Department of Planning and Environment

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Procedures Manual for the NSW Murray & Lower Darling Regulated Rivers (2022)

PREREQUISITE POLICY MEASURES

December 2022

Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

Published by NSW Department of Planning and Environment

dpie.nsw.gov.au

Prerequisite Policy Measures: Procedures Manual for the NSW Murray & Lower Darling Regulated Rivers (2022)

First published: 30 June 2019

Department reference number: PUB22/565

More information

Environmental Water Management | Operations Division

www.industry.nsw.gov.au/water/environmental-water-hub

Acknowledgements

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The NSW Department of Planning and Environment – Water would like to thank the NSW Department of Planning and Environment – Environment and Heritage, WaterNSW, the Commonwealth Environmental Water Office and the Murray-Darling Basin Authority who have provided input into this procedures manual.

Cover image: Edward River, Murray Valley National Park - James Dyer

Document revisions

Revision	Date	Publication number	Summary of revisions
1	30/06/2019	PUB19/312	Procedures Manual developed to meet MDBA requirements for PPMs
2	December 2022	PUB22/565	Updated to include new accounting arrangements (Table 6 and Appendices C to F) and other minor edits. Reviewed by the NSW PPM Working Group.

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Abbreviations

Abbreviation	Description
BOC	Basin Officials Committee
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
EWAG	Environmental Water Advisory Group
HEW	Held Environmental Water
IRORG	Independent River Operations Review Group
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
O&O document	Objectives and outcomes for river operations in the River Murray System document.
PPM	Prerequisite Policy Measure
PPM IP	NSW Prerequisite Policy Measure Implementation Plan
RMIF	River Murray Increased Flows
RMO	River Murray Operations
SO&Os	Specific Objectives and Outcomes for River Operations in the River Murray System
SCBEWC	Southern Connected Basin Environmental Watering Committee
SDL	Sustainable Diversion Limit
TAG	Technical Advisory Group
TLM	The Living Murray
WLWG	Water Liaison Working Group
WMA	Water Management Act 2000
WRP	Water Resource Plan
WSP	Water Sharing Plan

1. Introduction

1.1 Purpose

This Procedures Manual (the Manual) has been prepared to provide a detailed framework for the operation and continual improvement of PPMs in the NSW Murray and Lower Darling regulated river water sources. The implementation of PPMs will maximise the efficient use and beneficial outcomes from the use of water for the environment.

The objective of this Manual is to sufficiently codify the process of using PPMs in the NSW Murray and Lower Darling regulated river water sources to achieve an appropriate balance between providing protection for other water licence holders and allowing for the efficient and effective use of water for the environment to achieve the environmental outcomes envisaged under the Basin Plan.

1.2 Context

Prerequisite Policy Measures (PPMs) seek to maximise the beneficial outcomes of water recovered for the environment under the Basin Plan. In developing the Basin Plan, the Murray-Darling Basin Authority (MDBA) assumed that rivers will be managed to maximise environmental outcomes with the water available without impacting on other water users. This concept was being explored by Basin States for the multi-site environmental watering trials in the River Murray. The intended outcomes were for:

- environmental water flows throughout the length of the river, and between rivers; and protected from extraction, re-regulation or substitution
- to allow the release of environmental water on top of other in-stream flows, including unregulated flow events.

These outcomes were intended to be achieved through the unimplemented policy measures described under 7.15 of the Basin Plan, and are now referred to as PPMs:

- credit environmental return flows for downstream environmental use (return flows),
- allow the call of water for the environment from storage during unregulated flow events (piggybacking).

Implementing PPMs is critical to achieving the environmental outcomes of the Basin Plan with the water identified for recovery. PPMs are implemented via legislative and operational rule changes to create secure and enduring arrangements for the use and accounting of water for the environment. PPMs will assist to minimise the volume of water recovered by allowing for more efficient and effective use of water for the environment to maximise environmental outcomes, without impacting on the reliability of other water users.

In developing the PPMs, the NSW government is discharging its obligations to implement water reform and deliver on the Basin Plan. PPMs are supported by the NSW *Water Management Act 2000* and will enable the effective and efficient delivery of environmental water for beneficial outcomes.

1.3 Background

PPMs allow the use of water for the environment at multiple sites along the length of the river, and between rivers (environmental flow reuse, or return flows), and for HEW to be ordered from a headwater storage during unregulated events (piggybacking). These measures are significant changes to the way that water has historically been managed and accounted for in the Murray-Darling Basin.

Under the *Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin 2013*, NSW agreed to deliver a Prerequisite Policy Measures Implementation Plan by June 2017 to the Murray-Darling Basin Authority (MDBA). The NSW Prerequisite Policy Measures Implementation Plan (PPM IP) was endorsed by the MDBA in May 2017.

The MDBA has assessed the measures made through amendments to water sharing plans and changes to regulations and operational manuals and determined that PPMs are in effect. As of 1 July 2019, PPMs were considered to be in effect.

PPMs are applied during the operation of the SDL Adjustment Mechanism in the Basin Plan. Any increase to the SDL resulting from supply measures will be calculated by adding notified supply measures and removing any unimplemented PPMs from the benchmark conditions of development, while maintaining equivalent environmental outcomes and no detrimental impacts on reliability of supply of water to the holders of water access rights that are not offset or negated.

1.4 Relationship to other plans and legislation

The management of water for the environment, including the use of PPMs, occurs within the NSW water management framework, guided by the *Water Management Act 2000*.

PPMs are implemented within NSW through the NSW PPM IP and this Manual, together with supporting changes to Water Sharing Plans (WSPs) in each water source and the WaterNSW water supply work approvals.

To establish statutory support for the process set out in the NSW PPM Implementation Plan and the Manual, amendments will be made to the *Water Sharing Plan for the New South Wales Murray and Lower Darling Regulated Rivers Water Sources 2016*. Amendments to the water sharing plan require concurrence from the NSW Minister for Environment.

The roles and obligations of the river operator to implement PPMs are also recognised through the inclusion of specific conditions to the NSW Murray and Lower Darling water supply works approval.

For the Murray and Lower Darling regulated rivers, this Manual also relies upon the “river operations framework” for the River Murray System (RMS) (including the Lower Darling River), including:

- the Commonwealth *Water Act 2007* (of which the MDB Agreement is a schedule to)
- the 'Objectives and Outcomes for River Operations in the River Murray System' document approved by the Basin Officials Committee (BOC) from time to time
- any approvals made by the Basin Officials Committee (BOC) for additional actions that are available to be used.

The RMS framework will set out the operation of PPMs for shared resources in the Murray system that will be delivered by the River Murray System operator (MDBA River Operations), in accordance with the arrangements agreed to by the joint governments.

The Objectives and Outcomes for River Operations in the River Murray System sets out specific objectives and outcomes (SO&Os) that provide for directed releases and assumed losses to estimate return flows.

A table demonstrating how PPMs relate to Commonwealth and State plans and legislation is provided in Appendix A.

1.5 Overview of the PPM Procedures Manual

This Manual will be made publicly available by Department of Planning and Environment–Water (DPE-Water), and will be reviewed annually via the process set out in this Manual. Changes may arise from the annual review, or as a result of proposals brought forward for consideration. The publicly available Manual will be kept updated as changes are approved.

This Manual is set out as described in Table 1.

Table 1: Overview of the Manual

Section	Content
Section 1	**Introduction** Purpose Context Background Relationship of the Manual to other plans and legislation Overview of the NSW PPM Procedures Manuals
Section 2	**Overview of PPMs in NSW** NSW principles and objectives for PPM implementation Call of water from storage Environmental flow reuse Operability of PPMs in NSW from planning to reporting and review
Section 3	**Framework for the operation of PPMs** Key framework components Roles and responsibilities Consultation
Section 4	**The NSW Murray and Lower Darling system** Environmental water sites Water delivery pathways NSW Murray and Lower Darling PPM actions Risk mitigation
Section 5	**Adaptive management** Annual reporting Annual evaluation and review for continuous improvement

2. Overview of PPMs in NSW

This section describes how the PPM requirements to call water from storage and recognise environmental flows that are returned to the water source for downstream environmental benefits are enabled in NSW legislative and policy settings. This NSW overview includes arrangements for both the Murrumbidgee and NSW Murray and Lower Darling regulated rivers. These NSW arrangements will be strengthened and refined through the processes described in this Manual.

In NSW, PPMs apply to held environmental water (HEW) in the Murrumbidgee, NSW Murray and Lower Darling regulated rivers water sources. HEW is environmental water that is held as part of a licensed volumetric entitlement (see Appendix B).

In the NSW Murray regulated river water source, PPMs also apply to River Murray Increased Flows (RMIF) account water.

2.1 Principles underpinning NSW PPM implementation

The NSW PPM IP sets out 4 guiding principles for the implementation of PPMs:

1. NSW will implement PPMs to the extent that impacts on other licence holders can be mitigated or offset, while also enabling optimum environmental outcomes.
2. NSW will develop operational tools that are simple, practical to implement and cost effective.
3. Reliability and access characteristics of licensed entitlements held for environmental water purposes are the same as other licensed entitlements.
4. Adaptive management is required.

The development of this Manual has been based on these principles. The application of the processes in this manual will be guided by these principles to seek to maximise the beneficial outcomes of water recovered for the environment under the Basin Plan while maintaining reliability to other licence holders. Where there is uncertainty, NSW will adopt a precautionary approach to minimise potential detrimental impacts.

It is recognised that there are also benefits stemming from the implementation of PPMs. In some instances, these benefits may offset any detrimental impacts over the longer term. However, until the benefits and impacts can be determined, NSW will continue to implement PPMs based on the above principles.

PPM Assessment Guidelines were provided by the MDBA to inform the content and format of states' implementation plans for PPMs. The Guidelines require the arrangements for the implementation of PPMs to:

- be secure and enduring
- be fully operable
- be transparent

- identify and mitigate risks
- provide for releases of Held Environmental Water from storages on top of other in-stream flows, including unregulated events
- allow environmental water to flow throughout the length of the river, and between rivers; and be protected from extraction, re-regulation or substitution.

2.2 Call water from storage using piggybacking

PPMs enable HEW to be ordered from a headwater storage during unregulated flow events (piggybacking). Piggybacking allows the environmental water holders to target flows to nominated delivery points along the river.

The NSW environmental water manager works with WaterNSW to develop a water order including the target flow and location. This process is an extension of the consultation already undertaken via the Environmental Water Advisory Group (EWAG). The water order can request that the order be met from a headwater storage. Piggybacking allows such a water order to be placed during delivery of other system demands, including during unregulated flow events, with agreement from WaterNSW on matters such as the rates of releases, accounting arrangements, and flood/water quality risk mitigation measures. The planning, ordering and delivery process for HEW orders is set out in more detail in Section 2.4.

As the river operator in NSW, WaterNSW is required to meet system orders subject to operating constraints of the system. Flows that result from water orders made using piggybacking cannot be used to be meet other access licence water orders, planned environmental water rules or general system operational rules. HEW is recognised as it moves through the system through the delivery of target volumes according to the agreed water order and requires ongoing monitoring of flows along the river reach.

For shared resources in the Murray and Lower Darling, when water is called from storage, WaterNSW approves orders placed by the environmental water manager, following consultation with MDBA where necessary. WaterNSW then directs the MDBA to release orders in accordance with the Murray-Darling Basin Agreement and the ‘Objectives and Outcomes for River Operations in the River Murray System' document.

The methodology adopted in the Murrumbidgee and NSW Murray and Lower Darling for calculating the volume to be debited from an environmental account when using piggybacking is to determine the difference between releases made with the environmental water holder’s order and the releases that would have (hypothetically) been made without the environmental water order.

2.3 Environmental flow reuse

This section describes how the PPM requirement to recognise environmental flows that return to the water source from an environmental event is implemented.

Environmental flow reuse, or return flows, recognises the return flow of water downstream of an environmental watering event, allowing that water to be used for downstream environmental

benefits. These return flows are protected from extraction and re-regulation, including in the downstream system.

The procedures for environmental flow reuse, or return flows, are:

- A delivery pathway is nominated to describe the intended environmental watering event. The nominated delivery pathway allows a water order using HEW to nominate multiple environmental use sites along the length of a river, subject to delivery capacity and operating constraints.
- For environmental sites that are not considered accurate, an assumed use method is required. The assumed use method is used to estimate the delivery of environmental water and the downstream return flows.
- For each order using an assumed use method, an Assumed Use Statement is required for the purposes of debiting accounts.
- Return flows that result from water orders made using environmental flow reuse cannot be used to be meet other access licence water orders, planned environmental water rules or other general system operational rules. Return flows are recognised as they move through the system in line with the assumed use method.

Environmental flow reuse also applies when HEW is delivered into a downstream river system, such as inflow from the Murrumbidgee to the River Murray.

HEW flows from the Murrumbidgee River into the River Murray are managed under the bulk entitlement delivery arrangement provided under the Murray Darling Basin Agreement (Clause 98 MDBA's Role in the Operation of Storages). WaterNSW, as the NSW river operator, applies an agreed incremental loss rate, to recognise HEW delivery in the Murray from Balranald to South Australia. WaterNSW provides MDBA River Murray Operations (RMO) with daily flow volumes of HEW passing beyond the point of delivery (i.e., Balranald) for recognition in the Murray and delivery to the South Australian border. This flow is to be adjusted by RMO for travel time to the South Australian border and the water accounted as a bulk entitlement delivery to South Australia. This water is not to be reregulated for any use, and not to be reregulated into Lake Victoria. These accounting arrangements are outlined in Section 2.4.3 of this Manual.

For shared resources in the Murray system, to recognise and protect downstream environmental flows in the River Murray, NSW also uses Clause 98 of the Murray Darling Basin Agreement to direct the MDBA to deliver a bulk volume of NSW HEW to South Australia. These instructions reflect the assumed uses specified in the relevant Specific Objective and Outcome (SO&O).

2.4 Operability of PPMs in NSW

PPMs are operationalised through the valley-specific Procedures Manuals and supporting conditions in the relevant water supply work approvals held by WaterNSW. The Procedures Manuals codify the operational process and accounting arrangements so that an appropriate balance is achieved between providing for the efficient and effective use of water for the environment and providing protection for other water licence holders.

Relevant NSW agencies (Department of Planning and Environment-Water as the regulator, WaterNSW as the river operator and the Department of Planning and Environment-Environment and Heritage as the NSW environmental water manager) provided a joint letter of commitment to MDBA confirming that PPMs will continue to be implemented as per the arrangements described in the Procedures Manuals from 1 July 2019. This letter remains in effect until the new provisions in the relevant WSPs are gazetted and new conditions are placed on the water supply work approvals.

The sections below detail the arrangements for the implementation of PPMs, including event planning, water ordering, delivery, accounting, reporting and review processes.

2.4.1 Planning

Environmental watering events are often complex and require a process for developing and placing water orders. This process includes a requirement for river operators to be involved in the planning phase to ensure that events can be managed over a range of climatic and operational conditions. Existing forums such as environmental water advisory groups (EWAGs) and technical advisory groups (TAGs) are used by the environmental water managers for consultation at various stages in the planning and development of environmental watering events. Environmental water holders (the Department of Planning and Environment-Environment and Heritage and the Commonwealth Environmental Water Holder (CEWH),) develop annual environmental watering priorities and plans which consider a range of weather and water availability scenarios. Environmental water holders also work together to develop watering schedules which outline the purpose, conditions and arrangements for environmental watering events in NSW that use Commonwealth environmental water. They will work with WaterNSW to develop a proposal including the target flow and location.

An iterative process may be required during this planning phase and requires cooperation between the regulator, the river operator, and the environmental water holders, including agreement on any assumed use rates, consideration of impacts (both positive and negative) and risks, and any mitigation measures to be applied.

For significant environmental watering events, development of water orders must commence well in advance of the target release period to allow sufficient time for collaboration.

2.4.2 Ordering and release of water

Following the above planning process, the NSW environmental water manager (i.e., the Department of Planning and Environment-Environment and Heritage) prepares and places a water order.

The water order should contain:

- a general description of the proposed event, including its environmental objectives
- delivery details, including:
  - target flow and/or diversion rates and locations
  - start and end dates
  - any return flows (if applicable)
  - when delivery should cease (e.g. if particular flow threshold reached or if unregulated flows commence)

  - delivery pathway, if more than one site is nominated for watering
- accounting arrangements (reflecting any discussions from Section 2.3.1 above), including any assumed use method to be used
- nominate the entitlements to be used (and an upper volume limit if required) and any associated instructions regarding the split across water access licences
- the decision making process proposed to manage any potential variation in weather conditions or other relevant factors.

Water orders must be sufficiently detailed to provide guidance for river operators over a range of potential climatic conditions and may also require protocols for within-event decision making.

The river operator is required under their water supply work approval to provide timely advice regarding system flow limits, any matters that might vary the volume of water that would be required, and risks in delivery of the proposed order. An iterative process may be required to settle complex water orders and will require cooperation between the river operator and the environmental water manager.

