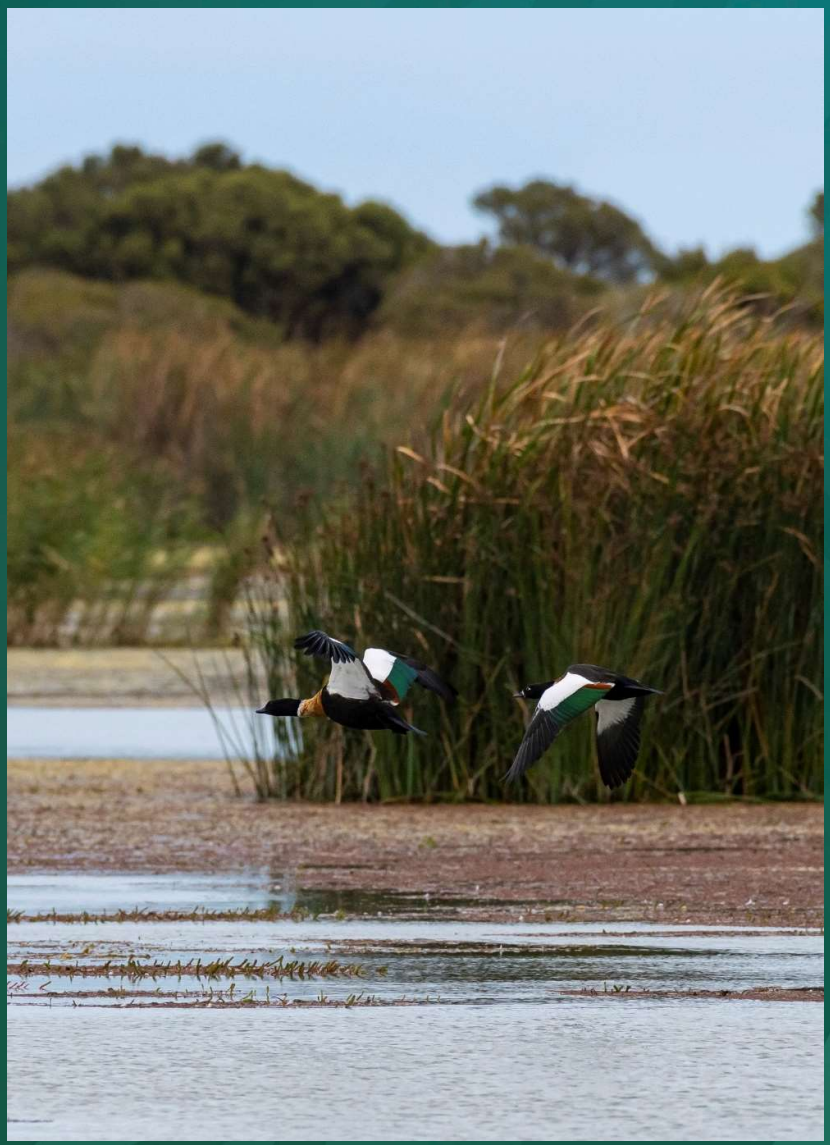
South Australian River Murray Water for the Environment Report 2021-22



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 Government of South Australia 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.

First Nations peoples should be aware that this publication may contain images of deceased persons or culturally sensitive material.

Acknowledgments

The South Australian River Murray Water for the Environment Report was prepared by staff in the Department for Environment and Water with contributions from the Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust, Nature Foundation and Renmark Irrigation Trust. A draft was provided to the Commonwealth Environmental Water Office and The Living Murray Program, with their feedback improving the quality of the Report.

The following agencies and organisations are acknowledged for their important role in management of water for the environment:

- Accolade Wines, Banrock Station
- Aquasave - Nature Glenelg Trust
- Australian Landscape Trust, Calperum Station
- Bio-R Oz Pty Ltd
- BirdsSA
- Chowilla Community Reference Committee
- Commonwealth Environmental Water Office
- Commonwealth Scientific and Industrial Research Organisation
- Coorong, Lower Lakes and Murray Mouth Community Advisory Panel
- Coorong, Lower Lakes and Murray Mouth Scientific Advisory Group
- First Peoples of the River Murray and Mallee Region
- Flinders University
- Gerard Country Ranger Team
- Investigator College
- Katarapko Community Advisory Panel
- Murray-Darling Basin Authority, including The Living Murray program
- Murraylands and Riverland Landscape Board
- Nature Foundation
- New South Wales Department of Planning, Industry and Environment
- Ngarrindjeri Aboriginal Corporation
- Pike Community Reference Committee
- Pike River Land Management Group
- Raukkan Community Council
- Renmark Irrigation Trust
- River Murray and Mallee Aboriginal Corporation
- River Murray Channel and Floodplain Scientific Advisory Group
- SA Water
- South Australian Research and Development Institute
- The Conservation and Hunting Alliance of SA
- The University of Adelaide
- The Goolwa to Wellington Local Action Planning Inc.
- The Mannum Aboriginal Community Association Incorporated
- The National Trust (Overland Corner)
- The Regent Parrot Recovery Team
- Treasury Wines
- Victorian Environmental Water Holder
- Wetland Habitats Trust

Cover image: Australian shelduck (*Tadorna tadornoides*) at Hindmarsh Island. Credit: John Kruger.

Foreword

The 2021-22 water year was exciting and unique. Extensive rainfall across the Murray-Darling Basin resulted in ongoing elevated flow conditions in the South Australian River Murray commencing mid-July 2021 and persisting for the remainder of the water year. Over 5,300 gigalitres (GL) of unregulated flows arrived at the South Australian border and was preserved for environmental outcomes. Importantly, these outcomes were supported and enhanced through the delivery of approximately 1,200 GL of water for the environment, which is equivalent to 13% of all flows across the South Australian border. Water for the environment was delivered through a collaborative effort and from a variety of sources.

Highlights of 2021-22 include:

- Prolonged, elevated in-channel flows for almost the entire water year resulting in a productive riverine environment and successful breeding by native fish.
- Successful implementation of a Lake Victoria Directed Release action, which used approximately 35 GL of held environmental water to alter operations of the Lake Victoria storage and enhance flow to South Australia.
- Over 6,185 GL was released from the barrages, supporting improved water level and salinity in the Coorong South Lagoon for *Ruppia tuberosa,* which forms critical habitat and foodweb components of the Coorong.
- Operations of regulators on Chowilla, Pike and Katarapko floodplains in conjunction with raising Locks 4, 5 and 6, inundating an additional 7,644 hectares of floodplain.
- A lake level cycle successfully completed at the Lower Lakes, reducing Lake Albert salinity by approximately 100 electrical conductivity (EC).
- Managing over 100 permanent and ephemeral wetlands, providing important habitat for threatened species.

The management of environmental water remains a significant focus area for the South Australian Government during periods of elevated flows. These conditions provide important opportunities to enhance flow and continue the recovery of the River Murray system in South Australia and across the Basin more broadly. Ongoing monitoring programs are essential in being able to assess the outcomes of the delivery of water for the environment. Monitoring results are fed back into the planning process and used to support future watering decisions in an adaptive management framework.

Hydroprogne caspia (Caspian tern) family at Pike floodplain.

Abbreviations

AHD	Australian Height Datum
AOO	annual operating outlook
AWA	Aboriginal Waterway Assessment
CAMBA	China-Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
CLLMM	Coorong, Lower Lakes and Murray Mouth. Also refers to the Lower Lakes, Coorong and Murray Mouth TLM Icon Site.
DEW	Department for Environment and Water
EC	electrical conductivity
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
Flow-MER	CEWO's Monitoring, Evaluation and Research (Flow-MER) Program
GL	Gigalitres
HEW	held environmental water
IPP	The Living Murray's Indigenous Partnerships Program
JAMBA	Japan-Australia Migratory Bird Agreement
MDBA	Murray–Darling Basin Authority
ML	Megalitres
NAC	Ngarrindjeri Aboriginal Corporation
NPW Act	*National Parks and Wildlife Act 1972*
QSA	flow at the South Australian border
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RMIF	River Murray Increased Flow
SA River Murray LTWP	Long-Term Environmental Watering Plan for the South Australian River Murray
SCBEWC	Southern Connected Basin Environmental Watering Committee
TLM	The Living Murray Program
VEWH	Victorian Environmental Water Holder
YOY	young of year

Neobatrachus sudelli (Sudell's frog) at Lake Limbra, Chowilla. Credit: Helga Kieskamp.

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Introduction and Purpose

The planning, delivery, monitoring, evaluation and reporting of water for the environment within the South Australian River Murray is coordinated by the Department for Environment and Water (DEW) in collaboration with other government agencies, research organisations, non-government organisations and community groups.

The primary purpose of this report is to provide a complete and public record of all environmental watering actions, regardless of water holder or manager, undertaken in the South Australian River Murray region throughout the 2021-22 water year. It is in addition to the reporting undertaken by DEW to meet the requirements of the Murray-Darling Basin Plan (Basin Plan). It fulfils the South Australian government's commitment to the Council of Australian Governments to publish an annual report on the use of River Murray water for the environment in South Australia for public information sharing (National Water Initiative Policy Guidelines for Water Planning and Management; COAG, 2010).

Water for the environment delivered in 2021-22 was provided by a number of water holders including the South Australian Minister for Climate, Environment and Water, the Commonwealth Environmental Water Holder (CEWH), The Living Murray (TLM) program, the Victorian Environmental Water Holder (VEWH) and New South Wales (NSW) Department of Planning and Environment (DPE). Along with DEW, there are a number of non-government organisations also involved in delivering this water to sites located throughout the South Australian River Murray, particularly the Murraylands and Riverland Landscape Board, Renmark Irrigation Trust, Australian Landscape Trust, Nature Foundation and Accolade Wines.

Throughout this report, 'water for the environment' refers to *held environmental water*, which is water available under a water access right (e.g. water licence) for the purposes of achieving environmental outcomes, as well as other water entitlements and allocations that were specifically used to support environmental outcomes. These outcomes are also underpinned by *planned environmental water*, which is water protected via a plan or legislation and cannot be used for non-environmental purposes (unless in an emergency). Receiving planned environmental water is critically important to achieving environmental outcomes in South Australia. In 2021-22, a significant volume of planned environmental water in the form of unregulated flows arrived in South Australia and supported environmental watering actions throughout the region.

