Victorian Murray Floodplain Restoration Project

Wetland Assessment - Gunbower National Park National Park

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Lower Murray Urban and Rural Water Corporation

Victorian Murray Floodplain Restoration Project

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Executive Summary

This report provides a high level overview of the Gunbower National Park Floodplain Restoration Project, being undertaken under the broader Victorian Murray Floodplain Restoration Project, and provides an initial assessment of the potential impacts to significant wetlands to inform the planning and approvals process for the project. This report builds on the findings of the Flora and Fauna Assessment report for the project (R8, 2020a) and incorporates findings from the project's Groundwater Assessment (R8, 2020b), Environmental Management Framework (R8, 2020c), Business Case (NCCMA, 2014) and other relevant documents.

An assessment of the project is provided in terms of potential impacts to Ramsar sites both within, adjacent to and downstream of the project area and impacts to other significant wetlands listed under the Directory of Important Wetlands in Australia. The report aims to establish what the potential impacts may be on the basis of the information currently available and provide inputs to the referrals being prepared under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Victorian Government's *Environmental Effects Act 1978* (EE Act).

The assessment has found that most of the potential impacts from construction of the project can be adequately managed through a construction specific aquatic fauna management plan and that most operational risks can be managed through the development of an Environmental Water Management Plan (EWMP). However, in some areas further work is recommended to enable a more comprehensive assessment of some potential impacts.

The assessment of the potential impacts on the Gunbower Forest Ramsar site found that the construction and/or operation of the project was unlikely to cause a negative change in most of the critical components, processes and services underpinning the Ecological Character Description in excess of the Limits of Acceptable Change (LAC). Further assessment is required on the potential for impacts to native fish during construction and the potential risk of carp degrading native fish habitat following managed inundation to confirm this for the Native Fish (species richness) LAC. Specific impacts to fish have been looked at further in a separate fish impact assessment report, which is included as an appendix to the Flora and Fauna Assessment Report (R8, 2020a). The fish impact assessment memo found that no significant impacts were expected to be caused to any threatened fish species as a result of the project.

The assessment of the project against the EPBC Act Matters of National Environmental Significance (MNES) significant impact criteria found that the project was unlikely to represent a significant impact with the implementation of mitigations for construction and operational phases of the project, recognising that further work is required to develop a construction specific aquatic fauna management plan and an EWMP including monitoring and adaptive management to address the threat of invasive species. The assessment also found that potential cumulative changes to hydrological regimes or the water quality of downstream wetlands cannot be fully characterised until the MDBA undertakes further modelling of the full package of adjustment measures when agreed to by Basin governments.

Important note about your report

The purpose of R8's engagement under the Victorian Murray Floodplain Restoration Project (VMFRP) is to design infrastructure for the VMFRP including regulators, levees, roads, access tracks and culverts. The purpose of this infrastructure is to allow floodplains to be watered at the hydraulic design levels nominated by VMFRP. R8 are also engaged to provide Regulatory Approvals and Cultural Heritage Services. The purpose of these services is to support VMFRP to lodge the necessary approvals documents for the project with the relevant approval authorities.

The sole purpose of this report and the associated services performed by R8 is to complete a Desktop Wetland Assessment Report for VMFRP in accordance with the scope of services set out in the contract between R8 and VMFRP. That scope of services, as described in this report, was developed with VMFRP.

R8 has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. However, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

In preparing this report, R8 has relied on information provided by VMFRP. In particular, the VMFRP has developed ecological objectives and, based on these, has proposed inundation levels and extents. R8 is reliant on VMFRP's prior flood modelling work and has designed the infrastructure in response to the VMFRP defined inundation levels and extents.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by R8 for use of any part of this report in any other context. This report has been prepared on behalf of, and for the exclusive use of VMFRP, and is subject to, and issued in accordance with, the provisions of the contract between R8 and VMFRP. R8 accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

1.1 Project overview - Victorian Murray Floodplain Restoration Project

The Gunbower National Park Floodplain Restoration Project (the project) is one of nine discrete environmental works projects being undertaken as part of the Victorian Murray Floodplain Restoration Project (VMFRP), which is being implemented as part of Victoria's obligations under the Murray Darling Basin Plan. The VMFRP aims to restore a more natural inundation regime across more than 14,000 ha of high ecological value Murray River floodplain in Victoria through the construction of new infrastructure and modification of existing infrastructure.

The Victorian Murray Floodplain Restoration Project (VMFRP) is being implemented as part of Victoria's obligations under the Murray Darling Basin Plan in partnership with Lower Murray Water, Goulburn Murray Water, Mallee Catchment Management Authority (CMA), North Central CMA, Parks Victoria and the Department of Environment, Land, Water and Planning (DELWP). LMW has been nominated by the partnership as the project proponent for the purpose of submitting referrals and approval applications.

R8 is a joint venture formed between Jacobs and GHD, which has been engaged by LMW to deliver design, cultural heritage and approvals services for the VMFRP. This desktop groundwater assessment has been prepared for the project to support the preparation of referrals under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Victorian *Environment Effects Act 1978*.

1.2 Purpose of this report

This report focuses on the Gunbower National Park Floodplain Restoration project and provides an assessment of the potential impacts to the wetlands and associated values arising from the project. The purpose of this report is to:

- Provide a high level overview of the potential implications of the works to be undertaken and managed inundation events at Gunbower Forest as part of the VMFRP for the site's status as a Ramsar site
- Provide a high level assessment of the project against the significant impact criteria for Ramsar sites contained in the Matters of National Environmental Significance Guidelines (DoE ,2013), and
- Provide inputs in relation to significant wetlands including Ramsar sites and wetlands listed under A Directory of Important Wetlands in Australia (DIWA) to support the preparation of referrals under the Victorian *Environmental Effects Act 1978* (EE Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Other potential impacts on Matters of National Environmental Significance protected under the EPBC Act such as threatened species or any other considerations relevant for an EE Act referral not directly related to wetlands such as waterways, estuaries or marine environments, have not been included in this report. These other matters are considered through other reports such as the Gunbower Flora and Fauna Assessment (R8, 2020a) and the referral documentation (R8, in preparation) where relevant.

1.3 Limitations

The following limitations apply to the assessment contained in this report:

- No site visit has been undertaken;
- Reports and records available on the public record have been used;
- The report is based on the current design footprints and construction activities and information provided by VMFRP to define the proposed area of inundation and operating regime. This assessment is therefore preliminary only as changes to the scope and location of works and inundation may change the findings and recommendations in this report.

1.4 Scope

This report has assessed the following potential impacts to Ramsar sites and DIWA listed wetlands within and downstream of the Project Area:

- Potential construction related impacts to wetlands occurring within the Areas of Investigation for this project
- Potential impacts to wetlands occurring within the Inundation Area as a result of managed inundation events under the proposed operating scenarios for the project
- Potential water quality and hydrology impacts to nearby or downstream wetlands from the release of return flows to the Murray River following managed inundation events

Any upstream or downstream hydrological changes or impacts in the Murray River associated with the delivery of environmental water to Gunbower Forest will be assessed and managed by the River Murray Operations Committee (RMOC) as part of their responsibility to oversee the operation of the river which is managed by the Murray-Darling Basin Authority on behalf of the relevant State and Commonwealth Governments. It is also understood that the environmental water requirements for VMFRP sites will be added to the existing river flows and therefore managed to ensure minimal, if any, changes in flows experienced downstream of the project sites.

Delivery of environmental water in the Murray River system is undertaken by the RMOC in accordance with a risk based approach to minimise impact to river users and the Commonwealth Environmental Water Holder's Framework for Determining Commonwealth Environmental Water Use (CEWO 2013). This approach requires environmental watering to consider the potential environmental risk, including downstream environmental risk, which may result from applying environmental water; and measures that may be taken to minimise those risks. The waterway mangers and water authority will also work with the RMOC to ensure that the planning and delivery of environment water delivery is undertaken to achieve ecological objectives and minimise adverse impacts on river hydrology which will be informed by a monitoring program.

Further modelling of the cumulative change to flows in the Murray River as a result of the VMFRP program of works will be undertaken by the RMOC to inform the risk based approach to management of environmental water delivery when individual VMFRP projects, if not all, are confirmed to proceed based on the outcomes of the approvals process.

Given the delivery of environmental water to Gunbower Forest is the responsibility of the RMOC and Murray-Darling Basin Authority, this assessment has focused on the potential hydrological and water quality impacts associated with return flows to the Murray River during and following a managed inundation event only.

This assessment has been undertaken at a high level and recommendations are made where further information is required to make a more thorough assessment.

1.4.1 Terminology

The following terms are used throughout this report to describe the project:

- Development Footprint – the area that the proposed infrastructure occupies, including laydown areas to be used during construction. This does not include access tracks.
- Construction Footprint - the project development footprint as well as the land required to construct the infrastructure (i.e. a construction buffer around the infrastructure footprint). This includes access tracks.
- Area of Investigation - the construction footprint, as well as a 20 m buffer around the Construction Footprint and access tracks.
- Inundation Area - area of land subject to flooding during managed events, up to a specific design water level.
- Project Area – combined area of the Area of Investigation and Inundation Area.

2. Project overview – Gunbower National Park

The Gunbower National Park Floodplain Restoration Project is located on the mid-Murray floodplain in Northern Victoria. Gunbower National Park covers approximately 46% of the Gunbower Forest and is part of the Gunbower-Koondrook-Perricoota Forest icon site under The Living Murray Program. The forest is bounded to the north by the River Murray and along its southern edge by private land and Gunbower Creek. The forest comprises a system of natural drainage paths, creeks, permanent and temporary wetlands, Black Box and Grey Box woodlands and River Red Gum forest. The forest is also listed as a wetland of international importance under the Ramsar Convention.

The project is designed to facilitate managed inundation in the targeted water regime classes within the project area in the middle and upper Gunbower Forest. Flows to the Gunbower Middle Forest would be pumped from the Murray River to address the deficit of overbank flow and wetland inflows. Flows to the Gunbower Upper Forest (through Camerons Creek) would be pumped from the National Channel (Gunbower Creek) and controlled gravity fed to enable delivery of water to wetland and floodplain habitat and to address a leaking regulator.

Broadly, the project aims to support the ecological values of the Gunbower National Park including a resident population of small-bodied native fish by providing permanent water to some areas of Upper Gunbower Forest. Under natural conditions in the Middle Forest flooding would have occurred on average seven years in ten and at present flooding is only occurring on average four years in ten (NCCMA, 2014). The managed inundation aims to replicate a more natural inundation regime equivalent to up to 50,900 ML/d flow in the Murray River (at Torrumbarry Weir) across approximately 704 ha of the Gunbower National Park. The planned inundation events will require a much lower volume of water than that involved in a natural inundation event as the proposed infrastructure will enable pumping to deliver water to target areas in the floodplain, whilst still achieving a similar frequency and duration of inundation as would occur during a natural inundation event. The project is intended to fill a deficit in the inundation regime and would only be operated if the desired frequency and extent of inundation of the floodplain had not occurred naturally. The operating scenarios can be delivered either as stand-alone watering events (into a dry forest) or as 'hybrid events', enhancing the inflow rate and/or duration of unregulated flows (NCCMA, 2014). There are existing environmental water works in place for the Lower Gunbower Forest undertaken under The Living Murray Program which, while complementary, are separate to this project.

The proposed works for the Gunbower National Park floodplain and wetlands are designed to provide a combination of pumped inflows from the Murray River and the National Channel via Camerons Creek into the Forest. The works will result in inundation of approximately 457 ha in Middle Gunbower Forest and 247 ha in Upper Gunbower Forest.