Environmental water holders are responsible for estimating the volume of water required to meet their environmental objectives in their water orders, having regard to advice from WaterNSW.

The river operator is responsible for operating the river including approving a water order. Operational risks and the available mitigation measures are to be considered by WaterNSW when considering water orders that require the release of water using PPMs. This will be undertaken in consultation with the environmental water manager prior to approval (or rejection) of an order using PPMs. Any orders that are refused/rejected will be documented in the annual environmental release river operations report, together with supporting explanations and rationale.

When an order that relies on the use of PPMs is accepted by the river operator, the release of water to meet that order should be incorporated into delivery planning for the valley and included in any advice regarding operation of the regulated river system to licensed water users and publicly for the community. The environmental water manager, in placing a water order relying on PPMs, is required to undertake appropriate communication actions to ensure that potentially affected landholders and the general community are aware of the proposed watering event.

The river operator is required to provide operational reporting on release of held environmental water, including regular environmental water use accounting during events.

2.4.3 Accounting

WaterNSW maintains water allocation accounts that record water allocation announcements, water ordered, water taken and carry over for each water access licence, including licenses owned by environmental water holders. They are responsible for determining and debiting volumes of HEW used during environmental watering events that rely on PPMs.

As accounting methods become established through the application of the process set out in the Procedures Manuals, the arrangements will be codified in the Manuals (see Section 4) and provided on the department's website.

The methodology generally adopted in the Murrumbidgee and NSW Murray and Lower Darling for calculating the volume to be debited from an environmental account when using piggybacking is to determine the difference between releases made with the environmental water holder's order and the releases that would have been (hypothetically) made without the environmental water order.

Where there is accurate measurement of take, the volume of take shall be debited from the account. Similarly, where there is accurate measurement of return flows, this volume shall be recognised downstream of the environmental site, with any agreed mitigation measures applied.

For environmental sites where measurement is not considered accurate, an assumed use method is used to estimate the volume of debit and/or return flow. WaterNSW will provide an assumed use statement to the environmental water manager that sets out the calculation of the volumes of water to be debited from water access licence accounts. Where relevant, the volume of water accounted as held environmental water that is to be passed into the Murray will also be specified, split by contributing environmental water holders/licences. Any additional assumptions made will also be identified.

As much as possible, assumed use statements reflect the requirements of the water order and capture the decisions made during the planning and ordering phases between the regulator, the river operator, and the environmental water holders, including agreement on any assumed use rates and mitigation measures to be applied. Existing dispute resolution procedures are to be applied in the event of a dispute.

Monthly reporting on water usage split by water holder/licence for each PPM watering action is to be provided (cumulative for the water year to the end of the previous month). Similarly, monthly reporting on return flows is required, again split by water holder/licence.

Bulk accounting arrangements for the shared resources in the River Murray System are detailed in the Specific Objective and Outcomes for directed release and assumed use in the Objectives and Outcomes for River Operations in the River Murray System document.

Murrumbidgee end-of-system HEW will be recognised in the Murray. WaterNSW will apply an agreed incremental loss to the HEW passing Balranald, and will provide MDBA River Murray Operations with the daily flow volumes of HEW for recognition in the Murray. This flow is to be adjusted by RMO for travel time to the South Australian border and the water accounted as a bulk entitlement delivery to South Australia. A similar approach is used for NSW HEW entering the River Murray from the Lower Darling at Burtundy.

Monthly reporting on return flows split by water holder/licence at the South Australian border is also required for each PPM watering action.

As much as practicably possible, losses applied to environmental water will be based on the 'incremental loss' resulting from the additional flow created by environmental water. Determining loss rates is based on best available information and will become more accurate as more data and information becomes available. In the early stage of PPM implementation, a more conservative or higher loss rate may be applied to ensure no detrimental impacts to reliability for other licensed water users. Methods will become more refined through their application in successive years.

2.4.4 Reporting

The river operator provides operational reporting on releases of environmental water during events. At a minimum, this will include monthly reporting on water usage split by water holder/licence for each PPM watering action, as well as return flow volumes again split by water holder/licence. Reporting on end-of-system return flows and any return flows reaching the South Australian border is required.

An Annual Environmental River Operations Report is to be prepared by the river operator that documents the application of the specific watering actions that used PPMs in that water year, including the accounting of river flows, transmission losses, and water delivery that occurred. Where information is available, the report includes comparisons of assumed use with actual/estimated river transmission losses and use, associated with watering actions that rely on that assumed use methods.

The environmental water manager will prepare an Annual Environmental Watering Statement that documents any issues that arose in the ordering or delivery and accounting of environmental water using PPMs. The environmental water manager consults with other environmental water holders and stakeholders including the CEWO, TLM and EWAGs when preparing these reports.

These annual reports form the basis for the annual review process.

2.4.5 Evaluation and review

The NSW PPM framework is underpinned by an adaptive management process to provide for the continuous improvement of the processes set out above.

The Department of Planning and Environment-Water, as the regulator, will conduct an annual evaluation and review of the implementation of PPMs for each water year. The review will be guided by the principles set out in the NSW PPM IP, this Manual and the MDBA's position statement on PPMs (2019). The Department of Planning and Environment-Water is responsible for ensuring that appropriate changes to the regulatory framework are made to give effect to any recommendations arising from this review, in consultation with key stakeholders including the Department of Planning and Environment-Environment and Heritage and WaterNSW.

This framework provides the necessary flexibility to enable the regulator, the environmental water holders, and river operators to learn, adapt and refine as environmental watering evolves. A structured review process provides an opportunity for capturing learnings and identifying areas for allows for improvement to the framework to facilitate continuous improvement for effective and efficient delivery of water for the environment.

The Department of Planning and Environment–Water will prepare and publish an annual evaluation and review report, including any findings of the review and recommendations.

2.4.6 Governance

The inter-agency PPM Working Group provides a forum for the collaboration on matters regarding the operation, implementation, review, and improvement of PPMs in NSW. Agencies responsible for water planning, operations and environmental water management are represented:

- NSW Department of Planning and Environment-Water (Chair)
- NSW Department of Planning and Environment-Environment and Heritage
- WaterNSW
- Murray-Darling Basin Authority
- Commonwealth Environmental Water Office.

The Department of Primary Industries-Fisheries also attend as observers.

The PPM Working Group considers the annual evaluation and review report and its recommendations to guide adaptive management and continual improvement, and provide recommendations as necessary. The PPM Working Group also assists in identifying and prioritising tasks on the NSW PPM work plan.

3. Framework for operation of PPMs

3.1 Key framework components

The operational framework for PPMs consists of the following components:

- PPM actions agreed and approved for use
- operational processes for planning, ordering and delivering events using PPMs (as set out in Section 2 of this Manual)
- accounting methods for managing environmental water released using PPMs and debiting accounts
- an annual review process to provide transparency regarding use of PPMs in that year and inform consideration of any changes or new measures that may be appropriate.

The annual process involving these elements is shown in Figure 1. Roles and responsibilities are detailed in Section 3.2.

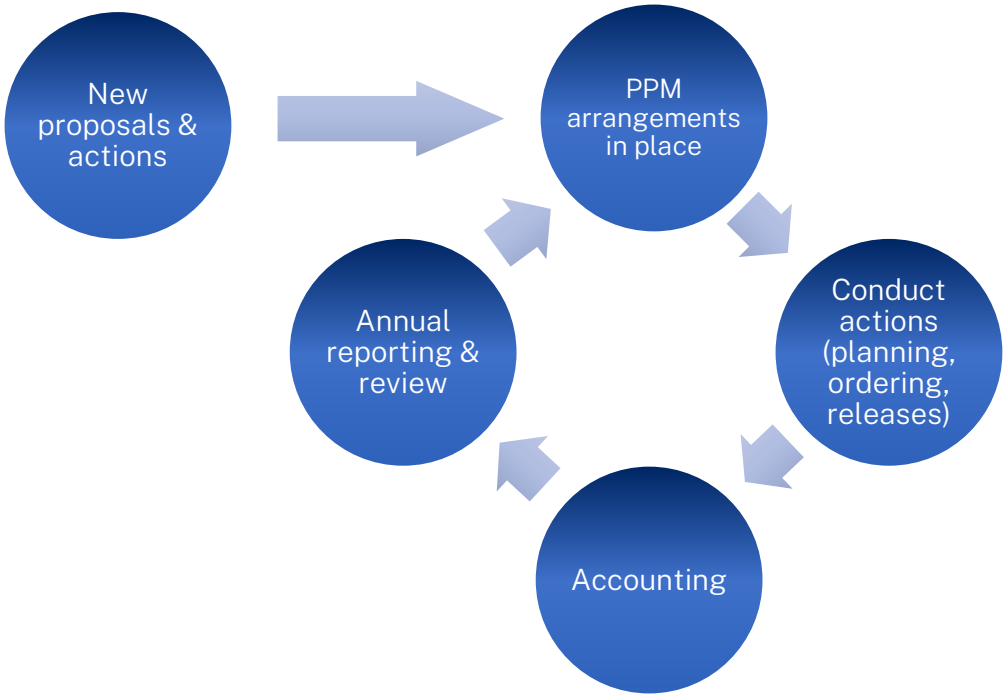

Figure 1: An overview of the PPM process

The process set out in Figure 1 applies only to those PPM actions on the NSW side of the Murray River, or in the Lower Darling River, that are undertaken by WaterNSW.

Actions in the Murray and Lower Darling Rivers involving the shared resources between NSW, Victoria, and South Australia are managed under the Murray-Darling Basin Agreement by the MDBA (on behalf of the States). These actions are undertaken in accordance with an over-arching arrangement between NSW, Victoria, South Australia and the MDBA to implement PPMs, but with different roles and responsibilities, as described in Section 3.2.

3.1.1 Actions

To allow water for the environment to be managed in new ways the NSW Government, as a member of the Basin Officials Committee (BOC) that oversees the MDBA's operation of the Murray River, has approved variations each year to the river operations framework for the RMS. These variations have supported environmental watering trials that have been conducted since 2010-11.

Amendments to the 'Objectives and Outcomes for River Operations in the River Murray System' document to implement joint venture aspects of PPMs are approved by BOC. Revisions to date include new definitions for 'directed release' and 'directed release water order', adding new SO&Os for specific storages under Clause 98 of the Murray-Darling Basin Agreement (directed releases from Hume Dam, directed releases from Lake Victoria, directed releases from Menindee Lakes) and adding a new SO&O for assumed use for directed releases of HEW from Hume Dam. The SO&Os include a structured annual review process to enable ongoing refinement of the operational delivery of PPMs.

In consultation with WaterNSW and environmental water holders, the Department of Planning and Environment–Water can agree to actions within NSW that will allow HEW and RMIF to be managed in new ways using PPMs. These actions must operate in conjunction with a number of supporting measures of the NSW PPM framework, including, where necessary:

- a delivery pathway,
- an assumed use method
- linked mitigation measures.

Actions and their supporting measures will be considered to mitigate or offset any detrimental impacts on the access rights of licensed water holders and any impacts to the efficient use of held environmental water. Actions can include mitigation measures to offset these risks as necessary. The Department of Planning and Environment–Water in its role as the regulator is responsible for approving actions, including accounting arrangements, and any subsequent variations following review.

Recognising that environmental watering actions using PPMs will develop over time, an adaptive management approach is required. To provide for changes over time, actions can be modified or new actions agreed, by the Department of Planning and Environment–Water in its role as the regulator or the BOC in relation to shared water resources. Changes will be made after consultation with the environmental water managers, WaterNSW and key stakeholders, primarily via the PPM Working Group.

It is noted that at times both piggybacking and environmental flow reuse (or return flows) will operate together. For example, when the environmental licence holder makes an order from a nominated water storage (piggybacking), whether during a regulated or unregulated flow event, they may also request the use of environment flow reuse to use any return flows further downstream, including in a downstream river systems.

In recognition that actions and their supporting measures will need to be tested to build a body of knowledge, particular actions and supporting measures may be trialled initially. These trials will ensure that material risks are appropriately identified and mitigated and that the actions are operable. Trials will also operate in conjunction with supporting measures including a delivery

pathway, an assumed use method and linked mitigation measures. Trials and their supporting measures must be reviewed and re-approved annually. If the application of a trial action proves successful, then it may be determined as an (ongoing) action following the annual review of the operation of PPMs.

3.1.2 Supporting measures

Watering actions rely on a number of supporting measures of the framework in order to operate. These are:

- **Delivery pathways:** describe the intended environmental watering event, and show how the watering actions, assumed use methods and mitigation measures link together.
- **Assumed use methods:** a method of estimating the delivery of environmental water is required whenever that use cannot be accurately measured. These methods will be used to produce Assumed Use Statements for the purposes of debiting accounts of HEW licences.
- **Mitigation measures:** any measures that must be taken to ensure that detrimental impacts on the access rights of licensed water holders are mitigated or offset.

Assumed use methods and accounting arrangements must be consistent with legal instruments, including bulk entitlements and the Murray-Darling Basin Agreement. As much as practicably possible, assumed used methods are to:

- use accurate metering and measurement where and when available (as nominated in the Manual)
- be fit-for-purpose with appropriate balance between rigour and practicality of implementation
- balance the delivery of HEW using PPMS for its efficient and effective use without generating unacceptable adverse impacts to licensed water holders
- provide a level of conservatism that is proportional to the confidence in the assumed use method and risks
- be reviewed over time and improved as experience and knowledge grows.

3.2 Roles and responsibilities

The key roles and responsibilities within the framework for the operation of PPMs within NSW are set out in Table 2.

Table 2: Roles and Responsibilities for the implementation of PPMs

Role	Organisation	Responsibilities
Regulator (shared resources) for actions under the Murray PPM IP that are administered by MDBA River Operations	Basin Officials Committee	• Agree any changes to the "Objectives and Outcomes for River Operations in the River Murray System" document • Approve those aspects of any large scale environmental watering event trials which deviate from past river practice
Regulator (within NSW) for actions under the NSW PPM IP and actions within NSW required to support BOC agreements	NSW Department of Planning and Environment–Water	• The effective implementation of PPMs via NSW's policy and regulatory framework • Adhere to the principles of the NSW PPM IP • Ensure the required statutory instruments are in place to give effect to agreed actions • Undertake annual review of the implementation of PPMs • Review and approve actions and any subsequent variations following the review phase of PPM operations • Assess assumed use/in-stream loss rates/methods as per principles and rules in this Manual • Approve proposed trials if suitable conditions and mitigation measures are demonstrated • Consult with the PPM Working Group on any new or revised actions or supporting measure • Consult with WaterNSW, Department of Planning and Environment–Environment and Heritage, MDBA and CEWO when conducting each annual review, including the annual evaluation and review report and its recommendations • Classification of take/return measurement at recognised environmental watering sites
River Operator (shared resources)	MDBA River Operations	• Manage release of environmental water at the wholesale level to meet NSW orders • Undertake bulk water accounting for HEW and RMIF within the River Murray system according to agreed rules, including estimates of directed releases from the upper Murray storages

Role	Organisation	Responsibilities
River Operator (within NSW)	WaterNSW	• Work collaboratively with Department of Planning and Environment–Environment and Heritage to develop orders for environmental water actions and recommend appropriate mitigation strategies • Assist in developing assumed use/in-stream loss rates/methods as per principles and rules in this Manual • Undertake risk assessment of proposed events and recommended mitigation strategies in collaboration with Department of Planning and Environment–Environment and Heritage prior to approval or rejection of water orders • Operate the river to give effect to agreed and trial actions for the delivery of PPMs, including advice and action on events (e.g. rain/inflows) that trigger changes to the action • Prepare an assumed use statement for an environmental watering event that relies on an assumed use method • Provide operational reporting on release of environmental water, including regular environmental water use accounting during events • Provide monthly reporting to environmental water holders on water usage and return flows • Submit an annual Environmental Releases River Operations Report on river operations involving actions • Support the development of new proposals and trials for the operation of PPMs • Classification of take/return measurement at recognised environmental watering sites

Role	Organisation	Responsibilities
Environmental Water Managers	NSW Department of Planning and Environment–Environment and Heritage	• Work collaboratively with other environmental water holders (i.e. CEWO and through the Southern Connected Basin Environmental Watering Committee - SCBEWC if appropriate) in the planning and coordinated use of environmental water in consultation with river operators, including risk assessments and mitigation measures • Work collaboratively with the river operator when developing orders for environmental water that rely on actions • In collaboration with other environmental water managers, submit an annual environmental watering statement to Department of Planning and Environment–Water that reports on the delivery / accounting issues for environmental watering relying on the use of PPMs • Development of new proposals for the operation of PPMs • As the environmental water manager for NSW, place water orders with WaterNSW
	Commonwealth Environmental Water Office	• Work collaboratively with Department of Planning and Environment-Environment and Heritage and other environmental water managers as appropriate, in the planning and coordinated use of environmental water in consultation with river operators, including risk assessments and mitigation measures • Work collaboratively with Department of Planning and Environment–Environment and Heritage to develop orders for environmental water that rely on PPM actions and their mitigation measures, and to develop new proposals for the operation of PPMs • Provide input into the annual environmental watering statement prepared by Department of Planning and Environment–Environment and Heritage

Role	Organisation	Responsibilities
	MDBA via The Living Murray Initiative	• Work collaboratively with Department of Planning and Environment-Environment and Heritage and other environmental water managers as appropriate, in the planning and coordinated use of environmental water in consultation with river operators, including risk assessments and mitigation measures • Work collaboratively with Department of Planning and Environment–Environment and Heritage to develop orders for environmental water that rely on PPM actions and their mitigation measures, and to develop new proposals for the operation of PPMs • Provide input into the annual environmental watering statement prepared by Department of Planning and Environment–Environment and Heritage

3.3 Consultation

Consultation is an important element in the delivery of water for the environment that relies on trial or agreed PPM actions. Consultation provides transparency regarding the operation of the agreed actions, and the performance of any mitigation measures.