This report provides a record of environmental watering activities along the South Australian River Murray during the 2021-22 water year and includes:

- an overview of river conditions in 2021-22
- a summary of the water for the environment actions undertaken, including sites and volumes
- key environmental observations and outcomes
- a list of reports that provide detailed information about monitoring and ecological outcomes.

Vegetation assessments at North Purnong. Credit: Sam Hardy, Murraylands and Riverland Landscape Board.

Planning for Environmental Watering

The watering actions undertaken throughout the 2021-22 water year were identified in the 2021-22 Water for the Environment Annual Plan for the South Australian River Murray (2021-22 Annual Plan; DEW, 2021) and guided by the Basin Annual Environmental Watering Priorities 2021–22 (MDBA, 2021), the Basin-Wide Environmental Watering Strategy (MDBA, 2019) and the Long-Term Environmental Watering Plan for the South Australian River Murray Water Resource Plan Area (SA River Murray LTWP; DEW, 2020). These documents (available on the DEW website), together with site-based management plans, describe key ecological objectives and targets for environmental watering in South Australia.

The 2021-22 Annual Plan describes the planning process undertaken in the lead up to the water year. A scenario-based planning approach is used, which enables flexibility in the delivery of water for the environment depending on the flow conditions experienced. The scenarios used in planning for 2021-22 are shown in Figure 1.

All environmental water and site managers in the region are invited to participate in the planning process which benefits from the input of Traditional Owner groups, scientific experts and community groups, including the Coorong, Lower Lakes and Murray Mouth (CLLMM) Community Advisory Panel, Chowilla Community Reference Committee, CLLMM Scientific Advisory Group, the Ngarrindjeri Aboriginal Corporation and the River Murray Mallee Aboriginal Corporation.

The proposed watering actions were submitted to the Southern Connected Basin Environmental Watering Committee (SCBEWC) and the Commonwealth Environmental Water Office (CEWO) in early 2021 to inform decisions on the use of water for the environment in South Australia as well as system-scale planning for the southern Murray-Darling Basin. Representatives from South Australia, as well as New South Wales, Victoria, MDBA, the VEWH, the CEWH, Murray Lower Darling Rivers Indigenous Nations (MLDRIN) and the Commonwealth Government are members of SCBEWC[1].

Planning for Flexible Management

To facilitate the planning process, MDBA provide annual operating outlooks (AOOs) for the water year ahead, which describe hypothetical flow conditions under a range of climate scenarios (Figure 1). DEW and site managers plan for environmental watering actions based on these flow scenarios, as described in the 2021-22 Annual Plan (DEW, 2021). It should be noted that while these scenarios are useful for planning purposes, they are indicative only, and may or may not reflect the conditions that occur.

Comparison of the actual flow to South Australia (without additional water for the environment) in 2021-22 indicates the 'near average' and 'wet' planning scenarios were most relevant through the spring of 2021-22 when the majority of environmental watering actions were undertaken (see dashed line in Figure 1).

More information on the actions planned for the 'near average' and 'wet' scenarios, and an indication of which of these were achieved, is shown in Appendix A.

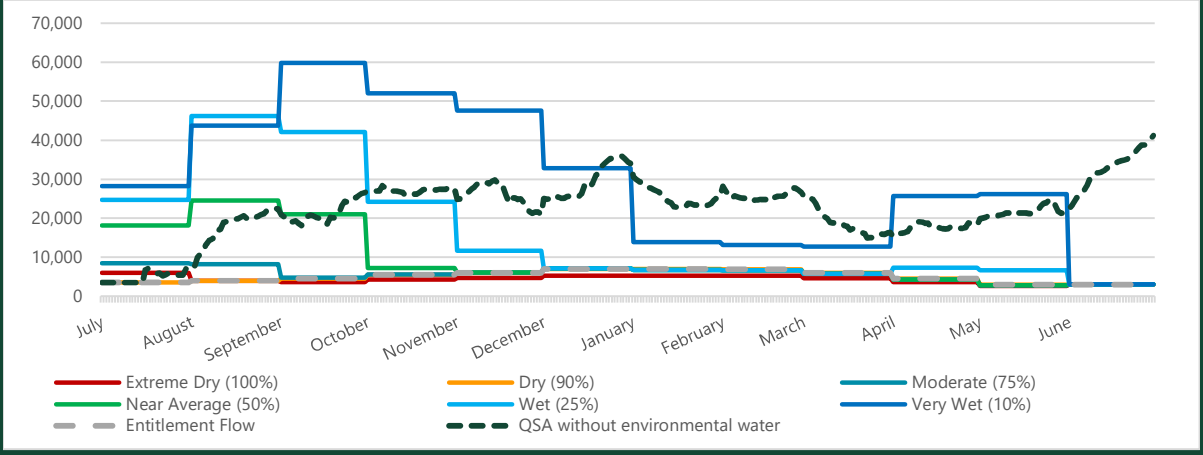


Figure 1. Actual flows to South Australia (QSA) in 2021-22 without water for the environment compared to planning scenarios.

[1] For more information regarding SCBEWC, refer to their annual reports

Overview of Flow Conditions in 2021-22

Wet conditions

2020-21: Moderate
2019-20: Dry

9,134 GL total flow across the South Australian border

2020-21: 3,080 GL
2019-20: 2,389 GL

The 2021-22 water year saw wet climatic conditions across the Murray-Darling Basin, following moderate conditions in 2020-21 (Bureau of Meteorology, 2022). Temperatures across the Basin were generally average to above average, creating warm, wet conditions for much of the year (Figure 3). Overall, Basin inflows were double the volumes recorded for 2020-21, and around 3,550 GL above the long-term average (MDBA, 2022).

High inflows from Murray tributaries resulted in the MDBA declaring unregulated flows at the South Australian border from 15 July 2021. Widespread winter and spring rainfall in the Northern Basin, Murray and Murrumbidgee River catchments saw continued unregulated conditions in South Australia for the remainder of the water year. Unregulated flows contributed over 5,315 GL to the total volume of 9,134 GL that arrived in South Australia in 2021-22.

The 2021-22 water year was unique when compared to conditions observed in recent decades, with elevated in-channel flows in South Australia for the entire year, apart from July 2021. Flows to South Australia during the critical spring/summer period were above 20,000 ML/day, peaking in late December 2021 at 37,542 ML/day (Figure 2). The water year ended with flows to South Australia exceeding 40,000 ML/day. Modelling by the MDBA indicates that, under natural conditions[1], flow at the South Australian border would have exceeded 50,000 ML/day throughout spring, peaking at around 75,000 ML/day in September.

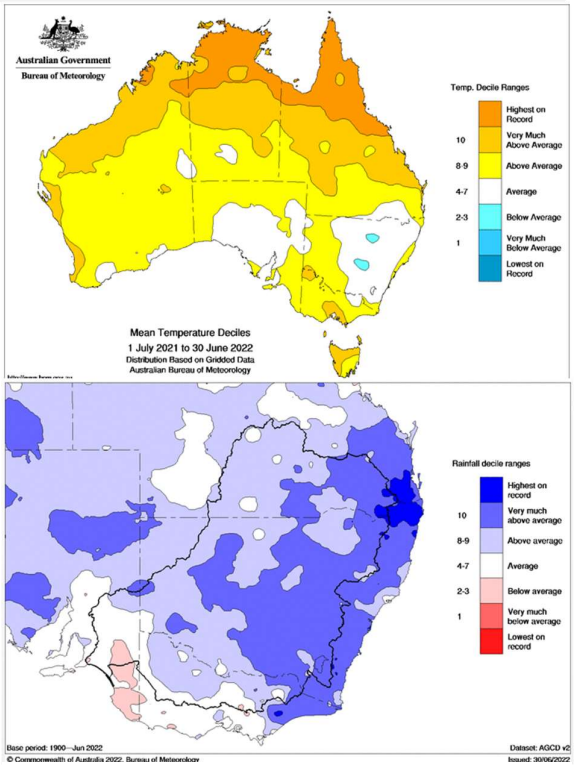


Figure 3. Australian mean temperature deciles (top) and Murray-Darling Basin rainfall deciles (bottom) 1 July 2021 to 30 June 2022. Source: Bureau of Meteorology.

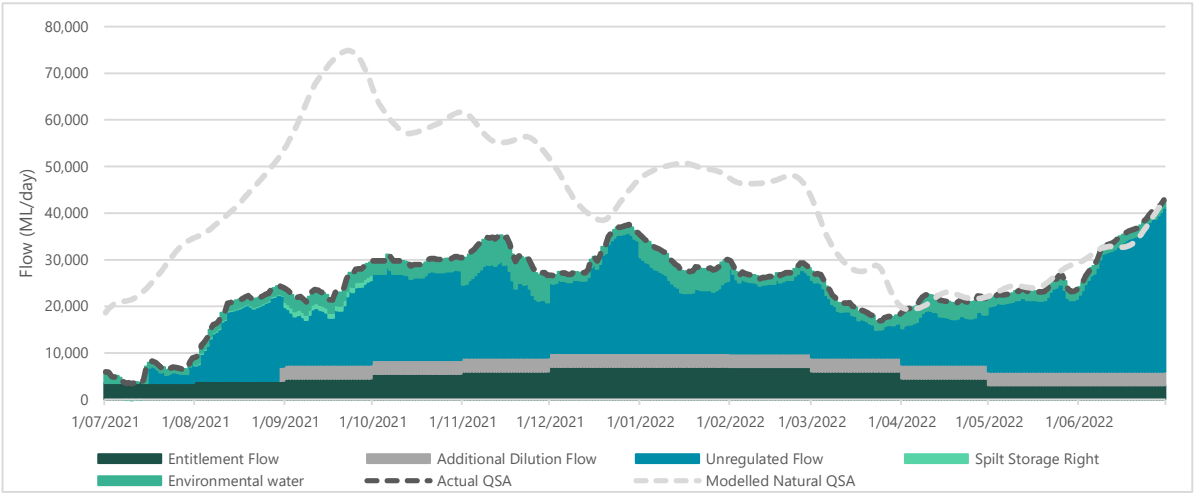


Figure 2. River Murray flows at the South Australian border (QSA) in megalitres per day (ML/day) during 2021-22.

