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GROUNDWATER DEPENDENT ECOSYSTEMS REPORT



Big Vein South Gold Project

Groundwater Dependent Ecosystem Assessment

for Strategic Minerals Corporation

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1 INTRODUCTION

This report describes the groundwater dependent ecosystem (GDE) assessment undertaken for the Big Vein South Gold Project (the project). The assessment draws on the results of the specialist groundwater assessment described in the Groundwater Report (Appendix C of the Environmental Assessment Report (EAR)), the specialist ecology assessment described in the Terrestrial Ecology Report (Appendix E of the EAR) and the stygofauna sample analysis conducted by C&R Consulting and described in the Aquatic Ecology Report (Appendix F of the EAR).

1.1 PROJECT DESCRIPTION

The project involves the construction and operation of an open cut gold mine on a greenfield site in North Queensland. The project site covers an area of approximately 2,281 ha and is located approximately 100 km north of Richmond and 380 km west of Townsville (Figure 1).

Open cut mining will be conducted using excavators and trucks. Gold ore will be processed on site to produce gold dore (solid bars containing gold alloy). The mine's peak production rate will be up to 1.95 million tonnes per annum (Mtpa) of run of mine (ROM) gold ore, yielding up to approximately 100,000 ounces of gold dore per annum. The mine life will be approximately 11 years.

The following mining and ore processing activities will be undertaken as part of the project:

- Developing three open cut pits, as follows:
- The main Big Vein South Pit (BVS Pit) located in the centre of the project site (Figure 2). Waste rock from this pit will be hauled by truck and stored in the Central and Southern Waste Rock Dumps (WRDs).
- Two small satellite pits, BV1 Pit and BV2 Pit, located in the northern part of the project site (Figure 2). Waste rock from these pits will be stored in the Northern WRD.
- Transporting mined ore in haul trucks from the open cut pits to the ROM area ore stockpiles located near the mine processing facilities at the southern end of the project site (Figure 2).
- Processing ore from the BV1 and BV2 Pits in the first 2 years of mining using Heap Leach Pads and gold elution. Processing ore mined from the BVS Pit in an on-site Carbon In-Leach (CIL) Plant from Year 3 onwards. The heap leaching process will generate spent heap leach residues. These residues will be reprocessed in the CIL Plant over the life of the mine. The CIL Plant will generate wet tailings and dewatered tailings. Wet tailings will be pumped to a Tailings Storage Cell. Dewatered tailings will be stored with waste rock in the Central WRD.
- Transporting dore bars from the site via plane to a refinery.

The majority of the mine infrastructure will be located at the southern end of the project site (Figure 2). Key mine infrastructure will include ore processing facilities, workshop, warehouse, administration buildings, haul roads and access roads, vehicle servicing, refuelling and wash down facilities, fuel storage facilities, diesel and solar power station, water supply and water management infrastructure. Workforce accommodation and a private airstrip will also be located at the southern end of the project site.

1.2 PROJECT SETTING

The project site is situated on the south-western edge of the Gregory Range at elevations of between approximately 360 m and 450 m Australian Height Datum (AHD). The north-eastern portion of the project site is characterised by a mosaic of sandstone scarps dissected by gullies, while the remainder of the project site is gently undulating and sloping to the west (Figure 3).

The project site is located adjacent to the Woolgar River (Figure 3) at the upstream end of the Flinders River Basin. The Woolgar River is a tributary of the Stawell River which joins the Flinders River approximately 100 km downstream of the project site. The Flinders River flows north through the Gulf Country and discharges into the Gulf of Carpentaria.

The Woolgar River is ephemeral and flows in a south-westerly direction along the northern and north-western boundaries of the project site. There are a number of ephemeral tributary drainage features traversing the project site, originating from the sandstone scarps to the east and flowing intermittently through the site to the Woolgar River (Figure 3).

The surface geology in the project site and its surrounds is shown in Figure 4. There is a narrow strip of alluvium along the north-western boundary of the project site, associated with the Woolgar River and its floodplain, that is largely unsaturated. In discrete areas below the Woolgar River channel, the base of the alluvium may intersect the groundwater table.

A weathered profile extends across the entire project site and its surrounds and is typically located at the ground surface, except where it is overlain by the alluvium. The weathered profile reaches depths of up to 40 m below ground level in the project site.

The groundwater table is generally deeper in elevated areas and shallower in the vicinity of the incised river and creeks. In the elevated plateau areas, the groundwater table is typically located at depths of approximately 50 m, and up to approximately 110 m, below ground level. In the lower-lying areas, the groundwater table is typically located within the weathered profile, between approximately 10 m and 50 m below ground level.

The local vegetation within the project site is characterised as open woodland dominated by Eucalyptus and Corymbia, with a variable native shrub layer.

1.3 GROUNDWATER DEPENDENT ECOSYSTEMS

The *Information Guidelines Explanatory Note: Assessing Groundwater-Dependent Ecosystems* (Doody, Hancock and Pritchard, 2019) (IESC GDE Guideline) defines GDEs as “ecosystems that require access to groundwater on a permanent (obligate) or intermittent (facultative) basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services”. Groundwater is defined as “water occurring naturally below ground level (whether in an aquifer or otherwise)” that is within the saturated zone or the soil capillary fringe zone but does not include water held in the soil of the unsaturated zone, unless it is a perched aquifer.

The IESC GDE Guideline identifies three types of GDEs as follows:

- Terrestrial GDEs where an ecosystem relies on the subsurface presence of groundwater (such as a perched aquifer or a shallow groundwater table). This includes groundwater dependent vegetation communities.
- Aquatic GDEs where an ecosystem relies on the surface expression of groundwater. Aquatic GDEs may include riverine water bodies fed by groundwater baseflow, wetlands, lakes, springs and estuarine, coastal and marine ecosystems.
- Subterranean GDEs which include cave and aquifer ecosystems.

The IESC GDE Guideline sets out a framework to guide the assessment of GDEs. For terrestrial and aquatic GDEs, the assessment methodologies are similar. A tailored assessment methodology is applied to subterranean GDEs.

1.4 REPORT STRUCTURE

This report is structured as follows:

- Section 1 provides an overview of the project and project setting, background information on GDEs and report structure;
- Section 2 presents the assessment undertaken for terrestrial and aquatic GDEs;
- Section 3 presents the assessment undertaken for subterranean GDEs;
- Section 4 summarises the conclusions of the GDE assessment.

2 TERRESTRIAL AND AQUATIC GDEs

2.1 METHODOLOGY

The terrestrial and aquatic GDE assessment has been undertaken in accordance with the framework set out in the Queensland *Groundwater Dependent Ecosystems: EIS Information Guideline* (DETSI, 2024) (Qld GDE Guideline) and the IESC GDE Guideline and involved the following:

- Identifying the terrestrial and aquatic GDE study area based on the maximum predicted extent of direct and indirect impacts from the project on terrestrial and aquatic GDEs.
- Identifying potential terrestrial and aquatic GDEs within the terrestrial and aquatic GDE study area based on a desktop search of relevant databases and information sources.
- Rationalising potential GDEs identified in the database searches with the site-specific groundwater and surface water data and relevant ground-truthed geology and ecology information, to develop a conceptual understanding of the ecohydrogeological regime, assess groundwater dependence and determine the presence of GDEs.
- Assessing potential impacts from the project on any confirmed GDEs and developing a monitoring and management program, as necessary.

The IESC GDE Guideline provides common decision rules that were used to guide the assessment of groundwater dependence of vegetation and to aid in the identification of terrestrial and aquatic GDEs. These include that *"vegetation associated with shallow groundwater (less than 10 m) is likely to be part of a GDE"* and *"as groundwater depth increases (> 20 m)... [there is] a low or no likelihood of groundwater dependence"*.

Based on the IESC GDE Guideline decision rules, the likelihood of terrestrial GDEs is categorised as follows:

- Highly unlikely to occur where groundwater is greater than 20 m below ground level;
- May occur where groundwater is 10 m to 20 m below ground level and the vegetation roots can access it; and
- Likely to occur where groundwater is less than 10 m below ground level and the vegetation roots can access it.

A conceptual ecohydrogeological model was developed based on the ground-truthed site-specific data, to illustrate the relationships between any potential terrestrial GDEs present and the relevant aspects of the surface geology, groundwater regime and surface water setting (Section 2.2.4).

2.1.1 GDE STUDY AREA

The terrestrial and aquatic GDE study area comprises the maximum predicted extent of potential direct and indirect impacts on terrestrial and aquatic GDEs. The GDE study area therefore comprises the project disturbance area, within which vegetation will be directly impacted, and any additional areas that are within the maximum predicted extent of the project's groundwater drawdown effects on the regional groundwater table. This area has been delineated by the groundwater specialist based on the project groundwater modelling results.

The Groundwater Report indicates that shallow perched groundwater may also occur within the GDE study area extents. However, where present, any perched groundwater is located above the regional groundwater table and, therefore, the perched groundwater and regional groundwater table are hydraulically disconnected. On this basis, perched groundwater will not be affected by drawdown on the regional groundwater table due to the project and therefore does not have any effect on the GDE study area extent.

The GDE study area is shown in Figure 4.

2.2 SITE-SPECIFIC ASSESSMENT

This section summarises the relevant site-specific data and field-validated information, obtained from the project groundwater and terrestrial ecology assessments, that has been used to confirm the actual presence of terrestrial and aquatic GDEs within the GDE study area.

2.2.1 GEOLOGY AND GROUNDWATER REGIME

The ground-truthed site geology is described in the Groundwater Report and includes the following geological units (in descending order):

- Localised alluvium associated with the Woolgar River and its floodplain;
- The weathered in-situ rocks of the Eromanga Basin and Proterozoic basement (herein called the 'weathered profile');
- Fresh (i.e. unweathered) Jurassic strata of the Eromanga Basin; and
- Fresh Proterozoic basement rocks, including the target gold ore.

