Lock 3 Reach Master Plan





Government of South Australia

Department for Environment and Water

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The Department for Environment and Water acknowledges Aboriginal people as the First Peoples and Nations of the lands and waters we live and work upon and we pay our respects to their Elders past, present and emerging. We acknowledge and respect the deep spiritual connection and the relationship that Aboriginal and Torres Strait Islander people have to Country.

The Department works in partnership with the First Peoples of South Australia and supports their Nations to take a leading role in caring for their Country.

The Master Plans Project was funded through the SARFIIP (South Australian Riverland Floodplains Integrated Infrastructure Program); a \$155 million investment program funded by the Australian Government through the Murray Darling Basin Authority and implemented by the South Australian Government to improve the watering and management of River Murray floodplains in South Australia's Riverland.

Project summary

Background

Lock 3 controls 85 km of the Murray River and contains the most diverse range of flow conditions of all the weir pools in the South Australian River Murray. The Reach connects many significant water bodies, including Lake Bonney, Banrock Station and Wachtels Lagoon. It is also the heart of the Riverland townships of Loxton and Barmera and others, which all rely on this stretch of river for human use, irrigation, industry and tourism.

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.

There has already been significant infrastructure investment in Lock 3 Reach to support River Murray environmental outcomes, namely at Pyap Lagoon, Yatco Lagoon and Beldora and Spectacle Lakes wetland complex, as well as recent investment on the Katarapko Floodplain.

Currently there are multiple key threats causing ecological decline in the region, including reduced frequency and duration of floodplain inundation, loss of variability in water levels, salinity load, and obstructions to fish passage. However, the extent of environmental benefit that could be achieved in this Reach has been constrained due to salinity risks, operational constraints and legacy social issues from past river management. This project aimed to address the complex combination of ecological and hydrological issues that is unique to the Lock 3 Reach.

Master Plans Project objective

The objective the Project was to develop a 'master plan' for achieving environmental outcomes in the Lock 3 Reach through future investment initiatives, in collaboration with community stakeholder groups. The Master Plans Project was informed through consultation and investigations, which identified and explored the feasibility of a suite of options and has made recommendations on a pathway to proceed, demonstrating the value of further investment. These investments are a combination of infrastructure investments (such as regulating structure upgrades e.g. stone weir) and operational investments (such as management of Lake Bonney), focused on achievement of environmental outcomes.

Ultimately, the outcomes of implementing a program of complementary works within the Bookmark Creek Complex, following the master plan development, are:

- Efficient and effective resource allocation (e-water, people, infrastructure) as a result of having a clear, prioritised pathway for future investment in Bookmark Creek Complex
- Confidence and increased flexibility in operations through having a detailed understanding of the outcomes of operational scenarios and how these contribute towards environmental outcomes
- Enhanced environmental outcomes as a result of increased hydraulic diversity and connectivity, particularly in improving unique fish habitat in the anabranch system
- Enhanced social, economic and recreational benefits associated with improved connectivity, amenity and condition of high value wetlands / floodplains throughout the region.

The finalised master plan is a key milestone in the Sustaining Riverland Environments (SRE) Program initiative, which will deliver practical projects to improve river and wetland health, and support native fish in the River Murray. Projects that are included in the master plan will have the opportunity to receive funding under the SRE program. In particular those that align strongly with SRE objectives.

While significant investigations and local planning initiatives have been developed in the region, there is no governing strategic direction for the entire Lock 3 Reach. Only after key threats, values and objectives have been clearly defined and holistic ecological and hydrological assessment undertaken with continued stakeholder engagement, can informed decisions be made in selecting the most feasible and appropriate infrastructure and management solutions for investment.

Master Planning process

The Master Plans Project began in July 2019 as an initiative of the South Australian Government as part of its South Australian Floodplains Integrated Infrastructure Program (SARFIIP), funded by the Federal Government through the Murray-Darling Basin Authority. The project has occurred over two years and is a continuation of the Environmental Pathways Project (EPP). EPP was aimed at ensuring the return of water to the environment under the Basin Plan is managed in an efficient and effective manner, improving the ecological health and resilience of the South Australian River Murray, between Locks 1-7.

Traditional River Murray planning approaches have started first with a set of discrete environmental objectives, to focus development of options for works and measures to best meet those objectives. The Master Plans Project was delivered using a new approach toward River Murray project planning and prioritisation, facilitating an open community forum to generate and collate ideas with a broad range of potential environmental objectives, rather than a single targeted objective. This resulted in a suite of potential options that can be prioritised for funding under future programs, based on their alignment with the various objectives of those programs.

Productive and beneficial engagement with the RMMAC Working Group through the Master Plans Project highlighted the need to maintain strong engagement with First Peoples throughout the application of the works and measures. This should be incorporated into planning of future master planning projects, and the next stages of project implementation.

Planning at a weir pool scale (such as the Lock 3 Reach), enabled an adequate project size for engagement with a variety of stakeholder groups, and generated a variety of potential opportunities and outcomes. It also enabled a large enough project footprint to realise a coordinated approach to future management in the Reach.

Site option profiles

Working with key stakeholders within the Riverland community, a comprehensive list of ideas and initiatives to support environmental outcomes has been compiled, collated and refined to form the foundations of the Lock 3 Reach Master Plan. These ideas and initiatives have been summarised into 'Site Option Profiles', with some 'Sites' consisting of multiple and in some instances, scalable options.

A total of 20 'Site Option Profiles' have been developed within the Lock 3 Reach:

- 1. Katarapko Creek
- 2. Katarapko Creek Floodplain West
- 3. Katarapko Island North
- 4. Clarks Floodplain
- 5. Rilli Reach
- 6. Rilli Lagoon
- 7. Thiele Flat
- 8. Loxton Riverfront
- 9. Katarapko Island South
- 10. Gerard Complex
- 11. Pyap Complex
- 12. Beldora and Spectacle Lakes
- 13. Yatco Lagoon
- 14. Loveday Mussels
- 15. Wachtels Lagoon
- 16. Lake Bonney
- 17. Loch Luna
- 18. Banrock Station
- 19. Overland Corner
- 20. Weir Pool 3 Reach



Site option profiles

Katarapko Creek

Location: River Murray anabranch, River Chainage Markers 513 to 482 Land Tenure: Crown record Creek Length: 16.2 km Normal Pool Level: 10.1 mAHD

PROPOSED OPTIONS	
Option #1:	Improve fish passage and flow conditions within Katarapko Creek by replacing the 'Stone Weir' structure with a new structure that can have variable heights and provide fish passage.
Description	The 'Stone Weir' structure currently restricts the flow within Katarapko Creek and creates a 'hydraulic step' and physical barrier, which prevents fish passage. This option aims to remove and replace the 'Stone Weir' with a structure, which will include a fish passage, as well as the ability to adjust the structure height. This will allow for fish passage whilst maintaining hydraulic conditions. The adjustable height design will align with the need to maintain water levels in the main channel, whilst introducing management flexibility to respond to river conditions as needed.
	Recent infrastructure constructed and managed to support outcomes within Eckert's Creek and on the Katarapko Floodplain, when operated, have the potential to improve flow conditions within Katarapko Creek. Structure design, including structure placement, should have consideration of this opportunity and the potential benefits it could yield for Katarapko Creek and in particular, large bodied native fish.
	A potential increase in future medium to high-flow events proposed under the Constraints Management Strategy (CMS) together with future natural high-flow events will continue to erode the structural integrity of 'Stone Weir' posing a risk to river levels and flow in the river, which would impact irrigation offtakes, navigation and the Loxton riverfront.
	Design considerations would need to account for access needs, including to support fire management activities on Katarapko Island, accessing structures for proposed floodplain watering options on Katarapko Island, ecological monitoring and recreational opportunities including canoeing, fishing, mountain biking and bushwalking.
Outcomes	 Improved hydraulic conditions for fish. Improved fish passage. Risk mitigation through the maintenance of water levels and flow in the river for navigation and irrigation extraction.

SITE BACKGROUND

Description

Katarapko Creek is an anabranch of the River Murray downstream of Lock 4. Located within the Katarapko section of the Murray River National Park, the creek provides high recreational value (e.g., canoeing, kayaking, camping) and contains habitat for native fish. Flows enter Katarapko Creek from the River Murray, downstream of Lock 4 and then converge with flows from Eckerts Creek (at The Splash), ultimately flowing back into the River Murray, immediately downstream of Loxton Township. The 'Stone Weir' structure sits immediately downstream of the Katarapko Creek inlet.

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

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in the wetland complex has been altered. Following the construction of Lock 3 in 1925, approximately 151 hectares of the wetlands in the wetland complex were permanently connected with the River Murray at weir pool level. The lack of water level variation in these areas resulted in the decline of floodplain habitat within the wetland complex. The installation of regulators has since enabled the wetting and drying of the wetlands, improving the ecology within this area¹.

The original Stone Weir was constructed circa 1908 and consisted of a stone-filled timber crib weir, which was designed to move more water down the main river channel by holding it back from Katarapko Creek. This kept water levels high for the navigation of steam boats and other vessels. This has created a major barrier for the movement of native fish and restricted flows through the creek.

WETLAND ECOLOGY

Ecological Role: Katarapko Creek is part of a larger protected area with diverse habitat and wetland types and is of high conservation value^{1,2}. Katarapko Creek is within the Murray River National Park which is proclaimed to conserve a significant proportion of South Australia's floodplain environments which are not represented widely in other reserve systems³.

Flora and Fauna: The major vegetation communities within the Katarapko floodplain include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire/ chenopod shrublands. It is home to a wide variety of wildlife, some of them listed as species of conservation significance under national and/or state legislation⁴. Katarapko is a priority floodplain for environmental flows in South Australia and is currently the only Demonstration Reach for Native Fish in South Australia^{4,5}.

WETLAND MANAGEMENT

Current Management:

The Department for Environment and Water's National Parks and Wildlife Service SA is responsible for the management of the Katarapko section of the Murray River National Park. Katarapko Creek is a popular destination for recreational tourism, including kayaking, fishing, camping and birding. As noted in the subsection below, there is currently no infrastructure at the Stone Weir to modify flow levels or provide fish passage through Katarapko Creek.

Infrastructure:

Stone Weir: The Stone Weir was originally constructed in 1908 to ensure adequate water levels were maintained through the Loxton irrigation area during low flow periods. The present weir is a 50 m wide constructed rock filled weir, which affords pedestrian access to Katarapko Island during periods of low flow. There are no regulators or structures which provide fish passage present at the weir during periods of low flow. A large scour hole has developed downstream of the weir that has the potential to threaten the integrity of the structure⁶. The size of the rock remaining at the crest is generally very large (>500 mm) with smaller sized rocks (>200 mm) at the edges of the weir where velocities are lower. Under regulated conditions, water flows through the permeable stone weir and the weir begins to be overtopped at flows greater than 8 000 megalitres per day (ML/day) in the main channel. It is completely inundated when flow reaches approximately 14 000 ML/day in the River Murray. The presence of the weir also lowers water velocity through Katarapko Creek, limiting the suitability of this creek to provide habitat for native fish.

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 Katarapko Creek, these included:

Environmental

- There is a low to medium risk associated with acid sulfate soils at this site⁷. This would require further assessment before any construction works or wetting and drying activities are undertaken.
- Consider how to pest-proof the weir (gate) and minimise construction footprint to avoid vegetation impacts.

Cultural

 Strong First Peoples cultural interests in the area. Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

- Site has strong community and historical value.
- Stone weir currently maintains water levels in the main river channel through Loxton. If Stone Weir was removed with no replacement structure, the main river water levels would drop approximately 27 cm during flows of 10,000 ML/day at Lock 5, potentially restricting boating and pumping activities through Loxton.
- Campers will have access to site and security will be an issue.

Operational/Logistics

• A large scour hole exists immediately downstream of 'Stone Weir' which presents a construction and design risk.

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Landcare
- Central Irrigation Trust
- Commonwealth Environmental Water Office (CEWO)
- Friends of the Riverland Parks
- Katarapko Advisory Panel (KAP)
- Loxton Waikerie Council
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

- Jensen A, South Australia, Department of Environment and Natural Resources, South Australian River Murray Wetlands Management Committee. Wetlands atlas of the South Australian Murray Valley: a summary of current knowledge of Murray Valley wetlands as a basis for integrated catchment management. Adelaide: Dept. of Environment and Natural Resources; 1996.
- 2. Thompson MB. River Murray Wetlands Their Characteristics, Significance and Management. Adelaide: University of Adelaide for the Department of Environment and Planning and the Nature Conservation Society of South Australia; 1986.
- 3. DENR. Murray River National Park Management Plan (Including Rilli Island, Media Island and Kapunda Island Conservation Parks). 1994.
- 4. DEW. EPBC Self-assessment- Operation of surface water management infrastructure on the Katarapko Floodplain. 2019.
- 5. Wallace TA. Eckerts-Katarapko floodplain Tree condition survey data April 2015-March 2019. Report produced by Riverwater Life Pty Ltd for the Department for Water and Environment, South Australian Government (Draft version released April 2019); 2019.
- DEWNR. Minute, Katarapko Stone Weir Lowering Crest height, File no: 11/5539, Document no: DEWNRD00011037. 2017.
- 7. Grealish G, Shand P, Grocke S, Baker A, Fitzpatrick R, Hicks W. Assessment of Acid Sulfate Soil Materials in the Lock 1 to Lock 5 Region of the Murray-Darling Basin. CSIRO: Water for a Healthy Country National Research Flagship.; 2010.



Katarapko Floodplain (West)

Location: River Murray anabranch, downstream of Lock 4. Land Tenure: Crown Record Wetland Size: 322 hectares (Ha) Normal Pool Level: +10.1 mAHD

PROPOSED OPTIONS	
Option #1:	Promote the conservation of the local regent parrot population, by supporting the installation of new embankments and structures enabling watering activities as described within the Regent Parrot Recovery Project.
Description	Katarapko Floodplain (West) falls within the 'Katarapko regent parrot floodplain habitat zone', identified as part of the Regent Parrot Recovery Project. There are a number of potential key watering sites within this area noted. Water from Katarapko Creek would be pumped into retention basins to support the conservation and improvement of vegetation important to the regent parrot. These activities are seen as a key part of the realising the conservation of the resident regent parrot population. Works would involve construction of regulating structures and blocking banks.
Outcomes	 Conservation and improvement of vegetation important to the regent parrot. Support the conservation of the current regent parrot population. Improved soil moisture conditions.

SITE BACKGROUND

Description

The Regent Parrot Recovery Project sites are located west of Katarapko Creek, an anabranch of the River Murray downstream of Lock 4. Located within the Katarapko section of the River Murray National Park, this area provides nesting and foraging habitat for the regent parrot, as well as opportunities for recreational activities, including canoeing, kayaking, and camping.

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

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in the wetland complex has been altered. The lack of inundation in these areas has resulted in the decline of floodplain habitat within the wetland complex.

WETLAND ECOLOGY

Ecological role: The Katarapko Floodplain (West) is part of a larger protected area with diverse habitat and wetland types and is of high conservation value ^{1,2}. The floodplain area is within the Murray River National Park which is proclaimed to conserve a significant proportion of South Australia's floodplain environments which are not represented widely in other reserve systems³.

Flora and fauna: The major vegetation communities within the Katarapko floodplain include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire/ chenopod shrublands. It is home to a wide variety of wildlife, some of them listed as species of conservation significance under national and/or state legislation⁴. Among the listed species is the vulnerable regent parrot (*Polytelis anthopeplus monarchoides*). Katarapko is a priority floodplain for environmental flows in South Australia and is currently the only Demonstration Reach for Native Fish in South Australia^{4,5}.

WETLAND MANAGEMENT

Current Management:

The Department for Environment and Water's National Parks and Wildlife Service is responsible for the management of the Katarapko section of the Murray River National Park. The park is a popular destination for recreational tourism, including kayaking, fishing, camping and birding.