[1] Natural conditions are representative of the scenario with no dams, weirs and consumptive diversions from the river but does not exclude impact of land use changes or levees in the river system.

Environmental Water Delivery

1,214 GL water for the environment

5,315 GL unregulated flows over almost 12 months

6,161 GL released out the barrages

14 GL pumped to wetlands and floodplains

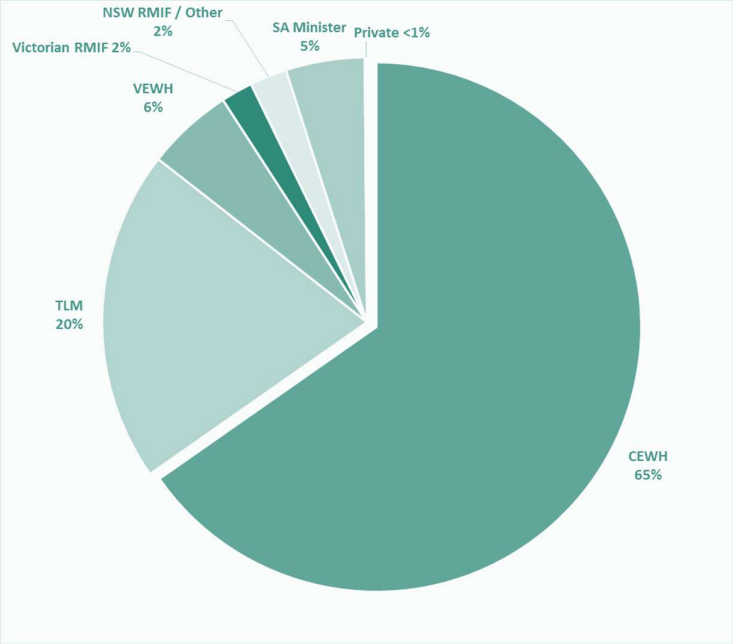
109 wetlands managed using water for the environment

3 major floodplain regulators operated

4 weirs on the main channel manipulated

1 Lower Lakes water level cycling event

In total, approximately 1,214 GL of water for the environment was delivered to South Australia (Figure 4). The CEWH provided approximately 793 GL (including approximately 162 GL held on licences in South Australia) and TLM provided approximately 246 GL (including 45 GL held on licences in South Australia). South Australia also received approximately 115 GL of water for the environment in the form of VEWH, NSW DPE and River Murray Increased Flow (RMIF) return flows from upstream. Approximately 44 GL of water for the environment held in South Australia by the South Australian Minister for Environment and Water was delivered. Environmental watering actions were also supported by a small volume of water for the environment held on a private licence and approximately 15 GL of consumptive water acquired and used for environmental outcomes in 2021-22 (Appendix B).



The majority of water for the environment (1,175 GL or ~97%) received by South Australia made its way along the length of the South Australian River Murray to the Lower Lakes and was released out the barrages, providing water quality and ecological benefits throughout the system. The remaining 3% (39 GL) of water for the environment was shared between over 100 wetlands. A number of watering actions were also supported by unregulated flows, including operation of the three floodplain environmental regulators, manipulation of four of the six main channel weirs and management of a small number of wetlands (Appendix B).

Figure 4. Proportion of water for the environment delivered to SA that was contributed by each water holder in 2021-22:

- *CEWH = Commonwealth Environmental Water Holder*
- *TLM = The Living Murray Program*
- *SA = SA Minister for Climate, Environment and Water*
- *VEWH = Victorian Environmental Water Holder*
- *RMIF = River Murray Increased Flow*

Werta Wert Wetland, Chowilla Floodplain

Outcomes of Water Delivery

To understand the ecological outcomes of the watering events undertaken within the SA River Murray, various monitoring programs have been implemented. Monitoring programs vary from a whole-of-Basin scale, such as CEWO's Monitoring, Evaluation and Research (Flow-MER) Program and TLM condition and intervention monitoring, to smaller site-scale programs funded variously by federal and state governments.

The following section provides a snapshot of outcomes observed at key watering sites and the water for the environment that supported these outcomes.

Aquatic vegetation at Beldora Lagoon. Credit: Stephanie Robinson, Murraylands and Riverland Landscape Board.

South Australian River Murray Channel and Floodplain

A suite of major environmental watering events occurred across the South Australian River Murray Channel and Floodplain in 2021-22. These included operations of the Chowilla, Pike and Katarapko floodplain regulators (in conjunction with raising of main channel Weirs 6, 5 and 4) and manipulation of Weir 2, all of which used unregulated flows. In addition, the elevated flows in the main River channel were enhanced for most of the year through the delivery of water for the environment. The outcomes of these watering actions are summarised in this section.

River Murray Channel Flows

6,412,673 ML delivered (5,237,808 ML of this was unregulated flows)

>600 River km watered

Site Water Manager: DEW

Source of water: CEWH, TLM, RMIF, VEWH, NSW DPE, SA, unregulated flows

Specific Ecological Objectives:

- Improved hydraulic conditions by increasing availability of fast flowing water.
- Facilitate the movement of carbon and nutrients between the floodplain and the river channel.
- Establish and maintain a diverse riparian plant community through beneficial groundwater and soil moisture conditions.
- Support long lived vegetation (e.g. *Eucalyptus camaldulensis* (river red gum), *Eucalyptus largiflorens* (black box), *Acacia stenophylla* (river cooba) and *Duma florulenta* (lignum)).
- Support spawning and recruitment of flow-cued and large-bodied native fish.
- Provide refuge habitats and breeding opportunities for a range of biota, including frogs.

Outcomes:

In 2021-22, flows to South Australia exceeded 20,000 ML/day for the first time since 2016, which historically would have occurred almost annually. These elevated flows were largely generated by unregulated flows arising in the upstream catchments, however, water for the environment played an important role in preventing flows from dropping below 20,000 ML/day at critical times of the year. The water for environment was largely return flows from upstream watering actions, which included releases from Hume Dam for outcomes at Barmah-Millewa Forest and a spring pulse in the Goulburn River. Approximately 35,000 ML of water for the environment was also released from Lake Victoria to enhance flow at the South Australian border in November and December. This important action saw flows between mid-December and mid–January remain above 30,000 ML/day generating average velocities above 0.3 m/s. These improved velocities were further supported by returning the weirs that had been raised for floodplain watering actions back to normal pool level and, in the case of Weir 2, further dropping water levels below normal pool level.

Riparian vegetation following inundation along the edge of the River channel at Overland Corner.

The increased water velocities in the River Murray channel created a temporary shift to a more 'lotic' or flowing river, which has been significantly impacted by river regulation in the Lower Murray in particular. These conditions are important for the breeding of flow-cued fish such as *Macquaria ambigua* (golden perch) and *Bidyanus* (silver perch; critically endangered under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*). Increased channel flows also assist with the downstream transport of seeds and eggs, as well as preferred food resources for native fish such as rotifers (a type of microinvertebrate). While negligible spawning and recruitment of *Maccullochella peelii* (Murray cod; vulnerable under the EPBC Act 1999) was observed in the Lower Murray in 2021-22, monitoring through the CEWO Flow-MER program detected abundant sub-adults, indicating that flow conditions have supported the survival of Murray cod believed to have been spawned during a breeding event in 2019-20 (Ye pers. comm 2022).

Spawning success for golden perch

The increased flows and lotic river conditions through spring and summer were conducive for the spawning of golden perch and the endangered silver perch. During spring-summer, eggs and larval golden perch and silver perch were detected along the entire reach of the Lower Murray by South Australian Research and Development Institute scientists during sampling for the CEWO Flow-MER Program. Subsequently, in autumn, young of year (YOY) golden perch and silver perch were sampled during electrofishing recruitment surveys. The golden perch recruitment event appears to be the largest of its kind in the Lower Murray since the high flow period from 2010-2014.

The images show different perch (either golden or silver) life stages observed during 2021-22, including:

a) Silver perch larvae, January 2022 downstream Lock 1
b) Golden perch larvae, January 2022 downstream Lock 6
c) Golden perch young-of-year, March 2022, downstream Lock 3

Photo credit: SARDI Aquatic Sciences

Lock 2 Weir Pool

1,264 ML delivered July -Dec

297 ha watered

Site Water Manager: DEW

Source of water: Unregulated flow

Specific Ecological Objectives:

- Facilitate the movement of carbon and nutrients between the floodplain and the river channel.
- Establish and maintain a diverse floodplain plant community through beneficial groundwater and soil moisture conditions.
- Support long lived vegetation (e.g. river red gum, black box, river cooba and lignum).
- Increase complexity of riparian, wetland and floodplain habitats, and thus increase diversity and abundance of shelter and food resources
- Enhance velocity and hydraulic diversity in the river channel during spring pulses.

Outcomes:

Weir 2 was manipulated for ecological outcomes between July and December 2021. Weir 2 was raised by 0.55 m above normal pool level to achieve a raised level of 6.65 m AHD. This high water level was maintained for 60 days during winter, with variation in water level of up to 0.10 m above and below the targeted peak water level achieved. Water level was steadily reduced over late winter-early spring and held almost 0.08 m below normal pool level until a steady but variable rise in water level in late spring-early summer to return to normal pool level.

Unregulated flows provided the water required to undertake the Weir 2 environmental watering action. By undertaking a weir pool raising in conjunction with the elevated flows in the River, the water level along the length of the weir pool was increased which in turn increased the area of inundation. Higher flows increased the extent of faster flowing lotic habitats along the River Murray. Weir pool lowering further enhanced the lotic (flowing) conditions and the ecological outcomes associated with a flowing river, particularly during spring.

Weir Pool 6 tree condition monitoring at Murtho

Chowilla Floodplain and Lock 6 Weir Pool

44,989 ML delivered Aug – Dec

4,194 ha watered

Site Water Manager: DEW

Source of water: Unregulated flow, TLM

Specific Ecological Objectives:

- Support long lived vegetation (e.g. river red gum, black box, river cooba and lignum).
- Establish and maintain a diverse floodplain plant community by providing beneficial groundwater and soil moisture conditions.
- Facilitate the movement of carbon and nutrients between the floodplain and the river channel
- Provide habitat for feeding and breeding opportunities for a range of biota, including waterbirds, frogs and native fish.

