Central Eyre Iron Project
Mining Lease Proposal

CHAPTER 19

GROUNDWATER

DISCLAIMER

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Subject to that declaration:

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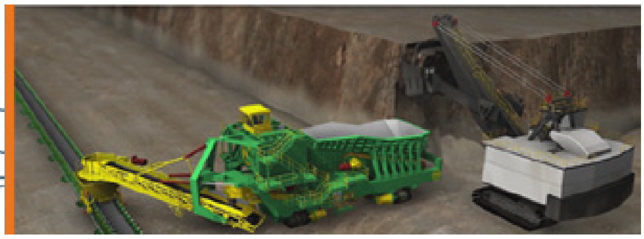

19 Groundwater

This chapter provides an overview of the potential environmental values relevant to groundwater at the proposed mining lease and surrounding region, including the regional hydrogeology and identification of potential groundwater users. It presents an assessment of potential impacts to groundwater resources and considers whether these altered groundwater conditions will impact environmental values. Where relevant, management and / or mitigation measures that would minimise potential impacts are identified.

Groundwater interactions associated with construction, operation and closure of the proposed mine include:

- Lowering of the water table associated with managing groundwater inflow into the pit via de-watering wells located around the perimeter of the mine pit and in pit sumps during advanced dewatering and mine operation
- Increases to groundwater recharge associated with development of the integrated landform
- Lowering of the water table associated with evaporation effects from the open pits following mine closure

Further details regarding the approach to the groundwater assessment are provided in Appendix N, the Groundwater Impact Assessment Technical Report.

It should be noted that the water supply for the project comprises a borefield located some 60 km to the south of the mine lease. The borefield and impacts are assessed as part of a Development application and supporting EIS. The borefield and the mine are sufficiently distant that cumulative impacts do not occur and the separate approval provides an appropriate assessment process.

19.1 Applicable Legislation and Standards

The relevant legislation relating to groundwater resources at the proposed mining lease is as follows:

- *Mining Act 1971*
- *Natural Resource Management Act 2004*
- *Environment Protection Act 1993*

The *Natural Resources Management Act 2004* (NRM Act) promotes sustainable and integrated management of the State's natural resources and provides for their protection. The Act includes provisions relating to the sustainable extraction of groundwater resources and provides prescription of water resources to protect against over use and to minimise adverse effects from development.

Water Affecting Activities (WAA) are regulated under Section 127 of the NRM Act. To undertake most types of WAA, a permit is required from the relevant authority, which in most cases is the Minister for Sustainability, Environment and Conservation, through the South Australian Government Department of Environment, Water and Natural Resources (DEWNR) or the relevant Regional Natural Resources Management Board (NRM Board). To obtain a permit, the applicant must demonstrate that the WAA will be appropriately managed to protect environmental values. The proposed mine is located within the Eyre Peninsula NRM Board region. Permits for WAA related to the proposed mine will be required under the NRM Act as part of the secondary approvals process.

The *Environment Protection Act 1993* also identifies Water Protection Areas in South Australia, which have been delineated for the purposes of providing them with special environmental protection.

The proposed mine is not located within a prescribed well area under the NRM Act or a water protection area prescribed under the *Environment Protection Act 1993*.

Further information regarding the requirements and relevance of the legislation is provided in Chapter 4.

The following standards provide a range of assessable criteria relevant to the protection and management of groundwater resources:

- Environment Protection (Water Quality) Policy
- The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)
- AS 1940-2004: The storage and handling of flammable and combustible liquids
- AS 1692-2006: Steel tanks for flammable and combustible liquids
- EPA 080/12: Liquid Storage Guidelines – Bunding and Spill Management, Update August 2012

The *Environment Protection (Water Quality) Policy* applies to all underground waters in South Australia and seeks to achieve water quality objectives that will protect or enhance defined environmental values. The protected environmental values for groundwater are beneficial uses of groundwater requiring protection against pollution:

- Aquatic ecosystems (freshwater)
- Recreational use and aesthetics (primary contact and aesthetics)
- Potable use
- Agriculture and aquaculture uses (irrigation, stock watering and aquaculture)
- Industrial use

Achievement of water quality objectives under the *Environment Protection (Water Quality) Policy* is achieved by compliance with the Water Quality Criteria specified in Schedule 2 of the policy.

ANZECC (2000) provides a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters. In general, these Guidelines should also apply to the quality of both surface water and of groundwater since the environmental values which they protect relate to above-ground uses (e.g. irrigation, drinking water, farm animal or fish production and maintenance of aquatic ecosystems).

The nominated Australian standards each specify specific design criteria that will be incorporated into the design of the proposed mining lease to protect the key environmental and stakeholder values relevant to groundwater resources.

19.2 Assessment Method

A Groundwater Impact Assessment (GIA) was completed in accordance with the National Water Commission (NWC) Framework for assessing cumulative potential impacts of mining operations on groundwater systems (NWC 2010). The assessment framework provides a risk-based approach to managing local and cumulative effects of mining and associated infrastructure on groundwater. The assessment incorporated the following tasks:

- Definition of a study area that encompasses all potential groundwater impacts
- Description of the existing environment within the study area and broader region, including climate, topography, geology, surface water and groundwater resources
- Identification of groundwater users or 'receptors' in the study area
- Development of a conceptual hydrogeological model to illustrate the water affecting activities (WAA) within the proposed mining lease
- Identification of potential impacts to groundwater systems due to project WAA informed by numerical groundwater modelling (including sensitivity analysis) to predict the effects of:

- Mine pit dewatering and groundwater inflow management with progressive development of the integrated landform (up to year 25)
- Post-mining (closure) including effects of the pit lake and altered recharge associated with the integrated landform

- Confirmation of whether a source, pathway and receptor linkage exists
- Assessment of the degree to which source, pathway and receptors linkages would affect receptors

For a detailed description of the impact assessment methodology refer to the Mine Groundwater Impact Assessment Technical Report in Appendix N.

19.3 Existing Environment

This section summarises the key contextual information for the study area relevant to undertaking the GIA. It includes consideration of the existing hydrological conditions, geological setting, groundwater conditions and the location and description of potential receptors.

The study area for the GIA was defined to encompasses all potential groundwater impacts (refer to Figure 19-1). The study area is consistent with the boundary of the numerical groundwater flow model which has been developed to assess the viability and impacts of the proposed mine.

19.3.1 Hydrology

Surface water on the Eyre Peninsula is sparse, with the occurrence of creeks and rivers limited by the topography and low rainfall. There are no prescribed surface water areas on the Eyre Peninsula. Within the study area there are no significant ephemeral creek lines present. Salt pans subject to inundation are present.

19.3.2 Geological setting

The study area lies within the Gawler Craton, an extensive region of Archaean to Mesoproterozoic crystalline basement. The Polda Trough (an east-west trending geological feature ranging between 10 and 40 km in width and extending more than 350 km from near Cleve in the east, beyond Elliston to the continental margin in the Great Australian Bight) cuts into the Gawler Craton towards the southern boundary of the study area. A thin veneer of Tertiary and Quaternary deposits overlies the basement rock and sediments of the Polda Trough.

The four major geological formations present in the study area are summarised in Table 19-1.

Table 19-1 Geological formations within the study area

Geological Age	Description	Distribution
Quaternary	Quaternary deposits, consisting of Holocene to Pleistocene aeolion (dune) sands, clayey sand, calcarenite and calcrete	Entire study area except where basement outcrops
Tertiary	Neogene (Miocene to early Pliocene) deposits and older Palaeogene (mostly Eocene) deposits	Entire study area except where basement outcrops
Jurassic	Polda Formation consisting of clayey sand containing detrital muscovite	Southern part of study area
Archaean	Archaean Sleaford Complex characterised by highly deformed and metamorphosed gneisses derived from sedimentary rocks	Entire study area

19.3.3 Regional Hydrogeology

Eyre Peninsula groundwater resources are of variable quality and quantity and most groundwater occurs in saline or brackish aquifers with typically low yields (Berens et al. 2011). This is particularly true for groundwater within the study area.

Groundwater salinity data from recent drilling investigations within the study area indicate that salinity ranges from 35,000 to 53,600 mg/L in the Tertiary sediment aquifer and ranges from 113,000 to 150,000 mg/L in the fractured rock (gneiss) aquifer (SKM 2014a) within the mine site.

The following sections provide a summary of the key hydrogeological formations relevant to the GIA.

Quaternary Aquifers

Within the proposed mining lease, the lithology of the Quaternary sediments is largely dominated by quartz sand forming dunes. Calcrete horizons are also found to varying degrees throughout the study area. These conditions are typical of the central, northern and eastern portions of the study area. Within these areas the Quaternary sediments are typically unsaturated. In low lying depressions such as around Lake Warramboo, lacustrine clay deposits are also present.

South west of the study area, along the coastal margin of the Eyre Peninsula, the Quaternary limestone sediments of the Bridgewater Formation act as isolated aquifers. These aquifers have formed as a result of slightly elevated rainfall (local to the western margins of the Eyre Peninsula) and the surface exposure of suitable host rock (Quaternary Limestone) to receive and store recharge (Department for Water Resources 2001). The lenses are located within the Musgrave Prescribed Wells Area (PWA) which is the administrative boundary that surrounds the groundwater lenses. The boundary of the PWA encroaches on the south western corner of the study area.

Fresh groundwater lenses located within the Musgrave PWA are an important potable water source for the Eyre Peninsula. The major lenses typically have high yields (from 5 up to 50 L/s) and low salinity (less than 1000 mg/L) (Department for Water Resources 2001). Groundwater levels within the Bridgewater Formation are typically higher than those in underlying aquifers and as such a downward gradient between the two aquifers is typically observed.

The closest groundwater lens within the Musgrave PWA to the proposed mining lease is the Polda Lens, located some 30 km south west of the proposed mining lease. The Polda Lens is located in the north eastern section of the Musgrave PWA. The lens is defined by a layer of fresh groundwater (salinity limit of 1000 mg/L) within the unconfined Quaternary limestone which overlies tertiary clay, acting as a physical barrier between fresh shallow groundwater and the underlying deeper saline groundwater.

The Quaternary groundwater lenses located within the Musgrave PWA are isolated lenses which are not connected with the broader saline Quaternary sediments found in the central portion of the study area.

Tertiary Aquifer

Within the study area, the Tertiary deposits consist of Neogene (Miocene to early Pliocene) deposits and older Palaeogene (mostly Eocene) deposits. The lithology of the Neogene deposits is predominantly clays and silts which acts as a confining layer when below the regional water table. In some areas erosion and re-deposition of older Palaeogene sediments during the Neogene has resulted in a coarser fluvial and marine sandy facies at the base of the Neogene (Hou et al. 2003). Where present, the reworked Palaeogene sediments act as an aquifer.

Palaeogene deposits, as depicted on the available palaeodrainage map (Hou et al. 2003), underlie the Neogene deposits to the south and west of the study area and consist of grey to black carbonaceous sand and silt (Flint and Rankin 1989). The thickness of the Palaeogene deposits is in the order of 20 m and, based on the lithological description, it is expected to act as an aquifer, albeit of low permeability.

Groundwater flow in the Tertiary aquifer is interpreted to be in a south westerly direction beneath the proposed mining lease. Isolated areas exist where no Tertiary sediments have been mapped (Neogene and Palaeogene) and these coincide with basement and topographic highs.

Within the Musgrave PWA lower salinity groundwater can occur in the Tertiary aquifer beneath freshwater lens. These occurrences are located some 30 km south west of the proposed mining lease.

Jurassic Polda Formation

Towards the south western edge of the study area, the Polda Trough incises basement rocks of the Gawler Craton. As the Polda Trough is located on the south western margin of the study area, some 30 km from the proposed mining lease, it is not considered significant in terms of the mine GIA.

