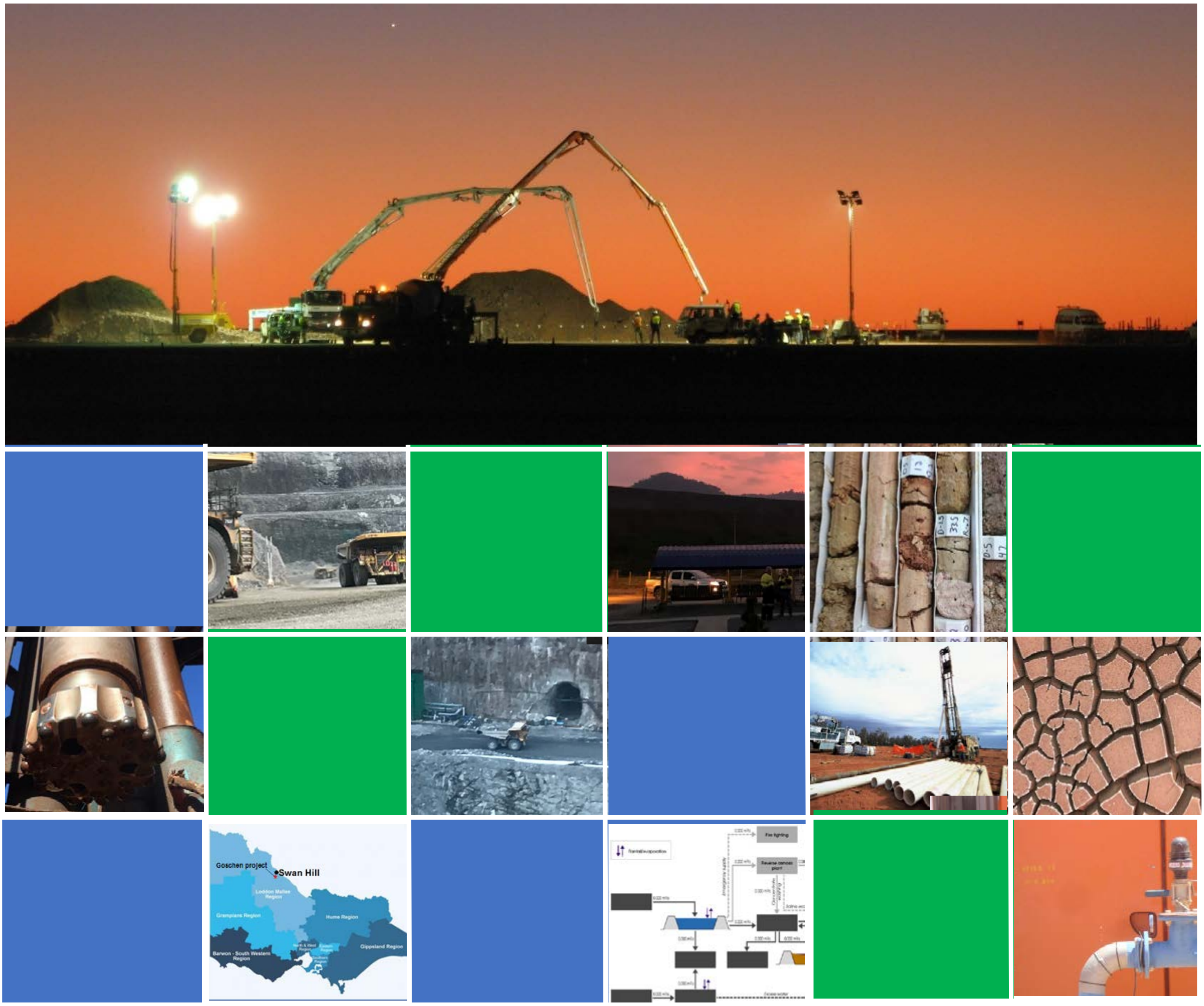

VHM Exploration Pty Ltd

Goschen Hydrogeological Assessment

31 May 2018

CDM Smith

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Document Title:	**Goschen Hydrogeological Assessment**
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Project Number:	1000035

Section 1 Introduction

1.1 Background

VHM Exploration Pty Ltd (VHM) has engaged CDM Smith Australia Pty Ltd (CDM Smith) to undertake hydrogeological studies to support development and permitting of the Goschen Project, a proposed mineral sand mine and processing operation located southwest of Swan Hill in the Loddon-Mallee Region of Victoria (Figure 1). VHM holds two Exploration Leases (ELs), EL5520 and EL6419.

Heavy Mineral Sand (HMS) deposits of the Murray Basin of Victoria are sourced from fluvial transport of heavy minerals from the weathered and eroded rocks of the Lachlan Orogen[1], which surround the eastern and southern parts of the Murray Basin to a paleo-coastline formed during Late Miocene-Early Pliocene marine regression across western Victoria and southeastern South Australia. Subsequent reworking of coastal sediments by wave action formed mineralised strandlines along northwest-southeast trending dune fields and sheet deposits associated with shallow nearshore sediments (Keeling *et al*, 2016). The mineralisation occurs within the Loxton-Parilla Sands unit (Olshina and van Kann, 2012) and, in Victoria, the valuable fraction of HMS deposits includes zircon, rutile, leucoxene and ilmenite minerals. Monazite is also present and is known to contain uranium and thorium.

1.2 Study Area

The VHM tenements reside within the Avoca River Basin, which itself resides in the much larger Murray geological basin. The northern limit of the tenement boundaries are approximately 15 km south of the township of Swan Hill (Figure 1). The tenements cover an area of approximately 760 km^2 and encapsulates the smaller towns of Kunat, Meatian, Lalbert, Tittybong and Cannie.

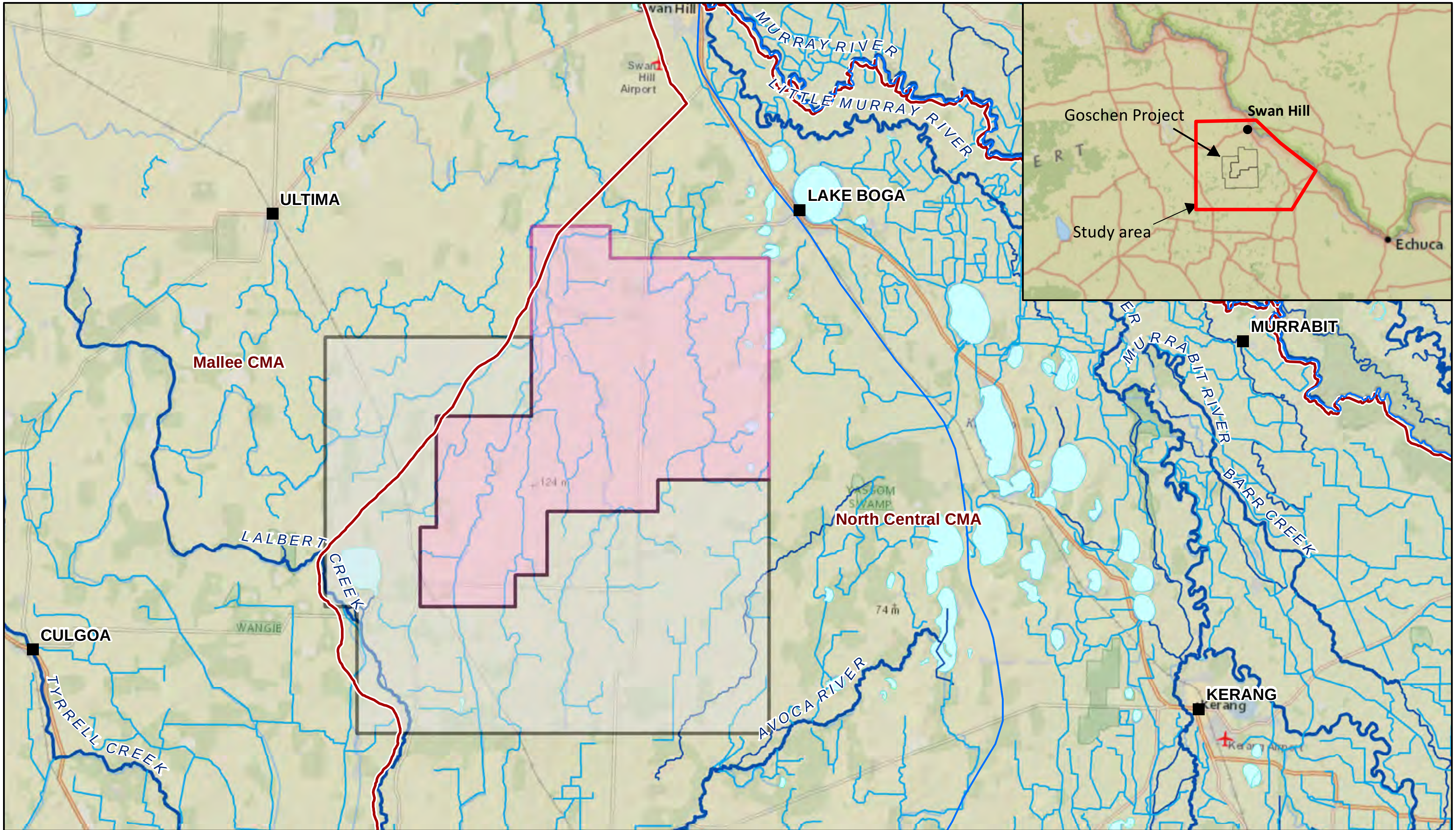
Lalbert Creek intersects the southwest corner of EL6419, whilst the Avoca River is located just outside the southeast boundary of EL6419 (Figure 1). The Kerang Lakes scatter the landscape to the east and northeast of the tenements, the most well-known being Lake Boga (Figure 1).

For the purposes of this hydrogeological assessment, the "Study Area" is presented on Figure 1 and includes VHM tenements, the Kerang Lakes and part of Avoca River.

Grampians Wimmera Mallee Water (GWMWater) manages groundwater and surface water licence diversions in the Study Area. There are no proclaimed groundwater management areas in the vicinity of the Goschen tenements and hence there are no relevant groundwater management plans or caps to consider.

The tenements reside on a boundary between two Catchment Management Authorities (CMAs) – the North Central and the Mallee CMAs (see Figure 1). Most of the tenement areas, however, reside in the North Central CMA jurisdiction, which is responsible for waterway management.

[1] An extensive belt of rocks deformed (folded and faulted) during Palaeozoic tectonism. The Lachlan Orogen (Fold Belt) dominates Eastern and Central NSW and Victoria, and extends into Tasmania and Queensland.



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Legend

- EL6419 tenement
- EL5520 tenement
- Catchment management authorities (CMA)
- Localities
- Canal
- Minor watercourse
- Major watercourse
- Lake

Figure 1

Goschen Project locality plan and study area

DATA SOURCE
VICMAP, 2017
Geofabric Product Suite V2.1.1 Bureau of Meteorology (BoM) 2011;1 Second SRTM v1.0 © Commonwealth of Australia (Geoscience Australia) 2011.

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1.3 Objectives

The hydrogeological assessment, which is to be undertaken in two parts (an initial desktop assessment followed by a field program) has the following objectives:

1. Characterisation of groundwater resources within and near to the Project area (recharge and discharge mechanisms, sources and sinks, etc.)
2. Identification of historical and existing beneficial uses of groundwater resources and the significance of groundwater systems in relation to existing users (environmental, social and commercial)
3. Identification of interactions between groundwater and surface water systems (wetlands, saline lakes, creeks and river)
4. Identification of interactions between different aquifers within and near to the Project area (e.g. deep and shallow, inland and riverine plain)
5. Analysis of seasonal influences on groundwater resources
6. Development of a conceptual hydrogeological model of the Goschen Project region, including uplands and riverine plain groundwater interactions
7. Assess potential effects of mining operations (water supply, mining and tailings disposal) on the groundwater baseline
8. Summarise relevant legislation, policy and guidelines to inform future project approvals documentation

This report directly addresses Objectives 1, 2, 5, 6 and 8, and partially addresses Objectives 3 and 4. Objectives 3 and 4 can be fully addressed at the completion of the field investigation program, along with any updates required for Objectives 1, 2, 5, 6 and 8.

Objective 7 can be addressed following completion of the proposed field investigation program and once a mine plan is provided.

