Long-term environmental watering plan for the South Australian River Murray water resource plan area

Updated November 2020

Acknowledgement of the Traditional Owners

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

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

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Glossary

Basin State	Defined in the *Water Act 2007* to mean (a) New South Wales; (b) Victoria; (c) Queensland; (d) South Australia; (e) the Australian Capital Territory.
Bonn Convention	The Convention on the Conservation of Migratory Species of Wild Animals - an environmental treaty aimed at conserving terrestrial, aquatic and avian migratory species throughout their range.
BWEWS	Basin-Wide Environmental Watering Strategy – published by the Murray-Darling Basin Authority, a legislative requirement under Chapter 8 of the Basin Plan.
CAMBA	China-Australia Migratory Bird Agreement – a bilateral agreement to protect and conserve migratory birds and their habitat.
CEW	Commonwealth Environmental Water.
CEWH	Commonwealth Environmental Water Holder.
CEWO	Commonwealth Environmental Water Office.
CLLMM	Coorong, Lower Lakes and Murray Mouth.
CMS	Constraints Management Strategy - strategy published by the Murray-Darling Basin Authority in 2013 that identifies further work to be undertaken on physical constraints.
CPS	Components, processes and services – attributes that are identified and described in the ecological character descriptions of Ramsar wetlands.
DEW	South Australian Department for Environment and Water.
Discharge	The volumetric flow rate of water i.e. volume of streamflow over a given time. In South Australia, this is often represented as ML/day.
ECD	Ecological character description - provides a description of a Ramsar wetland at the time of listing, where ecological character is the ecosystem components, processes, benefits and services that characterise the wetland. It can be used to assist in the assessment of possible change in the ecological character of the wetland.
EPBC Act	*Environment Protection and Biodiversity and Conservation Act 1999*. The Australian Government's environmental legislation which provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places ('matters of national environmental significance').
EWC	Environmental Water Committee – a committee established through the Basin Officials Committee in 2020 to replace the Environmental Water Working Group, which has been responsible for coordinating work on the implementation of Basin Plan Chapter 8.
EWR	Environmental water requirement - the water regime needed to sustain the ecological values of aquatic ecosystems and biological diversity at a low level of risk.
EWWG	Environmental Water Working Group – a multi-jurisdictional group convened by the MDBA for coordinating work on the implementation of Basin Plan Chapter 8.
FPRMM	First Peoples of the River Murray and Mallee Region - native title holders in the Riverland, South Australia, including areas of the River Murray around Renmark, Berri, Barmera, Waikerie and Morgan.
GL	Gigalitres – a measure of volume, where a gigalitre equals 1,000 megalitres or 1,000,000,000 litres.
HEW	Held environmental water – defined within Section 4 of the *Water Act 2007*.
JAMBA	Japan-Australia Migratory Bird Agreement – a bilateral agreement to protect and conserve migratory birds and their habitat.
KNYA	Kungun Ngarrindjeri Yunnan Agreement.
LAC	Limits of acceptable change - used in a Ramsar context to define and detect a change in the ecological character of wetlands.
Lower Lakes	Lakes Alexandrina and Albert.
LTAAY	Long-term average annual yield – a standardised way of expressing water recovery figures.
LTWP	Long-term environmental watering plan – a legislative requirement under Chapter 8 of the Basin Plan.
MACAI	Mannum Aboriginal Community Association Incorporated.
MDBA	Murray-Darling Basin Authority.
ML/day	Megalitres per day – a measure of flow or discharge, where a megalitre equals 1,000,000 litres.
MRL Board	Murraylands and Riverland Landscape Board.

NAC	Ngarrindjeri Aboriginal Corporation – a regional Indigenous organisation representing the Ngarrindjeri people, descendants of the original indigenous inhabitants of the lands and waters of the Murray River, Lower Lakes and Coorong and adjacent areas.
NRA	Ngarrindjeri Regional Authority – a regional Indigenous organisation representing the Ngarrindjeri people, descendants of the original indigenous inhabitants of the lands and waters of the Murray River, Lower Lakes and Coorong and adjacent areas.
PEA	Priority Environmental Asset – defined in section 8.49 of the Basin Plan as an environmental asset that can be managed with environmental water.
PEF	Priority Environmental Function - defined in section 8.50 of the Basin Plan as an ecosystem functions that can be managed with environmental water.
PEW	Planned environmental water – defined in Section 6 of the *Water Act 2007*.
Pool-connected wetland	A wetland that can be connected to the main River channel when South Australia is receiving its Entitlement and normal operating pool levels are being maintained.
PPM	Pre-requisite policy measure - measures designed to maximise the beneficial outcomes of water recovered for the environment under the Basin Plan (section 7.15).
QSA	Flow at the South Australian border. Unless otherwise stated, flow rates (or discharges) are expressed with respect to flow at the South Australian border.
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement – a bilateral agreement to protect and conserve migratory birds and their habitat.
SA	South Australia
SA Murray Region WRP area	South Australian Murray Region water resource plan area – defined in Chapter 3 of the Basin Plan and incorporates the Coorong. For the purposes of this LTWP, the Coorong is considered as part of the SA River Murray water resource plan area.
SA River Murray LTWP	The Long-Term Environmental Watering Plan for the South Australian River Murray Water Resource Plan Area.
SA River Murray WRP area	South Australian River Murray water resource plan area – defined in Chapter 3 of the Basin Plan. For the purposes of this plan, the Coorong is considered as part of this water resource plan area.
SCB	Southern Connected Basin - a collective term for the valleys located in the southern section of the Murray-Darling Basin, including Goulburn, Campaspe, Loddon, Murray (NSW, Victorian and South Australian), Murrumbidgee and Lower Darling.
SCBEWC	Southern Connected Basin Environmental Watering Committee - a multi-jurisdictional committee that provides advice on the coordinated delivery of environmental water.
SDL	Sustainable diversion limit – defined in the Basin Plan as the long-term average sustainable diversion limit.
Temporary wetland	A wetland basin that is not connected to the main River channel when South Australia is receiving its Entitlement flows and normal operating pool levels are being maintained.
TLM	The Living Murray Program – a long-running collaborative programme between the Murray-Darling Basin Authority and partner governments aimed at restoring the health of the River Murray system by recovering 500 gigalitres of water and constructing major water management structures at six environmental icon sites.
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples.
VEWH	Victorian Environmental Water Holder.
WRP area	Water resource plan area – identified for the purpose of implementing the Basin Plan, the water resource plan areas are listed in Chapter 3 of the Basin Plan.

Executive Summary

The first *Long-term Environmental Watering Plan for the South Australian River Murray Water Resource Plan Area* (SA River Murray LTWP) was published in 2015. It identified the priority environmental assets of the area and the environmental objectives, targets and environmental water requirements (EWRs) to be achieved for those assets over the longer term. A review and update of the 2015 LTWP has been triggered under section 8.22 of the Basin Plan by the accreditation of the *South Australian River Murray Water Resource Plan* (SA River Murray WRP) in 2019 by the Federal Minister for Water. This 2020 LTWP update has focussed on aligning the LTWP with the accredited WRP including sections relating to planned environmental water, Aboriginal values and uses, co-operative arrangements within and between water resource areas and strategies to address risks identified to water-dependent ecosystems.

The LTWP is of strategic importance for the management of the South Australian River Murray, its floodplain and wetlands, and the Coorong, Lower Lakes and Murray Mouth (CLLMM), providing direction for the most efficient and effective use of environmental water. Environmental water holders and managers will use this LTWP to guide environmental water decision making, and to inform the coordination of Basin-wide watering actions in the Southern Connected Basin.

The SA River Murray water resource plan area (SA River Murray WRP area) includes the River Murray and its floodplain (defined by the 1956 flood extent), from the South Australian/New South Wales/Victorian border (the border) to the Murray Mouth, and includes Lakes Alexandrina and Albert (the Lower Lakes). This LTWP also incorporates the Coorong in recognition of the intrinsic connection between the River Murray and the Coorong. Although considered by the Basin Plan to be part of the SA Murray Region water resource plan area, ecological outcomes in the Coorong are driven by surface water inputs from the River Murray via the Lower Lakes. For this reason the Coorong, Lower Lakes and Murray Mouth asset needs to be managed as a whole, and this approach is consistently applied by South Australia in annual environmental water planning and implementation, including the development of annual environmental watering priorities under the Basin Plan.

A landscape-scale approach has been used to define the environmental assets to reflect the ecological importance of the mosaic of habitats, rather than focussing on discrete management units that represent only a small portion of the SA River Murray WRP area. It also ensures that a holistic approach is taken to environmental water planning, delivery and evaluation.

Three priority environmental assets have been identified for the SA River Murray WRP area:

1. the Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset ('the CLLMM PEA') - equivalent to the Lower Lakes, Coorong and Murray Mouth TLM Icon Site and the Coorong, Lakes Alexandrina and Albert Ramsar Wetland of International Importance
2. the South Australian River Murray Channel Priority Environmental Asset ('the Channel PEA') - consists of the area between Wellington, South Australia, and the border and includes the channel component of the Riverland Ramsar site - a total distance of approximately 560 River kilometres. The lateral extent comprises the area inundated at flows up to 40,000 ML/day QSA (i.e. flow measured at the border) under normal River operations
3. the South Australian River Murray Floodplain Priority Environmental Asset ('the Floodplain PEA') an equivalent longitudinal extent to the Channel PEA, extending from Wellington, South Australia, to the border and includes the floodplain component of the Riverland Ramsar site and the Banrock Station Ramsar site. It consists of the area that is inundated when flows are between 40,000 ML/day QSA and 80,000 ML/day QSA (under normal River operations).

The outer floodplain (i.e. the area that requires flows above 80,000 ML/day QSA to be inundated) is not included as part of the Floodplain PEA as the Basin Plan defines a priority environmental asset as an environmental asset that can be managed with environmental water (section 8.49) and Murray-Darling Basin Authority (MDBA) modelling indicates that 80,000 ML/day QSA is the maximum flow rate at which active management of environmental water can occur (subject to the implementation of measures to address flow constraints). The outer floodplain represents approximately 40% of the whole floodplain. Despite not being part of the Floodplain PEA, the outer floodplain is still considered to be an area of high importance to South Australia for many reasons, including supporting a large proportion of the black box woodlands within the water resource plan area (WRP area), and connecting riparian zones with upland habitats. Unregulated flows above 80,000 ML/day QSA support the health of the high elevation floodplain areas and it is critical that there is no further reduction in t the occurrence of the unregulated flow events that are required to inundate the outer floodplain (Government of South Australia, 2012).

In total, 45 ecological objectives, 98 ecological targets and 16 EWRs were identified for the three priority environmental assets (PEAs). They represent what is needed to support each of the priority environmental assets in a healthy, functioning state.

An overall theme of the EWRs is the reinstatement of a more natural flow regime through the delivery of environmental water to the South Australian border, and downstream to the CLLMM. To meet the majority of the EWRs, environmental water will need to be delivered in conjunction with unregulated flows, as the volume of water required is greater than that provided by South Australia's Entitlement alone or available to the environment through water recovery programs. The availability of water for the environment and ability to make active management decisions on its use is critical for optimising water delivery patterns and achieving the best possible environmental outcomes.

The EWRs describe a desired long-term and variable hydrological regime that enables flexibility and adaptive management in response to climate and ecological condition. The EWRs can be used in annual planning, together with results from ecological monitoring, to identify vital watering actions for the PEAS, their need for water and risk of not watering.

In addition to the ecological information provided, the following management considerations are also explained and fulfil the LTWP content requirements described in the Basin Plan (section 8.19):

- Aboriginal values – consideration of, and where possible alignment with, Aboriginal values in order to maximise the benefits from environmental watering
- Co-operative arrangements – processes to be followed to ensure that watering actions across the WRP area and Southern Connected Basin (SCB) are coordinated
- Operational constraints – whether it is feasible to deliver the proposed watering action in view of operational constraints
- Long-term risks to providing for the EWRs – whether the proposed watering action addresses any of the potential long-term risks.

South Australia recognises the importance of and is committed to seeking and incorporating Aboriginal values and uses in the development of environmental water plans where possible. Within the SA River Murray WRP area, Aboriginal engagement in environmental water planning has occurred for many years with the Ngarrindjeri Regional Authority (NRA), the Ngarrindjeri Aboriginal Corporation (NAC) and the First Peoples of the River Murray and Mallee Region (FPRMM) through formal agreements with the South Australian Government. Collaboration between the FPRMM, Murraylands and Riverland Landscape Board (formerly Natural Resources SA Murray-Darling Basin) and DEW, has enabled the inclusion of FPRMM's perspectives into the management of the River Murray channel and its wetland and floodplain areas. Crucial to the strong working partnership that has developed between Ngarrindjeri and DEW staff are the Statement of Commitment and the Ngarrindjeri Yarluwar Ruwe (NYR) caring for country programme, which have facilitated active Ngarrindjeri participation and involvement in environmental water planning and management for the CLLMM, Channel and Floodplain Assets for a number of years. These relationships have led to an improved LTWP.

Co-operative arrangements within the WRP area are needed to ensure all River operators, environmental asset and site managers, environmental water holders and environmental water managers are working towards the common goal for the SA River Murray WRP area of a healthy, functioning and resilient ecosystem. They lead to decisions that are transparent, to priorities and trade-offs that are understood, and outcomes at the site-scale that contribute to desired outcomes at the LTWP asset and WRP area scale. The arrangements currently in place for environmental water management within the WRP area have been identified in this LTWP and will be described in detail in the *Water for the Environment Management Framework, South Australian River Murray* (Department for Environment and Water, in prep).

Co-operative arrangements between upstream WRP areas and the SA River Murray WRP area have progressed significantly in recent years through the operation of the Southern Connected Basin Environmental Watering Committee (SCBEWC). South Australia continues to work closely with the other Basin States, the MDBA and the Commonwealth Environmental Water Office (CEWO) to coordinate the management of water for the environment, including an increased focus on coordination for system-scale outcomes.

Constraints continue to have a significant impact on the feasibility of delivering environmental water to and within the SA River Murray WRP area, and more broadly throughout the Murray-Darling Basin. The constraints currently having the greatest impact on environmental water management in the SA River Murray WRP area are generally being addressed through the Constraints Management Strategy (CMS) or the implementation of policy measures relating to the sustainable diversion limit (SDL) adjustment mechanism.

Key long-term risks to providing for the EWRs of PEAs and priority ecosystem functions (PEFs) include:

- insufficient water available for SA River Murray WRP area priority assets/functions
- water cannot be delivered to SA River Murray WRP area priority assets/functions
- water quality is unsuitable for use at SA River Murray WRP area priority assets/functions.

Mechanisms for addressing these long-term risks include effective decision-making frameworks; addressing flow constraints at a Basin scale, and rigorous monitoring and evaluation programs. These key risks align with the risks identified in the SA River Murray WRP (Department for Environment and Water, 2019a).

Effective monitoring, evaluation and reporting will be critical to assessing both the effectiveness of this LTWP and the Basin Plan environmental watering framework more generally. The LTWP represents what is needed to support a healthy, functioning ecosystem and has not been restricted to what is achievable under the Basin Plan, nor what is likely to be monitored in the future. Work to prioritise monitoring indicators from the LTWP ecological targets and then quantify expected outcomes for these indicators has been undertaken as part of the state's reporting requirements under Matter 8, Schedule 12 of the Basin Plan (the achievement of environmental outcomes at an asset scale). This provides a clear line of sight between the LTWP and Matter 8 evaluation and reporting for the SA River Murray WRP area.

Review and update of this LTWP will ensure that it retains relevance and currency, and this must occur on at least a five yearly basis.

1. Introduction

The first *Long-term Environmental Watering Plan for the South Australian River Murray Water Resource Plan Area* (SA River Murray LTWP) was developed in 2015 in accordance with the environmental management framework within the Basin Plan. It built on many years of annual environmental water planning and brought together information developed through many long-running and successful projects and programs within the region. A review and update of the 2015 LTWP was triggered by the accreditation of the *SA River Murray Water Resource Plan* (SA River Murray WRP) in 2019 as well as it being five years since the first LTWP for the region was produced (see Basin Plan section 8.22). This 2020 LTWP update has largely focussed on aligning the LTWP with WRP sections relating to planned environmental water (PEW), Aboriginal values, co-operative arrangements and risks to water-dependent ecosystems.

Projects and programs within the region are focussed on addressing the major impacts arising from a long history of River regulation and development. Extractions for consumptive use and regulation via upstream storages have caused a reduction in the flows needed to generate within-channel pulses and overbank inundation, and provide water to the Lower Lakes, Murray Mouth and the Coorong. In addition, the construction of six weirs along the main channel of the River Murray in South Australia has stabilised water levels and slowed water velocities, creating lentic 'weir pools'. Together, these impacts have resulted in a decline in the ecological condition of the River, and its floodplain, wetlands and estuary. Aboriginal people within the SA River Murray water resource plan area (SA River Murray WRP area) rely on the interconnectivity between land, waters, spirit and all living things (Ngarrindjeri refer to this as Ruwe/Ruwar), and a decline in the ecological condition of the River system can also be understood as a threat to their health and wellbeing.

In addition to being a legislated requirement under Chapter 8 of the Basin Plan, this LTWP provides an opportunity for South Australia to outline the hydrological regimes needed to support a healthy, functioning South Australian River Murray ecosystem. The overall environmental objectives for the water-dependent ecosystems of the SA River Murray WRP area are derived from those identified in the Basin Plan for the Murray-Darling Basin Plan (section 8.04), as follows:

- to protect and restore water-dependent ecosystems of the SA River Murray WRP area
- to protect and restore the ecosystem functions of water-dependent ecosystems
- to ensure that water-dependent ecosystems are resilient to climate change, and other risks and threats.

This LTWP assists to meet these goals by:

- identifying the priority environmental assets and outlining the hydrological regimes needed to support them in a healthy, functioning state
- identifying priority ecosystem functions that focus on linking the assets and aligning environmental water management across the assets
- consolidating ecological information that will facilitate annual environmental water planning and prioritisation, and inform negotiations with water holders
- identifying constraints to the successful delivery of environmental water to and within the water resource plan area
- outlining the mechanisms in place to assist with coordinating environmental watering throughout the region and the Southern Connected Basin (SCB), and ensure priorities and any trade-offs are transparent
- providing a basis for evaluating the success of environmental water management and improving future versions of this LTWP.

The information within this LTWP is presented in the following sections:

Section 2 Context - Explains the spatial and temporal scale of the plan, and the processes and consistencies required under the Basin Plan that were followed when preparing the plan. It also identifies the types and volumes of environmental water potentially available, and the parties responsible for managing the water and environmental assets or sites in the region.

Section 3 Ecology - Describes the priority environmental assets and priority ecosystem functions identified within the SA River Murray WRP area and the processes used to identify them. A suite of ecological objectives, targets and EWRs is provided for each. Guidance on the use of the ecological content in annual and real-time planning is also provided.

Section 4 Management considerations - There are many other factors which need to be taken into account during decision-making or which influence the feasibility of delivering water. Some of these critical factors have been described, including Aboriginal values and uses, with a particular focus on those requiring description under the Basin Plan environmental water management framework.

Section 5 Monitoring, evaluation, reporting and improvement - A summary of environmental water reporting requirements is provided, as well as the link between the LTWP and the evaluation and reporting on the achievement of environmental outcomes at an asset scale (Basin Plan Schedule 12, Matter 8).

2. Context

2.1. Planning area

This LTWP has been developed for the SA River Murray WRP area, which is defined in Chapter 3 of the Basin Plan. The SA River Murray WRP area includes all the surface water resources defined as the prescribed watercourse in the River Murray Water Allocation Plan (Natural Resources SA Murray-Darling Basin, 2020). The extent includes the River Murray channel and its floodplain defined by the 1956 flood extent, from the South Australian/New South Wales/Victorian border to the Murray Mouth, and includes Lakes Alexandrina and Albert (the Lower Lakes).

This plan also incorporates the Coorong, which is considered by the Basin Plan to be within the SA Murray Region water resource plan area (SA Murray Region WRP area) (Figure 1). Ecological outcomes in the Coorong are primarily driven by surface water inputs from the River Murray via the Lower Lakes, with the volume of surface water arriving in the Coorong from the SA Murray Region WRP area being small and the groundwater inputs not well quantified or manageable. The Coorong and Lower Lakes have long been treated as a single environmental asset or site including recognition as a Wetland of International Importance under the Ramsar Convention on Wetlands and as an icon site through The Living Murray Initiative. It is therefore appropriate for the EWRs of the Coorong and the Lower Lakes to be included in the same LTWP.

Murrundi (River Murray), including the Kurangk (Coorong), Lakes and Murray Mouth, is an Aboriginal cultural landscape. The whole of the Kurangk (Coorong), Lakes and Murray Mouth site is part of the traditional lands and waters of the Ngarrindjeri nation, the Ngarrindjeri & Others (SAD 6027/98) native title claim, and includes registered Aboriginal sites such as the 'Meeting of the Waters' (Murray-Darling Basin Authority 2013b). In mid-2017 the First Nations of the South East lodged a Native Title claim which overlapped the southern area of the Coorong (SAD 211/2017). The claim is yet to be subject to any formal determination and the arrangements between the First Nations is still under discussion and yet to be formally resolved. The First Peoples of the River Murray and Mallee Region (FPRMM) have a native title consent determination (SAD 6026/1998) applying to lands and waters of the upper Murray, including the Riverland in South Australia.

2.2. Planning timeframe

The Basin Plan (section 8.22) outlines certain triggers for the review and updating of a LTWP, including the accreditation, amendment or adoption of the water resource plan for the water resource plan area, published updates to the Basin-Wide Environmental Watering Strategy (BWEWS) that materially affect the LTWP, or five years since completion of the previous LTWP. The State may also choose to revise and update the SA River Murray LTWP at any time.

The first LTWP was completed five years prior (November 2015) and the water resource plan for the SA River Murray WRP area was accredited in 2019, both triggering a need to undertake this review and update of the SA River Murray LTWP in 2020.

2.3. Consistency with preparation requirements

The SA River Murray LTWP was developed by the South Australian Department for Environment and Water (DEW) in accordance with Chapter 8 of the Basin Plan. Sections 3 and 4 of this LTWP fulfil the content requirements described in section 8.19 of the Basin Plan. This section describes how DEW met the LTWP preparation requirements that are described in section 8.20 of the Basin Plan and include:

- consultation requirements
- having regard to the Murray-Darling Basin Authority's BWEWS
- consistency with the 11 principles to be applied in environmental watering
- to not be inconsistent with relevant international agreements.

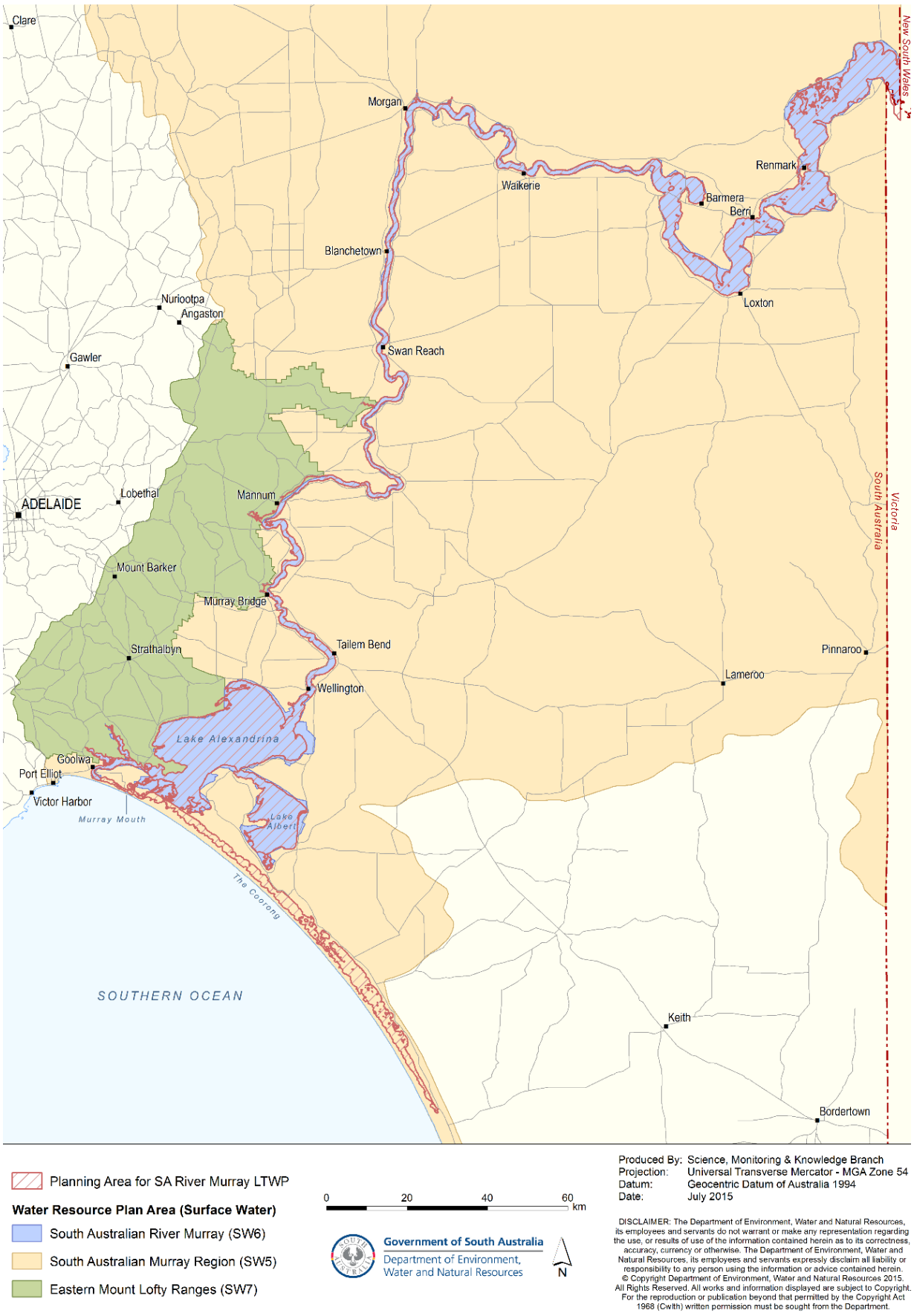


Figure 1. Comparison of the planning area of the SA River Murray LTWP to the SA River Murray WRP area

2.3.1. Consultation

2.3.1.1. LTWP preparation in 2015

Extensive consultation was undertaken by staff within DEW during the preparation of the first LTWP. This was described in detail in the 2015 LTWP and is summarised below:

- Input from the South Australian scientific community, Indigenous representative bodies (Ngarrindjeri Regional Authority and First Peoples of the River Murray and Mallee Region) and regional environmental water practitioners.
- Scientific input from regional experts was provided through their involvement in the development of four technical reports that formed the basis of the ecological content of the 2015 LTWP.
- Liaison with the MDBA, environmental water holders and upstream jurisdictions through the Environmental Watering Working Group (EWWG), an inter-jurisdictional group with representation from all the Basin governments.
- Engagement of key regional stakeholder groups that were involved in environmental water management projects (e.g. River Murray Advisory Committee, Nature Foundation South Australia, Coorong, Lower Lakes and Murray Mouth Community Advisory Panel, Local Action Planning Associations and the Scientific Advisory Group for the Lower Lakes, Coorong and Murray Mouth).
- Release of the draft LTWP for review by parties external to DEW, including to the general public via the Your Say page of the DEW website. The draft was also provided directly to Aboriginal representative bodies, key regional stakeholder groups and staff from other agencies i.e. MDBA (including staff involved in Basin Plan Implementation, The Living Murray Program and River Operations), CEWO and upstream jurisdictions. Presentations and meetings to discuss feedback on the draft were held where required.

2.3.1.2. LTWP update in 2020

Due to the extensive engagement undertaken on the 2015 LTWP, the targeted nature of the 2020 review and update, and the relatively minor changes, further consultation in relation to this 2020 update has been limited to key stakeholders. DEW staff continued to engage with the MDBA, CEWO and interstate agencies through the Environmental Water Working Group (EWWG). This consultation included a targeted workshop with EWWG members and River operators which was held on 28 July 2020.

DEW staff continue to engage with the River Nations on all aspects of environmental water planning and management, including this 2020 LTWP update. Advice and approval was sought from the First Peoples of the River Murray and Mallee Region (FPRMMR) Working Group, River Murray and Mallee Aboriginal Corporation (RMMAC) and Ngarrindjeri Aboriginal Corporation (NAC) on the inclusion of information relating to First Nations values and uses. DEW is also seeking to improve engagement with the South East Aboriginal Focus Group (SEAFG) on environmental water management in the CLLMM.

DEW greatly appreciates the time taken by organisations and individuals in reading and providing feedback on the SA River Murray LTWP and associated technical reports, which resulted in a much improved final product

2.3.2. Basin-Wide Environmental Watering Strategy

The Basin-Wide Environmental Watering Strategy (BWEWS) was initially published by the MDBA in November 2014 with a second edition released in 2019. Its development was a specific requirement of the Basin Plan (section 8.13). The Basin Plan also states that long-term watering plans must be consistent with any particular assets or functions, and their requirements, identified within the BWEWS.

The purpose of the BWEWS is to assist environmental water holders and managers to plan and manage environmental watering at the Basin scale. The BWEWS identifies expected environmental outcomes for four ecological components or 'themes': river flows and connectivity; native vegetation; waterbirds and fish (Murray-Darling Basin Authority, 2019). Assets considered important for supporting vegetation, waterbirds and native fish at the Basin-scale are identified in appendices of the BWEWS, and a number within the SA River Murray WRP area are listed. The BWEWS also includes a number of expected outcomes under each theme that are specific to the CLLMM.

Given the spatial scale applied to the identification of assets for this LTWP (see Section 3.1), the inclusion of vegetation, waterbird and native fish targets for these assets, and the focus on connectivity as a priority ecosystem function, this LTWP is considered to be consistent with the BWEWS. To further demonstrate this, Appendix 1 indicates the alignment between

the expected outcomes of the 2019 BWEWS and the ecological objectives identified for each of the priority environmental assets in this LTWP.

2.3.3. International agreements

The Basin Plan requires that a LTWP must not be inconsistent with relevant international agreements (section 8.20 (5)), which includes the Ramsar Convention, the Bonn Convention, Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA). The methods for identifying environmental assets and their environmental watering requirements (section 8.49) also state that the ecological objectives of an environmental asset should be consistent with the criteria used to identify the asset, and provide the example that if the asset is a declared Ramsar wetland, then the objectives must be directed towards maintaining the ecological character of the wetland.

Within the SA River Murray WRP area, there are three wetland and floodplain complexes that are included in the Ramsar List of Wetlands of International Importance (Table 1). The inclusion of a site in the Ramsar List involves a commitment to ensure that the ecological character of the site is maintained (where ecological character is the combination of the ecosystem components, processes and benefits/services[1] that characterise the wetland (Ramsar, 2009)). The ecological character of each of the three Ramsar wetlands was taken into account when developing the ecological objectives and targets of the priority environmental assets within the SA River Murray WRP area.[2] Consistency was achieved by ensuring that each critical component and process identified within the ecological character description of the three Ramsar wetlands was aligned with at least one ecological objective and target for the relevant priority environmental asset. This document does not however replace or supersede the work that is being undertaken on these wetlands specifically in association with their Ramsar listing but seeks to support the maintenance of ecological character by informing the management of environmental water.

2.3.3.1. Migratory bird species

Australia has signed three international bilateral agreements seeking to protect and conserve migratory birds and their important habitats in the East Asian - Australasian Flyway (Commonwealth of Australia, 2013a): JAMBA; CAMBA; ROKAMBA. Australia is also a party to the Bonn Convention (or the Convention on Migratory Species), which aims to conserve terrestrial, aquatic and avian migratory species throughout their range (UNEP/CMS Secretariat, 2014).

Birds listed under the JAMBA, CAMBA or ROKAMBA and the Bonn Convention must also be placed on the migratory species list of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which provides a legal framework within Australia to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places (Commonwealth of Australia, 2013c). EPBC-listed species, including migratory birds that have been recorded within the priority environmental assets of the SA River Murray WRP area, are listed in Appendix 2. The habitat and breeding requirements of these species have been considered in the development of the ecological objectives and targets of the priority environmental assets.

Table 1. Ramsar wetlands in the SA River Murray WRP area

Site	Date of designation	Area	Coordinates [3]
Banrock Station Wetland Complex	21/10/02	1,375 hectares	34°11'S 140°20'E
Riverland	23/09/87	30,640 hectares	34°02'S 140°51'E
The Coorong and Lakes Alexandrina & Albert Wetland	01/11/85	142,530 hectares	35°56'S 139°18'E

1 The national framework for describing the ecological character of Ramsar wetlands within Australia (Department of the Environment, Water, Heritage and the Arts, 2008) provides the following definition: "benefits and services are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as 'the benefits that people receive from ecosystems' (Ramsar Convention 2005a, Resolution IX.1 Annex A)".

2 At the time of writing, the ecological character description (ECD) for the Coorong Lakes Alexandrina and Albert Wetland was under revision. The ecological objectives and targets in this LTWP will be revised and updated, if required, in the future to reflect the revised ECD. Ngarrindjeri are formally engaged in this ECD revision (see section 4.1). The NRA have advised that this work takes into consideration Ramsar Convention resolutions pertaining to culture (Ramsar Convention 2002 & 2005) and will provide greater alignment of the management of the Ramsar site with other international agreements such as UNDRIP and further support South Australia in the implementation of Basin Plan requirements under Section 10, Part 14.

3 Notional 'centre point' only

2.4. Environmental water availability and management

2.4.1. Definition of environmental water

The environmental water available for use within the SA River Murray WRP Area consists of both 'held' and 'planned' environmental water, where:

- held environmental water (HEW) is water available under a water access right or held on a water licence for the purposes of achieving environmental outcomes (*Water Act 2007* section4)
- planned environmental water (PEW) is water that is committed or preserved for achieving environmental outcomes through a plan or legislation, and cannot be used for any other purpose unless required for emergency purposes or specified times and circumstances (*Water Act 2007* section 6).

The full definitions for held and planned environmental water, as per the *Water Act 2007*, are provided in Appendix 3.

The SA River Murray Water Resource Plan identifies held and planned environmental water in the South Australian River Murray (Department for Environment and Water, 2019a).

2.4.2. Held environmental water in the SA River Murray

South Australia has published a register of HEW for the SA River Murray WRP area as required under section 10.09 of the Basin Plan.

The *SA River Murray WRP area Held Environmental Water Register* is published on the DEW website and indicates a total HEW volume in the SA River Murray of approximately 253 GL at 29 June 2020 (Department for Environment and Water, 2020). The HEW register will be maintained on an annual basis in accordance with section 5.3.2 of the SA River Murray WRP however future updates of the register will not translate into this document and readers should refer to the website for an up-to-date volume of HEW.

2.4.3. Planned environmental water in the SA River Murray

PEW is defined in Section 5.3.2 of the SA River Murray Water Resource Plan (Department for Environment and Water, 2019a) and the accredited text has been copied below. Further information regarding each type of PEW and protection under State water management law can also be found in Section 5.6.3.1 of the SA River Murray WRP.