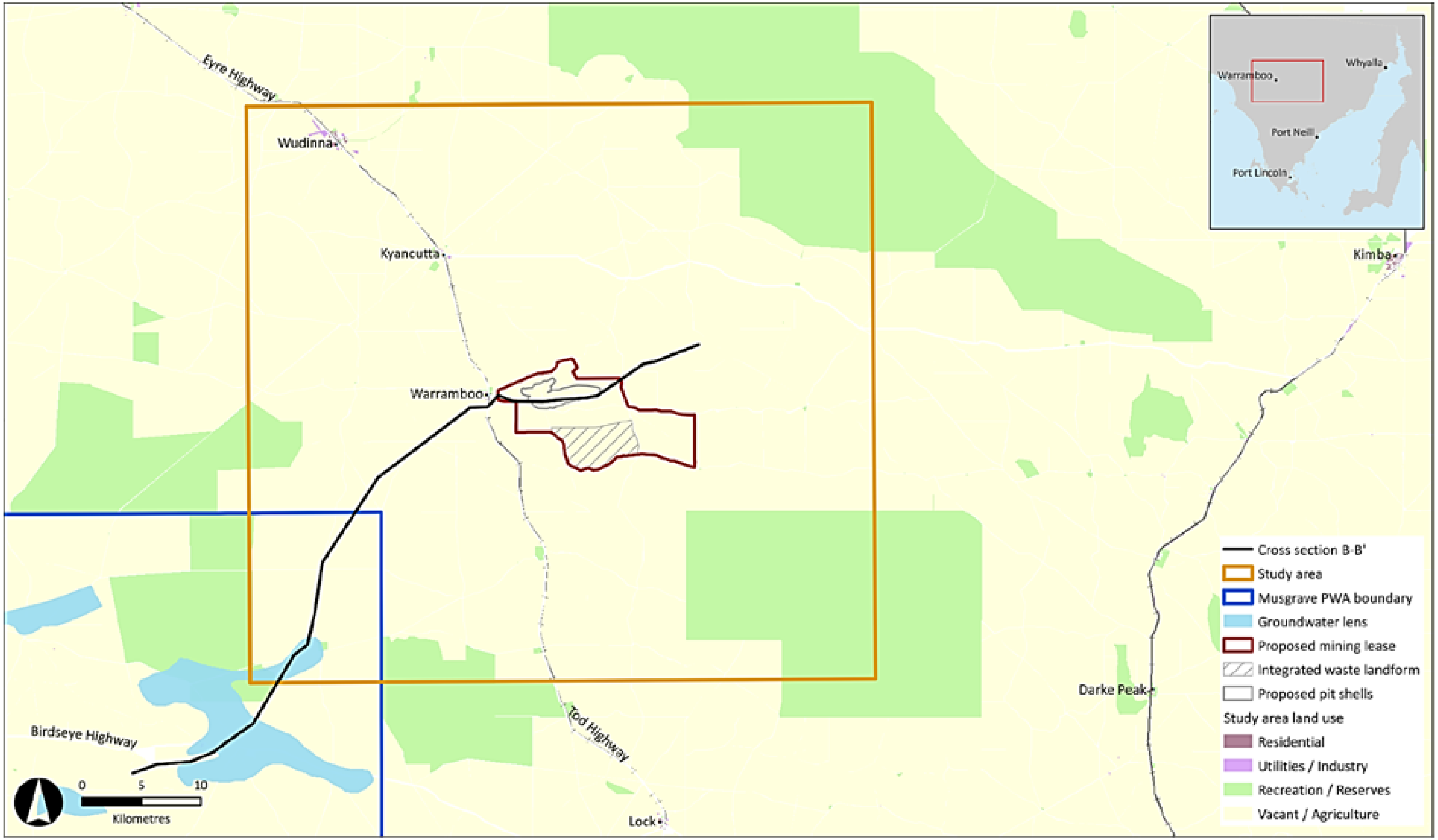

Figure 19-1 Project components, groundwater impact assessment study area and land use

Saprolite

Saprolite within the vicinity of the mine pits is characterised by grey silty clay (a remnant of the original basement rock) at the top, grading down to partially weathered basement with much of the original rock fabric still remaining. Recent drilling indicates that the thickness of the saprolite is in the order of 20 to 40 m within the vicinity of the proposed mine pit and integrated landform (SKM 2014d). The saprolite has been interpreted to act as an aquitard (refer to Appendix M for details).

Fractured rock aquifers

The basement material within the study area consists of the Archaean Sleaford Complex which is characterised by highly deformed and metamorphosed gneisses derived from sedimentary rocks. Where secondary porosity has developed in this material through fracturing and faulting, the unit acts as a fractured rock aquifer, with yields in the range of 1 to 20 L/s (SKM 2014a). Elsewhere in the bedrock, where secondary porosity is not as prevalent, yields are negligible.

Recharge to the basement aquifer is typically localised, irregular and occurs in areas where the basement outcrops (i.e. surface exposures). The rate of recharge is variable and is a function of the exposure, the degree of fracturing present and the composition of the rock type (Department for Water Resources 2001). Groundwater flow in the fractured rock aquifer is interpreted to be in a south-westerly direction beneath the proposed mining lease (SKM 2014a).

Summary of Hydrogeological Formations

A summary of the hydrogeological properties including aquifer parameters and water quality data for the key hydrogeological units is presented in Table 19-2.

Table 19-2 Summary of hydrogeological properties

Age	Name	Aquifer type	Approximate Thickness (m)	Description	Hydraulic conductivity (m/d)	Salinity (mg/L)
Quaternary	Undifferentiated Quaternary	Unsaturated in mine lease area	0-10	Predominantly arenaceous i.e. sands and calcarenite. Holocene to Pleistocene aged	0.02 to 0.004[1]	N/A
Tertiary	Upper Neogene (Miocene / Pliocene)	Confining layer or above water table	0-20	Predominantly argillaceous i.e. silts, clays with some sand/gravel	N/A	N/A
	Basal Neogene (Miocene / Pliocene)	Confined / Unconfined Aquifer	0-10	Coarser fluvial and marine sandy facies	0.5 to 3.0[2]	35,000 to 53,500[2]
	Palaeogene (Eocene - Poelpena)	Confined / Unconfined Aquifer	0-20	Grey to black carbonaceous sand and silt	0.2[3]	30,000[3]
Archaean	Saprolite	Aquitard	20 - 40	Highly weathered gneiss consisting of grey silty clay	0.01[3]	124,000[3]

Age	Name	Aquifer type	Approximate Thickness (m)	Description	Hydraulic conductivity (m/d)	Salinity (mg/L)
	Fractured basement	Confined Aquifer	180	Broken metamorphics (gneiss, including magnetite gneiss and schist)	0.025 to 2.25[2]	113,000 to 150,000[2]
	Unfractured basement	Low permeability aquifer / aquitard	500+	Metamorphics (gneiss, including magnetite gneiss and schist)	0.001[4]	N/A

Notes [1] Data from Coffey (2012) tailings storage facility geotechnical investigation bores.

[2] Data from SKM (2014d) drilling, construction and testing completion report.

[3] Data from Coffey (2013) hydrogeological investigations groundwater monitoring bore installation and sampling program.

[4] Upper estimate of unfractured rock hydraulic conductivity (Todd and Mays, 2005).

Groundwater Flow

Water table depths vary between approximately 5 m below ground level (mbgl) near salt lakes and exceed 20 mbgl in elevated areas (e.g. sand ridges).

Groundwater flow in both the Tertiary sediment aquifer and fractured rock aquifer is interpreted to be in a south westerly direction beneath the study area, as shown in Figure 19-2 and Figure 19-3 respectively. The figures show water level expressed as elevation relative to sea level (mAHD).

The hydraulic gradient is predominately driven by what is interpreted to be an enhanced groundwater recharge zone to the northeast of the proposed mine. Steeper gradients are associated with lower transmissivity aquifers. Steeper hydraulic gradients are observed where the saturated thickness of Tertiary sediments thins or the only aquifer is the low transmissivity basement fractured rock.

Locally, groundwater is inferred to discharge to salt (playa) lakes where it is lost through evapotranspiration, which is the sum of evaporation and plant transpiration. This interpretation is supported by shallow groundwater levels adjacent to salt lakes and elevated groundwater salinity suggesting evapo-concentration of salts (SKM 2014a).

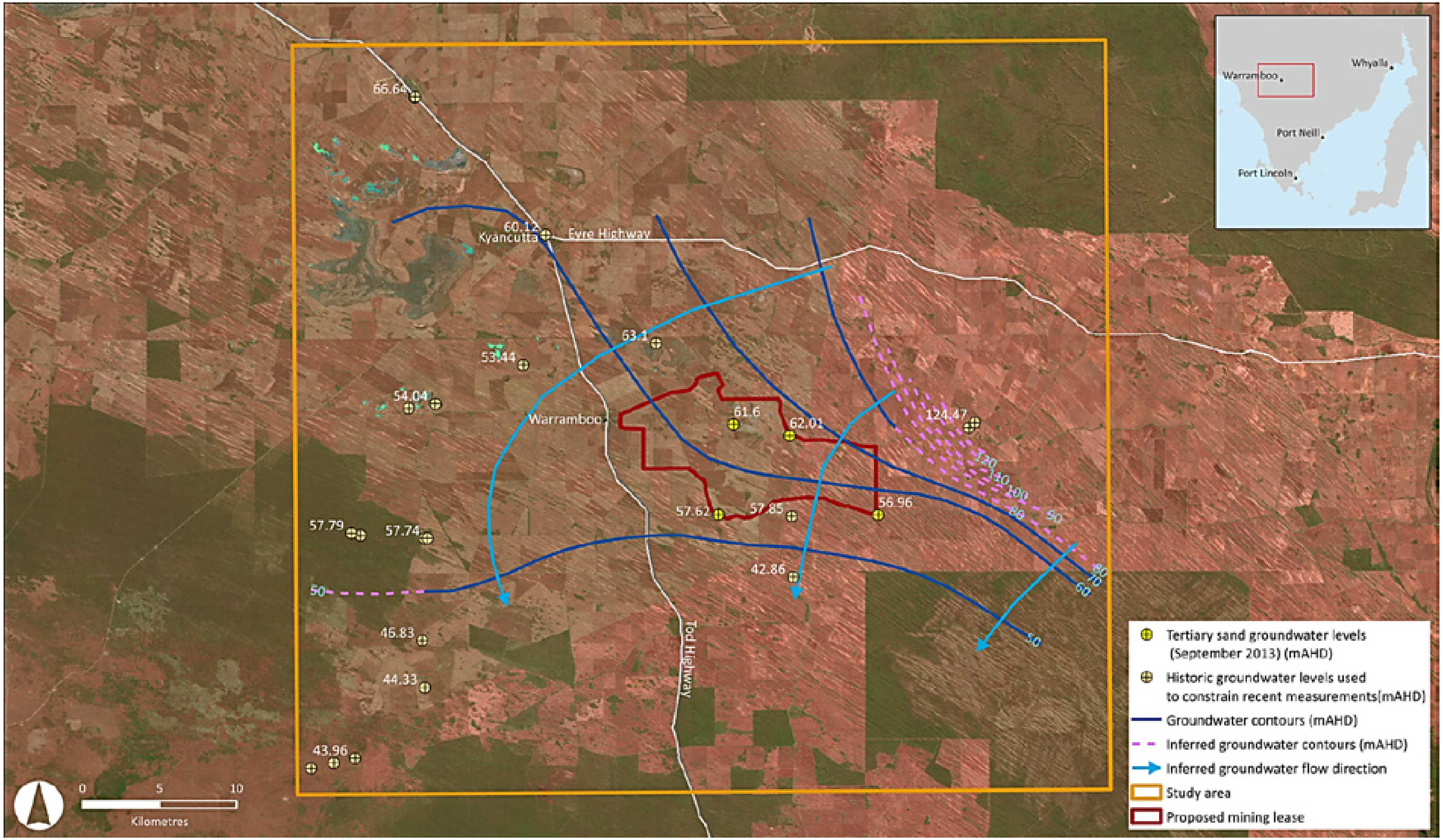

Figure 19-2 Inferred groundwater flow direction in the Tertiary sediment aquifer

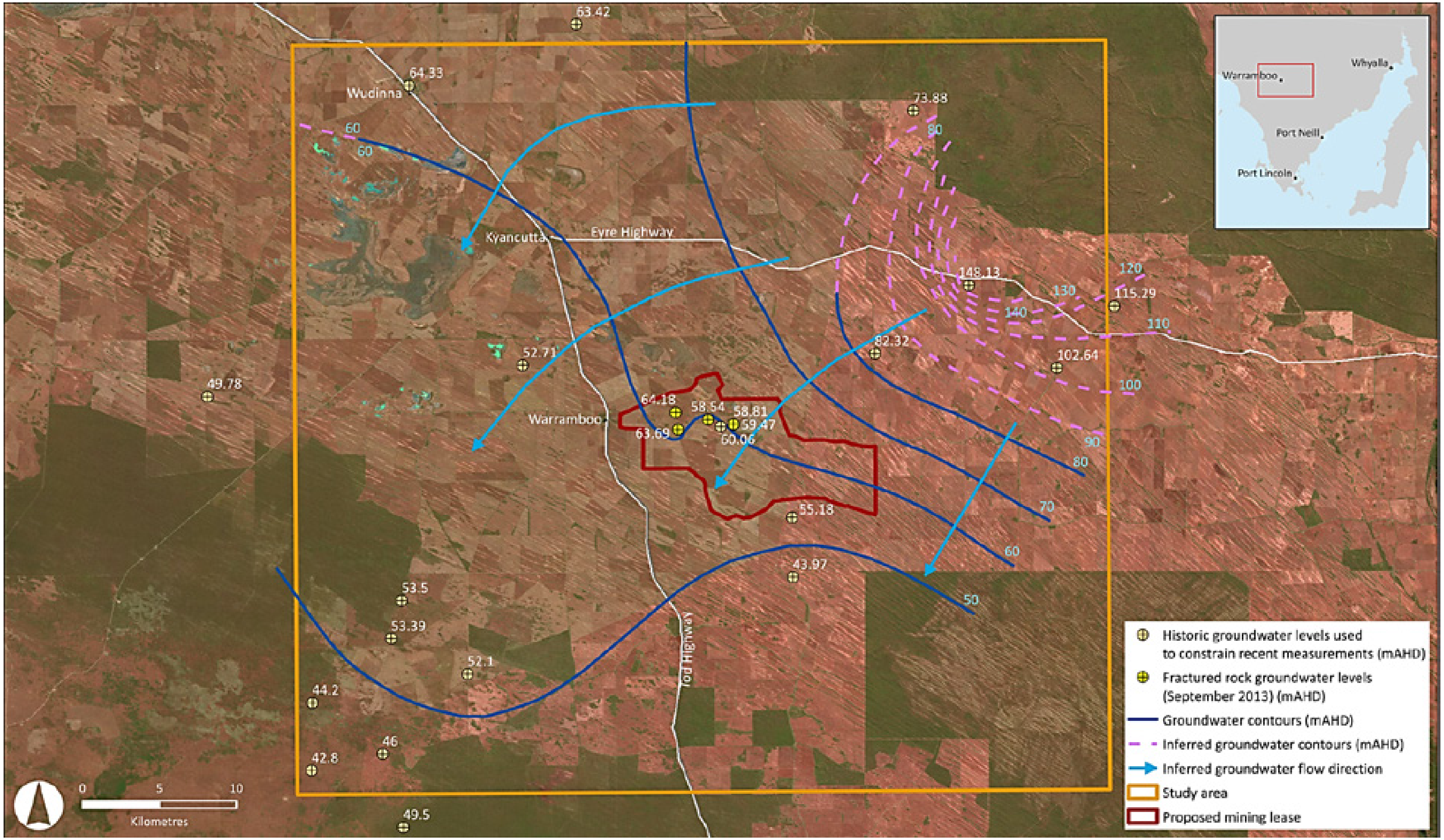

Figure 19-3 Inferred groundwater flow direction in the fractured rock aquifer

19.3.4 Conceptual Hydrogeolgical Model

A conceptual model was developed to illustrate how the WAA associated with mining (including pit development, groundwater inflow management and the development of the integrated landform) will fit within existing groundwater flow systems. The conceptual model is shown in Figure 19-4.