Section 2 Physical setting

2.1 Climate and topography

2.1.1 Climate

Average annual rainfall for the Study Area ranges around 330 mm (source: Bureau of Meteorology; BoM). Mean monthly and annual deviation from the mean rainfall data for the Lake Boga (Kunat) BoM climate station (77021) are presented in Figure 2, Figure 3 and Figure 4, respectively. The data show:

- Monthly rainfall is fairly consistent across the average year, with winter and late spring typically experiencing higher rates of rainfall (Figure 2);
- Annual rainfall over the period of record (1933 to 2018) ranges between around 130 and 610 mm (Figure 3);
- Annual rainfall varies from the average by between around -200 mm and 300 mm (Figure 3 and Figure 4);
- Rainfall trends showing extended periods of above and below average rainfall is evident in the data set (Figure 4);
  - Between 1933 and 1945 a below average rainfall trend is evident (essentially representing drought)
  - Between 1949 and 1993 a generally above average rainfall trend is evident
  - Between 1999 and 2009 a below average rainfall trend is evident (representing the Millennial Drought).

Average annual evaporation in the Study Area is around 1,800 mm and mean minimum and maximum temperatures range between 9.7 and 23°C (source: BoM).

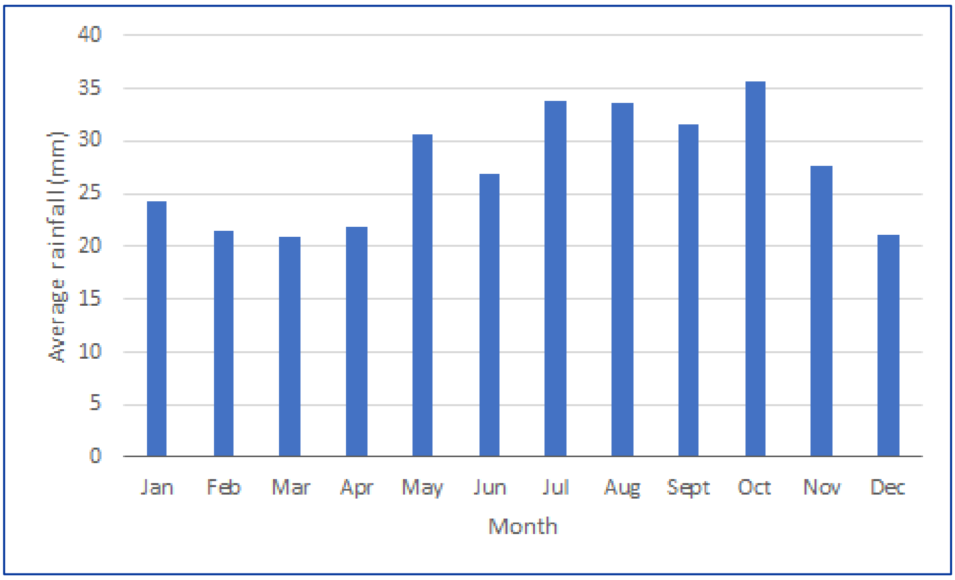


Figure 2 Lake Boga mean monthly rainfall data (source: BoM)

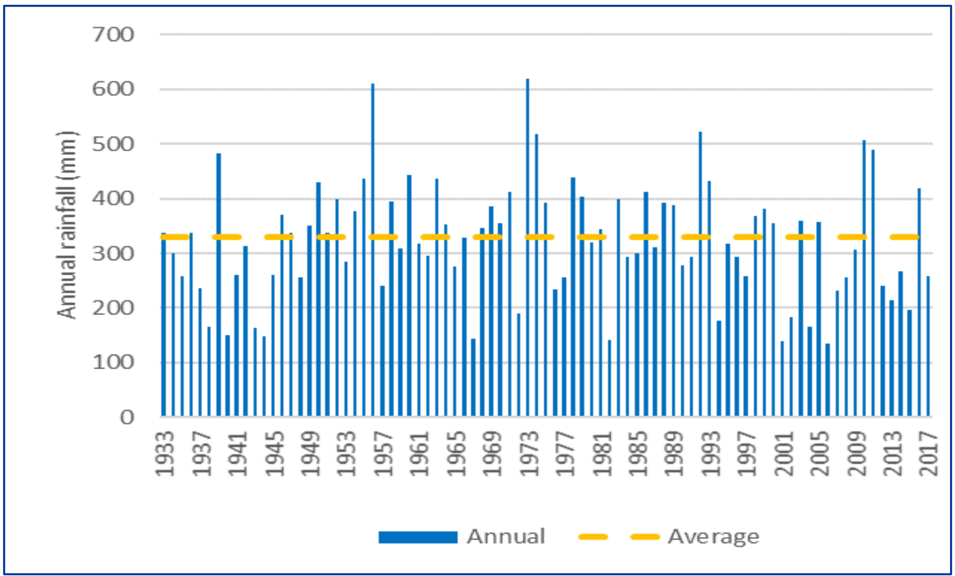


Figure 3 Lake Boga annual rainfall data (source: BoM)

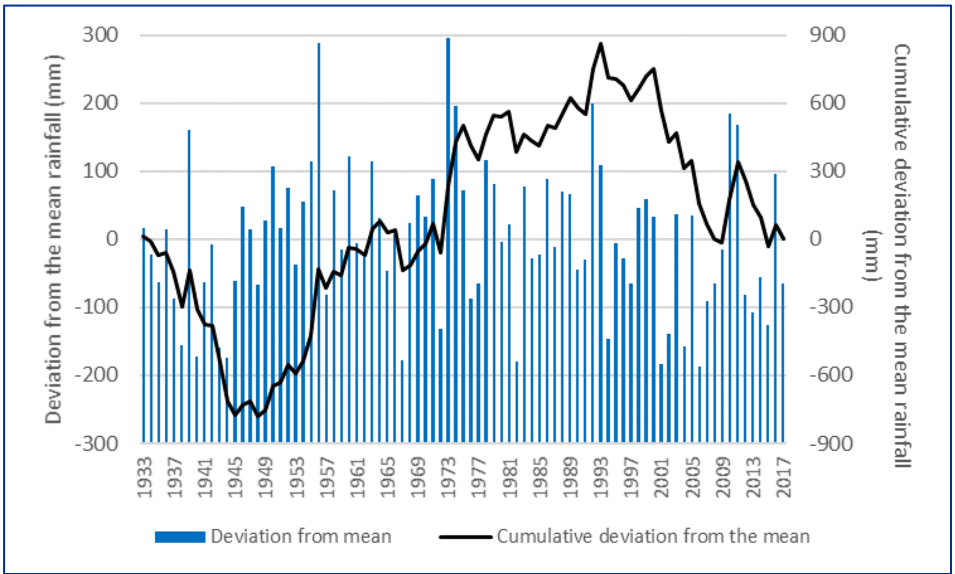
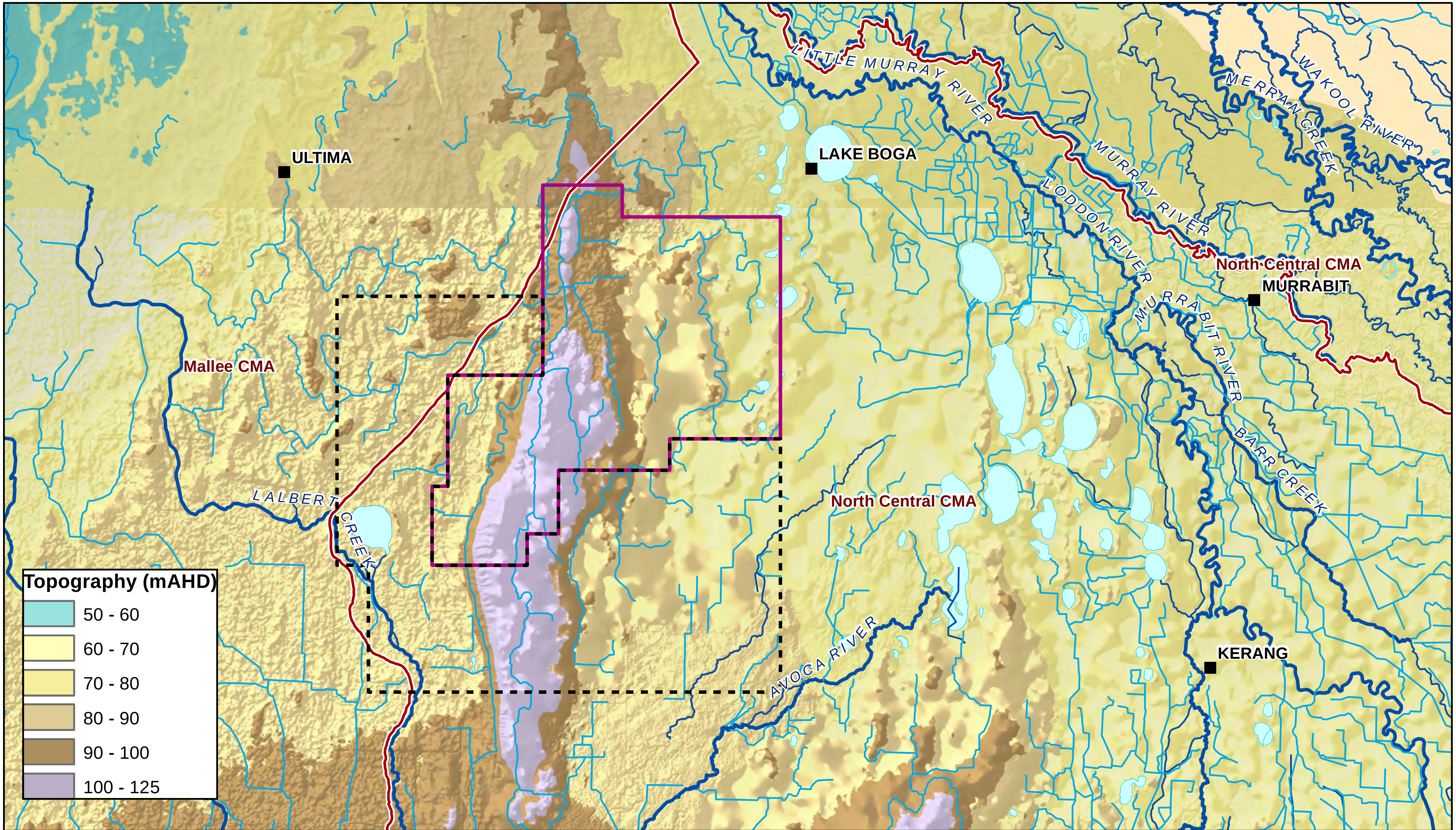


Figure 4 Lake Boga deviation from the mean annual rainfall data (source: BoM)

2.1.2 Topography

The topography of the area slopes gently from south to north, with the River Murray floodplain represented by the lowest elevations. The most striking topographic feature is the north-south oriented elevated area of between around 100 and 125 mAHD that can be seen transecting the Study Area (Figure 5).

The upland area on which the tenements are located is upwards of 10 m higher in elevation than the River Murray floodplain (Figure 5).



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Legend

- EL6419
- EL5520
- Catchment management authorities (CMA)
- Localities
- Canal
- Minor watercourse
- Major watercourse
- Lake

Figure 5
Study Area topography

DATA SOURCE
VICMAP, 2017
Geofabric Product Suite V2.1.1 Bureau of Meteorology (BoM) 2011;1 Second SRTM v1.0 © Commonwealth of Australia (Geoscience Australia) 2011.

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2.2 Geology

Figure 6 presents a west-east geological cross-section of Murray Basin sediments in northwestern Victoria, with the surface geology shown in Figure 7. Also shown in Figure 6 is the approximate extent of the Study Area considered in this report. Most of the tenements' area is outcropping Parilla Sand, with minor areas of Shepparton formation and Quaternary deposits (mainly associated with waterways and wetlands) to the south east and west.