Infrastructure:

There is currently no permanent infrastructure to support water delivery within the Katarapko Floodplain (West) area, with current efforts utilising a series of temporary embankments. The installation of additional embankments and structures would support the current management efforts and increase opportunities for outcomes within the floodplain.

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 Katarapko Floodplain, these included:

Environmental

- There is a low to medium risk associated with acid sulfate soils at this site ⁶ and this would require further assessment before any construction works or wetting and drying activities are undertaken.
- Potential investigations needed into whether to hold water for evaporative drying or return flow from the floodplain.
- Need to consider potential impacts on water quality and connectivity during high flows, and ecological benefits for species other than for regent parrots.
- Note that current watering efforts are already occurring in the southwest site (12.4 mAHD).

Cultural

• Strong First Peoples cultural interests in the area and within Gerard community. Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

- Site has strong community and historical value; further construction may be unpopular.
- National parks management requirements are important for this option.

KEY STAKEHOLDER INVOLVEMENT

- Central Irrigation Trust
- Commonwealth Environmental Water Office (CEWO)
- Floodplain and Wetlands Landscape SA
- Friends of the Riverland Parks
- Katarapko Advisory Panel (KAP)
- Loxton Waikerie Council
- Murray-Darling Basin Authority (MDBA)
- National Parks and Wildlife Service SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)

- Jensen A, South Australia, Department of Environment and Natural Resources, South Australian River Murray Wetlands Management Committee. Wetlands atlas of the South Australian Murray Valley: a summary of current knowledge of Murray Valley wetlands as a basis for integrated catchment management. Adelaide: Dept. of Environment and Natural Resources; 1996.
- 2. Thompson MB. River Murray Wetlands Their Characteristics, Significance and Management. Adelaide: University of Adelaide for the Department of Environment and Planning and the Nature Conservation Society of South Australia; 1986.
- 3. DENR. Murray River National Park Management Plan (Including Rilli Island, Media Island and Kapunda Island Conservation Parks). 1994.
- 4. DEW. EPBC Self-assessment- Operation of surface water management infrastructure on the Katarapko Floodplain. 2019.
- Wallace TA. Eckerts-Katarapko floodplain Tree condition survey data April 2015-March 2019. Report produced by Riverwater Life Pty Ltd for the Department for Water and Environment, South Australian Government (Draft version released April 2019); 2019.
- 6. Grealish G, Shand P, Grocke S, Baker A, Fitzpatrick R, Hicks W. Assessment of Acid Sulfate Soil Materials in the Lock 1 to Lock 5 Region of the Murray-Darling Basin. CSIRO: Water for a Healthy Country National Research Flagship.; 2010.



Katarapko Island (North)

Location: Weir Pool 3, River Chainage Markers 513 to 498 Land Tenure: Crown Record Area: 1,630 hectares (Ha) (approx.) Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS		
Option #1:	Improve floodplain condition by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments.	
Description	This option aims to optimise the floodplain inundation and retention extent through the installation of regulating structures and complementary embankments. Preliminary investigations have identified that an operating height of 13 mAHD could optimise outcomes whilst minimising impacts associated with construction and ongoing operations and maintenance. This increase in opportunity for e-watering and high-flow retention could lead to the improved condition of floodplain vegetation, including black box habitat.	
	 In addition to exploiting floodplain water associated with managed and natural high-flow events, additional opportunities for water delivery to be investigated include: Water siphoning via <i>The Splash</i> during Katarapko raising events, and Water pumping, as proposed in the Regent Parrot Recovery Plan. 	
	Katarapko Island (North) falls within the 'Katarapko regent parrot floodplain habitat zone', identified as part of Regent Parrot Recovery Plan. The strategic watering of this site to support the conservation and improvement of vegetation important to regent parrots, is seen as a key part of the realising the conservation of the current population.	
Outcomes	 Benefits associated with an improved water regime. Improved condition of floodplain vegetation. Improved soil moisture conditions. Increased opportunities for stands of black box woodland to receive water. Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population. 	

SITE BACKGROUND

Description

Katarapko Island (North) is located immediately downstream of Lock 4 and the township of Berri and lies within the Katarapko section of the Murray River National Park. Situated between the Katarapko Creek anabranch and the River Murray channel, the north island consists of temporary wetlands and interconnecting disposal basins. The island's only land access is via Stone Weir, located North West of the island near the inlet to Katarapko Creek.

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

Katarapko Island (North) was historically used for livestock grazing as well as timber harvesting. Large volumes of timber were cut from the island, including river red gum, which was sent to a sawmill located on the north-eastern section of the island. Since river regulation and the construction of locks and weirs along the River Murray, the water regime of the island's waterways has been altered. The lack of inundation in these areas following the construction of Lock 3 in 1925, has resulted in the decline of floodplain habitat within the wetland complex.

WETLAND ECOLOGY

Ecological role: Katarapko Island (North) is part of a larger protected area with diverse habitat and wetland types and of high conservation value^{1,2}. The island is within the Murray River National Park which is proclaimed to conserve a significant proportion of South Australia's floodplain environments which are not represented widely in other reserve systems³.

Flora and fauna: The major vegetation communities within Katarapko include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire/ chenopod shrublands. It is home to a wide variety of wildlife, some of them listed as species of conservation significance under national and/or state legislation⁴. Katarapko is a priority floodplain for environmental flows in South Australia and is currently the only Demonstration Reach for Native Fish in South Australia^{4,5}.

WETLAND MANAGEMENT

Current Management:

The Department for Environment and Water's (DEW) National Parks and Wildlife Service SAis responsible for the management of the Murray River National Park. The Katarapko section of the park is a popular destination for recreational tourism, including kayaking, fishing, camping and birding. As noted in the sub-section below, there is no water-related infrastructure on Katarapko Island (North) designed to improve floodplain condition.

Infrastructure:

Currently, there are temporary banks on the Katarapko Island North to support pumping activities.

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 Katarapko Island North, these included:

Environmental

- Due to the isolated nature of the island, there is a risk associated with allowing easier access from mainland to the island.
- There is a low to medium risk associated with acid sulfate soils at this site. This would require further assessment before any construction works or wetting and drying activities are undertaken.
- Construction and operations need to be mindful of the presence of salt in groundwater and accumulation of salt from evaporation of surface water.
- Need to consider whether water quality of impounded water can be managed.
- Note that the proposed structure could impede flows; clear environmental objectives needed.

Cultural

• High density of cultural material in the area. Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

- Site has strong community and historical value; further construction may be unpopular.
- National parks management requirements are important for this option; need to consider requirements for closing the park during construction including communications.

Economic

• Potential opportunity for tourism (kayaking/ canoeing); construction needs to be mindful of these recreational activities.

Operational/logistics

 Construction works need to be mindful on the impact on existing vegetation and cultural heritage within Katarapko Island. Access will be difficult as all equipment will need to be hauled via a barge. However, new infrastructure as proposed in the Katarapko Creek option profile could be utilised to allow for vehicle access and construction activities on the island. There would need to be clarity on sourcing of embankment materials, barge logistics and complementary embankments.

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Landcare
- Central Irrigation Trust
- Commonwealth Environmental Water Office (CEWO)
- Friends of the Riverland Parks
- Katarapko Advisory Panel (KAP)
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

- Jensen A, South Australia, Department of Environment and Natural Resources, South Australian River Murray Wetlands Management Committee. Wetlands atlas of the South Australian Murray Valley: a summary of current knowledge of Murray Valley wetlands as a basis for integrated catchment management. Adelaide: Dept. of Environment and Natural Resources; 1996.
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- 3. DENR. Murray River National Park Management Plan (Including Rilli Island, Media Island and Kapunda Island Conservation Parks). 1994.
- 4. DEW. EPBC Self-assessment- Operation of surface water management infrastructure on the Katarapko Floodplain. 2019.
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- 6. Grealish G, Shand P, Grocke S, Baker A, Fitzpatrick R, Hicks W. Assessment of Acid Sulfate Soil Materials in the Lock 1 to Lock 5 Region of the Murray-Darling Basin. CSIRO: Water for a Healthy Country National Research Flagship.; 2010.



Katarapko Island (South)

Location: Weir Pool 3, River Chainage Markers 513 to 482 Land Tenure: Crown Record

Wetland Size: 2,310 hectares (Ha) Normal Pool Level: 9.8 mAHD

	PROPOSED OPTIONS
Option #1:	Promote the conservation of the local regent parrot population, by supporting the installation of a new embankment and structure enabling watering activities as described within the Regent Parrot Recovery Project.
Description	Katarapko Island (South) falls within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the Regent Parrot Recovery initiative. The strategic watering of the south part near Yabby Creek to 12 mAHD supports the conservation and improvement of vegetation important to regent parrots, is seen as a key part of the realising the conservation of the current population.
Outcomes	 Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.
Option #2:	Improve floodplain condition by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water to 12 mAHD, through the installation of regulating structures, complementary embankments and exploring the potential of utilising the existing disposal basin infrastructure [including existing Central Irrigation Trust (CIT) network].
Description	This option aims to support the capability to retain water through the installation of new regulating structures and complementary blocking banks to 12 mAHD, and explore the potential of utilising the existing disposal basin infrastructure, in order to extend the duration of watering events such as those associated with high-flow events as well as promoting opportunities for delivering water via pumping.
	To support its prior function as a disposal basin, there is a significant network of blocking banks and complementary structures designed to support the retention of water on the floodplain. This presents an opportunity to investigate and where needed, remediate these existing structures to support the holding of water within the wetland to support pumping activities and extend the duration of watering events such as those associated with managed and natural high-flow events. To achieve this, a number of outflow points would also need to be investigated and potentially remediated to ensure water is retained, including recent structure upgrades delivered through the Riverine Recovery Project.
	This also includes exploring opportunities for delivery of water through the existing CIT network. This option will also need to consider the current watering activities within Yabby Creek for the 'horseshoes' located on the Katarapko Island (South).
Outcomes	 Benefits associated with an improved watering regime. Support the conservation of the current regent parrot population. Conservation and improvement of vegetation important to regent parrots. Improved soil moisture conditions. Increased opportunities for stands of black box woodland to receive water.

Option #3:	Improve floodplain condition by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water to 13 mAHD, through the installation of regulating structures, complementary embankments and exploring the potential of utilising existing disposal basin infrastructure.
Description	This option seeks to enhance the existing floodplain infrastructure to support opportunities to retain water, to extend the duration of watering events such as those associated with high-flow events, as well as promoting opportunities for delivering water via pumping. This also includes exploring opportunities for delivery of water through the existing CIT network.

	Additional existing infrastructure to those highlighted in 'Option 2' within the northern part of the floodplain present an opportunity to significantly increase the extent of inundation by investigating and where needed,
	remediating these structures to support the holding of water to 13 mAHD.
Outcomes	 Benefits associated with an improved watering regime. Support the conservation of the current regent parrot population. Conservation and improvement of vegetation important to regent parrots. Improved soil moisture conditions. Increased opportunities for stands of black box woodland to receive water.

SITE BACKGROUND

Description

Katarapko Island (South) is located on the River Murray opposite the township of Loxton within the Murray River National Park (Katarapko section). The northern and southern horseshoe Lagoons, consist of ephemeral wetlands covering approximately 123 hectares (ha), and are connected to the River Murray via Yabby Creek (inlet) and Bank 6 Creek (outlet). The island is only land accessible via Stone Weir, located at the inlet to Katarapko Creek.

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

The Katarapko Island Horseshoe Lagoon Complex was established in 1964 as a saline disposal basin and received water from the Loxton Comprehensive Drainage Schemes (CDS). This included an extensive embankment around the perimeter of the site. In the 1990s, improvement to irrigation practices and the construction of a piped water delivery system within the Loxton Irrigation Area significantly reduced the amount of irrigation drainage water delivered to the Katarapko Island Disposal Basin. Subsequently, additional inlet and outlet structures were installed to facilitate flushing flows through the basins. Since river regulation and the construction of locks and weirs along the River Murray, the water regime in the island has been altered. The lack of inundation in these areas following the construction of Lock 3 in 1925, has resulted in the decline of floodplain habitat within the wetland complex¹.

WETLAND ECOLOGY

Ecological role: Katarapko Island is part of a larger protected area with diverse habitat and wetland types and is of high conservation value^{1–3}. Katarapko Island South is within the Murray River National Park, which is proclaimed to conserve a significant proportion of South Australia's floodplain environments which are not represented widely in other reserve systems⁴.

Flora and fauna: The major vegetation communities within Katarapko include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire/ chenopod shrublands. It is home to a wide variety of wildlife, some of them listed as species of conservation significance under national and/or state legislation^{1,5}. Katarapko is a priority floodplain for environmental flows in South Australia and is currently the only Demonstration Reach for Native Fish in South Australia^{5,6}.

WETLAND MANAGEMENT

Current Management:

The Department for Environment and Water's (DEW) National Parks and Wildlife Service SA is responsible for the management of the Katarapko section of the Murray River National Park. The Park is a popular destination for recreational tourism, including kayaking, fishing, camping and birding. The Katarapko Island Horseshoe Lagoons are controlled through structures located at the inlet and outlet flow paths of the Horseshoe Lagoons. Environmental water is delivered by the Murraylands and Riverland Landscape Board via pumping using a barge on the River Murray. Current management aims to control wetting and drying regimes as well as extend inundation duration during unregulated flows.

Infrastructure:

Katarapko Island Horseshoe Lagoons Bank 6 Water Inlet Regulator Sluice Gate: This structure consists of five bay 1.2 m high, manually operated timber sluice gate structures that enable water to be held in the Katarapko Island Horseshoe Lagoons to extend the inundation time or manage the recession of a natural flood event at the wetland. When the inlet regulator is not in operation, the structure is fully open to allow movement of water into the Katarapko Island Horseshoe Lagoons during high flows. The northern inlet, Bank 6 upstream flow path structure connects to the main river channel when flows exceed 40,000 megalitres per day (ML/day) and river level is 12.0 mAHD¹.

Yabby Creek Outlet Regulator: This structure consists of four rows of 1200 mm x 1200 mm x 488 mm long concrete box culverts with aluminium stop logs and enables water to be held in the Katarapko Island Horseshoe Lagoons to extend the inundation time or manage the recession of a natural flood event at the wetland if desired. When the outlet regulator is not in operation, the structure will be fully open to allow movement of water into the Katarapko Island horseshoe lagoons during high flows. The southern outlet, Yabby Creek, becomes connected to the river channel at the elevation level of 10.02 mAHD and when flows exceed 15,000 ML/day¹.

As noted above, an embankment surrounds the former footprint of the saline irrigation basin constructed in 1964.

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 Katarapko Island South, these included:

Environmental

- Due to the isolated nature of the island, there is a risk associated with allowing easier access from the mainland to the island.
- There is a low to medium risk associated with acid sulfate soils at this site⁷. This would require further assessment before any construction works or wetting and drying activities are undertaken.
- Construction works need to be mindful of the impact on existing vegetation within Katarapko Island.
- Construction and operations need to be mindful of the presence of salt in groundwater and accumulation of salt from evaporation of surface water.
- Need to consider current natural flooding and whether the proposed banks on north end would impede flows.
- Investigate whether existing embankments are in the right spot for the desired outcomes.

Cultural

• High density of cultural material in the area. Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

- Site has strong community and historical value; further construction may be unpopular.
- National parks management requirements are important for this option; need to consider requirements for closing the park during construction including communications.

Economic

• Potential opportunity for tourism (kayaking/ canoeing); construction needs to be mindful of these recreational activities.

Operational/logistics

- Construction works need to be mindful on the impact on existing vegetation and cultural heritage within Katarapko Island.
- Consider utilising/ improving CIT network to pump water to the North Island as well.