2.1 Areas targeted for inundation

The Upper and Middle Gunbower Forest areas, while related, act separately and independently to each other in lower to medium level flooding events and therefore have been developed as separate environmental works areas. The Middle Gunbower Forest works have been split into two different areas to reflect a distinct change in elevation and therefore target water level. The split of the Middle Gunbower Forest also reflects changes to the proposed inundation extent since the completion of the Business Case in 2014 (environmental works were not proposed downstream of Deep Creek in the Business Case).

The key environmental works areas that will be targeted for managed inundation as part of the project include:

- Upper Gunbower Forest – inundation of approximately 247 ha of floodplain forest and wetlands containing:
    - Upper Camerons Creek
    - Camerons Creek Lagoon 1, 2, 3 and 4 (permanent wetlands)

- Black Charlie Lagoon (permanent wetland)
- Baggots Swamp (semi-permanent wetland)

- Middle Gunbower Forest (upstream of Deep Creek, 83.7 to 84.3 mAHD target water level) – inundation of approximately 336 ha of floodplain forest and wetlands including:
  - Deep Creek
  - Middle forest floodplain area
  - Pig Swamp (semi-permanent wetland)
  - Emu Hole Lagoon (semi-permanent wetland)
- Middle Gunbower Forest (downstream of Deep Creek, up to 83.4 mAHD target water level) – inundation of approximately 121 ha of floodplain forest and wetlands containing:
  - Red Rise Swamp – upper (semi-permanent wetland)
  - Red Rise Swamp – lower (semi-permanent wetland)
  - Broken Axle Creek
  - Spur Creek

2.2 Proposed infrastructure and construction

2.2.1 Proposed infrastructure

The project involves the construction of the infrastructure to divert, retain and release water in the Gunbower National Park including regulators, a fishway, pipelines, pump stations, a channel upgrade, a drop structure, a bridge, drainage outlets, road upgrades, erosion control works and a series of containment banks. The design process is currently ongoing. For a summary of the proposed infrastructure for the current design, please see Appendix A.

2.2.2 Fish passage through regulators

Where required, the regulators and drop structures will be designed to provide safe fish passage in accordance with the recommended design criteria for native fish (R8, 2019). Small regulator structures will be operated either in fully open or fully closed position. When water is released with the regulator gate in fully open position, fish have passage through the regulator both in managed release and natural flood scenarios. Structures will been designed to have flow velocities appropriate for fish passage (based on O'Connor et al, 2015).

The project specifically includes:

- Provision of safe downstream fish passage for native fish through all new regulating structures. This includes safe fish passage from the floodplain and into the Murray River during forest draining events and low Murray River flow water levels;
- Provision of screens for fish protection on each intake structure associated with the pump stations.
- Active fish passage is planned to be provided at the proposed Camerons Mid Creek Regulator to maintain connectivity for small bodied fish between the wetland areas separated by this structure, aligning with the Upper Gunbower Creek Fish Management Plan (ARI, 2020). The fish passage

provision at Camerons Mid Creek Regulator is a cone type fishway consisting of a simple channel and precast cones.

Explicit fish passage is planned to be provided at the proposed Camerons Mid Creek Regulator to maintain connectivity for small bodied fish between the wetland areas separated by this structure. The fish passage provision at Camerons Mid Creek Regulator is a cone type fishway consisting a simple channel and precast cones. Dedicated fishways are not required at any other structure.

2.3 Key construction activities

Construction activities would occur within the area identified in the construction footprint map attached. Construction activities would include:

- Establishment of construction sites, set down areas and access routes
- Removal of existing structures / block banks where required
- Construction / installation of new structures (including steel sheet pile wall on regulator structures and containment banks)

Construction would involve use of vehicles and machinery such as trucks, excavators, and access equipment such as forklifts. Importation of construction materials, including imported soils, would need to comply with Parks Victoria consent under Section 27 of the *National Parks Act 1975* and the *Environment Protection Act 1970*/future *Environment Protection Act 2017*. A Construction Environmental Management Plan (CEMP) would be prepared for the works and would detail the measures to avoid and minimise impacts during construction, a construction specific aquatic fauna management plan would also be prepared. Once construction of structures and all associated works are complete, all waste and spoil would be removed from the sites and disposed of as required by the CEMP.

2.3.1 Construction in the Murray River

The Brereton Pump Station will require construction works within the Murray River. For the pump stations this would include excavation and construction of intake pipes with fish screens which will draw from water levels down to the minimum river water level. The portion of the intake pipes near the edge of the bank profile will be concrete encased serving as an anchor for the floating pumps and protection for bank scouring / erosion.

2.3.2 Construction laydown areas

The construction footprint includes a working area (approx. 10 m) around the development footprint for proposed structures (e.g. regulators, drop structures pump stations) to accommodate movement of vehicles and machinery and some limited storage of equipment and materials. A working area (approx. 3 m) was also included around proposed laydown areas and minor works sites (e.g. blockage bank removals/ modifications). The specific laydown area details for each construction site will be confirmed as the detailed design process evolves, however sites will be selected to avoid and minimise impacts to ecological and cultural values.

2.3.3 Project area rehabilitation

Following completion of works, rehabilitation of construction areas would be undertaken in accordance with Parks Victoria consent under Section 27 of the *National Parks Act 1975*. General principles for site rehabilitation include:

- Use of local indigenous plant species
- Placement of habitat logs

- Retention and reuse of topsoil
- Rock beaching using materials consistent with the local geological settings, where practicable.

2.4 Key operational activities

The proposed works are intended to inundate areas of the Gunbower National Park floodplain with pumped inflows from the Murray River through a Pump Station on the Murray River and one on the National Channel.

Three separate operating scenarios have been identified for water delivery to the Gunbower National Park. These have been proposed to meet the ecological objectives of the project and include:

- Permanent wetland watering – targeted water delivery to wetlands only. The optimal inundation regime for permanent wetlands (Camerons Creek and Black Charlie Lagoon) is 10 years in 10 for a duration of 12 months. The expected frequency of operation is 10 years in 10 to achieve the optimal frequency. Black Charlie Lagoon will be filled in winter/spring and allowed to drawdown throughout the year while maintaining minimum residual pool water levels; some years will only require top-up water delivery. The lagoons and waterway of Camerons Creek will be allowed to fluctuate and periodically topped up to maintain sufficient water depth and connectivity to support aquatic biota.
- Forest floodplain watering – water delivery to the broader floodplain (including temporary wetlands) and a semi-permanent wetland, including:
    - River Red Gum (RRG) forest with flood dependent understorey (Baggot Swamp and mid-forest floodplain), temporary wetlands (Emu Hole and Red Rise Swamp) and associated creeks and low-lying areas. The optimal inundation regime is on average six years in 10 for between two to five months and would require pumping on average three years in 10 to achieve the optimal inundation regime. Inundation in other years is assumed to be provided through natural inundation under the Basin Plan 2750 scenario; and
    - Semi-permanent wetlands (Pig Swamp). The optimal inundation regime is on average seven years in 10 for six months and would require pumping on average four years in 10 to achieve the optimal inundation regime. Environmental water will be delivered to Pig Swamp three years in 10 under the RRG forest and temporary wetland scenario outlined above, with an additional one year in 10 delivered to achieve the optimal inundation regime for the semi-permanent wetland. Inundation in other years is assumed to be provided through natural inundation under the Basin Plan 2750 flow scenario.
- Hybrid events – topping up natural inundation events for the forest floodplain, temporary wetland and semi-permanent wetland watering due to natural inundation duration deficits. There are two options for extending the duration of natural floods that inundate the broader forest and associated wetlands:
    - Flood capture to retain floodwater on the floodplain for the required duration by closing the outlet regulators and low-lying inlet regulators from the Murray River after the river flow peak has passed; and
    - Follow up watering of the forest floodplain and wetlands following natural flow peaks and/or flood capture to achieve the required inundation extent and/or duration where the natural inundation extent or duration is inadequate to achieve ecological objectives.

A summary of the proposed operating scenarios for Gunbower National Park is provided in

Table **1** below.

Table 1. Modelled frequency of operational scenarios for the Gunbower National Park Floodplain Restoration Project.

Scenario	Site	Peak filling inflow rate (ML/d)	Preferred frequency	Duration	Required timing
Permanent wetland watering	Black Charlie Lagoon & Camerons Creek	15	10 years in 10	1-12 months	Winter/ Spring
Forest floodplain watering/ semi-permanent wetland inundation	Baggots Swamp	20	3 years in 10	2-3 months	Winter/Spring
	Pig Swamp	20	4 years in 10	6 months	Winter/Spring
	Emu Hole Lagoon	10	3 years in 10	4 months	Winter/Spring
	Middle Forest floodplain	125	3 years in 10	3-5 months	Winter/Spring

The indicative inflow patterns for the project are described below.

Upper Gunbower

The Upper Gunbower contains an area of RRG forest with flood dependent understorey immediately downstream of Black Charlie Lagoon. Watering events for Baggots Swamp will commence with the filling of the permanent wetlands to the full supply level of Black Charlie Lagoon, followed by overtopping the wetland into the surrounding floodplain of Baggots Swamp to the west. Once Black Charlie Lagoon is full, both the Camerons Mid Creek Regulator and pipeline outlet will be opened to provide a combined peak inflow rate of about 20 ML/day over a period of about 15 days to achieve the target water level of 84.8 m AHD in Baggots Swamp. RRG with flood dependent understorey vegetation fringing Camerons Creek will also be inundated at these higher target water levels. Inflows will then cease and the area will be allowed to drawdown naturally through evaporation and seepage, with a target inundation duration of 60 days.

Middle Gunbower

Watering events will commence with the opening of the Middle Forest Offtake Regulator gates. Flows are conveyed through the forest along flood runners in a northerly direction, before filling a southern pool formed by the banks of the Old Cohuna Main Channel and a northern pool formed by the banks of Deep Creek. During the initial filling and subsequent top-up to achieve the target watering duration, the Deep Creek Return Regulator would be closed.

From Deep Creek, flow continues in a northerly direction to the Middle Forest Third Tier, where it is contained by a number of containment banks and regulators.

Once the target watering duration has been achieved, water held in the Middle Forest pools can be drawn down through returns to the Murray River via the Deep Creek Return Regulator and Spur Creek. Small top-up flows will be delivered if and as required to achieve the target inundation duration of six months for Pig Swamp and four months for Emu Hole Lagoon. The Deep Creek Return Regulator could also be used to deliver water into the Middle Forest at higher river levels.

Environmental water volumes

The total volumes of water required under the proposed operating scenarios (excluding ramp up, ramp down and contingencies) are estimated to be approximately:

- 5,175 ML for forest floodplain watering (River Red Gum floodplain and permanent and semi-permanent wetlands)
- 875 ML for permanent and semi-permanent wetland watering events

Return flows

Return flows will occur under the Forest floodplain watering scenario on the broader floodplain. Under fully managed environmental delivery events to the semi-permanent and permanent wetlands return flows will not occur as water will be retained within the wetland systems before gradually infiltrating and evaporating. The total expected return flow volume from a Forest floodplain watering scenario is 1,540 ML, over an estimated 77 days at 20/ML/day.

3. Ramsar sites and wetlands included on the Directory of Important Wetlands in Australia potentially impacted by the project

There are significant wetlands within the Areas of Investigation and Inundation Areas for the project with potential for impact during construction and operation of the project. Gunbower Forest is a Ramsar site covering 19,931 hectares and Gunbower Island is listed under DIWA covering an area of 19,500 hectares. The parts of the Project Area relevant to the DIWA and Ramsar listings have some differences (see map in Figure 1 and Table 2). The Ramsar listing covers the broader Gunbower Forest floodplain including more terrestrial environments. For the purposes of this assessment, the focus is on wetland environments within these listed areas, as mapped in the Victorian Wetland Inventory, as a broader range of impacts to wider floodplain environments have been considered in flora and fauna assessments (R8, 2020a; 2020b).