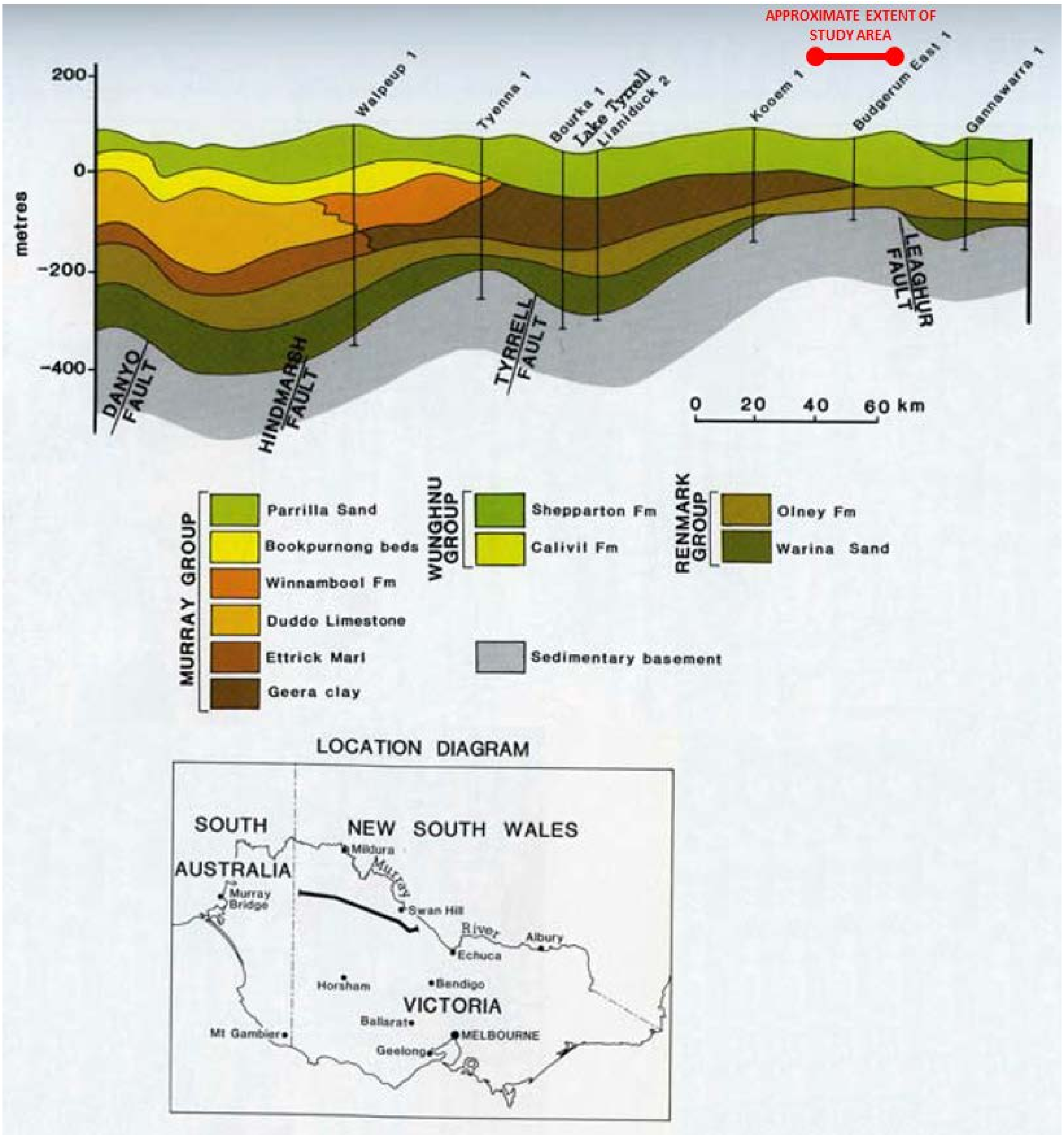


Figure 6 **West-east geological cross-section of Murray Basin beneath northwestern Victoria** (after Macumber, 1991)

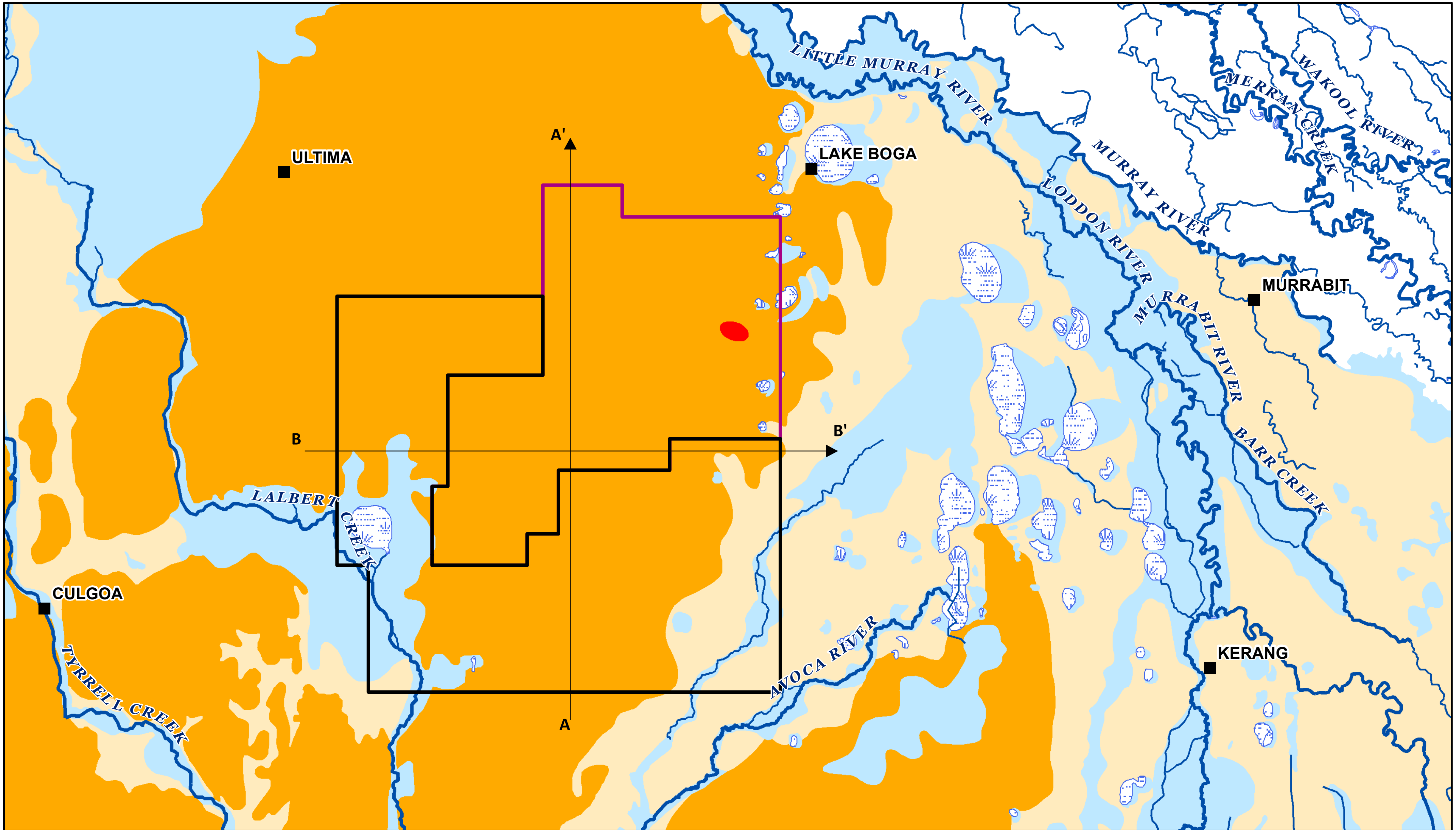
From oldest to youngest, the key stratigraphic units are:

- Renmark Group, comprising of fluvio-lacustrine sediments comprising gravels, sand, silt and clay (GeoScience Australia, 2017), which rests unconformably on pre-Tertiary basement and can reach thicknesses of up to 300 m. This unit can be absent beneath topographic highs. The Renmark Group is divided into the upper 'Olney Formation' and the lower 'Warina Sand'
  - The Olney Formation is typically poorly consolidated and comprises carbonaceous sand, silt and clay, as well as beds of brown coal and peat (GeoScience Australia, 2017)
  - The Warina Sand is also typically poorly consolidated and comprises carbonaceous sand, clay and silt sequences (GeoScience Australia, 2017)

  There appears to be a basement high and an absence of the Warina Sand unit beneath the Study Area, likely associated with the Leaghur Fault.
- Geera Clay comprising of carbonaceous silts and minor carbonates, as well as massive clays with minor sand and silt horizons, can be absent in some areas due (GeoScience Australia, 2017). The eastern limit of the Geera Clay is thought to occur in an approximate line between Swan Hill and Horsham to the southwest. However, little work has been done to define this easternmost boundary and given its complex inter-tonguing nature, its actual limits are highly uncertain (Birch, 2003).
- The Loxton-Parilla Sands (sometimes referred to as the Loxton Sand or the Pliocene Sand) is a typically well sorted, fine to medium quartz sandstone (GeoScience Australia, 2017). The Loxton-Parilla Sands is present over the whole of the marine Murray Basin, with an average thickness of about 60 m. The upper surface forms long prominent ridges that trend north-south and are likely formed as strandlines along a retreating late Tertiary seashore (Macumber, 1991). The Gredgwin Ridge*,* which forms the transition zone between marine (Loxton-Parilla Sands) and non-marine (Shepparton Formation) deposition in the Basin, occurs to the southeast of the project area.
- Shepparton Formation, unconsolidated to poorly consolidated mottled clay, silty clay with lenses of sand and gravel (GeoScience Australia, 2017), likely restricted to the eastern Study Area if present.
- Quaternary sediments, typically floodplain sediments.

2.3 Hydrostratigraphy

The Victorian Aquifer Framework (DELWP, 2018) provides maps of all major aquifers across Victoria with north-south and east-west orientated hydrogeological cross-sections for the Study Area presented as Figure 8 and Figure 9, respectively. The Study Area is dominated by the Pliocene Aquifer with an average thickness of around 80 m. In the central portion of the tenements, the hydrogeological cross-sections presented suggest the Loxton-Parilla Sands is likely to be directly underlain by the Renmark Group, but at the periphery of the tenements these units are separated by thin lenses of Geera Clay.



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Legend

- EL6419
- EL5520
- Cross Sections
- Minor watercourse
- Major watercourse
- Lake

Surface Geology

- Quaternary Deposits (various)
- Parilla Sand
- Shepparton Fmn
- Lake Boga Granite

Figure 7
Study Area surface geology

DATA SOURCE
VICMAP, 2017
Geofabric Product Suite V2.1.1 Bureau of Meteorology (BoM) 2011;1 Second SRTM v1.0 © Commonwealth of Australia (Geoscience Australia) 2011.

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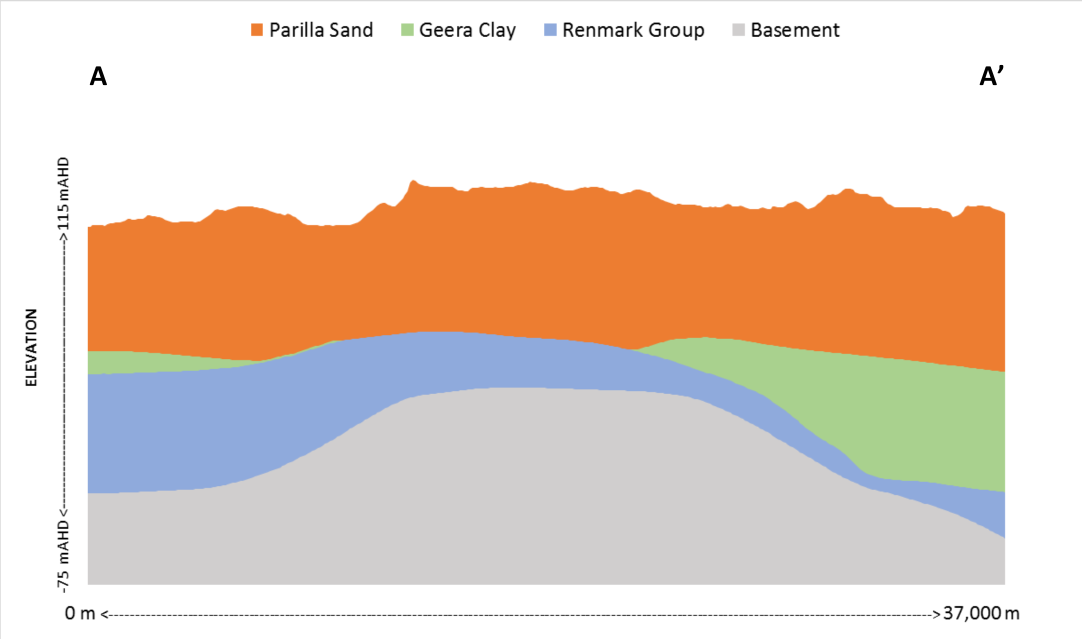


Figure 8 Inferred south-north hydrogeological cross-section through the Goschen tenements