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Landcare
- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Friends of the Riverland Parks
- Katarapko Advisory Panel (KAP)
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

- 1. Suitor L. Katarapko Island Saline Water Disposal Basin Hydrological Management Plan. DEWNR; 2012 Sep.
- Jensen A, South Australia, Department of Environment and Natural Resources, South Australian River Murray Wetlands Management Committee. Wetlands atlas of the South Australian Murray Valley: a summary of current knowledge of Murray Valley wetlands as a basis for integrated catchment management. Adelaide: Dept. of Environment and Natural Resources; 1996.
- 3. Thompson MB. River Murray Wetlands Their Characteristics, Significance and Management. Adelaide: University of Adelaide for the Department of Environment and Planning and the Nature Conservation Society of South Australia; 1986.
- 4. DENR. Murray River National Park Management Plan (Including Rilli Island, Media Island and Kapunda Island Conservation Parks). 1994.
- 5. DEW. EPBC Self-assessment- Operation of surface water management infrastructure on the Katarapko Floodplain. 2019.
- Wallace TA. Eckerts-Katarapko floodplain Tree condition survey data April 2015-March 2019. Report produced by Riverwater Life Pty Ltd for the Department for Water and Environment, South Australian Government (Draft version released April 2019); 2019.
- 7. Grealish G, Shand P, Grocke S, Baker A, Fitzpatrick R, Hicks W. Assessment of Acid Sulfate Soil Materials in the Lock 1 to Lock 5 Region of the Murray-Darling Basin. CSIRO: Water for a Healthy Country National Research Flagship.; 2010.



Katarapko Floodplains East: Thiele Flat

Location: Weir Pool 3, River Chainage Markers 492 to 490 Land Tenure: Crown Record Wetland Size: 120 hectares (Ha) Normal Pool Level: 9.8 mAHD

	PROPOSED OPTIONS
Option #1:	Improve floodplain condition in the northern (upstream) basin of Thiele Flat, by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to 12.8 mAHD.
Description	This option aims to support the capability to retain water through the installation of regulating structures and complementary blocking banks to 12.8 mAHD, in order to extend the duration of watering events such as those associated with high-flow events as well as prompting opportunities for delivering water via pumping. The existing bank around northern / eastern floodplain would need to be raised in localised locations. This will block several minor floodrunners. Connectivity could be improved by reinstating natural commence to flow levels and un-obstructed flow through the main inlets and connections within the wetland complex, through a review and remediation of sill levels and re-profiling of obstructed flow paths.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions. Replenish freshwater lenses over saline groundwater. Support temporary wetland habitat to promote food sources for waterbirds. Pest species managements, in particular mosquitos.
Option #2:	Improve floodplain condition in the southern (downstream) basin of Thiele Elat, by supporting opportunities

Option #2:	Improve floodplain condition in the southern (downstream) basin of Thiele Flat, by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, including weir pool raising, by enabling the retention of water through the installation of regulating structures and complementary embankments to 11 mAHD.
Description	This option aims to support the capability to maximise the opportunity presented by weir pool raising and capacity to retain water through the installation of regulating structures and small complementary blocking bank to 11 mAHD. This will support the capacity to extend the duration of watering events such as those associated with high-flow events and weir pool raising, as well as prompting opportunities for delivering water via pumping. Connectivity could be improved by reinstating natural commence to flow levels and un-obstructed flow through the main inlets and connections within the wetland complex, through a review and remediation of sill levels and re-profiling of obstructed flow paths.
Outcomes	Benefits associated with an improved watering regime.
	Conservation and improvement of floodplain vegetation.
	Replenish freshwater lenses over saline groundwater
	 Support temporary wetland habitat to promote food sources for waterbirds.
	 Pest species managements in particular mosquitos.

SITE BACKGROUND

Description

Katarapko Floodplains (East) consist of five wetlands (Clarks Floodplain, Loxton Riverfront Reserve, Rilli Reach/ Lagoons and Thiele Flat) located on the eastern bank of the River Murray, east of the Katarapko Island^{1,2}. Thiele Flat is contained within a river meander loop with the formation of an extensive sandbar and river terraces, and includes two temporary lagoons on the higher 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

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in the wetland complex has been altered. The lack of inundation in these areas has resulted in the decline of floodplain habitat within the wetland complex. Irrigation activities within Katarapko Floodplains (East) have also resulted in saline groundwater issues within these floodplains. A series of Salt Interception Schemes (SIS) have been installed in these areas to reduce the salinity impacts on the environment.

WETLAND ECOLOGY

Katarapko East Floodplains contains a number of smaller floodplain areas, currently watered by the Nature Foundation of SA (NFSA) with an aim to regenerate and sustain vegetation on the floodplain, notably river red gums, black box and lignum shrubland. The conservation rating is considered low to high ^{3,4}, but the ecological value has likely increased with the recent active management occurring at this site.

Flora and fauna: The major vegetation communities within Katarapko East Floodplain include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire/ chenopod shrublands. Low fauna diversity and abundances were recorded at these sites during the baseline survey in 2004, likely as a result of the temporal nature of the wetland and water quality issues⁵.

WETLAND MANAGEMENT

Current Management:

The Katarapko Floodplains (East) are included in the NFSA Water for Nature program, which is supported by the Commonwealth Environmental Water Office (CEWO) to deliver environmental water to wetland and floodplain sites along the Murray River. Options outlined within this profile seek to align and complement these activities. Current watering efforts are focused on the regeneration of red gums and black box on the river terraces on the south-western section of the site. Thiele Flat floodplain is accessible to the public for recreational purposes. Mosquitos are a known nuisance due to stagnant water conditions, more frequent watering could help to manage numbers.

A Salt Interception Scheme has been installed to help reduce the impact of saline groundwater entering the river.

Infrastructure:

Water delivery within the Katarapko Floodplains (East) includes the use of water pumps and sprinkler irrigation methods, utilising a combination of temporary and permanent infrastructure. The installation of additional embankments and structures would help optimise the current management efforts and increase opportunities for outcomes within the floodplain.

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 Thiele Flat, these included:

Environmental

 Bank already exists at 12.8 mAHD but some low points need filling; there may be environmental risks associated with cutting off existing flow paths.

Cultural

• There is a high density of cultural material in the area. Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

- Need to be mindful of midge breeding site in the area and determine appropriate management approaches. Consider community capacity building and awareness regarding midge ecology.
- Need to be aware of other interests in the site, including Nature Foundation pumping actions and camping grounds managed by councils.

Operational/logistics

• Need to consider how often flows would be able to be captured, the magnitude of QSA to enable inflows, and how the new bank would interact with river operations.

KEY STAKEHOLDER INVOLVEMENT

- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Loxton District Landcare
- Loxton Waikerie Council
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Nature Foundation of SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water
- Murray-Darling Basin Authority (MDBA)

- 1. Jensen A. Water for Nature Environmental Watering Site Monitoring Report- Thiele Flat, Lock 4 to Loxton Reach, South Australian Riverland. NFSA; 2016 Jul.
- Jensen A. Delivery of Environmental Water by Water For Nature Program in the South Australian River Murray Valley 2013-16. NFSA; 2016 Oct.
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- 4. Thompson MB. River Murray Wetlands Their Characteristics, Significance and Management. Adelaide: University of Adelaide for the Department of Environment and Planning and the Nature Conservation Society of South Australia; 1986.
- 5. SKM. River Murray Wetlands Baseline Survey Final Report. Sinclair Knight Merz, Armadale. Prepared for the River Murray Catchment Water Management Board.; 2004.



Katarapko Floodplains East: Loxton Riverfront Reserve

Location: Weir Pool 3, River Chainage Markers 489 to 488 Land Tenure: Certificate of Title / Crown Record Wetland Size: 68 hectares (Ha) Normal Pool Level: 9.8 mAHD

	PROPOSED OPTIONS	
Option #1:	Improve floodplain condition in the western (downstream) portion of the floodplain, by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to a height of 11.8 mAHD.	
Description	This option aims to support the capability to retain water through the installation of regulating structures and complementary blocking banks to 11.8 mAHD, in order to extend the duration of watering events such as those associated with high-flow events as well as prompting opportunities for delivering water via pumping. Connectivity could be improved by reinstating natural commence to flow levels and un-obstructed flow through the main inlets and connections within the wetland complex, through a review and remediation of sill levels and re-profiling of obstructed flow paths.	
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions. Replenish freshwater lenses over saline groundwater. Support temporary wetland habitat to promote food sources for waterbirds. 	

Option #2:	Improve floodplain condition in the eastern (upstream) portion of the floodplain, by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to a height of 12.8 mAHD.
Description	This option aims to support the capability to retain water through the installation of regulating structures and complementary blocking bank to 12.8 mAHD, in order to extend the duration of watering events such as those associated with high-flow events as well as prompting opportunities for delivering water via pumping. Connectivity could be improved by reinstating natural commence to flow levels and un-obstructed flow through the main inlets and connections within the wetland complex, through a review and remediation of sill levels and re-profiling of obstructed flow paths.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions. Replenish freshwater lenses over saline groundwater. Support temporary wetland habitat to promote food sources for waterbirds.

SITE BACKGROUND

Description

Katarapko Floodplains (East) consist of five wetlands (Clarks Floodplain, Loxton Riverfront Reserve, Rilli Reach, Rilli Lagoons and Thiele Flat) located on the eastern bank of the River Murray, east of the Katarapko Island^{1,2}. Loxton Riverfront Reserve is part of a mosaic of semi-connected habitat patches along the eastern side of the main River Murray channel from Bookpurnong to Loxton, opposite the Murray River National Park (Katarapko Island). The reserve is accessible to the public and has several public outdoor facilities (e.g. BBQ facility, picnic area, shelter) and contains the Loxton Caravan Park, a significant tourism asset for the region and local area.

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

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in the wetland complex has been altered. The lack of inundation in these areas has resulted in the decline of floodplain habitat within the wetland complex. Irrigation activities within Katarapko Floodplains (East) have also resulted in saline groundwater issues within these floodplains. A series of Salt Interception Schemes (SIS) have been installed in these areas to reduce the salinity impacts on the environment.

WETLAND ECOLOGY

Katarapko East floodplains contains a number of smaller floodplain areas, currently watered by the Nature Foundation of SA (NFSA) with an aim to regenerate and sustain vegetation on the floodplain, notably river red gums, black box and lignum shrubland. The conservation rating is considered low to high ^{3,4}, but the ecological value has likely increased with the recent active management occurring at this site.

Flora and fauna: The major vegetation communities within Katarapko East Floodplain include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire/ chenopod shrublands. Low fauna diversity and abundances were recorded at these sites during the baseline survey in 2004, likely as a result of the temporal nature of the wetland and water quality issues⁵.

WETLAND MANAGEMENT

Current Management:

The Katarapko Floodplains (East) are included in the NFSAs Water for Nature program, which is supported by the Commonwealth Environmental Water Office (CEWO) to deliver environmental water to wetland and floodplain sites along the Murray River. Options outlined within this profile seek to align and complement these activities.

The Loxton Riverfront Reserve is accessible to the public and is managed as a recreational reserve by the District Council of Loxton Waikerie. Current management targets include the regeneration of black box and lignum on the higher elevations of the floodplain while also filling a chain of floodplain lagoons and wetlands.

Infrastructure:

Water delivery within the Katarapko Floodplains (East) includes the use of water pumps and sprinkler irrigation methods, utilising a combination of temporary and permanent infrastructure. The installation of additional embankments and structures would help optimise the current management efforts and increase opportunities for outcomes within the floodplain. Management interventions should consider several recreational structures (e.g. BBQ facilities, shelters, picnic areas) located near and within the Loxton Riverfront Reserve as well as the impacts to the Loxton Caravan Park, including access.

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 Loxton Riverfront, these included:

Environmental

• Note that the eastern end of the area is currently used as a spill-over for stormwater retention which may create management issues during inundation.

Community/Social

- This is a site with several community uses. Consider recreational structures onsite, maintaining community access, walking trails, waste disposal station and impact of camping sites being temporarily out of commission.
- The local caravan park is an important stakeholder.

Economic

• Consider potential impacts on historic village area.

Operational/logistics

- Assess current road level to determine capacity to hold water. Consider extending and increasing height of road on west boundary for option #1.
- Existing pipe culvert could be upgraded to a regulating structure.

KEY STAKEHOLDER INVOLVEMENT

- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Loxton Caravan Park
- Loxton District Landcare
- Loxton Waikerie Council
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- Loxton Riverfront Advisory Group
- National Parks and Wildlife Service SA
- Nature Foundation of SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

- 1. Jensen A. Water for Nature Environmental Watering Site Monitoring Report- Loxton Riverfront Reserve, Lock 4 to Loxton Reach, South Australian Riverland. NFSA; 2016 Jul.
- Jensen A. Delivery of Environmental Water by Water For Nature Program in the South Australian River Murray Valley 2013-16. NFSA; 2016 Oct.
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- 4. Thompson MB. River Murray Wetlands Their Characteristics, Significance and Management. Adelaide: University of Adelaide for the Department of Environment and Planning and the Nature Conservation Society of South Australia; 1986.
- 5. SKM. River Murray Wetlands Baseline Survey Final Report. Sinclair Knight Merz, Armadale. Prepared for the River Murray Catchment Water Management Board.; 2004.



Katarapko Floodplains East: Clarks Floodplain

Location: Weir Pool 3, River Chainage Markers 512 to 506 Land Tenure: Certificate of Title / Crown Lease Wetland Size: 340 hectares (Ha) Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS	
Option #1:	Improve floodplain condition in the eastern (upstream) basin of Clarks Floodplain, by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to 13 mAHD.
Description	This option aims to support the capability to retain water through the installation of regulating structures and complementary blocking bank to 13 mAHD, in order to extend the duration of watering events such as those associated with high-flow events as well as prompting opportunities for delivering water via pumping. Connectivity could be improved by reinstating natural commence to flow levels and un-obstructed flow through the main inlets and connections within the wetland complex, through a review and remediation of sill levels and re-profiling of obstructed flow paths.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions. Replenish freshwater lenses over saline groundwater. Support temporary wetland habitat to promote food sources for waterbirds.

Option #2:	Improve floodplain condition in the western (downstream) basin of Clarks Floodplain, by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to 13 mAHD.				
Description	This option aims to support the capability to retain water through the installation of regulating structures and complementary blocking bank to 13 mAHD, in order to extend the duration of watering events such as those associated with high-flow events as well as prompting opportunities for delivering water via pumping. Connectivity could be improved by reinstating natural commence to flow levels and un-obstructed flow through the main inlets and connections within the wetland complex, through a review and remediation of sill levels and re-profiling of obstructed flow paths.				
Outcomes	 Benefits associated with an improved watering regime Opportunities for conservation and improvement of floodplain vegetation Improved soil moisture conditions Replenish freshwater lenses over saline groundwater Support temporary wetland habitat to promote food sources for waterbirds 				

SITE BACKGROUND

Description

Katarapko Floodplains (East) consist of five of wetlands (Clarks Floodplain, Loxton Riverfront Reserve, Rilli Reach, Rilli Lagoons and Thiele Flat) located on the eastern bank of the River Murray, east of the Katarapko Island ^{1,2}. Clarks Floodplain complex consist of four tight meander bends, creating a series of sandy peninsulas. At higher elevations, several flood channels run across the clay floodplain, allowing for flows across the floodplain¹.

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

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in the wetland complex has been altered. The lack of inundation in these areas has resulted in the decline of floodplain habitat within the wetland complex. Irrigation activities within Katarapko Floodplains (East) have also resulted in saline groundwater issues within these floodplains. A series of Salt Interception Schemes (SIS) have been installed in these areas to reduce the salinity impacts on the environment.

WETLAND ECOLOGY

The Katarapko East floodplains contain a number of smaller floodplain areas, all of them are currently watered by the Nature Foundation of SA (NFSA) with the aim to regenerate and sustain vegetation on the floodplain, mainly river red gums, black box and lignum shrubland. The conservation rating of the four floodplains included in this complex - Clarks Floodplain, Rilli Reach, Thiele Flat and Loxton Riverfront Reserve - is low to high ^{3,4}, but the ecological value has likely increased with the recent active management occurring at these sites.