The minimum consultation requirements associated with the implementation of PPMs within NSW are:

- The regulator (Department of Planning and Environment–Water) will consult with WaterNSW, Department of Planning and Environment–Environment and Heritage, MDBA (River Operations and TLM) and the CEWO via the NSW PPM Working Group when conducting each annual review, and when developing new, or revising existing, actions or supporting measures.
- The river operator (WaterNSW) will consult with water users or their representative groups via existing forums (such as Customer Advisory Groups) as necessary, and provide a summary as part of the requirements of the Annual Environmental Releases River Operations Report.
- The environmental water manager (Department of Planning and Environment–Environment and Heritage) will consult with:
  - the river operator (WaterNSW) regarding proposed watering actions using PPMs before placing an order
  - affected stakeholders when developing, and the community more generally when delivering, environmental water orders relying on the use of PPM actions as appropriate
  - other environmental water managers (including the CEWO) when preparing the Annual Environmental Watering Statement.

The NSW PPM Working Group includes relevant NSW and Commonwealth agencies to provide a forum regarding the operation, implementation and review of PPMs (see Section 0).

4. NSW Murray and Lower Darling system

4.1 Environmental sites

The classification of the accuracy of water use and return flow at environmental sites is intended to provide transparency and support the development of appropriate accounting arrangements and mitigation measures.

When developing actions, including accounting arrangements, that use PPMs, the accuracy of water take and/or return flows by sites within NSW (including in-stream use of NSW shares of water in the Murray and Lower Darling Rivers) must be categorised as described in Table 3..

Table 3: Classification of water take and return flows measurement sites for environmental watering

Classification	Description
Category 1 **Accurate (+/-5%)**	Take is metered or accurately measured, meeting the requirements of the National Framework for Non-Urban Water Metering, and is suitable for water account debiting.
Category 2	Does not meet requirements for Category 1: take and/or return flows is measured or estimated but requires mitigation measures to address uncertainty.

Examples of methods of measurement for category 2 sites could include:

- meters (including direct measurement devices using ultra-sonic or infra-red sensors at major canal offtakes)
- hydrographic flow measurement (rating table),
- extrapolation from single, point-in-time flow gauging
- assumed use/estimation method (including operationally estimated loss rates; calculations based on areas of inundation, seepage and evapotranspiration; simplified rules based on modelling results)
- models (including hydro-dynamic models, or hydrologic such as IQQM/Source).

If no site classification is provided, then a site will be deemed to be Category 2.

Environmental sites that receive water via agreed actions under this Manual are to be nominated in Table 4.

Table 4: Recognised environmental sites for PPMs in the NSW Murray and Lower Darling

Environmental site	Description	Measurement method	Classification
All wetlands, creeks and floodplains along the Upper River Murray between Yarrawonga and the SA Border, including the Barmah-Millewa Forest and the Edward-Wakool Systems and TLM sites (except where TML structures are used to enhance floodplain inundation or other structures are operated outside of routine arrangements to enhance floodplain inundation).	Floodplain wetlands and forest between Yarrawonga and the SA Border along the Upper Murray River, and along the Edward River and Gulpa Creek system, that are progressively inundated as flows increase. These measurement methods (assumed used) do not include any additional losses along the River Murray associated with environmental inflows from tributaries downstream of the Barmah-Millewa Forest including the Murrumbidgee River.	Directed releases from Hume Dam determined by River Murray Operations as agreed by BOC and detailed in SO&O 2.4: Additional release of water based on the difference between the actual release and a hypothetical release case meeting all other water requirements. Assumed use method as agreed by BOC and detailed in the SO&O 2.5: An initial loss of up to 50 GL, plus 0% to the component of the directed release which is intended to be delivered within the maximum planned regulated release downstream of Yarrawonga Weir (as described in SO&O 3.1b) 20% to that component of the directed release that occurs after the initial use has been determined and which is intended to effect a flow greater that the maximum regulated release downstream of Yarrawonga Weir (as described in SO&O 3.1b)	Category 2

Environmental site	Description	Measurement method	Classification
Edward–Wakool System	When the intended flow at Yarrawonga is less than the maximum planned release as described in SO&O 3.1b, environmental water deliveries made under PPMs into the Wakool System are subject to an additional assumed use.	Seasonal loss rates applied for diversion of operational water (Wakool Offtake, Yallakool Offtake, Colligen Offtake, Little Merran gauge, Waddy Cutting gauge) and any balance required to meet the seasonal flow threshold. Appendix C.	Category 2
Koondrook-Perricoota Forest	Wetlands and forest to the North of the Murray River downstream of the Torrumbarry Weir pool.	Take: Rating tables at flow gauge d/s of Torrumbarry regulator regulators. Also potential modelling required for some larger events Return flows: Four regulators controlling outflows to the Barbers Creek system: Barbers overflow Barbers Creek Cow Creek Calf Creek Crooked Creek regulator Thule Creek regulator, and Swan Lagoon upstream and downstream regulators.	TBD
Great Darling Anabranch (via directed releases from Lake Cawndilla when not a shared resources)	Effluent Creek with numerous lakes, including Lake Neary nature reserve.	Directed release volume shall be determined using the hydraulic discharge relationship at the Cawndilla outlet regulator. Wycott flow gauge (TBC) for flows passing through natural offtake point. Return flows to River Murray are to be determined using the loss relationship between the Bulpunga gauging station and Tara Downs gauging	Category 1 Category 2 Category 2

Environmental site	Description	Measurement method	Classification
		station for recognition at the South Australian border, allowing for travel time. Appendix F.	
Lower Darling in-channel delivery (via directed releases from Menindee Lakes when a shared resource)	Lower Darling River channel.	Directed releases from Menindee Lakes as agreed by BOC and detailed in SO&O 10.4. The volume of directed releases shall be the difference between the actual release and a hypothetical release without the directed release. The assumed use method specified in SO&O 10.4 shall be applied to determine the return flow at Burtundy, allowing for travel time.	Category 2
Lower Darling in-channel delivery (via directed releases from Menindee Lakes when not a shared resource)	Lower Darling River channel.	The volume of directed releases shall be the difference between the actual release and a hypothetical release without the directed release. Loss lookup tables (for Lower Darling River losses between Weir 32 and Burtundy) shall be applied to directed releases to determine the return flow volume at Burtundy, allowing for travel time. Appendix E. Incremental losses shall be applied to the return flow volume at Burtundy to determine the volume of water to be recognised at the South Australian border, allowing for travel time.	Category 2 Category 2 Category 2

Environmental site	Description	Measurement method	Classification
		Appendix D.	
River Murray in-channel delivery (via directed releases from Lake Victoria during unregulated flow conditions)	River Murray channel.	Directed releases from Lake Victoria during unregulated flow conditions as agreed by BOC and detailed in SO&O 9.4. The volume that Lake Victoria is below the effective full supply level (99% capacity) or below the relevant LVOS target on the date that unregulated flows at the South Australian border were forecast to cease if the directed releases had not occurred.	Category 2
Ability to receive and and/or deliver return flows to Victorian environmental sites	See Section 4.4.1.		
River Murray in-channel delivery to South Australia	Deliver return flows to South Australia (rather than capture in Lake Victoria) from Lower Darling, Great Darling Anabranch and Murrumbidgee.	Losses to be applied to return flows from tributaries as detailed in Table 6.	Category 2

Note: Italics represent SO&Os of the O&O document, approved by BOC and available on MDBA website.

4.2 Recognition of environmental inflows from the Northern Basin

Agreement on mechanisms to protect environmental water inflows from the Northern Basin is a key element of the Menindee Interjurisdictional Working Group forward work plan (approved November 2018, BOC 63). This element will focus on the management of environmental water entering Menindee Lakes and is dependent on the work of Department of Planning and Environment–Water under the Water Reform Action Plan in protecting environmental flows in the Northern Basin. This reform package is focused on a 'first flush' rule, individual daily extraction limits in the Barwon-Darling, active management of HEW and gaining a better understanding of Northern connectivity (as per BOC 65).

4.3 Delivery pathways

Delivery pathways describe the intended environmental watering event, and show how the watering actions, assumed use methods, and mitigation measures link together. An example is the release of environmental water from the major storage (Hume Dam) to coincide with downstream tributary inflows, often referred to as a "piggybacking" release, with the intent of:

- creating a peak flow of sufficient duration to inundate the Barmah-Millewa forest
- watering wetlands and forests in the Koondrook-Pericoota area
- flow through the Murray River to the South Australian border.

The following are general environmental watering delivery pathways (Table 5) for actions using PPMs, subject to approval of appropriate supporting measures. Delivery pathways for the application of PPMs in the NSW Murray and Lower Darling regulated river water sources will continue to be reviewed and refined in accordance with this Procedures Manual.

Table 5: General delivery pathways for the Murray and Lower Darling Valleys for NSW

Delivery pathway	Description
River Murray System (Hume Dam) via Barmah-Millewa	Hume Dam downstream to South Australian border via Barmah-Millewa and other wetlands.
River Murray System (Hume Dam) via Millewa Forest	Hume Dam downstream to South Australian border via the NSW Millewa Forest and other wetlands.
Edward–Wakool System	Hume Dam downstream to South Australian border via the Edward-Wakool System, including Werai Forest and potentially other wetlands.
Murrumbidgee tributary inflows of HEW	Residual held environmental water from the Murrumbidgee at Balranald recognised through to the South Australian border without regulation in Lake Victoria.
Lower Darling System (Menindee Lakes)	Menindee Lakes downstream to South Australian border, either via the Lower Darling River or the Great Darling Anabranch. This includes residual held environmental water from the Lower Darling (at Burtundy on the Lower Darling River and Tara Downs on the Great Darling Anabranch) recognised through to the South Australian border without regulation in Lake Victoria.
River Murray System (Lake Victoria)	Directed release from Lake Victoria to South Australia.

4.4 NSW Murray and Lower Darling actions

PPMs allow HEW and RMIF to be used and accounted for in new ways. The actions described in this manual include agreed actions which have been approved for ongoing use, as well as trial or interim actions which are to be approved annually. These watering actions are developed in consultation with WaterNSW and environmental water holders (see Section 2 and Section 3.3), and endorsed by the PPM Working Group.

Actions for the NSW Murray and Lower Darling are shown in Table 6, together with their linked delivery pathways, relevant assumed use methods and mitigation measures.

The trialling of new actions is also expected to be important to balance the effective implementation of PPMs with ensuring that there are no detrimental impacts to the reliability of licensed entitlements. The regulator (Department of Planning and Environment–Water) may agree to trial an action for a period, with additional conditions applied where appropriate and developed according to the processes described in Section 2 of this Manual. Trials and supporting measures, including mitigation measures, will be considered by the NSW PPM Working Group. Trials must be re-assessed each year as part of the NSW annual review process. Similarly, BOC may also approve trials where actions deviate from the standard O&O rules.

All actions and the supporting measures have been considered to minimise or offset, where necessary, potential detrimental impacts to the reliability of licensed water users.

Recognising that environmental watering actions using PPMs will require ongoing development over time, the adaptive management approach in Section 5 provides a process for including further actions or variations to existing actions and their supporting measures.

Table 6: Actions and supporting measures for the NSW Murray and Lower Darling Valleys

Action	Delivery Pathway	Assumed Use method	Mitigation measures
Directed releases from Hume Dam ***Assumed use for directed releases from Hume Dam***	*Hume Dam downstream to South Australian border via Barmah-Millewa and potentially other wetlands.* *Note that when the intended flow at Yarrawonga is less than the maximum planned release as described in SO&O 3.1b, environmental water deliveries into the Wakool system are subject to an additional use (see below).*	*O&O document:* *SO&O 2.4 Directed releases from Hume Dam.* *SO&O 2.5 Assumed use for directed releases from Hume Dam.* *NSW environmental water licences will be debited the volume of environmental release calculated according to SO&O 2.4, as advised each month by the MDBA. The volume of return flows shall be calculated according to SO&O 2.5.* Water orders will be managed under Bulk Entitlement Delivery arrangements. The volume of that order, and any amendments, will be placed in the WaterNSW accounting system at the time they are placed with the MDBA by WaterNSW.	*See SO&O 2.4 and 2.5* Water orders will be developed collaboratively by environmental water holders, the MDBA, GMW and WaterNSW.
Directed releases from Lake Victoria during unregulated flow conditions	*Lake Victoria to South Australian border.*	*O&O document:* *SO&O 9.4 Directed releases from Lake Victoria during unregulated flow conditions.* *NSW environmental water licences will be debited the volume of*	*See SO&O 9.4* Water orders will be developed collaboratively by environmental-water holders, the MDBA, GMW and WaterNSW.

Action	Delivery Pathway	Assumed Use method	Mitigation measures
		environmental release calculated according to SO&O 9.4, as advised each month by the MDBA. *The volume of the directed release is recognised at the South Australian border (i.e. no assumed use required).* Water orders will be managed under Bulk Entitlement Delivery arrangements. The volume of that order, and any amendments, will be placed in the WaterNSW accounting system at the time they are placed with the MDBA by WaterNSW.	
Directed releases from Menindee Lakes (when the MDBA has the ability to direct releases) ***Assumed use for directed releases from Hume Dam***	*Menindee Lakes to the Murray River, and then to the South Australian border.*	*O&O document:* *SO&O 10.4 Directed releases from Menindee Lakes (when the MDBA has the ability to direct releases).* *NSW environmental water licences will be debited the volume of environmental release calculated according to SO&O 10.4, as advised each month by the MDBA.* *The assumed use method specified in SO&O 10.4 shall be applied to*	*See SO&O 10.4*

Action	Delivery Pathway	Assumed Use method	Mitigation measures
		determine the return flow at Burtundy, allowing for travel time. Water orders will be managed under Bulk Entitlement Delivery arrangements. The volume of that order, and any amendments, will be placed in the WaterNSW accounting system at the time they are placed with the MDBA by WaterNSW.	
Directed releases from Hume Dam - return flows from the Wakool System (when the intended flow at Yarrawonga is less than the maximum planned release as described in SO&O 3.1b).	Hume Dam downstream to South Australian border via the Edward-Wakool System.	Interim accounting arrangement using the seasonal loss rate and thresholds for the diversion and use of operational water to meet environmental water targets in the Edward-Wakool. See Appendix C. Note that the interim accounting arrangement may also be applied at times where there is no specific directed release of environmental water from Hume Dam.	This interim arrangement for the accounting of environmental water applies to the net use of operation water only, with no return flows in the River Murray. Conservative seasonal loss rates are used with a risk profile similar to that used for NSW resource assessments (i.e. between the 95%ile and the maximum monthly loss recorded) Protocols for adaptive management, as described in this Manual, will be applied to review these losses.
Assumed use for directed releases from Hume Dam - return flows from Werai Forest (when the intended flow at Yarrawonga is less than the maximum planned	Hume Dam downstream to South Australian border via the Edward-Wakool System, including Werai Forest.	NSW is currently in the process of undertaking consultation with river operators and environmental water holders to determine a suitable accounting arrangement for assumed used and return flows in	An interim arrangement with an appropriate level of conservatism will be applied and subject to review as per the protocols for adaptive management set out in this Manual.