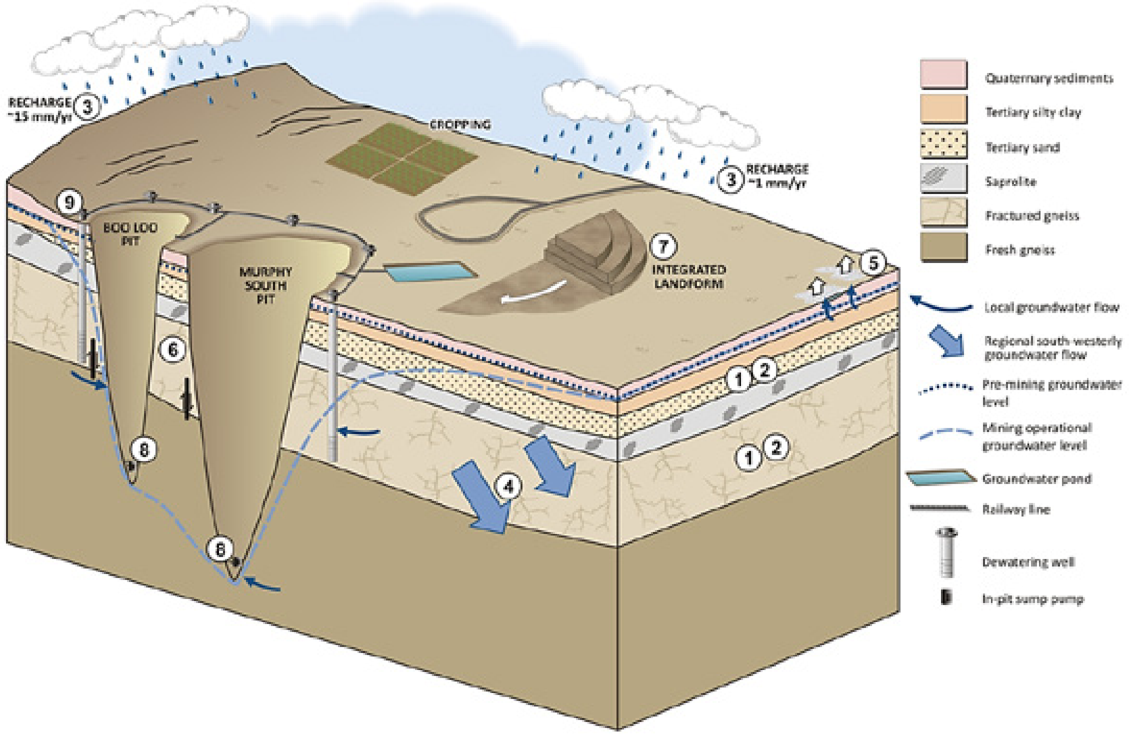

Figure 19-4 Proposed mine conceptual hydrogeological model (exaggerated z-axis)

Important features of the conceptual model are (refer to Figure 19-4):

1. Two main aquifers exist in the project area, the Tertiary sediment aquifer and fractured rock (gneiss) aquifer. The aquifers are separated by the low permeability saprolite layer which acts as an aquitard, limiting flow between the aquifers.
2. Local to the proposed mine area, groundwater salinity in the Tertiary sediment aquifer ranges from 35,000 to 53,600 mg/L, while groundwater salinity in the fractured rock aquifer is significantly higher ranging from 113,000 to 150,000 mg/L. More distant from the mine lease salinity is more variable. For instance in the Musgrave PWA some 30km south west of the mine lease, potable groundwater occurs. A bore audit and landowner survey of historic water bore records found that no groundwater suitable for agricultural use has been identified within approximately 20km of the mine site.
3. Recharge rates are around 1 mm/yr over the majority of the study area, while in the topographic highs in the northeast, recharge may be an order of magnitude higher (approximately 15 mm/yr).
4. Regional groundwater flow in both aquifers is in a southwesterly direction.
5. Locally, groundwater also discharges through evaporation to salt pans and playa lakes.
6. Two significant fracture zones have been inferred running in an east-west orientation through the Boo Loo pit and Murphy South pit which exhibit higher groundwater yields and estimates of hydraulic conductivity.
7. Modelling work suggests that enhanced recharge from the integrated landform is expected to be in the order of 50 mm/yr for a period of one year during the construction of the integrated landform. Following this, progressive rehabilitation will occur and the seepage is estimated to reduce to 6 mm/yr.

8. In-pit seepage is to be collected and transferred to the process water pond via in-pit sump pumps. The predicted inflow rates range from 4 to 17 ML/day from the Murphy South pit and from less than 0.5 to around 6 ML/day from the Boo Loo pit.
9. Dewatering wells (four in-pit and seven ex-pit wells) are predicted to abstract a further 12 ML/d (two years prior to mining) to 4 ML/d (end of mining at year 25).

19.3.5 Potential for Acid and Metalliferous Drainage

Acid mine drainage (AMD) analysis has been undertaken to characterise acid generation and metal leaching potential of mine materials. The results:

- Confirmed low total sulphur with approximately 2% of total waste material (oxide, fresh rock and tailings) considered potentially acid forming.
- Indicated approximately 10% of the oxide material to be encountered was classified as potentially acid forming (PAF), with the majority (estimated 90% by volume) of this PAF material classified as having low to very low acid generating potential (<0.5% sulphur).
- Indicated the tailings component has a high Acid Neutralisation Capacity (ANC) ratio >2 (average ratio of 17) and high ANC (average of 15.6 kg H^2SO^4/t).
- Indicated negligible or low metal and elemental concentrations with the exception of manganese (average of 1140 mg/kg compared to an ecological investigation level (EIL) of 500 mg/kg and average crustal abundance of 950 mg/kg for manganese).

The results of AMD analysis completed for the project are summarised in the Integrated Waste Landform (IWL) Management Plan in Appendix S. The results indicate that:

- There is some potential for AMD (see Section 19.5 for further consideration of the potential impact event), as described above.
- There are no heavy metals or other contaminants held within the tailings and waste material of the integrated landform with the potential to infiltrate through to the groundwater system. On this basis it is considered that there is no potential for impact due to metal leaching.

The results of mine pit lake geochemical assessment are presented in the Mine Pit Lake Assessment in Appendix O. The results indicate that:

- The pit lake will evolve to form a hypersaline lake at saturation with sodium chloride at approximately 360 g/L TDS.
- Acidification is not expected on the basis that:
  - Gneiss bedrock exhibits low sulphur concentrations averaging < 0.2%
  - Acidic pit wall run-off is not predicted since the moderate acid consuming capacity of the gneiss bedrock far outweighs the acid generating potential of thin discontinuous PAF zones in the oxide and sedimentary cover.
  - The acidic Tertiary aquifer will be permanently dewatered to a radius of 2 to 3 km and will not contribute direct seepage to the mine pit.

19.3.6 Groundwater Receptors

Groundwater receptors include environmental, social, cultural and economic elements of the receiving environment that may be altered by changes to groundwater conditions. For the GIA, potential groundwater receptors identified within the study area include:

- Groundwater Dependent Ecosystems (GDEs) – ecosystems which may be sensitive to changes in groundwater conditions due to a reliance on groundwater to meet ecological requirements
- Existing users of groundwater
- Musgrave PWA

- Economic (commercial) receptors including agriculture and mineral deposits.

In undertaking the GIA, all potential groundwater receptors within the study area were identified and are summarised below. Further investigation to confirm the existence of potential groundwater receptors was completed for a defined assessment area following prediction of the zone of influence for groundwater drawdown. These subsequent investigations are summarised in Section 19.5.1, as part of the source, pathway and receptor assessment.

Groundwater Dependent Ecosystems

The Australian GDE Atlas (published by the National Water Commission) provides a high level starting point to assist with the identification of GDEs and the management of their water requirements (Richardson et al. 2011). The mapping in the GDE Atlas relies on broad scale analysis, existing datasets and remote sensing methods and shows only general locations where groundwater interaction may occur (BoM 2014). Further, the GDE Atlas makes no assessment of ecosystem value, condition, sensitivity, threat or risk (BoM 2014).

GDEs, as defined by the Australian GDE Atlas are broadly classified as follows (Richardson et al. 2011):

- Ecosystems dependent on the subsurface presence of groundwater (e.g. terrestrial vegetation which depends on groundwater on a seasonal, episodic or permanent basis).
- Ecosystems dependent on the surface expression of groundwater (e.g. wetlands, lakes, seeps, springs and river baseflow systems).

Ecosystems dependent on the subsurface presence of groundwater

Although the GDE Atlas has identified patches of remnant vegetation within the study area as potential GDEs, they are considered unlikely to be ecosystems dependent on the sub-surface presence of groundwater.

Assessment of the site conditions in the vicinity of the proposed mine reveals that groundwater salinity in the water table aquifer is in in excess of 35,000 mg/L and groundwater levels are typically 5-15 m below ground level. Where shallow water tables exist in topographic lows, salt pans are formed. Therefore, mallee vegetation within the study area and in particular within the vicinity of the proposed mine is unlikely to be reliant on groundwater given these conditions.

Ecosystems dependent on the surface expression of groundwater

A small number of salt lakes have been identified as having potential for supporting GDEs:

- Lake Warramboo which comprises a series of small salt lakes located within the study area approximately 1.5 km north of the proposed mining lease boundary.
- A series of other small salt lakes located within the northern extent of the proposed mining lease.

These salt lakes become periodically inundated as a result of surface water pooling following large rainfall events. Groundwater is shallow at these locations and will discharge via capillary rise resulting in concentration of salts. The extent and duration of surface inundation is primarily controlled by rainfall and evaporation during winter.

The location of potential GDEs reliant on surface expression of groundwater within the study area are illustrated in Figure 19-5. The low ecological value of these GDEs is discussed in the Chapter 11 (Fauna and Pest Species).

Existing Users

All potential groundwater bores were extracted from the Water Connect database. The dataset was filtered to include only water bores not recorded as backfilled or abandoned. An audit comprising landowner survey was undertaken. None of the bores in the database were found to exist. Further none of the contacted landowners reported using groundwater, or even knowing of any local landowner using groundwater.

Musgrave Prescribed Wells Area

Groundwater modelling has shown the zone of influence around the mine is not predicted to reach the Musgrave PWA, with approximately 20 km distance between the predicted post closure zone of influence and Musgrave PWA (refer to Appendix N for further detail). On this basis, it is considered that there is no potential for impact to the Musgrave PWA.

Economic Receptors – Agriculture

The dominant land use in the study area is dryland agriculture (see Figure 19-1), including mixed cereal crops and grazing. Proposed mine activities resulting in lowering of the groundwater table are unlikely to impact agricultural values because crops are reliant on seasonal rainfall stored in the unsaturated zone of top-soils and sub-soils rather than being reliant on (saline) groundwater (i.e. a credible pathway does not exist).

Increasing the groundwater table has the potential to generate waterlogging and salinisation within soils which may adversely affect crop production. This is of particular concern where groundwater is already close to the surface. An assessment of the pre-mining depth to groundwater has been completed using a digital elevation model and inferred water table surface to identify areas within the proposed mining lease which are susceptible to an increase in the water table.

The inferred depth to water table is shown in Figure 19-7. The analysis identifies the following locations where groundwater is currently close the surface:

- Areas south east of the integrated landform where the current water table is between 5 and 10 mbgl. These areas coincide with swales between sand ridges and are likely to be sensitive to increases in the water table due to enhanced recharge from the integrated waste landform.
- Salt pans located within and adjacent to the proposed mine pit. This area is more likely to be affected by drawdown associated with mine dewatering rather than water table rise.

Mineral and Energy Industry

There are 15 mineral deposits recorded within the study area, none of which are currently active.

