

South Australian River Murray Water for the Environment Report 2018-19



**Government
of South Australia**

Department for
Environment and Water

Acknowledgements

The Department for Environment and Water (DEW) acknowledges and pays respect to the Traditional Owners and their Nations of the Murray-Darling Basin, who have a deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

This South Australian River Murray Water for the Environment Report was prepared by staff in DEW with contributions from Nature Foundation South Australia and Natural Resources South Australian Murray-Darling Basin.

The following agencies and organisations are acknowledged for their important role in environmental water management:

- Commonwealth Environmental Water Office (CEWO);
- Murray-Darling Basin Authority (MDBA) including The Living Murray (TLM) program;
- Natural Resources South Australian Murray-Darling Basin (NR SA MDB);
- Ngarrindjeri Aboriginal Corporation (NAC) and Ngarrindjeri Regional Authority (NRA);
- First Peoples of the River Murray and Mallee;
- Nature Foundation South Australia (NFA);
- Renmark Irrigation Trust;
- Accolade Wines, Banrock Station;
- Australian Landscape Trust, Calperum Station.

Photography

Cover: Pelicans at Disher Creek Source: Jan Whittle

Photographs by Sally Grundy, Mundoo Island Station are used with permission

Foreword

Each year South Australia prepares an overview of water delivered for the environment along the South Australian River Murray under the Murray-Darling Basin Plan. This report outlines the water volumes and timing of delivery, the sites watered and outcomes achieved for the 2018-19 water year.

Whilst 2018-19 was a dry year, approximately 850 gigalitres of water for the environment was delivered to South Australia, which is equivalent to 48% of all water delivered across the South Australian Border. Water was provided from a number of different sources including the Commonwealth Environmental Water Holder, The Living Murray, return flows from the Victorian Environmental Water Holder, as well as water held for the environment by the South Australian Minister for Environment and Water.

There were a range of very positive outcomes during 2018-19 including:

- good aquatic vegetation responses on the fringes of the Lower Lakes
- continuous connectivity between the Lower Lakes and the Coorong enabling significant diadromous fish migration, including upstream migration of young-of-year congolli and common galaxias in spring and summer
- the first observation of short-headed lamprey since 2011 at the Murray barrages
- large numbers of colonial waterbirds nesting in the Lower Lakes
- maintenance and improvement of vegetation condition at Chowilla and other sites supporting the survival of seedlings and saplings
- provision of habitat for a diverse range of floodplain and wetland plants and animals through operation of Chowilla and weir pool raising and enhanced survival of seedlings and saplings of native floodplain tree species that germinated during previous high flow and managed inundation events
- responses from native vegetation, waterbirds and frogs in the wetlands and floodplains associated with watering events
- responses from threatened species such as Murray hardyhead, regent parrot and southern bell frog.

Although there were a range of positive outcomes, there remains much to do to continue the recovery of the Murray system in South Australia. The continuing degraded state of the Coorong, particularly the South Lagoon, is of significant concern and continues to be the focus of efforts to restore the site.

Monitoring of watering events by the South Australian Government, scientists, local community members and landholders contributes to evaluating the effectiveness of the water delivered to the environment and informs the setting of objectives for future water delivery.

The Department for Environment and Water works with a range of partner organisations and water holders to coordinate the effective delivery of water to South Australia's River Murray priority environmental assets. Collaboration between our partners is essential to deliver water for the environment to achieve our short and long-term outcomes for the South Australian River Murray.



Ben Bruce

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Abbreviations

AHD	Australian Height Datum
ALT	Australian Landscape Trust
BWEWS	Basin-Wide Environmental Watering Strategy
COAG	Council of Australian Governments
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
CLLMM	Coorong, Lower Lakes and Murray Mouth
DEW	Department for Environment and Water
DEWNR	Department of Environment, Water and Natural Resources
EC	Electrical conductivity
EPBC	Environment Protection and Biodiversity Conservation
EWR	environmental watering requirement
GL	gigalitre (a billion litres)
LLCMM	Lower Lakes, Coorong and Murray Mouth Icon Site
m	metres
MDBA	Murray–Darling Basin Authority
ML	megalitre (a million litres)
NAC	Ngarrindjeri Aboriginal Corporation
NFSA	Nature Foundation South Australia
NGO	Non-Government Organisation
NRA	Ngarrindjeri Regional Authority
RIT	Renmark Irrigation Trust
River Murray LTWP	Long-Term Environmental Watering Plan for the South Australian River Murray
RMIF	River Murray Increased Flows
SA	South Australia
SAMDB	South Australia Murray–Darling Basin
SCBEWC	Southern Connected Basin Environmental Watering Committee
NR SAMDB	Natural Resources South Australia Murray–Darling Basin
TLM	The Living Murray Program
VEWH	Victorian Environmental Water Holder

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Pipeclay Billabong

Source: Jan Whittle

1. Introduction

The planning, delivery, reporting and evaluation of water for the environment within the South Australian Murray-Darling Basin is coordinated by the Department for Environment and Water (DEW) and undertaken in partnership with other government agencies including the Murray-Darling Basin Authority (MDBA) and Commonwealth Environmental Water Office (CEWO), research organisations, non-government organisations and community groups.

Environmental water delivery to South Australia in the 2018-19 water year was guided by the Long-Term Environmental Watering Plan for the South Australian River Murray (DEWNR 2015) (River Murray LTWP) and the Basin-Wide Environmental Watering Strategy (MDBA 2014) (BWEWS). These documents, together with site-based management plans describe key ecological targets and objectives for annual environmental water planning and delivery to South Australia.

As part of the planning process, environmental watering proposals for the major South Australian sites were developed and submitted to the MDBA Southern Connected Basin Environmental Watering Committee (SCBEWC) and the CEWO in early 2018 to inform and support whole of Murray system planning. These proposals form the basis of the 2018-19 Annual Environmental Watering Plan and Annual Priorities for the South Australian River Murray (DEW 2018a, DEW 2018b) and informed the Basin Environmental Watering Priorities (MDBA 2018).

Environmental water delivered to South Australia is primarily from two major environmental water holders: the Commonwealth Environmental Water Holder (CEWH) and The Living Murray (TLM) Program of the MDBA. Additional water for the environment is held by the South Australian Minister for Environment and Water, non-government organisations, and private irrigators. Water may also be provided by the Victorian Environmental Water Holder (VEWH) and New South Wales in the form of return flows from upstream environmental watering actions.

This report provides a summary of environmental watering actions along the River Murray in South Australia during the 2018-19 year and includes:

- an overview of river conditions in 2018-19
- a summary of the environmental watering actions that were undertaken including sites, volumes and approximate timing
- a summary of key environmental outcomes
- a summary of reports that provide detailed information about monitoring and ecological outcomes.

The purpose of this report is to provide a transparent and public record of watering events for the environment, regardless of water holder or manager, undertaken in the region throughout the year. It is in addition to the reporting undertaken by DEW to meet the requirements of the Murray-Darling Basin Plan (Basin Plan).

This report also meets the South Australian Government's commitment to the Council of Australian Governments (COAG) to publish an annual report on River Murray environmental water use in South Australia for public information sharing (National Water Initiative Policy Guidelines for Water Planning and Management 2010).



