Victorian Murray Floodplain Restoration Project

Desktop Groundwater Assessment - Guttrum and Benwell Forests

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Lower Murray Urban and Rural Water Corporation

Victorian Murray Floodplain Restoration Project

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Executive Summary

The Guttrum-Benwell 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 the Guttrum-Benwell 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 Guttrum and Benwell Floodplain Restoration Project area is underlain by shallow, relatively fresh groundwater (when compared with regional groundwater salinity), sitting at between 5 and 9 m below the ground surface. The watertable is in direct connection to the Murray River through the shallow aquifer system. There is thought to be limited hydraulic connection to deeper aquifers in the project area because of the presence of a low permeability unit below the watertable aquifer. This assessment has used available literature and data for the area. There is a good regional spread of monitoring information and the groundwater conceptual model for this site is considered to be well known at the whole of project scale.

A number of Ecological Vegetation Classes (EVCs) are mapped across the project area (R8 2020b), 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. The 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 temporary and limited groundwater dewatering and subsequent disposal of pumped groundwater. Typically banks and surface earthworks will not intersect groundwater and thus are not expected to have a groundwater effect during construction. Temporary removal of groundwater may be required for safe access to excavations associated with the larger structures. If this is the case, then minor impacts on adjacent vegetation and ecosystems are possible. The project would 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.

Operation of the proposed works will result in periods of elevated groundwater levels, wetting of soils and potentially mobilised salt from the unsaturated soil store into surface water for short periods. This could result in the displacement of salt to the Murray River and increased evapotranspiration of water from the floodplain, potentially concentrating salts in the soil. However, given the low salt store in the project area these issues are expected to be minor. Monitoring of flooding patterns and adaptive management of flooding to minimise waterlogging is expected to satisfactorily control this. Such adaptive management is inherently part of the proposed operation of the project.

There is one registered groundwater user close to the project site which has the potential to be impacted by temporary groundwater mounds if they form under the Benwell Forest during the planned inundations. This irrigation bore (bore ID WRK951262) around 600m to the south of forest. The potential impact to this user is expected to be limited to a slightly raised groundwater level with little to no change to groundwater quality. The available data suggests the effect on this user is likely to be minor to nil. The development of a groundwater mound at this site should be monitored during the operation of the project. A network of bores is present across the site to assist this task.

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.

Salinity discharges and any associated changes or impacts in the Murray River as a result of planned inundation of the Guttrum and Benwell Forests 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. Preliminary estimates for the project business case indicate that salt discharge to the Murray River from the works may be negligible (estimated salinity impact at Morgan <0.01 µS/cm EC) (Jacobs 2014). Discharges from the Guttrum and Benwell Forests project will seek to comply with these once finalised. Overall the assessment indicates that the impact from the project on groundwater receptors is likely to be low, with adaptive management of the post-works implementation expected to help limit any negative impacts to ecosystems from changes to groundwater salinity or waterlogging. Such management will include assessment of the response to flooding and adjustments to the flooding level and duration, as required, to limit negative effects.

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, Heritage Victoria, Aboriginal Victoria, Environmental Protection Authority, the North Central 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.

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 the information provided by VMFRP in the data handover pack at the commencement of the project. 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 Program overview - Victorian Murray Floodplain Restoration Project

The Guttrum and Benwell Forests 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 Guttrum and Benwell Forests Floodplain Restoration Project

The Guttrum and Benwell Forests Floodplain Restoration Project is located on the mid-Murray floodplain of 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 replicate a natural inundation regime equivalent to a 24,000 to 26,000 ML/d flow in the Murray River. 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 natural event.

Guttrum and Benwell Forests act independently to each other and are unique systems comprised of River Red Gum floodplain forests and woodlands interspersed with low-lying habitats including complexes of semi-permanent wetlands. The project aims to reinstate a more natural inundation regime across approximately 1,150 ha of high-ecological-value Murray River floodplain within Guttrum and Benwell Forests, through the construction of new infrastructure and the modification of existing infrastructure within the River Murray Reserve.

The main components of the project, based on the current design, include:

- **Guttrum Forest** - Four regulators, two pipelines, one outfall channel, one drop structure, two pump stations and associated power supply. A series of containment banks to support the inundation of the floodplain may also be required, however this is subject to further risk assessment.
- **Benwell Forest** – Four regulators (one large and three small), three pipelines, three drop structures, one pump station and associated power supply. A series of containment banks to support the inundation of the floodplain may also be required, however this is subject to further risk assessment.

Design and in some cases the type and location of infrastructure is currently being refined as part of the 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 environmental impacts.