19.3.7 Summary of Key Environmental Values

The key environmental values are the groundwater receptors identified as having a potential for impact from proposed mine WAA. These are:

- The potential users of the groundwater (primarily stock wells)
- GDEs reliant on surface expression of groundwater (Lake Warramboo and associated salt lakes)
- Agriculture

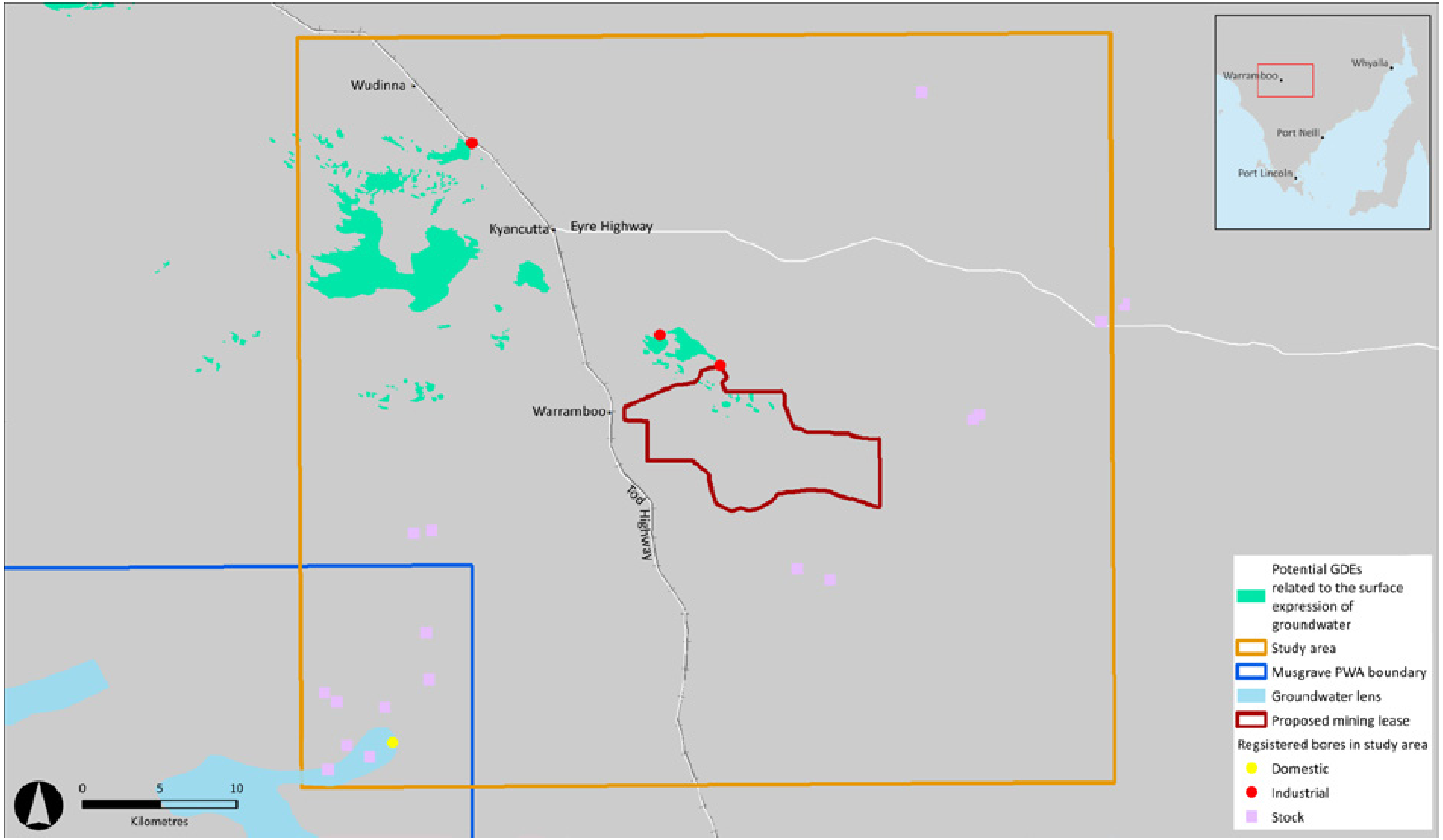

Figure 19-5 Potential groundwater receptors in the study area

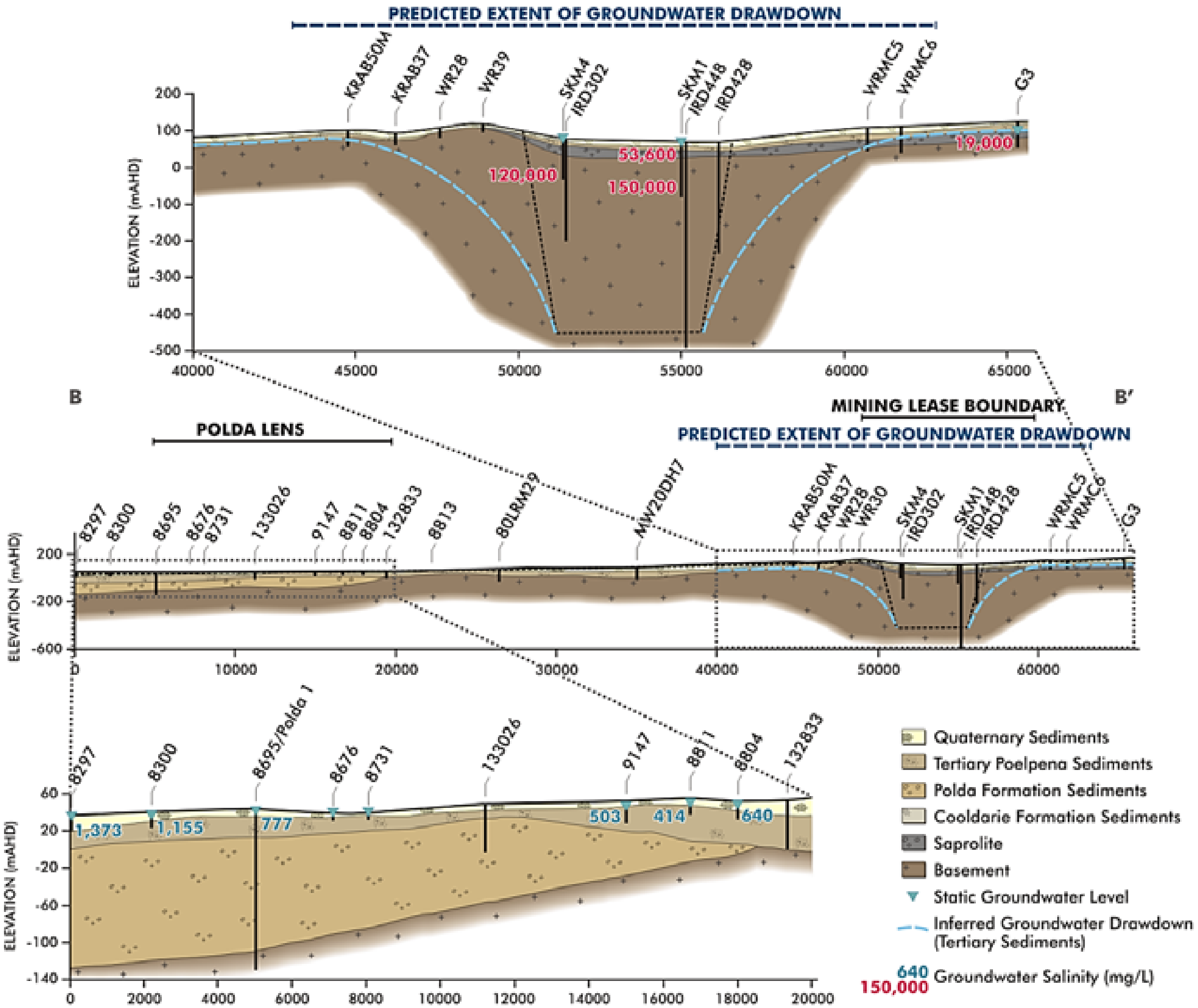

Figure 19-6 Hydrogeological cross section mine site to Musgrave PWA. Groundwater drawdown denotes water table at end of mining.

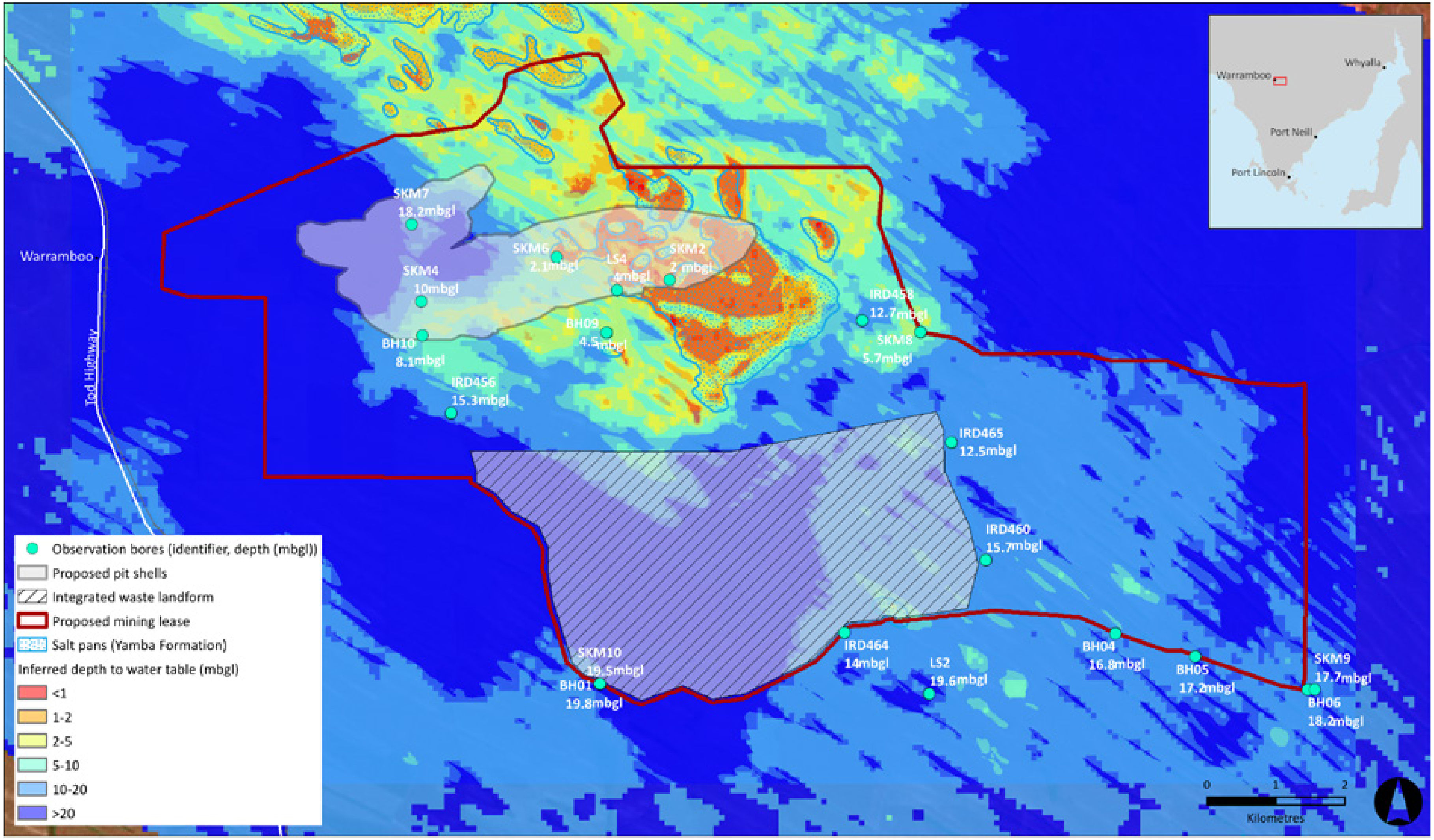

Figure 19-7 Inferred depth to water table within the proposed mining lease

19.4 Context and View of Affected Parties

Stakeholders relevant to groundwater include local landholders, Wudinna DC, agricultural industry, Eyre Peninsula Natural Resources Management Board, DEWNR and the EPA. The key environmental value identified by stakeholders is the importance of the proposed mining lease and surrounding area as a productive agricultural landscape. The long term retention of agricultural land is considered paramount to the local community and maximising the proportion of the proposed mining lease able to be successfully returned to a productive use following mine closure has been highlighted.

The protection of freshwater resources in the region has also been highlighted, reflecting the scarcity of potable water sources on the Eyre Peninsula.

Stakeholders are seeking the following outcomes in relation to the protection and management of groundwater resources (with Impact Event ID referencing Appendix C):

- No salinisation and water logging of agricultural land associated with elevation of the water table due to increased recharge from the integrated landform (IM_19-04, IM_19-05, PIM_19-11)
- No reduced quality/quantity of regional 'fresh' groundwater resources (Musgrave PWA) as a result of drawdown associated with dewatering and long term evaporation from the open pit (PIM_19-09, PIM_19-10)
- No impacts to Lake Warramboo due to drawdown associated with dewatering and long term evaporation from the open pit (PIM_19-15)
- No impact on groundwater from acid and metalliferous drainage, otherwise known as acid mine drainage (AMD) via infiltration and seepage (PIM_19-12, PIM_19-13).

All issue raised by stakeholders across the entire project are presented in Chapter 5 and summarised in Table 5-8. Impacts and risks relevant to each of the existing environmental values associated with groundwater and potential issues identified by stakeholders are discussed below and summarised in Table 19-6 with all impact events across the entire project presented in the Impact and Risk Register in Appendix C.

19.5 Potentially Impacting Events

Considering the views and contexts of affected parties and the issues raised during technical studies, an assessment of Source Pathway Receptor (SPR) has been undertaken, as per the methodology outlined in Chapter 6, to determine which potential impact events are considered applicable to this project. Potential impact events associated with the construction, operation and closure of the proposed mining lease that have a confirmed SPR linkage which affects groundwater values include:

- Groundwater level rise due to altered recharge from integrated landform affecting agricultural production (IM_19_04, IM_19_05). The impact and risk register presented in Appendix C provides confirmation of a source pathway and receptor for the potential impact event (PIM) considered above and therefore follows it through as an actual impact event (IM) with a complete impact and risk assessment.

