

Part 4B

Potentially Impacted Environmental Features, Management Measures and Impacts

The descriptions of potential environmental impacts throughout Part 4B are reliant upon a range of background information common to many of the key environmental issues. Background information on topography, meteorology, land ownership, land uses and surrounding residences is presented as Part 4A.



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4B.1 GROUNDWATER

The groundwater assessment was undertaken by RCA Australia (RCA, 2007). The full assessment is presented as Part 1 of the Specialist Consultant Studies Compendium, with the relevant information from the assessment summarised in the following subsections.

4B.1.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.5**), the potential groundwater impacts requiring assessment and their unmitigated risk rating are as follows.

- Groundwater pollution as a result of leakage or spillage (moderate to high risk).
- Drawdown of groundwater on and beyond the Project Site (moderate to extreme risk).
- Reduction in the yield / saturated thickness of groundwater bores:
 - on the Project Site or Proponent-owned land (high risk);
 - by <15% on non-project related properties (high risk); and
 - by >15% on non-project related properties (high risk).
- Impacts on groundwater-dependent ecosystems (moderate risk).

In addition, the Director-General's requirements issued by the Department of Planning require that the assessment of soil and water include a detailed water balance, and refer to the *Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000), and the various *State Groundwater Policy* documents.

This section commences with a review of the existing regional and local hydrogeology, local availability and use of groundwater resources and current statutory framework for the management of groundwater. Potential sources of groundwater contamination are then identified and the operational safeguards, controls and mitigation measures described. The section concludes with an assessment of the residual impacts upon the groundwater resources beneath and surrounding the Project Site following the implementation of these safeguards, controls and mitigation measures.

4B.1.2 The Existing Environment

4B.1.2.1 Hydrogeological Setting

In order to obtain an overview of the regional and local hydrogeological setting of the Project Site, RCA (2007) reviewed geological maps and consulted with the Proponent's consultant geologist to define the stratigraphic sequence below the Project Site. To obtain a regional overview of local groundwater levels, aquifer source (screened strata) and yield, the



Department of Water and Energy (DWE) database of registered groundwater bores within a 5km radius was reviewed. Finally, to identify the depth below surface and direction of flow of the groundwater table potentially impacted by the proposed mining activities, standing water levels (SWL's), conductivity values and yields were obtained from exploration bores, specifically constructed monitoring bores and local registered groundwater bores in 2002 and again in 2007.

Figure 4B.1 presents the interpreted 2002 and 2007 groundwater levels of the Project Site, approximately 35m and 34m below surface respectively, based on the fieldwork described above.

Based on the known stratigraphic sequence and the measured SWLs of the Project Site, RCA (2007) has determined that groundwater is contained in the following strata below the Project Site.

Overburden

Overburden materials comprise weathered conglomerates with some fracturing. The depth of groundwater within the overburden is limited and the layer is dry below and immediately surrounding the Project Site.

The hydraulic conductivity of this layer is expected to be low due to the weathering effects which produce clayey to sandy clay materials. Groundwater flow would occur through fracturing and storage within the overburden would be low due to the low porosity of the unit.

Alluvium

Unconsolidated alluvium is present in a north-south oriented drainage line to the north and south of the Project Site. The alluvial aquifer, which is not a significant water storage due to the limited aquifer extent and depth, is supported by infiltration from the sands and gravels of the drainage line bed during and following rainfall. However, as the Project Site is located up-gradient or at the headwaters of this drainage line, it represents less than 1% of the surface water catchment, and in turn infiltration potential (RCA, 2007).

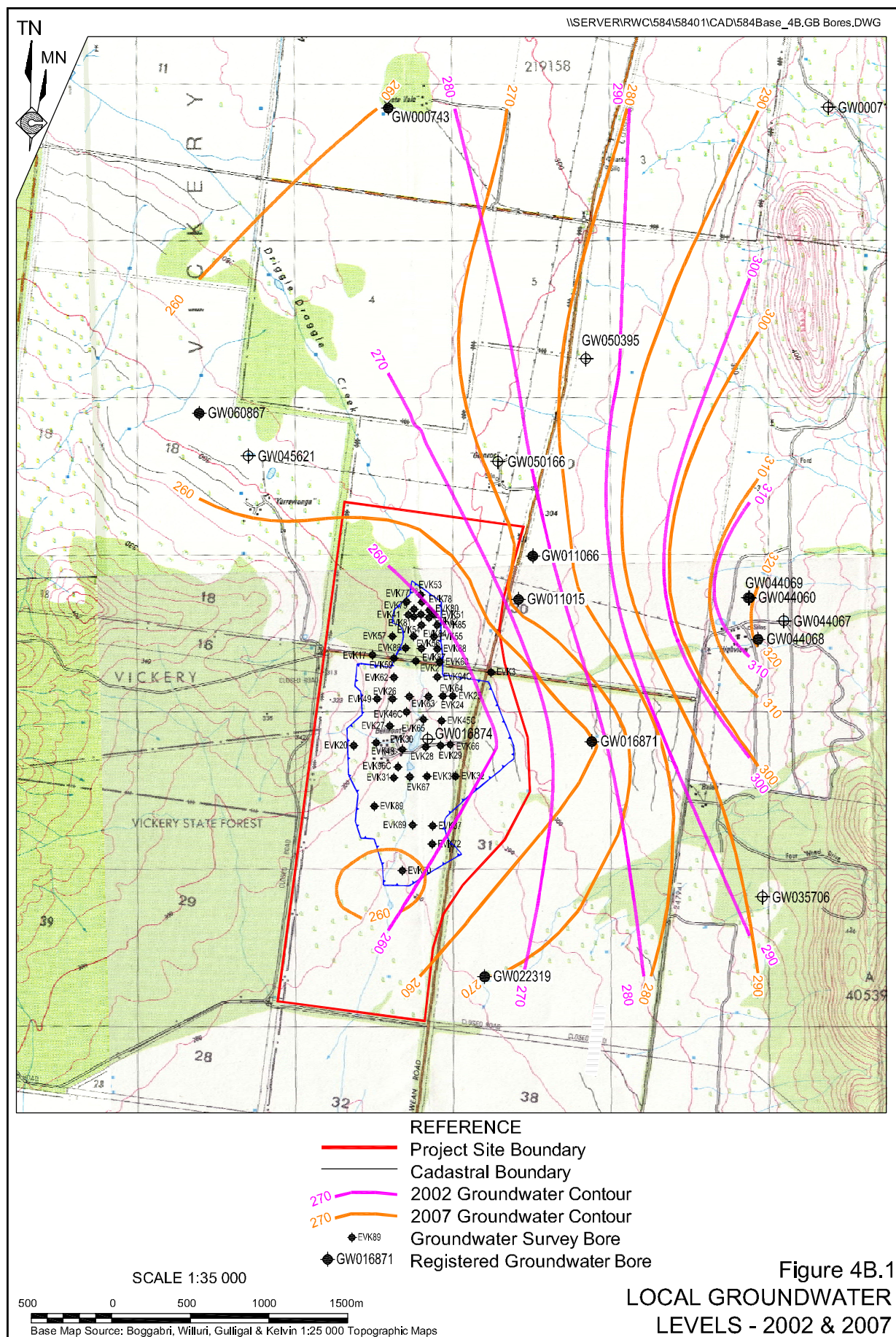
An underlying clay layer prevents infiltration to the underlying overburden, with the water draining away from the Project Site.

Coal Seams

Hydraulic conductivity and porosity in the three identified coal seams is considered low due to the compacted nature of the seams, however, fracturing, jointing, bedding and cleating provide a secondary porosity which dominates groundwater flow. As groundwater in these strata occurs mainly in the fractures, the groundwater storage is small.

The main water-bearing zones or aquifers occur in the coal seams with minor water-bearing zones in the interburden rocks. The groundwater is partially confined and under pressure in the coal seams with the interburden rocks acting as semi-confining layers or aquitards.





Interburden Between Coal Seams

Interburden between the coal seams have lower storage and hydraulic conductivities (generally by an order magnitude) values compared to the coal seams. These interburden layers act as aquitards but may provide water to the over- or under-lying coal seams by vertical leakage when there is a pressure drop in the coal seam such as would occur as a consequence of coal removal in adjacent areas. Groundwater flow in the interburden is governed by the presence of fractures and joints as in the case of coal seams.

