically sustainable development. Threatened species, populations and ecological communities are listed in this Act and are consistent with listings under the Commonwealth Environmental Protection and Biodiversity Conservation Act.

Crown Lands Act 1989

The *Crown Lands Act 1989* ensures that Crown land is managed for the benefit of the people of New South Wales. In particular, the Act provides for the management, proper development, conservation and the regulation of the conditions under which Crown land is permitted to be used or otherwise dealt with. The Land and Property Management Authority is responsible for the sustainable and commercial management of Crown land in New South Wales. A Crown land licence is a contractual agreement that grants the licensee a personal right to occupy and use Crown land for a particular purpose.

Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* forms the statutory framework for planning approval and environmental assessment in New South Wales. Implementation of the Environmental Planning and Assessment Act is the responsibility of the New South Wales Minister for Planning, statutory authorities and local councils.The need or otherwise for development consent is set out in environmental planning instruments, such as state environmental planning policies, regional environmental plans or local environmental plans. Environmental planning instruments relevant to the management of the icon site include:

- State Environmental Planning Policy (Infrastructure) 2007
- Murray Regional Environmental Plan Number 2
- Murray Local Environmental Plan 1989.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* lists threatened aquatic species, endangered populations and ecological communities, and key threatening processes. Potential impacts on species, populations and communities subject to the Fisheries Management Act are assessed by Industry and Investment New South Wales.

Water Management Act 2000

The *Water Management Act 2000* provides for the sustainable and integrated management of water sources in New South Wales to protect, enhance and restore water sources; their associated ecosystems, ecological processes and biological diversity; and their water quality. Any activity that affects the quantity or flow of water in a water source requires consent under this Act.

Victorian planning strategies

Victorian regional catchment strategies

The *Catchment and Land Protection Act 1994* (Vic.) established overarching strategic documents aimed at halting biodiversity decline through the implementation of priority programs, including those that protect and manage wetlands. The catchment management authorities are responsible for coordinating the implementation of the Regional Catchment Strategy and its sub-strategies and action plans under the *Water Act 1989 (Vic.).*

Victorian Northern Region Sustainable Water Strategy

Regional sustainable water strategies were legislated through 2005 amendments to the *Water Act (Vic.)* and fulfil Victoria's commitment to the National Water Initiative to carry out open statutory-based water planning. Sustainable water strategies take a long-term view of water resource planning and, as such, they guide the development, integration and implementation of management plans prepared by water corporations and catchment management authorities operating within each region.

Victorian River Health Strategy

The Victorian River Health Strategy was released in 2002 with the statewide objective of achieving healthy rivers, streams and floodplains that meet the environmental, economic, recreational and cultural needs of current and future generations.
The Victorian River Health Strategy provides the policy direction and planning framework for communities to work in partnership with government to manage and restore Victoria's rivers over the long term.

Victorian regional river health strategies

These strategies were established as a part of the Victorian Government's response to the Victorian River Health Strategy. They provide regional frameworks for catchment management authorities, as regional caretakers, to achieve regional river health outcomes.

Victorian Native Vegetation Management: A Framework for Action

Native Vegetation Management: A Framework for Action was released in 2002. The framework establishes the strategic direction for the protection, enhancement and revegetation of native vegetation across the Victorian landscape.

Improving the quality and amount of native vegetation in Victoria is critical to maintaining land and water health. The framework's main goal is to achieve a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation, leading to a net gain.

Yarrawonga–Echuca Waterway Action Plan

The Yarrawonga–Echuca Waterway Action Plan, developed by the Goulburn Broken Catchment Management Authority for the River Murray between Yarrawonga and Echuca, features management programs designed to:

- sustain continuing and demonstrable improvements in river condition into the future, while recognising economic and water use imperatives
- stimulate an increasingly holistic approach to managing this section of river, while also recognising its place in the broader Murray Basin ecosystem and economy
- generate an increasing level of interest, acceptance and commitment from stakeholders and the wider community.

The action plan proposes a series of strategies and actions for vegetation management, channel stability, habitat improvement, wetland management, community education and institutional arrangements (EarthTech Engineering Pty Ltd *et al*. 2002).

New South Wales planning strategies

New South Wales wetlands policy

The New South Wales wetlands policy promotes the sustainable conservation, management and wise use of wetlands in New South Wales, and the need for all stakeholders to work together to protect wetland ecosystems and their catchments. The policy provides a set of guiding principles that all government agencies will adopt and to which all stakeholders can refer when making decisions on wetlands management and conservation.

New South Wales RiverBank

In 2005 the New South Wales Government established New South Wales RiverBank as a $105 million environmental fund to buy water for the state's most stressed and valued inland rivers and wetlands for five years until 2011. New South Wales RiverBank helps deliver a sustainable future for regional communities through an equitable and open water purchase process buying water from willing sellers. This innovative program allows the access and use of water to support and improve environmental and the socioeconomic values of rivers and wetlands.

Murray Annual Operating Plan

New South Wales State Water Corporation operates the Edward–Wakool River system under the Murray Annual Operating Plan, which considers flows to the Edward River, Gulpa and Bullatale creeks, and other rivers and streams that affect water distribution to the Barmah–Millewa icon site.

Environmental water allocation account rules

New South Wales Office of Water allocates and manages River Murray entitlement access in consideration of the Barmah–Millewa environmental water allocation accounting rules. These rules, revised in 2007, are codified in the Water Sharing Plan for the New South Wales Murray and Lower Darling Regulated River Water Sources.

Trout cod and silver perch recovery plans

The trout cod (*Maccullochella macquariensis*) and silver perch (*Bidyanus bidyanus*) recovery plans outline reasons for the decline of trout cod and silver perch throughout their New South Wales range and recovery measures to ensure their long-term viability. The plans were developed under the Fisheries Management Act (NSW).

Lower Murray River Endangered Ecological Community Priority Action Statement

The following recovery strategies have been identified in the Lower Murray River Endangered Ecological Community Priority Action Statement under the Fisheries Management Act (NSW):

- improve the share of water for the environment in regulated rivers, restore natural seasonal flow patterns, and reduce the impact of cold water originating from large dams
- conserve and, where possible, restore habitats through the protection of aquatic and riparian (riverside) vegetation, and encourage the use of effective siltation control measures
- actively monitor populations of introduced fish species at key sites and undertake eradication and/or control programs where appropriate
- provide local councils, agencies and catchment management authorities with resource materials regarding habitat protection and threatened species provisions of the Fisheries Management Act (NSW) to support planning, determination, impact assessment and concurrent decision-making processes; this may include impact assessment guidelines, mitigating prescriptions, offsets and generic consent conditions
- prepare and implement a recovery plan for the lower Murray River endangered ecological community.

Murray Catchment Management Authority Catchment Action Plan

The Murray CMA Catchment Action Plan provides a strategic framework for investment in natural resource management, and provides support for landholders and managers of public land for a range of on-ground activities in the catchment. A key feature of the catchment action plan will be the continued development of collaborative partnerships with industry; landholder groups; Landcare; federal, state and local government; and Indigenous communities.

New South Wales Ramsar Plan 2006–09

The New South Wales Ramsar Plan 2006–09 aims to guide the New South Wales Department of Environment, Climate Change and Water and other participating stakeholders in the key actions planned over three years to allow New South Wales and Australia to fulfil their obligations under the Ramsar Convention. Although this plan is currently due for review, it continues to be used as a guide to provide direction for the management of Ramsar wetlands.

Delivering the Ramsar Convention in New South Wales

At the time of writing, *Delivering the Ramsar Convention in New South Wales: roles and responsibilities of stakeholders in the management of New South Wales Ramsar wetlands* is consistent with New South Wales legislation and resource management processes. This report updates the 2006 publication's aims of helping Ramsar site managers understand their roles and responsibilities in maintaining the values of their respective sites as well as the roles and responsibilities of governments and non-government agencies.

Governance and planning arrangements

The Living Murray program is jointly and collaboratively managed by partner governments. The Murray–Darling Basin Intergovernmental Agreement on Addressing Water Overallocation and Achieving Environmental Objectives in the Murray–Darling Basin (Council of Australian Governments 2004) outlines the governance arrangement for implementing TLM. The 2004 intergovernmental agreement is complemented by The Living Murray Business Plan, which provides operational policies to guide TLM implementation.

The groups with a direct role in TLM governance are the MDBA, Basin Officials Committee, The Living Murray Committee and the Environmental Watering Group (see **Figure 1.2** for TLM governance structure)

While the MDBA plays a key coordination role at a TLM-wide level, management and delivery of TLM activities at icon sites are primarily undertaken by responsible agencies in the jurisdictions where the icon sites are located. The ultimate responsibility to ensure the icon sites are successfully governed lies with the Goulburn Broken Catchment Management Authority and the New South Wales Department of Environment, Climate Change and Water, as the managers of the icon site.

Joint management

The Barmah–Millewa icon site includes the Barmah Forest in Victoria and the Millewa Forest in New South Wales. Wherever possible, TLM activities are coordinated using cross-border steering committees (see **Figure 1.2**) (see **Appendix A** for state-specific governance arrangements).

Integrated Coordinating Committee

The Integrated Coordinating Committee's main role is to coordinate environmental watering and other TLM activities across the Barmah–Millewa icon site. As part of its role, the Integrated Coordinating Committee oversees the development and review of the icon site's environmental management plans, condition monitoring and communication and engagement activities.

State-based icon site managers are responsible for TLM implementation at the icon site level. In Barmah–Millewa, the designated icon site managers are the chief executive officer of the Goulburn Broken Catchment Management Authority, Victoria and the Regional Western Rivers Region of National Parks and Wildlife Services, New South Wales. Icon site managers work in conjunction with the Integrated Coordinating Committee and are supported by other cross-border icon site committees, including the Technical Advisory Committee, Community Reference Group and Indigenous Reference Group (see **Appendix A**). Icon site managers are also responsible for coordinating consultations with traditional land owners and the broader community.

Technical Advisory Committee

The Technical Advisory Committee is a cross-border committee that provides technical advice to the Integrated Coordinating Committee regarding TLM activities at the Barmah–Millewa icon site, including environmental watering, condition monitoring and other monitoring activities.

Membership of the Technical Advisory Committee and its roles and responsibilities are detailed in the Barmah–Millewa Technical Advisory Committee's terms of reference. The role of chairperson will alternate annually with the lead icon site manager.

Indigenous Reference Group

The Indigenous Reference Group was established to provide advice to the Integrated Coordinating Committee about the adequacy of proposed consultation and communication processes. The Indigenous Reference Group includes representatives from the Yorta Yorta nation and New South Wales Aboriginal land councils. The Indigenous Reference Group consists of the Cummeragunja Aboriginal Lands Council, the Deniliquin Aboriginal Lands Council and representatives from the Yorta Yorta nation.

The responsibilities of the Indigenous Reference Group are detailed in the Barmah–Millewa Indigenous Reference Group's terms of reference.

Community Reference Group

The Community Reference Group will provide advice to the Integrated Coordinating Committee on the adequacy of community consultation, ensuring the process is open and transparent. The main functions of the Community Reference Group are to review the Barmah–Millewa icon site communication strategy (see **Chapter 6** for more details), and to provide advice on consultation with regional and local groups that have an interest in the water management at the icon site.

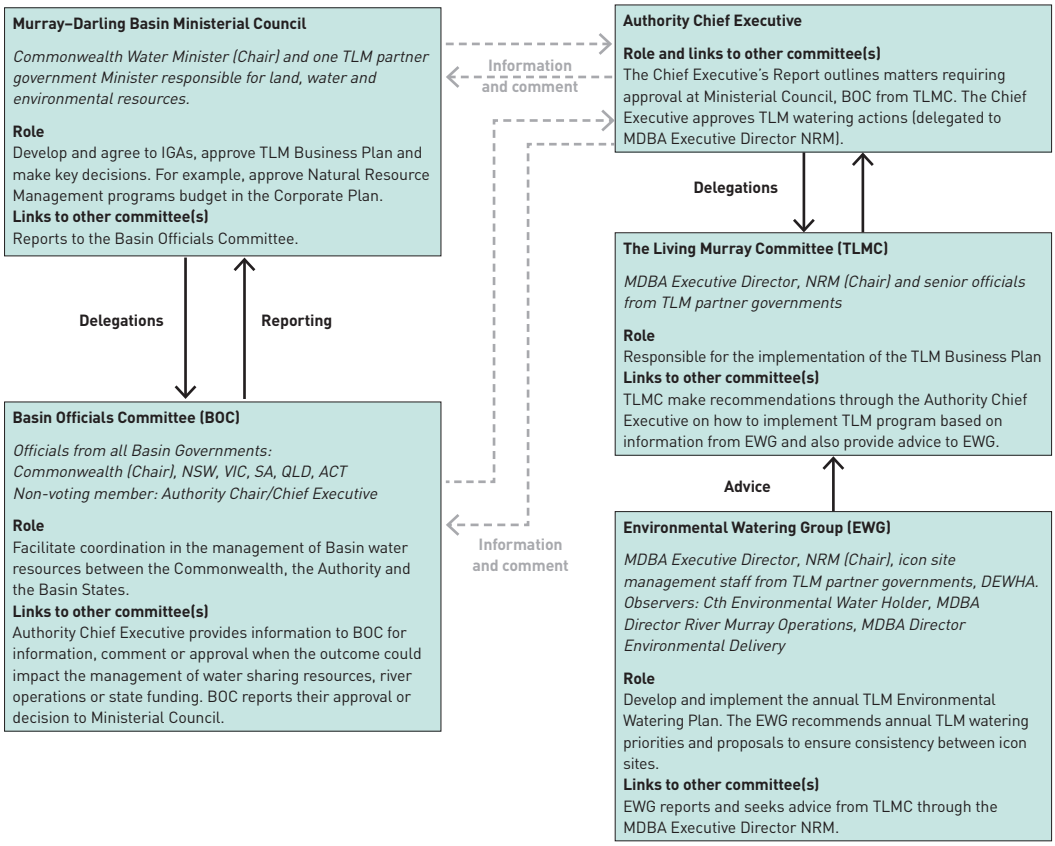


Figure 1.2: The Living Murray governance structure (MDBA 2010)

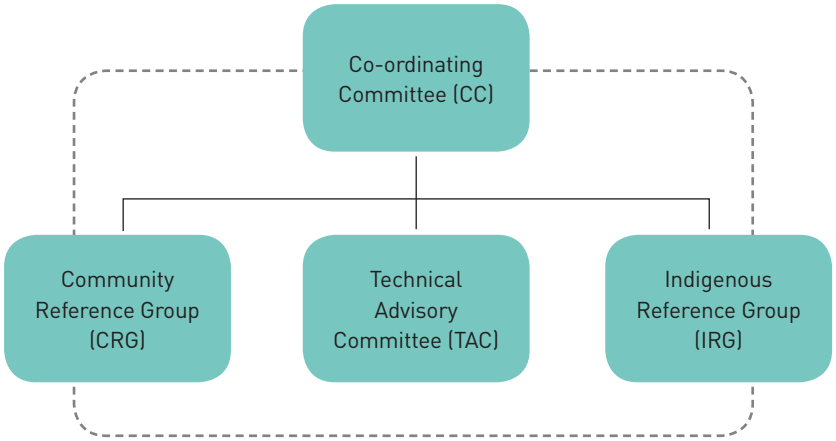


Figure 1.3: Cross-border management committees: Barmah–Millewa

2. Icon site description

The Barmah–Millewa Forest icon site covers 66,600 ha and straddles the Murray and Edwards rivers between the towns of Tocumwal, Deniliquin and Echuca (see **Figure 2.1**). The site is a continuous forest and wetland system 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.

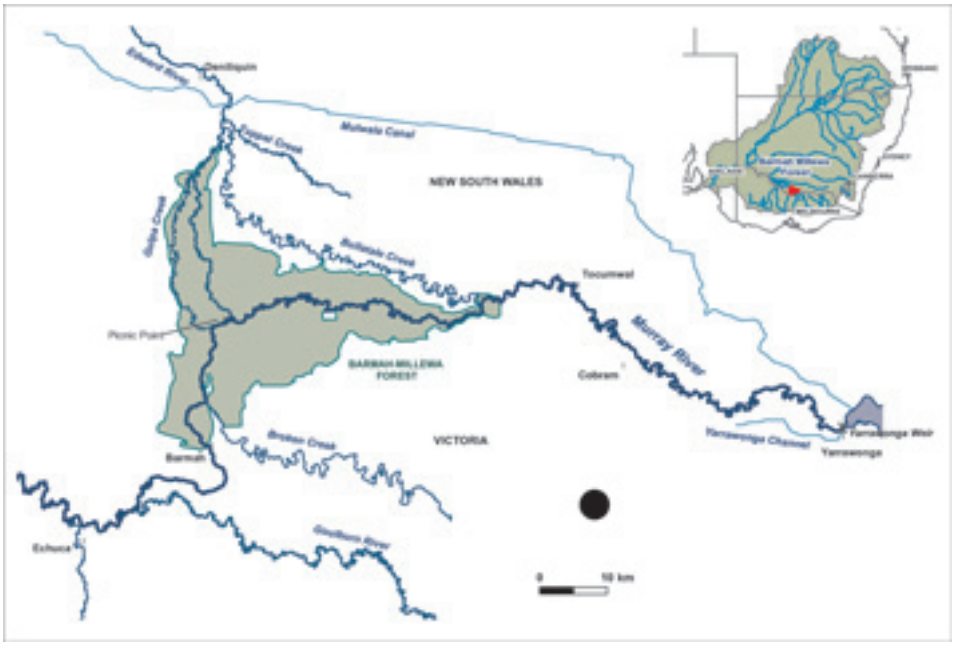


Figure 2.1: Barmah–Millewa Forest icon site

Description of key ecological assets of the icon site

The extensive floodplain forests are the result of a geologic fault line that created an uplifting of land about 25,000 years ago. Although only about 12 m high, it is an important feature in this otherwise flat landscape, changing the flow path and pattern of the River Murray and creating the Edward–Wakool River system section. The location where the Murray cuts through to the Goulburn channel is known as the Barmah Choke because of its limited flow capacity (~8.5 GL/d).

During higher river flows, the choke causes water to back up and break out across the floodplains of the Barmah and Millewa forests. This attenuates flood peaks, reducing the height of floods downstream. This regular flooding means that the forests can support flora and fauna typical of a region that receives two or three times more rainfall.

The Barmah–Millewa icon site is characterised by:

- swamps and marshes in the lower frequently flooded areas where water can pond
- rushbeds surrounding the swamps and marshes, also generally in wetter areas
- deeper lakes and billabongs that provide important reed bed areas during large colonial waterbird-breeding events
- open grassland plains, including large plains of moira grass. When flooded, these are highly significant as breeding and feeding habitat for colonial breeding water birds like egrets (g. *Egretta* or *Ardea*), herons (Ardeidae f.), spoonbills (Threskiornithidae f.) and marsh terns (*Chlidonias*)
- river red gum forest of various types and health, depending on inundation, with the lower elevation areas supporting larger and denser trees
- black box (*E. largiflorens)* woodland in the high, drier zones
- deep creek channels which distribute water throughout the forest and back to the river.

The Barmah–Millewa Forest icon site supports the largest river red gum forest in Australia, and is the largest and most intact freshwater floodplain system along the River Murray. The Victorian component of the icon site also supports the most extensive area of moira grass plains in the state, despite recent declines. It covered 5.2%, or 1,535 ha, in 1979 (Chesterfield 1979), although is now believed to cover 2.5%, or 850 ha (Victorian Department of Sustainability and Environment 2008).

River red gum continues to expand in distribution and abundance on the floodplain. Bren and Acenolaza (2002) modelled the future expansion of the species in Barmah–Millewa Forest based on post-regulated river trends in river red gum colonisation. This indicated that river red gum would colonise moira grass plains within 100 years. The observed giant rush (*Juncus ingens*) colonisation rates (not modelled), however, may indicate that the expiration of moira grass plains is more rapid.