Flora and fauna: The major vegetation communities within Katarapko East Floodplain include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire/ chenopod shrublands. Low fauna diversity and abundances were recorded at these sites during the baseline survey in 2004, likely as a result of the temporal nature of the wetland and water quality issues⁵.

WETLAND MANAGEMENT

Current Management:

The Katarapko Floodplains (East) are included in NFSA's Water for Nature program, which is supported by the Commonwealth Environmental Water Office (CEWO) to deliver environmental water to wetland and floodplain sites along the Murray River. Clarks Floodplain has been receiving e-water to improve habitat conditions for floodplain vegetation and sustain extensive regeneration of river red gum, black box and lignum. Efforts have focused on delivering water to flood runners and irrigating patches of elevated floodplain. A Salt Interception Scheme has been installed to help reduce the impact of saline groundwater. Options outlined within this profile seek to align and complement these activities.

Infrastructure:

Water delivery within the Katarapko Floodplains (East) includes the use of water pumps and sprinkler irrigation methods, utilising a combination of temporary and permanent infrastructure. The installation of additional embankments and structures would help optimise the current management efforts and increase opportunities for outcomes within the floodplain.

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 Clarks Floodplain, these included:

Environmental

 Potential investigations are required on benefits to vegetation in relation to inundation duration, and volumes of top up pumping required.

Cultural

• Aboriginal Waterways Assessment (AWA) and First Peoples have a strong interest in the area. Construction works need to be mindful not to disturb areas of cultural importance.

Operational/logistics

- Need to assess salinity impacts and SIS costs if inundating.
- This option needs land holder agreements and access to lockable structures for managers.
- Consider addition of culvert to large embankment for connectivity during high flow events.

KEY STAKEHOLDER INVOLVEMENT

- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Landholders
- Loxton District Landcare
- Loxton Waikerie Council
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board

- National Parks and Wildlife Service SA
- Nature Foundation of SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

- 1. Jensen A. Water for Nature Environmental Watering Site Monitoring Report- Clarks Floodplain, Lock 4 to Loxton Reach, South Australian Riverland. NFSA; 2016 Jul.
- Jensen A. Delivery of Environmental Water by Water For Nature Program in the South Australian River Murray Valley 2013-16. NFSA; 2016 Oct.
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Katarapko Floodplains East: Rilli Lagoon & Rilli Reach

Location: Weir Pool 3, River Chainage Markers 502 to 496 Land Tenure: Certificate of Title / Crown Record Wetland Size: Rilli Reach 67 (Ha) / Rilli Lagoon 268 (Ha) Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS						
Option #1:	Improve floodplain condition in the southern (downstream) lagoon, by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to a height of 12 mAHD.					
Description	This option aims to support the capability to retain water through the installation of regulating structures and complementary blocking banks to 12 mAHD, in order to extend the duration of watering events such as those associated with high-flow events as well as prompting opportunities for delivering water via pumping. Connectivity could be improved by reinstating natural commence to flow levels and un-obstructed flow through the main inlets and connections within the wetland complex, through a review and remediation of sill levels and re-profiling of obstructed flow paths.					
Outcomes	 Opportunities for conservation and improvement of floodplain vegetation. Improved soil moisture conditions. Replenish freshwater lenses over saline groundwater. Support temporary wetland habitat to promote food sources for waterbirds. 					

Option #2:	Promote the conservation of the local regent parrot population and improve floodplain condition in the northern (upstream) basin, by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to a height of 13 mAHD.				
Description	 The Katarapko Floodplains (East)/ Rilli Complex, falls within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the regent parrot recovery initiative. The strategic watering of this site, referred to the initiative as 'Westbrooks Lagoon', to support the conservation and improvement of vegetation important Regent Parrots, is seen as a key part of conserving the current population and is complementary to existing watering activities. Connectivity could be improved by reinstating natural commence to flow levels and un-obstructed flow through the main inlets and connections within the wetland complex, through a review and remediation of sill levels are partitioned flow and the matrix. 				
Outcomes	 Opportunities for conservation and improvement of floodplain vegetation. Improved soil moisture conditions. Replenish freshwater lenses over saline groundwater. Support temporary wetland habitat to promote food sources for waterbirds. Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population. 				

Option #3:	Improve connectivity by reinstating natural commence to flow levels and un-obstructed flow through Rilli Reach, through review and remediation of sill levels and re-profiling of obstructed flow paths and upgrading or replacing of floodplain infrastructure.
Description	An obstruction to flow exists at the road culvert structure across Rilli Reach, which if addressed would support improvements to flow and floodplain connectivity within the site. Connectivity could also be improved by reinstating natural commence to flow levels and un-obstructed flow through the wetland, through a review and remediation of sill levels and re-profiling of obstructed flow paths.
Outcomes	Opportunities for conservation and improvement of floodplain vegetation.

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Improved soil moisture conditions.

Replenish freshwater lenses over saline groundwater.

SITE BACKGROUND

Description

Katarapko Floodplains (East) consist of five of wetlands (Clarks Floodplain, Loxton Riverfront Reserve, Rilli Reach, Rilli Lagoons and Thiele Flat) located south of Berri and north of the township of Loxton on the east bank of the River Murray between Locks 3 and 4. Rilli Reach and Rilli Lagoons are located opposite the Murray River National Park, Katarapko Section and is protected by a Salt Interception Scheme designed to reduce salinity in the groundwater. It includes black box woodland on higher elevations of floodplain, with several flood runners throughout the floodplain^{1,2}.

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

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in the wetland complex has been altered. The lack of inundation in these areas has resulted in the decline of floodplain habitat within the wetland complex. Irrigation activities within Katarapko Floodplains (East) have also resulted in saline groundwater issues within these floodplains. A series of Salt Interception Schemes (SIS) have been installed in these areas to reduce the salinity impacts on the environment.

WETLAND ECOLOGY

Katarapko East Floodplains contains a number of smaller floodplain areas, all of them are currently watered by the Nature Foundation SA (NFSA) and aim to regenerate and sustain vegetation on the floodplain, mainly river red gums, black box and lignum shrubland. The conservation rating is low to high^{3,4}, but the ecological value has likely increased with the recent active management occurring at these sites.

Flora and fauna: The major vegetation communities within Katarapko East Floodplain include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire/ chenopod shrublands. Low fauna diversity and abundances were recorded at these sites during the baseline survey in 2004, likely as a result of the temporal nature of the wetland and water quality issues⁵.

WETLAND MANAGEMENT

Current Management:

The Katarapko Floodplains (East)/ Rilli Reach and Rilli Lagoon sites are included in the NFSA's Water for Nature program, which is supported by the Commonwealth Environmental Water Office (CEWO) to deliver environmental water to wetland and floodplain sites along the Murray River. The current e-water delivery at Rilli Reach aims to improve the health of stressed mature red gum and black box woodlands. Efforts also aim to sustain black box, red gum and lignum seedlings germinated by the 2011 flood peak. A Salt Interception Scheme has been installed to help reduce the impact of saline groundwater. Complementary monitoring of the Rilli Lagoons has also been conducted since January 2016. Watering efforts here aim to improve habitat conditions for red gum woodland, lignum swales, and black box woodland. Options outlined within this profile seek to align and complement these activities.

Infrastructure:

Current water delivery within the Katarapko Floodplains (East) includes the use of water pumps and sprinkler irrigation methods, utilising a combination of temporary and permanent infrastructure. The installation of additional embankments and structures would help optimise the current management efforts and increase opportunities for outcomes within the floodplain.

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 Rilli Lagoon, these included:

Environmental

• Construction and operations need to be mindful of the presence of salt in groundwater and accumulation of salt from evaporation of surface water.

Community/Social

• Note that the Nature Foundation SA currently manage pumping to the sites; need to consult with them on water supply.

KEY STAKEHOLDER INVOLVEMENT

- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Landholders
- Loxton District Landcare
- Loxton Waikerie Council
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Nature Foundation of SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

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Gerard Wetland Complex

Location: Weir Pool 3, River Chainage Markers 477 (inlet) to 473 (outlet) Land Tenure: Certificate of Title / Crown Record

Creek Length: 2,856 m Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS	
Option #1:	 Improve floodplain condition and outcomes associated with the Regent Parrot Recovery Project by: Supporting and expanding the inundation extent of existing environmental watering activities Increasing the duration of floodplain watering associated with managed and natural high-flow events, including weir pool raising, within the inner floodplain basins, through the installation of a structure and complementary bank to a height of 11.8 mAHD.
Description	This option aims to support the capability to maximise the opportunity presented by weir pool raising and capacity to retain water, through the installation of a regulating structure and complementary blocking bank to 11.8 mAHD. This will support the capacity to extend the duration of watering events such as those associated with high-flow events and weir pool raising, as well as prompting opportunities for delivering water via pumping. Current efforts to provide e-water to the site will be improved and managed extent expanded, under this option, which also includes the repairing of a breached bank. This area falls within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the Regent Parrot Recovery Project. The strategic watering of this site to support the conservation and improvement of vegetation important to regent parrots, is seen as a key part of the realising the conservation of the current population ¹ .
Outcomes	 Benefits associated with an improved watering regime. Improved soil moisture conditions. Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.

Option #2:	Improve connectivity by reinstating natural commence to flow levels and un-obstructed flow through the main upstream inlets to the wetland complex, through review and remediation of sill levels and re-profiling of obstructed flow paths.
Description	Less frequent high flow events, drought mitigation measures and changes in land management have led to deposition of material along the connecting creeks at the upstream end of the wetland. The deposition of material has potentially created high points within the creeks and artificially high sill levels that could be remediated to support more natural commence to flow levels and allow for un-obstructed flow through the wetland.
Outcomes	 Benefits associated with an improved watering regime. Enhanced capacity for greater exchange between the river and wetlands. Reduced build-up of sediment and abundant bullrush (<i>Typha spp</i>).

Option #3:	Improve floodplain condition and outcomes associated with the Regent Parrot Recovery Project by supporting opportunities for environmental watering and increasing the duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to a height of 11.8 mAHD.
Description	This option aims to optimise the floodplain inundation and retention extent through the installation of regulating structures and complementary embankments. Preliminary investigations have identified that an operating height of 11.8 mAHD could optimise outcomes whilst minimising impacts associated with construction and ongoing operations and maintenance. This increase in opportunity for e-watering and high-flow retention could lead to the improved condition of floodplain vegetation, including black box habitat.

	This area falls within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the regent parrot recovery initiative. The strategic watering of this site to support the conservation and improvement of vegetation important to regent parrots, is seen as a key part of the realising the conservation of the current population ¹ .
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.

Option #4:	Increase the extent of inundation proposed within 'Option 3' within outer lagoon through the installation of regulating structure and complementary embankment to a height of 12.3 mAHD.
Description	This option aims to complement the outcomes associated with 'Option 3' by increasing the extent of the managed area within the outer lagoon. It also seeks to introduce management flexibility by enabling the outer lagoon to be managed independently.
	This area falls within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the Regent Parrot Recovery Project. The strategic watering of this site to support the conservation and improvement of vegetation important to regent parrots, is seen as a key part of the realising the conservation of the current population ¹ .
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.

Option #5:	Improve flow conditions within Putjeda Creek by re-profiling it to connect at pool.
Description	It is believed that Putjeda Creek was once a pool connected flowing creek and over time less frequent high flow events, drought mitigation measures and changes in land and river management have led to the deposition of material along the connecting creek resulting in its permanent disconnection. The creek could be excavated to lower sill levels in order to connect to the river at pool. This will improve the creek's connections with the river and improve the volume and frequency of flow through the creek. Recent works undertaken as part of the Riverine Recovery Project excavated material to ensure the creek connects at flows between ~15 and 20 GL. The influence of weir pool manipulation, in particular raising on improving outcomes and mitigating risks for the creek, needs to be further investigated.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.

SITE BACKGROUND

Description

Gerard is bounded by the River Murray to the southwest, Katarapko (Murray River National Park) to the east and southeast, Spectacle Lakes to the west and the town of Winkie to the north. Putjeda Creek is connected to the eastern side of the river, immediately south of Gerard. The creek is connected to the River Murray at the inlet (river marker 477) and runs approximately 2,860 m until it flows into the river at marker 473.

Historical and Cultural Significance

Putjeda Creek is an area of high cultural value to the Gerard Community and the wider First Peoples of the River Murray and Mallee Region (First Peoples) community. The area around Gerard is the land of Ngawait, Erawirung and Ngayawung. The people of Gerard today have various kinship ties with the Aboriginal peoples of the Riverland and Eyre Peninsula (primarily as a result of the relocation of Aboriginal people from the Ooldea Mission in 1952). The community at Gerard is the largest group of Aboriginal people living together in the Riverland area of South Australia as a discrete Aboriginal community.

WETLAND ECOLOGY

Flora: The dominant wetland vegetation types on the floodplain include river red gum woodland (*Eucalyptus camaldulensis*), black box woodland (*Eucalyptus largiflorens*), lignum and samphire shrubland, and sedgelands. No nationally listed species have been recorded at the site. See references for further details of species composition².

Fauna: There are a number of listed species that have the potential to occur at this site, including the vulnerable regent parrot (*Polytelis anthopeplus monarchoides*) which has been recorded close to Putjeda Creek. Southern bell frogs (*Litoria raniformis*) are present at this site during pumped environmental watering events^{2,3}.

WETLAND MANAGEMENT

Current Management:

There are no structures that are actively managed to support water outcomes within Putjeda Creek. During the summer months, the creek often flows backwards (from outlet to inlet), due to restricted flows. Silting issues have also been identified within the creek, further restricting flows. Efforts to connect the creek at pool level will minimise these issues.

In collaboration with the Gerard Community, staff at the Murraylands and Riverland Landscapes Board currently pump e-water to the surrounding flood runners. Efforts to improve flow in this area will maximise environmental outcomes. During moderate flow events, i.e. ~15 to 20 gigalitres (GL) Putjeda Creek will fill with water, but it often goes stagnant due to restricted flows. Re-profiling portions of the creek as well as repairing a breached bank will improve these management conditions. There are also some roads and tracks that will have limited accessibility during an 80 GL inundation event, which will be further examined under the Constraints Measures Project.

Infrastructure:

Previous works completed aimed to restore the environmental and cultural values of the Putjeda Creek by improving the creek's connections with the river. This included the following works to allow for better flows:

- Re-profiling of the upstream inlet connection of the creek to the river.
- Removal of the high section (200-300m) at the downstream connection to the river.
- Upgrade to the 'gravel crossing' across the creek with box culverts/vehicle passage and excavation of a small section of creek to enable greater water flows at this point.
- Re-profiling of the downstream outlet connection to the river.

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 Gerard Complex, these included:

Environmental

- There are some risks associated with acid sulfate soils at this site⁴. This would require further assessment before any construction works or wetting and drying activities are undertaken.
- Construction and operations need to be mindful of the presence of salt in groundwater and accumulation of salt from evaporation of surface water.
- Note that Weir Pool Manipulation could potentially help deliver water for options 4 and 5.

Cultural

- Gerard Community are key stakeholders for this site.
- Construction works need to be mindful not to disturb areas of cultural importance.

Operational/logistics

• Sand will potentially be a confounding issue for re-profiling requirements.

KEY STAKEHOLDER INVOLVEMENT

- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Gerard Aboriginal Community
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

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Pyap Wetland Complex

Location: Weir Pool 3, River Chainage Markers 480 to 466 Land Tenure: Crown Lease Wetland Size: 110 hectares (Ha) Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS	
Option #1:	 Improve floodplain condition by promoting: An increase in the duration of floodplain watering associated with managed and natural high-flow events, through the retention of water, utilising existing infrastructure Opportunities for increased floodplain watering inundation extent and frequency associated with weir pool raising and Improved wetland drying management cycle activities through active drawdown and transport of floodplain nutrients associated with weir pool lowering.
Description	The current height of the main inlet structures to the wetland are set to 10.8 mAHD. This presents an opportunity to support the utility of existing structures to hold water within the wetland to extend the duration of watering events such as those associated with high-flow events and weir pool raising. It also presents an opportunity to complement existing management outcomes associated with wetland drying. Active wetland drawdowns associated with weir pool lowering allow for more rapid exposure of substrate and the transport of floodplain nutrients, including salt, back to river, avoiding the accumulation and concentration risks associated with drying via evaporation.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions.

