



Victorian Murray Floodplain Restoration Project

Desktop Groundwater Assessment - Gunbower National Park

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Lower Murray Urban and Rural Water Corporation



Victorian Murray Floodplain Restoration Project

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Executive Summary

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.

This report documents a desktop assessment of groundwater considerations associated with Gunbower National Park Floodplain Restoration Project to inform the referral documentation being prepared under the *Environment Effects Act 1978* (EE Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Gunbower National Park Floodplain Restoration Project area is underlain by groundwater typically between 5 - 10 m depth below ground surface. Depth to groundwater is less than 5 m in the southern portion of the Upper Gunbower project area, though. Groundwater salinity is relatively high, ranging between 7,000 to 35,000 mg/L. There are two surficial groundwater aquifers relevant to the project present across the project area. These aquifers are in hydraulic connection to deeper aquifers that also underly the project area.

A number of Ecological Vegetation Classes (EVCs) are mapped across the project area (R8 2020), most of which would be expected to contain species that are at least partially reliant on groundwater. As discussed in the Flora and Fauna Assessment prepared for the project (R8, 2020), it is expected that the project would generally have a positive impact to vegetation within the floodplain. That assessment and the EPBC Act and EE Act referral documentation provides further discussion of the benefits likely to be experienced on the floodplain as a result of managed inundation events.

Construction of the project may require groundwater dewatering and subsequent disposal of pumped groundwater. If this is the case, then minor impacts on adjacent vegetation and ecosystems are possible. These impacts can be mitigated by planning construction to minimise dewatering and to provide watering for any ecosystems that may experience an extended period of lowered groundwater levels.

Operation of the proposed works will result in elevated groundwater levels, wetting of soils and potentially mobilised salt from the unsaturated soil store. The cumulative impact of managed inundation of the Gunbower National Park as part of the project has the potential to raise groundwater levels under the inundated areas and surrounding land such that near-surface salinisation and waterlogging may become a risk to ecosystems in restricted areas. However, given the current groundwater level across the project area and the significant impact of forest evapotranspiration to groundwater levels under the forest, this risk is considered low across the majority of the project area. The exception being, in the southern half of the Upper Gunbower area where existing depth to groundwater levels are expected to be less than five metres, this risk may be greater than a low risk, especially for the land bordering the forest to the south in the Upper Gunbower inundation area, which would be expected to also have shallower groundwater levels.

Monitoring of development of potential groundwater mounds under inundated areas should be undertaken, focused on the land bordering the forest to the south in the Upper Gunbower inundation area, and adaptive management should be implemented to mitigate impacts, if identified.

There is also a minor risk of salt wash off to the Murray River from flood water recession. The magnitude of this has not been determined, however the relatively low salt store in the soil profile across the inundation area suggests this may be low.

Salinity discharges and any associated changes or impacts in the Murray River as a result of planned inundation of the Gunbower National Park floodplain would be considered and assessed on a cumulative basis by the Murray Darling Basin Authority (MDBA) through the protocols of the Basin Salinity Management 2030 Strategy (BSM2030). These protocols are yet to be finalised for the VMFRP projects. Adaptive management approaches will be used as required to limit negative effects, including assessment of the response to flooding and adjustments to the flooding level and duration.

The other beneficial uses to be protected are focussed on groundwater support of the environment and cultural values, and these are not expected to be adversely affected by operation of this restoration project.

Site specific working Draft Environmental Watering Management Plan's and Operating Plans have been developed for all sites. Further work on these draft documents will be completed by the proponent in consultation with DELWP, Parks Victoria, the North Central Catchment Management Authority and other relevant agencies. The finalised plans will document the avoidance and mitigation measures to be implemented for the project during operations (including the planned timing of inundation events), as well as responsibilities for implementation.

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 Groundwater 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 Gunbower National Park Floodplain Restoration Project

The Gunbower National Park Floodplain Restoration Project is located on the mid-Murray floodplain in Northern Victoria. The project is designed to facilitate managed inundation to address the hydrological deficit in the inundation regime caused by river regulation, particularly the reduced frequency and duration of floods. The managed inundation aims to deliver water across approximately 704 ha of the Gunbower National Park floodplain habitats at a similar extent to that of flows between 30,000 and 50,000 ML/d flow in the Murray River (as measured at Torrumbarry Weir). 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 degree of inundation as a higher flow natural event.

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 in to 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 Project 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 are shown in Figure 1 below and include:

- Upper Gunbower Forest (up to between 84.8 and 85.0 mAHD) - inundation of approximately 247 ha of floodplain forest and wetlands containing:
 - Upper Camerons Creek;
 - Camerons Creek Lagoons 1, 2, 3 and 4 (permanent wetlands);
 - Black Charlie Lagoon (permanent wetland); and
 - Baggots Swamp (semi-permanent wetland).
- Middle Gunbower Forest (upstream of Deep Creek, 83.7 to 84.4 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); and
- Emu Hole Lagoon (semi-permanent wetland).
- Middle Gunbower Forest (downstream of Deep Creek, up to between 83.0 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; and
 - Spur Creek.

Design of the type and location of infrastructure is currently being refined as part of the ongoing design process. Findings from on-site assessments, particularly ecology fieldwork and cultural heritage complex assessment (undertaken for the Cultural Heritage Management Plan) have and will continue to be progressively fed into the design, with modifications made to avoid and minimise impacts.