Sandstone Floor

Beneath the Belmont Seam is a layer of inter-bedded sandstone, granule and pebble conglomerate with a clay matrix and secondary siderite cement. An inspection of the geological logs of two exploration bores, EVK95 and EVK96, has determined that this layer would be largely impermeable, with the flow of water likely to be through joints and faults in the strata (see RCA, 2007 - Appendix 3).

RCA (2007) notes that tight (impermeable) volcanic formations have been identified to the east and north of the Project Site and represent a no-flow boundary. To the east, a no-flow boundary consistent with a topographic divide in CCA Zone 2 - Kelvin was assigned. To the north a constant head boundary was assigned approximately 5km to the north of the Project Site to represent the hydrogeological head at this location. The Namoi River to the south and west is considered by RCA (2007) to represent a constant head boundary.

4B.1.2.2 Groundwater Flow and Interaction with Surface Water

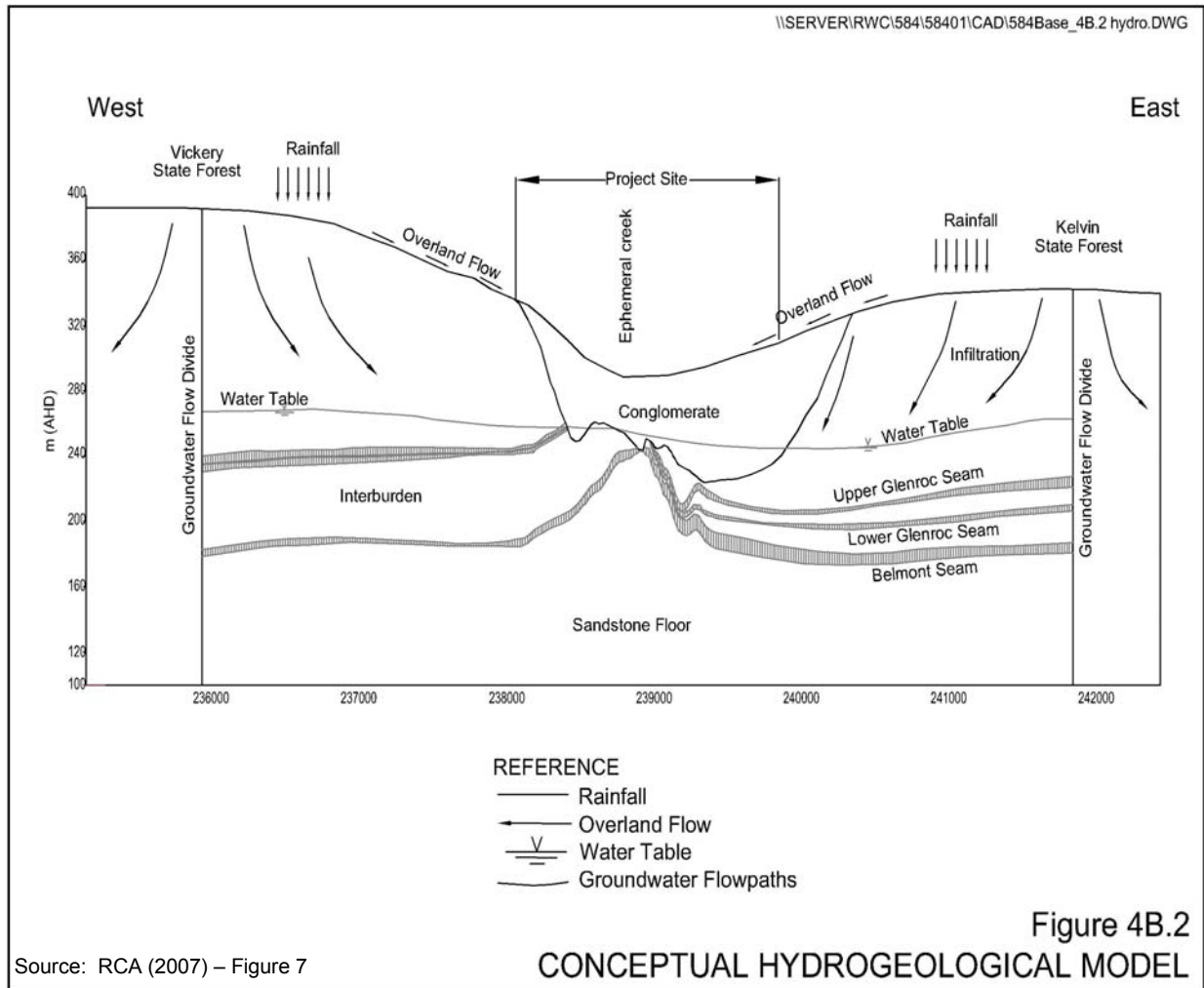
4B.1.2.2.1 Groundwater Flow

Based on the hydrogeological setting of the Project Site (see Section 4B.1.2.1), RCA (2007) developed a conceptual hydrogeological model for the Project Site and surrounds. The model, presented as **Figure 4B.2**, depicts the presence of overburden, interburden and coal seams with a groundwater level relatively constant through these layers at 35m below surface. Groundwater in the upper interburden strata is likely to be semi-confined by the presence of thick clay deposit which extends to a depth of about 20m below surface. Groundwater in the coal seams is likely to exhibit moderate confinement characteristics due to the overlying interburden.

As illustrated by the groundwater contours on **Figure 4B.1**, groundwater within each strata generally flows from east to west beneath the Project Site, following the more regional topographic fall from the Kelvin Range in the east to the Namoi River to the west (and south). Groundwater flow between the layers is expected to occur although generally at least an order of magnitude less than within each layer (RCA, 2007).



The hydraulic gradient displayed on **Figure 4B.2** indicates that the Project Site and surrounds is a groundwater recharge area with recharge occurring from rainfall.



4B.1.2.2.2 Groundwater – Surface Water Interaction

The inter-relationship between rainfall, water/seepage, and groundwater is depicted on **Figure 4B.2**. The typical relationship between shallow groundwater and surface water flows is represented as follows.

$$\text{Precipitation} = \text{evapotranspiration} + \text{infiltration} + \text{runoff}$$

The relationship between infiltration and runoff is difficult to determine as infiltration has three possible flow paths (springs, perched water or true groundwater) that are dependent on the geological profile. Neither springs nor perched water were identified on the Project Site during field investigations in 2002 and 2007, and although these features may occur during heavy rainfall, they are not considered to represent the existing long term hydrogeological regime. All infiltration is therefore considered to ultimately reach the true groundwater table.



On the Project Site, the true groundwater table is represented by the ‘hard rock’ aquifer of the conglomerate overburden, coal seams, interburden and shale / sandstone bedrock and an ‘alluvial’ aquifer, present along the channels created by the ephemeral drainage lines running north and south through the centre of the Project Site. During rainfall, infiltration from these drainage lines and surrounding areas to the underlying unconsolidated gravels and sands would support the alluvial aquifer system with flows to the north and south following surface topography. This drainage to the north and south, and presence of a clay aquitard layer (see Section 4B.1.2.1), would prevent further infiltration to the underlying ‘hard rock’ aquifer. Given the steep surface slopes adjacent to the site and the presence of surface gullies and creek beds promoting runoff, overall infiltration to the ‘hard rock’ aquifer is likely to be low and less than 10% of the total rainfall.

4B.1.2.3 Groundwater Quality

Table 4B.1 presents the analyses of groundwater samples collected from a total of nine open drill holes and piezometers on the Project Site in 2002. **Table 4B.2** presents the same analyses for a further four groundwater samples collected from four groundwater bores on the Project Site in March 2007 along with the available NHMRC, ARMCANZ and ANZECC Guideline values for health and agriculture. All bores were purged prior to sampling and analyses were undertaken by Australian Laboratory Service Environmental, who are NATA registered for the analytes tested.