Option #2:	Improve floodplain condition by supporting opportunities for environmental watering and increasing the management extent and duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the installation of regulating structures and complementary embankments to 11.3 mAHD.
Description	There is an opportunity to increase the managed inundation extent on the floodplain area within Pyap Lagoon. This can be achieved through a new regulating structure on the northern bank of the Lagoon with additional blocking banks to 11.3 mAHD. The proposed infrastructure would complement 'Option 1' outcomes enabling water to be retained at greater heights and extent, increasing the management footprint.
Outcomes	 Benefits associated with an improved watering regime. Enhanced capacity for greater exchange between the river and wetlands. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions.

Option #3:	Promote the conservation of the local regent parrot population, by supporting the installation of a new embankment and structure enabling watering activities as described within the Regent Parrot Recovery Project.
Description	Pyap Lagoon falls within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the regent parrot recovery initiative. The strategic watering of this site in combination with new embankments and regulating structures to 12.0 mAHD will be able to support the conservation and improvement of vegetation important to regent parrots.
Outcomes	 Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.

SITE BACKGROUND

Description

Pyap Wetland Complex (Pyap Lagoon, Pyap Horseshoe) is situated within a large bend of the River Murray approximately 3 km from Pyap and 10 km from Loxton. This permanent wetland complex is comprised of a single terminal horseshoe-shaped wetland basin orientated from east to west and surrounded by floodplain. The Pyap Horseshoe wetland is connected to the River Murray at its eastern end via two small creeks that connect to Pyap Lagoon. The Lagoon is another terminal wetland that was formerly a continuation of the Horseshoe and is connected to the river at pool level. The western end of the Horseshoe terminates within about 90 m of the river. The eastern end of the horseshoe is also connected to a third creek which runs through the floodplain to the east and terminates before meeting the river¹.

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

Prior to the regulation of flows in the River Murray and the construction of locks and weirs, the Pyap Wetland Complex would have had a more variable water regime. The installation of regulators has since enabled the wetting and drying of the lagoons, improving the ecological outcomes within this area.

WETLAND ECOLOGY

Pyap Lagoon has been classified as having low conservation value², however, other parts of the wetland act as important drought refuge for waterbirds and, therefore, it has medium to high conservation value^{2,3}.

Flora: Vegetation composition at Pyap includes river red gum and black box woodland and forest, lignum shrublands, saltbush and samphire shrubland, reedbeds and sedge, see^{1,4} for detailed description of flora at site. No rare, threatened or any submerged vegetation or floating plants were recorded during the vegetation survey conducted in 2013⁵. A later fish survey⁶ indicated a lack of submerged aquatic vegetation. A declared weed, skeleton weed (*Chondrilla juncea*), was found during the monitoring conducted in 2017-2018⁴.

Fauna: Fish and frog surveys were conducted during 2012⁷, 2013⁶ and 2017-2018⁴. Pyap has been found to have relatively high native fish species composition and during the Riverine Recovery Project (RRP) monitoring⁴ one pouched lamprey (*Geotria australis*), an uncommon species for the region, was found. The water regulating structures installed through the RRP in 2018/2019 provide the ability to use hydrological management to remove invasive common carp (*Cyprinus carpio*) from the lagoon and consolidate the lagoon bed. This management is expected to improve water quality, aquatic vegetation diversity, and aquatic vegetation abundance, ultimately improving native fish, frog, and waterbird diversity and abundance.

WETLAND MANAGEMENT

Current Management:

The Pyap wetland complex is primarily managed for wetting and drying cycles. Since the completion of the RRP construction in 2018, the Department for Environment and Water (DEW) manages the wetting and drying of the lagoon to achieve two partial drawdown events and one full drawdown event over a five year period. Current landholders use the floodplain for cattle grazing, wetland restoration, and recreational activities, including camping, kayaking/canoeing and fishing.

Infrastructure:

Vehicle crossings have been installed on the northern and southern arm of the western connection. An additional vehicle crossing with pipes is also present on the eastern creek. As part of RRP, regulating structures were installed at two locations in 2018 to allow for hydrological management (wetting and drying) of the horseshoe lagoon.

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 Pyap, these included:

Environmental

- There are some risks associated with acid sulfate soils and salinity at this site, and these would require further assessment before any construction works or wetting and drying activities are undertaken, see Addendum 1 to^{1,8} for updated information.
- Need to consider ecological benefit for species other than regent parrot.
- Consider and manage potential for banks in Option 2 and 3 to create impediments to flow.

Cultural

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

Community/Social

• Consider needs of landholders that use floodplain for recreational activities and cattle grazing.

Operational/logistics

- Construction works need to be mindful of potential impacts to fencing.
- Need access to embankment for option 2.
- Need for multiple culverts to prevent erosion or overtopping.

KEY STAKEHOLDER INVOLVEMENT

- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Loxton Waikerie Council
- Loxton Waikerie Landcare
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscapes Board
- National Parks and Wildlife Service SA
- Private landholders
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

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Beldora & Spectacle Lakes Wetland Complex

Location: Weir Pool 3, River Chainage Markers 489 to 463 Land Tenure: Crown Record

Wetland Size: 1,772 hectares (Ha) Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS	
Option #1:	 Improve floodplain condition by promoting: An increase in the duration of floodplain watering associated with managed and natural high-flow events, through the retention of water, utilising existing infrastructure and complementary works Opportunities for increased floodplain watering inundation extent and frequency associated with weir pool raising Improved wetland drying activities through active drawdown and transport of floodplain nutrients associated with weir pool lowering.
Description	The current height of the main inlet structures to the wetland are set to 10.58 mAHD. This presents an opportunity to support the utility of existing structures to hold water within the wetland to extend the duration of watering events such as those associated with high-flow events and weir pool raising. To achieve this a number of outflow points would need to be investigated and potentially remediated to ensure water can be retained. Raising of the bank on the western side of the inlet structure will also be needed, along with another small blocking bank to block a flow path to the river. The main inlet to the wetland is well positioned to exploit the benefits associated with weir pool manipulation. This presents an opportunity to increase the extent of managed floodplain area and have greater control of watering frequency through weir pool raising. It also presents an opportunity to complement existing management outcomes associated with wetland drying. Active wetland drawdowns associated with weir pool lowering allow for more rapid exposure of substrate and the transport of floodplain nutrients, including salt, back to river, avoiding the accumulation and concentration risks associated with drying via evaporation.
Outcomes	 Benefits associated with implementing a wetting and drying regime, as outlined in the Beldora and Spectacle Lakes Wetland Management Plan. Enhanced capacity for conservation and improvement of wetland and floodplain vegetation. Improved soil moisture conditions. Opportunities to mobilise salt out of the wetland.

Option #2:	Sustain on-going management and maintain floodplain access, through the replacement or reinforcement of floodplain infrastructure in support of an increase in managed high-flow events and weir pool raising.
Description	An increased frequency in managed high-flow events and inundation equivalents with the implementation of the Constraints Measures Strategy (CMS) project and future weir pool manipulation activities has the potential to impact on floodplain infrastructure. To mitigate against any damage to the ageing infrastructure at Beldora South and Paddy's Perry, an integrity assessment and potential upgrade or reinforcement of the structures is needed, to ensure they can withstand more frequent watering events and not compromise management outcomes and floodplain access.
Outcomes	 Benefits associated with implementing a wetting and drying regime, as outlined in the Beldora and Spectacle Lakes Wetland Management Plan. Improved resilience to high flow events.

Option #3:	Improve connectivity by reinstating natural commence to flow levels and un-obstructed flow through the main upstream inlets to the wetland complex, through review and remediation of sill levels and re-profiling of obstructed flow paths.
Description	Less frequent high flow events, drought mitigation measures and changes in land management have led to deposition of material along the connecting creeks at the upstream end of the wetland. The deposition of material has potentially created high points within the creeks and artificially high sill levels that could be remediated to support more natural commence to flow levels and allow for un-obstructed flow through the wetland.

	The Beldora community group have prioritised the following works to improve connectivity throughout the
	• reed removal at Spectacle Creek
	 channel opening along Spectacle Creek
	 reed removal at Paddys Perry and Beldora South structures
	removal of sheet pile at Beldora South structure.
Outcomes	• Enhanced capacity for greater exchange between the river and terminal wetlands.
	• Benefits associated with implementing a wetting and drying regime, as outlined in the Beldora and Spectacle
	Lakes Wetland Management Plan.

Option #4:	Promote the conservation of the local regent parrot population, by supporting the installation of a new embankment and structure enabling watering activities as described within the Regent Parrot Recovery Project.
Description	The 'Loveday 4x4 Lagoon' falls within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the regent parrot recovery initiative. The strategic watering of this site to support the conservation and improvement of vegetation important to regent parrots, is seen as a key part of conserving the current population.
Outcomes	 Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.

Option #5:	Promote improved floodplain condition and support opportunities for passive recreational activities, through the installation of new embankments and structures at a proposed floodplain watering site adjacent Spectacle Lakes.
Description	Install new structures and embankments to 11.8 mAHD in support of a proposed floodplain-watering site that seeks to promote improved floodplain condition, in particular black box habitat, while supporting opportunities for passive recreational activities, such as canoeing.
Outcomes	 Support recreational activities for the nearby Loveday 4x4 park. Enhanced capacity for conservation and improvement of wetland and floodplain vegetation. Improved soil moisture conditions.

SITE BACKGROUND

Description

The Beldora and Spectacle Lakes wetland complex is a series of managed, pool-connected wetlands including Beldora North and South and Spectacle Lakes. Beldora North wetland feeds water to the Beldora South Wetland and Spectacle Lakes. The lakes consist of two seasonally inundated basins that are joined by a creek and are connected to the broader wetland complex downstream by a wide channel. The lakes are surrounded by floodplains to the northwest/southwest and the Loveday 4x4 Adventure Park to the northeast/southeast.

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

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in the wetland complex has been altered. Following the construction of Lock 3 in 1925, approximately 151 hectares (Ha) of the wetlands in the wetland complex were permanently connected with the River Murray at weir pool level. The lack of inundation in these areas has resulted in the decline of floodplain habitat within the wetland complex. The installation of regulators has since enabled the wetting and drying of the wetlands, improving the ecology within this area¹.

WETLAND ECOLOGY

The wetland complex represents a site of significant ecological value, particularly due to the habitat it provides for native flora and fauna communities^{1,2}. It contains a mosaic of small temporary wetlands and larger waterbodies that provide a breeding habitat for a variety of wetland fauna. It is described as a wetland with high potential for ecological benefits and an important drought refuge for birds and aquatic fauna^{3,4}.

Flora: Plant structural formations include: reedbeds, sedgelands, lignum shrublands and river red gum and black box woodland and open forest (see² for detailed description of flora at site). Plant diversity is relatively low in Beldora North (due to static water level for 70 years), compared with Beldora South and Spectacle Lakes, with those plants that prefer static water levels favoured.

Fauna: Beldora wetland complex is considered to have a high diversity of frogs in relation to other wetlands in the region¹ and provides good habitat for birds. Baseline surveys were conducted during 2003-04, 2005^{2,5} and additional surveys were undertaken during 2006⁶ and 2012⁷. The southern bell frog, regent parrot, musk duck and freckled duck have been recorded as species of conservation significance at these sites.

WETLAND MANAGEMENT

Current Management:

The primary management activity is wetland conservation with some cattle grazing. The site is managed by Beldora Station in conjunction with the Department for Environment and Water (DEW) and the Murraylands and Riverland Landscape Board. The Beldora North Wetland inlet regulators are operated for the purpose of achieving ecological outcomes. The Spectacle Lakes-Beldora Wetland Management Plan provides the strategy for managing water levels via wetting and drying at Spectacle Lakes and the Beldora North and South Wetlands through the main Beldora North regulating structure.

The Spectacle Lakes land parcel is under lease relating to a pipeline and an annual licence issued for a 4WD training facility. In 2014, an earth bank with two regulating structures was constructed across the inlet of Beldora North. These regulating structures in the North were used from 2014 to implement a wetting and drying hydrological regime across the entire Beldora and Spectacle Lakes complex. Since the construction of the Northern structure, the Paddy's Perry and Beldora South regulating structures are no longer used but still allow for connectivity and vehicle access. Both smaller structures are fitted with fish screens to exclude large carp upon refilling in Beldora South and Spectacle Lakes if a full dry is not achieved in Beldora North.

Infrastructure:

The Beldora North main inlet channel (constructed under the Riverine Recovery Project) connects at pool level through two regulators and associated embankment. Each regulator is set to 10.58 mAHD (top of piers) and is comprised of box culverts that have rotating carp screens attached to the river side of the regulator. Both regulators provide vehicle access across the inlet. These regulating structures have been used since 2014 to wet and dry the entire complex.

A regulating structure was installed in 2003 across the inlet to Beldora South Wetland. This structure consists of six box culverts each 0.9 m high x 1.2 m wide and can manage water levels between +9.41 mAHD and 10.4 mAHD. There are also two small pipe culverts in the Beldora South Wetland, above weir pool level. This structure is not currently used to implement a wetting and drying regime but is fitted with fish screens and allows for vehicle access.

The Spectacle Lakes inlet channel connects to the Beldora North Wetland. During 2003, a regulating structure (Paddy's Perry) was installed across the inlet channel to Spectacle Lakes. The regulator has an invert of +9.43 mAHD and can manage water levels between +9.43 mAHD and up to +10.6 mAHD. It consists of two box culverts each 0.9 m high. This structure is not currently used to implement a wetting and drying regime but is fitted with fish screens and allows for vehicle access.

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 Beldora-Spectacle Lakes, these included:

Environmental

- There are some risks associated with acid sulfate soils at this site and this would require further assessment before any construction works or wetting and drying activities are undertaken, see Addendum 1 to¹ and ⁸ for updated information.
- Consider excluding flow from selected sections to limit carp entering the area.

Cultural

• Construction works need to be mindful not to disturb areas of cultural importance, particularly in relation to access points.

Community/Social

- Consider current uses of floodplain for recreational activities and cattle grazing. Livestock can damage wetlands in multiple
 ways if allowed unlimited access to the wetland. Livestock cause soil and plant disturbance through pugging and
 compacting wet soil, further causing erosion of stream banks and sedimentation of wetlands. Livestock also introduce
 nutrients to the water through their urine and faeces causing algal blooms. Allowing livestock to access wetlands is not
 only damaging to the wetlands but can affect livestock health and productivity⁹. Reducing/removing stock would lessen
 trampling and promote healthy soil and plant communities.
- Beldora community are very interested in clearing Spectacle Creek to improve connectivity to the pool-connected site.

Operational/logistics

- Consider the logical sequencing of these options.
- Confirm structural integrity of existing structures and suitability for refurbishment.
- Option 1 consider need for multiple culverts to prevent erosion or overtopping.

KEY STAKEHOLDER INVOLVEMENT

- Beldora Station
- Berri Barmera Council
- Berri Barmera Landcare
- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Loveday 4x4 Adventure Park
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

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Yatco Lagoon

Location: Weir Pool 3, River Chainage Markers 459 to 454 Land Tenure: Crown Record / Certificate of Title

Wetland Size: 346 hectares (Ha) Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS	
Option #1:	Support the current wetland management and associated outcomes with wetting and drying through the repair
	or replacement of existing central control structure on the main inlet (northern embankment).
Description	The central control structure on the main inlet (northern embankment) managing North Yatco Lagoon is in poor condition and leaks, reducing the efficiency of wetland management outcomes associated with wetting and drying cycles, including managing for invasive fish populations (i.e. carp). As the structure is seen as critical to maintaining current wetland exchange and taking advantage of potential future changes in hydrology through weir pool manipulation (raising and lowering) this option aims to replace or repair this structure with flow control boards in order to support future wetland management operations.
Outcomes	 Benefits associated with implementing a wetting and drying regime. Improved ability to manage invasive species.

