2021-22 Water for the Environment Annual Plan

For the South Australian River Murray

Government of South Australia

Department for Environment and Water

Acknowledgement of the Traditional Owners

The Department for Environment and Water acknowledges Traditional Owners of Country throughout Australia and recognises the continuing connection to lands, waters and communities. We pay our respect to Aboriginal and Torres Strait Islander cultures and to Elders both past and present.

The First Nations of South Australia, the Aboriginal Traditional Owners, have occupied, enjoyed and managed their customary lands and waters since time immemorial and continue their deep cultural, social, environmental, spiritual and economic connection today. The Government of South Australia acknowledges and pays respect to the Traditional Owners and their Nations. The South Australian government also acknowledges and respects the rights, interests and obligations of Traditional Owners to speak and care for their Country – lands and waters – in accordance with their laws, customs, beliefs and traditions. In acknowledging this history and connection we also recognise the deep and irreversible damage and dislocation that Aboriginal and Torres Strait Islander people have experienced and continue to experience through European colonisation, settlement and displacement. Aboriginal Nations have advocated strongly for a healthier Murray–Darling Basin and just settlement of their land and water rights. This commitment led to a stronger Basin Plan for South Australians and asks us as a State Government to better recognise Traditional Owner interests in our water resource management. The Department for Environment and Water seeks to enable partnerships with Aboriginal Nations built upon mutual respect and trust. We recognise the differences between Nations and their preferred approaches for engagement with Government and will work through these arrangements to support Traditional Owners to meet their customary rights and obligations in natural resource planning and implementation.

Foreword

The *2021-22 Annual Water for the Environment Plan for the South Australian River Murray* (the Annual Plan) is a key element in South Australia's river management framework. It builds on actions undertaken and outcomes achieved in previous years and is guided by the current ecological conditions in the River Murray and the ecological objectives and targets in the *Long Term Environmental Watering Plan for the South Australian River Murray* (2020).

The Annual Plan is prepared as part of the Basin Plan environmental water management framework, which determines how available environmental water will be used in the Murray-Darling Basin. A wide range of stakeholders have been engaged in its development, supporting a transparent process to determine environmental watering priorities.

Each year the water resource outlook is different, volumes of available environmental water change and environmental watering priorities vary. This presents a challenge to water holders and managers to maximise outcomes from the available resources. It is well understood that conditions can change rapidly; therefore the plan presents the priority needs under a wide range of scenarios.

I would like to thank all those who have been involved in the planning, management and delivery of water for the environment and look forward to another successful watering year in 2021-22.

Ben Bruce, Executive Director, Water and River Murray
Department for Environment and Water
May, 2021

Ferny cotula (*Cotula bipinnata*) on Chowilla Floodplain. Credit: DEW.

Cover image: Pied stilt (*Himantopus leucocephalus*) at Tolderol Game Reserve. Credit: Casey O'Brien, Murraylands and Riverland Landscape Board.

Acknowledgements

In addition to DEW staff, input from representatives and employees of the following organisations has been gratefully received:

- Banrock Station, Accolade Wines
- Chowilla Community Reference Committee
- Commonwealth Environmental Water Office
- Coorong, Lower Lakes and Murray Mouth Community Advisory Panel
- First Peoples of the River Murray and Mallee Region
- Katarapko Community Advisory Panel
- Local Action Planning groups and Landcare groups
- Murray-Darling Basin Authority
- Murraylands and Riverland Landscape Board
- Nature Foundation
- Ngarrindjeri Aboriginal Corporation
- Mannum Aboriginal Community Association Incorporated
- Pike Community Reference Group
- Renmark Irrigation Trust
- SA Water
- Scientific Advisory Group for the Lower Lakes, Coorong and Murray Mouth
- South Australian Research and Development Institute
- The University of Adelaide
- Flinders University
- Other South Australian government departments through interagency reference groups

Fish sampling at Shadows West wetland, LLCMM. Credit: Casey O'Brien, Murraylands and Riverland Landscape Board.

Glossary

Selected Terms and Acronyms

Name of unit	Symbol
AHD	Australian Height Datum
AOO	annual operating outlook
Barrage	specifically any of the five low weirs at the mouth of the River Murray constructed to exclude seawater from the Lower Lakes
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
d	day
DEW	Department for Environment and Water, previously Department of Environment, Water and Natural Resources (DEWNR)
Diadromous	fish that spend part of their lifecycle in both seawater and freshwater
Entitlement flow	minimum monthly River Murray flow to South Australia agreed in the Murray-Darling Basin Agreement, 1992
EWRs	environmental water requirements
Fishway	a generic term describing all structures designed to allow the passage of fish along a waterway
FPRMMR	First Peoples of the River Murray and Mallee Region
GL	gigalitre
ha	hectare
HEW	held environmental water
IO	Integrated Operations
IOS	Integrated Operations Strategy
LLCMM	Lower Lakes, Coorong and Murray Mouth
LTWP	Long Term Environmental Watering Plan for the South Australian River Murray Water Resource Plan Area (Department for Environment and Water, 2020)
m	metre
MACAI	Mannum Aboriginal Community Association Incorporated
MDBA	Murray-Darling Basin Authority
ML	megalitre
NAC	Ngarrindjeri Aboriginal Corporation
PEA	priority environmental asset
PEW	planned environmental water
QSA	river flow to South Australia, as measured at the State border
RMIF	River Murray increased flows
RMUF	River Murray unregulated flows
Return flow	environmental water used upstream which is returned to the river and is available for reuse downstream
SA	South Australia
SARDI	South Australian Research and Development Institute
SCBEWC	Southern -connected Basin Environmental Watering Committee
TLM	The Living Murray (MDBA program)
WAP	Water Allocation Plan
Water year	the period between 1 July in any given calendar year and 30 June the following calendar year
WRP	Water Resource Plan
YOY	young of year

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Summary

This document presents South Australia's priorities for environmental water delivery along the South Australian (SA) River Murray for the 2021-22 water year. It describes the water delivery requirements to best achieve a range of environmental outcomes along the SA stretch of the river channel, its floodplains and wetlands, through to the Coorong and Murray Mouth, consistent with the requirements under the Murray-Darling Basin Plan. In doing so, it identifies opportunities to maximise outcomes from watering in South Australia by using return flows from upstream watering actions. It also promotes delivery of water for the environment to the Lower Lakes, Coorong and Murray Mouth (LLCMM), while providing benefits to upstream environmental assets and functions en-route.

The *Annual Environmental Watering Plan* ("Annual Plan") is presented as follows:

- **Section 1: Introduction** provides background information relevant to environmental watering, including recent hydrological conditions in the region.
- **Section 2: Annual Planning Process** summarises how environmental managers identified objectives for environmental watering in South Australia, engaged with external stakeholders and Traditional Owners and identified and assessed any potential risks.
- **Section 3: Annual Priorities** presents the annual environmental watering priorities for the South Australian River Murray Water Resource Plan (WRP) area, which are submitted to the Muuray-Darling Basin Authority (MDBA) in accordance with Basin Plan requirements. It describes the preferred combination of all, or the SA River Murray multi-site proposal (SA multi-site) watering action, for the use of environmental water within the SA River Murray region.
- **Section 4: Environmental Water Management** outlines the next steps in undertaking delivery of water for the environment.

Juvenile emus (*Dromaius novaehollandiae*) at Pike Floodplain. Credit: Annie Kriesl, Murraylands and Riverland Landscape Board.

1. Introduction

1.1 Purpose of this Plan

The Annual Plan guides the delivery of water for the environment in the SA River Murray and has been developed in consultation with key stakeholders. The Annual Plan presents the priorities for delivery and use of water for the environment under a range of water availability scenarios. This information is submitted to the MDBA and the Commonwealth Environmental Water Holder (CEWH) to inform whole of basin water delivery planning and fulfils SA's Basin Plan requirements to develop annual watering priorities.

The Annual Plan is a part of SA's environmental water management framework which includes the development of the Annual Plan, the annual SA River Murray water for the environment report, the *Long Term Environmental Watering Plan for the South Australian River Murray Water Resource Plan Area* (*LTWP*) (Department for Environment and Water, 2020) and active management of environmental water delivered to SA. The Annual Plan integrates all of the proposed watering activities for the water year ahead and has been developed based on the best available data and science. However, it is recognised that water availability and delivery is subject to change depending on actual river and climatic conditions, which will necessitate real-time and adaptive water use.

The Annual Plan presents the water demands for the three Priority Environmental Assets (PEAs): the Lower Lakes, Coorong and Murray Mouth (LLCMM), the River Murray Channel and the River Murray Floodplain as described in the *LTWP*. The Annual Plan identifies the preferred volume and timing of flow to SA, as well as the optimal use of infrastructure such as regulators, weirs and pumps to facilitate water delivery.

The 2021-22 environmental watering priorities identified in the Annual Plan are consistent with the environmental watering requirements (EWRs) described in the *SA River Murray LTWP* and with the *Basin-Wide Environmental Watering Strategy* (Murray-Darling Basin Authority, 2019).

What is Environmental Watering?

Environmental watering is the delivery or use of water to achieve environmental outcomes, providing ecological benefits that contribute to a healthy, functioning river. Water for the environment ensures that important values of the SA River Murray, its wetlands, floodplains and estuary are maintained and that environmental objectives are achieved.

Water for the environment delivered along the River Murray in SA is coordinated by the Department for Environment and Water, with significant input from other government agencies, non-government organisations, scientific bodies and community stakeholders.

Water for the environment at Pipeclay Billabong. Credit: Darren Willis, Murraylands and Riverland Landscape Board.

1.2 The 2020-21 Water Year

91 days of unregulated flows

Over 40 temporary wetlands and floodplain areas inundated

First operations of **Pike** and **Katarapko** floodplain regulators

1 coordinated Southern Spring Flow through the channel

A brief summary of the 2020-21 water year to date (as of 31 March 2021) is outlined below, providing context for the conditions leading up to the 2021-22 water year. More information from earlier years can be found on the Department for Environment and Water's (DEW) website. More information on the outcomes of the environmental watering actions in 2020-21 will be presented in the annual environmental watering report that will be produced in late 2021.

South Australia received unregulated flows between 27 June – 25 September 2020, with SA Entitlement flow and water for the environment making up the flow to SA outside of this period. Flow to SA peaked at around 17,900 megalitres per day (ML/d) in November 2020 (Figure 1).

Water for the environment delivered to SA was used to support numerous watering actions throughout the year, including:

- first operations of the Pike and Katarapko floodplain regulators in conjunction with the raising of Weir 4 and Weir 5 in spring and early summer
- inundating over 40 temporary wetland and floodplain sites (including sites managed by DEW, Murraylands and Riverland Landscape Board, Australian Landscape Trust, Accolade Wines, Renmark Irrigation Trust and Nature Foundation) via pumping or irrigation
- delivering the Southern Spring Flow 2020, which was a coordinated in-channel flow pulse
- wetting and drying of 52 pool-connected wetlands
- managing the LLCMM throughout the water year, including manipulating water levels in the Lower Lakes and maintaining barrage and fishway releases to the Coorong.

Ecological Monitoring

Monitoring of key ecological outcomes from water for the environment actions across the SA River Murray included:

- spring productivity sampling along the SA River Murray channel and Pike and Katarapko Floodplains
- monitoring of aquatic and understorey vegetation, frogs, fish and waterbirds at various sites along the SA River Murray and LLCMM
- salt wedge, black bream and migratory fish monitoring, including lamprey, congolli and common galaxias at the LLCMM.

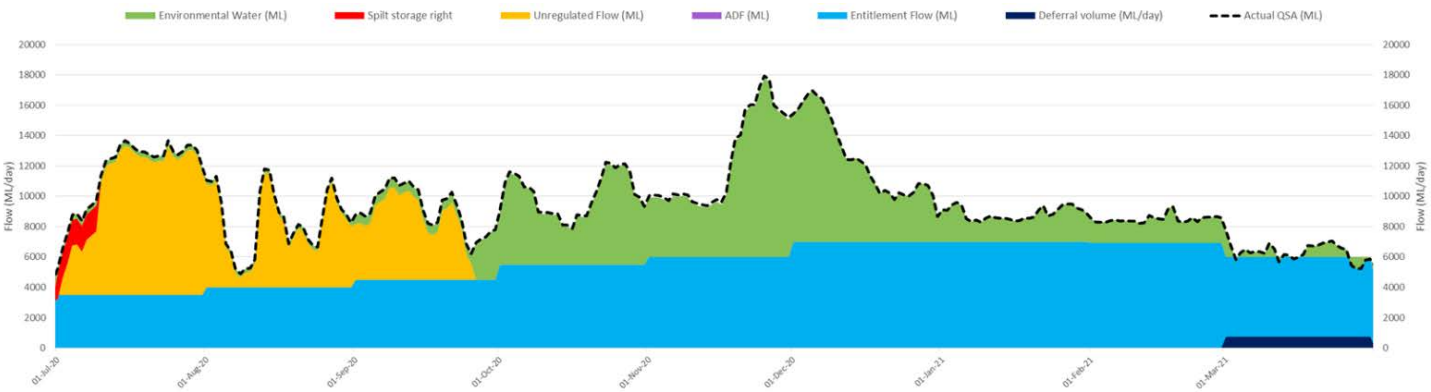


Figure 1. River Murray flows at the South Australian border 1st July 2020 to 31st March 2021.