Table 4B.1
Summary of Laboratory Water Quality Results (2002)

Parameter	Unit	Sampling Location								
		BG-1	BG-2	BG-3	BG-4	BG-5	BG-6	BG-7	BG-8	BG-9
pH (field)		6.3	7.2	6.9	7.1	7.0	6.9	7.0	6.6	6.4
pH (lab)		7.03	7.32	7.15	7.30	7.16	7.80	7.34	6.82	6.74
EC	µS/cm	2120	2960	2120	3160	3280	815	2080	3500	7000
Alkalinity (as Bicarbonate)	mg/L	950	560	560	1100	900	310	730	440	410
Chloride	mg/L	156	610	354	425	567	64	255	865	2198
Sulphate	mg/L	1	20	29	4	80	20	<1	42	60
Sodium (total)	mg/L	400	400	320	720	640	180	420	460	630
Potassium (total)	mg/L	7.0	3.9	3.4	6.2	6.6	11.8	5.4	3.4	10.7
Nitrite	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrate	mg/L	0.1	4.7	0.5	<0.1	0.1	0.5	0.2	1.2	3.6
Manganese	mg/L	1.4	0.007	0.010	0.086	0.32	0.19	0.19	<0.003	0.046
Magnesium (total)	mg/L	28	66	44	26	44	10.6	15.0	35	247
Iron	mg/L	0.80	0.08	0.92	0.44	1.0	8.0	1.3	0.03	5.3
Arsenic	mg/L	<0.002	0.005	0.002	0.012	0.009	0.002	<0.002	0.005	0.012
Aluminium	mg/L	0.27	<0.02	<0.02	0.62	1.4	5.5	2.1	<0.002	<0.02
Values shown in bold are outside or above the recommended drinking water guidelines. Values shown in <i>italics</i> are outside or above the recommended irrigation guidelines. Values <u>underlined</u> are outside or above the recommended livestock guidelines (see Table 4B.2 for guideline values).										
Source: Modified after RCA (2007) – Table 6										



Table 4B.2
Summary of Laboratory Water Quality Results (2007)

Parameter	Guideline ¹			Unit	Sampling Location (see Figure 4B.1)			
	Health	Irrigation	Livestock		EVK25	EVK40-P1	EVK61	EVK64
pH (lab)	6.5-8.5 ²	NG	NG		6.98	7.69	7.42	7.64
EC	500	NG	NG	µS/cm	297	1600	2340	2020
Alkalinity (as Bicarbonate)	200 ²	NG	NG	mg/L	143	492	904	790
Chloride	250 ²	700	NG	mg/L	16.8	226	289	204
Sulphates	500	NG	NG	mg/L	3	39	59	74
Sodium (total)	180 ²	NG	NG	mg/L	22	341	574	486
Potassium (total)	NG	NG	NG	mg/L	28	5	8	8
Nitrites	3	NG	NG	mg/L	0.037	0.015	0.013	0.025
Nitrates	50	NG	NG	mg/L	0.101	<0.010	0.525	1.58
Manganese	0.5	2.0	NG	mg/L	0.179	0.043	0.061	0.252
Magnesium (total)	0.1 ²	NG	NG	mg/L	4	23	23	19
Iron	0.3 ²	1.0	NG	mg/L	<0.05	<0.05	<0.05	<0.05
Arsenic	0.007	0.1	0.5	mg/L	0.001	<0.001	0.001	<0.001
Aluminium	0.2 ²	5.0	5.0	mg/L	0.03	<0.01	0.01	<0.01
¹ ANZECC (2000) ² Guidelines are aesthetic; no health based guidelines are available. NG No guideline available. Values shown in bold are outside or above the recommended drinking water guidelines. Values shown in <i>italics</i> are outside or above the recommended irrigation guidelines. Values <u>underlined</u> are outside or above the recommended livestock guidelines.								
Source: Modified after RCA (2007) – Table 6								

Considering the results listed in **Tables 4B.1** and **4B.2**, groundwater quality is summarised as follows.

- pH ranges from 6.3 to 7.7 in the laboratory and can be described as neutral.
- Electrical conductivity varies from 297µS/cm to 7000µS/cm, with an average value of approximately 2560µS/cm. The groundwater is therefore classified as brackish, ie. conductivity >1500 µS/cm.
- The water quality generally meets the NHRMC health guidelines (one Manganese and three Arsenic exceedances), although most water sampled does not meet the ANZECC drinking water guideline standard. Where guidelines are provided for agriculture, the water is generally suitable for agricultural (irrigation and/or livestock) purposes with a single exceedance related to aluminium levels obtained from BG-6 (a geological exploration hole).

4B.1.2.4 Water Use and Availability

A review of the groundwater database maintained by the Department of Water and Energy (DWE) (formerly part of the Department of Natural Resources) indicated that there are 30 registered water bores within a radius of 5km of the Project Site (**Figure 4B.3**). Available details for each of these bores, including ownership, SWL, usage and yield are presented in **Table 4B.3**.



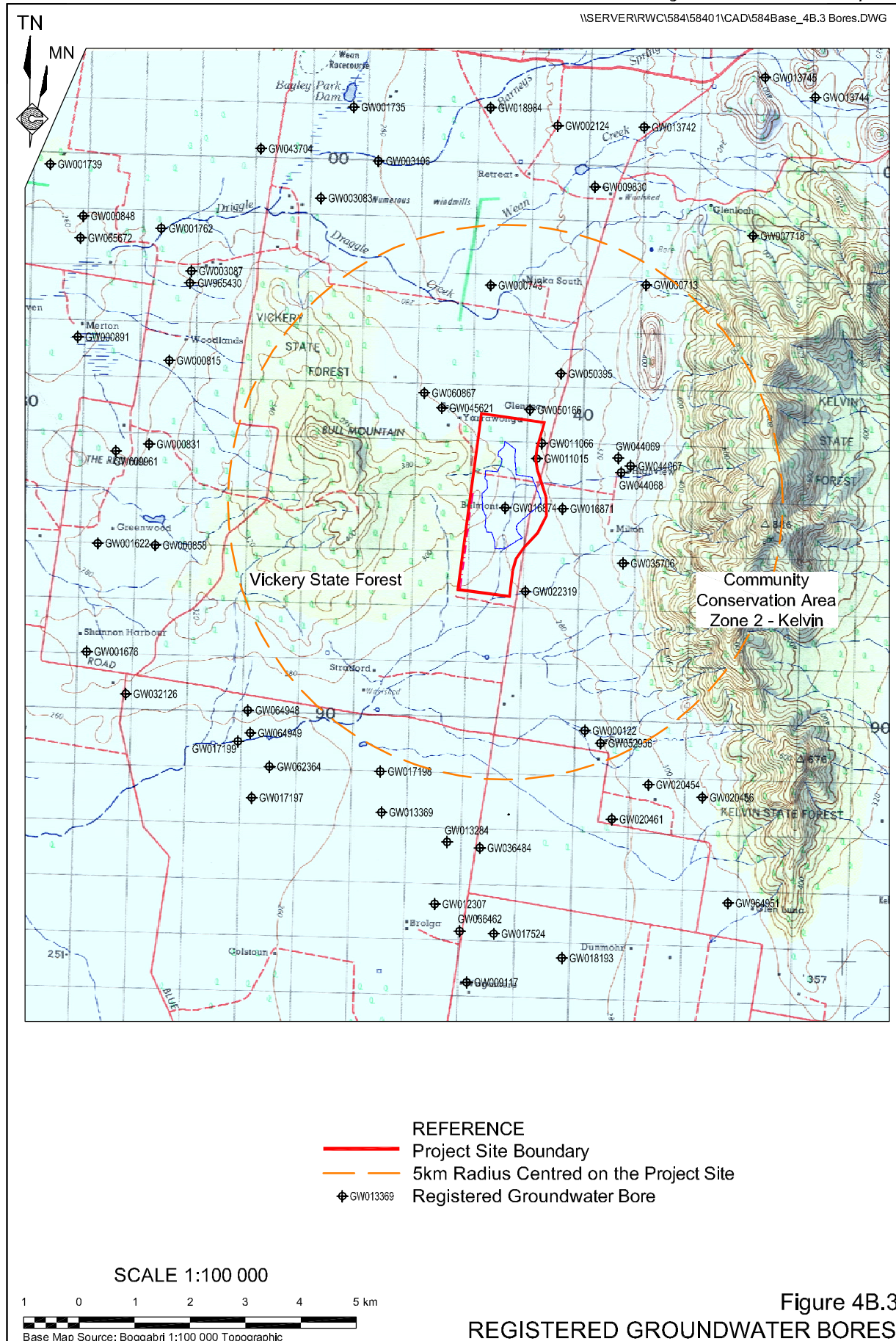


Table 4B.3
Registered Groundwater Bores (within 5km of the Project Site)