Outcomes:

Operation of the Chowilla Floodplain regulator occurred from late winter to early summer 2021, in conjunction with the raising of Weir 6. The Chowilla Floodplain regulator raised water level in Chowilla Creek by 3.29 m to 19.59 m AHD, while Weir 6 was raised by 0.43m to 16.68 m AHD to support flows onto Chowilla Floodplain. Following the operation, elevated flow conditions provided continued strong flows in the Chowilla anabranch, providing important habitat for large bodied native fish. Sampling undertaken in early 2022 found high numbers of adult Murray cod present across the Chowilla Floodplain and adjacent River Murray channel (Fredberg, Bice, & Zampatti, in prep). Recruitment of golden perch was also recorded during this sampling.

All of Chowilla's major wetlands received water during the floodplain inundation event, including Werta Wert, Lake Limbra and Coppermine Waterhole. Coppermine Waterhole in particular filled completely and spilled onto the surrounding floodplain. Soil moisture conditions along creek banks, wetlands and areas of floodplain improved (Wallace T. , in prep(a)), with a positive response observed in tree health and understorey vegetation (Wallace T., in prep(b); Nicol, et al., in prep).

Breeding birds were observed at several sites across Chowilla, with *Biziura lobata menziesi* (musk duck, rare under the *National Parks and Wildlife (NPW) Act 1972*) and a young *Aquila audax* (wedge-tailed eagle) successfully fledged at Werta Wert wetland, whilst *Himantopus leucocephalus* (pied stilt) were seen with independent young at Lake Limbra and Coombool Swamp. All 8 species of frog expected in the region, including *Litoria raniformis* (southern bell frog; vulnerable under the *EPBC Act 1999*) were detected, with tadpole surveys indicating a successful breeding event.

Small-bodied native fish were reasonably diverse across the floodplain during the regulator operation, however at the peak of the operation *Cyprinus carpio* (common carp) dominated the catch. Common carp are known to utilise floodplains, with DEW working with fish ecologists to investigate ways to minimise their impact. Native fauna including several *Chelodina longicollis* (long-necked turtles), medium-sized golden perch, *Nematalosa erebi* (bony bream) and a significant number of shrimp species were also observed during the small-bodied fish monitoring.

In addition to the Chowilla Floodplain regulator operation, water for the environment was delivered via pumping to flood runners in the NSW section of Chowilla Floodplain called Kulcurna[1] and via small scale irrigation to an area of black box trees on Monoman Island.

Floodplain full of foragers

The inundation event at Chowilla floodplain provided conditions for abundant macroinvertebrate productivity as water spread across flats, wetlands and waterholes. This created excellent foraging conditions for wetland birds, attracting a total of 44 species, numbering in the thousands at some wetlands. Hundreds of migratory waders including *Calidris ruficollis* (red-necked stint), *Calidris acuminata* (sharp-tailed sandpiper), *Limosa limosa melanuroides* (black-tailed godwit) and *Tringa stagnatilis* (marsh sandpiper) also stopped at Chowilla on their migration from the northern hemisphere.

Elseyornis melanops (black-fronted dotterel) on Lock 6 Floodplain. Credit: Helga Kieskamp.

[1] The 114 ML of NSW water for the environment that was delivered to Kulcurna wetlands is not included in this report

Pike Floodplain and Lock 5 Weir Pool

6,006 ML delivered July -Dec

2,295 ha watered

Site Water Manager: DEW

Source of water: Unregulated flow

Specific Ecological Objectives:

- Support long lived vegetation (e.g. river red gum, black box, river cooba and lignum).
- Establish and maintain a diverse floodplain plant community through beneficial groundwater and soil moisture conditions.
- Facilitate the movement of carbon and nutrients between the floodplain and the river channel.
- Restore and maintain resilient populations of native fish.
- Provide habitat and breeding opportunities for a range of biota, including waterbirds, frogs, and reptiles.

Outcomes:

Pike Floodplain regulators (Pike regulator and Tanyaca regulator on Pike Creek and Tanyaca Creek, respectively) were operated from late winter to early summer 2021 in conjunction with the raising of Weir 5. The Pike Floodplain regulators raised water level in the Pike anabranch system by 1.25 m to 15.8 m AHD, while Weir 5 was raised by 0.5 m to 16.8 m AHD to support flow into Pike Floodplain.

Following operation of the floodplain regulators, vegetation assessments found that two thirds of river red gums and all of the monitored river cooba were in good condition (Wallace, 2022). However, prolonged dry conditions saw a continued decline in black box condition, particularly at higher elevations beyond the watered areas. Two thirds of the lignum surveyed was in good condition, with decline observed in three unwatered sites (DEW, 2022a).

Pike packed with fish

A total of 10,384 fish from 14 species were recorded during annual fish condition surveys (Fredberg & Bice, 2022). Murray cod, silver perch and *Tandanus tandanus* (freshwater catfish; protected under the South Australian Fisheries Management Act 2007) were among those sampled, with silver perch sampled in the highest abundance since the commencement of surveys in 2009. Murray cod abundance has increased in each of the last three annual surveys.

With elevated within-channel flows throughout the 6 months prior to the annual fish survey, fish assemblages were significantly different to those from preceding years (Fredberg & Bice, 2022). The most notable differences were elevated abundances of small and medium bodied native species such as bony bream and unspecked hardyhead.

Melanotaenia fluviatilis (Murray rainbowfish) at Pike floodplain

Small-bodied fish surveys recorded abundant native *Hypseleotris* spp (carp gudgeon) and *Craterocephalus fulvus* (unspecked hardyhead), confirming their recruitment and survival across the floodplain system (Whiterod, 2021). Six frog species were heard calling across Pike Floodplain in high abundances, including the vulnerable southern bell frog (DEW, 2022b). Tadpoles from 5 of these species were also recorded, confirming successful breeding.

Waterbird surveys during the floodplain watering event recorded 38 species, with a single survey recording 200 *Anas gracilis* (grey teal), 50 *Chenonetta jubata* (maned ducks), and 38 *Tadorna tadornoides* (Australian shelducks) (Cale, 2022). Additionally, 89 Australian shelduck were observed roosting at Pike Regulator Wetland, with many birds in juvenile plumage. Woodland bird surveys conducted in spring and summer recorded 60 species (Cale, 2022). Notable records include *Entomyzon cyanotis* (blue-faced honeyeater), *Nymphicus hollandicus* (cockatiel) and *Todiramphus pyrrhopygius* (red-backed kingfisher).

Katarapko Floodplain and Lock 4 Weir Pool

2,323 ML delivered July -Dec

1,140 ha watered

Site Water Manager: DEW

Source of water: Unregulated flow

Specific Ecological Objectives:

- Support long lived vegetation (e.g. river red gum, black box, river cooba and lignum).
- Establish and maintain a diverse floodplain plant community through beneficial groundwater and soil moisture conditions.
- Facilitate the movement of carbon and nutrients between the floodplain and the river channel.
- Restore and maintain resilient populations of native fish.
- Provide habitat and breeding opportunities for a range of biota, including waterbirds, frogs, and reptiles.

Outcomes:

Katarapko Floodplain regulator was operated from late winter to early summer 2021 in conjunction with the raising of Weir 4. The Splash floodplain regulator raised water levels in Katarapko Creek by 3.2 m to 13.2 m AHD, the highest the regulator has been operated since it was constructed in 2019. Weir 4 was raised by 0.3 m to 13.5 m AHD to support flows into Katarapko Anabranch.

Following Katarapko Floodplain watering, autumn vegetation surveys showed that the majority of river red gums and three quarters of all black box surveyed were in good condition (Wallace T. A., 2022). Most of the black box in poorer condition classes were located in areas beyond the influence of floodplain watering. Native amphibious and flood-dependent understorey plants were present in similar abundance and species diversity to the 2021 survey. Results from both of those years showed a substantial improvement over the 2020 survey, prior to which abundance and species diversity had been in decline since 2017 (DEW, 2022).

The most common native fish recorded at Katarapko during fyke net surveys were carp gudgeon, followed by *Philypnodon grandiceps* (flathead gudgeon) and unspecked hardyhead (Whiterod, 2021). A broad range in size classes observed for these species indicated successful recent spawning and ongoing survival (Whiterod, 2021). *Retropinna semoni* (Australian smelt) and bony bream were the most numerous native fish sampled during annual electrofishing surveys (Fredberg & Bice, 2022). Three species of conservation significance were recorded: Murray cod, silver perch and freshwater catfish (Fredberg & Bice 2022). A *Geotria australis* (pouched lamprey), on its journey from the Southern Ocean to complete spawning, was detected at the Splash Regulator during the managed inundation (Fredberg, Bice, & Thwaites, 2022), an unusual record for Katarapko Floodplain. Invasive common carp were abundant across both fish surveys.

Rendered satellite imagery of Katarapko floodplain at the beginning (left, 15/07/2021) and peak (right, 23/09/2021) of floodplain inundation. Blue indicates inundation extent. Source: Sentinel hub

Birds flock to Katarapko

Inundation at Katarapko floodplain attracted various waterbird species to the site, including 100 *Malacorhynchus membranaceus* (pink-eared ducks) at a single wetland. Waterbird breeding activity was observed across the floodplain, while an immature *Haliaeetus leucogaster* (white-bellied sea eagle; endangered under the *NPW Act 1972*) was observed using the anabranch system. Woodland bird surveys observed *Polytelis anthopeplus* (regent parrot; vulnerable under the *EPBC Act 1999*) utilising the floodplain.

Immature *Haliaeetus leucogaster* (white-bellied sea eagle) at Katarapko floodplain. Credit: Belinda Cale

Flowering *Duma florulenta* (lignum) at Coppermine Waterhole, Chowilla.
Credit: Helga Kieskamp

Wetlands

61,963 ML delivered
22,808 ML of this was unregulated flows

4,836 ha watered

109 wetland sites watered

The delivery of water for the environment and management of wetland sites along the South Australian River Murray was facilitated by various organisations and water holders, including the Murraylands and Riverland Landscape Board, DEW, Accolade Wines, Nature Foundation, Renmark Irrigation Trust and Australian Landscape Trust. A full list of the wetland sites watered in 2021-22 is presented in Appendix C and D.