The following impact events were identified as potential benefits:

- Lowering of groundwater table as a result of pit dewatering and/or evaporation results in increased agricultural production (IM_19_01, IM_19_03)
- Lowered groundwater table during mining and post closure results in reduction in salinity impacts to vegetation (IM_19_02)

Salt scalds on land within the proposed mining lease and vegetation dieback provide evidence of the shallow saline groundwater table. While lowering of the groundwater table will reduce the threat to crops and vegetation, it is unclear if this will result in flushing of saline soils and remediation of areas currently impacted. For this reason, the above impact events are regarded as potential benefits, rather than benefits that are expected to occur.

For groundwater, a number of potential impact events (listed below) are not considered further as there is no confirmed linkage between source, pathway and receptor, as demonstrated in Section 19.3.5, Section 19.3.6 and Appendix C. These include:

- Drawdown of groundwater levels from dewatering, pit inflow management and evaporation from the open pits affecting existing bore users or agricultural values (PIM_19_01, PIM_19_04).
- Drawdown of groundwater levels from dewatering, pit inflow management and evaporation from the open pits post closure affecting environmental values (PIM_19_05).
- Drawdown of groundwater levels from dewatering, pit inflow management and evaporation from the open pits affecting the Musgrave PWA (PIM_19_09, 10).
- Infiltration and seepage from IWL leads to salinisation of groundwater and further salinisation of productive land (PIM_19_11).
- Metals leaching associated with acid mine drainage (PIM_19_12).
- Acid mine drainage to groundwater impacts on agricultural values (PIM_19_13).
- Changes to groundwater processes due to soil compaction under IWL result in impacts on productive land (PIM_19_14)
- Drawdown of groundwater levels from dewatering, pit inflow management and evaporation from the open pits affecting the Lake Warramboo Complex (PIM_19_15). This is because drawdown is expected to have minimal effect on the environmental value of Lake Warramboo (refer Chapter 11).
- Lowered groundwater table as a result of pit dewatering results in loss of environmental values (PIM_19_16).

19.5.1 Source, Pathway and Receptor Assessment

The source, pathway and receptor assessment for groundwater was informed by the GIA. Where a credible source and pathway were identified, groundwater modelling was completed to confirm which (if any) environmental values will be impacted by WAA associated with the proposed mine. Four categories of direct potential impacts were considered as part of the GIA:

- Groundwater quantity including consideration of changes to groundwater levels and pressure.
- Groundwater quality including consideration of salinity and water quality impacts.
- Groundwater and surface water interaction including consideration of changes to the level of interaction between groundwater and surface water systems.
- Physical disruption of aquifers including consideration of whether or not there would be permanent disruption of a groundwater system from the proposed activities and to what extent.

Activities occurring in support of proposed mine operations with the potential to alter groundwater conditions in the study area are summarised inTable 19-3. Although WAA would alter existing flow processes of groundwater beneath the proposed mining lease (aquifer disruption), these effects are considered within the groundwater quantity impact assessment.

Table 19-3 Summary of CEIP Mine water affecting activities and potential impact events

Activity	Category of Direct Impact	Description of potential effect
Pit construction and groundwater inflow management	Groundwater Quantity	Groundwater drawdown from groundwater abstraction to achieve safe and effective mining condition for the life of the mine (25 years)
	Groundwater-surface water interaction	Pit dewatering resulting in a radius of influence where current groundwater level at Lake Warramboo and its adjacent playa lakes would be reduced and the level of interaction between the aquifer and supported ecosystems may be altered
Development of integrated landform	Groundwater Quantity	Groundwater level rise due to altered recharge (altered surface material and removal of vegetation cover) from integrated landform development leading to salinisation and water logging of soils
	Groundwater Quality	Potential for AMD impacting on groundwater receptors via infiltration and seepage.
Formation of pit lake following closure	Groundwater Quantity	Permanent cone of depression around the pit following the completion of mining and decommissioning of the dewatering system due to evaporation. Hypersaline mine pit will evolve. Acidification is not expected.

Groundwater Model Assumptions

The GIA is based on the following key assumptions:

- 11 dewatering wells (four in-pit wells and seven ex-pit wells), with predicted combined abstractions ranging from 12 ML/day (two years prior to mining) to 4 ML/d (at the end of mining, year 25)
- Individual abstraction rates for the 11 dewatering wells range from approximately 0.43 to 1.73 ML/day (around 5 to 20 L/second)
- In-pit sumps that force groundwater levels to the base of the active mine pits, with the number of sumps determined by pit floor topography. Predicted total abstractions range between:
  - Four to 17 ML/day from Murphy South pit (46 to 200 L/second, for 25 years)
  - 0.5 and six ML/day from Boo Loo pit (1 to 70 L/second, years 15 to 25)
- Development of the Murphy South mine pit to 537 m below ground level
- Development of the Boo Loo mine pit to 220 m below ground level
- The dewatering system will be decommissioned at the end of mining (25 years)
- Integrated landform height of 135 m above ground level
- A post mining land use for the integrated landform of agricultural production, which is considered likely to have the highest recharge of identified closure options (agroforestry and native vegetation)
- Existing recharge rate of 1 mm/year

- Enhanced recharge from the integrated landform applied in a progressive manner as follows:
  - 50 mm/year for one year (reflecting the altered surface material and removal of vegetation cover) followed by
  - 6 mm/year once rehabilitation has taken place (ie one year after the landform material is deposited

The predicted annual pit abstraction volumes, comprising dewatering well abstraction and sump pump abstraction to manage groundwater pit inflows are shown in Figure 19-8.

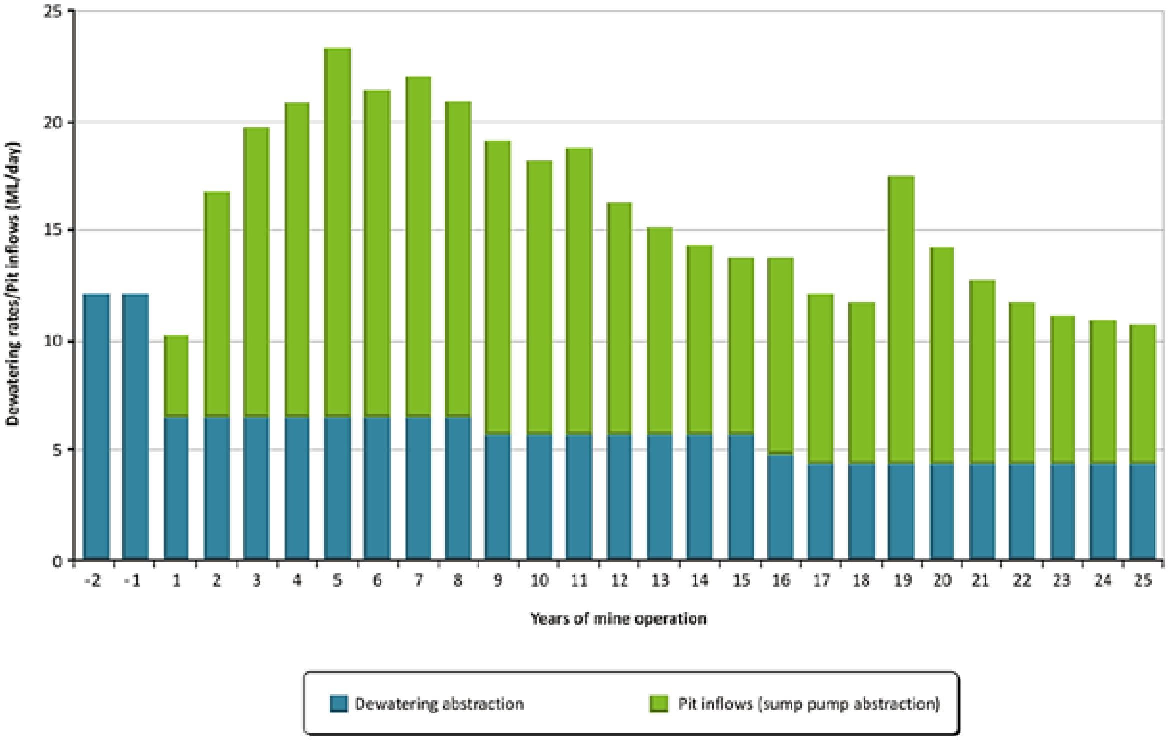

Figure 19-8 Predicted average annual dewatering rates during the 25 years of mine operation

As identified in the conceptual hydrogeological model, the Tertiary sediment aquifer and fractured rock (gneiss) aquifer are the two main aquifers within the study area (see Section 19.3.3). The assessment of effects presented in the following sections, addresses changes within both of these aquifers.

The numerical model adopted for the GIA considers predicted changes to the water table based on the combined effects of groundwater abstraction associated with pit dewatering, groundwater inflow management and altered recharge associated with the integrated landform. The model was constructed using the US Geological Survey's MODFLOW code. A Class 2 model confidence classification was targeted under the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) which reflects the availability and accuracy of existing data sets. A Class 2 model is described by the guidelines as suitable for "providing estimates of dewatering requirements for mines and excavations and assessing associated impacts".

The modelling was completed using hydraulic parameters derived from field testing and hydrogeological data (SKM 2014b) and a sensitivity analysis to define the credible range of drawdown that could be expected from WAA over 25 years and 1000 years post closure. It is noted that fractured rock aquifers (such as the fractured gneiss aquifer) are typically heterogeneous and the level of certainty assigned to estimates of hydraulic parameters derived from field testing is constrained by the scale of field testing programs.

The numerical model relies on key assumptions including the timing of rehabilitation, soil hydraulic properties and the profile of the integrated landform and soils in the study area. Uncertainty in this case has been addressed through the use of conservative modelling assumptions so that the assessment of potential impacts can be made with confidence (refer to Appendix M).

Predicted Effects of Water Affecting Activities due to Mine Development and Operation

The predicted drawdown at the completion of mining (year 25) for the Tertiary aquifer and the fractured rock (gneiss) aquifer is shown in Figure 19-9 and Figure 19-10 respectively.

The cone of drawdown (defined by the location of the one metre drawdown contour) is predicted to extend no more than seven kilometres from the mine pits in both aquifers under the base case hydrogeological conditions.

Throughout the life of the mine (25 years), groundwater levels beneath the integrated landform are not predicted to increase, as enhanced recharge is offset by the magnitude and extent of drawdown due to pit dewatering.

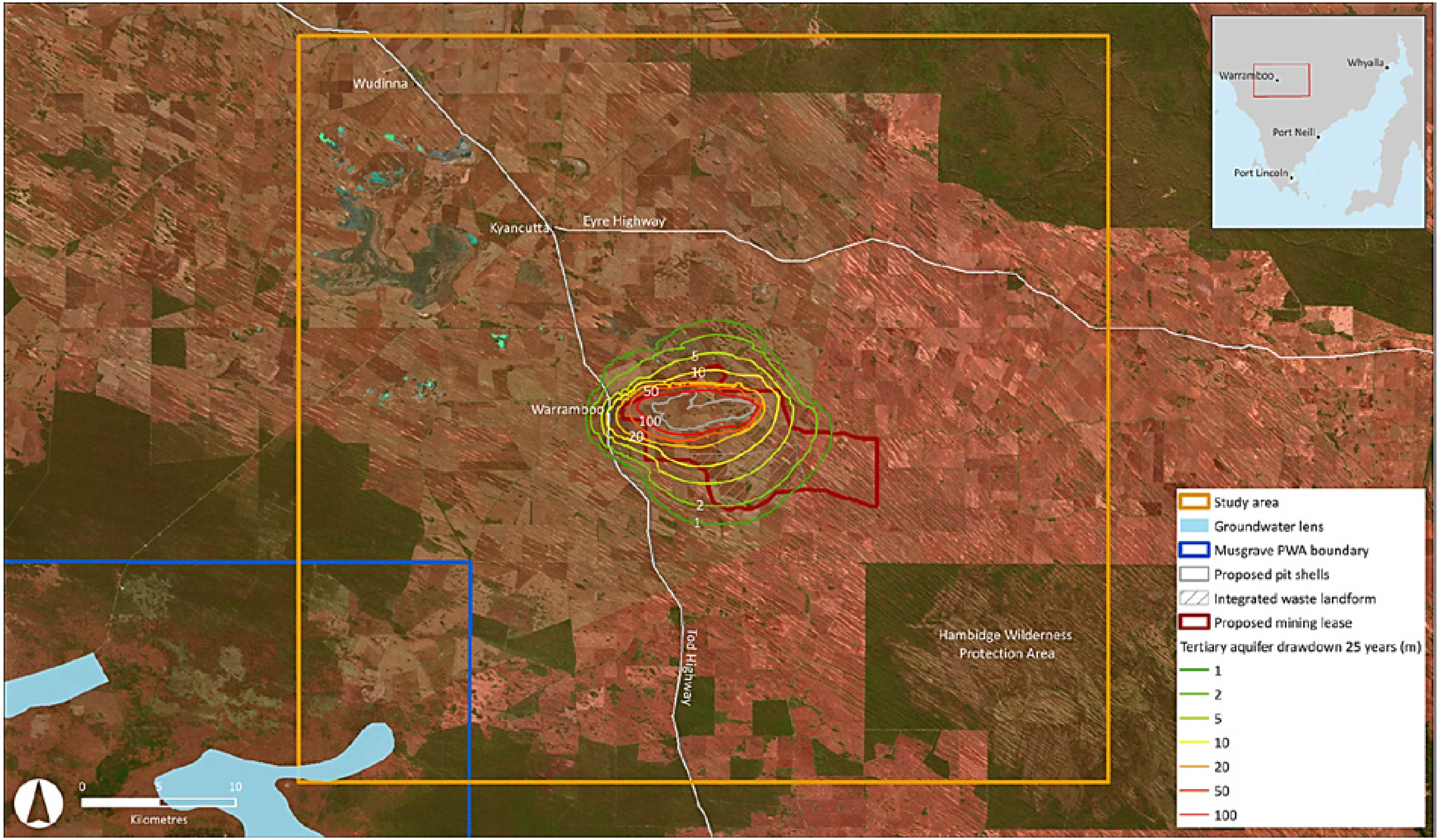

Figure 19-9 Predicted drawdown in the Tertiary aquifer at the completion of mining (base case, year 25)