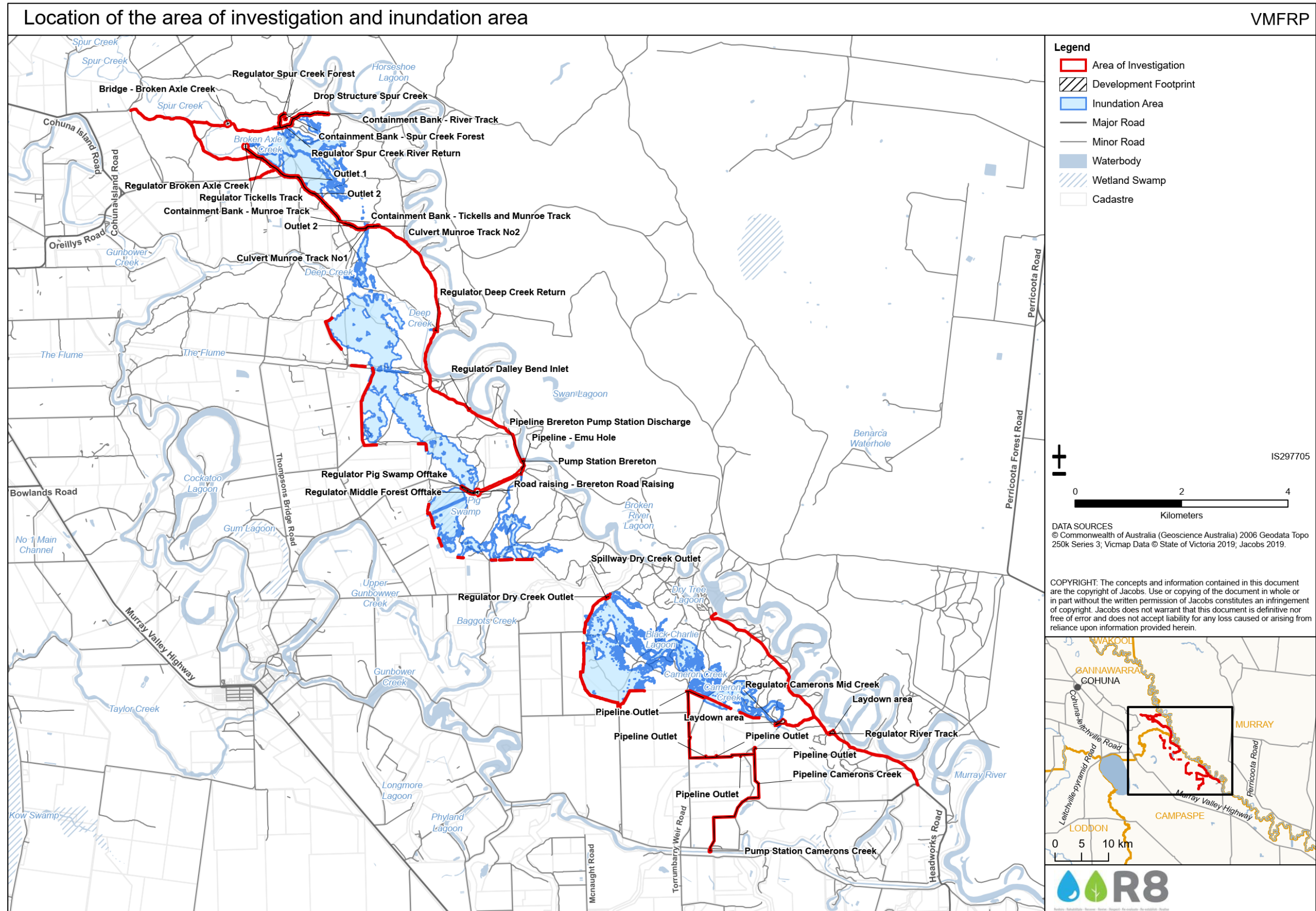


Figure 1: Figure showing inundation extent and location of construction elements for the project (R8 mapping product)

1.3 Project area

This assessment covers the hydrogeology of sections of the south-eastern end of the Gunbower National Park floodplains located on the mid-Murray floodplain of northern Victoria, around 30 km north-west of Echuca, Victoria. This area is part of the Gunbower-Koondrook-Perricoota Forest icon site under 'The Living Murray Initiative'.

The following terms are used to describe the project area:

- Development footprint - this is the area that the project infrastructure will occupy, based on the current design, and includes laydown areas to be used during construction. This area does not currently include power poles, stays or cables, containment banks or tracks used for access during construction and operation as these are still being finalised at the time of this investigation.
- Construction footprint - this includes the project infrastructure (included in development footprint) as well as the land required to construct the infrastructure. This includes access tracks.
- Area of investigation – this includes the development footprint, as well as a buffer around the construction footprint and access tracks. This buffer allows for possible design changes to avoid significant assets and includes potential levee works locations – levees are currently subject to further risk assessment to determine the need for works.
- Inundation area - area of land subject to flooding during managed events, up to a specific design water level. The inundation area comprises a system of natural drainage paths, creeks, permanent and temporary wetlands, Black Box and Grey Box woodlands and River Red Gum forest across Upper and Middle Gunbower Forest.

The environmental water delivery infrastructure included in the development and construction footprints are based on the current level of design for the project. Refinement of the design of the infrastructure will be undertaken as part of the project's ongoing design process, therefore the construction element of the project included in this report is indicative but is provided as a basis of assessing the potential impacts of the project during construction.

The focus of this assessment is the hydrogeology on the Victorian side of the Murray River, whilst recognising that the aquifers in question have some limited hydraulic connection to the NSW side.

1.4 Purpose of this report

This report documents a desktop assessment of groundwater considerations associated with Gunbower Forests Floodplain Restoration Project and will feed into the referral documentation being prepared under the *Environment Effects Act 1978* (EE Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.5 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;
- Detailed groundwater investigation and monitoring at the precise sites for the proposed works and area of inundation are not available and so general understanding of the hydrogeology and sites has been used. It is possible that future detailed studies may revise the findings presented here, once in possession of site-specific information.

- 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.

2. Key legislation

The following are the key legislation for this groundwater assessment. Other legislation may also apply:

- *Water Act 1989* – sets requirements for groundwater bore approval and licencing and regulates groundwater take and use from aquifers in Victoria. Groundwater users are regulated by this act and impacts on users and the environmental are also controlled. This act will control groundwater monitoring works undertaken by the project.
- *Catchment and Land Protection Act 1994* – deals with diffuse source effects in catchment, such as recharge and water quality changes.
- *Water Act 2007 (Cwth)* – deals with the management of salinity in the Murray River and sets the requires for the Basin Plan, which includes groundwater management and sustainable diversion limits for aquifers (SDL).
- *Environment Protection Act 1970* – specifically the State Environment Protection Policy (Waters of Victoria) (2018) which regulates the protection of surface water where groundwater may interact with surface water, including activities like the disposal of groundwater into the environment from dewatering activities.

In addition to the relevant acts, regulations under these acts are also important. Specifically, for groundwater, the protocols and agreements made under the Basin Salinity Management Plan 2030 (BSM2030) are important as they define the conditions and controls relating to salt discharge to the Murray River and anabranches.

Whilst a small number of project activities are located within NSW (notably the pump station inlet to the Murray River), the potential groundwater impacts and effected groundwater receptors are within Victoria, and as such, NSW legislation and regulations are not considered in this assessment.

3. Existing conditions

3.1 Regional hydrogeology

The Gunbower National Park project areas sit in the Riverine Plains area of the Murray Geological Basin. This basin was infilled with sediments during the Tertiary and Quaternary period. The regional hydrogeology is laid out in the Deniliquin 1:250,000 scale hydrogeological map (Williams and Wooley, 1992). Figure 2 shows a generalised hydrogeological cross section for this area, identifying the main units and their relationships. For this assessment, the focus is on the groundwater environment and current conditions off the shallow (upper) aquifer systems.

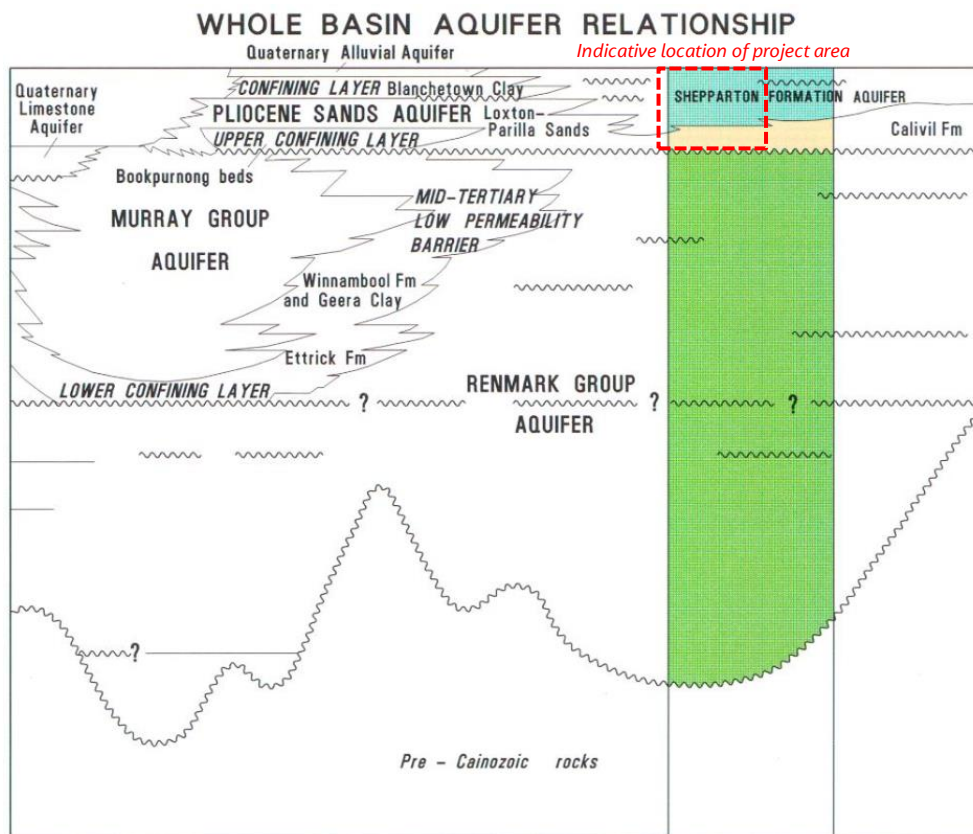


Figure 2: Regional hydrogeological units and their relationship within the Gunbower National Park project area (Indicative project area marked - Source: Deniliquin 1:250,000 Hydrogeological Map)