Action	Delivery Pathway	Assumed Use method	Mitigation measures
release as described in SO&O 3.1b)		Werai Forest for consideration by the PPM Working Group. Note that the assumed use method may also be applied at times where there is no specific directed release of environmental water from Hume Dam.	
Assumed use for directed releases from Hume Dam - return flows from Millewa Forest (when the intended flow at Yarrawonga is less than the maximum planned release as described in SO&O 3.1b) when Barmah regulators are closed	Hume Dam downstream to South Australian border via the Millewa Forest (i.e. Millewa regulators only open.	NSW will undertake consultation with river operators and environmental water holders to determine a suitable accounting arrangement for assumed used and return flows from Millewa Forest for consideration by the PPM Working Group.	An interim arrangement with an appropriate level of conservatism will be applied and subject to review as per the protocols for adaptive management set out in this Manual. For example, a 40% loss rate was applied for the November 2019 watering event (see the 2019-20 Annual Evaluation and Review Report).
Recognition of HEW inflows from the Murrumbidgee River (return flows) in the River Murray	Recognition of residual HEW from the Murrumbidgee River at Balranald through to the South Australian border without regulation in Lake Victoria.	Return flows are managed under Bulk Entitlement Delivery arrangements. When the Murray River is in regulated conditions an incremental loss will be applied to residual HEW from the Murrumbidgee recognised at Balranald. The appropriate loss will be determined from the loss look-up table based on flow at Boundary Bend in the River Murray and the	WaterNSW will provide RMO with the daily flow volume of HEW passing Balranald which will be adjusted by RMO for travel time to the SA border and reduced incrementally for transmission losses.

Action	Delivery Pathway	Assumed Use method	Mitigation measures
		corresponding residual HEW recognised at Balranald. When the Murray River in unregulated conditions, no loss rate is to be applied to return flows recognised at Balranald. See Appendix D.	
Directed releases from Menindee Lakes (under NSW control)		Once the total volume of Menindee Lakes falls below 480 GL, water held is no longer considered a shared resource of the River Murray System. Water in Menindee Lakes is then managed by NSW to extend supplies for local critical needs as long as possible until an inflow recovery event occurs A PPM proposal initiated by environmental water holders when Menindee Lakes in under NSW control will be considered by the Department of Planning and Environment–Water; depending on the local circumstances and risks at the time, the proposal may not be deliverable. The department will work with river operators and environmental water holders via the PPM Working Group under such constrained conditions to get the best balance of outcomes, consistent with legislated priorities and obligations. The following interim arrangements have been developed; the department will retain discretion to apply PPMs when Menindee Lakes is in NSW control on a case-by-case basis.	
Directed releases from Menindee Lakes (under NSW control) via the Lower Darling River	Menindee Lakes downstream to Burtundy (Lower Darling River).	The volume of directed releases shall be the volume of the additional releases from storage, calculated as the difference between actual releases and those estimated to have been made	Proportional losses are currently applied given the highly regulated release regime in the Lower Darling and limited range of flow variation.

Action	Delivery Pathway	Assumed Use method	Mitigation measures
Assumed use to estimate return flows		without the environmental water order (operational requirement, or the hypothetical release without the directed release). The volume of directed release shall be the minimum of: • The target flow +10% minus required operational flow, or • The observed flow minus required operational flow. The assumed use along the Lower Darling River shall be determined by applying the appropriate loss (%) to the HEW delivery released from Weir 32, based on the flow range and month. The assumed return flow for recognition at Burtundy shall be, after adjusting for travel time, the daily average flow passing W32 reduced by the determined assumed use. See Appendix E.	Data was filtered to remove periods of cease-to-flow conditions and flood conditions. 90% dry conditions were assumed. Losses will be reviewed as more data becomes available and deemed appropriate for use.
Recognition of HEW inflows from the Lower Darling at Burtundy to the South Australian border	Residual held environmental water from the Lower Darling at Burtundy, recognised through to the South Australian border without regulation in Lake Victoria.	Return flows from the Lower Darling River are managed under Bulk Entitlement Delivery arrangements. When the Murray River is in regulated conditions, an	Arrangements will require consultation and agreement with Victoria to facilitate delivery of outflows to the South Australian border. WaterNSW will provide RMO with the daily flow volume of HEW passing Burtundy

Action	Delivery Pathway	Assumed Use method	Mitigation measures
		incremental loss will be applied to residual HEW from the Lower Darling recognised at Burtundy. The appropriate loss will be determined from the loss look-up table based on flow at Boundary Bend in the River Murray and the corresponding residual HEW recognised at Burtundy. When the Murray River in unregulated conditions, no loss rate is to be applied to return flows recognised at Balranald. See Appendix D.	which will be adjusted by RMO for travel time to the South Australian border and reduced incrementally for transmission losses.
Directed releases from Menindee Lakes (under NSW control) via the Great Darling Anabranch **Assumed use to estimate return flows and recognition of HEW inflows from the anabranch at Tara Downs**	Menindee Lakes downstream to South Australian border, via the Great Darling Anabranch.	When environmental orders are being released from Lake Cawndilla, the volume debited will be the volume released to meet the environmental order only. When environmental water orders only are being released down the Anabranch, the assumed return flow should be determined as, after adjusting for travel time: i. when the daily average flow passing Tara Downs gauge (425054) is equal to or exceeds releases, no losses are to be applied. The full volume of the	Arrangements will require consultation and agreement with Victoria to facilitate delivery of outflows to the South Australian border. WaterNSW will provide RMO with the daily flow volume of HEW passing Tara Downs which will be adjusted by RMO for travel time to the SA border. Losses will be reviewed as more data becomes available and deemed appropriate for use.

Action	Delivery Pathway	Assumed Use method	Mitigation measures
		environmental debit is recognised at the South Australian border ii. when the daily average flow passing Tara Downs is less than releases, the flow at Tara Downs is reduced by a loss value and recognised at the South Australian border. The loss value applied is equivalent to the proportional daily loss that occurred between Bulpunga gauge (425011) and Tara Downs gauge. iii. after adjusting for travel time, when flows at Tara Downs reach 0 ML/day, no return flows are to be recognised. When environmental water orders are being released down the Anabranch with operational or surplus water, the assumed return flow should be determined as above, and reduced by the proportion of the total flow that is environmental water (assumed to be the proportion of the total release from Lake Cawndilla that is environmental water).	

Action	Delivery Pathway	Assumed Use method	Mitigation measures
		The assumed return flow recognised at Tara Downs, adjusted for travel time, will be the volume recognised at the South Australian border. See Appendix F.	

Note: *Italics represent SO&Os of the O&O document, approved by BOC and available on MDBA website*.

Note: These supporting measures are additional mitigation measures proposed for states to implement in addition to mitigation measures provided for under the O&O document.

4.4.1 In-river trade adjustments for return flows between NSW & Victoria

Inter-state environmental flow reuse will be facilitated by 'in-stream' adjustments. Endorsed by BOC (BOC 65), the 'in-stream' adjustment trial allows for the adjustment of environmental return flows between NSW and Victoria and provides an enabling mechanism to allow return flows in Victoria to be traded for immediate delivery in NSW and vice versa. Existing provisions can facilitate these actions, through allocation trade of returned flows for immediate delivery, and where necessary reallocation of resources between Victoria and NSW under clause 113 of the Murray-Darling Basin Agreement.

The 'in-stream' adjustment trial allows the use of HEW in an efficient manner. This option is available for use, on a trial basis, up to June 2023. BOC will consider the permanent adoption of the arrangements following a review of the results.

If an individual watering action is proposed to use inter-state trade of return flows between NSW and Victoria, it will be assessed by State Constructing Authorities in collaboration with MDBA River Operators. The State Constructing Authorities (WaterNSW in the case of NSW) provides written approval for the action to MDBA, recognising that the in-stream accounting option is used to make the trade adjustment. MDBA's monthly accounts model is revised as necessary to document the volume of trade which was adjusted in-stream, the month(s) of delivery and the river reaches involved. In addition, the volumes of trade adjustment in Hume that are reversed are also documented. The operation of the in-stream adjustments for inter-state trades are also reported as part of River Murray Operations' Annual Summary of River Operations, and be reviewed by the Independent River Operations Review Group in September of the year following any individual trial.

4.4.2 Additional mitigation measures between the States

A memorandum of understanding between Victoria and NSW is required in addition to and parallel to the SO&Os enabling PPMs. This MoU is required to cover off on those additional mitigation measures that are not within MDBA's power to enforce as the River Operator under the joint venture.

4.5 Risk mitigation

The use and accounting of HEW and RMIF using PPMs is a change to the way that water has traditionally been managed and accounted for in the NSW Murray and Lower Darling. Managing environmental water in different ways can potentially result in positive or negative impacts to other water users. Possible risks include impacts on the reliability of allocations due to directed releases and impacts to the efficient use of held environmental water. Both positive and detrimental effects of PPMs will be taken into account when considering any potential impacts and their mitigation measures to achieve an appropriate balance between allowing for the efficient and effective use of held environmental water licences to achieve the environmental outcomes and providing protection for other water licence holders.

Where there is uncertainty, initially conservative estimates of environmental water use will be applied. These methods and approaches will be improved over time as a body of knowledge is developed and more accurate measurement and modelling becomes available. These estimates will

be based on best available information and subject to review, refinement and improvement. The level of conservatism applied will be proportional to the confidence in the assumed use and level of risk. Over time, new and more innovative approaches to environmental watering will likely be developed and there needs to be flexibility in the way that rules are applied.

A description of possible risks and the mitigation measures that could be applied is shown below in Table 7. Mitigation measures will be considered in collaboration with the environmental water holders and the river operator.

Environmental watering is still relatively new in the NSW Murray and Lower Darling. Processes for review are described in Section 5 to provide an opportunity to review and reassess risks over time.

The BOC agreed to four new SO&Os related to the release and measurement of environmental water from River Murray storages. Each of these SO&Os identify the relevant risks and possible mitigation measures.

Table 7: Potential risks and mitigation measures associated with the operation of PPMs

Risk	Relevant action	Mitigation measure
Lower reliability of allocations due to lower utilisation of tributary inflows below major dams through directed releases from dams.	*Directed releases from Hume Dam.*	*See SO&Os 2.4 & 2.5* • *Ensure that each upper State is made aware of the other's orders for directed releases from Hume Dam and, if requested, provide an opportunity for WLWG to discuss potential mitigation measures or for States to amend their order.* • *Monitor the volume of directed releases and advise the WLWG and SCBEWC when the total volume of directed release from Hume Dam is approaching 600 GL in any water year.* • *Make directed releases greater than 700 GL during a water year if ordered by the upper States and if the WLWG assesses risks to water entitlements to be low.* • *Monitor the relative totals of directed releases ordered by each State and provide regular updates to WLWG.* • *Advise the WLWG of any risks to State water entitlements associated with directed releases.* • Water orders will be developed collaboratively by environmental water holders, the MDBA, GMW and

Risk	Relevant action	Mitigation measure
		WaterNSW.
	Directed releases from Menindee Lakes	*See SO&O 10.4* • *Directed releases from Menindee Lakes permitted:* • *Up to 400 GL each water year, ending May, when releases are able to be directed by the Authority;* • *If storage volumes in Menindee Lakes are forecast to be greater than 640 GL after the directed release;* • *When Menindee Lakes are reducing from 640 GL to 480 GL, if the release can be supplied solely from Lake Menindee and/or Lake Cawndilla or as otherwise agreed between NSW and the Authority.*
	Directed release from Lake Victoria during unregulated flow conditions.	*See SO&O 9.4* • *The Authority should plan to have a maximum target airspace of 100 GL, or a volume as otherwise advised by the WLWG and considering any input from the SCBEWC, at the end of the unregulated flow event. This volume of airspace should not exceed the volume ordered by an upper State.*

Under/over-estimating the volume of environmental water used:
Measurement inaccuracies.
Environmental water use estimated based on averages (for example, with conditions then resulting in greater actual use).
	Protection of flows along the river.	• Assumed use/river transmission loss estimates when:
		  • Sharing access to flows with consumptive water users, and
		  • Environmental flows exceed normal operating levels.
		• Post event accounting and review.
		• Improved management of supplementary events.
		• Water use based on total volume of water released for directed releases.

Risk	Relevant action	Mitigation measure
Increased river transmission losses, as a larger proportion of licensed water is required to be released for the end of the river system	Protection of flows along the river	Possible mitigation measures for this potential risk will be considered as PPMs are implemented and there is better understanding of environmental watering use under PPMs.
Mitigation measures are unduly conservative that impacts the efficient and/or effective use of HEW	Directed releases from dams. Protection of flows along the river for environmental flow reuse and return flows.	• Mitigation measures are evidence based and proportionate to actual risks • Post event accounting • Assumed use methods reviewed and refined • Documentation of procedures and methods • Consultation with environmental water holders • Annual review process • Assessments based on best available information/science.
Over-estimating the proportion of flows that are environmental along the river system, resulting in unduly restricted access for consumptive water users	Protection of flows along the river	• Conservative assumed use estimates. • Closer management of supplementary access.
Under-estimating the proportion of flows that are environmental water in the river system resulting in excessive consumptive use	Protection of flows along the river	• Regular assessment and review of assumed use • Post event reconciliation.
Unwanted inundation	Directed releases from dams for environmental watering	• Release rates limit to ensure flow remains within channel capacity limits as nominated in WSP • Evidence of consultation with potentially impacted landholders

Note: *Italics represent SO&Os of the O&O document, approved by BOC and available.*

4.5.1 Consideration of impacts

Some impacts to licensed water users are a result of existing operational arrangements and practices within the NSW water management framework. For example, water users can purchase and activate or trade previously unused water access licences, subject to rules within in the relevant water sharing plan. Alternatively, a large irrigator may change their water ordering behaviour which may impact the amount of water available in the dam for other water users.

However, there are other impacts that may arise during the implementation of PPMs which are not permitted under the current framework. These kinds of impacts would include allowing one licence holder to request priority of delivery over other water users during times when the amount of water that can be delivered is constrained. Priority of delivery is determined by the category of access licence that is being used to make the order.

NSW has and will continue to develop and implement PPMs in a way that achieves the objective of maximising environmental outcomes through the efficient and effective use of HEW without impacting on the reliability to other water users or by negating or offsetting unacceptable impacts. Where there is uncertainty, NSW will adopt a precautionary approach to minimise detrimental impacts.

5. Adaptive management

5.1 Reporting

Environmental watering actions provided by PPMs are different to traditional regulated river system operations and will require ongoing development over time. Therefore, an adaptive management approach is required with a rigorous process of review and evaluation to allow arrangements to evolve and improve over time, . It is also recognised that environmental watering actions will evolve and improve over time, and that there are benefits to ensuring that environmental watering actions using PPMs are conducted openly and transparently. The adaptive management starts with an annual reporting process to inform the ongoing development of environmental watering actions that use PPMs, and to provide transparency about the management and implementation of PPMs., The reporting process documents the environmental watering actions that have been conducted under the PPM provisions of this Manual and provides the necessary basis to inform the annual evaluation of PPMs.

There are two main reporting elements that are inputs to the annual review process:

1. An Annual Environmental Release River Operations Report that documents the application of specific agreed actions, trial actions, and associated supporting measures, including the accounting of river flows, transmission losses, and water delivery that occurred.
2. An Annual Environmental Watering statement that documents any issues that arose in the ordering or delivery and accounting of environmental water using the agreed and trial actions.

Both reports must document:

- any issues encountered in undertaking agreed actions, and any recommendations to address those issues or improve the operation of PPMs
- any feedback from consultation with stakeholders on the actions undertaken.

Submissions may also be invited form other key stakeholders such as the CEWO.

The MDBA prepares an annual report on River Murray operations that includes the use of actions approved by BOC to implement PPMs in the River Murray for shared resources.

5.1.1 Annual environmental release river operations report

The annual environmental river operations report shall be prepared by the River Operator (WaterNSW), and be submitted to the regulator (Department of Planning and Environment–Water) within three months of the end of each water year.

This report will include the following:

- a description of environmental watering actions undertaken during the relevant water year
- the performance in delivering the environmental water to meet the target flows and volumes requested in the orders

- the accounting undertaken for these actions, including:
  - a general description of the environmental flow events undertaken that rely on the use of agreed and trial actions,
  - the water orders placed by the environmental water holders,
  - accounts of environmental water use according to agreed methods for Assumed Use Statements,
  - comparisons of assumed use with actual river transmission losses associated with watering actions that rely on that assumed use,
  - the volumes of water delivered to the Murray Valley that have been accounted as environmental
- documentation of any issues that arose in the ordering or delivery and accounting of environmental water using the agreed and trial actions and details of how any issues were resolved
- documentation of any orders that were refused/rejected and supporting rationale.

The regulator may request additional content that is related to the delivery of environmental water using the agreed and trial actions, following consultation with WaterNSW and other stakeholders.

5.1.2 Annual environmental watering statement

The annual environmental watering statement shall be prepared by the Department of Planning and Environment-Environment and Heritage, and be submitted to the regulator (Department of Planning and Environment–Water) within three months of the end of each water year. As the NSW environmental water manager, the Department of Planning and EnvironmentEnvironment and Heritage will consult with other environmental water holders and stakeholders including the CEWO and EWAGs as necessary.

This report shall include the following:

- A brief description of environmental outcomes of the watering actions undertaken during the relevant water year, and the degree to which those environmental objectives were able to be satisfied, and
- Documentation of any issues that arose in the ordering or delivery and accounting of environmental water using the agreed and trial actions.

