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8.1 INTRODUCTION

This chapter provides a detailed groundwater assessment for the mine study area. The assessment has been prepared in accordance with the EIS TOR. This chapter identifies the existing environmental values of groundwater within the proposed mine site of the project. The assessment surmises potential impacts resulting from the project. Management measures to mitigate potential groundwater impacts are also discussed and highlighted throughout the chapter.

8.1.1 LEGISLATIVE FRAMEWORK

The Environmental Protection Policy (Water) 2009 (EPP Water) states that the Queensland Water Quality Guidelines (QWQG) takes precedence over other recognised guidelines such as the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC AND ARMCANZ, 2000). The QWQG indicate that the mine site falls within the Central Coast Queensland region and the relevant water types are upland streams.

Groundwater in Australia is managed through Groundwater Management Units (GMUs) or "Declared Areas" where groundwater is regulated. GMUs in Queensland are managed under a Water Resource Plan, which is implemented through a corresponding Resource Operations Plan. Areas where groundwater is not regulated are termed "Non-Declared Areas".

8.1.1.1 Declared Groundwater Area for Mine Site

The GMU indicates that the mine site lies on the edge of the Highland Groundwater Management Area, an area where the Queensland Government regulates the construction of bores and taking of water. Within this area, a water licence is generally required prior to taking water and a development permit is required prior to the construction of a bore. The exact requirements can vary from area to area and are prescribed by the Water Act 2000. The position of the declared groundwater areas are shown in Figure 1.

Highlands GMUs do not have specific Water Quality Objectives (WQOs) that need to be met for environmental and other public benefit outcomes. Within the Highlands GMU, an entitlement is required for all extraction purposes other than stock and domestic water use.

Water quality should therefore meet the EPP (Water) requirements. The requirements are based on DERMs QWQG, as these are given precedence over other recognised guidelines. The mine site falls within the Central Coast Queensland region of the guidelines and therefore existing water quality data should be compared with Central Queensland values for upland and lowland streams.

8.2 ASSESSMENT METHODS

8.2.1 DESKTOP REVIEW

The desktop component of this technical report included a literature review and search of relevant Commonwealth, State and Local databases. Specific information sourced and utilised included:

- historical groundwater bore records sourced from DERM;
- digital searches for GIS groundwater data sourced from DERM;
- sourced mapping in assisting to produce conceptual models for the Galilee Basin from (Phil Ferenczi per comm.,DEEDI);
- review of relevant Commonwealth, Queensland, and Local Guidelines and Standards including the Council of Standards- Australian and New Zealand Standards, Water Quality – Sampling, Part 11: Guidance on Sampling of Groundwater (AS/NZS 5667.11:1998), Queensland Water Quality Guidelines (DERM, 2009) and Australian and Resource Management Council of Australia and New Zealand - Minimum Construction Requirements for Water Bores in Australia (2003);
- review of relevant Commonwealth Standards for potable and drinking water prescribed in the National Health and Medical Research Council (2004);
- review of Commonwealth Standards in groundwater collection methods prescribed in the Australian Standards - Water Quality Sampling – Guidance on sampling of ground waters (1998) and Australian Standard - Test Pumping of Water Wells (1990);
- review of relevant Stygofaunal Guidelines including the Western Australia Environment Protection Agency of Methods and Survey Considerations of Subterranean fauna in Western Australia, No.54a (Draft), Technical Appendix to Guidance Statement No.54 (EPA, 2007); and
- published and grey literature including publications sourced from Great Artesian Basin Coordinating Committee (GABCC).

A summary of existing groundwater data within the study area was prepared by SKM (2009). A review of additional field data collected by E3 and discussions with the DERM hydrogeologists were added to the background data review to produce a conceptual model of groundwater in the mine area.

8.2.2 FIELD SURVEYS

The field work of site specific investigations at the mine was undertaken in September 2009 and May / June 2010. Field work data was used to input into the conceptual groundwater model in predicting the potential impacts at local and regional scales of the Project.

8.2.2.1 Bore Survey

A groundwater survey of available bores within the mine project areas was undertaken in order to assess the state of pre-mining regional groundwater. The locations of the bores assessed are included in the Groundwater Technical Report (Volume 5, Appendix 14). These sites form a network of observation points for monitoring groundwater quality prior to and throughout construction and operation activities.

8.2.2.2 Geophysical Survey

A review was undertaken of available geophysical logs from coal exploration holes to assess the potential aquifer zones and the presence of fresh or saline water in the stratigraphy. In addition gamma resistivity and Spontaneous Potential / Point Resistivity (SP / PR) tools were used on bores from this study in order to identify the likely strata layers containing groundwater and areas of higher permeability material.

8.2.2.3 Bore Installation

Environmental monitoring bores were installed to assess the hydraulic and chemical parameters of groundwater in the area of the mine based upon ARMCANZ 2003 guidelines “Minimum Construction Requirements for Water Bores in Australia”. Water bores were drilled by a licensed driller using an air rotary blade drilling technique with the capability to undertake mud rotary drilling if required. The boreholes were drilled at 150 mm diameter and were cased with either 50 mm or 100 mm diameter Class 18 factory slotted uPVC screen and casing. The environmental monitoring bores were generally screened across the bottom six m of the hole. Bores were backfilled with clean graded sand to 3 m above the screened interval, by at least a 1 m plug of bentonite and then grouted to the surface with a bentonite cement mix. Bores were completed with a cement pediment and lockable bore monument. The bores installed by this method included three 100 mm diameter bores and one 50 mm bore.

Further environmental monitoring bores were installed and constructed in existing coal exploration boreholes that had been maintained to monitor groundwater levels.

The environmental monitoring bores constructed in existing coal holes used 50 mm diameter factory slotted screen and casing. The bores were constructed in the same manner as the wells constructed into the drilled holes.

The locations of the bores assessed are shown in Figure 2. These sites form a network of observation points for monitoring groundwater quality prior to and throughout mining activities.

8.2.2.4 Water Level Monitoring

A survey of bore water levels on and surrounding the mine including the newly installed monitoring bores, and existing landowners bores was carried out in order to assess the piezometric surface and therefore the direction of flow in the aquifers. Water levels were measured using a manual groundwater level probe “interface probe”, GPS locations and elevations for each bore were recorded.

8.2.2.5 Water Sample Collection

Monitoring and landowner bores (where available) in the surrounding mine region were sampled to assess the geochemistry of groundwater. Newly constructed environmental monitoring bores were purged using a 50 mm diameter submersible pump for bores with static groundwater levels above 30 mbgl and using a 50 mm diameter pneumatic pump for bores with deeper static water levels. In order to comply with AS5667.11 1998 “Water Quality Sampling – Guidance on sampling of ground waters”, four to six bore volumes were purged from each bore prior to sampling. Pump flow rates differed depending on bore depth and static water level. Where sampling of surrounding landowners bores was undertaken, the water samples were collected directly from the bore or where down hole access was not available; the samples were collected from the pump outlet.