There is a small area of Woolgar River alluvium located at the north-western limit of the GDE study area. This area will be cleared of vegetation for the construction of mine infrastructure but is beyond the maximum predicted extent of groundwater drawdown from the project. The groundwater assessment determined that alluvium in the GDE study is largely dry and unsaturated and therefore there is no alluvial aquifer present.

The weathered profile is present across the entire GDE study area and is typically located at the ground surface, except where it is overlain by the Woolgar River alluvium. The weathered profile comprises poorly consolidated, fine-grained, clay-bound sands and silts and is expected to have relatively low physical strength, low to moderate bulk density and variable porosity. The groundwater assessment confirmed that the weathered profile is typically unsaturated, however saturation occurs in proximity to the Woolgar River and beneath the southern-most drainage feature that extends through the GDE study area.

The Jurassic strata forms a single, undifferentiated sedimentary rock formation, comprising mainly sandstone, with minor conglomerate, siltstone and claystone. This formation is expected to have relatively high physical strength and bulk density with relatively low porosity. The Jurassic strata is saturated in isolated areas to the north and east of the project site, corresponding to the location of the elevated plateaus. The majority of the Jurassic strata within the GDE study area is unsaturated.

The Proterozoic basement comprises folded metamorphic rocks (e.g., amphibolite), granite and intrusive dykes (dolerite and rhyolite) and typically underlies the weathered profile and the fresh Jurassic sediments (where present). The Proterozoic basement is a dry crystalline and metamorphosed rock mass that functions

as an aquiclude and is expected to exhibit high physical strength, high bulk density and low porosity. The Proterozoic basement contains groundwater in disconnected cracks in its upper profile but does not form a continuous, saturated aquifer.

2.2.2 GROUNDWATER AND SURFACE WATER INTERACTIONS

The groundwater assessment included an analysis of the depth to the unconfined groundwater table and the potential for groundwater interactions with surface water. The assessment determined that the groundwater table is located at a minimum depth of approximately 4 m, and up to 53 m, below the bed of the drainage features that traverse the GDE study area.

Hence, the groundwater table does not intersect the ground surface in the drainage features and there is no groundwater seepage through the creek beds or banks. On this basis, groundwater seepage does not provide baseflow to drainage features that are within the GDE study area.

The groundwater assessment determined that the groundwater table may intersect the ground surface in the Woolgar River bed during flow events in the river. However, the predicted maximum groundwater drawdown effects of the project do not extend to the Woolgar River bed and therefore it is not within the GDE study area.

2.2.3 TERRESTRIAL ECOLOGY

The terrestrial ecology assessment identified that the ground-truthed vegetation within the GDE study area is predominantly Eucalyptus and Corymbia woodland with occasional lancewood, ironwood and tea tree species (REs 2.3.21j, 2.5.18a and 2.11.1a). A literature review of plant physiology indicates that:

- Most of the root mass will occur in the shallow soil profile and will tend to decrease with depth (Jackson et al., 1996).
- Root structure, architecture and depth are dependent on environmental conditions (Feldman, 1984). The key factors that limit the downward growth of roots are horizontal stratification of sediments, soil bulk density, shallow bedrock and the groundwater table (Bennie, 1991).
- Root penetration in bedrock and heavy clay soils occurs where these materials are highly weathered and/or contain networks of connected cracks and fissures (Canadell et al., 1996). Root penetration into fresh, unweathered bedrock with limited cracking networks is unlikely.
- The mean maximum rooting depth for sclerophyllus trees is approximately 12 m +/- 3 m (Canadell et al., 1996). Sclerophyllus shrubs have a mean maximum rooting depth of approximately 3.5 m (Canadell et al., 1996).
- More typically, in Eucalyptus and Acacia forests arbuscular mycorrhizal fungi associated with the tree roots are typically observed at depths of up to 8 m below ground level (de Araujo Pereira et al., 2018).
- Under exceptional circumstances and in highly favourable soil conditions (e.g. in deep, sandy, well oxygenated soils and highly weathered and fractured rock), these tree species can develop deeper than average root systems. However, even under these conditions, the maximum rooting depth for mature individuals typically remains below 20 m (Canadell et al., 1996). Root penetration is reduced in less favourable conditions (i.e. more dense soils, fresh rock) (Canadell et al., 1996).

On this basis, under local environmental conditions, the likely maximum rooting depth of the woodland vegetation present within the GDE study area is expected to be up to 15 m below ground level.

2.2.4 GROUNDWATER ACCESSIBILITY

Terrestrial GDEs may occur where vegetation is underlain by an aquifer and the aquifer is accessible by the vegetation roots. The ability of the vegetation roots to access groundwater is dependent on the likely maximum rooting depth of the vegetation, as discussed in Section 2.2.3, and whether the physical characteristics of the local geology enable root penetration.

Root penetration can occur in bedrock and heavy clay soils where these materials are highly weathered and/or contain networks of connected cracks and fissures (Canadell et al., 1996). Conversely, root penetration into fresh, unweathered bedrock with limited crack networks is unlikely.

With regard to the relevant aquifer characteristics determined by the groundwater assessment and described in Section 2.2.1, the physical characteristics of both the fresh Proterozoic basement and Jurassic strata are expected to form a barrier to root penetration that would effectively preclude access to groundwater by terrestrial vegetation. The physical characteristics of the weathered profile and alluvium are unlikely to be physical barriers or significant constraints to root penetration. On this basis, the weathered profile or alluvium within 20 m of the ground surface represents the maximum potential rooting zone of woodland vegetation.

Figure 5 presents the conceptual ecohydrogeological model for the GDE study area and illustrates that, where the regional groundwater table is located at a depth greater than 20 m below ground level, or is located within the fresh rock formations, the groundwater is not accessible by the roots of the vegetation. Conversely, where the regional groundwater table is located in the alluvium or weathered profile at depths of up to 20 m below ground level, the groundwater can be accessed by the roots of the vegetation and this woodland vegetation may therefore be groundwater dependent.

Figure 6 shows the parts of the GDE study area where terrestrial GDEs will potentially occur, because the regional groundwater table is present within the maximum potential rooting zone of woodland vegetation (i.e. the regional groundwater table is less than 20 m below the ground surface and within the alluvium or weathered profile). Figure 7 shows the ground-truthed vegetation communities and depth to groundwater in these areas.

Figure 6 also shows the parts of the GDE study area where terrestrial GDEs are unlikely to occur. These are the areas where groundwater modelling indicates that the depth to groundwater is greater than 20 m below ground level, or the groundwater table is located within the Jurassic strata or below the top of the Proterozoic basement, and therefore the groundwater is not accessible within the maximum potential rooting zone of woodland vegetation.

2.3 DATABASE SEARCH RESULTS

This section describes the results of the desktop databases searches undertaken to identify potential terrestrial and aquatic GDEs within the GDE study area. It includes consideration of whether the desktop database search results are consistent with the more accurate site-specific assessment presented in Section 2.2.

2.3.1 DATABASES AND RESOURCES

The IESC GDE Guideline provides a list of resources that are useful for identifying potential GDEs, including:

- GDE Atlas (Bureau of Meteorology, 2019);
- Queensland GDE and potential aquifer mapping (Queensland GDE mapping) (Department of Environment and Science (DES), 2018);
- Queensland Wetland*Maps* (DES, 2019); and
- Queensland Springs Database (Queensland Government, 2019).

The GDE Atlas provides a national inventory and map of known GDEs and potential GDEs. Potential GDEs are assigned a low, moderate or high potential for interaction between groundwater and ecosystems. The GDE mapping in the GDE Atlas originates from two broad sources:

- National assessment. A national-scale analysis that has been developed based on a set of rules that describe potential for interaction between groundwater and ecosystems; and
- Regional studies. A more detailed analysis undertaken by various State and regional agencies using a range of different approaches.

The GDE Atlas indicates that the GDE mapping for the project site has been sourced from regional studies, and therefore the mapping of potential GDEs in the GDE Atlas mirrors the Queensland GDE mapping.

Queensland GDE mapping is a catchment-scale GDE mapping tool that integrates expert local knowledge of landscapes, and the ecosystems within them, with relevant existing datasets, including regional ecosystem and wetland mapping. Queensland GDE mapping identifies known GDEs that have been accurately identified as having some degree of groundwater dependence through supporting evidence (e.g. field validation). Queensland GDE mapping also identifies derived GDEs that have been assessed as potentially groundwater dependent through the application of various rule sets. Derived GDEs are classified with a low, medium or high confidence rating based on the level of confidence that local experts had in their prediction that the ecosystem is using groundwater, as opposed to other water sources.

The GDE Atlas integrates the Queensland GDE mapping by adopting “derived GDEs” as “potential GDEs” and applying the confidence levels as the potential for interaction between groundwater and ecosystems.

Queensland GDE mapping also maps the extents and properties of groundwater resources, including aquifers potentially supporting aquatic and terrestrial GDEs. The extents of the mapped potential GDE aquifers are aligned with the Land Zones of Queensland (Wilson and Taylor, 2012) that describe the major geologies and associated landforms and geomorphic processes. Land zones are generally derived through amalgamation of geological, land system and/or soil mapping units at regional scale (Neldner et al., 2023) and are not routinely confirmed by field inspection. The aquifer mapping is intended to complement the Queensland GDE mapping data and has not been integrated into the GDE Atlas.

Queensland Wetland*Maps* provides information on types and extent of wetlands across Queensland, including information on ecological values such as GDEs, where relevant. The Queensland Springs Database provides a comprehensive catalogue of springs and any associated aquatic GDEs.