Wetlands that partially or fully overlap with the Areas of Investigation are likely to be affected by construction of the project and wetlands that are within the Inundation Area are likely to be affected by changed hydrology during managed environmental watering events.

Eleven wetlands identified from the Victorian Wetland Inventory have the potential to be affected by the project. Ten of these wetlands are included within both the Ramsar and DIWA listed areas, one wetland is not included under either listing but still has the potential to be impacted by the project.

- Four wetlands (Ramsar and DIWA listed) are within the inundation area only, meaning they will only be affected by operational changes associated with the delivery of managed events at Gunbower National Park. These are likely to be positively affected by the changed hydrological regime with mitigation measures in place to manage risks.
- Seven wetlands (six of which are Ramsar and DIWA listed) are partially overlapping within the Area of Investigation, meaning parts of these wetlands may be directly affected by works and use or upgrades of access tracks depending on the final Construction Footprint.
- Four of the seven wetlands (three of which are Ramsar and DIWA listed) partially overlapping with the Area of Investigation are also partially overlapping with the Development Footprint meaning they may experience long term impacts due construction of permanent infrastructure within the wetland area, though areas affected are generally small in relation to wetland size and design will take into consideration avoiding and minimising impacts to the wetlands.

There is also a possibility that downstream wetlands could be affected during or following the delivery of managed events to Gunbower National Park due to changes in water quality or hydrology from return flows re-entering the Murray River from the floodplains.

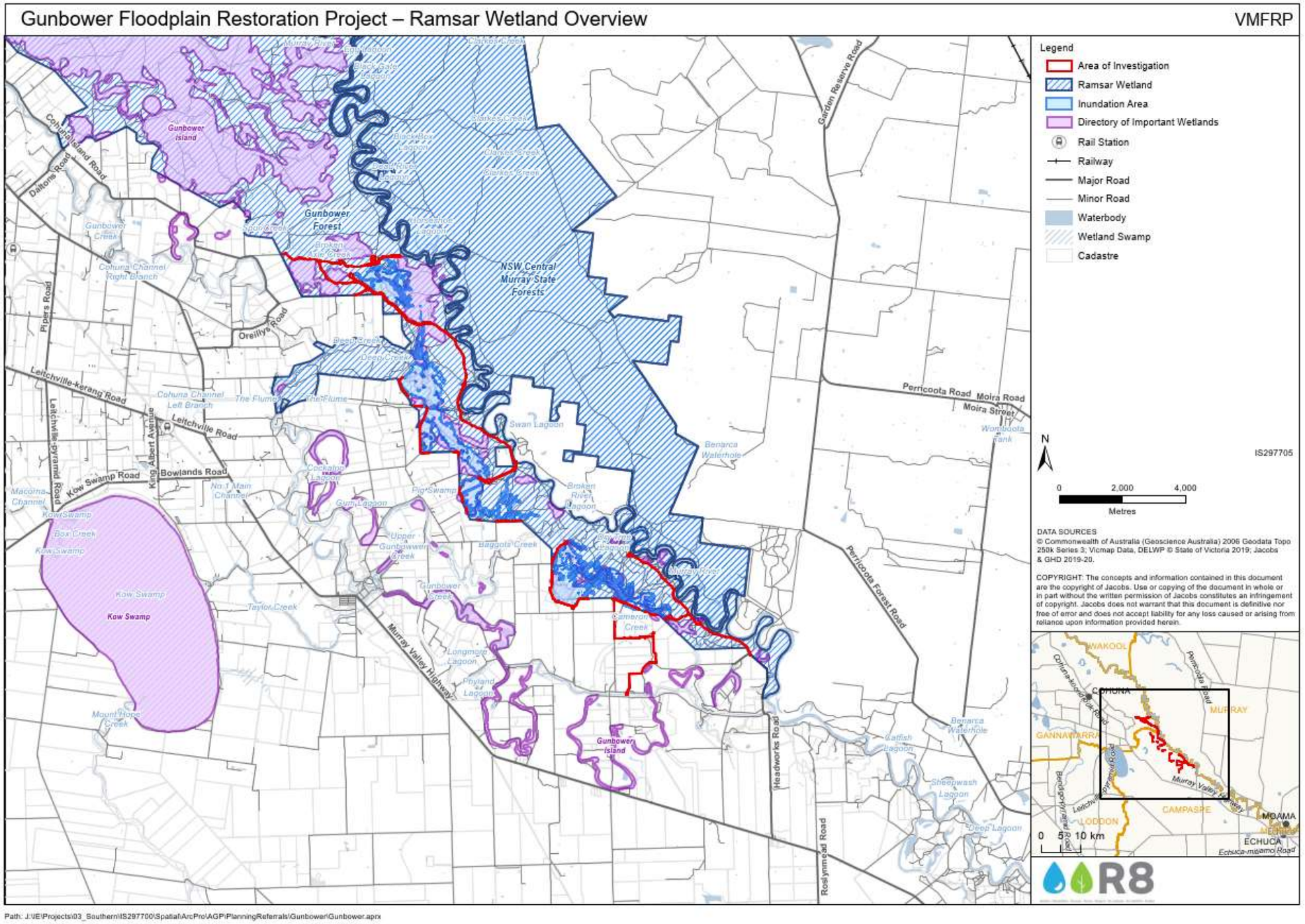

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Figure 1 Map of the project showing the boundaries of DIWA wetlands (purple) and Ramsar sites (blue) with the Area of Investigation and Inundation Areas

Table 2 Area of project activities that are located within each of Gunbower Forest Ramsar site and Gunbower Island DIWA site

	Area of Investigation (ha.)	Construction Footprint (structures and banks) (ha.)	Construction Footprint (tracks and roads) (ha.)	Development Footprint (ha.)	Inundation Extents (ha.)
Gunbower Forest Ramsar site	80.3	11.3	12.1	6.3	681.3
Gunbower Island DIWA site	7.5	0.1	0.7	0.5	304.8

Significant wetlands downstream of the project areas that therefore could be potentially affected by water quality or hydrology changes associated with managed inundation of Gunbower National Park and their approximate downstream distances are shown in Table 3.

Table 3 Significant wetlands downstream of the project

Ramsar title	DIWA title	Distance downstream*
NSW Central Murray Forests	Koondrook and Perricoota Forests	Adjacent to the Project Area on the opposite bank of the Murray River
	Beveridge Island	>100 km
	Major Mitchell Lagoon	>200 km
	Belsar Island	>200 km
Hattah-Kulkyne Lakes	Hattah Lakes	>300 km
	Kings Billabong Wetlands	>400 km
	Lake Ranfurly	>500 km

**Distances are approximate only and are likely to be greater than these values due to the sinuosity of the Murray River*

4. Overview of potential impacts

Potential impacts to Ramsar and DIWA sites within the Project Area have been considered against two main categories:

- Temporary or permanent construction impacts from on-ground works within Ramsar and/or DIWA wetlands within the Area of Investigation (Section 4.1)
- Impacts to Ramsar and/or DIWA wetlands within the Inundation Area due to changes in hydrology from the operation of new infrastructure under the floodplain restoration projects (Section 4.2).

4.1 Construction

Seven individual wetlands (six of which are covered by the Ramsar and DIWA listings) are partially within the Construction Footprint for the project, meaning they may be temporarily affected by works and use of access tracks. Of these, four wetlands (three of which are covered by the Ramsar and DIWA listings) are also partially within the Development Footprint meaning they may experience long-term impacts due to construction of permanent infrastructure within the wetland area, though areas affected are small in relation to wetland size and design will take into consideration opportunities to avoid and minimise impacts to the wetlands. A construction environmental management plan will be developed and implemented to mitigate impacts during construction.

The specific impact of works on wetland vegetation has not been quantified here, as a preliminary assessment has been undertaken as part of the native vegetation assessment under the *Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017) provided in the Gunbower National Park Flora and Fauna Assessment (R8, 2020a).

Potential impacts to wetlands from construction include:

- Physical disturbance within wetlands where upgrades of existing roads are required and construction of banks and structures will take place including disturbance or removal of vegetation and possible water quality impacts to wetlands. Specifically:
    - Upper Gunbower Levee, partially within Ramsar and DIWA listed wetlands
    - Dry Creek spillway and Dry Creek regulator within a Ramsar and DIWA listed wetland
    - Middle Forest Western Levee, partially within Ramsar and DIWA listed wetlands
    - Pig Swamp Western Levee, partially within Ramsar and DIWA listed wetlands
    - Munroe Track culvert 1 and culvert 2 within a Ramsar and DIWA listed wetland
    - Munroe Track containment bank partially within a Ramsar and DIWA listed wetland
    - Camerons Creek pipeline partially within a wetland (not DIWA or Ramsar listed)
    - Use of and upgrades of several existing roads and tracks within Ramsar and DIWA listed wetlands
- Temporary loss of habitat due to cofferdam construction, dewatering works and sediment/contaminant runoff into wet areas from the Construction Footprint. Cofferdams also have the potential to entrap or temporarily restrict movement of aquatic fauna including fish and turtles within wetlands and connected waterways. Cofferdams are likely to be required at a number of locations to prevent the inundation of the work sites during rainfall or flood flows (R8, 2020a). Details of the type, location and extent of the required cofferdams have not yet been determined. An aquatic fauna management plan would be developed and implemented as part of the construction environmental management plan. This plan would contain measures to mitigate impacts to aquatic fauna during works on wetlands and waterways.
- Transport or proliferation of invasive weeds impacting upon the health of wetland and floodplain vegetation communities. The construction environmental management plan would be required to include measures to mitigate the risk of introducing or spreading invasive weeds.

4.2 Operation

The ecological condition of Gunbower National Park has declined due to impacts associated with the regulation of the Murray River reducing the frequency and duration of flooding and artificial changes to the floodplain (e.g. levees, blockages in effluents). The condition was further exacerbated by the Millennium Drought. Significant and sustained flooding in 2010-2013 resulted in improvements in the ecological condition of the forest indicating a positive response to an enhanced flooding regime (NCCMA, 2014).

Environmental water delivery to the Gunbower National Park is expected to provide a range of benefits in line with the management goal: "*To reinstate a more natural water regime that protects and enhances the ecological values within the Gunbower National Park and, where possible, supports values in downstream areas of Gunbower Island." (*NCCMA, 2014 p.26)

Flooding is essential for the effective functioning of floodplain ecosystems; however, flow-ecology relationships and processes in rivers and floodplain wetlands are complex. Many biota in the Murray-Darling Basin are adapted to variable flow and respond to flooding, but the optimal frequency, timing, duration and magnitude of floods vary between biota. Despite the variability in response, some common themes emerge when the benefits of flooding are examined for different ecological elements (R8, 2020a):

- Vegetation: Hydrological regimes are the major factor responsible for determining the composition, structure, diversity and function of floodplain forest and wetland communities, EVC distribution strongly correlates to micro-elevation throughout these systems, with communities with obligate wetland understorey components inhabiting the lower and more frequently inundated areas, transitioning to the more flood 'tolerant' terrestrial species that have limited inundation on the periphery of such systems;
- Trees: Successful regeneration of floodplain trees usually occurs after major floods, while floods also provide an essential source of water to maintain tree canopy health. Trees enable terrestrial fauna to move into the inundated areas;
- Understorey: The obligate wetland understorey associated with several of the flood dependent vegetation communities within Gunbower National Park are stressed under the current frequency of flooding and is at risk of transitioning to more flood tolerant (terrestrial) communities. The understorey in the more terrestrial (flood tolerant) areas are also compromised due to a lack of recruitment opportunity. The understorey and ground cover, particularly in the flood-dependent communities, is a crucial habitat resource for a variety of threatened plant and animal species;
- Waterbirds: Flooding acts as the primary stimulus for breeding waterbirds, increasing reproductive performance as the flood pulse stimulates productivity in the wetlands and floodplain;
- Fish: Flooding may trigger spawning or migration to suitable breeding habitat;
- Frogs: Flooding promotes a rapid response in frog activity, including calling, spawning, and tadpole development and metamorphosis providing a food source to other species, and
- Soil processes: in the biotic context, flooding revitalises the soil microbiome in a similar fashion to the above ground ecology, with the added consideration of the value of soil bacteria and fungus on all higher life. In the abiotic context detrimental hydrological functions such as the accumulation of irrigation salinity in the floodplain is at the detriment of floodplain biodiversity. Effectively washing the salinity out of the floodplain is beneficial in this regard (although may move the salinity issue to another place) (R8, 2020a).