Presently, dense stands of river red gum have established across about 75% of the Porters and Algeboia moira grass plains in Millewa Forest. The encroachment of river red gums into areas that were predominately treeless is largely because of the change in natural flooding patterns (i.e. frequency, duration and extent), which allows seedlings to establish rather than being 'drowned out' during successive floods. The New South Wales Department of Environment, Climate Change and Water is currently mapping the extent of the moira grass plains that existed in the Millewa Forest before the 1974–75 floods, supposedly one of several river red gum regeneration events that occurred during the twentieth century (Forestry Commission of New South Wales 1984).

Values of the icon site

Environmental values

At least 381 indigenous flora species and 221 indigenous vertebrate fauna species have been recorded in Barmah Forest (Victoria Department of Sustainability and Environment 2004; Loyn *et al*. 2002).

The Barmah–Millewa Forest provides habitat for numerous flora and fauna species (including birds, fish and reptiles), and supports colonies of breeding waterbirds during appropriate seasonal conditions (MDBC 2004, appendixes B and C).

When flooded, Barmah–Millewa Forest provides important feeding and breeding habitat for thousands of waterbirds. About 54 species have been recorded breeding in the forest, including 25 colonial nesting species. Barmah Forest regularly supports 1% of the population of Australian white ibis (*Threskiornis molucca*) and straw-necked ibis (*T. spinicollis*) (Vic. Department of Sustainability and Environment 2003).

The site also supports large numbers of migratory bird species, including 13 listed under international migratory bird treaties (China–Australia Migratory Bird Agreement, Japan–Australia Migratory Bird Agreement, and the Republic of Korea – Australia Migratory Bird Agreement) and 23 listed under the Bonn Convention on Migratory Species.

The icon site is also known to support a range of threatened species (see **Appendix B**, which lists significant flora in Barmah–Millewa Forest), including:

- 6 nationally threatened flora species
- 11 state-listed flora species
- 13 nationally threatened fauna species
- 44 state-listed fauna species.

In addition to freshwater wetlands, Barmah–Millewa Forest supports five main vegetation types. River red gum communities are the most prevalent, with smaller areas of giant rush and moira grass plains. The area of each vegetation type is shown in **Table 2.1**.

Table 2.1: Area of key vegetation communities: Barmah–Millewa Forest

Vegetation types	Barmah (ha)[a]	Millewa (ha)[b]	Total area (ha) (percentage of total)
Giant rush	531	2,667[c]	3,198 (4.8)
Moira grass	850	774[c]	2,309 (3.5)
River red gum forest (with a flood-dependent understorey)	16,617	26,181	42,798 (64.8)
River red gum woodland (with flood-tolerant understorey)	9,711	4,002	13,713 (20.8)
River red gum/black box woodland	1,063	2,919	3,982 (6.0)
Total	29,457	36,543	66,000

a Data sourced from Department of Sustainability and Environment (2008)
b Data sourced from GHD (2009)
c Note: area of giant rush and moira grass in Millewa Forest are not provided in GHD (2009) and were derived from wetland area.

Ecosystem functions of the Barmah–Millewa Forest include connectivity, organic carbon storage, water supply, groundwater recharge, maintenance of flow regimes and flood control (Ward & Colloff 2010). For example, the Barmah Forest alone forms a natural flood retardation basin with an estimated holding capacity of 32.1 GL (Victorian Department of Sustainability and Environment & Goulburn Broken Catchment Management Authority 2005).

Cultural values

Indigenous values

The Barmah–Millewa Forest is listed on the Register of the National Estate in recognition of its importance as part of Australia's heritage and outstanding natural values. There are important and significant land associations and connections to the Barmah–Millewa Forest among Indigenous Australians and the broader community (MDBC 2004). Consequently, the cultural landscape within the icon site reflects both Indigenous and European activities.

Since time immemorial, this area has been the heartland of the Yorta Yorta people. It has supported Yorta Yorta society for over 60,000 years, providing a rich abundance of food, medicinal and cultural resources. The ongoing connection to this landscape is evident through Yorta Yorta creation stories and their wealth of traditional ecological knowledge.

The Yorta Yorta nation's recently-completed land use and occupancy map demonstrates an ongoing connection to the forest, showing known occupancy and harvest sites for plant, wood, earth, invertebrates, fish, reptile, bird and mammal resources (Tobias 2009).

Of particular significance to the Yorta Yorta is their totem animal – the broad-shelled turtle (*Macrochelodina expansa*). In 2009–10, the Yorta Yorta carried out a cultural survey for this species with the assistance of the Arthur Rylah Institute. A focus of Yorta Yorta is now to develop a cultural report of their totem and further investigate key aspects of turtle ecology.

Heritage values

The range of non-Indigenous historic places in the forest reflects a number of different phases of European activity in the area. Artefacts of early European settlement are scattered throughout the forest, though predominantly the events that occurred and their effects are considered to have most historical value instead of what remains.

Social values

The Barmah–Millewa Forest is also popular for recreation and tourism, with most visitors attracted to the river environs. Barmah–Millewa Forest receives about 100,000 visitors a day per year (Abel & O'Connell 2006). Popular activities include bike-riding, boating, bushwalking, camping, canoeing, cycling, fishing, four-wheel driving, horse-riding, orienteering, picnicking and scenic driving — all of which continue under the forest's recent reservation status conversion to national park, which means that previously allowed activities such as hunting and dog-walking are no longer permitted. The strong interest for nature studies, including activities such as birdwatching and interpretive cruises of the lakes, highlights the abundance of wildlife in the area, along with its ecology and history.

Economic values

The components, functions and attributes of Barmah–Millewa Forest provide a variety of direct and indirect economic values to the area. Direct economic values, post-National Park reservation, are largely derived from activities associated with recreation and tourism. In contrast, the natural functions of this icon site have important and indirect measurable values such as flood and flow control, nutrient retention and water quality maintenance. These values support or protect economic activities, and hence have direct and measurable values.

3. Ecological objectives and water requirements

The Living Murray First Step icon site objectives

Based on an understanding of the icon site's characteristics and ecological requirements First Step Decision interim ecological objectives were developed and approved by Murray–Darling Basin Ministerial Council in 2003. For the Barmah–Millewa icon site, the interim ecological objective is to enhance forest, fish and wildlife values, ensuring:

- successful breeding of thousands of colonial waterbirds in at least three years in 10
- healthy vegetation in at least 55% of the area of the forest, (including virtually all of the giant rush, moira grass, river red gum forest and some river red gum woodland).

Since these objectives were approved by Ministerial Council in 2003, jurisdictional agencies have continued to review and refine the First Step interim objectives to develop refined ecological objectives for icon sites.

These refined ecological objectives reflect eight years of learning's from the delivery of environmental water, monitoring, modelling and consultation activities and scientific research, and enable a clearer, more effective, evaluation of environmental responses to environmental water delivery.

In consultation with communities, the First Step Decision objectives that relate to Victorian environmental water management plans have been extended to develop overarching objectives. These overarching objectives better reflect the specific icon site values that the environmental waterings aim to protect, as well as relevant jurisdictional management plans and obligations.

The objectives for the Barmah–Millewa environmental water management Plan are at **Table 3.1**. In addition to the overarching objectives, more detailed objectives have been developed to guide icon site management. Targets to measure progress towards these objectives are under development for this icon site.

Table 3.1: Revised First Step Decision ecological objectives for Barmah–Millewa icon site

Icon site ecological objectives		
Overarching objectives	**Detailed objectives**	**Targets**
To maintain and, where practicable, enhance the ecological character of the Barmah–Millewa floodplain		
Vegetation • Restore the extent and distribution of healthy wetland and floodplain vegetation communities	• 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 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.	Targets under development
Waterbirds • Provide suitable feeding and breeding habitat for a range of waterbirds, including colonial nesting species	Promote and/or sustain successful breeding events for thousands of colonial and migratory waterbirds in at least 3 years in 10 by inundating selected floodplain and wetland areas to provide suitable nesting and feeding habitat.	Targets under development
Fish • Support successful breeding and recruitment of native fish species	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.	Targets under development
Other water-dependent species • Provide high quality feeding, breeding and nursery habitat for native frogs, turtles and crayfish	• 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.	Targets under development

Water requirements

Ecological communities within the Barmah–Millewa icon site have evolved to use a variable flooding regime, dictated by the combination of natural seasonal flows and the effect of the Barmah Choke. To meet ecological objectives set for the icon site, specific flows are needed to meet the water requirements of vegetation communities, waterbirds and fish.

The preferred water requirements of key vegetation communities and biota are defined in **Table 3.2**, based on the pre-regulation flooding regime. Specific River Murray flows are needed to create flooding within different communities.

Vegetation

Water requirements of the various vegetation communities can be defined in terms of the seasonality, depth, duration and frequency of flooding, and the tolerable drying phase duration. These characteristics influence important stages in plant life cycles including germination, establishment and growth (Roberts 2006). Figure 3.1 demonstrates a cross-section of the forest, showing key vegetation communities and their water requirements. Figure 3.1 shows the commence-to-flow discharges for these communities. 'Effective flooding' (i.e. with a minimum required depth of water) of these communities occurs at higher discharges. Although this work was undertaken on the Barmah Forest component of the icon site only, it is expected that the commence-to-flow thresholds for the vegetation types will be similar for Millewa Forest. Only the area of inundation in the chart would alter with Millewa Forest's inclusion.

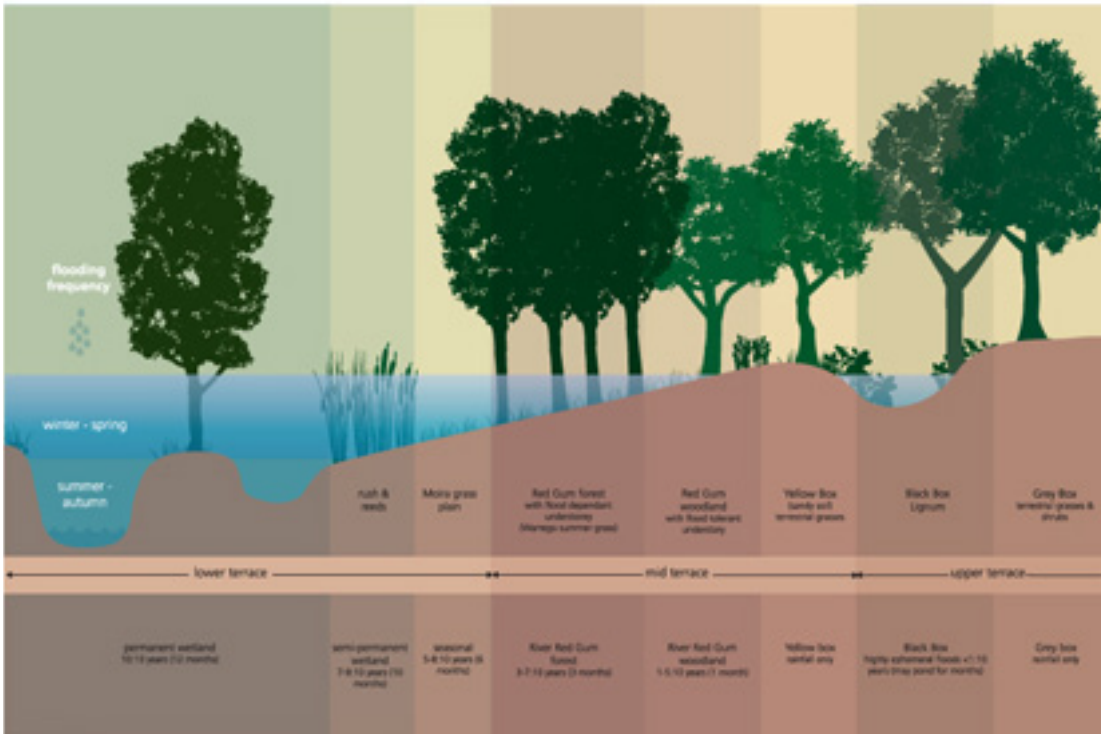
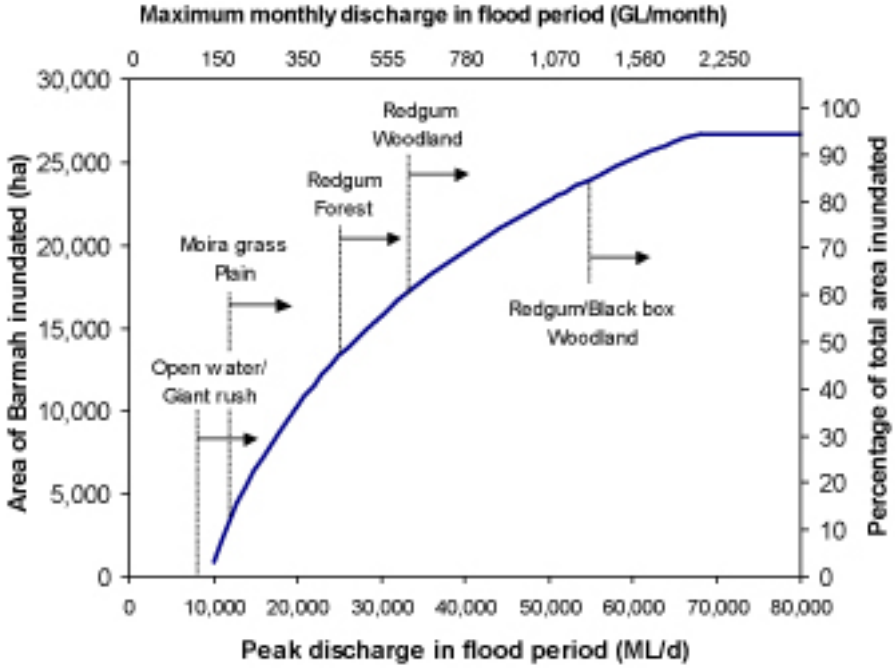


Figure 3.1: Cross-section of floodplain showing key vegetation communities and their water requirement: Barmah–Millewa

Figure 3.2: Area of Barmah Forest inundated as a function of River Murray flood peak: at Tocumwal (instantaneous peak discharge, ML/d) and Yarrawonga (monthly total discharge, GL/m)



Source: Bren *et al*. (1987 & 1988)

Waterbirds

To meet the ecological objective for waterbirds (successful breeding events of thousands of colonial and migratory waterbirds in at least 3 years in 10), long floods (15–18 GL/d for four to five months) lasting through spring into early summer are required. This would ensure that a range of species could nest, breed and fledge chicks before water levels started to decline.

As well as ensuring that water depth is maintained under nesting colonies until chicks are fledged, sufficient food resources must be available to support chicks and adults. Nesting colonial waterbirds will travel to wetlands within a 20 km radius of their nest sites in search of food; the success of a breeding event therefore depends on the availability of food resources within travelling distance of breeding colonies (Reid 2006).

Fish

Regular floods of varying sizes are also needed to meet the ecological objectives for native fish. Studies have shown that flooding can influence the spawning and recruitment success of both small- and large-bodied species.

Most small-bodied species, including pygmy perch (*Nannoperca vittata*), smelt (*Retropinna semoni*) and gudgeon (Eleotridae family), are not flow-dependent spawners and so benefit from the lower range of flows. Higher flows provide connectivity through the floodplain and increase their access to a wider range of habitats.

Golden perch (*Macquaria ambigua*), silver perch, Murray cod (*Maccullochella peelii*) and trout cod are able to spawn during low-flow and flood conditions. However, the response and mechanism is different for each species (King *et al*. 2007). Golden perch and silver perch are able to spawn during floods and within channel flows, although higher spawning activity occurs during flood conditions. Spawning of Murray cod and trout cod depends on photoperiod (natural day length) and water temperature rather than flow conditions, but similarly higher recruitment occurs following floodplain inundation (King *et al.* 2007 & 2010). The productivity pulse and consequent increase in zooplankton is thought to provide a valuable food resource for larvae and juveniles.

Finally, floods in the Barmah–Millewa icon site have an important role in maintaining habitat and creating connectivity within floodplain creeks and wetlands for a variety of fish species.

Late spring and summer floods present a heightened risk for native fish because forest flooding during warm and hot conditions has a greater potential to generate black anoxic water that can be toxic to fish within the forest and within the river channel.

Wetland specialists such as the threatened southern pygmy perch (*N. australis*) exist within the forest's creek habitats but not within the main river channel. Environmental water can be used to maintain these habitats during prolonged dry spells and prevent the loss of the local populations of these species.

Table 3.2: Water requirements of key vegetation communities and biota: Barmah–Millewa icon site

Component	Timing	Duration	Frequency	Depth (if critical)	Maximum time between floods	River flows required (at Yarrawonga)
Giant rush	Winter to mid-summer	7–10 months	7–10 years in 10	Not critical	2 years	4.5–12 GL/d
Moira grass plains	Winter to mid-summer	5–9 months (no more than 10 months) Note: an annual dry period of 2–3 months from late summer to early autumn is needed	6–10 years in 10	Minimum depth = 0.5 m	3 years	12–25 GL/d
River red gum forest	Winter to spring	3–5 months	4–9 years in 10	Not critical	4 years	15–35 GL/d
River red gum woodland	Winter to spring	1–4 months	3–5 years in 10	Not critical	5 years	35–55 GL/d
Black box woodland	Spring	1–3 months	1–2 years in 10	Not critical	12 years	55–60 GL/d
Breeding conditions for colonial nesting waterbirds — e.g. ibises and spoonbills (both Threskiornithidae family), and egrets (genera *Egretta* or *Ardea*)	Spring to summer	4 months (30 GL/d for 3 months, 18 GL/d for 1 month)	3 years in 10	Relatively stable water levels are required (i.e. no sudden reduction in depth)	2 years	18–30 GL/d
Fish:	Native fish requirements will generally be met by those specified for vegetation and waterbirds.					
Low-flow specialists, flood-dependent spawners	Important to avoid commencement of overbank watering in late spring/summer because of higher water temperatures and heightened risk of black anoxic water events causing fish kills. Targeted maintenance of pool habitats along creeks within the forest (e.g. Toupna Creek) may be required during prolonged dry spells to maintain populations of threatened species such as southern pygmy perch.					

Source: Adapted from Sharley and Huggan (1995); Ward (1991); Roberts and Marston (2000); Bren *et al.* (1988); Leitch (1989); and Dexter (1978), all cited in Vic. Department of Sustainability and Environment and Goulburn Broken Catchment Management Authority (2005)

Climate and rainfall in the Murray–Darling Basin

Historically the climate of the Murray–Darling Basin has been variable. Climate change science indicates a likely increase in this variability, resulting in more frequent and extreme floods and droughts (MDBA 2010). Consequently, river storages and the use of environmental water will be managed according to these varying river flows.

From 1996–2010, the Murray–Darling Basin was in drought, characterised by below-average rainfall in autumn and winter and few wet periods. This drought was significantly drier than the Federation Drought (mid-1890s to early 1900s) and the droughts of the World War II era (c. 1937–45).

Beginning in spring 2010, and continuing through the summer of 2010-11, widespread, above average rainfall across the Murray–Darling Basin broke the long standing drought. This rainfall was associated with the development, beginning in 2010, of a moderate to strong La Nina event making 2010 the wettest year on record for the Murray–Darling Basin.

Antecedent hydrological conditions

The combined effects of river regulation and water extraction have caused a reduction in the frequency, size and duration of the floods needed to sustain the Barmah–Millewa icon site. In addition, Barmah–Millewa Forest experienced drought conditions from 2000–10. During that decade, one medium-size flood occurred in 2005, when about 57% of the floodplain was inundated. Otherwise most of the forest's wetlands and waterways completely dried up – many for the first time in decades and some possibly for the first time in recorded history.