Coppermine Waterhole

Source: Jan Whittle

2. Overview of flow conditions in 2018-2019

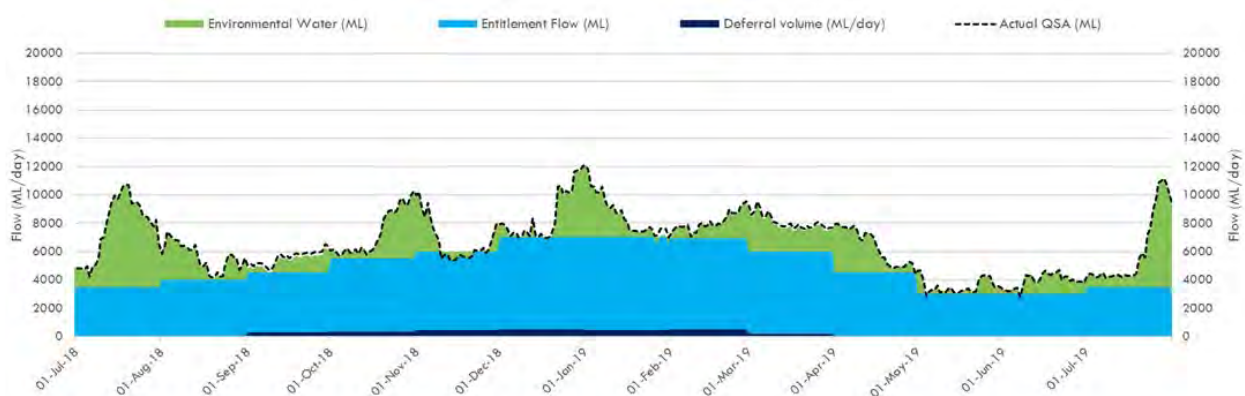
The 2018-19 water year was another dry year, with climate conditions across the Murray-Darling Basin generally warmer and drier than average and system inflows in the driest 7% of years on record (MDBA 2019). As a result, South Australia did not experience any unregulated flow events in 2018-19 and the only water South Australia received above entitlement flow was from environmental water holders (Figure 1).

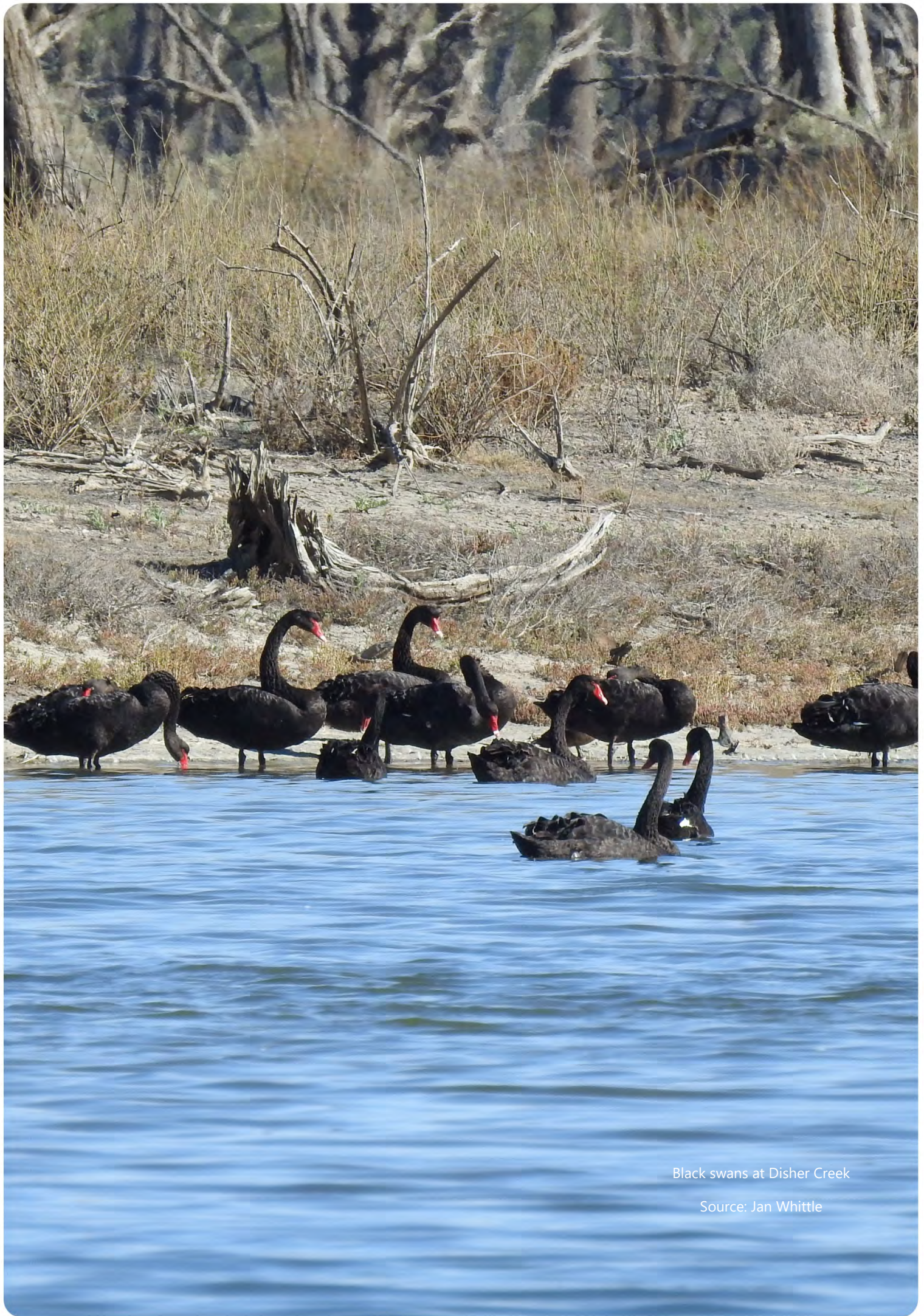
The highest flows were in late December 2018/early January 2019 when flow to South Australia was above 10,000 megalitres per day (ML/day) for about two weeks, peaking at 12,000 ML/day on 1 January 2019. There were positive steps towards coordinating a southern connected basin channel action, however there were difficulties in delivering enough water to run the river and deliver the volume of environmental water planned. As a result, there was less environmental water delivered to the Lower Murray than planned (MDBA in prep).

Despite the continuing dry conditions, a number of successful environmental watering events occurred including:

- raising of Weir 2 by 50 centimetres (cm) and Weir 5 by 35 cm in spring
- in-channel rise in the Chowilla Anabranch, including raising of Weir 6 by 20 cm
- supporting permanent water in wetlands that provide habitat, including for threatened fish species
- inundation of temporary wetland/floodplains (including wetlands on the Chowilla Floodplain and sites managed by DEW, Australian Landscape Trust, Banrock Station, Nature Foundation SA (NFSA) and Ngarrindjeri Aboriginal Corporation) via pumping or irrigation
- wetting and drying of pool-connected managed wetlands
- delivery to the Coorong, Lower Lakes and Murray Mouth (CLLMM) to support manipulation of water levels in the Lower Lakes and barrage and continuous fishway releases.

Figure 1: River Murray flows 2018-19





Black swans at Disher Creek

Source: Jan Whittle

3. Environmental water delivery

In total, approximately 850,000 ML of water for the environment was delivered to South Australia (see Table 1) comprising of:

- approximately 562,000 ML (including approximately 156,000 ML held on licences in South Australia) from the CEWH
- approximately 96,000 ML (including 45,000 ML held on licences in South Australia) from TLM
- return flows from upstream watering actions undertaken by the VEWH provided approximately 35,000 ML
- River Murray Increased Flow (RMIF) of 111,000 ML
- approximately 45,000 ML of environmental water held by the South Australian Minister for Environment and Water
- a small volume of environmental water held on a private licence for the management of the pool-connected Banrock Station Wetland.

The majority of the water for the environment (784,000 ML or 92%) received by South Australia made its way along the River Murray before making it to the Lower Lakes and Coorong. It provided water quality and ecological benefits to upstream reaches of the main River channel for New South Wales, Victoria and South Australia as it travelled through the system.

Environmental water delivered to South Australia was used to support numerous watering actions throughout the year, including:

- raising Weir 2 by 50 cm and Weir 5 by 45 cm in Spring
- operating Chowilla Regulator to raise anabranch water levels within-channel by 2.1 metres, including raising Weir 6 by 22 cm
- inundating over 40 temporary wetland and floodplain areas (including wetlands on Chowilla Floodplain and sites managed by DEW, Australian Landscape Trust, Banrock Station and NFSA) via pumping or irrigation
- wetting and drying of pool-connected wetlands
- managing the CLLMM throughout the year, including manipulating water levels in the Lower Lakes and maintaining barrage and fishway releases.