In addition to the above databases, the project site is located within the *Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* (GABORA Water Plan) area. The GABORA Water Management Protocol 2017 (Department of Natural Resources, Mines and Energy, 2019) implements parts of the GABORA Water Plan and requires a register of GDEs to be maintained. The GABORA GDE register includes locations of watercourses and springs that are supplied in part by underground water from an aquifer managed under the GABORA Water Plan.

2.3.2 POTENTIAL GDE AQUIFERS

Queensland GDE mapping identifies the following potential GDE aquifers within the GDE study area (Figure 8):

- Alluvial;
- Sandy plain; and
- Sedimentary rock (sandstone).

There are also areas within the GDE study area where there is no mapped aquifer, and consequently these areas have been classified as “exclusion zones”. Exclusion zones are defined as areas with low permeability surfaces and little or no infiltration. As such, there is not enough groundwater available in exclusion zones to support GDEs.

The potential GDE aquifers identified in the desktop mapping within the GDE study area are not consistent with the site-specific geology and groundwater information determined by the project groundwater assessment and described in Section 2.2.1. The potential GDE aquifers are therefore not present.

2.3.3 POTENTIAL AQUATIC GDEs

The Woolgar River bed is a registered GDE watercourse under the GABORA Water Management Protocol 2017 (Department of Natural Resources, Mines and Energy, 2019) (Figure 8). As discussed in the Groundwater Report and Section 2.2.2, the predicted maximum groundwater drawdown effects of the project do not extend to the Woolgar River bed and therefore this registered GDE watercourse is not within the GDE study area.

The GDE Atlas indicates that there are no springs or spring wetlands within the terrestrial and aquatic GDE study area. This is supported by the Queensland Springs Database.

Queensland WetlandMaps indicates that the Woolgar River bed is a riverine wetland area. The GDE Atlas maps segments of the Woolgar River bed riverine wetland area as moderate and high potential aquatic GDEs, however these are not located within the GDE study area (Figure 8).

Queensland WetlandMaps also indicates that the drainage features within the GDE study area are riverine wetlands. The GDE Atlas maps short segments of these drainage features as potential aquatic GDEs as follows:

- There are several moderate potential aquatic GDEs described as “*channels that are dependent on fluctuating, episodically saturated permeable sedimentary rock (sandstone) aquifers*”. Consistent with this rule set, where these drainage features extend into mapped alluvial aquifers or exclusion zones, they are no longer mapped as potential aquatic GDEs (Figure 8).

- There are two high potential aquatic GDEs described as “*channels within 50 m of the old loamy and sandy plain contact zone that are dependent on fresh seasonally saturated sandy plain aquifers*”. These high potential aquatic GDEs are mapped along short segments of the drainage features within 50 m of the boundary between the mapped alluvial and sandy plain aquifers.

The desktop mapping of potential GDE aquifers is not consistent with the site-specific geology and groundwater information discussed in Section 2.2.1. Therefore, the rule sets underpinning the desktop mapping of potential aquatic GDEs are not applicable to the GDE study area.

The groundwater assessment also confirmed that there are no groundwater-surface water interactions or surface expressions of groundwater in the GDE study area. Furthermore, the groundwater table is located at a minimum depth of approximately 4 m, and up to 53 m, below the bed of the drainage features that traverse the GDE study area. On this basis, the site-specific field data and ground-truthed information confirms there are no drainage features within the GDE study area that are dependent on groundwater. The potential aquatic GDEs identified in the desktop mapping are therefore not present.

2.3.4 POTENTIAL TERRESTRIAL GDEs

The GDE Atlas indicates that there are low and moderate potential terrestrial GDEs within the GDE study area (Figure 8).

The low potential terrestrial GDE is described as a regional ecosystem (RE) (specifically RE 2.3.23a/2.10.1a) containing Eucalyptus species that are dependent on alluvial aquifers with fresh, seasonal flow. The area mapped as a low potential terrestrial GDE aligns with the desktop mapping of the alluvial aquifer (Figure 8).

The mapped areas of moderate potential terrestrial GDEs are described as follows:

- Treed regional ecosystems (specifically RE 2.10.2x5a and 2.10.1a) within 50 m of a channel dependent on fresh, seasonally saturated sandstone aquifers. These moderate potential terrestrial GDEs relate to the same drainage feature (channel) segments that are mapped as moderate potential aquatic GDEs (Section 2.3.3).
- Treed regional ecosystems (specifically REs 2.5.9/2.5.18a, 2.5.9/2.5.9x2a and 2.10.1a) within 50 m of the old loamy and sandy plain contact zone that are dependent on fresh, seasonally saturated sandy plain aquifers. These moderate potential terrestrial GDEs follow the boundary between the desktop mapping of alluvial and sandy plain aquifers.

The ground-truthed REs (Section 2.2.3) differ from the specific REs that support the desktop mapping of potential terrestrial GDEs, however, they contain similar species of woodland vegetation.

The desktop mapping of potential GDE aquifers is not consistent with the site-specific geology and groundwater information discussed in Section 2.2.1. Hence, the rule sets that underpin the classification of potential terrestrial GDEs are not applicable to the GDE study area. The potential terrestrial GDEs identified in the desktop mapping are therefore not present within the GDE study area.

The GDE Atlas also indicates that the riparian vegetation along the Woolgar River is a low potential terrestrial GDE. The ground-truthed site geology indicates there is localised alluvium associated with the Woolgar River that may support this riparian vegetation. However, as discussed in Section 2.2.1, the Woolgar River alluvium is beyond the maximum predicted extent of groundwater drawdown from the project. Hence, any potential

terrestrial GDEs associated with the Woolgar River alluvium are not within the GDE study area and will therefore not be impacted by groundwater drawdown from the project.

2.4 GDEs IDENTIFIED IN THE STUDY AREA

This section describes the presence and distribution of potential aquatic and terrestrial GDEs within the GDE study area. These have been determined through an assessment undertaken using site-specific data and ground-truthed information sourced from the groundwater and terrestrial ecology assessments and described in Section 2.2. The assessment also considered the desktop mapping of potential GDEs, where these were consistent with the ground-truthed site-specific data.

2.4.1 AQUATIC GDEs

Based on the field validation that confirms the lack of interaction between groundwater and surface water (Section 2.2.2), the drainage features within the GDE study area are not potential aquatic GDEs.

Hence, there are no potential aquatic GDEs present within the GDE study area, and therefore the project's effects on groundwater are not expected to give rise to any impacts on aquatic GDEs.

2.4.2 TERRESTRIAL GDEs

Based on the field-validated geology, groundwater and ecology information described in Section 2.2, and the IESC GDE Guideline decision rules described in Section 2.1, the potential terrestrial GDEs identified within the GDE study area are as follows:

- Woodland vegetation in areas where the groundwater table is located in the alluvium or weathered profile at depths of between 15 m and 20 m below ground level. These potential terrestrial GDEs have been assessed as having a low likelihood of accessing groundwater.
- Woodland vegetation in areas where the groundwater table is located in the alluvium or weathered profile at depths of between 10 m and 15 m below ground level. These potential terrestrial GDEs have been assessed as having a moderate likelihood of accessing groundwater.
- Woodland vegetation in areas where the groundwater table is located in the alluvium or weathered profile at depths of up to 10 m below ground level. These potential terrestrial GDEs have been assessed as having a high likelihood of accessing groundwater.

Figure 7 shows the distribution of potential terrestrial GDEs across the GDE study area.

2.5 IMPACT ASSESSMENT

The groundwater assessment concluded that the project is not likely to result in a significant change to surrounding groundwater quality or associated impact on any sensitive environmental features. As a result, the potential GDE impacts of the project are limited to the direct effects of mining disturbance and the indirect effects of changes to groundwater levels. The direct effects of mining disturbance on terrestrial vegetation are assessed in the Terrestrial Ecology Report. The potential indirect impacts on terrestrial GDEs due to changes in groundwater levels are assessed in this section.

The project's effects on groundwater levels during mining and post closure are presented in the Groundwater Report. The maximum drawdown due to project mining is predicted to occur at the end of mining operations. Post mining, groundwater levels around the BVS Pit final void will recover in line with the establishment of a final void lake. Hence, the maximum potential impact on any GDEs due to groundwater drawdown will occur at the end of mining and the extent of any impact from drawdown on GDEs would reduce in the post mining phase due to the recovery in groundwater levels. The extent of maximum predicted drawdown is generally localised within the project disturbance area (within which vegetation will be directly impacted). Since vegetation communities that are potential terrestrial GDEs will be cleared from the project disturbance area, there is no potential for additional indirect impacts on terrestrial GDEs present within the project disturbance area.

In discrete areas, the maximum predicted drawdown from the project on the unconfined water table extends beyond the north and north-east boundary of the project disturbance area. These are the areas shown in Figure 7 that are outside the project disturbance area but inside the GDE study area. As discussed in Section 2.4.2 and shown in Figure 7, potential terrestrial GDEs have been identified in the area to the north of the project disturbance area that is predicted to be affected by groundwater drawdown from the project. Groundwater modelling indicates that the depth to groundwater in this area is predicted to increase by up to approximately 10 m as a result of the maximum drawdown due to mining. For a portion of this area, the impacted groundwater table is predicted to remain accessible by the roots of the vegetation (specifically, the depth to groundwater will remain less than 15 m below ground surface and above the fresh rock formations).

There are discrete areas where groundwater modelling indicates that drawdown from project mining activities would lower the groundwater table such that it is no longer accessible to the vegetation roots. At these locations, the depth to groundwater following maximum drawdown from the project will be greater than 15 m below ground level and within the fresh rock formations. Hence, the condition of woodland vegetation in these areas could potentially be impacted by the predicted changes to groundwater depth due to the project. These areas of potential indirect impacts to terrestrial GDEs (that are outside the directly impacted project disturbance area) are shown in Figure 9 and comprise a total area of approximately 43 ha of Least Concern vegetation.