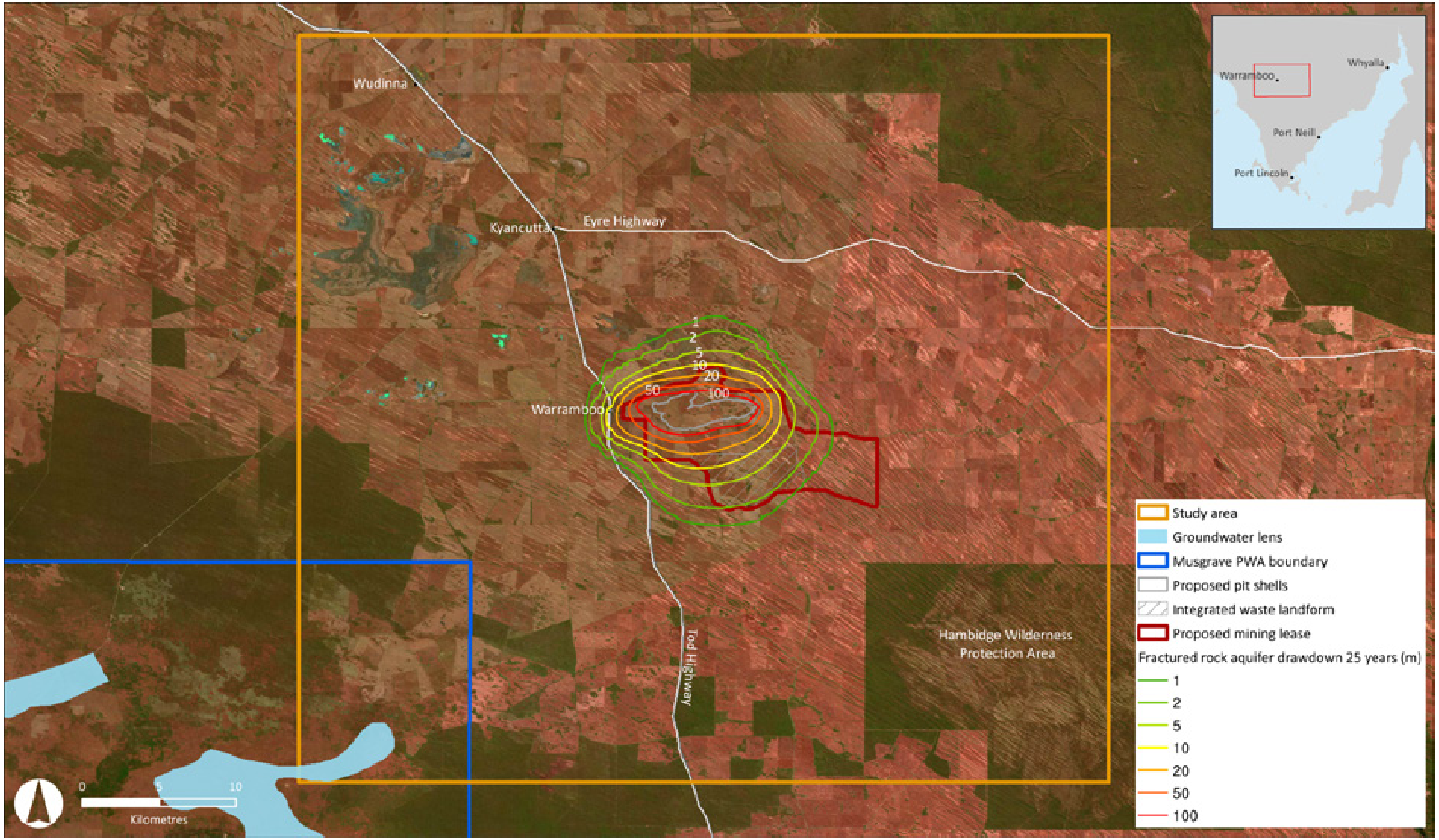

Figure 19-10 Predicted drawdown in the fractured rock aquifer at the completion of mining (base case, year 25)

Predicted Effects of Water Affecting Activities Post-Closure

Following decommissioning of the dewatering system at the completion of mining, groundwater will continue to discharge into the pit and a pit lake is predicted to form. As shown in Figure 19-11, the pit lake water level is predicted to stabilise at approximately -275 m AHD approximately 1000 years post closure. This is approximately 335 m below the pre-mining groundwater level (350 mbgl) and as such a permanent cone of depression is predicted to form around the pits. A new steady state groundwater flow regime will be maintained once the pit lake level has stabilised.

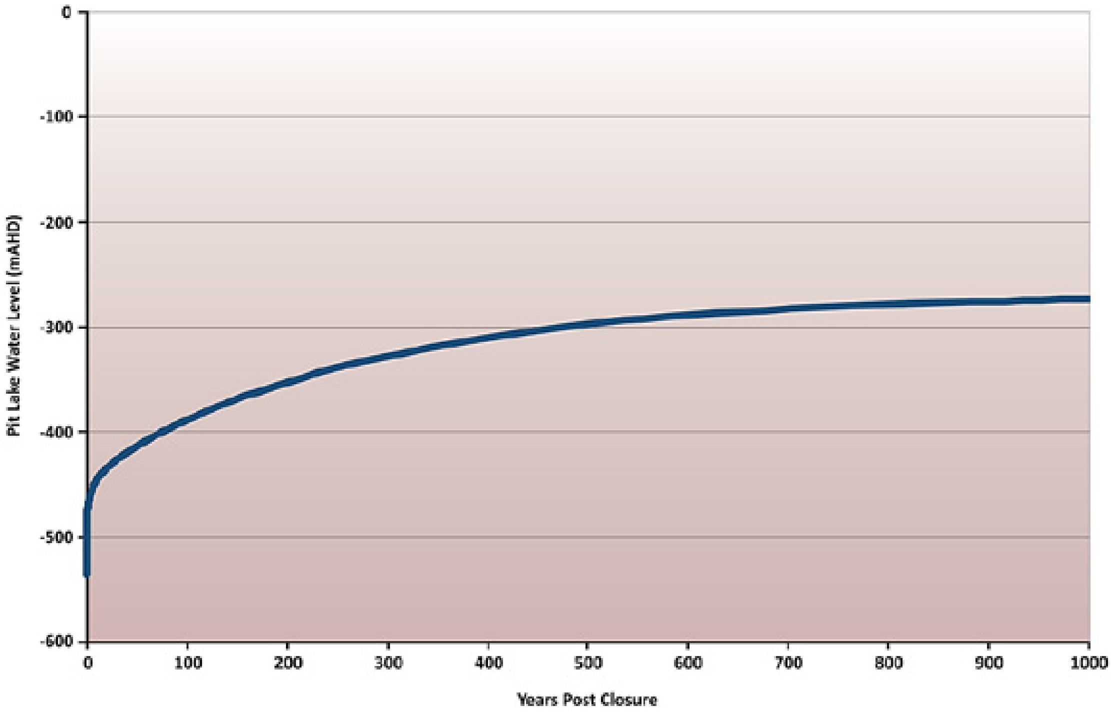

Figure 19-11 Predicted pit lake level post closure (base case scenario)

The predicted drawdown at 1000 years post closure for the Tertiary aquifer is shown in Figure 19-12. The cone of drawdown (defined by the location of the one metre drawdown contour) is predicted to extend no more than 10 kilometres from the mine pits under the base case hydrogeological conditions. Similarly, groundwater drawdown in the Fractured Rock aquifer is not expected to extend more than 10 km from the mine pits (refer to Numerical Groundwater Flow Model Report in Appendix M).

Groundwater levels beneath the integrated landform are not predicted to increase 1000 years post closure, as enhanced recharge is offset by the magnitude and extent of drawdown due to ongoing evaporation from the pit.

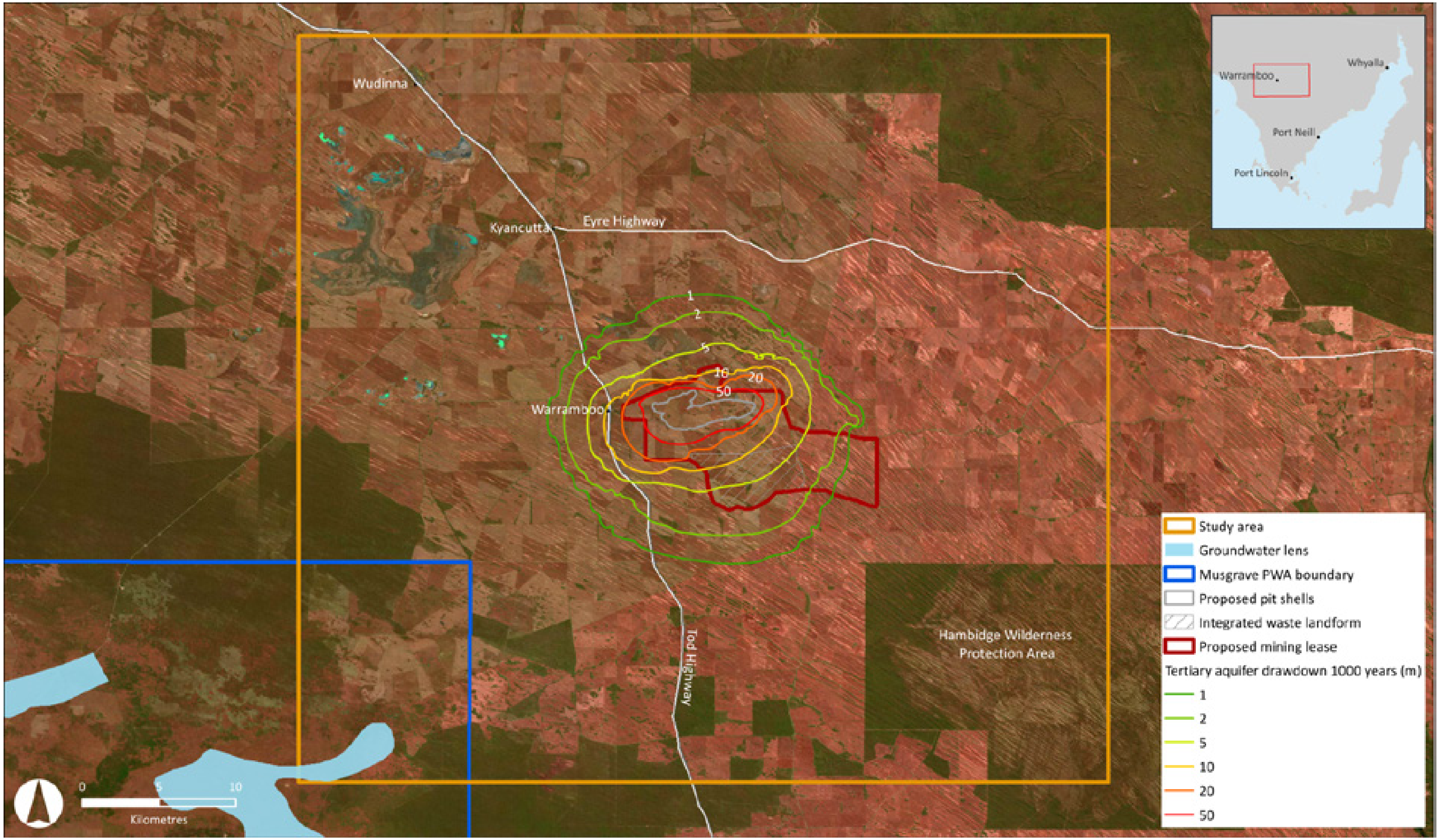

Figure 19-12 Predicted drawdown in the Tertiary aquifer 1000 years post closure (base case)

Model Sensitivity

Model uncertainty analysis was conducted by varying aquifer diffusivity, which is a function of aquifer transmissivity and storage capacity. The uncertainty analysis considered credible ranges of aquifer diffusivity as follows:

- High aquifer diffusivity (high transmissivity and low storage) resulting in an extensive, relatively flat cone of depression.
- Low aquifer diffusivity (low transmissivity and high storage) resulting in a less extensive, relatively steep cone of depression.

The uncertainty analysis considered:

- The aquifers of interest in the study area (Tertiary aquifer and fractured rock (gneiss) aquifer).
- Three time-based scenarios (End of mining (year 25) and post closure (45 and 1000 years after closure)).

The results of the uncertainty analysis are presented in Figure 19-13 for the Tertiary aquifer and Figure 19-14 for the fractured rock aquifer. The results indicate that there is only a modest difference in the extent of the drawdown cone for the modelled scenarios (see Appendix N for further details).

The sensitivity of the simulated water level recovery in the mining pit is shown in Figure 19-15. The results indicate pit lake water levels that range between -300 and -225 m AHD with the best estimate model simulating a level of -275 m AHD after 1000 years.

The numerical model also relies on key assumptions including the timing of rehabilitation, soil hydraulic properties and the profile of the integrated landform and soils in the study area. Uncertainty in this case has been addressed through the use of conservative modelling assumptions so that the assessment of potential impacts can be made with confidence (refer to Appendix M).