Consistent with the definition in the Water Act, the following volumes are identified as PEW in the *South Australian River Murray Water Allocation Plan* (SAMDB NRMB 2019b):

- Dilution and Loss (Principle 4 and 5 of the River Murray Water Allocation Plan (WAP)): PEW volume = the volume available for dilution loss purposes under clause 88(b)-(c) of the Agreement MINUS the volume made available for class 9 water access entitlement shares under the River Murray WAP from this source (Principles 21, 22, 30 and 31 SAMDB NRMB 2019b) MINUS the volume made available for other purposes under clause 88A of the Agreement (Principle 4 SAMDB NRMB 2019b).
- Unallocated Entitlement (Principle 1a.i and Principle 7-46 of the River Murray WAP): PEW volume = the unallocated portion of annual South Australian Entitlement MINUS any volume deferred under clause 91 of the Agreement (Principle 1b) MINUS the volume made available for class 9 water access entitlement shares under the River Murray WAP from this source (Principles 21, 22, 30 and 31 SAMDB NRMB 2019b).
- Unregulated Flow (Principle 6 of the River Murray WAP): PEW volume = unregulated flow to South Australia that cannot be allocated or used for consumptive purposes under the Agreement, unless required under emergency circumstances.
- Additional Dilution Flow (Principle 6 of the River Murray WAP): PEW volume = Additional Dilution Flow determined and delivered by the MDBA.
- Lindsay River Allowance (Principle 6 of the River Murray WAP): PEW volume = Lindsay River Allowance as the volume determined by the MDBA in accordance with River Murray Commission Meeting No 267 Agenda Item 12 (MDBA 2011).
- EMLR inflows (Principle 1 of the River Murray WAP): PEW volume = flows received into the River Murray at Lake Alexandrina from the EMLR tributaries.

Principles 1 and 4-46 under the revised River Murray WAP (SAMDB NRMB 2019b) operate to provide a legislative obligation that defines the consumptive pool and places an upper limit on the volume that can be allocated, therefore protecting the

residual volumes as PEW. Sections 104(1), 104(3) and 104(4) of the Landscape Act also operate to provide a legislative obligation which assists in protecting PEW.

All water delivered to South Australia outside of South Australia's Entitlement (under clause 88 of the Agreement), excluding trade for consumptive purposes, is preserved for environmental purposes within the South Australian River Murray and South Australian Murray Region WRP areas.

2.4.4. South Australia's Entitlement

Under the *Murray-Darling Basin Agreement 2008* (*Water Act 2007* (Cwlth) Schedule 1), South Australia is entitled to receive up to 1850 GL/year. The 1850 GL comprises:

- a volume of 58 GL/month (696 GL/year) for dilution and losses (clause 88b), unless the Ministerial Council determines otherwise
- a variable monthly volume of up to 1154 GL/year (clause 88a), unless restricted in a period of special accounting (clause 128). This volume is provided over a water year, in monthly quantities that vary according to the historic consumptive (irrigation) pattern of demand. Lesser volumes are provided in the cooler months (April to September), and peak volumes are delivered in the warmer months (December and January).

South Australia's Entitlement includes both held and planned environmental water. Currently, held environmental water that is part of South Australia's Entitlement is also provided in proportional monthly volumes that vary between months (Figure 2), however this may change in the future if one of the following four mechanisms under the *Murray-Darling Basin Agreement 2008* (MDB Agreement) is implemented:

- Clause 90 Variation to South Australia's Entitlement
- Clause 91 South Australia's Storage Right
- change the timing of the delivery of held environmental water using trade
- permanent change to the pattern of delivery of South Australia's Entitlement (noting that this would require a change to the MDB Agreement).

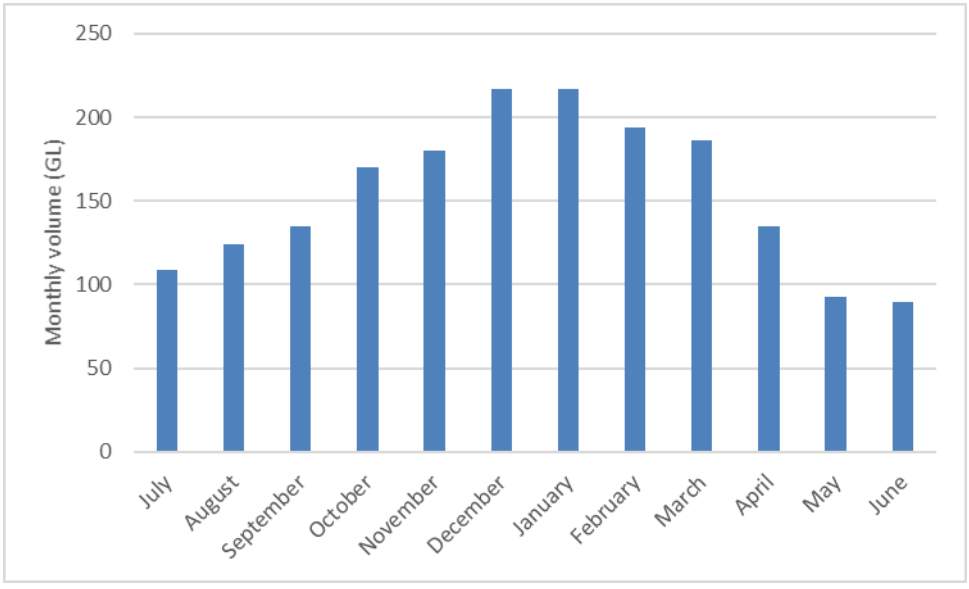


Figure 2. South Australian River Murray Entitlement annual delivery pattern (at full Entitlement)

2.4.5.Flows above South Australia's Entitlement

River Murray flows in addition to Entitlement may be comprised of:

- interstate water trade
- deliveries of deferred water (critical human water needs, private carry over)
- environmental water that is not traded
- Additional Dilution Flow (a volume of 3,000 ML/day that is released once storage volumes in Hume and Dartmouth Reservoirs and Menindee Lakes exceed specified triggers)
- Lindsay River Dilution Flow (the residual of a 250 ML/day 'Lindsay River Dilution Allowance' that is provided down the Lindsay River, via the Mullaroo Offtake, to meet water supply demands (of an acceptable quality) and losses in the Lindsay River. The residual is treated as an unaccounted return flow to South Australia and is additional to the South Australian Dilution and Loss Entitlement. It equates to ~70 GL/year)
- unregulated flow.

Environmental water allocations may be traded to South Australia from elsewhere in the SCB due to the direct allocation of environmental water to an action in the SA River Murray WRP area or as return flows from an upstream watering action. These allocations are generally from the Commonwealth Environmental Water portfolio or The Living Murray portfolio. Under some circumstances, the Victorian Environmental Water Holder (VEWH) may also trade environmental water to South Australia. These traded volumes are in addition to the held and planned environmental water that is part of South Australia's Entitlement, and result in an increase in the flow to the South Australian border.

Arrangement for trading return flows to South Australia from environmental watering actions undertaken in New South Wales are still evolving as work on the implementation of the pre-requisite policy measures continues (see Section 4.3).

2.4.6. Environmental water holders

There are three key environmental water holders that hold water access rights in the SA River Murray WRP area. The volume held by each is indicated in the HEW Register available on the DEW website (Department for Environment and Water, 2020).

2.4.6.1. Commonwealth Environmental Water Holder (CEWH)

The Commonwealth Environmental Water Holder (CEWH), supported by the CEWO, manages the Commonwealth's environmental water portfolio, which has been created through water buy-backs or investment in water-saving infrastructure.

Decisions on the use of Commonwealth environmental water holdings are made by the CEWH. The majority of the South Australian held water is Class 3 and may be traded for use in other SCB reaches and may not be prioritised for use at assets within South Australia. Alternatively, a greater volume than that held in South Australia may be prioritised for South Australian assets and this requires additional environmental water to be delivered to South Australia.

2.4.6.2. The Living Murray Program (TLM)

Advice and recommendations on the use of TLM water are provided through the Southern Connected Basin Environmental Watering Committee (SCBEWC), an inter-jurisdictional forum where South Australia is represented by DEW, with approval for implementation given by the MDBA. Similar to the Commonwealth environmental water holdings, the water held in South Australia is not required to be prioritised for assets within South Australia; and a greater volume than that held in South Australia may be allocated to South Australian assets.

2.4.6.3. South Australian Minister for Environment and Water

The South Australian Minister for Environment and Water holds water access entitlements that are committed to environmental purposes and form part of South Australia's Entitlement. The majority of the volume held is Class 9 water and is tied to the management of specific wetlands within the SA River Murray WRP area so there is limited flexibility in the use of this water. A small volume has been committed for environmental use through the *Implementation Plan for Augmentation of the Adelaide Desalination Plant*, and the location of its use is flexible (within the South Australian portion of the Murray-Darling Basin). Decisions on the allocation and use of this water are made within DEW according to the Policy for Use of the Minister's Reserve.

2.4.7. Managers of planned environmental water

Generally, PEW in South Australia is not actively managed but is delivered to the environment through normal River operations. DEW, SA Water and MDBA work co-operatively to manage water delivery arrangements. Management of unregulated flows is governed by the Use of Unregulated Flows Policy and Procedure.

2.4.8. Environmental site managers

There are a number of environmental site managers within the SA River Murray WRP area, with varying levels of involvement and responsibilities in managing environmental water delivery to and within the assets. Key managers include various projects and programs within DEW as well external organisations and individuals, including:

- Water, Infrastructure and Operations, DEW – including The Living Murray Program (TLM)
- Murraylands and Riverland Landscape Board (MRL)
- Ngarrindjeri Aboriginal Corporation (NAC)
- Ngarrindjeri Regional Authority (NRA)
- Mannum Aboriginal Community Association Incorporated (MACAI)
- First Peoples of the River Murray and Mallee Region (FPRMM)
- Australian Landscape Trust (ALT)
- Banrock Station Wine and Wetland Centre
- Nature Foundation SA (NFSA)
- Renmark Irrigation Trust (RIT)
- Various local wetland community groups and landholders.

3. Ecology

3.1. Asset scale

The key purpose of defining priority environmental assets and their EWRs is to inform the allocation and delivery of environmental water, and contribute towards a healthy, functioning South Australian River Murray ecosystem. There are multiple means of delivering environmental water within the SA River Murray WRP area (including flow provisions, infrastructure operations and pumping), all of which influence different areas, making the selection of an appropriate spatial scale for environmental assets challenging.

When selecting the spatial scale for environmental assets within this water resource plan area (WRP area), the following aspects of environmental water management were taken into account:

- planning (the identification of objectives, targets and EWRs)
- delivery (the allocation and delivery of environmental water)
- environmental water accounting (reporting, where possible at an asset-scale, on the volumes of held and planned water delivered)
- reporting on ecological outcomes (monitoring, evaluation and reporting on the response to environmental watering at an asset-scale).

Based on these considerations, a landscape-scale approach was chosen for defining environmental assets, with three assets identified within the SA River Murray WRP area (Figure 3):

1. the Coorong, Lower Lakes and Murray Mouth
2. the South Australian River Murray Channel
3. the South Australian River Murray Floodplain.

This spatial scale was chosen primarily because it reflects the ecological importance of the mosaic of habitats that comprise the South Australian River Murray ecosystem, rather than focussing on discrete management units that represent only a relatively small portion of the WRP area. It also ensures that a holistic approach is taken to environmental water planning, delivery and evaluation, enabling the contribution of outcomes at smaller scales towards the achievement of outcomes at the larger scale to be considered.

Each of the three environmental assets meet all five of the criteria for identifying an environmental asset provided in Schedule 8 of the Basin Plan.[4] The Basin Plan further defines a ***priority*** environmental asset as an environmental asset that can be managed with environmental water (section 8.49). The full extent of two of the three environmental assets within the SA River Murray WRP area can be managed with environmental water (in conjunction with unregulated flows): the South Australian River Murray Channel Asset and the CLLMM Asset. Therefore, for both of these, the priority environmental asset is equivalent to the environmental asset.

The South Australian River Murray Floodplain Asset extends to the 1956 flood level, requiring flows in excess of 100,000 ML/day QSA to be fully inundated. MDBA modelling indicates that 80,000 ML/day QSA is the maximum flow rate at which active management of environmental water can occur, either through releases of held environmental water from storages or changes in dam storage operations (subject to the implementation of the Constraint Measures Program). In addition, delivery through the operation of infrastructure is unlikely, with weirs along the River Murray in South Australia not in operation when flows exceed between 55,000 and 70,000 ML/day (depending on the lock). For these reasons, the South Australian River Murray Floodplain Priority Environmental Asset is considered to be the portion of the Floodplain Asset that is inundated by flows up to and including 80,000 ML/day QSA, which is approximately 60% of the whole floodplain (compare Figure 3 and Figure 4). This threshold is based on modelled data and therefore may be altered in the future.

The three priority environmental assets of the SA River Murray WRP area are:

1. the Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset ('the CLLMM PEA')
2. the South Australian River Murray Channel Priority Environmental Asset ('the Channel PEA')
3. the South Australian River Murray Floodplain Priority Environmental Asset ('the Floodplain PEA').

[4] Evidence that the assets meets the Basin Plan Schedule 12 Criteria for Identifying an Environmental Asset is provided throughout this document where the individual assets are described in more detail, as well as in key references.

It should be noted that the term 'priority' is used throughout this document in accordance with the Basin Plan definition and is based on the operational feasibility of delivering environmental water. Despite not being part of the 'priority' asset, the outer floodplain (i.e. the area that requires flows above 80,000 ML/day QSA to be inundated) is still considered to be an area of high importance to South Australia for many reasons, including supporting a large proportion of the black box woodlands within the WRP area, and connecting riparian zones with upland habitats. The close association of these two habitat types is important for species such as the Regent Parrot (a nationally and state-listed threatened species) which nests in floodplain trees but feeds in mallee vegetation (Ecological Associates, 2010).

Unregulated flows above 80,000 ML/day QSA support the health of the high elevation floodplain areas and it is critical that there is no further reduction in the occurrence of the unregulated flow events that are required to inundate the outer floodplain (Government of South Australia, 2012). Further research is needed to better understand the condition of the outer floodplain and the role that it plays in the South Australian River Murray ecosystem, including the importance of providing connectivity to the adjacent uplands.

The following sections of the LTWP provide further information for each of the priority environmental assets, including:

- Location and geographic extent
- Conservation significance
- Ecological attributes
- Ecological objectives, targets and EWRs.

3.2. Identifying ecological objectives, targets and EWRs for the priority environmental assets

The ecological objectives, targets and EWRs within this LTWP represent what is needed in order to support each of the priority environmental assets in a healthy, functioning state. They were identified through three sub-projects that consolidated many years of knowledge and experience from existing projects and programs such as The Living Murray Initiative and Murray Futures. A full description of the ecological objectives, targets and original EWRs, and the methods and detailed background information (including conceptual models and hydrological modelling) used in their development, is presented in four separate background reports:

- Ecological objectives, targets and environmental water requirements for the South Australian River Murray Floodplain environmental asset (Kilsby, et al., 2015)
- Ecological objectives, targets and environmental water requirements for the Coorong, Lower Lakes and Murray Mouth (O'Connor, et al., 2015)
- River Murray Channel environmental water requirements: Ecological objectives and targets (Wallace, et al., 2014a)
- River Murray Channel environmental water requirements: Hydrodynamic modelling results and conceptual models (Wallace, et al., 2014b).

A consistent approach was taken when identifying ecological objectives, ecological targets and EWRs for all three of the priority environmental assets:

- Each of the ecological objectives provide a clear statement of what the delivery of the EWRs are intended to achieve. There are a number of objectives for each asset, with each objective focussed on a key biotic group or ecological process; however the inter-dependencies between the objectives should not be overlooked.
- Ecological targets are nested within an ecological objective and there may be more than one target per objective. As much as possible, the targets are 'SMART' i.e. specific, measurable, achievable, realistic and time-bound. This format informs monitoring and provides a means of assessing the change in condition and progress towards achieving the objectives. This assessment should not be undertaken as a pass or fail on an annual basis but rather as a consideration of trajectory over longer timeframes (see pp 26-27 in Wallace, et al., 2014a).
- The EWRs are descriptions of the water regimes needed to sustain the ecological values of the priority environmental assets at a low level of risk (Department of Environment, Water and Natural Resources, 2014a). They represent a hydrological regime in the appropriate metrics for the given environmental asset. The EWRs are based on hydrological, hydraulic and hydrodynamic modelling outputs together with an understanding of the needs of different biota and processes. The feasibility of meeting the EWRs under various Basin Plan water recovery and constraint management scenarios has not been tested.

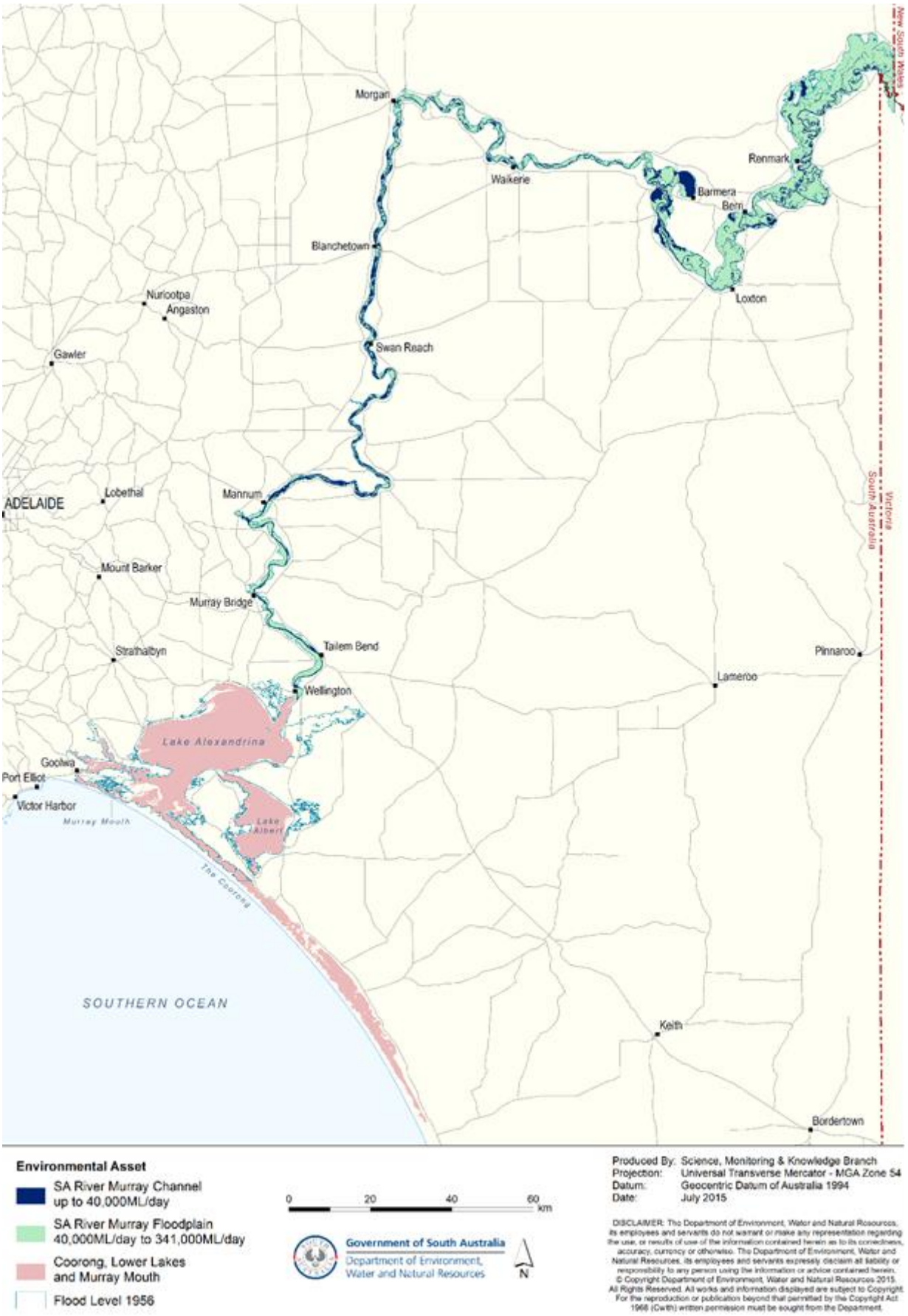


Figure 3. Map of the three environmental assets within the SA River Murray WRP area

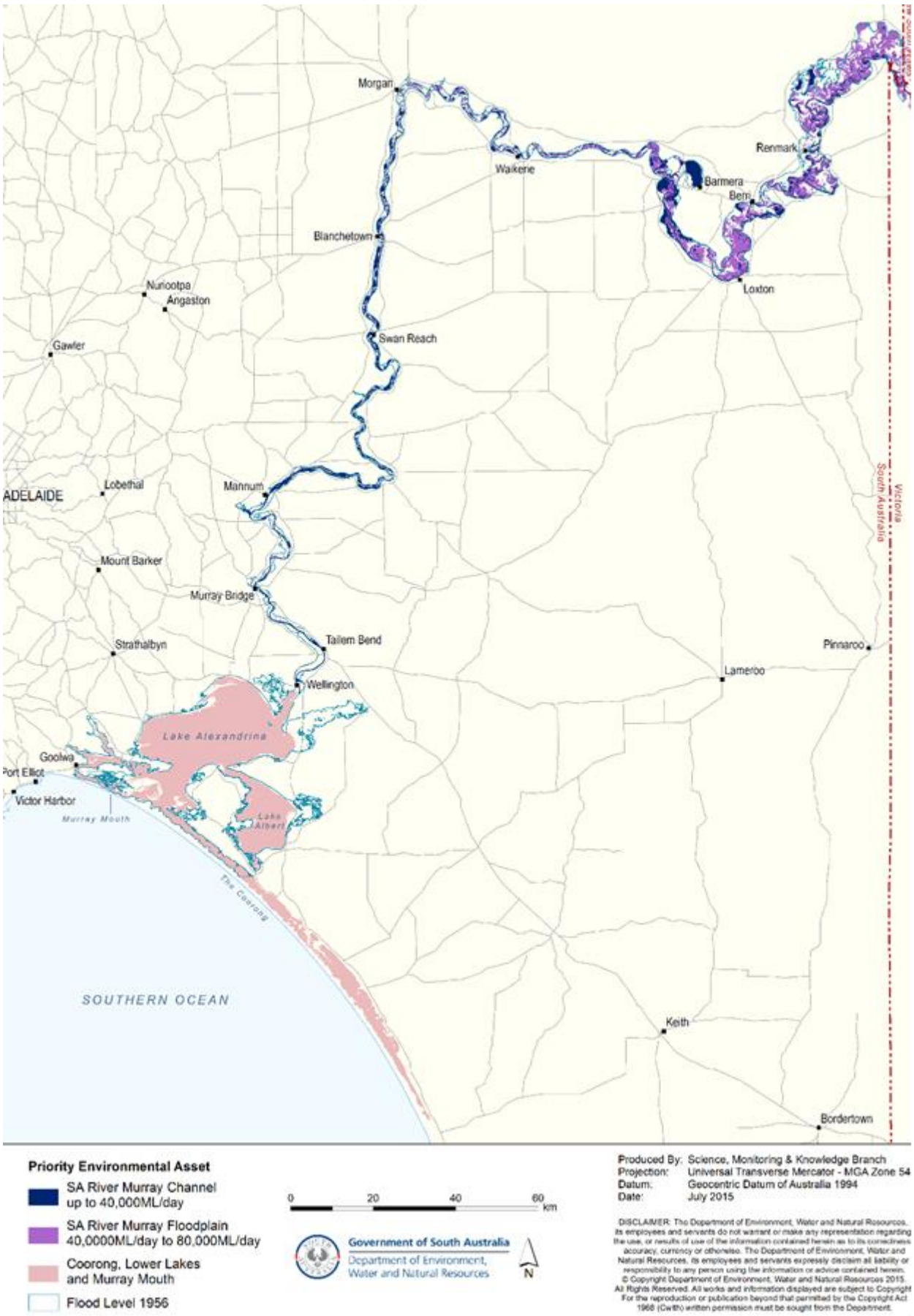


Figure 4. Map of the three priority environmental assets within the SA River Murray WRP area

3.2.1. Having regard for groundwater

Consideration was given to groundwater during the development of the EWRs, although no groundwater metrics are expressed in the EWRs either because it is not considered a significant ecological driver (relative to surface water) or because there is insufficient data. Regional groundwater is highly saline and groundwater-derived base flows do not contribute to meeting the EWRs of the Channel and Floodplain assets. Ecological targets relating to groundwater recharge have been expressed for the Channel and the Floodplain.

There is very little known about groundwater flows to or from the CLLMM. With Lakes Alexandrina and Albert being such large bodies of surface water, groundwater levels in the surrounding shallow aquifers are strongly influenced by water levels in the Lakes; however there is insufficient data to quantify this relationship. Freshwater soaks along the edge of the Coorong are important ecologically, but are primarily rainfall-fed. There are indications that groundwater discharge is widespread in the Coorong South Lagoon; however no estimate of volume is currently available (Haese, et al., 2008).

3.3. The SA River Murray Channel Priority Environmental Asset

3.3.1. Location and geographic extent

The South Australian River Murray Channel Priority Environmental Asset ('the Channel PEA') covers an area of approximately 28,800 hectares (Figure 5 and Figure 6). The longitudinal extent is from Wellington, South Australia, to the South Australian border - a total distance of approximately 560 River kilometres. The lateral extent consists of the area that is inundated at flows up to 40,000 ML/day QSA (under normal River operations), which is considered to be the discharge at which overbank flows commence and water starts to spread more broadly across the floodplain. The Channel PEA incorporates ephemeral habitats as well as areas of permanent water, including the main River channel, and permanently inundated wetlands and anabranches (where anabranches are distinguished as flowing habitats).

3.3.2. Conservation significance

The Channel PEA intersects two Ramsar-listed Wetlands of International Importance - the Riverland Ramsar Site and Banrock Station Wetland Complex.

The Riverland Ramsar site is described in Newall, et al. (2009). The site extends from Renmark, South Australia, to the New South Wales/Victoria/South Australian border (approximately 80 River kilometres). It encompasses the floodplain on both sides of the River, covering a total area of 30,615 hectares. The permanent waterbodies and the areas that are inundated by flows up to 40,000 ML/day QSA (approximately 3,840 hectares) fall within the Channel PEA.

The Banrock Station Wetland Complex Ramsar site is described in Butcher, et al. (2009). It is located approximately 430 River kilometres from the Murray Mouth and covers a total area of 1,375 hectares, which includes 1,068 hectares of floodplain and 307 hectares of mallee uplands. The part of the floodplain that is inundated by flows up to 40,000 ML/day QSA (approximately 190 hectares) falls within the Channel PEA.

The Living Murray Initiative (TLM) recognises six icon sites for their high ecological and cultural values (Commonwealth of Australia, 2015a), including the River Murray Channel TLM icon site.[5] The Channel Icon Site extends for over 2,000 River kilometres from Hume Dam near Albury, New South Wales, to Wellington, South Australia (Murray-Darling Basin Commission, 2006b). The icon site is separated into five reaches, two of which occur in South Australia. The vision for the River Murray Channel Icon Site is 'a healthy and productive River Murray' (Commonwealth of Australia, 2015a). There is consistency between the vision and extent of the South Australian reaches of the Channel Icon Site and the Channel PEA. The Channel PEA also intersects the Chowilla Floodplain TLM icon site, namely the section of the Chowilla Floodplain that is within the SA River Murray WRP area and is inundated by up to 40,000 ML/day QSA.

[5] *Murrundi (River Murray) is central to Ngarrindjeri culture and spiritual beliefs. The NRA note that, while they received formal recognition from the Australian Government through incorporation of the preferred Ngarrindjeri engagement process into the development and implementation of the MDBA's Lower Lakes, Coorong and Murray Mouth Icon Site Environmental Watering Plan (Murray-Darling Basin Authority, 2013b), this was not the case for the River Murray Channel TLM Icon Site (see Section4.1 for further details).*

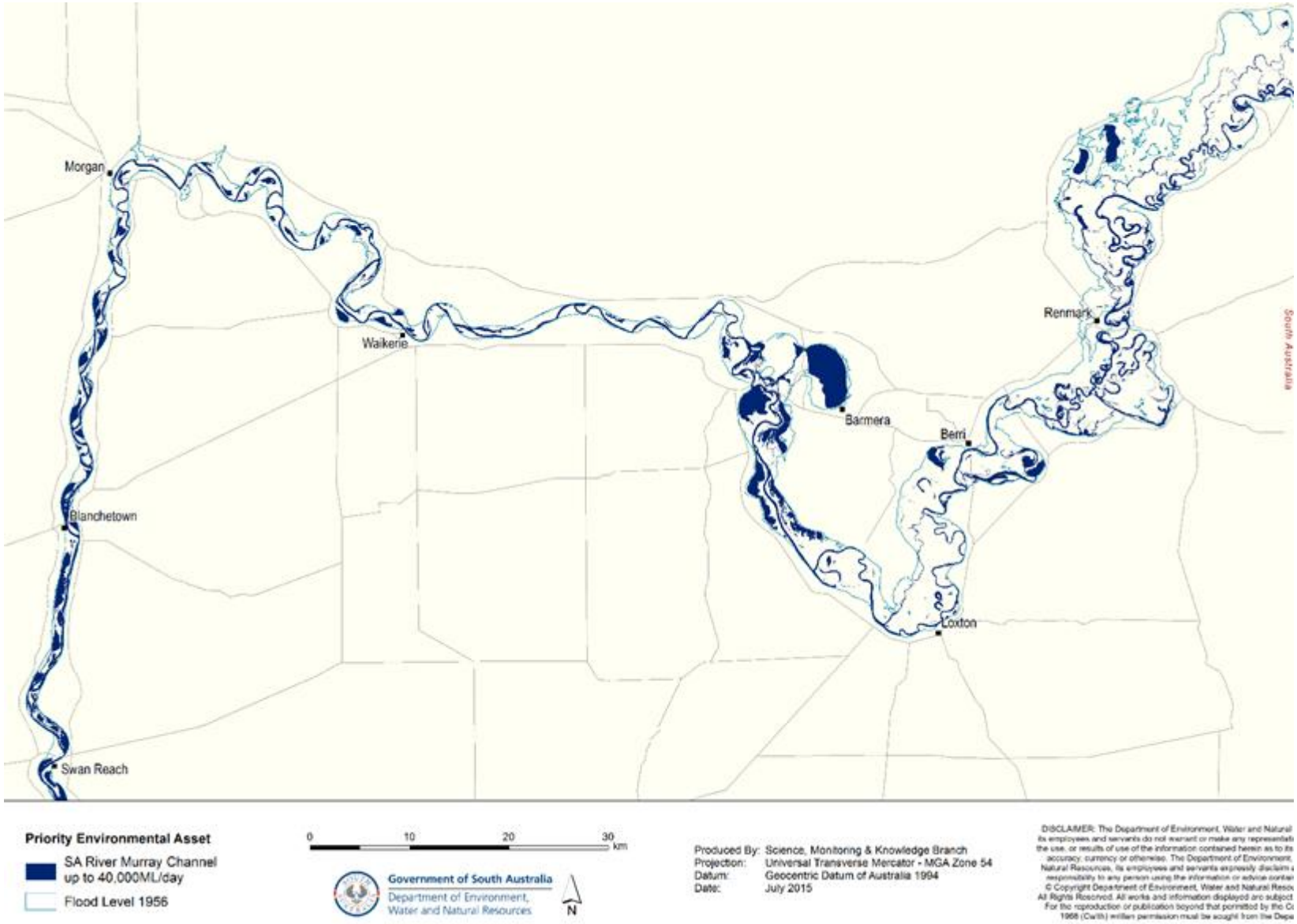


Figure 5. Spatial extent of the Channel Priority Environmental Asset between the border and Swan Reach

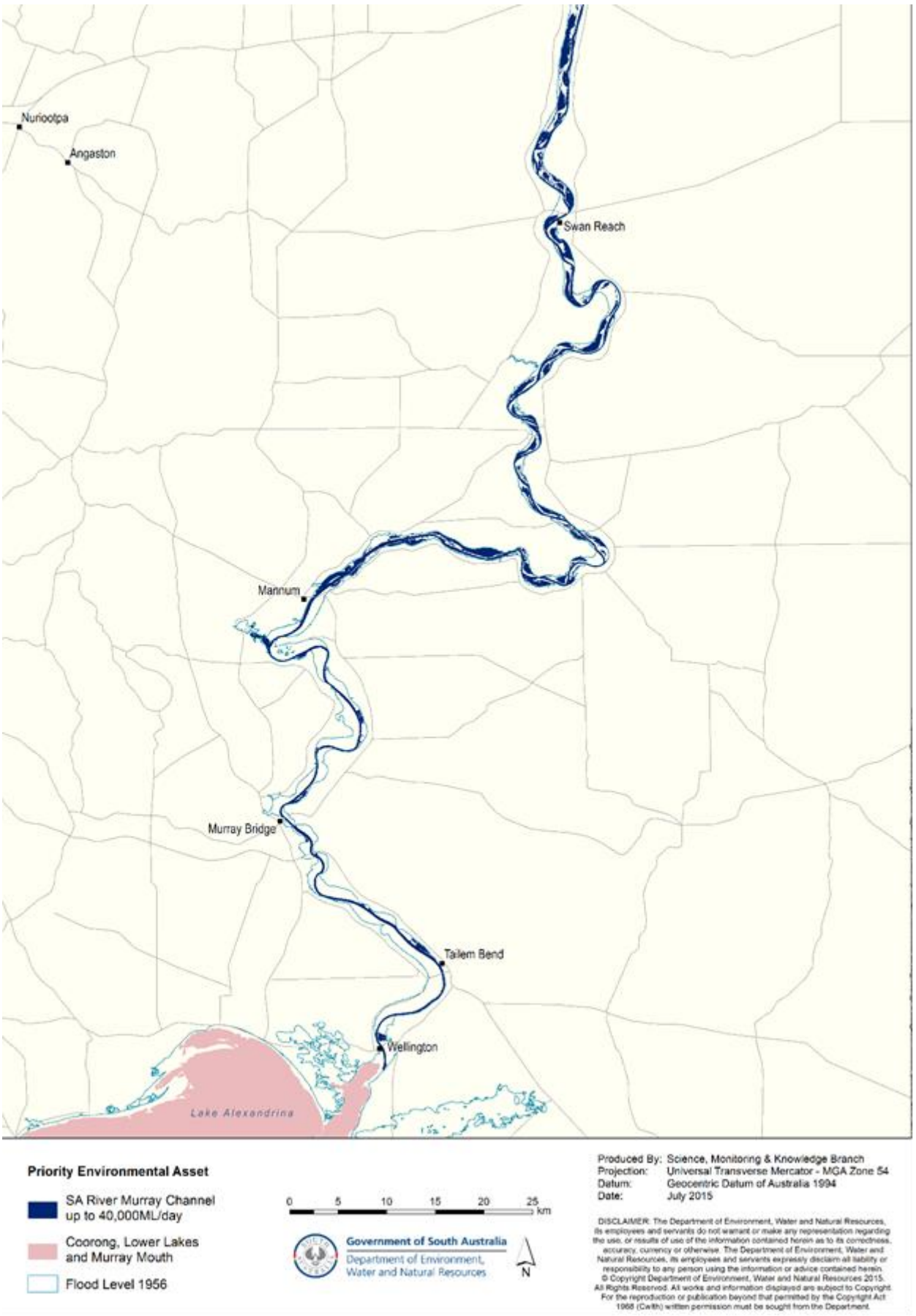


Figure 6. Spatial extent of the Channel Priority Environmental Asset between Swan Reach and Wellington

Data from the DEW's biological database indicates that within the Channel PEA the following species of conservation significance have been recorded at least once[6]:

- 50 plant species (Table 16 in Appendix 2) listed as Endangered, Vulnerable or Rare under the South Australian *National Parks and Wildlife Act 1972* ('state-listed')
- 77 protected fauna species (Table 17 in Appendix 2), of which 63 are state-listed species, three species are listed as nationally threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and 11 species are both state and nationally listed
- 11 migratory bird species that are listed under international agreements (Table 17 in Appendix 2).