The project area sits between Kerrang and Echuca in a section of the Murray Basin in which the thick Shepparton Formation overlays the Calivil Formation, with the Renmark Group aquifer underlying both. Bedrock underlies these stratigraphic units at a depth of around 180m across the project area. Figure 3 presents an indicative cross-section of these units in the project area.

The project is to the east of the extent of the Blanchetown Clay aquitard unit, which act as a confining layer above regional aquifers elsewhere in the region. The Loxton-Parilla Sand aquifer is present in western parts of the Gunbower National Park but is absent in the project area.

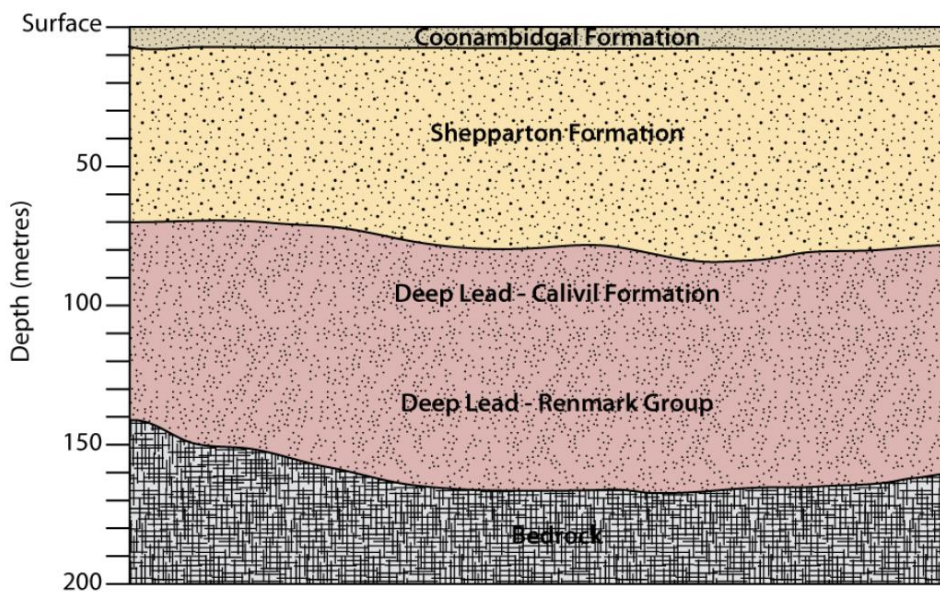


Figure 3: Indicative cross-section of hydrogeological units in the project area (Hale and Butcher, 2011)

3.2 Project area hydrogeology

The relevant aquifer sequence at the project area is summarised by the following hydrogeomorphic units (from the surface downward; numbers refer to Aquifers as defined in the Victorian Aquifer Framework (DELWP, 2020a)):

- Coonambidgal Formation (100): Quaternary alluvial sedimentary deposits, where saturated, consisting of clay, sands and sandy clays that are part of the contemporary floodplain and the recent geological past. The upper layer of the formation is predominantly finer grained and can act to retard vertical infiltration. The unit is around 8 m thick across the project area.
- Shepparton Formation aquifer (102): A thick sequence of Upper Tertiary to Quaternary aged, generally fine grained sediments, with occasional shoestring sands throughout. Sometimes split into the Upper and Lower Shepparton Formation, the Upper part is thinner, around 25 m thick in the project area, and contains small and discrete sand lenses thought to be limited in connection. The Lower Shepparton Formation is thicker, between 40 and 110 m thick, and sand is generally absent. This formation is a regional aquifer and is typically saline or brackish in water salinity.

The Calivil and Renmark Group units are thought to interact with the Shepparton Formation through providing an upward hydraulic gradient to the shallower aquifer under the forest (refer Section 3.3 below), however the units are not expected to interact with the water delivered under this project in the short-term.

The local surface geology is shown in Figure 3 below. The Quaternary aquifer (Coonambidgal Formation) is present across all of the project area, thinning further south of the Gunbower Forest area. The Shepparton Formation outcrops at the surface to the west of the project area, past the township of Gunbower (FedUni, 2015).

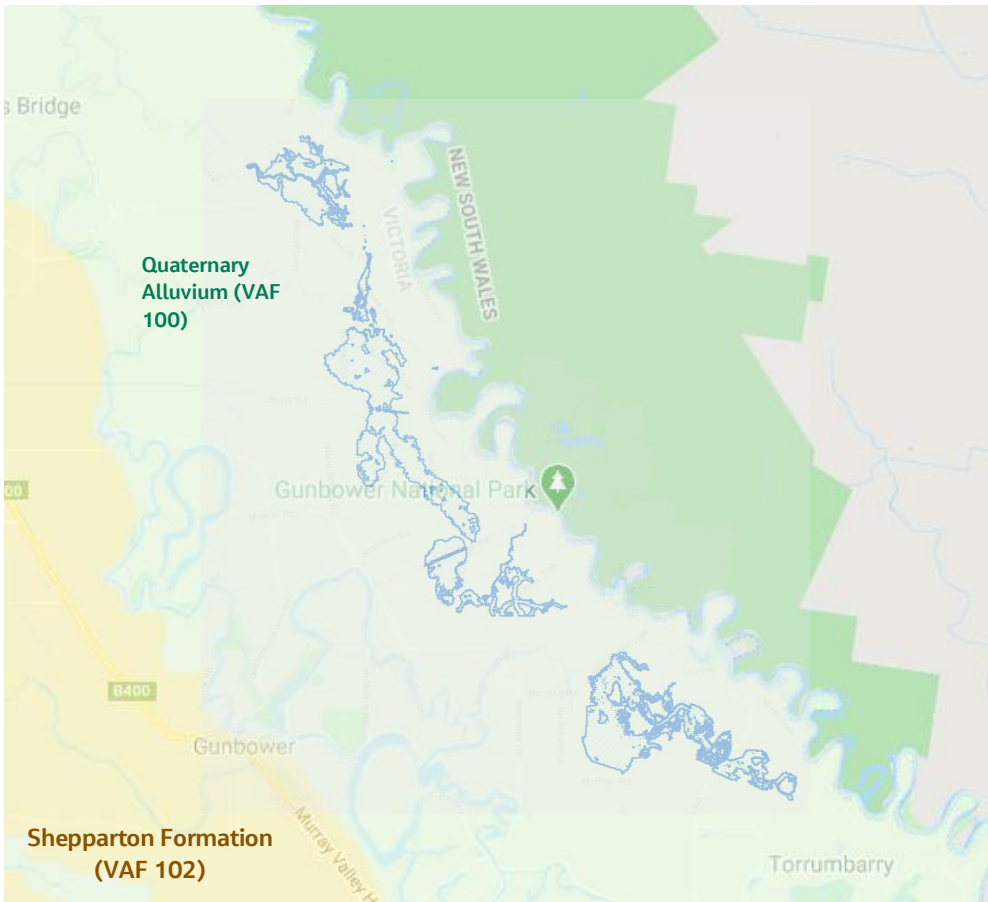


Figure 3: Surface geology across the project area with the proposed inundation area overlaid (Source: FedUni, 2015).

