



Site options profile #L15

Weir Pool 3 - Draft

Lock 3 Master Plan



Location: River Chainage Markers 516.2 to 431.1, Bookpurnong to Overland Corner.

Length: 84.8 km

Land Tenure: N/A

Normal Pool Level: +9.8 mAHD

PROPOSED OPTIONS	
Option #1:	Enable weir pool lowering (WPL) to -60 cm below normal pool level (NPL) to generate temporary lotic habitats and variability in cross-sectional velocity across the whole length of the weir pool, whilst protecting fresh groundwater lenses, sustaining long-lived vegetation and enhancing plant diversity.
Description	Lowering of Weir 3 is limited to +9.77 mAHD (-3 cm below NPL) under current constraints. Investigations are required to confirm whether existing infrastructure allows for lowering capacity of the weir to increase to -60 cm below NPL. Increasing the lowering range would require potential constraints (e.g. water quality, navigation and pump access) to be managed to avoid adverse environmental, social and economic outcomes.
Outcomes	• Temporary disconnection and drying of in-channel habitats and pool-connected floodplain, wetland and anabranch ecosystems that are permanently inundated at NPL (part of introducing a more variable water regime). • Temporarily increased lotic habitat and hydraulic diversity in Weir Pool 3 during lowering (temporary extension of habitats for Murray Cod and other fauna that prefer fast-flowing water). • Export salt by draining saline groundwater and impounded wetland water into the river and out to sea on a more frequent basis leading to long-term improvements in water quality and reduced water quality constraints (noting that removal of salt will relax water quality constraints and increase opportunities for active management in other parts of Weir Pool 3 itself and the downstream river reaches in the long term). • Temporarily increased flow velocities in permanent anabranches with their outlet/s in lowered weir pool 3 (e.g. Katarapko Creek). • Temporarily reduced flow velocities in permanent anabranches with their inlet/s in lowered weir pool 3 (e.g. two inlet creeks to Banrock Creek complex). • Increased food web complexity and long-term ecosystem resilience below NPL from more variable water regime. • Increased productivity due to transport of matter from pool-connected floodplains, wetlands and anabranches to the river during recession at beginning of WPL (and back from the river during subsequent refill to NPL after lowering). • Improved health and diversity of trees, reedbeds and understorey plants that otherwise have a permanent static water regime by temporarily aerating their root zones (and subsequent recharging of soil moisture when returning to NPL). • Improved seed and egg bank viability, plant germination and animal hatching in shallow water and exposed soils, snags and other substrates. • Improved soil health and enhanced nutrient cycling from temporary drying and soil aeration (long-term reduction in Acid Sulfate Soils). • Increased dispersal and movement of plants and animals through Weir Pool 3 habitats and along the length of the river. • Recharge freshwater lenses by draining during WPL and refilling when returned to NPL.
Option #2:	Enable weir pool raising (WPR) to +60 cm above normal pool level (NPL) to increase inundation extent and lateral connectivity and generate variability in water levels that supports an interconnected mosaic of diverse submerged, littoral, riparian and floodplain habitats and mixed cohorts of native woody-perennial plants, whilst protecting perennial lotic habitats.
Description	Weir Pool Raising (WPR) in Weir Pool 3 is currently constrained to +10.02 mAHD (+22 cm above NPL) due to weir stability with the raising only to occur at flows above 20,000 megalitres per day (ML/day) due to salinity risks from Lake Bonney discharge at lower flows. Top of piers is at +10.39 mAHD, which presents an opportunity for WPR of c. +60 cm above NPL (+9.8 mAHD). This would require weir stability and water quality issues to be addressed. The interactions between WPR and flows into wetland complexes (e.g. Lake Bonney and Banrock Station) need to be modelled across a range of flow and weir pool manipulation (WPM) scenarios to optimise integrated operations.

Outcomes	• Temporary increased extent and depth of inundation in channel habitats and floodplain, wetland and anabranch ecosystems within the influence of WPR under the given flow regimes (part of introducing a more variable water regime). • Temporarily reduced lotic habitat in Weir Pool 3 during raising, including temporarily reduced flow velocities in permanent anabranches with their outlet/s in raised weir pool 3 (e.g. Katarapko Creek) • Temporarily increased flow velocities in permanent anabranches with their inlet/s in raised weir pool 3 (e.g. Banrock Creek wetland complex). • Export salt by inundating impounded wetlands and subsequently flushing salt into the river when returning to NPL and out to sea on a more frequent basis leading to long-term improvements in water quality and reduced water quality constraints (noting that removal of salt will relax water quality constraints and increase opportunities for active management in Weir Pool 3 and downstream weir pools in the long term). • Increased area and diversity of littoral, riparian and floodplain communities, including increased diversity in age classes from repeat events at different heights. • Increased food web complexity and nutritional value in biofilm, plankton and macroinvertebrate communities, leading to long-term ecosystem resilience above NPL from more variable water regime. • Improved area, health and diversity of trees, reedbeds and understorey plants that otherwise only receive water during floods by temporarily increasing soil moisture. • Improved seed and egg bank viability, plant germination, biofilm colonisation and animal hatching in freshly inundated sediments, snags and other substrates. • Improved soil health and enhanced nutrient cycling in freshly inundated sediments. • Increased connectivity, matter transport, dispersal and movement of plants and animals through Weir Pool 3 habitats and across the elevation gradient during WPR (from the channel through wetlands and anabranches to the floodplain). • Recharge groundwater by saturating soils and inundating dry wetland basins during WPR.
-----------------	---