2. Annual Planning Process

South Australia commences annual planning each February, guided by previous watering actions and uses a scenario-based approach based on Annual Operating Outlooks (AOO) provided by the MDBA and projected water for the environment allocations and availability. The SA planning process includes the development of site based annual environmental watering proposals and a SA multi-site proposal describing the preferences for coordinated delivery of water for the environment for all sites.

These proposals are prepared by site managers and consolidated into this overarching Annual Plan document. Watering proposals developed for sites in the SA River Murray region in 2021-22 and their proponents are listed in Table 1. DEW leads the annual planning and prioritisation process with input from site and water managers, Traditional Owners and stakeholder groups.

The proposed watering actions include: whole of Channel delivery, management of the LLCMM, management of large scale floodplain infrastructure and River Murray weirs, as well as delivery of water to wetlands. Managed wetting and drying of pool-connected wetlands and pumping to temporary wetlands will be undertaken by DEW, the Murraylands and Riverland Landscape Board, Nature Foundation, Renmark Irrigation Trust, Accolade Wines and the Australian Landscape Trust.

Water for the environment proposals are provided to the Southern-Connected Basin Environmental Watering Committee (SCBEWC) as part of the annual planning process. SCBEWC is coordinated by the MDBA and brings together agencies from the Commonwealth, New South Wales, Victorian and South Australian governments to coordinate and manage water for the environment across the southern-connected Basin within the Murray-Darling Basin. SCBEWC ensures environmental water management is consistent with the Environmental Watering Plan (Chapter 8 of the Basin Plan), including the *Basin-wide Environmental Watering Strategy* (Murray-Darling Basin Authority, 2019) and facilitates collective water for the environment planning for the major water holders. This approach supports effective coordination while allowing different environmental water holders to make independent decisions on watering actions.

Table 1. Environmental watering proposals submitted to the Murray Darling Basin Authority and/or the Commonwealth Environmental Water Office for 2021-22.

Watering Proposal	Proponent
Lower Lakes, Coorong and Murray Mouth	SA Department for Environment and Water
SA River Murray Channel and Floodplain	SA Department for Environment and Water
Chowilla, Pike and Katarapko Floodplains	SA Department for Environment and Water
Weir Manipulation	SA Department for Environment and Water
Various wetlands along the River Murray and Lower Lakes	Murraylands and Riverland Landscape Board
Wetlands in the Renmark area	Renmark Irrigation Trust
Banrock Station wetlands	Accolade Wines
Calperum Station lakes and wetlands	Australian Landscape Trust
Various wetlands along the River Murray and Lower Lakes	Nature Foundation

2.1 Planning Inputs

2.1.1 Planning Scenarios

A scenario-based approach was used to develop proposed watering actions for the 2021-22 water year. Six resource availability scenarios were identified based on the MDBA AOOs 'without e-water' model runs provided in March 2021. The scenarios used were: 99 per cent (extreme dry), 90 per cent (dry), 75 per cent (moderate), 50 per cent (near average), 25 per cent (wet) and 10 per cent (very wet) (Figure 3). These percentages refer to the likelihood of exceeding different water availability conditions based on the analysis of historical inflows, current storage volumes and operational considerations for the upcoming water year. A volume of held environmental water (HEW) potentially available for delivery to SA in 2021-22 under each of the resource availability scenarios was assumed for planning purposes (Table 3). For each scenario and each site/asset, objectives are defined and optimal water delivery determined (i.e. added to hydrographs) to achieve those objectives, taking into account estimated environmental water availability.

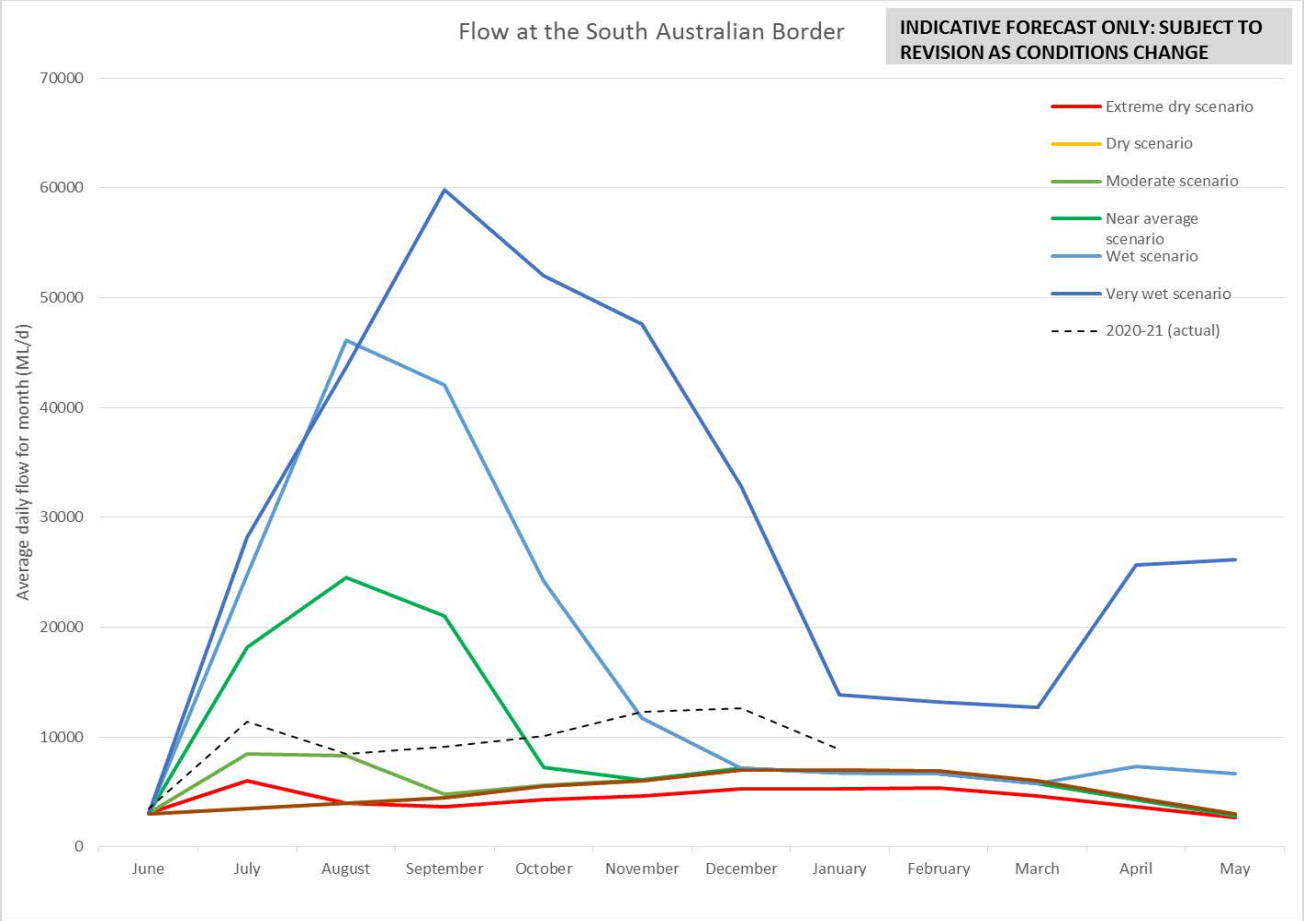


Figure 2. Annual operating outlooks (AOOs) provided by the Murray-Darling Basin Authority in March 2021.

2.1.2 Water for the Environment Availability

Held Environmental Water

The priorities were developed prior to water allocation announcements being made. For the purposes of planning and prioritisation, potential HEW availability was estimated under each resource availability scenario, based on environmental water delivery in recent years and advice from water holders (Table 2).

Potential HEW availability is taken into account during planning so that the proposed actions and associated outcomes consider the feasibility of delivery.

Table 2. Estimate of held environmental water available from Victorian and NSW held Commonwealth Environmental Water and The Living Murray water in 2021-22 under each resource availability scenario (Early April, 2021). 60 – 70% assumed flow to SA border.

Scenario	Estimate of HEW available		
	Total upstream of SA border	60% of total	70% of total
Extreme dry (99%)	887	532	621
Dry (90%)	1046	628	732
Moderate (75%)	1172	703	820
Near average (50%)	1614	968	1130
Wet (25%)	1832	1099	1282
Very wet (10%)	2116	1270	1481

HEW is available from the following sources: the CEWH, The Living Murray (TLM), the South Australian Minister for Environment and Water and non-government organisations. More information regarding HEW and its sources can be found in the *LTWP* (Department for Environment and Water, 2020) or on the DEW website. HEW is used in accordance with the *Water Allocation Plan for the River Murray Prescribed Watercourse* (*WAP*) (SA Murray-Darling Basin Natural Resources Management Board, 2019).

Planned Environmental Water Availability

Planned environmental water (PEW) is defined under the *South Australian River Murray Water Resource Plan* (*WRP*) (Department for Environment and Water, 2019a) as any water that is committed or preserved for achieving environmental purposes or outcomes and that cannot be used for any other purpose unless required in emergency (in accordance with Section 6 of the Water Act). PEW is also identified in the *WAP* (SA Murray-Darling Basin Natural Resources Management Board, 2019) and includes the unallocated portion of annual SA Entitlement flow, unregulated flows to SA and the dilution and loss component of SA's Entitlement flow.

Tauwitchere Barrage. Credit: DEW.

2.2 SA River Murray Environmental Water Planning

2.2.1 Site-based Planning

A suite of environmental watering activities occur at a range of sites within the SA River Murray, including small scale individual wetlands, large scale floodplains, lock reaches and the River Murray channel scale.

The types of watering events that can occur at these sites include:

- the operation of regulators within floodplain anabranches, e.g. Chowilla, Pike and Katarapko floodplains
- weir pool manipulations, including raising and some lowering
- river channel and floodplain watering via augmentation of unregulated flows or creation of in-channel flow events (e.g. spring pulses)
- pumping and water delivery via infrastructure into temporary wetlands
- wetting and drying of managed pool connected wetlands
- LLCMM management, including lake level variations, lake cycling, fishway operations and barrage releases.

The development of site-based watering proposals has been undertaken by the respective site water managers. The watering proposal template (provided by the MDBA) was used for each site to outline the preferred watering options (including management actions and ecological objectives) for each of the AOO scenarios. The information used to develop the watering proposals includes site condition data, past watering history and outcomes, site operating or management plans, consideration of risk assessments and capacity to monitor and mitigate risks, modelling outputs and input from Traditional Owners and the community. The outcomes and evaluation of previous years' monitoring projects and the lessons learnt, from past water delivery and operations are also incorporated into the decision making process for site proposals.

Water held within the Wetlands Consumptive Pool (Class 9), as described in the *WAP* (SA Murray-Darling Basin Natural Resources Management Board, 2019), is allocated across managed pool connected wetlands within the SA River Murray WRP area. Watering proposals for these wetlands are prepared by site managers, including the Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust and Nature Foundation.

Specific advice and input into water for the environment planning at sites is sought from the Traditional Owners in a variety of ways throughout the year including through the process of watering proposal development,

During the proposal development phase, site managers also seek advice and input from various stakeholders, including but not limited to scientific experts, water holders, non-government delivery partners, landholders and community groups.

Long-thumbed frog (*Limnodynastes fletcheri*) at Wellington East. Credit: Casey O'Brien, Murraylands and Riverland Landscape Board

2.2.2 SA River Murray Multi-site Planning

DEW has developed a SA multi-site watering proposal for 2021-22, outlining the optimal delivery of water for the environment within the SA River Murray system. The SA multi-site proposal seeks to align the site-specific watering actions that have been identified in this document, minimise risks, maximise the effectiveness of environmental water delivery and enhance ecological outcomes throughout the system. The SA multi-site approach is supported by SA policy which prevents return flows from environmental watering actions, such as the operation of the Chowilla regulator and weir raisings, from being re-allocated for consumptive use, ensuring this water remains within the River Murray channel for delivery to other downstream environmental watering sites or the LLCMM for ecological benefit.

The SA multi-site proposal identifies:

- Objectives for the SA multi-site watering action
- Assumptions used in developing the SA multi-site
- Environmental watering actions relating to each scenario and the additional benefits associated with the SA multi-site
- Proposed environmental water volume and optimal delivery pattern for the SA multi-site under different scenarios.