Wetlands and areas of floodplain within the Gunbower Forest Ramsar site are expected to experience these benefits due to the project.

Potential impacts associated with managed inundation could arise through changes to hydrology and water quality. These impacts are considered in the following sections and would be managed through an Environmental Watering Management Plan (EWMP). In addition, complementary measures would be required to support the project such as monitoring and adaptive management measures to address pest plant and animal invasion.

5. Potential impacts on the Gunbower Forest Ramsar site ecological character

5.1 Ramsar Convention

The Convention on Wetlands (Ramsar, Iran, 1971) is an intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. The convention was adopted in 1971 and came into force in 1975. Since then, almost 90% of UN member states have become "Contracting Parties", including Australia, and over 2,000 sites worldwide have been listed under the convention.

Under the Ramsar Convention, contracting parties, including Australia, are expected to manage their Ramsar sites so as to maintain the ecological character of each site.

Ecological character is defined as the combination of the ecosystem components, processes, benefits and services that characterise the wetland at a given point in time. The current ecological character description for the Gunbower Forest Ramsar site was prepared in 2011. Change in ecological character is defined as the human-induced adverse alteration of any ecosystem component, process and/or ecosystem benefit or service. Changes to the ecological character of the wetland outside natural variations may signal that uses of the site or externally derived impacts on the site are unsustainable and may lead to the degradation of natural processes, and thus the ultimate breakdown of the ecological, biological and hydrological functioning of the wetland (DEWHA, 2008).

5.2 Listing Criteria

The Gunbower Forest Ramsar site was originally nominated as a wetland of international importance under the Ramsar Convention in 1982. The site is located on the Murray River floodplain in Victoria approximately 30 kms north-west of Echuca. The Ramsar site covers are area of 19,931 ha on Gunbower Island, an area of predominantly River Red Gum (*Eucalyptus camaldulensis*) forest between the Murray River and the anabranch of Gunbower Creek. The Ramsar site features a variety of permanent and temporary freshwater wetlands including lakes, swamps, lagoons and flooded forest (Hale & Butcher, 2011).

The ecological character description (ECD) for the Gunbower Forest Ramsar site details the criteria for which the site is listed, the ecological character of the site and threats to the ecological character (Hale & Butcher, 2011).

The Gunbower Forest Ramsar site currently meets four of the Ramsar criteria for listing, as defined by Hale & Butcher (2011) (Table 4).

Table 4 Ramsar criteria for listing

Group A: Sites containing representative, rare or unique wetland types	
Criterion 1	A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Group B: Sites of international importance for conserving biological diversity	
Criterion 2	A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
Criterion 4	A wetland should be considered internationally important if it supports plants and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Criterion 8	A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

The rationale behind Gunbower Forest meeting these criteria is detailed below:

Criterion 1 is due to Gunbower Forest being part of the second largest river red gum forest in the Murray-Darling Basin, the size and intact nature of the forested floodplain making it one of the best representatives of the wetland type Xf (freshwater tree-dominated wetlands) (Hale and Butcher, 2011)

Criterion 2 is due to Gunbower Forest supporting EPBC listed species (Hale and Butcher, 2011):

- Australasian Bittern (*Botaurus poiciloptilus)*
- Murray Cod (*Maccullochella peelii*)
- Silver Perch (*Bidyanus bidyanus*)
- River Swamp Wallaby-grass (*Amphibromus fluitans*)
- Winged Peppercress (*Lepidium monoplocoides*)

Criterion 4 is based on the role Gunbower Forest plays in supporting breeding of wetland birds, frogs, turtles and fish during periods of inundation (Hale and Butcher, 2011).

Criterion 8 is due to Gunbower Forest providing a migratory route between habitat in the Murray River and floodplains, with Gunbower Creek an important passage for native fish. Native fish of the Murray River utilise anabranch and flood runner channels when available, many species spawn on the floodplain and river red gum forests make a significant contribution to in-stream nutrient accumulation and productivity and provide important shelter in the form of coarse woody debris and shaded water (Hale and Butcher, 2011).

5.3 Limits of Acceptable Change

The Limit of Acceptable Change is the level of variation that is considered acceptable in a particular component or process of the ecological character of the wetland. Variation beyond this limit indicates a change in ecological character which may lead to a reduction or loss of the criteria for which the site was Ramsar listed.

The Gunbower Forest Ramsar site currently meets four of the Ramsar criteria for listing. The ecological character description (Hale & Butcher, 2011) identifies 13 critical components, processes and services that significantly contribute to the recognised ecosystem value and importance of the Gunbower Forest Ramsar site, these are described in Table 5. Further information on how the limits of acceptable change were derived, baseline condition and confidence level is provided in Appendix B.

Table 5 Description of the critical components, processes and services contributing to the ecosystem value and importance of the Gunbower Forest Ramsar Site and limits of acceptable change (Hale & Butcher, 2011)

Critical component, process or service	Description	Limits of acceptable change
Hydrology	▪ Inundation of the site is driven largely by flows within the Murray River and major tributaries. ▪ The hydrology of the site is highly regulated and seasonality of low and moderate flow is determined largely by irrigation needs. ▪ Large scale floods that inundate the forest are generally the result of catchment scale rainfall events.	▪ No less than four events in any 10 year period of 13,700 ML/d for three months (Murray River at Torrumbarry); and a maximum interval of three years between the stated flow event. ▪ No less than five events in any 20 year period of 30,000 ML/d for two months (Murray River at Torrumbarry) and a

Critical component, process or service	Description	Limits of acceptable change
	▪ Groundwater sources are secondary with the site being termed a "flushing zone" losing groundwater to the river following inundation.	maximum interval of five years between the stated flow event. ▪ No less than 10 events in any 50 year period of 40,000 ML/d for one month (Murray River at Torrumbarry) and a maximum interval of 10 years between the stated flow event.
Wetland vegetation	▪ There are two critical wetland vegetation categories: floodplain forests and floodplain marshes. ▪ Approximately 80 percent of the site is covered in inundation dependent forest and woodland (river red gum and black box), which has a combined extent of over 16 000 hectares. ▪ River red gum forest is the dominant vegetation community, comprising 65 percent of the site. ▪ Seventy-five native aquatic/wetland plant species recorded in floodplain marshes. ▪ Species richness and cover of plants in floodplain marshes is highly variable temporally and spatially. ▪ The site is important for the threatened swamp wallaby-grass and winged peppercress.	**Floodplain forest** Extent of floodplain forest and woodland vegetation to be no less than: ▪ 7500 hectares of river red gum forest ▪ 4280 hectares of river red gum woodland ▪ 2400 hectares of black box woodland River red gum condition to be "moderate" or better for at least 80% of the forest. **Floodplain marshes** ▪ Extent of spike sedge wetland to be no less than 270 hectares. ▪ Extent of tall marsh wetland to be no less than 125 hectares. **Threatened species** ▪ Presence of swamp wallaby-grass in permanent and intermittent wetlands within the site. ▪ Presence of winged peppercress near Reedy Lagoon when waterlogging occurs.
Fish	• Data deficient. • Twelve native species of fish have been recorded from within the site. • Results from surveys indicate that abundance varies considerably and that invasive species generally comprise 16 - 36 percent of the total abundance and up	**Species richness** Presence of the following species in no less than two in five annual surveys: ▪ Australian Smelt (*Retropinna semoni*)

Critical component, process or service	Description	Limits of acceptable change
	to ninety percent of biomass of large bodied fish.	▪ Carp Gudgeons (*Hypseleotris spp*.) ▪ Dwarf Flat-headed Gudgeon (*Philypnodon macrostomus*) ▪ Flat-headed Gudgeon (*Philypnodon grandiceps)* ▪ Fly-specked Hardyhead (*Craterocephalus stercusmuscarum*) ▪ Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*). **Threatened species** Presence of Murray Cod (*Maccullochella peelii*) and Silver Perch (*Bidyanus bidyanus*) in Gunbower Creek in three out of five of annual surveys.
Wetland birds	▪ Sixty-six species of wetland bird have been recorded from the site. This includes nine species listed under international migratory agreements as well as the endangered Australasian bittern. ▪ Maximum counts recorded during the 1974 floods comprise approximately 6000 individuals. ▪ A large proportion of the wetland birds recorded within the site have been observed breeding	**Abundance** Successful breeding (80 percent of chicks fledged) of colonial nesting waterbirds during flood events. **Threatened species** Presence of the Australasian Bittern when tall marsh is inundated.
Diversity of wetland types	▪ The site supports the part of the second largest remaining river red gum forest and provides a mosaic of vegetated wetland habitats.	See LAC for hydrology and vegetation
Physical habitat	▪ Gunbower Forest provides habitat for feeding and breeding of wetland birds.	See LAC for hydrology, vegetation and wetland birds
Threatened species	▪ The Ramsar site supports at least five species listed as threatened under the EPBC Act and/or the IUCN Red List.	See LAC for wetland birds, fish and vegetation
Ecological connectivity	▪ The site provides important migratory routes between riverine, wetland and floodplain habitats for fish spawning and recruitment.	See LAC for hydrology and native fish
Carbon cycling	▪ As part of a major floodplain system, the site is important for the cycling of nutrients, particularly carbon both on the	See LAC for hydrology and vegetation

Critical component, process or service	Description	Limits of acceptable change
	floodplain and as a source of organic carbon to receiving waterways.	

The ecological character description sets limits of acceptable change for these 13 critical components, processes and services (Hale & Butcher, 2011). Limits of acceptable change have differing levels of confidence.

5.4 Potential impacts to LACs

The impact of the project on the Ramsar site has been assessed in relation to the potential impact on or exceedance of the Limits of Acceptable Change identified in the Ecological Character Description for the Gunbower Forest Ramsar site. This considered the critical components, processes and services underpinning the Ecological Character Description of Gunbower Forest. The outcomes are summarised in Table 6 and further detail on the assessments is contained in Sections 5.4.1 to 5.4.13.