Figure 1. Declared Groundwater Areas

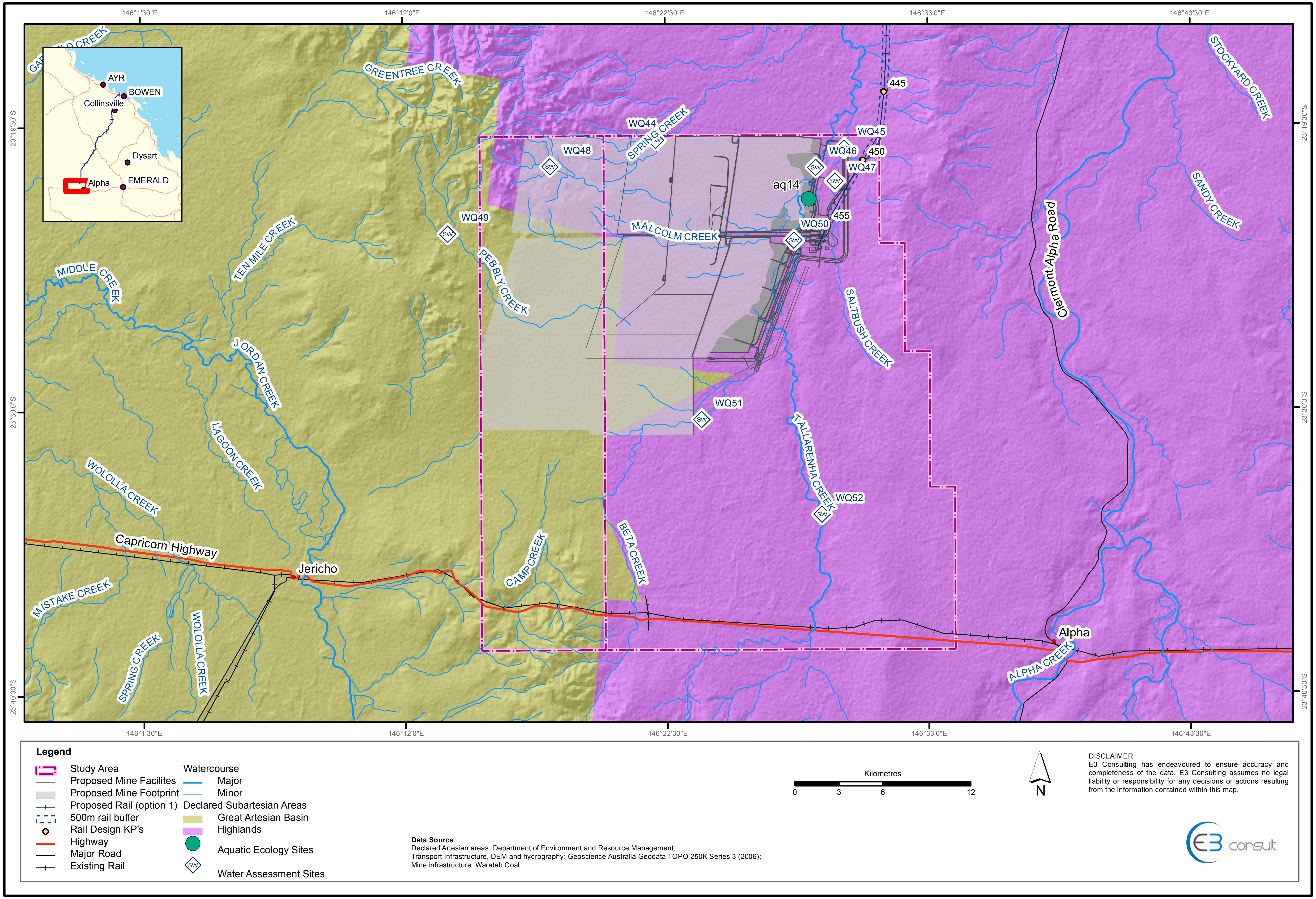
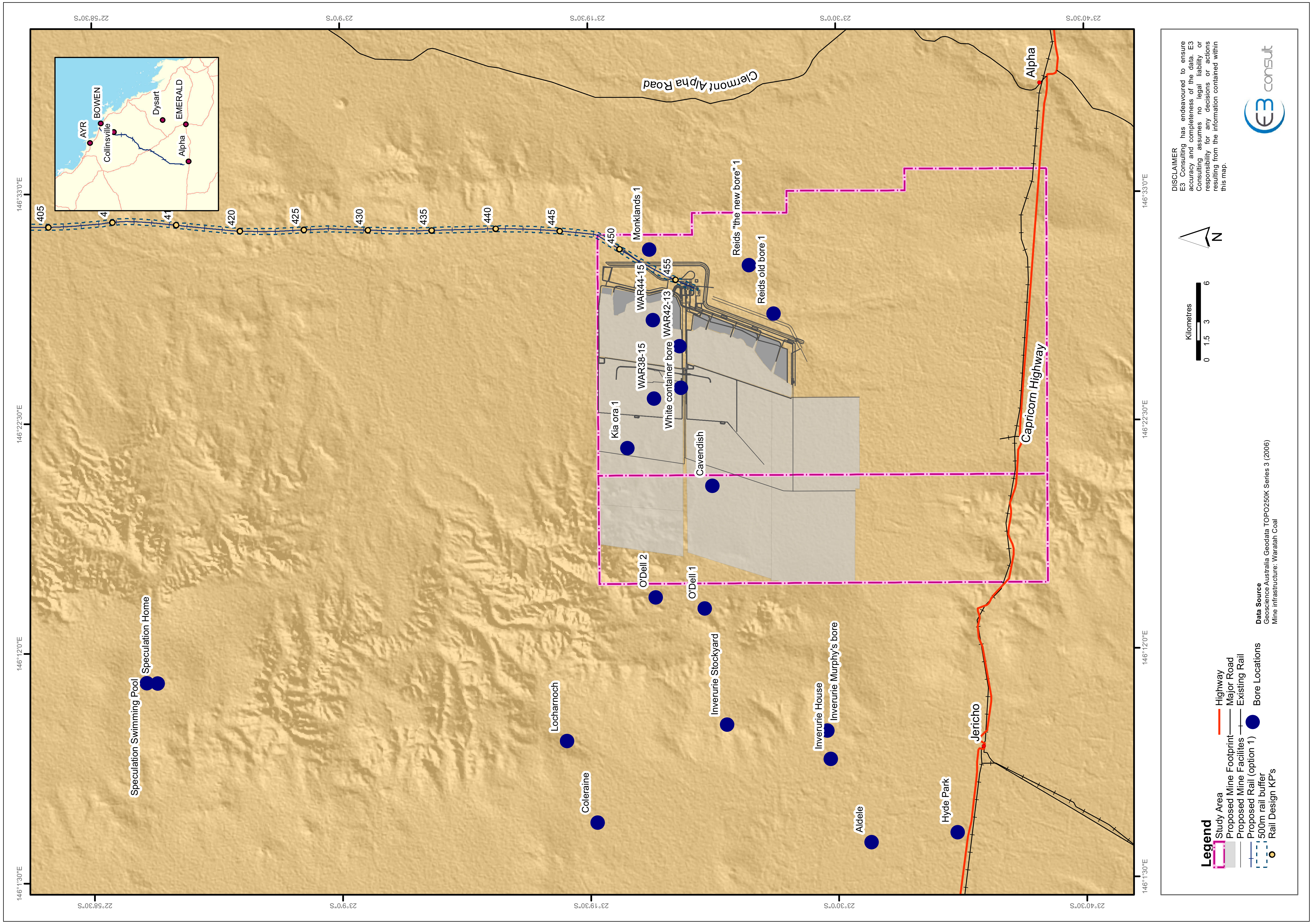


Figure 2. Monitoring Network Bore Locations



The following field parameters were assessed at the time of sampling:

- electrical conductivity (mS/cm);
- pH;
- dissolved oxygen (% saturation);
- water temperature (°C); and
- turbidity (NTU).

Samples were analysed for the following suite of parameters:

- metals (arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc);
- nutrients (ammonia as N, nitrate as N, nitrite + nitrate as N, total kjeldahl nitrogen as N, total nitrogen as N and total phosphorous as P);
- total dissolved solids;
- alkalinity (carbonate alkalinity as $CaCO_3$ and hydroxide alkalinity as $CaCO_3$);
- Sulfate as SO_4^{2-}; and
- major anions / cations (calcium, chloride, magnesium, nitrate as N, potassium, sodium, total anions and total cations).

Ionic balance was reported by the laboratory as an indication of whether other major unreported ions are present outside of those tested. The ionic balance for the results were <5%, and indicated no other major ions were present.

8.2.2.6 Aquifer Tests

Permits for long term pump tests were not received by the time the fieldwork was undertaken as the mining exploration leases over the land did not allow the removal of water for purposes other than environmental (i.e. water quality) sampling. Therefore, water levels were monitored with both pressure transducers and manual water level meters during bore development.

Water levels were also monitored during the purging and sampling of the monitoring bores. This monitoring data was used to assess aquifer parameters and in particular transmissivity, storage and hydraulic conductivity. The data were also used to monitor water levels for potential indicators of leakage / connections between bores screened in different aquifers. A v-notch weir was used to assess flow rates during bore development.

Constant rate discharge tests were carried out on WAR38-15(New), WAR42-13 (New) and WAR44-15 (New) with water levels monitored at adjacent bores. Table 1 contains detail of the three aquifer tests. Aquifer tests were carried out in accordance with AS 2368-1990 "Test Pumping of Water Wells".

Table 1. Aquifer test details

BORE ID	PUMP TIME (MIN)	PUMP RATE (L/MIN)
WAR38-15 (New)	10	9
WAR42-13 (New)	220	9
WAR44-15 (New)	184	9

8.2.2.7 Slug Tests

Slug tests were undertaken on 11 bores around the project site. A slug of water was introduced into each bore to artificially raise the water level in the bore. Water levels were monitored at one second intervals prior to slug injection, throughout the injection period and throughout the period of recovery.

8.2.2.8 Stygofauna Sample Collection

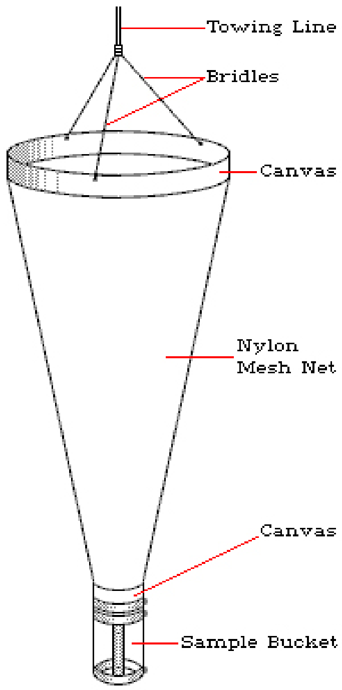
Stygofauna samples were collected in order to assess the potential for groundwater ecosystems within the MLA. Stygofauna were collected from the pump discharge of WAR38-15New, WAR38-15(63), WAR42-13(New), WAR42-13(80), WAR44-15(New), WAR44-15(Retro) using a phytoplankton net of 0.45 µm mesh size. Figure 3 illustrates the stygofauna net setup. The trap consists of a plankton net (44 mm diameter) with a small collection vial / sump attached to the bottom. A total of 300 L of groundwater was filtered through the net at each sampling location in order to meet stygofauna collection guideline requirements (Western Australian EPA, 2007).

The material that did not pass through the mesh was preserved in 70 % ethanol solution for later identification. The methods used for the collection of stygofauna were based upon the sampling methods and guidelines for subterranean fauna in Western Australia (Western Australian EPA, 2007).

8.2.2.9 Double Ring Infiltrometer Test

A double ring infiltrometer was used to assess the saturated hydraulic conductivity of shale layers in the Rewan geological formation as the shales of the Rewan Formation are interpreted to be one of the aquitards overlying the mine site geology. The infiltration test was undertaken on a sample of shale not on soil, therefore results were not used to assess recharge. Details of the infiltration test are outlined in the groundwater technical report.

Figure 3. Stygofauna Net Setup



Sourced: http://el.erdc.usace.army.mil/zebra/zmis/zmishelp/plankton_nets.htm

8.2.2.10 Groundwater Modeling

Predictive modelling was undertaken to assess the impact of the mine on the groundwater regime. The specific goals of the model were:

- predicting the amount and extent of drawdown around the mining operations;
- predicting the groundwater inflow rates to the mine void; and
- identifying areas for monitoring.

Predictive modelling included both 3D numerical modelling and analytical modelling to provide a check on numerical results. A detailed description of the modelling process is provided in the Groundwater Technical Report (Volume 5, Appendix 14).

8.3 DESCRIPTION OF ENVIRONMENTAL VALUES

8.3.1 WATER QUALITY – TERTIARY AQUIFERS

Tertiary groundwater within the study area is dominated by sodium cations and chloride anions. Based upon Hem (1992), the water is classed as sodium calcium and chloride sulphate bicarbonate waters. Figure 4 illustrates the trend in groundwater chemistry along the likely groundwater flow paths perpendicular to the Tallarenha Creek. A tertiary aquifer geochemistry map of the region is provided in Figure 5.