Option #3:	Enable WPL and raising to greater extents (WPR +60 cm, WPL -60 cm) than under current constraints to achieve widespread environmental benefits from increased variability in water regimes across the elevation gradient (both above and below NPL), increased diversity and maximum flow velocities in the channel and anabranches and improved water quality.
Description	It has been estimated that the River Murray experienced water level variations on a variety of time scales, ranging over approximately 12 metres from lows during dry periods to the top of the biggest floods. Implementing the full range of operations in the Weir Pool Operating Plan for Weir Pool 3 across the elevation range from +60 cm WPR to -60 cm WPL (a vertical range of 1.2 m, one tenth of the natural range) will generate a substantially greater degree of water level variability than under current constraints. This will promote a spatially and temporally complex mosaic of wet, dry and drying floodplain lentic and lotic aquatic habitats across a wider elevation gradient than current. It is also expected that a combination of WPR and WPL will export salt from pool-connected wetlands (e.g. Lake Bonney) that will relax water quality constraints on WPM in Weir Pool 3 and downstream reaches of the River Murray.
Outcomes	As for Options 1 and 2, but it is expected that a management regime that includes both WPR and lowering will have additional benefits associated with varying water levels over the full 1.2 m height variation from WPR +60 cm to WPL -60 cm, especially enabling the export of salt out of Lake Bonney to the river and then to the ocean, and including: • Increased ecosystem health, complexity and resilience within channel and otherwise permanent (pool-connected) wetland habitats from increased variability in water regime from maximum WPR to maximum WPL. • Increased water regime variability and more frequent wetting and drying of floodplain, wetland and anabranch ecosystems between NPL and maximum WPR. • Increased connectivity between upstream and downstream reaches as well as channel, floodplain, wetland and anabranch ecosystems across time and space. • Increased food web complexity and nutritional value of biofilm, plankton and macroinvertebrate communities. • Improved transport of matter along the river and between channel and floodplain, wetland and anabranch ecosystems. • Increased productivity and habitat complexity, including a wide and diverse littoral zone connected to woodland communities with a diversity of plant age classes as well as species. • Reduced need for pumping environmental water to temporary habitats and associated costs. *Refer to individual wetland and anabranch profiles for site-specific implications of weir pool raising and lowering.

SITE BACKGROUND

Description

Weir Pool 3 encompasses the channel area between River Murray Weirs and Locks 3 and 4 (at Overland Corner and Bookpurnong, respectively) as well as the area of the floodplain under the influence of Weir 3 at different flows. The River Valley part of this reach has a wide floodplain containing a range of wetlands and anabranches that narrows to enter the River Gorge at the Weir 3 end of the reach. The WPM Zone of Influence includes the River Murray channel, permanent (pool-connected) and temporary wetlands, permanent and temporary anabranches and areas of floodplain¹. At 85 km in length, Weir Pool 3 is comparatively longer than other weir pools, which creates greater velocities in the upper sections of the weir pool⁶. The area immediately downstream of Weir and Lock 4 (Weir Pool 3 tailwaters) is considered the best remaining main channel habitats for Murray Cod in the SA River Murray.

Wetland and floodplain units currently connected at normal pool level (NPL) include Loch Luna, Lake Bonney, Kingston Common, Wachtels Lagoon and Katarapko Creek. Structures to disconnect waterways from the weir pool are in place at Banrock Station, Loveday Swamps and Mussels Lagoons, Yatco Lagoon, Beldora and Spectacle Lakes and Pyap Complex. The two inlet creeks to the Banrock Station Wetland Complex are immediately upstream of Lock and Weir 3 and thus will be affected by manipulation of Weir Pool 3 and can be used to by-pass flows around the weir, if required.

Water is drawn from Weir Pool 3 to service Kingston, Cobdogla, Moorook, Pyap, Loxton, Media, Sherwood, and Rilli irrigation districts, with irrigation drainage diverted to Cobdogla and Loveday evaporation basins. Town water supplies for Kingston-on-Murray, Moorook, Pyap and Loxton are also derived from Weir Pool 3.