Table 6 Assessment of the potential impacts of the project on the critical components, processes and services that have had direct LACs developed

LAC	Assessment
Hydrology	The hydrology LAC is unlikely to be exceeded as the project is not expected to have any influence on the maintenance of average recurrence intervals of flows within the Murray River at Torrumbarry. The project will enable more frequent inundation of the floodplain to enhance ecological values of wetlands and River Red Gum forest which is aligned with the intent of the hydrology LAC.
Vegetation – floodplain forest	The vegetation – floodplain forest LAC is unlikely to be exceeded as the operating scenarios under the project are expected to improve the condition of floodplain forest within the Inundation Area for the project through increased triggering of germination events. These improvements in condition as well as the recharge of groundwater accessible to floodplain forest following environmental watering is expected to facilitate the forest's recovery from drought and help build the resilience of the systems to future extended dry periods (NCCMA, 2014).
Vegetation – floodplain marshes	The vegetation – floodplain marshes LAC is unlikely to be exceeded as no areas of Spike-sedge Wetland are proposed to be impacted and a total of 0.07 hectares of Tall Marsh is proposed to be impacted by the project, far less than would exceed the LAC.
Vegetation – threatened species	The vegetation – threatened species LAC is unlikely to be exceeded as Winged Peppercress presence within the Ramsar site will not be affected by this project and habitat for River Swamp Wallaby-grass is expected to be enhanced resulting in continued presence within the Ramsar site.
Native fish (species richness)	Some localised impacts to the six native fish species relevant to the LAC are possible due to construction. Mitigations are proposed for these construction impacts and these species are likely to benefit from improved habitat conditions following environmental watering within the inundation area (R8, 2020a). The risk of Carp entering Upper Gunbower Forest during environmental watering and degrading habitat important for these species remains high following mitigation (NCCMA, 2014). A fish assessment for the project looked at the potential impacts of the project on threatened species, it was found that the project was not expected to have significant impact on these species (R8, 2020a). Although the assessment didn't specifically look

LAC	Assessment
	at the remaining four fish species which are not listed under the EPBC Act or FFG Act, they occupy a similar habitat and rely on similar conditions to complete their lifecycle as the fish species considered in the assessment. It is unlikely that the project will decrease the presence of these species in annual surveys following environmental watering with planned mitigations in place such as carp screens on pumps and regulators and manual removal of carp from permanent wetlands.
Native fish (threatened species)	The native fish – threatened species LAC is unlikely to be exceeded as Gunbower Creek is the key habitat area relevant to the LAC and does not occur within the Area of Investigation or the Inundation Area for the project and there is no return of water to Gunbower Creek under the proposed operating scenarios (NCCMA, 2014).
Wetland birds (abundance)	The wetland bird – abundance LAC is unlikely to be exceeded as the project is expected to have significant benefits for wetland birds across the Gunbower Forest.
Wetland birds (threatened species)	The wetland bird – threatened species LAC is unlikely to be exceeded as the Australasian bittern would be expected to benefit from improvements in habitat quality and availability during inundation. It is unlikely that Australasian bittern would be impacted by construction.

5.4.1 Hydrology

The Hydrology LAC is based on maintaining the average recurrence interval of flows of various magnitudes for events that are considered important for critical components at the site measured in the Murray River at Torrumbarry. The LAC is aimed at influencing areas of wetlands, River Red Gum forest, River Red gum woodland and Black Box woodland within the Ramsar site.

Implementing the project will modify the hydrology of wetlands and River Red Gum forest within the inundation extent of the project. This change will affect the frequency and extent of inundation of surface water and potentially affect groundwater flow into these wetlands. Ecological objectives and targets have been developed for the project to improve the ecological values of the site including native vegetation communities, native fauna within wetlands and wetland birds. Operational scenarios have been developed in line with these objectives (NCCMA, 2014).

As the project itself will not change the average recurrence interval of flows within the Murray River it is not plausible that the hydrology LAC will be exceeded by the project. The project will also aim to improve the condition of wetlands and River Red Gum forest which is aligned with the intention of the hydrology LAC. Although the project is not likely to significantly change the average recurrence interval of Murray River flows at Torrumbarry, the project will enable more frequent inundation of the floodplain to enhance ecological values, which is aligned with the intent of the hydrology LAC.

5.4.2 Vegetation (floodplain forest)

The floodplain forest LAC is based on the total extent of River Red Gum forest (no less than 7500 hectares), River Red Gum woodland (no less than 4280 hectares) and Black Box woodland (no less than 2400 hectares) within the Ramsar site, and maintaining River Red Gum condition as “moderate” or better for at least 80% of the forest (Hale & Butcher, 2011).

Under the project, a total of approximately 19.57 hectares of native vegetation is proposed to be removed (R8, 2020a). This vegetation removal occurs across a range of EVCs, some of which can be equated to River Red Gum forest, River Red Gum woodland and Black Box woodland. Assuming no loss of extent since the time of listing (1982) the project would have to remove 826 ha of River Red Gum Forest, 477 hectares of River Red Gum woodland and 294 hectares of Black Box woodland to exceed the LAC for floodplain forest (Hale & Butcher, 2011). As the vegetation removal for the project is proposed to be far less than these areas, the project will not reduce the extent of River Red Gum forest, River Red Gum woodland or Black Box woodland beyond the LAC.

The operating scenarios under the project are expected to improve the condition of River Red Gum within the Inundation Area for the project. These improvements in condition as well as the recharge of groundwater accessible to River Red Gum is expected to facilitate the forest's recovery from drought and help build the resilience of the systems to future extended dry periods (NCCMA, 2014). It is not expected that any decline in condition would be caused by this project and this LAC will not be exceeded.

5.4.3 Vegetation – (floodplain marshes)

This LAC is based on the extent of EVC 819 Spike-sedge Wetland being no less than 270 hectares and EVC 812 Tall Marsh being no less than 125 hectares within the Gunbower Forest Ramsar site (Hale & Butcher, 2011). When the ecological character description was developed the extent of Spike-sedge Wetland within the forest was mapped as covering 310 hectares and Tall Marsh was mapped as covering 140 hectares. No areas of Spike-sedge Wetland are proposed to be impacted and a total of 0.06 hectares of Tall Marsh is proposed to be impacted by the project (R8, 2020a). The extent of floodplain marsh vegetation impact proposed by the project is far less than would exceed the LAC.

5.4.4 Vegetation (threatened species)

This LAC is specifically linked to two threatened species known to exist within the Gunbower Forest Ramsar site, River Swamp Wallaby-grass (*Amphibromus fluitans*) and Winged Peppercress (*Lepidium monoplocoides*) (Hale & Butcher, 2011). The LAC is based on presence within the Gunbower Forest Ramsar site for River Swamp Wallaby-grass and presence at a known location near Reedy Lagoon for Winged Peppercress (Hale & Butcher, 2011). Reedy Lagoon is located 30 km downstream of the Project Area and Winged Peppercress was not recorded in the Area of Investigation during targeted surveys (R8, 2020a). An impact assessment was undertaken for River Swamp Wallaby-grass through the flora and fauna assessment for the project (R8, 2020a). River Swamp Wallaby-grass was recorded in a degraded state within the Area of Investigation due to a lack of recent flooding and browsing by herbivores. Individuals recorded during field assessment in 2019 were not located close to the revised Construction Footprint and it was concluded that the project is not expected to result in a significant impact to this species (R8, 202a). Further surveys were recommended in spring 2020 for Middle Gunbower (downstream of Deep Creek) to confirm the presence or absence of River Swamp Wallaby-grass in this area (R8, 2020a).

Areas of habitat for River Swamp Wallaby-grass, permanent and intermittent wetlands within the Ramsar site, will not be extensively impacted by construction of the project although some localised impacts will occur (R8, 2020a). The flooding regime delivered through the project is expected to enhance the condition and function of River Red Gum flood dependent understory and temporary wetlands and support threatened flora (NCCMA, 2014).

Winged Peppercress presence within the Ramsar site will not be affected by this project and habitat for River Swamp Wallaby-grass is expected to be enhanced resulting in continued presence within the Ramsar site. In conclusion this LAC will not be exceeded as a result of the project.

5.4.5 Native fish (species richness)

This LAC is based on annual surveys confirming presence of six native fish species in no less than two in five years (Hale & Butcher, 2011):

- Australian Smelt (*Retropinna semoni*)
- Carp Gudgeons (*Hypseleotris* spp.)
- Dwarf Flat-headed Gudgeon (*Philypnodon macrostomus*)
- Flat-headed Gudgeon (*Philypnodon grandiceps*)
- Fly-specked Hardyhead (*Craterocephalus stercusmuscarum*)
- Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*).

All of these species have been recently detected in Camerons Creek (Sharp 2014, 2015) which is within the Inundation Area for the project and partially overlaps with the Construction Footprint. The business case for the project states that an expected benefit of the project is that small-bodied native fish in Camerons Creek will be able to access enhanced food resources and permanently inundated habitat within Black Charlie Lagoon following environmental water delivery (NCCMA, 2014).

The Upper Gunbower Creek Fish Management Plan (Stuart, 2020) sets out ecological objectives for small-bodied native fish to inform management decisions for the Upper Gunbower section of the project and further enhance conditions for these species.

A flora and fauna assessment undertaken for the project investigated likelihood of occurrence and impact to threatened fish species within the Construction Footprint and Inundation Area as a result of the works and future operation of the project (R8, 2020a). Only two of the six native fish species relevant to this LAC are listed as threatened and therefore included in the impact assessment, Murray-Darling Rainbowfish and Fly-specked Hardyhead. It was found that localised impacts from construction were possible on these two species however could be mitigated through implementation of a construction environmental management plan, including an aquatic fauna management plan, for works around waterways including activities such as coffer dam construction, dewatering works, and any potential for sediment/ contaminant run-off into wet areas from construction footprint. The construction impacts were considered unlikely following mitigation (R8, 2020a). Both species were found to be likely to benefit from improved habitat conditions following environmental watering (R8, 2020a). The remaining four species have not had an impact assessment undertaken although have similar characteristics to Murray-Darling Rainbowfish and Fly-specked Hardyhead in that they are also small-bodied fish that inhabit wetlands. The potential impacts and mitigations are likely to be very similar if not identical as they occupy the same types of habitat. The fish assessment included in the flora and fauna assessment concluded that no significant impacts were expected to occur on threatened species as a result of the construction or operation of the project (R8, 2020a).

The business case for the project also identified the risk of increasing the abundance of pest fish in Camerons Creek and Black Charlie Lagoon in the Upper Gunbower Forest area to aquatic vegetation, still water habitats and the ecological value of the forest. A number of pest fish species are expected to be present in the project's supply points including Carp, Goldfish, Tench, Gambusia, Oriental Weatherloach and Redfin Perch (NCCMA, 2014). All pest fish compete for resources and habitat with native fish, however, Carp are particularly destructive as they are highly invasive and can impact on wetland plants, habitats, turbidity, and native fish (Koehn et al. 2000). Carp can dominate floodplain fish communities where the shallow warm waters provide ideal conditions for spawning and growth (Stuart & Jones 2006). Carp screens are proposed to restrict movement of adult carp and other large-bodied fish species entering Black Charlie Lagoon, however young carp will be able to enter and potentially grow to adult size and degrade the aquatic habitat impacting on native fish. Although Carp can currently enter Black Charlie Lagoon at any time, but more frequently during high flow events on the Murray River, the project will increase the exposure of Carp to the Upper Gunbower Forest as eggs and larvae will now be able to enter via pumping as well. The residual risk rating for wetland vegetation following the use of carp screens is high according to the business case (NCCMA, 2014). This is an issue that will need to be adaptively managed during the operational phase of the project. The Carp screens are expected to be effective in reducing the numbers of Carp entering the permanent wetlands however if monitoring of wetland condition following environmental watering finds that much higher numbers of Carp are present as a result of the project's operational scenarios a Carp Management Plan would be recommended, including details of manual removal from Black Charlie Lagoon. The potential impact of Carp on the six native fish species relevant to the LAC is not expected to outweigh the benefit of improved access to enhanced food resources and habitat under the project's operating scenarios following the implementation of mitigations.

Some localised impacts to the six native fish species relevant to the LAC are possible due to construction. Mitigations are proposed for these construction impacts through a construction specific aquatic fauna management plan, and these species are likely to benefit from improved habitat conditions following environmental watering within the inundation area.

5.4.6 Native fish (threatened species)

This LAC is specifically linked to the presence of two threatened species in Gunbower Creek in three out of five annual surveys, Murray Cod (*Maccullochella peelii*) and Silver Perch (*Bidyanus bidyanus*) (Hale & Butcher, 2011). Gunbower Creek is not within the Area of Investigation or the Inundation Area for the project and there is no return of water to Gunbower Creek under the proposed operating scenarios (NCCMA, 2014). Gunbower Creek will not be affected by the project and therefore this LAC will not be exceeded by the project.