3.3 Groundwater Flow and Levels

Statewide mapping of groundwater levels indicates depth to groundwater is 5 – 10 m below the surface across most of the project area, except for the southern side of the Upper Gunbower Forest project area which is expected to have groundwater levels of < 5m below ground level (Figure 4.) The mapping also clearly demonstrates the impact of the transpiration by forests on lowering groundwater levels, as well as the impact of widespread irrigation (on the plains to the west and south of the forest) to keep groundwater levels elevated. Outside of the forest, groundwater levels are mapped as less than 5 m below ground level, indicating a hydraulic gradient into the forest. This is supported by groundwater level monitoring data from bores just south and west of the Gunbower Forest, which show groundwater levels to be consistently shallower than 5 m below ground level (FedUni 2020).

Hydrographs for selected groundwater bores close to the project area have been included in Figure 5 similarly showing the significantly shallow groundwater elevations away from the forest (4.5-5.5 m above under the forest; FedUni 2020). There is also thought to be a relatively significant groundwater gradient down the forest (south-east to north-west; SKM 2013).

Groundwater levels across the forest are known to respond to flood events and are thought to be still recovering from the 2010 flood (SKM 2013). Current groundwater levels are significantly lower (3-5 m) than those of the early 1990s when high groundwater levels were observed across much of Victoria prior to the Millennium drought (SKM 2013). There is also thought to be an upwards gradient from the Calivil Formation to the overlying Shepparton Formation under the Gunbower Forest driven by the difference in levels that results from transpiration under the forest and recharge of the deeper system outside of the forest. This gradient is thought to be swapped in the irrigated areas (SKM 2013). That is, groundwater flow is downward outside the forest.

It has previously been estimated that approximately 165,000 ML/year of Murray River water is lost into the watertable under the forest from seepage (Jacobs, 2013). Given the groundwater gradient into the Gunbower Forest from the plains to the south-west, this extra water is likely to be predominantly consumed by evapotranspiration under the forest rather than be lost to regional aquifers. The lack of groundwater level monitoring data within the forest, however, makes identifying the exact relationship between the pressure and watertable surface in the aquifers in the floodplain and the Murray River difficult.

Regionally, groundwater flow is to the north-west, parallel to the general course of the Murray River in this area. In some cases, there will be localised flow toward the Murray River, depending on river level. Local flow cells are possible that may change the local flow direction from the general pattern described above.

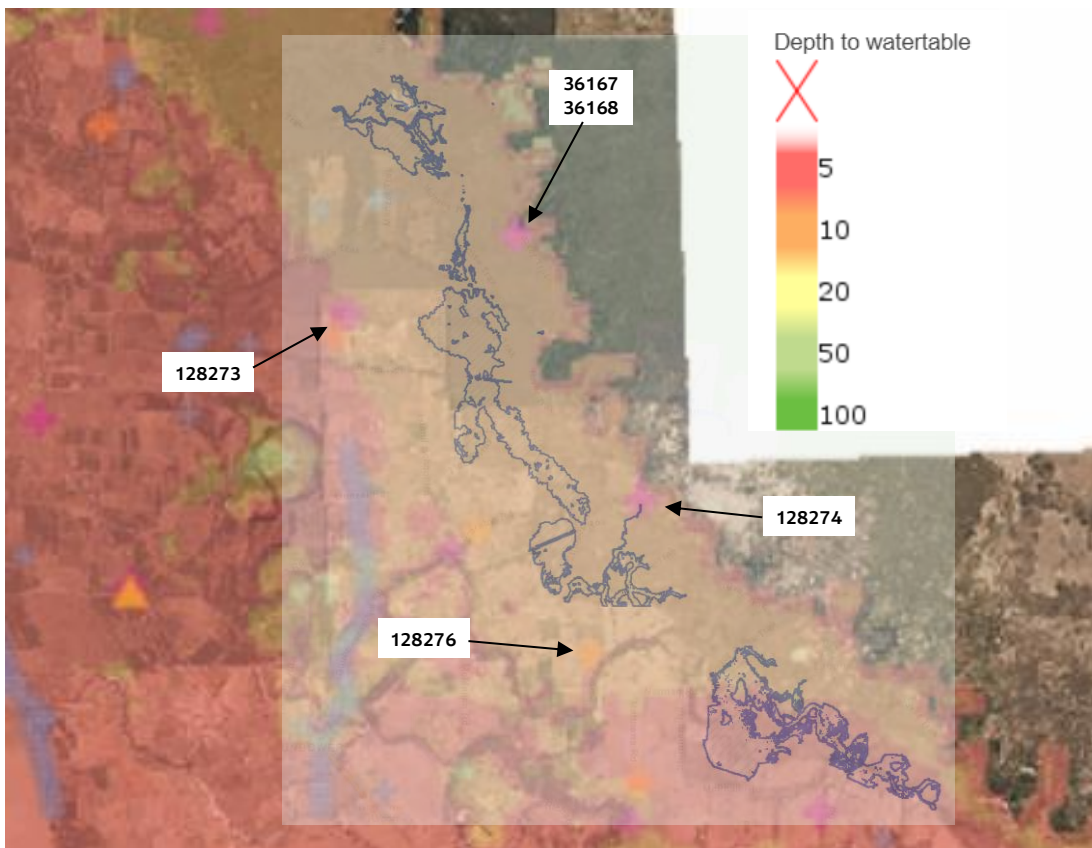


Figure 4: Interpreted depth to groundwater from statewide mapping with project inundation area overlain (FedUni, 2020).