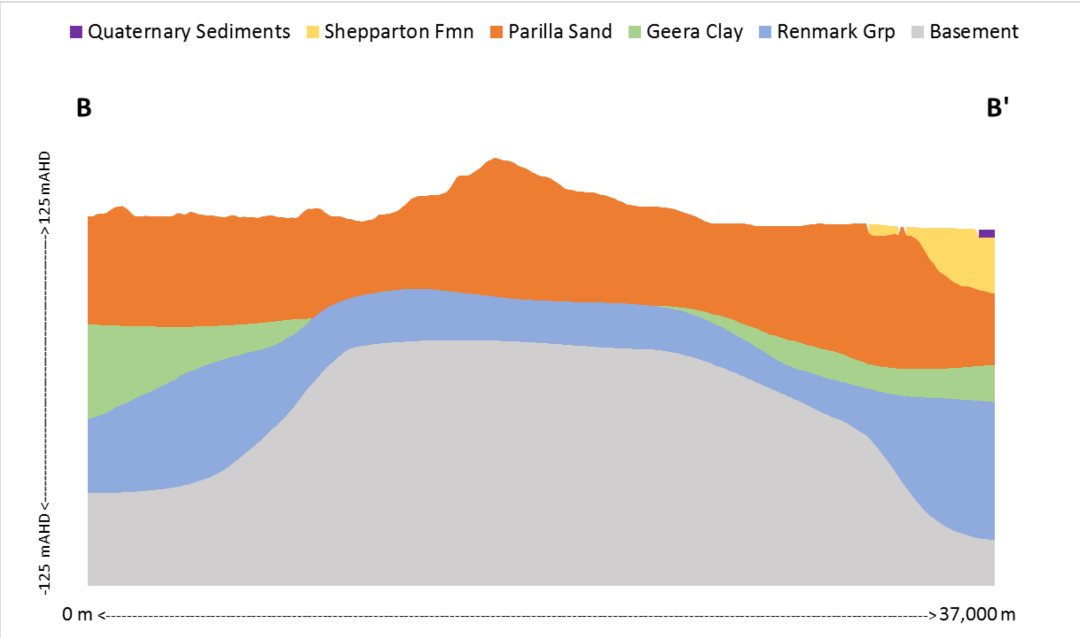


Figure 9 Inferred west-east hydrogeological cross-section through the Goschen tenements

2.3.1 Loxton-Parilla Sands

The Loxton-Parilla Sands hosts the mineralisation targeted by the proposed mine and also hosts the water table aquifer in the Study Area (the Pliocene Aquifer).

Groundwater discharge from the Pliocene Aquifer is observed as the many lakes and lunettes (crescent-shaped dunes) occurring in the Wimmera-Mallee region of northwestern Victoria, e.g. Lake Lalbert (western Study Area), Lake Tyrell to the west of Lalbert Creek and Lake Cullen to the east of the Study Area. Within the Study Area, groundwater discharge will be to the Murray River floodplain, with localised areas of discharge restricted to areas where the water table occurs at elevations that intersect the ground surface.

2.3.2 Geera Clay

Where present, in the Study Area, the Geera Clay separates the Loxton-Parilla Sands from the Renmark Group and forms an important aquitard unit that restricts movement of groundwater between these two hydrostratigraphic units (HSUs). The geological cross-sections presented as Figure 8 and Figure 9 show there is unlikely to be a confining unit (Geera Clay) separating the Loxton-Parilla Sands and Renmark Group HSUs beneath the central tenement areas.

2.3.3 Renmark Group (Olney Formation)

Sands of the Renmark Group form important groundwater aquifers, however the brown coals and ligneous claystones that can develop at the top of the Renmark Group, can lower the effective porosity and hydraulic conductivity of the HSU (Birch, 2003). In the Study Area it is probable that only the Olney Formation (the shallowest of the two units comprising the Renmark Group) is present (see Figure 6).

As discussed above, the Renmark Group is possibly directly connected to the Pliocene Aquifer in central parts of the Study Area, whilst at the periphery it is likely to be hydraulically separated by the presence of the lower permeability Geera Clay.

2.4 Groundwater recharge and discharge mechanisms

2.4.1 Recharge

The primary recharge mechanism in this area is the infiltration of rainfall. Rainfall recharge will actively occur over the Study Area except where the water table is very shallow or intersects the surface, in these locations evaporative discharge will occur at least seasonally. Two datasets are available to inform the potential rate of groundwater recharge:

- Crosbie et al. (2009) used the 1-D model called WAVES to model diffuse groundwater recharge, deriving an estimate of average annual recharge in this area of between 6 to 37 mm
- Leaney et al. (2011) used the relationship between deep drainage and rainfall for different soil orders and vegetation cover to derive an estimate of average annual groundwater recharge in this area of between 7 and 8 mm

Assuming a recharge rate of 7.5 mm/year, this corresponds to an annual recharge rate of approximately 5,700 kL/year over the tenement areas.

Groundwater elevation contours are mapped for the Pliocene Aquifer, as part of the Murray Darling Basin 'Basin-in-a-box' data series (MDBA, 2002). Figure 10 presents the interpreted contours, which suggest the major watercourses of the Study Area (Lambert and Tyrell Creeks, and Avoca River) may be sources of groundwater recharge during creek flow events.

Recharge to aquifers (below the Parilla Sands) is driven by leakage from the Parilla Sand aquifer and from groundwater throughflow. Groundwater throughflow represents the movement of groundwater into the site from the south and east (Figure 10).

2.4.2 Discharge

The groundwater elevation contours shown in Figure 10 are also overlain with interpreted groundwater flow directions for the Pliocene Aquifer. The regional contouring suggests groundwater flow in beneath the tenements is generally to the north and northwest. Groundwater will therefore leave the site area (discharge) to north and northwest.

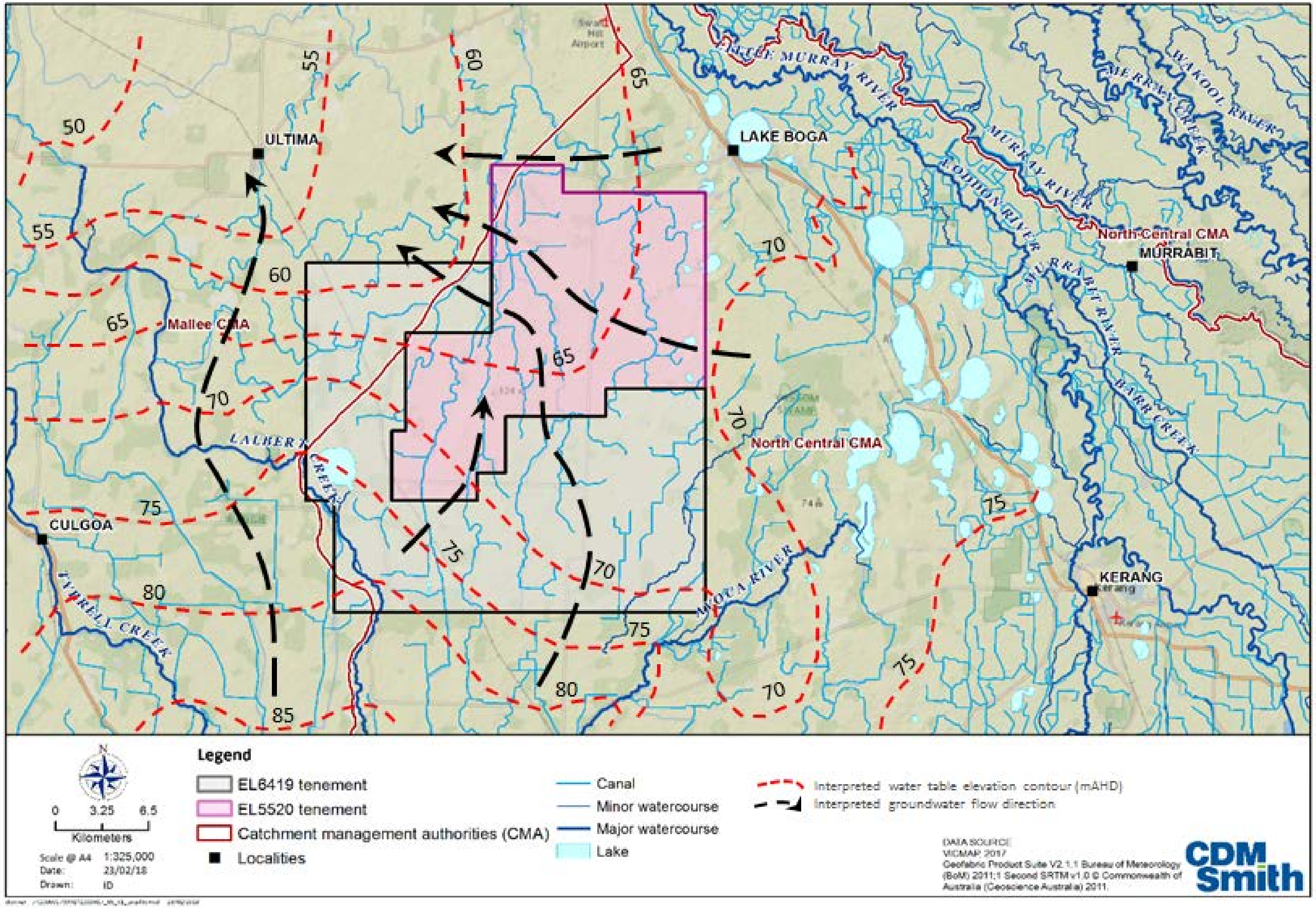


Figure 10 Interpreted groundwater elevation contours and indicative flow directions for the Pliocene Aquifer

2.5 Water table depth

Regional scale depth to groundwater contours are available as part of the Murray Darling Basin 'Basin-in-a-box' data series (MDBC, 2002). Figure 11 presents an interpreted depth to water table plan for the Study Area, indicating the depth to water table is typically negatively aligned with topography, i.e. water table depth is greatest beneath higher ground elevations and least beneath lower ground elevations. Beneath the north-south orientated ridge / strandline within the tenements, the depth to water table is more than 40 m below the ground surface, whereas closer to the Murray River in the northeast and to the west and southwest of the tenements the water table is within 5 m of the ground surface. Over much of the tenements, the water table is expected to be 10 m or more below ground surface. The water table will be held within the Parilla Sand Aquifer.

2.6 Aquifer interactions

Interaction between the Pliocene Aquifer and the underlying Renmark Group aquifer will be greatest where the confining Geera Clay HSU is absent, and where coarser grained materials in both aquifers are in contact. As discussed previously, the Study Area resides close to the approximate eastern extent of the Geera Clay in the Murray Basin (see Figure 6, Figure 8 and Figure 9) and, it is possible the aquitard is absent beneath the central tenement areas (proposed field investigations will address this issue concerning presence or absence of the Geera Clay HSU.

Groundwater hydrographs for existing nested bores (see Figure 11 for locations) that monitor water levels in the Pliocene and Renmark Group aquifers outside the tenements are presented as Figure 12 and Figure 13, providing some insight into the likely connection between the two aquifers and responses to local and regional stresses (such as pumping and recharge). Where they are connected, the separate hydrographs for each nested well should have a similar elevation and fluctuation pattern, and where they are separated by low permeability layers the hydrographs will differ to some extent.

The hydrographs suggest there is typically a downward hydraulic gradient from the Pliocene Aquifer to the underlying Renmark Group aquifer. Although the relative groundwater elevations indicated by Nested Site 4 indicate the opposite, there is a sudden drop in groundwater head recorded for the Loxton-Pliocene Aquifer bore 110186 between 1992 and 1994 that is not easily explained (the dataset for that time period may not be reliable or indicate the influence of an unknown stress during that period). To the north of the Study Area, there appears a reversal in gradients, with an upward hydraulic gradient from the underlying Renmark Group to the overlying Parilla Sand Aquifer (Figure 13).

Whilst connection is apparent at Nested Site 1, the same connection is not evident for the other nested sites. Nested Site I is located close to what is likely a groundwater discharge zone, which would explain the close separation of hydrographs for bores 50305 (Loxton-Parilla Sands) and 50308 Renmark Group (Olney Formation).

2.7 Groundwater quality

2.7.1 Salinity

Groundwater quality has been assessed using datasets of the distribution of groundwater salinity (as total dissolved solids; TDS) developed as part of the Murray Darling Basin 'Basin in a Box' data series (MDBC, 2002). This has been supplemented by a collation of groundwater quality data that are available for existing bores in the area (and derived from the Victorian Water Management Information System). Table 1 presents summary groundwater quality data for the Study Area. The interpreted spatial distribution of water table aquifer salinity concentrations is shown in Figure 14.