Bore No	Property	Usage	Distance to limit of mining (m)	Total Depth (m)	Water Bearing Zone Strata	Yield (L/sec)	SWL (m)	Saturated Thickness (m)
GW016874	"Belmont"	Stock	0	53.9	Coal/ Sandstone	0.88	32.68	21.2
GW011015	"Glenroc"	Stock	650	39	Sandstone	0.44	12.58	26.4
GW016871	"Belmont"	Stock	300	62.5	Sandstone, grey	0.38	NF	NK
GW011066	"Glenroc"	NK	600	47.9	Shale, black	0.63	NT	NK
GW045621	"Yarrowonga"	Stock	1300	NK	NK	NK	DRY	NK
GW060867	"Yarrowonga"	Domestic / stock	1600	100	Basalt, fractured	1.25	DES	NK
GW050166	"Glenroc"	Stock	1000	NK	NK	NK	NT	NK
GW022319	"Roseberry"	Stock	750	52.4	Gravel	0.2	14.17	38.23
GW044068	"Yarrari"	Domestic / stock	1500	43.5	Stones, white	0.32	50.92	7.42
GW044069	"Yarrari"	Domestic / stock	1400	47.8	Rock, Black	0.38	22.59	25.21
GW044067	"Yarrari"	Stock	1600	121.9	NK	NK	NT	NK
GW050395	"Glenroc"	Stock	1800	36.6	NK	NK	19.52	17.08
GW035706	"Belah"	Domestic / stock	1700	124.9	NK	NK	DES	NK
GW000743	"Costa Vale"	Stock	3000	70.4	Rock	0.72	9.46	60.94
GW017198	"Brolga"	Stock	3200	37.5	NK	NK	NT	NK
GW000122	NK	NK	2500	152.4	Shale	0	NT	NK
GW013369	"Brolga"	Stock	4000	22.3	NK	NK	NT ¹	NK
GW017199	"Brolga"	Stock	4700	37.5	NK	NK	NT ¹	NK
GW052956	"Surrey"	Domestic / stock	3000	53	rock, slightly conglomerated	0.1	34 [#]	19
GW062364	"Stratford"	Test hole	4500	30.5	Clay	0.25		30.5
GW064948	NK	Monitoring Bore	4200	49	NK	NK	NT	NK
GW064949	NK	Monitoring Bore	4500	41	NK	NK	NT	NK
GW000713	"Penryn"	NK	4000	65.2	Rock, Black	0.51	18.9 [#]	46.33
GW003083	"NK"	NK	5000	100	Unknown	0.61	30.8 [#]	69.2
GW013284	"Brolga"	Stock	4300	18.3	NK	NK	NT	NK
GW020454	"Carlton"	Stock	4100	73.2	NK	NK	NT	NK
GW020456	"Carlton"	Stock	5000	56.4	Slate	NK	NT	NK
GW020461	"Carlton"	Irrigation	4200	47.2	Clay, Fine Gravel	0	31.1	16.1
GW036484	NK	Test Hole	4400	40	Sand, Gravel	0.38	NT	NK
GW009830	"Penryn"	Stock	4500	67.1	Sandstone	0.76	NT	NK
DES – destroyed NT – not tested due to blockage NF – Not found NK – not known [#] – Taken from Department of Water and Energy register.								
Source: Modified after RCA (2007) – Table 13								



A review of **Table 4B.3** shows that the majority of licenced bores were established with the intention of providing stock and/or domestic supplies. However, as a consequence of the quality (see Section 4B.1.2.3.), the majority of bores are solely used for agricultural purposes. The information provided by the DWE database also indicates that the majority of the groundwater bores are located within the shale / sandstone underlying the Belmont Coal Seam, although several are identified as screening the coal or ‘black rock’.

Yields, when identified were generally less than 1L/s, although a higher yield of 1.25L/s is recorded for bore GW060867 which screens a fractured basalt strata.

4B.1.3 Potential Impacts on Groundwater Quality and Availability

4B.1.3.1 Potential Sources of Groundwater Contamination

The potential sources of groundwater contamination include:

- fuel, oil or other hydrocarbon spills or leaks;
- acid or salinity generation by the overburden and or coal reject material; and
- explosives residues.

The overburden and interburden rock lithologies primarily comprise conglomerates, sandstones and mudstones which were formed in a freshwater environment (Jeffery Beckett, pers comm).

These are not considered to provide source material for acid mine drainage or salinity generation. Further evidence for the non-acid and salinity generating nature of the overburden and interburden is provided by the assessment of local groundwater quality which indicates neutral to slightly alkaline water with an average electrical conductivity of 2 560µS/cm (brackish). Analysis of the Belmont coal reject material (see **Table 2.6**) indicates that sulphur concentrations are low (see **Table 2.6**), and therefore the risk of acid formation is minimal.

Based on experience elsewhere, explosives residues would be unlikely to have any measurable effect on the chemistry of the groundwater. In any event, negligible quantities of explosives would be used throughout the life of the mine. Potential contamination by fuel, oil or other hydrocarbons is therefore the main issue that needs to be managed across the Project Site.

4B.1.3.2 Potential Impacts on Groundwater Availability

The void created by the open cut operation would intercept the groundwater table (currently situated approximately 34m below surface). The creation of the void would create a pressure gradient in the aquifer with water then ‘seeping’ into open cut. The dewatering of the in-flowing groundwater (“mine in-flow”) would also maintain the pressure gradient between the aquifer (high pressure) and void (low pressure) resulting in the continuance of these in-flows.



Ultimately, the dewatering required may lead to a lowering of the aquifer water levels, which may subsequently impact on the yield of the groundwater bores on landholdings surrounding the Project Site.

4B.1.4 Management Measures and Mitigation Measures

4B.1.4.1 Groundwater Contamination

Although it is not anticipated that the Project would have a significant or long-term impact on the level or quality of groundwater beneath landholdings surrounding the Project Site, specific controls and management practices have been proposed by the Proponent for hydrocarbon management. These would ensure hydrocarbon products are prevented from seeping into the ground and ensure that water flowing from areas on the Project Site with the potential to generate hydrocarbon-contaminated water, eg. wash down areas, workshops, hydrocarbon storage and refuelling areas, is not contaminated by hydrocarbons.

- All hydrocarbon products would be securely stored.
- All of the mining fleet would be refuelled within designated areas of the Project surface facilities. With the exception of some maintenance activities on mobile equipment, all maintenance works requiring the use of oils, greases and lubricants would be undertaken within designated areas of the Project surface facilities, i.e. maintenance workshop.
- All water from wash-down areas and workshops would be directed to oil/water separators and containment systems.
- All storage tanks would either be self-bunded tanks or bunded with an impermeable surface and a capacity to contain a minimum 110% of the largest storage tank capacity.

4B.1.4.2 Groundwater Availability

Modelling groundwater drawdown resultant from mine in-flows suggests that there would be limited impact on the standing water levels of registered groundwater bores on properties not owned by the Proponent (see Section 4B.1.5.5). Emphasis on the management of groundwater would therefore be placed on monitoring of surrounding groundwater bores to verify the predicted minimal impact on groundwater availability and developing mitigation measures to ensure that any reduction in available groundwater is replaced by a comparable water source or otherwise compensated. Replacement and/or compensatory measures would be developed in consultation with the effected land owner but may include:

- deepening of the effected bore to increase the available saturated thickness;
- drilling and installation of a replacement bore outside the area of drawdown impact;



- construction of surface water capture and containment structures such as dams or rainwater tanks to supplement reduced groundwater source; or
- transfer of groundwater drawn from a Proponent-owned bore or the void itself.

These mitigation/compensatory measures would be formalised through the development of contingency plans (see Section 4B1.6.2).

Table 5.1 presents the details of commitments made in relation to groundwater monitoring and contingency planning.

4B.1.5 Assessment of Impacts

4B.1.5.1 Impact Assessment Criteria

As groundwater is used predominantly for stock or irrigation purposes (as a consequence of the poorer quality not meeting aesthetic drinking water guideline levels – see **Tables 4B.1** and **4B.2**), water quality would be assessed predominantly against the (NEPM) agricultural irrigation guideline levels, with the ANZECC guideline levels used where no NEPM guidelines have been published.

Impacts on the water quality parameters of pH, TDS, other anions and heavy metals (not considered by the NEPM criteria) would be based on comparisons to baseline monitoring of groundwater quality taken from all groundwater bores within the Project Site.