Planning for environmental water delivery to South Australia is coordinated by DEW staff and is undertaken in consultation with community groups including the Community Advisory Panel and the Scientific Advisory Group for the Lower Lakes, Coorong and Murray Mouth, Chowilla Community Reference Committee, the Ngarrindjeri Regional Authority and the First Peoples of the River Murray and Mallee.

The planning of environmental water use in the Southern Connected Basin is coordinated by the SCBEWC with representatives from New South Wales, Victoria, South Australia, MDBA, the VEWH, the CEWH and the Commonwealth Government. In addition to providing environmental water to DEW, the CEWH provided water to the Australian Landscape Trust, Natural Resources SA MDB Board, NFSA, Ngarrindjeri Aboriginal Corporation, Renmark Irrigation Trust (RIT) and Banrock Station to undertake local environmental watering projects.

Table 1: Volume of environmental water delivered to SA from different water holders in 2018-19

Provider	Volume (ML)
Commonwealth Environmental Water Holder (CEWH)	561,768
The Living Murray (TLM)	95,894
River Murray Increased Flow (RMIF)	111,324
Victorian Environmental Water Holder (VEWH)	35,402
SA Minister for Environment and Water	44,596
Accolade Wines (Banrock Station Wetland)	1,380
Total	850,364

Table 2: Use of water from holders of water for the environment in 2018-19

Type of watering	Type of Water in ML						TOTAL ML
	CEWH	TLM	RMIF	VEWH	SA Minister	Accolade	
Flow through + threatened fish	1,447	-	-	-	-	-	1,447
Temporary wetlands - floodplain/channel	10,402	1,942	-	-	49	-	12,393
Temporary wetlands - CLLMM	500	-	-	-	1,050	-	1,550
Weir pool manipulation	1,502	-	-	-	-	-	1,502
Chowilla Anabranch in-channel rise	-	8,000	6,200	-	-	-	14,200
Pool-connected wetlands	-	-	-	-	33,995	1,380	35,375
CLLMM (lake levels and barrage/fishway releases)	547,916	85,952	105,124	35,402	9,502	-	783,896
TOTAL ML	561,768	95,894	111,324	35,402	44,596	1,380	850,364



Banded stilt

Source: Martin Stokes



Flowering black box

Source: Alison Stokes

4. Outcomes of water delivered to the environment

High-level objectives for the 2018-19 water year were set for delivering water to the environment in South Australia that were consistent with the objectives of the Basin Plan. These high-level objectives were:

- Coordinate the delivery of environmental water to South Australia to maximise the potential outcomes for floodplains, wetlands, the channel and the CLLMM.
- Maintain and/or improve bird, vegetation and fish communities subject to the prevailing conditions.
- Maximise outcomes from watering in South Australia by using return flows where possible.
- Deliver environmental water to the CLLMM while providing benefits to upstream environmental assets and functions en route.
- Maximise environmental outcomes through the operation of infrastructure where appropriate.
- Deliver environmental water consistent with the EWRs of the SA River Murray LTWP and contribute to the ecological objectives for priority environmental assets and priority ecosystem functions described in the SA River Murray LTWP.

The ecological objectives for specific watering activities are summarised in the *2018-2019 Annual Environmental Watering Plan for the South Australian River Murray* (DEW 2018a). These objectives are used to guide the planning and delivery of water demands for priority environmental assets in South Australia.

As part of the annual planning process undertaken by DEW, individual site based water demands are combined into one set of hydrographs for the water year. This is referred to as the multi-site watering proposal. The multi-site proposal describes the water delivery profile that would achieve the greatest benefit with the water available under each planning scenario. Delivery of the proposed hydrograph would optimise environmental outcomes and enable multiple benefits to be achieved with the available water. These proposals are provided to the MDBA and CEWO and summarised in the *2018-19 Annual Environmental Watering Priorities for the South Australian River Murray Water Resource Plan Area* (DEW 2018b) and the *2018-2019 Annual Environmental Watering Plan for the South Australian River Murray* (DEW 2018a).

Annual priorities are also received by the MDBA from New South Wales and Victoria for the Southern Connected Basin. The priorities are considered for the whole of the Southern Connected Basin by the MDBA in consultation with SCBEWC, which meets regularly to identify watering opportunities throughout the year. Not all demands can be met due to a combination of water availability, policy challenges and system constraints that impact on the delivery of environmental water in conjunction with operational flows.

Locations of sites that received water for the environment are shown in Figures 2, 3 and 4.