Figure 4. Piper Diagram Of Tertiary Aquifer Geochemistry

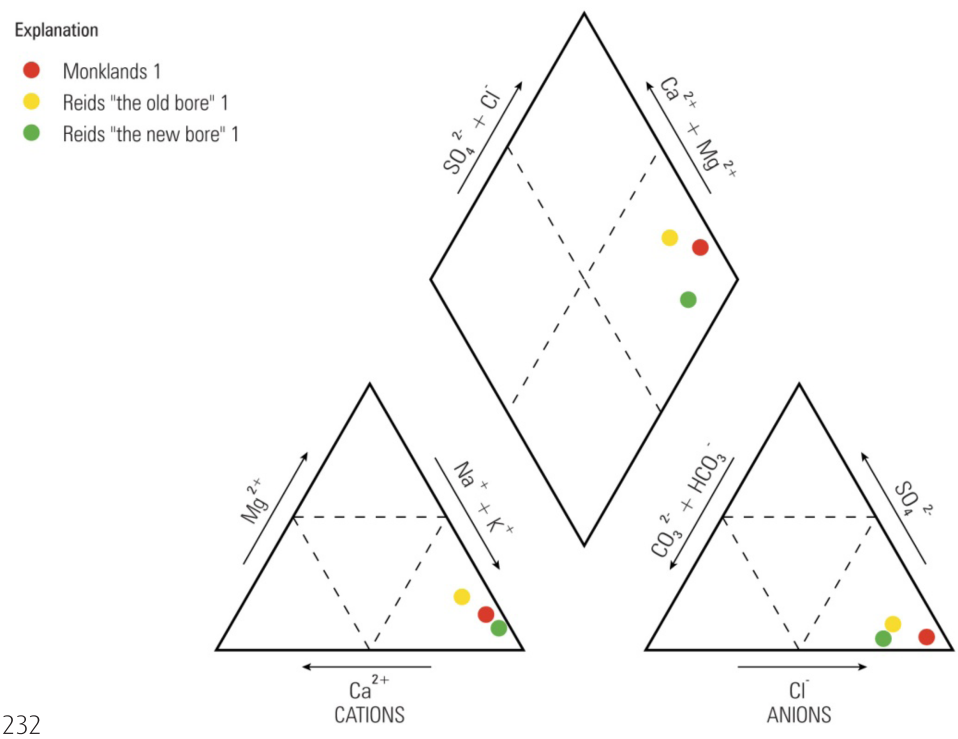
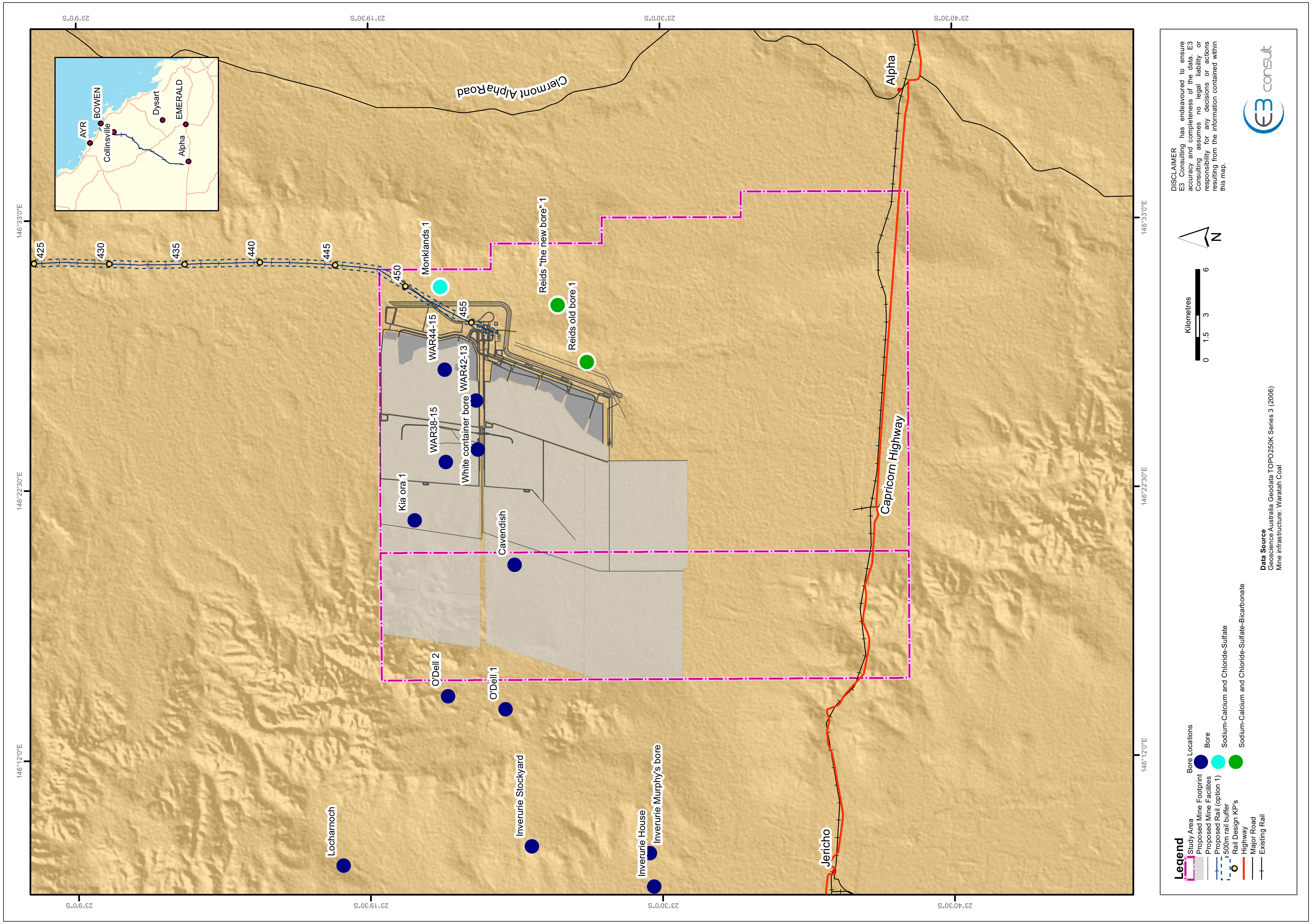


Figure 5. Tertiary Aquifer Geochemistry



The tertiary aquifers within the study area are generally slightly brackish, pH neutral, contain low concentrations of trace metals, and have elevated nutrient concentrations.

The likely cause of the increased nutrient loading may be a combination of livestock effluent, other farming practices or general nitrogen movement in shallow systems. The ratios of nutrients in the Tertiary aquifer samples are illustrated in Figure 6. This shows that tertiary aquifer waters are dominated by nitrate, nitrite, and total nitrogen.

Increased levels of both N and P in various forms may be the result of nutrients from stock effluent leaching through the vadose zone and entering the shallow tertiary groundwater. Increased nutrient leaching may have been accentuated as a result of the significant late summer rainfall events of the 2009 – 2010 seasons.

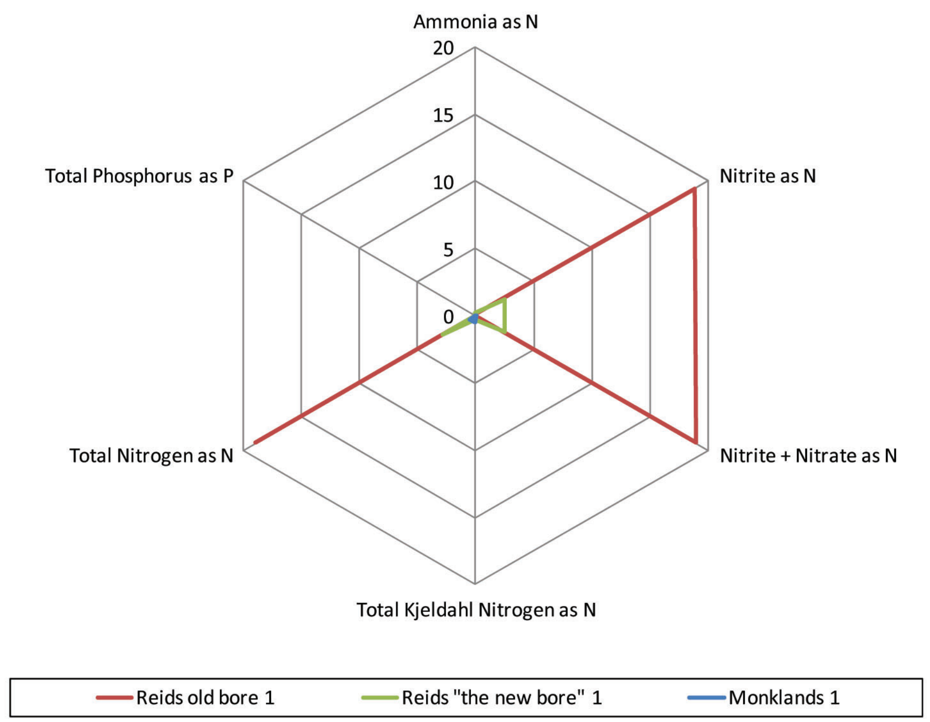
8.3.1.1 Stockwater

Groundwater from the Tertiary aquifers within and surrounding the mine site exceeded the ANZECC AND ARMCANZ (2000) stock drinking water guidelines for two of the constituents analysed, being Total Dissolved Solids and Nitrite as N. Both of these were exceeded at several of the wells and were at times an order of magnitude above the guideline limits. Trace metals were generally present in concentrations below the ANZECC AND ARMCANZ (2000) livestock drinking water criteria.

8.3.1.2 Irrigation

The Tertiary aquifer groundwater did not exceed the ANZECC AND ARMCANZ (2000), irrigation water thresholds for the constituents analysed. Tertiary groundwater can therefore be considered generally suitable for irrigation purposes.

Figure 6. Radar Plot of Tertiary Aquifer Nutrient Data



8.3.1.3 Potable

Samples collected from the tertiary aquifers in and surrounding the mine did not exceed the Australian drinking water standard (NHMRC and NRMMC 2004) guideline values for health for the analytes tested.

8.3.1.4 Ecosystems

The ANZECC AND ARMCANZ (2000) freshwater 99 % criteria were exceeded on a number of occasions. Nitrogen, nitrate, nitrite and phosphorous exceed ANZECC AND ARMCANZ (2000) freshwater 99 % criteria within the shallow aquifers; however, they were generally lower than the ANZECC AND ARMCANZ (2000) 95 % criteria. Copper concentrations were also above the guidelines; however, the observed concentration range of 0.001 – 0.009 mg/L is significantly below both naturally occurring freshwater concentrations and the livestock drinking water guideline of 1 mg/L. Zinc concentrations exceeded the guidelines, with a maximum observed concentration of 4.18 mg/L.

No groundwater dependent ecosystems were identified in proximity to the mine.