In addition to these physical structures and works, the project will inundate approximately 1,150 ha of the floodplain along the Murray River in the vicinity of Guttrum and Benwell Forests during operation. For the

purposes of this desktop assessment of groundwater considerations, the development footprint, construction footprint and inundation footprints have all been considered (see definitions in Section 1.3 below).

1.3 Project area

This assessment covers the hydrogeology of the Guttrum and Benwell Forests floodplains located on the mid-Murray floodplain of northern Victoria, around 20km north-east of Kerang, Victoria. This area forms part of a wider regional ecosystem with Campbells Island across the Murray in New South Wales and the Gunbower-Koondrook-Perricoota Forest icon site not far upstream.

The following terms are used to describe the project area:

- Development footprint - this is the area that the project infrastructure will occupy. This includes the kiosk station associated with the potential power supply but does not include power poles, stays or cables, containment banks or tracks used for access during construction and operation.
- 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.
- Inundation area - area of land subject to flooding during managed events, up to a specific design water level. The inundation area comprises the majority of the Guttrum Benwell State Forests which extends along the Murray River north of Koondrook-Murrabit Road between Cassidy Lane and Hall Road. The inundation area in the Guttrum State Forest comprises the upper and lower wetland complexes including Reed Bed Swamp, Little Reed Bed Swamp and Guttrum Swamp. The Benwell State Forest inundation area comprises Benwell Swamp, a wetland complex representing a large portion of the Forest, and a wetland complex in the south-western corner of the forest, separated by a higher ridge and existing track.

The environmental water delivery infrastructure included in the development and construction footprints are based on the current design for the project. Refinement of the design of the infrastructure will be undertaken as part of the project's design process, therefore the construction element of the project included in this report is indicative, but 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 Guttrum and Benwell 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;
- Capability and experience of R8 staff have informed the assessment , which may not always be linked to a referenceable source; and,
- Detailed groundwater investigation and monitoring at the precise sites for the proposed works and area of inundation are recent and not finalised and so general understanding of the hydrogeology and sites has been used as well to inform this assessment. Future detailed studies may revise the findings presented here, once in possession of site-specific information and longer term records.

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 requirements for the Basin Plan, which includes groundwater management and sustainable diversion limits for aquifers (SDL).
- *Environment Protection Act 1970* – specifically the State Environmental 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.

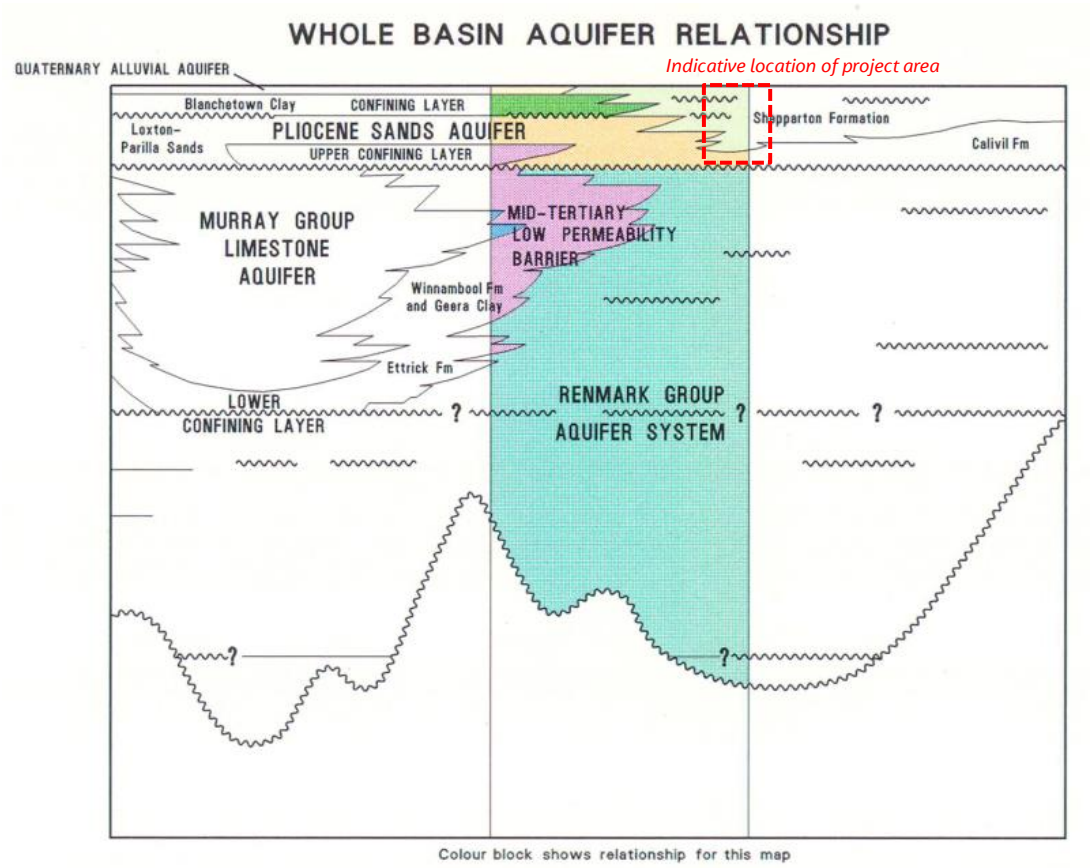
In addition to the relevant acts, regulations under these acts are also important. Specifically, for groundwater, the protocols and agreements made under the Basin Salinity Management Plan 2030 (BSM2030) are important as they define the conditions and controls relating to salt discharge to the Murray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