5.4.7 Wetland birds (abundance)

This LAC is based on the successful breeding (80% of chicks fledged) of colonial nesting waterbirds during flood events (Hale & Butcher, 2011). Colonial waterbird nesting typically takes place in the lower Gunbower Forest (NCCMA, 2014). The Inundation Area for the project is expected to contribute to the provision of foraging areas for colonial waterbirds (NCCMA, 2014) rather than have a direct impact on successful breeding of colonial nesting waterbirds during flood events. The project is "expected to reinstate a diversity of foraging habitat and food sources that will support a high carrying capacity of waterbirds across Gunbower Forest including those residing/breeding in the Gunbower National Park and those residing/breeding in the lower forest that use broader foraging areas" (NCCMA, 2014 p.27). This LAC will therefore not be exceeded by the project.

5.4.8 Wetland birds (threatened species)

This LAC is specifically linked to the presence of one threatened species, Australasian Bittern (*Botaurus poiciloptilus*), when tall marsh is inundated (Hale & Butcher, 2011). The business case for the project states that an expected benefit of inundation is provision of habitat for threatened species including Australasian Bittern (NCCMA, 2014). The flora and fauna assessment also found that Australasian bittern would be expected to benefit from improvements in habitat quality and availability during inundation and that it was unlikely that any impact from activities occurring within the Construction Footprint would occur on the species (R8, 2020a). The project is not expected to exceed the LAC for wetland birds (threatened species).

5.4.9 Diversity of wetland types

This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland condition. As a result, no direct LAC has been developed and instead the critical service is assessed indirectly through changes in the average return interval and duration of specific flow events, extent and condition of river red gum forests and woodlands and extent of floodplain marshes (Hale & Butcher, 2011). See Sections 5.4.1, 5.4.2 and 5.4.3 for assessment of the project against these LACs.

5.4.10 Physical habitat

This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland vegetation. In addition, wetland bird abundance can be used as a surrogate measure. As a result, no direct LAC has been developed and instead the critical service is assessed indirectly through changes in the average return interval and duration of specific flow events, extent and condition of river red gum forests and woodlands, extent of floodplain marshes and abundance of wetland birds (Hale & Butcher, 2011). See Sections 5.4.2, 5.4.3 and 5.4.7 for assessment of the project against these LACs.

5.4.11 Threatened species

This critical service is indicated by the presence of threatened species at the site. No direct LAC has been developed and instead the critical service is assessed through presence of threatened species including wetland birds, native fish and vegetation species (Hale & Butcher, 2011). See Sections 5.4.8, 5.4.6 and 5.4.4 for assessment of the project against these LACs.

5.4.12 Ecological connectivity

The site maintains connectivity between the river and floodplain wetlands and channels for fish spawning and recruitment. This service is maintained by hydrology and can also be indicated by the species richness and abundance of native fish. No direct LAC has been developed and instead the critical service is assessed indirectly through changes in hydrology and native fish populations (Hale & Butcher, 2011). See Sections 5.4.1, 5.4.5 and 5.4.6 assessment of the project against these LACs.

5.4.13 Carbon cycling

This service is provided by the uptake of carbon by vegetation, the deposition of organic matter (coarse woody debris and litter) on the floodplain and the mobilisation of particulate and dissolved organic carbon to receiving river systems with flood return waters. This service is maintained by vegetation extent, forest structure and hydrology. No direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and floodplain forest extent (Hale & Butcher, 2011). See Section 5.4.1 and 5.4.2 for assessment of the project against these LACs. It is expected that carbon cycling will improve due to improved vegetation condition and increased frequency of inundation of the floodplain.

5.5 Risks to Ramsar listing

The project is expected to have a positive impact on the ecological character of the Gunbower Forest Ramsar site. There will be some localised negative impacts associated with construction of the project as detailed in Section 4.1. Based on the assessment of the project in terms of the possible causation of exceedance of LACs for the Ramsar site detailed in Section 5.4 it is not considered that the project causes a significant risk to the project negatively impacting the ecological character of Gunbower Forest or affecting the site's listing as a Ramsar site.

6. High level significance assessment for Ramsar sites against the MNES significant impact criteria

6.1.1 Gunbower Forest Ramsar site

The table below provides a summary of the significant impact criteria for Ramsar wetlands (DoE, 2013) and an assessment of the project against those criteria for the Gunbower Forest Ramsar site.

Areas of the wetland being destroyed or substantially modified
The project will result in a small area of the wetland being destroyed or substantially modified. The total size of Construction Footprint within the Ramsar site which may be subjected to short-term impacts during construction is 11.3 ha. due to the construction of structures and banks, and 12.1 ha. due to the construction or upgrade of tracks and roads. The total size of the Development Footprint, areas within which may experience long-term impacts due construction of permanent infrastructure within the Ramsar site is 6.3 ha.
A substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flow to and within the wetland
704 ha. of the Gunbower Forest Ramsar site is within the Inundation Area for the project and will be subjected to a substantially modified hydrological regime. The ecological objectives which form the basis of the operating scenarios have been developed with the aim of improving the environmental values within the Project Area. As a result, the modification is expected to have positive benefits rather than causing an impact due to altered hydrology (NCCMA, 2014). Increased groundwater recharge following managed inundation of the Upper and Middle Gunbower Forest is expected to benefit River Red Gum woodland and forest, improving canopy condition in drier times (NCCMA, 2014) and resulting in improved recruitment within this community.
A substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health
Hypoxic blackwater events have the potential to occur during watering of Gunbower National Park, either on the floodplain (i.e. formation in wetlands during the drawdown phase) or the River Red Gum and Forest Watering scenario which (in the Middle Forest) includes return flows to the Murray River (i.e. return to the channel). low levels of oxygen in hypoxic blackwater can cause stress to or death of aquatic biota. The risk of hypoxic blackwater events occurring as a result of Gunbower National Park managed floodplain inundation is relatively high due to high organic loads, minimal circulation and warm water temperatures (NCCMA, 2014). However, the risk of hypoxic blackwater events causing significant ecological impacts is considered to be low. The main ecological risks are the potential for hypoxic blackwater formed on the floodplain to return to the Murray River and impact the channel species, and for it to form in permanent wetlands (Black Charlie Lagoon and Camerons Creek) and impact the resident small-bodied native fish population. However, the risk of hypoxic blackwater impacting ecological values will be closely monitored and managed using a number of methods (pre-watering blackwater risk assessment, monitoring water quality during event, managing the volume of return flows and dilution flows in the Murray River, watering during cooler months to reduce risk, providing inflows to freshen wetlands etc.). It is expected that the risk of hypoxic blackwater events will reduce as more frequent floodplain watering will reduce the build-up of organic material between events that can cause blackwater events (NCCMA, 2014). There is a risk that during managed floodplain inundation events, the infiltration of water causes the watertable to rise exposing vegetation to saline groundwater which could cause poor health or death of

floodplain vegetation (NCCMA, 2014). The business case found that this would be unlikely to occur and that groundwater and salinity monitoring and adaptive management could be effective mitigations with the residual risk characterised as negligible (NCCMA, 2014).

Some localised water quality impacts are possible during construction due to the runoff of sediment or contaminants from works sites into wet areas (NCCMA, 2014, R8, 2020a). Mitigations such as soil erosion control measures and sediment management approaches will be implemented to reduce this risk.

The project could cause a short-term substantial and measurable change in the water quality of the Ramsar site due to a blackwater event in some localised areas depending on organic carbon loads, flow through volumes and dilution potential. However due to the low risk of ecological impacts to the resident native fish community, it is not considered that this change will adversely impact on biodiversity, ecological integrity, social amenity or human health.

The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected

The habitat and lifecycle of a range of native species is expected to benefit from the delivery of environmental water to Gunbower National Park including River Red Gum trees and understory, wetland plants, aquatic fauna including fish, macroinvertebrates, frogs and turtles, waterbirds and terrestrial fauna including woodland birds (NCCMA, 2014).

There are some expected localised and mainly temporary (although some small permanent reductions) impacts to habitat, from construction of the works. The expected project impacts are detailed in Section 4.1 and include:

- Physical disturbance within wetlands where upgrades of existing roads are required and construction of banks and structures will take place including disturbance or removal of vegetation and possible water quality impacts to wetlands
- Entrapment, restriction of passage or temporary loss of habitat due to cofferdam construction, dewatering works and sediment/contaminant runoff into wet areas from the Construction Footprint.
- Transport or proliferation of invasive weeds impacting upon the health of wetland and floodplain vegetation communities.

The flora and fauna assessment also identified the potential risk of turtle breeding being disrupted if works along river banks are undertaken in spring to summer (R8, 2020a).

These impacts are localised and will be mitigated through the implementation of a construction environmental management plant and a construction specific aquatic fauna management plan to be developed for all works around waterways including wetlands (R8, 2020a).

With the implementation of planned mitigations it is not expected that the project will seriously affect the habitat or lifecycle of native species dependent on the Gunbower Forest Ramsar site.

An invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland

Transport or proliferation of invasive weeds impacting upon the health of wetland and floodplain vegetation communities has been identified as a potential risk from construction and mitigations are proposed within the Environmental Management Framework to reduce this risk. It is expected that with more frequent inundation under the project's operating scenarios the incidence of some terrestrial weeds will be reduced (R8, 2020a) but the effectiveness will be determined by the frequency of inundation and whether weeds can re-establish between watering events. An EWMP will be developed to adaptively manage weed invasions under the operation of the project (NCCMA, 2014).

The business case identified the risk of introduction and increased abundance of pest fish, particularly Carp, within Camerons Creek and Black Charlie Lagoon (NCCMA, 2014). Carp can damage the ecological value of habitat and impact upon the native small-bodied fish community. Impacts to the native fish community within Black Charlie Lagoon could affect ecological character of the Gunbower Forest Ramsar site, see 5.4.5 for more

details. Although Carp are currently able to access these environments during high flow events on the Murray River, the project may increase the number of Carp as larvae and eggs pass through screens on pumps and enter the permanently inundated wetlands. A fish assessment undertaken for threatened fish species within the project area concluded that significant impacts under the EPBC Act or FFG Act were unlikely to occur as a result of construction or operation of the project provided that appropriate mitigations were implemented such as a construction specific aquatic fauna management plan, use and maintenance of screens on pumps and manual removal of carp from permanent wetlands as needed (R8, 2020a).

With the implementation of an EWMP which includes monitoring and adaptive management to track any occurrence of potential weeds and appropriate action taken, either through refinement of the watering regime or other control measures, and the implementation of mitigations to reduce the risk of pest fish it is considered unlikely that an invasive species harmful to the ecological character of the Ramsar site would be established or spread by the project.

6.1.2 Downstream Ramsar sites within 500 km downstream of the Project Area, including NSW Central Murray Forests (immediately adjacent across Murray River from Project Area) and Hattah-Kulkyne Lakes

The table below provides a summary of the significant impact criteria for Ramsar wetlands (DoE, 2013) and an assessment of the project against those criteria for and any adjacent or downstream Ramsar listed wetlands that could potentially be affected by the project.

Areas of the wetland being destroyed or substantially modified
No areas of the downstream Ramsar sites are currently within the Area of Investigation or Inundation Area of the project and therefore downstream Ramsar sites will not be destroyed or substantially modified due to the project.
A substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flow to and within the wetland
Return flows from the project are expected to re-enter the Murray River only under the Forest floodplain watering scenario and the volumes are small (1,540 ML per event) compared with the magnitude of flow in the Murray River. It is therefore not expected that return flows would cause a substantial or measurable change within the adjacent NSW Central Murray Forests Ramsar site or at Hattah-Kulkyne Lakes which is over 300 km downstream. Further hydrological modelling will be undertaken by the MDBA when the full package of adjustment measures is agreed to by Basin governments (NCCMA, 2014).
The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected
No area of habitat or lifecycle of native species within an adjacent or downstream Ramsar site is expected to be impacted as a result of the project as the Investigation Areas where the works will take place and the Inundation Area are not within these Ramsar sites.
A substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health
Impacts to water quality at adjacent or downstream Ramsar sites could arise as a result of return flows entering the Murray River from the Gunbower National Park floodplain during or following a managed inundation event.