8.3.2 WATER QUALITY – PERMIAN AQUIFERS

Water of the Permian aquifers is dominated by chloride anions, sodium and potassium cations and is classified by Hem (1992) as sodium-calcium, chloride-sulfate and chloride-sulfate-bicarbonate waters (Figure 7).

The weathered Permian geochemistry of the mine is shown in Figure 8.

Figure 7. Piper Diagram of Permian Aquifer Geochemistry

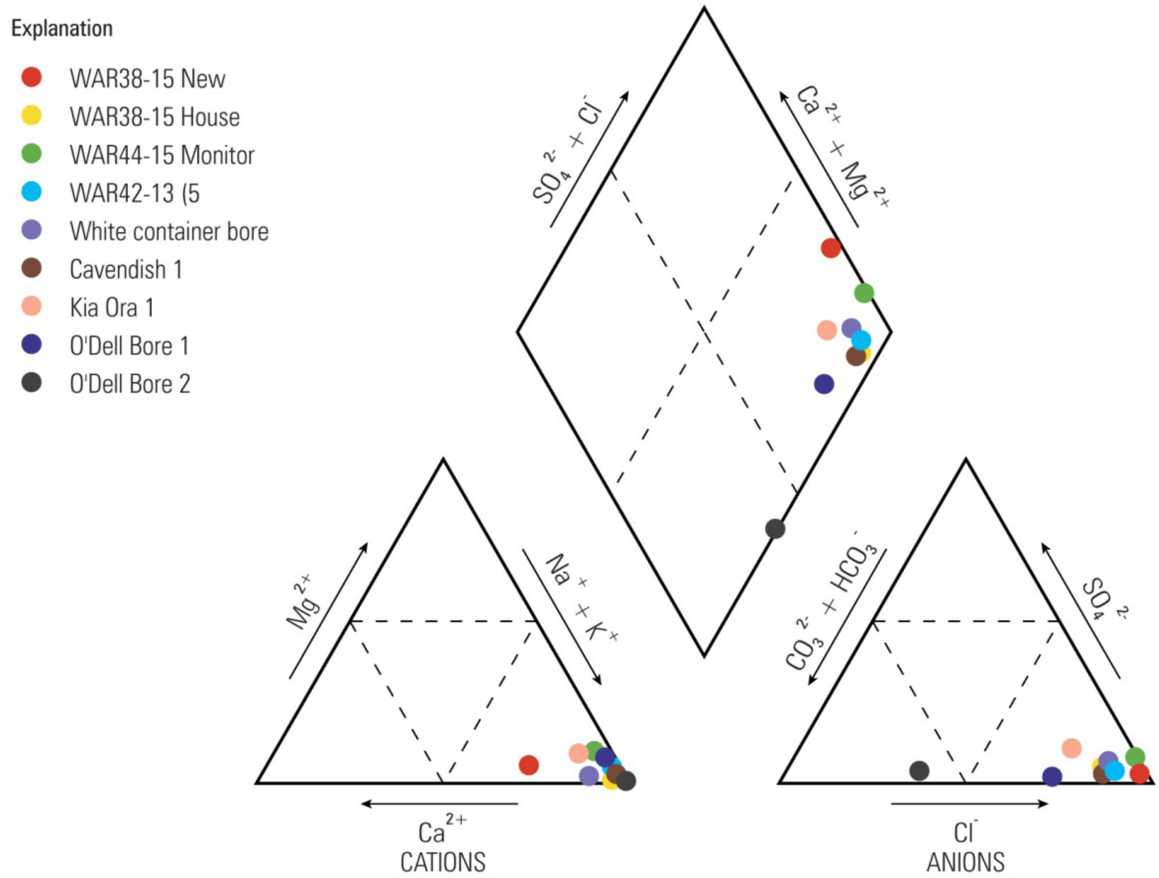


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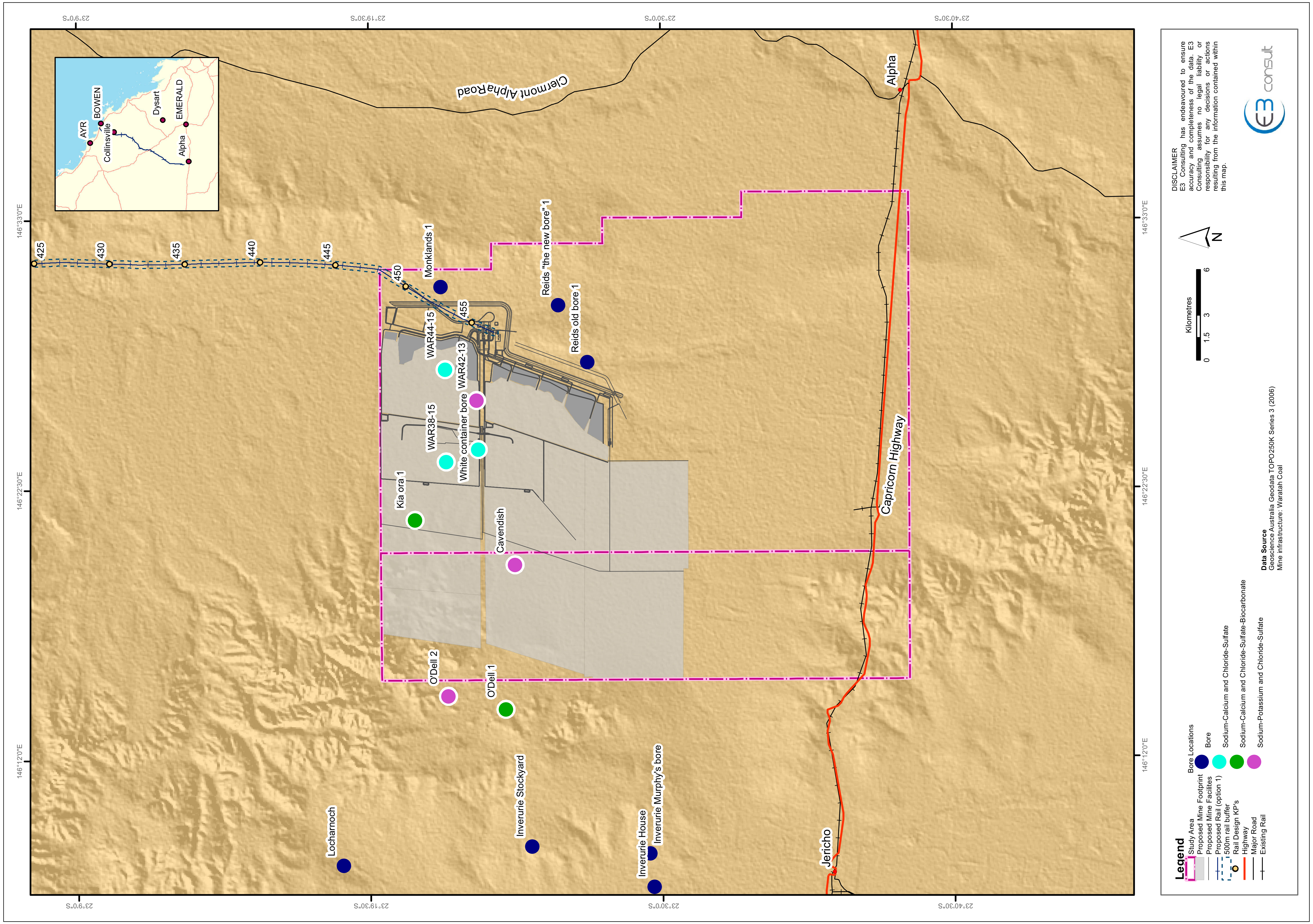
Figure 8. Weathered Permian Geochemistry



The Permian aquifers are characterised by neutral to slightly alkaline pH, trace metals in low concentrations and elevated levels of nitrogen, total kjeldahl nitrogen and ammonia. Figure 9 and Figure 10 outline the respective ratios of nutrients in the Permian aquifer samples. Figure 9 shows that the bores have a similar pattern indicating similar nutrient ratios while Figure 10 shows the bores have different ratios suggesting different influences on the groundwater. Bores that terminate in the various coal seams and surrounding interburden and overburden layers have high nitrogen and ammonia compared to bores of the weathered Permian zone (Cavendish 1, O'Dell bore 1 and O'Dell bore 2).

The water quality within the Permian aquifers is likely to reflect the age of the water and the characteristics of the aquifer material. The Permian aquifers often occur in and around the various coal seams as stated in SKM (2009). The presence of trace metals may be the result of leaching of these metals from the coal into the groundwater.