3. Existing conditions

3.1 Regional hydrogeology

The Guttrum and Benwell Forests 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 Swan Hill 1:250,000 scale hydrogeological map (O'Rorke, *et al.* 1992). Figure 1 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 of the shallow (upper) aquifer systems.

Figure 1: Regional hydrogeological units and thier relationship within the Guttrum-Benwell Forests project area (Indicative project area marked - Source: Swan Hill 1:250,000 Hydrogeological Map)



The project area sits in a section of the Murray Basin in which the Blanchetown Clay aquitard, which confines the Loxton Parilla Sand to the west, is absent. The project is also just to the east of the extent of the Upper Mid-Tertiary Aquitard units (which underly the Loxton Parilla Sand to the west – the Winambool Fm and Geera Clay in Figure 1). Groundwater investigations in the Forests in 2014 identified that the Loxton-Parilla Sand is absent in the project area, and the Calivil Formation underlies the Shepparton Formation under the Forests (HGEC, 2014).

While there have been numerous studies undertaken to describe the geology and hydrogeology of the Kerang Lakes catchment area to the west of the project area as part of investigations associated with the irrigation area, the Guttrum and Benwell Forests were not the focus of these investigations as they are outside of the irrigation areas. Work done in 2014 for North Central Catchment Management Authority (NCCMA) included installation of groundwater monitoring bores across both Guttrum and Benwell Forests, and a reconceptualisation of the hydrogeological system (HGEC, 2014; Dyson & Hocking, 2014). The current assessment is based on this 2014 work, as well as the geological sequence published by the Government of Victoria through the Victorian Aquifer

Framework (DELWP, 2020a) and the Geology of the Murray Basin, Southeastern Australia (Brown and Stephenson, 1991).

3.2 Project area hydrogeology

The current understanding of the hydrogeological system in the project area is primarily informed by site investigations undertaken by NCCMA in 2014 (HGEC, 2014) which updated the conceptualisation in the most recent geological mapping and Victorian Aquifer Framework (DELWP, 2020). In these latter interpretations, the Loxton-Parilla Sand is defined as present under the Shepparton Formation and the clay nature of the Lower Shepparton Formation is not anticipated. The 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).

- Quaternary aquifer (Coonambidgal Formation: 100): Quaternary alluvial sedimentary deposits, consisting of fine grained silts and clays overlying coarser-grained sediments that are part of the contemporary floodplain and the recent geological past, between 2 and 5 m thick across the project area. This unit is typically unsaturated in the project area (Dyson & Hocking, 2014);
- Shepparton Formation aquifer (102): A thick sequence of Upper Tertiary to Quaternary aged sediments, interpreted as consisting of the Upper and Lower Shepparton Formations in the project area;
    - Upper Shepparton Formation: Generally fine grained sediments, with occasional shoestring sands throughout. The sand lenses are thought to be limited in connection and appear to be small and discrete, representing paleochannels of the river. This formation is a regional aquifer and is typically saline or brackish in water quality. The sub-unit is between around 10 and 20m thick under the project area, and holds the watertable in the project area (Dyson & Hocking, 2014). At the site the upper aquifer units are considered to be acting as a local aquifer, more so than a regional one (P Dyson, pers. comm., 2020);
    - Lower Shepparton Formation - Yando Clay: Heavy, grey clay, equivalent in age to the Loxton-Parilla Sand. At least 35 m thick across the project area and acts to limit vertical flow between the Upper Shepparton Formation the underlying Calivil/Renmark Formations (Dyson & Hocking, 2014).