Small volumes of environmental water were released in 2008–09 and 2009–10 to maintain critical drought refuges. While this improved the health of reed and rush beds and fringing river red gum (Cunningham in prep.), some of the higher regions of the floodplain had not been watered since 1996. During the spring and summer of 2010, Barmah–Millewa Forest experienced the greatest flood extent for a decade (inundating about 85%[2] of the floodplain for a short period in September and again in December), though the lower terraces of the floodplain had been in receipt of flooding since July 2010.

Despite the prolonged low flows over the past decade, condition monitoring show Barmah–Millewa Forest still supports a diverse range of fish species. Murray cod recruitment has been found to be high in recent surveys, and silver perch, Murray cod, golden perch and trout cod were all recorded spawning in spring 2009 (Rourke *et al*. 2010).

No major waterbird breeding events occurred between 2005 and 2010. Small-scale breeding occurred in 2009–10 at several sites in Millewa Forest that received environmental water. The 2010 spring-summer bird breeding event was extremely significant, one that was unlikely to have been surpassed during the previous 60 years.

An unfortunate effect of the drought has been the mass colonisation of giant rush on Barmah Lake since 2007. While giant rush provides suitable habitat for a number of colonial-nesting waterbird species, it also forms dense mono-specific stands that may exclude all other plant species to the detriment of other wetland biodiversity.

The flood events of 2010–11 resulted in a major waterbird breeding event in Millewa Forest, with colonial and non-colonial nesting waterbirds recorded at six wetlands. As well as these identified sites, the flooded river red gum communities within the Millewa Forest have supported a range of nesting waterbirds such as grey teal (*Anas gracilis*) and Eurasian coot (*Fulica atra*). At the time of writing, it is estimated that 10,500 to 15,500 birds were nesting at these locations as a result of the 2010–11 floods.

Past management actions and activities

Barmah–Millewa Forest has been used for timber harvesting (commercial and firewood) and commercial stock grazing since the mid-1800s. Logging and grazing have ceased in line with land tenure changes to national park in both the Barmah and Millewa forests in 2010. Fire has been used to manage fuel-loads and as a management tool to control giant rush (Ward 2009a). Fuel reduction burns and timber-thinning for ecological purposes remain management options.

2 Initial estimate provided by Parks Victoria; may be subject to revision following measurement.

4. Water delivery

Prioritising water requirements

The Living Murray (TLM) Annual Watering Plan, developed by the Environmental Watering Group, includes a flexible decision framework to guide prioritisation of environmental watering actions, icon site environmental watering proposals developed by icon site managers with jurisdictional agencies, water availability forecasts and management objectives for water resource scenarios (see **Table 4.1**).

Throughout the year the Environmental Watering Group recommends environmental watering actions to the Murray–Darling Basin Authority (MDBA) for approval. These recommendations are based on the Annual Environmental Watering Plan and the volume of water available in The Living Murray environmental water portfolio.

Sites are prioritised for watering in the Barmah–Millewa icon site using a numeric scoring system based on a site's departure from an 'ideal' flood history (Bren 1988). Under this method, each water management area within the forest is assigned an annual flood score based on flood rankings from 0 for 'No flooding' to 3 for 'Completely flooded'. The ideal flooding score is based on the ideal long-term flooding frequency for the dominant vegetation type found in most of that water management area.

The feasibility of flooding targeted sites also needs to be considered when developing annual priorities, including commence-to-flow thresholds (see **Appendix D** of this report) and the duration required for flows to spread to the targeted area (such as those derived from hydrodynamic model outputs; see **Appendix E** of this report).

Prioritisation occurs under each water availability scenario—extreme dry, dry, median and wet (see **Table 4.1**). The actual decision-making process for delivery of environmental water can be complex (as is variously discussed in more detail in the following sections) because it needs to consider factors (e.g. King *et al*. 2010) such as:

- identification of the ecological objective (as determined from field observation, recognition of flood requirement, understanding of risk assessment, predictions of flood requirement being met without intervention, and knowledge of management intervention options and their likely success)
- available water volume for potential delivery
- identification of water volume required to successfully achieve ecological objectives
- ability to deliver the water to the selected target (usually depends upon suitable river levels being achieved before commence-to-flow thresholds can be breached or upstream channel capacity constraints such as those identified in **Appendix D**)
- antecedent flows (i.e. previously inundated floodplain uses less water than a current dry floodplain)
- time of year (reflects differing biological requirements, weather statistics, water volumes, competing management activities and requirements etc.)
- relative and/or compounding priorities (such as the number of nesting birds or time since last successful breeding)
- understanding of potential negative risks (such as blackwater or carp spawning) when watering a particular target
- forecasted weather and flows likely to support watering aims (e.g. probability of a natural flood or substantial rainfall event occurring to achieve or undermine target in with/without water management action)
- complementary management activities to maximise environmental targets being sought by watering actions.

For example, small volumes of environmental water (less than 1 GL) available during extreme dry scenarios (drought conditions) are likely only to target drought refuges for threatened fish species in waterways. Areas in which antecedent flooding during wetter periods has created waterbird breeding responses that are nearing completion but are threatened by premature flood subsidence may instead need to receive small allocations of environmental water. However, this action will depend on factors such as the species involved, their number, the last time of successful breeding and their location (for water delivery).

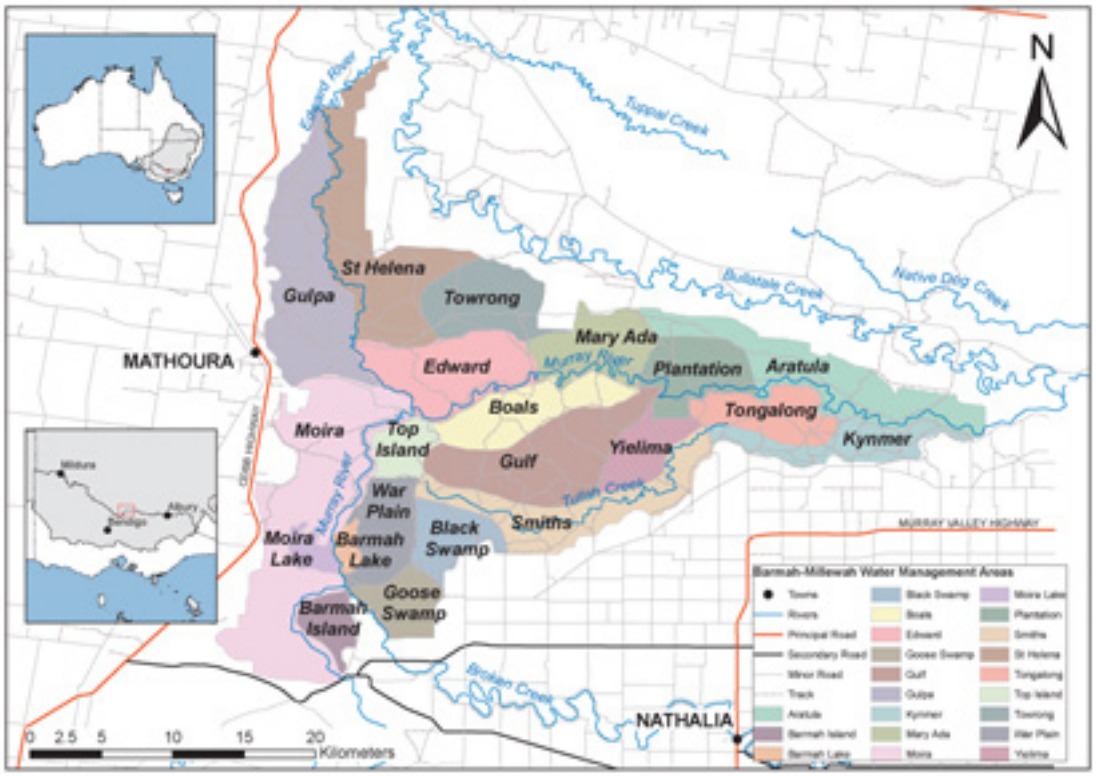


Figure 4.1: Barmah–Millewa water management area boundaries

Table 4.1: Objectives under different water availability scenarios

	Extreme dry	Dry	Median	Wet
Ecological watering objectives	Avoid irretrievable loss of key environmental assets	Ensure priority river reaches and wetlands have maintained their basic functions	Ecological health of priority river reaches and wetlands have been protected or improved	Improve the health and resilience of aquatic ecosystems
Management objectives	Avoid critical loss of species, communities and ecosystems Maintain key refuges Avoid irretrievable damage or catastrophic events	Maintain river functioning with reduced reproductive capacity Maintain key functions of high priority wetlands Manage within dry spell tolerances Support connectivity between sites	Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna Promote low-lying, floodplain-river connectivity Support medium flow river and floodplain functional processes	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna Promote higher floodplain-river connectivity Support high flow river and floodplain functional processes
Example priority locations for Barmah–Millewa Forest	Gulf Creek Toupna Creek	Gulf Creek Toupna Creek Boals Deadwoods	Assume normal year so open all regulators in forest; areas that get watered will depend on actual flows	All regulators open

The Living Murray works and water modelling

Water modelling

Modelling completed in 2008 found that the environmental water requirements of the floodplain icon sites (with the exception of Barmah–Millewa and the Lower Lakes, Coorong and Murray Mouth and River Murray Channel icon sites) could largely be met by a combination of the proposed TLM works, the 500 GL of recovered TLM water and 70 GL long-term Cap equivalent (LTCE) of River Murray Increased Flows.

This modelling was based on a number of assumptions including the use of unregulated flow events for environmental watering actions. It was also agreed as a modelling principle that return flows could be used to water at multiple environmental sites. There are a number of constraints to the implementation of this principle which TLM are currently working to resolve.

Further modelling is also planned to allow greater optimisation of works and measures to achieve icon site ecological objectives as we gain a greater understanding of operating scenarios.

Water management infrastructure

More than 50 water management structures exist within the Barmah–Millewa icon site. Most of the larger structures were built in the late 1930s following regulation of the River Murray to prevent water loss from the regulated river into the forest.

More recently, many smaller structures have been constructed to re-permit flow into previously blocked creeks or into areas where improved water management for the wetland system ecology has been identified (Department of Sustainability and Environment & Goulburn Broken Catchment Management Authority 2005).

The Living Murray investigations at Barmah–Millewa Forest, including development of a hydraulic model for the icon site, showed that options to use infrastructure to create large-scale flooding are limited. The shedding nature of the floodplain means that once the river's flow drops, water runs off the floodplain and only a few wetland basins retain water for longer periods. Achieving the forest's ecological objectives would therefore generally require sustained high-river flows, requiring the use of natural river freshes and environmental water allocations (see **Chapter 3**, 'Refined ecological objectives'). Flood easements up to 25,000 ML/d have been purchased between Hume and Yarrawonga to avoid legal issues associated with flooding private land.

Small-scale works to improve water management within the Barmah–Millewa Forest have been developed to various stages. Construction has been completed for fishways on Stevens Weir on the Edwards River and on Gulpa Creek, in New South Wales. Detailed designs for a number of proposals have been completed and are ready for implementation should funds become available through TLM or another source.

Table 4.2: The Living Murray water management infrastructure: Barmah–Millewa Forest

Structure	Function	Status
Fishways on Stevens Weir, Edward River and Gulpa Creek (NSW)	Provision of fish passage through weirs and regulators.	Stevens Weir construction proposed for completion in June 2011. Edward River off-take construction proposed for completion in April/May 2011. Gulpa Creek construction completed December 2010.
Kynmer Creek regulator (Vic.)	To allow more frequent inflows (when required), it has been proposed to replace an existing block bank with a regulator, similar to other forest waterways.	Detailed design completed.
Gulf Creek fishway (Vic.)	The large regulators on the upstream end of the waterway (near the River Murray) prevent fish returning to the River Murray when closed. To prevent fish stranding behind the regulators, it is proposed to construct a single fishway on the northern Gulf Creek regulator.	Detailed design completed.
Upgrade of tertiary regulators (Vic.)	Refurbishment and renewal of existing tertiary regulators within Barmah Forest.	Construction completed.

Operating regimes for environmental water actions

This section of the environmental water management plan provides a broad description of the proposed operating regimes to maximise ecological outcomes from the use of The Living Murray Water portfolio and works. To meet the proposed operating regimes a combination of unregulated and regulated environmental water may be used. While this environmental water management plan focuses on the use of environmental water from The Living Murray's Water Portfolio, there may also be other sources of environmental water available to meet the proposed regimes.

The proposed operating strategy (**Schedule 2**) for the Barmah–Millewa Forest icon site aims to achieve the ecological objectives set for the forests by providing the water requirements for key vegetation communities, including wetlands, giant rush, moira grass plains, river red gum forest and woodland and black box communities. The operating strategy also includes specific flow recommendations to support breeding events of waterbirds, including colonial and non-colonial nesters.

If necessary, Barmah–Millewa Forest can be managed to a degree as separate water management areas, through activation of specific flow-paths (via channels and regulators). However, this does not provide full connectivity with the river and is the preferred approach only when water is limited (Vic. Department of Sustainability and Environment & Goulburn Broken Catchment Management Authority 2005). As flood magnitude increases, the ability to manage the forest in this way decreases.

As an example, **Table 4.3** describes how different regulators could be operated to target specific water management areas during different times of the year. Water management during natural flooding periods aims to inundate open wetland environments (e.g. colonial waterbird breeding sites and moira grass plains), depending on antecedent flood conditions. Outside such periods, the opposite course of action may be taken, by closing regulators to avoid flooding within sensitive wetlands.

For the purposes of TLM modelling, preferred and minimum operating strategies were developed for the Barmah–Millewa icon site. **Table 4.4** illustrates the links between the operating regime and ecological objectives.

Table 4.3: Variable operation of Barmah–Millewa Forest regulators during seasonal and unseasonal flood periods

River Murray flow at Yarrawonga (GL/d)	July to mid-December		Mid-December to May	
	Regulators to be opened	Water management area affected	Regulators to be opened	Water management areas affected
11	Victoria • Gulf Creek (partial)	• Gulf	Victoria • tertiary regulators • Sandspit • Boals • partial Bull Paddock • partial Stewarts Kitchen	• Boals Deadwood • partial Top Island • Tongalong Creek • Towong water management area
	New South Wales • Mary Ada	• Mary Ada	New South Wales • Mary Ada (partial)	–
12	Victoria • Sandspit • Bull Paddock, Stewarts Kitchen • 25% Gulf	• Smiths • Gulf • northern Barmah (except Boals) • Edward, Moira and Aratula	Victoria • tertiary regulators • Sandspit • Boals • partial Bull Paddock • partial Stewarts Kitchen	• Boals Deadwood • partial Top Island • Tongalong Creek • Towong water management area
	New South Wales • Mary Ada • selected others (depending on duration)	–	New South Wales • Mary Ada • selected others (depending on duration)	–
13	Victoria • Sandspit • Bull Paddock • Stewarts Kitchen • 50% Gulf	• Smiths • Gulf • northern Barmah (except Boals) • Edward • Moira • Aratula	Victoria • all except for minimal Gulf	• all (minimal Gulf) • Towong, increasing to most other water management areas
	New South Wales • Mary Ada • selected others (depending on duration)	–	New South Wales • Mary Ada • selected others (depending on duration)	–
14	Victoria • All, except Boals Deadwoods	• all, except parts of Boals Deadwood • Edward • Moira • Aratula • Plantation • Towong • St Helena	Victoria • all, with more Gulf	• all (moderate Gulf) • Towong, increasing to most other water management areas
	New South Wales • Mary Ada • selected others (depending on duration)	–	New South Wales • Mary Ada • selected others (depending on duration)	–
≥15	all regulators open (Gulf and Mary Ada progressively opened greater up to 25 GL/d)	all	all regulators open	all

Table 4.4: Operating regime that contribute to the ecological objectives

Ecological objective	Vegetation community (Area inundated in hectares)	Mechanism to meet objective (river flows)	Frequency (years in 10)	Duration (days)	Estimated volume of water required	Estimated volume of water used
Preferred operating scenario						
Healthy vegetation in at least 55% of the area of the forest	Low-lying creeks and wetlands (1,000)	11 GL/d	9	30	There are no current estimates for volumes of water required or used at Barmah–Millewa Forest. Once the floodplain is wetted up, the forests function as a flow through system; about 95% of flows return to the river.	
	Wetlands and moira grass plains (7,000–10,000)	18 GL/d	7	120		
	Red gum forest (17,000)	30 GL/d	5	90		
	Red gum woodland (24,000)	60 GL/d	3	30		
Successful breeding events of thousands of colonial waterbirds in at least three years in 10	Creeks, wetlands, moira grass plains, red gum forest and woodland (24,000)	30 GL/d 18 GL/d	3	90 30		
Minimum operating strategy						
Healthy vegetation in at least 55% of the area of the forest	Low-lying creeks and wetlands (1,000)	11 GL/d	5	30	As above	
	Wetlands and moira grass plains (7,000–10,000)	18 GL/d	3	120		
	Red gum forest (15,000)	25 GL/d	2	30		
Successful breeding events of thousands of colonial and migratory waterbirds in at least three years in 10	Creeks, wetlands, moira grass plains, red gum forest and woodland (15,000)	25 GL/d 18 GL/d	2	90 30		

Water accounting and measurement

Water accounting methodology will be developed and agreed in advance by The Living Murray Committee and the Basin Officials Committee. Consistency of water accounting methodology will be sought wherever possible. Where relevant, water accounting will be consistent with the Water Accounting Conceptual Framework and Australian Water Accounting Standards.

The best available, most appropriate and cost-effective measurement technique will be used to determine environmental water use. The appropriateness of the measurement technique is likely to differ depending on icon site and event. For example, under dry conditions, environmental water pumped into Hattah Lakes is likely to be measured using a meter while return flows are measured via a gauging station. Under wet conditions, environmental water returning from Barmah–Millewa Forest will need to be modelled.

Water use

Water used within the icon site will vary depending on antecedent conditions. When the floodplain is dry, about 30% of floodwaters are lost through seepage, with about 70% returning to the river. Once the floodplain is wet, the forests function as a flow-through system. About 95% of flows return to the river.

Because of the numerous entry points, the lack of fall through the forest and inability to measure flows exiting the forest, measurement of water flow entering and exiting Barmah–Millewa Forest is extremely complex.

In the past, MDBA has used net loss calculations to estimate water use within the forests for investigative purposes. The net loss calculations have not yet been used to debit environmental water. These calculations use flow data from surface water monitoring sites

and measure diversion volumes within the reach of the river containing the site to be watered. They determine the total daily inflow and outflow (net loss) from the site. The continual changes in the River Murray channel at measurement sites mean that net loss calculations may be fairly inaccurate.

Sources of environmental water

A number of sources of environmental water for the Barmah–Millewa Forest exist in addition to TLM entitlements. These include state-based environmental entitlements — for example, the Murray Flora and Fauna Bulk Entitlement (Vic.) and the Department of Environment, Climate Change and Water's RiverBank program (NSW) — and water recovered through the Australian Government's Water for the Future buyback program. In addition, Barmah–Millewa Forest has its own environmental water allocation, the Barmah–Millewa Environmental Water Allocation.