There has already been significant investment in infrastructure as part of the Riverine Recovery Project (RRP) and SA Riverland Floodplain Integrated Infrastructure Program (SARFIIP) to support wetland and anabranch management in this reach, including at Pyap Lagoon, Yatco Lagoon, Beldora Wetlands and on the Katarapko Floodplain.

Cultural Significance

The River Murray and Mallee Aboriginal Corporation (RMMAC) holds native title over the River Murray within the Lock 3 Reach. The First Peoples' intimate knowledge and understanding of Country and active participation across all levels is vital to the effective management of this landscape.

Post-colonial Use

Weirs were constructed in the SA River Murray between 1922 and 1930 with the primary aim of creating stable water levels to support riverboat navigation, but they also established reliable town water and irrigation supplies. Lock and Weirs 3 and 4 were constructed in 1925 and 1929, respectively². Increased water extraction and river regulation have led to fundamental changes in flow regime, especially reduced small and medium floods (overbank flows), changes in seasonality of flows and reduced lateral connectivity along the river, with a substantial reduction in water reaching SA¹. Installation of the weirs has resulted in static water levels at a relatively high position within the channel and a decline in fast-flowing (lotic) habitat, impacting flow-dependent species inhabiting the channel, such as Murray Cod, Golden perch and Murray Crays (the latter now extinct in SA)⁶. Removal of large woody habitat ("snags") from the river to enhance navigation also commenced around this time, continuing until the mid-1990s. This practice has reduced structural complexity and habitat availability in the channel and anabranches.

SITE ECOLOGY

The entire SA River Murray Channel is a designated Icon Site under *The Living Murray* Initiative in recognition of its ecological and cultural significance.

Flora: Plant functional groups include⁵:

- Terrestrial dry
- Terrestrial damp
- Floodplain
- Amphibious fluctuation tolerator – low growing
- Amphibious fluctuation tolerator – emergent
- Amphibious fluctuation tolerator – woody
- Amphibious fluctuation responder – plastic
- Amphibious fluctuation responder – floating
- Perennial – emergent
- Submerged – k selected (completely water-dependent species requiring inundation duration of greater than 6 months)
- Submerged – r selected (those that colonise recently flooded areas).

Fauna: The upper 16km of Weir Pool 3 contains fast-flowing (lotic) channel habitat supporting large-bodied fish including golden perch (*Macquaria ambigua*), the critically endangered silver perch (*Bidyanus bidyanus*) and the vulnerable Murray cod (*Maccullochella peelii*), alongside other biota dependent on lotic conditions. This reach is significant due to the scarcity of this type of lotic habitat within the SA River Murray channel⁶. Hollow-bearing river red gums (*Eucalyptus camaldulensis*) along the main river channel provide a corridor for movement and nesting habitat for regent parrots⁷ (*Polytelis anthopeplus monarchoides*), which are listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. Stable water levels result in simple river red woodlands dominated by trees of only a few age groups in narrow bands with low levels of understorey diversity and cover.

SITE MANAGEMENT

Current Management: The Lock and Weir 3 structures are managed by SA Water. The weir pool is not currently managed for ecological purposes. Weir 3 was raised to +20 cm above NPL in 2015 for operational purposes, however, concerns regarding the stability of the weir prevented it from being raised higher¹. WPL

is currently highly constrained due to pump access by irrigators and navigation issues due to sand bar exposure around Loxton. In addition, a flow threshold of 20,000 ML/day QSA is in place for Weir Pool 3 manipulations for ecological benefits in order to manage salinity impacts from Lake Bonney¹. Maintaining Weir Pool 3 at or near Normal Pool Level (NPL) has resulted in a range of adverse ecological impacts, such as:

- Limiting over bank flows, and thus connectivity between low-lying floodplain and channel habitats, to periods of unregulated flow.
- Simplified in-channel ecosystems and geomorphology through bank slumping and erosion.
- Simple biofilm, macroinvertebrate and plankton communities of poor nutrition in channel and pool-connected wetlands.
- Narrow and simple bands of riparian and littoral vegetation (dominated by a few species with stands of limited age classes).
- On-going drainage of saline groundwater to the river channel from irrigation areas and sedimentation of the channel above Weir 3.
- Lost opportunities for spawning of flow-cued fish species and recruitment of fish needing fast-flowing water (e.g. Murray Cod, Golden perch and Silver perch).
- Permanent loss of species (e.g. Murray Crays) and habitat diversity at a weir pool scale, especially loss of perennial lotic habitats (now restricted to upper weir pool and anabranch habitats).
- Limiting inundation of temporary wetlands, which are predominantly dry and disconnected except during periods of unregulated flow, so that they only support simple communities that are trending towards dominance by annual weeds and/or terrestrial species.
- Limited opportunity for transport of salt, carbon, organic matter and nutrients through the river system.