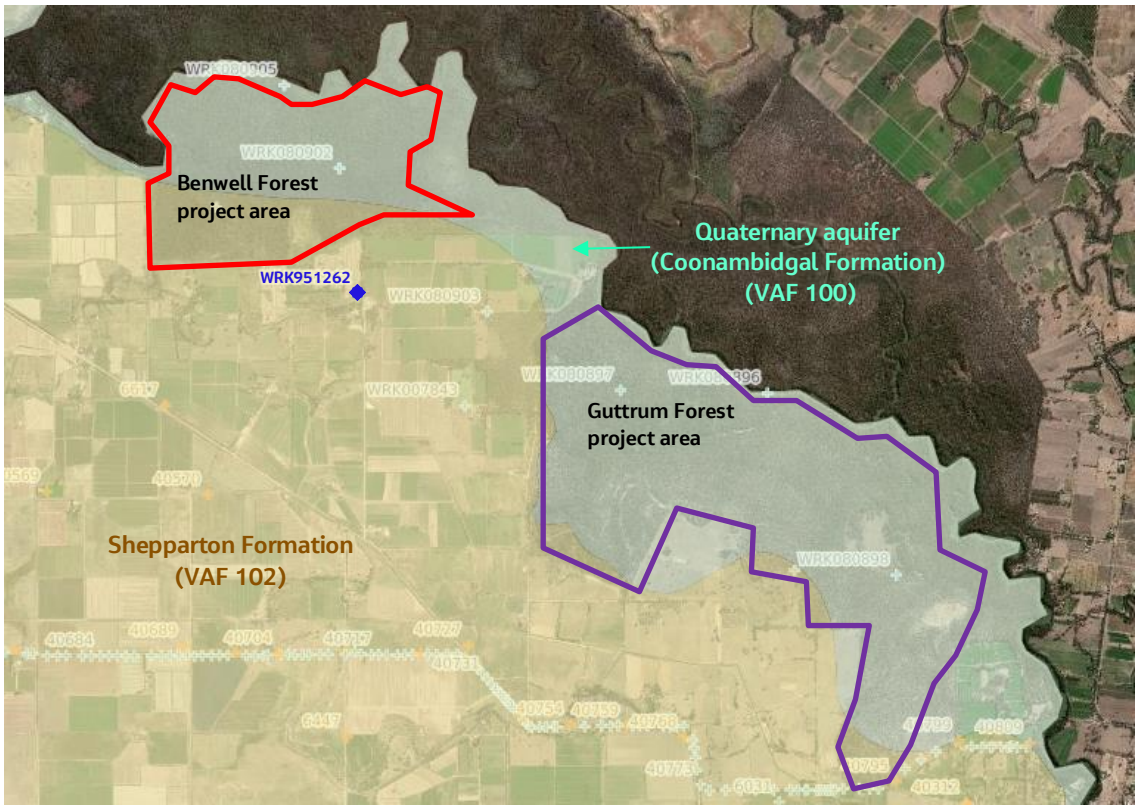
The local surface geology is shown in Figure 2 below. The Quaternary aquifer (Coonambidgal Formation) is present across almost all of the project area and aligns with the southern boundary of the forest extents. In the south of the Benwell Forest, where available geological mapping shows the Upper Shepparton Formation outcropping at the surface (FedUni, 2015), the interpretation of bore logs from NCCMA's 2014 work suggests that the Coonambidgal Formation may be present further south than geological mapping may indicate (HGEC, 2014).

The presence of the clay matrix in the Quaternary aquifer may act to impede infiltration of groundwater from the surface into the underlying Upper Shepparton Formation and the watertable. The Yando Clay is also expected to impede vertical groundwater flow between the Upper Shepparton Formation and underlying aquifers, and preference lateral groundwater flow of the Upper Shepparton to and from the Murray River (Dyson & Hocking, 2014).

Groundwater levels in the Yando Clay from 2014 suggest an upward groundwater gradient into the Upper Shepparton from deeper aquifers, the rate of which is limited by the low interpreted permeability of this aquifer (Dyson & Hocking, 2014).

Regional 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. Local flow cells are possible, indeed are considered likely, that may change the local flow direction from the general pattern described above.

Figure 2: Surface geology across the project area, noting the only irrigation bore close to the project areas (Source: FedUni, 2015)



3.3 Groundwater and soil salinity

Groundwater salinity in the watertable aquifer across the project area has been measured as low to moderate, typically 300 – 1,400 mg/L (NCMA, 2014). While salinities in the underlying Yando Clay are significantly higher (7,200 – 15,600 mg/L), and groundwater gradients between this unit and the Upper Shepparton Formation indicate an upward flux, the low permeability of the Yando Clay is thought to be limiting the vertical flow of more saline groundwater into the watertable (Dyson & Hocking, 2014).

State-wide mapping, as presented in Figure 3, shows salinity of the watertable as much higher than indicated by the sampling undertaken in 2014 (7,000 to 35,000 mg/L; FedUni, 2015).

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 (North) AEM survey area (Cullen et al. 2008).

Figure 4 shows the interpreted salt loads in the area from the AEM survey. It can be seen from this figure that soil salinity in the project area has been mapped as low (most of the areas is below 100 t/ha/m) with small areas of moderate soil salinity (up to 200 t/ha/m).