A preliminary semi-quantitative assessment of the potential salinity impacts of environmental watering activities at Gunbower National Park was undertaken and the estimated salinity impact at Morgan under the operating scenarios was found to be negligible (<0.01 µS/cm EC) (Jacobs 2014).

The business case for the project states that the nature of any downstream salinity and/or water quality impacts, and any potential cumulative impacts with other measures, could not be formally ascertained at the time of writing. This is because such impacts will be influenced by other measures that may be operating upstream of this site, including other supply/efficiency/constraints measures under the sustainable diversion limit (SDL) adjustment mechanism, and the associated total volume of water that is recovered for the environment.

Due to the small volume of return flow expected to re-enter the Murray River as a result of managed inundation of the Gunbower National Park floodplain under the project (1,540 ML per event under the River Red Gum and Forest watering scenario), substantial and measurable water quality impacts to downstream Ramsar sites would not be expected to occur as a result of the project.

Further modelling will be undertaken by the MDBA when the full package of adjustment measures is agreed to by Basin governments (NCCMA, 2014). This will identify any cumulative impacts that may occur downstream from the full package of works.

An invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland

No changes to invasive species occupancy are expected to result at any adjacent or downstream Ramsar site due to the project as the Investigation Area where the works will take place and the Inundation Area are not within these Ramsar sites.

7. Environmental Effects Referral Assessment

As identified in Section 4 there are significant wetlands within the Areas of Investigation and Inundation Areas for the project with potential for impact during construction and operation of the project. The following tables address specific questions contained in Section 13 – Water Environments of the EE Act referral form relating to wetlands.

Are any waterways, wetlands, estuaries or marine environments likely to be affected?
Wetlands that partially or fully overlap with the Areas of Investigation are likely to be affected by construction of the project and wetlands that are within the Inundation Area are likely to be affected by changed hydrology during managed environmental watering events. There is also a possibility that downstream wetlands could be affected during or following the delivery of managed events to Gunbower National Park due to changes in water quality or hydrology from return flows re-entering the Murray River from the floodplains. As discussed in Section 6.1.2, a substantial and measurable change in the water quality or hydrology of a downstream wetland is considered unlikely as a result of the project. Further hydrological modelling will be undertaken by the MDBA when the full package of adjustment measures is agreed to by Basin governments (NCCMA, 2014). Eleven wetlands identified from the Victorian Wetland Inventory, ten of which are covered under the Ramsar and DIWA listings, have the potential to be affected by the project. See Section 4 for a description of the nature of these impacts.
Are any of these water environments likely to support threatened or migratory species?
Wetlands within Gunbower National Park are likely to support threatened or migratory species. The flora and fauna assessment for the project describes threatened and migratory species likely to be present, survey methods and potential impacts (R8, 2020a). Wetlands and connected waterways have potential to support the following listed threatened species: ▪ Growling Grass Frog (*Litoria raniformis*) listed as vulnerable under the EPBC Act, listed under the FFG Act and included as vulnerable on the Victorian Government's threatened fauna advisory list (R8, 2020a). ▪ Sloane's Froglet (*Crinia sloanei*) listed as endangered under the EPBC Act (R8, 2020a). ▪ Murray Cod (*Maccullochella peelii peelii*) listed as vulnerable under the EPBC Act, listed under the FFG Act and included as vulnerable on the Victorian Government's threatened fauna advisory list (R8, 2020a). ▪ Silver Perch (*Bidyanus bidyanus*) listed as critically endangered under the EPBC Act, listed under the FFG Act and included as vulnerable on the Victorian Government's threatened fauna advisory list (R8, 2020a). ▪ Macquarie Perch (*Macquaria australasica*) listed as endangered under the EPBC Act, listed under the FFG Act and included as endangered on the Victorian Government's threatened fauna advisory list (R8, 2020a). ▪ Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*) listed under the FFG Act (R8, 2020a) ▪ Golden Perch (*Macquaria ambigua*) included as near threatened on the Victorian Government's threatened fauna advisory list (R8, 2020a). ▪ Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*) listed under the FFG Act ▪ Broad-shelled Turtle (*Chelodina expansa*) listed under the FFG Act and included as endangered on the Victorian Government's threatened fauna advisory list (R8, 2020a).

- Murray River Turtle (*Emydura macquarii*) included as vulnerable on the Victorian Government's threatened fauna advisory list (R8, 2020a).

Twelve species listed as migratory under the EPBC Act are predicted to occur, or were previously recorded from a Victorian Biodiversity Atlas (VBA) and Protected Matters Search Tool (PMST) search of a 10 km buffer of the Construction Footprint. None of these species were considered to have potential to occur within the Construction Footprint (R8, 2020a).

One EPBC listed flora species, River Swamp Wallaby-grass (*Amphibromus fluitans,*EPBC listed Vulnerable) was identified within the Investigation Area during the most recent field assessment, and two others, Stiff Groundsel (*Senecio behrianus,* EPBC Act listed Endangered) and Winged Peppercress (*Lepidium monoplocoides*, EPBC Act listed Endangered) are known to occur close to the Project Area in similar habitat. These three species are not considered to be significantly impacted by either the construction works or proposed inundation. As flood responders, all three species are likely to benefit from the restoration of a more natural inundation cycle.

Are any potentially affected wetlands listed under the Ramsar Convention or in 'A Directory of Important Wetlands in Australia'?

Potentially affected wetlands are included within both the Gunbower Forest Ramsar site and the Gunbower Island DIWA listing.

The NSW Central Murray Forests Ramsar site is directly adjacent to the Project Area and could potentially be affected by hydrological or water quality changes due to the project. As discussed in Section 6.1.2, it is unlikely that changes would be substantial or measurable due to the relatively small volumes of return flows to the Murray River.

The Hattah-Kulkyne Lakes Ramsar site is located more than 300 km downstream from the project. As discussed in Section 6.1.2, it is unlikely that changes would be substantial or measurable due to the relatively small volumes of return flows to the Murray River.

Further modelling of potential changes would be carried out by the MDBA once the full package of SDL adjustment measures has been confirmed (NCCMA, 2014).

Is there a potential for extensive or major effects on the health or biodiversity of aquatic, estuarine or marine ecosystems over the long-term?

Due to construction impacts within the Investigation Areas

Overall, the project is expected to benefit wetlands by reinstating a more favourable hydrological regime to improve the ecological values of the Project Area. However, construction activities have the potential to impact temporarily and permanently on wetlands within the final Construction Footprints within the Area of Investigation, including wetlands listed under the Gunbower Forest Ramsar site and Gunbower Island DIWA area. Potential impacts are described in Section 4.1.

The areas of individual wetlands overlapping with the Construction Footprint and Development Footprint are small. Given the abundant wetland habitat elsewhere across the Gunbower National Park unaffected by construction and the proposed mitigations to reduce construction impacts it is not likely that construction activities will lead to an extensive or major effect on the health or biodiversity of wetlands over the long-term.

Due to operational changes within the project area

Operational changes within the project area are likely to be positive for wetland environments within the Inundation Area as defined through the specific ecological objectives and targets for the project The project is designed to have the operational flexibility to vary the timing, depth, duration and extent of inundation so that individual managed events are able to target specific ecological outcomes.

There are some environmental risks associated with the delivery of environmental water to Gunbower National Park under the project. These risks fall under the categories of vegetation, birds, geomorphology, groundwater and fish. The full details of the risk assessment, including mitigations and residual risk can be found in Appendix 4 of the business case (NCCMA, 2014).

The only risk that remains high following mitigation is the transport of pest fish (particularly Carp) into the forest during environmental water delivery causing impacts on aquatic vegetation, still water habitats and reducing the ecological value of the forest. This risk is of particular importance as it potentially affects the Native fish (species richness) LAC as described in the Ecological Character Description for the Gunbower Forest Ramsar site (Hale & Butcher, 2011).

A fish assessment for threatened fish species within the project area found that with the implementation of adaptive management including monitoring of wetland condition and appropriate mitigations including the use of Carp screens on pumps and manual removal of Carp from permanent wetlands as needed, significant impacts were not expected on the two threatened fish species inhabiting the permanent wetlands of Upper Gunbower Forest (R8, 2020a). As these two threatened species have similar habitat and lifecycle needs to the further four species relevant to the Native fish (species richness) LAC, it is not expected that the project would cause a change that would exceed the LAC.

Downstream wetlands potentially affected by water quality or hydrology changes

As discussed in Section 3, a substantial and measurable change in water quality or hydrology leading to extensive or major effects on the health or biodiversity of adjacent or downstream wetlands is unlikely as a result of the project however this can't be fully confirmed until further investigation, including modelling of return flows, has taken place.

Is mitigation of potential effects on water environments proposed?

Mitigation measures for potential effects on wetlands due to construction impacts within the project area and due to operational changes within the project area are outlined in Section 8. Mitigations to manage risks to downstream wetlands due to hydrological or water quality impacts will be developed through the EWMP if needed.

8. Measures to reduce risk

An Environmental Management Framework (EMF) has been developed which sets out the governance framework, processes and procedures that will be applied to manage environmental risks and impacts during construction and operation of the project (R8, 2020c).

8.1 Construction

The following mitigation measures are proposed to minimise and avoid impacts on water environments during construction of the project:

- Develop and implement a Construction Environmental Management Plan (CEMP) and site specific environmental management plans prior to construction

General mitigation measures for all VMFRP works are detailed in the EMF and include requirements for:

- Design and planning
- Mitigation impacts on land use and amenity
- Management of flora and fauna
- Vehicle hygiene, weed and disease management
- Storage and handling of chemicals and fuels
- Waste management
- Earthworks and construction activities
- Cofferdam and dewatering
- Site pack up and rehabilitation

Further details can be found within the EMF (R8, 2020c).

8.2 Operation

An Environmental Water Management Plan (EWMP) will be developed for Gunbower National Park to manage the risks associated with the delivery of managed inundation events. Implementation of the EWMP will be guided by the Victorian environmental watering program planning and management framework and will include:

- Long-term management objectives and water regime requirements for the Forests. These have already been developed as part of the Ecological Objectives and Hydrological Requirements Justification Paper for Gunbower (North Central CMA, 2014b) and have been described in Section 3 – ecological objectives.
- Management measures to manage the risk associated with achieving the project's ecological objectives (i.e. factors outside delivery of environmental water inhibiting ability to achieve objective) and delivery of environmental water.
- Complementary actions to enhance the outcomes of environmental watering (e.g. pest plant and animal control)
- A summary of environmental monitoring (long term and intervention) included in the VMFRP Ecological MER Plan (ARI, 2020a).
- Summary of consultation that has been undertaken as part of the EWMP development.
- Roles and responsibilities for environmental water delivery and associated management of Gunbower National Park / Gunbower Forest. These will be assigned as part of process for developing the EWMP.

Mitigation measures would be implemented to minimise risks associated with pest plants, including:

- Timing water delivery to drown seedlings, minimise growth, germination and seed set. Time water delivery to promote native species.
- Controlling current populations and eradicate/control new infestations via existing management strategies (e.g. Parks Victoria pest management action plans/strategies). Support partner agencies to seek further funding for targeted weed control programs if necessary.

Carp pose a potential risk to habitat relied upon by small-bodied native fish. The following mitigation measures are required:

- Carp screens in inlet pumps.
- Monitoring of Carp numbers, and if deemed excessive or impacting on wetland condition or native fish, development and implementation of a Carp Management Plan.