Option #2:	Improve floodplain condition by promoting:
	 An increase in the duration of floodplain watering associated with managed and natural high-flow events, through the retention of water, utilising existing infrastructure and complementary works Opportunities for increased floodplain watering inundation extent and frequency associated with weir pool raising Improved wetland drying management cycle activities through active drawdown and transport of floodplain nutrients associated with weir pool lowering.
Description	The current height of the main inlet structures to the wetland are set to 10.8 mAHD. This presents an opportunity to support the utility of existing structures to hold water within the wetland to extend the duration of watering events such as those associated with high-flow events and weir pool raising. To achieve this, the central regulator in the northern structure would need to be replaced or repaired and a number of outflow points would need to be investigated and potentially remediated to ensure water can be retained. Works would include raising of the access track on the eastern side of the main structure across the lagoon and blocking of several flood runners along the eastern edge of the lagoon, which connect to the river at this level. Some flood runners are understood to be acceptable to block, whilst others will require a regulator to retain connection to the river. The main inlet to the wetland is well positioned to exploit the benefits associated with weir pool manipulation. This presents an opportunity to increase the extent of managed floodplain area and have greater control of watering frequency through weir pool raising. It also presents an opportunity to complement existing management outcomes associated with wetland drying. Active wetland drawdowns associated with weir pool lowering allow for more rapid exposure of substrate and the transport of floodplain nutrients, including salt, back to river, avoiding the accumulation and concentration risks associated with drying via evaporation.
Outcomes	 Benefits associated with implementing a wetting and drying regime. Enhanced capacity for conservation and improvement of wetland and floodplain vegetation. Improved soil moisture conditions. Opportunities to mobilise salt out of the wetland.

Description

Yatco Lagoon (North and South) is a permanent shallow wetland situated on the west bank of the River Murray immediately upstream of the irrigation township of Moorook. The main connection to the river occurs at the northern, most downstream end of the wetland complex. The southern lagoon is connected to the river through a smaller, 3.9 km long channel.

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

Prior to the regulation of flows in the River Murray and the construction of locks and weirs, the Yatco Lagoons would have had a more variable water regime. Installation of regulators has since enabled wetting and drying of the lagoons, improving ecological outcomes within this area.

WETLAND ECOLOGY

Yatco Lagoon was assessed as having low- moderate conservation value. It is likely that this assessment has improved since considering investments and management actions through RRP and other programs¹.

Flora: Vegetation composition at Yatco Lagoon includes river red gum and black box woodland, sedges and bulrush, see references^{2,3} for detailed description of flora at this site. The floodplain and riparian zone flora were in a poor condition at the latest baseline survey³.

Fauna: Fish and frog surveys have been conducted on several occasions^{3,4}. Across the surveys eight native and five exotic species of fish were found. No species of state or national significance were recorded. In total, five species of frogs have been recorded at Yatco Lagoon, among them the listed Southern bell frog (*Litoria raniformis*). During the baseline survey conducted in 2005, Yatco Lagoon was found to have a higher mean diversity of waterbirds than other wetlands in the region, this was thought to be because the wetland acts as a drought refuge during dry times and has a high variety of habitats.

WETLAND MANAGEMENT

Current Management:

The north and south lagoons are managed by the Murraylands and Riverland Landscape Board in conjunction with private landholders. Each lagoon can be managed independently for drying and wetting operations. Currently, the northern lagoon takes approximately two summers to draw down. The timing of the wetting and drying cycles are and have been variable and the hydrograph is due for review.

Infrastructure:

In 2008, a causeway between the north and south lagoon was constructed which included the addition of sluice gates on existing infrastructure in order to manage the north and south lagoons separately. Other works during this construction period included upgrading an embankment with additional flow regulators and carp screens to improve the connectivity and fish movements between the river and the lagoon.

New regulators were recently installed (with sluice gates and carp screens) at a series of locations, including between the middle creek and north lagoon, middle creek and south lagoon, and between the south and north lagoons. One of the former structures is still in-situ, but was not upgraded.

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 Yatco, these included:

Environmental

- Acid sulfate soil (ASS) risk is considered to be low in the northern Yatco lagoon, while the risk in the Southern lagoon is considered to be low to moderate, see reference⁵ for hazard assessment and risk associated with acid sulfate soils and metal mobilisation. ASS should be further assessed before any work progresses.
- Capacity to export salt from site needs assessment in relation to current and proposed structures.

Cultural

• Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

 Local stakeholders have expressed interest in the existing structure being left in place, however, note the existing structure is a flow/management constraint.

Operational/logistics

- Consider upgrading existing structures; central structure in Option 2 under repair.
- Need to ensure good accessibility to structures.

KEY STAKEHOLDER INVOLVEMENT

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

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Loveday Mussel Lagoons Wetland Complex

Location: Weir Pool 3, River Chainage Markers 455 to 447 km Land Tenure: Crown Record

Wetland Size: 157. 2 hectares (Ha) Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS	
Option #1:	Promote and enhance wetting and drying wetland management outcomes, by allowing for the independent management of the North and South Loveday and Mussels Lagoons.
Description	The central causeway structure and associated pipe culverts, dividing the North and South Loveday Lagoons provide an opportunity to manage these two lagoons independently. The presence of acid sulfate soils (ASS) in the North Lagoon has limited wetland management within the basin with prolonged lowered water levels, at times resulting in an odour nuisance to the surrounding community. Therefore, to achieve outcomes in the South Lagoon associated with longer drying periods and flexibility for managing for ASS in the North Lagoon, replacing or upgrading the existing causeway structures which divides the north and south lagoons is required. Designs for retrofit of six structures to enable regulation would be required. A review and potential upgrade of the inlet structure via the North Lagoon would also enhance management flexibility and outcomes. In addition, the replacement of the 'red gate' control structure would support the intended independent management of Loveday from the Mussels Lagoons, increasing operational flexibility. The existing structure is in poor condition and likely to need full replacement to function as a regulator.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions. Improved acid sulfate soil management. Improved invasive fish species management.

Option #2:	Improve connectivity by reinstating natural commence to flow levels and un-obstructed flow through the main upstream inlets to the wetland complex, through review and remediation of sill levels and re-profiling of obstructed flow paths.
Description	Less frequent high flow events, drought mitigation measures and changes in land management have led to deposition of material and promotion of reed growth along the connecting creeks at the upstream end of the wetland. The deposition of material has potentially created high points within the creeks and artificially high sill levels that could be remediated to support more natural commence to flow levels and un-obstructed flow through the wetland. The likely focus for remediation works would be Sheepyard Creek and the two tributaries that form Blackfellows Creek. Assessment will be required to determine target commence-to-flow levels and exactly where flow obstructions are.
Outcomes	 Benefits associated with an improved watering regime. Enhanced capacity for greater exchange between the river and terminal wetlands. Reduced build-up of sediment and abundant bullrush (<i>Typha spp</i>). Conservation and improvement of wetland vegetation. Improved soil moisture conditions. Improved management of invasive fish species.

Option #3:	Improve floodplain condition by promoting:
	 An increase in the duration of floodplain watering associated with managed and natural high-flow events, through the retention of water, utilising existing infrastructure and complementary works Opportunities for increased floodplain watering inundation extent and frequency associated with weir pool raising Improved wetland drying activities through active drawdown and transport of floodplain nutrients associated with weir pool lowering.

Description	The current height of the main inlet structures to the wetland are set to 10.15 mAHD. This presents an opportunity to support the utility of existing structures to hold water within the wetland to extend the duration of watering events such as those associated with high-flow events and weir pool raising. To achieve this a number of outflow points would need to be investigated and potentially remediated to ensure water can be retained. Works would likely require upgrade of the main causeway structure (as described in Option #1), a new regulator structure on Blackfellows Creek, and a new crossing structure within the floodplain at the northern end of the Big Mussel lagoon, as it appears that the existing structure is not wide enough for vehicle access.
	The main inlet to the wetland is well positioned to exploit the benefits associated with weir pool manipulation. This presents an opportunity to increase the extent of managed floodplain area and have greater control of watering frequency through weir pool raising. It also presents an opportunity to complement existing management outcomes associated with wetland drying. Active wetland drawdowns associated with weir pool lowering allow for more rapid exposure of substrate and the transport of floodplain nutrients, including salt, back to river, avoiding the accumulation and concentration risks associated with drying via evaporation.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions.

Option #4:	Sustain on-going management and maintain floodplain access, through the replacement or reinforcement of aging floodplain infrastructure in support of an increase in managed high-flow events and weir pool raising.
Description	An increase frequency in managed high-flow events and inundation equivalents with the implementation of the Constraints Measures Strategy (CMS) project and future weir pool manipulation activities has the potential to impact on aging floodplain infrastructure. To mitigate against any damage to the aging infrastructure, an integrity assessment and potential upgrade or reinforcement of the structures is needed, to ensure they can withstand more frequent watering events and not compromise management outcomes and floodplain access. If assessments indicate that replacement of critical infrastructure is necessary, there is an opportunity to review the structure heights and potentially increase the extent of water retention. Preliminary investigations indicate that the strategic replacement of structures to 10.5 mAHD could yield increased outcomes whilst minimising impacts associated with construction and ongoing operations and maintenance.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions.

SITE BACKGROUND

Description

The Loveday Swamps (North and South Basin) and the Mussel Lagoons Wetland Complex are located on the eastern side of the River, approximately 4 km from the township of Cobdogla. The wetlands lie between the River Murray to the west, and irrigated highland to the east. The wetland complex is comprised of both permanent and temporary wetland basins, including managed wetlands (Little Mussel Lagoon, Big Mussel Lagoon, Pipeline Lagoon, Sheepyard Lagoon, Germein Swamp, Dons Swamp and Gordons Swamp), an unmanaged permanent wetland (OP Lagoon), and a number of unmanaged temporary wetlands. The wetland complex is connected to the River Murray via the 'main inlet' and other flow paths including Sheepyard Creek and Blackfellows Creek¹.

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

In the late 19th-early 20th century, the Loveday Mussel Lagoons Wetland Complex was used for grazing. The adjacent Loveday Swamps were utilised as irrigation disposal basins from the 1970s onwards. The SA Field and Game Association (Barmera-Moorook Region) has managed the wetland complex since 1984 when it began leasing the area from the Cobdogla Irrigation Trust. The construction of locks and weirs along the River Murray led to several wetland basins within the Loveday Mussel Lagoons Wetland Complex to become permanently connected at pool level. The installation of regulators has since enabled the wetting and drying of wetlands, improving the ecological health of the area¹.

WETLAND ECOLOGY

The wetland complex is composed of a number of connecting permanent waterbodies, ephemeral wetlands and areas that are hydrologically manipulated. It is considered to have high conservation value² and moderate to high conservation status³. The swamps are extensively used as feeding and breeding areas by waterbirds and fish.

Flora: Vegetation composition at the wetland complex includes river red gum and black box woodland and forest, lignum shrublands, saltbush and samphire shrubland, reedbeds and sedge. See references^{1,4}, for detailed description of flora and fauna at site.

Fauna: The swamps provide some of the best waterbird breeding habitat in the region and surveys have been conducted by Murraylands and Riverland Landscape Board with the assistance of members of the SA Field and Game Association. A total of 98 bird species have been recorded across the wetland complex, among them the regent parrot (*Polytelis anthopeplus monarchoides*) which is listed as vulnerable regionally and nationally¹. This species is believed to have reduced dramatically since the 1950s and it was thought at some stage to be extinct in the wild. A total of twelve fish species, eight native and four invasive have also been found across the fish surveys conducted at the wetlands^{1,4}, no fish species of national significance were found. A total of six frog species have been recorded at the complex; among them, the nationally and state-listed Southern bell frog (*Litoria raniformis*)¹. Two species of tortoise have been recorded in Loveday Mussel Lagoons Wetland Complex, the Macquarie turtle (*Emydura macquarii*) and Eastern long-necked tortoise (*Chelodina longicollis*)³.

WETLAND MANAGEMENT

Current Management:

The Loveday Mussel Wetland Complex has restricted access and is managed by the SA Field and Game Association - Barmera-Moorook Region (excluding the North Basin) in conjunction with the Berri Barmera Landcare Group, and Murraylands and Riverland Landscape Board. The wetland is utilised for recreational activities, including fishing and duck hunting.

The permanent basins (i.e. Big and Little Mussel Lagoons, Pipeline Lagoon, Sheepyard Lagoon and Dons Swamp) are hydrologically managed as temporary wetlands and are wet and dried through the operation of several flow-control structures located across the site. As noted above, the control structure 'red gate' is currently inoperable as it is jammed closed. The Loveday Mussel Lagoons Wetland Complex must not be dried while Loveday Swamp South Basin is full due to groundwater issues. There are a number of temporary flow paths across the wetland complex that could be improved to increase lateral connectivity within this area.

The presence of exposed acid sulfate sediments during lowered water levels in Loveday North has also led to odour issues.

Infrastructure:

Loveday Swamps (North and South Basin) and the Loveday Mussel Lagoons Wetland Complex are hydrologically connected. Loveday Swamp (North) connects to the main river channel via a regulator, and to Loveday Swamp (South) via the causeway pipes. Loveday South connects to Loveday Mussel Lagoon via the EWS Weir ('red gate') and the main river channel via Blackfellows Creek. The EWS weir ('red gate') is currently inoperable as it is jammed closed. The Loveday Mussel Lagoons connects to the river via the main inlet regulator, Blackies Oven and Sheepyard Creek.

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 Loveday Mussels, these included:

Environmental

- There are significant risks associated with acid sulfate soils at this site and these would require further assessment before any construction works or wetting and drying activities are undertaken^{5,6}.
- Need to determine management intentions for southern lagoon in relation to intended wet-dry regime.

Cultural

• Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

• Field and Game community group is important stakeholder.

Operational/logistics

- Need to ascertain that existing infrastructure to be retained can withstand the expected new water levels.
- Site will need a new management plan for management of new structures.

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Landcare
- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Field and Game Association (Barmera-Moorook Region)
- SA Water

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Wachtels Lagoon

Location: Weir Pool 3, River Chainage Markers 449 to 440 Land Tenure: Crown Record Wetland Size: 678 hectares (Ha) Normal Pool Level: 9.8 mAHD

PROPOSED OPTIONS	
Option #1:	Improve wetland and floodplain condition by promoting variable water levels created through weir pool manipulation (lowering and raising).
Description	The main inlet to the wetland is positioned to exploit the benefits associated weir pool manipulation. This presents an opportunity to increase the extent of managed floodplain area and have greater control of watering frequency through weir pool raising. Weir pool lowering will expose significant areas of substrate otherwise permanently inundated and promote the active transport of floodplain matter and nutrients, including salt, back to river.
	Preliminary investigations have identified that raising and lowering by +/-60 cm at flows of 20 gigalitres (GL) would increase opportunities for improving managed floodplain extent (raising) and exposed substrate (lowering) whist improving the health of native vegetation and mitigating against water quality risks.
	An increased frequency in managed high-flow events and inundation equivalents with the implementation of the Constraints Measures Strategy (CMS) project and future weir pool manipulation activities has the potential to impact on aging floodplain infrastructure. To mitigate against any damage to the aging infrastructure an integrity assessment and potential upgrade or reinforcement of the structures is needed, to ensure they can withstand more frequent watering events and not compromise management outcomes and floodplain access.
Outcomes	 Benefits associated with wetting and drying management. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions.