3.3.3. Ecological attributes

In 2014, a project was undertaken through the Goyder Institute for Water Research to identify ecological objectives and targets for in-channel habitats and processes, as well as the EWRs needed to meet those targets (Wallace, et al., 2014a). In doing so, a series of conceptual models describing the hydro-ecological relationships for key components of the Channel asset were developed (Wallace, et al., 2014b), including:

- ecosystem processes and physio-chemical conditions - carbon and nutrient loads, productivity, dissolved oxygen, cyanobacteria, groundwater and salinity, hydraulic conditions (velocity)
- biofilm composition
- vegetation - aquatic and understorey vegetation (11 functional groups based on water-regime preferences); dominant floodplain perennial species (approximately 2,600 hectares of River red gum woodlands, 250 hectares of black box[7] and 670 hectares of lignum[7])
- fish - long-lived apex predators (Murray cod); flow-dependent specialists (golden perch and silver perch); foraging generalists (mostly small-bodied, short-lived species e.g. Australian smelt); floodplain specialists (southern purple-spotted gudgeon and Murray hardyhead); other natives (freshwater catfish); and non-native species (common carp, redfin perch, eastern gambusia, goldfish)
- temporary wetlands - approximately 3,100 hectares, important habitat and breeding sites for frogs (11 species), waterbirds (six functional groups) and invertebrates.

3.3.4. Ecological objectives, targets and environmental water requirements

A total of 16 ecological objectives and 29 nested ecological targets have been identified for the Channel PEA (Table 2 taken from Wallace, et al., 2014a) based on the previously identified key components. These objectives and targets focus on abiotic processes, water quality, biofilms, vegetation, wetlands, groundwater and fish.

Wallace, et al., 2014a identified seven EWRs with median discharges ranging from 10,000 to 40,000 ML/day QSA for the Channel PEA, Together the EWRs describe the desired variable flow regime to meet the ecological objectives and targets. The metrics for the Channel PEA EWRs include:

- discharge - measured as ML/day QSA, the EWR specifies both a median value and the range that the discharge should remain within
- duration – the number of days that the discharge needs to remain within the specified range
- timing – the season during which the EWR event needs to occur
- average return frequency - how often the EWR event needs to occur. The frequency metric represents an average return interval in years (not a regular pattern) and should be calculated as a rolling average over an appropriate timeframe. This can also be calculated as the percent of years that an event occurs on average
- maximum interval - the maximum number of years between events that meet the EWR metrics.

[6] Presence/absence records from DEW's biological database have been provided as an indication of the number of threatened species that have been found within each PEA only. Currently there are very few fish records and no invertebrate records entered into the dataset. This is not a comprehensive list and does not reflect species records that have not been provided to DEW for input to the database.

[7] Due to the small areas of black box woodlands and lignum shrublands within the Channel PEA, these vegetation communities are not represented in the ecological objectives and targets for this asset

Table 2. Ecological objectives and targets for the SA River Murray Channel Priority Environmental Asset

Table taken from Wallace, et al. (2014a)

Type	Ecological Objective	Ecological Target
Ecosystem processes	Provide for the mobilisation of carbon and nutrients from the floodplain to the river to reduce the reliance of in-stream foodwebs on autochthonous productivity.	Open-water productivity shows a temporary shift from near zero or autotrophic dominance (positive Net Daily Metabolism) towards heterotrophy (negative Net Daily Metabolism) when QSA >30,000 ML/day.
	Provide diverse hydraulic conditions over the range of velocity classes in the lower third of weir pools so that habitat and processes for dispersal of organic and inorganic material between reaches are maintained.	Habitat across the range of velocity classes is present in the lower third of weir pools for at least 60 consecutive days in Sep–Mar, at a maximum interval of 2 years.
	Maintain a diurnally-mixed water column to ensure diverse phytoplankton and avoid negative water quality outcomes.	Thermal stratification does not persist for more than 5 days at any time.
	Ensure adequate flushing of salt from the Murray to the Southern Ocean.	Basin Plan Objective: Salt export, averaged over the preceding 3 years, is ≥2 million tonnes per year.
	Maintain habitats and provide for dispersal of organic and inorganic material and organisms between river and wetlands.	Inundation periods in temporary wetlands have unrestricted lateral connectivity between the river and wetlands in >90% of inundation events.
Water Quality	Maintain water quality to support aquatic biota and normal biogeochemical processes.	Biovolume <4 mm^3/L for all Cyanobacteria, where a known toxin producer is dominant.
		Biovolume <10 mm^3/L for all Cyanobacteria, where toxins are not present.
		Basin Plan Target: Maintain dissolved oxygen above 50% saturation throughout water column at all times.
Groundwater and soil	Throughout the length of the Channel asset (i.e. SA border to Wellington), establish and maintain groundwater and soil moisture conditions conducive to improving riparian vegetation.	Establish and maintain freshwater lenses in near-bank recharge zones.
		Maintain soil water availability, measured as soil water potential > -1.5 MPa at soil depth 20–50 cm, to sustain recruitment of long-lived vegetation across the elevation gradient in the target zone.
		Reduce soil salinity (measured as EC 1:5) to <5000 µS/cm to prevent shifts in understorey plant communities to salt-tolerant functional groups across the elevation gradient in the target zone.
Biofilms	Promote bacterial rather than algal dominance of biofilms and improve food resource quality for consumers.	Annual median biofilm composition is not dominated (>80%) by filamentous algae.
		Annual median biofilm C:N ratios are <10:1.
Vegetation	Throughout the length of the Channel asset (i.e. SA border to Wellington), establish and maintain a diverse native flood-dependent plant community in areas inundated by flows of 10,000–40,000 ML/day QSA.	In standardised transects spanning the elevation gradient in the target zone[8], 70% of river red gums have a Tree Condition Index score ≥ 10.
		A sustainable demographic is established to match the modelled profile for a viable river red gum population in existing communities spanning the elevation gradient in the target zone.
		Species from the Plant Functional Group 'flood-dependent/responsive' occur in 70% of quadrats

[8] *The target zone is the area inundated by flows of 10,000-40,000 ML/day (under normal River operations)*

Type	Ecological Objective	Ecological Target
		spanning the elevation gradient in the target zone at least once every 3 years.
	Throughout the length of the Channel asset (i.e. SA border to Wellington), establish and maintain a diverse macrophyte community in wetlands inundated by flows up to 40,000 ML/day QSA.	Native macrophytes from the emergent, amphibious and flood- dependent functional groups occur in 70% of quadrats spanning the elevation gradient in the target zone at least once every 3 years.
Fish	Restore the distribution of native fish.	Expected species[9] occur in each mesohabitat (channel, anabranch, wetlands) in each weir pool/reach.
	Restore resilient populations of Murray cod (a long-lived apex predator).	Population age structure[10] of Murray cod includes recent recruits[11], sub-adults and adults in 9 years in 10.
		Population age structure of Murray cod indicates a large recruitment[12] event 1 year in 5, demonstrated by a cohort representing >50% of the population.
		Abundance (CPUE[13]) of Murray cod increases by ≥50% over a 10-year period.
	Restore resilient populations of golden perch and silver perch (flow-dependent specialists).	Population age structure of golden perch and silver perch includes YOY[14] with sub-adults and adults in 8 years in 10.
		Population age structure of golden perch and silver perch indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.
		Abundance (CPUE) of golden perch and silver perch increases by ≥30% over a 5-year period.
	Restore resilient populations of freshwater catfish.	Population age structure of freshwater catfish includes YOY, with sub-adults and adults in 9 years in 10.
		Population age structure of freshwater catfish indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.
		Abundance (CPUE) of freshwater catfish increases by ≥30% over a 5-year period.
	Restore and maintain resilient populations of foraging generalists (e.g. Australian smelt, bony herring, Murray rainbowfish, unspecked hardyhead, carp gudgeons, flathead gudgeons).	The length-frequency distributions for foraging generalists include size classes showing annual recruitment.
	Minimise the risk of carp recruitment.	The relative abundance and biomass of common carp does not increase in the absence of increases in abundance and biomass of flow-dependent native fish.

[9] Expected species are those that were historically abundant (e.g. silver perch, freshwater catfish) and would not be considered beyond their extant range (e.g. trout cod), vagrants (i.e. spangled perch) or not expected to occur (e.g. mature Murray cod in temporary wetlands)

[10] Population age structure is inferred from length-frequency distributions and validated by otoliths where appropriate

[11] 'Recent recruits' are fish <2 years old

[12] 'Recruitment' refers to survival and growth of the larvae and juveniles to YOY (young of year).

[13] CPUE is 'catch per unit effort' resulting from formal surveys using standard techniques (e.g. boat-mounted electrofishing, fyke nets)

[14] YOY = Young of Year.

Table 3. Environmental water requirements for the SA River Murray Channel Priority Environmental Asset

Table taken from Wallace, et al. (2014a)

EWR #	Median discharge (ML/day QSA)	Discharge variability (ML/day QSA)	Duration (days)	Preferred timing	Average return frequency (years)	Maximum interval (years)
IC1	10,000	7,000 - 12,000	60	Sep-Mar	1.05	2
IC2	15,000	15,000 -20,000	90	Sep-Mar	1.33	2
IC3	20,000	15,000 - 25,000	90	Sep-Mar	1.8	2
IC4	25,000	20,000 - 30,000	60	Sep-Mar	1.7	2
IC5	30,000	25,000 - 35,000	60	Sep-Mar	1.8	2
IC6	35,000	30,000 - 40,000	60	Sep-Mar	1.8	2
IC7	40,000	35,000 - 45,000	90	Sep-Mar	2.1	3

3.4. The SA River Murray Floodplain Priority Environmental Asset

3.4.1. Location and geographic extent

The South Australian River Murray Floodplain Priority Environmental Asset ('the Floodplain PEA') covers an area of approximately 54,300 hectares (Figure 7 and Figure 8). The longitudinal extent is equivalent to the Channel PEA, extending from Wellington, South Australia, to the South Australian border - a total distance of approximately 560 River kilometres. The Floodplain PEA consists of the area that is inundated when flows are between 40,000 and 80,000 ML/day QSA (under normal River operations). It runs immediately adjacent to the Channel PEA, and at any given cross-section, the Channel PEA must be fully inundated before inundation of the Floodplain PEA commences. The outer floodplain, which requires flow of greater than 80,000 ML/day QSA to be inundated, is also ecologically important. However it is unable to be managed with environmental water and so does not meet the Basin Plan definition of a priority environmental asset.

The Floodplain PEA consists of a mosaic of ephemeral habitats. A key factor is the influence of landform on water retention capacity as high flows recede, with some areas shedding water ('shedding floodplain') and others retaining water in depressions or basins ('temporary wetlands'). The Floodplain PEA does not contain any areas of permanent water and the distance to the main River channel differs along the length of the floodplain. Above Overland Corner is the Valley geomorphic zone where the floodplain is up to 10 kilometres wide, while below Overland Corner is the Gorge geomorphic zone which is constrained to approximately 2 - 3 kilometres (Walker and Thoms 1993). The area between Mannum and Wellington is dominated by reclaimed swamps and very little floodplain habitat remains.

3.4.2. Conservation significance

The Floodplain PEA intersects two Ramsar-listed Wetlands of International Importance - the Riverland Ramsar Site and Banrock Station Wetland Complex (see Section 3.3.2 for brief descriptions). The areas of these Ramsar sites that are inundated by flows between 40,000 and 80,000 ML/day QSA (approximately 13,250 hectares and 710 hectares, respectively) fall within the Floodplain PEA.

The Floodplain PEA intersects the portion of the Chowilla Floodplain TLM Icon Site that is within the SA River Murray WRP area and is inundated by flows between 40,000 and 80,000 ML/day QSA. There is a strong link between the Floodplain PEA and the Chowilla Icon Site, with Chowilla targets used to develop the Floodplain PEA targets as this site has the most comprehensive baseline data available for any area of the floodplain. Further information on the Chowilla Icon Site is available in Murray-Darling Basin Authority (2012) and Wallace, et al. (2014).

Data from the DEW's biological database indicates that within the Floodplain PEA the following species of conservation significance have been recorded at least once[15]:

- 47 plant species (Table 16 in Appendix 2) listed as Critically Endangered, Endangered, Vulnerable or Rare under the South Australian *National Parks and Wildlife Act 1972* ('state-listed')
- 60 protected fauna species (Table 17 in Appendix 2) of which 50 are state-listed species, three species are listed as nationally threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and seven species are both state and nationally listed
- five migratory bird species that are listed under international agreements (Table 17 in Appendix 2).

3.4.3. Ecological attributes

The development of the ecological objectives and targets for the Floodplain PEA (Kilsby, et al., 2015) largely drew on a recent synthesis of the current understanding of the likely response of key ecological components of the floodplain ecosystem to changes in flow (see Bice, et al., 2014). The ecological components of the Floodplain PEA overlap considerably with those of the Channel PEA as these two assets are adjacent and continuous with each other. The main difference between the two is the effect that changes in geomorphology (i.e. elevation) have on hydrology. The Floodplain PEA consists of ephemeral areas that sit at higher elevations and are inundated later, and hence less frequently and for shorter durations, than the Channel PEA.

Bice, et al. (2014) presents hydro-ecological conceptual models for three flow bands relevant to the Floodplain PEA: 40,000 ML/day QSA - the threshold between the Channel and Floodplain PEAs; 60,000 ML/day QSA - a small overbank flow; and 80,000 ML/day QSA - a large overbank flow. Based on this report, the key abiotic and biotic components of the Floodplain PEA are:

- nutrients, carbon, biofilms and microbes
- microfauna (microcrustaceans and rotifers)
- vegetation (11 functional groups based on water-regime preferences; dominant floodplain perennial species including approximately: 12,150 hectares of River red gum woodlands; 4,330 hectares of black box; 9,010 hectares of lignum; 210 hectares of River cooba)[16]
- macroinvertebrates (five trait groups)
- frogs (eight species commonly found on the floodplain)
- fish (four guilds of native species: circa-annual spawning nester; flow dependent specialist; foraging generalist; and wetland/floodplain specialist)
- waterbirds (continental nomads, international migratory species and regional residents).

[15] Presence/absence records from DEW's biological database have been provided as an indication of the number of threatened species that have been found within each PEA only. Currently there are very few fish records and no invertebrate records entered into the dataset. This is not a comprehensive list and does not reflect species records that have not been provided to DEW for input to the database.

[16] As inundation of the Floodplain PEA does not commence until the Channel PEA is inundated, the areas of vegetation are inclusive of the areas found within the Channel PEA

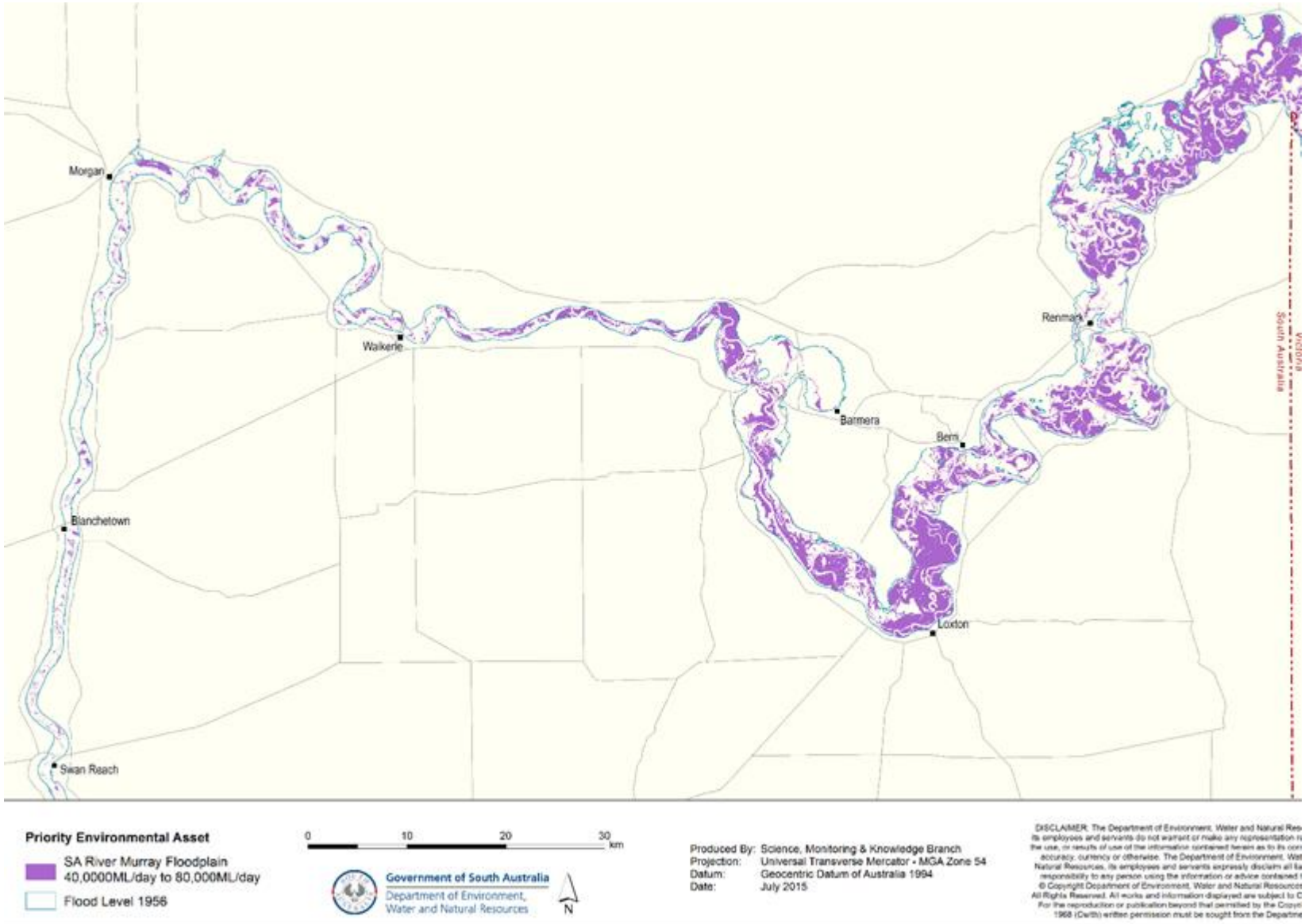


Figure 7. Spatial extent of the Floodplain Priority Environmental Asset between the border and Swan Reach

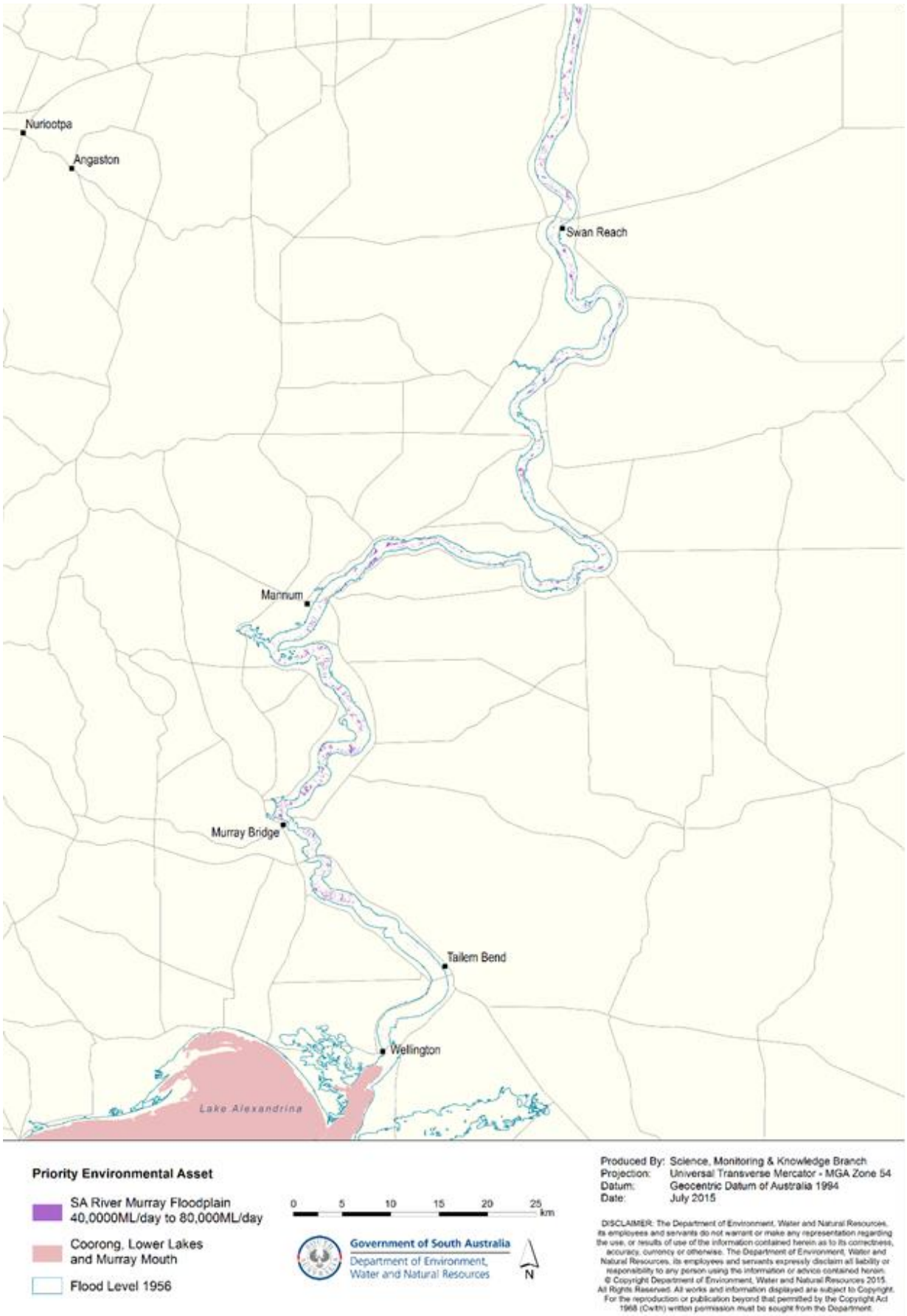


Figure 8. Spatial extent of the Floodplain Priority Environmental Asset between Swan Reach and Wellington

3.4.4. Ecological objectives, targets and environmental water requirements

Twenty one ecological objectives and 40 nested ecological targets have been identified for the Floodplain PEA (refer Table 4 from Kilsby, et al., 2015). These objectives and targets are based on the key components (identified above) as well as existing objectives and targets for the Channel (Wallace, et al., 2014a), Chowilla Floodplain (Wallace, et al., 2014), and Pike and Katarapko Floodplains (Wallace, Denny, & Bice, 2017).

Kilsby, et al., 2015 identified five EWRs for the Floodplain PEA with median discharges ranging from 50,000 to 80,000 ML/day QSA. Together the EWRs describe the desired variable flow regime to meet the ecological objectives and targets. The metrics of the Floodplain PEA EWRs are:

- discharge - measured as ML/day QSA, the EWR specifies both a median value and the range that the discharge should remain within
- duration - the number of days that the discharge needs to remain within the specified range
- timing - the season during which the EWR event needs to occur
- average return frequency - how often the EWR event needs to occur. The frequency metric represents an average return interval in years (not a regular pattern) and should be calculated as a rolling average over an appropriate timeframe
- rate of rise and fall - represented as the change in water level over time (metres per day). In the lower Murray, the rate of change is influenced by a change in discharge and weir operations
- maximum interval - the maximum number of years between events that meet the EWR metrics.

Table 4. Ecological objectives and targets for the SA River Murray Floodplain Priority Environmental Asset

Modified from Table 3-1 in (Kilsby, et al., 2015). All ecological objectives and targets are taken directly from or are consistent with objectives and targets developed through the Chowilla and SARFIIP projects and presented in Wallace (2014) and (Wallace, Denny, & Bice, 2017), respectively.

Type	Ecological Objective	Ecological Target
Ecosystem processes	Provide for the mobilisation of carbon, nutrients and propagules from the floodplain to the river	During inundation periods, record an increase in the abundance and diversity of invertebrate food resources, nutrients and DOC relative to those available during base flow[17]
	Provide diverse hydraulic conditions and complex habitat for flow dependent biota and processes	Deliver flows in a manner that reduces the proportion of slow flowing habitat and increases the proportion of moderate velocity habitat thereby reinstating a diversity of velocity classes representative of natural conditions[17]
	Implement a seasonal and multi-year hydrograph that encompasses variation in discharge, velocity and water levels	Discharge, water level and duration metrics of planned e-water represent a seasonally variable hydrograph
Water quality	Maintain water quality to support water dependent biota and normal biogeochemical processes[18]	Maintain dissolved oxygen above 50% saturation throughout water column at all times, in connected waters
Groundwater and soil	Establish groundwater conditions conducive to maintaining diverse native vegetation across the Floodplain PEA	Establish and maintain freshwater lenses in near-bank recharge zones[17]
	Establish soil conditions conducive to maintaining diverse native vegetation across the Floodplain PEA	Maintain soil water availability, measured as soil water potential at soil depth 20-50cm, greater than -1.5 MPa in order to sustain the recruitment of long-lived vegetation

[17] *Further data is required to populate a SMART target; this may be progressed through the development of an integrated monitoring and evaluation plan for the SA River Murray WRP area*

[18] *Normal biogeochemical processes are defined in (Wallace, et al., 2014)*

Type	Ecological Objective	Ecological Target
		Reduce soil salinity (EC 1:5) to below 5,000 µS/cm to prevent permanent shifts in understorey plant communities to salt tolerant functional groups
		Maintain soil sodicity below the exchangeable sodium percent (ESP) value of 15 (highly sodic)
	Maintain sedimentation and erosion processes within normal ranges during overbank flows within the Floodplain PEA	Limit the maximum rate of drawdown (averaged over 3 consecutive days) to ≤0.025 m/day (0.05m/day in any one day) to minimise risk of bank failure
Vegetation	Maintain a viable, functioning River Red Gum population within the Floodplain PEA	In standardised transects that span the Floodplain PEA elevation gradient and existing spatial distribution, >70% of all trees have a Tree Condition Index Score (TCI) ≥10[19].
		A sustainable demographic[20] that matches the modelled profile for a viable population is established within existing communities across the floodplain elevation gradient.
	Maintain a viable, functioning Black Box population within the Floodplain PEA	In standardised transects that span the Floodplain PEA elevation gradient and existing spatial distribution, >70% of all trees have a TCI ≥10[19]
		A sustainable demographic[19] that matches the modelled profile for a viable population is established within existing communities across the floodplain elevation gradient
	Maintain a viable, functioning River Cooba population within the Floodplain PEA	In standardised transects that span the Floodplain PEA elevation gradient and existing spatial distribution, >70% of all trees have a TCI ≥10[19]
		A sustainable demographic[19] that matches the modelled profile for a viable population is established within existing communities across the floodplain elevation gradient
	Maintain a viable, functioning Lignum population within the Floodplain PEA	In standardised transects that span the floodplain elevation gradient and existing spatial distribution, ≥70% of Lignum plants have a Lignum Condition Score (LCI) ≥6 for colour[21]
	Establish and maintain diverse water dependent vegetation within aquatic zones across the Floodplain PEA	In aquatic zones, a minimum of 40% of cells either inundated or dry containing inundation-dependent or amphibious plant taxa once every two years on average with maximum interval no greater than 4 years[22]. Native water dependent species richness >30 across the Floodplain PEA.
		In aquatic zones, a minimum of 80% of cells either inundated or dry containing native flood dependent or amphibious plant taxa once every four years on average

[19] Methodology follows (Souter, et al., 2009), which describes the scoring system and considers 30 trees along a transect within a 0.25 hectare quadrat (100 m x 25 m).

[20] Sustainable demographic is described in (Wallace, et al., 2014a)

[21] Condition of lignum plants that intersect or lie within 2.5 m from either side of a 100 m transect (0.05 hectare quadrat) (Wallace, et al., 2014a) are assessed using the standardised LCI method (Scholz, et al., 2007).

[22] Methodology follows (Gehrig, et al., 2014); measurement of 45 one-metre by one-metre cells at each site, distributed across three elevation bands (15 cells per band), 50 m apart

Type	Ecological Objective	Ecological Target
		with maximum interval no greater than 6 years[22] Native water dependent species richness >50 across the Floodplain PEA.
	Establish and maintain diverse native vegetation comprising native flood dependent and amphibious species within the shedding floodplain zones across the Floodplain PEA	In shedding floodplain zones, a minimum of 20% of cells containing native flood dependent or amphibious plant taxa once every three years on average with maximum interval no greater than 5 years[22]. Native flood dependent and amphibious species richness >20 across the Floodplain PEA.
		In shedding floodplain zones, of 40% of cells containing native flood dependent or amphibious plant taxa once every five years on average with maximum interval no greater than 7 years[22]. Native flood dependent and amphibious species richness >30 across the Floodplain PEA.
		In shedding floodplain zones, of 65% of cells containing native flood dependent or amphibious plant taxa once every seven years on average with maximum interval no greater than 10 years[22.] Native flood dependent and amphibious species richness >50 across the Floodplain PEA.
Fish	Restore resilient populations of circa-annual nester-spawners within the South Australian River Murray	Population age structure of Murray cod includes recent recruits, sub-adults and adults in 9 years in 10.
		Population age structure of Murray cod indicates a large recruitment event 1 year in 5, demonstrated by a cohort representing >50% of the population.
		Abundance, as measured by Catch Per Unit Effort (CPUE), of Murray cod increases by ≥50% over a 10-year period.
		Population age structure of freshwater catfish includes Young Of Year (YOY), with sub-adults and adults in 9 years in 10.
		Population age structure of freshwater catfish indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.
		Abundance (CPUE) of freshwater catfish increases by ≥30% over a 5-year period.
	Restore resilient populations of flow-dependent specialists within the SA River Murray	Population age structure of golden perch and silver perch includes YOY with sub-adults and adults in 8 years in 10.
		Population age structure of golden perch and silver perch indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.
		Abundance, as measured by CPUE, of golden perch and silver perch increases by ≥30% over a 5-year period.
	Restore resilient populations of wetland/floodplain specialists within aquatic zones across the Floodplain PEA during floodplain flow events	The length-frequency distributions for wetland/floodplain (native fish) specialists within aquatic zones across the Floodplain PEA include size classes showing annual recruitment.

Type	Ecological Objective	Ecological Target
		Increase range and abundance of wetland/floodplain (native fish) specialists within aquatic zones across the Floodplain PEA.
	A low proportion of total fish community, measured as abundance and biomass, is comprised of non-native species	The relative abundance and biomass of non-native species does not increase in the absence of increases in abundance and biomass of native fish.
Frogs	Provide habitat conducive to supporting diverse communities of riparian frogs within the Floodplain PEA	Each of 8 riparian frog species present within the Floodplain PEA will be recorded across the floodplain in any three year period.
		Tadpoles will be recorded from 8 species in later stages of metamorphosis across the Floodplain PEA in any three year period.
Waterbirds	Create conditions conducive to successful, small scale breeding events for waterbirds across the Floodplain PEA	Minimum inundation periods required for successful breeding by a range of water bird species are provided. Preliminary minimum 120 days.
	Provide refuge for the maintenance of adult populations of waterbirds across the Floodplain PEA	During continental dry periods an increase in the observed to expected ratio of waterbird species[17]
Other fauna	Provide habitat conducive to supporting communities of native woodland birds, reptiles and mammals across the Floodplain PEA	Each of the bird species known to utilise similar floodplain woodland habitats in the region will be recorded at 50% sites across the Floodplain PEA in any three year period[17].
		Each of the reptile species known to utilise similar floodplain/woodland habitats in the region will be recorded at 50% sites across the Floodplain PEA in any three year period[17].
		Each of the native mammal species known to utilise similar floodplain/woodland habitats in the region will be recorded at 50% sites across the Floodplain PEA in any three year period[17].

Table 5. Environmental water requirements for the SA River Murray Floodplain Priority Environmental Asset

Taken from Klisby, et al., 2015.

EWR #	Median discharge (ML/day QSA)	Discharge variability (ML/day QSA)	Duration (days)	Preferred timing	Average return frequency (years)	Max interval (years)	Max rate of water level rise (m/day)	Max rate of water level fall (m/day)
FP1	50,000	45,000-55,000	30	Sep-Dec	1.6	5	0.05	0.025
FP2	60,000	55,000-65,000	30	Sep-Dec	2.0	5	0.05	0.025
FP3	70,000	65,000-75,000	30	Sep-Dec	2.6	5	0.05	0.025
FP4	80,000	75,000-85,000	30	Sep-Dec	3.6	5	0.05	0.025
FP5	80,000	75,000-85,000	60	Sep-Dec	7.6	8	0.05	0.025

3.5. The Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset

3.5.1. Location and geographic extent

The Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset (the 'CLLMM PEA') is equivalent to:

- the Lower Lakes, Coorong and Murray Mouth TLM Icon Site (CLLMM Icon Site)
- the Coorong, Lakes Alexandrina and Albert Ramsar Wetland of International Importance (Coorong and Lakes Ramsar Site).

The geomorphology, hydrology and water quality of the CLLMM PEA is extremely complex. The site is already well described in a number of documents, particularly the Lower Lakes, Coorong and Murray Mouth Environmental Water Management Plan (Murray-Darling Basin Authority, 2013b) and the Ecological Character Description of the Coorong, Lakes Alexandrina and Albert Wetland of International Importance (Phillips, et al., 2006), with a synopsis provided in O'Connor, et al. (2015). The following summary has been adapted from text provided in these documents.

The CLLMM PEA covers a total approximate area of 142,530 hectares (Figure 9), and consists of four sub-regions:

1. the Lower Lakes - comprised of Lake Alexandrina (approximately 65,000 hectares) and Lake Albert (approximately 23,000 hectares); both are large, shallow, permanent lakes surrounded by fringing, ephemeral wetlands
2. the lower reaches of the Eastern Mount Lofty Ranges (EMLR) tributaries - the lower reaches of the tributaries within the boundaries of the CLLMM PEA while the tributaries themselves are part of the EMLR water resource plan area, which is covered by a separate LTWP
3. the Murray Mouth estuary - the area from the Goolwa Barrage to Pelican Point
4. the Coorong - a long (approximately 140 km), narrow (approximately 2 - 3 km), shallow lagoon, which is separated into the North Lagoon and South Lagoon by a narrow constriction at Parnka Point.

Flows from upstream areas of the Murray-Darling Basin arrive via the Channel PEA and pass into Lake Alexandrina (approximately 5 km south of Wellington) and out to the Southern Ocean via the Murray Mouth Estuary. Lake Alexandrina also connects to the terminal Lake Albert through the Narrung Narrows on the eastern side. The Lower Lakes are physically separated from the Murray Mouth and Coorong via a complex series of islands, channels and five barrages. The barrages were constructed in the 1930s to prevent ingress of saline water to the Lower Lakes and to regulate lake water levels. Fishways have since been incorporated into the barrages to allow fish movement between freshwater and saline environments.

At times, small volumes of freshwater pass into Lake Alexandrina from the EMLR tributaries, which are fed by unconfined aquifers and regional rainfall. When conditions are dry in the EMLR and there is no flow in the tributaries, freshwater from Lake Alexandrina helps to maintain inundation of the wetlands in the lower reaches of the EMLR tributaries, providing important habitat for birds, frogs and fish.

The salinity and morphology of the Murray Mouth estuary varies depending on freshwater flows and coastal conditions and processes. Freshwater outflows are required to keep the Murray Mouth open. Due to the impacts of regulation and extraction, constriction and closure of the Murray Mouth has occurred in recent history. Dredging operations to maintain an open Murray Mouth commenced on 9 January 2015 and at 6 September 2020 had removed over 6 000 000 cubic metres of sand (Department for Environment and Water, 2020).