The regulator may request additional content that is related to the delivery of environmental water using the agreed or trial actions, following consultation with the NSW environmental water manager and other stakeholders.

5.2 Annual evaluation and review of PPM operations

The Department of Planning and Environment–Water will conduct an annual evaluation and review of the implementation of PPMs that will consider the outcomes of undertaking PPMs actions, based on the two reporting elements described above. This annual review report is to include:

- whether general operational procedures were followed for the delivery of HEW via PPMs

- whether the current PPM actions and the associated supporting measures provide for the effective and efficient use of held environmental water
- whether there are sufficient mitigation measures in place, and whether they have been effective
- any proposals for variations or new actions and/or supporting measures that may be brought forward by the river operator or the environmental water holder
- any issues relating to PPMs raised through consultation with stakeholders in the valley
- the results and recommendations of the reporting elements provided by the river operator and environmental water manager
- whether the actions and associated supporting measures should be expanded, modified, or remain unchanged
- reporting on the implementation of recommendations from previous reviews
- recommendations endorsed by the PPM Working Group.

The review will be guided by the principles set out in the NSW PPM IP, and the assessment guidelines set out by the MDBA. The review may be undertaken by an independent body.

The Department of Planning and Environment–Water is responsible for ensuring that appropriate changes to the regulatory framework are made to give effect to any recommendations arising from this review, in consultation with key stakeholders including the Department of Planning and Environment-Environment and Heritage and WaterNSW.

The Department of Planning and Environment–Water will prepare and publish the annual evaluation and review report each year, including any findings of the review and recommendations.

It is proposed that the annual review (Figure 2) will operate to a two to three-year cycle (Table 8) to adequately allow for reporting, consultation and review, including any consequential amendments that made be required to this Manual. A three-month period has been provided for each review element (e.g. reporting, consultation, review).

Table 8: Annual PPM review cycle

	Review Activity				
	Watering Actions	**Reporting & consultation**	**Reporting**	**Review & consultation**	**Manual amendments**
	Department of Planning and Environment-Environment and Heritage, WaterNSW	WaterNSW, Department of Planning and Environment-Environment and Heritage	Department of Planning and Environment-Water	Department of Planning and Environment-Water together with the PPM Working Group	Department of Planning and Environment-Water
July					
August					

	Review Activity				
	Watering Actions	Reporting & consultation	Reporting	Review & consultation	Manual amendments
	Department of Planning and Environment-Environment and Heritage, WaterNSW	WaterNSW, Department of Planning and Environment-Environment and Heritage	Department of Planning and Environment-Water	Department of Planning and Environment-Water together with the PPM Working Group	Department of Planning and Environment-Water
September					
October					
November					
December					
January					
February					
March					
April					
May					
June					Publication

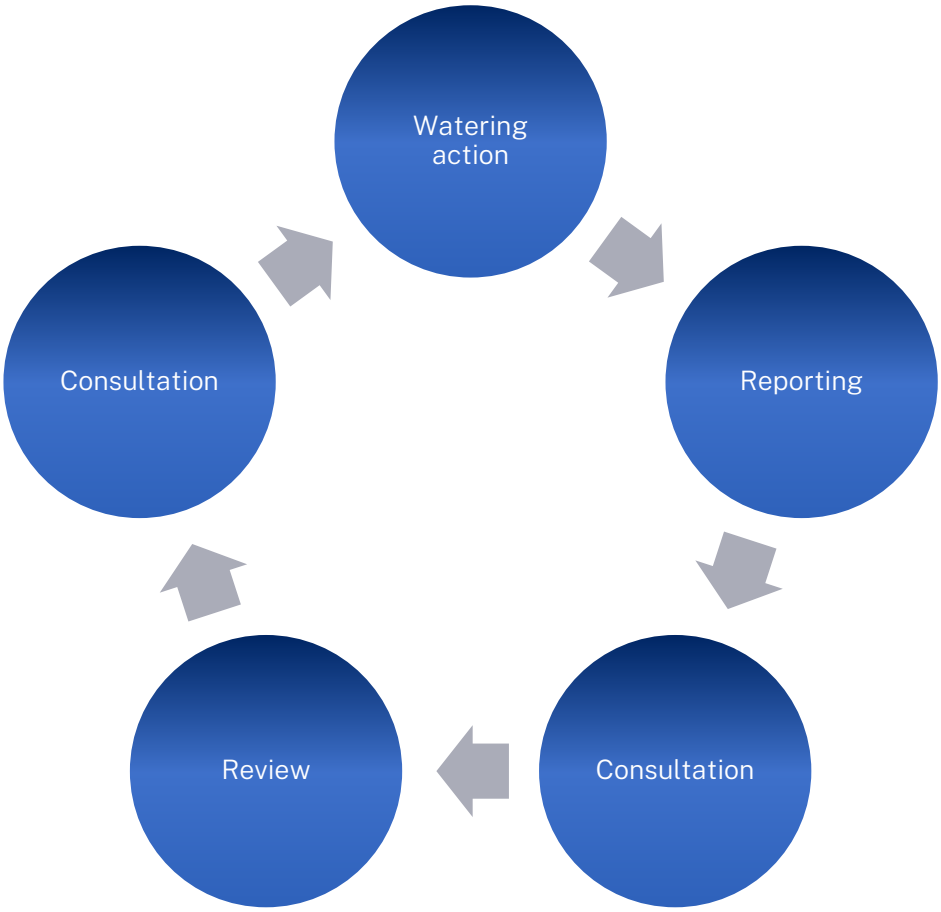

Figure 2: An overview of the annual PPM review cycle

References

MDBA, 2015. *Pre-requisite Policy Measures Assessment Guidelines*. 9 April 2015.

MDBA, 2019, *Prerequisite policy measures – MDBA Position Statement*, Murray–Darling Basin Authority Canberra, 2019. CC BY 4.0.

Appendix A Relationship of NSW PPMs to other plans and legislation

Table A.1: Relationship of NSW PPMs to other plans and legislation

Legislation or Plan	Overview and relationship to Procedures Manual
Commonwealth	
Water Act 2007 (Commonwealth)	Makes provision for the management of water resources of the Murray-Darling Basin.
Basin Plan	A legislative instrument developed as a requirement of the Water Act 2007. Aims to protect and restore key water-dependent ecosystems. Determines the amount of water that can be extracted annually from the Basin for consumptive use. **PPMs are a requirement of the Plan.**
Basin-wide Environmental Watering Strategy (MDBA)	Sets out the expected outcomes at a whole-of-basin scale that should be achievable with the environmental water available, and efficient and effective strategies to achieve them. This document guides the work of governments, water holders and environmental managers. **PPMs will assist in achieving expected outcomes.**
Environmental Watering Plan (MDBA)	The purposes of the environmental watering plan are to safeguard existing environmental water; plan for the recovery of additional environmental water; and coordinate the management of existing environmental water. **PPMs will assist in meeting the purposes of the Environmental Watering Plan.**
Environmental Watering Schedule (CEWO)	Developed periodically for the purposes of the Environmental Watering Plan to identify environmental watering priorities. **PPMs will assist in meeting environmental watering priorities.**

Legislation or Plan	Overview and relationship to Procedures Manual
Basin Annual Environmental Watering Priorities (MDBA)	Guide the annual planning and prioritisation of environmental watering across the Basin. They represent annual steps toward the long-term outcomes in the Basin-wide Environmental Watering Strategy. They aim to achieve the most effective use of water for the environment; promote better environmental outcomes across the Basin; and coordinate watering between environmental water holders and water managers. **PPMs will assist in achieving the aims of the Basin Annual Environmental Watering Priorities.**
Portfolio Management Plan (CEWO)	Sets out plans for managing the Commonwealth environmental water portfolio in the NSW Murray and Lower Darling Regulated Rivers for each water year. **PPMs will assist in managing Commonwealth environmental water portfolio**
NSW	
Water Management Act 2000	The WMA provides the legislative framework for the sharing of water between industry, communities and the environment in NSW. **PPMs must be implemented in accordance with the WMA.**
Water Management Regulation 2011	The Regulation is a supporting instrument to the WMA. It provides the administrative direction for the management of NSW's water resources and specifies how issues are to be dealt with at a local level. **PPMs must be implemented in accordance with the Regulation.**
Protection of the Environment Operations Act 1997	The POEO Act enables the NSW Government to set out explicit protection of the environment policies and adopt more innovative approaches to reducing pollution. The POEO Act includes prohibition of pollution of waters. **PPMs must be implemented in such a way as to avoid pollution of waters (e.g. triggering of blackwater events)**
Murray Lower Darling Water Resource Plan	The WRP outlines how water resources will be managed to be consistent with the Murray-Darling Basin Plan. **PPMs must be implemented in accordance with the WRP.**

Legislation or Plan	Overview and relationship to Procedures Manual
Water Sharing Plan for the New South Wales Murray and Lower Darling Regulated Rivers Water Sources 2016	Water sharing plans are a legislative tool under the WMA that sets out rules for access licences and water supply works approvals. WSPs contains rules which specify how water is shared between the environment and water users in a water source. **PPMs must be implemented in accordance with the WSPs.**
Annual Watering Plan (Department of Planning and Environment-Environment and Heritage)	Outlines the priorities for environmental water use in the coming year, depending on climatic factors and water availability. **PPMs will assist in meeting the priorities of the Annual Watering Plan.**
Works Approval (WaterNSW)	Water Supply Works Approvals manage river operations and are controlled by Department of Planning and Environment-Water. **PPM Procedures Manuals will translate how these approval conditions are to be managed in day-to-day river operations.**
NSW PPM Implementation Plan	The PPM Implementation Plan sets out high level principles to guide PPM development and implementation. It identifies preferred implementation options and associated processes required to incorporate PPMs into the regulatory and operational frameworks that guide water management and operation in NSW. **PPM Implementation Plan and review of this plan by MDBA informs the development of the PPM Procedures Manual.**

Appendix B List of water access licences

Access licences that are either licensed environmental water under section 8 of the *Water Management Act 2000*, held by the Commonwealth Environmental Water Holder, or are specified in the table below, as well as River Murray Increased Flows account water, may order water under the Environmental Flow Reuse Rules or the Piggybacking Rules set out in this Manual.

Table B.1: List of water access licences (as at October 2022, accessed via the NSW environmental water register)

Water Access Licence No	Environmental Holder Group
8718	NSW DPE (WATER)
11065	NSW DPE (WATER)
11066	NSW DPE (WATER)
11277	PRIVATE
11377	NSW DPE (WATER)
12990	NSW DPE (WATER)
14585	NSW DPE (WATER)
15937	NSW DPE (WATER)
16383	NSW DPE (WATER)
20264	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
30638	NSW DPE (WATER)
30639	NSW DPE (WATER)
30640	NSW DPE (WATER)
36350	NSW DPE (WATER)
37272	NSW DPE (WATER)
37273	NSW DPE (WATER)
41359	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
41715	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)

Appendix C Edward-Wakool System interim environmental water accounting arrangement

The accounting arrangement described below was agreed at the NSW PPM Working Group on 5 September 2019 and was first applied in the 2019-20 water year.

Background

The Edward-Wakool system (the system) is part of the NSW Murray Regulated River. To enable PPMs in the system, and in particular return flows, an environmental water accounting mechanism is needed.

The hydrology of the Edward-Wakool system is complex and it is recognised there are many opportunities and options for environmental water delivery. An agreed environmental water accounting approach was needed that considered operational constraints and practicalities, potential impacts on all entitlement holders and accounting efficiencies.

Until the application of this accounting arrangement, no assumed use had been applied to environmental flows in the Wakool system and no return flows had been recognised. In previous watering events, the environmental water holders were debited the full volume of water entering the Wakool system that contributed to environmental water targets.

Broadly, there are two methods of delivering water into the Edward-Wakool system for achieving environmental outcomes, both of which need to be defined in terms of accounting:

1. Delivery of environmental water.
2. Diversion of operational water.

To date, environmental water holders have used operational water in the system, hence this approach focuses on improving environmental watering accounting arrangements for the diversion and use of operational water only.

The NSW PPM working group have agreed to an interim accounting approach. While the approach was recognised as conservative, it provides an improved accounting arrangement providing improved efficiency for water for the environment. The arrangement applies to net use of operational water only and not directed releases; hence no return flows are provided for under this approach.

Interim accounting approach: seasonal loss rates

The interim accounting approach applies a seasonal loss rate to all environmental water inflows that exceed the seasonal loss threshold (Table C.1). The environmental water holders are also charged for the balance of any flow required on top of operational requirements to meet the loss threshold.

The loss threshold can be considered as the identified inflow (to the system), below which there is a possibility of no outflows from the Wakool system and also as a proxy for greater River Murray System conditions.

Table C.1: Seasonal loss rate and threshold for environmental water accounting in the Wakool System

Season	Month	Loss (%)	Loss threshold (ML/d)
Summer	January	80	450
Summer	February	80	450
Autumn	March	65	350
Autumn	April	65	350
Autumn	May	65	350
Winter	June	55	250
Winter	July	55	250
Winter	August	55	250
Spring	September	70	375
Spring	October	70	375
Spring	November	70	375
Summer	December	80	450

Historical system losses (2000-2018) were calculated using the Wakool System loss method. Wakool System losses are calculated in the MDBA Accounts, via a method previously approved by the Water Liaison Working Group. The system losses were used to determine the seasonal loss rate and loss threshold.

It is noted that:

- periods of unregulated flow conditions were filtered out,

- the monthly loss was calculated using only months where there were seven or more days of data available,
- travel time for the system is within a month, and therefore it is assumed that phenomenon such as loss and gains from bank storage are reduced by using monthly data,
- the use of average loss behaviour can be a potential risk of impact to water users in the NSW Murray system. An approach with a risk profile similar to that use for NSW resource assessments is used to determine the seasonal loss rate (between the 95%ile and the maximum monthly loss recorded), and
- there is limited confidence in the data currently available.

This approach has been applied from 1 July 2019 and is to be consistent with the NSW PPM.

Reporting, evaluation and review

This accounting arrangement is subject to the reporting, review and evaluation process described in the Procedures Manual. To support and inform the evaluation of the accounting method, Wakool system losses considered as part of the review.

Appendix D Incremental loss method for return flows of environmental water in the River Murray from the Murrumbidgee

The accounting arrangement described below was documented in July 2021.

The arrangement was updated following NSW PPM Working Group #7 (31 March 2022) to include a new loss lookup table for flows greater than 20,000 ML/day.

Introduction

River and floodplain connectivity in the southern Basin is a key objective for environmental water managers. Pre-requisite Policy Measures (PPMs) seek to maximise the beneficial outcomes of water recovered for the environment, including recognising environmental water throughout the length of the river, and between rivers. Accounting of environmental water delivered along the Murray regulated valley and across the South Australian border is important for recognising the volume of environmental water crossing the border and for helping environmental managers make good decisions for use of held environmental water (HEW) accounts.

Understanding the relationship between flow conditions and losses is a key element of river forecasting and operations. Accounting and distribution of those losses have a significant influence on the system. This paper focuses particularly on the losses and recognition of volumes of HEW, as the greater the losses attributed to HEW, the greater the volume of HEW may be required to achieve connectivity.

Previous methods took a proportional loss approach for all water delivery, where the total loss was determined and then apportioned to the volumes of HEW delivered. The proportional method overestimates the loss, as the total loss experienced by the system is considered to be caused equally by all water deliveries (e.g. irrigation diversion and South Australia's entitlement flow). This includes HEW delivered from the Murrumbidgee River, and results in a lower volume of environmental water recognised at the South Australian border. However, the bulk of the loss experienced by the system is due to normal River Murray deliveries. The addition of HEW from the Murrumbidgee River in the River Murray only results in an incremental increase in loss.

The incremental loss approach pre-calculates the likely losses, based on conservative conditions, without affecting water users. Likely losses associated with different flow conditions are captured in a flow look-up table. Operators can assign losses for Murrumbidgee River HEW entering the River Murray to recognise the volume of environmental water at the South Australian border.

This paper describes the method used for accounting for HEW losses for HEW from the regulated Murrumbidgee River entering the River Murray and as it travels through to the South Australian border. HEW accounting within the Murrumbidgee valley is out-of-scope and is dealt with via a separate method. Later sections of the paper discuss the potential for applying this method to other HEW entering the River Murray and other systems where a method for determining losses to HEW is required.

Method & requirements

The method presented here is used to calculate the losses to HEW based on the flow conditions during delivery, determined using historical loss data. This is the loss incurred as it travels through the River Murray. Analysis of historical flow and loss data resulted in a loss look-up table based on conservative estimates of losses in each flow range. This table can then be used to determine what losses to apply to HEW that has entered the River Murray from an upstream tributary when it reaches the South Australian border.