2.6 MONITORING AND MANAGEMENT

The groundwater monitoring program for the project is described in the Groundwater Report.

The groundwater monitoring network comprises 14 monitoring bores and three Vibrating Wire Piezometers (VWPs) (Figure 3) and was designed to establish baseline groundwater levels and quality within the project site. The baseline groundwater monitoring data will be used to derive compliance monitoring triggers that will be included in the Environmental Authority (EA) groundwater conditions.

The EA groundwater conditions will specify the compliance monitoring program to be implemented throughout the life of the project to confirm the actual extent of groundwater impacts and validate the conservative groundwater modelling predictions presented in the Groundwater Report.

The compliance monitoring program will incorporate the existing groundwater monitoring network. The existing groundwater monitoring network includes bores located outside the maximum predicted zone of groundwater drawdown that can be used for monitoring background conditions in the aquifers. It also includes bores located within the predicted maximum zone of groundwater drawdown that can be used to validate the groundwater drawdown predictions. The groundwater monitoring network is therefore suitable for identifying and monitoring the effects of the project on the groundwater regime.

The EA groundwater conditions will also contain groundwater level triggers, based on the predicted drawdown, and quality compliance triggers, based on site-specific water quality objectives derived from baseline water quality data. The project Progressive Rehabilitation and Closure Plan (PRCP) also includes a groundwater monitoring program for the post closure phase and milestone criteria related to the final void groundwater sink and associated post mining groundwater levels. This includes continuation of groundwater level and quality monitoring, monitoring of the BVS Pit final void lake level and milestone criteria related to groundwater quality/achievement of a collective final void sink.

The operational and post closure groundwater monitoring and comparison of monitoring results with relevant groundwater level and quality trigger values/milestone criteria will identify any unanticipated groundwater drawdown effects or quality issues arising from the project and ensure the early identification of any potential groundwater contamination or unexpected groundwater drawdown effects. If identified, this would enable further assessment of the potential for any associated unanticipated impacts on GDEs and, where necessary, suitable management measures for any significant impacts.

In addition, the EA will include a requirement to undertake an annual review of the groundwater monitoring program and supporting data to ensure it is fit for purpose, to review the accuracy of the groundwater predictions and to review the suitability of the groundwater triggers and EA groundwater conditions.

If the operational or post closure groundwater level monitoring results confirm the groundwater levels and/or changes in groundwater levels resulting from the project are likely to result in potential impacts on any GDEs, vegetation surveys will be undertaken to monitor the condition of the potential terrestrial GDEs in the affected areas. The results of any vegetation surveys would detect any significant impacts on the vegetation condition and enable the assessment of feasible mitigation measures. In the event that there are no feasible mitigation measures available, offsets would be provided for any associated significant residual impacts on prescribed environmental matters.

3 SUBTERRANEAN GDEs

3.1 INTRODUCTION

Subterranean GDEs are ecosystems associated with groundwater in caves and aquifers. The IESC GDE Guideline proposes that the main indicator that an aquifer ecosystem is present is that the aquifer supports a stygofauna community.

Stygofauna are aquatic animals (generally invertebrates such as crustaceans) that are adapted to living in groundwater. Stygofauna are best known from limestone, calcrete and fractured rock aquifers, but can also occur in alluvial aquifers (Hancock et al., 2005). Within alluvial aquifers, stygofauna are typically concentrated in the hyporheic zone where surface waters and groundwater mix.

3.2 METHODOLOGY

The subterranean GDE assessment has been undertaken with consideration for the framework set out in the Queensland *Groundwater Dependent Ecosystems: EIS Information Guideline* (DETSI, 2024) and the IESC GDE Guideline, as well as guidance provided in the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITI, 2015), and involved the following:

- Conducting a desktop habitat assessment to assess the potential presence of stygofauna and suitable stygofauna habitat within the project site and its surrounds, based on a desktop search of relevant GDE databases and the site-specific geology and groundwater data.
- Undertaking a stygofauna sampling program to verify the results of the desktop habitat assessment and to confirm the presence or absence of stygofauna in the aquifers that will be affected by the project.
- Assessing the potential impacts from the project on any confirmed stygofauna assemblages or stygofauna habitat.
- Identifying any monitoring and management measures required, as relevant.

3.3 DESKTOP HABITAT ASSESSMENT

The key findings of the desktop habitat assessment are as follows:

- The Queensland subterranean aquatic fauna database (DES, 2016) provides a catalogue of subterranean aquatic fauna sampling undertaken in Queensland by government, industry and research institutions. This database indicates there are no records of stygofauna in the project site or its surrounds.
- The GDE Atlas indicates there are no mapped subterranean GDEs or groundwater dependent cave areas in the vicinity of the project site.
- There are no limestone or calcrete aquifers present within the vicinity of the project site. The lithology of the local geology typically comprises a weathered profile of fine-grained, clay-bound sands and

silts, underlain by interbedded sandstone, siltstone and claystone and a crystalline and metamorphosed rock mass. These lithologies do not represent likely stygofauna habitat.

- Local drainage features are ephemeral and lack alluvium, indicating that there is negligible potential for hyporheic mixing zones that typically host stygofauna.
- Areas of saturated Woolgar River alluvium contain a hyporheic mixing zone that represents possible stygofauna habitat. This alluvium naturally exhibits significant and rapid changes in water levels in response to seasonal flow events, creating conditions that are not considered to be conducive to the presence of groundwater dependent organisms.

The findings of the desktop habitat assessment indicate that significant stygofauna habitat or assemblages are unlikely to occur in the aquifers that will be affected by the project.

3.4 STYGOFAUNA SAMPLING

A stygofauna sampling program was undertaken to confirm the findings of the desktop habitat assessment and to provide a baseline assessment of the presence of stygofauna within the project site and its surrounds. The sampling program is described in the Aquatic Ecology Report and involved two rounds of sampling, undertaken at the end of the 2018-2019 wet season and the end of the 2020-2021 wet season. Appropriate stygofauna sampling locations were selected with consideration of the guidance provided in the IESC GDE Guideline. The sampling program encompassed the range of possible stygofauna habitats within the project site and surrounds and included five field sites along the Woolgar River and nine groundwater monitoring bores. An additional five shallow groundwater bores were targeted, however these bores were dry and therefore samples could not be collected. The stygofauna sampling locations are described in the Aquatic Ecology Report and shown in Figure 3.

Each sampling round resulted in five samples collected from the hyporheic zone within the Woolgar River alluvium (i.e. 10 samples in total) and nine samples collected from the groundwater monitoring network (i.e. 18 samples in total) as follows:

- Six bores targeting the Proterozoic Basement (MB1B, MB2B, MB4B, MB5B, MB6B and MB7B);
- Two bores targeting the Jurassic strata (MB2A and MB7A); and
- One bore targeting the weathered profile (MB3B).

Bore sampling was undertaken using a method that complies with the *Environmental Protection (Water) Policy 2009 - Monitoring and Sampling Manual, Biological Assessment: Background information on sampling bores for stygofauna* (Queensland Government, 2018).

The monitoring bores were sampled more than six months after bore construction to enable any stygofauna communities to establish prior to sampling, in accordance with the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITI, 2015).

The samples were analysed for the presence of stygofauna by Stygoecologia. Fauna present in the samples were identified using morphological features to the lowest practical taxonomic level (i.e. class, order or family). Where specimens were identified to be stygofauna, based on the presence of specialised stygofauna adaptations, an assessment of groundwater dependency for each taxa was made.

The stygofauna sampling results are presented in the Aquatic Ecology Report and show that:

- No obligate stygofauna were detected in any samples.
- No stygofauna were detected in the samples collected from the groundwater monitoring bores.
- Stygofauna were detected in the hyporheic zone in the Woolgar River alluvium.

Fauna detected in the samples collected from the hyporheic zone within the Woolgar River alluvium (coleoptera, diptera, ephemeroptera, hemiptera, nematodes and oligochaetes) are commonly found in soil, aquatic sediments and on the surface of water bodies. These specimens use groundwater optionally or opportunistically and do not require groundwater systems to complete their lifecycle.

The absence of obligate stygofauna is consistent with the findings of the desktop habitat assessment that the groundwater regime generally provides unfavourable conditions for the presence of significant groundwater dependent stygofauna assemblages.

3.5 IMPACT ASSESSMENT

The presence of stygofauna within the hyporheic zone in the Woolgar River alluvium indicates that this may be an aquifer ecosystem and therefore a potential subterranean GDE. However, the stygofauna detected in the Woolgar River alluvium are unlikely to be unique to the project site and its surrounds. As discussed in the Groundwater Report, the Woolgar River alluvium is essentially continuous along the length of the river. There are no significant geological boundaries or structures to truncate groundwater flow. It is therefore highly unlikely that any subterranean fauna associated with the Woolgar River alluvium would be endemic or highly localised.

Regardless, the Woolgar River alluvium is located outside the maximum predicted extent of drawdown from the project. Hence, the project is not predicted to have any effect on groundwater levels in the hyporheic zone in the Woolgar River alluvium where the stygofauna were detected. The Groundwater Report also explains that the project activities are not predicted to give rise to any significant impacts on groundwater quality in the Woolgar River alluvium.

On this basis, the project is not predicted to give rise to any impacts on stygofauna or potential subterranean GDEs.

3.6 MONITORING AND MANAGEMENT

As explained in Section 2.6, the groundwater monitoring program and EA groundwater conditions will be designed to identify any unanticipated groundwater drawdown effects or quality issues arising from the project. If unanticipated effects are identified, this would enable further assessment of any potential impacts on stygofauna or subterranean GDEs.