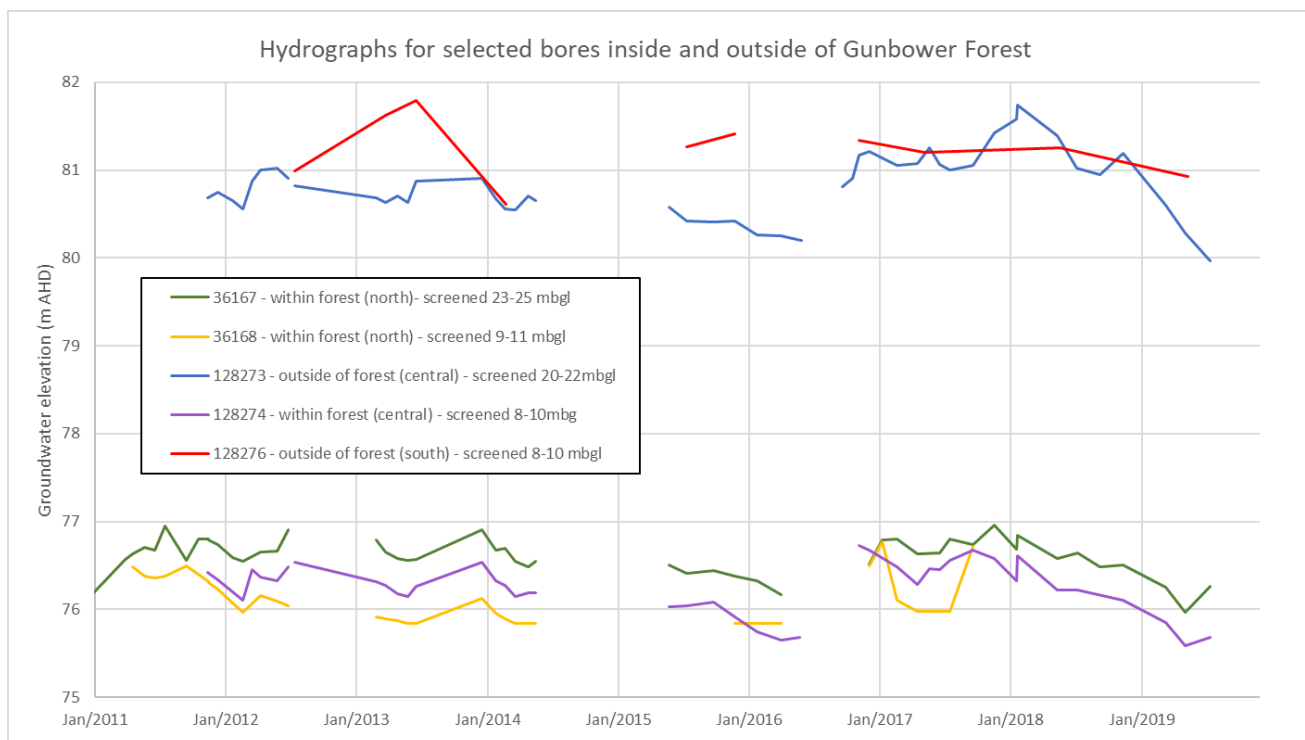


Figure 5: Groundwater levels in selected bores near the project area – refer to Figure 4 for locations (DELWP, 2020).

3.4 Groundwater and soil salinity

There is limited information available on groundwater and soil salinity in the project area, consisting of minor bore data and regional scale mapping products.

The very limited available salinity data from groundwater bores in the Gunbower Forest (two bores on one site in the south of Middle Gunbower Forest, upstream Deep Creek) indicates the high variability of watertable salinity, with results ranging from 3,200 to 30,400 $\mu\text{S}/\text{cm}$, although typically over 10,000 $\mu\text{S}/\text{cm}$ (FedUni 2020).

State-wide mapping indicates groundwater salinity in the project area is expected to range from about 7,000 to 13,000 mg/L across Middle Gunbower (upstream Deep Creek) and the eastern half of the Upper Gunbower inundation extent. Elsewhere in the Gunbower National Park, groundwater salinity is expected to range between 13,000 to 35,000 mg/L (FedUni, 2015). Figure 6 presents this spread of salinity values. This data indicates groundwater salinity in the watertable aquifer across the project area is relatively high, although may be fresher close to the surface of the watertable.

Soil salinity has been mapped over the project area and for the riverine corridor in the area by airborne electromagnetic surveys (AEM). The project area falls in the Barr Creek to Gunbower (South) AEM survey area (Cullen et al. 2008).

Figure 7 shows the interpreted salt loads in the area from the AEM survey. It can be seen from this figure that soil salinity in the unsaturated zone in the project area (ground surface to the interpreted watertable) has been mapped as generally low (most of the project area is below 100 t/ha/m), with small areas of moderate soil salinity (100 - 200 t/ha/m) noted in the centre of Middle Gunbower (upstream Deep Creek) inundation extent. This is in contrast to the mapped groundwater salinity, where some areas of higher groundwater salinity have lower soil salinity, and vice versa. This inconsistency highlights the nature of these mapping products as estimates only.

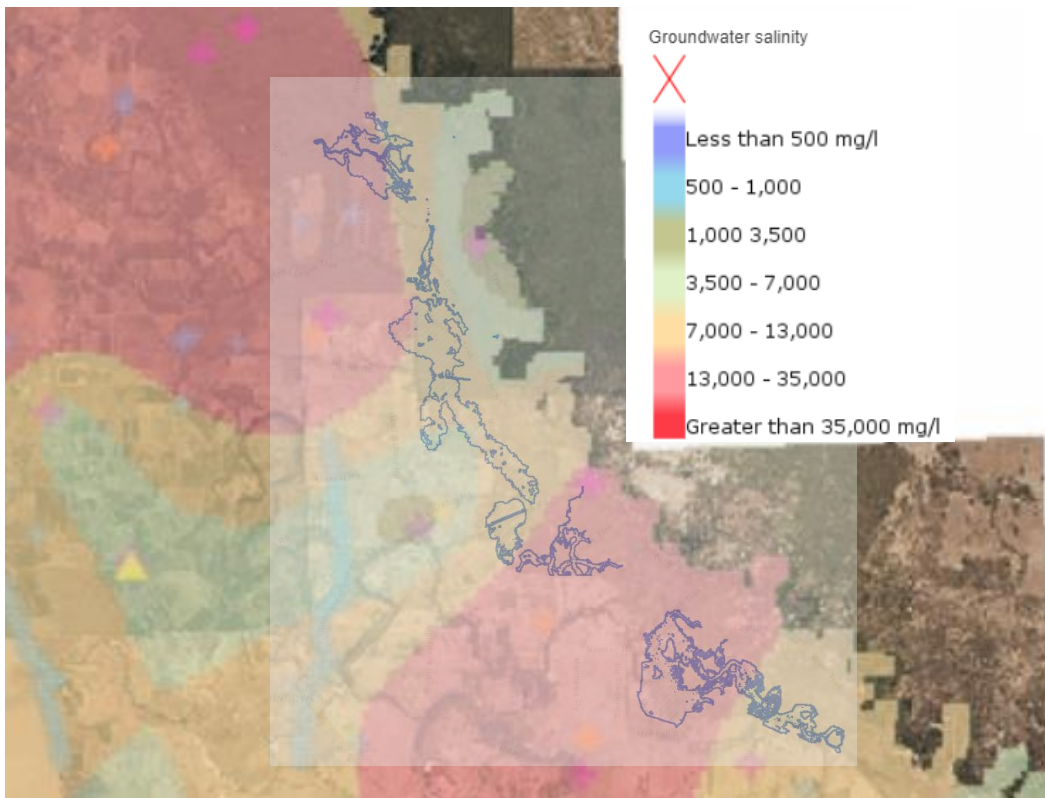


Figure 6: Interpreted groundwater salinity for the project area with project inundation area overlain (Source: FedUni, 2020)