Consultation with individual site managers, external scientific experts and other key stakeholders was undertaken in the development of the SA multi-site. The development of the SA multi-site was also supported by integrated operations modelling and risk assessments.

2.2.3 Integrated Operations

Integrated Operations (IO) is a term used to describe the coordination of water delivery to SA with large scale environmental watering involving infrastructure operation, to manage the potential risks of adverse impacts and, where possible, achieve cumulative benefits across the SA River Murray. A number of tools have been developed to assist with this coordination, including the *Integrated Operations Strategy* (*IOS*) (in prep) and the *South Australian River Murray Environmental Water Source Model* (the *Source Model*).

The *IOS* has been developed to support the decision-making complexity associated with an increasing number of large scale watering opportunities. It documents ecological and hydrological thresholds, in particular levels of concern for flow and water quality parameters, that may arise through the combination of multiple watering events and river flows (integrated operations) occurring during the same year. The *Source Model* is a hydrological modelling platform that forecasts the impact on hydrodynamic and water quality parameters resulting from environmental watering actions.

Burr daisy (*Calotis cunefolia*) at Lake Limbra. Credit: DEW.

During annual planning, the individual site based watering proposals and river flows for each of the AOO's are combined and Source modelling is undertaken to forecast the response of surface water parameters to the combined suite of site proposals. The modelling results are then assessed against the thresholds outlined in the *IOS*, to identify the potential risks of the combined operations. Where modelling indicates that thresholds are not exceeded, the combined suite of watering proposals may be incorporated into the SA annual environmental watering priorities and plan. Where modelling indicates that thresholds are expected to be exceeded and these risks are identified as unacceptable, watering operations and proposals may need to be revised. In some water resource scenarios, not all site watering events may be able to be undertaken due to these risks.

The *IOS* and *Source Model* were used in the development of the annual priorities within this Annual Plan and as part of the development of the SA multi-site proposal.

2.3 Community Engagement

A wide range of stakeholders including a number of community groups are consulted regarding the environmental watering actions proposed for 2021-22. Consultation is undertaken by site managers through long-standing and ongoing arrangements. The stakeholders consulted during development of the proposals include the Coorong, Lower Lakes and Murray Mouth Community Advisory Panel (which includes representatives from the Ngarrindjeri Aboriginal Corporation (NAC), Coorong commercial fishery, irrigators, Landcare organisations, local government, boating organisations, shack owners association and landholders), Coorong, Lower Lakes and Murray Mouth Scientific Advisory Group, Chowilla Community Reference Committee, Katarapko Community Advisory Panel (which include representatives from irrigation trusts, Local Action Planning associations, Landcare organisations and local government), representatives from the Pike Land Management Group and other Pike floodplain landholders, the Murraylands and Riverland Landscape Board, private landholders, industry groups and the general public. During stakeholder meetings, annual priorities and associated modelling is presented and discussed, with site tours undertaken when possible.

Engagement between DEW and non-government organisations that deliver environmental water to wetlands also occurs to help coordinate wetland management activities across the region. These organisations include the Australian Landscape Board, Nature Foundation, Renmark Irrigation Trust and Accolade Wines.

Chowilla Community Reference Committee members and DEW staff during site visit. Credit: DEW.

2.4 First Nations Engagement

Indigenous engagement is undertaken by environmental water managers throughout the year including when developing watering proposals and during the development of the Annual Plan. This includes engagement with the NAC on watering objectives and actions proposed for the LLCMM and the River Murray Channel and Floodplain and with the First Peoples of the River Murray and Mallee Region (FPRMMR) on the actions proposed for the Chowilla, Pike and Katarapko Floodplains, the River Murray Channel and Floodplain, wetland pumping and weir manipulation watering actions.

Funding from The Living Murray program supports two dedicated First Nations staff to assist with engagement between DEW, FPRMMR and NAC. Where possible and appropriate, engagement with First Nations groups is undertaken in collaboration with Commonwealth Environmental Water Office and/or MDBA staff to ensure both site-based and system-scale planning and priorities are discussed.

The NAC is engaged in the delivery of water for the environment on an ongoing basis throughout the water year, including on-country tours to discuss barrage operations, lake level management and water for the environment; regular meetings with the NAC board/NAC staff; participation from the Yarluwar-Ruwe coordinator (NAC) in LLCMM planning workshops; and reviewing and providing cultural input to the LLCMM and River Murray Channel SCBEWC water for the environment proposals. In 2020-21, a dedicated 'learning circles' project was delivered by NAC and DEW which aimed to understand and document Ngarrindjeri cultural values and priorities and to assist in decision-making for the planning and delivery of water for the environment to Ngarrindjeri Ruwe (Country). Outcomes and Ngarrindjeri priorities for water delivery from this project will be incorporated into 2022-23 water for the environment planning.

NAC learning circles workshop, Tailem Bend, March 2021. Credit: DEW.

The FPRMMR is engaged throughout the year on the planning and delivery of water for the environment. This engagement includes discussions and presentations at First Peoples Working Group (FPWG) meetings, sharing of information and time spent on Country. Aboriginal Waterways Assessments (AWAs) are a tool used by Traditional Owners to assess the cultural values of wetlands and other important sites to support water for the environment and wetland management planning. The FPRMMR has refined the AWA process and have undertaken assessments at 23 floodplain and wetland sites with some sites also revisited over the past year. AWAs enable the sharing of knowledge between First Peoples and environmental water managers about environmental watering actions and the management of sites to meet cultural and environmental outcomes. Members of the FPRMMR and FPWG have also been engaged through workshops with the environmental water managers which aim to further develop understanding of river management and help develop materials which can be used to share knowledge. Through these workshops the FPRMMR is working with DEW to compile existing knowledge and understanding of the River Murray which will be shared among community and inform improved ecological outcomes based upon Traditional knowledge.

Aboriginal Waterway Assessment on the Chowilla Floodplain. Credit: DEW.

3. Annual Priorities for 2021-22

South Australia has developed discrete site-specific watering proposals for a number of locations throughout the SA River Murray system in the 2021-22 water year. A summary of site-based actions are presented below. Appendix A provides detailed information regarding the proposed actions under each water resource availability scenario.

3.1 Site-based Watering Actions

3.1.1 Lower Lakes, Coorong and Murray Mouth Icon Site

Lakes Alexandrina and Albert

Water for the environment will be used to help seasonally alter water levels in the weir pool below Lock 1 within the range +0.55 to +0.85 m Australian Height Datum (AHD) during 2021-22.

For dry to moderate water availability scenarios, water levels in the Lower Lakes during spring and early summer will be managed to around +0.75 to +0.80 m AHD. In autumn, a minimum of +0.55 m AHD will be targeted. This water level regime should prevent extended drying of critical wetland habitat in the Lower Lakes that supports threatened fish and frogs, including southern pygmy perch, listed under state legislation and southern bell frog, listed under the *Environment Protection and Biodiversity Conservation Act, 1999 (Commonwealth)*.

For near average, wet and very wet water availability scenarios, water levels in the Lower Lakes during spring and early summer will be managed to around +0.8 to +0.85 m AHD. In autumn, a minimum of ≥ +0.60 m AHD will be targeted. This water level regime should enhance submerged and emergent aquatic vegetation growth and promote recruitment of threatened fish and frogs. An early summer surcharge in water levels below Lock 1 also allows barrage releases to continue into late summer, providing benefits to the Coorong food web.

Environmental water delivery and barrage operations will aim to maintain lake levels above the Basin Plan target of +0.4 m AHD at all times.

Ngarrindjeri Aboriginal Corporation staff undertaking threatened fish sampling on Mundoo Island, March 2021. Credit: Scotte Wedderburn, University of Adelaide

Barrage Operations, Murray Mouth estuary and the Coorong

Environmental water is required to maintain continuous flow at all 11 fishways on the lower Murray barrages, providing year-round connectivity between the Lower Lakes and the Coorong estuary. Continuous fishway flow at all fishways is expected to be achieved under all water availability scenarios. When conditions allow, additional barrage flows will be prioritised adjacent to fishways, to facilitate migration for native fish.

For the dry water availability scenario, a small winter pulse is requested to facilitate upstream lamprey migration and downstream congolli migration. In previous years, late autumn/winter 'freshes' from the Goulburn River have aligned with winter flow requirements in the LLCMM. For moderate to very wet scenarios, unregulated flows will meet the winter volumes needed to support native fish migration in the LLCMM.

Oral disc of pouched lamprey caught at Goolwa barrage (left) and Goolwa barrage fishway (right). Credit: DEW.

For dry, moderate and near-average scenarios, black bream recruitment will be targeted from November to February, with releases managed at Goolwa (and Tauwitchere if sufficient water is available) to create suitable salinity stratification.

For all water availability scenarios, the majority of flows are required at the SA border from September to December 2021 to support barrage releases during this period and into summer. The timing of this action aligns to upstream migration of young-of-year congolli and common galaxias and the delivery of freshwater to the Coorong for salinity outcomes and the provision of freshwater-derived zooplankton and phytoplankton, which are important components of the estuarine food-chain.

A range of outcomes can be achieved in the Coorong and Murray Mouth estuary depending on the magnitude of barrage flows. Under a dry water resources scenario, barrage flows in spring and early summer in addition to the fishways-only flows are required to support the Coorong food web in parts of the North Lagoon.

Shorebirds, Coorong North Lagoon. Credit: Sabine Dittmann, Flinders University.

During a moderate to near average scenario, moderate barrage flows can provide a greater area of influence into the majority of the Coorong North Lagoon. Flows of this magnitude can also create suitable habitat throughout the entire North Lagoon to support adult estuarine fish, as well as suitable feeding habitat for waterbirds, particularly migratory waders.

High flow years (i.e. wet and very wet scenarios) can provide an even greater area of influence, extending to the Coorong South Lagoon. If high barrage flows occur between October and January, extending the duration of an unregulated flow event is a priority so that water levels in the Coorong South Lagoon may be maintained long enough for the aquatic macrophyte *Ruppia tuberosa* to flower and set seed. High flows are also correlated to positive recruitment events for small-mouth hardyhead, an important food source in the Coorong for large-bodied fish and waterbirds.

3.1.2 SA River Murray Channel and Floodplain

In 2021-22, water for the environment will be delivered along the entire length of the SA River Murray channel and floodplain to subsequently arrive in the LLCMM. The proposed water for the environment delivery patterns aim to enhance flow conditions to meet the environmental water requirements (EWRs) identified in the *SA River Murray LTWP* (Department for Environment and Water, 2020).

A priority outlined for the SA River Murray channel is working with upstream states, the MDBA and the CEWH on coordinating River Murray watering actions that targets outcomes throughout the system. Following a coordinated spring pulse in 2020-21 which reached >15,000 ML/day at the SA border, an increased pulse of >20,000 ML/day at the SA border is sought.

The extreme dry water resource availability scenario indicates below Entitlement base flows to SA. Under these conditions, it is not possible to use water for the environment to increase base flows to a level where they meet the EWRs. Instead, increased flows in late spring/summer are requested to address potential risks associated with low flows and hot, dry conditions such as thermal stratification, low dissolved oxygen and algal blooms.

Under the dry to moderate water resource availability scenarios, a spring fresh (Figure 3) of 15,000 to 20,000 ML/day at the SA border is requested to support a range of outcomes in the main channel and near-bank areas. The preferred timing of the pulse is in late spring/early summer and it is expected to provide outcomes such as improved hydraulic conditions, increased food resources and habitat availability for native fish populations, increased breeding success for native fish and native vegetation growth and survival through improved soil water availability and groundwater freshening.

In the near average water resource availability scenario, water for the environment will be used to increase the size of a small unregulated flow event to 30,000 ML/day at the SA border. Expected outcomes are similar to those associated with actions in the dry to moderate scenarios but with greater confidence of success. Of particular importance is the significant improvement in hydraulic conditions under these flow conditions, with fast flowing water throughout all of the lock reaches.

In the wet to very wet water resource availability scenarios, spring flows are sought to increase the height and slow the recession of a late winter/early spring high flow event. In the wet and very wet scenarios these flows will create an overbank event (Figure 3) along the length of the SA River Murray, inundating areas of the floodplain and wetlands. This inundation of low elevation floodplain zones and temporary wetlands will provide outcomes for frog and bird breeding and widespread improvement in the condition of long-lived vegetation such as lignum, river red gum and black box.