This section outlines the ecological outcomes observed during the delivery of water to both managed pool-connected wetlands and ephemeral wetlands in 2021-22.

Pool-connected Wetlands

47,555 ML delivered[1] (20,929 ML of this was unregulated flows)

3,628 ha watered

Site Water Managers: DEW, Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust, Nature Foundation

Source of water: SA, private, unregulated flows

In 2021-22, 52 pool-connected wetlands across 40 wetland complexes were managed by various organisations, including DEW, the Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust, and Nature Foundation.

Wetland infrastructure was managed to increase water level variability, including undertaking partial or complete dry phases at wetland sites. Dry phases helped to consolidate sediments and extend riparian vegetation along the wetland fringes, improving water quality and clarity upon refilling. This manipulation of water levels also provides foraging and breeding habitat for waterbirds, frogs and other water-dependant fauna. Water level variation also improved tree health in river red gum, black box, and river cooba, providing habitat for species such as the vulnerable regent parrot.

These watering activities supported 8 frog species, including the vulnerable southern bell frog, across a number of pool-connected wetlands along the South Australian River Murray.

The increased flow conditions pushed water levels higher in many pool-connected wetlands, inundating larger areas of these sites. At the Beldora and Spectacle Lakes Wetland Complex in particular, dry lignum basins that had not been inundated since 2016 received water, with southern bell frogs recorded calling at the site for the first time since 2018.

Abundant habitat at Narrung

An aquatic vegetation boom resulting from a successful dry and refill of Narrung wetland in 2019-20 continued to provide significant habitat opportunities in 2021/22. Native fish, such as *Atherinosoma microstoma* (smallmouth hardyhead), *Philypnodon grandiceps* (big-headed gudgeon), and *Afurcagobius tamarensis* (Tamar River goby), comprised 95-98% of the fish assemblage in spring 2021 and autumn 2022.

Fish monitoring at Narrung wetland. Credit: Sam Hardy, Murraylands and Riverland Landscape Board.

[1] This volume included 285 ML of privately held All Purpose Consumptive (Class 8) water delivered to Paiwalla wetland and 1,232 ML of All Purpose Consumptive (Class 3) water held by the SA Minister for Environment and Water delivered to Loveday Basins (North and South).

Ephemeral Wetlands

14,407 ML delivered[1] (1,879 ML of this was unregulated flows)

1,208 ha watered

Site Water Managers: DEW, Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust, Nature Foundation, Renmark Irrigation Trust

Source of water: CEW, SA, unregulated flows

During 2021-22, 57 ephemeral wetlands received water for the environment, including 3 wetlands in the Lower Lakes region. Management of ephemeral wetlands was undertaken by 7 organisations; DEW, the Murraylands and Riverland Landscape Board, Accolade Wines, Nature Foundation, Australian Landscape Trust, and Renmark Irrigation Trust. Below is a summary of the key ecological outcomes observed by each organisation at their ephemeral wetland sites.

Murraylands and Riverland Landscape Board

Water for the environment was delivered to 28 ephemeral wetlands in 2021-22. This water stimulated an extensive bird breeding response, most notably of piscivorous (fish eating) species such as *Phalacrocorax carbo* (great cormorant) and *Anhinga novaehollandiae* (Australian darter) at Nikalapko and Markaranka.

Long lived vegetation, such as river red gum, black box, and river cooba responded positively to watering, with increased canopy growth observed at a majority of wetlands. Germination of river red gums was also observed at numerous sites, including Markaranka, Wigley Reach, Murtho-Wiela Connector, Old Parcoola, Maize Island and Akuna.

Golden perch and freshwater catfish were detected at Bookmark Creek in early autumn 2022, demonstrating the value of flowing habitat for native large-bodied fish species. The endangered *Craterocephalus fluviatilis* (Murray hardyhead; *EPBC Act 1999*) were also supported at Berri Evaporation Basin.

Shorebirds were supported at Tolderol Game Reserve Wetlands, with cryptic waterbird species including *Porzana fluminea* (spotted crake), *Zapornia tabuensis* (spotless crake), *Lewinia pectoralis* (Lewin's rail) and *Gallirallus philippensis mellori* (buff-banded rail) regularly observed during late summer and autumn 2022.

An additional 15 ephemeral wetlands planned to receive water for the environment in 2021-22 via pumping were instead inundated, either fully or partially, by increased river flows. The extent of inundation varied depending on the site's elevation. Several wetlands were flooded higher than could have been achieved by pumping, reaching stressed floodplain plants. Although some sites were only partially inundated, connectivity with the River Murray provided an opportunity to export accumulated salts, nutrients, and carbon.[1]

A blanket of blossoms at Markaranka

Herbs, grasses, and native lilies blanketed the ground with in response to water delivery at Markaranka. These plants are known food sources for the vulnerable regent parrot and may act to reduce the distance nesting parrots have to travel to forage.

Timing and duration of watering were critical to ensuring plants were present at the time parrots began nesting. Pumping started in autumn to a shallow depth and the site was allowed to dry directly after. The rapid germination of many plant species demonstrated the floodplain's healthy seed bank. By winter, plants had matured and begun producing fruit and seed in time for the regent parrot nesting period. The variety of species observed included *Atriplex semibaccata* (creeping saltbush), *Alternanthera spp.* (joyweed), and *Lepidium spp.* (peppercress).

[1] This volume included 624 ML of All Purpose Consumptive (Class 3) water held by the SA Minister for Environment and Water pumped to Tolderol Game Reserve Wetlands for environmental outcomes.

Accolade Wines

One wetland received environmental water in spring of 2021 on Banrock Station. Lignum and understorey plant communities responded positively to watering, with recruitment of black box and river red gum seedlings. *Elseyornis melanops* (black-fronted dotterel) were found nesting along the edge of the lagoon, their chicks successfully fledging.

Nature Foundation

Nature Foundation managed the delivery of water for the environment to 12 temporary wetlands in 2021-22. Watering at Warnock/Lescheid Wetland on Pike Floodplain supported the vulnerable southern bell frog, while approximately 26 vulnerable regent parrots were observed following watering at Murbpook Lagoon. Other wetland sites experienced positive vegetation responses to watering, including the recruitment of black box seedlings at some sites.

Australian Landscape Trust

Eight wetlands received water for the environment on Calperum Station in 2021-22. Wetland watering prompted *Podiceps cristatus australis* (great crested grebe; rare under the *NPW Act 1972*) breeding, with 7 nests and at least 7 juveniles successfully fledging around Lake Woolpolool. A small breeding event of *Cygnus atratus* (black swan) also occurred, with approximately 20 nests producing 50 cygnets. Environmental watering sites provided essential feeding habitat for juvenile swans.

Numerous migratory bird species listed in Japan, China, and Republic of Korea – Australia Migratory Bird Agreements (JAMBA; CAMBA; ROKAMBA) were observed using wetland sites, including sharp-tailed sandpipers, red-necked stints, and *Hydroprogne caspia* (Caspian terns).

Regent parrots at Murbpook Lagoon

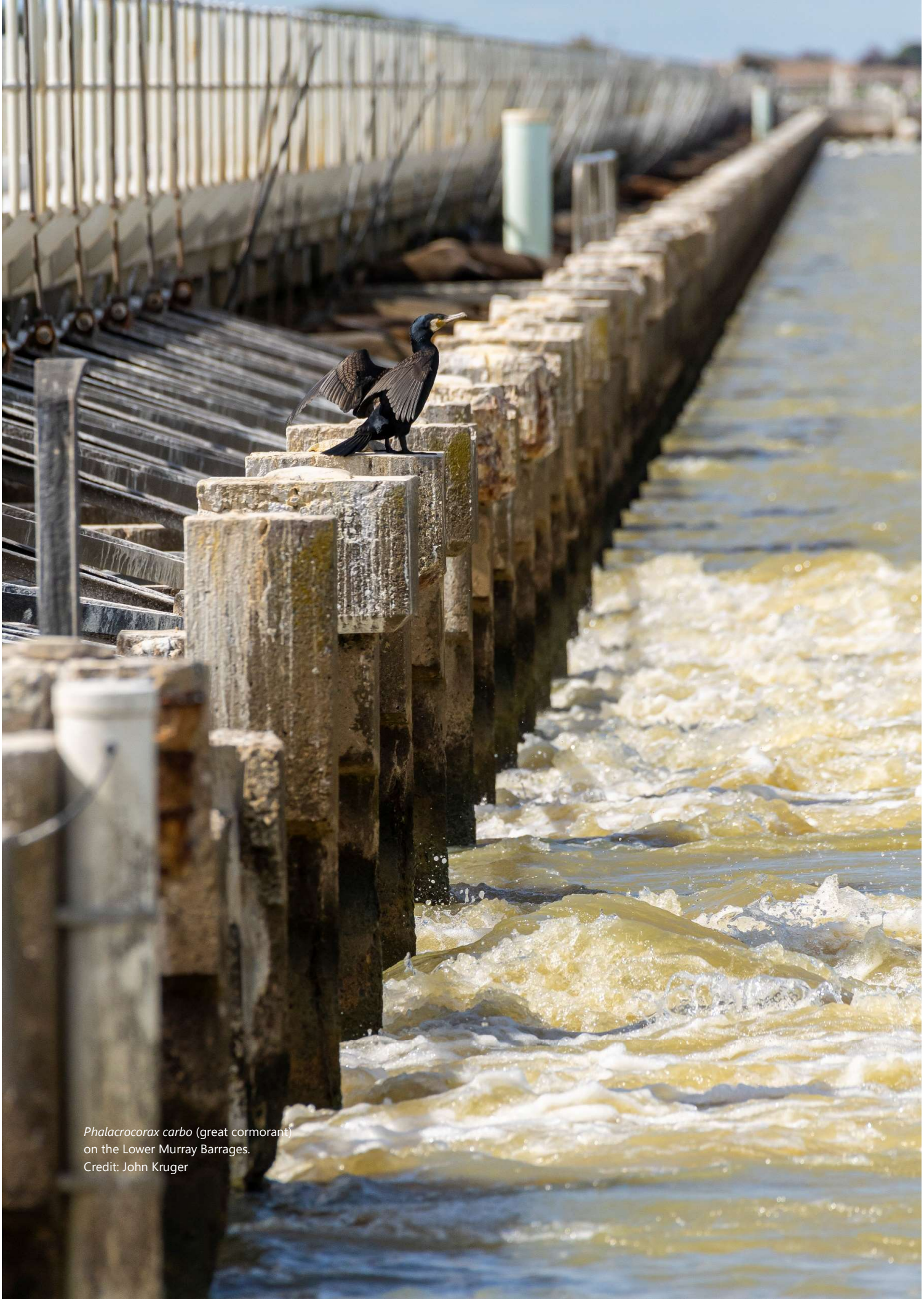
Flocks of the vulnerable regent parrot have been observed across Murbpook Lagoon, with approximately 26 individuals counted in total. Three parrots were observed in a single tree, which may have been used for breeding (photo below). These are all encouraging signs ahead of the coming breeding season.