4 CONCLUSIONS

The GDE assessment has been conducted in accordance with the framework set out in the Qld GDE Guideline and the IESC GDE Guideline. It has been informed by relevant site-specific data and ground-truthed information on geology, hydrogeology, ecology and stygofauna, provided by specialist consultants in these areas, and has considered available desktop database information.

The key conclusions of the GDE assessment are as follows:

AQUATIC GDEs

- There are no aquatic GDEs present within the GDE study area and therefore the project's effects on groundwater are not expected to give rise to any impacts on aquatic GDEs. This is based on the following:
- The Woolgar River bed is outside the maximum predicted extent of groundwater drawdown from the project.
- Within the GDE study area, the groundwater table does not intersect the ground surface and there is no groundwater seepage through the creek beds or banks to provide baseflow to drainage features.

TERRESTRIAL GDEs

- Woodland vegetation in areas where the groundwater table is located in the alluvium or weathered profile at depths of up to 20 m below ground level is a potential terrestrial GDE.
- Potential terrestrial GDEs present within the project disturbance area will be directly impacted by vegetation clearing. The impacts on vegetation, including any GDEs, within the project disturbance area are addressed in the Terrestrial Ecology Report.
- Potential terrestrial GDEs present outside the project disturbance area but within the maximum predicted extent of groundwater drawdown from the project may be indirectly impacted by changes in groundwater levels from the project. The total area of terrestrial GDEs that may be indirectly impacted is approximately 43 ha of woodland vegetation.

SUBTERRANEAN GDEs

- The project's effects on groundwater are not expected to give rise to any impacts on any stygofauna or potential subterranean GDEs. This is based on the following:
- There are no mapped groundwater dependent cave areas within the vicinity of the project site.
- The project is not predicted to affect groundwater levels in the hyporheic zone in the Woolgar River alluvium that was found to host stygofauna.
- Stygofauna assemblages or significant stygofauna habitat have not been identified in any formation that will be affected by the project.
- The project is not expected to cause groundwater contamination.

MONITORING AND MANAGEMENT

The project groundwater monitoring program and EA groundwater conditions will be designed to identify any unanticipated groundwater effects from the project and will involve the following:

- Groundwater monitoring will be undertaken during the operations and post closure phases to confirm the actual extent of groundwater drawdown including the area where groundwater modelling indicates that potential terrestrial GDEs may be impacted by changes in groundwater levels associated with the project.
- If the groundwater level monitoring results confirm the groundwater levels and/or changes in groundwater levels resulting from the project are likely to result in potential impacts on any GDEs, vegetation surveys will be undertaken to monitor the condition of the potential terrestrial GDEs in the affected areas. The results of any vegetation surveys would detect any significant impact on the vegetation condition. Offsets would be provided for any associated significant residual impacts on any prescribed environmental matters.
- Groundwater monitoring and comparison of monitoring results with relevant groundwater level and quality trigger values will identify any unanticipated groundwater drawdown effects or quality issues arising from the project. If unanticipated effects are identified, this would enable further assessment of any potential for any associated unanticipated impacts on GDEs.

5 REFERENCES

Bennie, A.T.P (1991). *Growth and Mechanical Impedance*. Chapter 19. In: *Plant Roots the Hidden Half*. Waisel, Y., Eshel, A. and Kafkafi, U. (Eds.), pp. 393 – 414. Marcel, New York.

Bureau of Meteorology (2019) *GDE Atlas*. Accessed January 2025 at <<http://www.bom.gov.au/water/groundwater/gde/>>

Canadell, J., Jackson, R.B., Ehleringer, J.R., Mooney, H.A, Sala, O.E, Schulze, E.D. (1996). *Maximum Rooting Depth of Vegetation Types at the Global Scale*. *Oecologia*, 108:583-595.

De Araujo Pereira, A.P., Santana, M. C., Bonfim, J.A., de Lourdes Mescolotti, D., Cardoso, E.J.B.N. (2018). *Digging deeper to study the distribution of mycorrhizal arbuscular fungi along the soil profile in pure and mixed Eucalyptus grandis and Acacia mangium plantations*. *Applied Soil Ecology*, 128:1-11.

Department of Environment and Science (2016). *Queensland Subterranean Aquatic Fauna Database*. Accessed August 2023 at <www.data.qld.gov.au/dataset/queensland-subterranean-aquatic-fauna-database>.

Department of Environment and Science (2018). *Groundwater dependent ecosystems and potential aquifer mapping – Queensland*. Accessed January 2025 at <<https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={2DF30B15-FA92-47EC-BD2F-5FF1F311DC69}>>.

Department of Environment, Science and Innovation (2019). *WetlandMaps – Interactive Maps and Wetlands Data in Queensland*, *WetlandInfo* website. Accessed January 2025 at <<https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/get-mapping-help/wetland-maps/>>

Department of Environment, Science and Innovation (2024). *Groundwater dependent ecosystems: EIS information guideline*, ESR/2020/5301, Queensland Government, Brisbane.

Department of Natural Resources, Mines and Energy (2019). *Great Artesian Basin and Other Regional Aquifers Water Management Protocol 2017*.

Department of Science, Information Technology and Innovation (2015). *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna*.

Department of Science, Information Technology, Innovation and the Arts (2012). *Land Zones of Queensland*.

Doody, T.M., Hancock, P.J. and Pritchard, J.L. (2019). *Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems*. Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Australian Government.

Environment Protection and Biodiversity Conservation Act 1999

Feldman, L.J. (1984). *Regulation of Root Development*. *Annual Review of Plant Physiology* 1984, 35:223-42. California, USA.

Hancock, P.J., Boulton, A.J. and Humphrey, W. F. (2005). *Aquifers and hyporheic zones: Towards an ecological understanding of groundwater*. *Hydrogeology Journal*, 13(1), 98–111.

Jackson, R.B., Canadell, J., Ehleringer, J.R., Mooney, H.A., Sala, O.E, and Schulze E.D. (1996). *A global analysis of root distributions for terrestrial biomes*. *Oecologia* 108: 389-411.

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S., Butler, D.W., McDonald, W.J.F, Richter, D., Addicott, E.P. and Appelman, C.N. (2023). *Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland*. Version 7.0. Queensland Herbarium, Queensland Department of Environment, Science and Innovation, Brisbane.

Queensland Government (2018). *Environmental Protection (Water) Policy 2009 - Monitoring and Sampling Manual*, Biological Assessment: Background information on sampling bores for stygofauna.

Queensland Government (2019). *Queensland Springs Database*. Accessed August 2023 at <www.data.qld.gov.au/dataset/springs>.

Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017.

Wilson, P.R. and Taylor, P.M. (2012). *Land Zones of Queensland*. Queensland Herbarium, Queensland Department of Science, Information Technology, Innovation and the Arts, Brisbane.