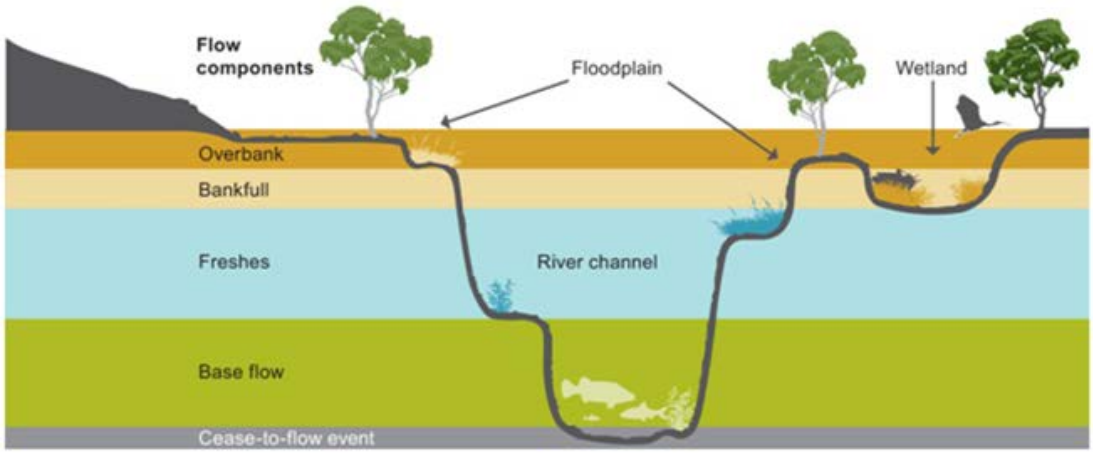


Figure 3. Conceptual illustration of flow components and their influence on different parts of the river channel and its floodplain. Source: Murray-Darling Basin Authority.

Some areas of the channel and floodplain will also benefit from weir pool manipulations, which are proposed at a range of sites subject to the prevailing conditions. Changes in water level will vary depending on the weir pool and flow conditions. The following potential weir manipulation actions are under consideration.

In a moderate scenario, it is proposed that weir pool 2 may be raised by 0.55 metres, weir pool 4 may be raised by 0.30 metres and weir pool 5 may be raised by 0.50 metres above normal pool level.

Under a near average and wet scenario, the above raising of weir 2, 4 and 5 is also proposed along with a raise in weir pool 6 to 0.42 metres above normal pool level. In addition to the above raising of weirs 2, 4, 5 and 6, it is also proposed to lower weir pool 2 to 0.08 metres below pool level (this is within the normal operating range) to extend the duration of lotic conditions in the River channel as the flow across the border reduces at the end of spring.

No weir manipulations are proposed under the extreme dry or dry scenarios.

Raising weir pool 4 by 0.30 metres, weir pool 5 by 0.55 metres and weir pool 6 by 0.42 metres as discrete watering actions under the moderate to wet scenarios will occur only if the proposed Katarapko floodplain operations (which incorporate weir pool 4 raising), Pike floodplain operations (which incorporate weir pool 5 raising) and Chowilla floodplain operations (which incorporate weir pool 6 raising) cannot occur (see Appendix A for details).

The durations of these weir raising actions range from approximately 90-150 days (including the filling and drawdown phase) depending on the scenario and weir pool and are proposed to take place between July and December 2021. Weir raisings are undertaken to provide for the mobilisation of carbon, nutrients and propagules from the floodplain to the river, support the growth and expansion of littoral vegetation, create diverse and productive biofilm and macroinvertebrate communities, promote groundwater freshening and relieve soil salinity stress in the littoral zone.

Murray hardyhead (*Craterocephalus fluviatilis*) caught at Lyrup lagoon. Credit: Stephanie Robinson, Murraylands and Riverland Landscape Board.

3.1.3 Managed Floodplains

Chowilla Floodplain

In 2021-22, the proposed Chowilla Floodplain environmental watering actions include operation of the Chowilla Creek regulator if the moderate, near average or wet water resource availability scenarios eventuate. Under extreme dry to dry water availability scenarios, pumped delivery of water to a number of priority wetlands and floodplain areas will take place. Inflows via Pipeclay Creek and Slaney Creek weirs will be managed to optimise outcomes for native fish species through the anabranch.

Under a moderate water resource availability scenario, the Chowilla Creek regulator will be operated along with a partial raising of weir 6 to generate an in-channel rise or up to a low floodplain inundation. Pumped delivery of water will also be considered in conjunction with the regulator operation to deliver water to high priority wetlands not inundated through low level use of the regulator under this scenario.

Under a near average water resource scenario a mid to high level regulator operation will be undertaken depending on the level of River Murray flows received along with an associated full raising of weir 6. This will enable inundation across approximately 5000 ha of floodplain and wetlands.

Under a wet water resource availability scenario, operation of the regulator and the associated raising of Weir 6 will be undertaken to generate a high to maximum extent floodplain inundation of approximately 7000 to 8000 ha of floodplain and wetlands.

The regulator operations will provide improved soil moisture conditions within creek banks and across wetlands and floodplains, supporting tree condition and regeneration of floodplain understorey vegetation. The watering will provide feeding and breeding habitat for birds and amphibians and allow the mobilisation of carbon and nutrients from the floodplain to the River.

The inundation extent from the mid to high level operations of the regulator will extend into areas of black box trees in the mid-elevation areas of the floodplain that haven't been watered since natural flooding in 2016.

Coppermine Waterhole. Credit: DEW

Pike Floodplain

In 2021-22, the Pike Floodplain, through the operation of the Pike and Tanyaca regulator, is planned to be operated under a dry, moderate, near average or wet water resource availability scenario. A key outcome of these events will be to provide follow-up water to boost soil moisture and vegetation health following the 2020-21 managed inundation.

Under the extreme dry availability scenario, there will not be sufficient water to operate the regulators, however the infrastructure will be operated so that base flows through the anabranch will be optimised. Under this and the dry scenario the pumped delivery of water to priority wetlands and floodplain areas will be considered in conjunction with NGO's and the Murraylands and Riverland Landscape Board as described in Section 3.1.4.

Under the dry water resource availability scenario, the Pike and Tanyaca regulators will be operated to provide an in-channel rise or low level managed floodplain inundation up to 15 m AHD with weir 5 remaining at normal pool level. This action will improve near bank soil moisture and provide some additional water to fringing vegetation along the channels of the floodplain.

Under a moderate water resource availability scenario, the regulator will be operated to generate a low floodplain inundation up to 15.4 m AHD at the Pike regulator with an associated raising of weir 5 to 16.8 m AHD. This would inundate an area slightly greater than the 2020-21 event providing valuable follow-up watering to areas that received water last year to assist in recovery and resilience.

Under a near average to wet water resource availability scenario, operation of the Pike and Tanyaca regulators up to 15.8 m AHD at Pike and the associated raising of weir 5 to 16.8 m AHD will be undertaken to generate a medium extent floodplain inundation of approximately 945 ha. Such an operation would provide benefits for trees and understorey vegetation and create breeding and feeding resources for a range of wildlife. This inundation would extend into areas of black box trees not reached by the 2020-21 watering event and that haven't been watered since natural flooding in 2016.

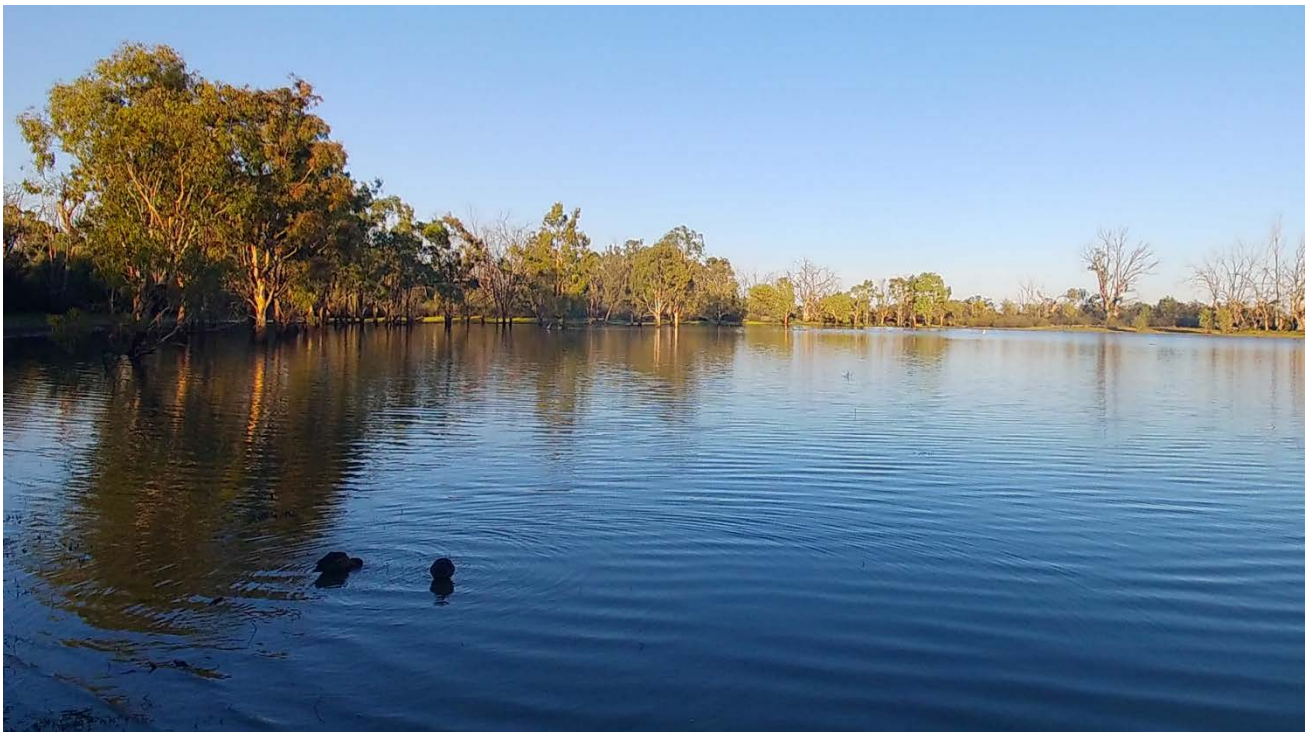
Katarapko Floodplain

In 2021-22, the Katarapko Floodplain, through the operation of The Splash regulator, is planned to be operated under a dry, moderate, near average or wet water resource availability scenario. Under extreme dry conditions, base-flows through the Eckert's anabranch will be maintained to provide optimal flow conditions for native fish.

Under a Moderate, Near Average or Wet scenario in 2020-21, The Splash environmental regulator will be operated to achieve a medium extent managed inundation, delivering water to up to 500 - 600 ha. Additional inflows generated by raising weir 4 in association with the inundation event will minimise the risk of negative water quality outcomes. This inundation is expected to improve soil moisture availability and hence conditions for vegetation growth in the inundated and immediately adjacent zone. Inundation of wetlands and adjacent floodplain areas will provide opportunities for small-scale breeding opportunities for waterbirds and amphibians and extend their foraging habitat. Conditions conducive to the germination of flood-dependent vegetation are expected to be created as water levels drop back down. Carbon and nutrients mobilised from the riparian zone and inundated sections of the floodplain will be mobilised and should be available to the aquatic food web.

Under a dry scenario The Splash environmental regulator will be raised to create an in-channel rise upstream through the Eckert's anabranch system. This is expected to improve recharge of bank soil moisture content to support the condition of riparian trees and regeneration of diverse riparian understorey vegetation. Localised minor overbank inundation will occur, delivering water to additional stands of low-lying river red gum and lignum. Weir 4 will not be required to be raised to support this operation. Under this scenario, the pumped delivery of water to priority wetlands and floodplain areas will be considered in conjunction with the Murraylands and Riverland Landscape Board as described below.

Under Extreme Dry conditions, base-flow conditions through the Eckert's anabranch will be maintained to provide optimal flow conditions for native fish.



Katarapko Floodplain. Credit: DEW

3.1.4 Wetlands

Multiple wetland sites along the SA River Murray are identified as priorities for receiving water for the environment in 2021-22 in the extreme dry to wet water resource availability scenarios. Wetland watering, predominantly via pumping, will be undertaken by the Murraylands and Riverland Landscape Board and DEW, along with a number of Non-Government Organisations (NGO's) including the Australian Landscape Trust, Renmark Irrigation Trust, Nature Foundation and Accolade Wines. The work of these groups is vital in delivering benefits across numerous sites along the SA River Murray providing valuable refuge habitat and complementing the outcomes achieved through Channel and floodplain delivery and weir manipulation.

Wetland watering priorities are reviewed throughout the year based on changing conditions and emerging information. Additional sites and watering actions may be considered when further need for water for the environment is demonstrated as a priority and opportunities to address ecological needs arise.

Sites are primarily located in the Riverland region of the River Murray in South Australia, but also include wetlands fringing the Lower Lakes. In 2021-22, under the projected wet to very wet water resource availability scenario many temporary wetlands will be naturally inundated. Under the moderate to wet scenarios some wetlands may be partially or fully watered as a result of weir pool raising and/or floodplain regulator operations and therefore will require no (or less) pumped delivery.