The Coorong receives inflows at the northern end from Lake Alexandrina and the Southern Ocean, and at times to the southern end via Salt Creek. It is a 'reverse estuary' (i.e. salinity increases with distance from the Mouth), with salinities ranging from fresh to brackish in parts of the Murray Mouth estuary to hyper-saline in areas of the South Lagoon. This gradient varies temporally depending on inflows from the Lower Lakes, Southern Ocean and Salt Creek.

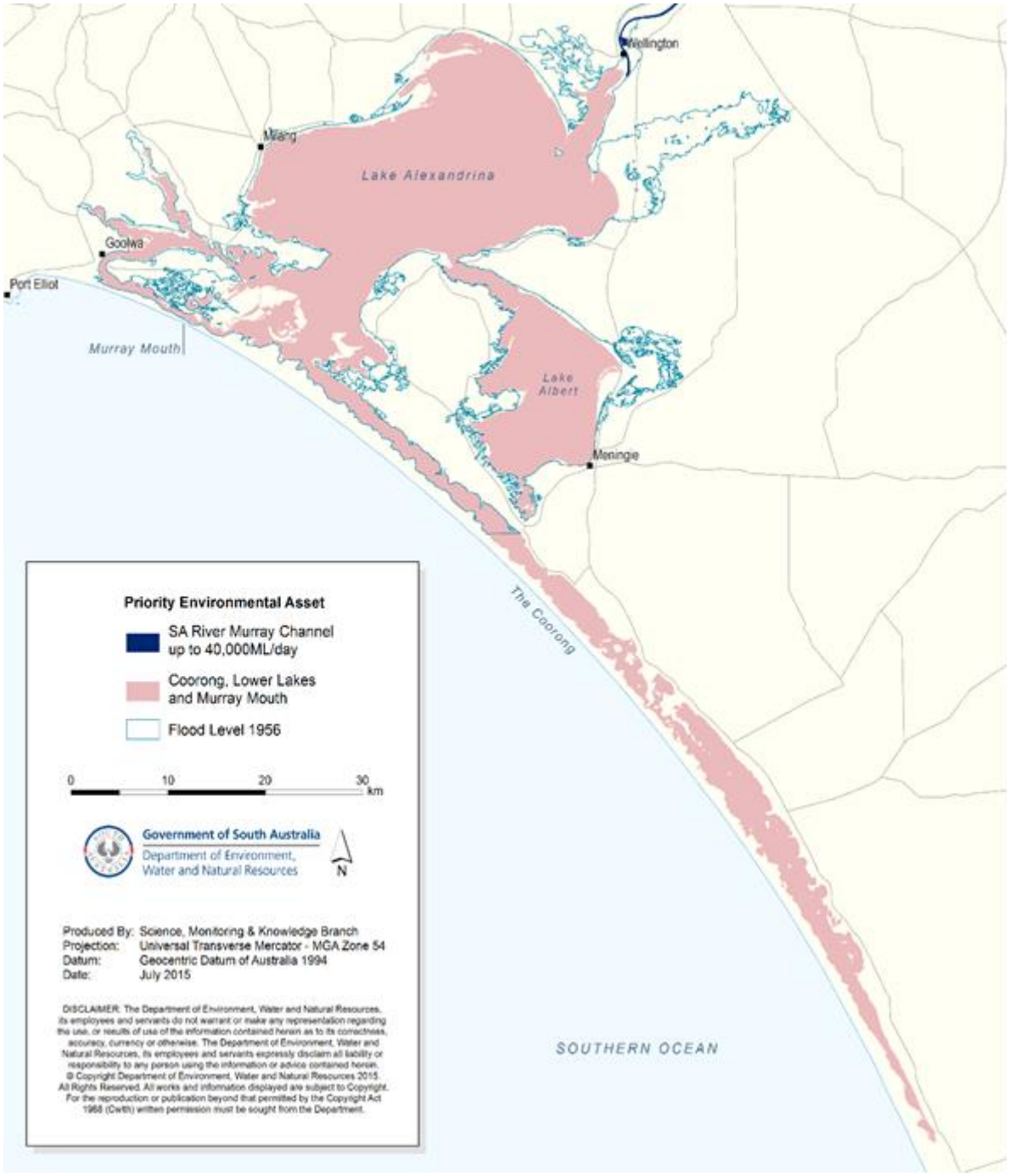


Figure 9. Spatial extent of the Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset

3.5.2. Conservation significance

The CLLMM PEA is recognised as a site of high ecological and cultural value through The Living Murray Initiative and as a Wetland of International Importance under the Ramsar Convention. As the only estuary of the Murray-Darling Basin, the CLLMM is also a unique geomorphological feature of the Basin.

Detailed descriptions of the conservation values of the CLLMM are provided in the Lower Lakes, Coorong and Murray Mouth Environmental Water Management Plan (Murray-Darling Basin Authority, 2013b) and the Ecological Character Description of the Coorong and Lakes Alexandrina and Albert Wetland of International Importance (Phillips, et al., 2006). O'Connor, et al. (2015) provided the following summary of some of the key values of the asset:

- waterbirds: regularly supports >200,000 waterbirds during summer (Paton, 2010), significant numbers of colonial-nesting and beach-nesting waterbirds (O'Connor, et al., 2013) and a number of threatened waterbird species (Department of Environment, Water and Natural Resources, 2013b)
- fish: plays an important role for 49 native fish species, including diadromous, endangered and commercially caught species (Phillips, et al., 2006; Ye, et al., 2014)
- vegetation: characterised by a range of ecologically significant submerged, emergent and fringing vegetation species and communities including, *Gahnia* sedgelands, Fleurieu Peninsula swamps and *Ruppia tuberosa* (Phillips, et al., 2006).

Data from the DEW's biological database indicates that within the CLLMM PEA the following species of conservation significance have been recorded at least once[23]:

- 63 plant species (Table 16 in Appendix 2) listed as Endangered, Vulnerable or Rare under the South Australian *National Parks and Wildlife Act 1972* ('state-listed')
- 130 protected fauna species (Table 17 in Appendix 2), of which 95 are state-listed species, five species are listed as nationally threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and 30 species are both state and nationally listed
- 29 migratory bird species that are listed under international agreements (Table 17 in Appendix 2).

The significance of the CLLMM PEA is further indicated by the inclusion of three overall environmental objectives within the Basin Plan that specifically relate to this asset, as follows:

> section 8.06 (3) An objective is to protect and restore connectivity within and between water-dependent ecosystems by ensuring that:
>
> > (c) the Murray Mouth remains open at frequencies, for durations, and with passing flows, sufficient to enable the conveyance of salt, nutrients and sediment from the Murray-Darling Basin to the ocean; and
> >
> > (d) the Murray Mouth remains open at frequencies, and for durations, sufficient to ensure that the tidal exchanges maintain the Coorong's water quality (in particular salinity levels) within the tolerance of the Coorong ecosystem's resilience; and
> >
> > *Note: This is to ensure that water quality is maintained at a level that does not compromise the ecosystem and that hydrologic connectivity is restored and maintained.*
> >
> > (e) the levels of the Lower Lakes are managed to ensure sufficient discharge to the Coorong and Murray Mouth and help prevent river bank collapse and acidification of wetlands below Lock 1, and to avoid acidification and allow connection between Lakes Alexandrina and Albert, by:
> >
> > > (i) maintaining levels above 0.4 metres Australian Height Datum for 95% of the time, as far as practicable; and
> > >
> > > (ii) maintaining levels above 0.0 metres Australian Height Datum all of the time

The CLLMM PEA also includes a significant 'Sacred Site' – the Meeting of the Waters' (registered Aboriginal heritage site under the SA *Heritage Act 1988*). This includes the waters and the bed of the lakes, river and estuary. Its spiritual and cultural

[23] *Presence/absence records from DEW's biological database have been provided as an indication of the number of threatened species that have been found within each PEA only. Currently there are very few fish records and no invertebrate records entered into the dataset. This is not a comprehensive list and does not reflect species records that have not been provided to DEW for input to the database.*

significance is essential to the wellbeing and productivity of the Ngarrindjeri nation, Ngarrindjeri lands and waters, and all living things (Ngarrindjeri Nation 2006).

3.5.3. Ecological attributes

A project was undertaken by DEWNR (O'Connor, et al., 2015) that reviewed information from the following key sources:

- the existing objectives and targets for the CLLMM TLM Icon site (Maunsell Australia Pty Ltd, 2009; Murray-Darling Basin Commission, 2006a) and a recent TLM condition monitoring refinement project (Robinson, 2014)
- the critical components, processes and services (CPS), and limits of acceptable change (LAC) from the draft, updated ecological character description (ECD) for the Coorong and Lakes Alexandrina and Albert Ramsar site Coorong (Department for Environment and Water, in prep (a))
- outputs from the MDBA's quantitative environmental outcomes workshops for shorebirds, general waterbirds, Coorong fish and *Ruppia tuberosa*, and subsequent content in the BWEWS (Murray-Darling Basin Authority, 2014e; Murray-Darling Basin Authority, 2014a).

This review highlighted the following as key ecological attributes for the CLLMM PEA:

- ecosystem processes and physio-chemical conditions - hydrology, connectivity, salinity gradients, diversity and extent of wetland types, Murray Mouth openness
- vegetation – freshwater submergent and emergent communities, submergent and emergent halophytes, *Ruppia tuberosa*
- macroinvertebrates - taxonomic richness, distribution, biomass and sediment conditions
- fish – diversity, diadromous species, endangered species, estuarine species, small-mouthed hardyhead
- waterbirds - diversity, abundance, breeding, state and nationally threatened species, species listed under international treaties and migratory agreements, >1% total flyway population size.

High-level conceptual models of the Lower Lakes and of the Coorong are provided in Maunsell Australia Pty Ltd (2009). Hydro-ecological conceptual models of the likely response of vegetation, macroinvertebrates, fish and waterbirds in the CLLMM under six discharges ranging from Entitlement to 80,000 ML/day QSA are provided in Bice, et al. (2014).

3.5.4. Ecological objectives, targets and environmental water requirements

In total, eight ecological objectives and 29 nested ecological targets have been identified for the CLLMM PEA (Table 6 from O'Connor, et al. 2015). The detailed methods for developing these objectives and targets are described in O'Connor, et al. (2015). Seven of the eight ecological objectives are exact representations of TLM 'targets', as their content and wording was consistent with the definition of 'ecological objectives' used in this LTWP (refer Section 3.2). Two additional objectives relating to fish diversity and salinity were developed as they were identified as a critical CPS but there was no corresponding TLM target. This ensured that all CPS and LAC[24] described in the ECD have been represented by an ecological objective within the LTWP.

O'Connor, et al. 2015 identified four EWRs for the CLLMM PEA, which considered the EWRs described in Lester, et al. (2011) and Heneker (2010) needed to maintain salinities of < 700 µS/cm and < 1000 µS/cm in Lake Alexandrina, but incorporated additional metrics to further describe the desired hydrological regime for the site (O'Connor, et al., 2015).

The Coorong South Lagoon metrics were developed in 2015 (O'Connor, et al. 2015) based on expert advice. The metric represents target water levels and shows an incremental increase when moving though the EWRs, with the water level for the lowest EWR (EWR-CLLMM1) indicating target levels under low flow conditions. Under these conditions, strong *Ruppia tuberosa* recruitment events are unlikely, however the target water level range will support existing adult populations of *Ruppia tuberosa* within the deeper channel, and is important for general mudflat health to support waterbird populations, including migratory waders.

This metric provides guidance for environmental water planning but should not preclude targeting higher levels in real-time event planning should the opportunity arise for improved outcomes.

In total there are nine metrics for each of the EWRs, as follows:

[24] *LAC are not equivalent to ecological objectives or targets, and instead represent thresholds that indicate a change in ecological character. Their use in the development of ecological objectives in the LTWP was limited to ensuring that all relevant attributes of the asset had been incorporated*

1. Annual barrage flow - the minimum volume (gigalitres per year) released from the barrages (all gates) over the course of a water-year. For some EWRs this should be calculated as a rolling average (i.e. average volume over multiple years).
2. Average return interval - the desired average frequency that the minimum annual volume is released e.g. 1-in-3 ARI means once every three years (or 33% of years) on average and does not seek to describe a regular pattern.
3. Maximum interval - the maximum number of years between events that meet the EWR metrics.
4. Timing – barrage releases should occur over the entire water-year but the EWRs seek to vary the monthly outflow volume with peaks outflows in late spring/early summer in order to support seasonal ecological processes. This variation is described in Figure 10.Figure 10
5. Lake water level range - the range that Lake water levels should remain within throughout the year (in mAHD); water level values should be calculated as the average across the Lower Lakes rather than a minimum or maximum at any given location.
6. Lake water level timing - describes the months when maximum and minimum water levels should occur.
7. Coorong South Lagoon water level - the range that water levels (in mAHD) should remain within at the indicated time. This should be based on the minimum water level at any given point rather than an average across multiple locations.
8. Coorong South Lagoon water level timing - the months when South Lagoon water levels need to remain within the specified range.
9. Coorong South Lagoon duration - the number of days that South Lagoon water levels need to remain within the specified range.

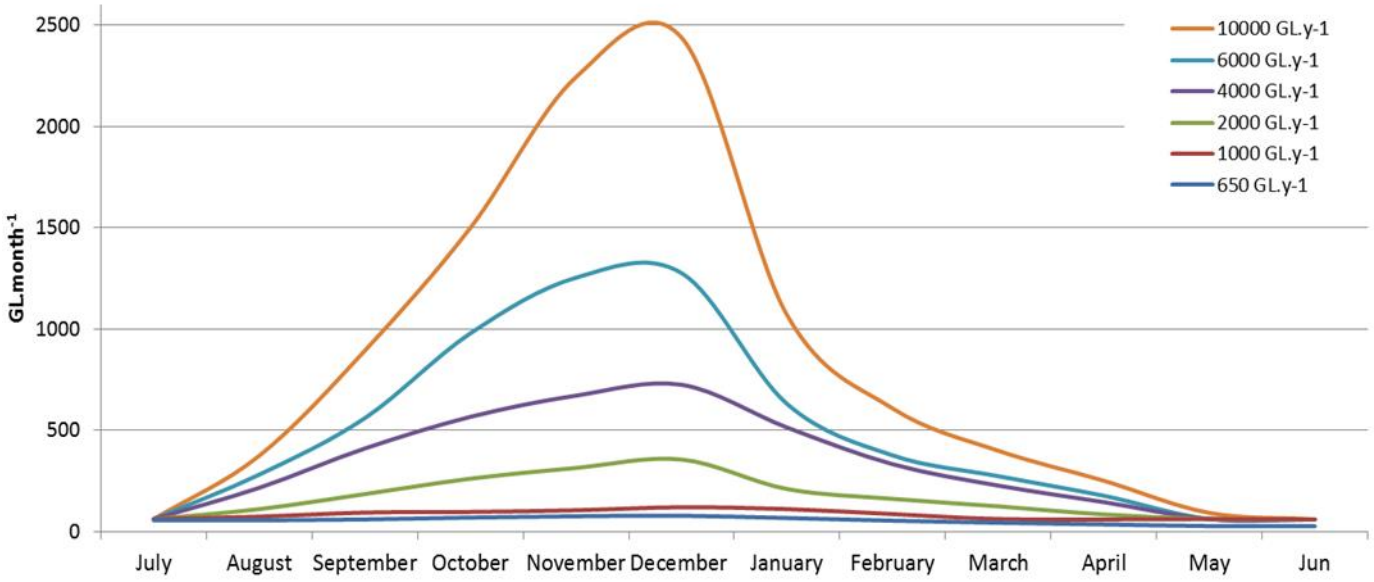


Figure 10. Hypothetical optimal timing of barrage releases for various annual flow scenarios

Table 6. Ecological objectives and targets for the Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset

Table taken from O'Connor, et al. (2015). Note, additional target detail and supplementary information, and the source reference for the target information have not been transferred into this long-term plan and should be sourced from Table 1 in O'Connor, et al. (2015).

Type	Ecological objective	Ecological targets
Waterbirds	Maintain or improve waterbird populations in the Coorong and Lower Lakes	Abundances, area of occupation and extent of occurrence of TLM target waterbird species (Table 18 in Appendix 4) to be above defined median reference values (median of data from the 15 years between 2000 and 2014) (Paton, 2014a)
		Detect annual breeding activity in waterbird species that are expected to breed annually at the site (Table 19 in Appendix 4) and at least two breeding events in any four consecutive years in species that breed regularly at the site (Table 20 in Appendix 4) (Department of Environment Water and Natural Resources, in prep (a))
		Provide functional mudflat habitat to sustain active shorebird foraging behaviour during November-March with a foraging effort of <50%. (Murray-Darling Basin Authority, 2014e)
		Maintain abundances of 12 waterbird species (Table 21 in Appendix 4) at or above 1% of the total flyway population size (Department of Environment Water and Natural Resources, in prep (a))
Fish	Maintain a spatio-temporally diverse fish community and resilient populations of key native fish species in the lower lakes and Coorong	A spatio-temporally diverse fish community is present including all 23 fish families stated in the Ramsar site draft Ecological Character Description (Table 22 in Appendix 4) (Department of Environment Water and Natural Resources, in prep (a))
		Annual detection of juvenile Catadromous fish at abundances ≥ that of defined 'Recruitment Index' values (44.5 for *Congolli*, and 6.1 for *Common galaxias*) (Bice, et al., 2014)
		Annual detection of migration for Anadromous species (short-headed and pouched lamprey) at index values of >0.6 (Bice, et al., 2014)
		Maximise fish passage connectivity between the Lower Lakes and Coorong, and between the Coorong and the sea by allowing fishways to operate year-round (Murray-Darling Basin Authority, 2013b)
		Maintain or improve abundances of Murray hardyheads and pygmy perch so that 'Relative Abundance Index' values of ≥1 are achieved on an annual basis (Wedderburn, 2014)
		Detect recruitment success of Murray hardyheads and pygmy perch at least every second year (Wedderburn, 2014)
		Maintain or improve abundances, distribution and recruitment of black bream and greenback flounder with population condition score ≥3 (Ye, et al., 2014a)
		Facilitate regular recruitment and a broader distribution of juvenile mulloway (Ye, et al., 2014a)
		Maintain an average Catch-Per-Unit-Effort (CPUE) of small-mouthed hardyhead sampled in spring/early summer of > 120 for adults, and >790 for juveniles (Ye, et al., 2014b)
		Maintain the proportional abundance of small-mouthed hardyhead juveniles at >60% in 75% of defined monitoring sites within the CLLMM (Ye, et al., 2014b)

Type	Ecological objective	Ecological targets
Macroinvertebrates	Maintain or improve invertebrate communities in estuarine and lagoon sediments	Macroinvertebrate taxonomic distinctness falls within the expected ranges of a regional reference (Dittman, 2014)
		The distribution of macroinvertebrate species remains within or above the species-specific reference level for their index of occurrence (Dittman, 2014)
		The area of occupancy where abundance and biomass are at or above the reference level should be >20% of the monitoring sites (Dittman, 2014)
		The macroinvertebrate community has a higher multivariate similarity to the community present in years with flow than without flow (Dittman, 2014)
	Maintain habitable sediment conditions in mudflats	Median grain size of sediments in the Coorong and Murray Mouth will remain between 125 – 500 µm (Dittman, 2014)
		Sediment organic matter content between 1 and 3.5 % dry weight in the Coorong and Murray Mouth (Dittman, 2014)
Vegetation	Restore *Ruppia tuberosa* colonisation and reproduction in the Coorong at a regional and local scale	A continuous distribution of *Ruppia tuberosa* beds along a 50 km section of the southern Coorong (excluding outliers) (Paton, 2014b)
		Within the abovementioned distribution, 80% of the monitored sites should have *Ruppia tuberosa* plants present in winter and summer (Paton, 2014b)
		50% of sites with *Ruppia tuberosa* to exceed the local site indicators for a healthy *Ruppia tuberosa* population (Paton, 2014b)
		Support a resilient *Ruppia tuberosa* population with seed densities of 2000 seeds/m^2 by 2019 and 50% of sites having 60% cover in winter and a seed bank of 10,000 seeds/m^2 by 2029 in the Coorong South Lagoon (Paton, 2014b)
	Maintain or improve aquatic and littoral vegetation in the Lower Lakes	Maintain or improve diversity of aquatic and littoral vegetation in the Lower Lakes as quantified using the LLCMM vegetation indices (Nicol, et al., 2014b)
Water quality	Establish and maintain stable salinities in the lakes and a variable salinity regime in the Murray estuary and Coorong.	Barrage outflows sufficient to maintain electrical conductivity in Lake Alexandrina at a long-term average of 700 µS/cm, below 1,000 µS/cm 95% of years and below 1,500 µS/cm 100% of the time (Heneker, 2010)
		To support aquatic habitat: maintain a salinity gradient from 0.5 ppt to 35ppt between the Barrages and Murray Estuary area, <45ppt in the North lagoon, and from 60ppt to 100 ppt in the South lagoon (Lester, et al., 2011)
Ecosystem processes	Maintain a permanent Murray Mouth opening through freshwater outflows with adequate tidal variations to improve water quality and maximise connectivity between the Coorong and the sea	Maintain an open Murray Mouth, as indicated when the Diurnal Tidal Ratio (DTR) at Goolwa exceeds 0.3, with minimum DTR values of 0.05 and 0.2 at Tauwitchere and Goolwa respectively (Murray-Darling Basin Authority, 2013b; Department of Water Land and Biodiversity Conservation, 2008)
		Maintain a minimum annual flow required to keep the Murray Mouth open (730—1,090 GL/year) (Murray-Darling Basin Authority, 2013b)

Table 7. Environmental water requirements for the Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset

Table taken from O'Connor, et al. (2015). 'Timing' of barrage flows, lake levels and Coorong South Lagoon water levels include the entire duration of each month specified (i.e. from the beginning of the first month to the end of the final month).

EWR #	Average return interval (years)	Maximum interval (years)	Annual barrage flow (GL/year)	Barrage flow timing	Lakes water level range (mAHD)	Lakes water level timing	Coorong south lagoon water level (mAHD)	Coorong south lagoon water level timing	Coorong south lagoon duration (days)
CLLMM1	1-in-1	N/A	>650[25]	Jul-Jun, with peak barrage outflows in Oct-Dec	0.4-0.75	Maximum lake levels Dec-Feb and minimum lake levels in Mar-May	0.0 to 0.2	Sept-Nov	≥90
							-0.2 to -0.4	Feb-Mar	-
CLLMM2	1-in-2	N/A	>3150[26]	Jul-Jun, with peak barrage outflows in Oct-Dec	0.4-0.83	Maximum lake levels Dec-Feb and minimum lake levels in Mar-May	0.35-0.45	Sept-Dec	≥120
							0 to -0.5	Mar-April	-
CLLMM3	1-in-3	5	>6,000	Jul-Jun, with peak barrage outflows in Oct-Dec	0.4-0.83	Maximum lake levels Dec-Feb and minimum lake levels in Mar-May	0.35-0.45	Sept-Jan	≥150
							0 to -0.5	Feb-April	-
CLLMM4	1-in-7	17	>10,000	Jul-Jun, with peak barrage outflows in Oct-Dec	0.4-0.9	Maximum lake levels Dec-Feb and minimum lake levels in Mar-May	0.35-0.45	Sept-end Feb	≥180
							n/a	n/a	-

[25] *A total average barrage outflow of 2,000 GL/year over a three year rolling period (i.e. not less than 6,000 GL over three years) and not less than 650 GL/year in any one of the three years (Heneker 2010; Lester et al. 2011)*
[26] *A total average barrage outflow of 4,000 GL/year over a three year rolling period (i.e. not less than 12,000 GL over three years) and not less than 3150 GL/year in any one of the three years (Heneker 2010; Lester et al. 2011)*

3.6. Application of the environmental water requirements

3.6.1. EWRs contribution to targets

The methods used to develop the EWRs for this LTWP do not provide a single EWR per objective or target; rather, the suite of EWRs for each PEA describes a variable flow regime which is required to achieve the ecological targets. To assist with annual planning and environmental watering decisions, such as potential benefits or trade-offs under different flow scenarios, a matrix was developed that assessed the likely contribution of each EWR in isolation towards achieving each of the ecological targets. The assessment uses a coarse ranking system and so a result of no change in ranking does not necessarily mean there is no improvement in contribution, and outcomes will be dependent on antecedent flows and prevailing ecosystem condition (Wallace, et al., 2014a). The matrices were populated based on the flow-ecology conceptual models (see PEA descriptions above) and expert opinion. The results are presented in the three tables below:

- Table 8. Assessment of contribution of SA River Murray Channel Priority Environmental Asset EWRs towards ecological targets
- Table 9. Assessment of contribution of SA River Murray Floodplain Priority Environmental Asset EWRs towards ecological targets
- Table 10. Assessment of contribution of Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset EWRs towards ecological targets.

The matrices developed for the Floodplain PEA and the CLLMM PEA show the importance of flows of 70,000 ML/day QSA or greater in achieving ecological outcomes, with the higher EWRs likely to result in a 'large positive contribution' to the greatest number of targets. However, the need for a long-term variable flow regime consisting of baseflows, in-channel freshes and overbank flows (as represented by the suite of EWRs for each asset) should not be overlooked.

3.6.2. EWRs and annual planning

The EWRs for the priority environmental assets are not presented in the form of prescriptive five-year hydrographs because the feasibility of delivery will be highly dependent on climatic conditions. In order to meet the majority of the EWRs, environmental water will need to be delivered in conjunction with unregulated flows, as the volume of water required is greater than that provided by South Australia's Entitlement or available to the environment through water recovery programs. The need to deliver an EWR in any given year will also depend on antecedent climate conditions and the condition of the different ecological components of the asset. Therefore the EWRs describe a desired long-term and variable hydrological regime in a way that enables flexibility and adaptive management in response to climate and ecological condition.

In recent years, South Australia has used a scenario-based approach to plan and prioritise environmental watering actions each year. The process is described in the Annual Environmental Watering Plans for the South Australian River Murray, which are published on the DEW website. The EWRs can be used to inform annual planning by:

- comparing desired return frequency (i.e. the average return frequency metric of EWR) to actual return frequency (i.e. how often the EWR has been met based on surface water data) over a 20-year period, where an EWR is considered to be met within any given water-year when the volume/discharge, duration, timing, water level and rate of change metrics have all been satisfied. A 20-year timeframe is preferred as it captures the longest 'maximum interval' specified by any of the EWRs (i.e. 17 years for EWR - CLLMM4) and ensures results are based on long-term watering histories
- assessing the number of years since the EWR was met and comparing to the maximum interval metric of the EWR.

These assessments are hydrological and assume the flow-ecology relationship is well understood. Decisions should also be informed by results from ecological monitoring that indicate current condition, need for water and risk of not watering. Once accurate forecasts of climatic conditions are available then the assessment should be revisited and watering actions refined based on what is feasible to deliver.

In addition to the ecological information, management considerations within Section 4 should also be taken into account during planning and decision-making, including:

- Aboriginal values – consideration of, and where possible alignment with, Aboriginal values in order to maximise the benefits from environmental watering

- co-operative arrangements – processes to be followed to ensure that watering actions across the WRP area and SCB are coordinated, and potential risks to water quality are considered
- operational constraints – whether it is feasible to deliver the proposed watering action in view of operational constraints
- long-term risks to providing environmental water – whether the proposed watering action addresses any of the potential long-term risks.

3.6.3. EWRs and management levers

The description of landscape-scale environmental assets for the SA River Murray LTWP and their EWRs encourages the reinstatement of a more natural flow regime through the delivery of environmental water to the South Australian border, and subsequently downstream to the CLLMM. Achieving most EWRs will require an unregulated flow event to occur, with environmental water used to boost the magnitude or duration of the event. However, the PEAs incorporate many smaller scale management units that offer alternative opportunities for delivering environmental water and meeting some of the EWR metrics in discrete locations.

In particular, environmental regulators on Chowilla, Pike and Katarapko anabranches as well as the main channel weirs can be raised to increase the extent of inundation of parts of the Channel and Floodplain PEAs, while pumps can be used to deliver water to discrete temporary wetland basins in any of the three PEAs. Each of these management units have their own management plans and site-specific objectives and targets, but these types of actions will also contribute to partially meeting the ecological targets of the PEAs. The mechanism for evaluating the contribution of localised environmental water delivery to the PEA ecological targets is addressed through Matter 8 evaluation and reporting (see Section 5.1.1), and the information used to inform adaptive management of both the site and the PEA.

By modelling the flow rate at which temporary wetlands are inundated (commence-to-flow), sites that are likely to receive water as a result of enhancing flows at the South Australian border can be identified. Cross-referencing these commence-to-flow values and the discharge metrics of the EWRs for the Channel PEA and the Floodplain PEA provides an indication of the wetlands that will be influenced by the delivery of different flow events, noting that this relationship will change in lock reaches when weir manipulations or operation of large environmental regulators are undertaken.

Fringing temporary wetlands of the CLLMM PEA are influenced by water levels in the Lower Lakes (which are largely influenced by barrage operations) and the effects of wind seiching, and their desired hydrological regime is provided by the variable Lake levels specified in the CLLMM PEA EWRs. Pumping water to these wetlands may be required at times, depending on climatic conditions and the ability to maintain the appropriate seasonal Lake level pattern.

The Channel PEA also includes a large number of pool-connected wetlands; that is wetlands that are permanently inundated due to the stable water levels created by the weirs. At some of these wetlands, wetting and drying regimes have been reinstated through the installation of infrastructure that enables them to be disconnected from the River. These managed pool-connected wetlands have their own management plans that describe site-specific objectives and targets. The unmanaged and the managed pool-connected wetlands use planned environmental water and held environmental water, respectively. It may be difficult to determine the direct contribution that pool-connected wetlands make to the Channel PEAs ecological targets, which focus largely on outcomes from the delivery of additional water to South Australia. However, increased flows and the re-establishment of lotic habitats in the main channel will increase the value of the lentic conditions provided by off-channel habitats.

Table 8. Assessment of contribution of SA River Murray Channel Priority Environmental Asset EWRs towards ecological targets

Table taken from Wallace, et al. (2014a)

Assessment based on the following ranking system:

Score	Requirements or processes met	Contribution towards Ecological Targets
1	All or most	Large positive contribution
2	Some	Moderate positive contribution
3	Very few or none	Contribution unlikely to be detectable or expected

Channel Ecological Target	EF[27]	Channel EWR[28]						
		IC1 (10,000)	IC2 (15,000)	IC3 (20,000)	IC4 (25,000)	IC5 (30,000)	IC6 (35,000)	IC7 (40,000)
Open-water productivity shows a temporary shift from near zero or autotrophic dominance (positive Net Daily Metabolism) towards heterotrophy (negative Net Daily Metabolism) when QSA >30,000 ML/day.	3	3	3	3	2	2	1	1
Habitat across the range of velocity classes is present in the lower third of weir pools for at least 60 consecutive days in Sep–Mar, at a maximum interval of 2 years.	3	3	3	2	1	1	1	1
Thermal stratification does not persist for more than 5 days at any time.	3	1	1	1	1	1	1	1
Basin Plan Objective: Salt export, averaged over the preceding 3 years, is ≥2 million tonnes per year.	3	3	2	2	2	1	1	1
Inundation periods in temporary wetlands have unrestricted lateral connectivity between the river and wetlands in >90% of inundation events.	3	3	3	3	2	2	2	1

[27] *EF = entitlement flow and is provided as a comparison only*

[28] Refer

Table 3 for full description of Channel EWRs. The discharge magnitude has been provided (in brackets) to assist with cross-referencing, however the EWR consists of several metrics including duration, return frequency and timing.