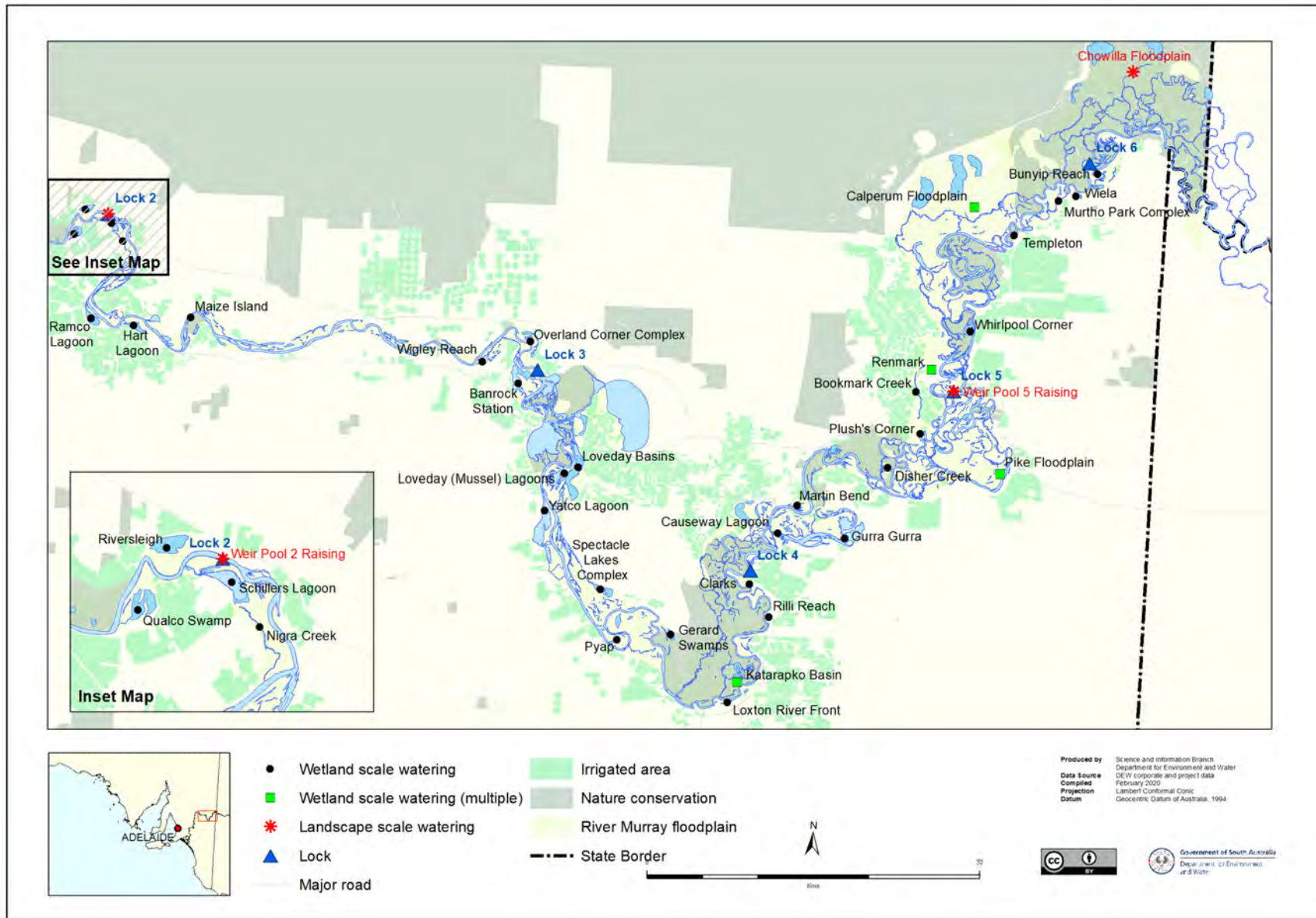


Figure 2: Map 1 - Sites along the River Murray that received water in 2018-19

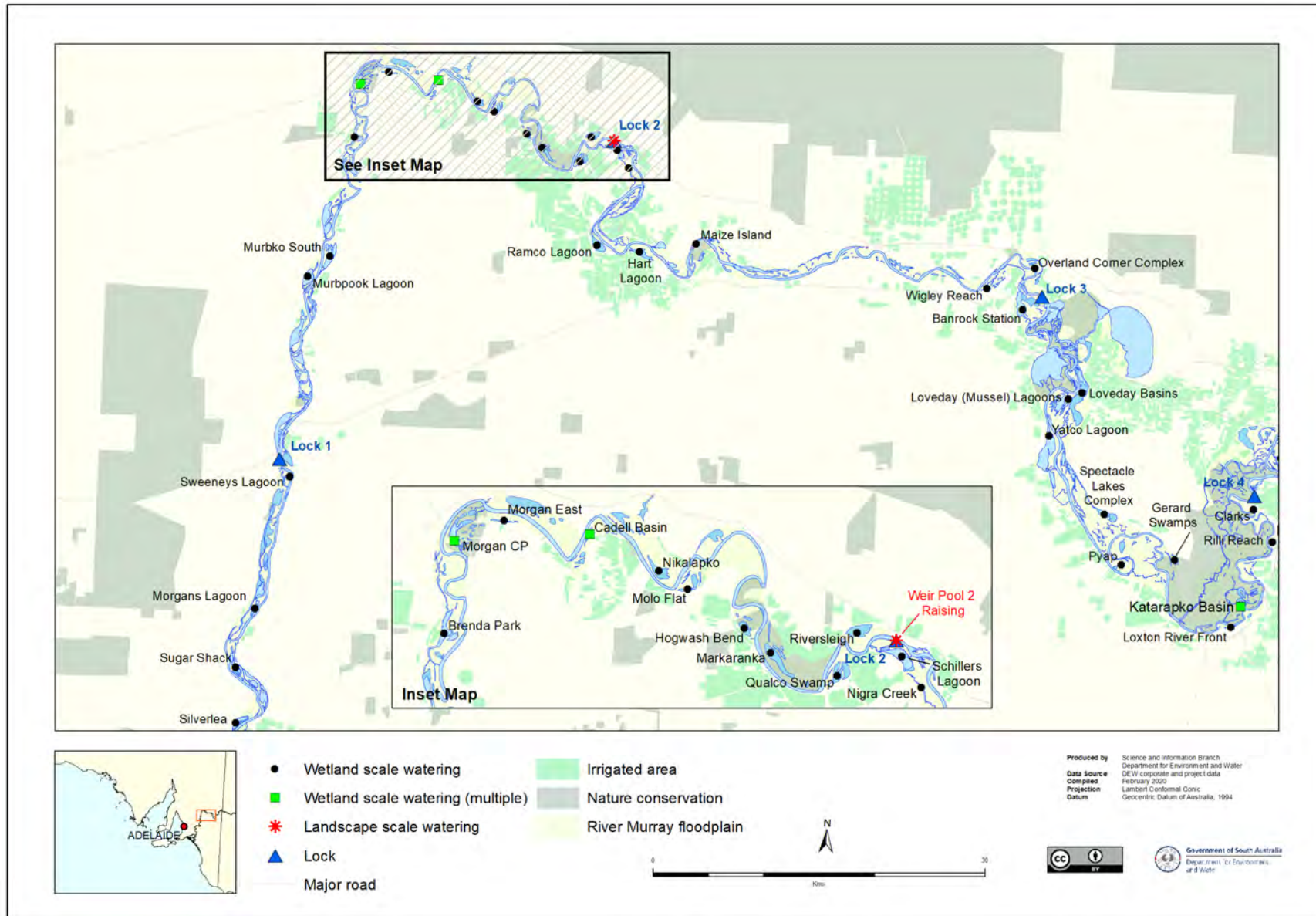


Figure 3: Map 2 - Sites along the River Murray that received water in 2018-19



Figure 4: Map 3 - Sites along the River Murray that received water in 2018-19

4.1 Coorong, Lower Lakes, and Murray Mouth

4.1.1 Watering Overview

Location: The Coorong, Lower Lakes, and Murray Mouth (CLLMM)

Area: More than 140,000 hectares

Water released out of the barrages (ML): 373,000 ML

Site Water Manager: DEW

Source of water: CEWH, TLM, VEWH

Specific Ecological Objectives:

- Support Lower Lakes threatened fish and frog recruitment and Coorong waterbird and estuarine fish habitat in spring and summer.
- Continuous (year round) connectivity between the Lower Lakes and the Coorong estuary.
- Successful winter diadromous fish migration.

4.1.2 Description of Watering

Dry conditions and high demand across the Murray-Darling Basin meant limited flows were delivered during spring and summer to the Lower Lakes and Coorong. Water levels in the Lower Lakes did not exceed 0.8m Australian Height Datum (AHD), and were not surcharged in early summer as is usually the case. From October 2018 to early February 2019, barrage releases ranged from 500 – 1500 ML/d. The total annual barrage release volume was 377 GL, much less than in previous years. Steady releases from Goolwa barrage were managed in a way to create 'salt wedge' conditions in the Goolwa estuary, in an attempt to achieve a second consecutive year of black bream recruitment.

All water released through the barrages in 2018/19 was provided by the CEWH and without this water, the barrages would typically have been closed for much of the year and the water level in the below Lock 1 weir pool would likely have fallen below the 0.4 m AHD Basin Plan threshold.

4.1.3 Monitored Outcomes

Spring/summer Lower Lakes and Coorong outcomes

Monitoring in the Goolwa estuary demonstrated that ideal salinity conditions for black bream recruitment were created, although recruitment was not detected (Ye *et al* 2019). However, monitoring did confirm the cohort of black bream that recruited in the 2017/18 water year were abundant and wide-spread in the Coorong, which can be attributed to consistent freshwater releases providing suitable nursery conditions.

Monitoring in the Lower Lakes showed mixed outcomes from spring/summer environmental water delivery. Aquatic vegetation monitoring in spring 2018 identified increased diversity and cover in many species, including submergent plants. This suggests that seasonal lake level variation between +0.5 and +0.9 m AHD has been successful in facilitating aquatic vegetation germination and growth (Nicol *et al* 2019). Small-bodied threatened fish monitoring in the Lower Lakes indicated recruitment in spring 2018 for southern pygmy perch (Figure 5), however by autumn 2019, there was little evidence that those new recruits survived and the overall southern pygmy perch population decreased (Wedderburn, 2019).



Figure 5: Southern pygmy perch Source: Scotte Wedderburn

Conditions in mudflats in the Coorong North Lagoon were favourable and macroinvertebrate communities were similar to previous years. The Coorong South Lagoon however, remains in a degraded state (Dittmann *et al* 2019).

A similar pattern was observed for waterbirds in the Coorong, with the Murray Mouth estuary (53 species) and Coorong North Lagoon (51 species) supporting a much higher diversity of waterbirds than the Coorong South Lagoon (34 species) in January 2019 (Paton *et al* 2019) (see Figure 6). Consecutive years of low flows are contributing to a continued decline in conditions in the Coorong South Lagoon. Indicators for waterbirds, fish and macroinvertebrates are all trending towards values experienced in the Millennium Drought.