Groundwater levels and the saturated thickness within bores on neighbouring landholdings would be monitored with any variations over 10% considered a significant impact given these levels would be expected to naturally vary by this amount. Hence, the criteria for assessing the degree of impact upon groundwater level and saturated thickness has therefore been determined to be a >10% decrease in water level or saturated thickness.

4B.1.5.2 Assessment Methodology

The extent of groundwater inflows into the open cut void and the effect the Project would have on groundwater levels, borehole yields, groundwater level re-establishment and availability of groundwater from existing bores has been predicted using a groundwater modelling program, “Visual Modflow” (RCA, 2007). The model was designed to simulate the behaviour of the five separate geological strata potentially affected by the Project, which from shallowest to deepest are as follows.

1. Conglomerate overburden.
2. Glenroc coal seams and interburden.
3. Interburden between the Lower Glenroc and Belmont coal seams.
4. Belmont coal seam.
5. Sandstone floor.



Based on permeability testing completed by RCA in 2002 and comparison to similar geological formations, RCA (2007) determined the initial hydraulic conductivity, porosity and specific yield parameters for the model. **Table 4B.4** summarises these parameters.

Table 4B.4
Groundwater Model Parameters

Strata	Permeability adopted for the slopes (m/s)		Permeability adopted for the valley (m/s)		Specific Yield	Total Porosity %	Effective Porosity %
	$K_x = K_y$	K_z	$K_x = K_y$	K_z			
Overburden	1.8×10^{-7}	1.8×10^{-8}			0.001	5	1
- Mid-slope			5×10^{-8}	5×10^{-9}			
- Valley			7×10^{-5}	3×10^{-6}			
Glenroc Seam Sequence and Interburden	1.8×10^{-7}	1.8×10^{-8}	6×10^{-6}	6×10^{-7}	0.01	10	5
Interburden between Lower Glenroc and Belmont Seams	1.8×10^{-7}	1.8×10^{-8}	5×10^{-8}	5×10^{-9}	0.001	5	1
Belmont Seam	1.8×10^{-7}	1.8×10^{-8}	6×10^{-9}	6×10^{-7}	0.01	10	5
Sandstone Floor	1.8×10^{-8}	1.8×10^{-9}	5×10^{-7}	5×10^{-8}	0.001	5	1

Source: Modified after RCA (2007) – Tables 10 and 12

The permeability of the underlying volcanics layer was considered as this represents a no-flow boundary in the model. However, for this reason, no further parameter estimation was required. Similarly, the alluvial aquifer was not considered due to the minimal impact on this by the Project and lack of interaction with the hard rock aquifers due to the presence of the clay aquitard.

Figure 4B.4 presents an east-west and north-south cross-sectional representation of the groundwater model and hydraulic conductivity parameters. The model was calibrated to ensure it predicted the observed groundwater levels identified in groundwater bores surrounding the Project Site with an acceptable level of error.

Once calibrated (and validated), the model was run in transient mode for a period of 7 years (the expected life of the Project) to allow comparison of mine in-flows and aquifer drawdown over time. Additional details regarding the groundwater model design and operation are provided in RCA (2007).



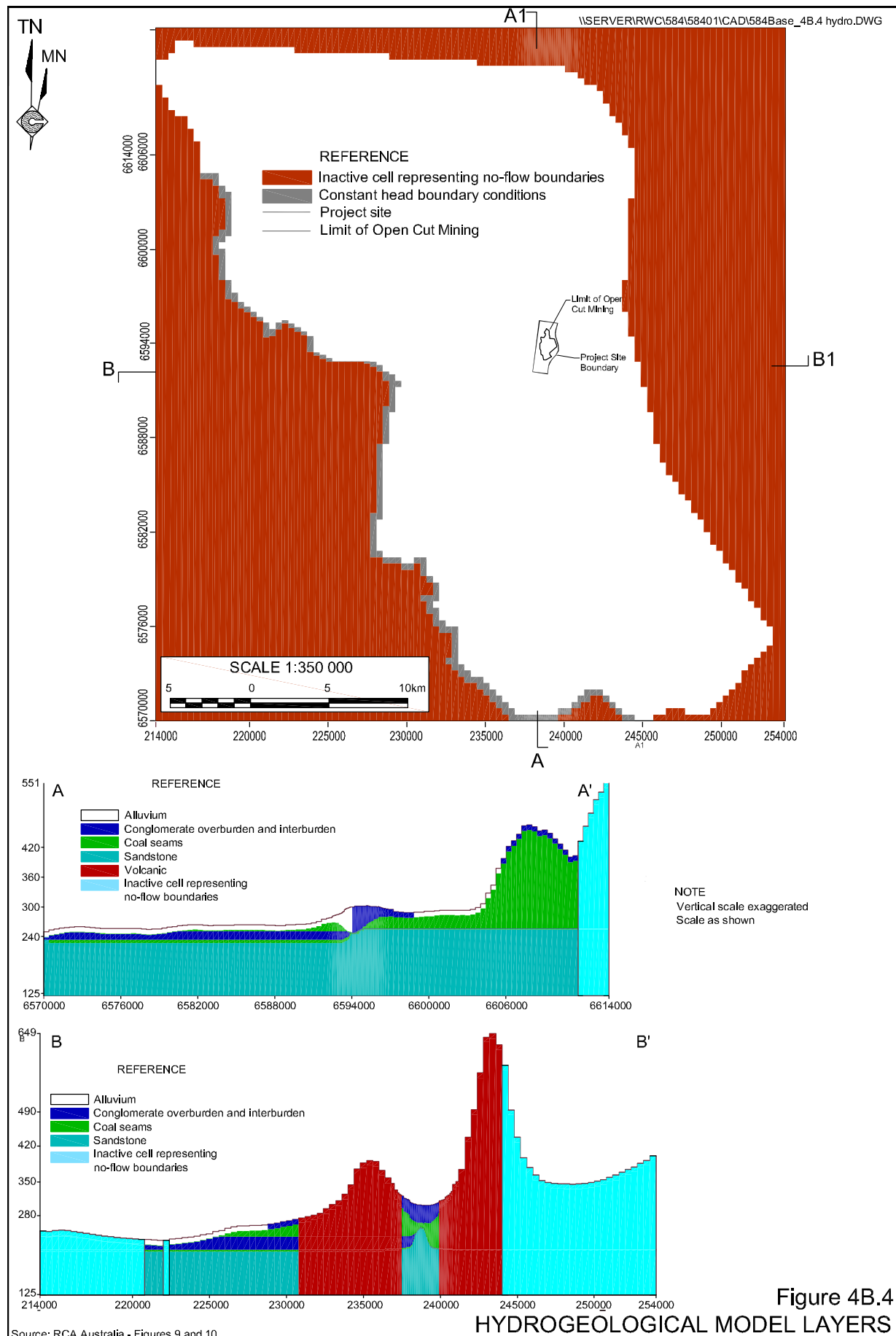


Figure 4B.4

Source: RCA Australia - Figures 9 and 10



4B.1.5.3 Mine In-flows

Based on the model simulations, the average inflow of groundwater to the open cut during the three modeled periods is predicted to average 1 643m³/day during Years 1 to 3, increasing to an average of 2 235m³/day during Years 4 to 5 before decreasing during Years 6 to 7 to 1 813m³/day. **Table 4B.4** presents the modeled inflow results (averaged over the three year period) along with the predicted evaporation during the equivalent period (based on an evaporation rate of 1 900mm/year and the average surface area of the open cut during each period).