Barmah–Millewa Environmental water allocation

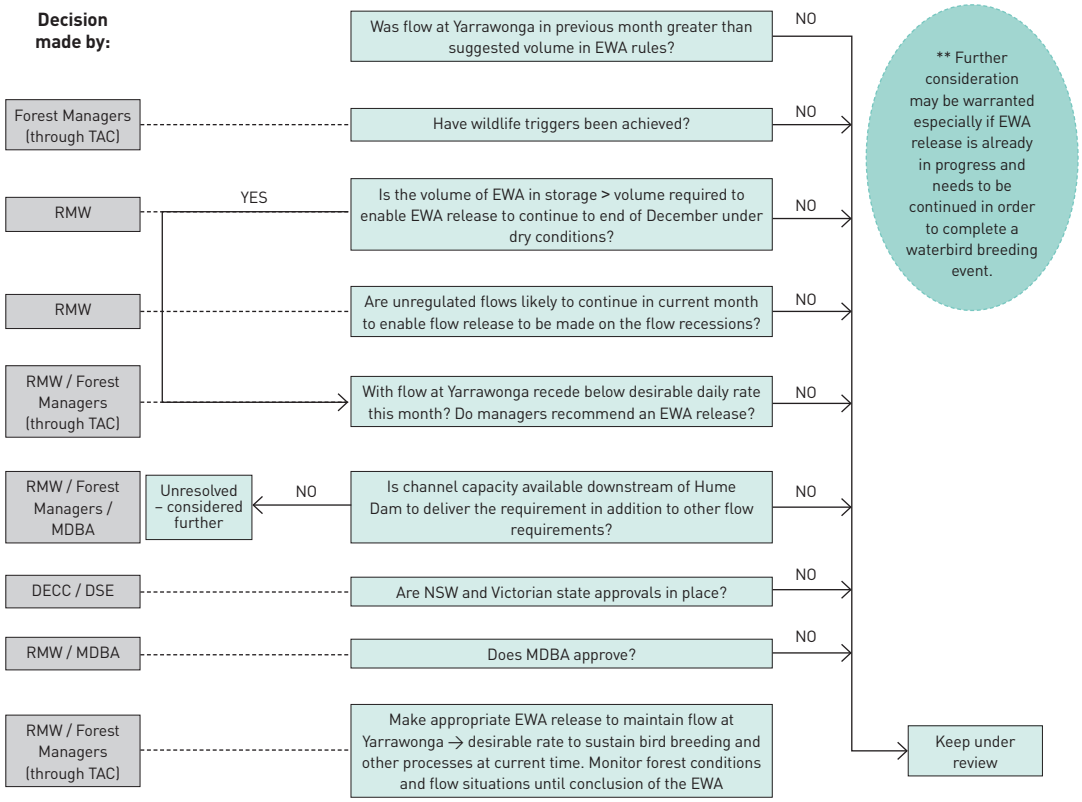
The Barmah–Millewa Environmental Water Allocation is a rules-based allocation established in 1993. The Murray–Darling Basin Ministerial Council authorised a high-security environmental water entitlement of 100 GL/y, to be drawn equally from Victoria and New South Wales[3], and a low-security allocation of 50 GL (again to be contributed equally by the two states) to be provided in years when the Victorian irrigation allocation exceeds 130%.

The Ministerial Council endorsed the revised operating rules for the Barmah–Millewa Environmental Water Allocation in May 2007, describing the rules and triggers for use of this environmental water allocation (see **Appendix F**).

A maximum of 700 GL of the environmental water allocation can be carried over in storage (Victorian Department of Sustainability and Environment & Goulburn Broken Catchment Management Authority 2005). The environmental water allocation was first used in 1998, when 98 GL was released. Since then, releases were made in 2000 (341 GL); 2005 (513 GL) and 2010–11 (276 GL at mid-January, with another 450 GL expected to be released by February). A flow chart outlining the decisions used for considering release of the Barmah–Millewa environmental water allocation is provided in **Figure 4.2**.

3 The New South Wales component of the Barmah–Millewa Environmental Water Allocation is also noted under *Water Management Act 2000* (NSW). The Water Sharing Plan for the Murray and Lower Darling Regulated Rivers Water Sources defines the environmental water allocation rules (s. 15) and the conditions under which the allocation may be used for the forests or, conversely, borrowed for consumptive water use. As a provision under the water sharing plan, and because the environmental water allocation affects the bulk water supply of the New South Wales River Murray water source, the use and management of the environmental water allocation is subject to audit and review.
The Victorian Murray Bulk Entitlement process provided for agreement for management of the Victorian component, including an increased allocation, accrual in storage, triggers for release, and loaning in dry times.

Figure 4.2: Environmental water allocation (release decision path): Barmah–Millewa Forest



Annual 'alternating' arrangements

High-river flows now often occur outside the natural flooding period (May to mid-December) at the Barmah–Millewa icon site. These increased river flows usually arise from the rain rejection of pre-ordered irrigation supplies and typically cause River Murray flows to increase from near-forest channel capacity of about 10,400 ML/d to a flow of 12,000 to 15,000 ML/d or more, over five to seven days.

To minimise the impact of unseasonal flooding on each side of the river, New South Wales and Victoria have agreed to implement 'alternating' arrangements for taking the increased flows. Barmah takes unseasonal flows in 'even' years and Millewa takes these flows in 'odd' years.

This cooperative arrangement has allowed the wetlands in each state a better chance of drying every second year, thereby assisting in returning them to a more natural flood and drying regime. However, during extended low-flow periods, as has been recently experienced, it may be advantageous to accept flows at any time.

Consumptive water on route

There may be opportunities to maximise environmental benefits for Barmah–Millewa Forest through the transfer of consumptive water to downstream users. This may be sufficient to generate flows through low-lying creeks within the forests. Consumptive water can also be used in tandem with environmental water to improve ecological outcomes for the forest. For example, environmental water can be 'piggybacked' on irrigation flows to create higher flows in-river to water low-lying wetlands and river red gums, which could not be achieved by releases of environmental water alone. Any water used within the forest will be debited from the appropriate environmental account.

State-based environmental entitlements

State-based environmental entitlements from Victoria and New South Wales can be used at Barmah–Millewa, including the Victorian Murray Flora and Fauna Bulk Entitlement (27.6 GL high-security) and the New South Wales Adaptive Environmental Water Allocation (32.027 GL). These entitlements can also be used at other sites along the River Murray.

Evaluation and management of potential risks

The Environmental Watering Group will explore ecological risks associated with the inability to implement key actions to achieve environmental objectives under the icon site environmental water management plans. A further description of the process by which risk management is being progressed is provided in The Living Murray Environmental Watering Plan. Attention will also be given to identifying legal issues and approaches to mitigating them, which may arise from operation of the river and its works to achieve environmental outcomes.

In the first instance, the approach to managing these issues will follow that adopted by the MDBA and state authorities as part of normal river management. This will involve the MDBA (or other groups as appropriate) notifying the level of risk involved in proposed management actions and the appropriate method for mitigating this risk.

While a comprehensive risk assessment for environmental water delivery has not yet been carried out, a preliminary assessment was undertaken for delivery of the Barmah–Millewa environmental water allocation in 2010. This assessment considered delivery of 13,000 to 16,000 ML/d for up to four weeks; key risks identified include the potential for developing blackwater, encouraging further encroachment of giant rush, creating potential fish strandings and inducing birds to breed without sufficient water resources. A detailed risk assessment of environmental watering will be undertaken to identify threats and attribute a level of risk to each, using a standard risk assessment approach. This will allow the setting of priorities to ameliorate those risks.

A risk summary of threats to ecosystem services, taken from the Barmah Forest Ramsar Site Ecological Charter Description (Victorian Department of Sustainability and Environment 2008), is provided in **Appendix G**. The summary provides information about general risks to the forest ecosystem, although not those risks specifically associated with environmental watering.

5. Environmental monitoring

Different monitoring methods are used to assess progress toward the icon site ecological objectives. These include system-wide intervention monitoring of River Murray icon site conditions. The Living Murray Outcomes (TLM) Evaluation Framework (MDBC 2007) outlines the rationale for these monitoring methods, which are summarised below.

River Murray system-scale monitoring

Conducted annually, River Murray system-scale monitoring and evaluation focuses on the system's ecological health, measuring improvements relating to fish, waterbirds and vegetation.

Icon site condition monitoring

Condition monitoring assesses each icon site's condition in relation to its ecological objectives. Condition monitoring is typically conducted on a medium-frequency basis (months to years), depending on the rate of change. Condition monitoring includes standard methodologies for monitoring fish, birds and vegetation, as well as icon site-specific methods for monitoring other ecological objectives (see **Schedule 1**). These monitoring activities have been classified into three categories — A, B and O:

- 'A' category monitoring activities are undertaken at all icon sites using agreed standardised methodologies:
  - fish condition monitoring using the Murray–Darling Basin Authority Sustainable Rivers Audit methodology
  - waterbird condition monitoring using a standard on-ground method to link with the annual aerial waterbird survey
  - tree condition monitoring for river red gum and black box using on-ground assessments linked to remote-sensing data.
- 'B' category contains icon site-specific monitoring using locally appropriate methods. This monitoring responds to unique icon site characteristics and is less easily standardised.
- 'O' category uses icon site monitoring related to objectives and is less easily linked to The Living Murray ecological objectives. Examples include:
  - frog monitoring and turtle monitoring projects.

6. Community consultation and communication

Community support for activities delivered under The Living Murray (TLM) program at the Barmah–Millewa Forest icon site depends on effective engagement with a range of stakeholders.

Engagement focuses on ensuring that the community is informed of the context, history, proposed processes, constraints and opportunities for water management in the Barmah–Millewa Forest. In turn, this will enable the community to engage effectively in decisions about water management at the icon site and will ensure that community values and knowledge are considered in decision-making where possible. The Barmah–Millewa Community Reference Group plays a key role in this process by advising on the most appropriate methods of engagement.

Communication and engagement activities have included field trips, site visits, briefings to key stakeholder groups (such as local government and adjoining landholders), media releases, events and publications. Despite the recent ongoing drought and low irrigation allocations, the local and wider community has been generally supportive of environmental watering events in Barmah–Millewa Forest. It is understood that community opinion may shift without a proactive program of communication and consultation.

An engagement strategy has been developed specifically aimed at engaging the community on TLM activities within the Barmah–Millewa Forest (see **Schedule 3**). The plan was developed in consultation with the the Barmah–Millewa Community Reference Group.

7. Indigenous engagement

The Living Murray (TLM) recognises the diverse and multiple interests that Indigenous Australians have in the water resources of the River Murray. The Living Murray has and will continue to engage with Indigenous Australians in identifying and protecting areas of cultural significance.

In addition, TLM is committed to incorporating Indigenous social, spiritual and customary objectives in its environmental water planning and management, as long as those objectives align with the environmental watering needs of The Living Murray ecological assets. It is envisaged that the strategies for achieving those Indigenous objectives will be incorporated as schedules to the Environmental Water Management Plans in the future.

Indigenous engagement is a key component of The Living Murray at the Barmah–Millewa Forest. Indigenous communities with an interest in the Barmah–Millewa Forest have been identified as the Yorta Yorta nation (Vic.) and the Cummeragunja and Deniliquin Aboriginal land councils (NSW).

The position of Indigenous facilitator for TLM's project team communicates and engages with Indigenous communities of Barmah–Millewa, ensuring that the views of Traditional Owners are considered when decisions regarding TLM implementation are made. The Indigenous facilitator attends the Technical Advisory Committee and a member of the Yorta Yorta nation attends meetings of the Integrated Coordinated Committee.

The Yorta Yorta nation is developing objectives for the Barmah–Millewa Forest. It is anticipated that there will be some overlap with TLM ecological objectives; however, these objectives are likely to extend beyond fish, waterbirds and vegetation. The use and occupancy map developed by the Yorta Yorta (Tobias 2009) will be an important information source in developing cultural objectives.

The Yorta Yorta are currently developing a paper on cultural water with assistance provided from community interviews. This paper, together with information from the Yorta Yorta use and occupancy map (Tobias 2009), is being used to develop a strategy to protect culturally important fauna and flora. The aim is to provide Yorta Yorta people with the opportunity to maintain cultural harvesting of icon site resources and ongoing sustainability of their cultural economy.

8. Adaptive management and reporting

An adaptive approach is critical in managing water-dependent ecosystems because it enables land managers and policy-makers to update strategies based on the outcomes of research and watering actions. This is known as 'learning by doing' and involves designing, implementing, monitoring, reporting and evaluating our work.

Environmental water management plans are constantly refined by adaptive management, which incorporates outcomes from environmental delivery, ecological monitoring, works, modelling and community consultation.

The Living Murray (TLM) Annual Environmental Watering Plan is developed at the start of each watering season and complements the environmental water management plan for each icon site. As the season progresses, the annual water planning process responds to water availability, opportunities and environmental priorities. A flexible decision-making framework is included in the annual plan so the Environmental Watering Group can assess water priorities throughout the year according to water resource condition.

Highlighting and analysing previous activities and outcomes, the Murray–Darling Basin Authority (MDBA) works with icon site managers to produce an annual TLM implementation report (as required under clause 199 of The Living Murray Business Plan) used by the Independent Audit Group. An annual external audit is conducted to ensure TLM is implemented at an appropriate level of transparency and accountability, and to promote public confidence in the program's efforts and outcomes. The implementation report and external audit are presented to the Murray–Darling Basin Ministerial Council.

To capture the key learning and changing icon site management practices, schedules appended to the Environmental Watering Management Plan are updated as required.

Adaptive management

A close relationship is required between water management and monitoring to ensure that the system is operated to optimise ecological outcomes and minimise environmental risks.

Management of environmental water delivery at Barmah–Millewa Forest will occur adaptively in line with the process illustrated in **Figure 8.1**.

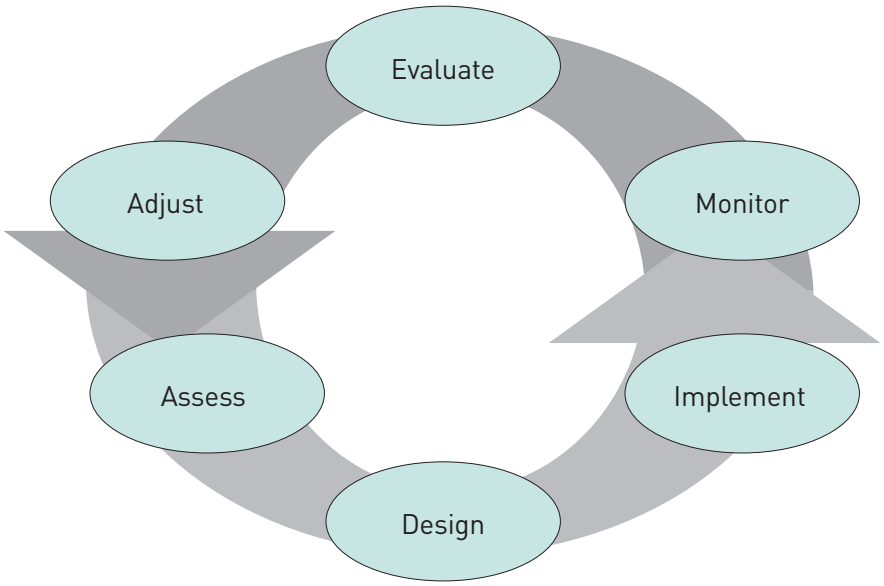


Figure 8.1: Adaptive management cycle

Assess

The ecological issues, objectives, water requirement, priority areas and actions, and associated risks for restoring the floodplain are assessed. This stage requires community and expert input.

Design

Knowledge about floodplain condition and ecology are used to develop hypotheses in terms of expected responses and set objectives and targets. Interventions are designed.

Implementation

The recommended interventions are implemented.

Monitoring

The monitoring program will be coordinated by the Goulburn Broken Catchment Management Authority in conjunction with land managers. The different types of monitoring are discussed in **chapter 5**.

Evaluation

The monitoring results will be evaluated in light of the expected outcomes/ecological response. Triggers will be identified to inform if or how management needs to adjust (e.g. the size of flood event adopted depending on water availability). Both short-term and long-term triggers will be used. Short-term triggers include water movement into or out of structures and whether specific biota (flora and fauna) begin to appear; longer-term triggers will include more detailed targets for ecological response.

Adjust

The icon site management committee will consider the monitoring outcomes (and any new knowledge on the issues) to determine whether changes are required to the operating strategy and to re-define the expected outcomes from the operation (i.e. the objectives).

Assess

Proposed changes will be assessed by the icon site management committee to consider if such changes still meet their expectations. Additional information provided through this step will be reviewed and considered.

Design

The program then moves back to the design stage where agreed changes are converted into changes to structural, operation or procedural plans.

Reporting

Improvements to actions and practices at the icon site (identified through the adaptive management process) will be reported to stakeholders through the existing governance arrangements described in **chapter 1**. This environmental water management plan will be reviewed periodically to capture the key lessons and changes in icon site management practices.

The outcomes achieved against the environmental water management plans will provide evidence of TLM progress. This information will be incorporated into the annual TLM implementation report and presented to the Murray–Darling Basin Ministerial Council. This meets the obligation to report on the annual progress of The Living Murray Initiative under clause 199 of The Living Murray Business Plan.

Appendix A: State governance arrangements

Victorian arrangements

The Victorian Department of Sustainability and Environment is responsible for delivery of The Living Murray program in Victoria. The department provides high-level policy input and coordinates the delivery of The Living Murray program across all Victorian icon sites.

All Victorian icon sites, except the Hattah Lakes, are multi-jurisdictional. Interstate coordination for these cross-border sites occurs through the integrated coordinating committees and icon site management committees.

The chief executive officers of the Mallee, North Central and Goulburn Broken catchment management authorities act as regional icon site coordinators for their respective icon sites, and are responsible for TLM delivery at each icon site. Accordingly, the Department of Sustainability and Environment has entered into a memorandum of understanding with the Mallee, North Central and Goulburn Broken catchment management authorities that establishes a collaborative working relationship between the organisations, sets out a common understanding of intent, and commits the organisations to subjurisdictional arrangements for delivery of The Living Murray Business Plan.

State water authorities (Goulburn–Murray Water and SA Water) are the Murray–Darling Basin Authority's delegated constructing authorities for the icon sites. As such, state water authorities are responsible for detailed design and construction under the Environmental Water Management Plan after the MDBA has approved an investment proposal.

A Victorian Living Murray Steering Committee has been set up to oversee delivery of The Living Murray program in Victoria (see **Table A1**). This high-level committee comprises representatives from key agencies responsible for implementing the program and is chaired by the Department of Sustainability and Environment. Goulburn–Murray Water has also convened a state construction committee to oversee the detailed design and construction phases.

Yorta Yorta Cooperative Management Agreement

In June 2004, the Yorta Yorta nation and the State of Victoria entered into a cooperative management agreement over designated areas that included Barmah State Park and Forest (now Barmah National Park). This agreement established a formal role for the Yorta Yorta nation in managing Crown land and water.

The agreement established an eight-member committee known as the Yorta Yorta Joint Body. Five members of the Yorta Yorta Joint Body represent the Yorta Yorta people and three members represent the State of Victoria. The Yorta Yorta Joint Body provides a forum for exchanging ideas, discussing management issues and making recommendations to the Minister for Environment on managing designated Crown land and waters.

Recent changes to their reservation status, to 'national park', of Barmah Forest and the Millewa forests included the opportunity for the Yorta Yorta people to be directly involved in joint management of the national park. The Yorta Yorta are now formerly recognised as a joint land manager of Barmah National Park.

Table A1 (below) identifies all agencies involved in TLM delivery at the Barmah–Millewa icon site.

New South Wales arrangements

The Office of Environment and Heritage (OEH) was formed on 4 April 2011 as a separate office within the NSW Department of Premier and Cabinet following an announcement of new administrative arrangements for the public service in NSW which saw most of the functions of the Department of Environment, Climate Change and Water (DECCW) transferred to the new Office of Environment and Heritage. The NSW Office of Water, previously part of DECCW is now part of the Department of Primary Industries. Under the new administrative arrangements, OEH reports to the Minister for the Environment and Heritage and the New South Wales Office of Water reports to the Minister for Primary Industries.