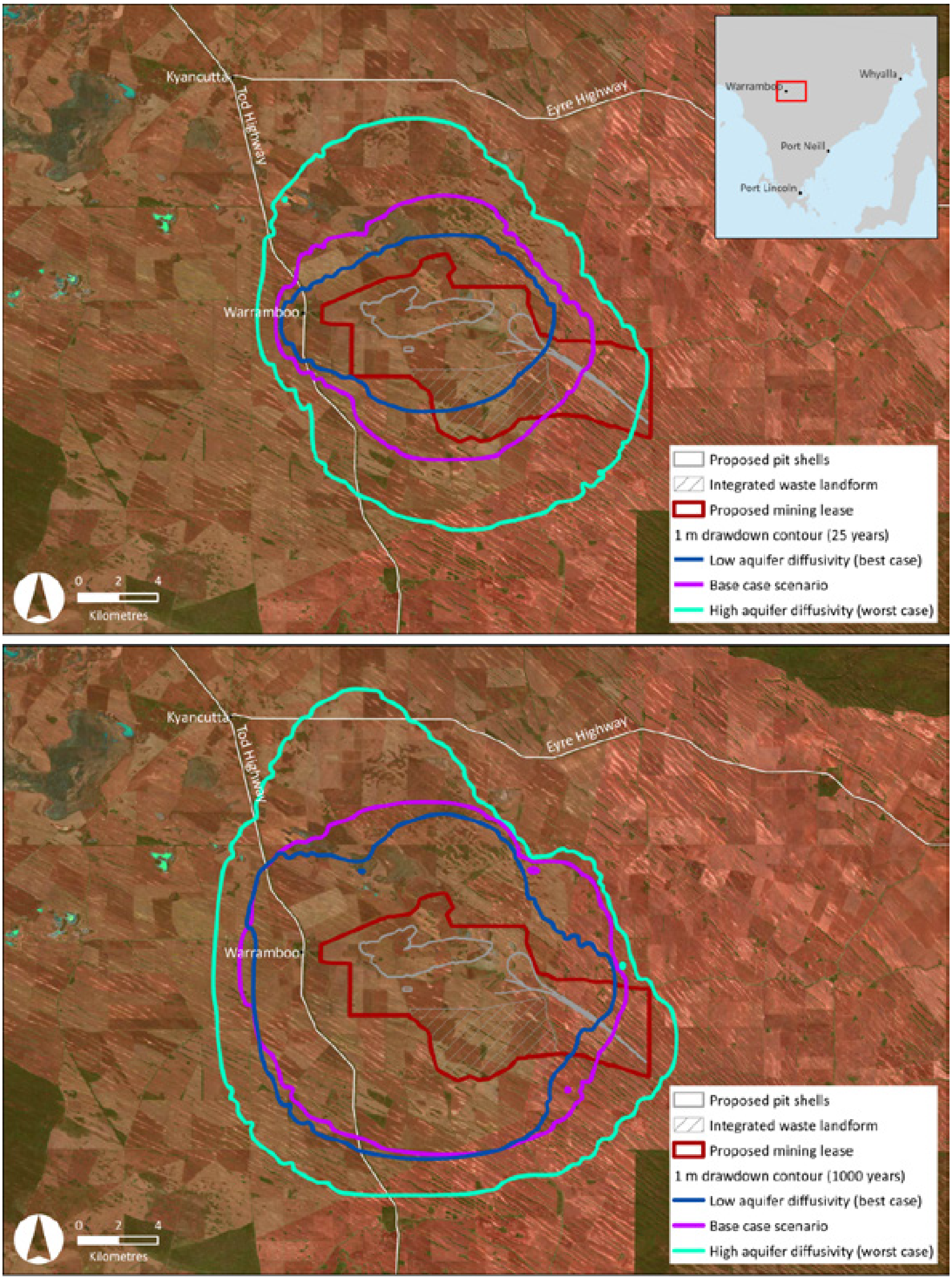

Figure 19-13 Model uncertainty – extent of drawdown (1 m contour) in the Tertiary aquifer at the end of mining (year 25) (top) and 1000 years after closure (bottom)

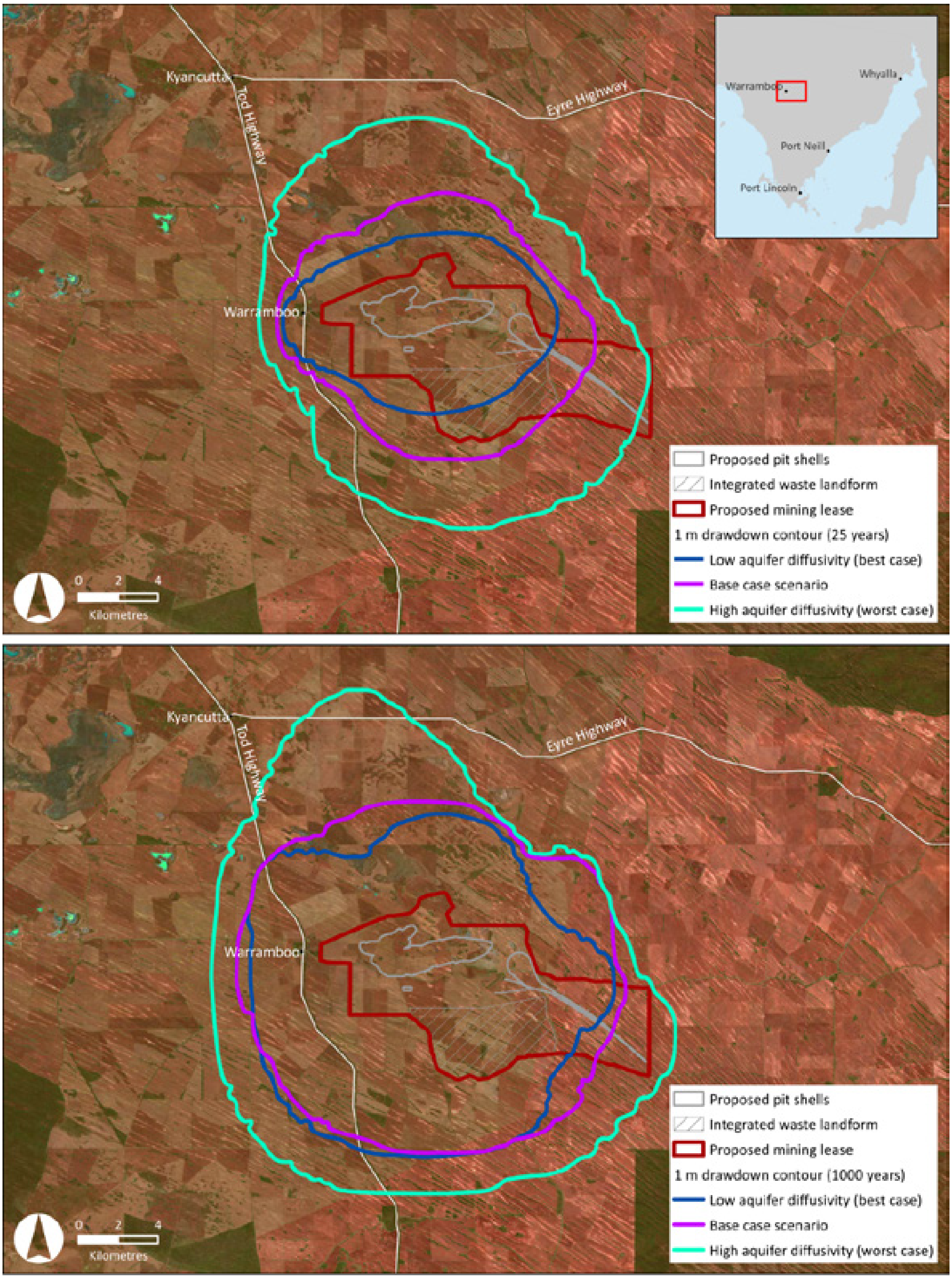

Figure 19-14 Model uncertainty – extent of drawdown (1 m contour) in the fractured rock aquifer at the end of mining (year 25) (top) and 1000 years after closure (bottom)

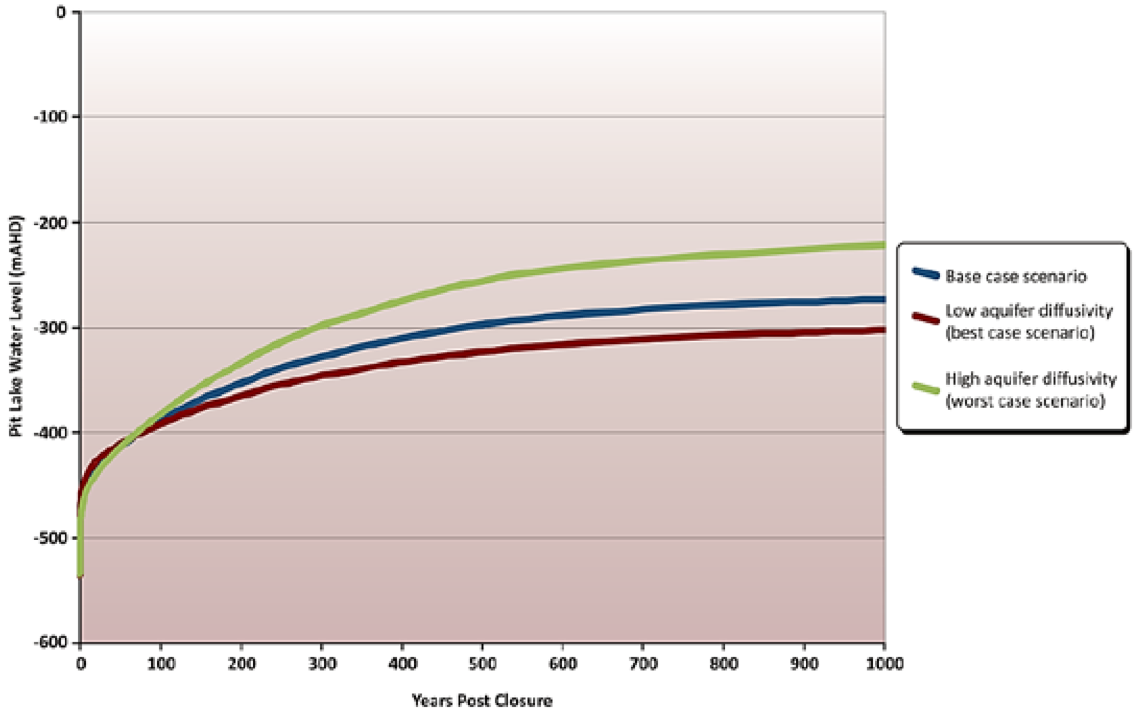

Figure 19-15 Model uncertainty – predicted water levels in the pit post mine closure

Assessment of Potential Impact Events

The source, pathway and receptors assessment is based on an area within the study area extending approximately 20 km from the proposed mine pits. This assessment area comprises the zone of influence predicted by the modelling, including sensitivity analysis. The assessment area, predicted drawdown contours and potential receptor locations are illustrated in

The assessment of groundwater receptors from the GIA identified:

- Six groundwater wells within the assessment area. An audit of these recorded wells conducted by Iron Road determined that none of these bores exist, further no landowners report any use of groundwater within the assessment area.
- Lake Warramboo and its adjacent salt lakes are located within the predicted zone of influence of groundwater drawdown, with groundwater levels predicted to decrease in the long term by approximately one to five metres in the vicinity of Lake Warramboo. Potential impacts and risks to the ecological values of the Lake Warramboo Complex have been addressed in Chapter 11 Fauna and Pest Species and Chapter 12 Vegetation and Weeds.
- The zone of influence around the mine is not predicted to reach the Musgrave PWA, with approximately 20 km distance between the predicted post closure zone of influence and Musgrave PWA.

Although the numerical groundwater flow model does not predict any increase in the water table elevation, it is acknowledged that there are several areas located to the southeast of the integrated waste landform where groundwater is currently within 5 to 10 m of the surface (Figure 19-7). These areas may be sensitive to an increase in the water table elevation, due to the shallow water table, the proximity to IWL on the southern side away from the drawdown influence of the pit. Any water table rise in this area could result in salinization of the soil profile and crop root zone. The impact and risk associated with groundwater level rise is assessed in Section 19.7.1.

The GIA findings are consistent with the general observation that groundwater within the study area is highly saline and suited only to industrial purposes.

An AMD assessment was undertaken to determine the potential for AMD to impact groundwater receptors via groundwater infiltration and seepage. As previously identified, groundwater in the vicinity of the proposed mining lease is highly saline and has low pH, with no users identified within a 20 km radius of the proposed pits. Therefore, the only credible receptor associated with AMD was considered to be productive agricultural land.

Based on the limited quantity of PAF material identified (an estimated 2% of the total volume of waste rock and tailings material to be encountered with the majority of PAF having low to very low acid generating potential, see Appendix S Conceptual Integrated Landform Design for Rehabilitation and Closure), the fact that the overburden waste contains sufficient concentrations of buffering potential to neutralise AMD and low level of seepage within the landform, any impact from AMD on agricultural land is likely to be diluted to extent that impacts are insignificant at points where groundwater interacts with surface. Therefore, credible pathway does not exist.

Dewatering of the pit and the development of a cone of depression around the mine pit following mine closure means that any seepage from the IWL will report to the depressed water table and then seep slowly to the pit. There is no predicted expression at surface to impact on agricultural land (Numerical Groundwater Flow Model Report in Appendix M).