The method requires data sets of long-term daily flows and corresponding losses. This is typically obtained through a well-calibrated daily hydrological model of the system.

Data

The Murray Darling Basin Authority (MDBA) has developed a daily hydrological model (in SOURCE) for the River Murray system. The model outputs used in this analysis were from a model using historical data, which covered over 100 years of simulation. Loss data was extracted from this model for the reaches from Boundary Bend to the South Australian border. Daily data was filtered to remove days on which large inflows from the Lower Darling would significantly influence the loss behaviour of this reach, resulting in about 70 years of simulation data remaining.

The daily data was separated into flow classes, with a summary of data available for these flow classes shown in Figure D.1.

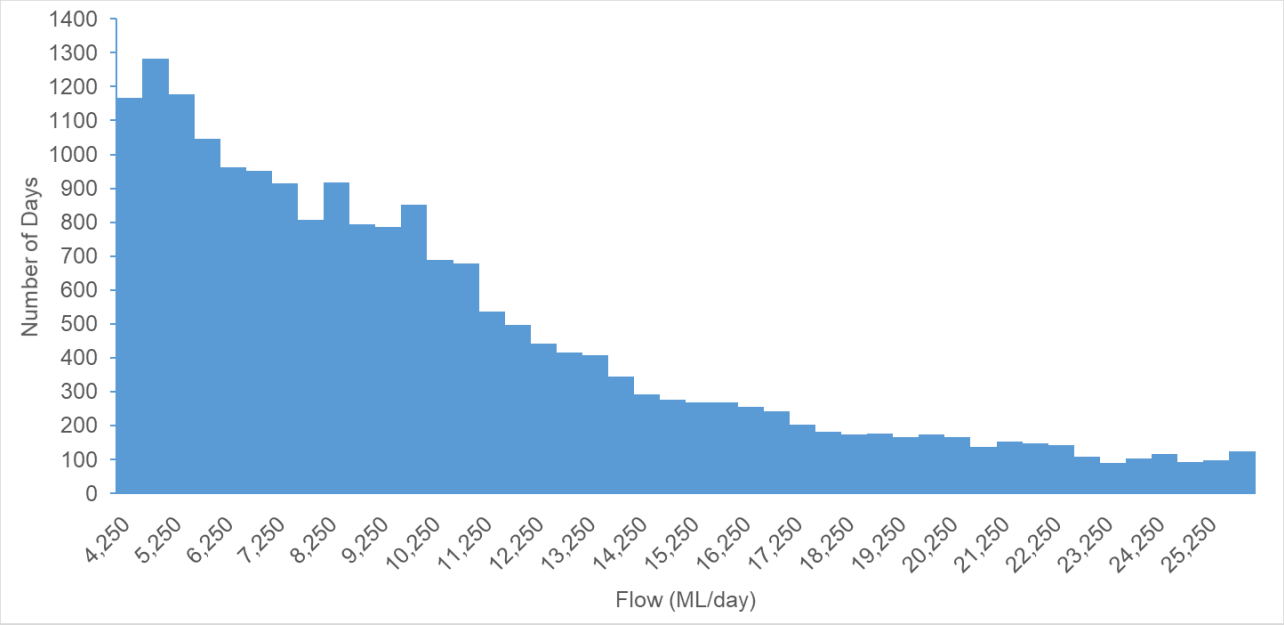

Figure D.1: Days of data available by daily flow rate.

Data was checked for uniformity of distribution within each flow class by comparing the mid-flow value of the flow range against the average flow within the class. Results showed that the average flow and the mid-flow values matched very closely, indicating likely uniform distribution of datapoints. This provided a smooth transitional behaviour in loss rates between classes.

Consideration must be given to the amount of data underpinning this analysis for a given flow. For example, greater than 500 days of data is available for flows below 12,000 ML/day, therefore, there is low risk of underestimating the losses. However, if a flow class has a small number of data points (<200 days), the confidence in the associated loss value is lower. This means the confidence in the method is lower when there are larger flows in the system, and higher when there are smaller flows. Losses are of particular importance when only small volumes are moving through the system.

Incremental loss method

The incremental loss method analyses the daily losses experienced for each flow class range over 100 years, examines the range of values, and uses the most conservative losses to produce a loss look-up table for river operators.

To calculate incremental losses:

- separate daily flow data into flow classes, keeping each data point with its associated loss value
- analyse each flow class and determine loss values at key percentile intervals
- create non-linear smoothing curves fitted to key loss percentiles across all flow classes
- determine the rate of change for each curve (representing a particular loss percentile)
- determine the incremental loss by finding the cumulative rate of change along the smooth curve to jump from one flow class to another
- identify the most conservative estimate for the flow class. That is, the worst-case incremental loss is taken as the final incremental loss value associated with increasing flow from one flow class to another.

This loss analysis adopts a worst-case incremental loss to ensure other water users in the NSW Murray are not paying for losses for the delivery of HEW from the Murrumbidgee River to the South Australian border. These incremental losses are significantly less than the proportional method used previously and demonstrates progress in accounting for losses resulting from the additional flow created by HEW moving through the system.

Results

The availability of uniformly distributed data resulted in a relatively smooth transition of loss values between classes for most loss exceedance plots (Appendix D.1), but the loss function over a number of flow classes still showed rapid fluctuating changes. To smooth the loss function further, a 4th degree polynomial was fitted for each exceedance condition. This results in a smooth loss function for each exceedance condition (Figure D.2), which shows consistent behaviour between flow classes within an exceedance condition, and also smooth transitional behaviour between exceedance conditions, ultimately aiding in the creation of a smooth loss look-up table.

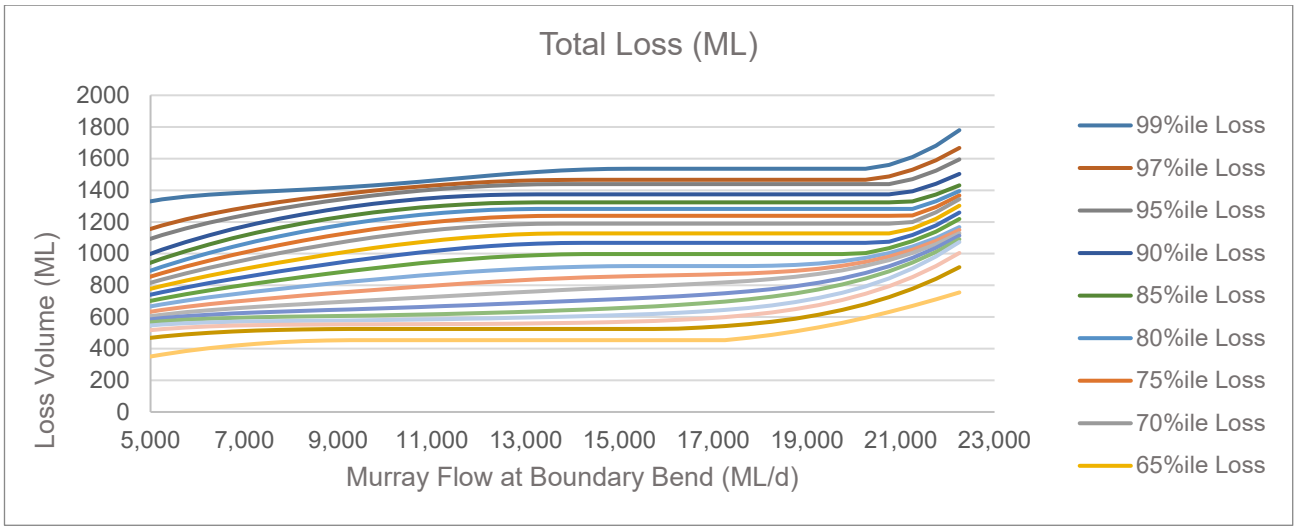

Figure D.2: Loss volumes at various Murray River flow rates.

Figure D.3 shows the change in loss volumes between flow classes. It plots the incremental loss behaviour of each exceedance condition over all the flow classes and shows consistent, graduated differences between the various percentiles. Losses generally increase for all exceedance conditions for flows under 15,000 ML/day. For flows between 13,000 ML/day and 20,000 ML/day, exceedance conditions below the 50th percentile generally show a minimal increase in losses. All exceedance conditions show a rapid increase in losses for flows above 20,000 ML/day.

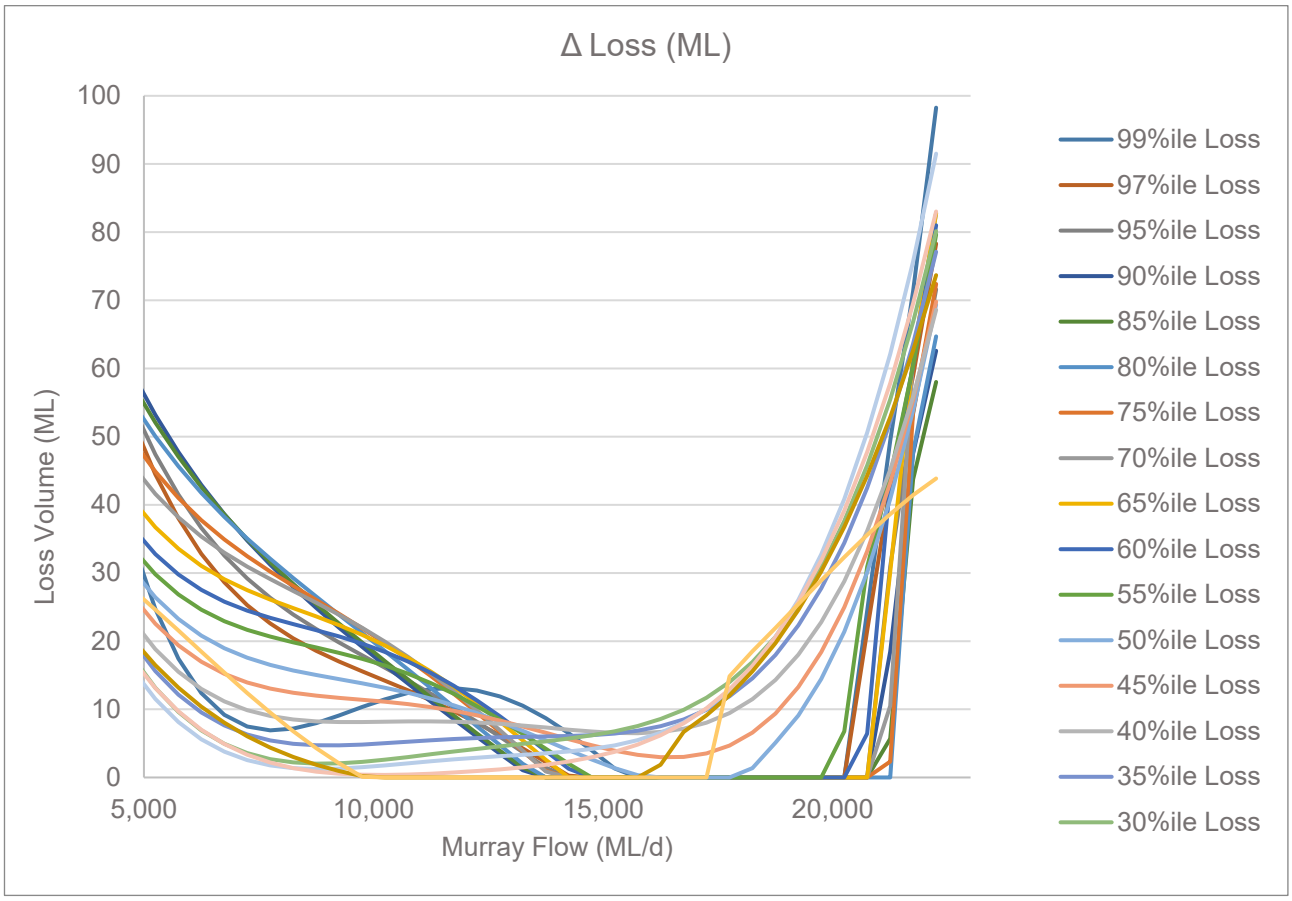

Figure D.3: Change in loss volumes between flow rates.

The incremental loss analysis approach undertaken grouped all the data together and used 500 ML/day increments. This analysis could have been undertaken on a seasonal basis, and with various flow increments. Testing this method under various seasonal conditions and flow increments does not yield significant differences in the results (Appendix D.2). Further analysis of seasonal data and flow increments should be part of a review process.

Application

Flows up to 20,000 ML/day

Table D.1 shows the final incremental loss table. The table shows the River Murray is generally highly efficient in the flow ranges from 10,000-20,000 ML/day, with any increases in flow typically resulting in a 2-5% increase in loss.

Operators can use Table D.1 to look up a flow on a given day in the Murray River at Boundary Bend on the vertical axis, up to 20,000 ML/day, after removing the influence of the HEW being delivered from the Murrumbidgee River through Balranald. The HEW volume being delivered through Balranald is then taken from the horizontal axis. The corresponding value at the intersection of the appropriate vertical and horizontal axis values is the loss value which can be applied to the HEW being delivered that day.

No loss value is applied if the River Murray is in unregulated conditions.

Flows exceeding 20,000 ML/day

For flows above 20,000 ML/day there is a rapid increase in losses (Figure D.3).

As an interim arrangement, operators can use Table D.2 to look up a flow on a given day in the Murray River at Boundary Bend on the vertical axis, over 20,000 ML/day, after removing the influence of the HEW being delivered from the Murrumbidgee River through Balranald.

The HEW volume being delivered through Balranald is then taken from the horizontal axis. The corresponding value at the intersection of the appropriate vertical and horizontal axis values is the loss value which can be applied to the HEW being delivered that day. If the corresponding loss is greater than 100%, the loss value will be capped at 100%.

No loss value is applied if the River Murray is in unregulated conditions.

Note that the assumed use calculations are estimated from operational data as return flows need to be recognised at South Australia in real-time.

Extending implementation to the Lower Darling

The incremental loss method could be used in reaches where recognition of environmental water entering from tributaries is a priority. The data which underpins the analysis of losses in the River Murray for this implementation is from Boundary Bend to the South Australian border. It is only applicable to flows in the River Murray within this reach.

In lieu of further analysis, scaling these results to represent a subset of this reach (e.g. from the Lower Darling to South Australian border) could be an appropriate extension of application of this analysis. It prevents the introduction of discrepancies caused by random data fluctuations and

effectively analysing losses along the same reach twice, without resulting in any additional accuracy.

Subsequent analysis indicated that the losses in the Murrumbidgee incremental loss method predominately come from losses in the reach between Wentworth to South Australia, suggesting that a dedicated Lower Darling incremental loss method would closely match the Murrumbidgee method and outputs. The distance between Burtundy and Wentworth is significantly longer than Balranald and Boundary Bend. Furthermore, the reach shows characteristics akin to those between Wentworth to South Australia, and therefore assuming no losses between Burtundy and Wentworth is not appropriate.

Considering the distance from Burtundy to Wentworth and its similarity to the reach between Wentworth and South Australia, as an interim measure the losses between Burtundy and Wentworth are considered to be similar to those experienced from Boundary Bend to Wentworth. The Murrumbidgee incremental loss method (Table D.1) will be applied as an interim arrangement for HEW return flows from the Lower Darling to determine flows at South Australia.

This approach is an interim measure only and an enduring method will be developed in due time and worked through the NSW PPM Working Group.

The incremental loss method is dependent on high quality, long-term flow and corresponding loss data. A well-calibrated daily flow model, with realistic loss to flow relationships is the most likely source of this data. The MDBA Murray model is fit for this purpose. If a similar approach is to be applied to recognising losses in other systems, an appropriate hydrological model with similar levels of climatic input data would be required.

Future work to incorporate climate change

The incremental loss method is based on conditions experienced during the last 100 years. Stochastic climate modelling work being done for Regional Water Strategies could help examine whether the range of losses experienced during the model run is likely to be sufficiently broad to cater for future climate variability.

Review

The incremental loss analysis could be periodically performed with extended model data to ensure the conservative loss volumes captured in the look-up table are still reflective of River Murray flow conditions.

Table D.1: Loss look-up table for Murrumbidgee water (HEW) entering the Murray (flows up to 20,000 ML/day at Boundary Bend).