Within OEH, the management of the icon site is coordinated by the Parks and Wildlife Group. The icon site manager for the Millewa forests is the Parks and Wildlife Group's western rivers regional manager. However, water delivery is jointly coordinated within OEH by the Parks and Wildlife Group, the Waters, Wetlands and Coast Division, and the New South Wales Office of Water.

The New South Wales Minister for the Environment and Heritage is the environmental water holder of water licences administered by OEH's Waters, Wetlands and Coast Division. The OEH has secured water for the environment through planning mechanisms, water purchase and water-efficient infrastructure, and manages discretionary environmental water entitlements in New South Wales through a whole-of-government agreed framework.

The New South Wales Office of Water undertakes all water planning and licensing arrangements under that state's *Water Management Act 2000*; it is responsible for managing access to water and ensuring water is shared between the environment, towns and cities, farmers and industry, and Indigenous Australian cultural activities.

The State Water Corporation was established as New South Wales' rural bulk water delivery business in 2004; its functions include delivery of environmental water, including environmental flows to the Millewa icon site under the Murray Annual Operating Plan.

A cooperative management agreement for the Millewa icon site is currently being developed between the Yorta Yorta nation and OEH.

Table A1: Agencies involved in delivery of The Living Murray program

Agency	Description and role
Murray–Darling Basin Authority	Responsible for coordination at a TLM-wide level. Representatives on Integrated Coordinating Committee and Technical Advisory Committee.
Department of Sustainability, Environment, Water, Population and Communities	This department develops and implements national policy, programs and legislation to protect and conserve Australia's environment and heritage. Under the *Water Act 2007* (Cwlth), the Commonwealth Environmental Water Holder was established to manage Commonwealth-acquired water entitlements used to protect or restore environmental assets. Representatives on the Environmental Watering Group and state and/or catchment watering groups.
Office of Environment and Heritage, Department of Premier and Cabinet (NSW)	OEH is responsible for water in the environment and water licensing and allocation. It incorporates functions of the Murray Wetland Working Group. OEH chairs the Murrumbidgee Environmental Water Advisory Group and is a member of The Living Murray Environmental Watering Group.
New South Wales Office of Water, Department of Primary Industries(NSW)	This agency is responsible for water extraction in terms of planning and licensing under the Water Management Act 2000 (NSW); it leads New South Wales' commitment to The Living Murray Environmental Works and Measures Program, and directs the operations of New South Wales State Water in accordance with water sharing plans, legislation and policies. The agency is a member of The Living Murray Environmental Watering Group and Technical Advisory Committee.
National Parks and Wildlife Service, Office of Environment and Heritage (NSW)	Land manager of Murray Valley National Park and Murray Valley Regional Park (ex-Millewa forest group) under the National Parks and Wildlife Act 1974 (NSW). New South Wales icon site manager and water manager within forest boundaries.
New South Wales State Water	New South Wales' rural bulk water delivery corporation; also manages, operates and maintains New South Wales water regulation infrastructure. Manages and operates Murray–Darling Basin Authority-identified assets in accordance with the Murray–Darling Basin Agreement; it is a New South Wales state construction authority.
Murray Catchment Management Authority (NSW)	Responsible for managing natural resource issues at the catchment scale through engagement of regional communities, development of a catchment action plan and implementation of incentive programs. Catchment management authority chair for the Murray–Lower Darling Environmental Water Advisory Group and Community Reference Group , and a member of the Technical Advisory Committee.
Department of Primary Industries within the Department of Trade and Investment, Regional Infrastructure and Services, New South Wales	Responsible for management of fish communities and aquatic habitats within New South Wales, including threatened species, populations and ecological communities. Provides advice on biological requirements for fish and undertakes monitoring of fish communities.
Department of Sustainability and Environment (Vic.)	Responsible for implementing TLM in Victoria, the department is also a project and site owner for public land and manages approvals and referrals for the state. It has representatives on the Integrated Coordinating Committee and Technical Advisory Committee.
Parks Victoria	Land manager for Barmah National Park. It has representatives on the Integrated Coordinating Committee and Technical Advisory Committee.
Goulburn Broken Catchment Management Authority (Vic.)	Victorian icon site manager; it has representatives on the Integrated Coordinating Committee (chair alternate years) and Technical Advisory Committee (chair alternate years).
Goulburn–Murray Water (Vic.)	This is the Victorian constructing authority for TLM. Responsible for operation and maintenance of infrastructure built through TLM Initiative. It has representatives on the Technical Advisory Committee.
Yorta Yorta Nation Aboriginal Corporation	Recognised in Victoria as the Registered Aboriginal Party. Victoria will ensure cooperative management of Barmah Forest with the Yorta Yorta people in land and water management decision-making relating to the protection, management and sustainability of their country, including cultural and environmental values.
Victorian Environmental Water Holder	Independent manager of Victorian environmental water entitlements (effective July 2011)

Appendix B: List of significant flora in Barmah–Millewa Forest

Common name	Scientific name	Conservation status[a]			
		Vic.	NSW	Cwlth	Other
FLORA					
Austral pillwort	*Pilularia novae-hollandiae*		e		
Austral trefoil	*Lotus australis*	k			
Bear's-ear	*Cymbonotus lawsonianus*	r			
Blue burr-daisy	*Calotis cuneifolia*	r			
Bluish raspwort	*Haloragis glauca f. glauca*	k			
Buloke	*Allocasuarina luehmannii*	L			
Buloke mistletoe	*Amyema linophylla subsp. orientale*	v			
Button rush	*Lipocarpha microcephala*	v			
Common joyweed	*Alternanthera nodiflora*	k			
Cotton sneezeweed	*Centipeda nidiformis*	r			
Dark roly-poly	*Sclerolaena muricata var. semiglabra*	k			
Downs nutgrass	*Cyperus bifax*	v			
Dwarf bitter-cress	*Rorippa eustylis*	r			
Dwarf brooklime	*Gratiola pumilo*	r			
Fat spectacles	*Menkea crassa*	L, e			
Ferny small-flower buttercup	*Ranunculus pumilio var. politus*	k			
Floodplain fireweed	*Senecio campylocarpus*	r			
Hypsela	*Hypsela tridens*	k			
Jerry-jerry	*Ammannia multiflora*	v			
Lax flat-sedge	*C. flaccidus*	v			
Leafless bluebush	*Maireana aphylla*	k			
Mountain swainson-pea	*Swainsona recta*	L, e	e	EN	
Mueller daisy	*Brachyscome muelleroides*	L, e	v	VU	
Native couch	*Cynodon dactylon var. pulchellus*	k			
Native peppercress	*Lepidium pseudohyssopifolium*	k			
Pale flax-lily	*Dianella sp. aff. longifolia (Riverina)*	v			
Pale swamp everlasting	*Helichrysum aff. rutidolepis (lowland swamps)*	v			
Reader's daisy	*B. readeri*	r			
Ridged water-milfoil	*Myriophyllum porcatum*	L, v		VU	
River swamp wallaby grass	*Amphibromus fluitans*		v	VU	
Riverina bitter-cress	*Cardamine moirensis*	r			
Short-bristle wallaby-grass	*Austrodanthonia setacea var. breviseta*	r			
Silky umbrella-grass	*Digitaria ammophila*	v			
Slender bitter-cress	*C. tenuifolia (small flower form)*	k			
Slender darling-pea, Slender swainson, Murray swainson-pea	*S. murrayana*	L, e		VU	

Common name	Scientific name	Conservation status[a]			
		Vic.	NSW	Cwlth	Other
Slender love-grass	*Eragrostis exigua*	e			
Slender sunray	*Rhodanthe stricta*	L, e			
Slender tick-trefoil	*Desmodium varians*	k			
Small scurf-pea	*Cullen parvum*	L, e	e		
Smooth groundsel	*S. glabrescens*	r			
Smooth minuria	*Minuria integerrima*	r			
Spiny-fruit saltbush	*Atriplex spinibractea*	e			
Squat picris	*Picris squarrosa*	r			
Summer fringe-sedge	*Fimbristylis aestivalis*	k			
Twiggy sida	*Sida intricata*	v			
Umbrella wattle	*Acacia oswaldii*	v			
Violet swainson-pea	*S. adenophylla*	L, e	e		
Waterbush	*Myoporum montanum*	r			
Wavy marshwort	*Nymphoides*	v			
Winged peppercress	*L. monoplocoides*	L, e		EN	
Yelka	*C. victoriensis*	k			
Yellow-tongue daisy	*B. chrysoglossa*	L, v			

Source: Advisory List of Rare or Threatened Plants in Victoria — 2005 (Victorian Department of Sustainability and Environment 2005); Victorian Flora Information System (2007); *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth)

a **Environmental Protection and Biodiversity Conservation Act** : EX – Extinct; CR — Critically endangered; EN –Endangered; VU – Vulnerable)
New South Wales Threatened Species: listed under the *Threatened Species Conservation Act 1995* (NS)
Victorian FFG: listed under the *Flora and Fauna Guarantee Act 1988* (Vic.) L – Listed; N – Nominated for listing as threatened; I – Rejected for listing as threatened, taxon invalid or ineligible; D – Delisted as threatened under the Flora and Fauna Guarantee Act; (x – Presumed extinct; e – Endangered; v – Vulnerable; r – Rare; k –Poorly known).

Appendix C: List of significant fauna in Barmah–Millewa Forest

Common name	Scientific name	Conservation status*			
		VIC	NSW	Cwlth	Other
FAUNA					
Australasian bittern	*Botaurus poiciloptilus*	L, EN	v		
Australian painted snipe	*Rostratula australis*	L, CR		VU	
Australian shoveler	*Anas rhynchotis*	VU			
Azure kingfisher	*Alcedo azurea*	NT			
Bandy bandy	*Vermicella annulata*	L, NT			
Barking owl	*Ninox connivens*	L, EN	v		
Black-chinned honeyeater	*Melithreptus gularis*	NT	v		
Blue-billed duck	*Oxyura australis*	L, EN	v		
Brolga	*Grus rubicunda*	L, VU	v		
Brown toadlet	*Pseudophryne bibronii*	L, EN			
Brown treecreeper	*Climacteris picumnus*	NT	v		
Brush-tailed phascogale	*Phascogale topoatafa*	L, VU	v		
Bush stone-curlew	*Burhinus grallarius*	L, EN	e		
Carpet python	*Morelia spilota metcalfei*	L, EN			
Caspian tern	*Sterna caspia*	L, NT			C
Cattle egret	*Ardea ibis*				J, C
Crimson-spotted (Murray) rainbowfish	*Melanotaenia fluviatilis*	L, DD			
Diamond dove	*Geopelia cuneata*	L, NT			
Diamond firetail	*Stagonopleura guttata*	L, VU	v		
Eastern bearded dragon	*Pogona barbata*	DD			
Flat-headed galaxias	*Galaxias rostratus*	I, VU	ce		
Fork-tailed swift	Apus pacificus				J, C, RoK
Freckled duck	*Stictonetta naevosa*	L, EN	v		
Freshwater catfish	*Tandanus tandanus*	L, EN	e		
Gilberts whistler	*Pachycephala inornata*		v		
Glossy ibis	*Plegadis falcinellus*	NT			C
Golden perch	*Macquaria ambigua*	I, VU			
Great egret	*Ardea alba*	L, VU			J, C
Greenshank	*Tringa nebularia*				J. C, RoK
Grey-crowned babbler	*Pomatostomus temporalis*	L, EN			
Hardhead	*Aythya australis*	VU			
Hooded robin	*Melanodryas cucullata*	L, NT	v		
Intermediate egret	*Ardea intermedia*	L, CR			
Large-footed myotis	*Myotis adversus*		v		
Latham's snipe	*Gallinago hardwickii*	NT			J, C, RoK
Lewin's rail	*Rallus pectoralis*	L, VU			
Little bittern	*Ixobrychus minutus*	L, EN			
Little egret	*Egretta garzetta*	L, EN			
Long-eared bat	*Nyctophilus timoriensis* (Eastern form)	L, VU		VU	

Common name	Scientific name	Conservation status*			
		VIC	NSW	Cwlth	Other
Macquarie perch	*Macquaria australasica*	L, EN	e	EN	
Marsh sandpiper	*Tringa stagnatilis*				C, RoK
Masked owl	*Tyto novaehollandiae*	L, EN	v		
Murray cod	*Maccullochella peelii peelii*	L, EN		VU	
Murray hardyhead	*Craterocephalus fluviatilis*	L, CR		VU	
Murray river turtle	*Emydura macquarii*	L, DD			
Musk duck	*Biziura lobata*	VU			
Nankeen night heron	*Nycticorax caledonicus*	NT			
Painted honeyeater	*Grantiella picta*	L, VU	v		
Painted snipe	*Rostratula australis*	L, CR	e	VU, M	C
Pied cormorant	*Phalacrocorax varius*	NT			
Plains wanderer	*Pedionomus torquatus*	L, CR		VU	
Purple-crowned lorikeet	*Glossopsitta porphyrocephala*		v		
Red-necked stint	*Calidris ruficollis*				J, C, RoK
Regent honeyeater	*Xanthomyza phrygia*	L, CR	e	EN, M	
Royal spoonbill	*Platalea regia*	VU			
Sharp Tailed sandpiper	*Calidris acuminata*				J, C, RoK
Silver perch	*Bidyanus bidyanus*	L, CR	v		
Southern bell frog, growling grass frog	*Litoria raniformis*	L, EN		VU	
Southern purple-spotted gudgeon	*Mogurnda adspersa*	L, RX	e		
Southern pygmy perch	*Nannoperca australis*		e		
Square-tailed kite	*Lophoictinia isura*	L, VU	v		
Squirrel glider	*Petaurus norfolcensis*	L, EN	v		
Striped legless lizard	*Delma impar*	L, EN		VU	
Superb parrot	*Polytelis swainsonii*	L, EN	v	VU	
Swift parrot	*Lathamus discolor*	L, EN	e	EN	
Tree goanna	*Varanus varius*	VU			
Trout cod	*Maccullochella macquariensis*	L, CR	e	EN	
Turquoise parrot	*Neophema pulchella*	L, NT	v		
Whiskered tern	*Chlidonias hybridus javanicus*	NT			
White-bellied sea-eagle	*Haliaeetus leucogaster*	L, VU			C
White-throated needletail	*Hirundapus caudacutus*				J, C, RoK

Source: Advisory List of Threatened Vertebrate Fauna in Victoria - 2007 DSE (2007) Barmah Forest Ramsar Site Strategic Management Plan and SFNSW & NSW NPWS (2002) and EPBC Act (www.environment.gov.au/epbc/index.html)

* Conservation status is provided as follows:
VIC: Status in Victoria
L = species **listed** as threatened in Victoria under the *Flora and Fauna Guarantee Act 1988*
N = **Nominated** for listing as threatened but has not yet completed the listing process.
I = Nominated but rejected for listing as threatened **invalid** or **ineligible**
D = Previously listed as threatened but subsequently removed from the threatened list following nomination for **delisting**.
EX = Extinct (DSE 2007)
RX = Regionally Extinct (DSE 2007)
WX = Extinct in the Wild (DSE 2007)
CR = Critically Endangered (DSE 2007)
EN = Endangered (DSE 2007)
VU = Vulnerable (DSE 2007)
NT = Near Threatened (DSE 2007)
DD = Data Deficient (DSE 2007)
NSW: Status in NSW, as listed under the *NSW Threatened Species Conservation Act 1995* &/or *Fisheries Management Act 1994*
ce = critically endangered
e = endangered
v = vulnerable
ep = endangered population
C'wlth: National conservation status, as listed under the *Environment Protection and Biodiversity Conservation Act 1999*
EX = Extinct
CR = Critically Endangered
EN = Endangered
VU = Vulnerable
CD = Conservation Dependant
M = migratory).
Other: other relevant listings
J = Japan–Australia Migratory Bird Agreement
C = China–Australia Migratory Bird Agreement
RoK = Republic of Korea – Australia Migratory Bird Agreement
B = Bonn Convention on Migratory Species

Appendix D: Commence-to-flow thresholds for Barmah–Millewa waterways

Forest	Regulator name	Commence-to-flow threshold (GL/d)
Barmah (Victoria)	Kynmer Creek	~12.5
	Black Engine Creek	3.4
	Sandspit Regulator	9
	Gulf regulators (two)	←3
	Stewarts Kitchen	9
	Bull Paddock	9
	Punt Paddock	~8
	Big Woodcutter	~7.5
	Boals Creek	~5
	Little Budgee Creek	4.1
	Sapling Creek	~7.5
	Island Creek	~7.5
	War Creek	~5.8
	Cutting Creek	←3
	Barmah Lake	←3
	Goose Neck	Anything above Rices Weir overflow[a] sill
Millewa (New South Wales)	Mary Ada	3.5
	House Creek	6
	Pinchgut Creek	4.5
	Nestrons	4.5
	Walthours	4.5
	Duck Lagoon (through Gulpa Creek)	0.37[b]
	Reedbed North	0.37[b]
	Reedbed South	0.37[b]
	McCartneys Creek	0.5[b]
	Horse-shoe Lagoon	0.5[b]
	St Helena	1[c]
	Black Swamp	1.2[c]

Notes: a Broken Creek flow; b Gulpa Creek flow; c Edward River flow
Source: Adapted from Ward 2009b; Rodda pers. comm.; Childs pers. comm.

Appendix E: Hydraulic model outputs

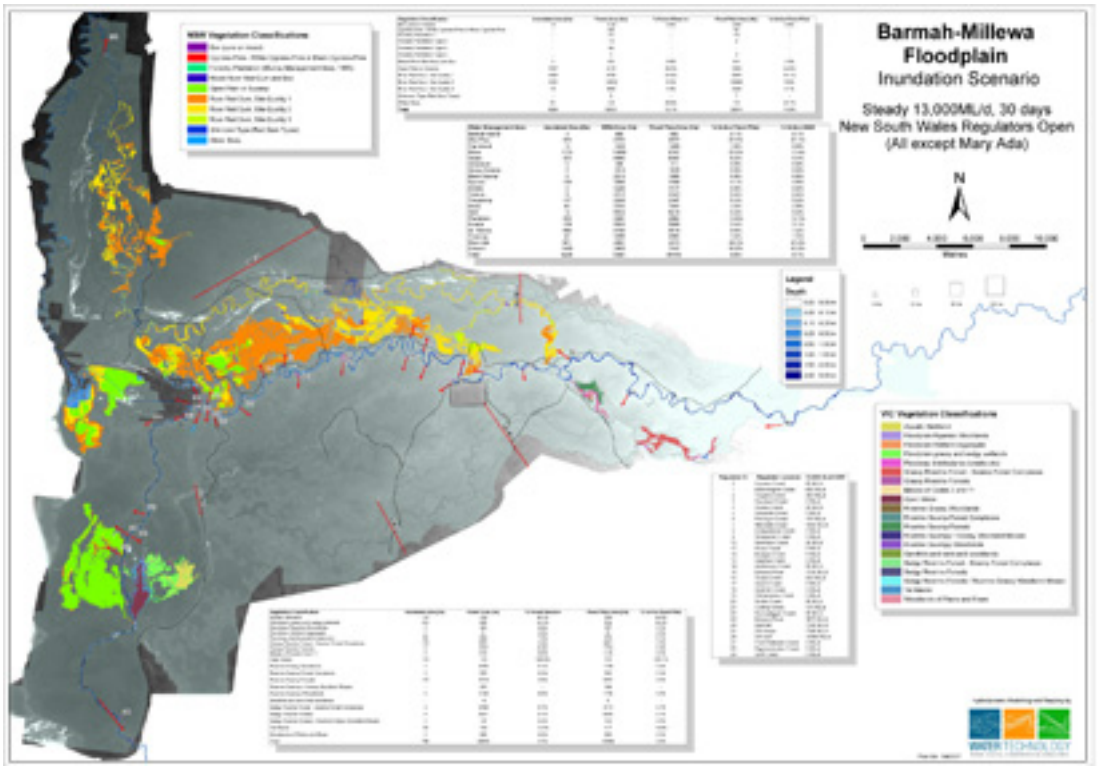
The following are hydrodynamic maps displaying flooded areas at various river levels (one month of constant flow). These maps have been created using a digital terrain map (from data collected using light detection and ranging) of the forest and applying a one- and two-dimension hydrodynamic algorithm model to simulate various metrics of flow distribution within the forest.