Table 4B.5
Total Seepage to the Void

Modeled Period	Inflow (kL)		Average Active Open Cut Surface Area (m ²)	Annual Evaporation (kL)	Balance (ML)
	Daily	Annual			
Year 1 to 3	1 643	599 695	298 000	566 200	33.5
Year 4 to 5	2 235	815 775	404 500	768 550	47.2
Year 6 to 7	1 813	661 745	350 633	666 203	-4.5
Source: RCA (2007) – Table 14					

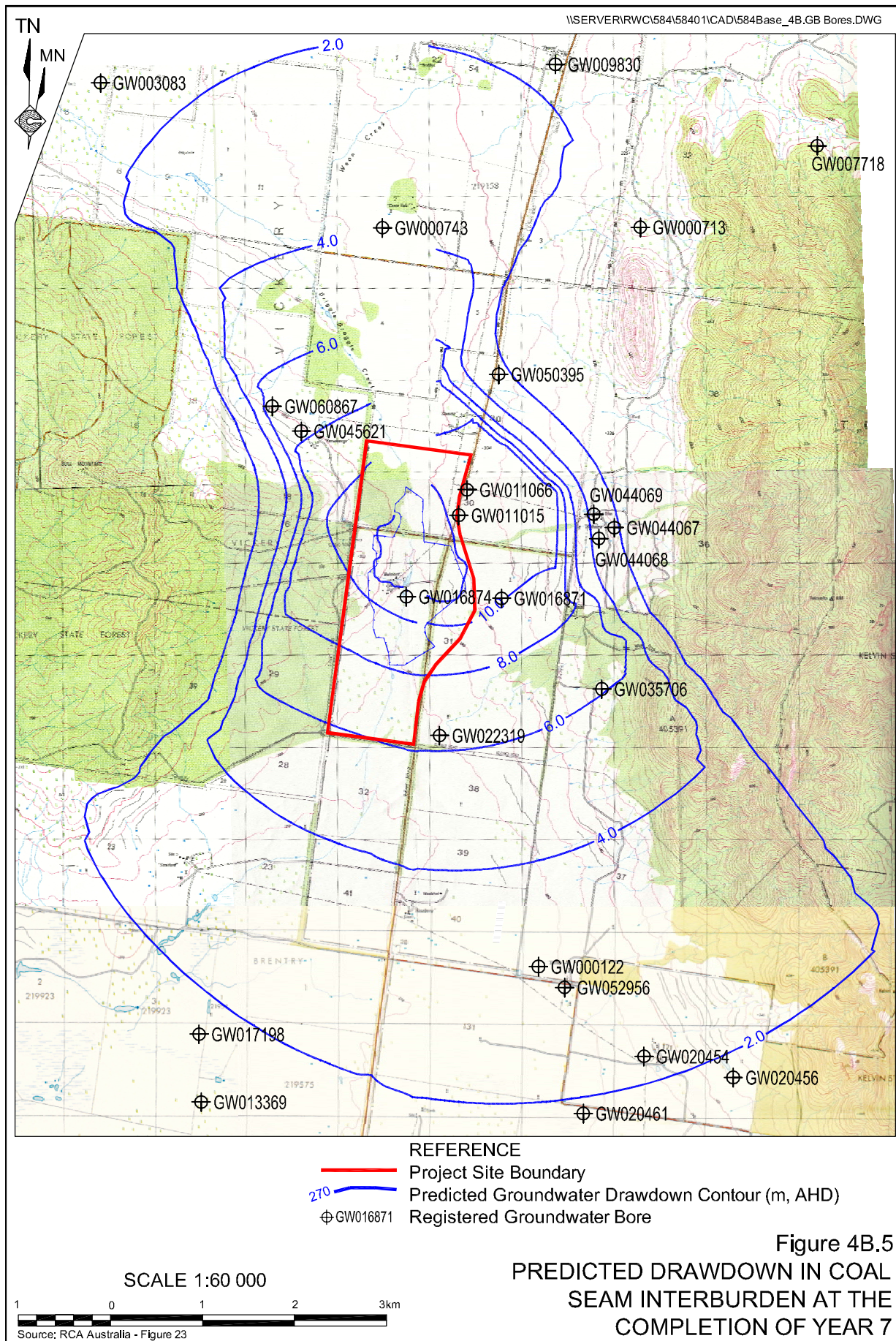
The increasing volume of water entering the open cut over the first 4 to 5 years of operation (see **Table 4B.4**) is expected due to the steeper hydraulic gradient caused by the increase in area and depth of the open cut. This ultimately decreases during the final few years of the Project as the hydraulic gradient decreases following a local lowering of the groundwater table (see **Figure 4B.5** and **Figure 4B.6**) and decrease in the area of the open cut mine exposed. It is also worthy of note that the inflows predicted for each stage of the open cut mine are likely to be an overestimate of the actual inflows. This is due to the methodology adopted for the prediction of groundwater inflow, which assumes that the bulk of material for each stage is removed instantaneously, rather than by progressive excavation. This provides for an artificially high initial discharge of water to the open cut void.

When comparing the predicted inflow of groundwater to open cut against likely evaporation, the model predicts that there may be a small surplus of water accumulating in the open cut area during the Year 1 to 3 and Year 4 to 5 periods (see **Table 4B.5**). However, given that the model is likely to provide an overestimate of mine inflows, little water would accumulate within the void, as is the case with other coal mines in the area.

4B.1.5.4 Groundwater Drawdown and Re-establishment

The drawdown in the regional water table predicted by the model at the completion of the Project is presented in **Figure 4B.5** for the interburden layer between the Glenroc and Belmont coal seams, and **Figure 4B.6** for the shale / sandstone floor of the open cut. These layers represent those in which the majority of registered bores are screened. The modelling results presented on **Figures 4B.5** and **4B.6** predict that a relatively steep zone of depression of up to 11m would be created at the Project Site boundary. The drawdown in groundwater levels would, however, decrease to 2m or less generally within 5km of the limit of open cut mining.





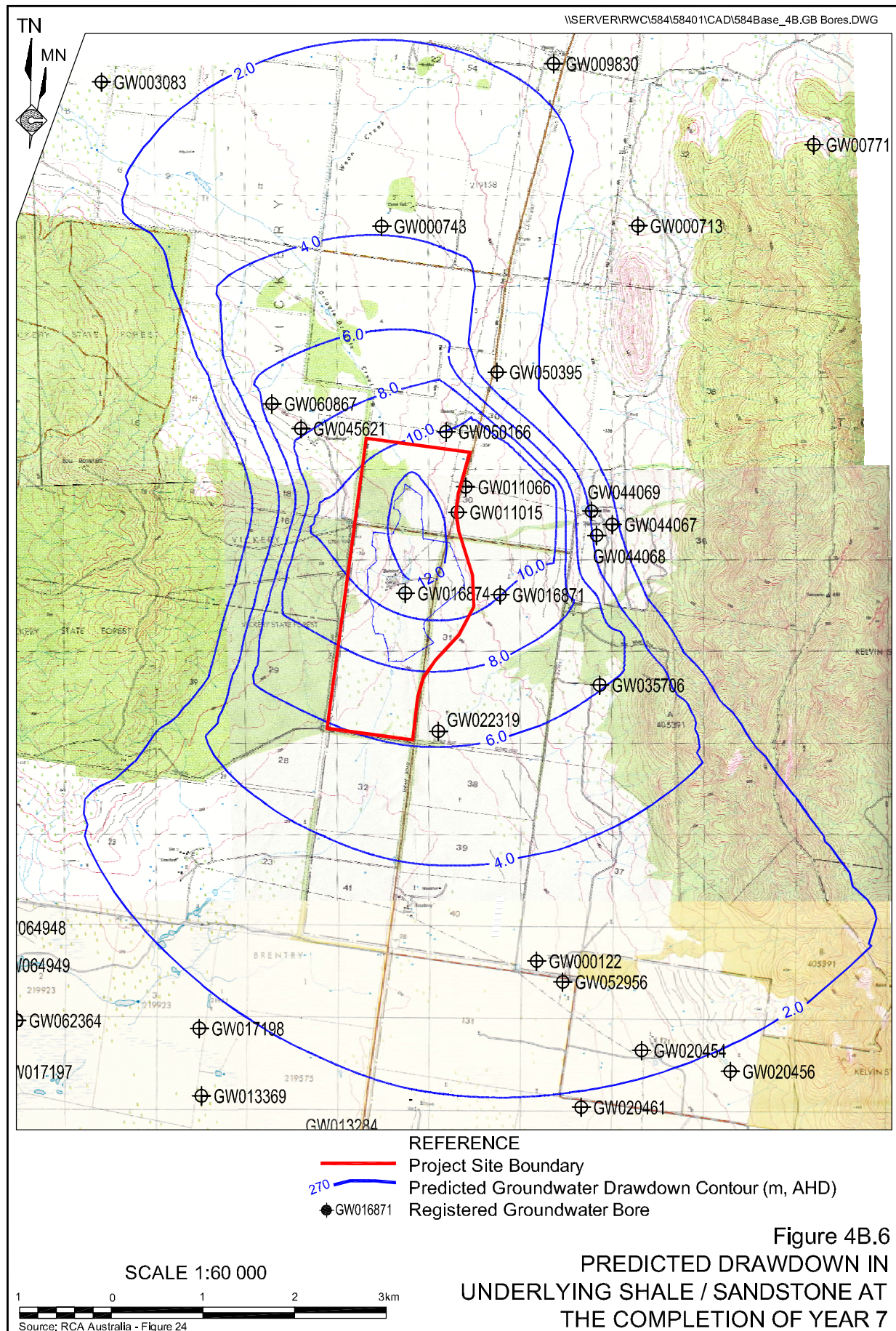


Figure 4B.6
PREDICTED DRAWDOWN IN
UNDERLYING SHALE / SANDSTONE AT
THE COMPLETION OF YEAR 7



This zone of impact is largely restricted to project-related properties and is discussed in greater detail in Section 4B.1.5.5.