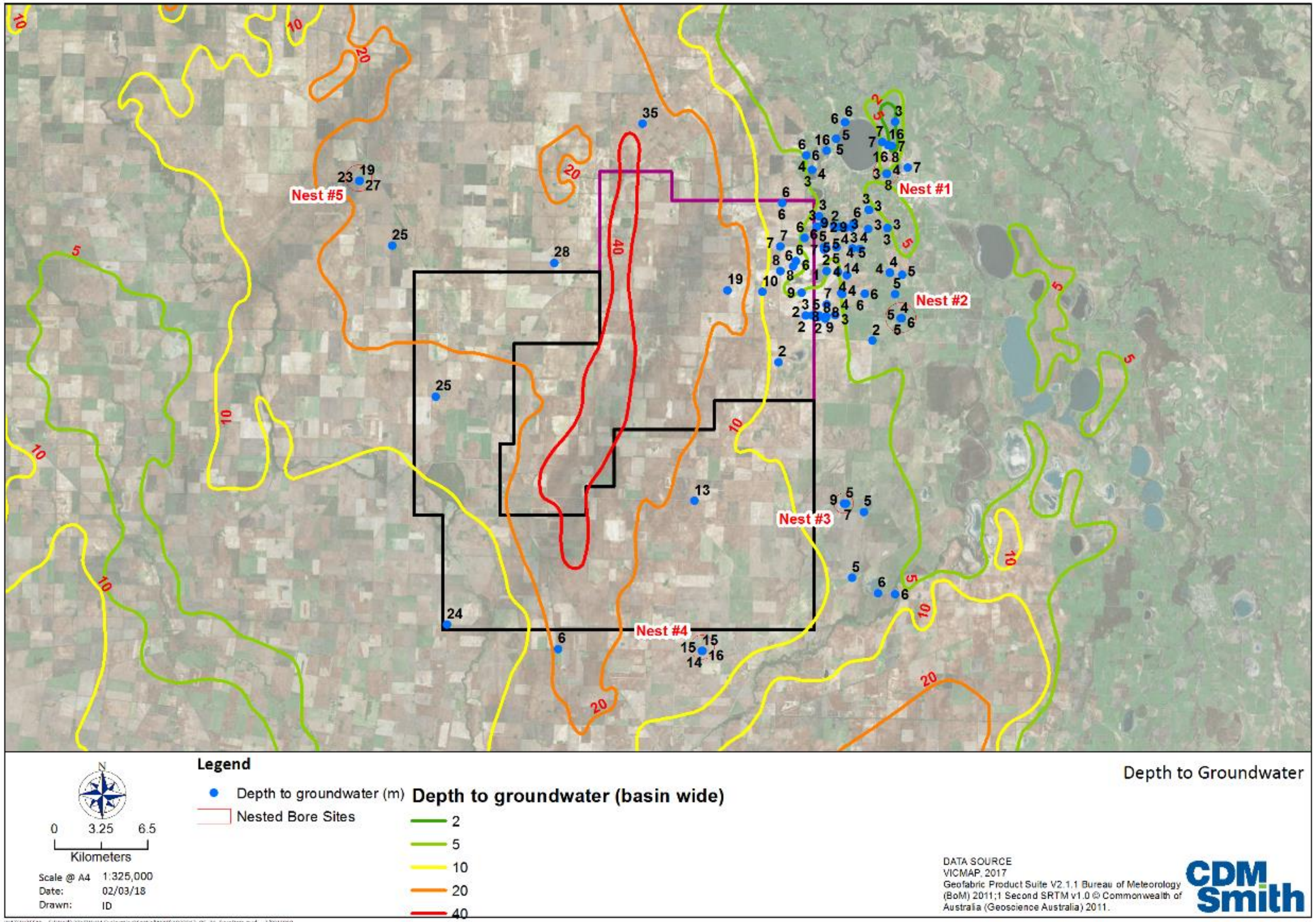


Figure 11 Depth to water table

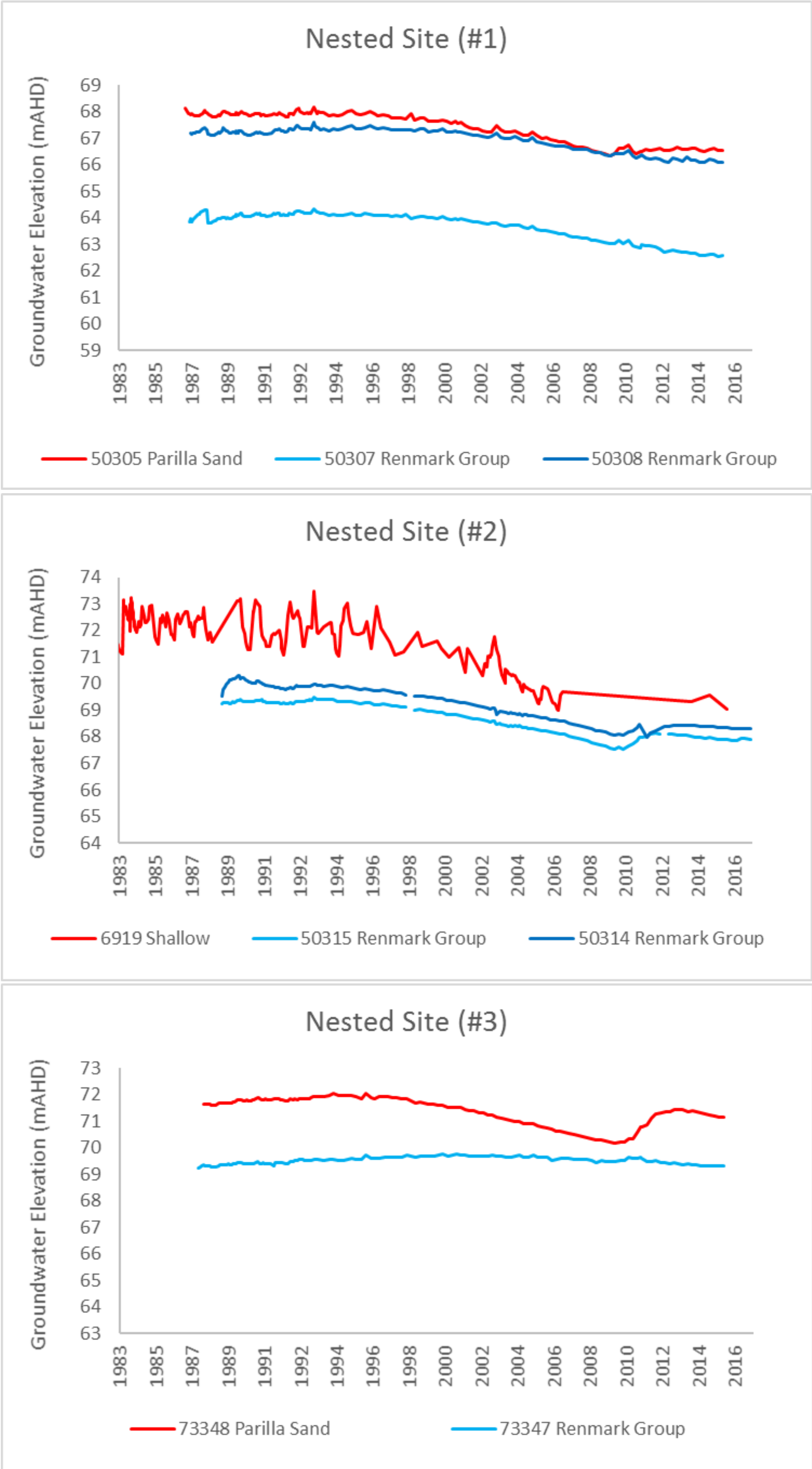


Figure 12 Nested site hydrographs (sites 1, 2 and 3)

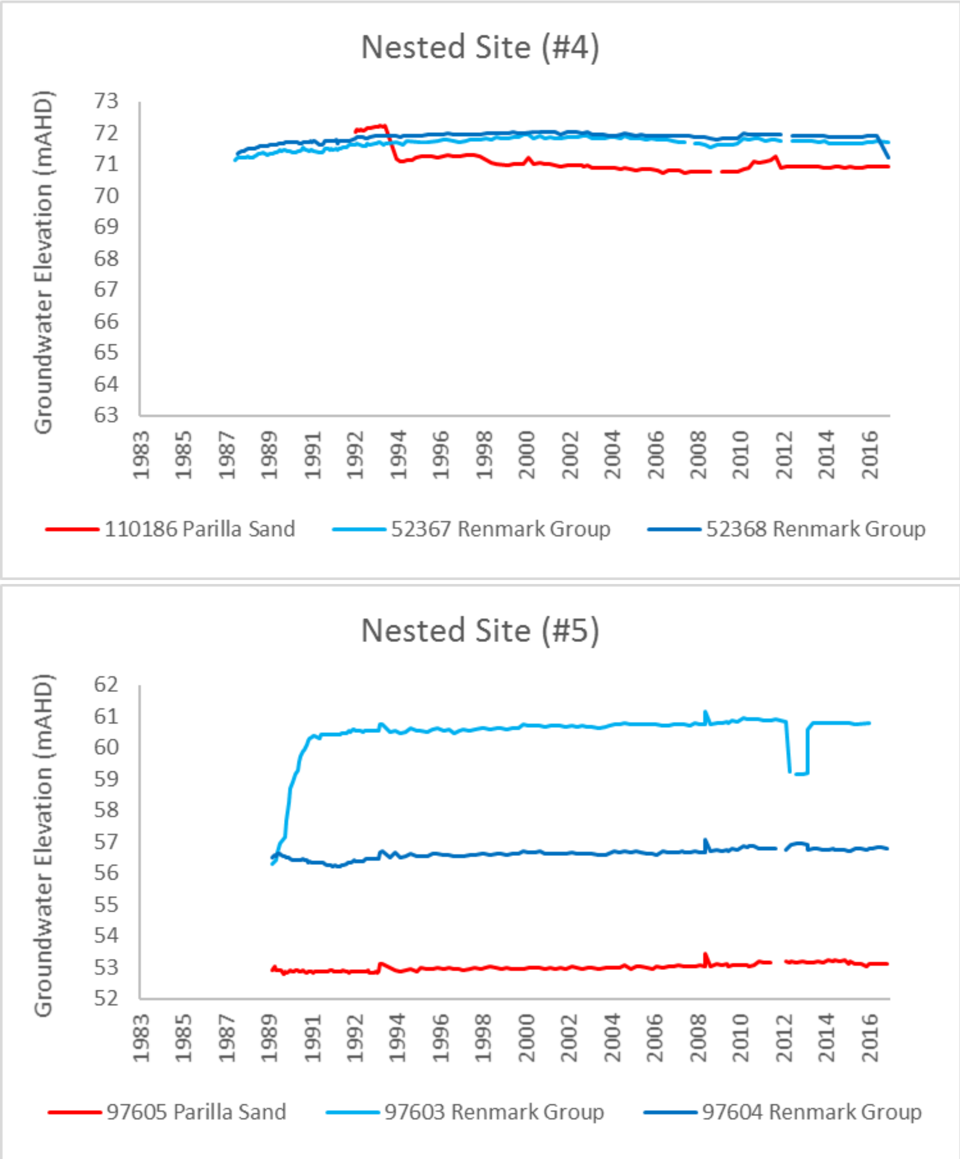
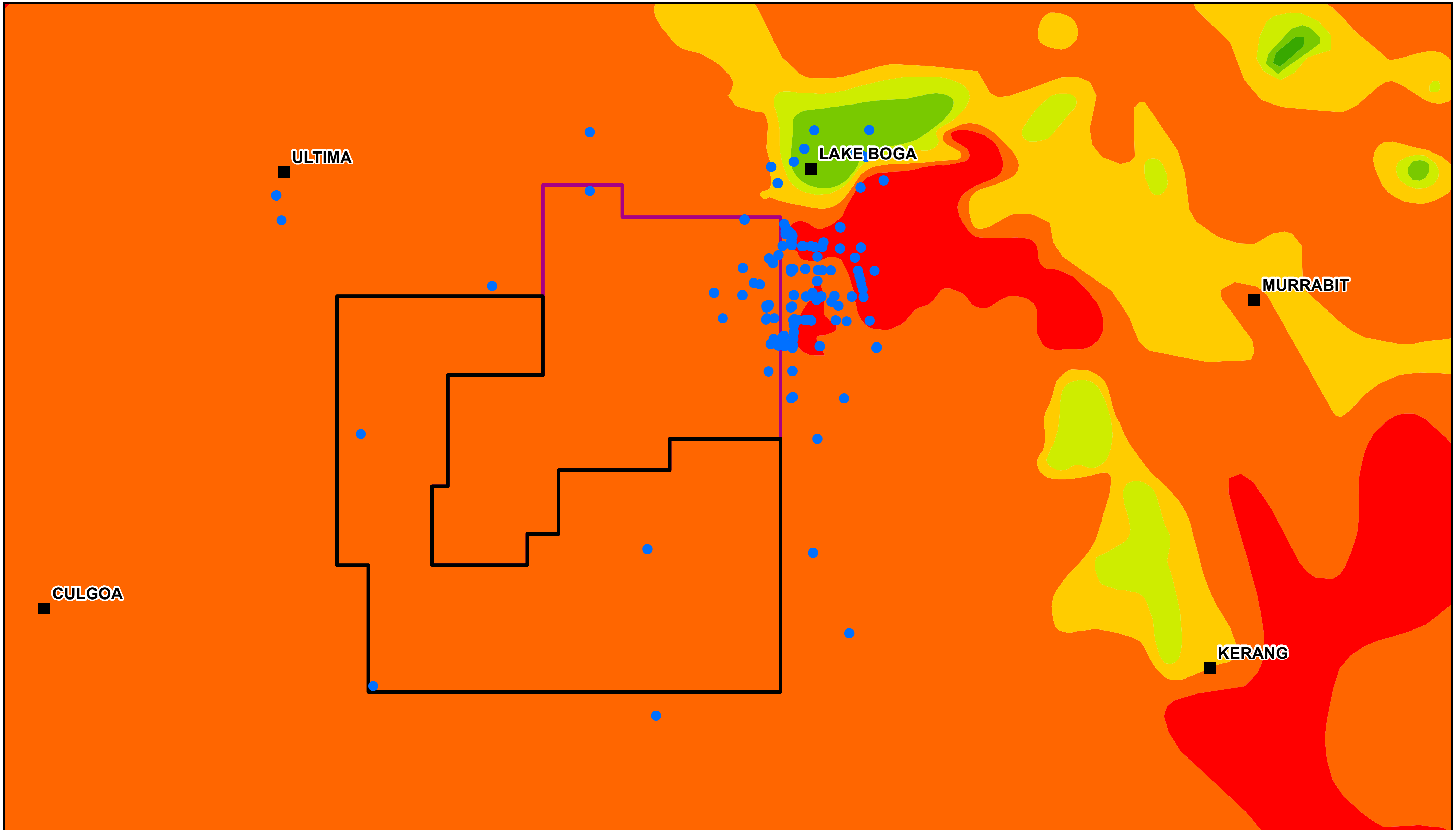