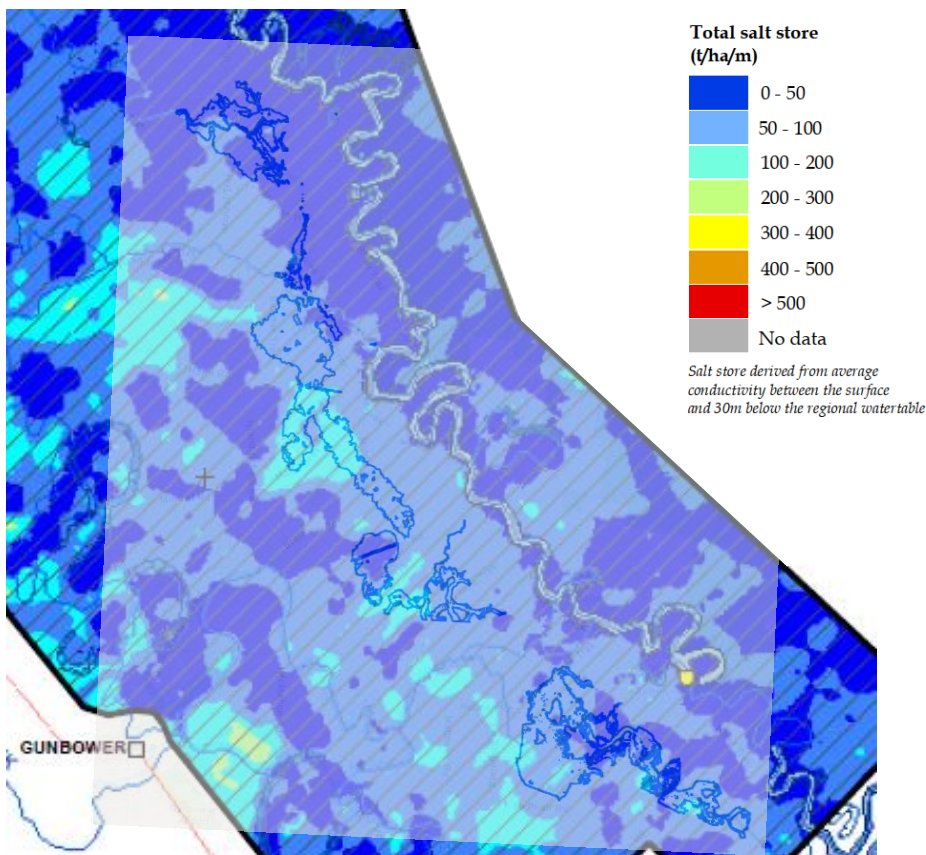


Figure 7: Interpreted Salt Store in the unsaturated zone for the project area with project inundation area overlain (Cullen et al. 2008)

3.5 Beneficial uses of groundwater

The quality of groundwater in Victoria is protected under the 2018 State Environment Protection Policy (SEPP) (Waters) (SEPP Waters), issued under the Environment Protection Act 1970 and administered by EPA Victoria. The SEPP (Waters) defines a range of protected beneficial uses for defined segments of the groundwater environment, which are based on groundwater salinity. Beneficial uses of groundwater are considered to be precluded when relevant groundwater quality thresholds set out in the SEPP (Waters) for those beneficial uses have been exceeded.

The groundwater at the project area falls within segments E and F of the SEPP (Waters). In accordance, the groundwater beneficial uses presented listed below are protected in the project area. Water quality standards are described for most of these beneficial uses and are provided in the SEPP (Waters).

- Water dependent ecosystems and species;
- Agriculture and irrigation (stock watering);
- Water-based recreation (primary contact recreation);
- Traditional Owner cultural values;
- Cultural and spiritual values;
- Buildings and structures;
- Geothermal properties.

3.5.1 Groundwater use

A search of the area was conducted for this project using an online groundwater database (VVG, FedUni, 2015). The search (last accessed 12 August 2020) indicates there are no licenced groundwater users within 1 km of the project inundation area. To confirm this a search of the WMIS on-line data base was also conducted which confirmed that the nearest licenced bore is 1.3 km from the south eastern extent of the inundation area, but this bore is screened between 119 and 135 metres below the surface and so is in a separate aquifer system from the shallow aquifer which is potentially relevant to this project. The closest licenced bore that is screened in the shallow aquifer system is a bore located approximately 5 km from the south east extent of the inundation area. This bore is considered to be too distant from the inundation to be affected.

3.5.2 Ecological Vegetation Classes

Groundwater plays an important role in sustaining aquatic and terrestrial ecosystems. A number of Ecological Vegetation Classes (EVCs) are mapped across the project area as identified in Figure 8 to Figure 10, some of which are thought to contain species are at least partially reliant on groundwater (R8 2020).

As identified in the Flora and Fauna Assessment prepared for the project (R8, 2020), of the nine EVCs previously modelled as occurring within the project's managed inundation area, seven have been identified during the field assessment (2019). These EVCs are wetland, flood-dependent or flood-tolerant vegetation communities and are likely to benefit from the proposed watering regime.

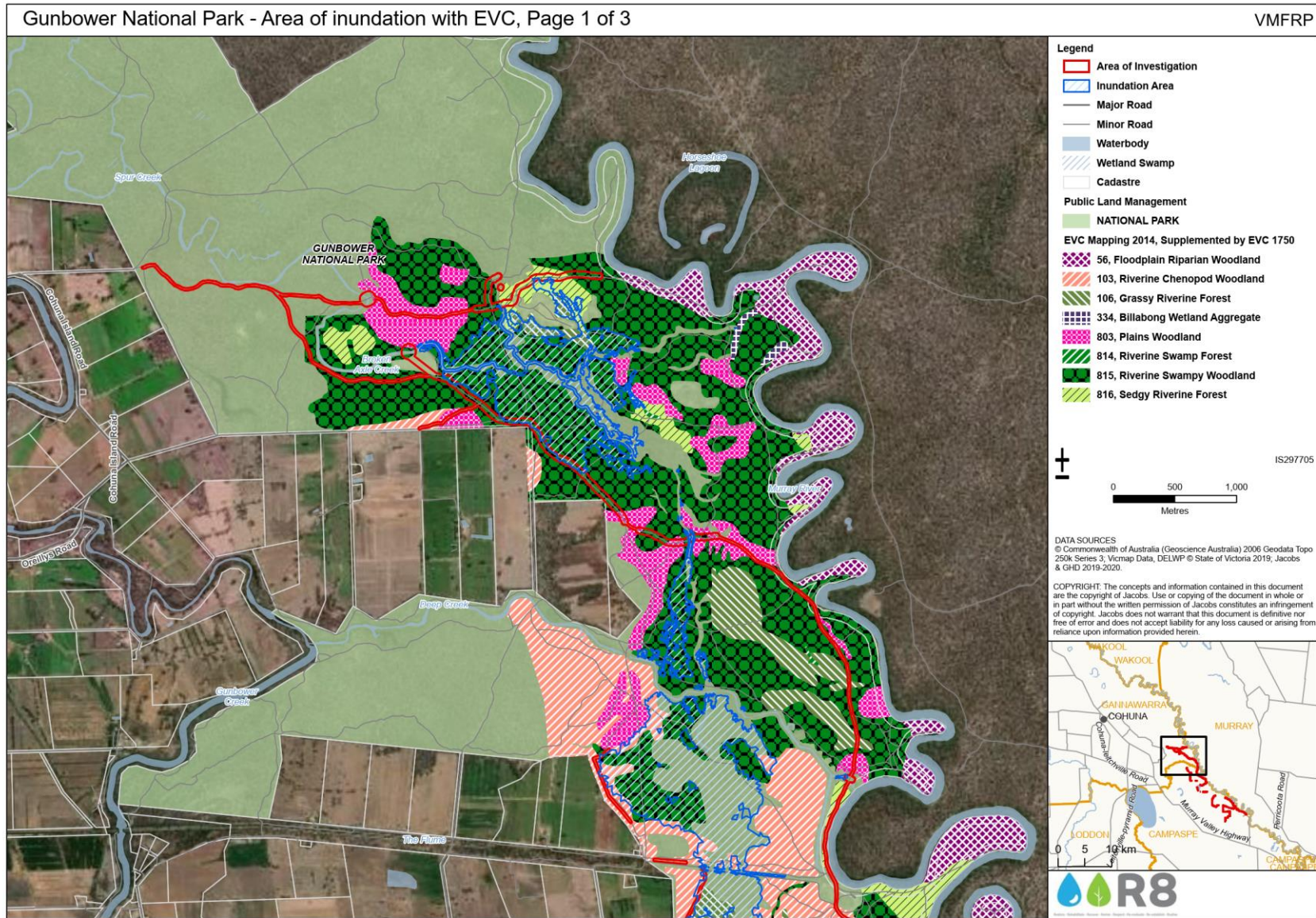


Figure 8: Ecological Vegetation Classes present within the northern portion of the Middle Gunbower project area, as mapped by R8 (R8 mapping product, after R8 2020)