*Polytelis anthopeplus (*regent parrot) at Murbpook Lagoon. Credit: Coral Johnston.

Himantopus leucocephalus (pied stilt) at Warrego Street wetland. Credit: Grant Schwartzkopff.

Renmark Irrigation Trust

Water for the environment was pumped to 8 temporary wetlands by Renmark Irrigation Trust in 2021-22. Long lived vegetation such as river red gums and black box were supported by the watering, while understorey vegetation improved in condition. Following inundation, increased observations of various waterbird and frog species were recorded at all sites, with southern bell frogs observed at Johnsons Waterhole.



Phalacrocorax carbo (great cormorant) on the Lower Murray Barrages.
Credit: John Kruger

Coorong, Lower Lakes and Murray Mouth

6,398,055 ML delivered to the CLLMM
5,223,188 ML of this was unregulated flows

142,500 ha watered

6,161,000 ML released out the barrages
3,859,538 ML of this was unregulated flows

Lake Level Management and Barrage Releases

Ecological Objectives:

- Facilitate the movement and recruitment of diadromous fish.
- Create favourable water level and salinity conditions in the Coorong to support the Coorong foodweb, aquatic vegetation particularly *Ruppia tuberosa,* estuarine fish, waterbirds and benthic invertebrate populations.
- Support the recruitment of threatened fish and frog populations in the Lower Lakes wetlands.
- Establish and maintain diverse aquatic vegetation in the Lower Lakes wetlands.

Fish monitoring in the Lower Lakes. Credit: J Kruger.

Outcomes:

Approximately 6,161,000 ML of water was released out the barrages in 2021-22, which included water for the environment and unregulated flows. These barrage releases exceeded the 3-year rolling average Basin Plan minimum of flows over the barrages, the first time this has occurred since 2018-19. Flow over the barrages helped export salt from the Murray-Darling Basin and provided continuous connectivity between the River Murray and Coorong Estuary.

Despite the increased flows over the barrages, fishway monitoring showed only moderate abundances of young of year (YOY) *Pseudaphritis urvillii* (congolli) and *Galaxias maculatus* (common galaxias) migrating upstream from the Coorong to Lake Alexandrina, with abundances only just meeting the minimum target threshold (Bice et al. 2022 in prep). It is unknown why abundances of migrating YOY fish were lower than in recent years.

Salt Creek Releases

Following high rainfall in the region, the South East Flows Restoration Project infrastructure at Salt Creek and Morella Basin was utilised for the first time since construction was completed in 2019. Flows between 200-800 ML/d were released from Salt Creek to the Coorong South Lagoon during August and September 2021. Following this event, the Salt Creek and Morella fishways were assessed for the first time, with 61,361 fish from seven different native species detected. The study recommended that flows through fishways to facilitate fish passage should be prioritized when water is available (Ye et al. 2022).

Aldrichetta forsteri (yelloweye mullet), congolli and smallmouth hardyhead sampled during Salt Creek Fishway monitoring. Credit: Qifeng Ye


Various waterbird species feeding in the Coorong. Credit: J Kruger

As a result of the increased inflows, water levels in the Lower Lakes remained relatively high. This, along with consistent flow through the barrages, assisted in reducing salinity in Lake Alexandrina from 1000 EC in 2020-21 to 300-400 EC in 2021-22. Aquatic plant communities in the Lower Lakes responded positively to these conditions, with an increase in submerged aquatic vegetation at some sites. *Nannoperca australis* (southern pygmy perch; vulnerable under the *EPBC Act 1999*) were recorded in the highest abundances since the Millennium Drought, while the endangered Murray hardyhead were only recorded in low numbers in November 2021 (Wedderburn et al. 2022).

In early August 2021, water levels in the Lower Lakes underwent a rapid 'lake level cycle', whereby levels were lowered from around 0.82 m AHD to 0.65 m AHD, and then refilled to 0.8 m AHD over a period of three weeks. This action, which aimed to draw salt water out of Lake Albert and provide a diluting effect upon refill, resulted in a salinity reduction in Lake Albert of around 100 EC.

From September 2021 onwards, flows from Tauwitchere and Ewe Island barrages were increased to direct more water to the Coorong to support the food web. Monitoring programs reported a widespread distribution of ruppia (mixture of *Ruppia tuberosa, Ruppia megacarpa* and *Althenia sp.*) in both the North and South Lagoon of the Coorong, as a result of sustained flows and high Coorong water levels from winter to early summer 2021-22. Flowering, fruiting and seeding was observed in the South Lagoon, resulting in the best Type II turion production observed in the last 20 years. Freshwater flows to the Coorong also supported a substantial smallmouth hardyhead recruitment event, an improvement in benthic invertebrate abundance and diversity in the Coorong North lagoon, a range expansion of several Coorong fish into the South lagoon, and improvements in some species of waterbirds in the Coorong, particularly black swan and *Pelecanus conspicillatus* (Australian pelican). Unfortunately, overall waterbird numbers in the Coorong were significantly lower than recent years, with much of the decrease driven by reductions in abundances of small-bodied migratory waders.

From late November 2021 to mid-February 2022, flows from Goolwa and Mundoo barrages were managed to create estuarine/salt wedge conditions downstream of Goolwa barrage in an attempt to provide conditions conducive to *Acanthopagrus butcheri* (black bream) recruitment. In March and April 2022, hundreds of YOY black bream were sampled in the Coorong North lagoon by South Australian Research and Development Institute scientists.


Juvenile *Acanthopagrus butcheri* (black bream) collected in the River Murray Estuary

Partnering with First Nations

DEW and partner organisations involved in delivering water for the environment in South Australia acknowledge and pay respect to the First Nations of the Murray–Darling Basin, who have a deep cultural, social, environmental, spiritual, and economic connection to their lands and waters. DEW and partner organisations work with members of the River Murray and Mallee Aboriginal Corporation, the Mannum Aboriginal Community Association Incorporated, and the Ngarrindjeri Aboriginal Corporation (NAC) to ensure cultural priorities and local knowledge are incorporated into environmental watering programs. Many groups are directly involved with operating water management infrastructure such as regulating structures and pumps, and collecting monitoring data to support decision-making.

The MDBA's The Living Murray's Indigenous Partnerships Program (TLM – IPP) ensures First Nations knowledge and cultural values can be incorporated into icon site management, supporting the employment of Indigenous Facilitators at the Chowilla and CLLMM icon sites and broader engagement with local community members to support The Living Murray's watering programs.

Ngarrindjeri connecting with Sea Country (Yarluwar-Ruwe)

"Water birds such as the Kungari are important to Ngarrindjeri, not only because they are a Ngatji (totemic species) but the Kungari eggs are a food source for people and are a significant part of Ngarrindjeri culture,

"It shows how Ruwe (Country) can respond with some additional water. This is a place of creation, where the fresh and salt water mix and our Ngatjis need these waters to heal to enable their breeding."
Rick Hartman (Yarluwar-Ruwe Project Coordinator, Ngarrindjeri Aboriginal Corporation).

Black swans (Kungari) flourished in response to increased flows from the River Murray along with timely delivery of water for the environment. Kungari undertook more than one breeding event, which increased their overall abundance in the Lower Lakes and Coorong. Kungari is a special ngartji (totemic species) for the Ngarrindjeri people and swan egg collection and eating is a culturally important tradition that was able to be upheld in 2021-22.

A Ngarrindjeri Yarning Circle Project in 2020-21 identified a number of important cultural values that Ngarrindjeri would like to see protected or enhanced through increased flow and delivery of water for the environment. There was also discussion about the Ngarrindjeri community connection to country and involvement in ecological / cultural monitoring. As a result, a yabby monitoring project was undertaken for the first time in 2021-22. Ngarrindjeri community members participated through the setting and retrieval of nets, weighing and measuring yabbies, determining their sex and also assessing the quality of wetland habitat.

Yabby monitoring at the Lower Lakes

Tim Hartman, Chief Executive Officer from the NAC, said that as Ngarrindjeri, they have a cultural obligation to care for and manage country. 'Yarning circles help build, share, and express knowledge though a process of open dialogue and deep reflection,

"For the Ngarrindjeri, our vision is all people caring, sharing, knowing and respecting the lands, the waters and all living things."

Collaborative engagement between DEW and the Ngarrindjeri continued in 2021-22, with increased community participation through the sharing of important Ngarrindjeri cultural values. The Yarning Circles project involved four workshops on Country stretching from Tailem Bend to Meningie. These discussions not only aided in gaining a better understanding of what is important to Ngarrindjeri, but also fostered an understanding of the importance of water for the environment for the health of the River Murray system. It is important to build relationships and gain trust amongst the Ngarrindjeri community to help achieve ecological and cultural objectives. The Yarluwar-Ruwe Project Coordinator (employed on behalf of MDBA's TLM – IPP) who represents the NAC, has been influential in guiding this process.

Healthy country means healthy Ngarrindjeri people and culture, everything is connected

The Yarning Circles project, established in 2020-21 as a joint initiative between the Ngarrindjeri Aboriginal Corporation and DEW, continued in 2021-22. As part of these Yarning Circles, Ngarrindjeri advice was incorporated into annual water for the environment actions. These included maintaining lake levels higher in spring/summer to ensure freshwater Ngatjis (totemic species) were able to successfully breed and reproduce and maintaining barrage releases to provide connectivity and assist in freshening the Coorong and Murray Mouth.