Figure 13 Nested site hydrographs (sites 4 and 5)

Table 1 Summary of groundwater chemistry data for the Study Area

Aquifer	Count	Min	Max	Average
Total Dissolved Solids				
Pliocene	27	1,277	58,490	22,425
Olney	11	4,229	45,013	25,720
EC				
Pliocene	150	221	85,800	48,361
Olney	0	-	-	-
pH				
Pliocene	6	5.3	7.5	6.6
Olney	2	7.1	8.5	7.8



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Bores with Chemistry Information

Shallowest Aquifer Salinity (TDS)

- 1000 - 1500 mg/L
- 1500 - 3000 mg/L
- 3000 - 7000 mg/L
- 7000 - 14000 mg/L
- 14000 - 35000 mg/L
- 35000 - 100000 mg/L

Figure 14
Shallow aquifer groundwater salinity
(from the MDBA in a Box Data Compilation)

DATA SOURCE
VICMAP, 2017
Geofabric Product Suite V2.1.1 Bureau of Meteorology (BoM) 2011;1 Second SRTM v1.0 © Commonwealth of Australia (Geoscience Australia) 2011.

CDM Smith

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The available groundwater salinity data and mapping for the water table aquifer indicates groundwater salinity ranges from 14,000 to 35,000 mg/L across the Study Area. The collation of bore data for the area indicates the average groundwater salinity for the water table aquifer is 22,425 mg/L. The available bore data for the deeper aquifer suggests a similar range in groundwater salinity.

Electrical Conductivity (EC) data are also available for a larger number of bores (around 120) in the Study Area, indicating an average EC of 48,361 µS/cm. The average EC for bores located within the tenements is 48,806 µS/cm. A crude conversion of this value to TDS (using a conversion factor of 0.69) suggests an average TDS of 33,369 mg/L.

2.7.2 Beneficial Uses

The State Environment Protection Policy (SEPP) – Groundwaters of Victoria specifies suitable uses of groundwater based on the TDS of the groundwater. Table 2 presents a summary.

Table 2 SEPP Groundwaters of Victoria Beneficial Use Segments (mg/L TDS)

Beneficial Use	A1 (0-500)	A2 (501-1000)	B 1001-3500)	C (3501-13000)	D (>13000)
Maintenance of ecosystems	✓	✓	✓	✓	✓
Potable water supply: - Desirable - Acceptable	 ✓ 	 ✓			
Potable mineral water supply	✓	✓	✓		
Agriculture, parks and gardens	✓	✓	✓		
Stock watering	✓	✓	✓	✓	
Industrial water use [1]	✓	✓	✓	✓	✓
Primary contact [2]	✓	✓	✓	✓	✓
Buildings & structures	✓	✓	✓	✓	✓

Notes: 1. Including mining
2. Recreation and water sports

The groundwater salinity data summarised in Table 1 indicate Loxton-Parilla Sands groundwater has an average groundwater salinity of 22,425 mg/L and Olney Formation groundwater has an average groundwater salinity of 25,720 mg/L. This leads to classification of both aquifers as having Beneficial Use Segment D groundwater, which is suitable for the following uses:

- Maintenance of ecosystems;
- Industrial water use;
- Primary contact; and
- Buildings and structures.

The groundwater data are also consistent with the state-wide salinity maps for the aquifers defined by the Victorian Aquifer Framework that show, for the Loxton-Parilla Sands and Olney Formation aquifers, groundwater is classified as Segment D groundwater across the entire Study Area. These maps were developed by DELWP (2014), based on a combination of information sources, including:

- The previous Beneficial Use Map Series (published in 1995 by the Victorian Department of Conservation and Natural Resources)

- Salinity measurements for approximately 50,000 bores in Victoria
- Re-iteration of the draft mapping based on consultation with local experts, to produce a final product

2.8 Potential sensitive groundwater receptors

Potential groundwater receptors in the Study Area include private users of groundwater (i.e. human consumption) and the environment. However, considering the SEPP criteria and average groundwater salinity concentrations, it is unlikely any potential groundwater users in the Study Area would be totally reliant on groundwater sourced from the Loxton-Parilla Sands or Olney Formation aquifers. This is supported by the observation that the state-wide database of registered groundwater users indicates there is only one domestic and stock bore within the tenement boundaries (Figure 15). Eight stock bores are located outside the northeast and southeast tenement boundaries where groundwater salinity mapping suggests better quality groundwater being available for this type of use (Figure 14). However, the state-wide database is known to have poor reliability in terms of representing current groundwater bores and users, given that data are never removed from the database.

Potential environmental receptors have been identified using the BOM Groundwater Dependent Ecosystem (GDE) Atlas. Figure 15 shows the locations of streams, wetlands and terrestrial vegetation that has been classified by the BOM GDE Atlas as having a high likelihood of being groundwater dependent, meaning that groundwater meets some or all the ecosystem water requirements. There are no baseflow dependent streams in the area, but there are many unnamed wetlands to the northeast of the tenement that are classified as GDEs, and to the east of the tenement boundary there is an extensive amount of terrestrial vegetation and wetland GDEs. These wetland GDEs likely rely to a large extent on surface water flows and local recharge.

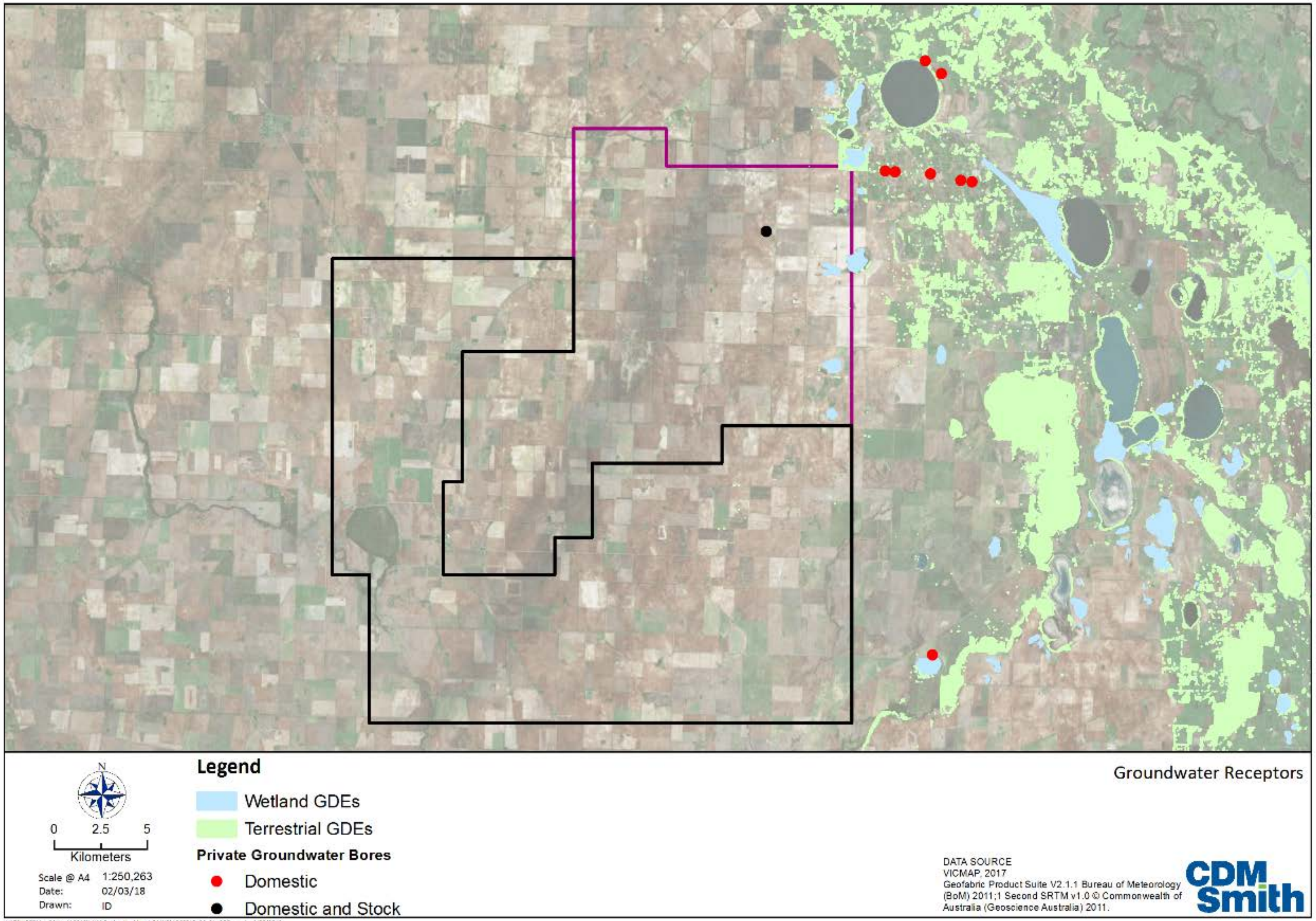

Figure 15 Potential Groundwater Receptors

Section 3 Conceptual hydrogeological model

Figure 16 presents the preliminary conceptual hydrogeological model of the Study Area, which is a schematic showing the essential mechanics of groundwater interactions:

Pre- mining;

1. Rainfall recharge over the uplands area, on which the VHM tenements are located;
2. Groundwater discharge from the Loxton-Parilla Sands and Olney Formation (Renmark Group) aquifers to the lower lying landscape associated with the Murray River floodplain;
3. Groundwater discharge via evapotranspiration from riparian and wetland vegetation, evaporation from shallow water tables, and to the river itself;
4. Seepage to the Olney Formation (Renmark Group) aquifer in the Upland areas, driven by head gradients, from the Pliocene Aquifer, with limited potential for seepage where the Geera Clay is present; and
5. Seepage to the Pliocene Aquifer near to the Murray River floodplain, driven by head gradients, from the Olney Formation (Renmark Group) aquifer, with limited potential for seepage where the Geera Clay is present.