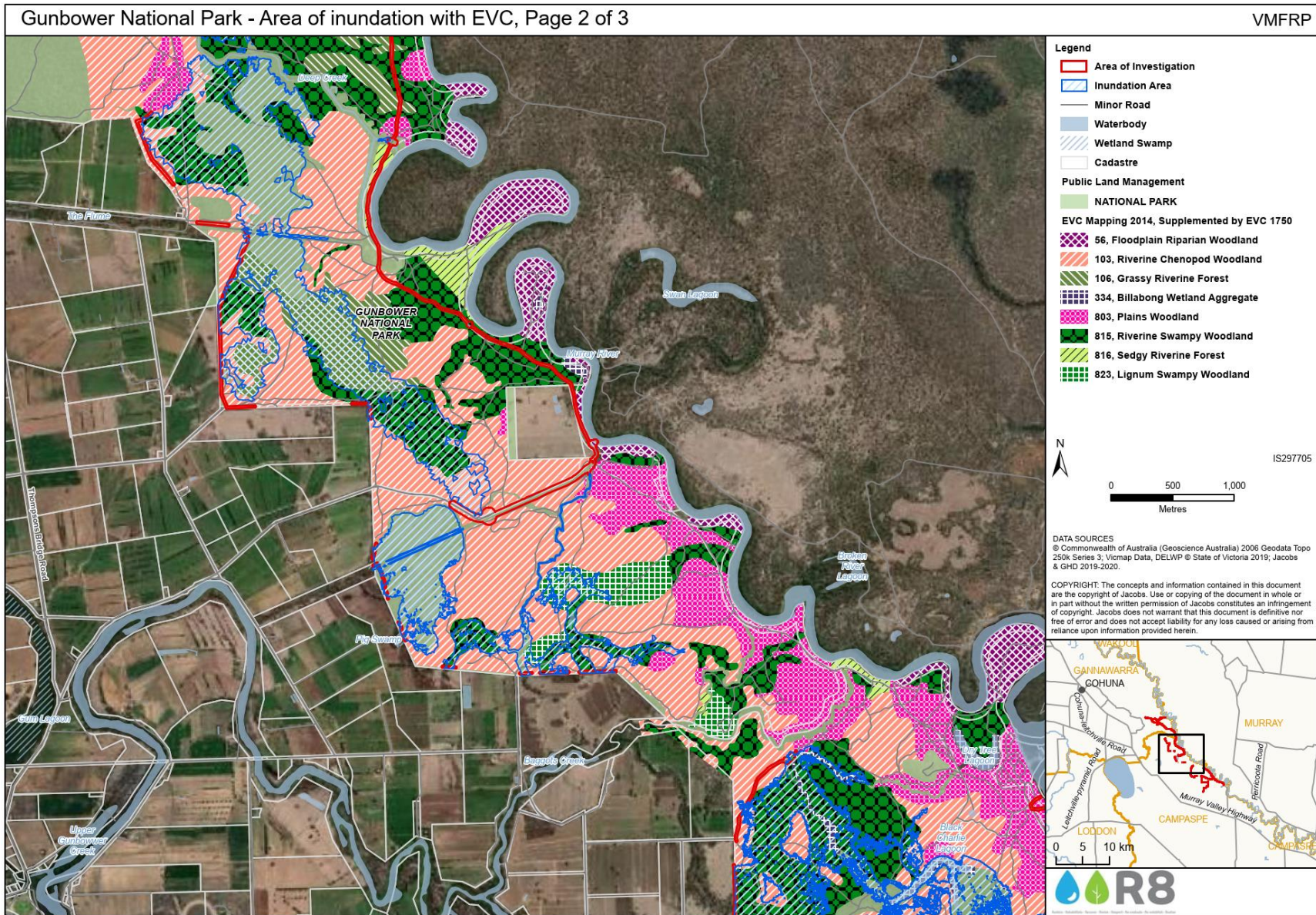


Figure 9: Ecological Vegetation Classes present within the central portion of the Middle Gunbower project area, as mapped by R8 (R8 mapping product, after R8 2020)

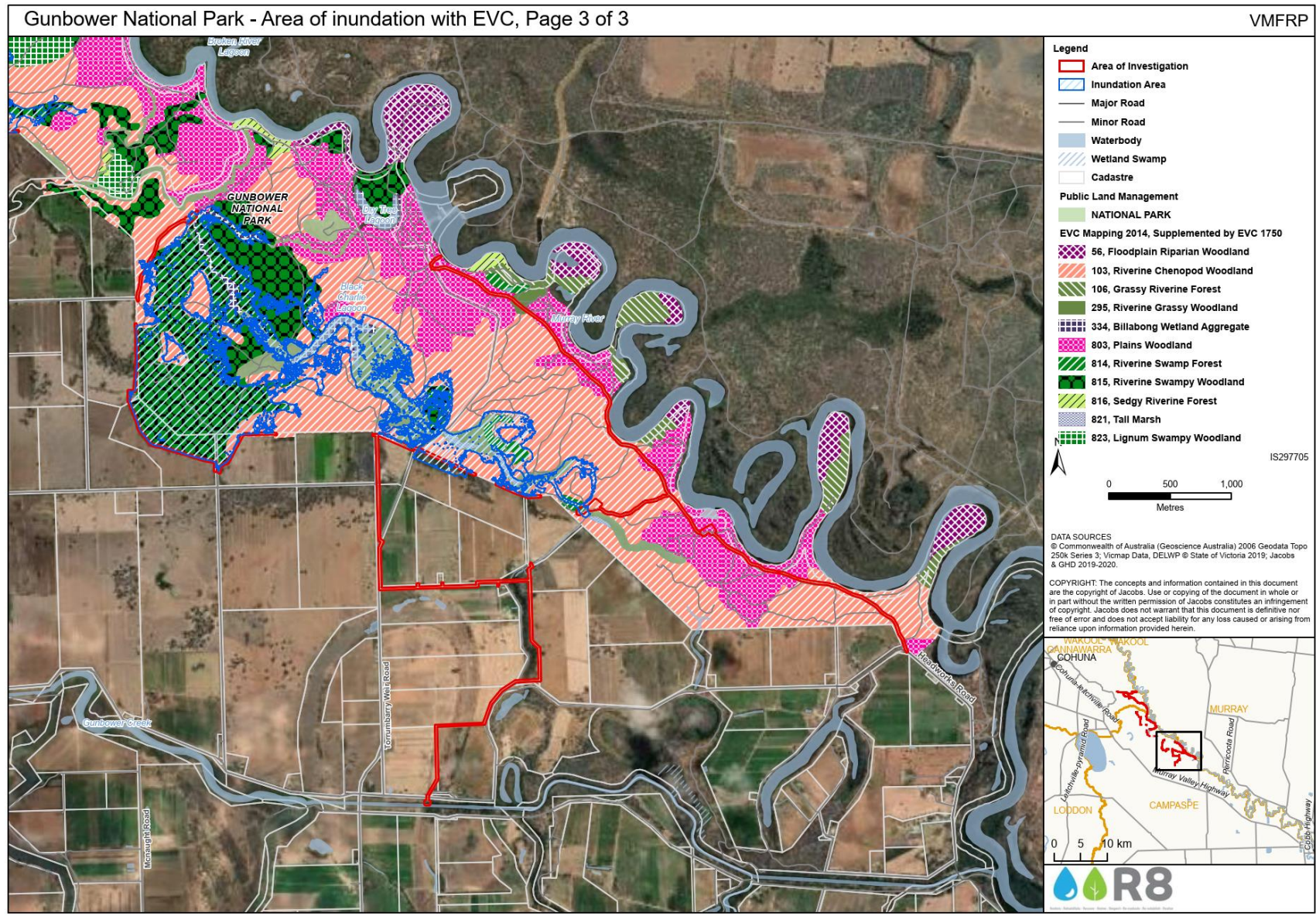


Figure 10: Ecological Vegetation Classes present within the Upper Gunbower project area, as mapped by R8 (R8 mapping product, after R8 2020)

4. Potential effects

The potential groundwater effects of the proposed construction and operation of the works are described below.