Celebrating the Yarning Circles project with a tour across the Murray barrages

Round table discussions with NAC staff in the early planning phase for developing annual watering proposals was also successful, with cultural values and ideas put forward to aid delivery of water for the environment to the CLLMM Icon Site. This process has been undertaken annually for many years, with 2021-22 seeing continued involvement and a willingness to discuss important Ngarrindjeri cultural values.

The Ngarrindjeri community continue to assist DEW and The University of Adelaide with on-ground threatened fish monitoring in the Lower Lakes, encouraging the two-way sharing of information which is blending western science with traditional Ngarrindjeri cultural knowledge. In 2021-22, yabby monitoring was also undertaken in collaboration with DEW and The University of Adelaide following encouragement from Ngarrindjeri. Timely and adequate delivery of water for the environment can be directly linked to the health and habitat condition for key species, including the threatened small-bodied fish southern pygmy perch and Murray hardyhead.

The Yarluwar-Ruwe Project Coordinator is an active member of the CLLMM Community Advisory Panel, which meets every two months to discuss barrage and lake-level management along with engagement activities. At each meeting, updates were provided to the group on Ngarrindjeri engagement activities undertaken on behalf of TLM – IPP, but also additional activities undertaken between the NAC and DEW, Landscape Boards SA, local Councils and the private sector.

Aboriginal Waterway Assessments (AWA) continue to be an important means of connecting to Country for the First Peoples of the River Murray and Mallee Region (FPRMMR), allowing for the sharing of information and knowledge about many sites, including the Chowilla Icon Site, and gaining Traditional Owner perspectives. A post-watering AWA was undertaken at Coppermine Waterhole following an earlier assessment undertaken during very dry conditions. This provided participants with the chance to observe the benefits of water for the environment delivered during the Chowilla floodplain regulator operation. Additionally, an AWA was undertaken at Lake Littra during November 2021 for the first time, a site also inundated during the Chowilla floodplain operation.

A young FPRMMR community member assisted the Chowilla ecologist in undertaking monitoring activities including frog surveys during the operation. Training in tree condition monitoring methods for application in monitoring scar trees at Chowilla was also undertaken with FPRMMR community members in December 2021.

First Peoples assist with ecological monitoring at Chowilla

A First Peoples community tour was held in November 2021 to see ecological monitoring in action and to observe the floodplain responses following inundation. Participants of all ages from Elders through to young children were able to observe the very positive results from the inundation at a number of sites and assist with small bodied fish and tadpole surveys.

First Peoples community assisting with fish and tadpole surveys while touring Chowilla

FPRMMR Working Group meetings included discussions about planning for watering actions across wetlands, floodplains and the River Murray channel, and sharing information from monitoring. The FPRMMR Working Group provides a valuable forum for engagement and involvement in a range of projects related to water for the environment.

The Australian Landscape Trust's Riverland Indigenous Ranger team managed all pumps involved in providing water for the environment to Calperum ephemeral wetlands, along with collecting delivery data and assisting with environmental monitoring.

Nature Foundation engaged FPRMMR to be involved in water delivery, photopoint surveys and meter readings at two wetland sites. FPRMMR also assisted with site preparation for the environmental watering at Murbpook Lagoon.

Communication and Engagement

Water for the environment managers in South Australia strive to maintain community input and engagement throughout the water year. Planning annual delivery of water for the environment starts early and involves workshops with environmental water holders, scientific experts, First Nations, non-government organisations and river operators. These workshops consider the water resource forecast for the year ahead, facilitating discussions around what watering events may be possible and aiding in the development of watering proposals aimed to meet site specific and basin-wide targets.

Further community and non-government organisation consultation took place during the development of watering proposals for all major watering actions. For the Chowilla floodplain Icon Site, Pike and Katarapko floodplains, and CLLMM Icon Site, there are established reference groups with an in-depth knowledge of the region, its infrastructure and ecological processes. These groups provided valuable input to help plan for the delivery of water for the environment in 2021-22. Additionally, site tours, meetings and presentations were undertaken with various stakeholders to gain feedback on proposed actions and to share information about the outcomes of water delivery. One-on-one conversations with landholders and industry representatives were also undertaken.

Community consultation and engagement continued throughout the water year from the initial planning phase through to the seasonal delivery of water for the environment. Methods of communication and engagement included radio and television interviews, social media posts, letter notifications, community surveys, the development of videos, and presentations to various interest groups. Various tours involving a diverse range of stakeholders were undertaken on the Chowilla and Katarapko floodplains, and within the Coorong, Lower Lakes and Murray Mouth region.

In an effort to reach the wider community, DEW staff worked closely with CEWO and MDBA to develop a range of communication products about water for the environment activities and outcomes in the region, as well as the elevated within-channel flows which provided ecological benefits all along the River Murray.

Pike floodplain community tour.

Regular updates on the outcomes of water delivery were posted on the River Murray SA Facebook page and Murraylands and Riverland Landscapes Board Facebook page. A number of media releases and videos were also produced by DEW, including:

- Critically endangered Murray River fish population booms in SA Riverland (ABC, 2021).
- Fast-flowing Murray River creates perfect spawning conditions for native fish like callop (ABC, 2022).
- Hugely successful floodplains watering operations come to end (DEW, 2021).
- Spring environmental flows a further boost to SA's River Murray (DEW, 2021).
- Floodplains already showing positive signs from environmental watering (DEW, 2021).
- Environmental watering of floodplains and weir pool manipulation underway (DEW, 2021).
- Raising event to get underway at Lock 2 Weir Pool (DEW, 2021).
- When Chowilla gets a drink (YouTube, 2022).
- River Murray floodplains set to be replenished by rains and rehab plan (Channel 7, 2021).
- Ultrasonic sound recorders detect bat species hanging out at Chowilla (DEW, 2022).
- Fish stocks increase in the Coorong despite fishing and seal impacts (Channel 7, 2021).
- River Murray flows deliver breeding success for Coorong black swans (The Murray Valley Standard, 2022).
- Ngarrindjeri Yarning Circles (DEW, 2021).
- Yarning circles foster sharing of traditional Ngarrindjeri water knowledge (DEW, 2021).
- Coorong fishers reel in the benefits of water for the environment (DEW, 2021).
- Short film commemorates a decade of healing in the Coorong and Lower Lakes (DEW, 2021).

Nature Foundation leading a community bird walk at Murbpook Lagoon. Credit: Nature Foundation.

Non-government organisations were also actively involved in community engagement, with the Nature Foundation, Renmark Irrigation Trust, Accolade Wines and Australian Landscape Trust (Calperum Station) promoting the importance of water for the environment through mainstream and social media.

Nature Foundation, in partnership with the Goolwa to Wellington Local Action Planning Association, received a grant to hold a number of citizen science activities in 2021-22. Many of these events coincided with water for the environment activities. Renmark Irrigation Trust ran a tour with Renmark North Primary School at their Warrego Street watering site.

Monitoring

A number of monitoring programs aim to capture the ecological responses to water for the environment along the South Australian River Murray. These include:

- Condition and intervention monitoring at the Chowilla Floodplain and Lower Lakes, Coorong and Murray Mouth Icon Sites through the MDBA's TLM Program.
- Condition and intervention monitoring associated with weir pool manipulation and floodplain regulator operations coordinated by DEW.
- CEWO's Flow-MER Program, which collects data along the South Australian River Murray Channel.
- Monitoring of selected South Australian River Murray wetlands and floodplain areas by the Murraylands and Riverland Landscape Board.
- Monitoring by non-government organisations.

Monitoring reports are produced for many of these projects (Appendix E), with many available on the CEWO Flow-MER and MDBA websites.

An extensive network of real-time surface water monitoring stations that measure a range of parameters including water level, salinity, dissolved oxygen and water temperature are found throughout the SA River Murray, Lower Lakes and Coorong and are operated and maintained by DEW. The data generated is critical for water managers to inform decisions on environmental flow delivery and the operation of infrastructure. Surface water monitoring data can be accessed here: Data - Water Data SA

Elevated within-channel flows inundating Hogwash Bend.

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Appendix A

Water for the Environment Actions Planned for 2021-22

Table 1a and 1b: Summary of water for the environment actions proposed under the near average and wet water resource scenarios in the 2021-22 Annual Plan

1a. Near average conditions

Site	Proposed Action	Status for 2021-22
CLLMM	Spring and early summer flows to maintain lake levels >0.80 m AHD.	**Achieved**
	Summer/ autumn base flows to maintain autumn lake levels 0.55 – 0.60 m AHD	**Not targeted** due to increased River Murray flows
Channel and Floodplain	Augment flow at the South Australian border to >30,000 ML/day for 30 days.	**Achieved** due to sufficient River Murray flows and a directed release from Lake Victoria
Weir Pool Manipulation	Raise Weir 2 to 6.65 m AHD.	**Achieved,** operated to 6.65 m AHD
Chowilla Floodplain	Operate Chowilla floodplain regulator to 19.6 m AHD and Weir 6 to 19.85 m AHD to generate a medium-high extent managed floodplain inundation.	**Achieved**, regulator operated to 19.59 m AHD, Weir 6 raised to 19.67 m AHD
Pike Floodplain	Operate Pike floodplain regulator to 15.8 m AHD and Weir 5 to 16.8 m AHD to generate a medium extent managed floodplain inundation.	**Achieved**, regulator operated to 15.8 m AHD, Weir 5 raised to 16.8 m AHD
Katarapko Floodplain	Operate Katarapko floodplain regulators to 13.2 m AHD and Weir 4 to 13.5 m AHD to generate a medium extent managed floodplain inundation.	**Achieved**, regulator operated to 13.2 m AHD, Weir 4 raised to 13.5 m AHD
Ephemeral Wetlands	Delivery of water to up to 29 priority ephemeral wetlands located along the River Murray from the border to the Lower Lakes.	**Partially achieved,** delivered to 57 priority ephemeral wetlands (an additional 15 that would have otherwise been pumped became naturally inundated)
	Additional delivery of water to wetland sites by Non-Government Organisations including Renmark Irrigation Trust, Accolade Wines, Nature Foundation and the Australian Landscapes Trust.	**Achieved**