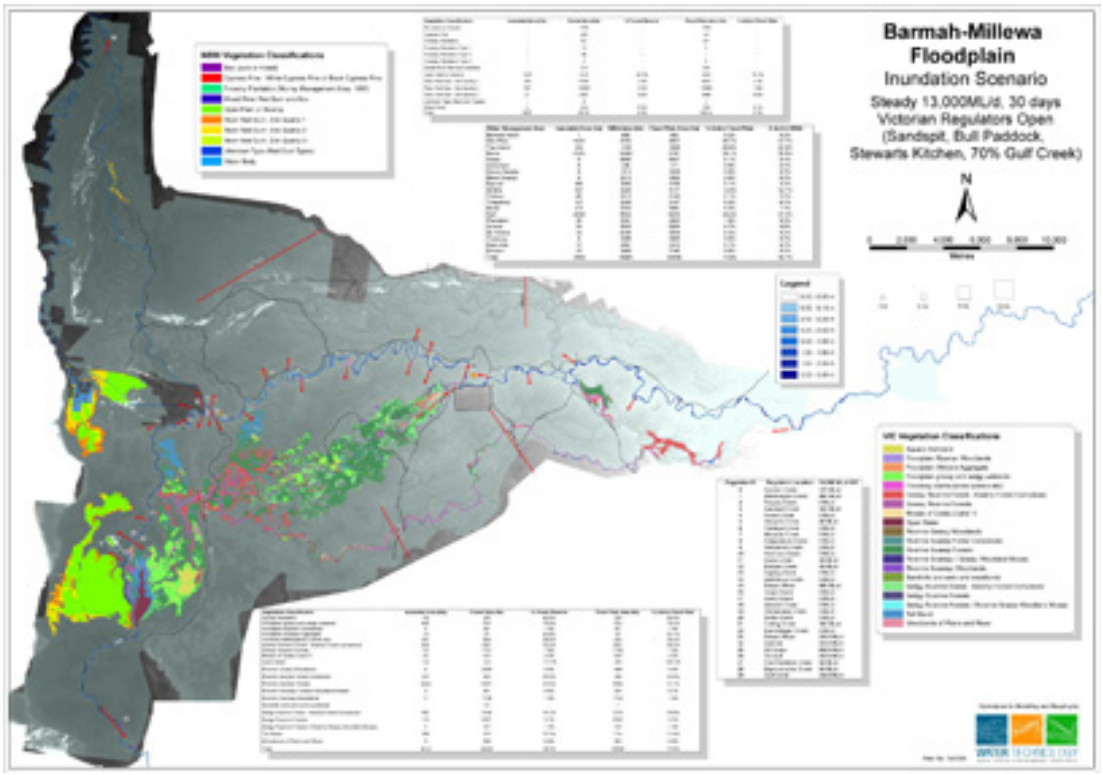
The maps show expected flood distribution within the forest at stable river flows downstream of Yarrawonga (simulated constant flow for one month). River flows up to 10,400 ML/d downstream of Yarrawonga are retained within channel capacity and therefore all forest regulators remain closed (results in no flows entering the forest apart from a few unregulated waterways that do not result in forest flooding).

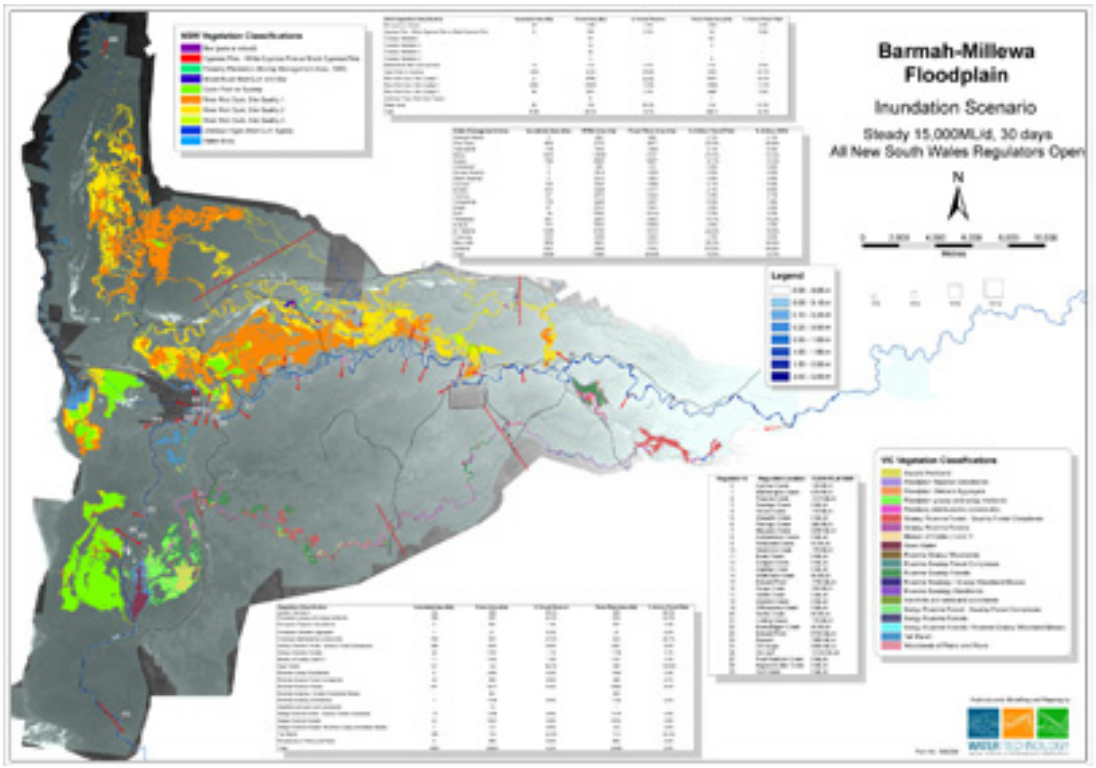
But for flows between 10,400 and 18,000 ML/d, increasing numbers of regulators have to be opened or overbank flow in the river will result, potentially causing erosion and damaging roads. Flows up to 15,000 ML/d can generally be managed through either forest — the following maps show the effect of regulators on just one side of the river being opened at these resultant levels. Flows beyond 60,000 ML/d for one month are generally regarded as flooding all the floodplain within the icon site (which is ~95% of the area of the reserve).

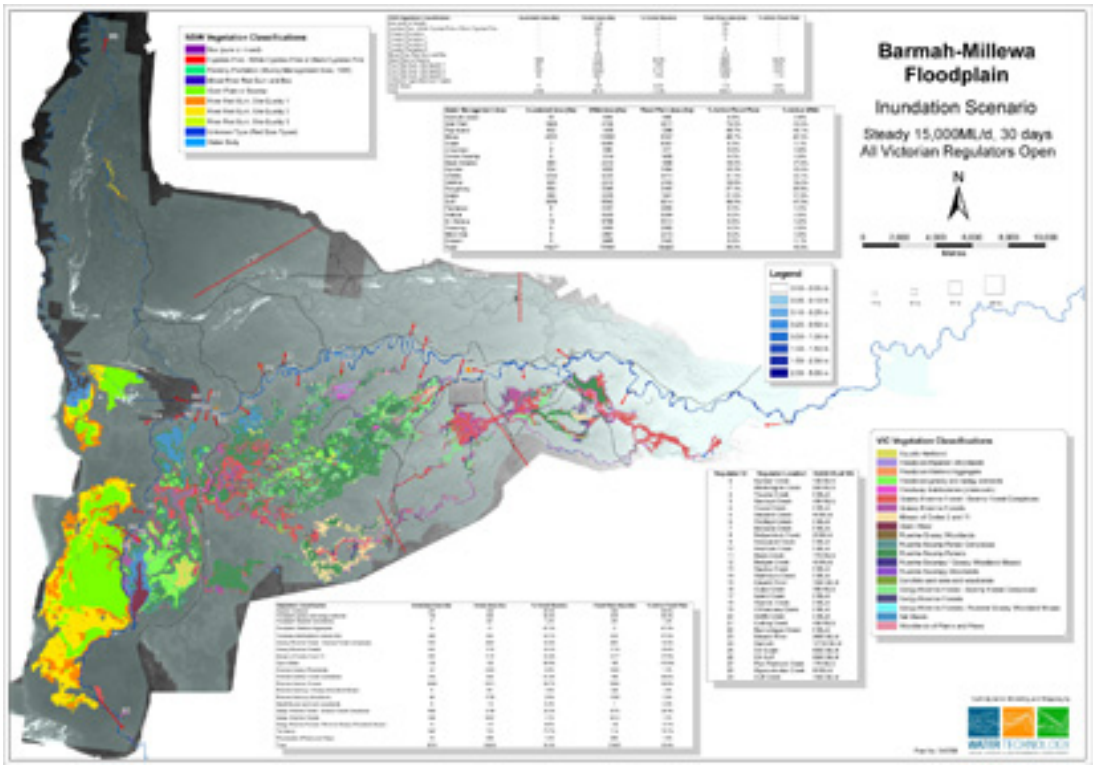
The following flows have been stimulated and are displayed below:

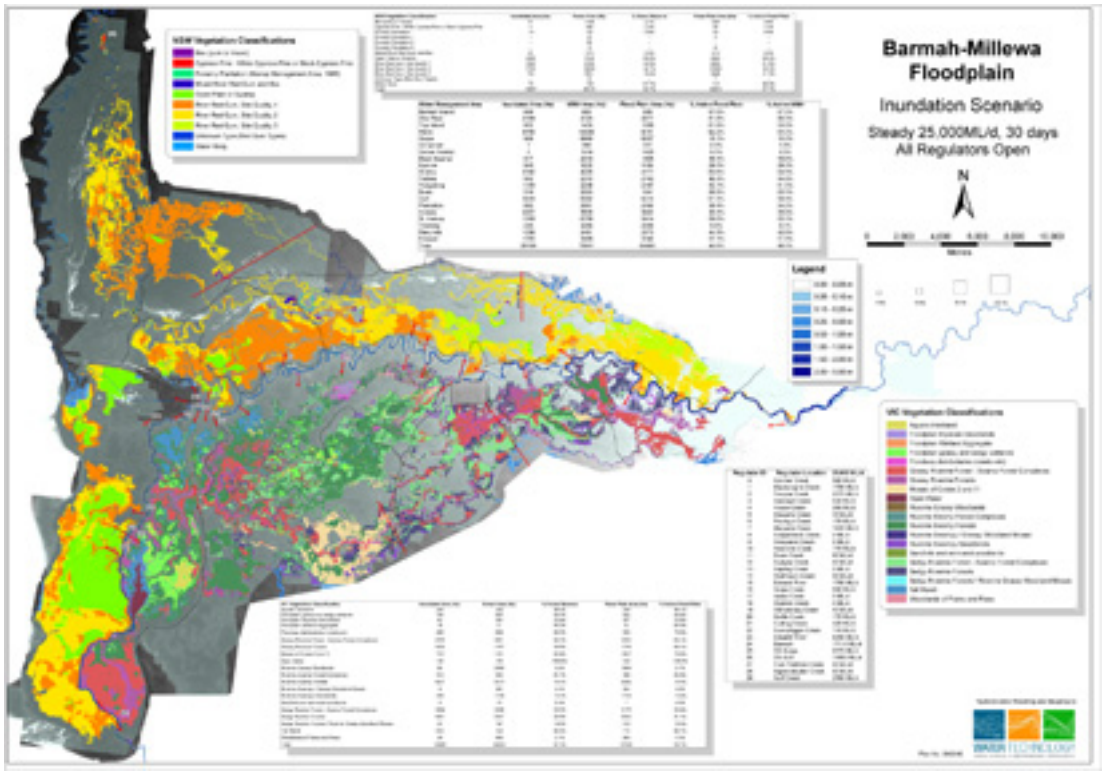
- 13,000 ML/d (with only selected Victorian regulators open)
- 13,000 ML/d (with only selected New South Wales regulators open)
- 15,000 ML/d (with only all Victorian regulators open)
- 15,000 ML/d (with only all New South Wales regulators open)
- 25,000 ML/d (with all forest regulators open)
- 35,000 ML/d (with all forest regulators open)
- 45,000 ML/d (with all forest regulators open)
- 60,000 ML/d (with all forest regulators open).

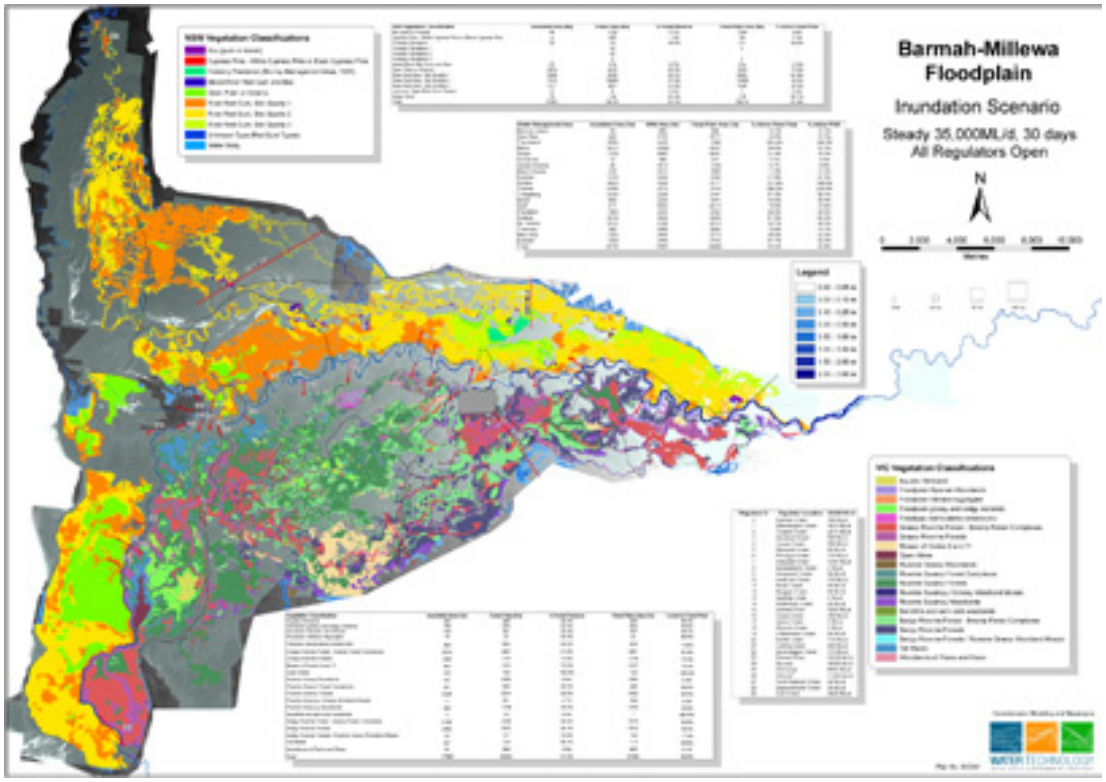

Barmah-Millewa
Floodplain
Inundation Scenario
Steady 13,000ML/d, 30 days
New South Wales Regulators Open
(All except Mary Ada)
N

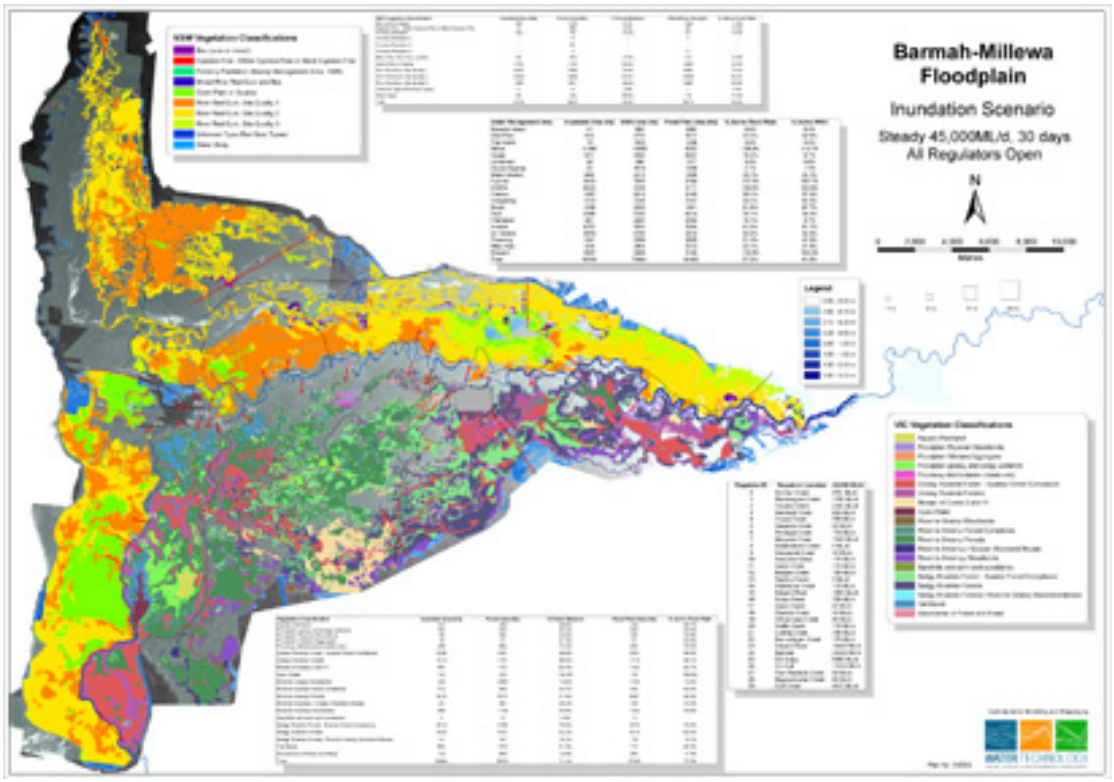

Barmah-Millewa
Floodplain
Inundation Scenario
Steady 13,000ML/d, 30 days
Victorian Regulators Open
(Sandspit, Bull Paddock,
Stewarts Kitchen, 70% Gulf Creek)
N