Channel Ecological Target	EF[27]	Channel EWR[28]						
		IC1 (10,000)	IC2 (15,000)	IC3 (20,000)	IC4 (25,000)	IC5 (30,000)	IC6 (35,000)	IC7 (40,000)
Biovolume <4 mm^3/L for all Cyanobacteria, where a known toxin producer is dominant, **or** <10 mm^3/L for all Cyanobacteria where toxins are not present.	3	2	1	1	1	1	1	1
Basin Plan Target: Maintain dissolved oxygen above 50% saturation throughout water column at all times.	3	3	3	2	2	2	1	1
Establish and maintain freshwater lenses in near-bank recharge zones.	3	3	2	2	2	2	1	1
Maintain soil water availability, measured as soil water potential > -1.5 MPa at soil depth 20–50 cm, to sustain recruitment of long-lived vegetation across the elevation gradient in the target zone.	3	3	3	2	2	2	2	1
Reduce soil salinity (measured as EC 1:5) to <5000 µS/cm to prevent shifts in understorey plant communities to salt-tolerant functional groups across the elevation gradient in the target zone.	3	3	3	2	2	2	2	1
Median biofilm composition is not dominated (>80%) by filamentous algae.	3	2	2	2	1	1	1	1
Median biofilm C:N ratios are <10:1.	3	2	2	2	1	1	1	1
In standardised transects spanning the elevation gradient in the target zone, 70% of river red gums have a Tree Condition Index score ≥ 10.	3	3	2	2	2	2	2	1
A sustainable demographic is established to match the modelled profile for a viable river red gum population in existing communities spanning the elevation gradient in the target zone.	3	3	3	2	2	2	2	1
Species from the Plant Functional Group 'flood-dependent/responsive' occur in 70% of quadrats spanning the elevation gradient in the target zone at least once every 3 years.	3	3	3	2	2	2	2	1
Native macrophytes from the emergent, amphibious and flood- dependent functional groups occur in 70% of quadrats spanning the elevation gradient in the target zone at least once every 3 years.	3	3	3	3	2	2	2	1
Expected fish species occur in each mesohabitat (channel, anabranch, wetlands) in each weir pool/reach.	3	3	3	3	3	2	1	1

Channel Ecological Target	EF[27]	Channel EWR[28]						
		IC1 (10,000)	IC2 (15,000)	IC3 (20,000)	IC4 (25,000)	IC5 (30,000)	IC6 (35,000)	IC7 (40,000)
Population age structure of Murray cod includes recent recruits, sub-adults and adults in 9 years in 10.	3	3	3	2	2	2	2	2
Population age structure of Murray cod indicates a large recruitment event 1 year in 5, demonstrated by a cohort representing >50% of the population.	3	3	3	3	3	3	3	2
Abundance (CPUE) of Murray cod increases by ≥50% over a 10-year period.	3	3	3	2	2	2	2	2
Population age structure of golden perch and silver perch includes YOY with sub-adults and adults in 8 years in 10.	3	3	2	2	2	2	2	1
Population age structure of golden perch and silver perch indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.	3	3	2	2	2	2	2	1
Abundance (CPUE) of golden perch and silver perch increases by ≥30% over a 5-year period.	3	3	3	2	2	2	2	1
Population age structure of freshwater catfish includes YOY, with sub-adults and adults in 9 years in 10.	3	3	3	2	2	2	2	1
Population age structure of freshwater catfish indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.	3	3	3	3	3	2	2	1
Abundance (CPUE) of freshwater catfish increases by ≥30% over a 5-year period.	3	3	3	3	3	2	2	1
Length-frequency distributions for foraging generalists include size classes showing annual recruitment.	1	1	1	2	2	2	2	2
Relative abundance and biomass of common carp do not increase in the absence of increases in abundance and biomass of flow-dependent native fish.	1	1	2	2	2	1	1	1

Table 9. Assessment of contribution of SA River Murray Floodplain Priority Environmental Asset EWRs towards ecological targets

Table taken from Kilsby, et al. (2015)
Assessment based on the following ranking system:

Score	Requirements or processes met	Contribution towards Ecological Targets
1	All or most	Large positive contribution
2	Some	Moderate positive contribution
3	Very few or none	Contribution unlikely to be detectable or expected

Floodplain Ecological targets	Floodplain EWR[29]				
	FP1 (50,000)	FP2 (60,000)	FP3 (70,000)	FP4 (80,000; 30-days)	FP5 (80,000; 60-days)
During inundation periods, record an increase in the abundance and diversity of invertebrate food resources, nutrients and DOC relative to those available during base flow	2	1	1	1	1
Deliver flows in a manner that reduces the proportion of slow flowing habitat and increases the proportion of moderate velocity habitat thereby reinstating a diversity of velocity classes representative of natural conditions	1	1	1	1	1
Discharge, water level and duration metrics of planned e-water represent a seasonally variable hydrograph	1	1	1	1	1
Maintain dissolved oxygen above 50% saturation throughout water column at all times, in connected waters	1	1	1	1	1
Establish and maintain freshwater lenses in near-bank recharge zones	2	1	1	1	1
Maintain soil water availability, measured as soil water potential at soil depth 20-50cm, greater than -1.5 MPa in order to sustain the recruitment of long-lived vegetation	2	2	1	1	1
Reduce soil salinity (EC 1:5) to below 5000 µS/cm to prevent permanent shifts in understorey plant communities to salt tolerant functional groups	2	2	1	1	1

[29] *Refer Table 5 for full description of Floodplain EWRs. The discharge magnitude has been provided (in brackets) to assist with cross-referencing, however the EWR consists of several metrics including duration, return frequency and timing.*

Floodplain Ecological targets	Floodplain EWR[29]				
	FP1 (50,000)	FP2 (60,000)	FP3 (70,000)	FP4 (80,000; 30-days)	FP5 (80,000; 60-days)
Maintain soil sodicity below the exchangeable sodium percent (ESP) value of 15 (highly sodic)	2	2	1	1	1
Limit the maximum rate of drawdown (averaged over 3 consecutive days) to ≤0.025 m/day (0.05m/day in any one day) to minimise risk of bank failure	1	1	1	1	1
In standardised transects that span the Floodplain PEA elevation gradient and existing spatial distribution >70% of all River red gum trees have a TCI ≥10	3	3	2	1	1
A sustainable demographic that matches the modelled profile for a viable River red gum population is established within existing communities across the floodplain elevation gradient	3	3	3	2	1
In standardised transects that span the Floodplain PEA elevation gradient and existing spatial distribution, >70% of all black box trees have a TCI ≥10	3	3	2	2	1
A sustainable demographic that matches the modelled profile for a viable black box population is established within existing communities across the floodplain elevation gradient	3	3	3	2	1
In standardised transects that span the Floodplain PEA elevation gradient and existing spatial distribution, >70% of all River cooba trees have a TCI ≥10	3	3	2	1	1
A sustainable demographic that matches the modelled profile for a viable River cooba population is established within existing communities across the floodplain elevation gradient	3	3	3	2	1
In standardised transects that span the floodplain elevation gradient and existing spatial distribution , ≥70% of Lignum plants have a LCI ≥6 for colour	3	3	3	1	1
In aquatic zones, a minimum of 40% of cells either inundated or dry containing inundation- dependent or amphibious plant taxa once every two years on average with maximum interval no greater than 4 years. Native water dependent species richness >30 across the Floodplain PEA.	3	2	1	1	1
In aquatic zones, a minimum of 80% of cells either inundated or dry containing native flood dependent or amphibious plant taxa once every four years on average with maximum interval no greater than 6 years. Native water dependent species richness >50 across the Floodplain PEA.	3	3	2	1	1

Floodplain Ecological targets	Floodplain EWR[29]				
	FP1 (50,000)	FP2 (60,000)	FP3 (70,000)	FP4 (80,000; 30-days)	FP5 (80,000; 60-days)
In shedding floodplain zones, a minimum of 20% of cells containing native flood dependent or amphibious plant taxa once every three years on average with maximum interval no greater than 5 years. Native flood dependent and amphibious species richness >20 across the Floodplain PEA.	2	2	1	1	1
In shedding floodplain zones, of 40% of cells containing native flood dependent or amphibious plant taxa once every five years on average with maximum interval no greater than 7 years. Native flood dependent and amphibious species richness >30 across the Floodplain PEA.	3	2	1	1	1
In shedding floodplain zones, of 65% of cells containing native flood dependent or amphibious plant taxa once every seven years on average with maximum interval no greater than 10 years. Native flood dependent and amphibious species richness >50 across the Floodplain PEA.	3	3	2	1	1
Population age structure of Murray cod includes recent recruits, sub-adults and adults in 9 years in 10.	2	2	1	1	1
Population age structure of Murray cod indicates a large recruitment event 1 year in 5, demonstrated by a cohort representing >50% of the population.	2	2	1	1	1
Abundance (CPUE) of Murray cod increases by ≥50% over a 10-year period.	2	2	1	1	1
Population age structure of Freshwater catfish includes YOY, with sub-adults and adults in 9 years in 10.	2	2	1	1	1
Population age structure of Freshwater catfish indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.	2	2	2	1	1
Abundance (CPUE) of Freshwater catfish increases by ≥30% over a 5-year period.	2	2	2	1	1
Population age structure of Golden perch and Silver perch includes YOY with sub-adults and adults in 8 years in 10.	1	1	1	1	1
Population age structure of Golden perch and Silver perch indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.	1	1	1	1	1
Abundance (CPUE) of Golden perch and Silver perch increases by ≥30% over a 5-year period.	1	1	1	1	1

Floodplain Ecological targets	Floodplain EWR[29]				
	FP1 (50,000)	FP2 (60,000)	FP3 (70,000)	FP4 (80,000; 30-days)	FP5 (80,000; 60-days)
The length-frequency distributions for wetland/floodplain (native fish) specialists within aquatic zones across the Floodplain PEA include size classes showing annual recruitment.	3	3	2	1	1
Increase range and abundance of wetland/floodplain (native fish) specialists within aquatic zones across the Floodplain PEA	3	3	2	1	1
The relative abundance and biomass of non-native species does not increase in the absence of increases in abundance and biomass of native fish.	2	2	1	1	1
Each of eight riparian frog species present within the Floodplain PEA will be recorded across the floodplain in any three year period.	2	1	1	1	1
Tadpoles will be recorded from eight species in later stages of metamorphosis across the Floodplain PEA in any three year period.	2	2	1	1	1
Minimum inundation periods required for successful breeding by a range of water bird species are provided. Preliminary minimum 120 days.	3	3	2	1	1
During continental dry periods an increase in the observed to expected ratio of waterbirds	2	2	1	1	1
Each of the bird species known to utilise similar floodplain woodland habitats in the region will be recorded at 50% sites across the Floodplain PEA in any three year period.	3	3	3	2	1
Each of the reptile species known to utilise similar floodplain/woodland habitats in the region will be recorded at 50% sites across the Floodplain PEA in any three year period.	3	3	3	2	1
Each of the native mammal species known to utilise similar floodplain/woodland habitats in the region will be recorded at 50% sites across the Floodplain PEA in any three year period.	3	3	3	2	1

Table 10. Assessment of contribution of Coorong, Lower Lakes and Murray Mouth Priority Environmental Asset EWRs towards ecological targets

Table taken from O'Connor, et al. (2015)
Assessment based on the following ranking system:

Score	Requirements or processes met	Contribution towards Ecological Targets
1	All or most	Large positive contribution
2	Some	Moderate positive contribution
3	Very few or none	Contribution unlikely to be detectable or expected

CLLMM Ecological Targets	Species or wetland	CLLMM EWRs[30]			
		CLLMM1 (>650)	CLLMM2 (>3,150)	CLLMM3 (>6,000)	CLLMM4 (>10,000)
Abundances, area of occupation, and extent of occurrence of TLM target waterbird species to be above defined median reference values (median of data from the 15 years between 2000 and 2014)	n/a	3	2	1	1
Detect annual breeding activity in waterbird species that are expected to breed annually at the site and at least two breeding events in any four consecutive years in species that breed regularly at the site	n/a	3	2	1	1
Provide functional mudflat habitat to sustain active shorebird foraging behaviour during November-March with a foraging effort of <50%	n/a	3	2	1	1
Maintain abundances of 12 waterbird species at or above 1% of the total flyway population size	n/a	3	2	1	1
A spatio-temporally diverse fish community is present including all 23 fish families stated in the Ramsar site draft Ecological Character Description	n/a	2	2	1	1

[30] *Refer Table 7 for full description of CLLMM EWRs. The annual barrage outflow volume has been provided (in brackets) to assist with cross-referencing, however the EWR consists of several metrics including water levels, duration, return frequency and timing.*

CLLMM Ecological Targets	Species or wetland	CLLMM EWRs[30]			
		CLLMM1 (>650)	CLLMM2 (>3,150)	CLLMM3 (>6,000)	CLLMM4 (>10,000)
Annual detection of juvenile Catadromous fish at abundances ≥ that of defined 'Recruitment Index' values (44.5 for *Congolli*, and 6.1 for *Common galaxias*.	n/a	2	1	1	1
Annual detection of migration for Anadromous species (short-headed and pouched lamprey) at index values of >0.6.	n/a	3	2	1	1
Maximise fish passage connectivity between the Lower Lakes and Coorong, and between the Coorong and the sea by allowing fishways to operate year-round	n/a	2	1	1	1
Maintain or improve abundances of Murray hardyheads and pygmy perch so that 'Relative Abundance Index' values of ≥1 are achieved on an annual basis	Murray hardyhead	1	2	2	2
	Yarra pygmy perch	2	1	1	1
Detect recruitment success of Murray hardyheads and pygmy perch at least every second year	Murray hardyhead	1	2	2	2
	Yarra pygmy perch	1	1	1	1
Maintain or improve abundances, distribution and recruitment of black bream and greenback flounder with population condition score ≥3.	Black bream	2	2	1	1
	Greenback flounder	3	2	1	1
Facilitate regular recruitment and a broader distribution of juvenile mulloway	n/a	3	2	1	1
Maintain an average Catch-Per-Unit-Effort (CPUE) of small-mouthed hardyhead sampled in spring/early summer of > 120 for adults, and >790 for juveniles	n/a	3	2	1	1

CLLMM Ecological Targets	Species or wetland	CLLMM EWRs[30]			
		CLLMM1 (>650)	CLLMM2 (>3,150)	CLLMM3 (>6,000)	CLLMM4 (>10,000)
Maintain the proportional abundance of small-mouthed hardyhead juveniles at >60% in 75% of defined monitoring sites within the CLLMM	n/a	2	1	1	1
Macroinvertebrate taxonomic distinctness falls within the expected ranges of a regional reference.	Lower Lakes	2	2	2	2
	Coorong	2	1	1	2
The distribution of macroinvertebrate species remains within or above the species-specific reference level for their index of occurrence.	Lower Lakes	2	2	2	2
	Coorong	2	1	1	2
The area of occupancy where abundance and biomass are at or above the reference level should be >20% of the monitoring sites.	Coorong	2	1	1	1
The macroinvertebrate community has a higher multivariate similarity to the community present in years with than without flow.	Lower Lakes	2	2	2	2
	Coorong	2	1	1	2
Median grain size of sediments in the Coorong and Murray Mouth will remain between 125 – 500 µm	n/a	2	1	1	2
Sediment organic matter content between 1 and 3.5 % dry weight in the Coorong and Murray Mouth.	n/a	1	1	2	2
A continuous distribution of *Ruppia tuberosa* beds along a 50 km section of the southern Coorong (excluding outliers).	n/a	3	2	1	1
Within the abovementioned distribution, 80% of the monitored sites should have *Ruppia tuberosa* plants present in winter and summer	n/a	3	2	2	1

CLLMM Ecological Targets	Species or wetland	CLLMM EWRs[30]			
		CLLMM1 (>650)	CLLMM2 (>3,150)	CLLMM3 (>6,000)	CLLMM4 (>10,000)
50% of sites with *Ruppia tuberosa* to exceed the local site indicators for a healthy *Ruppia tuberosa* population	n/a	3	3	2	1
Support a resilient *Ruppia tuberosa* population with seed densities of 2,000 seeds/m^2 by 2019 and 50% of sites having 60% cover in winter and a seed bank of 10,000 seeds/m^2 by 2029 in the Coorong South Lagoon	n/a	3	2	1	1
Maintain or improve diversity of aquatic and littoral vegetation in the Lower Lakes as quantified using the LLCMM vegetation indices	n/a	1	1	1	1
Barrage outflows sufficient to maintain electrical conductivity in Lake Alexandrina at a long term average of 700 µS/cm, below 1,000 µS/cm 95% of years and below 1,500 µS/cm 100% of the time	n/a	3	1	1	1
To support aquatic habitat: maintain a salinity gradient from 0.5 ppt to 35 ppt between the Barrages and Murray Estuary area, <45 ppt in the North Lagoon, and from 60 ppt to 100 ppt in the South Lagoon	Coorong	2	1	1	1
Maintain an open Murray Mouth, as indicated when the Diurnal Tidal Ratio (DTR) at Goolwa exceeds 0.3, with minimum DTR values of 0.05 and 0.2 at Tauwitchere and Goolwa respectively	Coorong	3	1	1	1
Maintain a minimum annual flow required to keep the Murray Mouth open (730—1,090 GL/year)	Coorong	3	1	1	1

3.7. Priority ecosystem functions

The Basin Plan (Schedule 9) provides the following criteria for identifying ecosystem functions:

- supports the creation and maintenance of vital habitats and populations
- supports the transportation and dilution of nutrients, organic matter and sediment
- provides connections along a watercourse (longitudinal connectivity)
- provides connections across floodplains, adjacent wetlands and billabongs (lateral connections).

Processes or functions consistent with these criteria have been identified as key ecological attributes for each of the PEAs within the SA River Murray WRP area (the Channel, the Floodplain and the CLLMM), and so ecological objectives relating to ecosystem functions have been included for each asset.

The identification of PEFs for the SA River Murray WRP area as a whole was undertaken through a DEWNR project described in Bonafacio (2015) and the following information has been extracted from this report. PEFs are considered to be those that occur within two or more of the PEAs and rely on connectivity between the PEAs. By aligning the ecological objectives of the PEAs with ecosystem functions identified in the scientific literature, 10 PEFs have been identified. An associated ecological objective has been developed for each PEF (Table 11). A unique suite of ecological targets and EWRs for the PEFs has not been developed as it is assumed that the targets and EWRs of the priority environmental assets capture those of the PEFs. This is justified on the basis that the approach aligned the existing objectives of the PEAs and these already have associated EWRs and targets.

Connectivity throughout the WRP area is implicit to the achievement of the asset EWRs, with the primary mechanism for delivery being the provision of environmental water to the SA border, which then flows onto the CLLMM. This reflects a continuing shift towards more integrated management of the SA River Murray WRP area as a whole. For example, in recent years proposed multi-site watering actions for the SA River Murray WRP area have been developed (Department of Environment, Water and Natural Resources, 2014b) that seek to align the desired water delivery pattern for the CLLMM with that of the Channel or Floodplain. This was further investigated through hydrological modeling of the alignment of the asset EWRs (see section 3.7.1 below).

Table 11. Priority ecosystem functions and associated ecological objectives for the SA River Murray WRP area

Priority ecosystem functions	Ecological objectives
Flow variability	Improve flow variability throughout the SA River Murray
Lateral hydrological connectivity	Improve the lateral hydrological connectivity between the Channel and Floodplain
Longitudinal hydrological connectivity	Improve the longitudinal hydrological connectivity between the Channel and CLLMM
Mobilisation and transport of salt	Increase the mobilisation, transport and export of salt through the SA River Murray
Mobilisation and transport of carbon and nutrients	Increase the mobilisation, transport and export of nutrients and carbon through the SA River Murray
Primary productivity	Enhance primary productivity due to increased lateral and longitudinal connectivity
Transport of plant propagules	Facilitate the transport of plant propagules throughout the SA River Murray due to increased lateral and longitudinal connectivity
Dispersal of faunal larvae and juveniles	Facilitate the dispersal of faunal larvae throughout the SA River Murray due to increased lateral and longitudinal connectivity
Faunal recruitment	Enhance the recruitment into faunal populations due to increased lateral and longitudinal connectivity
Secondary productivity	Increase secondary productivity due to increased lateral and longitudinal connectivity

3.7.1. Alignment of environmental water requirements

In order to improve the understanding of the hydrological connectivity between the three assets, to promote integrated management across the SA River Murray WRP area and to inform the development of future regional multi-site watering actions, a modeling exercise was undertaken that assessed the alignment of the EWRs of the Channel and Floodplain with the EWRs for the CLLMM in terms of volume, timing and frequency. The modeling inputs were hypothetical hydrographs of flows at the border that met the discharge, duration, timing, rate of rise and rate of fall metrics of the Channel and the Floodplain EWRs and assumed that outside of the EWR delivery period, flows were equivalent to SA Entitlement. The methods, assumptions and outputs are described in Department of Environment, Water and Natural Resources (unpublished).

In general, the modelled outputs indicated that there was good alignment between the timing of the Channel/Floodplain EWRs and the preferred annual barrage release pattern. This modelled outcome is strongly influenced by key assumptions in the modelling exercise that outside the delivery period for the channel/floodplain EWRs, flows returned to low baseflows equivalent to SA Entitlement only.

In terms of volume, the modeled outputs[31] indicate the following:

- the lowest Channel EWR (EWR-IC1) does not deliver sufficient water to meet the minimum required barrage outflow volume (650 GL/year)
- the remainder of the Channel EWRs (EWR-IC2 to EWR-IC7) and all of the floodplain EWRs (EWR-FP1 to EWR-FP5) provide sufficient volume for the lowest CLLMM EWR (EWR-CLLMM1)
- the highest Channel EWR (EWR-IC7), which has a discharge metric of 40,000 ML/day QSA, and all the Floodplain EWRs (EWR-FP1 to EWR-FP5) provide sufficient volume for EWR-CLLMM2, which specifies an annual barrage outflow volume of greater than 3,150 GL/year
- the three largest Floodplain EWRs (EWR-FP3 to EWR-FP5) which have discharges of 70,000 ML/day QSA or above, provide sufficient volume for EWR-CLLMM3, which has an annual barrage outflow metric of greater than 6,000 GL/year
- the two largest Floodplain EWRs (EWR-FP4 and EWR-FP5) which have discharges of 80,000 ML/day QSA, provide sufficient volume for the largest CLLMM EWR (EWR-CLLMM4), which has an annual barrage outflow metric of greater than 10,000 GL/year.

Comparison of the average return interval metrics of the Channel and Floodplain EWRs with those of the CLLMM show that, in general, the CLLMM EWRs require in-channel pulses and small to medium overbank flows to occur more frequently than specified by the Channel and Floodplain EWRs. This difference may partly be due to slightly different approaches to describing the ARI metrics, with the CLLMM using whole years, while the Channel and Floodplain used fractions.

The CLLMM EWRs incorporate metrics for the Coorong South Lagoon (water levels, timing and duration), which were largely based on the conditions needed to support the life-cycle of *Ruppia tuberosa* and derived from Ye, et al. (2014, cited in O'Connor, et al. 2015) and expert opinion (O'Connor, et al., 2015). To strengthen the basis for the values of the South Lagoon metrics, a Coorong 1D hydrodynamic model was used to estimate the alignment of these metrics and the barrage outflow metrics.

The modeling results indicate relatively good alignment between the barrage outflows (volume and delivery pattern) and the Coorong South Lagoon water level metrics for two of the EWRs (EWR-CLLMM1 and EWR-CLLMM3), although for EWR-CLLMM3 there may be some difficulty maintaining water levels throughout January. For EWR-CLLMM2, the barrage outflows may not be sufficient to reach the desired water level range in the South Lagoon. Modeled results for EWR-CLLMM4 indicate Coorong water levels exceed the specified range in late spring/early summer then decline rapidly to below the specified range in late summer. This is a preliminary analysis only and further exploration is required into the ability to optimise Coorong South Lagoon water level conditions through altered barrage operations.

This information will assist with planning for coordinated watering actions within the SA River Murray WRP area by providing an understanding of the nature of the flow events required to achieve the CLLMM EWRs as well as meeting the

[31] *The interpretations presented are based on the median modelled annual barrage outflow volumes for each channel/floodplain EWR only; results may vary in years where losses are lower or higher than median.*

Channel and Floodplain hydrological requirements. These types of watering actions will assist in achieving the objectives for the PEFs.

4. Management considerations

4.1. Aboriginal values

The River Murray, and its floodplains and wetlands, are central to the life and culture of Aboriginal nation groups in the WRP area. Murrundi (the South Australian River Murray) meanders from the South Australia/Victoria border, through the traditional lands of the First Peoples (Ngaiawang, Ngawait, Nganguraku, Erawirung, Ngintait, Ngaralte, Ngarkat language groups), Peramangk and Ngarrindjeri peoples, before meeting the sea at the Murray Mouth (Department for Environment and Water, 2019a). The traditional lands of the Ngarrindjeri also extends along the length of the Coorong while the South East Clan Groups (Tanganekald, Meintangk and Bunganditj language groups) have traditional ties to the South East region which includes the Coorong South Lagoon (Department for Environment and Water, 2018).

The River Nations along Murrundi are represented by the River Murray Mallee Aboriginal Corporation (RMMAC), the Mannum Aboriginal Community Association Incorporated (MACAI) and the Ngarrindjeri Regional Authority (NRA)/Ngarrindjeri Aboriginal Corporation (NAC) (Department for Environment and Water, 2019a). The South East Clan Groups are engaged in water resource planning through the South East Aboriginal Focus Group (SEAFG) (Department for Environment and Water, 2018). There are close cultural, family and historical connections between Aboriginal people from across the SA MDB region (Hemming, et al., 2000).

The strong association between Aboriginal people and the environment is reflected in their Creation stories, which pass on important knowledge, cultural values and beliefs and reflect the relationships between land, water, animals and people (Australian Govenment, 2015; Ngarrindjeri Nation, 2006).

Through the development of the water resource plans, Aboriginal Nations were engaged to articulate objectives and desired outcomes for the water resources in the regions based on Nations values and uses (refer Part 14 of the SA River Murray WRP and Part 14 of the SA Murray Region WRP). The values expressed below are consistent with those outlined in the water resource plans.

4.1.1. Ngarrindjeri values

Note: The information on Ngarrindjeri cultural values and aspirations expressed in this section are those directly provided by the Ngarrindjeri Regional Authority for the 2015 LTWP and subsequently supported, with minor amendments, by the Ngarrindjeri Aboriginal Corporation for inclusion in this 2020 LTWP update.

The Ngarrindjeri Aboriginal Corporation (NAC) and Ngarrindjeri Regional Authority (NRA) are both regional Indigenous bodies representing the Ngarrindjeri Nation. The Ngarrindjeri are the Traditional Owners and Native Title Claimants of the land and waters of the River, Coorong and Lakes Alexandrina and Albert and adjacent areas, and have cultural authority and responsibility for areas extending up the River to Morgan through their member organisation the Mannum Aboriginal Community Association Incorporated (MACAI). The Ngarrindjeri have occupied, enjoyed, managed and used their inherited lands and waters of the River Murray, Lakes and Coorong since time immemorial.

4.1.1.1. Ngarrindjeri Yarluwar Ruwe (Sea Country)

The River Murray, Lower Lakes, Kurangk (Coorong) and Murray Mouth area are central to Ngarrindjeri cultural and spiritual beliefs. This association is expressed through Kaldowinyeri stories (cultural and spiritual histories) about Yarluwar-Ruwe (Sea Country) which reveals the significance of the relationship between the country and the people, both practically and spiritually. Kaldowinyeri stories and oral traditions explain how the land and water, animals and people came to be, and what and who they are. Creation ancestors such as Ngurunderi and Pondi, the Muntjingga and Thukabi teach Ngarrindjeri how to respect and understand the connection between the lands, the waters and the sky.

The Kaldowinyeri stories also record dramatic changes in the 'ecological character' of the region over millennia and explain the richness of 'natural resources' – especially the wealth of fresh and salt water marine life such as fish, shellfish, eels, waterbirds and water plants. The Ngarrindjeri have always depended on their Yarluwar-Ruwe and its resources. Old People's living places (e.g. middens, burial grounds and other sacred places) are evidence of thousands of years of Ngarrindjeri sustainable use of their lands and waters since creation.

The following provides an overview of key parts of the Ngurunderi Kaldowinyeri Story (Ngarrindjeri Nation, 2006, p8):

A long, long time ago Ngurunderi our Spiritual Ancestor chased Pondi, the giant Murray Cod, from the junction where the Darling and Murrundi (River Murray) meet. Back then, the River Murray was just a small stream and Pondi had nowhere to go. As Ngurunderi chased him in his bark canoe he went ploughing and crashing through the land and his huge body and tail created the mighty River Murray. When Ngurunderi and his brother-in-law Nepele caught Pondi at the place where the fresh and salt water meet they cut him up into many pieces, which became the fresh and salt water fish for the Ngarrindjeri people. To the last piece Ngurunderi said, "you keep being a Pondi (Murray Cod)". As Ngurunderi travelled throughout our Country, he created landforms, waterways and life. He gave to his people the stories, meanings and laws associated with our lands and waters of his creation. He gave each Lakalinyeri (clan) our identity to our Ruwe (country) and our Ngarjtis (animals, birds, fish and plants) - who are our friends. Ngurunderi taught us how to hunt and gather our foods from the lands and waters. He taught us, don't be greedy, don't take any more than what you need, and share with one another. Ngurunderi also warned us that if we don't share we will be punished.

Ngarrindjeri respect the gifts of Creation that Ngurunderi passed down to our Spiritual Ancestors, our Elders and to us. Ngarrindjeri must follow the Traditional Laws; we must respect and honour the lands, waters and all living things. Ngurunderi taught us our Miwi, which is our inner spiritual connection to our lands, waters, each other and all living things, and which is passed down through our mothers since Creation. Our Great Grandmothers, Grandmothers and mothers fought to protect our Spiritual waters from desecration when a bridge to Kumarangk (Hindmarsh Island) was to be built. Ngurunderi taught us how to sustain our lives and our culture from what were our healthy lands and waters. Our lands and waters must be managed according to our Laws to make them healthy once again. As the Ngarrindjeri Nation we must maintain our inherent sovereign rights to our Yarluwar-Ruwe. Ngarrindjeri people have a sovereign right to make our living from the lands and waters in a respectful and sustainable way.

Ngarrindjeri have strong cultural and spiritual connections to particular places, to particular species of animals and plants, and all elements of the environment are part of their kinship system. Particular animal and plant species are the Ngartji (totem or special friend) of Ngarrindjeri people, who have special responsibility to care for their Ngartji. This relationship is described in the following statement made by Ngarrindjeri Rupelli (traditional leader), George Trevorrow (deceased):

Ngartji to non- Aboriginal people is like a totem which each one of us has and each group belongs to. It could be the pelican. It could be the swan. It could be the mullet. There are different species of…animal, fish, plant, but each group belongs to that ngartji. A ngartji is something that is more than a close friend. It's more your best friend. It is something that is more closely to you (George Trevorrow in Bell, 1998, p205).

To care for Ngartji is to care for country – Ngartjis are also important indicators of the health of the lands and waters. Freshwater wetlands are referred to as 'nurseries' by Ngarrindjeri in recognition of the important role these areas play in providing food and shelter for many types of Ngartjis. Submerged plants in these nursery areas are critical for food and shelter for animals and their young. They are understood to be like the lungs of the system – cleansing the land and water.

4.1.1.2. Ngarrindjeri Ruwe/Ruwar (lands, waters, body spirit and all living things)

Ngarrindjeri use the concept of Ruwe/Ruwar to encapsulate the interconnection between country, body and spirit. Ngarrindjeri Ruwe/Ruwar frames Ngarrindjeri rights and responsibilities as traditional owners and is centred on an understanding that all things are connected. This interconnection is fundamental to wellbeing and it is for this reason that healthy lands and waters are critical to healthy Ngarrindjeri people and culture. The Ngarrindjeri 'Vision for Country' encapsulates the Ngarrindjeri philosophy of being (Ruwe/Ruwar) and is outlined below:

Our Lands, Our Waters, Our People, All Living Things are connected. We implore people to respect our Ruwe (Country) as it was created in the Kaldowinyeri (the creation). We long for sparkling, clean waters, healthy land and people and all living things. We long for the Yarluwar-Ruwe (Sea Country) of our ancestors. Our vision is all people Caring, Sharing, Knowing and Respecting the lands, the waters and all living things (Ngarrindjeri Nation, 2006, p5).

Ngarrindjeri perceive the lands and waters as a living body – the River Murray, Coorong, and Lakes Alexandrina and Albert Wetland are part of the Ngarrindjeri living body. Ngarrindjeri Creation ancestors made, and are a part of this living body. This fundamental spiritual connection (Ruwe/Ruwar) is reliant on healthy lands and waters, and the maintenance of connectivity between the River Murray, Coorong, Lower Lakes and Murray Mouth as created by Ngurunderi and other Creation Ancestors. The health of Ruwe/Ruwar relies on maintaining the foundational and ongoing spiritual connection

between Ngurunderi (the Creator and Spiritual Ancestor), Ruwe (Country, Lands and Water) and the Ngarrindjeri Nation (Birckhead, et al., 2011, p38).

> *'Ecological' based descriptions of connectivity and of Ngarrindjeri Yarluwar Ruwe as ecological attributes, assets or critical components, processes and services are based on understandings of the relationship between humans and non-humans - conceived in Western cultural terms as the divide between 'nature' and 'culture'. For Ngarrindjeri the 'environment' cannot be compartmentalised: the lands and waters are a living body and the Ngarrindjeri are part of the living body. All things are connected and interconnected and are an embodiment of Ruwe/Ruwar (land, body, spirit) which extends 'ecological' connectivity to humans and is therefore inherently cultural.*

4.1.1.3. Ngarrindjeri and water

Freshwater flows that come down the Murray-Darling system into the lands and water of the Ngarrindjeri are seen by the Ngarrindjeri as the life blood of the living body of the River Murray, Lower Lakes and Coorong. Ngarrindjeri are part of the water. It is life, gives life and is living. The cultural and spiritual relevance for Ngarrindjeri of water as a source of life and as part of the living body is that it flows within, around and through Ngarrindjeri country. The exercise of Ngarrindjeri cultural rights and the fulfilment of Ngarrindjeri responsibilities include being interconnected with and being part of the living water: the flow of water forms part of the interconnectedness of Ngarrindjeri to their country. The NRA (Ngarrindjeri Regional Authority, 2012, p3) have taken the following position regarding *a priori* rights to water in its submission to the MDBA:

> *Ngarrindjeri consider that they have the first right, a right attached to the exercise of our cultural rights, interests and responsibilities, that precede all other rights including but not limited to the legislative function of the MDBA to allocate water for particular uses. The rights and interests of the Ngarrindjeri require that water flows into, through and from our country from up river.*

Ngarrindjeri Ruwe/Ruwar requires connectivity, flow, and mixing to occur between all living things and the lands and waters, and the spirit world. Flows come together and mix and produce life – fish breed in the lakes and Coorong; birds breed in the places where life is being produced; these things are recognised in Ngarrindjeri philosophy. The failure of water to flow into Ngarrindjeri country impacts upon Ngarrindjeri to exercise rights and the fulfilment of responsibilities as custodians of the land, water and sky.

4.1.1.4. The Meeting of the Waters – Murray Mouth

The 'Meeting of the Waters', which includes the Murray Mouth, is significant as a registered Aboriginal 'site' under the Aboriginal Heritage Act 1988 (SA). It includes the waters and the bed of the lakes, river and estuary. Its spiritual and cultural significance is essential to the wellbeing of lands and waters and all living things, including Ngarrindjeri. The cultural health of this area requires adequate fresh water flows from up river to flush out the Murray Mouth and ensure that the Ngarrindjeri are able to continue to exercise their cultural rights in this area, including the flushing of the Murray Mouth. The following statements by Ngarrindjeri Rupelli (traditional leader), George Trevorrow (deceased) illustrates the importance of the area:

> *That's what we're talking about when we call it the meeting of the waters. Those waters, once they start mixing, that is the spiritual waters of this area, and of the Ngarrindjeri. This is where the major connections happen. This is the breeding place for all the ngatji, and everything that goes with the mixing of the water underneath the water, so it's very, very important to us spiritually, because those things, as I said, they are closer than a friend to you. They are nearly almost part of you. They speak to you, you speak to them, and this is the place where they all come to (Trevorrow in Bell, 2014, p563).*

> *Ngarrindjeri have long-term knowledge of the impacts of changing flows in the 'Meeting of the Waters' site. This includes Creation stories that incorporate the importance of the mixing of the salt and fresh waters, and the importance of fresh water to the maintenance of the health of the land and the waters. The 'Meeting of the Waters' site has been recognised as significant to natural resource management and water planning in South Australia and the Murray-Darling Basin (Hemming, 2009; Murray-Darling Basin Authority, 2013b).*

4.1.1.5. Ngarrindjeri 'Speaking as Country' - Yannarumi

Ngarrindjeri people have a deep obligation and responsibility towards their traditional country based on the Creation. Ngarrindjeri speaking lawfully as country (Yannarumi), i.e. exercising their right and responsibilities to speak for, care for and manage Ngarrindjeri Yarluwar-Ruwe, is therefore critical to the health of lands and waters. Ngarrindjeri Yannarumi can be understood as a form of Ngarrindjeri cultural health practice and assessment process, a life giving assessment of lands and waters.

Ngarrindjeri require an improvement to the health of their lands and waters to support Ngarrindjeri wellbeing. The lands and the waters within the CLLMM region have been degraded and further losses of species, water quality, flows and breeding events will have an increased detrimental effect on Ngarrindjeri wellbeing. The NRA takes responsibility for assessing whether something is healthy, lawful and creates wellbeing – based on the concept of Ngarrindjeri Ruwe/Ruwar.

4.1.1.6. Native Title Determination

The Ngarrindjeri and Others Native Title Claim (SAD 6027/98) was lodged in 1998 and encompassed the entire Coorong Lagoon and National Park. In mid-2017 the First Nations of the South East lodged two claims (Part A and Part B) with the Part B claim overlapping the southern extent of the Ngarrindjeri and Others Native Title Claim (from approximately Salt Creek south).

In late 2017 the northern section of the Ngarrindjeri and Others Native Title claim (Part A) was determined and recognised Ngarrindjeri Native Title rights, including rights to the waters (including 'Meeting of the Waters') on and flowing through their Country from the Lower Murray, Lakes, Coorong and surrounding lands. The Part A claim runs south encompassing the Coorong Lagoon to Salt Creek, then taking in the Coorong dunes and western half of the lagoon for approximately 18 km further south.

At the time of writing, The Ngarrindjeri and First Nations of the South East are in mediation regarding the overlapping (Part B) Native Title claim area. Negotiations related to Ngarrindjeri co-management arrangements for Coorong National Park are currently on hold pending the Native Title outcome.

4.1.2. Ngarrindjeri involvement in environmental water planning

Ngarrindjeri have developed an engagement framework that provides well-developed structures and practices to support equitable and effective Ngarrindjeri engagement in water resource research, policy development and management processes within the South Australian Murray-Darling Basin (SA MDB) region (Hemming, et al., 2014). Foundational to this new form of engagement is the development of the contract law, Kungun Ngarrindjeri Yunnan Agreement (KNYA), which translates to 'listening to Ngarrindjeri people talking'.