1b. Wet conditions

Site	Proposed Action	Status for 2021-22
CLLMM	Flows added to the back of an elevated flow event to slow recession and maintain higher barrage release volumes through summer.	**Partially achieved** due to prolonged elevated flows. A directed release from Lake Victoria helped maintain higher flows to the Coorong in early summer
	Summer/ autumn base flows to maintain autumn lake levels >0.60 m AHD.	**Achieved**
Channel and Floodplain	Augment flow at the South Australian border to 50,000 ML/day for 40 days.	**Not achieved** due to insufficient River Murray flows
Weir Pool Manipulation	Raise Weir 2 to 6.65 m AHD.	**Achieved,** operated to 6.65 m AHD
	Raise Weir 2 to 6.65 m AHD, then lower to 6.02 m AHD.	**Achieved,** operated to 6.65 m AHD then 6.02 m AHD
Chowilla Floodplain	Operate Chowilla floodplain regulator to 19.75 m AHD and Weir 6 to 19.85 m AHD to generate a high extent managed floodplain inundation.	**Not achieved** due to insufficient River Murray flows
Pike Floodplain	Operate Pike floodplain regulator to 15.8 m AHD and Weir 5 to 16.8 m AHD to generate a medium extent managed floodplain inundation.	**Achieved**, regulator operated to 15.8 m AHD, Weir 5 raised to 16.8 m AHD
Katarapko Floodplain	Operate Katarapko floodplain regulators to 13.2 m AHD and Weir 4 to 13.5 m AHD to generate a medium extent managed floodplain inundation.	**Achieved**, regulator operated to 13.2 m AHD, Weir 4 raised to 13.5 m AHD
Ephemeral Wetlands	Delivery of water to up to 7 priority pool-connected wetlands located along the River Murray from the border to the Lower Lakes.	**Achieved,** delivered to 57 priority ephemeral wetlands (an additional 15 that would have otherwise been pumped became naturally inundated)
	Additional delivery of water to wetland sites by Non-Government Organisations including Renmark Irrigation Trust, Accolade Wines, Nature Foundation and the Australian Landscapes Trust.	**Achieved**

Appendix B

Environmental Watering Actions Undertaken in 2021-22

Table 2: Volume of water for the environment delivered across the South Australian River Murray region from different water holders (e.g. Commonwealth Environmental Water Holder (CEWH), The Living Murray (TLM), South Australian Minister for the Environment and Water (SA), Victorian Environmental Water Holder (VEWH), River Murray Increased Flow (RMIF) and private holdings in SA (Private)) in 2021-22.

Watering Action/ Location	Held environmental water						Other SA-held water used for environmental outcomes	Unregulated flows	Total volume (ML)
	CEWH	TLM	VEWH	Victorian RMIF	NSW RMIF / Other	SA (incl. privately held)			
CLLMM	780,990	246,002	64,320	23,484	27,566	20,092	12,411	5,223,189[5]	**6,398,054**
Chowilla Floodplain / Lock 6								44,989	**44,989**
Pike Floodplain / Lock 5								6,006	**6,006**
Katarapko Floodplain / Lock 4								2,323	**2,323**
Lock 2 Manipulation								1,264	**1,264**
Managed pool-connected wetlands (Appendix C)						25,108	1,518	20,929	**47,555**
Pumped wetlands (Appendix D)[6]	11,587	2				315	624	1,879	**14,407**
TOTAL	**792,577**	**246,004**	**64,320**	**23,484**	**27,566**	**45,515**	**14,553**	**5,300,579**[5]	**6,514,598**

[5] Transmission losses resulting from upstream environmental water return flows (i.e. increased flow to South Australia) of 14,619 ML were calculated and applied against the unregulated flows between the SA border and Wellington (refer the *Policy for Application of Losses to Environmental Water* for more information)

[6] Includes Bookmark Creek, Dishers Creek, Berri Evaporation Basin which are gravity-fed rather than pumped.

Appendix C

Managed Pool-Connected Wetlands

Table 3: Pool-connected wetland complexes managed in 2021-22 by Accolade Wines, SA Department for Environment and Water (DEW), Murraylands and Riverland Landscape Board (MRLB), Australian Landscape Trust (ALT) and Nature Foundation. Includes 52 wetlands across 40 wetland complexes.

Wetland Complexes	Actions	Manager
Banrock Wetland	Filled in spring, commenced dry in late spring	Accolade Wines
Big Bend	Commenced dry in autumn, filled in winter	MRLB
Brenda Park	Filled in winter	MRLB
Causeway Wetland Complex	Connected to the River all year	MRLB
Devon Downs South	Connected to the River all year	MRLB
Hart Lagoon	Connected to the River all year	MRLB
Irwin Flat	Connected to the River all year	MRLB
Kroehn's Landing	Connected to the River all year	MRLB
Lake Merreti	Filled in winter, commenced dry in summer, filled in autumn	ALT
Lake Woolpolool	Filled in winter	ALT
Loveday Basins	Filled in spring	DEW
Loveday Mussels Lagoons	Connected to the River all year	MRLB
Martin Bend	Connected to the River all year	MRLB
Morgan Conservation Park	Connected to the River all year	MRLB
Morgans' Lower Murray	Connected to the River all year	MRLB
Murbko South	Filled in spring	MRLB
Murbpook Lagoon	Filled in spring	Nature Foundation
Narrung	Connected to the River all year	MRLB
Nelwart	Connected to the River all year	MRLB
Ngak Indau	Filled in spring, commenced dry in summer	DEW
Nigra Creek/ Schillers Lagoon	Connected to the River all year	MRLB
North Caurnamont	Filled in summer	MRLB
North Purnong	Commenced dry in summer, filled in autumn	MRLB
Paiwalla	Filled in autumn	MRLB
Pilby Complex	Filled in spring	DEW
Pipeclay Billabong	Filled in spring	DEW
Pyap Horseshoe	Connected to the River all year	MRLB
Ramco Lagoon	Connected to the River all year	MRLB
Reedy Creek	Connected to the River all year	MRLB
Riverglades	Connected to the River all year	MRLB
Silver Lea	Filled in spring	MRLB
Slaneys Billabong	Filled in spring	DEW
Spectacle Lakes /Beldora	Filled in spring	MRLB
Sugar Shack Complex	Filled in spring	MRLB
Sweeny's Lagoon	Filled in winter	MRLB
Teal Flat Complex	Filled in spring	MRLB
Teringie	Connected to the River all year	MRLB
Waltowa	Partially opened in summer	MRLB
Wongulla Lagoon	Connected to the River all year	MRLB
Yatco Complex	Filled in spring	MRLB

Appendix D

Pumped Wetlands

Table 4: Volume of water for the environment pumped to a total of 57 wetlands by the SA Department for Environment and Water (DEW), Murraylands and Riverland Landscape Board (MRLB), Nature Foundation, Renmark Irrigation Trust (RIT), Accolade Wines, and Australian Landscape Trust (ALT) in the South Australian River Murray region in 2021-22.

Watering Action/ Location	Volume (ML)	Manager
Above Lock 6		
Monoman Island	2	DEW
Lock 5 to Lock 6		
Amazon Floodplain	237	ALT
Amazon 6'	75	ALT
Amazon Uplands East	7	ALT
Bookmark Creek[1]	4[2]	MRLB
Bookmark Creek Wetlands NW basin	65	RIT
Jane Eliza Woodlot	167	RIT
Johnsons Waterhole	164	RIT
Merreti East Floodplain	351	ALT
Mundic Billabong	50	Nature Foundation
Murtho Park Flats	270	MRLB
Murtho/Wiela Connector	229	MRLB
Namoi Street	42	RIT
Ral Ral Bridge Floodplain	44	RIT
Squiggly Creek	<1	MRLB
Warego Street	69	RIT
Warnock/Lescheid Wetland	40	Nature Foundation
Widewaters West	161	ALT
Woolpolool South	16	ALT
Woolpolool Swamp (includes 115 ML re-used at Woolpolool Swamp South)	632	ALT
Lock 4 to Lock 5		
Berri Evaporation Basin[1]	11[3]	MRLB
Goat Island	29	Nature Foundation
Katarapko Regent Parrot Floodrunner	9	MRLB
Martins Bend Temporary 1 & 2	40	MRLB
Plush's Bend	33	RIT
Twentysixth Street	33	RIT
Lock 3 to Lock 4		
Clarks Minor Floodrunner	3	Nature Foundation
Loxton Floodplain Lagoons	30	Nature Foundation
Stanitzki Lignum Floodrunners	1	Nature Foundation
Lock 2 to Lock 3		
Akuna	285	MRLB
Eastern Lagoon, Banrock Station	1,420	Accolade Wines
Maize Island	115	MRLB
Old Parcoola	360	MRLB
Overland Corner (main)	114	MRLB

[1] Bookmark Creek and Berri Evaporation Basin are gravity fed rather than pumped

[2] An additional 445 ML of unregulated flow was used to support environmental outcomes at Bookmark Creek

[3] An additional 1,316 ML of unregulated flow was to support environmental outcomes used at Berri Evaporation Basin

Toolunka Temporary	8	MRLB
Wigley Reach Western Channel	85	MRLB
Lock 1 to Lock 2		
Cadell Ephemeral Wetlands	51	Nature Foundation
Cadell Temporary Wetland	294	Nature Foundation
Markaranka Depression	101	MRLB
Markaranka East Basin	303	MRLB
Markaranka Floodrunner 2	14	MRLB
Markaranka Floodrunner 5	19	MRLB
Markaranka Main Basin	3,285	MRLB
Markaranka Regent Parrot Strip	12	MRLB
Molo Flat Eastern Channel	52	MRLB
Molo Flat Western Channel	47	MRLB
Morgan CP North	161	MRLB
Murbpook Northern Floodrunners	73	Nature Foundation
Nikalapko	749	MRLB
Nilkra (Taylor Flat)	840	MRLB
Riversleigh Lagoon	90	Nature Foundation
Lock 1 to Wellington		
Greenways Landing	40	Nature Foundation
Sugar Shack Wetland 5	220	MRLB
Sugar Shack Wetland 6	31	MRLB
Lower Lakes		
Tolderol Game Reserve Wetland	624	MRLB
Investigator College Currency Creek Wetland	14	MRLB
Milang Snipe Sanctuary	8	Nature Foundation

Appendix E

List of Monitoring Reports for 2021-22

Bice, C.M., Zampatti, B.P. and Fredberg, J. (2022). *Fish assemblage structure, movement and recruitment in the Coorong and Lower Lakes in 2021/22*, in prep. South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

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