Figure 3: Interpreted groundwater salinity for the Guttrum and Benwell Forests project area (FedUni, 2015)

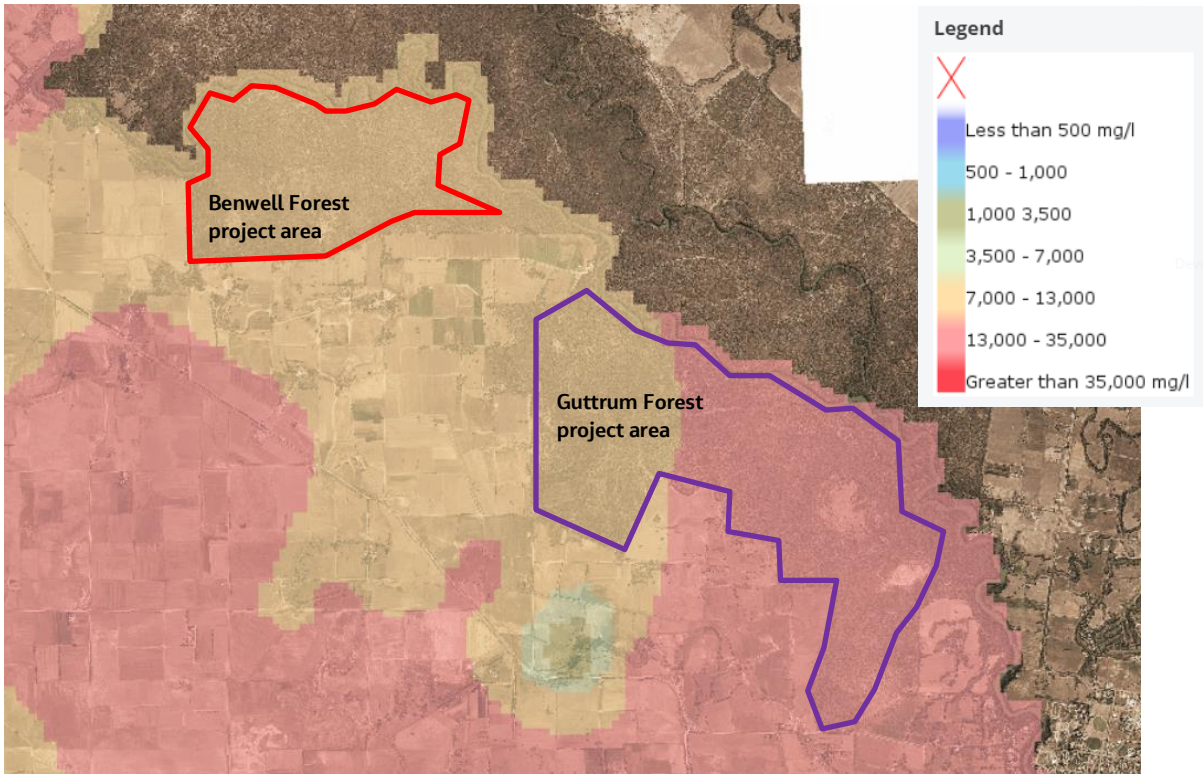
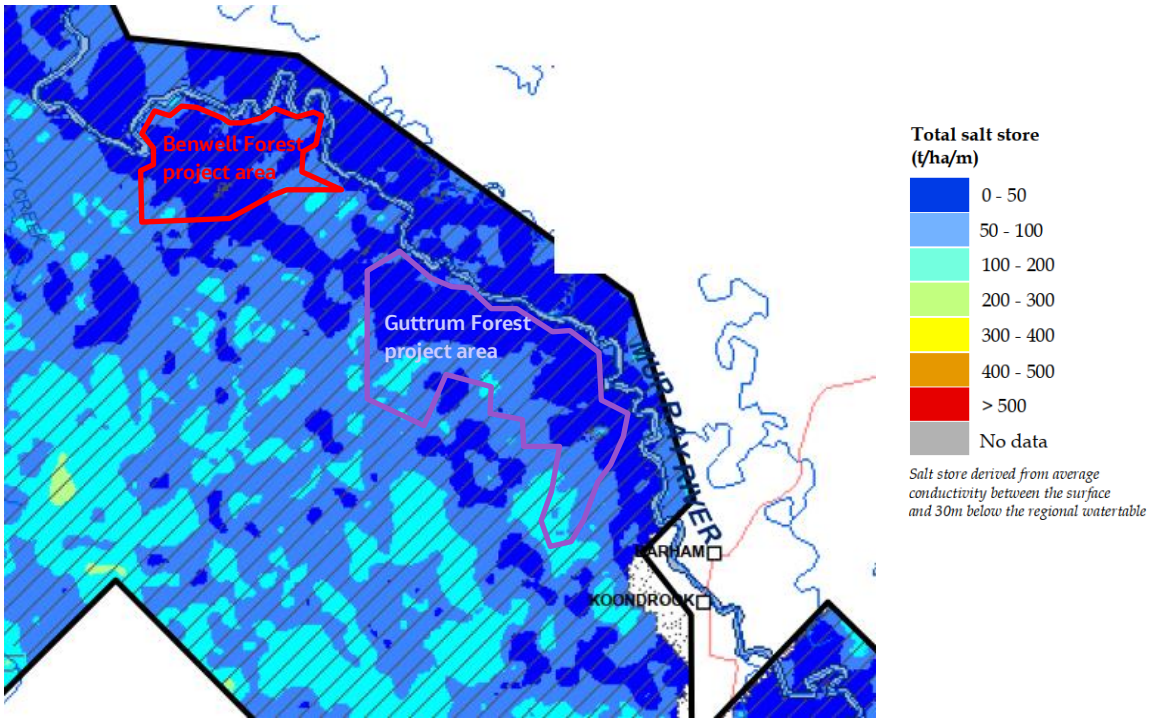