Following the completion of the Project, the groundwater model predicts a 75% recovery after 7 years with complete recovery predicted after 100 years (RCA, 2007).

4B.1.5.5 Groundwater Availability

The location of registered groundwater bores within 5km of the limit of open cut mining are illustrated on **Figure 4B.3**. **Table 4B.6** presents the predicted impact of this drawdown on these bores.

Based on the results of modelling, six of the 30 registered bores within 5km of the Project Site would suffer a reduction in saturated thickness of 10% or greater. Of these, four are located on properties recognised as project-related. The only non-project related bores affected are predicted to be GW052956 on the “Surrey” property and GW020461 on the “Carlton” property which would suffer reductions of 16% and 10% respectively. This may impact on the yields of these two bores, with the Proponent committed to mitigating any reduction (should it occur) as described in Section 4B.1.6.2.

4B.1.5.6 Groundwater Quality

The potential for the Project to impact adversely on groundwater quality is dependent upon the storage and use of liquid or soluble potential contaminants on site such as hydrocarbons, pesticides, herbicides and soluble inorganic salts, and the chemical properties of the overburden, interburden and coal reject materials, each of which would be placed within and above the former open cut and in out-of-pit dumps.

With the exception of diesel fuel for equipment operation and explosives, no substance capable of contaminating groundwater would be used on the Belmont Project Site. The potential for contamination of groundwater which drains or leaches from the replaced overburden, interburden and coarse and fine reject materials is a function of the chemistry of the component non-coal and coal materials. As noted in Section 2.7.2, chemical characterisation of the rejects and leachates testing of the overburden/interburden materials has not identified any material which would adversely affect groundwater quality (when compared against the nominated criteria). The chemical characteristics of the Project Site overburden and interburden and implementation of hydrocarbon management practices described in Section 4B.1.4.1, would make groundwater contamination as a result of the Project highly unlikely.

4B.1.5.7 Groundwater Dependent Ecosystems

No groundwater dependent ecosystems have been identified on or immediately surrounding the Project Site. As groundwater dependent ecosystems are typically associated with groundwater discharge zones which are not present on or surrounding the Project Site, it is unlikely that the Project would impact on any, as yet unidentified, groundwater dependent ecosystems.



Table 4B.6
Groundwater Model Parameters

Bore No	Property	Distance to the limit of mining (m)	Water Bearing Zone Strata	Predicted Initial water level # (m)	Predicted water level at yr 7 # (m)	Saturated Thickness (m)	Reduction in Saturated Thickness (%)
Bores with Predicted drawdown $\geq 1\text{m}$							
GW016874*	"Belmont"	0	Coal/ Sandstone	258	245	21.2	58
GW011015*	"Glenroc"	650	Sandstone	258	246	26.4	42
GW016871*	"Belmont"	300	Sandstone, grey	257	247	NK	NK
GW011066*	"Glenroc"	600	Shale, black	258	247	NK	NK
GW045621*	"Yarrowonga"	1300	NK	258	251	NK	NK
GW060867*	"Yarrowonga"	1600	Fractured basalt	258	252	NK	NK
GW050166*	"Glenroc"	1000	NK	258	248	NK	NK
GW022319*	"Roseberry"	750	Gravel	257	249	38.23	19
GW044068*	"Yarrari"	1500	Stones, white	302	300	7.42	23
GW044069*	"Yarrari"	1400	Rock, Black	301	299	25.21	7
GW044067*	"Yarrari"	1600	NK	312	310	NK	NK
GW050395*	"Glenroc"	1800	NK	283	282	17.08	9
GW035706*	"Belah"	1700	NK	257	251	NK	NK
GW000743	"Costa Vale"	3000	Rock	258	254	60.94	5
GW017198	"Brolga"	3200	NK	252	250	NK	NK
Bores with Predicted drawdown $\leq 1\text{m}$							
GW000122	NK	2500	Shale	260	253	NK	NK
GW013369	"Brolga"	4000	NK	252	251	NK	NK
GW017199	"Brolga"	4700	NK	248	247	NK	NK
GW052956	"Surrey"	3000	Rock, slightly conglomerated	256	253	19	16
GW062364*	"Stratford"	4500	Clay	249	252	30.5	3
GW064948	NK	4200	NK	248	247	NK	NK
GW064949	NK	4500	NK	248	247	NK	NK
GW000713	"Penryn"	4000	Rock, Black	299	299	46.33	0
GW003083	NK	5000	Unknown	255	253	69.2	2
GW013284	"Brolga"	4300	NK	253	252	NK	NK
GW020454	"Carlton"	4100	NK	256	254	NK	NK
GW020456	"Carlton"	5000	Slate	257	255	NK	NK
GW020461	"Carlton"	4200	Clay, Fine Gravel	256	254	16.1	10
GW036484	NK	4400	Sand Gravel	254	253	NK	NK
GW009830	"Penryn"	4500	Sandstone	258	256	NK	NK
* = Project Related # = Determined from modelling NK = Not Known							
Source: Modified after RCA (2007) – Table 13							

The DWE has advised that tree roots have been recorded within bores of the region to a depth of 30m, suggesting some degree of groundwater dependence. GCNRC (2007a) advises, however, that the vegetation communities found in and adjacent to the Project Site, most notably within Vickery State Forest are highly unlikely to set roots at these depths and as such would not be dependent on groundwater (recorded to be >30m below surface in 2002 and 2007).



4B.1.6 Groundwater Monitoring and Contingency Plans

4B.1.6.1 Groundwater Monitoring

Should the Project be approved, a groundwater monitoring program would be implemented focussing on establishing up-to-date baseline levels for standing water level, saturated thickness and water quality and monitoring changes to these which could be attributable to the mining activities. The program would be finalised by the Proponent's hydrogeological consultant and in consultation with the Department of Water and Energy. Based upon the current knowledge of the groundwater occurrences beneath and surrounding the Project Site the following groundwater monitoring program is proposed.

In order to establish baseline values and monitor changes to existing groundwater level, saturated thickness and yield, it is proposed to monitor 11 registered bores that may be affected by the Project (see **Figure 4B.7**), namely:

- GW050395, GW050166, GW011015 & GW011066 – on the “Glenroc” property;
- GW045621 – on the “Yarrowonga” property;
- GW044068 and GW044069 – on the “Yarrari” property;
- GW022319 – on the “Roseberry” property;
- GW052956 – on the “Surrey” property; and
- GW020961 – on the “Carlton” property.

Where the existing bore construction precludes ready sampling, a piezometer would be established adjacent to that bore for that purpose. Following the establishment of baseline condition, monitoring would be undertaken prior to the commencement of mining and at 3 monthly intervals thereafter.

It is also proposed that three piezometers would be constructed on Proponent-owned land between the open cut and the nearest non Project-related groundwater bores. A continuous data logger would be installed in each. The indicative location of the three proposed monitoring piezometers are presented on **Figure 4B.7**. Data from these loggers would be downloaded every 3 months and compared against modelling predictions of groundwater drawdown.

Given that the open cut void would act as a sink within the local piezometric surface (see RCA, 2007) and the general absence of potential groundwater pollutants, monitoring of groundwater quality at the bores would be undertaken at a reduced frequency (annually). However, combined groundwater and surface water collecting in the open cut void sump(s), at greatest risk of contamination by hydrocarbons, would be sampled on a 6 monthly basis or following substantial inflows and analysed for parameters identified in Section 4B.1.5.1.

The results of groundwater monitoring would be reported to the relevant government agencies on an annual basis in an Annual Environmental Management Report (AEMR).