Figure 6: Curlew sandpipers Source: Martin Stokes

Continuous connectivity

Continuous connectivity between the Lower Lakes and the Coorong facilitates both upstream and downstream fish movement, salt export and the provision of organic matter and micro-biota, which is important to the Coorong food web (Bice *et al* 2015). Barrage fishways remained open every day of the year and at least one or more barrage bays were open for the majority of time, except during short periods of reverse head. Therefore, the objective of continuous connectivity was achieved in 2018/19.

Consistent low flow years in 2017/18 and 2018/19 have led to increased salinity levels in Lakes Alexandrina and Albert. Salinity at Milang exceeded 1,000 EC in January and February 2019 (noting the Basin Plan salinity target for Milang is <1000 EC 95% of the time).

Continuous connectivity also facilitates fish movement between fresh and salt water, a requirement for some species to complete their lifecycles. The barrages now host 11 fishways, with all five barrages having one or more fishways. All

fishways remained open throughout 2018/19, providing continuous passage for fish. Despite a general decrease in abundances of fish utilising fishways in 2018/19, which is typical of lower-flow conditions, the abundance of young-of-year diadromous fishes (congolli and common galaxias) moving upstream from the estuary to Lake Alexandrina in spring and summer achieved the target levels (Bice *et al* 2019).

Winter diadromous fish migration

Winter flows are important between the Lower Lakes and Coorong to attract lampreys to migrate upstream from the ocean to the River Murray and to attract adult congolli and common galaxias to move downstream from the Lower Lakes to the estuary in the Coorong. In 2018/19, the highest barrage releases were made during winter 2018, as a result of South Australia receiving significant return flows of water for the environment from the Goulburn River in Victoria. The highest daily barrage release rate was in August 2018, with approximately 8,000 ML per day released.

Despite large volumes released, only six pouched lamprey and a single short-headed lamprey were sampled at the Murray Barrages. Despite the low numbers of lamprey compared to previous years, this was the first record of a short-headed lamprey since 2011. All pouched lamprey were observed in winter (July–August), whilst the short-headed lamprey was observed in October (Bice *et al*, 2019).

While winter and spring lamprey migration did occur, the numbers of lamprey were below target levels described in the Lower Lakes, Coorong and Murray Mouth condition monitoring plan (DEWNR, 2017).

Learnings

The autumn drawdown of water levels in the Lower Lakes was the second consecutive year that levels were drawn down and remained below 0.55 m AHD for a prolonged period of time. This helped to maximise flows to the Coorong for migration of diadromous fishes. However, habitat throughout the freshwater channel systems of Hindmarsh Island that supported hundreds of newly recruited southern pygmy perch in spring 2018 was dried in autumn 2019 (Wedderburn & Barnes 2019), meaning that these new recruits were likely stranded and lost. Management of minimum lake levels requires a consideration of both the flow requirements of the Coorong and threatened fish communities in the Lower Lakes in order to maximise outcomes whenever possible.

Case Study: Coorong pelican drone monitoring

Innovative drone monitoring revealed the iconic Australian Pelican was actively breeding in the Coorong South Lagoon in 2018/19. University of Adelaide ecologist Jarrod Hodgson worked with TLM staff in DEW to undertake monthly drone monitoring in the Coorong in an effort to better understand pelican breeding behaviour. Pelicans form breeding colonies on secluded islands or shorelines where they undertake unique courtship rituals. Within the Coorong, the islands near Jacks Point are the prime nesting location.

Mr Hodgson was able to monitor a large island colony of Australian pelicans using photo (see example below) and video footage to determine stages of breeding, including the incubation of eggs and the presence of chicks and juveniles (Hodgson, 2019). During dry conditions, the survival of pelican fledglings and juveniles is dependent on rainfall and delivery of water for the environment. Barrage flows are critical in supporting Coorong fish stocks – food for pelicans.



Source: Jarrod Hodgson

4.2 Chowilla Floodplain

4.2.1 Watering Overview

Location: North of the River Murray at the South Australian Border

Area watered (ha): 2,250 hectares

Water use (ML): 41,943 ML (27,743 ML return flows) = Net use 14,200 ML

Timing: August – December 2018

Site Water Manager: DEW

Source of water: TLM

Environmental Watering Objectives:

- Provide variability in hydraulic conditions (depth, velocity, turbulence).
- Reduce salinity of near-bank groundwater due to lateral infiltration of low salinity surface water and reduce soil salinity and improved soil moisture availability in inundated and adjacent zones.
- Promotion of bacterial-dominated biofilm communities with higher nutritional value (compared to algal biofilms) benefiting consumers that use biofilms as a food resource.
- Create lateral connection and inundation of early commence to flow wetlands connected.
- Assist in achieving the Ecological Target for trees adjacent to anabranch creeks and for lignum in inundated areas.
- Support ongoing growth of seedlings and saplings of river red gum, black box and cooba that have established in response to flooding and environmental watering in recent years and to support ecological targets for flood dependent and aquatic understorey vegetation.

4.2.2 Description of Watering

An 'in-channel rise' operation of the Chowilla Environmental Regulator was undertaken between August and December 2018 with the target height of 18.5 m AHD. The target height was achieved at the start of October 2018 and maintained for four weeks. Lock 6 weir pool was also raised by 20 cm in conjunction with the Chowilla Regulator operation.

The operation raised water levels in Chowilla Creek and throughout the anabranch by about 2.1 m above normal level, bringing water to near the top of the creek banks and pushing water along low level flow paths into Coppermine and Werta Wert wetlands and into Hancock Creek which fills Lake Limbra. The operation resulted in the inundation of approximately 2,250 hectares (ha).

In addition, there was targeted pumping to Woolshed Creek, Brandy Bottle Waterhole, Coppermine Complex and Twin Creeks inundating 263 ha with 1,942 ML. Water for the environment delivered via pumping extended up from Woolshed Creek through the Coppermine Complex linking up the Coppermine Waterhole which had been filled as a result of the in-channel rise operation of the Chowilla Creek regulator in spring 2018.

Brandy Bottle Waterhole and Twin Creeks received water for the environment delivered via pumping from Monoman Creek during autumn 2018.

4.2.3 Monitored Outcomes

Monitoring of birds, fish and frogs at sites that were inundated during the regulator operation, such as Lake Limbra, Coppermine Waterhole, White Cow and Werta Wert wetlands was undertaken during the event.

Surveys conducted across four wetlands inundated by the Chowilla Environmental Regulator operation throughout 2018/19 recorded 26 species of waterbirds/water associated birds. Coppermine Waterhole was observed to have a higher number of species than the other wetlands surveyed. Woolshed Creek was observed to have a significantly higher number of species than the other wetlands surveyed – 22 species were recorded within the creek while the other three wetlands

were observed to have between three and nine species present. Grey teal and Pacific black duck, were the most widespread waterbird/ water associated species observed across all ephemeral wetlands inundated.

Delivering water for the environment in dry years is particularly important to provide refuge areas for bird species to feed and breed. Four bird species not often seen were recorded during these surveys:

- Seven ground cuckoo-shrikes were sighted during summer bush bird monitoring. Ground cuckoo-shrikes are a rare, unpredictable and nomadic outback bird (Figure 7).
- The highly secretive Lewin's rail was heard calling in an area of flooded lignum near Lock 6. This bird is notoriously shy, but can be identified by its unique call.
- A juvenile white-bellied sea-eagle was sighted at Pilby Lagoon in mid-January, this species is listed as vulnerable in South Australia.
- The rarely seen Baillon's Crake with its beautiful pale green bill and legs and distinctive white and black barring on its undertail was observed near Coppermine Waterhole in February 2019.



Figure 7: Ground cuckoo-shrike near Coppermine Floodplain Complex Source: Helga Kieskamp

Vegetation at Coppermine Waterhole, including the surrounding trees, understorey and aquatic vegetation such as extensive stands of spiny mud grass also benefited from the watering (Figure 8).

Fish surveys were undertaken in spring of 2018 at Lake Limbra, White Cow, Hancock Creek, and Werta Wert. Seven native fish species were captured across the four sites. Notably, Hancock Creek and White Cow had captures of golden perch (Figure 9). At White Cow, one 500 mm long golden perch was recorded, while at Hancock Creek nine golden perch, all under 40 mm, were recorded.