Figure 4: Interpreted Salt Store in the unsaturated zone for the project area (Cullen et al. 2008)



3.4 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.

3.4.1 Groundwater bore use

A search of the area from an online groundwater database (FedUni 2015) indicates there is only one registered groundwater user close to the project area, namely an irrigation bore around 600m south of Benwell Forest (bore ID WRK951262 – marked on Figure 2). The flooding of the Benwell Forest beyond natural patterns has the potential to generate an increase in groundwater levels (mounding) under the forest which may cause a (lesser) rise in the elevation of groundwater in the adjacent areas. The potential impact to this user is a slightly elevated groundwater level with little to no change to groundwater quality.

The primary use of groundwater in the project area is otherwise environmental use associated with floodplain vegetation and ecosystems.

3.4.2 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 5 and Figure 6, some of which are thought to contain species are at least partially reliant on groundwater (R8 2020b).

As identified in the Flora and Fauna Assessment prepared for the project (R8, 2020), of the ten EVCs previously modelled as occurring within the project's managed inundation area, five 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.

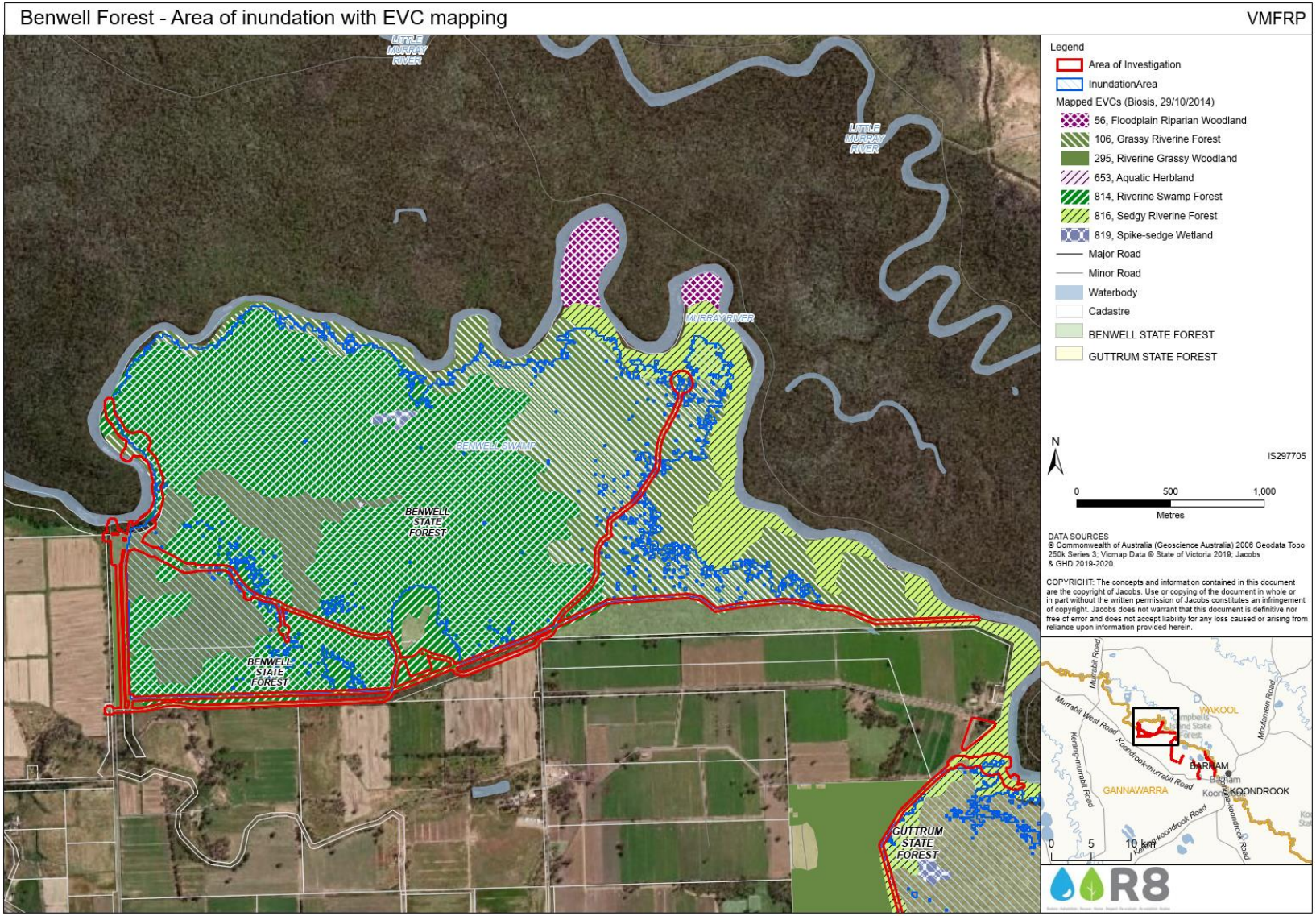


Figure 5: Ecological Vegetation Classes present within the Benwell Forest project area, as mapped by R8 (R8 mapping product, after R8 2020)