The provision of water for the environment at these sites will contribute to the recovery of threatened species such as the regent parrot, Murray hardyhead and southern bell frog, each listed under the *Environment Protection and Biodiversity Conservation Act, 1999* (Commonwealth). Water delivered to these sites also enables the survival of long-lived vegetation such as black box, river red gum and lignum floodplain communities as well as providing conditions for aquatic and amphibious species and the regeneration of understorey plants thereby creating areas of diverse critical habitat for a range of wildlife including waterbirds and amphibians.

In addition to the delivery of water to temporary wetlands, approximately 52 pool-connected wetlands will be managed across all water resource availability scenarios. Wetland infrastructure will be operated to implement variable water level management, where appropriate, to improve wetland condition and support water-dependant flora and fauna communities that have been impacted by river regulation since European settlement. Wetland management provides the opportunity to reduce the impact of common carp, improve water quality and increase foraging and breeding areas for wildlife including threatened species.

Turtle hatchlings at Narrung Wetlands. Credit: Regional Wetland Team, Murraylands and Riverland Landscape Board.

3.2 System-scale Watering Actions

3.2.1 SA River Murray Multi-site

The 2021-22 SA River Murray multi-site watering proposal aims to meet watering objectives at individual sites, as well as provide additional landscape-scale outcomes. The SA multi-site proposal is underpinned by the objectives, targets and EWRs in the *SA River Murray LTWP* (Department for Environment and Water, 2020) and the expected outcomes in the *Basin-wide Environmental Watering Strategy* (Murray-Darling Basin Authority, 2019).

The SA multi-site watering action for 2021-22 has the following aims:

- coordinate the delivery of environmental water to South Australia to maximise the potential outcomes throughout the South Australian River Murray system
- provide pathways for the dispersal, migration and movement of native water-dependent biota
- provide pathways for the dispersal and movement of organic and inorganic sediment to maximise the delivery of resources to downstream reaches and to the ocean
- deliver environmental water to the LLCMM, while providing benefits to upstream environmental assets en-route
- increase the effectiveness of environmental watering and the extent of benefits by aligning the timing, magnitude and duration of discrete actions
- maximise outcomes from watering in South Australia by using return flows where possible
- maximise the areas of inundation through infrastructure operations where possible, whilst still improving hydraulic conditions within the main river channel.

These SA multi-site objectives are an extension of the environmental watering objectives for site-based actions, which are summarised in Appendix A. The graphs provided in Appendix A indicate the relative timing of the river channel water demands, the LLCMM water demands and the operation of regulator and locks infrastructure.

In the development of the 2021-22 SA multi-site proposal, the following alignment between site proposals were considered:

- weir pool raisings as a part of floodplain operations will fulfil the objectives of the individual weir pool raising proposals
- the sequencing of weir pool operations and river channel pulse actions to ensure objectives of both actions may be achieved
- minimising the effects of infrastructure operations on flow hydraulics and velocity within the main river channel in critical periods.

The estimated volume of water for the environment required to deliver the 2021-22 SA multi-site proposal ranges from approximately 953 GL in the dry scenario to 1308 GL in the wet scenario (Table 3). The SA multi-site volumes represent the volume of environmental water required to be delivered to the South Australian border to support all proposed watering actions in the South Australian River Murray for that scenario. These volumes are in addition to water for the environment on South Australian licences (approximately 250 GL), which is delivered as part of South Australia's Entitlement and therefore included in the base flow represented in the AOOs. The SA multi-site volumes factor in return flows from site-based watering actions (e.g. Chowilla regulator operation) and their contribution to meeting other downstream demands. The volumes also factor in the contribution that the river channel water demand makes to the LLCMM water demands.

This SA multi-site proposal will continue to be used and revised during real-time management planning and was provided to environmental water holders via SCBEWC to support delivery planning for the 2021-22 water year.

Pipeclay Wetland. Credit: Darren Willis, Murraylands and Riverland Landscape Board

Table 3. Indicative volume of environmental water required per month to deliver the SA multi-site action. Options under each scenario represent alternative demand profiles and are not cumulative.

Scenario		Indicative volume (GL) of e-water required per month												Total est.
AOP	**Option**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	volume (GL)
Dry	LLCMM Option 1	66	44	70	220	309	101	51	41	32	31	41	40	**1,045**
Dry	LLCMM Option 2	66	44	70	220	309	101	20	41	32	31	10	10	**953**
Moderate	Chowilla Option D	44	78	125	225	309	151	51	40	41	30	40	40	**1,174**
Moderate	Chowilla Option E	44	20	105	229	309	151	51	40	41	30	40	40	**1,101**
Near Average	Option 1			282	400	198	151	50	40	40	30	40	40	**1,272**
Wet	Chowilla Option G		107	237	184	248	222	100	40	40	30	40	40	**1,290**
Wet	Chowilla Option H		115	248	184	248	222	100	40	40	30	40	40	**1,308**

3.2.2 Cooperative Arrangements between Water Resource Plan Areas

There is no active management of water for the environment in the Eastern Mount Lofty Ranges WRP area or the SA Murray Region WRP area. Opportunities to coordinate environmental watering between these areas and the SA River Murray are limited. The catchments of the Eastern Mount Lofty Ranges WRP area flow to the lower River Murray and Lake Alexandrina, with the outflow from these catchments contributing approximately 0.5 per cent of the total annual runoff to the Murray-Darling Basin (CSIRO 2007). The timing and volume of environmental watering in the Eastern Mount Lofty Ranges WRP area occurs in response to flow events as they occur, rather than being able to be managed or manipulated to achieve coordinated outcomes with environmental watering in the SA River Murray WRP area. Any flow reaching Lake Alexandrina cannot be allocated and is considered PEW within the SA River Murray WRP area.

The SA Murray Region WRP area includes the Coorong and Murray Mouth, however in recognition of the intrinsic connection between the Coorong and the Lower Lakes, South Australia seeks to manage the site as a whole as described in *the SA River Murray LTWP* (Department for Environment and Water, 2020).

Water holders and managers of water for the environment in SA, NSW, Victoria, the MDBA and CEWO have worked together for several years to trial, plan and coordinate annual multi-site environmental watering events. This planning aims to maximise the use of unregulated flows, water for the environment and return flows at multiple sites as water moves through the southern-connected Basin.

The SCBEWC and Water Liaison Working Group contribute to the development of the multi-site events each year. Over the last three years this has included the planning and implementation of a coordinated River Murray channel spring pulse watering event aimed at optimising benefits along the River Murray Channel as well as achieving alignment with tributary inflows and watering actions at wetland and floodplain sites and the LLCMM.

Red-kneed dotterel (*Erythrogonys cinctus*). Credit: Casey O'Brien, Murraylands and Riverland Landscape Board

4. Environmental Water Management

The *SA River Murray LTWP* and the *SA Environmental Watering Framework* provide additional information regarding the SA River Murray ecological assets and water for the environment planning, policies and management.

Following annual planning, environmental water is provided, principally by the CEWH and TLM, to support priority watering actions. After water has been agreed for delivery for a particular site/outcome, operational event plans that set out the specifics of infrastructure operations and water delivery are finalised and implemented.

Delivery of water for the environment is undertaken at any time during the year. There is also a need for 'real time' water delivery planning, approvals processes, water delivery, infrastructure operations, monitoring and consultation to adapt to current conditions. The collection of data through monitoring activities is undertaken regularly during planning and water delivery. Importantly, the monitoring results and outcomes provide feedback for decision-making processes and planning in the current and subsequent years (under an adaptive management framework).

The annual environmental water management process (Figure 5) involves:

- Annual planning – development of environmental watering priorities and plans, consultation
- Environmental water provision – approvals, trades
- Water delivery and 'real time' management - infrastructure operations, monitoring
- Reporting and evaluation – water accounting and data analysis

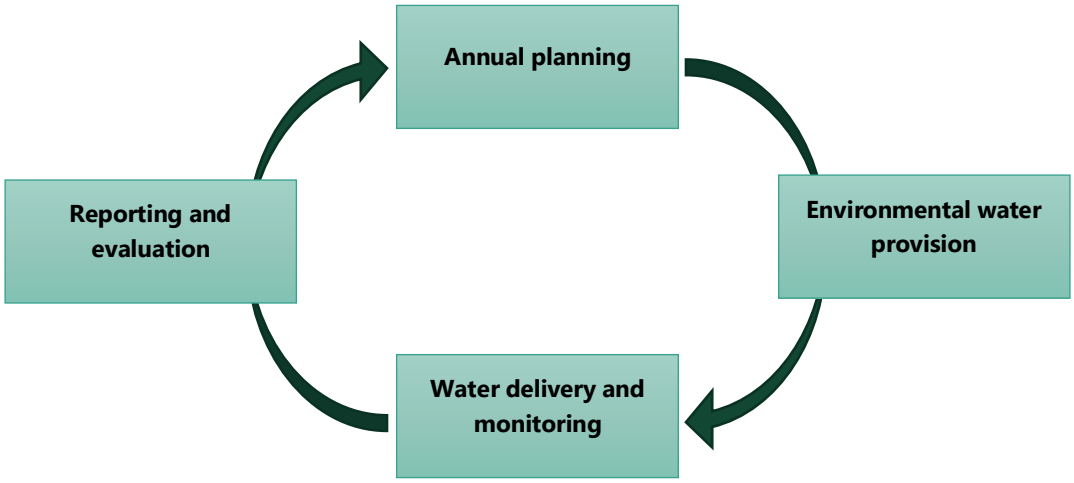


Figure 4: Overview of the annual environmental water management process.

4.1 Environmental Water Provision

Decisions to supply environmental water to meet identified demands in the watering proposals are made by environmental water holders. This includes the Commonwealth Environmental Water Holder (in relation to Commonwealth environmental watering holdings), the Southern-Connected Basin Environmental Watering Committee (in relation to 'Joint Water', that is TLM, RMIF and River Murray unregulated flow (RMUF)) and DEW on behalf of the SA Minister for Environment and Water (who makes decisions on the use of water on the Minister's water licences).

4.2 Environmental Water Delivery

Delivery and monitoring of water for the environment is undertaken throughout the year. This includes the delivery of water (which may include environmental water or unregulated flows) to the SA border and the subsequent management of the water, at the sites identified within the SA River Murray Annual Environmental Watering Priorities.

Environmental water delivery incorporates the following activities:

- development of water delivery plans
- approvals
- continuous 'real time' planning,
- hydrological modelling
- water delivery in conjunction with infrastructure operation
- monitoring
- ongoing consultation as required.

4.2.1 Real Time Planning and Operations

'Real time' planning is the short-term planning and decision making that occurs on an ongoing basis throughout the year, particularly leading up to and during the delivery of environmental water. The timeframes are shorter than annual planning and the associated water resource forecasts are more accurate than the annual AOOs.

Real time planning is necessary where the River conditions and flows at the South Australian border (QSA) differ from the AOO scenarios used in annual planning, resulting in the need to revise the proposed water events. The divergence from the planning AOOs may be due to:

- environmental water requirements identified within the individual watering proposals or SA multi-site are not available, or are unable to be delivered at the required time
- relatively rapid changes in River conditions e.g. QSA increases or decreases at rates greater than anticipated for example the occurrence of unregulated flows
- conditions have switched from one AOO outlook to the next, e.g. from dry to near average
- there are significant changes in water quality
- river conditions (flow) do not align with the specific AOO curves used in annual planning.

Environmental water managers are provided with information on the short-term forecasts of river conditions and environmental water availability. This information is used by the water managers to determine which watering event (or scale of event) may be feasible to undertake.

Where real time planning has led to changes to a watering event, it may be necessary to undertake further modelling and apply the *IOS* to ensure adverse impacts within the river channel are avoided.

Operational Advisory Groups hold regular teleconferences to ensure coordination and communication during watering events and rapid responses to any issues that may arise. Membership of these groups includes holders of HEW, managers of environmental assets and river operators. South Australia has representatives on these cross-jurisdictional committees and actively participates in the planning and coordination of large scale environmental watering events for 2021-22.

Nelwart. Credit: DEW

4.3 Monitoring and Evaluation

Monitoring and evaluation is critical for improving knowledge of floodplains, wetlands, LLCMM and the River Murray system. They are vital to understanding the physical and biological components of the river system and how these have responded over time to changing water and flow conditions.

Ongoing monitoring programs are essential in being able to assess the outcomes of the delivery of water for the environment. In addition to this, the evaluation and interpretation of monitoring results are fed back into the planning process and are used to support future watering decisions in an adaptive management framework. This continuous improvement in knowledge and learning increases the effectiveness of environmental water planning and delivery and helps to achieve management and ecological outcomes.