Murray	Incremental Loss Vol (by Murrumbidgee Return Vol)										Incremental Loss % (by Murrumbidgee Return Vol)									
Flow Range	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
4000 - 4500	65	124	176	223	266	305	339	370	397	421	13.0%	12.4%	11.7%	11.2%	10.6%	10.2%	9.7%	9.2%	8.8%	8.4%
4500 - 5000	124	176	223	266	305	339	370	397	421	442	24.9%	17.6%	14.9%	13.3%	12.2%	11.3%	10.6%	9.9%	9.4%	8.8%
5000 - 5500	111	158	200	239	273	304	331	355	378	398	22.2%	15.8%	13.3%	11.9%	10.9%	10.1%	9.5%	8.9%	8.4%	8.0%
5500 - 6000	100	142	180	215	245	274	299	323	343	361	20.0%	14.2%	12.0%	10.7%	9.8%	9.1%	8.5%	8.1%	7.6%	7.2%
6000 - 6500	90	128	163	194	223	250	273	294	310	325	18.0%	12.8%	10.9%	9.7%	8.9%	8.3%	7.8%	7.3%	6.9%	6.5%
6500 - 7000	81	116	149	177	204	227	248	265	279	290	16.3%	11.6%	9.9%	8.9%	8.1%	7.6%	7.1%	6.6%	6.2%	5.8%
7000 - 7500	74	106	135	162	185	206	222	237	250	260	14.7%	10.6%	9.0%	8.1%	7.4%	6.9%	6.3%	5.9%	5.5%	5.2%
7500 - 8000	67	97	123	146	167	184	200	213	224	232	13.4%	9.7%	8.2%	7.3%	6.7%	6.1%	5.7%	5.3%	5.0%	4.6%
8000 - 8500	62	88	111	132	151	167	180	191	199	204	12.3%	8.8%	7.4%	6.6%	6.0%	5.6%	5.2%	4.8%	4.4%	4.1%
8500 - 9000	55	79	101	120	136	151	162	169	174	176	11.0%	7.9%	6.7%	6.0%	5.5%	5.0%	4.6%	4.2%	3.9%	3.5%
9000 - 9500	51	73	91	109	122	133	141	146	150	150	10.1%	7.3%	6.1%	5.4%	4.9%	4.4%	4.0%	3.7%	3.3%	3.0%
9500 - 10000	46	66	83	96	107	117	122	125	128	128	9.2%	6.6%	5.5%	4.8%	4.3%	3.9%	3.5%	3.1%	2.8%	2.6%
10000 - 10500	42	58	73	85	94	100	105	110	114	117	8.4%	5.8%	4.8%	4.2%	3.7%	3.3%	3.0%	2.8%	2.5%	2.3%
10500 - 11000	36	51	63	73	81	90	98	102	103	103	7.3%	5.1%	4.2%	3.6%	3.3%	3.0%	2.8%	2.6%	2.3%	2.1%
11000 - 11500	32	44	56	67	77	84	88	90	90	90	6.4%	4.4%	3.7%	3.4%	3.1%	2.8%	2.5%	2.3%	2.0%	1.8%
11500 - 12000	29	42	53	63	69	74	76	76	80	88	5.7%	4.2%	3.5%	3.1%	2.8%	2.5%	2.2%	1.9%	1.8%	1.8%
12000 - 12500	28	39	48	55	59	62	64	70	78	88	5.5%	3.9%	3.2%	2.8%	2.4%	2.1%	1.8%	1.8%	1.7%	1.8%
12500 - 13000	24	34	42	46	47	55	62	69	78	94	4.8%	3.4%	2.8%	2.3%	1.9%	1.8%	1.8%	1.7%	1.7%	1.9%
13000 - 13500	21	29	33	39	46	53	62	74	89	108	4.2%	2.9%	2.2%	1.9%	1.8%	1.8%	1.8%	1.8%	2.0%	2.2%
13500 - 14000	17	23	31	37	45	55	68	84	102	124	3.3%	2.3%	2.1%	1.9%	1.8%	1.8%	1.9%	2.1%	2.3%	2.5%
14000 - 14500	15	22	30	39	50	62	77	96	119	146	3.1%	2.2%	2.0%	1.9%	2.0%	2.1%	2.2%	2.4%	2.6%	2.9%
14500 - 15000	14	22	32	43	56	72	90	112	140	174	2.9%	2.2%	2.1%	2.1%	2.2%	2.4%	2.6%	2.8%	3.1%	3.5%
15000 - 15500	15	25	36	50	64	83	106	133	167	209	3.1%	2.5%	2.4%	2.5%	2.6%	2.8%	3.0%	3.3%	3.7%	4.2%
15500 - 16000	18	29	42	57	76	98	125	160	201	253	3.5%	2.9%	2.8%	2.9%	3.0%	3.3%	3.6%	4.0%	4.5%	5.1%
16000 - 16500	20	33	48	67	90	118	152	193	246	316	4.0%	3.3%	3.2%	3.4%	3.6%	3.9%	4.3%	4.8%	5.5%	6.3%
16500 - 17000	24	40	58	80	108	142	184	240	308	392	4.8%	4.0%	3.9%	4.0%	4.3%	4.7%	5.2%	6.0%	6.8%	7.8%
17000 - 17500	29	47	69	97	131	175	231	299	383	483	5.7%	4.7%	4.6%	4.8%	5.2%	5.8%	6.6%	7.5%	8.5%	9.7%
17500 - 18000	36	61	89	121	164	220	288	372	472		7.3%	6.1%	5.9%	6.1%	6.6%	7.3%	8.2%	9.3%	10.5%	
18000 - 18500	44	73	106	150	206	274	358	458			8.8%	7.3%	7.0%	7.5%	8.2%	9.1%	10.2%	11.4%		
18500 - 19000	52	87	132	188	256	340	440				10.3%	8.7%	8.8%	9.4%	10.3%	11.3%	12.6%			
19000 - 19500	65	110	165	233	317	418					13.0%	11.0%	11.0%	11.7%	12.7%	13.9%				
19500 - 20000	81	136	205	288	388						16.3%	13.6%	13.6%	14.4%	15.5%					
20000 - 20500	100	169	252	353							20.0%	16.9%	16.8%	17.7%						
20500 - 21000	124	207	308								24.9%	20.7%	20.5%							
21000 - 21500	152	252									30.4%	25.2%								
21500 - 22000	187										37.4%									
22000 - 22500																				

Table D.2: Loss look-up table for Murrumbidgee water (HEW) entering the Murray (flows over 20,000 ML/day at Boundary Bend)[1].

Murray	Incremental Loss Vol (by Murrumbidgee Return Vol)										Incremental Loss % (by Murrumbidgee Return Vol)									
Flow Range	2,000	4,000	6,000	8,000	10,000	12,000	14,000	16,000	18,000	20,000	2,000	4,000	6,000	8,000	10,000	12,000	14,000	16,000	18,000	20,000
4000 - 6000	344	602	789	910	964	964	964	964	964	964	17.2%	15.0%	13.1%	11.4%	9.6%	8.0%	6.9%	6.0%	5.4%	4.8%
6000 - 8000	602	789	910	964	964	964	964	964	964	964	30.1%	19.7%	15.2%	12.0%	9.6%	8.0%	6.9%	6.0%	5.4%	4.8%
8000 - 10000	457	578	630	630	630	630	630	630	630	630	22.8%	14.4%	10.5%	7.9%	6.3%	5.3%	4.5%	3.9%	3.5%	3.2%
10000 - 12000	314	366	366	366	366	366	366	366	366	372	15.7%	9.2%	6.1%	4.6%	3.7%	3.1%	2.6%	2.3%	2.0%	1.9%
12000 - 14000	174	174	174	174	174	193	228	270	318	371	8.7%	4.3%	2.9%	2.2%	1.7%	1.6%	1.6%	1.7%	1.8%	1.9%
14000 - 16000	57	79	102	128	155	189	231	278	331	388	2.9%	2.0%	1.7%	1.6%	1.6%	1.6%	1.7%	1.7%	1.8%	1.9%
16000 - 18000	50	74	99	125	161	202	250	303	360	420	2.5%	1.8%	1.7%	1.6%	1.6%	1.7%	1.8%	1.9%	2.0%	2.1%
18000 - 20000	47	73	102	139	179	227	279	337	397	460	2.4%	1.8%	1.7%	1.7%	1.8%	1.9%	2.0%	2.1%	2.2%	2.3%
20000 - 22000	50	81	117	158	206	257	315	375	439	592	2.5%	2.0%	1.9%	2.0%	2.1%	2.1%	2.2%	2.3%	2.4%	3.0%
22000 - 24000	58	94	135	183	235	293	353	419	592	1236	2.9%	2.3%	2.3%	2.3%	2.4%	2.4%	2.5%	2.6%	3.3%	6.2%
24000 - 26000	67	109	156	209	266	327	396	592	1236	2026	3.4%	2.7%	2.6%	2.6%	2.7%	2.7%	2.8%	3.7%	6.9%	10.1%
26000 - 28000	78	125	178	235	299	369	592	1236	2026	2960	3.9%	3.1%	3.0%	2.9%	3.0%	3.1%	4.2%	7.7%	11.3%	14.8%
28000 - 30000	89	142	200	265	336	592	1236	2026	2960	4038	4.5%	3.5%	3.3%	3.3%	3.4%	4.9%	8.8%	12.7%	16.4%	20.2%
30000 - 32000	100	161	226	309	592	1236	2026	2960	4038	5253	5.0%	4.0%	3.8%	3.9%	5.9%	10.3%	14.5%	18.5%	22.4%	26.3%
32000 - 34000	113	185	309	592	1236	2026	2960	4038	5253	6591	5.7%	4.6%	5.2%	7.4%	12.4%	16.9%	21.1%	25.2%	29.2%	33.0%
34000 - 36000	168	293	592	1236	2026	2960	4038	5253	6591	8037	8.4%	7.3%	9.9%	15.5%	20.3%	24.7%	28.8%	32.8%	36.6%	40.2%
36000 - 38000	221	592	1236	2026	2960	4038	5253	6591	8037	9566	11.1%	14.8%	20.6%	25.3%	29.6%	33.7%	37.5%	41.2%	44.6%	47.8%
38000 - 40000	592	1236	2026	2960	4038	5253	6591	8037	9566	11150	29.6%	30.9%	33.8%	37.0%	40.4%	43.8%	47.1%	50.2%	53.1%	55.7%
40000 - 42000	1151	1939	2874	3952	5167	6504	7950	9479	11064	12667	57.5%	48.5%	47.9%	49.4%	51.7%	54.2%	56.8%	59.2%	61.5%	63.3%
42000 - 44000	1434	2368	3446	4661	5999	7444	8974	10558	12162	13742	71.7%	59.2%	57.4%	58.3%	60.0%	62.0%	64.1%	66.0%	67.6%	68.7%
44000 - 46000	1724	2802	4016	5354	6799	8329	9913	11517	13098	14606	86.2%	70.0%	66.9%	66.9%	68.0%	69.4%	70.8%	72.0%	72.8%	73.0%
46000 - 48000	2013	3227	4565	6010	7539	9123	10727	12308	13816	15193	100.7%	80.7%	76.1%	75.1%	75.4%	76.0%	76.6%	76.9%	76.8%	76.0%
48000 - 50000	2292	3630	5075	6604	8190	9793	11374	12881	14258	15439	114.6%	90.8%	84.6%	82.6%	81.9%	81.6%	81.2%	80.5%	79.2%	77.2%
50000 - 52000	2552	3997	5526	7112	8715	10296	11803	13180	14361	15270	127.6%	99.9%	92.1%	88.9%	87.2%	85.8%	84.3%	82.4%	79.8%	76.4%
52000 - 54000	2783	4313	5897	7501	9082	10590	11966	13147	14056	14610	139.2%	107.8%	98.3%	93.8%	90.8%	88.2%	85.5%	82.2%	78.1%	73.1%
54000 - 56000	2974	4558	6162	7743	9251	10628	11809	12717	13272	13377	148.7%	114.0%	102.7%	96.8%	92.5%	88.6%	84.3%	79.5%	73.7%	66.9%
56000 - 58000	3114	4718	6299	7806	9183	10363	11273	11826	11932	11932	155.7%	117.9%	105.0%	97.6%	91.8%	86.4%	80.5%	73.9%	66.3%	59.7%
58000 - 60000	3188	4769	6277	7654	8834	9743	10297	10403	10403		159.4%	119.2%	104.6%	95.7%	88.3%	81.2%	73.6%	65.0%	57.8%	
60000 - 62000	3185	4693	6070	7250	8159	8713	8819	8819			159.2%	117.3%	101.2%	90.6%	81.6%	72.6%	63.0%	55.1%		
62000 - 64000	3089	4466	5646	6555	7109	7215	7215				154.4%	111.7%	94.1%	81.9%	71.1%	60.1%	51.5%			
64000 - 66000	2885	4066	4974	5529	5634	5902					144.3%	101.6%	82.9%	69.1%	56.3%	49.2%				
66000 - 68000	2558	3466	4021	4176	5273						127.9%	86.7%	67.0%	52.2%	52.7%					
68000 - 70000	2089	2643	3487	4585							104.4%	66.1%	58.1%	57.3%						
70000 - 72000	1735	2732	3830								86.7%	68.3%	63.8%							
72000 - 74000	1905	3003									95.3%	75.1%								
74000 - 76000	2094										104.7%									
76000 - 78000																				

[1] The maximum loss value that can be applied is 100%

Appendix D.1: Exceedance curves for Murrumbidgee losses for Murray flow rates

Appendix D.2: Seasonal comparison tables (summer & winter)

Flow Class	Row Ref	Flow Range	n	TOT BB Flow	TOT Loss	Loss %
4,000.00	895	4000 - 4500	25	106107.29	13310.777	12.5%
4,500.00	2073	4500 - 5000	39	184804.58	22321.892	12.1%
5,000.00	3339	5000 - 5500	43	223371.02	27850.899	12.5%
5,500.00	4509	5500 - 6000	46	266450.8	30989.963	11.6%
6,000.00	5591	6000 - 6500	75	469062.81	51007.982	10.9%
6,500.00	6549	6500 - 7000	113	766733.96	82808.026	10.8%
7,000.00	7503	7000 - 7500	177	1286334.8	130448.83	10.1%
7,500.00	8417	7500 - 8000	199	1542689.9	159752.07	10.4%
8,000.00	9223	8000 - 8500	268	2208667.6	212924.16	9.6%
8,500.00	10137	8500 - 9000	214	1871294	168947.76	9.0%
9,000.00	10931	9000 - 9500	177	1636836.3	134288.44	8.2%
9,500.00	11722	9500 - 10000	204	1988389.4	175703.61	8.8%
10,000.00	12563	10000 - 10500	216	2214743.4	175754.89	7.9%
10,500.00	13262	10500 - 11000	208	2234270.4	182114.39	8.2%
11,000.00	13936	11000 - 11500	188	2112040	159099.22	7.5%
11,500.00	14477	11500 - 12000	171	2006112	154158.14	7.7%
12,000.00	14966	12000 - 12500	138	1688936.1	124950.45	7.4%
12,500.00	15416	12500 - 13000	159	2024874.3	142747.65	7.0%
13,000.00	15831	13000 - 13500	141	1863576.5	118115.71	6.3%
13,500.00	16239	13500 - 14000	113	1552161.3	90858.552	5.9%
14,000.00	16580	14000 - 14500	78	1109162.3	63218.891	5.7%
14,500.00	16871	14500 - 15000	61	899586.51	51565.067	5.7%
15,000.00	17146	15000 - 15500	78	1188021.4	67543.261	5.7%
15,500.00	17421	15500 - 16000	87	1369076.2	69577.478	5.1%
16,000.00	17686	16000 - 16500	46	745334.14	43595.684	5.8%
16,500.00	17927	16500 - 17000	39	651631.71	31826.641	4.9%
17,000.00	18186	17000 - 17500	27	464940.85	23569.186	5.1%
17,500.00	18390	17500 - 18000	21	370181.97	15842.413	4.3%
18,000.00	18546	18000 - 18500	16	291323.91	14610.051	5.0%
18,500.00	18737	18500 - 19000	20	374111.17	15427.546	4.1%
19,000.00	18922	19000 - 19500	26	499739.77	22428.159	4.5%
19,500.00	19088	19500 - 20000	13	256005.83	13043.2	5.1%
20,000.00	19245	20000 - 20500	20	404586.92	19334.594	4.8%

Flow Class	Row Ref	Flow Range	n	TOT BB Flow	TOT Loss	Loss %
4,000.00	916	4000 - 4500	220	930785.04	129199.43	13.9%
4,500.00	2081	4500 - 5000	209	989170.48	133533.31	13.5%
5,000.00	3357	5000 - 5500	276	1454195.1	183134.8	12.6%
5,500.00	4543	5500 - 6000	255	1463312.7	185161.6	12.7%
6,000.00	5590	6000 - 6500	282	1756479.5	205166.11	11.7%
6,500.00	6544	6500 - 7000	269	1812405.2	197608.91	10.9%
7,000.00	7500	7000 - 7500	226	1639698.7	168662.79	10.3%
7,500.00	8416	7500 - 8000	178	1375414	136115.27	9.9%
8,000.00	9226	8000 - 8500	244	2012572.2	187899.56	9.3%
8,500.00	10142	8500 - 9000	178	1555770.3	147301.57	9.5%
9,000.00	10935	9000 - 9500	190	1757578.6	153466.66	8.7%
9,500.00	11721	9500 - 10000	209	2037089.4	181042.25	8.9%
10,000.00	12573	10000 - 10500	162	1658343.6	138118.8	8.3%
10,500.00	13261	10500 - 11000	164	1762534.1	146455.62	8.3%
11,000.00	13939	11000 - 11500	149	1674443.6	123884.76	7.4%
11,500.00	14473	11500 - 12000	135	1585984.2	119397.13	7.5%
12,000.00	14973	12000 - 12500	114	1393078	95887.239	6.9%
12,500.00	15415	12500 - 13000	95	1210773	83272.649	6.9%
13,000.00	15830	13000 - 13500	113	1497634.5	97563.984	6.5%
13,500.00	16238	13500 - 14000	111	1522402.5	93074.851	6.1%
14,000.00	16583	14000 - 14500	99	1413464.3	78606.425	5.6%
14,500.00	16876	14500 - 15000	101	1487707.1	83795.118	5.6%
15,000.00	17151	15000 - 15500	90	1371716.3	90324.647	6.6%
15,500.00	17420	15500 - 16000	86	1353686.4	80910.976	6.0%
16,000.00	17688	16000 - 16500	86	1395110.4	82954.856	5.9%
16,500.00	17945	16500 - 17000	99	1653486.8	79987.52	4.8%
17,000.00	18185	17000 - 17500	90	1550872.4	76170.348	4.9%
17,500.00	18386	17500 - 18000	66	1171429.9	55835.482	4.8%
18,000.00	18572	18000 - 18500	76	1385184.6	65548.094	4.7%
18,500.00	18747	18500 - 19000	80	1498404.7	71336.472	4.8%
19,000.00	18923	19000 - 19500	70	1346160.6	61389.64	4.6%
19,500.00	19090	19500 - 20000	79	1558027.6	77550.831	5.0%
20,000.00	19262	20000 - 20500	81	1637320.5	73805.454	4.5%

Appendix E Lower Darling River loss calculations

The accounting arrangement described below was documented in December 2021, following discussion at the NSW PPM Working Group Meeting #6 (29 October 2021).