FIGURES



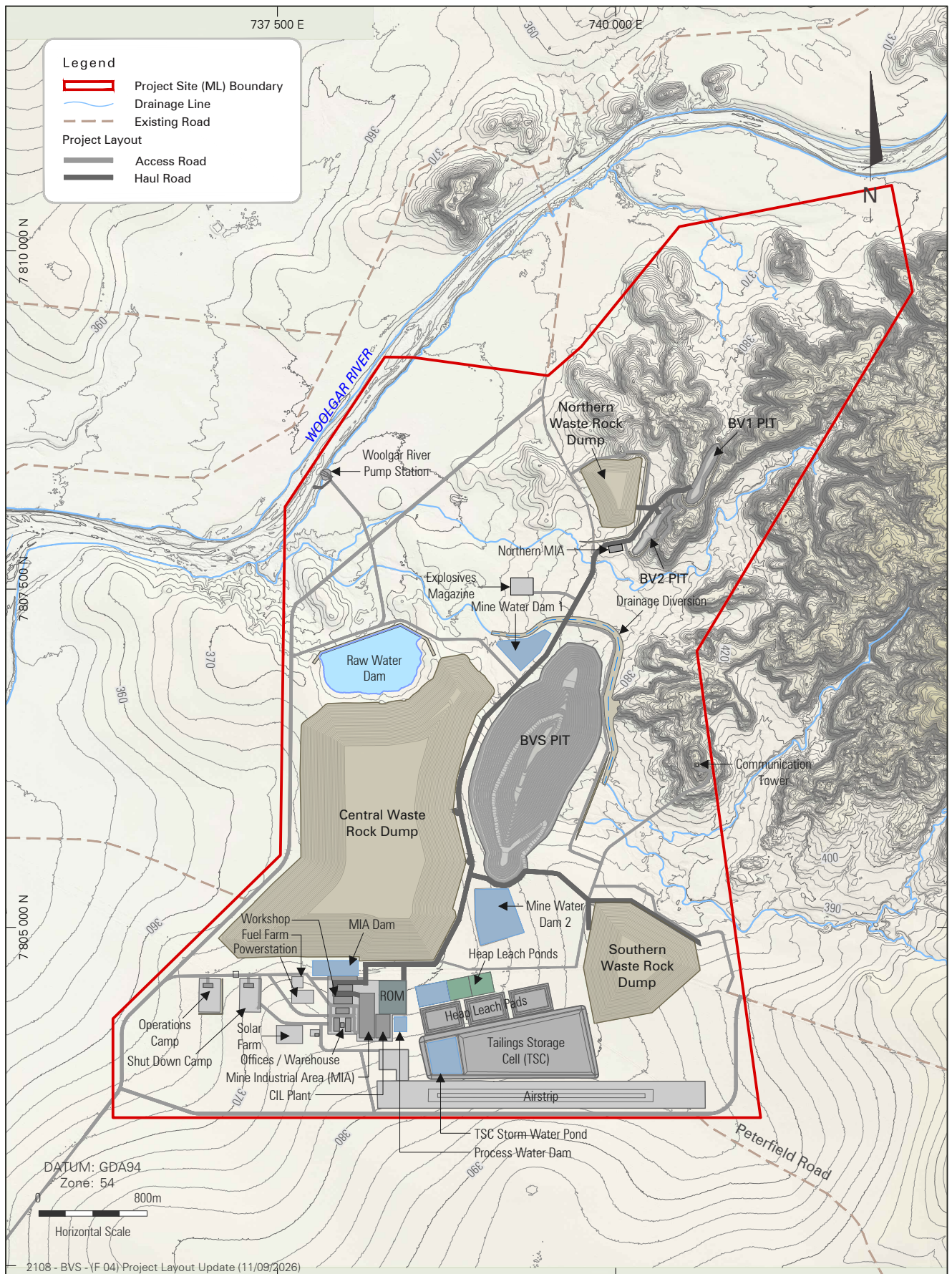
HANSEN
ENVIRONMENTAL
CONSULTING



BIG VEIN SOUTH GOLD PROJECT

Location Plan

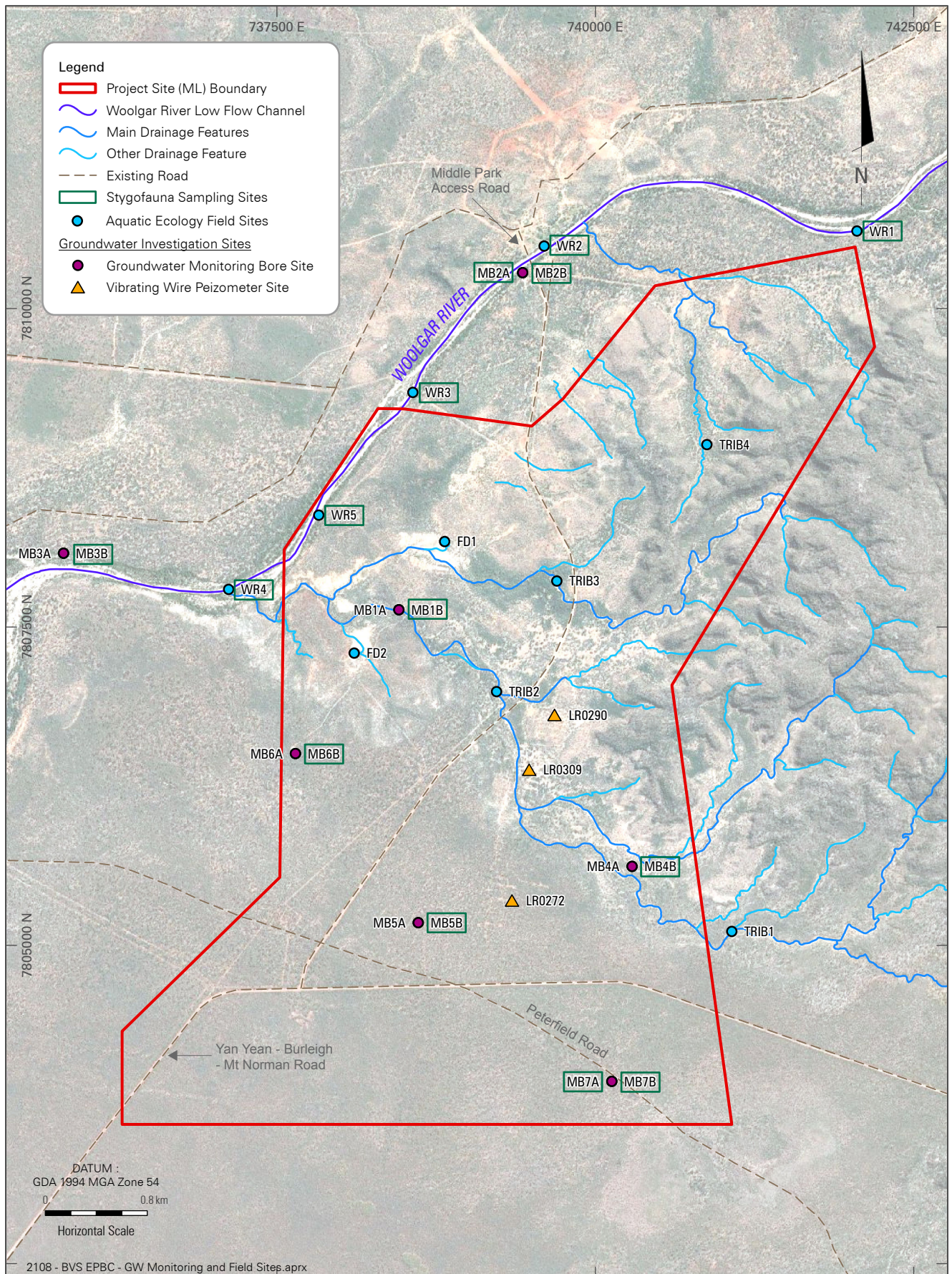
FIGURE 1



BIG VEIN SOUTH GOLD PROJECT

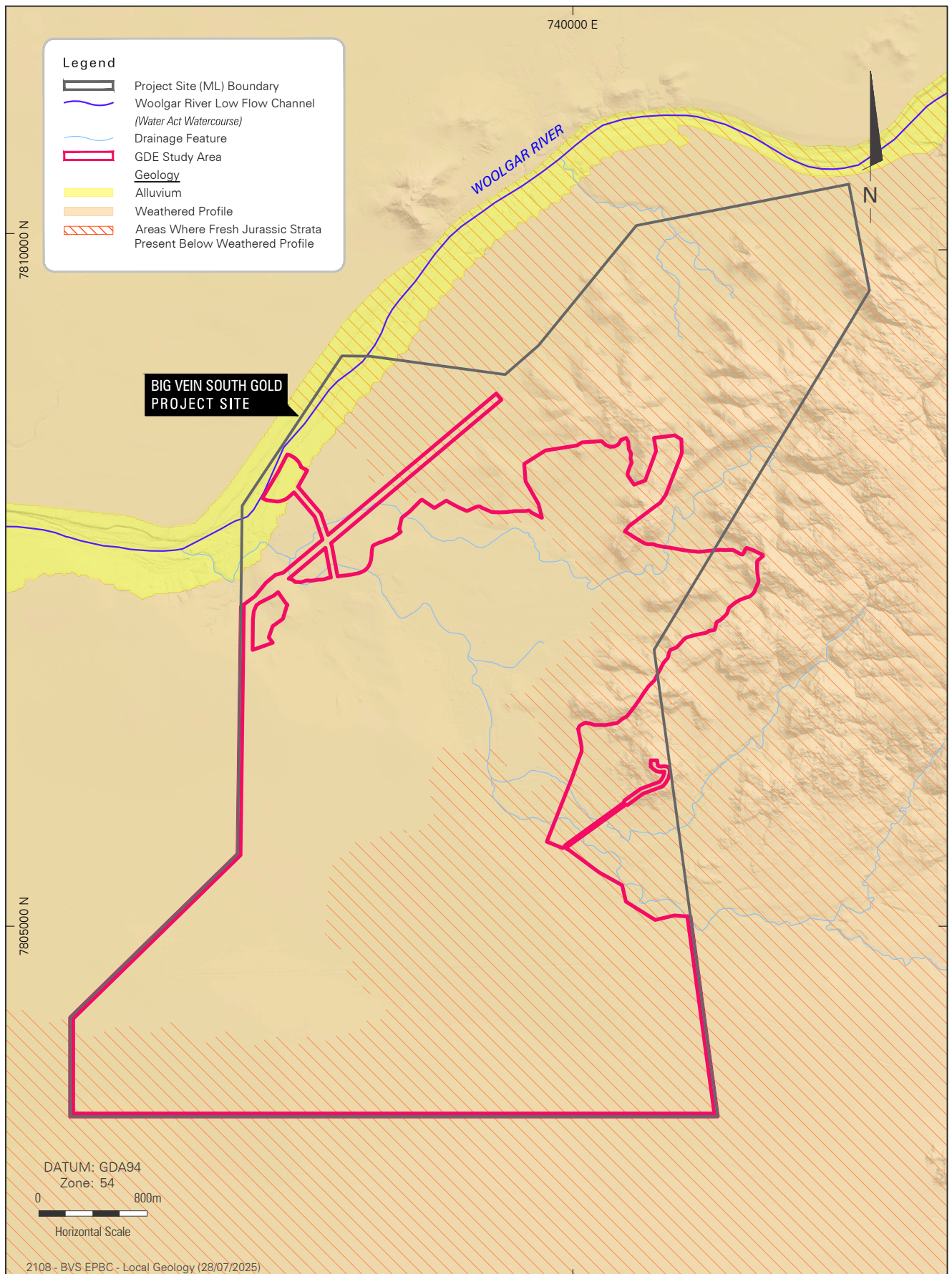
Project Layout

FIGURE 2



BIG VEIN SOUTH GOLD PROJECT
Groundwater Monitoring Network and
Woolgar River Field Sites