During mining

If dewatering is required during future mining operations it is anticipated there will be localised changes to the groundwater system around the mine, with:

4. Seepage from the Olney Formation (Renmark Group) aquifer towards the mining area, driven by a reversal in head gradients; and

6. Localised inflow from the surrounding Pliocene Aquifer due to the development of a cone of depression.

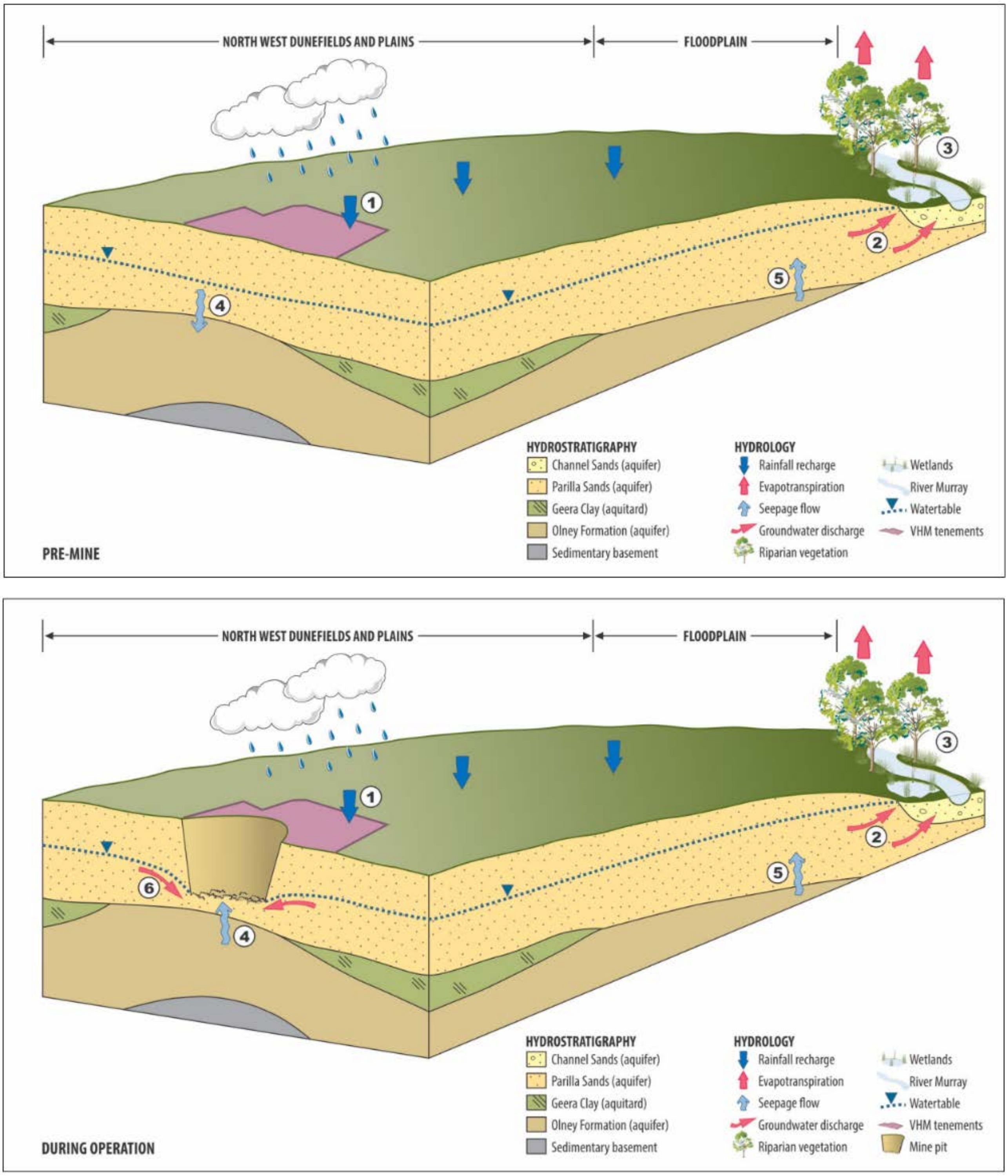

Figure 16 Conceptual hydrogeological model, pre and during mining operations

Section 4 Data and information gaps, and preliminary recommendations

4.1 Data and information gaps

Table 3 provides a summary of gaps in critical understandings relevant to the hydrogeology of the Goschen Project and Study Area, and the extent to which a mining operation will impact on groundwater resources and potentially sensitive receptors. Many of the data / information gaps are inter-related. The key data gaps are:

- Specific location of the proposed mine within EL 5520 and EL 6419;
- Depth of mineralisation to be mined;
- Water table elevation and depth to water table at the specific location of the proposed mine;
- Dewatering requirements (based on depth of mineralisation and water table);
- Hydraulic connection between Loxton-Parilla Sands and Olney Formation HSUs;
- Mine water supply requirements (yield and water quality); and
- Location of potentially sensitive groundwater receptors relative to the proposed mine.

There is a large number of monitoring wells (around 120) within and in close proximity to the Study Area that have been critically reviewed for their inclusion in a future baseline monitoring program for the site. The review process considered the following:

- Whether specific bores are classified as either 'State Observation' bore, 'observation' bore or 'investigation' bore;
- Bore location, i.e. co-ordinates available and in an area, that provides value for the Goschen Project;
- Bore construction details, e.g. constructed depth, screen interval depth, to allow the bore to be attributed to an aquifer; and
- Monitoring history, i.e. recent (less than 10 years).

The critical review produced a subset of 37 bores (out of the available 120 or so) that might be considered for inclusion in a future sampling program to establish a baseline for the Project, and to inform environmental compliance during the life of mine. Around 15 of these bores are located on the Goschen tenements. It will be necessary to sight these existing wells to ensure they can be accessed and then, if they can be, contact the bore owners to obtain permission to monitor the wells. 15 of the wells are recorded as 'State Observation Bores', which means the bores are owned and maintained by the Victorian Department of Environment, Land and Water Planning (DELWP). For the remaining 17 wells the owner is not recorded, but they are potentially owned by the CMA within which they reside (i.e. North Central and Mallee).

The existing wells provide adequate monitoring coverage of the receptors located within the tenement boundary (i.e. private groundwater users and GDEs). The adequacy of the monitoring network relevant to GDEs and groundwater users will need to be revisited, once the need for groundwater dewatering is determined. If dewatering is required (i.e. the water table intersects the final depth of the proposed mine), the impact on GDEs will need to be revised to consider the predicted groundwater drawdown cone that will develop as a result of the dewatering activities. If dewatering and/or a groundwater supply is required, pumping tests will be required to inform hydraulic parameters, which are used to assist in groundwater modelling and drawdown calculations.

Table 3 Summary of data gaps and relative ranking

Data gap	Discussion
Location of proposed mine and mine plan	• The location of the proposed mine, and depth of mining in relation to topography is important for defining depth to water table, dewatering requirements and excess water management • The location of the proposed mine in relation to possibly sensitive groundwater receptors will, to a large extent, determine the potential for mine water affecting activities (dewatering, water supply development, waste management) to impact on the ability of these receptors to maintain access to environmental water requirements (e.g. pumping water levels, water table depth, groundwater discharge)
Water table elevation	• The depth to water table at the proposed mine may mean that dewatering is required to maintain safe access and dry mining conditions • The depth to water table (and saturated thickness of Pliocene Aquifer) at locations of possibly sensitive groundwater receptors may be critically important to their ability to access environment water requirements, and mine water affecting activities may impact adversely on this
Dewatering requirements	• Dewatering activities, if necessary, have the potential to lower water tables at possibly sensitive groundwater receptors thereby impacting on environmental water requirements • Dewatering may result in excess water requiring specific management strategies such as re-injection and evaporative ponds, particularly if saline
HSU hydraulic connection	• Mine water affecting activities (e.g. dewatering, excess water management) has the potential to change the nature of hydraulic connection between the Loxton-Parilla Sands and Olney Formation HSUs • Reversal of hydraulic gradients between HSUs may impact on water resources (quantity and quality) of either HSU, particularly if the Geera Clay is absent beneath some or all of the tenement area • It will be necessary to identify the extent (spatial and thickness) of Geera Clay beneath the tenements
Mine water supply requirements	• If water salinity is not a constraint on mine water supply development, groundwater presents as an opportunity to meet mine and process water demands • Water supply can rely on dewatering if required or a dedicated wellfield abstracting water from either the Loxton-Parilla Sands or Olney Formation aquifers, siting of which will need to consider – Vicinity of possibly sensitive groundwater receptors – Potential for altering hydraulic interactions between HSUs
Locations of possibly sensitive groundwater receptors	• The location of the proposed mine in relation to possibly sensitive groundwater receptors will, to a large extent, determine the potential for mine water affecting activities to impact on the ability of these receptors to maintain access to environmental water requirements

4.2 Preliminary recommendations

The following recommendations are made to assist in developing a more comprehensive understanding of potential interactions between the proposed mine and groundwater resources, with reference to data gaps identified in Table 3:

1. Review previous mineral resource drill hole records that might include details concerning ‘water cuts’
2. Obtain hydrogeological data specific to the proposed mine location via drilling investigations targeting the Pliocene and Renmark Group aquifers, including the presence or not of the Geera Clay
3. Obtain groundwater head and quality data specific to and in the vicinity of the proposed mine location via newly constructed monitoring wells

Figure 17 provides nominal locations for proposed drilling investigations and monitoring well construction, and Table 4 provides details and purpose of the proposed locations.