Site specific monitoring is undertaken at all key watering sites, with the methods used, data management and analysis based on the site monitoring plans developed by the water managers, in conjunction with advice from scientific and community stakeholders. As well as supporting site specific watering decisions, the data collected assists with the assessment of environmental water delivery outcomes along the river and supports the evaluation of the *Murray-Darling Basin Plan*.

Red-kneed dotterels (*Erythrogonys cinctus*) at Gum Flat. Credit: Helga Kieskamp

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Appendices

Appendix A. Summary of water for the environment actions proposed for 2021-22 under water resource availability scenarios

Extreme dry scenario

Table 4: Extreme dry AOO: Proposed operations and objectives for each site

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
River Murray Channel	Spring pulse: • ≥ 10,000 ML/d for 2 months	Dec - Jan	284 GL	▪ Prevent persistent thermal stratification and conditions for algal blooms ▪ Maintain resilient populations of foraging generalist fish species ▪ Minimise the risk of carp recruitment
Weir Pools	No Actions proposed			
Chowilla	Action A: Pumping up to 12 priority wetlands	Winter-Spring or Autumn	5-11 GL	• Maintain viable river red gum, black box, river cooba and lignum populations • Improve the abundance and diversity of grass and herblands; flood dependant understorey vegetation; and submerged and emergent aquatic vegetation. • Provide habitat conducive to supporting diverse communities of riparian frogs • Provide refuge for the maintenance of adult populations of waterbirds
	Action B: Manage inflows via Pipeclay Creek and Slaney Creek weirs to optimise outcomes for native fish through the anabranch.	All year	N/A as continuously flowing system	• Maintain flow mosaic characteristic of Chowilla Anabranch system • Maintain the extent and diversity of distribution of native fish.
Katarapko	Maintain base-flow conditions through anabranch	All year	N/A	• Targeting optimal anabranch flow conditions for native fish
Pike	Maintain base-flow conditions through anabranch	All year	N/A	• Targeting optimal anabranch flow conditions for native fish
Wetlands	Delivery of water to up to 40 priority wetlands (25 wetland complexes) located along the River Murray from the border to the Lower Lakes.	All year	13.2 GL	• Provide for the critical ecological needs for threatened species including the southern bell frog, Murray hardyhead and regent parrot by providing targeted refugia, breeding and foraging habitat. • The prevention of loss and desiccation of long-lived vegetation due to prolonged dry periods.
LLCMM	Option A: Small winter flow pulse	Jul	30.0 GL	• Promote conditions to support lamprey and congolli migration (Goolwa, Mundoo and Tauwitchere prioritised)
	Option B: Spring and early summer flows to maintain lake levels >0.7 m AHD	Sept – Dec	440.0 GL	• Maintain lakes levels fish and frog habitat • Maintain continuous flows at all fishways (YOY congolli and galaxias migration) and >500 ML/d attractant flow prioritised from Tauwitchere
	Option C: Summer/ autumn base flows to maintain autumn lake levels >0.5 m AHD and maintain flows at all fishways	Jan – May	190.0 GL	• Promote continuous connectivity between the river and estuary • Promote continuous fish passage for diadromous fish • Provide fishways functional year-round

Dry scenario

Table 5: Dry AOO: Proposed operations and objectives for each site

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
River Murray Channel	Spring pulse targeting flows at the SA border ≥ 15,000 ML/day for 45 days with a short peak ≥ 20,000 ML/day (8-days)	Oct – Dec (peak in early Nov)	612.5 GL	▪ Improved hydraulic conditions by increasing availability of moderate-fast flowing water ▪ Maintain/improve native vegetation growth and condition through improved soil water availability and groundwater freshening ▪ Support spawning and recruitment of golden perch and silver perch ▪ Support recruitment and juvenile survival of Murray cod.
Weir Pools	No Actions proposed			
Chowilla	Action A: Pumping up to 12 priority wetlands	Winter-Spring or Autumn	5 – 11 GL	• Throughout the length of the Channel asset (i.e. SA border to Wellington), establish and maintain groundwater and soil moisture conditions conducive to improving riparian vegetation and maintaining diverse native vegetation. • Maintain viable river red gum, black box, river cooba and lignum populations • Improve the abundance and diversity of grass and herblands; flood dependant understorey vegetation; and submerged and emergent aquatic vegetation. • Provide habitat conducive to supporting diverse communities of riparian frogs • Provide refuge for the maintenance of adult populations of waterbirds
	Action C: Manage inflows via Pipeclay Creek and Slaney Creek weirs to optimise outcomes for native fish through the anabranch.	All year	N/A as continuously flowing system	• Maintain flow mosaic characteristic of Chowilla Anabranch system • Maintain the extent and diversity of distribution of native fish.
Katarapko	Operate the Katarapko regulators to generate a low extent managed floodplain inundation: • regulator raised 11.5 m AHD • Lock 4 not raised	Jul – Oct	Filling 0.69 GL Losses 0.66GL Total 0.76 GL *(additional QSA: 19.8 GL)*	• Improved recharge of bank soil moisture content, supporting the condition and regeneration of riparian trees and regeneration of diverse riparian understorey vegetation. • Very localised minor overbank inundation will occur delivering water to additional stands of low-lying river red gum and lignum.
Pike	Operate the Pike regulators to generate an In-channel rise or up to low extent managed inundation • Regulator raised to 15 m AHD – 30 days at peak • Lock 5 not raised	Late Jul – Late Sept	Filling 3.3 GL Losses 0.24 GL Total 3.5 GL *(additional QSA: 71,6 GL)*	• Improved recharge of bank soil moisture content, supporting the condition and regeneration of riparian trees and regeneration of diverse riparian understorey vegetation. • Very localised minor overbank inundation will occur delivering water to additional stands of low-lying trees and lignum.
Wetlands	Delivery of water to up to 40 priority wetlands.	All year	13.2 GL	Same outcomes/objectives as described for wetlands for the extreme dry AOO.
LLCMM	Option A: Winter flow pulse	Jul-Aug (alt Jun-Jul)	100.0 GL	• Promote conditions to support Lamprey and congolli migration (Goolwa, Mundoo and Tauwitchere prioritised)
	Option B: Spring and early summer flows to maintain lake levels >0.75 m AHD	Sept – Dec (alt Oct –Jan)	450.0 GL	• Maintain lakes levels fish and frog habitat

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
				• Maintain continuous flows at all fishways (YOY congolli and galaxias migration) and >500 ML/d attractant flow prioritised from Tauwitchere • Support North Lagoon ecology – estuarine fish, invertebrate and waterbird habitat • Support fringing vegetation
	Option C: Summer/ autumn base flows to maintain autumn lake levels >0.55 m AHD and maintain flows at all fishways	Jan – June	230.0 GL	• Promote continuous connectivity between the river and estuary • Promote continuous fish passage for diadromous fish • Provide fishways functional year-round • Threatened fish habitat in Lower Lakes not suffer further degradation

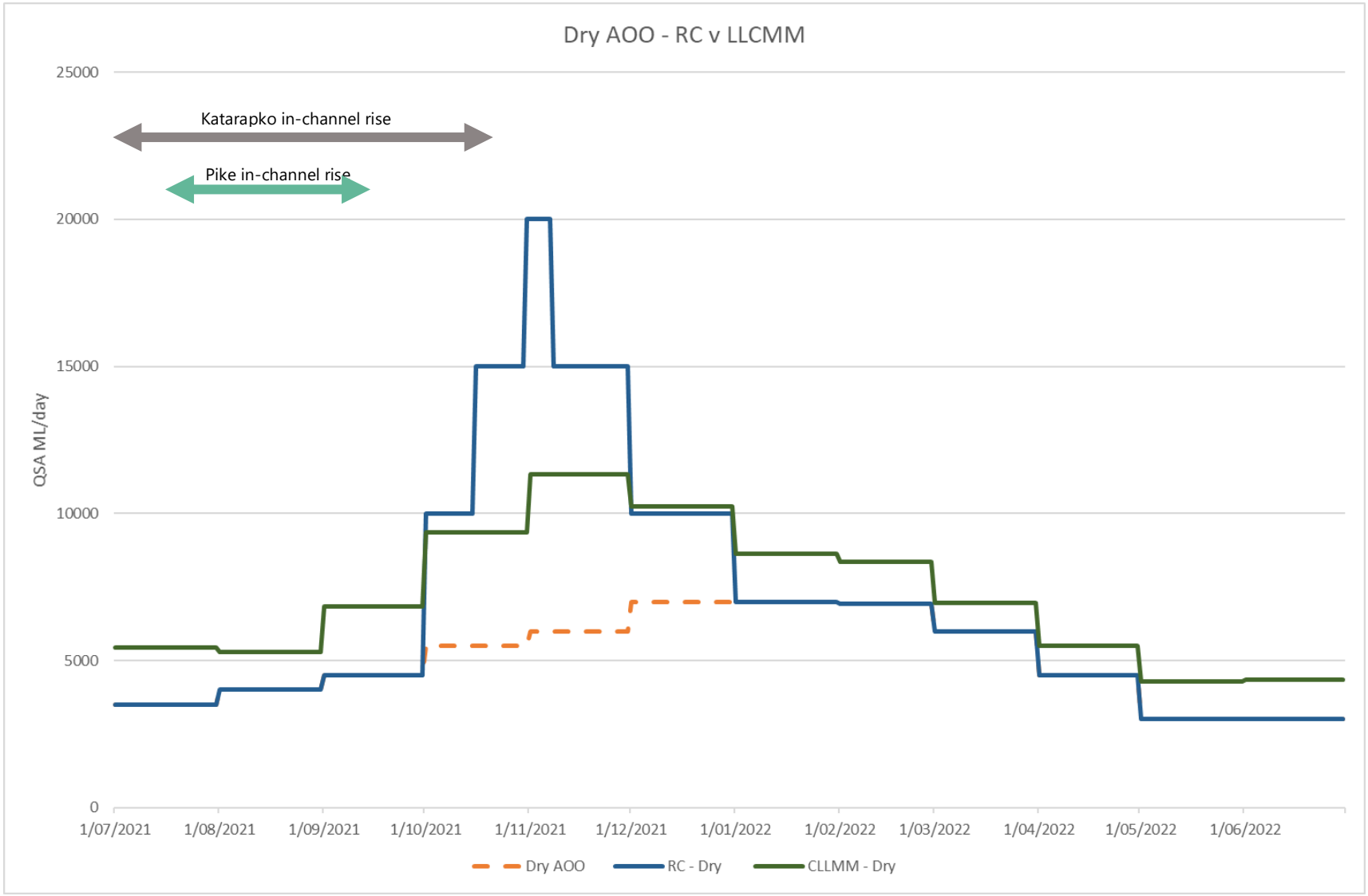

Figure 5. Preferred delivery pattern of SA multi-site environmental water under a Dry (90%) AOO scenario. Options are exclusive not cumulative; arrows indicate timing of proposed site-based environmental watering actions; AOO, LLCMM and River Channel demand is presented as a reference point.

Moderate AOO

Table 6: Moderate AOO: Proposed operations and objectives for each site

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
River Murray Channel	Spring pulse targeting flows at the SA border ≥ 15,000 ML/day for 45 days with a short peak ≥ 20,000 ML/day (8-days)	Oct – Dec, peak in early Nov	616.1 GL	Same outcomes/objectives as described for the River Murray Channel for the dry AOO.
Weir Pool 2	Raise +55 cm above NPL to 6.65 m AHD	Aug – Nov	Filling 9.2 GL	• Meet objectives in LTWP for SA River Murray, including improved water quality, ecosystem processes and conditions for vegetation, fish and fauna. • To provide for the mobilisation of carbon, nutrients and propagules from the floodplain to the river, support the growth and expansion of littoral vegetation, create diverse and productive biofilm and macroinvertebrate communities, promote groundwater freshening and relieve soil salinity stress in the littoral zone.
Weir Pool 4	+30 cm above NPL (as above) NOTE: this separate operation not required if Katarapko floodplain inundation including Weir 4 raising is undertaken	As above	Filling 6.3 GL	
Weir Pool 5	+50 cm above NPL (as above) NOTE: this separate operation not required if Pike floodplain inundation including Weir 5 raising is undertaken	As above	Filling 12.8 GL	
Chowilla	Action C: Pumping up to 12 priority wetlands	Winter-Spring or Autumn	5 – 11 GL	• Establish and maintain groundwater and soil moisture conditions conducive to improving riparian vegetation and maintaining diverse native vegetation. • Maintain viable river red gum, black box, river cooba and lignum populations • Improve the abundance and diversity of grass and herblands; flood dependant understorey vegetation; and submerged and emergent aquatic vegetation. • Provide habitat conducive to supporting diverse communities of riparian frogs • Provide refuge for the maintenance of adult populations of waterbirds
	Action D: Operate Chowilla regulator to generate an in-channel rise to low extent managed floodplain inundation: • Regulator max 18.9 m AHD • Lock 6 up to 19.65 m AHD	July – late Sept, peak in Aug	Filling 27.2 GL Losses 6.0 GL Total 33.2 GL	• Provide for the mobilisation of carbon, nutrients and propagules from the floodplain to the river • Maintain habitats and provide for dispersal of organic and inorganic material and organisms between river and wetlands. • Maintain water quality to support aquatic biota and normal biogeochemical processes. • Establish and maintain groundwater and soil moisture conditions conducive to improving riparian vegetation and maintaining diverse native vegetation. • Promote bacterial rather than algal dominance of biofilms and improve food resource quality for consumers. • Maintain viable river red gum, black box, river cooba and lignum populations • Improve the abundance and diversity of grass and herblands; flood dependant understorey vegetation; and submerged and emergent aquatic vegetation.