It was updated after PPM Working Group Meeting #7 (31 March 2022) to include loss lookup tables for flows between 9,000 to 19,000 ML/day.

A loss treatment has been developed for held environmental water (HEW) deliveries in the Lower Darling. These losses determine the assumed use of environmental water to determine the volume of return flows at Burtundy.

Data

Data was extracted from the Lower Darling section of the Source Murray Model developed by the Murray Darling Basin Authority (MDBA). Daily releases from Weir 32 (W32) (425012) and associated daily losses from W32 to Burtundy were extracted for the period July 1895 to June 2019.

The model does not replicate actual releases from W32, but rather mimics assumed rules for releases from W32 and models the associated loss.

The model has been calibrated with actual data (from 1983 to 2019) at Burtundy gauging station (425007). The calibration shows good model fidelity in reproducing the observed data (Figures E.1 and E.2).

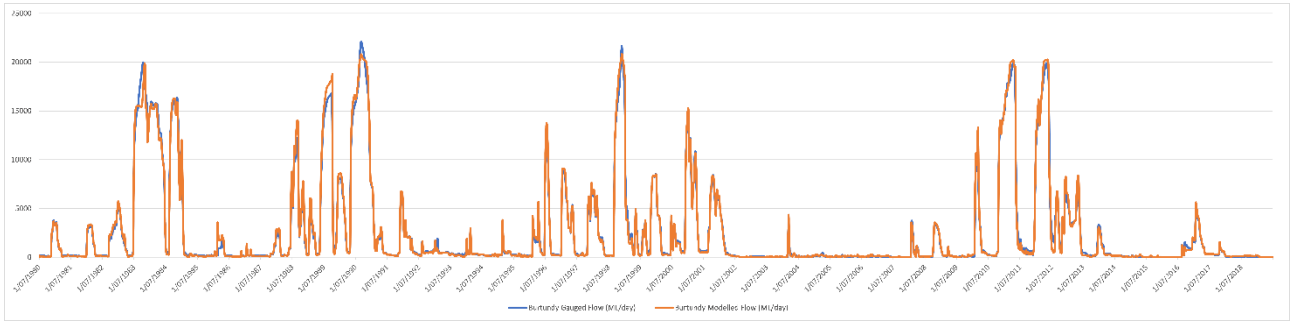

Figure E.1. Calibrated model output flow versus observed flow at Burtundy between 1983 to 2019

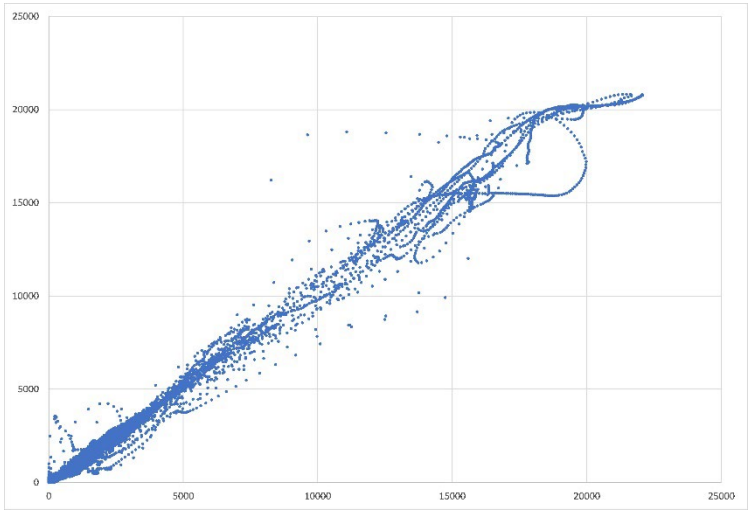

Figure E.2. Calibrated model output data versus observed data at Burtundy between 1983 to 2019

Loss analysis

The loss analysis was based on filtered data. The filter excluded all daily data where the average flow for the previous 30 days was below 1 megalitre (ML)/day (cease-to-flow conditions) and above 10,000 ML/day (flood conditions).

Using the filtered data and assuming 90 % dry conditions, monthly proportional losses were calculated (percent loss) for various flow bands. The results are presented in Table E.1. The number of data points available for the associated loss calculation is presented in Table E.2.

Proportional losses were calculated in this exercise. The highly regulated release regime in the Lower Darling and limited range of flow variation makes proportional losses preferable to an incremental loss arrangement. Using the 90th percentile risk profile is a conservative assumption designed to provide reassurance to other licence holders on their limited exposure to potential impacts.

Table E.1. Calculated 90th percentile proportional losses between Weir 32 to Burtundy[1] (%)

Flow Range	200-400	400-600	600-800	800-1000	1000-1200	1200-1400	1400-1600	1600-1800	1800-2000	2000-3000	3000-4000	4000-5000	5000-6000	6000-7000	7000-8000	8000-9000
Percentile	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Jul	23.9	12.4	9.9	7.9	6.8	5.9	5.3	4.95	4.6	4.2	3.5	3	3.3	3.6	4.4	5.6
Aug	29.8	15.7	12.1	13.5	10.3	7.2	6.7	5.8	5.3	4.6	4	3.7	3.3	4	5.05	6.1
Sep	38.4	19.8	16.2	12.3	10.3	9.2	8.1	7.3	6.8	6.1	4.7	4.1	4.2	4.5	5.2	6.2
Oct	41.6	23.9	17.1	14.2	12.4	10.5	9.8	8.8	8.1	6.8	5.4	4.9	5.1	5.3	5.6	6.6
Nov	51.1	27.2	20.6	15.8	13.1	11.7	10.4	9.4	8.8	**7.7**	**6**	**5.3**	**4.9**	**5.1**	**6.2**	**6.6**
Dec	55.9	30.2	22.1	17.9	14.9	12.8	11.4	10.6	9.6	**8.3**	**6.3**	**5.6**	**5.3**	**5.6**	**6.3**	**7.1**
Jan	49	30.1	21.5	17.2	14.5	13.1	11.4	10.8	9.3	**8.2**	**6.4**	**5.5**	**5.2**	**5.3**	**6.2**	**6.9**
Feb	43.3	27.9	20.5	16.1	13.9	11.9	10.9	9.6	9	7.6	6	5.1	4.6	5.2	5.8	6.6
Mar	35	24.8	18	14.5	11.9	10.3	9.3	8.3	7.8	6.9	5.3	4.6	4.2	4.4	5.5	6.6
Apr	28.1	18.7	12.9	10.6	9	8.1	7.6	7	6.3	5.5	4.5	3.9	3.6	4.45	5.3	6.9
May	27.1	12.8	11.2	8.2	7.2	6	4.8	4.6	4.6	4.7	3.5	3.3	3.4	4	4.7	7.6
Jun	21.9	11	9	7.2	6.3	5.6	5.1	4.7	4.3	3.9	3.1	4.4	4.3	5.4	5.1	5.9

[1] Values in bold blue text have been smoothed to remove data spikes.

Table E.2. Number of data points available for loss calculations

Flow Range	200-400	400-600	600-800	800-1000	1000-1200	1200-1400	1400-1600	1600-1800	1800-2000	2000-3000	3000-4000	4000-5000	5000-6000	6000-7000	7000-8000	8000-9000
Percentile	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Jul	49	453	12	17	7	11	19	9	12	89	85	108	65	47	49	29
Aug	111	447	16	19	19	18	19	19	19	70	79	59	31	19	22	38
Sep	118	308	16	10	8	9	11	8	12	68	75	77	53	47	51	85
Oct	50	447	20	23	26	22	29	21	29	106	105	60	44	49	46	96
Nov	1613	49	54	43	52	41	23	33	34	141	163	189	135	127	146	146
Dec	1300	47	34	26	38	36	30	25	27	157	156	195	168	189	239	282
Jan	1222	54	33	29	31	30	28	32	42	221	292	325	196	145	160	180
Feb	1345	92	49	49	48	54	56	59	63	287	201	142	48	45	30	67
Mar	2247	117	26	29	29	22	19	21	19	72	47	38	19	27	22	56
Apr	2741	97	7	8	9	8	8	9	9	36	26	28	17	20	26	29
May	354	142	6	7	7	10	5	5	7	46	49	57	30	32	32	23
Jun	150	279	12	11	12	9	11	11	12	58	52	46	16	18	22	45

The results in Table E.1 show the river increases in efficiency up to around 6,000 ML/day, after which losses begin to increase (box within table). This is likely due to water commencing to fill flood runners and flowing onto the floodplain.

Data availability is an ongoing challenge (see Table E.2) for this analysis; however the loss analysis generally shows smooth transitional behaviour between flow bands and the seasons, indicating that smoothing and curve fitting may be sufficient to mitigate issues arising from insufficient data.

Application

For flows less than 5,000 ML/day, the loss rate is selected and applied from Table E.1 based on the flow band and the month.

As an interim measure, it is proposed that for flows above 5,000 ML/day, the highest loss rate over the year for the corresponding flow band is applied as the single loss number. This means there is no seasonal variation applied for flows above 5,000 ML/day.

Three examples on how to use Table E.1 are provided below.

Example 1

A HEW delivery of 1,100 ML/day from Weir 32, contributing to a total flow at Weir 32 of 1,200 ML/day, is planned to be conducted in October. Using Table E.1, the associated transmission for the HEW delivery loss is 12.4%, which equates to 136.4 ML/day. The volume of return flow to be recognised at Burtundy, adjusted for travel time is 963.6 ML/day.

Example 2

A HEW delivery of 4,200 ML/day is planned to be conducted in February. Using Table E.1, the associated transmission loss is 5.1%, which equates to 214.2 ML/day at Burtundy.

Example 3

A HEW delivery of 6,200 ML/day is planned to be conducted in August. According to the recommended loss rate for flows greater than 5,000 ML/day mentioned above, and looking at Table E.1, the maximum (non-seasonal) transmission loss is 5.6%, which equates to 347.2 ML/day at Burtundy.

Updated loss analysis (>9,000 ML/day)

Subsequent to the approved loss procedure being implemented in 2021/22, flows in the Lower Darling exceeded the range covered by Table E.1. Therefore, the method has been updated to account for flow bands above 9,000 ML/day (Table E.3).

Flows exceeding 9,000 ML/day result in significant channel outbreaks which increases losses. It is difficult to determine the seasonally varying nature of these losses due to limited data. Therefore, an approach similar to loss rates applicable for 5,000 ML/day to 9,000 ML/day is used.

The loss rate applicable for flow ranges 9,000 ML/day to 19,000 ML/day is taken as the 90th percentile loss rate, based on daily loss data, over November to February. The loss rates are discretised based on flows, incrementing by 1,000 ML/day.

Table E.3. Loss rates for flows 9,000 – 19,000 ML/day

Flow (ML/day)	9,000-10,000	10,000-11,000	11,000-12,000	12,000-13,000	13,000-14,000	14,000-15,000	15,000-16,000	16,000-17,000	17,000-18,000	18,000-19,000
Loss (%)	15 %	15 %	14 %	12 %	11 %	12 %	10 %	11 %	11 %	10 %

Incremental losses to be applied in the River Murray

Incremental losses are then to be applied to the volume of return flows at Burtundy, to account for losses in the River Murray to the South Australian border (Appendix D).

No additional loss value is applied if the River Murray is in unregulated conditions.

Appendix F Return flow recognition for held environmental water releases down the Great Darling Anabranch

The accounting arrangement described below was agreed out-of-session (via email) by the NSW PPM Working Group in May 2022.

A draft arrangement was first presented at the PPM Working Group Meeting on 31 March 2022.

Background

Under PPMs, water for the environment released from Lake Cawndilla down the Great Darling Anabranch (the Anabranch) from Lake Cawndilla can recognised in the River Murray through to the South Australian border. This accounting arrangement is an interim measure under PPMs and will be subject to review and evaluation.

There is limited time (three to four days) for determining the volume of return flows from the Anabranch, before this parcel of water passes Lake Victoria and reaches the South Australian border. A clear and agreed accounting approach is required for timely recognition for river operators.

Debiting of directed releases

When environmental orders are being released from Lake Cawndilla, the volume released from the Lake Cawndilla outlet to meet the order will be the amount debited.

When environmental orders are being released from Lake Cawndilla with operational water, the amount debited will be the volume released to meet the environmental order only.

Return flow accounting

In-channel losses between Lake Cawndilla and the end of Anabranch are uncertain. Until further data is available, when environmental water orders only are being released down the Anabranch the assumed return flow should be determined as:

i. after adjusting for travel time, when the daily average flow passing the Tara Downs gauge (425054) is equal to or exceeds releases, no losses are to be applied and the full volume of the environmental debit is recognised at the South Australian border,

ii. after adjusting for travel time, when the daily average flow passing Tara Downs is less than releases, the flow at Tara Downs is reduced by a loss value and recognised at the South Australian border. The loss value applied is equivalent to the proportional daily loss that occurred between the Bulpunga gauge (425011) and Tara Downs

iii. after adjusting for travel time, when flows at Tara Downs reach 0 ML/day, no return flows are to be recognised.

When environmental water orders are being released down the Anabranch with operational or surplus water, the assumed return flow should be determined as above, and reduced by the proportion of the total flow that is environmental water (assumed to be the proportion of the total release from Lake Cawndilla that is environmental water).

Risks and mitigation measures

The following risks apply to these interim accounting measures:

- where possible, the Tara Downs gauge should be calibrated during periods when there is water flowing down the Anabranch
- the Tara Downs gauge can be backwater affected. Periods of backwater are established onsite, and water level data is used to determine when the rating can be used (or not). Backwater was last observed at Tara Downs in November 2016 to April 2017. Corresponding flows at Lock 10 at Wentworth (425010) were upwards of 70,000 ML/d. In the event the Tara Downs gauge is affected by backwater, a suitable loss value shall be applied to the daily average flow passing Bulpunga gauge (425011) to determine return flow volumes of environmental water
- the interim approach assumes that environmental water delivery in the Anabranch remains in-channel. The natural commence to flow level of lakes along the Anabranch is around 500 ML/day[2]. Opportunistic cropping of the lakes along the Anabranch is known to occur. The opening or removal of any block banks will affect the losses and return flow volumes. The environmental water holders with work the Anabranch Private Irrigation District and landholders (including National Parks and Wildlife Service) to notify them when environmental water is being released down the Anabranch.

Consultation on this approach with the department's Victorian counterparts and MDBA river operators is required.

Review and evaluation

This approach for accounting for return flows from the Anabranch is an interim arrangement and will reviewed and evaluated, including:

- investigate the use of a loss lookup table similar to that used for determining return flows in the Lower Darling. The use of a loss lookup table would provide consistency in how losses are applied in both the Darling River and the Anabranch. It would also allow the calculation of return flows when there is mix of operational water and environmental water delivery. There may be data limitations to progressing this work
- a review of the losses along the Anabranch should be completed at the end of the proposed watering event to inform or improve this interim approach.

[2] THE LIVING MURRAY Information Paper No. 10