Although AMD analysis completed for the project confirms a potential source for AMD (the presence of PAF materials in the integrated waste landform), a source, pathway, receptor linkage has not been confirmed. However, consistent with industry standard practice the integrated waste landform will be designed to minimise the likelihood of AMD (through co-disposal with neutralising material) and prevent AMD from reaching groundwater receptors (through appropriate mixing and placement within the integrated landform). Further, the ongoing implementation, review and update of the IWL Management Plan will allow compliance with planning and waste handling requirements to be regularly verified.

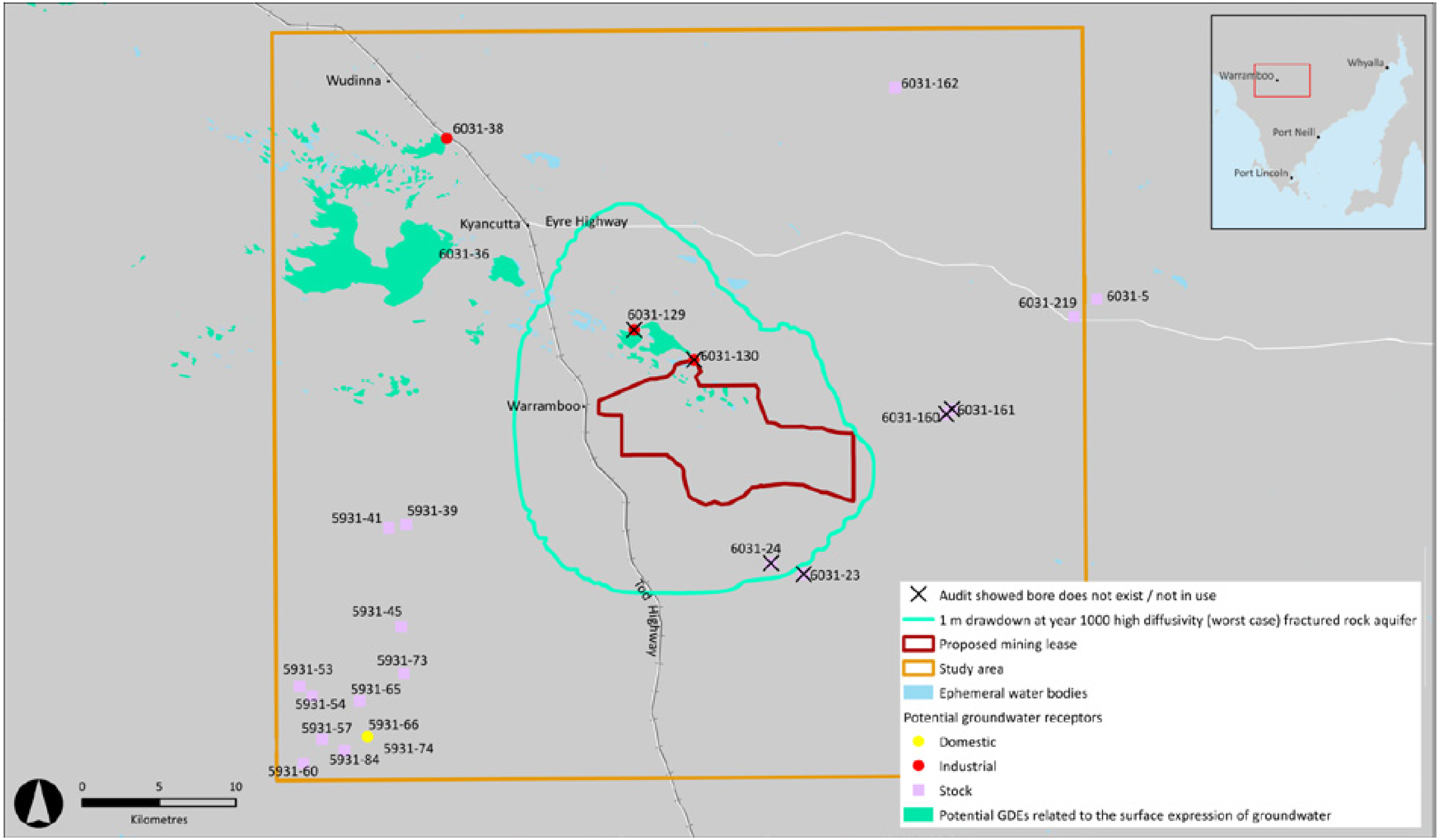

Figure 19-16 Predicted zone of drawdown influence and receptor identification

19.6 Control Measures to Protect Environmental Values

The following section identifies design and control measures implemented to mitigate the level of impact and risk associated with groundwater such that it is considered as low as reasonably practicable.

19.6.1 Design Measures

The following design control measures have been incorporated to minimise impacts and risks to groundwater receptors as a result of the construction, operation and closure of the CEIP:

- Dewatering, conveying and stacking of tailings to reduce the amount of water recharging to groundwater compared to 'wet' tailing design alternatives
- The integrated waste landform will incorporate co-disposal of potentially acid forming (PAF) material with neutralising material within the landform to prevent AMD.
- The soil cover profile will be designed to act as a store and release cover to minimise infiltration into the landform and though-drainage into any stored PAF material. Storage of PAF material will not occur in the top 10 m layer of the integrated waste landform, to demonstrate that it is well buried within the landform. The integrated waste landform will be designed in accordance with the Global Acid Rock Drainage (GARD) Guide (INAP 2009).
- Abstraction of a saline groundwater resource for mine processing (considered suitable for limited industrial purposes only) which is not used by surrounding land owners and is not connected to potable groundwater resources in the region. The salinity of abstracted groundwater is expected to be in excess of 100,000 mg/L (SKM, 2014a)
- Controlled groundwater abstraction during advanced dewatering in line with construction requirements
- Hydrocarbon and chemical storage facilities would be designed in accordance with Australian Standards, relevant legislation and best practice guidelines
- Fuel and lubricant storage and dispensing facilities designed and installed in accordance with:
  - AS 1940-2004: The storage and handling of flammable and combustible liquids
  - AS 1692-2006: Steel tanks for flammable and combustible liquids
  - Relevant South Australian legislation
  - Best practice guidelines

19.6.2 Management Strategies and Commitments

Management measures that will be adopted to assist in the avoidance or mitigation of groundwater impacts and risks during the construction, operation and closure of the proposed mining lease are outlined in Table 19-4.

Table 19-4 Control and Management Strategies: Groundwater

Control and Management Strategies	Project Phase[1]
ADVANCED DEWATERING	
Controlled and recorded abstraction of water in accordance with defined water requirements and approved abstraction volumes for dewatering wells. Groundwater abstracted during early dewatering will be used during construction for earthworks and dust suppression. Dewatering volumes will be managed to meet construction water requirements. Water from dewatering will be desalinated for use in integrated waste landform topsoil suppression.	CO

Control and Management Strategies	Project Phase[1]
ACID MINE DRAINAGE	
Implementation of an IWL Management Plan, including appropriate AMD management actions. The IWL Management Plan will be updated throughout the life of the project as more information from ongoing testwork programmes is completed.	CO OP CL
MANAGEMENT OF CHEMICALS AND HAZARDOUS SUBSTANCES	
All hazardous materials (oils, fuels and chemicals) will be managed in accordance with relevant regulations and guidelines, including appropriate storage and bunding, material safety data sheets, spill response etc.	CO OP
MONITORING OF EFFECTS FROM WATER AFFECTING ACTIVITIES	
Monitoring of groundwater levels to assess compliance with predicted drawdown / water table elevation. Although the numerical groundwater flow model does not predict an increase to water table elevation, there are several areas located to the south east of the integrated landform which have been identified as sensitive to any increase in water table elevation as a result of recharge from the integrated waste landform. These are areas where groundwater is already within five to 10 m of the surface (see Figure 19-7). Observation wells will be used between the integrated waste landform and these sensitive areas to provide an early indication of potential issues. Management options should an issue with water table elevation be identified include acquisition of the affected land and groundwater pumping.	CO OP CL

[1]CO = Construction, OP = Operation, CL = Closure

19.7 Impact and Risk Assessment

This section identifies and assesses potential impact events associated with existing groundwater values as a result of the construction, operation and closure of the proposed mine. Potential impact events (confirmed by the presence of a source, pathway and receptor) are those which are predicted to occur as a result of the development, whilst risk events would not be expected as part of the normal operation of the project, but could occur as a result of uncertainty in the impact assessment process or as a result of faults, failure of control strategies and unplanned events. Although the risks may or may not eventuate, the purpose of the risk assessment process is to identify management and mitigation measures required to reduce the identified risks to a level that is as low as reasonably practicable. This assessment has been undertaken in accordance with the methodology outlined in Chapter 6.

Impact and risk events were identified through technical studies and stakeholder consultation. Impact events can include multiple sources, pathways or receptors and where practical have been grouped together to minimise duplication of information. A summary of impact and risk events relating to groundwater is presented in Table 19-6 at the end of this section (with Impact IDs) and a complete register of impact and risk events by source, pathway and receptor is provided in Appendix C.

Impacts and risks are assessed following the application of the design measures outlined in Section 19.6.1. Where required, management measures are proposed to reduce the impact to a level that is considered as low as reasonably practicable. The key environmental risks will be monitored through the environmental management framework.

19.7.1 Impacts to Agricutural Production from Groundwater Level Rise due to Altered Recharge from Integrated Waste Landform

Although the development of the integrated landform will alter recharge locally, groundwater levels beneath the integrated landform are not predicted to increase during the life of the mine or post closure. As such, the impact due to enhanced recharge is considered **negligible**.

Although the numerical groundwater flow model does not predict any increase in the water table elevation, it is acknowledged that there are several areas located to the southeast of the integrated waste landform where groundwater is currently within 5 to 10 m of the surface. These areas may be sensitive to an increase in the water table elevation. In the event that the model predictions are incorrect, there is potential for water logging and salinisation of soils in susceptible parts of the study area.

Given only a small change to water levels may be required for impact to occur, the use of observation wells located between the integrated landform and the sensitive areas will be used to provide an early indication of potential issues and implement management options such as acquisition of the land and groundwater pumping.

The consequence of groundwater level rise from recharge from the integrated landform is considered **moderate** based on a localised contamination (salinisation) impact that could be remediated in the long term. With the implementation of monitoring to provide a leading indicator of potential groundwater elevation issues and inform adaptive management strategies, it is considered **rare** that impacts to agricultural receptors will occur due to mining operations. As such, the risk is considered **low**.

19.7.2 Summary of Impacts and Risks

Through the implementation of design and management controls, the identified impact has been reduced to **negligible** and associated risk has been reduced to low. A summary of each of the identified impacts and risks is presented in Table 19-5.

Table 19-5 Impact and Risk Summary: Groundwater

Impact ID	Impact Event	Level of Impact[1]	Level of Risk[2]
IM 19-04 IM 19-05	Groundwater Quantity – Impacts to agricultural production from groundwater level rise due to altered recharge from integrated landform	Negligible	Low

[1] Impact events are expected to occur are part of the project. Level of impact is assessed post control strategies, as per the impact assessment methodology provided in Chapter 6

[2] Level of risk reflects the risk that the assessment of impact is incorrect due to uncertainties in the assessment method, the control strategies, or in assumptions uses. Risk is assessed post control strategies, as per the risk assessment methodology provided in Chapter 6

19.7.3 Justification and Acceptance of Residual Impact and Risk

With the implementation of design and operational management measures, the identified impact associated with groundwater is considered to be **negligible**. The associated risk has been reduced to **low**. The impacts and risks are considered as low as reasonably practicable.

19.8 Proposed Outcomes

In accordance with the methodology presented in Chapter 6, outcomes have been developed for all impact events with a confirmed linkage between source, pathway and receptor. Each outcome is supported by measureable assessment criteria that will be used to assess compliance against the proposed outcomes during the relevant phases (construction, operation, closure) of the project. Proposed outcomes and measurement criteria have been developed for each of the impact events identified with a confirmed linkage and these are presented in Table 19-6 below. Outcomes for the entire project are presented along with all impact events in Appendix C.

Table 19-6 Outcomes and Assessment Criteria: Groundwater

Proposed Outcome	Impact ID	Impact Event	Draft Outcome Measurement Criteria	Draft Leading Indicator Criteria
No impacts to agricultural productivity for third party land users as a result of groundwater recharge from the IWL, including: · reduction in crop yield; · reduction in grain quality; or · adverse health impacts to livestock other than where agreed between the tenement holder and the affected user.	IM 19_04 IM 19_05	Groundwater Quantity – Impacts to agricultural production from groundwater level rise due to altered recharge from integrated landform	Groundwater level rise due to seepage from the IWL is less than 2 metres above background, taking into account seasonal variation. Post closure, groundwater monitoring demonstrates that drawdown from the pit is negating any increase in groundwater level from IWL seepage.	Groundwater monitoring results within and outside the proposed mining lease boundary are in line with model predictions and seasonal variations.

19.9 Findings and Conclusions

The GIA has included a systematic consideration of potential groundwater effects and assessment of source, pathway and assessment linkages. This assessment has confirmed a source, pathway and receptor linkage for one impact event.

Although changes to the existing groundwater regime are expected as part of the proposed development, the absence of groundwater receptors within the assessment area (comprising the predicted zone of influence and a 10 km buffer), means that there will be no impact to groundwater receptors associated with groundwater drawdown. **Negligible** impact is also expected due to groundwater level rise, with the numerical groundwater flow model predicting no increase in the water table elevation.

Risks to groundwater receptors will be alleviated wherever possible through the implementation of control and management strategies. The risk of salinisation and waterlogging of soils to occur in areas susceptible to groundwater table rise has been assessed as a **low** level residual risk.

The outcome proposed ensures that Iron Road will manage groundwater effects to a level which is as low as reasonably practicable.