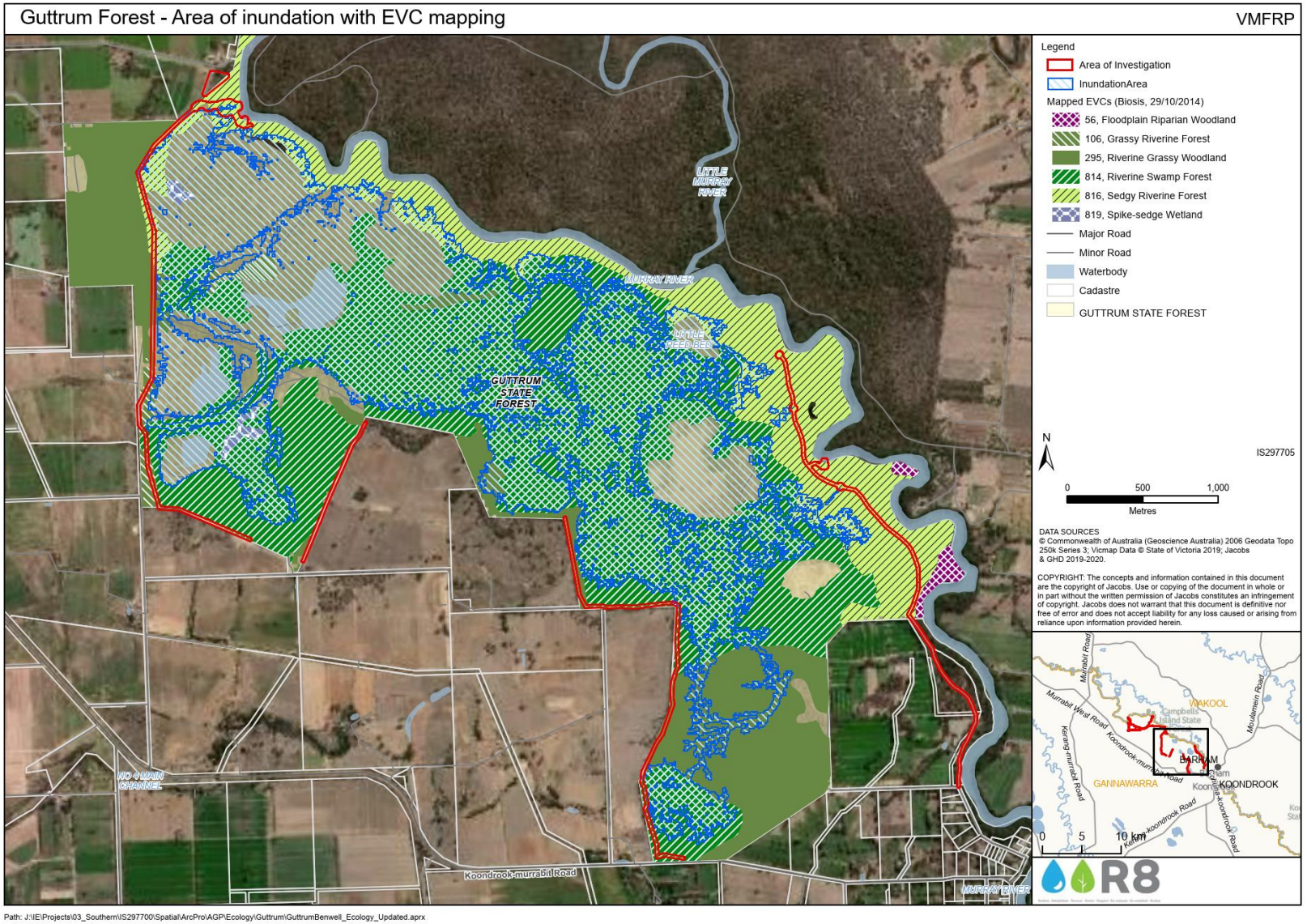


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Figure 6: Ecological Vegetation Classes present within the Gutturm Forest project area, as mapped by R8 (R8 mapping product, after R8, 2020)

4. Potential effects

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

- Temporary and limited drawdown of groundwater levels during construction, specifically this may be required for the regulators, pump stations and inflow structures as these may need to be dug into the subsurface. Typically banks and surface earthworks will not intersect groundwater and thus are not expected to have a groundwater effect during construction. Temporary removal of groundwater may be required for safe access to excavations associated with the deeper structures.
- Increased groundwater level, as a result of flood recharge, across the inundated area. The rise in groundwater levels across the inundated area may generate a groundwater mound that causes a (lesser) rise in the groundwater levels surrounding the inundated areas. This increased groundwater level may reach an existing irrigation bore (bore ID WRK951262), which is around 600m south of the inundated area at Benwell Forest. The potential change in groundwater quality from the influence of the groundwater mound is expected to be minor to none. A desktop review indicates any impact to the bore is expected to be minor.
- Reduced groundwater salinity immediately following flood events, as a result of flood 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 flood 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 from 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. This process has been examined by Jacobs (2014) and the possible salinity impacts were considered to be negligible for this area (estimated salinity impact at Morgan <0.01 µS/cm EC). The assessment did note a number of uncertainties around these estimates, primarily related to limited available background information to confirm hydrogeological conditions particularly relating to the salt wash-off conditions and infiltration rates. This report did not identify ecologically concerning levels of salinity, rather it was focussed on the downstream effects of salt in the Murray River overall. A classification of the over-all risk of salt mobilisation being negligible is considered reasonable, because of the levels of conservatism of parameters used in the analysis, which would be expected to over-estimate the results, and the relatively low salt store in the soil profile across the project area (Cullen et al. 2008).

  Salinity discharges and any associated changes or impacts in the Murray River as a result of planned inundation of the Guttrum and Benwell Forest 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 Guttrum and Benwell Forest project will comply with these once finalised.