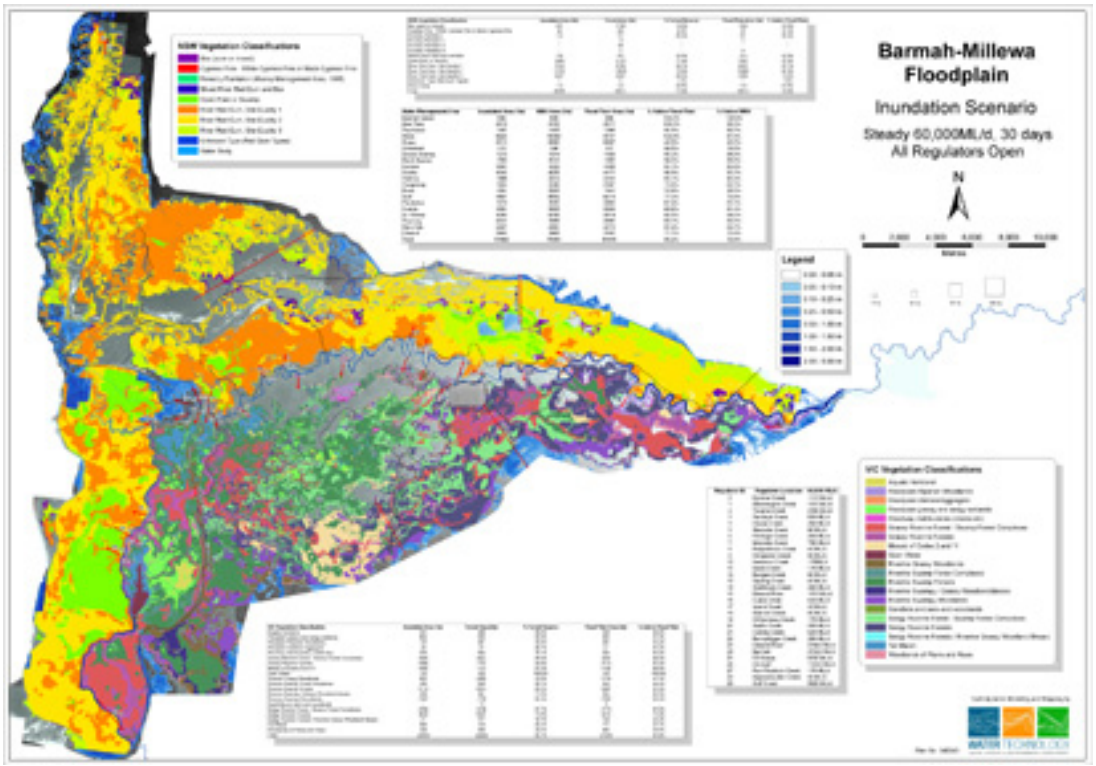

Barmah-Millewa
Floodplain
Inundation Scenario
Steady 15,000ML/d, 30 days
All New South Wales Regulators Open
N


Barmah-Millewa
Floodplain
Inundation Scenario
Steady 15,000ML/d, 30 days
All Victorian Regulators Open
N


Barmah-Millewa
Floodplain
Inundation Scenario
Steady 25,000ML/d, 30 days
All Regulators Open
N


Barmah-Millewa
Floodplain
Inundation Scenario
Steady 35,000ML/d, 30 days
All Regulators Open
N


Barmah-Millewa
Floodplain
Inundation Scenario
Steady 45,000ML/d, 30 days
All Regulators Open
N


Barmah-Millewa
Floodplain
Inundation Scenario
Steady 60,000ML/d, 30 days
All Regulators Open
N

Appendix F: Operating rules for the Barmah–Millewa Forest Environmental Water Allocation

Approved by the Murray–Darling Basin Ministerial Council (Meeting 42, 25 May 2007)

Reference:

MDBC technical report 2006–13, July 2006, Murray–Darling Basin Commission, Canberra

Introduction

Interim operating rules (see **Attachment A**), initially approved by council meeting 30 (on 30 March 2001) for management of Barmah–Millewa Forest Environmental Water Allocation were extended by council meeting 40 (19 May 19 2006) until 30 June 2007. However, foreshadowed changes to Victoria's sales allocation required revised rules to be developed by that date. To develop the new rules, an inter-jurisdictional steering committee was set up; that committee has supervised substantial hydrological modelling work.

While a summary of the modelling work undertaken is provided in the *MDBC technical report 2006–13*, more detailed descriptions of the modelling can be found in the MDBC technical reports No's 2006–4 (Part 1), 2006–7 (Part 2), 2006–8 (Part 3), 2006–10 (Part 4), and 2006–12 (Part 5).

The main aim of revising the interim rules were to preserve the rights of both forest and water users while removing reference to Victoria's sales allocation and fully defining the exceptional circumstances under which New South Wales will have an improved water availability and reliability, especially during long drought periods.

Following are major changes incorporated in to the revised rules:

(a) exogenous trigger for allocation of lower security entitlement to Barmah–Millewa Forest Environmental Water Allocation

(b) definition of the exceptional circumstances under which the New South Wales general security allocation limit for borrowing can be lifted from 30% to 50%

(c) applying evaporation losses only to carried over component of Barmah–Millewa Forest Environmental Water Allocation as a proportion of total loss in Hume and Dartmouth storages

(d) not restricting use of Barmah–Millewa Forest Environmental Water Allocation when some water has been borrowed

(e) independent state accounts of Barmah–Millewa Forest Environmental Water Allocation with rules to balance these accounts whenever possible (Barmah–Millewa Forest Environmental Water Allocation releases and spills no longer shared equally)

(f) allowing each state to overdraw independently whenever it has sufficient reserve

(g) non-spillage of Barmah–Millewa Forest Environmental Water Allocation water borrowed by states in previous years

(h) creation of new The Living Murray reference condition and refinement of various other rules.

Changes made in the reference condition and in the interim rules formed the basis of the development of the revised rules (described below). Some clauses in the revised rules needed additional explanation and explanatory notes are provided in Appendix 1 of the revised rules. The proposed revised rules were notionally endorsed by the inter-jurisdictional steering committee on 12 July 2006. It is recommended that the proposed rules be adopted for the management of the Barmah–Millewa Forest Environmental Water Allocation when the interim rules expire on June 30, 2007.

1. Allocation of entitlement

1.1 Annual allocation

The annual allocation of entitlement to the Barmah–Millewa Forest Environmental Water Allocation is supplied equally by New South Wales and Victoria. The annual allocation consists of two components:

(a) a 100 GL high-security allocation

(b) a 50 GL lower-security allocation.

1.2 High-security allocation

The high-security water has the same reliability as Victoria's water right or high reliability water share along the River Murray. High-security allocations for Barmah–Millewa Forest Environmental Water Allocation are made throughout the season as Victorian allocations are announced.

1.3 Lower-security allocation

The lower security water is allocated when the total natural inflow to Hume Reservoir for preceding months, which vary from 30 months on 1 July to 35 months on 1 December exceeds the triggers in Table F1 (see explanatory note 1.3).

1.4 Timing of lower-security allocation

Preliminary lower-security allocations are made in July to reserve water for the environment, but these allocations may be reduced in August when the first formal allocation is made. Formal lower security allocations made after July cannot be reduced and allocations are not increased after December (see explanatory note 1.4).

1.5 Allocation limit

Any increase in the allocation is limited to the volume that will bring each state's share of the account to 350 GL (see explanatory note 1.5).

2. Carryover

The unused water in the environmental water account will be carried over from one year to the next.

3. Overdraw

Allowance has been made for the allocation to be overdrawn by up to 100 GL (50 GL from each state) to ensure adequate water is available for forest watering, provided a state has sufficient reserves. A state can overdraw independently (see explanatory note 3).

4. Evaporation loss

The Barmah–Millewa Forest Environmental Water Allocation is reduced by evaporation. The evaporation loss applied to the environmental water account is determined as a fraction of the total loss from the Hume and Dartmouth Reservoirs. The fraction is calculated as the non-borrowed, carried over component of the environmental water account divided by the total storage in the two reservoirs. Evaporation losses will be shared pro rata between each state's share of the non-borrowed, carried-over components of the environmental water account except when a state's share of the account is negative. A state's share of evaporation becomes nil when a state's share of the account is negative (see explanatory note 4).

5. Borrow and payback

5.1 Borrow and payback triggers

Each state's share of the environmental water account can be borrowed for consumptive use by that state, subject to the following rules:

(a) Each state can borrow that volume of water necessary to increase its allocation to its target allocation.

(b) Water borrowed is paid back when it is no longer required to supply the target allocation.

Table F1: Lower security water allocations

Month	1 Jul	1 Aug	1 Sep	1 Oct	1 Nov	1 Dec
Period (months)	30	31	32	33	34	35
Trigger (GL)	8,650	8,988	9,243	9,253	9,267	9,280
Modelled frequency (%)	49	53	61	69	75	76

5.2 Target allocation

The target allocation for Victoria is 100% of water right or high reliability water share. The target allocation for New South Wales is normally 30% general security allocation, but this can be increased to 50% under exceptional circumstances.

5.3 New South Wales exceptional circumstances

Exceptional circumstances for New South Wales are defined as occurring when the average November allocation (including carryover) for the four years up to and including the current year would otherwise have been less than 50%. However, exceptional circumstances cannot be declared in consecutive years (see explanatory note 5.3).

5.4 Forest watering while borrowing

Release of the non-borrowed component of the environmental water account is allowed even though some of the environmental water account remains borrowed.

5.5 Borrowing in the fifth year of drought

Each state will consider, consult and justify before making a decision to borrow water in the fifth year of drought when a release might be made under subclause 8.2 of these rules.

5.6 Borrowing for other environmental purposes

If the commission agrees, water may be borrowed from the environmental water account for other environmental purposes provided that:

(a) the required water has not already been borrowed for consumptive use,

(b) water is not required in that year by the Barmah–Millewa Forest

(c) the required water can be repaid at the start of the following year (see explanatory note 5.6).

6. Spillage

6.1 Priority of spills

When Hume physically spills, water will first spill from the carried over component of other environmental entitlements, then from the Barmah–Millewa Forest Environmental Water Allocation (see explanatory note 6.1).

6.2 Account imbalances

If the states' shares of the environmental water account are unequal when the account spills, water spills first from the state with the bigger account until the states' accounts are in balance or the spillage limit is reached.

7. Internal spills

Each state's share of the allocation is stored on their respective sides of the storages. The states' shares of the environmental water account will not be affected by internal spills in Hume or Dartmouth.

8. Release triggers

8.1 Trigger flows

Releases are made from the Barmah–Millewa Forest Environmental Water Allocation under the trigger flow conditions specified in subclauses 8.2 to 8.5.

The trigger flows are the monthly flows in the River Murray downstream of the Yarrawonga Weir in the preceding months. In interpreting these triggers, the usable component of the environmental water account is defined as the total environmental water account allocation less twice the maximum water borrowed by either states.

8.2 October release for a five-year drought

Releases are triggered in October if four years have passed with no release or without a flow downstream of Yarrawonga of at least 500 GL/m from September to November and 400 GL/m in December.

8.3 October release following a September drought

Releases are triggered in October if the September flow exceeded 500 GL/m and the usable component of the account is ↗400 GL.

8.4 November release following an October drought

Releases are triggered in November if the October flow exceeded 500 GL/m and the usable component of the account is ≥400 GL.

8.5 December release

Releases are triggered in December if the flow exceeded 500 GL/m for both October and November.

9. Release targets

9.1 Target flows

Releases for the Barmah–Millewa Forest will attempt to achieve the target flows downstream of the Yarrawonga Weir specified in subclauses 9.2 and 9.3.

9.2 Normal target flows

The normal target flows downstream of the Yarrawonga Weir are 500 GL/m for October and November, and 400 GL/m for December.

9.3 Special target flows

Except for releases triggered under subclause 8.2, if three years pass with no flow of ↗660 GL/m in any one month from August to November, then the target flow is increased from 500 GL/m to 660 GL/m at Yarrawonga:

(a) for October if a release starts in October, or

(b) for November if a release starts in November (see explanatory note 9.3)

9.4 Reduction of target flows for a fifth year of drought

The targets for releases triggered under subclause 8.2 must be reduced if the flow in either October or November is less than 300 GL/month.

10. Amendment of release triggers and targets

These operating practices for making releases (clauses 8 and 9) can be varied and refined from time to time to improve environmental outcomes:

(a) in a given year by agreement between the managers of the environmental water account in consultation with water managers in the two states, and in consultation with Murray–Darling Basin Commission officers, or

(b) as an agreed permanent change to a rule approved by the commission after a review of the long-term impacts.

11. Accounting for releases

11.1 Accounting for release from the Barmah–Millewa Forest Environmental Water Allocation

Releases from the Barmah–Millewa Forest Environmental Water Allocation are calculated as the difference between the releases from Hume Dam to meet the target flows and the releases that would have been made to meet all other requirements other than new environmental uses agreed after 29 August 2003 (see explanatory note 11.1).

11.2 Sharing of releases between the states

Until one state's ability to release is exhausted, releases are shared between the states in amounts which tend most to equalise the state's remaining Barmah–Millewa Forest environmental water accounts (including water that has been borrowed). When one state's ability to release is exhausted, water can continue to be released from the other state's account.

A state's ability to release water is exhausted if:

(a) all its remaining account has been borrowed, or

(b) its account is empty and its overdraw limit has been reached (see explanatory note 11.2)

12. Barmah–Millewa Forest Environmental Water Allocation and special accounting

12.1 Declaration of periods of special accounting

For the purposes of declaring periods of special accounting under clause 122 of the Murray–Darling Basin Agreement, the non-borrowed component of the Barmah–Millewa Forest Environmental Water Allocation must not be considered to be part of the New South Wales or Victorian reserves.

12.2 Special accounts of state water use

The release by a state of the Barmah–Millewa Forest Environmental Water Allocation must not be treated as a water diversion for the purposes of special accounting under paragraph 124(a) of the Murray–Darling Basin Agreement.

Explanatory notes

Revised operating rules for the Barmah–Millewa Forest Environmental Water Allocation—July 2006 (DRAFT)

Additional information that some clauses of the revised operating rules for the Barmah–Millewa Forest Environmental Water Allocation needed is provided below as explanatory notes.

1.3 Lower-security allocation

Hume natural inflows are the inflow that would have occurred to Hume Reservoir but for the influence of the Dartmouth Dam and the Snowy Scheme. Inflows to the Hume Reservoir are calculated by water balance and are adjusted for the net impact of the Snowy Scheme and the impoundments and losses in Dartmouth.

If the cumulative Hume natural inflows for the past 31 months at 1 August exceed 8,988 GL, then a lower-security allocation of 50 GL is made. If the inflow is less than this trigger volume, no allocation is made in this month but it may be made in subsequent months if inflows increase and the corresponding trigger in those months is exceeded.

1.4 Timing of lower-security allocation

Allocations are made at the start of the month based on inflows for the preceding months as prescribed in **Table 1** of the operating rules. Any lower-security allocation made in July is preliminary only and is made to ensure that sufficient resources are reserved for a subsequent formal allocation. If the trigger is exceeded only in July, no lower-security allocation is made. However, if the trigger is exceeded in any of the months from 1 August to 1December, the allocation is made even if the trigger is exceeded in only one month.

1.5 Allocation limit

The Barmah–Millewa Forest Environmental Water Allocation can contain a maximum of 700 GL at any time. This limits each state's share of the account to a maximum of 350GL. When any new allocation is added to the account, the allocated volume is limited to the volume that will bring each state's share of the account to 350GL. Once an allocation has been made, water not allocated because of the 350 GL limit is not available for topping up the Barmah–Millewa Forest Environmental Water Allocation later in the season.

3. Overdraw

Each state can independently overdraw a maximum of 50 GL irrespective of whether the other state is overdrawing. Provision of overdraw allows each state to bring their next year's allocation forward on the basis of a pro-rata share of reserve so that the environmental water account can be released in the current year. For this to occur, a state must have sufficient water in reserve (excluding the Barmah–Millewa Forest Environmental Water Allocation and the mandatory reserve) for the environmental water account to be overdrawn without affecting the current year's or next year's allocation for other users.

For New South Wales to have sufficient reserves, it must have made a general security allocation of 100%. For Victoria to have sufficient reserves for maximum overdraw, it must have made an allocation greater than 100% of water right or high reliability water share.

4. Evaporation loss

Evaporation losses from Barmah–Millewa Forest Environmental Water Allocation are calculated on the basis of pro-rata losses from the volume of the Hume and Dartmouth reservoirs at the end of the month.

The loss adjustment in any month will be the total net evaporation from the Hume and Dartmouth reservoirs divided by the total storage volume in Hume and Dartmouth and multiplied by the water volume of the environmental water account less the water borrowed less the water allocated to the account in the current year.

For example, for a given month:

> if Hume storage = 1,600 GL, Dartmouth storage = 2,200 GL, Hume evaporation loss = 18 GL, Dartmouth evaporation loss = 12 GL, Barmah–Millewa Forest Environmental Water Allocation = 550 GL (New South Wales = 240 GL, Victoria = 310 GL), borrow from the environmental water account = 20 GL (New South Wales = 13 GL, Victoria = 7 GL) and the current year's allocation to the environmental water account = 150 GL (75 GL from each state), then the Barmah–Millewa Forest Environmental Water Allocation losses for that month = (550 – 20 — 150)*(18 + 12)/ (1,600 + 2,200) = 3 GL.

This is calculated as follows:

$$BM_{Loss} = \frac{(Hume_{Loss} + Dartmouth_{Loss}) \times Max(0, BM_{EWA} - BM_{Borrow} - BM_{CurrentYearAllocation})}{(Hume_{Storage} + Dartmouth_{Storage})}$$

Evaporation losses are shared pro rata between each state's share of the non-borrowed, carried-over components of the environmental water account, except when a state's share of the account is negative. A state's share of evaporation becomes nil when a state's share of the account is negative.

For each state, pro-rata loss is calculated as follows:

$$BM_{Loss}(VIC) = BM_{Loss} \times \frac{(VIC_{EWA} - VIC_{Borrow} - VIC_{CurrentYearAllocation})}{Max(0.001, BM_{EWA} - BM_{Borrow} - BM_{CurrentYearAllocation})}$$

$$BM_{Loss}(NSW) = BM_{Loss} \times \frac{(NSW_{EWA} - NSW_{Borrow} - NSW_{CurrentYearAllocation})}{Max(0.001, BM_{EWA} - BM_{Borrow} - BM_{CurrentYearAllocation})}$$

In the above example, evaporation loss for New South Wales' share of the account would be 3* (240 – 13 – 75)/(550 – 20 –150) = 3* 0.40 = 1.20 GL; the Victorian share of the account would be 3* (310 – 7 – 75)/(550 – 20 – 150) = 3* 0.60 = 1.80 GL.

5.3 New South Wales exceptional circumstances

For the purpose of defining New South Wales exceptional circumstances, the four-year average November allocation for New South Wales is calculated as the sum of the November general security allocation and the November carryover (expressed as a percentage) for the previous three years plus the carryover for the current year (expressed as a percentage), and 30% general security allocation for current year, all divided by four.

This can be mathematically expressed as follows:

$$\frac{\sum_{i=1}^{3}(CarryOver_{Nov} + GenSecAllocation_{Nov}) + Carryover_{Currentyear} + 30\%}{4}$$

If this four-year average November allocation is less than 50%, New South Wales is considered to be under exceptional circumstances for the purpose of managing the Barmah–Millewa Forest Environmental Water Allocation.

5.6 Borrowing for other environmental purposes

Water year starts at 1 July and ends at 30 June.

6.1 Priority of spills

Hume spills are accounted in the following order:

(a) the carried-over component of environmental water other than Barmah–Millewa Forest Environmental Water Allocation

(b) the carried-over component of Barmah–Millewa Forest Environmental Water Allocation

(c) consumptive water.

This gives a higher priority/importance to the preservation of reliability of existing entitlements and the Barmah–Millewa Forest Environmental Water Allocation over the new environmental water created after 29 August 2003.

6.1 Spillage limit

When Barmah–Millewa Forest Environmental Water Allocation spills following the Hume spills, a state's share of the environmental water account spills down to a limit of 100 GL if that state has not borrowed any water in the previous year. If a state has borrowed in the previous year, the spillage limit for that state is increased by its borrow until it reaches 200 GL.

For example, if a state has borrowed more than 100 GL in the previous year, this state's Barmah–Millewa Forest account spills down to 200 GL rather than 100 GL. If the other state did not borrow in the previous year, its share of the account will spill down to 100 GL.

9.3 Special target flows

A special target flow of 660 GL applies for one month only. The special target flow is not tried in November if an attempt had already been made in October to achieve the special target, irrespective of the success or failure. However, if the flood is initiated in November, the special target is attempted in November.

In the fifth year of drought, special targets are often not met because of limited water resource availability because of the long dry-spell. For this reason, the special target flow of 660 GL is not attempted during the fifth year flooding.