Option #2:	Improve connectivity by reinstating natural commence to flow levels and un-obstructed flow through the main upstream inlets to the wetland complex, through review and remediation of sill levels and re-profiling of obstructed flow paths.
Description	Less frequent high flow events, the installation of crossing structures, drought mitigation measures and changes in land management have led to deposition of material and promotion of reed growth along the connecting creeks at the upstream end of the wetland. The deposition of material has potentially created high points within the creeks and artificially high sill levels that could be remediated to support more natural commence to flow levels, which with the management of abundant bullrush (<i>Typha spp</i>) could allow for un-obstructed flow through the wetland.
	There are several existing structures on connecting creeks and flow paths to the floodplain. A concept design is currently underway to replace an existing crossing with dual cell trafficable box culverts, remove reeds and silt build-up at the inlet, and re-profile between 250-500 m of downstream channel. Additional efforts will investigate further similar opportunities to undertake works at existing structures that maximise lateral connectivity and promote transport processes (water, carbon, nutrients, biota) between the river channel and the lagoon.
Outcomes	 Enhanced capacity for greater exchange between the river and wetlands. Manage build-up of sediment and abundant <i>Typha spp</i>.

SITE BACKGROUND

Description

Wachtels Lagoon is located on the western side of the River Murray, approximately 4 km from the township of Cobdogla and bypasses 9km of the river. Three inlet creeks are located within Moorook Game Reserve and feed the southern, downstream end of the lagoon.

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

Prior to the regulation of flows in the River Murray and the construction of locks and weirs, Wachtels Lagoon would have had a more variable water regime. The stabilisation of water levels has led to permanent inundation of low-lying areas and reduced frequency and duration of inundation of the surrounding floodplains.

WETLAND ECOLOGY

Flora

Vegetation composition at Wachtels Lagoon includes river red gums (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) with an understory of lignum, and grasses and sedges in low lying areas. Samphire can be seen on the low lying salt affected soils. Dense reeds line much of the shore line in the lagoon with grasses and samphire dominating further up the banks⁵.

Fauna

This area is an important nesting habitat for numerous waterbird species, particularly during flood periods. Large numbers of great cormorants nest in the lagoon lagoon⁵. An exclusion zone exists within the lagoon to protect white-bellied sea eagles that are found nesting in this location.

WETLAND MANAGEMENT

Current Management:

Wachtels Lagoon is managed by National Parks and Wildlife Service SA and serves as a popular destination for river-based recreational activities. Waterfowl hunting is permitted in the reserves on declared open days.

Infrastructure:

A new channel section was created in recent years to connect the southern point of the lagoon with part of an existing, silted inlet channel. Sediment removal works were previously performed at a culvert crossing at the start of the second inlet creek. However, the inlet to the first, southern creek has virtually closed due to sedimentation and reed accumulation, as well as a clogged culvert crossing that is set too high.

A concept design is currently underway to replace an existing crossing with dual cell trafficable box culverts, remove reeds and silt build-up at the inlet, and re-profile between 250-500 m of downstream channel.

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 Wachtels Lagoon, these included:

Environmental

- There is a low to moderate risk associated with acid sulfate soils at this site and this would require further assessment before any construction works or wetting and drying activities are undertaken⁶.
- Construction works need to be mindful of the impact on white-bellied sea eagle habitat.
- There is a risk associated with any construction activity of introducing pest species.
- Further investigations needed on salinity and risks at this site.
- Current condition of the wetland is quite good with low carp numbers, clear water and good seedbank.

Cultural

• Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

- Need to manage potential impacts on camp sites from construction and future operations.
- Need to maintain access to water for irrigators and stock and domestic connections.

Operational/logistics

 If progressing this option, need to consider additional operation and maintenance (O&M) costs and limited access for people to do O&M work in parks.

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Landcare
- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office
- Loxton Waikerie Council
- Loxton Waikerie Landcare
- Murray-Darling Basin Authority (MDBA)

- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- South Australian Murray Irrigators (SAMI)
- SA Water

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Lake Bonney

Location: Weir Pool 3, River Chainage Markers 438 (connection) Land Tenure: Crown Record

Wetland Size: 1,700 hectares (Ha) Normal Pool Level: +9.8 mAHD

PROPOSED OPTIONS		
Option #1:	Improve wetland and floodplain condition by promoting variable water levels created through weir pool manipulation (lowering and raising) and high flow events.	
Description	The main inlet to the wetland is positioned to exploit the benefits associated weir pool manipulation (WPM). This presents an opportunity to increase the extent of managed floodplain area and have greater control of watering frequency through weir pool raising. Weir pool lowering (WPL) will expose significant areas of substrate otherwise permanently inundated and promote the active transport of floodplain matter and nutrients, including salt, back to river.	
	Preliminary desktop investigations have identified that raising and lowering by +/-60 cm at flows of 20 gigalitres (GL) would increase opportunities for improving managed floodplain extent (raising) and exposed substrate (lowering) whilst mitigating risk associated with water quality and improving the health of native vegetation.	
	The <i>Caring for Country Management Plan</i> for Lake Bonney states that in co-operation with the Department for Environment and Water (DEW), water level manipulation via Lock 3 would provide an opportunity to improve fringing vegetation around the edges of Lake Bonney and potentially reduce surface water salinity. It is anticipated that this action will improve the condition and diversity of vegetation around the lake edge. It will also help to lower the salinity of the water in Lake Bonney by releasing salty water from the lake during lowering by re-filling the lake with lower salinity water from the river ¹ .	
	Preliminary modelling indicates that through regular WPM activities with intermittent high-flow events, salt levels in the lake can be managed and maintained; with salt levels remaining below risk thresholds within the river at key locations. However, hydrodynamic modelling and monitoring demonstrates that during the recession of high- flow events and weir pool manipulation, Loch Luna receives an influx of salt from Lake Bonney, which persists in the wetland, before receding back into Lake Bonney. This option includes an investigation on how best to protect Loch Luna from any salt influx from Lake Bonney as it supports weir pool manipulation and high-flow events in the Lock 3 reach.	
Outcomes	 Benefits associated with an improved water regime. Conservation and improvement of wetland vegetation. Improved soil moisture conditions. Improved lateral connectivity. Provision of fresh water recharge to salt-affected floodplains. Improved recreational and tourism opportunities whilst ensuring environmental benefits. 	

Option #2:	Investigate the desired short and long-term ecological, cultural, social and economic outcomes for Lake Bonney, including benefits associated with reduced salt and the solutions needed to achieve them (e.g. salt interception, WPM, water pumping, etc.).
Description	A number of community driven proposals exist that seek to outline the management of Lake Bonney, including the desired salt level to support outcomes. This option seeks to investigate the short and long-term outcomes for Lake Bonney and the water quality conditions required to achieve them and the potential solutions (e.g. salt interception, WPM, water pumping, etc.) for salt reduction within Lake Bonney. For example, preliminary modelling suggests export of saline water via a pipe from the southern end of the lake to the main channel would provide significant salinity benefits, while allowing management for reach-wide targets.

Description

Lake Bonney is located above Lock 3 and next to the township of Barmera. It is located adjacent the Loch Luna wetland complex and is connected to the River Murray via Chambers Creek. Lake Bonney is the largest permanent lake in South Australia upstream of Wellington, with a volume of approximately 59,000 megalitres (ML). Surrounding land use includes agriculture on the north and west side and recreation areas and local businesses on the south side of the lake. The lake is approximately 7 km long and 3.5 km wide, covering an area of about 1,700 hectares (Ha) at normal pool level. It has an average depth of 1 to 2 m with a maximum depth of approximately 4 m².

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.

RMMAC and Berri Barmera Council established a Memorandum of Understanding (MOU) dated 23 September 2014, which provided a framework to guide administration of joint acre, control and management arrangements of lands around Lake Bonney that are subject to native title determination.

Post-colonial Use

Prior to the regulation of flows in the River Murray and the construction of locks and weirs, Lake Bonney would have had a more variable water regime. The stabilisation of water levels has led to permanent inundation of low-lying areas and reduced frequency and duration of inundation events.

WETLAND ECOLOGY

Lake Bonney was assessed by Thompson (1986) and Jensen (1996) as having a high to moderate conservation value because of the enormous size and depth which provides habitat for a large amount of species usually associated with the main river channel. It is extensively used for spawning by fish during floods, and is an important breeding area for tortoises and a large number of waterbirds use the Lake^{3,4}.

The floodplain surrounding Lake Bonney is highly modified and dominated by river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) open woodland, over a sparse grassy understorey and open chenopod shrubland^{2,5}. The Lake's ecological value is reduced by its high salinity levels which limit the diversity of species and vegetation within and surrounding the Lake. The last official vegetation survey only found fragments of submerged aquatic vegetation in a small bay on the western side of the Lake⁵ and reported that the overall tree health was generally poor².

The Lake is an important breeding ground for the 3 species of River Murray tortoises, Short-necked (*Emydura macquarii*), Long-necked (*Chelodina longicollis*) and Broad-shelled (*Chelodina expansa*)^{3,6}.

WETLAND MANAGEMENT

Current Management:

Lake Bonney has high cultural, environmental and social value to Barmera and the Riverland communities. Recreational activities include boating, fishing, camping, and swimming. There are commercial camp parks located on the lakeshore (e.g. Camp Kedron and Barmera North Lake Caravan Park) as well as various undesignated areas where free camping has not been restricted.

Infrastructure:

Lake Bonney is connected by an inlet at the north-western side of the lake through Chambers Creek, which ultimately joins the River Murray near Cobdogla. As a significant volume of water evaporates annually (over 26 GL per year), most of the water recharge occurs via the river with some groundwater inflows.

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 Lake Bonney, these included:

Environmental

- Potential risks include reducing the ecological health of Loch Luna by increasing its salinity in the process of exporting salt from Lake Bonney. The overall risk of soil acidification and water acidification in Lake Bonney is considered to be low⁷.
- May allow reed establishment around Lake Bonney which will help reduce wave impacts.

Cultural

- Lake Bonney is a significant cultural site with co-management arrangements between RMMAC and council.
- Construction works need to be mindful not to disturb areas of cultural importance.
- Bush Tucker Gardens are being proposed and RMMAC want protection of cultural assets, good plant growth and barriers to vehicle movements.

Community/Social

 Concerns that "excessive" recovery of aquatic plants could affect recreational tourism opportunities, such as boating, for the lake.

Operational/logistics

- Need to determine whether the connection at Nappa Bridge will dry under a WPL of 60cm.
- Need to understand requirements for freshening the whole lake vs half of the lake.
- The Macintosh canal should remain an option as it can protect Loch Luna from salinity impacts.

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Council Environment and Sustainability Committee
- Berri Barmera Council Lake Bonney Caring for Country Advisory Committee
- Berri Barmera Landcare
- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Loxton Waikerie Council
- Loxton Waikerie Landcare
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Overland Corner Group
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- South Australian Murray Irrigators (SAMI)
- SA Water

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Loch Luna Complex

Location: Weir Pool 3, River Chainage Markers 435 to 432 Land Tenure: Crown Record Wetland Size: 220 hectares (Ha) Normal Pool Level: +9.8 mAHD

PROPOSED OPTIONS		
Option #1:	Improve floodplain condition by promoting variable water levels created through weir pool manipulation (lowering and raising), whilst managing for salt influx from Lake Bonney following high-flow events and weir pool manipulation.	
Description	The wetland is positioned to exploit the benefits associated with weir pool manipulation and associated variable water levels. Weir pool manipulation (WPM) presents an opportunity to increase the extent of managed floodplain area and have greater control of watering frequency through weir pool raising. Weir pool lowering (WPL) presents an opportunity to expose otherwise permanently inundated substrate and promote the active transport of floodplain matter and nutrients, including salt, back to river. WPL also promotes the creation of temporary lotic conditions within the Nockburra and Chambers Creek anabranches. Hydrodynamic modelling and monitoring demonstrates that during the recession of high-flow events and weir pool manipulation, the wetland receives an influx of salt from Lake Bonney, which persists in the wetland, before receding back into Lake Bonney. This option includes an investigation on how best to protect Loch Luna from any salt influx from Lake Bonney and it will support weir pool manipulation events in the Lock 3 Reach.	
Outcomes	 Conservation and improvement of wetland vegetation. Improved soil moisture conditions. Improved lateral connectivity. Temporary lotic conditions within the Nockburra and Chambers Creek anabranches. Provision of fresh water recharge to salt-affected floodplains. Restoration of variable water levels supporting an interconnected mosaic of diverse littoral, riparian and floodplain habitats and mixed cohorts of native woody-perennial plants across the lateral extent of the WPM Zone of Influence. 	

Option #2:	Explore infrastructure options and remediate obstructed flow paths to minimise impacts of salt from Lake Bonney during weir pool manipulation by promoting alternative pathways for flow back to river.
Description	This option includes an investigation on protecting Loch Luna from any salt influx in order to maintain the existing aquatic flora and fauna communities that are valued by recreational users. It will investigate the potential to use new structures to utilise alternative flow paths during a weir pool manipulation event to manage the risk of salt transport into Loch Luna. This option will also address any barriers to flow. There are several pipes under the access tracks that might obstruct flow or are set artificially high. This option will review the need to upgrade these structures and address barriers that restrict flows.
Outcomes	 Conservation and improvement of wetland vegetation. Improved soil moisture conditions. Improved lateral connectivity. Provision of fresh water recharge to salt-affected floodplains. Restoration of variable water levels supporting an interconnected mosaic of diverse littoral, riparian and floodplain habitats and mixed cohorts of native woody-perennial plants across the lateral extent of the WPM Zone of Influence.

SITE BACKGROUND

Description

The Loch Luna wetland complex is approximately 6km west of Barmera and is a part of the floodplain between Lake Bonney and Lock 3. The area is protected in the Loch Luna Game Reserve, which is comprised of permanent wetlands, narrow creeks, shallow swamps, as well as floodplains and seasonally inundated lowlands. The Loch Luna lakes are comprised of two large wetlands that are permanently connected to the River Murray at Lock 3 pool level. These lakes are linked to the river through a series of creeks and channels that make up the Nockburra and Chambers Creek sections to the south. Irrigation offtakes occur at several locations within the wetland complex.

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

Prior to the regulation of flows in the River Murray and the construction of locks and weirs, Loch Luna would have had a more variable water regime. The stabilisation of water levels has led to permanent inundation of low-lying areas and reduced frequency and duration of inundation of the surrounding floodplains.

WETLAND ECOLOGY

Ecological role: Loch Luna wetland complex comprises mostly permanent wetlands. It is part of the Loch Luna Game Reserve and is a wetland of importance and high conservation value due to its diverse vegetation^{1,2}. It is also important habitat for water birds and other aquatic life^{2–4}.

Flora: Vegetation composition at Loch Luna wetland complex includes river red gum and black box woodland and forest, lignum, saltbush and shrublands, reedbeds and sedgelands. See^{2,5} for detailed description of flora at site. The tree and vegetation survey concluded that the trees in this wetland complex were mainly in good to excellent health and the complex had generally a low diversity of emergent aquatic vegetation which was restricted to narrow fringes around the wetland basins⁵.

Fauna: The complex is an important nesting habitat for numerous waterbird species, particularly during flood periods. Loch Luna also provides habitat for tortoise breeding^{2,3}. See reference⁵ for further details about species composition at site.

WETLAND MANAGEMENT

Current Management:

The wetland complex is currently managed by National Parks and Wildlife SA, and is primarily used for recreational activities. The wetland complex has numerous narrow creeks and shallow swamps, making it a popular kayaking and canoeing destination. Waterfowl hunting is permitted within designated areas of the reserve on declared open days³.

Infrastructure:

No structures have been installed within the Loch Luna wetland complex.

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 Loch Luna, these included:

Environmental

- Hydrodynamic modelling and monitoring demonstrates that during the recession of high-flow events the wetland receives an influx of salt from Lake Bonney, which persists in the wetland, before receding back into Lake Bonney. Impacts to both ecology and irrigators would need to be considered for any future management decisions.
- There is a medium to high risk of acid sulfate soils across this site, see reference for further details⁶.
- Loch Luna is currently in good condition; investigations could assess whether condition could be maintained with intermittent fluxes in salinity.