Figure 9. Radar Plot of Permian Aquifer Nutrient Data

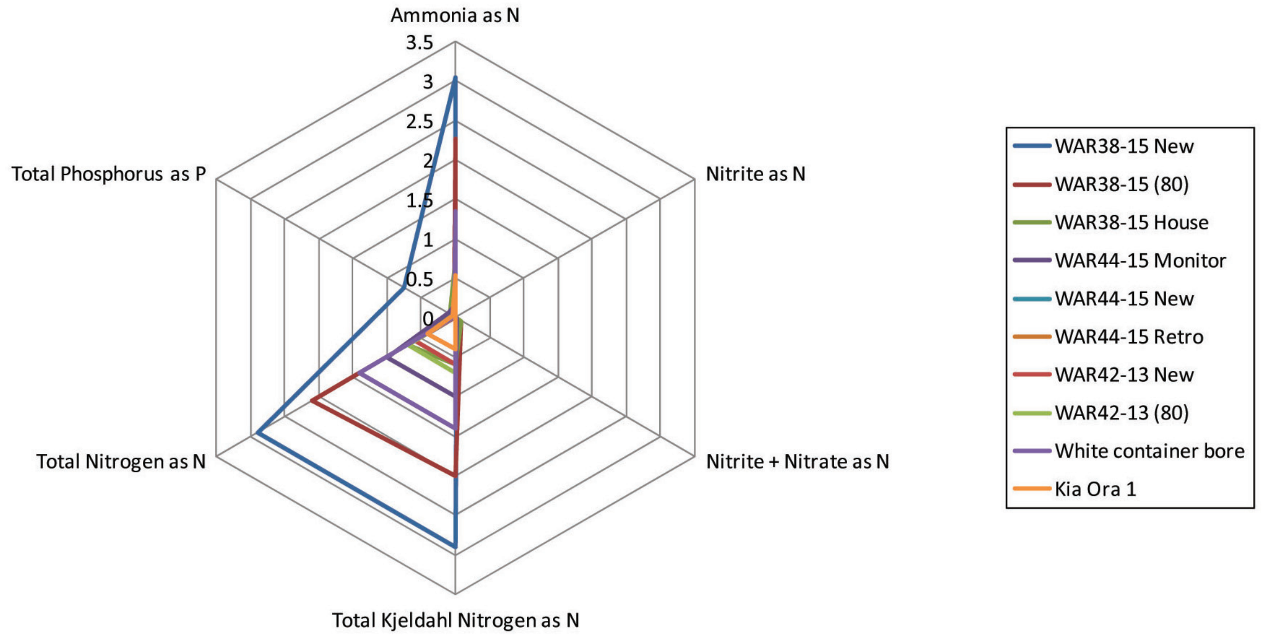
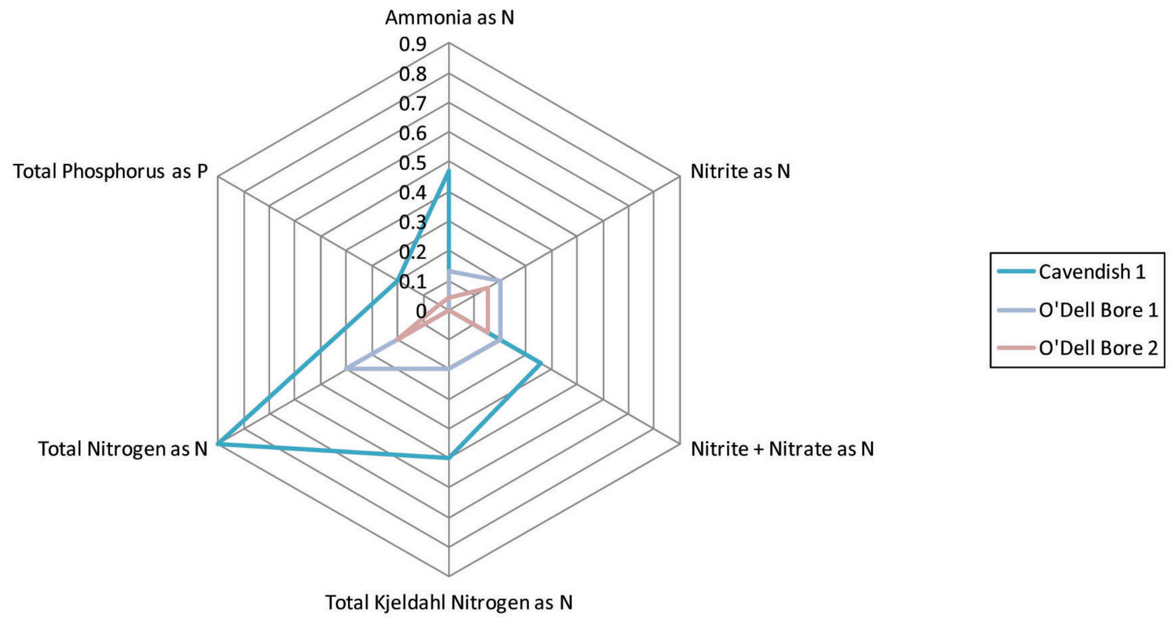


Figure 10. Radar Plot of Permian Aquifer Nutrient Data



8.3.2.1 Stock Water

Total dissolved solids consistently exceeded the ANZECC AND ARMCANZ (2000) stock drinking water guidelines with 12 of the 17 wells analysed being above guideline limits. Exceedances ranged from minor to up to eight times the guideline limit. Nitrite also exceeded guideline limits at two of the wells.

8.3.2.2 Irrigation

Water within the mine is currently not used for irrigation purposes; however, chloride, iron, manganese, total P and zinc exceeded ANZECC AND ARMCANZ (2000) primary industry guidelines and a number of constituents exceeded the ANZECC AND ARMCANZ (2000) freshwater 99 % guidelines. Negative down flow effects from irrigating land with water from Permian aquifers may occur, particularly in areas where surface runoff is directed towards streams. These effects may include soil anion build up, raised concentrations of potentially harmful nutrients and metals in both shallow groundwater and surface water bodies.

8.3.2.3 Potable

Groundwater from the Permian aquifers was generally below the NHMRC and NRMMC (2004) levels for health for a number of the analytes assessed. Both Nickel and Cadmium marginally exceeded the guideline levels at one of the wells sampled (War44-15 Retro).

8.3.2.4 Ecosystems

The ANZECC AND ARMCANZ (2000) freshwater 99 % criteria were exceeded at a number of the wells. Total dissolved metals which include: ammonia, arsenic, cadmium, chloride, copper, iron and manganese nitrate, nitrate + nitrite, total N, total P, total dissolved solids and zinc were present in the Permian aquifers at concentrations greater than those specified in the ANZECC AND ARMCANZ (2000) freshwater 99 % guidelines. The high number of exceedances is a result of the stringent criteria put in place for the protection of 99 % of aquatic species with most dissolved metals identified at concentrations only marginally above trace levels. At a number of the sites nutrients were identified at levels an order of magnitude above guideline limits and are likely related to the high total dissolved solids also identified at most of the sites.

No groundwater dependent ecosystems were identified in proximity to the mine.

8.3.3 WATER QUALITY – GREAT ARTESIAN BASIN AND ASSOCIATED AQUIFERS

Landowners bores sampled in this study and located in the GAB and associated aquifers reported water quality dominated by sodium and potassium cations and chloride anions. According to Hem (1992) these are classified as Sodium – Calcium and Chloride – Sulfate – Bicarbonate waters (Figure 11) and are characterised by neutral to slightly acidic pH, slightly elevated levels of trace metals and raised background levels of nutrients. Water quality data for bores sampled sites are provided in the Groundwater Technical Report (Volume 5, Appendix 14). The cation-anion results reflect reports by GABCC (2009), which state that the GAB aquifers are generally sodium bicarbonates with chloride and minor carbonate.

8.3.3.1 Stock Water

Groundwater from the GAB and associated aquifers west of the mine site did not exceed the ANZECC AND ARMCANZ (2000) stock drinking water guidelines. Groundwater from these aquifers can therefore be considered suitable for livestock drinking water.

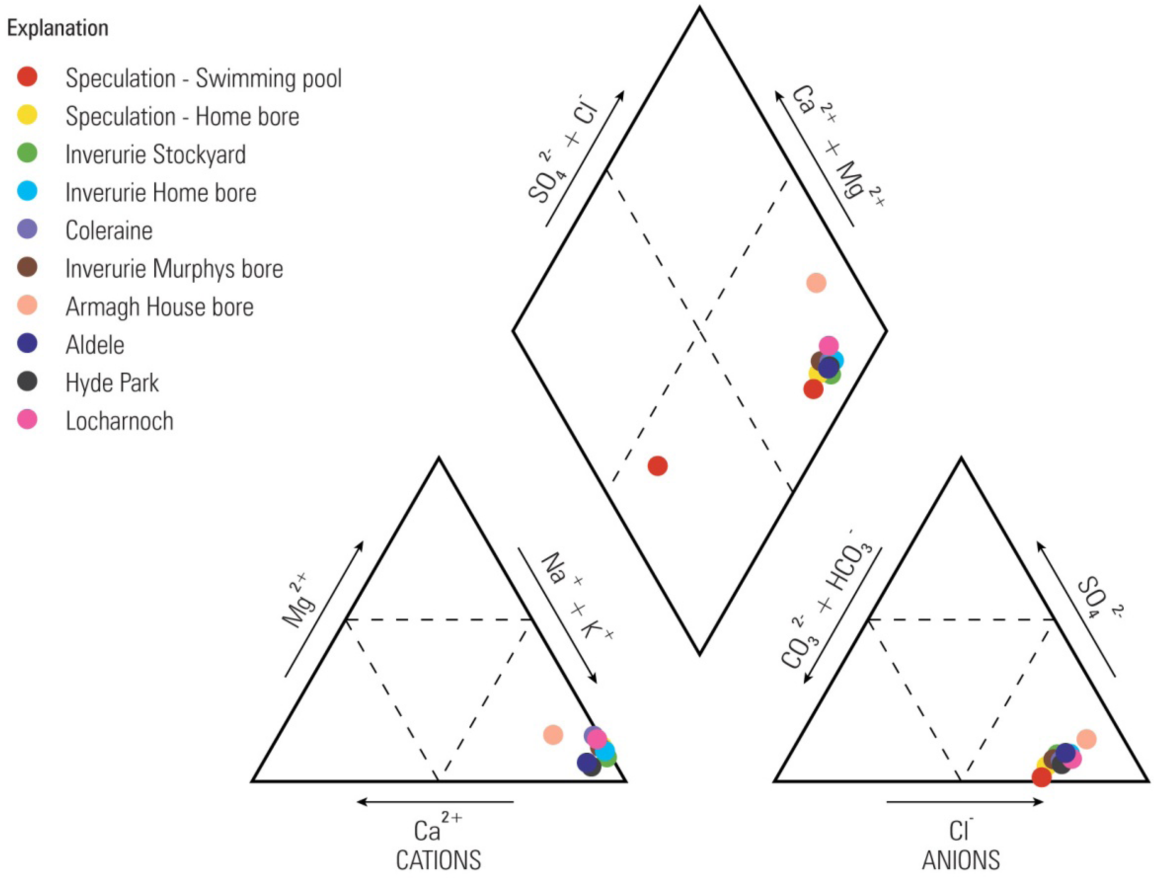
8.3.3.2 Irrigation

The GAB aquifer groundwater samples did not exceed the ANZECC AND ARMCANZ (2000) irrigation water thresholds for the constituents analysed. Groundwater can therefore be considered suitable for irrigation purposes.

8.3.3.3 Potable

Groundwater from the GAB and associated aquifers did not exceed NHMRC and NRMMC 2004 for the analytes assessed.

Figure 11. Piper Diagram of the GAB and Associated Aquifers Geochemistry



8.3.3.4 Ecosystems

The ANZECC AND ARMCANZ (2000) freshwater 99 % species protection criteria were exceeded at a number of wells and for a number of parameters. Water quality within the GAB and its associated aquifers sampled during this study exceeded the ANZECC AND ARMCANZ 2000 freshwater 99 % guideline values for copper, nickel, zinc, nitrate, total nitrogen, and phosphorous. The high number of exceedances is a result of the stringent criteria put in place for the protection of 99 % of aquatic species with most dissolved metals identified at concentrations only marginally above trace levels. Nitrogen levels were above guideline values at all of the sites with exceedances generally doubling the relevant guideline limit.