Infrastructure: Weir 3 was constructed in 1925 and comprises a series of concrete piers with fixed and adjustable sections including trestles which are removed in high flows (above 55-63 ML/day) and reinstated at 60-64.5 ML/day¹. Water levels within the weir pool are managed via removable stop logs². An adjacent lock alters the water level to allow boats to navigate between the weir pools. A vertical slot fishway was installed alongside weir 3 in 2008 to facilitate movement of fish between 40-1000 mm in length³. Top of piers is currently 10.39 mAH⁴.

ISSUES AND DRIVERS

As part of the Master Planning Project engagement process, an ongoing register of issues and drivers relating to sites and options was maintained. These highlighted key considerations and investigations that would need to be factored in and undertaken as part of any next steps towards realising the outcomes described within the option profiles. For WPM, these included:

Environmental

- Weir pool lowering (WPL): WPL has the potential to increase flow of saline regional groundwater towards the River Murray, raising salinity levels in the main channel and in permanent anabranches and wetlands⁵. Similarly, WPL may export salt which has concentrated over time in pool-connected wetlands, also impacting the water quality of downstream sites⁵. While there are ecological benefits in using WPL as a method of mobilising salt from terminal wetlands, its transport through creeks and the main river channel could present both an ecological risk to sensitive flora and fauna, but also an economic risk if water is unsuitable for use by downstream irrigators^{1,5}. WPL may also expose sandbars near Loxton, impacting navigation between Loxton and Lock 4, which is marginal at NPL¹. Investigations are required to determine the severity of the issue and identify any mitigations, if appropriate.
- Weir pool raising (WPR): Weir stability may be an issue for raising above 20 cm above NPL, while flows currently bypass the weir at approximately 50 cm above NPL¹. Raising has potential to create a temporary loss of lotic habitat in the upper weir pool, which has been identified as the best in-channel Murray Cod habitat in SA River Murray and may also impact on flow-cued fish populations. To minimise these impacts, fish habitat provision needs to be undertaken at a population scale (informed by modelling) with WPR as one component of an overall, coordinated management regime.
- Maintenance of static weir pool levels has resulted in fresh groundwater lenses at the downstream end of the weir pool that support healthy, long-lived vegetation such as river red gums, river coobah and black box that need to be considered in terms of risks associated with implementing a more variable water regime in Weir Pool 3.

Cultural

- Construction works and subsequent management need to be mindful not to disturb areas of cultural importance.

Community/Social

- Weir pool raising and lowering: Changes in water level could drown pumps or restrict pump access for private irrigators (and stock and domestic). Investigations are required to determine whether pumps and/or offtakes need to be altered to better manage fluctuations in water level.

Operational/logistics

- Fishway function is impaired by both raising and lowering – entrance out of the water during lowering, attractant flow potentially impacted by raising. Investigations are required to precisely measure the fishway entrance and exit spill levels to determine the operational ranges that can be accommodated by the current design and whether modifications are required.

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Landcare
- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Gerard Aboriginal Community
- Loxton Waikerie Council
- Loxton Waikerie Landcare
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- Murray-Darling Basin Authority (MDBA)
- South Australian Murray Irrigators

REFERENCES

¹Muller, K.L and Creeper, N.L. 2020. Interim Weir Pool Manipulation Operations Plan for Locks 6 to 1. Part Two: Operating Plan for Locks 6 to 1. A report for Department of Environment and Water, Government of South Australia, Adelaide, SA 5000.

²MDBA <https://www.mdba.gov.au/water-management/infrastructure/weirs-locks>. Accessed 1 December 2020.

³Barrett, J. and Mallen-Cooper, M. 2006. The Murray River's 'Sea to Hume Dam' fish passage program: Progress to date and lessons learned. Ecological Management & Restoration Volume 7, Issue 3

⁴URS 2014. Final Report River Murray Lock and Weir no's 1 to 10

⁵Denny, M.L., Creeper, N.L. & Gilmore, K.L. (2021). Weir pool management framework: Ecological conceptual models, DEW Technical report 2021, Government of South Australia, Department for Environment and Water, Adelaide.

⁶Bice, C. M. et al. 2017. Putting the "river" back into the lower River Murray: quantifying the hydraulic impact of river regulation to guide ecological restoration. Transactions of the Royal Society of South Australia

⁷Harper, M.J. 2020. Maximise Water Delivery for Regent Parrot Outcomes - Management Framework Prepared by the South Australian Regent Parrot Recovery Team for the Commonwealth Environmental Water Office, Australian Department of the Environment and Energy.