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
				• Restore and maintain resilient populations of native fish within aquatic zones across the Channel and floodplain • Provide habitat conducive to supporting diverse communities of riparian frogs • Provide refuge for the maintenance of adult populations of waterbirds.
	Option E: Operate Chowilla regulator and Weir 6 to generate a medium extent managed floodplain inundation: • Regulator max 19.1 m AHD • Weir 6 up to 19.85 m AHD	July – early Novt,	Filling 32 GL Losses 11.6 GL Total 44.1 GL *(Additional QSA 92.3 GL Aug-Sept)*	Same as described for the above Option D, but there will be increased areas of inundation resulting in greater achievement of outcomes/objectives including benefits to some black box community
Katarapko	Operate Katarapko regulators and Weir 4 to generate a medium extent managed floodplain inundation: • Regulator max 13.0 m AHD • Weir 4 raised +30 cm to 13.5 m AHD	Jul – mid Dec	Filling 11.3 GL Losses 1.6 GL Total 12.9 GL (*Additional QSA 2.1 GL Sept-Oct)*	• Improve soil moisture availability and hence conditions for vegetation growth across the inundated channels and floodplains, while allowing for the germination of flood-dependent vegetation immediately adjacent. • Inundation of wetlands and adjacent floodplain areas may provide opportunities for small-scale breeding opportunities for waterbirds and amphibians and extend their foraging habitat. • Upon recession, conditions conducive to the germination of flood-dependent vegetation are anticipated. • Carbon and nutrients will also be mobilised from the riparian zone and inundated sections of the floodplain, making them available to the aquatic food web.
Pike	Operate Pike regulators and Weir 5 to generate a low extent managed floodplain inundation: • Regulator max 15.4 mA HD • Weir 5 raised +50cm to 16.8 m AHD	Jul – Nov	Filling 19.9 GL Losses 3.1 GL Total 23.0 GL *(Additional QSA 29.1 GL Sept-Oct)*	• Improve soil moisture availability and hence conditions for vegetation growth across the inundated channels and floodplains, while allowing for the germination of flood-dependent vegetation immediately adjacent. • Inundation of wetlands and adjacent floodplain areas may provide opportunities for small-scale breeding opportunities for waterbirds and amphibians and extend their foraging habitat. • Upon recession, conditions conducive to the germination of flood-dependent vegetation are anticipated. • Carbon and nutrients will also be mobilised from the riparian zone and inundated sections of the floodplain, making them will be mobilised and should be available to the aquatic food web. • Water delivery will inundate an area slightly greater than the 2020-21 event, providing valuable follow-up watering to areas that received water last year to assist in recovery and resilience.
Wetlands pumping	Delivery of water to up to 40 priority wetlands.	All year	13.2 GL	Same outcomes/objectives as described for wetlands for the extreme dry AOO.

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
LLCMM	Option A: Spring and early summer flows to maintain lake levels >0.80 m AHD	Sept – Dec (alt Oct-Jan)	580.0 GL	• Enhance habitat with the lakes for fish and frogs • Maintain continuous flows at all fishways (YOY congolli and galaxias migration) and >1000 ML/d attractant flow prioritised from Tauwitchere • North Lagoon ecology – estuarine fish, invertebrate and waterbird habitat and Goolwa (black bream recruitment) (70:30 flow split Tauwitchere: Goolwa)
	Opiton B: Summer/ autumn base flows to maintain autumn lake levels >0.55 m AHD and to maintain flows at all fishways	Jan-Jun	240.0 GL	• Continuous connectivity between the river and estuary • Continuous fish passage for diadromous fish • Fishways functional year-round • Threatened fish habitat in Lower Lakes does not suffer further degradation

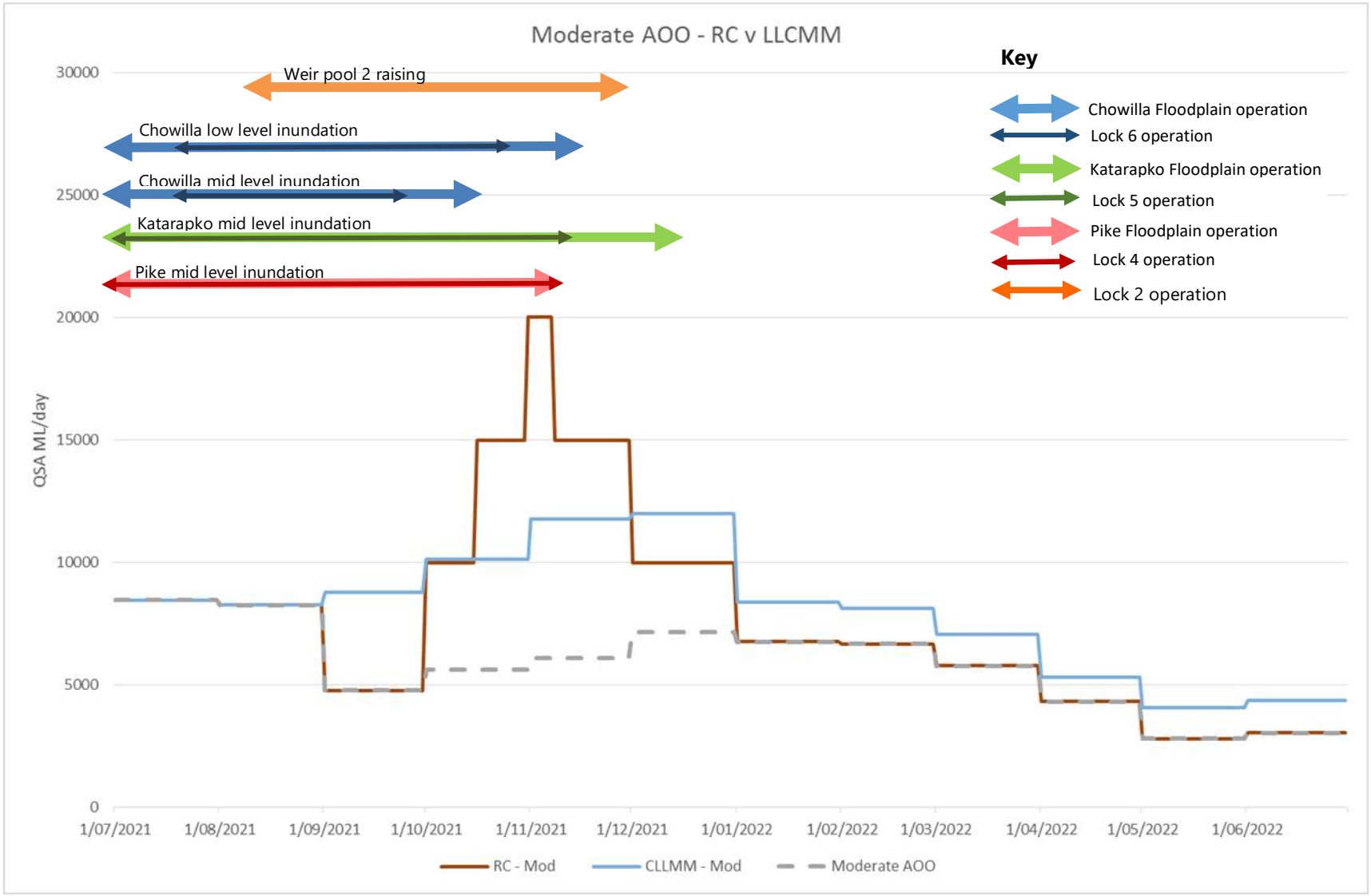

Figure 6. Preferred delivery pattern of SA multi-site environmental water under a Moderate (75%) AOO scenario. Options are exclusive not cumulative; arrows indicate timing of proposed site-based environmental watering actions; AOO, LLCMM and River Channel demand is presented as a reference point.

Near Average

Table 7: Near average AOO: Proposed operations and objectives for each site

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
River Murray Channel	Augment unregulated flows to achieve flow at the SA border of ≥ 20,000 ML/day for ≥90-days, including ≥ 30-days with flows ≥ 30,000 ML.day	Sept – Oct	666.4 GL	• Same outcomes/objectives as described for the River Murray Channel for the moderate AOO, with the addition of: o Abundant fast flowing habitat available throughout all lock reaches o Growth of emergent aquatic plants in temporary wetlands inundated by high flows o Improved river red gum population demographics in inundated areas and areas adjacent due to lateral recharge of groundwater.
Weir Pool 2	+55cm above NPL to 6.65 m AHD	Aug – Nov	8.6 GL	As per objectives/outcomes for Moderate AOO
Weir Pool 4	+30 cm above NPL NOTE: this separate weir raising is not required if Katarapko floodplain inundation including lock 4 raising is undertaken	As above	8.7 GL	
Weir Pool 5	+50cm above FSL NOTE: this separate weir raising is not required if Pike floodplain inundation including lock 5 raising is undertaken	As above	13.9 GL	
Weir Pool 6	+42cm above FSL NOTE: this separate weir raising is not required if Chowilla floodplain inundation including lock 6 raising is undertaken	As above	2.2 GL	
Chowilla	Operate the Chowilla regulator and Weir 6 to generate a medium-high extent managed floodplain inundation: • Regulator max 19.6 m AHD • Weir 6 up to 19.85 m AHD	July – late Nov	Filling 54.2 GL Losses 11.6 GL Total 65.8 GL *Additional QSA 16.3 GL in Aug)*	As per outcomes/objectives identified in Chowilla moderate AOO but there will be increased areas of inundation resulting in greater achievement of outcomes/objectives including benefits to areas of black box community
Katarapko	Operate the Katarapko regulators and Weir 4 to generate a medium extent managed floodplain inundation: • Regulator max 13.0 m AHD • Weir 4 raised +30cm to 13.5 m AHD	Jul – mid Dec	Filling 11.3 GL Losses 1.6 GL Total 12.9 GL	As per outcomes/objectives identified in Katarapko moderate AOO
Pike	Operate Pike regulator and Weir 5 to generate a medium extent managed floodplain inundation: • Regulator max 15.8 m AHD • Weir 5 raised +50 cm to 16.8 m AHD	Jul – Nov	Filling 23.3 GL Losses 4.0 GL Total 27.2 GL	As per outcomes/objectives identified in Pike moderate AOO

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
Wetlands	Delivery of water to up to 29 priority wetlands.	All year	8.9 GL	Same outcomes/objectives as identified for wetlands in moderate AO) (but less wetlands needing to be pumped as they are inundated via flows forecast in the AOO)
LLCMM	Option A: Spring and early summer flows to maintain lake levels >0.80 m AHD	Oct-Dec (alt Nov-Jan)	710 GL	• Enhance lakes fish and frog habitat • Maintain continuous flows at all fishways (YOY congolli and galaxias migration) • >2000 ML/d attractant flow prioritised from Tauwitchere (North Lagoon ecology – estuarine fish, invertebrate and waterbird habitat) and Goolwa (black bream recruitment) (80:20 Tauwitchere: Goolwa)
	Option B: Summer/ autumn base flows to maintain autumn lake levels 0.55 – 0.60 m AHD	Jan-Jun	240 GL	• Maintain continuous fishway flows and provide pulsing opportunities from Tauwitchere