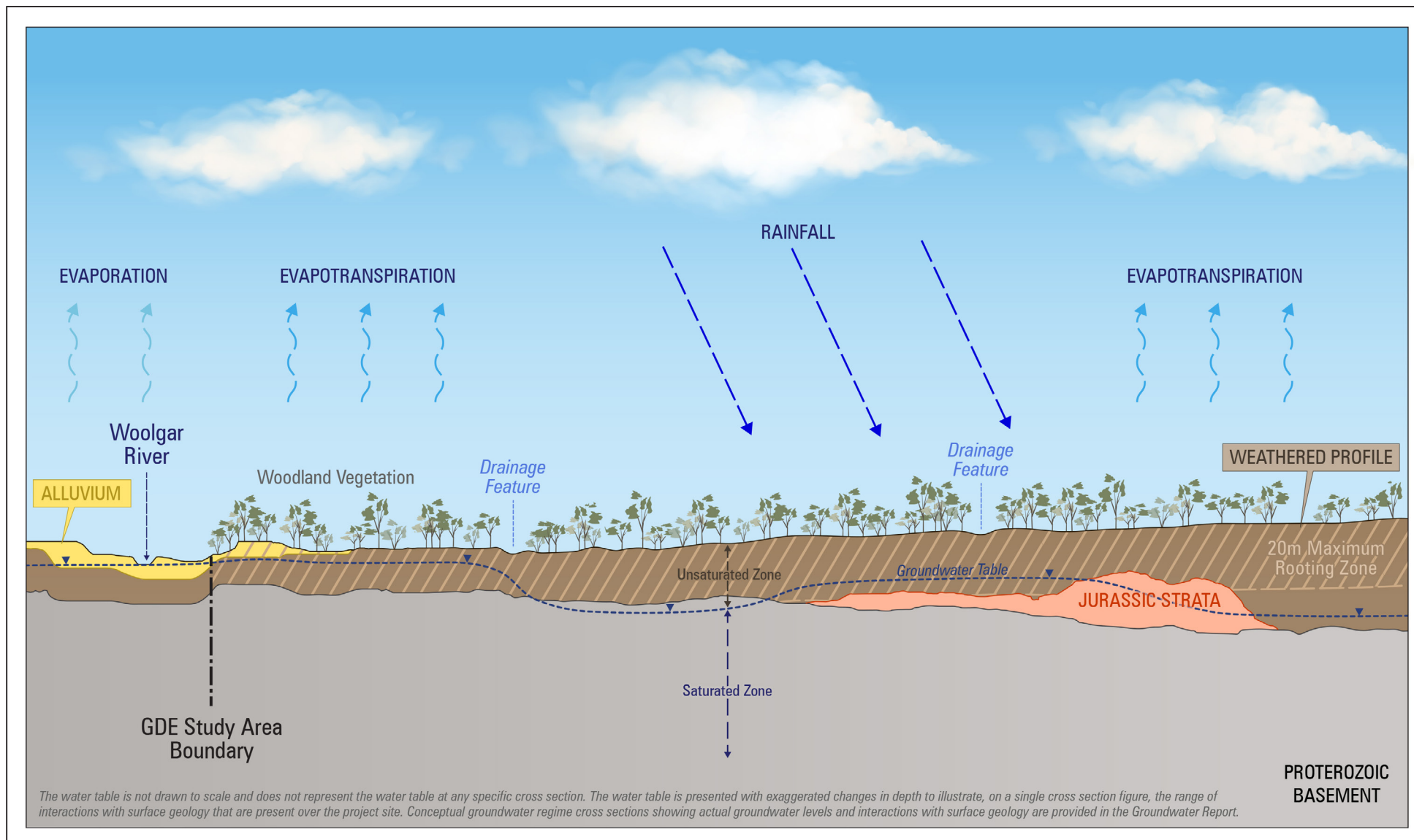
FIGURE 3

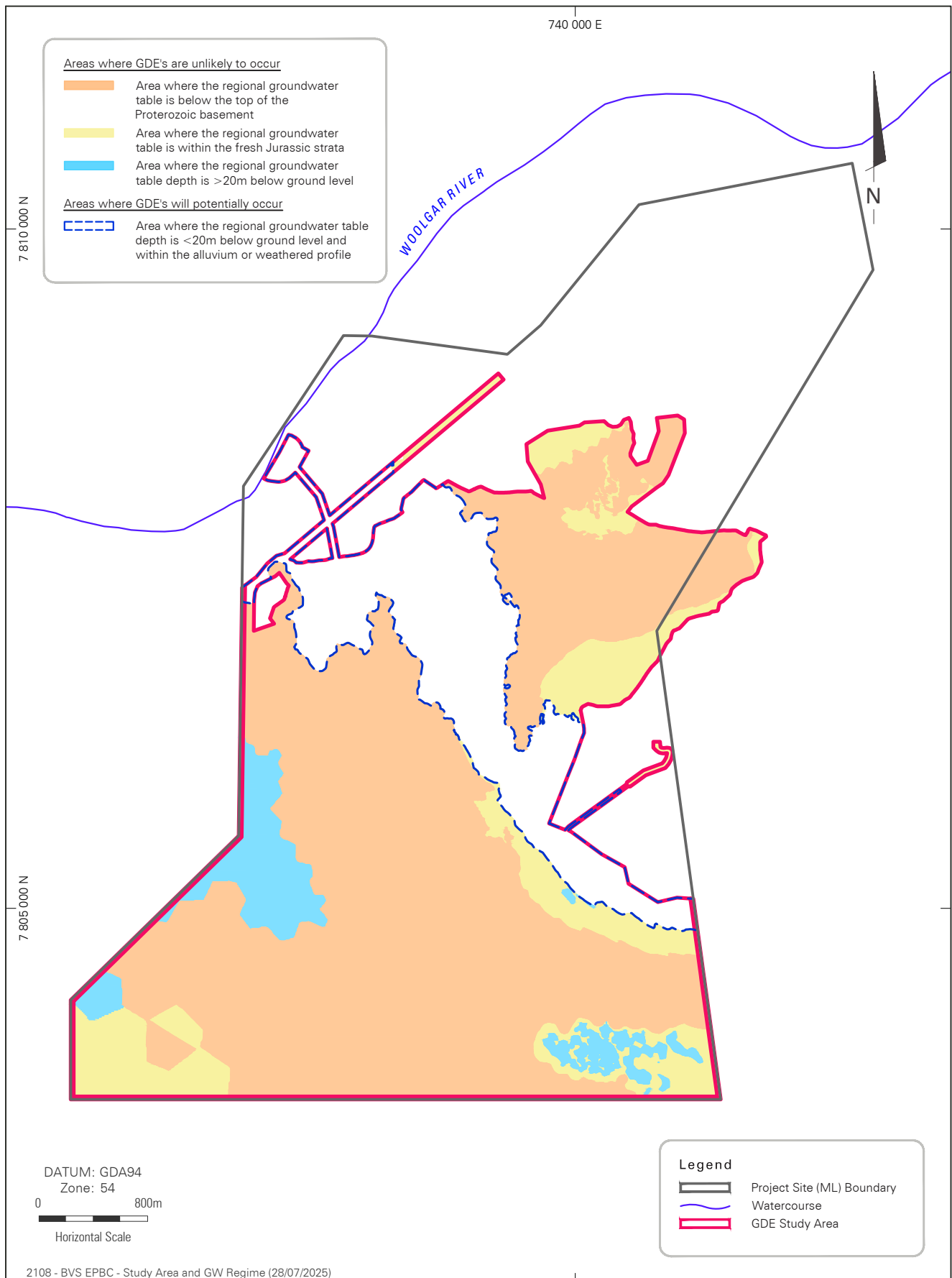


BIG VEIN SOUTH GOLD PROJECT

Local Geology

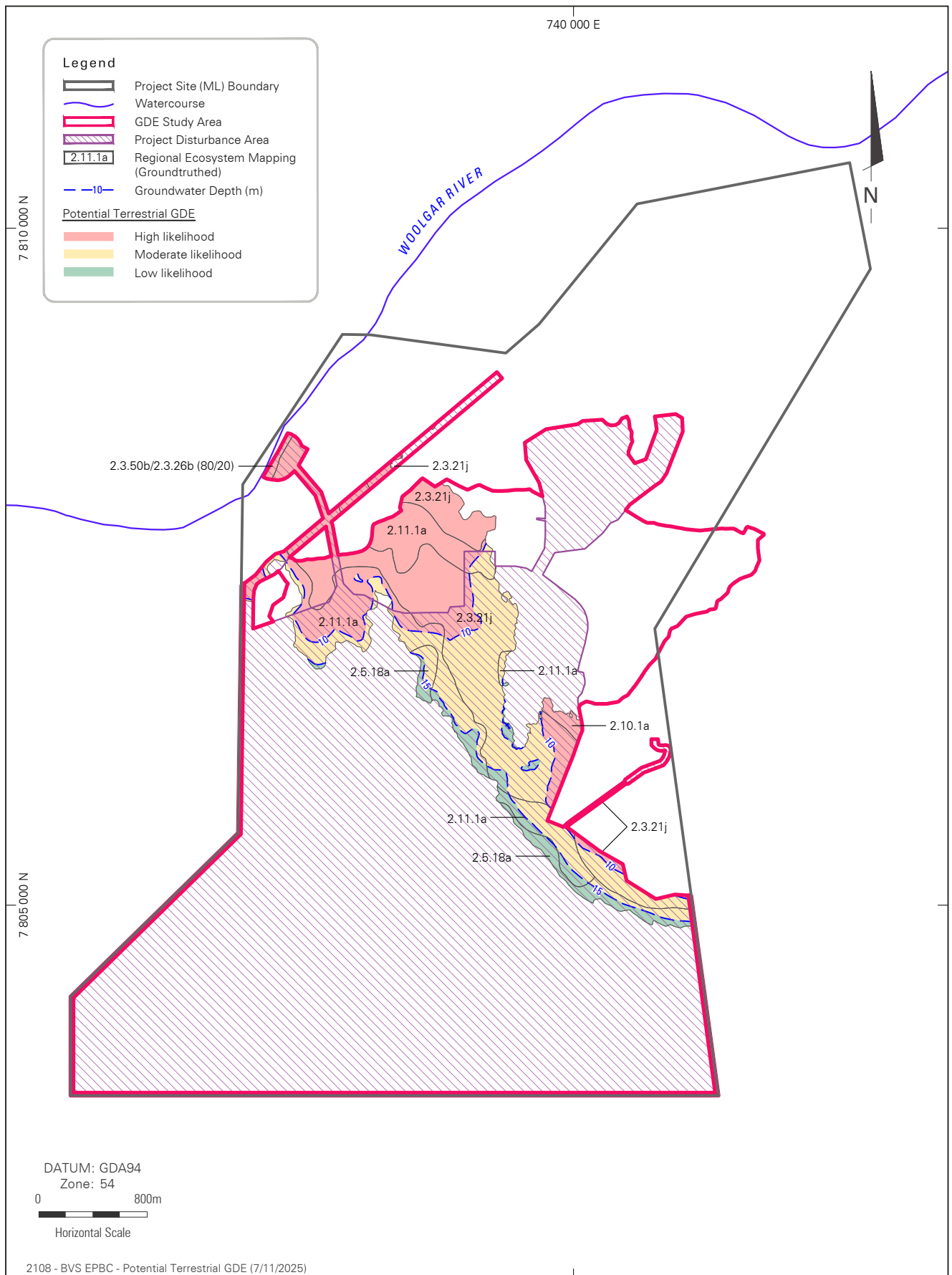
FIGURE 4





BIG VEIN SOUTH GOLD PROJECT
Groundwater Dependent Ecosystem Study Area
and Groundwater Regime

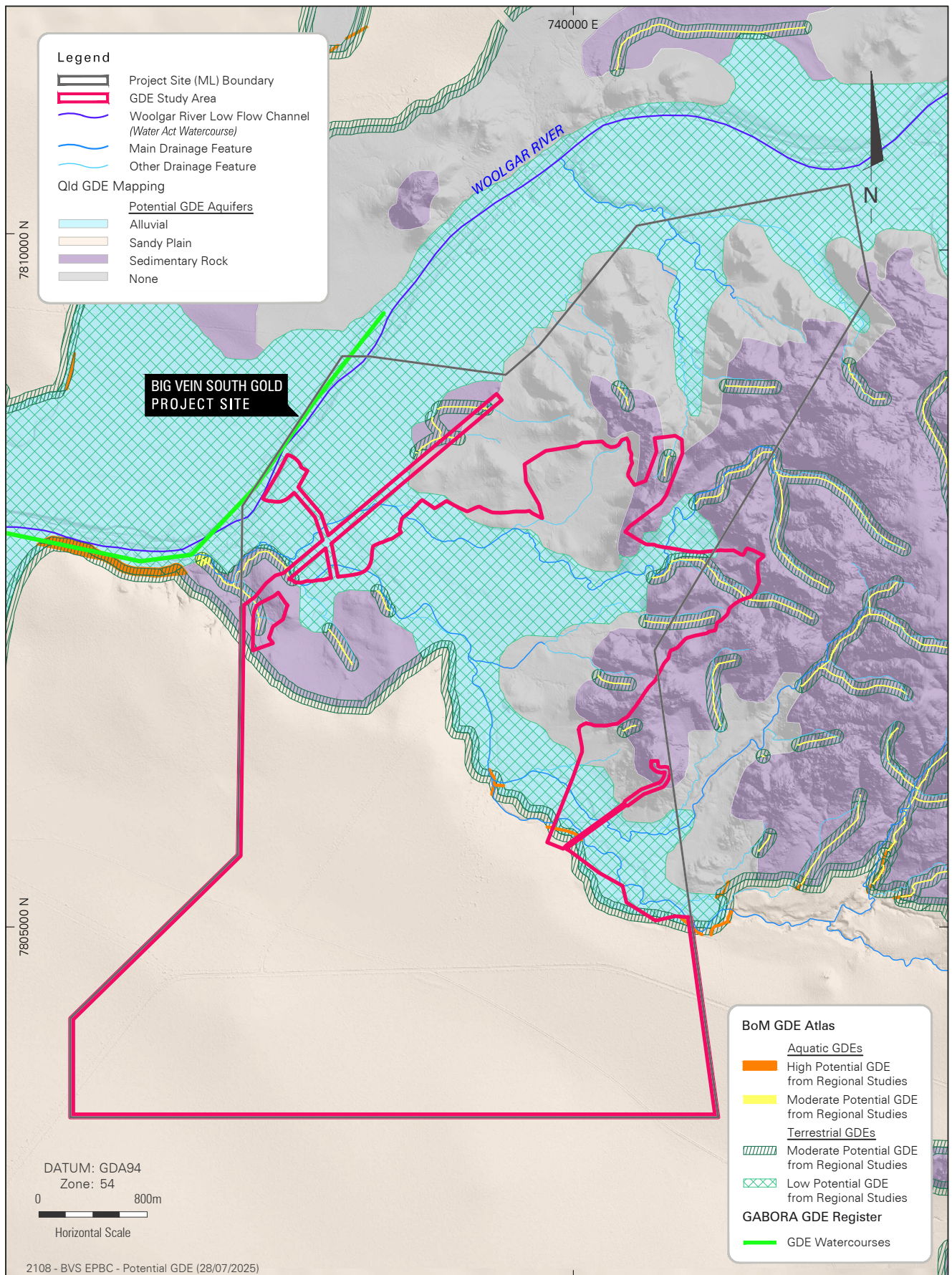
FIGURE 6