A range of other aquatic fauna were also observed during the fish surveys, mostly at Werta Wert with three eastern long-necked turtles surveyed there, along with high numbers of fairy shrimp, freshwater mussels and shield shrimp.



Figure 8: Coppermine Floodplain Complex Source: Jan Whittle



Figure 9: Gallop at Chowilla Source: Jan Whittle

Frogs were sampled across seven sites in five wetlands during October and December in 2018 and in February in 2019. Six species of frog were recorded at White Cow and Coppermine Waterhole, five species at Werta Wert, four species at Hancock Creek and two species at Lake Limbra. The southern bell frog, which is listed as a vulnerable species under the *EPBC Act (Cwlth)*, was found in White Cow wetland and Coppermine Waterhole, where between 10-50 male southern bell frog were recorded calling (Figure 10). The eastern banjo frog and spotted marsh/grass frog were the most widespread species, being present in all wetlands surveyed.



Figure 10: Southern bell frog Source: Jan Whittle

4.3 Weir pool manipulation

4.3.1 Watering Overview

Location: Weir pool 2 and 5, River Murray South Australia

Area watered (ha): Weir pool 2: 197 ha; Weir pool 5: 408 ha

Water use (ML): Weir pool 2: 5,617 ML (5,060 ML return flows) = Net use 557 ML

Weir pool 5: 8,033 ML (7,088 ML return flows) = Net use 945 ML

Timing: mid-August – mid November 2018

Site Water Manager: DEW

Source of water: CEWH

Environmental Watering Objectives:

- Maintain the extent and condition of riparian and in-channel vegetation by increasing periods of growth for non-woody vegetation communities that closely fringe or occur within the River Murray channel, anabranches and low elevation floodplain wetlands.
- Maintain current species diversity, extending distributions and improving breeding success and numbers of water dependant bird species by supporting suitable habitat conditions and food resources for water bird growth, survival and maintenance of population condition and diversity.
- Contributing to riverine functions by supporting primary and secondary production along the River Murray through the mobilisation and transport of nutrients, carbon cycling and biotic dispersal.
- Supporting the managed export of salt and nutrients from the River Murray system.

4.3.2 Description of Watering

Raising of Weirs 2 and 5 above the normal operating level was undertaken between August and November 2018. The target height for Weir 2 was 6.60 m AHD, which is 0.50 m above normal operating level. The target height for Weir 5 was 16.65 m AHD, which is 0.35 m above normal operating level.

Raising commenced on 15 August 2018 (noting that weir pools were already slightly above normal pool level but within normal operating range). The average daily increase in water levels was 0.02 m/d and the target height was reached on 28 August 2018.

Water levels were held at the target height for 45 days (with some operational variability) and drawdown to return to normal operating level commenced on 13 October 2018. Weir pools returned to normal operating level by 5 November 2018 for Weir 5 and 14 November 2018 for Weir 2. The average daily decrease in water levels was 0.015 m/d.

Three managed, temporary wetlands were inundated by the Weir 5 raising: Murtho temporary basin, Templeton and Whirlpool Corner. As managed sites with infrastructure, there was the opportunity to retain water within these wetlands for a longer period (six weeks extension) by closing the structures within the wetlands while the weirs were still at the higher levels. After six weeks the structures were re-opened allowing water within the basins to return to the River. The purpose of retaining the water was to improve/consolidate the benefits of inundation for vegetation, waterbirds and other fauna and frog breeding.

4.3.3 Monitored Outcomes

Observations

The following observations were made by the NR SAMDB Wetlands Team:

- Spotted grass frog, eastern sign bearing froglet, Peron's tree frog, eastern banjo frog and the long thumbbed frog were recorded calling at Woolenook Bend, Murtho Park, Paringa Paddock, Templeton and Whirlpool Corner between September and November 2018.
- The southern bell frog was recorded at Templeton in September 2018.
- Birds were monitored at Bookmark Creek and Hart Lagoon in September 2018. Waterbird species of note were Freckled Duck, Australasian Shoveler, Great Egret, Australasian Darter.

Sentinel

Satellite imagery before and during the weir pool manipulations was used to record the change in area of inundation (Figures 11, 12 and 13). The imagery shows water extending into temporary wetland basins at Big Toolunka Wetland in Weir 2 reach (Source: Sentinel Playground, <https://apps.sentinel-hub.com/sentinel-playground>, Sinergise Ltd).

Photopoints

Existing photopoints (established by the NR SAMDB Wetlands Team) at Whirlpool Corner Wetland, Hart Lagoon and Ramco Lagoon were monitored before (7 Aug 2018), during (13 Sep 2018) and after (18 Dec 2018) the event, with dominant plant species present in the photos identified (Figure 14, 15 and 16).

A number of species were observed growing on Whirlpool Corner wetland bed during December 2018 photopoint monitoring (i.e. after drawdown) including nardoo, red water milfoil, joyweed and rosinweed. Flowering black box and emu bush were also observed around the margins of the wetland bed.

At Hart Lagoon, vegetation observed growing in the littoral zone that had been wet then dried due to weir pool manipulation included rosinweed, sea blite (Figure 16) and marsh club-rush.



Figure 11: Sentinel images for Big Toolunka during the weir pool raising Source: DEW



Figure 12: Sentinel image for Big Toolunka at the peak of the weir pool raising Source: DEW



Figure 13: Sentinel image for Big Toolunka post the weir pool raising Source: DEW



Figure 14: Whirlpool Corner – 18 August 2018 (pre weir pool 5 raising) Source: NR SAMDB



Figure 15: Whirlpool Corner – 13 September 2018 (weir pool 5 at 0.35 m AHD above normal operating level) Source: NR SAMDB



Figure 16: Whirlpool Corner – 18 December 2018 (post weir pool 5 raising) Source: NR SAMDB



Figure 17: Sea blite at Hart Lagoon – 18 December 2018 (post weir pool 2 raising) Source: NR SAMDB

4.4 River Murray Wetlands

DEW manages a number of pool connected wetlands along the River Murray with infrastructure in accordance with the site specific wetland management plans and in partnership with the NR SAMDB Wetlands Program. Water for the environment is held by the SA Minister for Environment and Water for this purpose and sites watered in 2018-19 are listed in Table 3.

Table 3: Pool connected wetlands that received water from the SA Minister's licence in 2018-19

Site	Lock Reach	Delivery Partner
Devon Downs South	Below Lock 1	NR SAMDB
Morgan's Lower Murray	Below Lock 1	NR SAMDB
Big Bend	Below Lock 1	NR SAMDB
Paiwella	Below Lock 1	NR SAMDB
Reedy Creek	Below Lock 1	NR SAMDB
Sugar Shack	Below Lock 1	NR SAMDB
Sweeny's Lagoon	Below Lock 1	NR SAMDB
Silverlea	Below Lock 1	NR SAMDB
Teal Flat	Below Lock 1	NR SAMDB
Brenda Park	Lock 1	NR SAMDB
Bunyip Reach	Lock 1	NR SAMDB
Murbko South	Lock 1	NR SAMDB
Hart Lagoon	Lock 2	NR SAMDB
Ramco Lagoon	Lock 2	NR SAMDB
Nigra Creek – Schillers Lagoon	Bypasses Lock 2	NR SAMDB
Loveday Basin	Lock 3	NR SAMDB
Pyap	Lock 3	NR SAMDB
Spectacle Lakes - Beldora	Lock 3	NR SAMDB
Yatco	Lock 3	NR SAMDB
Banrock Station Wetland	Bypasses Lock 3	Accolade Wines
Causeway Complex	Lock 4	NR SAMDB
Lake Merreti	Lock 5	ALT
Pipeclay Billabong	Lock 6	NR SAMDB
Slaneys Billabong	Lock 6	NR SAMDB

In addition, there were a number of wetlands managed in partnership with the NR SAMDB Wetlands Program, as well as by non-governmental organisations including NFSA, RIT, Accolade (Banrock Station) and Australian Landscapes Trust. Summaries of these actions are included in the sections below.