- Shallow groundwater in the vicinity of vegetation may occur for extended periods of time during and immediately after flooding. Vegetation that has shallow groundwater level for extended periods can become waterlogged. It is noted that the majority of vegetation communities within the project area are flood dependant and capable of withstanding some degree of waterlogging. Potential implications of

inundation would be investigated and ongoing monitoring of vegetation would be undertaken in accordance with the project's operational guidelines and adapted as required to support achievement of the identified ecological objectives for the project.

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;	Beneficial effect expected Water dependent ecosystems use soil water and shallow groundwater as a water source during dry periods. The intent of the project is to provide additional reserves of shallow soil water to enhance vegetation health and to thus support the ecology dependent on soil water and shallow groundwater.
Agriculture and irrigation (stock watering);	Bore WRK951262 may experience a minor rise in groundwater elevation from potential groundwater mounding under Benwell Forest. This bore is registered for irrigation. Limited information suggests any impact is likely to be minor. No effect is expected for other users.
Water-based recreation (primary contact recreation);	No effect expected as the water quality and availability for this beneficial use will 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;	Limited information – no significant effect expected No specific cultural requirements have been identified for this assessment but given that the water quality is expected not to significantly change and that the effect on reliant ecosystems is expected to be beneficial, it is expected that there is minimal risk to cultural and spiritual values as a result of groundwater impacts.
Buildings and structures;	No effect expected as the water quality and availability for this beneficial use will not alter.
Geothermal properties;	No effect expected as 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.

Additional environmental mitigation measures relating to 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, Heritage Victoria, Aboriginal Victoria, Environmental Protection Authority, 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 (and after then) as part of investigations by North Central CMA. These bores should continue to be monitored to establish baseline conditions and continue to be monitored during operations to enable the groundwater effects to be verified. The monitoring should particularly consider the progression of any groundwater mound that may develop under Benwell Forest, which has the potential to impact the groundwater level at bore WRK951262.

6. References

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