No groundwater dependent ecosystems were identified in proximity to the mine.

8.3.4 STYGOFAUNA RESULTS

Analyses of samples collected from the bores indicated that there were no Stygofauna. Results from the stygofauna sampling regime are outlined in the Aquatic Ecology Technical Report (Volume 5, Appendix 13).

8.3.5 REWAN FORMATION INFILTRATION RESULTS

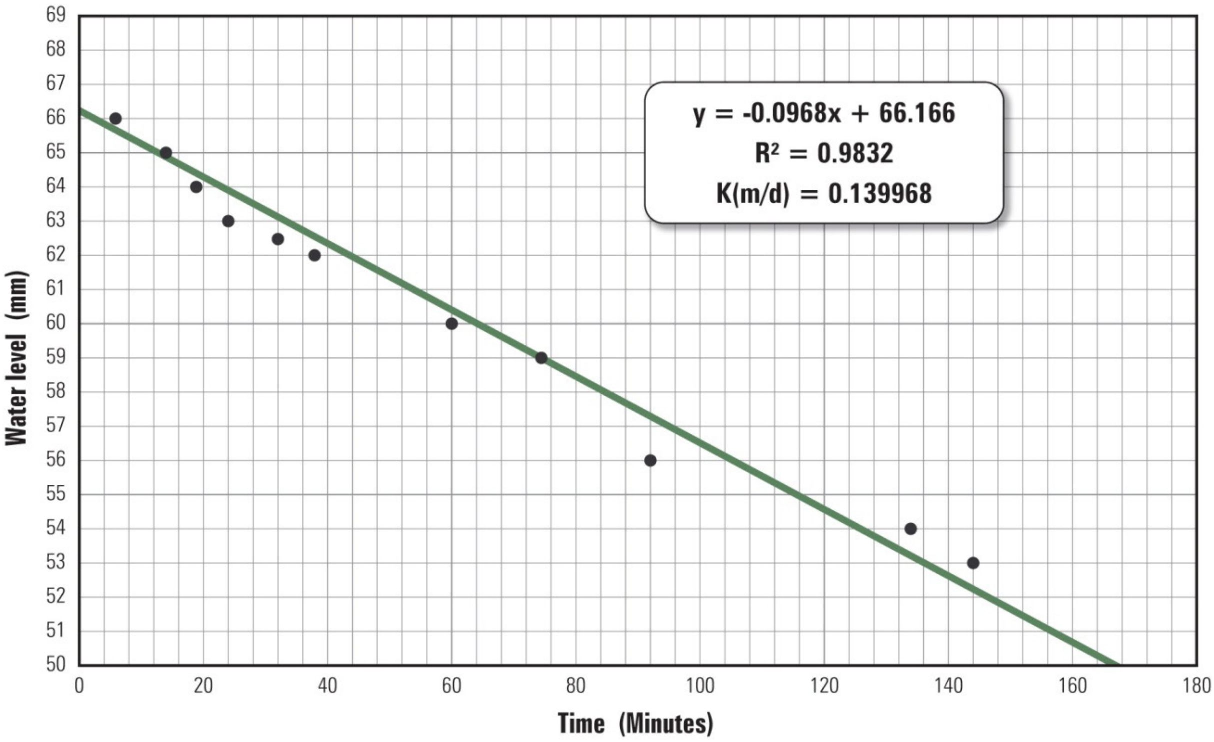
Results from a controlled infiltration experiment on shale layers in the Rewan Formation (fm) are presented in Figure 12. The slope of the linear trend provides an indication of the infiltration rate into the shale sample. The test resulted in a predicted infiltration rate of 0.14 (m/d). This result is within the likely hydraulic conductivities of the confining beds of the GAB of between 1 – 0.001 m/d (Habermehl, 1980).

8.3.6 TERTIARY AQUIFER HYDROGEOLOGICAL REGIME

8.3.6.1 Distribution

Data characteristics of shallow tertiary aquifers within and surrounding the study site are sparse. DERM supplied data for bores within a 50 km radius from the approximate centre of the mine. This data was limited with respect to aquifer depths and parameters. The available data indicate that tertiary aquifers occur predominantly alongside and below surface water bodies such as wetlands and streambeds. The depth of the aquifers ranged from 4 mbgl – 77.2 mbgl, with an average depth of 37.62 m and an average aquifer thickness of 2.02 m.

Figure 12. Double Ring Infiltrometer Test Results



8.3.6.2 Groundwater Occurrence, Recharge and Flow

Data from DERM bores show boreholes in the vicinity of the mine have a static water level of 9.3 m and a total depth of 28.3 m. Bore "Monklands 1" is an equivalent depth; however, is 3.8 km east north east of bore 12030076 and the static water level of 15 m is significantly deeper resulting in an estimated groundwater gradient of 0.0015 m/m in an easterly direction.

Tallerenha Creek lies to the west of bore 12030076. The Tallerenha Creek may recharge the shallow Tertiary aquifer during the wet season resulting in a gradient away from the creek.

8.3.6.3 Hydraulic Parameters and Yield

Due to the limited amount of historic tertiary aquifer data, it is difficult to accurately estimate aquifer hydraulic parameters. Limited yield data were available from the DERM database specifically for the tertiary aquifers. The available data indicate a range in aquifer yields of between 0.01 – 0.27 L/s.

8.3.7 PERMIAN AQUIFER HYDROGEOLOGICAL REGIME

8.3.7.1 Distribution

Water bearing layers exist within the Permian strata at various depths. Aquifers within the Permian strata are usually associated with coal seams and the overburden and interburden above and between the various coal seams. A number of bores exist within a 50 km radius of the mine that is screened in Permian aquifers. There is no apparent pattern to the spatial distribution of bores that terminate in Permian aquifers.

8.3.7.2 Groundwater Occurrence, Recharge and Flow

Recharge around the bores installed occurs locally by horizontal flow rather than vertical recharge as no disturbance of overlying water levels in bores was reported. Long term pump tests may provide further data to assess this hypothesis. Regional recharge may be occurring at leaky areas further west.

Based on groundwater contouring, the likely groundwater flow direction within the Permian aquifers including the various coal seams and interburden layers is in a north easterly direction (Figure 13 to Figure 15).