4.4.1 Natural Resources South Australian Murray-Darling Basin Watering Overview

Location: Wetland and floodplain sites (details in Table 4), River Murray South Australia

Area watered (ha): 867.2 ha

Water use (ML): Total water used 9,748 ML (details in Table 4)

Timing: Most sites received water from spring 2018 until autumn 2019. Bookmark Creek and Tolderol received water all year.

Site Water Manager: NR SAMDB Wetlands Program

Source of water: CEWO / SA Ministers Licence / Tolderol licence

Environmental Watering Objectives:

- Support black box, river red gum and lignum floodplain communities.
- Support the following nationally threatened species: regent parrots, Murray hardyhead and southern bell frogs.
- Provide waterbird habitat for species from a range of functional groups, with the potential for waterbird breeding to occur at some wetland sites.
- Support regent parrot populations at Markaranka Flat Wetland Complex, Hogwash Bend and Morgan Conservation Park.
- Provide frog breeding opportunities for a range of species.
- Provide adequate foraging habitat for migratory shorebirds and maintain a variety of habitat for waterbirds including cryptic species such as the EPBC-listed Australasian bittern at Tolderol.
- Improve aquatic habitat for potential threatened fish surrogacy at Investigator College wetland.

4.4.2 Description of Watering

The majority of water was delivered to wetlands in October, November and December 2018 through a range of measures including pumping, flow-control structures and installation of temporary embankments. Water used by wetlands is measured through flow gauges where water is pumped, or else calculated using the wetland evaporation calculator where flow control structures and temporary embankments are used. Regular contact was made with landholders and pumping contractors to ensure pumping inundated the wetlands to the preferred levels.

Water was delivered to Berri Evaporation Basin and Disher Creek to manage salinities over the winter months before delivering water to freshen the complex in early spring to trigger Murray hardyhead breeding. Murray hardyhead are known as a boom and bust species that can rapidly breed when appropriate environmental conditions and habitats align (Whiterod et al 2019). Water quality was measured regularly at these sites to ensure salinity levels were within the required range for Murray hardyheads.

4.4.3 Monitored Outcomes

Overall the following outcomes were observed at the sites watered by the NR SAMDB Wetland Program:

- Southern bell frogs were heard calling at four wetland sites (out of seven sites monitored) as a result of watering.
- Breeding calls were heard for all six frog species expected in the Riverland area.
- Breeding of Murray hardyheads was observed in Disher Creek and Berri Evaporation Basin.
- Improvement in the growth of juvenile river red gums surrounding many of the wetlands.
- Growth of mature river red gums, including improvement in canopy density and extent, coobah trees and lignum within and surrounding the wetlands.
- Freshening of salinities within wetlands watered.

- Increase in waterbird use of the wetlands including ibis, darters, purple swamp hens, masked lap-wings, pelicans, egrets and spoonbills.

Table 4: Water used for NR SAMDB Wetland Program watering in 2018-19

Site	Area (hectares)	Volume CEWO ML	Volume Ministers Reserve ML	Volume Tolderol license ML	Status
Bookmark Creek	45	386	63		Completed
Berri Evaporation Basin	100	1,007			Completed
Overland Corner	68	1,045			Completed
Markaranka	80	1,916			Completed
Molo Flat	32	740			Completed
Wiela	46	596			Completed
Morgan East	8	200			Completed
Gerard lignum basin	40	147			Completed
Nikalapko	46	1,036			Completed
Hogwash Bend	34	545			Completed
Wigley Reach	20	413			Completed
Morgan CP	82	336			Completed
Maize Island	9	150			Completed
Disher Creek	17	54			Completed
Whirlpool Corner	30	22			Completed
Templeton	8	38			Completed
Murtho temporary	2	4			Completed
Tolderol	200		5	1,035	Completed
Investigator College	0.2		10		Completed
TOTAL	867.2	8,635	78	1,035	

Berri Evaporation Basin and Disher Creek

Fish monitoring at Berri Evaporation Basin in November 2018 resulted in the capture of 15 mature Murray hardyhead from 35-59 mm in length (Figure 18). The fish survey in March 2019 only resulted in the capture of one adult fish. While these numbers are low, they demonstrate that this unique population continues to persist and that the delivery of water for the environment to these sites helps ensure that these important and genetically distinct subpopulations continue to survive.

Fish monitoring at Disher Creek in February 2019, resulted in the capture of 602 mature fish from a range of size classes, indicating a healthy population structure. These fish were found at all monitoring sites across the Disher Creek Complex. In November 2018, 15 Murray hardyhead were captured at Disher Creek.



Figure 18: Murray hardyhead caught at Berri Evaporation Basin, November 2018 Source: Sam Hardy

Wiela wetland

Watering at Wiela wetland resulted in increased waterbird use by a range of birds including ibis, ducks, emus and pelicans, as well as improvement in the growth of juvenile river red gums surrounding the wetland bed edge (Figure 19). A total of five frog species were heard calling following the filling of the wetland, including the eastern banjo frog, eastern sign bearing froglet, long-thumbed frog, Peron's tree frog and spotted grass frog.



Figure 19: Wiela, December 2014 (young river red gums in foreground germinated ~ early/mid 2013) Source: Rebecca Turner

Overland Corner

A total of six frog species were recorded at Overland Corner wetland following pumping, including the nationally threatened southern bell frog. Waterbird use of the wetland increased and birds present included ibis, darters, purple swamp hens, masked lap-wings, pelicans, egrets and spoonbills (Figure 20).



Figure 20: Spoonbill and ibis at Overland Corner, December 2018 Source: NR SAMDB

Tolderol wetland

Over 11,500 birds were counted from September 2018 to May 2019 during the monthly surveys. Whiskered tern, tree martin, red-kneed dotterel, black-tailed native-hens, white-fronted chats and black swans were the other most prolific species surveyed throughout the season. Other observations included sharp-tailed sandpiper (Figure 21) and red-capped plover (Figure 22) and 27 rare glossy ibis were seen throughout the various bays over summer.



Figure 21: Sharp-tailed sandpiper observed at Tolderol Game Reserve in 2018 Source: NR SAMDB



Figure 22: Red-capped plover observed at Tolderol Game Reserve in 2018 Source: NR SAMDB

4.4.4 Nature Foundation South Australia Watering Overview

Location: Multiple Wetland and floodplain sites detailed in (see Table 5), River Murray South Australia

Area watered (ha): 192.32 ha

Water use (ML): Total water used 1,544 ML (details in Table 5)

Timing: Water was delivered throughout 2018-19

Site Water Manager: NFSA

Source of water: CEWO

Environmental Watering Objectives:

- Support black box, river red gum and lignum floodplain communities.
- Support food sources for waterbirds.
- Manage water quality and salinities in wetlands.
- Support management of wetting and drying cycles to support biodiversity and wetland health and create drought refuge in dry periods.

4.4.5 Description of Watering

Wetland watering was undertaken by NFSA in partnership with the CEWO. A summary of the sites watered by NFSA is included in Table 5. Delivery of water to the sites throughout 2018-19 used a variety of delivery mechanisms, including pumps, hoses and sprinklers and existing irrigation networks. Water used by wetlands was measured through meters where water was pumped and some small holding banks were installed to assist in retention of water.

Table 5: Watering sites for Nature Foundation South Australia in 2018-19

Site	Hectares	Volumes CEWO ML
Cadell Lagoon	24	323.3
Disher Creek		23.6
Greenways Landing	9.2	40.0
Milang	1.6	13.3
Qualco Lagoon and Swale	41	561.3
Riversleigh Lagoon and Surrounds	69	236.8
Loxton Riverfront Lagoon	3.5	30.5
Clarks	1.8	7.6
Lyrup Lagoon, Gurra	14	64.4
Plush's Bend	3.4	75.7
Pike	23.26	158.0
Rillis Westbrooks	1.62	9.8
	168.38	1544.3

4.4.6 Monitored Outcomes

Monitoring undertaken on wetlands watered in 2018-19 indicates that trees responded to watering, with trees that received water in significantly better health than those that did not receive water (NFSA 2019). Trees, including red gums and black box that have not received water are declining in health with no significant rain received in the area and high summer temperatures since September 2018.