In 2009 a whole-of-government KNYA was entered into between the Ngarrindjeri and the South Australian Government which established a consultation and negotiation framework between parties in relation to natural resource management (NRM) and cultural heritage management (CHM) (see Hemming, et al., 2011). The KNYA established and funded a joint taskforce that created a formal context for the NRA to negotiate regarding South Australian Government programs on Ngarrindjeri Ruwe/Ruwar. The KNYA includes recognition of Ngarrindjeri traditional ownership; and recognition of the NRA (established in 2007) as the Ngarrindjeri peak body. The KNYA was originally guided by the KNYA taskforce strategic implementation plan, co-written by the former DEWNR (now DEW) which outlines a number of objectives for KNYA taskforce to provide guidance on how it can support and implement positive outcomes (Department of Environment Water and Natural Resources, and Ngarrindjeri Regional Authority, 2012a; Department of Environment Water and Natural Resources, and Ngarrindjeri Regional Authority, 2012b).

Underpinning the KNYA strategy is the foundational Ngarrindjeri management planning document - the Ngarrindjeri Nation Yarluwar-Ruwe Plan: Caring for Ngarrindjeri Sea Country and People (Ngarrindjeri Nation, 2006). The plan articulates a broad vision and a set of strategic directions for caring for Ngarrindjeri country. The Ngarrindjeri Yarluwar-Ruwe (NYR) Program (established in 2007) has been further developing and implementing the visions of the plan (Hemming, et al., 2007). The NYR Program works with state and local Government, Landscape SA boards (formerly NRM boards) and local communities for natural resource management that recognises Ngarrindjeri values and incorporates Ngarrindjeri expertise and capacity. This governance model combined with the KNYA strategy have been central to Ngarrindjeri engagement in many South Australian and Australian Government projects (e.g. Murray Futures Program) and the development of the Ngarrindjeri Partnerships Project (NPP) with the SA Government. These programs focused on strengthening Ngarrindjeri

capacity, enhancing skills and gaining experience in regional NRM and CHM, including water-related research, policy development, planning and management.

Ngarrindjeri engagement in State Government water policy and planning was strengthened through the signing of a SA MDB water planning statement of commitment (SOC) between NRA, former DEWNR, and former SA MDB and South-East NRM Boards. The SOC is one of many frameworks that recognises and supports equitable Ngarrindjeri engagement in water management while acknowledging how the parties will work together, particularly to meet the Indigenous Values and Uses requirements of Chapter 10 Part 14 of the Basin Plan. Ngarrindjeri engagement in water planning is highlighted in the annual environmental water planning process which documents how water for the environment is to be used for the LLCMM, Channel and Floodplain Assets (through The Living Murray Program). This engagement further extends to regional wetland planning and monitoring (through Landscape SA Boards) and water quality planning and engagement in the review of the Coorong, Lakes Alexandrina and Albert Ramsar wetland Ecological Character Description (see Collings, 2012; Department of Environment, Water and Natural Resources, 2013a; Hemming, et al., 2014; Murray-Darling Basin Authority, 2013b).

A second important and formal agreement was developed in 2014 between Ngarrindjeri and the State of South Australia – the 'Speaking as Country Deed'. The deed affirms the importance of freshwater flows down the River Murray and an open Murray Mouth, and for the parties to work together to ensure end of system flow objectives support the maintenance of the cultural health of the registered 'Meeting of the Waters' heritage site. The deed acknowledges that Ngarrindjeri speak for, control and care for their country and embodies the concept of Ngarrindjeri Yannarumi.

4.1.3. First Peoples of the River Murray and Mallee Region values

The First Peoples of the River Murray and Mallee Region (FPRMM) are the traditional owners of the section of River Murray between the border and Morgan and have interests that extend further down the River. They have maintained a long association with the River Murray and see it as a living body (Murray-Darling Basin Authority, 2012). The river environment provided resources such as water, fish, yabbies and plant material, including the use of bark from River red gums as canoes, while the surrounding floodplain was a place to harvest animals such as possums and kangaroos for food, providing the basis for a rich cultural economy (Murray-Darling Basin Authority, 2012).

The FPRMM are the native title holders of about 260 km^2 of land and waters in the Riverland, South Australia, including areas of the River Murray around Renmark, Berri, Barmera, Waikerie and Morgan (Native Title Research Unit AIATSIS). The South Australian Government and the FPRMM have entered into The River Murray and Crown Lands Indigenous Land Use Agreements (ILUA), which commenced on the same day the Native Title determination was made in favour of the FPRMM. This native title consent determination recognises their non-exclusive rights to access, hunt, fish, camp, gather and use the natural resources, undertake cultural activities, conduct ceremonies and meetings, and protect places of cultural and religious significance (Native Title Research Unit AIATSIS).

The River Murray and Mallee Aboriginal Corporation (RMMAC) is the Registered Native Title Prescribed Body Corporate for the native title consent determination and administers land on behalf of the FPRMM (Native Title Research Unit AIATSIS). RMMAC have prepared a strategic plan, which sets out objectives and strategies for working with government agencies and other stakeholders to achieve those objectives (River Murray and Mallee Aboriginal Corporation, 2013). This strategic plan provides the following vision '*The People, River and Mallee are at the centre of everything we do. Our driving force is the spirit of our Ancestors. Our vision is to ensure our people achieve economic independence through education and employment while preserving our environment, heritage and cultural and spiritual wellbeing for now and into the future*' (River Murray and Mallee Aboriginal Corporation, 2013). A number of values, aims and priorities are identified within the strategic plan, with a key value being ecological sustainability and a key aim to '*Protect and repair our country, waters, flora, fauna and air*' (River Murray and Mallee Aboriginal Corporation, 2013).

4.1.4. First Peoples of the River Murray and Mallee Region involvement in environmental water planning

The FPRMM have been involved in the planning and management of Chowilla Floodplain for many years (including prior to the construction of the environmental regulator), primarily through the Chowilla TLM Icon Site Program. Further collaboration between the FPRMM, the Wetlands and Floodplains team and the NRM Communities team of Riverland and Murraylands Landscape Board (formerly Natural Resources SA MDB), and the Aboriginal Partnerships team, has seen the inclusion of FPRMMs perspectives into the management of other wetland and floodplain areas. This engagement has been formalised into the Landscape SA – First Peoples Working Group, which meets bimonthly to coordinate First Peoples

engagement in DEW projects. The First Peoples Coordinator has been employed by DEW to coordinate the Working Group and support the engagement of the FPRMM in a range of natural resources management projects, including input into wetland and floodplain management plans (Natural Resources SA Murray-Darling Basin, 2015a). Members of the Landscape SA – First Peoples Working Group have indicated support for the environmental water and wetland management programs, and their objectives, for their role in protecting and maintaining Aboriginal cultural and heritage values (Natural Resources SA Murray-Darling Basin, 2015b).

4.1.5. Integrating Aboriginal values

The Government of South Australia recognises the importance of Aboriginal culture and values, and is committed to seeking and incorporating these in the development of environmental water plans where possible.

There is a strong alignment between ecological objectives and targets identified in this LTWP and Aboriginal values. For Ngarrindjeri, a range of objectives and targets outlined in this plan for restoring the freshwater flows required to sustain healthy functioning 'ecosystems' are also crucial in maintaining interconnectivity of Ruwe/Ruwar which is central to Ngarrindjeri cultural life in the River, Coorong, Lower lakes and Murray Mouth. Further consideration of Aboriginal values will continue to occur at smaller spatial and temporal scales e.g. during annual environmental water planning for the region.

The consideration of the values, aspirations and views of Aboriginal Nation Groups in decision-making through their participation in the development of water resource and environmental water plans is prescribed under the Basin Plan (2012). The Environmental Watering Plan of the Basin Plan requires that environmental watering is undertaken in a way that maximises its benefits and effectiveness by having regard to Indigenous values (section 8.35), with these values being integrated through engagement with relevant Indigenous organisations when identifying the objectives of Indigenous people during water resource planning (section 10.52). Ngarrindjeri consider the engagement process with the SA Government provides well-developed structures and practices to support equitable and effective Ngarrindjeri engagement and participation in the implementation of the Murray-Darling Basin Plan and is the preferred approach to engagement with Ngarrindjeri. In particular implementing the SOC will support Basin Plan compliance in Aboriginal engagement, as well as progress a number of Ngarrindjeri water related interests.

4.2. Co-operative arrangements

4.2.1. Co-operative arrangements within the SA River Murray water resource plan area

Environmental water management within the SA River Murray WRP area continues to evolve and, as such, the information provided in this section is correct at the time of publication but may be subject to further change. There is a growing number of environmental managers responsible for managing environmental sites, including multiple areas within the LTWP PEAs, and a variety of mechanisms for delivering environmental water. Asset and site (intra-asset) managers, as well as the areas that they are responsible for managing are described in Section 2.4.8.

Co-operative arrangements are important to ensure all environmental asset and site managers, environmental water holders and environmental water managers are working towards the common goal of a healthy, functioning and resilient SA River Murray ecosystem. These arrangements ensure that decisions are transparent, priorities and trade-offs are understood, and outcomes at the site-scale contribute to desired outcomes at the LTWP asset and WRP area scale. With a finite volume of environmental water available, it is not always possible to deliver all desired actions; however the benefits of environmental water management can be maximised if a single allocation of environmental water is used efficiently and effectively to achieve multiple outcomes at multiple sites.

For the purposes of the SA River Murray LTWP, co-operative arrangements refer to the policies, processes and forums that should be observed by all relevant parties (DEW staff and external to DEW) involved in managing environmental water and sites within the WRP area. These are further described in section 5.6.1 and 5.6.1.1 of the SA River Murray WRP (Department for Environment and Water, 2019a).

Co-operative arrangements within South Australia may be formal or informal, and participation of stakeholders may be both direct and in-direct. For example, community groups undertaking environmental site management may be indirectly involved in forums through staff from the Murraylands and Riverland Landscape Board representing their interests or directly through participation in workshops (refer Figure 7 in the SA River Murray WRP). Interactions between Government and Ngarrindjeri may take place through the KNYA taskforce, leader to leader meetings or with the NAC. FPRMM interactions with Government are occurring through the River Murray and Crown Lands ILUA Liaison Committee and First

Peoples NRM Working Group, which was established by the River Murray and Mallee Aboriginal Corporation (RMMAC) and DEW to facilitate greater involvement of First Peoples in the department's projects.

There are additional site-specific planning and management mechanisms (e.g. site-specific advisory groups). These are still relevant and are not replaced by the arrangements described within this document. However, their decisions and activities with respect to environmental water management should be consistent with state policies and plans, and fed through to the policy and operational areas of DEW to ensure there is strategic oversight of environmental water management across the WRP area.

Generally, planned environmental water (PEW) is not actively managed and therefore these co-operative arrangements are not directly relevant, unless South Australia is receiving less than Entitlement or water allocations are less than 100%. Under these circumstances, river managers and managers of sites that rely on PEW, will need to participate in any additional co-operative arrangements that apply to the WRP area and across the Southern Connected Basin under dry conditions, e.g. Dry Allocation Framework in the Water Allocation Plan for the River Murray Prescribed Watercourse or arrangements agreed through Southern Connected Basin Environmental Watering Committee (SCBEWC).

There are five key phases in the management of environmental water, each of which can be undertaken at multiple spatial scales (WRP area, LTWP asset or intra-asset 'site'):

1. Planning and prioritisation
2. Collaboration and allocation
3. Delivery
4. Monitoring
5. Evaluation and reporting

Table 12 below indicates the existing co-operative arrangements for each phase of environmental water management. The co-operative arrangements listed are those that apply to the management of environmental water within the SA River Murray WRP area only and apply across all assets and sites. The table does not include the arrangements that operate at a smaller scale i.e. planning, management and monitoring mechanisms that are relevant to a single asset or site (e.g. the Barrage Operations Advisory Group or TLM Icon Site monitoring); nor those that operate at a broader scale (e.g. activities overseen by the SCBEWC). The 'co-operative mechanism' column provides the title of the arrangement currently in place; further detail is generally documented through internal DEW policies, procedures and Terms of Reference and is available from the administrator. The 'administrator' column indicates the party responsible for overseeing the policy, procedure or forum; it does not list all groups or individuals that should participate in implementation as all parties involved in environmental water management within the SA River Murray WRP area are expected to participate.

Environmental site and water managers must also have regard to the flow management targets for a number of key water quality factors (including dissolved oxygen, cyanobacteria or biovolume and salinity) as outlined in Chapter 9 of the Basin Plan. In particular, the asset and water managers should consider potential water quality impacts during annual and real-time planning (including potential cumulative impacts from multi-site actions), manage any risks that may emerge once water is being delivered in real time, and report annually on how they have had regard for flow management targets as part of their obligations under Schedule 12, Matter 14.

The co-operative arrangements currently in place are expected to be expanded over time to improve coordination, minimise risk and optimise the outcomes of environmental watering in the SA River Murray WRP area. Current arrangements will be described in detail in the *Water for the Environment Management Framework, South Australian River Murray* (Department for Environment and Water, in prep).

Table 12. Co-operative arrangements for environmental water management within the SA River Murray WRP area

Environmental water management phase	Co-operative mechanism	Description	Administrator
Planning and prioritisation			
State annual planning for the WRP area	Standard Operating Procedure: Develop Annual Watering Plan	Describes process for developing an annual environmental watering plan for the WRP area for the upcoming water year	DEW E-Water[32]
	Watering Proposal Template	To be completed by each asset/site manager (including a risk assessment) - key input to annual plan and prioritisation. The template used for the SA River Murray WRP area is generally based on the template developed by SCBEWC, with minor changes to improve relevance to the region.	DEW E-Water; MRL Wetlands[33]
State annual priorities for the WRP area	Annual Prioritisation	Method currently being further refined. Process/outcome documented in the Annual Environmental Watering Priorities, which are submitted to the MDBA by 31 May each year, and the Annual Environmental Watering Plan for the South Australian River Murray, which is published on the DEW website each year.	DEW E-Water
Multi-site planning for the WRP area	Watering Proposal Template	Undertaken as a component of annual planning to develop a potential delivery pattern for outcomes at multiple assets/sites	DEW E-Water
Collaboration and allocation			
Collaborate on water allocation	Through the Annual Environmental Watering Plan for the WRP area	Collaboration is via SCBEWC for TLM water or undertaken directly between asset/site managers, river operators and the CEWO	n/a
Notify allocation approval	Schedule (CEWO) Instructions (TLM)	TLM inform the relevant asset/site managers via email. CEWO develop a watering schedule, which specifies the agreed watering action and accounting methodologies	DEW E-Water; DEW Water Delivery[34]
Trade environmental water	Standard Operating Procedure: Trade Environmental Water	Environmental water held interstate is generally traded onto a South Australian licence held by the Minister for Environment and Water. Some external site	DEW Finance[35]

[32] *DEW E-water refers to the Environmental Water Team within the Water Infrastructure and Operations Branch of DEW*
[33] *MRL Wetlands refers to the Wetland and Floodplain Team in the Murraylands and Riverland Landscape Board*
[34] *DEW Water Delivery refers to the Water Delivery Team within the Water Infrastructure and Operations Branch of DEW*
[35] *DEW Finance refers to the Finance Branch of DEW, who complete the trades of environmental water under Chinese wall arrangements as per Basin Plan section 12.52*

Environmental water management phase	Co-operative mechanism	Description	Administrator
		managers have their own licence for environmental watering so will not trade onto the Minister's licence	
Report trade activity	Process yet to be formalised	Advice is provided by DEW Licensing upon receipt of trades to DEW Finance who then advise DEW E-Water who keep a record of all environmental water trades and their purpose	DEW E-Water
Delivery			
Real-time planning	E-flows Reference Group	DEW asset/site managers participate in regular meetings when planning the delivery of environmental water (including unregulated flows) to the WRP area. Each asset/site manager will have their own arrangements in place for operational planning at a site scale but this information should be fed through to the E-flows Reference Group and River Murray Operations Working Group (RMOWG).	DEW E-Water
Assessment of potential water quality impacts	Guidelines for Having Regard to Targets for Managing Water Flows	Potential cumulative impacts in the context of current conditions are assessed through the RMOWG as per the Guidelines	DEW Water Delivery
Advise on extraction/use from River	River Murray Action Request Form	To be completed by asset/site managers and submitted to DEW Water Delivery, where an assessment will be undertaken and referred to the RMOWG as necessary	DEW Water Delivery
Deliver water to SA border	Water order to MDBA and liaison with SA Water	Requires knowledge of all environmental water allocations and trades, and ensures water is available for environmental watering actions at the appropriate time	DEW Water Delivery
Deliver water to asset/site	Standard Operating Procedure: Deliver Environmental Water	The mechanism for delivering water varies widely and each asset/site manager will have their own arrangements in place for water delivery. Water delivery must be undertaken consistent with the approved action.	Asset/site manager
Report watering activity	Standard Operating Procedure: Record Environmental Use Spreadsheet template for environmental water accounting	Asset/site managers should provide regular written updates to DEW E-Water and DEW Water Delivery to ensure there is oversight of all watering activities underway	Asset/site manager

Environmental water management phase	Co-operative mechanism	Description	Administrator
Monitoring and evaluation			
Measure site-specific water use	The mechanism for measuring the volume of water used will depend on the type of watering action as follows: • Pumping/drip irrigation - metered[36] • Gravity fed wetland basins - modelled • Large scale actions - modelled using DEW-approved models, and measurements to calculate discharge over structures and area inundated	Asset/site managers are responsible for ensuring that water use complies with the allocated/approved volume.	Asset/site manager
Report water use	Standard Operating Procedure: Record Environmental Water Use	Describes process for site managers to report volumes of water use to DEW E-Water. This data is needed to enable the State to meet legislated reporting requirements under the Basin Plan (Matter 9 - Identification of environmental water and the monitoring of its use)	DEW E-Water
	Spreadsheet template for environmental water accounting	Standard template to be used by asset and site managers to report volumes as per procedure	DEW E-Water; DEW Water Delivery
	Standard Operating Procedure: Produce Annual Report on Environmental Watering	Each year a report is published summarising environmental water use and key ecological outcomes	DEW E-Water
Reconcile environmental water licenses (water volumes and cost)	Standard Operating Procedure: Reconcile Environmental Water Accounts	For licenses held by the Minister, reconciliation is completed by DEW E-Water. If an externally-held licence is used for environmental watering then the environmental water manager is responsible for providing a reconciliation to DEW Licensing.	DEW E-Water; external site managers; DEW Licensing[37]
Monitor ecological outcomes	Site-specific outcomes recorded through various existing programs (e.g. TLM icon site monitoring, wetland monitoring through MRL Wetlands and monitoring associated with weir manipulations, and Pike and Katarapko floodplain management) and used for continued adaptive management of		

[36] *Refer South Australian Licensed Water Use Metering Policy*
[37] *DEW Licensing refers to the Water Licensing Branch of DEW*

Environmental water management phase	Co-operative mechanism	Description	Administrator
Evaluate and report ecological outcomes		these sites. Intervention monitoring of the SA River Murray Channel asset is undertaken by CEWO. Collation and evaluation of information from these programs will enable the State to meet legislated reporting requirements under the Basin Plan (Matter 8 - the achievement of outcomes at an asset scale).	

4.2.2. Co-operative arrangements with upstream water resource plan areas

The SA River Murray WRP area is strongly influenced by environmental watering activities that take place in upstream water resource plan areas, particularly the Victorian Murray WRP area, the Northern Victoria WRP area, the New South Wales Murray and Lower Darling WRP area, and the Murrumbidgee WRP area (refer sections 5.2.4; 5.2.4.1; 5.6.2: 5.6.2.1 of the SA River Murray WRP). Collectively these four interstate water resource plan areas, together with the SA River Murray WRP area, represent the Southern Connected Basin of the Murray-Darling Basin. There are mechanisms in place to maintain and improve co-operative arrangements for the planning and delivery of environmental water in the Southern Connected Basin.

There are a number of cross-jurisdictional committees to facilitate the management of environmental water and in which South Australian representatives participate including:

- Southern Connected Basin Environmental Watering Committee (SCBEWC), which coordinates the planning and delivery of environmental water to maximise ecological outcomes each year through co-operative watering regimes. SCBEWC also considers management of potential water quality risks associated with multi-site watering such as black water events and cumulative salinity impacts. Membership includes holders of environmental water as well as managers of held and planned water, managers of environmental assets, planners and operators responsible for environmental water delivery
- the Environmental Water Committee (EWC) provides formal advice, strategic guidance and problem resolution for matters relating to joint government and Basin Plan business to enable improved integration of environmental water delivery and river operations to achieve outcomes under the relevant intergovernmental agreements and the Basin Plan
- the Water Liaison Working Group (WLWG), which assesses the deliverability of environmental water, implications for the Barmah Choke and overall River Murray system operations and coordination
- the Environmental Water Improvement Group (EWIG), which supports the development of processes and procedures relating to the delivery and accounting of environmental water and implementation of Prerequisite Policy Measures (PPMs).

In addition to these cross-jurisdictional arrangements, representatives from South Australia participate in regular bi-lateral teleconferences with the CEWO.

4.2.3. Co-operative arrangements between water resource plan areas within SA

There are two other water resource plan areas in South Australia – the Eastern Mount Lofty Ranges (EMLR) WRP area and the SA Murray Region WRP area. There are some co-operative environmental watering arrangements with both of these areas.

4.2.3.1. Eastern Mount Lofty Ranges water resource plan area

There is no active management of water for the environment within EMLR WRP area and as such, long-term cooperative arrangements have been established through policies within the relevant water planning documents (i.e. WAPs). The EMLR WRP area has two prescribed water resource areas within its boundary: EMLR and Marne Saunders.

Flows from the EMLR tributaries (average 78 GL per year) are received into the River Murray (Department for Environment and Water, 2019a). The Water Allocation Plan (WAP) development process for the EMLR assessed whether taking or using water from the prescribed resource of the EMLR has an impact on adjacent water resource areas. It was concluded that the EMLR contributes small volumes to the lower River Murray and Lake Alexandrina and ultimately to Lake Albert, the Murray Mouth and the Coorong. The consumptive use limits for the EMLR (Section 3.4 of the EMLR WAP) have been set to provide water to the local environment, including the terminal wetlands where the EMLR streams meet the River Murray and Lake Alexandrina (Natural Resources SA Murray-Darling Basin, 2013). Protecting low flows has been identified as a key tool for providing part of the EWRs in the Eastern Mount Lofty Ranges (Natural Resources SA Murray-Darling Basin, 2019) and is being addressed through the Flows for the Future Program. The monitoring and reporting arrangements for WAP policies are described in Section 8 of the EMLR WAP.

The EMLR WAP notes that conditions in the River Murray and Lake Alexandrina can also directly affect the environmental condition of the lower reaches of the EMLR streams as occurred during the millennium drought. To minimise this impact the Water Allocation Plan for the River Murray Prescribed Watercourse (River Murray WAP) incorporates principles that prevent increased extractions from the tributaries of Lake Alexandrina (Natural Resources SA Murray-Darling Basin, 2020).

There are two additional mechanisms that will assist with minimising the impacts of low water levels in Lake Alexandrina on the lower reaches of the EMLR streams. The first mechanism is the inclusion of a particular objective in the Basin Plan (section 8.06) to maintain water levels in the Lower Lakes above 0.4 m AHD for 95% of the time and above 0.0 m AHD all of the time. The second mechanism is a documented decision-making process for the management of the Lower Lakes during extreme drought (Murray-Darling Basin Authority, 2014c).

The Marne River and Saunders Creek begin in the high rainfall hills zone, flowing east down the hills, through gorges and then out onto the low rainfall plains zone to eventually meet the River Murray. Flow from the Upper Marne River to its mouth at the River Murray is now uncommon, with most outflows from the hills zone recharging the groundwater on the plains zone instead in most years. Flow from the Upper Saunders to its mouth is even more uncommon given the smaller discharge volumes from this area, to the point it is unknown when this last occurred (Department for Environment and Water, 2019a). The WAP for the Marne Saunders PWRA includes policies to protect the spring flow for the Marne Mouth Wetland, which is located at the junction of the Marne River with the River Murray.

4.2.3.2. SA Murray Region water resource plan area

Potential inflows from the south-east into the CLLMM PEA are low (median 42 GL per year) when compared to the flows from the River Murray (average 5,685 GL per year) (Department for Environment and Water, 2019a). The South Lagoon of the Coorong has been historically impacted by the redirection of water (both floodwater and saline groundwater) into the South East drainage system and out to sea rather than into the Coorong (Department for Environment and Water, 2019a). The DEW South East Flows Restoration Project was established to manage water release from Morella Basin via Salt Creek, improve outcomes for en-route South East wetlands and increase flows to the Coorong when required for salinity management. The pattern of releases at Morella Basin and Salt Creek can be altered in consideration of potential outcomes and impacts within the South Lagoon of the Coorong, including salinity, nutrients and biotic responses (particularly *Ruppia tuberosa*).

Decisions on the release volume, flow rate and timing of releases are made each year by the South Eastern Water Conservation and Drainage Board (SEWCDB) following the objectives, procedures and governance structures outlined in the *South East Flows Restoration Project Operations Manual* (Department for Environment and Water, 2019) and advice from DEW and SEWCDB staff. The Board will receive a recommendation on proposed operations via the Director, Water Infrastructure Operations, DEW, who is accountable for decisions regarding Morella and Salt Creek releases to the Coorong. The SEWCDB consists of an eight member statutory body established under the *South Eastern Water Conservation and Drainage Act 1992*. The SEWCDB staff use a digital elevation model and seasonal weather conditions to provide advice to the Director, Water Infrastructure and Operations and the Board. DEW staff seek advice from the Lower Lakes, Coorong and Murray Mouth Scientific Advisory Group and Community Advisory Panel on the potential risks and benefits to the Coorong of the proposed release patterns, and provide advice to the Barrage Operations Advisory Group on Morella and Salt Creek operations. The development of a policy and procedure to guide decisions on the release of water from the South East into the Coorong is underway.

4.3. Operational constraints

Constraints have a significant impact on the feasibility of delivering environmental water to and within the SA River Murray WRP area. It is important for environmental asset and site managers in this area to have a good understanding of these constraints so that they can be factored into their annual and real-time planning for environmental water delivery. There are several types of constraints that may affect the volume of environmental water that can be delivered.

4.3.1. Definitions

The Basin Plan defines a ***physical constraint*** as a natural formation or a physical structure (for example, a pipe or channel) that limits the volume of water that can pass a given location. It does not provide a definition for ***operational constraint.***

The *Preliminary Overview of Constraints to Environmental Water Delivery in the Murray–Darling Basin* (Murray-Darling Basin Authority, 2013c) provides a broad definition for flow constraints and further defines three types of constraints, as follows:

- ***Flow constraints*** limit how water can be actively delivered through the river system to deliver EWRs, and include:
    - ***physical constraints***, such as the rate at which water can be released from a storage (release capacities) or the level to which water can rise before passing over the river bank onto adjacent land (channel capacities)

    - ***operational constraints***, relating to the effective management of water resources through a range of operating protocols (for instance, the requirement to maximise reliability of supply for consumptive use, or to protect infrastructure and private property from inundation)
- ***management or policy constraints***, such as the lack of protection for environmental flows as they travel downstream.

The Basin Plan (section 8.19 (6)) requires that a long-term watering plan identify ***operational constraints,*** but it is difficult to clearly distinguish one type of constraint from another. For example, due to the risk of exceeding a flow threshold at which point water inundates private land (a physical constraint), river operating rules may set maximum flow rates for a given location in-line with the physical constraint (an operational constraint). A policy may then be established to ensure environmental water delivery causes no or minimal third party impacts (a policy constraint).

Rather than differentiating between the specific categories of constraints, this plan will refer to the key ***flow constraints*** that influence the ability to manage and deliver environmental water to and within the SA River Murray WRP area, where the flow constraint may be a physical, operational or policy constraint.

4.3.2. Constraints Management Strategy

The MDBA and Basin States are undertaking considerable work on constraints which will provide Basin-wide benefits through the Sustainable Diversion Limit (SDL) Adjustment Mechanism and implementation of the Constraints Management Strategy: 2013-2024 (CMS), which was published by the MDBA in November 2013 (Murray-Darling Basin Authority, 2013a). A summary of this work is provided below.

4.3.2.1. Constraints Management Strategy key focus areas

The CMS identifies seven key focus areas where physical constraints are to be further investigated:

1. Gwydir (Northern Basin)
2. Hume Dam to Yarrawonga Weir
3. Yarrawonga Weir to Wakool Junction
4. Murrumbidgee River
5. Goulburn River
6. Lower Darling
7. River Murray in South Australia

Six of these key focus areas are located upstream of South Australia and, of these, five represent key physical constraints that restrict the capacity to manage the delivery of environmental water to South Australia under high flow conditions. In each key focus area, work has been undertaken regarding relaxation of constraints which has involved investigation and modelling of the extent that flow rates can be periodically increased or supplemented to deliver environmental water through the Basin, while simultaneously addressing and minimising impacts to third parties.

Basin States have agreed to a final package of constraints measures for the key focus areas by June 2016 as part of the Basin Plan SDL Adjustment Mechanism. The agreed package of works is to be implemented by 2024 in line with the Basin Plan timeframes.

4.3.2.2. River Murray in South Australia key focus area

Constraint measures to be investigated in the SA River Murray key focus area relate to the ability to manage flows up to 80,000 ML/day QSA. Overbank flows and floodplain inundation are natural occurrences that were experienced at a much greater frequency in the past. They are essential for supporting floodplain and in-channel health, and providing water to the Lower Lakes, Murray Mouth and Coorong. It is anticipated that, at times, augmented water delivery such as the addition of environmental water or operational changes may contribute to delivering high flow events. As part of investigating the practical delivery of augmented high flows, the CMS work includes consideration of potential impacts to, and future planning for, private property owners (e.g. shacks), councils and infrastructure operators (e.g. operators of boat ramps or roads along the floodplain).

The upper threshold of 80,000 ML/day QSA is based on MDBA modelling that indicates this is the maximum flow at which active management of environmental water can be undertaken either through releases of held environmental water from storages or changes in dam storage operations. However, realising this flow threshold is dependent on the implementation

of constraint measures in the upstream key focus areas (see above) to allow deliveries of the required volume and flow magnitude to the SA border to be released from upstream storages.

4.3.2.3. Constraints Management Strategy operational and management constraints

The CMS identifies nine broad operational and management constraints (expressed as outcomes) that require redress by Basin States (primarily) and the MDBA (to the extent that it is responsible for river operations). Of the nine constraints, the following four have been identified as priorities (Murray-Darling Basin Authority, 2014b):

1. protection of environmental flows from extraction and re-regulation
2. delivery of water on top of other in-stream flows
3. environmental water to be used throughout the length of a river
4. channel capacity sharing.

The first three of these priority operational and management constraints coincide with the pre-requisite policy measures (PPMs) (s7.15 of the Basin Plan) that have been assessed as implemented by the MDBA as of June 2019. Basin States have implemented the PPMs in each valley within their jurisdictions and will continue to refine PPMs in accordance with the recommendations from the MDBA (Murray-Darling Basin Authority, 2019). The MDBA will work with Basin States to undertake further scoping and analysis of the other operational and management constraints identified in the CMS (Murray-Darling Basin Authority, 2014b).

A summary is provided in Table 13 of the constraints that are currently being addressed through the CMS and PPMs that are considered to be having the greatest impact on environmental water management in the SA River Murray WRP area. Addressing these constraints is critical to achieving many environmental outcomes along the Lower River Murray, particularly the Floodplain and CLLMM where significant volumes are required to achieve inundation and flow requirements.

Table 13. Key flow constraints for the SA River Murray WRP area being addressed through the CMS and PPMs

Constraint	Implication for environmental watering in the SA River Murray WRP area	Constraint management
Public and private infrastructure, and access routes affected during higher flows	Potential reluctance to allocate or deliver environmental water that may contribute to a total flow to South Australia without addressing known impacts to infrastructure and private property, including, but not limited to, dwellings, shacks and council infrastructure located close to the river's edge.	Being addressed as part of the CMS project in South Australia (see above).
Protection of environmental flows from extraction and re-regulation; Environmental water to be used throughout the length of a river	The protection of environmental flows from extraction and re-regulation once they pass the point of extraction relies on trading mechanism and the implementation of PPMs by State governments. This is critical for South Australia to receive adequate volumes of return flows from environmental water used at upstream locations.	Ongoing refinement of PPM Implementation.
Delivery of water on top of other in-stream flows	River operating and accounting rules are not conducive for environmental water holders to release water on top of unregulated flows. This prevents the ability to increase flow peaks and their duration through the use of environmental water.	Ongoing refinement of PPM Implementation.
Physical constraints in upstream locations	Low managed delivery flow thresholds in many upstream locations limit the timing and volume of environmental water that can be released from storages for delivery at the South Australian border. This limits the ability to boost flow peaks.	Focus of CMS business cases for upstream locations (see above).

4.3.3. Other constraints and management strategies

In addition to the constraints that are being addressed through the CMS or the SDL Adjustment Mechanism, there are many challenges to environmental water delivery to and/or in the SA River Murray WRP area. Some of these are not constraints *per se* but challenges to the ability to achieve a certain flow delivery pattern or water level at specific times of the year. For instance, flow to South Australia consists of water sourced from storages in multiple valleys (e.g. Murray River, Goulburn River, Darling River, Murrumbidgee River) and the coordination of water provisions from these multiple sources to achieve a particular flow event at the South Australian border can be logistically difficult. The associated large distances and long travel times for water delivery, also make it difficult to respond to rapid changes in flow conditions. This is compounded by uncertainty around travel times for water releases, as well as natural flow peaks, due to differences between events as a result of the influence of antecedent conditions. Knowledge and experience in the coordination of environmental watering actions across multiple catchments is growing and mechanisms such as the establishment of the SCBEWC have been important in managing water in consideration of these challenges.

The flow constraints and the current understanding of the implications for environmental watering in the SA River Murray WRP area are provided in Table 14. This list is not limited to constraints that occur within the SA River Murray WRP area, but also includes those that occur upstream of the WRP area and have a major impact on environmental water delivery to the South Australian border. For each flow constraint identified, Table 14 indicates how the constraint is currently being, or in the future may be, managed. The constraints and management strategies may change in the future as managers and River operators gain greater experience in managing environmental water.

One of the major flow constraints that can significantly impact on the delivery of environmental water to South Australia at critical times (particularly summer and autumn) is the Barmah Choke channel capacity constraint. The Barmah Choke has the lowest capacity of any stretch of the River Murray (Murray-Darling Basin Authority, 2013a) due to a naturally occurring narrow stretch of river that passes through the Barmah-Millewa Forest. Once channel capacity is exceeded overbank flows into the Forest occur. At certain times of the year it is not desirable to flood the Forest as it may result in negative environmental outcomes and high water losses; therefore flows downstream of Yarrawonga Weir are kept below approximately 10,600 ML/day (Murray-Darling Basin Authority, 2013a). This timing coincides with high irrigation demands over summer and the necessity to transfer water to Lake Victoria to provide South Australia's Entitlement flow, which occupy most of the available channel capacity, and therefore limits the volume of environmental water that can be passed downstream of Hume Dam.

Historically it has not been desirable to inundate the Forest from mid-December through to the end of April (Murray-Darling Basin Authority, 2013a). Travel time from Yarrawonga to the CLLMM is approximately five to six weeks, therefore this constraint may impact on environmental water delivery to the CLLMM from January to May. Environmental water delivery to the CLLMM in addition to that provided within South Australia's Entitlement is critical in summer and autumn in order to prevent the likelihood of low water levels in the Lower Lakes, maintain barrage outflows for Murray Mouth maintenance and prevent Coorong South Lagoon salinity thresholds from being exceeded. The Barmah Choke channel capacity constraint poses a significant long-term risk to the delivery of the EWRs for the CLLMM PEA.