Figure 13. Weathered Permian Groundwater Contouring

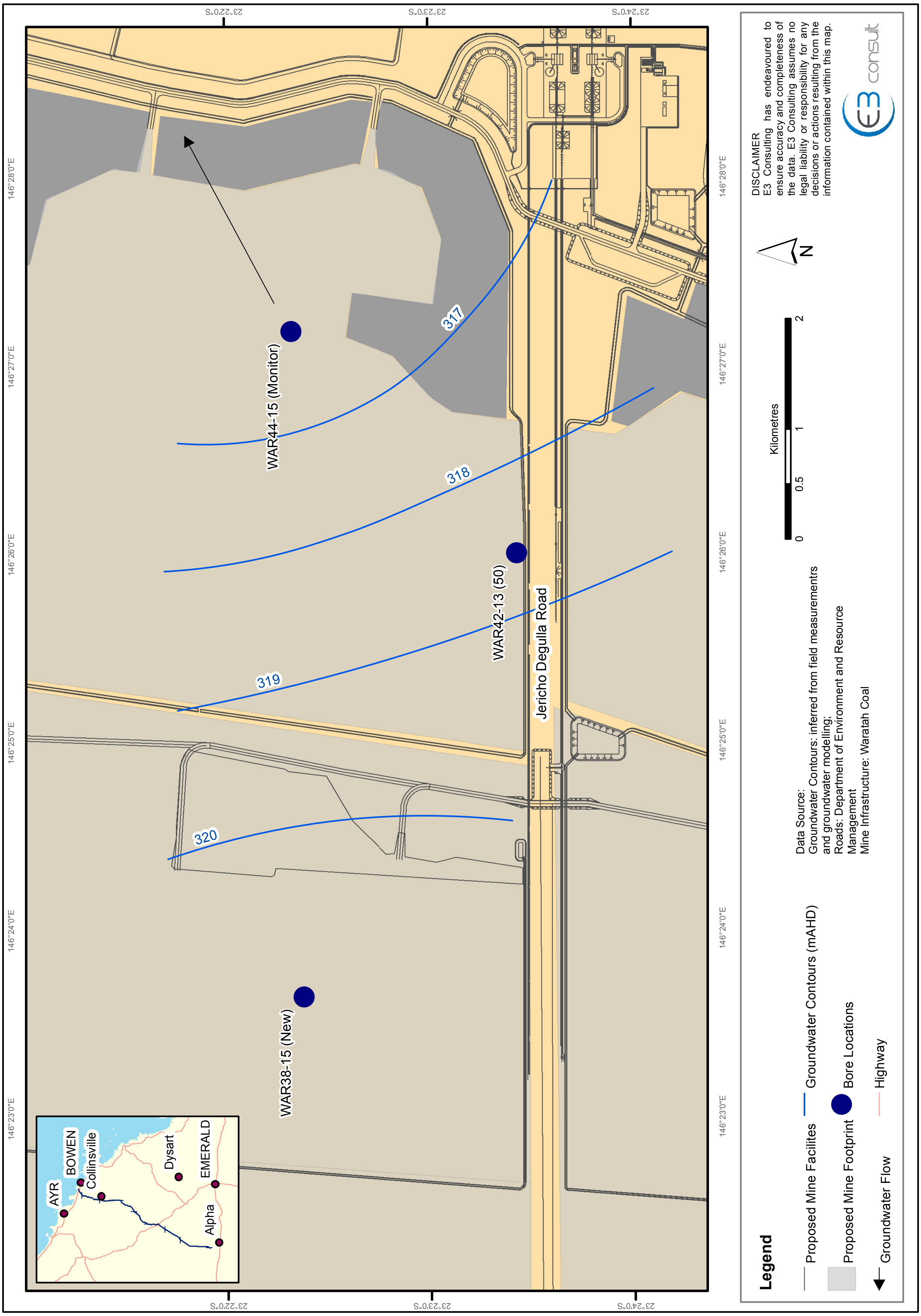


Figure 14. Interburden Coal Seam ‘D’ Upper and ‘D’ Lower Groundwater Contouring

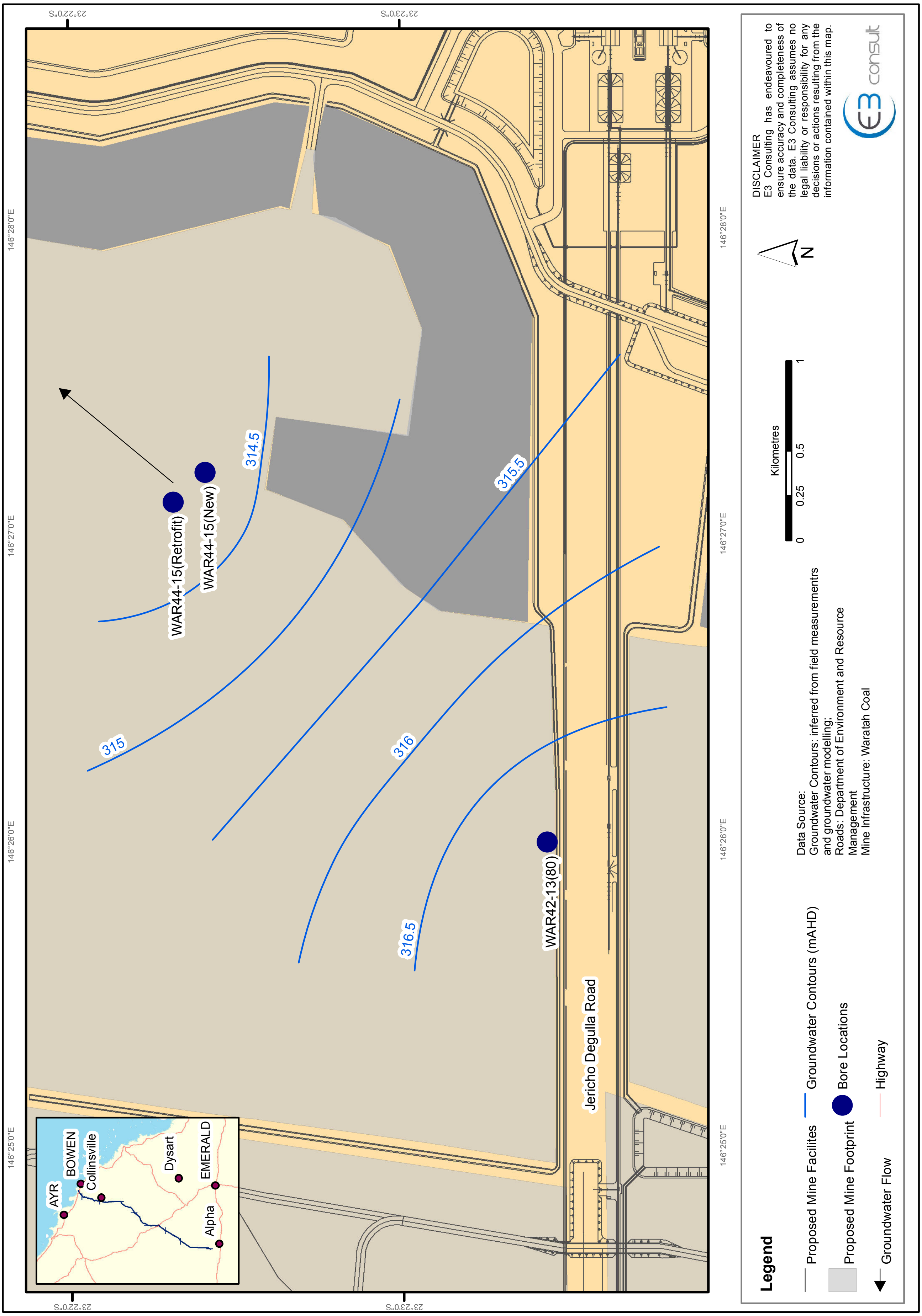
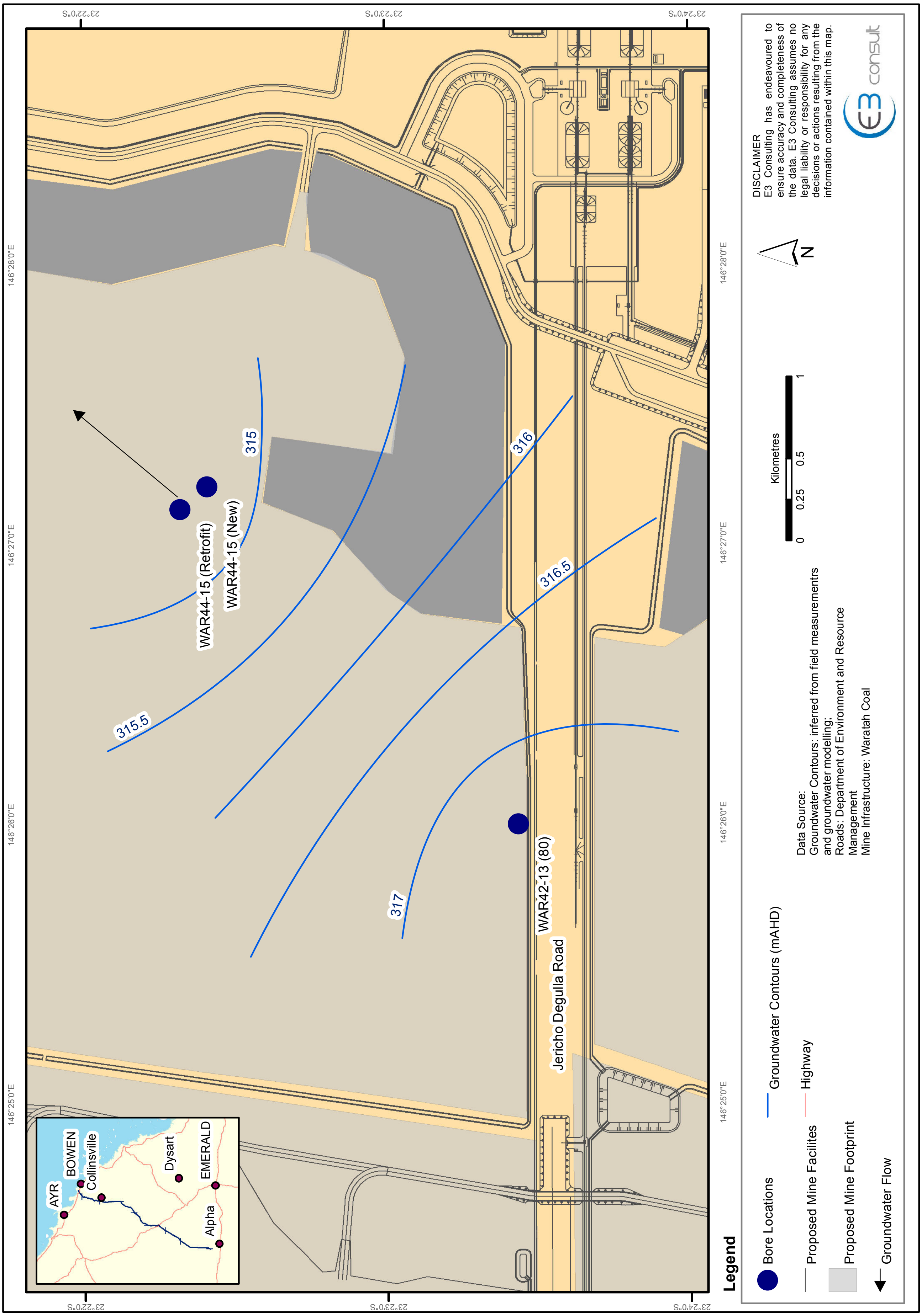


Figure 15. Coal Seam 'D' Lower Groundwater Contouring



8.3.7.3 Hydraulic Parameters and Yield

Hydraulic parameters vary within the Permian aquifers at the mine. The weathered Permian sediments above the position of the coal seams display a range in hydraulic conductivity between 0.001 – 0.0029 m/d.

Transmissivities within the coal seams ranged from 9 – 34 m^2/d based on the constant rate drawdown tests. Calculated values of hydraulic conductivity are taken into account, as values of transmissivity and relative thickness of each aquifer ranges from 1.8 m/d to 6.8 m/d. Storage values within the coal seams ranged from 3.4×10^{-4} – 9.1×10^{-5}.

Hydraulic parameters in the interburden layers displayed similar characteristics to those of the coal seams. Pumping tests and bore production carried out on bores WAR38-15(New), WAR42-13(New) and WAR44-15(New) indicate yields within the Permian strata of between 0.15 L/s – 0.3 L/s.

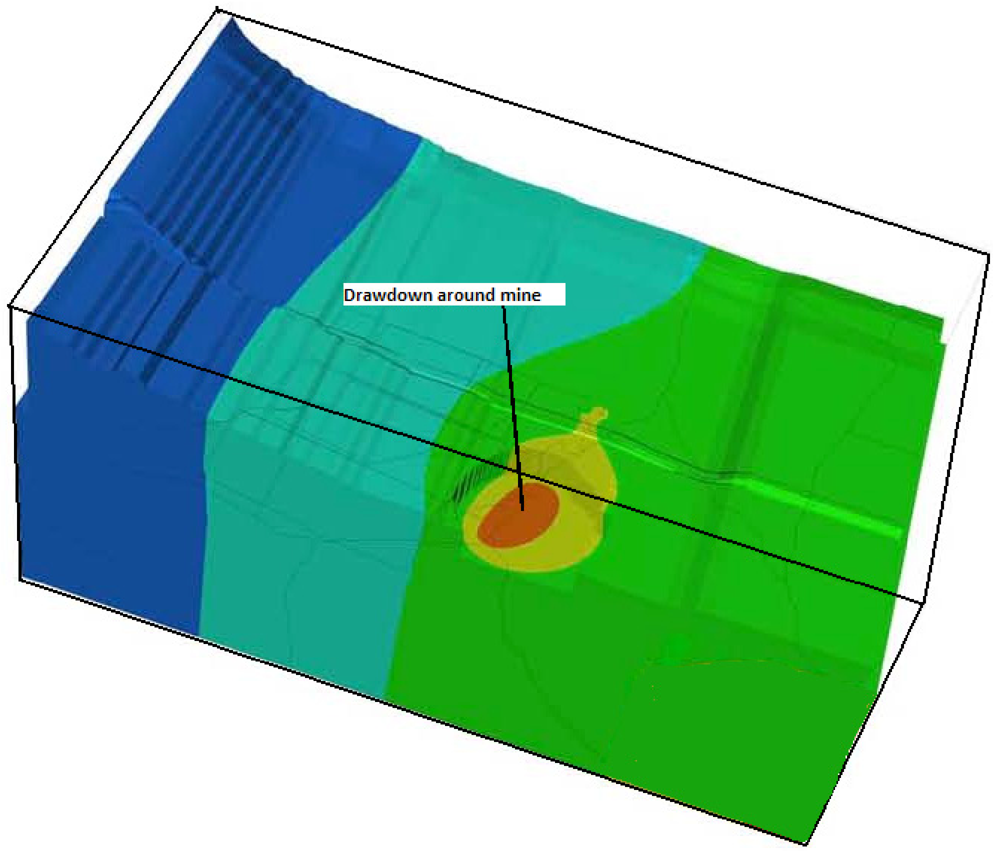
8.3.8 PREDICTIVE MODELING RESULTS

8.3.8.1 Drawdown

A series of predictive steady state simulations of the open cut and underground mining sequence from year one to year 25 was undertaken to assess the potential area of influence of drawdown around the mine at 5 year intervals.