BIG VEIN SOUTH GOLD PROJECT

Potential Terrestrial Groundwater Dependent Ecosystems

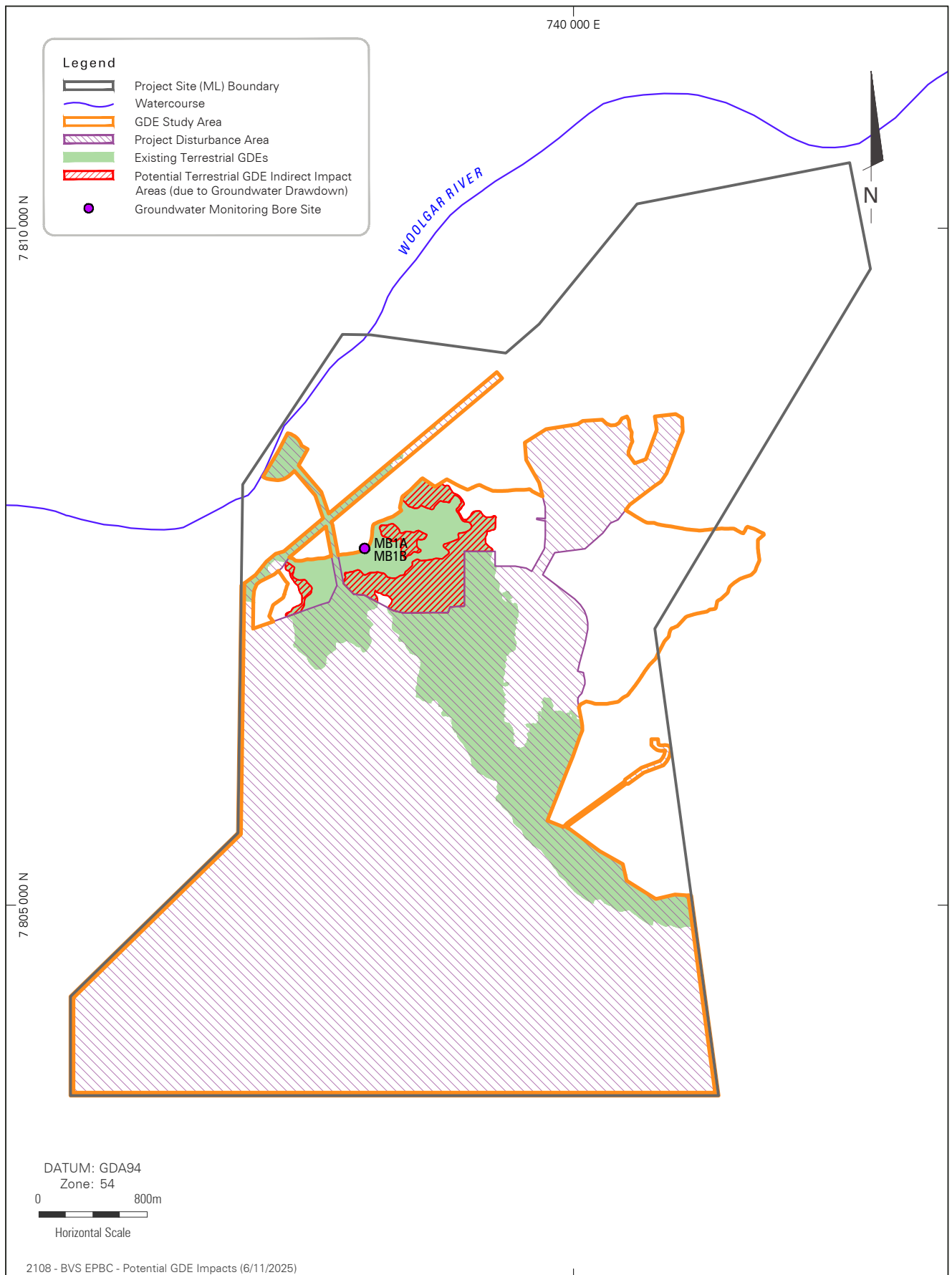
FIGURE 7



BIG VEIN SOUTH GOLD PROJECT

Mapped Potential Groundwater
Dependent Ecosystems

FIGURE 8



BIG VEIN SOUTH GOLD PROJECT
Potential Terrestrial Groundwater Dependent
Ecosystems Impact Areas

FIGURE 9