In 2018, the Murray-Darling Basin Ministerial Council established the cross-jurisdictional Capacity Policy Working Group to investigate options to mitigate shortfall risk for all water users (Doolan, et al., 2019). This work is underway and investigating a number of options including policy and infrastructure solutions. Additionally, by providing upstream environmental water holders improved flexibility to deliver water at higher flows across the Southern Connected Basin, full implementation of the Constraints Management Strategy will alleviate some of this risk to environmental water users.

Table 14. Flow constraints that influence environmental water management along the Lower Murray in South Australia

Constraint	Implication for environmental watering in the SA River Murray WRP area	Constraint management
Physical capacity to release water from storages during high flows limits quantity of water that can be delivered to South Australia.	The current understanding is that flows to South Australia can only be boosted by approximately 10,000 ML/day, depending on flows conditions at the time (Murray-Darling Basin Authority, 2014d). This limits	This constraint is factored into environmental water planning. The learnings gained over time will provide a more accurate understanding of the volume of environmental water that can be

Constraint	Implication for environmental watering in the SA River Murray WRP area	Constraint management
	the flow rates that can be achieved through enhancing unregulated flows.	added including under certain unregulated flow conditions.
Channel capacity through the Barmah Choke and operational/policy decisions to minimise summer inundation of the Barmah-Millewa Forest to avoid potential adverse environmental impacts.	Limits the volume of environmental water that can be delivered below the Barmah Choke in summer, particularly during periods of low flow when competing demands are high. As a result, there is a risk that at times insufficient water can be delivered to South Australia to maintain water levels in the Lower Lakes and provide for barrage releases.	In 2018 the Murray-Darling Basin Ministerial Council established the cross-jurisdictional Capacity Policy Working Group to investigate policy and infrastructure solutions.
Various factors may constrain the use of Lake Victoria in managing environmental water delivery, including: • operating rules (Lake Victoria Operating Strategy) • specific objective and outcome for improving water quality using Lake Victoria (Murray-Darling Basin Authority, 2015) • channel capacity constraints at both the inlet and outlet.	These constraints can limit the potential to operate Lake Victoria to: • provide a source of environmental water • store environmental water for release at an alternative time • be bypassed and allow longitudinal connectivity and ensure flow peaks move into South Australia.	There has been increased flexibility in the operation of Lake Victoria to facilitate environmental watering actions, including a pre-release of environmental water to prevent a short-term drop in flow rates at the South Australian border and delivery to CLLMM PEA over summer. Opportunities to trial further flexibility in operations should continue to be explored.
Weir pools are generally managed within a given operating range to advantage extraction for consumptive use, recreation and other riparian uses.	Weir manipulations are constrained due to operational limitations, which restricts the flexibility of operation and achievement of ecological outcomes through the raising and lowering of weir pools.	A transition to establishing variable weir pool levels will require a change to standard practice in South Australia and will need to be implemented over time. This may be addressed through future revisions in the Water Allocation Plan for the River Murray Prescribed Watercourse and development of operating procedures for weir pool level manipulation and through the CMS.
Weir manipulation, the operation of environmental regulators and boosting unregulated flows will affect certain private and public infrastructure and access.	Operating infrastructure and augmenting flows needs to consider known likely impacts.	Trial weir pool raisings have been undertaken to test communication protocols and approval processes, and will continue across most reaches. CMS projects are investigating impacts and considering options to mitigate potential impacts.
Works and construction activity on the floodplain, including environmental works.	Reluctance to enhance flow peaks through the addition of environmental water if it may impact on construction works and incur additional expenses. Flow peaks may also	Contractual arrangements with constructing bodies should consider potential impacts of peaks in flow, including through the addition of environmental water, so as to limit

Constraint	Implication for environmental watering in the SA River Murray WRP area	Constraint management
	be managed, where required, so as to avoid impacting on construction activity.	financial penalties where possible. Watering decisions should also consider the likely benefit of watering and the impact on construction, including the delay in future site operation for environmental outcomes.
Distance to permanent water limits the feasibility of pumping to some temporary wetland and floodplain habitats.	Physical limitations of pumping infrastructure and the costs of delivery limit the wetlands/floodplain areas that can be actively watered through pumping.	In some circumstances, alternative watering techniques, such as reservoir-fed drip irrigation, may provide a more efficient or cost-effective method of delivering water to priority areas in need. There have been some trials into alternative watering techniques and these should continue to be explored in the future.
Logistics of barrage operations.	Physical operation of barrages is time consuming and can limit opportunities to rapidly open or close gates, particularly under low lake level conditions where there is an increased risk of salt water ingress.	Investigate options for installing additional automated gates on Goolwa barrage.

4.4. Long-term risks to providing environmental water

4.4.1. Identification of risks

The risks to the condition and availability of Basin water resources identified in the Basin Plan (section 4.02) are:

a) insufficient water available for the environment
b) water being of a quality unsuitable for use
c) poor health of water dependent ecosystems

A risk assessment was undertaken as part of the SA River Murray WRP development in accordance with Part 9, Chapter 10 of the Basin Plan. A water resource plan must be prepared having regard for the risks to the condition and availability of Basin water resources identified by the Basin Plan (section 4.02), and in accordance with the AS/NZS ISO 31000:2009 *Risk Management – Principles and Guidelines* (4.04(3)) (Department for Environment and Water, 2019b). This risk assessment determined that the management of connected water resources upstream of the South Australia border remains a source of medium risk for the River Murray with resulting impacts on water-dependent ecosystems. Six of the ten medium risks identified relate to upstream connected water resources (section 5.2.4 of the SA River Murray WRP) that effect water quality, quantity or regime, which in turn cause impacts on water-dependant ecosystems. The remaining four risks relate to the impact of climate extremes on water dependent ecosystems.

The risks identified cannot be fully addressed by the South Australia alone as the strategies to address these risks include the successful implementation of the Basin Plan in full, which includes full implementation of Prerequisite Policy Measures, constraints for the system to be addressed, the additional 450 GL from efficiency measures to be recovered and no reduction of planned environmental water across the Basin. This will require implementation of all WRPs for the Southern Connected Basin in the Murray-Darling Basin including the associated long-term environmental watering plans. Anything less will compromise the ecological character of the Ramsar sites and impact on the PEAs and PEFs identified in the SA River Murray WRP area.

4.4.2. Potential risk mitigation strategies

The strategies identified within the SA River Murray WRP (section 5.9.11), need to be maintained for the level of risk to remain the same. In addition the following needs to occur: 1) effective decision-making frameworks; 2) addressing flow constraints, and 3) rigorous monitoring and evaluation programs.

4.4.2.1. Effective decision-making frameworks

The co-operative arrangements section of this LTWP describes the processes in place within the WRP area to facilitate the coordination of environmental water management and guide decision-making across the region. DEW will continue to strengthen these arrangements into the future including through implementation of the Enhanced Environmental Water Deliver supply measure (under the Sustainable Diversion Limit Adjustment Mechanism). In addition, DEW will continue to participate in arrangements to coordinate environmental watering across the Southern Connected Basin (SCB) (see Section 4.2.2).

4.4.2.2. Addressing flow constraints

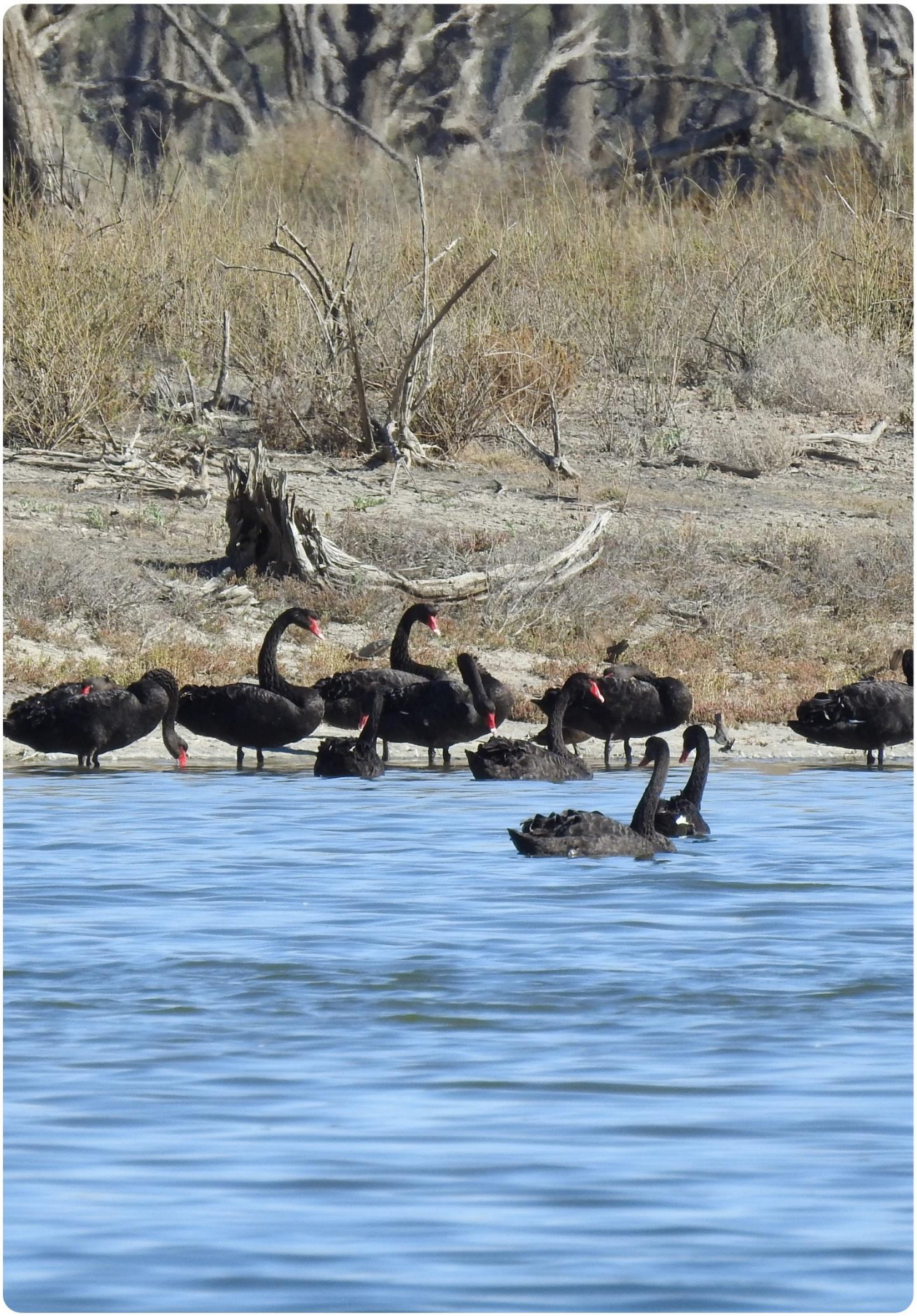
Flow constraints pose a major risk to providing the EWRs of the priority environmental assets of the SA River Murray WRP area, and modelling indicates that relaxation of constraints can improve the delivery of environmental watering events (Gibbs, et al., 2012). Further details of the constraints that influence environmental water delivery to and within the SA River Murray WRP area are provided in the Operational Constraints section of this LTWP (Section 4.3).

4.4.2.3. Rigorous monitoring and evaluation programs

Monitoring and evaluation will be undertaken to enable the assessment of ecological outcomes at the priority environmental assets within the SA River Murray WRP area (see Section 5). The information gathered through the implementation of this monitoring and evaluation will be critical for ongoing management and to support the recognition of the environmental assets within the SA River Murray WRP area as priorities for the Basin.

The River Murray WAP recognises the need for monitoring and evaluation of water demand and water availability to inform adaptive management for climate change (Natural Resources SA Murray-Darling Basin, 2020). The impacts of climate change remain an ongoing significant issue for the future health and productivity of the Murray-Darling Basin.

Further research and monitoring are needed to better quantify the impacts (forecast and actual) of climate change on water availability and water demand and the resulting impacts on water-dependent ecosystems. This information will assist with the identification of specific mitigation strategies which may include altering water resource plans to manage resources differently (section 10.51) and a review of the Basin Plan (section 6.06).



5. Monitoring, evaluation, reporting and improvement

5.1. Environmental water reporting requirements

This section presents a brief summary of the main reporting requirements associated specifically with environmental watering activity in the SA River Murray WRP area. There are many other broader natural resource management reports produced that incorporate information relating to the condition of the SA River Murray and environmental watering but these have not been included here (e.g. state and regional NRM reporting). Additional requirements may also include reporting to funding bodies that have supported investigations and works for environmental outcomes such as the installation of flow regulators, and reporting requirements for Ramsar-listed wetlands.

5.1.1. Basin Plan reporting requirements

Schedule 12 of the Basin Plan lists four 'Matters' that relate to reporting against the implementation of the Environmental Watering Plan (Basin Plan Chapter 8), three of which South Australia is required to report on (Table 15). The MDBA and CEWO are responsible for reporting against the fourth Matter (Matter 7 - the achievement of environmental outcomes at a Basin-scale) and information provided by the Basin States will contribute to Matter 7 reporting.

Annual reporting against Matters 9 and 10 commenced for the 2013-14 water year and the first report was submitted to the MDBA before 31 October 2014. Since then SA has completed Matter 9 and 10 reporting annually as required. The first report against Matter 8 was submitted in October 2020, and reports on environmental outcomes up to 30 June 2019. Matter 8 reporting will be completed every five years.

Table 15. Reporting requirements for Basin States relating to Basin Plan Chapter 8 Environmental Watering Plan

Item	Matter	Reporting frequency	Due
8	The achievement of environmental outcomes at an asset scale	Five-yearly	First report due 31 October 2020 then five-yearly
9	The identification of environmental water and the monitoring of its use	Annual	31 October each year
10	The implementation of the environmental management framework (Part 4 of Chapter 8)	Annual	31 October each year

5.1.1.1. Matter 8 evaluation and reporting

DEW has developed an approach to five-yearly Matter 8 reporting which will contribute to the MDBA's evaluation of Basin Plan environmental outcomes at the Basin-scale. The MDBA has identified three key objectives for evaluation and reporting in its 2020 evaluation framework (Murray-Darling Basin Authority, 2019b):

- Accountability: Address Reporting/legislative requirements
- Implementing and adapting: Identify opportunities for improvements to facilitate implementation of the Basin Plan and to improve capacity to achieve outcomes
- Communicating: Benefits and impacts of the Basin Plan.

In addition, South Australia has identified the following objectives for Matter 8 environmental outcome reporting:

- To meet Basin Plan reporting obligations under Schedule 12
- To communicate Basin Plan outcomes to key stakeholders (including the community)
- To inform South Australia's, the Australian Governments' and other State's environmental water delivery decision-making and adaptive management capacity

- To make a meaningful contribution to the MDBA's evaluation of the effectiveness of the Basin Plan (at Basin-scale), and our own evaluation of the effectiveness of the Basin Plan at an asset scale (within State water resource plan areas).

A framework has been developed which guides DEW's Matter 8 five-yearly evaluation and reporting (Figure 11). It illustrates the link between the Basin Plan environmental objectives, environmental watering plans and strategies (i.e. State and Basin-wide), and asset-scale environmental outcomes evaluation and reporting (Matter 8). DEW views Matter 8 as an evaluation of the achievement of environmental outcomes at an asset scale, and the reporting of that evaluation to the MDBA. The framework is influenced by best practice evaluation standards and includes evaluation questions to support the evaluation of environmental outcomes.

South Australia's approach is underpinned by the development of expected environmental outcomes for prioritised ecological targets from this LTWP. Expected environmental outcomes quantify the extent to which we expect to meet the LTWP targets over three time-points post-Basin Plan implementation (2019, 2029 and 2042). These time points were chosen to align with key Basin Plan implementation activities and reporting.

South Australia's Matter 8 reporting for the South Australian River Murray provides an assessment and evaluation of the expected environmental outcomes across key themes, including flow and ecosystem function, vegetation, fish and birds.

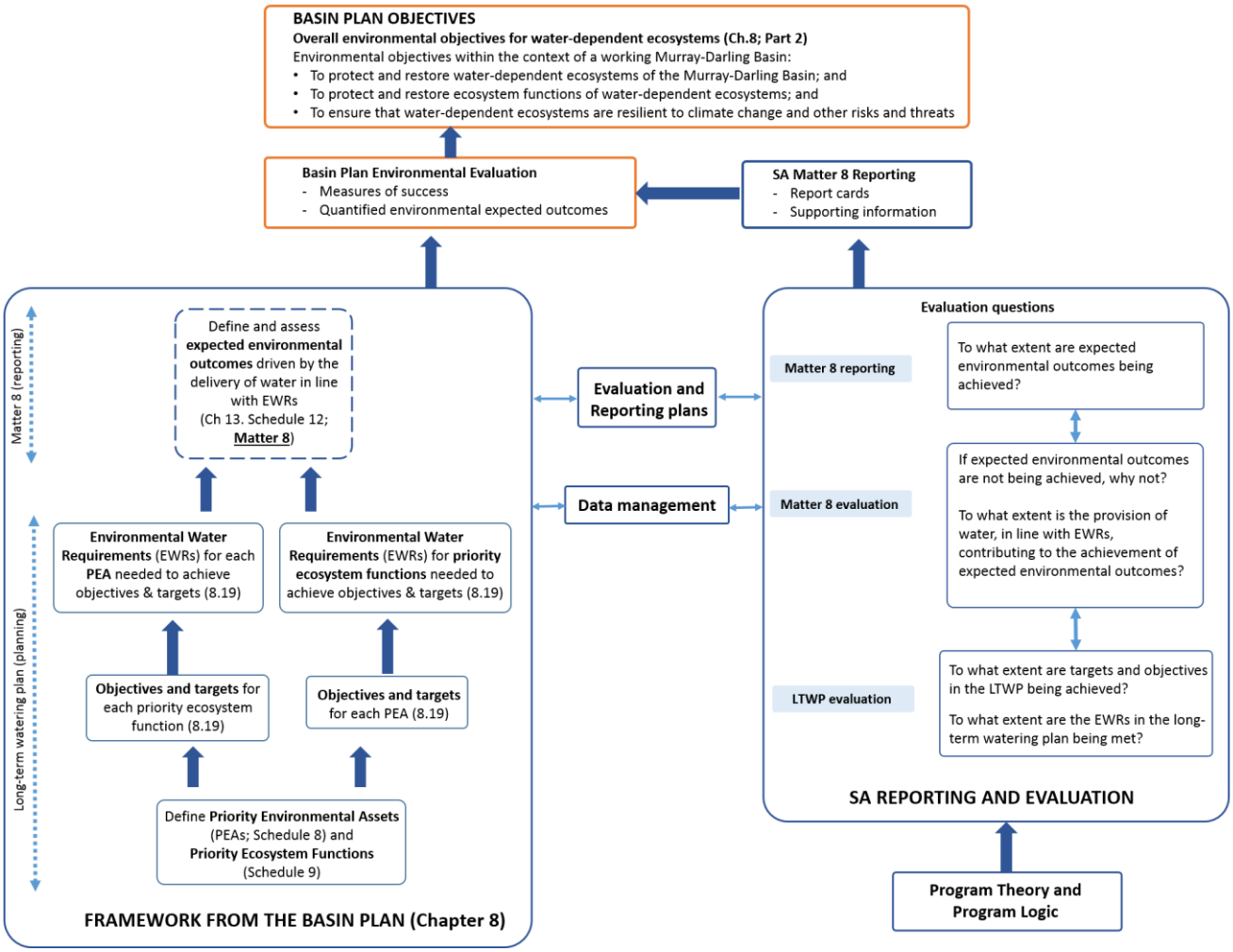


Figure 11. South Australia's Matter 8 framework

5.1.1. Other reporting requirements

Additional reporting of environmental watering activity within the SA River Murray WRP area is summarised below.

5.1.1.1. Water use reporting

Reconciliation of use against environmental water licences and accounts is reported to DEW Licensing and is due quarterly in line with the conditions for use associated with the water accounts.

5.1.1.2. Ecological and operational reporting to water holders

Reporting of environmental water use to environmental water holders (CEWO and TLM) is agreed with the holders and varies depending on the site and watering action.

For TLM, long-term environmental monitoring programs are in place at Chowilla and the LLCMM Icon Sites, including intervention and condition monitoring. Information generated through these programs is used to report on responses to environmental watering, and the environmental condition of the sites.

For CEWO, reporting requirements vary depending on the site and watering action, and is agreed between the CEWO and the site manager prior to water delivery. Ecological outcomes arising from the delivery of Commonwealth environmental water to the Channel PEA and areas of the Floodplain PEA that are inundated by flows of less than 60,000 ML/day QSA (excluding Chowilla) will be monitored and evaluated through the CEWO's Long-Term Intervention Monitoring Project (LTIM Project).

For the South Australian Minister for Environment and Water reporting requirements are met through information gathered in the preparation of DEW's annual environmental watering report (see below).

5.1.1.3. Public reporting of environmental watering activity

An annual environmental watering report is produced by DEW at the end of each water year. This report summarises the volumes and timing of environmental water delivered within the SA River Murray WRP area, provides an evaluation of actual against planned actions and highlights some of the key environmental outcomes achieved through environmental water delivery. The report is published on DEW's website and meets the South Australian Government’s commitment to the Council of Australian Governments (COAG) to provide transparency and accountability for public information sharing of River Murray environmental water use in South Australia (Council of Australian Governments, 2010).

5.2. Review of this plan

The triggers and timeframes for reviewing and updating this LTWP are provided in Section 2.2. Information generated through the implementation of site-specific monitoring programs, together with annual and five-yearly reporting (and associated plans), will be instrumental in updating and improving future versions of the LTWP.

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Appendix 1. Alignment of BWEWS expected outcomes with ecological objectives of the SA River Murray WRP area priority environmental assets

Theme	BWEWS Expected Outcome	Code[38]	Channel PEA Objective	Floodplain PEA Objective	CLLMM PEA Objective
Longitudinal connectivity	To keep base flows at least 60% of the natural level	RFC_1	Provide diverse hydraulic conditions over the range of velocity classes in the lower third of weir pools so that habitat and processes for dispersal of organic and inorganic material between reaches are maintained; Maintain a diurnally-mixed water column to ensure diverse phytoplankton and avoid negative water quality outcomes	Provide diverse hydraulic conditions and complex habitat for flow dependent biota and processes; Maintain water quality to support water dependent biota and normal biogeochemical processes	
	30% overall increase in flows in the River Murray: from increased tributary contributions from the Murrumbidgee, Goulburn, Campaspe, Loddon and Lower Darling catchments collectively	RFC_3			
	30 to 40% increase in flows to the Murray mouth.	RFC_4	Ensure adequate flushing of salt from the Murray to the Southern Ocean		Maintain a permanent Murray Mouth opening through freshwater outflows with adequate tidal variations to improve water quality and maximise connectivity between the Coorong and the sea
Lateral connectivity	30 to 60% increase in the frequency of freshes, bank-full and lowland floodplain flows in the Murray, Murrumbidgee, Goulburn–Broken and Condamine–Balonne catchments	RFC_5	Provide for the mobilisation of carbon and nutrients from the floodplain to the river to reduce the reliance of in-stream foodwebs on autochthonous productivity; Maintain habitats and provide for dispersal of organic and inorganic material and organisms between river and wetlands; Throughout the length of the Channel asset, establish and maintain groundwater and soil moisture conditions conducive to improving riparian vegetation	Provide for the mobilisation of carbon and nutrients from the floodplain to the river; Establish groundwater conditions conducive to maintaining diverse native vegetation across the Floodplain PEA; Establish soil conditions conducive to maintaining diverse native vegetation across the Floodplain PEA	

[38] *The code for each BWEWS expected outcome has been taken from the 2015-16 Southern Connected Basin Environmental Watering Proposal Template*

Theme	BWEWS Expected Outcome	Code39	Channel PEA Objective	Floodplain PEA Objective	CLLMM PEA Objective
Vegetation - Forests and woodlands	Maintain the current extent of forest and woodland vegetation including approximately: 360,000 hectares of river red gum; 409,000 hectares of black box; 310,000 hectares of coolibah	WDV_1	Throughout the length of the Channel asset, establish and maintain a diverse native flood-dependent plant community in areas inundated by flows of 10,000 - 40,000 ML/day QSA	Maintain a viable, functioning River red gum population within the Floodplain PEA; Maintain a viable, functioning black box population within the Floodplain PEA	
	No decline in the condition of river red gum, black box and coolibah across the Basin	WDV_2			
	By 2024, improved condition of river red gum in the Lachlan, Murrumbidgee, Lower Darling, Murray, Goulburn–Broken and Wimmera–Avoca	WDV_3			
	By 2024, improved recruitment of trees within river red gum, black box and coolibah communities—in the long-term achieving a greater range of tree ages.	WDV_4			

[39] *The code for each BWEWS expected outcome has been taken from the 2015-16 Southern Connected Basin Environmental Watering Proposal Template*

Theme	BWEWS Expected Outcome	Code[40]	Channel PEA Objective	Floodplain PEA Objective	CLLMM PEA Objective
Vegetation - Shrublands	Maintain the current extent of extensive lignum shrubland areas within the Basin; by 2024, improvement in the condition of lignum shrublands.	WDV_5		Maintain a viable, functioning lignum population within the Floodplain PEA	
Vegetation - non-woody	Maintain the current extent of non-woody vegetation; by 2024, increased periods of growth for communities that: closely fringe or occur within the main river corridors; form extensive stands within wetlands and low-lying floodplains; a sustained and adequate population of *Ruppia tuberosa* in the south lagoon of the Coorong, including *R. tuberosa* to occur in at least 80% of sites across at least a 43 km extent, and by 2029, the seed bank to be sufficient for the population to be resilient to major disturbances.	WDV_6	Throughout the length of the Channel asset, establish and maintain a diverse native flood-dependent plant community in areas inundated by flows of 10,000 - 40,000 ML/day QSA; Throughout the length of the Channel asset, establish and maintain a diverse macrophyte community in wetlands inundated by flows up to 40,000 ML/day QSA	Establish and maintain diverse water dependent vegetation within aquatic zones across the Floodplain PEA; Establish and maintain diverse native vegetation comprising native flood dependent and amphibious species within the shedding floodplain zones across the Floodplain PEA	Restore *Ruppia tuberosa* colonisation and reproduction in the Coorong at a regional scale; Maintain or improve aquatic and littoral vegetation in the Lower Lakes

[40] *The code for each BWEWS expected outcome has been taken from the 2015-16 Southern Connected Basin Environmental Watering Proposal Template*

Theme	BWEWS Expected Outcome	Code[41]	Channel PEA Objective	Floodplain PEA Objective	CLLMM PEA Objective
Waterbirds	From 2024, the number and type of waterbird species present in the Basin will not fall below current observations	WB_1		Provide refuge for the maintenance of adult populations of waterbirds across the Floodplain PEA	Maintain or improve waterbird populations in the Coorong and Lower Lakes
	Significant improvement in waterbird populations in the order of 20 to 25% over the baseline scenario, with increases in all waterbird functional groups	WB_2		Create conditions conducive to successful, small-scale breeding events for waterbirds across the Floodplain PEA	
	Breeding events (the opportunities to breed rather than the magnitude of breeding *per se*) of colonial nesting waterbirds to increase by up to 50% compared to the baseline scenario	WB_3			
	Breeding abundance (nests and broods) for all of the other functional groups to increase by 30–40% compared to the baseline scenario, especially in locations where the Basin Plan improves over-bank flows.	WB_4			
	At a minimum maintain populations of the following four key species: curlew sandpiper, greenshank, red-necked stint and sharp-tailed sandpiper, at levels recorded between 2000 and 2014.	WB_5			

[41] *The code for each BWEWS expected outcome has been taken from the 2015-16 Southern Connected Basin Environmental Watering Proposal Template*

Theme	BWEWS Expected Outcome	Code	Channel PEA Objective	Floodplain PEA Objective	CLLMM PEA Objective
Fish - Broad outcomes	No loss of native species currently present within the Basin	**F_1**	Restore the distribution of native fish; Restore and maintain resilient populations of foraging generalists		
	Improved population structure of key species through regular recruitment	**F_2**		Restore resilient populations of wetland/floodplain specialists within aquatic zones across the Floodplain PEA during floodplain flow events	Maintain a spatio-temporally diverse fish community and resilient populations of key native fish species in the Lower Lakes and Coorong
	Increased movement of key species	**F_3**			
	Expanded distribution of key fish species and populations in the northern and southern Basin	**F_3a**			
	Improved community structure of key native fish species.	**F_3b**			
Fish - Short-lived species[42]	Restored distribution and abundance to levels recorded pre-2007 (prior to major losses caused by extreme drought). This will require annual or biennial recruitment events depending on the species	**F_4**	Restore the distribution of native fish; Restore and maintain resilient populations of foraging generalists	Restore resilient populations of wetland/floodplain specialists within aquatic zones across the Floodplain PEA during floodplain flow events	Maintain a spatio-temporally diverse fish community and resilient populations of key native fish species in the Lower Lakes and Coorong
Fish - Moderate to long-lived species[43]	Improved population structure (i.e. a range of size/age classes for all species and stable sex ratios where relevant) in key sites. This will require annual recruitment events in at least eight out of 10 years at 80% of key sites, with at least four of these being 'strong' recruitment events	**F_5**	Restore resilient populations of Murray cod; Restore resilient populations of golden perch and silver perch; Restore resilient populations of freshwater catfish; Minimise the risk of carp recruitment	Restore resilient populations of circa-annual nester-spawners; Restore resilient populations of flow-dependent specialists; A low proportion of total fish community, measured as abundance and biomass, is comprised of non-native species	

[42] *Based on Appendix 6 of the BWEWS short-lived species relevant to the SA River Murray WRP area = Murray hardyhead, southern pygmy perch, Yarra pygmy perch, southern purple-spotted gudgeon*

[43] *Based on Appendix 6 of the BWEWS moderate to long-lived species relevant to the SA River Murray WRP area = silver perch, golden perch, Murray cod, freshwater catfish*

	10–15% increase of mature fish (of legal take size) for recreational target species (Murray cod and golden perch) in key populations	**F_6**	Restore resilient populations of Murray cod; Restore resilient populations of golden perch and silver perch	Restore resilient populations of circa-annual nester-spawners within the SA River Murray; Restore resilient populations of flow-dependent specialists within the SA River Murray	
	Annual detection of species and life stages representative of the whole fish community through key fish passages; with an increase in passage of Murray cod, trout cod, golden perch, silver perch, Hyrtl's tandan, congolli, short-headed lamprey and pouched lamprey through key fish passages to be detected in 2019–2024; compared to passage rates detected in 2014–2019.	**F_7**			Maintain a spatio-temporally diverse fish community and resilient populations of key native fish species in the Lower Lakes and Coorong (*note, includes nested targets for congolli, common galaxias, short-headed lamprey, pouched lamprey, Murray hardyhead, pygmy perch, black bream, greenback flounder, mulloway and small-mouthed hardyhead*)
Fish - Estuarine species[44]	Detection of all estuarine-dependent fish families throughout 2014–2024	**F_8**			
	Maintenance of annual population abundance (Catch Per Unit Effort – CPUE) of key estuarine prey species (sandy sprat and small-mouthed hardyhead) throughout the Coorong	**F_9**			
	Detection of a broad spatial distribution of black bream and greenback flounder; with adult black bream and all life stages of greenback flounder present across >50% of the Coorong in eight out of 10 years	**F_10**			

[44] *Based on Appendix 6 of the BWEWS estuarine species = mulloway, black bream, greenback flounder, sandy sprat, small-mouthed hardyhead; and four diadromous species (congolli, common galaxias, short-headed lamprey, pouched lamprey)*

	Detection in nine out of 10 years of bi-directional seasonal movements of diadromous species through the barrages and fishways between the Lower Lakes and Coorong	**F_11**	
	Increased rates of native fish passage in 2019–2024 compared to 2014–2019	**F_12**	
	Improved population structure of mulloway, including spawning aggregations at the Murray mouth in six out of 10 years and recruitment in at least five out of 10 years.	**F_13**	
Fish - key species [45]	Significant increases in the distributions of key species in the southern Basin.	**F_15**	Restore resilient populations of wetland/floodplain specialists within aquatic zones across the Floodplain PEA during floodplain flow events

[45] *Based on Appendix 6 of the BWEWS key species relevant to the SA River Murray WRP area = southern pygmy perch, southern purple-spotted gudgeon, Yarra pygmy perch, Murray hardyhead, diadromous species (Congolli, short-headed and pouched lamprey)*

Appendix 2. Species of conservation significance recorded within SA River Murray WRP area Priority Environmental Assets

Table 16. Threatened plant species[46]

Scientific Name	Common Name	EPBC Status	State Status	Priority Environmental Asset			No. of assets recorded in
				Channel	Floodplain	CLLMM	
Acacia dodonaeifolia	Hop-bush Wattle	n/a	Rare			Y	1
Acacia lineata	Streaked Wattle	n/a	Rare	Y	Y		2
Acacia menzelii	Menzel's Wattle	Vulnerable	Vulnerable		Y		1
Acacia montana	Mallee Wattle	n/a	Rare		Y		1
Acacia pinguifolia	Fat-leaf Wattle	Endangered	Endangered			Y	1
Acacia rhetinocarpa	Resin Wattle	Vulnerable	Vulnerable			Y	1
Acacia rhigiophylla	Dagger-leaf Wattle	n/a	Rare				0
Acanthocladium dockeri	Spiny Everlasting	Critically Endangered	Endangered		Y		1
Adiantum capillus-veneris	Dainty Maiden-hair	n/a	Vulnerable	Y			1
Atriplex australasica	n/a	n/a	Rare			Y	1
Atriplex morrisii	n/a	n/a	Vulnerable	Y			1
Austrostipa echinata	Spiny Spear-grass	n/a	Rare			Y	1
Austrostipa tenuifolia	n/a	n/a	Rare			Y	1
Baumea acuta	Pale Twig-rush	n/a	Rare			Y	1
Billardiera scandens var. scandens	Eastern Apple-berry	n/a	Rare			Y	1
Bothriochloa macra	Red-leg Grass	n/a	Rare	Y			1
Brachyscome graminea	Grass Daisy	n/a	Rare	Y	Y		2
Brachyscome melanocarpa ssp. melanocarpa	Black-fruit Daisy	n/a	Vulnerable		Y		1
Brachyscome paludicola	Swamp Daisy	n/a	Rare*	Y	Y	Y	3

[46] *Presence/absence records from DEW's biological database have been provided as an indication of the number of threatened species that have been found within each PEA only. This is not a comprehensive list and does not reflect species records that have not been provided to DEW for input to the database.*

Scientific Name	Common Name	EPBC Status	State Status	Priority Environmental Asset			No. of assets recorded in
				Channel	Floodplain	CLLMM	
Brachyscome parvula	Coast Daisy	n/a	Rare		Y		1
Caladenia colorata	Coloured Spider-orchid	Endangered	Endangered			Y	1
Caladenia flaccida	Drooping Spider-orchid	n/a	Vulnerable			Y	1
Caladenia fragrantissima	Scented Spider-orchid	n/a	Vulnerable			Y	1
Caladenia ornata	Ornate Pink Fingers	Vulnerable	Endangered			Y	1
Caladenia reticulata	Veined Spider-orchid	n/a	Rare			Y	1
Caladenia richardsiorum	Little Dip Spider-orchid	Endangered	Endangered			Y	1
Caladenia tensa	Inland Green-comb Spider-orchid	Endangered	n/a			Y	1
Caladenia valida	Robust Spider-orchid	n/a	Endangered			Y	1
Callistemon brachyandrus	Prickly Bottlebrush	n/a	Rare	Y	Y		2
Callitriche sonderi	Matted Water Starwort	n/a	Rare	Y	Y		2
Callitriche umbonata	Water Starwort	n/a	Vulnerable	Y	Y		2
Calocephalus sonderi	Pale Beauty-heads	n/a	Rare	Y	Y		2
Calotis scapigera	Tufted Burr-daisy	n/a	Rare	Y	Y		2
Centrolepis cephaloformis ssp. cephaloformis	Cushion Centrolepis	n/a	Rare			Y	1
Ceratophyllum demersum	Hornwort	n/a	Rare	Y		Y	2
Christella dentata	Soft Shield-fern	n/a	Rare	Y		Y	2
Cladium procerum	Leafy Twig-rush	n/a	Rare			Y	1
Correa aemula	Hairy Correa	n/a	Rare	Y			1
Correa alba var. pannosa	White Correa	n/a	Rare			Y	1
Corybas expansus	Dune Helmet-orchid	n/a	Vulnerable			Y	1
Corynotheca licrota	Sand Lily	n/a	Rare	Y			1
Crassula peduncularis	Purple Crassula	n/a	Rare		Y		1
Cyperus bifax	Downs Flat-sedge	n/a	Rare		Y		1
Cyperus flaccidus	Flaccid Flat-sedge	n/a	Rare		Y		1