In year one draw downs of more than five m extend to a maximum of 1.1 km (Figure 16) from the open cuts and 5.9 km in year five. While between year 10 to year 25 the resulting drawdown was estimated to extend to approximately 11 km in an east-west direction and 5 km in a north- south direction. It is predicted via modeling results that a drawdown will extend to 15 km by year 25. To provide an indication of uncertainties in the model, simulations with variations of hydraulic model parameters and steady state simulations yielded estimates to extend up to approximately 30 km from the mine during the mine life. The assumptions used in developing this model (see Volume 5, Appendix 14) are conservative and are anticipated to provide an indication of impacts at the larger end of the scale of potential impacts.

Figure 16. Example Model Output of the Potential Drawdown around the Mine



8.3.8.2 Inflows

The predicted mine inflows from the above modelling are summarised in Table 2.

Table 2. Estimated mine inflows

YEAR	INFLOW ESTIMATES (ML/YEAR)
1	980-1,400
5	1,020-4,700
10	1,850-2,550
15	1,650-4,850
20	2,200-9,500
25	3,800-12,300

These estimates are based upon simulations with mass balance errors for the model between 0.07 % (Year 10) to 8.7% (Year 1), which are considered reasonable for a model of this type.

It should be noted that the inflow estimates are considered conservative as the model assumes flow rates will remain constant for the life of the mine however in reality inflows will likely reduce over time due to changes in the hydraulic head. The model also assumes:

- all inflows will be captured by mine dewatering systems (i.e. sumps and pumps);
- no pre-drainage of the mine occurs (therefore initial filling of the mines are included in the inflow estimates);
- includes pore water in the mined material; and
- excludes evaporation.

Simulations with increased vertical hydraulic conductivity to simulate cracking reported inflows up to an order of magnitude higher than the above estimates. However, further detailed data is required before reliable estimates can be made.

8.3.8.3 Groundwater Recovery

Groundwater recovery was not complete in simulations of 50 years following mining. Given the absence of transient calibration data, the uncertainties in long term simulations beyond this are considered too large to provide meaningful results.

Current information from monitoring of mines indicates that full recovery of groundwater levels requires many decades (typically in the order of 50-100 years) and in some instances will not fully recover to pre-mining levels. This may be due in part to changes to aquifer permeability and reduced infiltration by fine spoil material reducing permeability in infiltration areas and from the mining processes. It is also possible that evaporation from water filled open cut mine voids may maintain water levels at lower depths than pre-mining levels. More detailed data including transient data during mining would be required to refine this assessment.

8.4 POTENTIAL IMPACTS

8.4.1 GREAT ARTESIAN BASIN

The coal reserves of the mine area are outside the GAB. The presence of shale aquitards in units between the coal seams and the GAB aquifers and the predominantly easterly groundwater flow, interpreted as being due to drape folds further to the west, suggests a very low to no potential for negative impacts on the GAB groundwater resources resulting from open cut, longwall and underground coal mining.

8.4.2 MINE INFLOWS

The numerical modelling indicates inflows to the mine will be around 980 to 12,300 ML/year during mining. This is anticipated to reduce over the mine's life as drawdown dewaters the surrounding aquifers.

8.4.3 DRAWDOWN AND WATER LEVELS

The extraction of groundwater by mine dewatering will lower the elevation of the piezometric surface of the aquifers and create a cone of depression around the mine. The cone of depression is anticipated to extend between 11 km to 30 km from the mine.

The model simulations indicate that drawdown may impact bores in the shallow Tertiary and Permian aquifers within 11 km to 30 km of the mine. There is potential for drawdown to impact surrounding property owner's bores of the Tertiary and Permian aquifers where a connection is present between the aquifers. Where no connection is present, then the depressurisation of underlying aquifers is unlikely to impact on farm bores. The impact is anticipated to be greater to the east of the study area as the mine will intercept recharge and dewater aquifers sloping from the east.

No groundwater dependent ecosystems were identified in proximity to the mine. Vegetation that extracts groundwater is likely to be in alluvial areas where shallow groundwater is within the root zone (2 m to 5 m depth). Where these alluvials are not connected to the underlying aquifers and resultant depressurisation of the aquifers does not affect the alluvials, no significant impact is anticipated. The water is considered to be generally suitable for irrigation or livestock watering although some saline aquifers will not be suitable for these uses. Dewatering of the aquifers will result in the loss of this groundwater and these environmental values within the impacted area around the mine.

8.4.4 IMPACT OF SUBSIDENCE

The likely maximum level of subsidence is estimated to be 3.27 m in the north western section of the underground mine footprint. Given these levels of subsidence, cracking of the overlying geology is likely to occur. This cracking may result in rapid infiltration of rainfall into the aquifers surrounding the mine, potentially leading to increased rates of flow into the goafs requiring increased dewatering.

8.4.5 GROUNDWATER CONTAMINATION

The potential for groundwater contamination may occur as a result of impacts from coal rejects disposal; mining; goafing of the coal seam aquifers; leaking disposal facilities; spills and leaks from chemical, fuel and oil storage and handling at workshops and mine operations infrastructure. As no prior mining has occurred in the area of the mine no prior impacts from coal reject disposal could have occurred.

The potential for impacts from surface storages of rejects, waste, fuel, oil and chemical storages are considered to be low because:

- groundwater levels around the mine are generally not shallow and will become deeper due to drawdown around the mine;
- appropriately constructed storage and handling will result in low potential for leakages or spills; and
- the assessment of potential for acid generation and heavy metals impacts from the mine overburden and coal reject indicate a low potential for these impacts. This assessment is presented in Volume 5, Appendix 7.

The groundwater is generally brackish to saline and useable for livestock drinking water and therefore, the potential for further deleterious impacts to potential uses is lower.

8.5 MANAGEMENT MEASURES

Management measures will be implemented within the MLA and surrounding region to include:

- groundwater inflow can be controlled by strategically placed sumps for pumping to surface storage, treatment and / or reuse in the mine water management system. Consideration will also be given to reuse of water in other operations and / or for dust suppression;
- the impact of drawdown on alluvial water levels and farm bores will be monitored by implementation a groundwater monitoring program throughout construction and operation;
- in the event of drawdown dewatering alluvial systems such as creeks, artificial recharge may be necessary to maintain wet season flows. This can occur through artificial recharge and / or injection of captured water into the underlying alluvial layers. This should only be done where the recharge water is of equal or better quality than the water present in the aquifers;
- where drawdown impacts farm bores, replacement bores and pumps may be drilled to either intersect deeper areas of the aquifers currently being used or to access deeper aquifers below the level of mining;
- where groundwater is required for abstraction, a permit to take water and a development application to install a bore will be required. In addition, Waratah will enter into agreements with landholders to mitigate or make good, any impacts where groundwater abstraction affects groundwater in existing landowner bores;
- containment of all fuels, oils, chemicals and other materials should be undertaken to avoid the potential for impact to shallow groundwater. In the event groundwater contamination occurs, the impact will be assessed and remediated in accordance with the requirements of the EP Act;
- surface flows would be managed with appropriate erosion and sediment controls to minimise potential for erosional scouring of soils or increased sediment loading of recharge water leading to changes in

recharge of shallow aquifers. Sediment control structures will be regularly checked, repaired, replaced and / or cleaned out. The control shall be maintained so that they will always have 70% of their capacity available. An ESCP will be prepared to ensure the ongoing management of this potential impact; and

- in the identified areas of shallow unconfined groundwater, a site specific assessment of the depth and vulnerability of groundwater will be undertaken prior to site works.

8.6 CONCLUSION

The mine lies east of the boundary of the GAB and includes groundwater in the Galilee Basin. The presence of aquitards at the base of the GAB suggests a very low to no potential for impacts from the mine to the GAB. Modelling suggests the mine will have significant impacts to groundwater users within 12 km to 30 km of the mine from drawdown around the mine voids.

The potential for groundwater contamination may occur as a result of impacts from coal rejects disposal, mining, goafing of the coal seam aquifers, leaking tailings dams, spills and leaks from chemical, fuel and oil storage and handling at workshops and mine operations infrastructure.

A monitoring program with trigger levels has been suggested to assess the actual impacts from the mine during its development and Waratah Coal will enter into agreements with local land users for monitoring and "make good" arrangements where unacceptable impacts are reported. Further longer term hydraulic testing is required to fully predict the extent of potential impacts.

Mitigation measures to manage these have been provided and include site specific studies of vulnerable groundwater areas, management and containment measures for potential contaminants and a commitment to enter into agreements with landholders regarding groundwater usage (if required) and "make good" requirements if groundwater is impacted by project activities.

8.7 COMMITMENTS

Waratah Coal commits to:

- the implementation of long term pumping tests of bores in the mine area to assess impacts on local users;
- updating the conceptual model with data obtained during the monitoring to assess any potential impacts on the mine on groundwater ecosystems;
- refinement of the groundwater model based upon above data to assess transient scenarios;
- undertaking geotechnical works to assess subsidence potential for cracking to affect the groundwater regime;
- collection of mine inflows for reuse;
- implementation of the groundwater monitoring program;
- developing ESCPs prior to the commencement of construction to reduce impacts on groundwater;
- implementation of management plans and containment structures for potential contaminants;
- remediation of groundwater contamination caused by the project;
- site specific investigation of the areas identified from geotechnical review; and
- enter into agreements with surrounding landowners regarding monitoring of impacts and make good provisions where impacts occur.