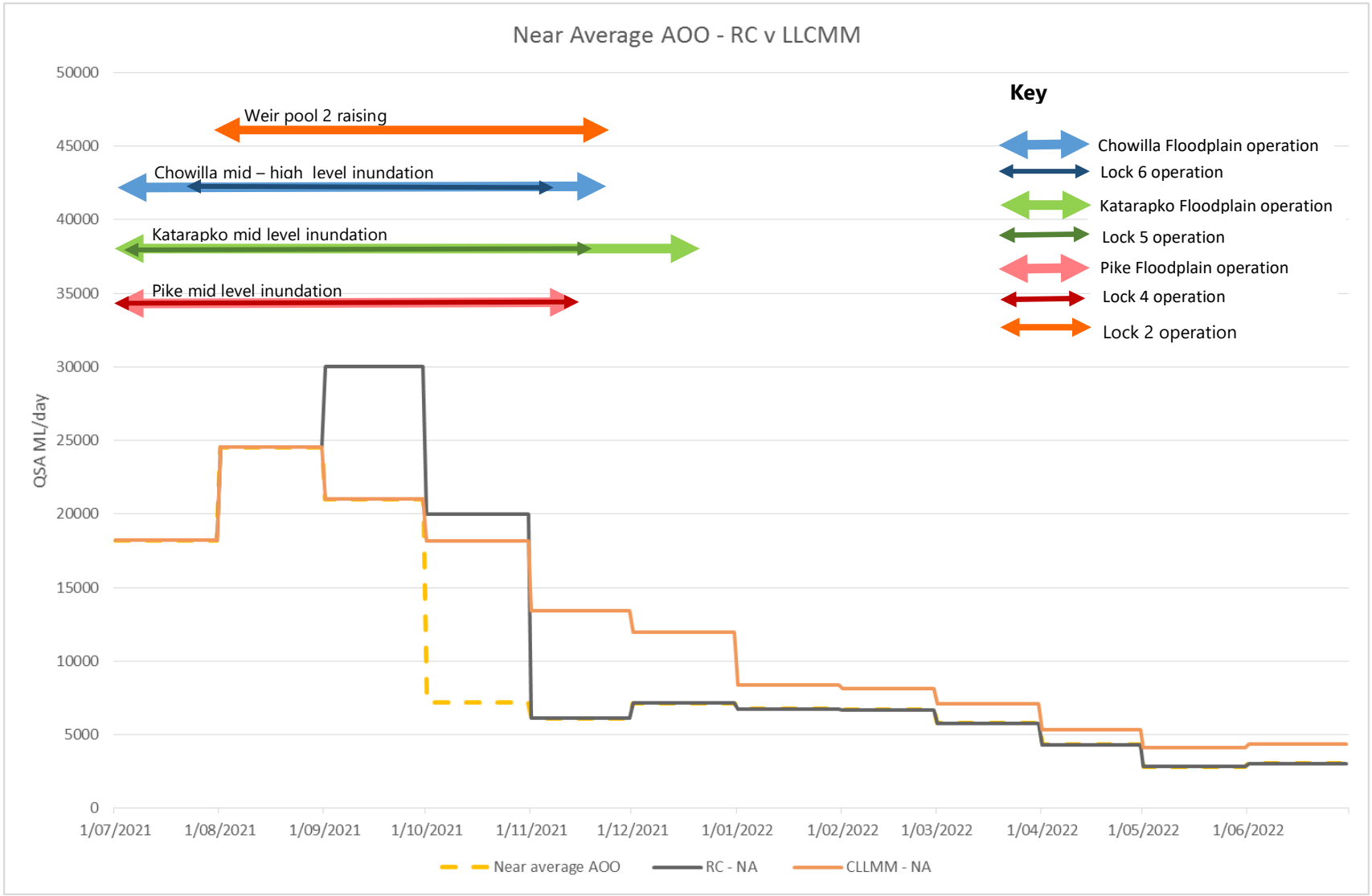

Figure 7. Preferred delivery pattern of SA multi-site environmental water under a Near Average (50%) AOO scenario. Options are exclusive not cumulative; arrows indicate timing of proposed site-based environmental watering actions; AOO, LLCMM and River Channel demand is presented as a reference point.

Wet AOO Scenario

Table 8: Wet AOO: Proposed operations and objectives for each site

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
River Murray Channel	Augment unregulated flows to achieve: • 50,000 ML/d for ~ 40 days • 30,000 ML/d in Oct to extend >30,000 ML/d flows for 3 months • 20,000 ML/d in Nov to extend >20,000 ML/d flows for 5 months	Late Aug – Nov	705.2 GL	• Same as outcomes/objectives for the River Murray Channel near average AOO • Water delivery aims to increase the height and slow the recession of a late winter/early spring high flow event. • Inundation of low elevation areas the SA River Murray Floodplain occurs along the entire length of the River in SA • Support a large recruitment event for Murray cod • Provide breeding habitat for riparian frog species
Weir Pool 2	Option 1: +55 cm to 6.65 m AHD	Jul – Oct	9.0 GL	As per objectives/outcomes for Weir Pools in the moderate AOO
	Option 2: +55 cm to 6.65 m AHD then lowered by -10 cm to 6.0 m AHD	Jul – early Dec	Filling 8.6 GL Refilling 1.3 GL	
Weir Pool 4	+30 cm above NPL	Aligned to WP 2 option 1	8.7 GL	
Weir Pool 5	+50cm above NPL	As above	13.9 GL	
Weir Pool 6	+42cm above NPL	As above	2.2 GL	
Chowilla	Action G: Operate the Chowilla regulator and Weir 6 to generate a high extent managed floodplain inundation: • Regulator max 19.75 m AHD • Lock 6 up to 19.85 m AHD	early July – early Dec	Filling 68.9 GL Losses 26.7 GL Total 95.6 GL	As per outcomes/objectives identified for Chowilla in near average AOO, but with an increased areas of inundation resulting in greater achievement of outcomes/objectives including benefits to areas of black box community
	Action H: Operate the Chowilla regulator and Weir 6 to generate a high extent managed floodplain inundation: • Regulator max 19.85 m AHD • Weir 6 up to 19.85 m AHD	early Jul – early Dec	Filling 76.4 GL Losses 31.4 GL Total 107.8 GL	
Katarapko	Operate the Katarapko regulators and Weir 4 to generate a medium extent managed floodplain inundation: • Regulator max 13.0 mAHD • Weir 4 up +30cm to 13.5 mAHD	Jul – mid Dec	Filling 18.1 GL Losses 1.6 GL Total 19.8 GL	As per outcomes/objectives identified for Katarapko in the moderate AOO
Pike	Operate the Pike regulators and Weir 5 to generate a medium extent managed floodplain inundation: • Regulator max 15.8 m AHD • Weir 5 raised +50cm to 16.8 m AHD	Jul – Nov	Filling 22.3 GL Losses 4.0 GL Total 26.3 GL	As per outcomes/objectives identified for Pike in the moderate AOO

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
Wetlands	Delivery of water to up to 7 priority wetlands.	All year	2.3 GL	As per outcomes/objectives identified for wetlands in the near average AOO (but less wetlands needing to be pumped as most are inundated via flows forecast in the AOO)
LLCMM	Option A: Flows added to the back of unregulated event to slow recession and maintain higher barrage release volumes through summer	Oct – Dec (alt Nov –Jan)	670 GL	• Spring and summer outcomes for both North and South Coorong ecology
	Option B: Summer/ autumn base flows to maintain autumn lake levels >0.60 m AHD	Jan – Jun 2022	240 GL	• Maintain continuous fishway flows with attractant flow and provide pulsing opportunities from Tauwitchere

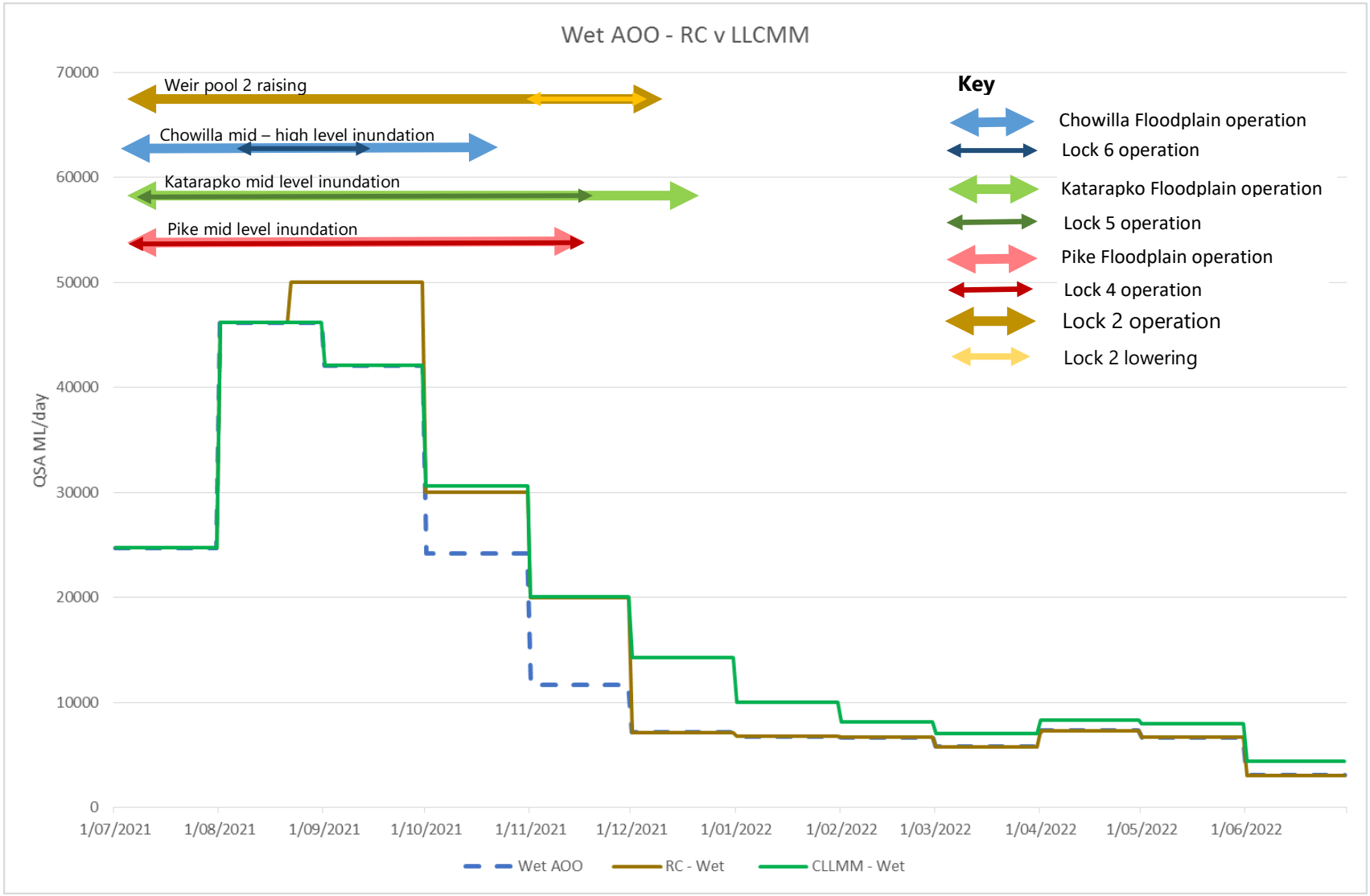

Figure 8. Preferred delivery pattern of SA multi-site environmental water under a Wet (25%) AOO scenario. Options are exclusive not cumulative; arrows indicate timing of proposed site-based environmental watering actions; AOO, LLCMM and River Channel demand is presented as a reference point.

Very wet scenario

Table 9: Very wet AOO: Proposed operations and objectives for each site

Site	Management action(s) / objectives	Timing	Volume	Ecological Outcomes/Objectives
River Murray Channel	Augment unregulated flows to achieve flow at the SA border ≥ 70,000 ML/day for ≥ 30 days.	Sept – Oct, Dec	585.0 GL	▪ Large areas of the South Australian floodplain inundated ▪ See *LTWP* for targets achieved (Department for Environment and Water, 2020)
Weir Pools	Potential operation may be undertaken on the rising or falling limb of the unregulated flows, if feasible in order to extend the duration of inundation – however this will depend on the actual timing and scale of the unregulated flow conditions.			
Chowilla	Potential operation of the regulator may be undertaken on the rising or falling limb of the unregulated flows if feasible, in order to extend the duration of inundation – however this will depend on the actual timing and scale of the unregulated flow conditions.			
Katarapko	As above for Chowilla			
Pike	As above for Chowilla			
Wetlands	Delivery of water to up to 3 priority wetlands	All year	1.9 GL	Same as identified for wetlands in wet AOO (but less wetlands needing to be pumped as most are inundated via flows forecast in the AOO).
LLCMM	**Option A**: Flows on end of unregulated event to slow recession and maintain higher barrage release volumes through summer	Nov – Mar	500 GL	Spring and summer outcomes for Coorong North and South Lagoon ecology, in particular *Ruppia tuberosa* and estuarine fish recruitment
	Option B: winter flow pulse for lamprey and congolli migration	June	120 GL	Promote conditions to support lamprey and congolli migration (Goolwa, Mundoo and Tauwitchere prioritised)

Published by the Department for Environment and Water.
Government of South Australia
June 2021

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ABN 36702093234

Report prepared by:
Department for Environment and Water
Water and River Murray Branch
Water Infrastructure and Operations Directorate

www.environment.sa.gov.au

Government of South Australia

Department for Environment and Water