11.1 Accounting for release from the Barmah–Millewa Forest Environmental Water Allocation

The following example illustrates how releases from the Barmah–Millewa Environmental Water Allocation are accounted.

Assume that a total volume of 300 GL was released from Hume Dam to meet the target flows at Yarrawonga for Barmah–Millewa flooding, including other environmental uses. If a release of 200 GL was required to meet the downstream requirements for irrigators and South Australian supply, releases from the Barmah–Millewa Forest Environmental Water Allocation would be 300 GL – 200 GL = 100 GL. This is because the downstream demand of 200 GL would have been released anyway even if forest flooding had not been initiated.

11.2 Sharing of releases between states

Examples given in Table F2 illustrate the sharing of the Barmah–Millewa Forest Environmental Water Allocation releases between states.

Table F2: Examples of sharing of environmental water account releases between states

Item	New South Wales (GL)	Victoria (GL)
Initial account	300	200
Borrowed water	100	0
Available overdraw	0	50
Example 1: Sharing a release of 100 GL	100	0
Releases	200	200
Final account		
Example 2: Sharing a release of 300 GL	200	100
Releases	100	100
Final account		
Example 3: Sharing a release of 400 GL	200	200
Releases	100	
Final account		
Note: Borrowed water cannot be released		
Example 4: Sharing a release of 450 GL	200	250
Releases	100	–50
Final account		
Note: States may have different overdraws		

Appendix G: Barmah Ramsar site ecosystems services — risk assessment

Ecosystem service as listed in the Barmah Forest Ramsar site ecological character description (Victorian Department of Sustainability and Environment 2008).

Note: The Millewa Forest ecological character description is currently in preparation, though it is anticipated to contain similar attributes to those contained in the Barmah ecological character description.

Table G1: Bio/physical grouping of ecosystem services

Ecosystem service	Bio/physical group
Flood control	Hydrology
Groundwater recharge	Hydrology
Supports all four of the freshwater wetland types in Victoria	Wetland type
Supports depleted wetland types	Wetland type
Supports vegetation communities representative of the Murray fans bioregion	Flora
Supports a large variety of communities	Flora and fauna
Supports the largest red gum forest in Australia	Flora
Part of a large natural floodplain system	Wetland function
Supports the most extensive area of moira grass plains in Victoria	Flora
Provides drought refuge for waterbirds	Fauna
Supports a high diversity of species	Flora and fauna
Supports threatened species	Flora and fauna
Provides one of Victoria's largest waterfowl breeding areas	Fauna
Supports an abundance of waterbirds	Fauna

Table G2: Risks to ecosystem services shown by the impact of threats on bio/physical groups

Threat	Bio/physical grouping of ecosystem service (as detailed above)			
	Hydrology	Wetland type/function	Flora	Fauna
Pest animals —exotic				
Carnivores (feral dog, fox, cat)	–	–	Yes — foraging fruits and spreading weed seeds	Yes — predation
Omnivores (pig)	–	Some — by modifying indigenous flora balance	Yes — foraging and habitat disturbance (weed introduction)	Yes — predation and habitat disturbance
Herbivores (rabbit/hare, horse, deer and goat)	–	Potential — by modifying indigenous flora balance	Yes — grazing and habitat disturbance (weed introduction)	Some — habitat disturbance
Pest animals — native				
Kangaroo	–	Yes — by reducing flora biomass if in large numbers and/or drought conditions	Yes – grazing	Some — habitat reduction
Gum leaf skeletoniser and phasmids (stick insects)	–	Yes — by inducing heavy leaf litter fall and thus promotion of blackwater potential	Yes — reducing health of red gums	Yes – reducing food resource for folivors (e.g. koalas) and nectivors (e.g. honeyeaters)
Pest plants				
Terrestrial exotic species (blackberry, bridal creeper)	–	Some — by reducing indigenous flora extent	Yes — by excluding indigenous flora	Yes — by reducing habitat for many native species and increasing cover and food resource for some exotic species (may increase habitat for other fauna, though replaces natural habitat)
Aquatic exotic species (cabomba, arrowhead)	Potential — modifying flow patterns when choking waterways	Some — by reducing indigenous flora extent	Yes — by excluding indigenous flora	Yes — by reducing/ modifying habitat for many native species (e.g. choking waterways)
Terrestrial native species (river red gum, white cedar)	Potential — modifying flow patterns when choking waterways	Potential — modifying flow patterns when choking waterways and altering wetland structure/type	Yes — by excluding other indigenous flora through shading and resource competition	Potential — bymodifying habitat structure and assemblage
Aquatic native species (giant rush)	Potential — modifying flow patterns when choking waterways	Potential — modifying flow patterns when choking waterways and altering wetland structure/type	Yes — by excluding other indigenous flora through shading and resource competition	Potential — by modifying habitat structure and assemblage
Physical				
Erosion (waterways)	Yes — directly affects commence-to-flow and flood regime	Yes — directly affects flood regime and flows	Yes — can affect flood regime requirements and/ or tolerances of some plants	Yes — can affect management/flood regime to feeding/nesting areas
Water quality				
Nutrient load	–	–	Yes — can affect plant survival, growth and species diversity	Yes — can affect fauna survival and breeding
Temperature	–	–	Yes — can affect plant survival, growth and species diversity	Yes — can affect fauna survival and breeding
Electrical conductivity	–	–	Yes — can affect plant survival, growth and species diversity	Yes — can affect fauna survival and breeding

Threat	Bio/physical grouping of ecosystem service (as detailed above)			
	Hydrology	Wetland type/function	Flora	Fauna
Agricultural runoff	–	potential – un–seasonal flows can influence wetland type and function	Yes — can introduce pollutants (chemical runoff)	Yes — can impact on habitat
Blackwater	–	–	–	Yes — can affect survival of animals who draw oxygen from water
Flood regime				
Flood duration	Yes — where exceeds natural regime	Yes — can directly influence wetland type and function	Yes– influences distribution, species diversity and health	Yes — influences habitat availability impacting breeding and feeding success
Flood depth	Yes — where exceeds natural regime	Yes — can directly influence wetland type and function	yes– influences distribution, species diversity and health	Yes — influences habitat availability impacting breeding and feeding success
Rate of rise and drawdown	Yes — where exceeds natural regime	Yes — can directly influence wetland type and function	Yes — influences distribution, species diversity and health	Yes — influences habitat availability impacting breeding and feeding success
Flow regime (lentic or lotic)	–	Yes — can directly influence wetland type and function	Yes — influences distribution, species diversity and health	Yes — influences habitat availability impacting breeding and feeding success
Return frequency (including inter-flood duration)	Yes — where exceeds natural regime	Yes — can directly influence wetland type and function	Yes — influences distribution, species diversity and health	Yes — influences habitat availability impacting breeding and feeding success
Instream barriers				
Debris	Yes — can impact on flow	–	Yes — can affect plant survival, growth and species diversity	Yes — can impact on migration and movement
Vegetation	Yes — can impact on flow	Yes — can impact species composition and structure	Yes — can affect plant survival, growth and species diversity	Yes — can impact on habitat availability and suitability
Infrastructure	Yes — can impact on flow	Yes — can impact species composition and structure	Yes — can affect plant survival, growth and species diversity	Yes — can impact on migration and movement
Sedimentation (in front of regulating structures)	Yes — directly affects commence–to–flow and flood regime	Yes — directly affects flood regime and flows	Yes — encouraging establishment of some notable pest plant species	Yes — affecting management/flood regime to feeding/nesting areas

Schedules

For all schedules see ←www.mdba.gov.au/programs/tlm/icon_sites/emp.→.

Schedule 1: Condition monitoring plan

Schedule 2: Operating strategy

Schedule 3: Communications plan

List of figures and tables

Figures

1.1	Location of The Living Murray icon sites	4
1.2	The Living Murray governance structure	11
1.3	Cross-border management committees: Barmah–Millewa	12
2.1	Barmah–Millewa Forest icon site	13
3.1	Cross-section of floodplain showing key vegetation communities and their water requirement: Barmah–Millewa	17
3.2	Area of Barmah Forest inundated as a function of River Murray flood peak at Tocumwal (instantaneous peak discharge, ML/d) and Yarrawonga (monthly total discharge, GL/m)	18
4.1	Barmah-Millewa water management area boundaries	22
4.2	Environmental water allocation (release decision path): Barmah–Millewa Forest	28
8.1	Adaptive management cycle	33

Tables

2.1	Area of key vegetation communities: Barmah–Millewa Forest	15
3.1	Revised first step decision ecological objectives for Barmah-Millewa icon site	16
3.2	Water requirements of key vegetation communities and biota: Barmah–Millewa icon site	19
4.1	Objectives under different water availability scenarios	22
4.2	The Living Murray water management infrastructure: Barmah–Millewa Forest	24
4.3	Variable operation of Barmah–Millewa Forest regulators during seasonal and unseasonal flood periods	25
4.4	Operating regime that contribute to the ecological objectives	26
A1	Agencies involved in delivery of The Living Murray program	37
F1	Lower security water allocations	49
F2	Examples of sharing of environmental water account releases between states	54
G1	Bio/physical grouping of ecosystem services	55
G2	Risks to ecosystem services shown by the impact of threats on bio/physical groups	56

Abbreviations and acronyms

GL	gigalitres
GL/d	gigalitres a day
LTCE	long-term Cap equivalent
MDBA	Murray–Darling Basin Authority (absorbed the functions of the former Murray–Darling Basin Commission in December 2009)
MDBC	Murray–Darling Basin Commission (now the Murray–Darling Basin Authority
ML/d	megalitres a day
TLM	The Living Murray

Glossary

Aquatic ecosystem	Any water environment from small to large, from pond to ocean, in which plants and animals interact with the chemical and physical features of the environment.
Baseline condition	An environmental quality or condition defined at a point in time and used as a benchmark for determining a change in the environmental quality or condition. For The Living Murray, the baseline condition is 2002, when the program was announced.
Basin Officials Committee	A jurisdictional committee to coordinate the management of Basin water resources between the Commonwealth, the Authority and the Basin states.
Ecological objective	An objective is a statement of the desired condition; it is not necessary to quantify an objective.
Ecological targets	A target is generated from the ecological objective and will ideally be quantitative.
Environmental water	Water that is available for the environment.
Environmental Watering Group	A jurisdictional committee that develops and implements the annual TLM Environmental Watering Plan. The Environmental Watering Group recommends annual TLM watering priorities and proposals to ensure consistency between icon sites.
Icon site environmental water management plan	A plan that details the aims, objectives and management actions at an icon site in accord with TLM. The plan is complementary to state based plans and processes.
Minimum operating strategy	The minimum water used or required to achieve an environmental objective.
Murray–Darling Basin Ministerial Council	Ministerial council that develops and agrees to the intergovernmental agreements, approves TLM business plans and makes key decisions (e.g. approves Natural Resource Management programs budget in the Corporate Plan).
Objective	See 'Ecological objective'.
Ramsar Convention on Wetlands of International Importance (Ramsar Convention)	An international treaty adopted in the Iranian city of Ramsar in 1971 that focuses on the conservation of internationally important wetlands.
River Management Division	A business unit of the Murray–Darling Basin Authority responsible for operating the River Murray system in accordance with the Murray–Darling Basin Intergovernmental Agreement. River Management Division manages the River Murray system to ensure that the available water is continuously accounted for and distributed to New South Wales, Victoria and South *Australia in accordance with* the Murray–Darling Basin Agreement.
River Murray Increased Flows (RMIF)	The component of the water recovered under the Snowy Water Inquiry Outcomes Implementation Deed (SWOID) that is returned to the River Murray System as an environmental flow.

Target	See 'ecological target'
The Living Murray Committee	A jurisdictional committee that is responsible for implementation of The Living Murray Business Plan.
Unregulated Flow	The volume of water surplus to regulated requirements and determined by the volume of flow in the River Murray exceeding (or predicted to exceed) the inlet channel capacity for Lake Victoria and entitlement flow for South Australia
Water regime class	Spatial classification of the floodplain into areas with common water regimes and ecological characteristics.
Water requirements	Includes the flow, volume, timing, duration, velocity, depth, quality or any other attribute that is required to meet the ecological target.

References

Abel, N & O'Connell, D 2006, *Values from Barmah Forest,* in *Barmah Forest: A review of its values, management objectives and knowledge base*, Goulburn Broken Catchment Management Authority, Shepparton, Victoria.

Bren, LJ, O'Neill, IC & Gibbs, NL 1987, 'Flooding in the Barmah Forest and its relation to flow in the Murray–Edward river system', *Australian Forest Research*, vol. 17, pp. 127–44.

Bren, LJ, O'Neill, IC & Gibbs, NL 1988, 'Use of map analysis to elucidate flooding in an Australian riparian river red gum forest', *Water Resources Research*, vol. 24, no. 7, pp. 1152–62.

Bren, L & Acenolaza, P 2002, *Impact of burning on red gum regeneration on Moira grass plains in Barmah Forest*, Department of Forestry, University of Melbourne, Creswick.

Cunningham (in prep.), 'Stand Condition Modelling for the whole Murray River floodplain,

Council of Australian Governments 2008, *Agreement on the Murray Darling Basin Reform*, viewed 2011, **←www.coag.gov.au/intergov_agreements→**.

Council of Australian Governments 2004, *Murray–Darling Basin Intergovernmental Agreement on Addressing Water Overallocation and Achieving Environmental Objectives in the Murray–Darling Basin*, viewed 2011, **←www.coag.gov.au/intergov_agreements→.**

Department of Environment, Water, Heritage and the Arts 2009, website viewed 22 January 2009, **←www.environment.gov.au→**.

Department of Sustainability, Environment, Water, Population and Communities 2011a, *Environment Protection and Biodiversity Conservation Act 1999*, viewed 2011, **←www.environment.gov.au/→**

Department of Sustainability, Environment, Water, Population and Communities 2011b, *Bilateral bird agreements*, viewed 2011, **←www.environment.gov.au/→**

Dexter, BD 1978, 'Silviculture of the river red gum forests of the central Murray floodplain', *Proceedings of the Royal Society of Victoria*, vol. 90, pp. 175–94.

EarthTech Engineering Pty Ltd, Fluvial Systems Pty Ltd, Ecos Consulting Pty Ltd, Dr Jane Roberts, and Dr Vincent Clark and Associates 2002, *River Murray - Yarrawonga-Echuca Action Plan*, Report to Goulburn Broken Catchment Management Authority, Department of Land and Water Conservation and Murray–Darling Basin Commission.

Forestry Commission of New South Wales 1984, *Notes on the silviculture of the major New South Wales forest types, five river red gum types,* Forestry Commission of New South Wales, Sydney, Australia.

King, AJ, Tonkin, Z & Mahoney, JM 2007, *Assessing the effectiveness of environmental flows on fish recruitment in Barmah–Millewa Forest*, report to Murray–Darling Basin Commission, Arthur Rylah Institute for Environmental Research, Victorian Department of Sustainability and Environment.

King, AJ, Ward, KA, O'Connor, P, Green, D, Tonkin, Z & Mahoney, J 2010, 'Adaptive management of an environmental watering event to enhance native fish spawning and recruitment', *Freshwater Biology*, vol. 55, pp. 17–31.

Leitch, C 1989, *Towards a strategy for managing the flooding of Barmah Forest*, seminar on Barmah Forest organised by the State Working Group on River Murray Wetland and Forest Management, Victorian Department of Conservation Forests and Lands, Benalla, Victoria.

Loyn, RH, Lumsden, LF & Ward, KA 2002, 'Vertebrate fauna of Barmah Forest, a large forest of river red gum *Eucalyptus camaldulensis* on the floodplain of the Murray River, Australia', *The Victorian Naturalist*, vol. 119, no. 3, pp. 14–32.

Maunsell Pty Ltd 1992, *Barmah–Millewa Forests Water Management Plan*, final report to the Murray–Darling Basin Commission, Canberra.

MDBA 2010, *Guide to the proposed Basin Plan — Overview*, MDBA, Canberra.

MDBA 2011, *Barmah–Millewa Forest icon site condition monitoring plan*, MDBA, Canberra.

Murray–Darling Basin Commission (MDBC) 2004, *The Living Murray Environmental Works and Measures Program*, MDBC, Canberra.

Murray–Darling Basin Commission 2006, *Water application across the River Murray system and icon sites: Status report*, MDBC publication No. 25, Canberra.

Murray–Darling Basin Commission 2007, *The Living Murray Outcomes and Evaluation Framework: A framework for monitoring and evaluating the achievement of outcomes and objectives of The Living Murray*, MDBC, Canberra.

Reid, J 2006, *Waterbirds and water regimes in Barmah Forest: A review of its values management objectives and knowledge base*, Goulburn Broken Catchment Management Authority, Victoria.

Roberts, J 2006, *Floodplain vegetation responses to water regime, grazing and fire,* in *Barmah Forest: A review of its values management objectives and knowledge base*, Goulburn Broken Catchment Management Authority, Victoria.

Roberts, J & Marston, F 2000, *Water regime of wetland and floodplain plants in the Murray-Darling Basin: A sourcebook of ecological knowledge*, Technical Report 30–00, CSIRO Land and Water, Canberra.

Rourke, M, Raymond, S & Tonkin, Z 2010, *Barmah–Millewa fish condition monitoring 2010 Annual Summary*, Industry and Investment (NSW), Arthur Rylah Institute for Environmental Research and Department of Sustainability and Environment, Heidelberg, Victoria.

Sharley, T & C Huggan (eds) 1995, *Chowilla resource management plan: final report*, prepared by the Chowilla Working Group in consultation with the Chowilla Reference Group, Murray–Darling Basin Commission, Canberra.

State Forests of New South Wales & New South Wales National Parks and Wildlife Service, 2002, *Information sheet on Ramsar wetlands — Central Murray red gum forests*, State Forests of New South Wales and New South Wales National Parks and Wildlife Service, New South Wales.

Tobias 2009, *Living proof — The essential data-collection guide for Indigenous use-and-occupancy map services*, Ecotrust, Canada.

Victorian Department of Sustainability and Environment 2003, *Barmah Forest Ramsar Site: Strategic Management Plan*, Department of Sustainability and Environment, Melbourne, Victoria.

Victorian Department of Sustainability and Environment 2006, *Environmental Effects Act: Ministerial Guidelines Victorian Government*, Department of Sustainability and Environment, Melbourne, Victoria.

Victorian Department of Sustainability and Environment 2008, *Barmah Forest Ramsar site ecological character description*, Department of Sustainability and Environment, Melbourne, Victoria/

Victorian Department of Sustainability and Environment & Goulburn Broken Catchment Management Authority 2005, *Asset Environmental Management Plan: Barmah Significant Ecological Asset — Draft,* Department of Sustainability and Environment and Goulburn Broken Catchment Management Authority, Victoria.

Ward, KA 1991, *Barmah–Millewa Forests trial watering — Investigation of the moira grass plains in Barmah Forest, Victoria*, report for the Murray–Darling Basin Commission (NRMS Project No. M007B) and the Floodplain Ecology Group, Department of Conservation and Environment, Victoria.

Ward, KA 2009a,'Controlling giant rush infestations, Victoria', *Wetlands Australia: National Wetlands Update 2009*, No. 17, pp. 36–37, Australian Government, Canberra.

Ward, KA 2009b, *Observations of Barmah Forest waterway commence-to-flow thresholds*, Goulburn Broken Catchment Management Authority, Shepparton, Victoria.

Ward, KA & Colloff, M 2010, 'Ecosystem response modelling for the Barmah–Millewa Forest: the interface between science and management', *Ecosystem response modelling in the Murray–Darling Basin*, N Saintilan & I Overton (eds), chapter 20, pp. 345–56 CSIRO Publishing, Canberra.

Australian Government

MURRAY–DARLING
BASIN AUTHORITY