Cultural

• Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

- Consider potential impacts to Canoe Trails and camping sites in National Park.
- Short-term salinity spikes for long term freshening may have short-term impacts but long-term benefits for irrigators drawing water from Loch Luna.
- To negate potential issue posed by salinity affecting irrigators with pumps on Chambers Creek, they could be assisted to hook into the Central Irrigation Trust (CIT) network.

Operational/logistics

- Need to investigate feasibility of water exchange with Lake Bonney using this approach and compare to alternatives such as McIntosh Canal and pipeline from Bonney to main channel.
- Potentially investigate the necessity of additional infrastructure to split flow through Cobdogla Basin and Nockburra Creek.

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Council Environment and Sustainability Committee
- Berri Barmera Council Lake Bonney Caring for Country Advisory Committee
- Berri Barmera Landcare
- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Loxton Waikerie Council

- Loxton Walkerie Landcare
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Overland Corner Group
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- South Australian Murray Irrigators (SAMI)
- SA Water

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Banrock Station Wetland Complex

Location: Between River Chainage 435 (above Lock 3) to 423 (below Lock 3) Land Tenure: Crown Lease

Wetland Size: 240 hectares (Ha) Normal Pool Level: Varies from 9.8 mAHD at inlet to 6.5 mAHD at outlet

PROPOSED OPTIONS	
Option #1:	Support current management outcomes and improve management flexibility by supporting capacity to manage the two lagoon systems separately, through the installation of a regulating structure and complementary embankment.
Description	To support current wetting and drying management activities within the lagoon system and associated outcomes (and to introduce management flexibility) it is proposed to install a regulating structure and complementary embankment to manage the eastern and western lagoons separately. This will introduce the capacity to tailor separate management hydrographs for the lagoons, in support of management outcomes for both risks and benefits.
	Structure and embankment heights will consider the complementary outcomes and measures outlined in Option 2 and 3.
Outcomes	 Benefits associated with wetting and drying regime. Greater connectivity between the river and wetlands. Improve management flexibility.

Option #2:	Promoting opportunities for increased extent of inundation and duration of floodplain watering in the Eastern lagoon, associated with managed and natural high-flow events through the retention of water, utilising infrastructure proposed in Option 1 and complementary works.
Description	This option aims to complement investment in Option 1 by raising the height (via an embankment and existing road network) of the lowest point of connection between the eastern and western lagoons. This will allow for retention of water within the Eastern Lagoon, further increasing management capacity to tailor separate management hydrographs for the lagoons in the support of management outcomes for both risks and benefits. Embankment height will consider the complementary outcomes and measures outlined in Option 1 and 3.
Outcomes	 Benefits associated with a wetting and drying regime. Greater connectivity between the river and wetlands.

Option #3:	 Improve floodplain condition by promoting: An increase in the duration of floodplain watering associated with managed and natural high-flow events, through the retention of water, utilising existing infrastructure and complementary works Opportunities for increased floodplain watering inundation extent and frequency associated with weir pool raising.
Description	Option 3 builds on 1 and 2 by enabling watering of greater extent. The lowest height of the main inlet structures to the wetland are set to 10.5 mAHD. This presents an opportunity to support the utility of these structures, by building up the perimeter access track, to hold water within the wetland to extend the duration of watering events, such as those associated with high-flow events and weir pool raising. This will enable ongoing access and track utility during high watering events.
	The main inlets to the wetland are well positioned to exploit the benefits associated with weir pool manipulation. This presents an opportunity to increase the extent of managed floodplain area and have greater control of watering frequency through weir pool raising.
Outcomes	 Greater connectivity between the river and wetlands. Benefits associated with implementing a wetting and drying regime. Improved fish habitat.

Option #4:	Promote conservation of local regent parrot populations, by supporting the installation of a new embankment and structure enabling watering activities as described within the Regent Parrot Recovery Project.
Description	Banrock Bend (proposed watering site) and Banrock Swamp (existing water site) fall within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the Regent Parrot Recovery Project. The strategic watering of these sites up to 8.8 mAHD will support the conservation and improvement of vegetation important to regent parrots at these sites and is seen as a key part of conserving the current population.
Outcomes	 Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.

SITE BACKGROUND

Description

The Banrock Station Wetland Complex straddles Lock 3 and is approximately 26 km northwest of Berri. The wetland consists of two large basins referred to as the Eastern and Western Lagoons, which join during high flow events. The Banrock Station Wetland Complex is bounded to the northwest, north and east by the River Murray, and the Banrock Station Vineyard to the south and southwest. Since 1992, the site has had wetting and drying cycles that are semi-natural and intermittent. In 2002, the site was designated as a Wetland of International Importance under the Ramsar Convention on Wetlands. Current land use includes horticultural, winery tourism, recreational activities, and wetland management.

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

Prior to the regulation of flows in the River Murray and the construction of locks and weirs, Banrock Station would have had a more variable water regime. The stabilisation of water levels has led to permanent inundation of low-lying areas and reduced frequency and duration of inundation of the surrounding floodplains. The installation of regulators has since enabled the wetting and drying of wetlands, improving the ecological outcomes within this area¹.

WETLAND ECOLOGY

Banrock station wetland is a complex of connected permanent and ephemeral wetlands. It is a wetland of importance and high conservation value^{2–4}. The Banrock station wetland complex supports a range of biological diversity (including diversity in habitat types) found in the region. It provides non-breeding habitat for multiple migratory waterbirds listed under the international migratory bird treaties and provides an alternative migration path around Lock 3 for small native fish as well as large-bodied fish. It is also a refuge area for waterbirds and other aquatic fauna during drought, and a roosting site for waterbirds^{1,5,6}.

Flora: The dominant wetland vegetation types on the floodplain include river red gum woodland (*Eucalyptus camaldulensis*), black box woodland (*Eucalyptus largiflorens*), lignum and samphire shrubland, and sedgelands. Aquatic herblands are present in Banrock Lagoon providing significant habitat value for aquatic biota, see references for further details of species composition at site^{1,5}.

Fauna: The site supports a high diversity of ecological communities and species, including plants, birds, mammals, reptiles, fish, amphibians, waterbirds and wetland-dependent species listed as threatened, see references for further details of species composition at site^{1,5}. Among the listed species are the Vulnerable regent parrot (*Polytelis anthopeplus monarchoides*) and the Vulnerable Southern bell frog (*Litoria raniformis*). In addition, the site is one of the few locations in South Australia where the rare river snail (*Notopala sublineata*) has been successfully bred⁵. Snail breeding was completed in PVC tubes imbedded into the wetland bed and in the lower end of Banrock Creek. The populations within the wetland itself are no longer present as a consequence of the wetting to drying cycles. However, the snails are still present within Banrock Creek.

WETLAND MANAGEMENT

Current Management:

The wetland complex is managed by Accolade Wines and adjoins to the Banrock Station Wine and Wetland Centre, which promotes wetland conservation as well as its wines and cellar door. Banrock Station's Wetland Manager operates a series of control structures to implement wetting and drying regimes. Additional works could improve connectivity within the wetland complex, and increase the amount and duration of flowing creek habitat in the Banrock Creek system¹. Ecological monitoring and the evaluation of environmental assets are regularly completed in order to retain its Ramsar accreditation.

Infrastructure:

Crude control structures were installed at the downstream end of Banrock Lagoon and on inlet creek in the 1950s, with the lagoon being managed to maintain a water level of 8.6mAHD. In 1992, flow control gates were installed on the inlet channel of Banrock Creek, which enabled the management of wetting and drying management regimes at the margins of Banrock Lagoon. A series of self-guided trails were completed in 2001, which included information huts and five bird hides for bird watching.

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 Banrock, these included:

Environmental

- There is a variable risk of acid sulfate soils ranging from low to high across this site⁷. This would require further assessment before any construction works or wetting and drying activities are undertaken.
- Note the site is Ramsar listed with associated management requirements.

Cultural

• Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social/Economic

- Tourism value needs to be maintained.
- Potential impacts on vineyard aspects of business need consideration.

Operational/logistics

- Note that the perimeter access track must continue to allow for use during high water events and provide access to Lock 3.
- Consider potential to siphon water from existing basin to the regent parrot site.
- Note that the long embankment will potentially create issues with water flowing back and erosion; mitigation and management of erosion risk need consideration.

KEY STAKEHOLDER INVOLVEMENT

- Banrock Station Wine and Wetland Centre
- Commonwealth Environmental Water Office (CEWO)
- Loxton-Waikerie Council
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- Regent Parrot Recovery Team
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- SA Water

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Overland Corner

Location: River Chainage Markers 431 to 423 km (below Lock 3) Land Tenure: Crown Record Wetland Size: 450 hectares (Ha) Normal Pool Level: 6.2 mAHD (downstream of Lock 3) and 7.0 maHD (upstream inlet)

PROPOSED OPTIONS	
Option #1:	Improve floodplain condition by supporting opportunities for environmental watering and increasing the extent and duration of floodplain watering associated with managed and natural high-flow events, by enabling the retention of water through the replacement of the leaking downstream structure and upstream (inlet) levee with regulating structure and complementary blocking banks to 8.5 mAHD.
Description	Proposed works include an upgrade to the existing regulator to address water retention issues. Currently, the downstream (DS) regulator leaks, reducing the effectiveness of e-watering pumping events. This leaking DS structure and US (inlet) levee will be replaced with new regulating structures to 8.5 mAHD and complementary blocking banks will be installed at the managed inner lignum basin. This will enhance pumping outcomes by extending the current wetland management area and promote dual-management of inner lignum basins and the outer wetland.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture conditions. Enhanced capacity for greater exchange between the river and wetlands.

Option #2:	Support watering activities and outcomes proposed in 'Option 1' and those associated with the Regent Parrot Recovery Project by extending proposed infrastructure required to support 'Option 1' to 9 mAHD and constructing additional blocking bank at downstream basin.
Description	Overland Corner falls within the 'Katarapko Regent Parrot Floodplain Habitat Zone', identified as part of the Regent Parrot Recovery Project. The strategic watering of this site to support the conservation and improvement of vegetation important to regent parrots, is seen as a key part of realising the conservation of the current population. Proposed works include extending proposed infrastructure required to support Option #1 to 9 mAHD and constructing an additional blocking bank at DS basin. This would improve the ability to provide water to key areas of regent parrot habitat as well as providing opportunities to extend the duration and increase the extent of floodplain watering through pumping and high-flow retention. The existing access road would also be built up to enable access during watering events for important tourist activities.
Outcomes	 Conservation and improvement of vegetation important to regent parrots. Support the conservation of the current regent parrot population.

Option #3:	Investigate options to install infrastructure that will deliver environmental water from above Lock 3.
Description	Proposed works would investigate alternate water transport options in order to save money on pumping costs. Pumping alternatives could include utilising the head difference that exists between weir pools 2 and 3 and connecting the wetland from upstream of Lock 3, via a gravity pipe into the upstream section of the wetland.
Outcomes	 Benefits associated with an improved watering regime. Conservation and improvement of floodplain vegetation. Improved soil moisture. Enhanced capacity for greater exchange between the river and wetlands. Reduced pumping and associated costs.

Description

The Overland Corner wetland complex is located immediately downstream of Lock 3 on the east side of the River Murray. The wetland complex is bounded by Old Coach Road to the north, the River Murray to the south and west, and a combination of private land and Crown land dedicated to the National Trust of SA for reserve purposes to the east. The wetland complex is comprised of several temporary wetlands, which are not connected at pool level at normal flow conditions.

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

Prior to the regulation of flows in the River Murray and the construction of locks and weirs, Overland Corner would have had a more variable water regime. The stabilisation of water levels has led to reduced frequency and duration of inundation within the surrounding floodplains.

WETLAND ECOLOGY

Overland Corner wetland complex complements other wetlands nearby, providing a network of temporary and permanent aquatic habitat and was therefore given a moderate to high ecological value^{1,2}. Overland corner consists of a number of temporary wetlands which get inundated during River Murray flood events³.

Flora: The dominant wetland vegetation types on the floodplain include river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) woodland, lignum and samphire shrubland, and sedgelands, see references for further details of species composition at site^{3,4}.

Fauna: Seven frog species have been recorded at Overland Corner among them the vulnerable southern bell frog (*Litoria raniformis*). The diversity of frog species at Overland Corner is considered to be high compared to other wetlands in the Riverland^{3,4}. The wetland also supports important habitat for wetland birds, migratory bird species and the vulnerable regent parrot (*Polytelis anthopeplus monarchoides*).

WETLAND MANAGEMENT

Current Management:

Wetland management is undertaken by the Murraylands and Riverland Landscape Board in conjunction with the National Trust of SA, SA Water, Commonwealth Environmental Water Office (CEWO), and local landholders. During e-water pumping events, several sandbags need to be placed on the leaking main regulator. Approximately, 500 megalitres (ML) of water are pumped to Overland Corner during each event. Several ecological surveys are also regularly completed at the wetland complex, which includes surveys of the threatened Southern bell frog.

Infrastructure:

A downstream regulating structure (5 box culverts) was installed in 2003, which helps retain water during e-water pumping events. This is the main regulator at Overland Corner. A pump is located on the upstream side of the wetland and is connected to the designated pumping channel. A local landholder is the current owner of the existing pumping infrastructure. The maximum pump capacity is 20 megalitres per day (ML/day). In addition, two pipe culverts under vehicle access tracks are located on the eastern side of the wetland but are not used to regulate water levels. Non-permanent infrastructure also occurs across the upstream inlet and adjacent to the River Murray. The bank previously held water during pumping projects but is now a barrier to natural flows.

Cultural Heritage: Construction works need to be mindful not to disturb areas of cultural importance.

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 Overland Corner, these included:

Environmental

- There is a low to medium risk associated with acid sulfate soils at this site⁵. This would require further assessment before any construction works or wetting and drying activities are undertaken.
- Good opportunities to improve floodplain vegetation.
- Note that the site is currently a fish free environment with healthy bird/amphibian and submerged plant communities and lots of community engagement; the current pumping approach keeps the site fish-free.

- Would need to manage option 3 for risk of allowing carp to enter the site.
- Return flows may be inhibited by blocking banks.

Cultural

• Construction works need to be mindful not to disturb areas of cultural importance.

Community/Social

- MDBA needs to be engaged early if changing Joint Venture structures.
- The connection between the Overland Hotel and houseboats that tie up on the river is very important socially.
- Note this is a National Trust of SA and Biosphere site with high levels of community connection.

Operational/logistics

- Need to build access tracks to 8.5-9 mAHD.
- Construction may encounter issues with physical constraints of site. Nowhere for lay-down areas etc.
- Potential investigations could look at feasibility and effectiveness of retrofitting fish screens at 'Liggy Flat'.
- Note that Option 3 offers reduced O&M costs by allow passive filling and not needing to pump (but risk of introducing carp).

KEY STAKEHOLDER INVOLVEMENT

- Berri Barmera Council
- Berri Barmera Landcare
- Central Irrigation Trust (CIT)
- Commonwealth Environmental Water Office (CEWO)
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- National Trust of SA
- Private Landholders
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- Regent Parrot Recovery Team
- SA Water

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Weir Pool 3

Location: River Chainage Markers 516.2 to 431.1, Bookpurnong to Overland Corner. Land Tenure: N/A

Length: 84.8 km 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 seed and egg bank viability, plant germination and animal hatching in shallow water and expo

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.

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

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 length ³. Top of piers is currently 10.39 mAHD⁴.

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
- Murray-Darling Basin Authority (MDBA)
- Murraylands and Riverland Landscape Board
- National Parks and Wildlife Service SA
- River Murray and Mallee Aboriginal Corporation (RMMAC)
- South Australian Murray Irrigators

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