- Temporary and limited drawdown of groundwater levels during construction, specifically this may be required for the regulators and inflow structure, as these may need to be dug into the subsurface below groundwater level. Typically banks and surface earthworks will not intersect groundwater and thus are not expected to have a groundwater effect during construction. Given the generally deep groundwater level across most of the northern parts of the project area, any interaction is likely to be limited in extent and duration. Temporary removal of groundwater may be required for safe access to excavations associated with the deeper structures, particularly in the south of the Upper Forest area where groundwater levels are expected to be less than 5 m below the surface.
- Increased groundwater level, as a result of flood recharge, across the inundation area during a managed inundation event. While there is risk of a cumulative effect on groundwater levels over time from a change in inundation regime (i.e. increase in frequency and duration of inundation), this is not expected to impact to any significant level on groundwater receptors (forest ecosystems or local groundwater users) because of the capacity of the Gunbower Forest (terrestrial vegetation) to then re-use the stored floodwater from groundwater via evapotranspiration. The exception to this is in the Upper Gunbower project area where current groundwater levels are < 5m in places and therefore water levels may increase to a level that may impact groundwater receptors (forest ecosystems or local groundwater users). The development of groundwater mounds under the inundation area should be monitored, especially in the Upper Gunbower area, to ensure groundwater levels are not being raised to levels that may impact on groundwater receptors outside the inundation area. These impacts may include near-surface salinisation from shallow saline groundwater or waterlogging in the area adjacent to the inundation area. Cleared, irrigated land bordering the forest where groundwater levels are already shallow may be at particular risk. Management of the watering program should be adapted as required to support the identified ecological objectives for the wider area if these issues arise.
- Reduced groundwater salinity immediately following managed inundation events, as a result of recharge (of river water) that is generally lower salinity than groundwater. This phenomenon is also observed during natural floods, so is not an unusual occurrence in the floodplain. What is different with respect to the application is that the recharge is augmented beyond the natural level for a given event. It is unknown at this stage what reliance ecosystems present in the project have to current groundwater salinities, however it would be expected that a slight freshening of the water quality would not have a negative impact on ecosystem health, as the near river environment is one where vegetation has evolved with the presence of flood water. There are no identified high salinity groundwater systems in this area, and this is believed to indicate that the vegetation is adaptable within the salinity range expected in this project. It is essentially impossible to control or mitigate this effect for a given level and duration of flooding, however the likely impact to groundwater receptors from this effect would be expected to be negligible to minor.
- Modified groundwater quality of the watertable during and after managed inundation events. This is an analogous response to the salinity change noted above. Trace amounts of contaminants (such as nutrients) that are present in the flood water may enter groundwater during inundation. This process naturally occurs but will be augmented by the operation of the works. There is little published information on the impact of this in groundwater and it has generally been considered by workers in the field that the impact is minor.
- Mobilisation of salt from either the soil surface or shallow groundwater to return to the Murray River. Salt on the soil surface may be dissolved and entrained by flood water and then held in solution until the release of the flood water, which then discharges salts to the Murray River. The risk of this delivering significant masses of salt to the Murray River from project operation at Gunbower National Park is considered low, given the generally low soil salt store. However, this may become more of an issue if the cumulative impact of groundwater mound rise under the inundation area raises groundwater levels to above the Murray River water level pushing more groundwater, and therefore salt, into the River. This has the potential to increase the salinity in the Murray River and impact on downstream users of the River. Adaptive management approaches should be used as required to limit negative effects, including assessment of the response to flooding and adjustments to the flooding level and duration.

Salinity discharges and any associated changes or impacts in the Murray River as a result of planned inundation of the Gunbower floodplain will be considered and assessed on a cumulative basis by the MDBA through the protocols of the Basin Salinity Management 2030 Strategy (BSM2030). These protocols are yet to be finalised for floodplain restoration projects, but discharges from the Gunbower National Park project will need to comply with these once finalised.

The following table describes the potential effects on the beneficial use of groundwater as a result of the construction and operation of the project.

Table 1: Expected effect on groundwater beneficial uses

Beneficial Use	Potential Effect
Water dependent ecosystems and species;	Net beneficial effect expected in areas of planned inundation. Potential long-term, low level risk to ecosystems and species outside of inundated areas from near-surface salinisation and waterlogging driven by groundwater mound rise under the inundation areas. This is particularly relevant in the southern section of the Upper Gunbower Forest project area.
Agriculture and irrigation (stock watering);	No known current use of groundwater for stock watering in the project area. The water quality and availability for this beneficial use should not alter.
Water-based recreation (primary contact recreation);	No effect expected The water quality and availability for this beneficial use should not alter.
Traditional Owner cultural values;	No specific cultural requirements have been identified for this assessment. The Desktop Historical Heritage Assessment and the Cultural Heritage Management Plan deal with potential impacts of the project on historical and cultural values. Given that the water quality is not expected to change and the effect on reliant ecosystems is expected to be beneficial, it is expected that there is minimal risk to cultural values dependent on groundwater.
Cultural and spiritual values;	No specific cultural and spiritual requirements have been identified for this assessment. The Desktop Historical Heritage Assessment and the Cultural Heritage Management Plan deal with potential impacts of the project on historical and cultural values. Given that groundwater quality is not expected to change significantly and the effect on reliant ecosystems is expected to be generally beneficial, it is expected that there is minimal risk to cultural values dependent on groundwater.
Buildings and structures;	No effect expected. The water quality and availability for this beneficial use will not alter.
Geothermal properties;	No effect expected. The water temperature at the surface is below the threshold for geothermal water and no effects are expected at depth.

5. Recommended mitigation measures

The following management measures are recommended during the construction and operation of the project:

- Seek to minimise the total volume and rate of groundwater extraction for construction purposes;
- Develop a strategy for managing project-specific dewatering activities, including disposing of groundwater in accordance with regulatory requirements. Identified mitigation measures would be integrated into construction plans;
- Avoid disposal of groundwater from construction activities to land;
- Monitoring of the development of potential groundwater mounds under the inundation areas, focused on the south section of the Upper Gunbower Forest project area. Implement adaptive management of environmental water delivery to mitigate impacts if identified.

Additional environmental mitigation measures relating to construction dewatering activities are provided in the VMFRP Environmental Management Framework.

Site specific working Draft Environmental Watering Management Plan's and Operating Plans have been developed for all nine VMFRP projects. Further work on these draft documents will be completed by the proponent in consultation with DELWP, Parks Victoria, the Mallee Catchment Management Authority and other relevant agencies. The finalised plans will document all avoidance and mitigation measures to be implemented for the project during operations (including the planned timing of inundation events), as well as responsibilities for implementation.

5.1 Further work

Specific groundwater level and quality information is required for the area to form a baseline for the potential construction and operation impacts, as well as to monitor the effects of inundation outside of the inundated area. A number of monitoring bores were established across the project area in 2014 as part of investigations by North Central CMA. These bores should be monitored to establish baseline conditions and continue to be monitored during operations to enable the groundwater effects to be verified, including monitoring the development of groundwater mounds.

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