Scientific Name	Common Name	EPBC Status	State Status	Priority Environmental Asset			No. of assets recorded in
				Channel	Floodplain	CLLMM	
Cyperus nervulosus	n/a	n/a	Rare		Y		1
Cyperus sphaeroideus	n/a	n/a	Rare			Y	1
Dianella porracea	Pale Flax-lily	n/a	Vulnerable		Y		1
Diplachne parviflora (NC)	Small-flower Beetle-grass	n/a	Rare		Y		1
Diuris behrii	Behr's Cowslip Orchid	n/a	Vulnerable			Y	1
Dodonaea subglandulifera	n/a	Endangered	Endangered	Y	Y		2
Duma horrida ssp. horrida	Spiny Lignum	n/a	Rare	Y	Y		2
Elatine gratioloides	Waterwort	n/a	Rare	Y	Y	Y	3
Eragrostis infecunda	Barren Cane-grass	n/a	Rare	Y	Y		2
Eragrostis lacunaria	Purple Love-grass	n/a	Rare	Y	Y		2
Eremophila gibbifolia	Coccid Emubush	n/a	Rare	Y			1
Eremophila polyclada	Twiggy Emubush	n/a	Rare	Y			1
Eucalyptus fasciculosa	Pink Gum	n/a	Rare			Y	1
Eucalyptus leucoxylon ssp. megalocarpa	Large-fruit Blue Gum	n/a	Rare			Y	1
Euphrasia collina ssp. osbornii	Osborn's Eyebright	Endangered	Endangered			Y	1
Exocarpos strictus	Pale-fruit Cherry	n/a	Rare	Y	Y		2
Fimbristylis aestivalis	Summer Fringe-rush	n/a	Rare			Y	1
Geijera parviflora	Wilga	n/a	Rare	Y			1
Goodenia gracilis	Grampians Goodenia	n/a	Vulnerable	Y	Y		2
Goodenia heteromera	Spreading Goodenia	n/a	Rare	Y	Y		2
Gratiola pedunculata	Stalked Brooklime	n/a	Rare	Y	Y		2
Gratiola pumilo	Dwarf Brooklime	n/a	Rare	Y	Y		2
Haegiela tatei	Small Nut-heads	n/a	Rare			Y	1
Hakea tephrosperma	Hooked Needlewood	n/a	Rare	Y			1
Hydrilla verticillata	Waterthyme	n/a	Rare	Y			1

Scientific Name	Common Name	EPBC Status	State Status	Priority Environmental Asset			No. of assets recorded in
				Channel	Floodplain	CLLMM	
Hypolepis rugosula	Ruddy Ground-fern	n/a	Rare			Y	1
Isolepis producta	Nutty Club-rush	n/a	Vulnerable			Y	1
Juncus prismatocarpus	Branching Rush	n/a	Endangered				0
Lachnagrostis robusta	Tall Blown-grass	n/a	Rare	Y		Y	2
Lawrencia berthae	Showy Lawrencia	n/a	Rare	Y			1
Leionema microphyllum	Limestone Phebalium	n/a	Rare			Y	1
Lepidium pseudotasmanicum	Shade Peppercress	n/a	Vulnerable	Y	Y		2
Leucopogon clelandii	Cleland's Beard-heath	n/a	Rare			Y	1
Lobelia concolor	Poison Pratia	n/a	Rare	Y	Y	Y	3
Lycopodiella serpentina	Bog Clubmoss	n/a	Endangered			Y	1
Lythrum salicaria	Purple Loosestrife	n/a	Rare	Y	Y	Y	3
Maireana decalvans	Black Cotton-bush	n/a	Endangered		Y		1
Maireana pentagona	Slender Fissure-plant	n/a	Rare	Y	Y		2
Maireana rohrlachii	Rohrlach's Bluebush	n/a	Rare		Y		1
Melaleuca squamea	Swamp Honey-myrtle	n/a	Rare			Y	1
Mentha diemenica	Slender Mint	n/a	Rare	Y			1
Micromyrtus ciliata	Fringed Heath-myrtle	n/a	Rare			Y	1
Montia australasica	White Purslane	n/a	Rare		Y	Y	2
Myoporum parvifolium	Creeping Boobialla	n/a	Rare	Y	Y	Y	3
Myriophyllum crispatum	Upright Milfoil	n/a	Vulnerable		Y		1
Myriophyllum papillosum	Robust Milfoil	n/a	Rare	Y	Y		2
Najas tenuifolia	Water Nymph	n/a	Endangered	Y			1
Nymphoides crenata	Wavy Marshwort	n/a	Rare	Y	Y		2
Olearia pannosa ssp. cardiophylla	Velvet Daisy-bush	n/a	Rare			Y	1
Olearia pannosa ssp. pannosa	Silver Daisy-bush	Vulnerable	Vulnerable			Y	1

Scientific Name	Common Name	EPBC Status	State Status	Priority Environmental Asset			No. of assets recorded in
				Channel	Floodplain	CLLMM	
Olearia passerinoides ssp. glutescens	Sticky Daisy-bush	n/a	Rare			Y	1
Orobanche cernua var. australiana	Australian Broomrape	n/a	Rare	Y	Y		2
Osteocarpum acropterum var. deminutum	Wingless Bonefruit	n/a	Rare				0
Ottelia ovalifolia ssp. ovalifolia	Swamp Lily	n/a	Rare		Y		1
Ozothamnus pholidotus	Scaly Haeckeria	n/a	Vulnerable				0
Philotheca angustifolia ssp. angustifolia	Narrow-leaf Wax-flower	n/a	Rare	Y		Y	2
Picris squarrosa	Squat Picris	n/a	Rare	Y	Y	Y	3
Poa fax	Scaly Poa	n/a	Rare			Y	1
Podolepis jaceoides	Showy Copper-wire Daisy	n/a	Rare			Y	1
Pomaderris halmaturina ssp. halmaturina	Kangaroo Island Pomaderris	Vulnerable	Vulnerable			Y	1
Prasophyllum constrictum	Tawny Leek-orchid	n/a	Rare				0
Prostanthera eurybioides	Monarto Mintbush	Endangered	Endangered		Y		1
Pteris tremula	Tender Brake	n/a	Rare	Y			1
Pterostylis arenicola	Sandhill Greenhood	Vulnerable	Vulnerable			Y	1
Pterostylis curta	Blunt Greenhood	n/a	Rare			Y	1
Ranunculus inundatus	River Buttercup	n/a	Rare			Y	1
Ranunculus papulentus	Large River Buttercup	n/a	Vulnerable			Y	1
Rorippa laciniata	Jagged Bitter-cress	n/a	Rare	Y			1
Scaevola calendulacea	Dune Fanflower	n/a	Vulnerable			Y	1
Schizaea fistulosa	Narrow Comb-fern	n/a	Vulnerable			Y	1
Sclerolaena muricata var. villosa	Five-spine Bindyi	n/a	Rare	Y			1
Scutellaria humilis	Dwarf Skullcap	n/a	Rare				1
Spiranthes australis	Austral Lady's Tresses	n/a	Rare			Y	1

Scientific Name	Common Name	EPBC Status	State Status	Priority Environmental Asset			No. of assets recorded in
				Channel	Floodplain	CLLMM	
Spyridium fontis-woodii	Woods Well Spyridium	n/a	Endangered			Y	1
Stellaria multiflora ssp. collaris	Rayless Starwort	n/a	Rare		Y		1
Stellaria palustris var. tenella	Swamp Starwort	n/a	Rare	Y			1
Swainsona behriana	Behr's Swainson-pea	n/a	Vulnerable		Y		1
Thelymitra epipactoides	Metallic Sun-orchid	Endangered	Endangered			Y	1
Veronica decorosa	Showy Speedwell	n/a	Rare	Y			1
Viminaria juncea	Native Broom	n/a	Rare			Y	1
Wurmbea latifolia ssp. vanessae	Broad-leaf Nancy	n/a	Rare			Y	1
Zannichellia palustris	n/a	n/a	Rare	Y	Y		2
Zoysia macrantha ssp. walshii	Manila Grass	n/a	Rare			Y	1
Total number of threatened species recorded in each Priority Environmental Asset				**50**	**47**	**63**	

Table 17. Threatened fauna species[47]

'Migratory status' indicates the international agreement the species is listed under where Bonn = Bonn Convention, CAM = CAMBA, JAM = JAMBA and ROK = ROKAMBA
(Y) indicates a migratory bird species has been recorded in the asset, however it is not a state or nationally listed threatened species

Scientific Name	Common Name	EPBC Status	State Status	Migratory Status	Priority Environmental Asset			No. of assets recorded in
					Channel	Floodplain	CLLMM	
Acanthiza iredalei	Slender-billed Thornbill	ssp	ssp	n/a			Y	1
Acrobates pygmaeus	Feathertail Glider	n/a	Endangered	n/a	Y			1
Actitis hypoleucos	Common Sandpiper	Migratory	Rare	Bonn/CAM/JAM/ROK	Y		Y	2
Anhinga novaehollandiae novaehollandiae	Australasian Darter	n/a	Rare	n/a	Y	Y	Y	3
Anseranas semipalmata	Magpie Goose	n/a	Endangered	n/a		Y	Y	2
Antigone rubicunda	Brolga	n/a	Vulnerable	n/a	Y	Y		2

[47] *Presence/absence records from DEW's biological database have been provided as an indication of the number of threatened species that have been found within each PEA only. Currently there are very few fish records and no invertebrate records entered into the dataset. This is not a comprehensive list and does not reflect species records that have not been provided to DEW for input to the database.*

Scientific Name	Common Name	EPBC Status	State Status	Migratory Status	Priority Environmental Asset			No. of assets recorded in
					Channel	Floodplain	CLLMM	
Arctocephalus pusillus	Australian Fur Seal (Brown Fur Seal)	n/a	Rare	n/a			Y	1
Arctocephalus tropicalis	Subantarctic Fur Seal	Endangered	Endangered	n/a			Y	1
Ardea intermedia plumifera	Plumed Egret	n/a	Rare	n/a	Y	Y	Y	3
Ardenna carneipes	Flesh-footed Shearwater	Migratory	Rare	JAM/ROK			Y	1
Ardeotis australis	Australian Bustard	n/a	Vulnerable	n/a	Y	Y	Y	3
Arenaria interpres interpres	Ruddy Turnstone	Migratory	Rare	Bonn/CAM/JAM/ROK		Y	Y	2
Bidyanus bidyanus	Silver Perch	Critically endangered	n/a	n/a	Y	Y		2
Biziura lobata menziesi	Musk Duck	n/a	Rare	n/a	Y	Y	Y	3
Botaurus poiciloptilus	Australasian Bittern	Endangered	Endangered	n/a	Y		Y	2
Bubulcus ibis coromandus	Eastern Cattle Egret	n/a	Rare	n/a	Y		Y	2
Burhinus grallarius	Bush Stonecurlew	n/a	Rare	n/a	Y	Y	Y	3
Calidris alba alba	Sanderling	Migratory	Rare	Bonn/CAM/JAM/ROK			Y	1
Calidris canutus rogersi	Red Knot	ssp	Endangered	n/a			Y	1
Calidris ferruginea	Curlew Sandpiper	Critically Endangered; Migratory	Endangered	Bonn/CAM/JAM/ROK	Y		Y	2
Calidris melanotos	Pectoral Sandpiper	Migratory	Rare	Bonn/JAM/ROK	Y		Y	2
Calidris pugnax	Ruff	Migratory	Rare	Bonn/CAM/JAM/ROK			Y	1
Calidris subminuta	Long-toed Stint	Migratory	Rare	Bonn/CAM/JAM/ROK	Y		Y	2
Calidris tenuirostris	Great Knot	Critically endangered; Migratory	Endangered	Bonn/CAM/JAM/ROK			Y	1
Caperea marginata	Pygmy Right Whale	Migratory	Rare	Bonn			Y	1
Cereopsis novaehollandiae (NC)	Cape Barren Goose	n/a	Rare	n/a			Y	1
Cereopsis novaehollandiae novaehollandiae	Cape Barren Goose	n/a	Rare	n/a	Y	Y	Y	3
Charadrius bicinctus bicinctus	Double-banded Plover	Migratory	n/a	Bonn	(Y)	(Y)	(Y)	3

Scientific Name	Common Name	EPBC Status	State Status	Migratory Status	Priority Environmental Asset			No. of assets recorded in
					Channel	Floodplain	CLLMM	
Charadrius leschenaultii leschenaultii	Greater Sand Plover	ssp; Migratory	Rare	Bonn/JAM/CAM/ROK	Y		Y	2
Charadrius mongolus mongolus	Lesser Sand Plover	n/a	Endangered	n/a			Y	1
Charadrius veredus	Oriental Plover	Migratory	n/a	Bonn/JAM/CAM/ROK	(Y)		(Y)	2
Chelodina expansa	Broadshelled Turtle	n/a	Vulnerable	n/a	Y	Y		2
Chlidonias leucopterus	White-winged Tern	Migratory	n/a	CAM/JAM/ROK			(Y)	1
Cinclosoma castanotum (NC)	Chestnut-backed Quailthrush (Chestnut Quailthrush)	n/a	ssp	n/a	Y	Y	Y	3
Cladorhynchus leucocephalus	Banded Stilt	n/a	Vulnerable	n/a	Y	Y	Y	3
Climacteris affinis	White-browed Treecreeper	n/a	Rare	n/a		Y		1
Climacteris affinis superciliosus	White-browed Treecreeper (FR, LNE, MM)	n/a	ssp	n/a	Y			1
Coracina papuensis robusta	White-bellied Cuckooshrike	n/a	Rare	n/a	Y	Y	Y	3
Corcorax melanorhamphos	White-winged Chough	n/a	Rare	n/a	Y	Y		2
Coturnix ypsilophora australis	Brown Quail	n/a	Vulnerable	n/a	Y	Y	Y	3
Craterocephalus fluviatilis	Murray Hardyhead	Endangered	n/a	n/a	Y	Y	Y	3
Dasyornis broadbenti (NC)	Rufous Bristlebird	n/a	Rare	n/a			Y	1
Dasyornis broadbenti broadbenti	Rufous Bristlebird	n/a	Rare	n/a			Y	1
Dasyurus viverrinus	Eastern Quoll	Endangered	Endangered	n/a			Y	1
Diomedea exulans complex	Wandering Albatross	ssp	ssp	n/a			Y	1
Dromaius novaehollandiae	Emu	ssp	ssp	n/a	Y	Y	Y	3
Echiopsis curta	Bardick	n/a	Rare	n/a			Y	1
Egretta garzetta nigripes	Little Egret	n/a	Rare	n/a	Y	Y	Y	3
Egretta sacra sacra	Pacific Reef Heron	n/a	Rare	n/a			Y	1
Elanus scriptus	Letter-winged Kite	n/a	Vulnerable	n/a			Y	1

Scientific Name	Common Name	EPBC Status	State Status	Migratory Status	Priority Environmental Asset			No. of assets recorded in
					Channel	Floodplain	CLLMM	
Emydura macquarii	Macquarie River Turtle	n/a	Vulnerable	n/a	Y	Y	Y	3
Entomyzon cyanotis cyanotis	Blue-faced Honeyeater	n/a	Rare	n/a	Y	Y		2
Epthianura crocea crocea	Yellow Chat	n/a	Rare	n/a			Y	1
Eubalaena australis	Southern Right Whale	Endangered	Vulnerable	n/a			Y	1
Eulamprus heatwolei	Yellow-bellied Water Skink	n/a	Vulnerable	n/a			Y	1
Falco hypoleucos	Grey Falcon	Vulnerable	Rare	n/a			Y	1
Falco peregrinus macropus	Peregrine Falcon	n/a	Rare	n/a	Y	Y	Y	3
Falco subniger	Black Falcon	n/a	Rare	n/a	Y		Y	2
Falcunculus frontatus	Crested Shriketit	n/a	Rare	n/a	Y			1
Gallinago hardwickii	Latham's Snipe	Migratory	Rare	Bonn/JAM/ROK	Y	Y	Y	3
Globicephala macrorhynchus	Short-finned Pilot Whale	n/a	Rare	n/a			Y	1
Haematopus fuliginosus fuliginosus	Sooty Oystercatcher	n/a	Rare	n/a			Y	1
Haematopus longirostris	Pied Oystercatcher	n/a	Rare	n/a			Y	1
Haliaeetus leucogaster	White-bellied Sea Eagle	n/a	Endangered	n/a	Y	Y	Y	3
Halobaena caerulea	Blue Petrel	Vulnerable	n/a	n/a			Y	1
Hieraaetus morphnoides	Little Eagle	n/a	Vulnerable	n/a	Y	Y	Y	3
Hydrurga leptonyx	Leopard Seal	n/a	Rare	n/a			Y	1
Hylacola cauta	Shy Heathwren	n/a	ssp	n/a	Y		Y	2
Hylacola cauta cauta	Shy Heathwren (EP, YP, FR, MM, upper SE)	n/a	Rare	n/a			Y	1
Ixobrychus dubius	Black-backed Bittern (Australian Little Bittern)	n/a	Endangered	n/a		Y	Y	2
Kogia breviceps	Pygmy Sperm Whale	n/a	Rare	n/a			Y	1
Larus dominicanus dominicanus	Kelp Gull	n/a	Rare	n/a			Y	1
Leipoa ocellata	Malleefowl	Vulnerable	Vulnerable	n/a	Y	Y	Y	3
Lewin pectoralis pectoralis	Lewin's Rail	n/a	Vulnerable	n/a			Y	1

Scientific Name	Common Name	EPBC Status	State Status	Migratory Status	Priority Environmental Asset			No. of assets recorded in
					Channel	Floodplain	CLLMM	
Lichenostomus cratitius	Purple-gaped Honeyeater	n/a	ssp	n/a	Y		Y	2
Lichenostomus cratitius occidentalis	Purple-gaped Honeyeater (mainland SA)	n/a	Rare	n/a	Y		Y	2
Limosa lapponica	Bar-tailed Godwit	Migratory	ssp	Bonn/CAM/JAM/ROK			Y	1
Limosa limosa melanuroides	Black-tailed Godwit	n/a	Rare	n/a	Y		Y	2
Litoria raniformis	Southern Bell Frog	Vulnerable	Vulnerable	n/a	Y	Y	Y	3
Lophochroa leadbeateri	Major Mitchell's Cockatoo	n/a	Rare	n/a		Y		1
Lophochroa leadbeateri leadbeateri	Major Mitchell's Cockatoo (LNE, MM)	n/a	ssp	n/a		Y		1
Macronectes giganteus	Southern Giant Petrel	Endangered; Migratory	Vulnerable	Bonn			Y	1
Manorina flavigula	Yellow-throated Miner	ssp	ssp	n/a	Y	Y		2
Melanodryas cucullata	Hooded Robin	n/a	ssp	n/a	Y	Y		2
Melanodryas cucullata cucullata	Hooded Robin (YP, MN, AP, MLR, MM, SE)	n/a	Rare	n/a	Y	Y	Y	3
Melithreptus gularis	Black-chinned Honeyeater	n/a	ssp	n/a			Y	1
Mesoplodon bowdoini	Andrews' Beaked Whale	n/a	Rare	n/a			Y	1
Mesoplodon grayi	Gray's Beaked Whale (Scamperdown Whale)	n/a	Rare	n/a			Y	1
Microeca fascinans	Jacky Winter	n/a	ssp	n/a	Y	Y	Y	3
Mirounga leonina	Southern Elephant Seal	Vulnerable	Rare	n/a			Y	1
Morelia spilota	Carpet Python	n/a	Rare	n/a	Y	Y		2
Myiagra inquieta	Restless Flycatcher	n/a	Rare	n/a	Y	Y	Y	3
Myotis macropus	Large-footed Myotis	n/a	Endangered	n/a	Y			1
Nannoperca obscura	Yarra Pygmy Perch	Vulnerable	n/a	n/a			Y	1
Neophema chrysogaster	Orange-bellied Parrot	Critically endangered	Endangered	n/a			Y	1

Scientific Name	Common Name	EPBC Status	State Status	Migratory Status	Priority Environmental Asset			No. of assets recorded in
					Channel	Floodplain	CLLMM	
Neophema chrysostoma	Blue-winged Parrot	n/a	Vulnerable	n/a	Y		Y	2
Neophema elegans elegans	Elegant Parrot	n/a	Rare	n/a	Y		Y	2
Neophema petrophila zietzi	Rock Parrot	n/a	Rare	n/a			Y	1
Neophema splendida	Scarlet-chested Parrot	n/a	Rare	n/a		Y		1
Ninox connivens connivens	Barking Owl	n/a	Rare	n/a		Y		1
Northiella haematogaster (NC)	Bluebonnet (Eastern and Naretha)	n/a	ssp	n/a	Y	Y	Y	3
Notechis scutatus	Tiger Snake	ssp	n/a	n/a	Y	Y	Y	3
Numenius madagascariensis	Far Eastern Curlew	Critically endangered; Migratory	Endangered	Bonn/CAM/JAM/ROK			Y	1
Numenius phaeopus variegatus	Whimbrel	n/a	Rare	n/a			Y	1
Oriolus sagittatus sagittatus	Olive-backed Oriole	n/a	Rare	n/a	Y	Y		2
Ornithorhynchus anatinus	Platypus	n/a	Endangered	n/a	Y			1
Oxyura australis	Blue-billed Duck	n/a	Rare	n/a	Y	Y	Y	3
Pachycephala inornata	Gilbert's Whistler	n/a	Rare	n/a	Y	Y		2
Pachycephala rufogularis	Red-lored Whistler	Vulnerable	Rare	n/a			Y	1
Pandion haliaetus cristatus	Eastern Osprey	n/a	Endangered	n/a	Y		Y	2
Parvipsitta pusilla	Little Lorikeet	n/a	Endangered	n/a			Y	1
Petroica boodang boodang	Scarlet Robin	n/a	ssp	n/a	Y	Y	Y	3
Petroica phoenicea	Flame Robin	n/a	Vulnerable	n/a			Y	1
Philemon citreogularis citreogularis	Little Friarbird	n/a	Rare	n/a	Y	Y		2
Physeter macrocephalus	Sperm Whale	Migratory	Rare	Bonn			Y	1
Plectorhyncha lanceolata	Striped Honeyeater	n/a	Rare	n/a	Y	Y	Y	3
Plegadis falcinellus	Glossy Ibis	Migratory	Rare	Bonn	Y	Y	Y	3
Pluvialis fulva	Pacific Golden Plover	Migratory	Rare	Bonn/CAM/JAM/ROK	Y		Y	2
Podiceps cristatus australis	Great Crested Grebe	n/a	Rare	n/a	Y	Y	Y	3

Scientific Name	Common Name	EPBC Status	State Status	Migratory Status	Priority Environmental Asset			No. of assets recorded in
					Channel	Floodplain	CLLMM	
Polytelis anthopeplus monarchoides	Regent Parrot	Vulnerable	Vulnerable	n/a	Y	Y		2
Pomatostomus temporalis	Grey-crowned Babbler	n/a	ssp	n/a	Y		Y	2
Pseudophryne bibronii	Brown Toadlet	n/a	Rare	n/a	Y		Y	2
Pseudophryne semimarmorata	Marbled Toadlet	n/a	Vulnerable	n/a			Y	1
Pterodroma mollis	Soft-plumaged Petrel	Vulnerable	n/a	n/a			Y	1
Pteropus poliocephalus	Grey-headed Flying-fox	Vulnerable	Rare	n/a			Y	1
Rattus lutreolus	Swamp Rat	n/a	Rare	n/a		Y	Y	2
Rostratula australis	Australian Painted-snipe	Endangered	Endangered	n/a	Y		Y	2
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat	n/a	Rare	n/a			Y	1
Spatula rhynchotis	Australasian Shoveler	n/a	Rare	n/a	Y	Y	Y	3
Stagonopleura bella	Beautiful Firetail	n/a	Rare	n/a			Y	1
Stagonopleura bella interposita	Beautiful Firetail (SE)	n/a	ssp	n/a			Y	1
Stagonopleura bella samueli	Beautiful Firetail (MLR and KI)	n/a	ssp	n/a			Y	1
Stagonopleura guttata	Diamond Firetail	n/a	Vulnerable	n/a	Y		Y	2
Sterna hirundo longipennis	Common Tern	Migratory	Rare	Bonn/CAM/JAM/ROK			Y	1
Sterna paradisaea	Arctic Tern	Migratory	n/a	Bonn			(Y)	1
Sternula albifrons sinensis	Little Tern	n/a	Endangered	n/a	Y		Y	2
Sternula nereis nereis	Fairy Tern	Vulnerable	Endangered	n/a	Y		Y	2
Stictonetta naevosa	Freckled Duck	n/a	Vulnerable	n/a	Y	Y	Y	3
Stipiturus malachurus	Southern Emuwren	ssp	ssp	n/a			Y	1
Stipiturus malachurus intermedius	Southern Emuwren (Mount Lofty Ranges)	Endangered	Endangered	n/a			Y	1
Stipiturus malachurus polionotum	Southern Emuwren (South East)	n/a	Rare	n/a			Y	1
Strepera versicolor	Grey Currawong	n/a	ssp	n/a	Y	Y	Y	3
Tachyglossus aculeatus	Short-beaked Echidna	ssp	ssp	n/a	Y	Y	Y	3

Scientific Name	Common Name	EPBC Status	State Status	Migratory Status	Priority Environmental Asset			No. of assets recorded in
					Channel	Floodplain	CLLMM	
Thalassarche carteri	Indian Yellow-nosed Albatross	Vulnerable; Migratory	Endangered	Bonn			Y	1
Thalassarche cauta cauta	Shy Albatross	Vulnerable	Vulnerable	n/a			Y	1
Thalassarche chrysostoma	Grey-headed Albatross	Endangered; Migratory	Vulnerable	Bonn			Y	1
Thalassarche melanophris	Black-browed Albatross	Vulnerable; Migratory	ssp	Bonn			Y	1
Thinornis cucullatus cucullatus	Hooded Plover	Vulnerable	Vulnerable	n/a		Y	Y	2
Trichosurus vulpecula	Common Brushtail Possum	n/a	Rare	n/a	Y	Y		2
Tringa brevipes	Grey-tailed Tattler	Migratory	Rare	Bonn/CAM/JAM/ROK			Y	1
Tringa glareola	Wood Sandpiper	Migratory	Rare	Bonn/CAM/JAM/ROK	Y	Y	Y	3
Turnix varius varius	Painted Buttonquail	n/a	Rare	n/a			Y	1
Varanus rosenbergi	Heath Goanna	n/a	Vulnerable	n/a			Y	1
Varanus varius	Lace Monitor	n/a	Rare	n/a	Y	Y		2
Vombatus ursinus	Common Wombat	n/a	Rare	n/a			Y	1
Xenus cinereus	Terek Sandpiper	Migratory	Rare	Bonn/CAM/JAM/ROK			Y	1
Zanda funerea whiteae	Yellow-tailed Black Cockatoo	n/a	Vulnerable	n/a			Y	1
Zapornia tabuensis	Spotless Crake	n/a	Rare	n/a	Y	Y	Y	3
Total number of threatened species (state/national) per PEA					**77**	**60**	**130**	
Total number of migratory species per PEA					**11**	**5**	**29**	

Appendix 3. Definitions of held and planned environmental water

The following definitions of held and planned environmental water are taken from Sections 4 and 6 of the *Water Act 2007*.

Held environmental water means water available under:

(a) a water access right; or

(b) a water delivery right; or

(c) an irrigation right;

for the purposes of achieving environmental outcomes (including water that is specified in a water access right to be for environmental use).

Planned environmental water

(1) For the purposes of this Act, ***planned environmental water*** is water that:

(a) is committed by:

(i) the Basin Plan or a water resource plan for a water resource plan area; or

(ii) a plan made under a State water management law; or

(iii) any other instrument made under a law of a State;

to either or both of the following purposes:

(iv) achieving environmental outcomes;

(v) other environmental purposes that are specified in the plan or the instrument; and

(b) cannot, to the extent to which it is committed by that instrument to that purpose or those purposes, be taken or used for any other purpose.

(2) For the purposes of this Act, ***planned environmental water*** is water that:

(a) is preserved, by a law of a State or an instrument made under a law of a State, for the purposes of achieving environmental outcomes by any other means (for example, by means of the setting of water flow or pressure targets or establishing zones within which water may not be taken from a water resource); and

(b) cannot, to the extent to which it is preserved by that instrument for that purpose or those purposes, be taken or used for any other purpose.

(3) The water may be committed to, or preserved for, the purpose or purposes referred to in paragraph (1)(a) or (2)(a) either generally or only at specified times or in specified circumstances.

(4) Without limiting paragraph (1)(b) or (2)(b), the requirements of paragraph (1)(b) or (2)(b) are taken to have been met even if the water is taken or used for another purpose in emergency circumstances in accordance with:

(a) the instrument referred to in that paragraph; or

(b) the law under which the instrument is made; or

(c) another law.

Appendix 4. Species lists for the CLLMM Priority Environmental Asset ecological targets

Species lists sourced from Department of Environment Water and Natural Resources, (in prep (a), cited in O'Connor, et al., 2015).

Table 18. TLM target waterbird species

Common Name	Scientific Name
Australasian bittern	*Botaurus poiciloptilus*
Australian pelican	*Pelecanus conspicillatus*
Australian spotted crake	*Porzana tabuensis*
Banded stilt	*Cladorhynchus leucoceohalus*
Black swan	*Cygnus atratus*
Chestnut teal	*Anas castanea*
Common greenshank	*Tringa nebularia*
Curlew sandpiper	*Calidris ferruginea*
Fairy tern	*Sterna nereis*
Latham‟s snipe	*Gallinago hardwickii*
Pied oyster catcher	*Haematopus longirostris*
Red-capped plover	*Charadrius ruficapillus*
Red-necked avocet	*Recurvirosta novaehollandiae*
Red-necked stint	*Calidris ruficollis*
Sanderling	*Calidris alba*
Sharp-tailed sandpiper	*Calidris acuminata*

Table 19. Waterbird species that breed annually in the CLLMM

Common Name	Scientific Name
Australian pelican	*Pelecanus conspicillatus*
Black swan	*Cygnus atratus*
Caspian tern	*Hydropogne* (*Sterna*) *caspia*
Crested tern	*Thalasseus bergii*
Fairy tern	*Sterna nereis nereis*
Hooded plover	*Thinornis rubricollis*
Australian white ibis	*Threskiornis molucca*
Australian pied oyster catcher	*Haematopus longirostris*
Sooty oystercatcher	*Haematopus fuliginosus*
Red-capped plover	*Charadrius ruficapillus*
Straw necked ibis	*Threskiornis spinicollis*

Table 20. Waterbird species that breed regularly in the CLLMM

Common Name	Scientific Name
Australian Pelican	*Pelecanus conspicillatus*
Pied cormorant	*Phalacrocorax varius*
Red-capped plover	*Charadrius ruficapillus*
Royal spoonbill	*Platalea regia*
Silver gull	*Chroicocephalus novaehollandiae*

Table 21. Waterbird species that should be present in the CLLMM in abundances >1% of current flyway thresholds

Common name	Scientific name
Fairy Tern	*Sterna nereis nereis*
Australian Pied Oystercatcher	*Haematopus longirostris*
Banded Stilt	*Cladorhynchus leucocephalus*
Chestnut Teal	*Anas castanea*
Curlew Sandpiper	*Calidris ferruginea*
Great Cormorant	*Phalacrocorax carbo carboides*
Red-necked Avocet	*Recurvirostra novaehollandiae*
Red-necked Stint	*Calidris ruficollis*
Sharp-tailed Sandpiper	*Calidris acuminata*
Red-capped Plover	*Charadrius ruficapillus*
Sanderling	*Calidris alba*

Table 22. Common CLLMM fish families

Family	Scientific name	Common name
Anguillidae	*Anguilla australis*	Southern shortfin eel
Arripidae	*Arripis georgianus*	Australian herring
Arripidae	*Arripis truttaceus*	Western Australian salmon
Atherinidae	*Atherinosoma microstoma*	Smallmouth hardyhead
Atherinidae	*Craterocephalus fluviatilus*	Murray hardyhead
Atherinidae	*Craterocephalus stercusmuscarum fulvus*	Unspecked hardyhead
Bovichtidae	*Pseudaphritis urvillii*	Congolli
Clupeidae	*Hyperlophus vittatus*	Sandy sprat
Clupeidae	*Nematolosa erebi*	Bony herring
Clupeidae	*Sardinops sagax*	Australian pilchard
Clupeidae	*Spratelloides robustus*	Blue sprat
Eleotridae	*Hypseleotris spp.*	Carp gudgeon complex
Eleotridae	*Philypnodon grandiceps*	Flat-headed gudgeon
Eleotridae	*Philypnodon macrostomus*	Dwarf flat-headed gudgeon
Engraulidae	*Engraulis australis*	Australian anchovy
Galaxiidae	*Galaxias maculatus*	Common galaxias
Geotriidae	*Geotria australis*	Pouched lamprey
Gobiidae	*Afurcagobius tamarensis*	Tamar goby
Gobiidae	*Arenigobius bifrenatus*	Bridled goby
Gobiidae	*Favonigobius lateralis*	Southern Longfin Goby
Gobiidae	*Pseudogobius olorum*	Bluespot goby
Gobiidae	*Tasmanogobius lasti*	Lagoon goby
Hemiramphidae	*Hyporhamphus melanochir*	Southern garfish
Hemiramphidae	*Hyporhamphus regularis*	River garfish
Melaenotaenidae	*Melanotaenia fluviatilis*	Murray rainbowfish
Mordaciidae	*Mordacia mordax*	Short-headed lamprey
Mugilidae	*Aldrichetta forsteri*	Yelloweye mullet
Mugilidae	*Liza argentea*	Goldspot mullet
Mugilidae	*Mugil cephalus*	Sea mullet
Myliobatidae	*Myliobatis australis*	Southern eagle ray
Nannopercidae	*Nannoperca australis*	Southern pygmy perch
Nannopercidae	*Nannoperca obscura*	Yarra pygmy perch
Percichthyidae	*Macquaria ambigua*	Golden perch
Pleuronectidae	*Ammotretis rostratus*	Longsnout flounder
Pleuronectidae	*Rhombosolea tapirina*	Greenback flounder
Retropinnidae	*Retropinna semoni*	Australian smelt
Sciaenidae	*Argyrosomus japonicus*	Mulloway
Sparidae	*Acanthopagrus butcheri*	Black bream
Tetraodontidae	*Contusus brevicaudus*	Prickly toadfish
Tetraodontidae	*Contusus richei*	Barred toadfish

Tetraodontidae	*Tetractenos glaber*	Smooth toadfish
Tetrarogidae	*Gymnapistes marmoratus*	Soldier

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