8.3 Further assessment

To enable a more definitive assessment of the potential for impacts to downstream wetlands and the flora and fauna that depend on them from operation of the project, the following modelling should be undertaken:

- The potential downstream hydrological changes due to return flows to the Murray River following environmental watering of the Gunbower National Park.
- The potential for water quality changes (salinity and dissolved oxygen) associated with these return flows.

9. References

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Appendix A. Summary of proposed infrastructure

Area	Main components
Upper Gunbower	▪ Three small regulators: o Camerons Creek River Track Regulator o Camerons Mid Creek Regulator o Dry Tree Creek Outlet Regulator ▪ Dry Tree Creek culvert ▪ Containment banks / levees –– adjacent to and supporting the Camerons Mid Creek Regulator ▪ One cone and fishway – Camerons Mid Creek fishway. ▪ One spillway located within Baggots Creek Track ▪ One Pump Station located on GMW's National Channel ▪ One Pipeline to deliver environmental water into Gunbower National Park. The pipeline will also include several irrigation and stock and domestic supply offtakes to replace existing customer points. ▪ Power supply to new pump station.
Middle Gunbower (upstream Deep Creek)	▪ One Pump station located on the bank of the Murray River and associated discharge pipeline. ▪ Power supply to new pump station. ▪ Five regulators: o Pig Swamp Offtake Regulator o Emu Hole Lagoon Offtake Regulator o Middle Forest Offtake Regulator o Deep Creek River Return Regulator o Dalley Bend Inlet Regulator ▪ Emu Hole Lagoon offtake pipeline ▪ Middle Forest offtake pipeline (main discharge to OSCC) ▪ Old Straight Cut Channel minor upgrade works ▪ Road and car park works: o Brereton Road works o Riverside car parking area ▪ Containment banks/levees as required
Middle Gunbower (downstream	▪ Three spillways:

of Deep Creek)	○ Broken Axle Creek Spillway ○ Munroe Track Spillways 1 & 2 ▪ Four regulators: ○ Broken Axle Creek Regulator ○ Tickells Track Regulator ○ Spur Creek River Return Regulator ○ Spur Creek Forest Regulator ▪ One drop structure: Spur Creek drop structure ▪ Three culverts: Broken Axle Creek Culvert and Munroe Track Culvert 1 and 2 ▪ Drainage Outlets within the containment banks ▪ A series of containment banks on Munroe Track, Tickells Track and River Track as required.

Appendix B. Baseline condition and Limits of Acceptable Change for critical components, processes and services (Hale & Butcher, 2011)

Critical components, processes or services	Baseline condition and range of natural variation where known	LAC	Basis of LAC	Level of confidence
Hydrology - Inundation of the site is driven largely by flows within the Murray River and major tributaries - The hydrology of the site is highly regulated and seasonality of low and moderate flow is determined largely by irrigation needs - Large scale floods that inundate the forest are generally the result of catchment scale rainfall events - Groundwater sources are secondary with the site being termed a 'flushing zone' losing groundwater to the river following inundation	Characterised as ARI of Murray River flows (Murray River at Torrumbarry) considered important for maintaining ecological character: - 13,700 ML/d for three months ARI 2.6 years (commence to flow into forest) with a maximum interval between events of three years - 30,000 ML/d for two months ARI 4 years (50% of River Red Gum forest and 30% of River Red Gum woodland) with a maximum interval between events of five years - 40,000 ML/d for one month ARI 5 years (inundation of all River Red Gum forest and woodland and Black Box Woodland) with a maximum interval between events of ten years The LAC is assessed over time spans to account for the variability in hydrology at the	No less than four events in any 10 year period of 13,700 ML/d for three months (Murray River at Torrumbarry); and a maximum interval of three years between the stated flow event. No less than five events in any 20 year period of 30,000 ML/d for two months (Murray River at Torrumbarry) and a maximum interval of five years between the stated flow event. No less than 10 events in any 50 year period of 40,000 ML/d for one month (Murray River at Torrumbarry) and a maximum interval of 10 years between the stated flow event.	Hydrology LACs have been set based on conditions at the time of listing. The existing hydrological regime may not have been sufficient to maintain the character of the site in the long-term. Hydrology LACs have been set based on the understanding that any further change in the frequency and extent of floodplain inundation is likely to result in a change in character.	Medium

Critical components, processes or services	Baseline condition and range of natural variation where known	LAC	Basis of LAC	Level of confidence
	site (i.e. to allow for three to ten occurrences of the specified flow events within the assessment period)			
Vegetation – floodplain forest - Approximately 15,800 ha. (80% of site) is covered in inundation dependent forest and woodland made up of river red gum forest (8326 ha.), river red gum woodland (4757 ha.) and black box woodland (2694 ha.) - River red gum forest is the dominant vegetation community, comprising 65% of the site	The extent of forested wetland vegetation communities at the time of listing is indicated by water regime classes: - 8326 hectares of river red gum forest - 4757 hectares of river red gum woodland; and - 2694 hectares of black box Woodland. In addition, there are benchmarks for tree condition with 93% of the river red gum forest and woodland in moderate or better condition in 2003.	Extent of floodplain forest and woodland vegetation to be no less than: - 7500 hectares of river red gum forest - 4280 hectares of river red gum woodland - 2400 hectares of black box woodland River red gum condition to be "moderate" or better for at least 80% of the forest.	Insufficient information on the extent and condition of floodplain forest and variability in these measures was available. 10 percent change has been selected informed by local knowledge and expert opinion of the steering committee. Forest structure and structural diversity are also important characteristics of river red gum forests in terms of habitat value however in the absence of information, no LAC was developed.	Low
Vegetation – floodplain marshes - Seventy-five species of native aquatic/wetland plant species recorded in floodplain marshes - Species richness and cover of plants in floodplain marshes is highly variable temporally and spatially	The extent of floodplain marshes at the time of listing is unknown. Wetland EVC mapping at the time of the 2011 ECD development indicates 310 hectares of spike-sedge wetland and 140 hectares of tall marsh wetland.	Extent of spike sedge wetland to be no less than 270 hectares. Extent of tall marsh wetland to be no less than 125 hectares.	As with the extent of floodplain forest, there is no indication of variability, but extent of inundation and community composition will vary considerably over wetting and drying cycles. As such an objective, statistically based LAC cannot be determined and a figure of 10 percent change has been selected informed by local	Moderate

Critical components, processes or services	Baseline condition and range of natural variation where known	LAC	Basis of LAC	Level of confidence
			knowledge and expert opinion of the steering committee.	
Vegetation – threatened species - The site is important for the threatened swamp wallaby-grass and winged peppercress	The site supports nationally threatened swamp wallaby-grass and winged peppercress. There was no indication of the extent or location swamp wallaby-grass at the time of listing. Winged peppercress is known from a single location near Reedy Lagoon.	Presence of swamp wallaby-grass in permanent and intermittent wetlands within the site. Presence of winged peppercress near Reedy Lagoon when waterlogging occurs.	Based on presence only within Gunbower Forest for swamp wallaby-grass and presence at the known location near Reedy Lagoon for winged peppercress.	Low
Native fish (species richness) - Data deficient - Twelve native species of fish have been recorded from within the site - Results from surveys indicate that abundance varies considerably and that invasive species generally comprise 16-36% of the total abundance and up to 9% of biomass of large-bodied fish	Data for native fish are limited from the Ramsar site. A total of 12 native fish species have been recorded in the site but there is no indication of variability.	Presence of the following species in no less than two in five annual surveys: - Australian smelt (*Retropinna semoni*) - Carp gudgeons (*Hypseleotris spp.*) - Dwarf flat-headed gudgeon (*Philypnodon macrostomus*) - Flat-headed gudgeon (*Philypnodon grandiceps*) - Fly-specked hardyhead (*Craterocephalus stercusmuscarum*) - Murray-Darling rainbowfish (*Melanotaenia fluviatilis*).	Insufficient quantitative data was available to develop a quantitative LAC. There is a lack of underlying knowledge of variability in fish species richness and the relationship with ecological character. As such the LAC has been developed based on expert opinion with respect to fish that are characteristic of the site and would be expected to be present.	Low
Native fish (threatened species)	Two threatened native species of fish are known from the site. Population size, dynamics and	Presence of Murray cod and silver perch in Gunbower Creek	Insufficient quantitative data was available to develop a quantitative LAC. LAC was	Low

Critical components, processes or services	Baseline condition and range of natural variation where known	LAC	Basis of LAC	Level of confidence
	distribution are not fully understood, however all fish surveys to date have recorded both Murray cod and silver perch at the site.	in three out of five of annual surveys.	developed based on previous records of threatened fish species present.	
Wetland birds (abundance) - Sixty-six species of wetland bird have been recorded from the site. - Maximum counts recorded during the 1974 floods comprise approximately 6000 individuals - A large proportion of the wetland birds recorded within the site have been observed breeding	A total of 66 species of wetland bird have been recorded from the site. However, there is no indication of the number of species that regularly utilise the habitats within the site. There is evidence that the site periodically supports hundreds of colonial nesting waterbirds during significant flood events.	Successful breeding (80 percent of chicks fledged) of colonial nesting waterbirds during flood events.	Based on successful breeding of colonial nesting waterbirds.	Low
Wetland birds (threatened species) - The species list includes nine species listed under international migratory agreements and the endangered Australasian bittern	The site supports the threatened Australasian bittern but records are scarce and there are no population estimates.	Presence of the Australasian bittern when tall marsh is inundated.	Insufficient data from the Ramsar site to set a quantitative LAC. LAC based on presence only.	Medium
Diversity of wetland types - The site supports part of the second largest remaining river red gum forest and	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in	See LAC for hydrology and vegetation	No direct LAC has been developed and instead the critical service is assessed indirectly through changes in the average return interval and	N/A

Critical components, processes or services	Baseline condition and range of natural variation where known	LAC	Basis of LAC	Level of confidence
provides a mosaic of vegetated wetland habitats	extent and condition of wetland condition.		duration of specific flow events, extent and condition of river red gum forests and woodlands and extent of floodplain marshes.	
Physical habitat - The site provides habitat for feeding and breeding of wetland birds	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland vegetation. In addition, wetland bird abundance can be used as a surrogate measure.	See LAC for hydrology, vegetation and wetland birds	No direct LAC has been developed and instead the critical service is assessed indirectly through changes in the average return interval and duration of specific flow events, extent and condition of river red gum forests and woodlands, extent of floodplain marshes and abundance of wetland birds.	N/A
Threatened species - The Ramsar site supports at least five species listed under the EPBC Act and/or the IUCN Red List	This critical service is indicated by the presence of threatened species at the site.	See LAC for wetland birds, fish and vegetation	No direct LAC has been developed and instead the critical service is assessed through presence of threatened species.	N/A
Ecological connectivity - The site provides important migratory routes between riverine, wetland and floodplain habitats for fish spawning and recruitment	The site maintains connectivity between the river and floodplain wetlands and channels for fish spawning and recruitment. This service is maintained by hydrology and can also be indicated by the species richness and abundance of native fish.	See LAC for hydrology and native fish	No direct LAC has been developed and instead the critical service is assessed indirectly through changes in hydrology and native fish populations.	N/A
Carbon cycling - As part of a major floodplain system, the site is important	This service is provided by the uptake of carbon by vegetation, the deposition of organic matter	See LAC for hydrology and vegetation	No direct LAC has been developed and instead the critical service will be assessed	N/A

Critical components, processes or services	Baseline condition and range of natural variation where known	LAC	Basis of LAC	Level of confidence
for the cycling of nutrients, particularly carbon both on the floodplain and as a source of organic carbon to receiving waterways	(coarse woody debris and litter) on the floodplain and the mobilisation of particulate and dissolved organic carbon to receiving river systems with flood return waters. This service is maintained by vegetation extent, forest structure and hydrology.		indirectly through changes in hydrology and floodplain forest extent.	