Observations made during the watering events noted the following state or Commonwealth listed threatened species or listed migratory species:

- Murray hardyhead at Lyrup Lagoon.
- Freckled duck at Greenways Landing (Figure 23 and 24) and Plush's Bend.
- A small flock of regent parrots at Greenways Landing and Qualco.
- Latham's snipe and Australasian bittern at Milang Snipe Sanctuary (Figure 25 and 26).
- striped honeyeater (rare in South Australia) at Qualco.



Figure 23: Freckled duck at Greenways Landing, November 2018 Source: Ron Kelertas



Figure 24: Greenways Landing Aerial, November 2018 Source: Ron Kelertas



Figure 25: Milang Snipe Sanctuary, November 2018 Source: Regina Durbridge



Figure 26: Latham's snipe Source: Martin Stokes



Twilight Tour
Source: DEW

5. Consultation and Communication

5.1 Consultation

Environmental water managers in South Australia use a variety of methods to gain feedback and advice on the delivery of water for the environment. This occurs in both the early planning stages and throughout the year as water for the environment is delivered and managed. The planning stage starts with a workshop early in the year with environmental water holders, scientific experts and river operators to consider the water resource forecast for the year ahead and to start considering what watering events may be possible. The results of this workshop are then used by site managers to develop watering proposals to determine how environmental water requirements for key sites and priority environmental assets might be met.

The development of watering proposals is undertaken in consultation with the local community, non-government organisations and traditional owners. At major assets, such as the Chowilla Floodplain and the CLLMM, there are established reference groups which have an in-depth knowledge of the asset, its infrastructure and water for the environment.

Consultation is undertaken using a range of different methods, depending on the group or person being engaged for feedback. Site tours, meetings and presentations are key approaches used by site managers to gain feedback from key reference groups during the planning process. Face-to-face conversations with individual landholders and industry representatives are also effective and used where required.

In 2018/19, South Australian managers of environmental water conducted 11 tours for Chowilla and the CLLMM to improve understanding about the sites and the way they are managed. Additional information about the engagement and consultation undertaken along the River Murray is included below.

5.1.1 CLLMM Consultation

On-going consultation occurs with the CLLMM Community Advisory Panel every two months (Figure 27) and the Scientific Advisory Group every quarter. Two joint meetings of these groups were held and provided direction to real-time barrage operations and management. In addition, seven presentations were given to these community and scientific reference groups on key issues regarding the CLLMM. Feedback from the Ngarrindjeri Regional Authority was incorporated into planning and on-going advice throughout the year was gained through the 'Water Statement of Commitment' group.

Management of water being released through the barrages is guided by an Operation Advisory Group and over 36 teleconferences were held to coordinate water delivery and operations.



Figure 27: Coorong, Lower Lakes, and Murray Mouth Community Advisory Panel, April 2019 Source: Stephen Madigan

5.1.2 Chowilla Consultation

Site managers at Chowilla meet on a regular basis to provide updates and receive feedback from the Chowilla Community Reference Committee. Management of water on site is coordinated by the Chowilla Operations Group which holds weekly teleconferences. Numerous presentations and floodplain tours are undertaken during watering events with both school groups and community organisations to improve understanding of how the infrastructure operates and the benefits of watering. Event specific factsheets have been developed and are available on the DEW website (<https://www.environment.sa.gov.au/topics/river-murray/improving-river-health/the-living-murray-program/chowilla-floodplain>).

Consultation occurs with neighbouring landholders and irrigators in the Lock 6 to Lock 7 weir pool when required with information updates provided via email and or post.

Chowilla Floodplain Icon Site management and environmental watering are discussed regularly with representatives of the First People of the River Murray and Mallee Region (Figure 28). Workshops were held with the First Peoples Working Group and River Murray and Mallee Aboriginal Corporation Directors to seek their input into the watering proposal and regular updates were provided to the group during the event.

DEW Aboriginal Rangers and the Chowilla Indigenous Facilitator worked with the Chowilla ecologist to undertake the floodplain and wetland fish surveys during the watering event.



Figure 28: Working with Traditional Owners Source: Fiona Giles

5.1.3 Weirpool Consultation

Communication was undertaken with the boarder community via the weekly DEW River Murray Flow Report and local ABC radio. Stakeholders who had also previously indicated an interest in weir pool manipulation were emailed directly throughout the event, alerting them to operational changes and start and finish points. This included landholders, councils, caravan parks as well as other State Government departments (e.g. Department of Planning Transport and Infrastructure).

5.1.4 NR SAMDB Wetland Program Consultation

A range of community engagement activities were undertaken during the watering program in 2018/19, including ongoing contact with landholders and wetland groups on the progress of watering. Feedback from the landholders and community group members regarding the outcomes seen at the wetlands was very positive.

Consultation with the First Peoples of the River Murray and Mallee by NR SAMDB Wetland Program has been ongoing with a number of presentations provided to the First Peoples Working Group regarding wetland management. A tour involving approximately 20 people from the community was undertaken at Hogwash Bend and Maize Island on 20 May 2019.

The Gerard Aboriginal Country Rangers were contracted to undertake watering at Gerard Lignum Swamp and Hogwash Bend North Lagoon.

5.2 Communication

In 2018/19, DEW, the NR SAMDB and the NGOs released 17 Media Releases on water delivery for the environment or regarding new infrastructure construction and operation. Examples of these are included below (Figure 29). In addition, 23 radio interviews were conducted relating to management of water for the environment.



Water regulation in local wetlands shows growth

POSITIVE growth has been recorded across Riverland wetlands after an increase of water was delivered during the recent spring/summer period.

Water was delivered to 18 wetland sites including Maize Island Conservation Park and Hogwash Bend Conservation Park, as well as Overland Corner Wetland where a monitoring program was run by local environmental groups.

Natural Resources South Australian Murray-Darling Basin (SAMDB) Floodplains and Wetlands Team together with support from the Overland Corner Wetland Group and Berri Barmera Landcare volunteers followed the progress of native flora that inhabit the Overland Corner site.

Natural Resources

November 2018
After 2 dry years



A photo comparison of the Overland Corner Wetland before the delivery of environmental watering and four months following, showing the added water's positive impact.
PHOTO: Supplied

SAMDB floodplain and wetlands project officer Sam Harly said the environmental watering had

positive results.

"This water for the environment has helped restore and protect these

significant local wetlands," he said.

"Overland Corner, situated above the normal water level in the River Murray is a 'temporary' wetland and only receives water from the river in a high-flow event.

"Between high-flow events, the wetland needs water to be pumped into it to keep it in a healthy condition and support the diverse range of important native plants and animals that live in the area."

Overland Corner's "temporary" wetland was filled in October/November last year, with refills through the summer period.

The monitoring program showed that environmental watering maintained and improved the condition of long-lived vegetation such as river red gum, black box, river cooba and lignum.

The River Murray Times, 12 July 2019, 1C

Figure 29: Example of articles from media releases in 2018-19

Other forms of communication undertaken by DEW included:

- Letters sent to landholders to provide information about watering events.
- Facebook/twitter posts.
- Blog articles including on the DEW blog "Good Living".
- Updated Basin DEW and MDBA website information.
- Conference presentations / presentations to outside organisations.
- Development of pamphlets on operations.
- Attending regional Field Days to talk to community members.
- Providing updates through the DEW Weekly Flow Report.

The NR SAMDB Wetland Program also deliver a range of communication products, including newspaper articles, radio interviews, social media including Facebook, Twitter and Instagram, as well as articles in newsletters.



Golden Headed Cisticola
Source: Sally Grundy



MUNDOO ISLAND STATION
Coorong, South Australia

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Coorong Sunrise
Source: Sally Grundy

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