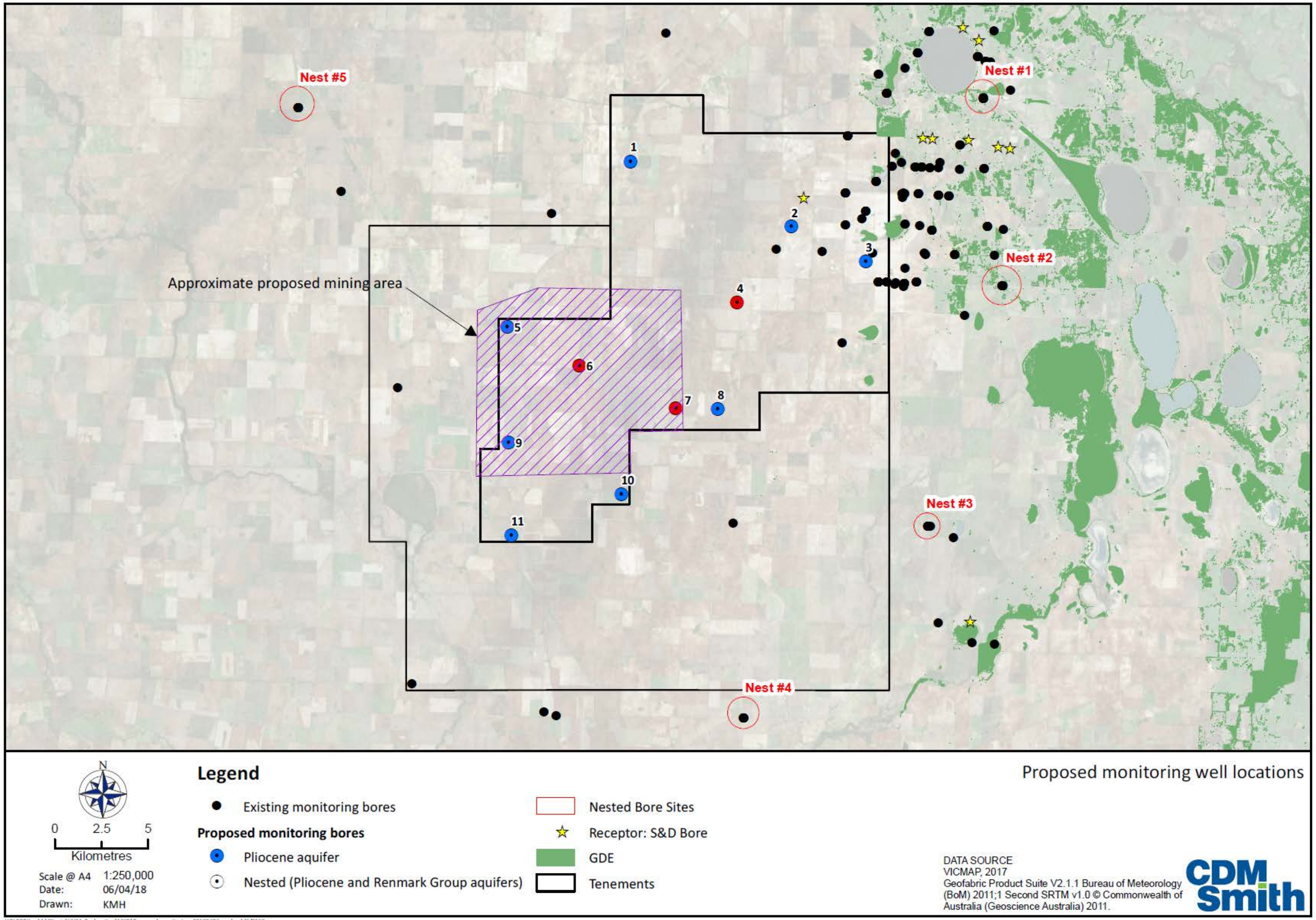

Figure 17 **Recommended baseline groundwater monitoring network**

Table 4 Summary new bore installations

<table>
<tr><th>Location</th><th>Detail</th><th>Purpose</th></tr>
<tr><td colspan="3">Dedicated Pliocene aquifer monitoring bores</td></tr>
<tr><td>1, 2, 3</td><td>• Located outside proposed mine development area at the northern and northeastern extent of EL 5520
• Bores 2 and 3 located ‘mine-side’ of identified stock bore and GDEs
• Drilling and logging of cuttings from surface to Olney Formation
• Grout Geera Clay intersection, if present
• Construction of Pliocene aquifer monitoring well (completed with 50 mm DN Cl.12 PVC casing and screens), screening at least 12 m below water table</td><td rowspan="2">• Identify
– Thickness of Loxton-Parilla Sands and Geera Clay, if present
– Presence or not of Geera Clay
– Depth to water table up-hydraulic gradient of mine development area
• Establish baseline
– Gauge water table / pressure head of the Pliocene aquifer
– Sample groundwater from Pliocene aquifer and analyse for selected water quality analytes
– Establish ‘sentinel’ monitoring locations that will be used to demonstrate impact of mine water affecting activities up-hydraulic gradient of the proposed mine development area (Bores 2 and 3 near potentially sensitive receptors)</td></tr>
<tr><td>8, 10, 11</td><td>• Located outside proposed mine footprint at the immediately to the south and southeast extent of EL5520
• Drilling and logging of cuttings from surface to Olney Formation
• Grout Geera Clay intersection, if present
• Construction of Pliocene aquifer monitoring well (completed with 50 mm DN Cl.12 PVC casing and screens), screening at least 12 m below water table</td></tr>
<tr><td>5, 9</td><td>• Located within the proposed mine development area, but outside proposed mine footprint to ensure longevity of construction
• Drilling and logging of cuttings from surface to Olney Formation
• Construction of Pliocene aquifer monitoring well (completed with 50 mm DN Cl.12 PVC casing and screens), screening to base of aquifer to assist in understanding aquifer response to mine development and dewatering</td><td>• Identify
– Thickness of Loxton-Parilla Sands and Geera Clay, if present
– Presence or not of Geera Clay
– Depth to water table
• Establish baseline
– Gauge water table depth / elevation (in the Loxton-Parilla Sands HSU)
– Sample groundwater from the Loxton-Parilla Sands HSU and analyse for selected water quality analytes</td></tr>
</table>

Table 4 Summary new bore installations (cont.)

Location	Detail	Purpose
Nested Pliocene and Renmark Group aquifer monitoring bores		
4, 6, 7	• Located within proposed mine footprint but not in areas proposed for mine development to ensure longevity of construction • Drilling and logging of cuttings from surface to 12 or so metres into the Olney Formation • Construction of nested monitoring wells (completed with 50 mm DN Cl.12 PVC casing and screens), one completed in the Pliocene aquifer and the second completed in the upper Olney Formation and isolated from the Loxton-Parilla Sands / Geera Clay	• Identify – Thickness of HSUs encountered – Presence or not of Geera Clay – Depth to water table beneath and near proposed mine development area • Establish baseline – Gauge pressure heads in the two HSUs screened – Sample groundwater from the two HSUs and analyse for selected water quality analytes • Aquifer testing – Observation wells for aquifer testing (necessary to derive storativity estimates)
Pliocene aquifer pilot aquifer testing bores		
4, 6, 7	• Located within 20 to 30 m of Pliocene aquifer observation well (depending on aquifer thickness) • Constructed to intersect Pliocene aquifer, completed with 150 mm DN Cl. 12 PVC casing and screens	• Identify – Aquifer hydraulic properties (hydraulic conductivity / transmissivity, storativity, leakance etc. • Establish – Likely dewatering pumping rates (calculated and modelled) – Groundwater supply potential (calculated and modelled) – Zone of mine influence on Pliocene and Renmark Group aquifers • Inform – Groundwater effects assessment – Approvals process

Section 5 Legislation, policy and guidelines

This section provides a summary of key legal requirements and considerations within the context of future approvals scheduling specific to groundwater components of Project approvals, including water licensing and potential impacts on sensitive receptors. The policies and guidelines that may be relevant to the development, operations and closure of a mine, have been summarised.

Table 5 Summary of Primary Legislative Approvals

	Legislation	Governing Department	Summary	Relevance to Project
Groundwater Extraction	*Water Act 1989 (Vic)*	Department of Environment, Land, Water and Planning (DELWP)	This Act provides legislation for water entitlements issued and allocated in Victoria. The Act defines water entitlements and establishes the mechanisms for managing Victoria's water resources.	Water for mine dewatering, ore processing and for water supply purposes requires the granting of a licence to extract and use groundwater or surface water under the Act. It is expected that a water licence, as administered under Part 4B (Water Use Licences and Water Use Registrations) will be required to be granted approval for mine water supply or dewatering purposes. Take and use licences are issued and managed according to caps on the resource, known as permissible consumptive volumes. Forward planning will need to take into account DELWP guidelines on how to determine resource share such as caps in groundwater and unregulated systems as detailed in Water Resource Share Guidance http://waterregister.vic.gov.au/images/documents/ResourceShareGuidance_051015.pdf A take and use licence will also need to consider the licence requirements of Goulburn Murray Water who are responsible for issuing groundwater and surface water licences in this area. The project may need to take groundwater for the purposes of dewatering and or mine water supply, and depending on volume and location of the license, a groundwater Pumping Impact Assessment may be required. The assessment will involve • A description of the hydrogeological setting • Identification of any assets (existing bores and GDEs) within 5km of the license location • Completion of a pumping test and analyses of results (including water quality sampling), and • Completion of risk assessment.
	Water Act 2007 (Cth)	Murray-Darling Basin Authority (MDBA)	This Act empowers the Murray-Darling Basin Authority to promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of the water and other natural resources of the Murray–Darling Basin. Under the remit of this Act, the Murray-Darling Basin Authority has prepared the Basin Plan. Victoria is producing plans for its five water resource plan areas including: • Wimmera-Mallee surface water • Wimmera-Mallee groundwater • Victorian Murray surface water • Northern Victoria surface water, and • Goulburn Murray groundwater.	It is expected that the forward approvals will require demonstration of alignment with the objectives of the water resource plans prepared under the Basin Plan. For example, the Basin Plan provides long-term average sustainable diversion limits for the Wimmera-Mallee water resource plan (currently in draft form). Forward assessment of hydrological flows as relevant to the Goschen Project are to demonstrate that diversion effects are well within the sustainable limits for the catchment area (subject to assessment of potential impacts as part of the surface water study).
Groundwater Quality	*State Environment Protection Policy Groundwaters of Victoria 1997*	Environment Protection Authority (EPA) Victoria	The SEPP (Groundwaters of Victoria) was developed to provide an integrated framework of environment protection goals for groundwater. It aims to maintain and, where necessary, improve groundwater quality to a standard that protects existing and potential beneficial uses of groundwaters. The SEPP sets a consistent approach to, and provides quality objectives for, groundwater protection throughout Victoria.	The Groundwater SEPP identifies the protected beneficial uses of groundwater and specifies groundwater quality indicators and objectives. Groundwater objectives outlined in the SEPP are based primarily on trigger values outlined in ANZECC/ARMCANZ (2000) water quality guidelines for surface water. It is expected that the forward approvals will require demonstration of alignment with the maintenance of beneficial uses defined under the SEPP (Groundwaters of Victoria), as relevant to the area of influence determined from the assessment of hydrogeological impacts from the Goschen Project.
Environment Protection	*Heritage Rivers Act 1992 (Vic)*		This Act provides for the protection of public land in particular parts of rivers and river catchment areas in Victoria which have significant nature conservation, recreation, scenic or cultural heritage attributes. Section 8 of the Act requires management plans to be prepared for each heritage river and natural catchment area that are listed.	There are no Heritage Rivers within the mine lease.
	Environment Protection and Biodiversity Conservation Act 1999 (Cth)	Commonwealth Department of Environment and Energy (DoEE)	The EPBC Act and supporting regulations provide for the protection of the environment and conservation of biodiversity in Australia, specifically for Matters of National Environmental Significance (MNES).	The trigger for relevance of an EPBC Act referral is subject to a test of significance, specific to listed MNES that have potential to be significantly affected by the proposal. For the project, MNES associated with Wetlands of National Importance (e.g. Kerang Wetlands, located within 10 km of the eastern boundary of the Goschen exploration lease areas) warrant early assessment to determine the potential for direct or indirect effects. Other MNES's, such as Listed Threatened Ecological Communities, Listed Threatened Species and Listed Migratory Species that rely to some degree on interaction with groundwater to maintain ecological function will need to also need to be considered. An Assessment Bilateral agreement is in effect between the Commonwealth and Victorian Governments, to provide for potential accreditation of the Victorian assessment processes to address MNES under the EPBC Act. This is intended to provide an avenue for a single environmental assessment that can address Commonwealth and Victorian processes, under specified statutory instruments.

	Legislation	Governing Department	Summary	Relevance to Project
	Catchment and Land Protection Act 1994 (Vic)	Department of Environment, Land, Water and Planning (DELWP)	This Act enables the integrated catchment management framework for the sustainable management of land and water resources in Victoria, and provides for the establishment of the Victorian Catchment Management Council. Catchment Management Authorities (CMAs) are responsible for all planning and coordination of land, water and biodiversity management in their respective areas. Under the Act, certain plants are declared as noxious weeds in Victoria.	The Goschen Project is located within the Mallee CMA and the North Central CMA regions. The obligations of the Mallee and North Central CMAs include the governance of the Regional Catchment Strategies (RCS), and supporting Implementation Plans for priority catchment assets: • http://www.malleecma.vic.gov.au/resources/corporate-documents/mallee-regional-catchment-strategy.html • http://www.nccma.vic.gov.au/sites/default/files/publications/nccma-78628_north_central_cma_rcs_-_may_2013_web_0.pdf Priority catchment assets of primary relevance are expected to include: • Avoca Basin Terminal Lakes System and Creeklines (to the west of EL 6419) – in the Mallee CMA • Lower Avoca River and Lower Loddon River, as two of the Notable Assets in the North East Central CMA Regional Catchment Strategy.
	Environmental Effects Act 1978 (Vic)	Department of Environment, Land, Water and Planning (DELWP)	This Act provides for assessment of proposed projects that are capable of having a significant effect on the environment. The Act does this by enabling the Minister administering the *Environment Effects Act* to decide that an Environment Effects Statement (EES) should be prepared. The EES process is guided with reference to the Ministerial Guidelines for Assessment of Environmental Effects under the *Environment Effects Act 1978* (Ministerial Guidelines).	The trigger for relevance of an *Environmental Effects Act* referral is subject to a test of significance, in accordance with the Ministerial Guidelines. An EES is typically required only for projects likely to have significant regional or State wide environmental impacts. An assessment of significance of the proposed Goschen Project mine activities in the context of local and regional surface water and groundwater values is required. The assessment of significance is subject to the informed evaluation of direct and indirect effects arising from groundwater abstraction and dewatering activities on local and regional receptors. A self-assessment against the Ministerial Guidelines, to provide a risk-based assessment of the potential for an EES trigger, is recommended, supported by early agency engagement.
Planning	*Mineral Resources (Sustainable Development) Act 1990 (Vic)*	Department of Economic Development, Jobs, Transport and Resources (DEDJTR) (Earth Resources Regulation Branch (ERR))	This Act governs the approval of mineral exploration and development activities in Victoria. The submission of a Work Plan for proposed exploration and development activities is required to be supported by the information as specified in relevant Schedules of the Mineral Resources (Sustainable Development) (Mineral Industries) Regulations 2013.	Staged development of the Goschen Project will require the planning and scheduling of Work Plan applications as the project progresses. For example, a Work Plan will be required to support the establishment of the proposed groundwater monitoring bore network and the test production bores, which will need to include: • Project overview (in this case how will the work activity interact with groundwater, drilling and development method) • Characteristics of work sites (including environmental features and specific sensitive features such as potentially sensitive groundwater receptors) • Information sources • Location / site maps (in this case showing locations of proposed bores and potentially sensitive receptors) • Assessment of environmental impacts (in this case linked to groundwater), mitigation and control measures • Description of proposed rehabilitation of disturbed areas • Evidence of consultation and community engagement • Proposed environmental monitoring, auditing and reporting during the work activities In the context of the hydrogeology assessment, the outcomes of the studies will inform the appraisal of the existing environmental setting and specific sensitive features, and the evaluation of potential impacts and appropriate management / control measures for the proposed staged works.

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