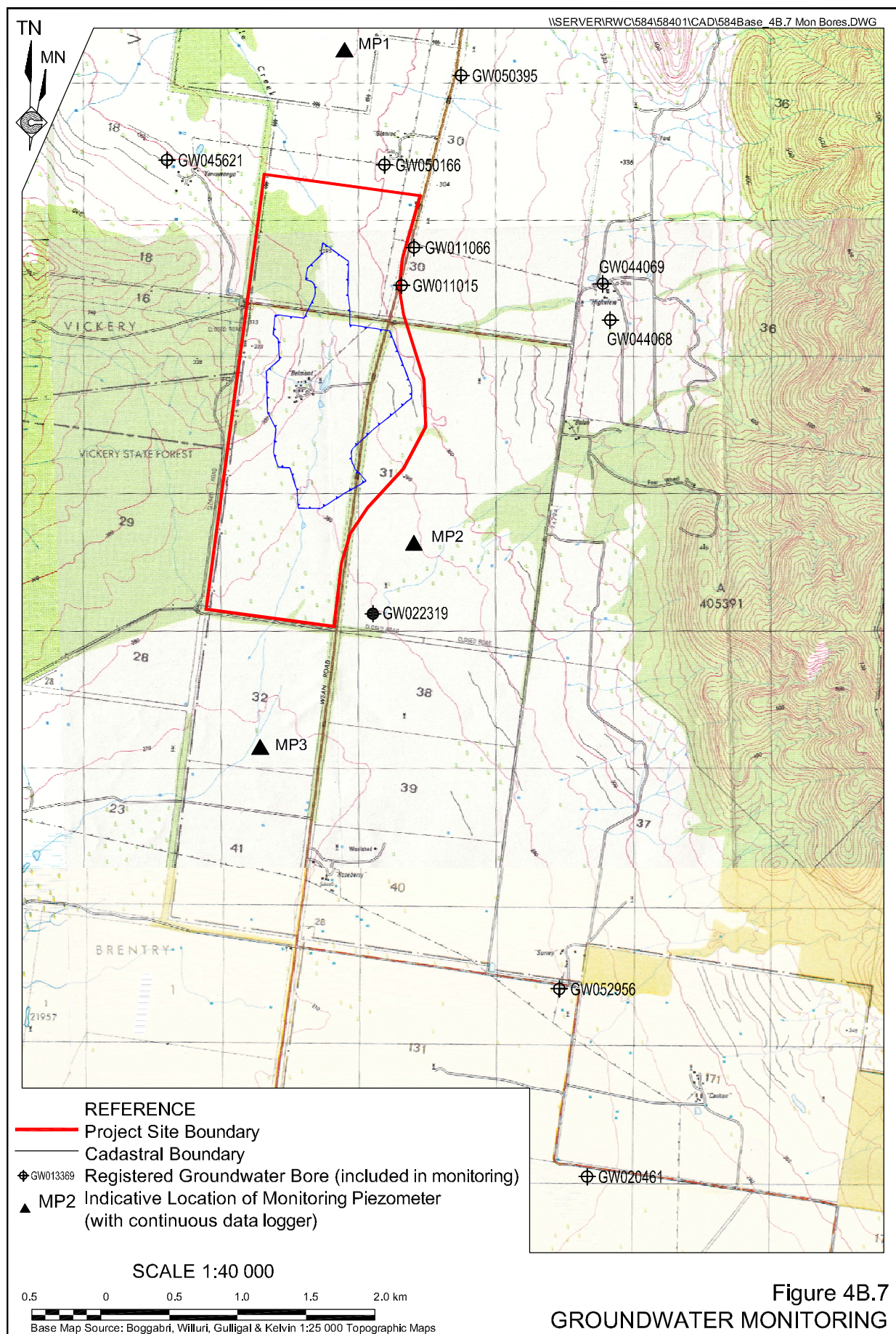


Figure 4B.7
GROUNDWATER MONITORING



4B.1.6.2 Contingency Plans

4B.1.6.2.1 Groundwater Availability

Given the reliance of the identified groundwater bores on a significant saturated thickness to achieve their quoted yield, should standing water levels within bores on non project-related properties reduce by more than 10% from the baseline pre-mining levels, and this be assessed to be a result of mining, the Proponent would deepen the existing bore or establish a new bore in the impacted area. A new bore, if required, would be installed to greater depth than the original such that the yield of the new bore is at least equal to the pre-mining yield.

Should it be considered that deepening or re-drilling a bore would be insufficient to provide a replacement source of comparable quality water, the Proponent would investigate the possibility constructing additional surface water containment structures, eg. dams, water tanks, on the effected property or providing direct transfer of comparable quality water from other sources, eg. open cut void, other Proponent-operated groundwater bores.

Ultimately, the most appropriate compensatory measure would be adopted following advice from a hydrogeological consultant and consultation between the Proponent and affected land owner.

4B.1.6.2.2 Groundwater Quality

Should the monitoring data show that any of the groundwater quality impact assessment criteria defined in Section 4B.1.5.1 are exceeded, the data would be statistically analysed to assess if the impacts are due to natural variations or the activities relating to the mine. If the change is considered to be related to mining, the impacted bore would be resampled. If the exceedance is still observed, the following measures would be undertaken.

Additional bores would be installed around the area to assess the extent of the impact and the risk to the nearest groundwater user would be assessed. If this risk is significant either:

- remedial options would be assessed such as groundwater pumping and treatment, or hydraulic isolation; or alternatively
- remediation would be undertaken if necessary.



4B.2 FLORA AND FAUNA

The flora and fauna assessments were undertaken by Geoff Cunningham Natural Resource Consultants Pty Ltd (GCNRC) and Countrywide Ecological Service (CES) respectively. Both assessments are presented in full as Parts 2 and 3 of the Specialist Consultant Studies Compendium, with the relevant information from each summarised in the following sub-sections.

4B.2.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.6**), the potential ecological impacts requiring assessment and their unmitigated risk rating are as follows.

- Disturbance to native vegetation / habitat within nominated areas (high risk).
- Disturbance to native vegetation / habitat outside nominated areas (moderate risk).
- Disturbance to threatened flora / fauna and endangered ecological communities (high risk).
- Disturbance leading to local population reduction (high risk).
- Disturbance leading to local extinction(s) (extreme risk).
- Reduced local biodiversity (moderate risk).
- Reduced regional biodiversity (high risk).

The Director-General's requirements issued by the Department of Planning require that the assessment of threatened species and their habitat include a field survey of the site conducted and documented in accordance with the draft *Guidelines for Threatened Species Assessment* (DEC, 2005).

Sub-sections 4B.2.2 (Flora) and 4B.2.3 (Fauna) describe and assess the existing Threatened species and their habitat, identify the ecological management issues, proposed controls, safeguards and mitigation measures for the Threatened species and their habitat.

4B.2.2 Flora

4B.2.2.1 Study Methodology

The flora study of GCNRC (2007a) has been completed over two distinct periods. An initial assessment was completed in 2002 over the Project Site and a transport route. This initial assessment has been supplemented by additional desktop and field surveys completed in December 2006 to verify whether any substantial changes in community composition or structure had occurred and meet the updated requirements of the Department of Environment and Climate Change for threatened species assessment (as outlined in DEC (2005)).



2002 Survey and Assessment

A study area was defined as the Project Site and that section of the transport route between the Project Site and Hoad Lane (SR 95). Previous studies of vegetation incorporating the study area were reviewed to provide an indication of the likely vegetation communities to be identified. 1:10 000 scale aerial photographs were then viewed stereoscopically to select representative sampling sites within the study area. Prior to a field survey of the study area, a search of the documented records held on the Department of Environment and Climate Change, Atlas of NSW Wildlife Database for the Boggabri 1: 100 000 mapsheet was completed to identify Threatened plant species previously recorded within the local area.

A field inspection of the area was carried out on 23 and 24 February, 2002. Traverses were made by four-wheel drive vehicle and, on foot where the timber cover, fencing and topography prevented vehicle access. Similar inspections were made on 22, 23, 24 July, and 17 and 18 August, 2002.

Initially (during the February 2002 surveys), a total of 30 sample sites were described. At each site, the species composition data was recorded with the exception of one site that was completely devoid of cover having been recently cultivated. At these sites, quadrats of 50m x 50m were examined to record the occurrence of all ground cover species present.

A further 20 sites were described as part of the July/August 2002 field surveys, again with area 50m x 50m, with the original observations for the initial 30 sites checked.

2006 Survey and Assessment

A new search of the documented records held on the then Department of Environment and Conservation, Atlas of NSW Wildlife Database for the Boggabri 1: 100 000 mapsheet was completed.

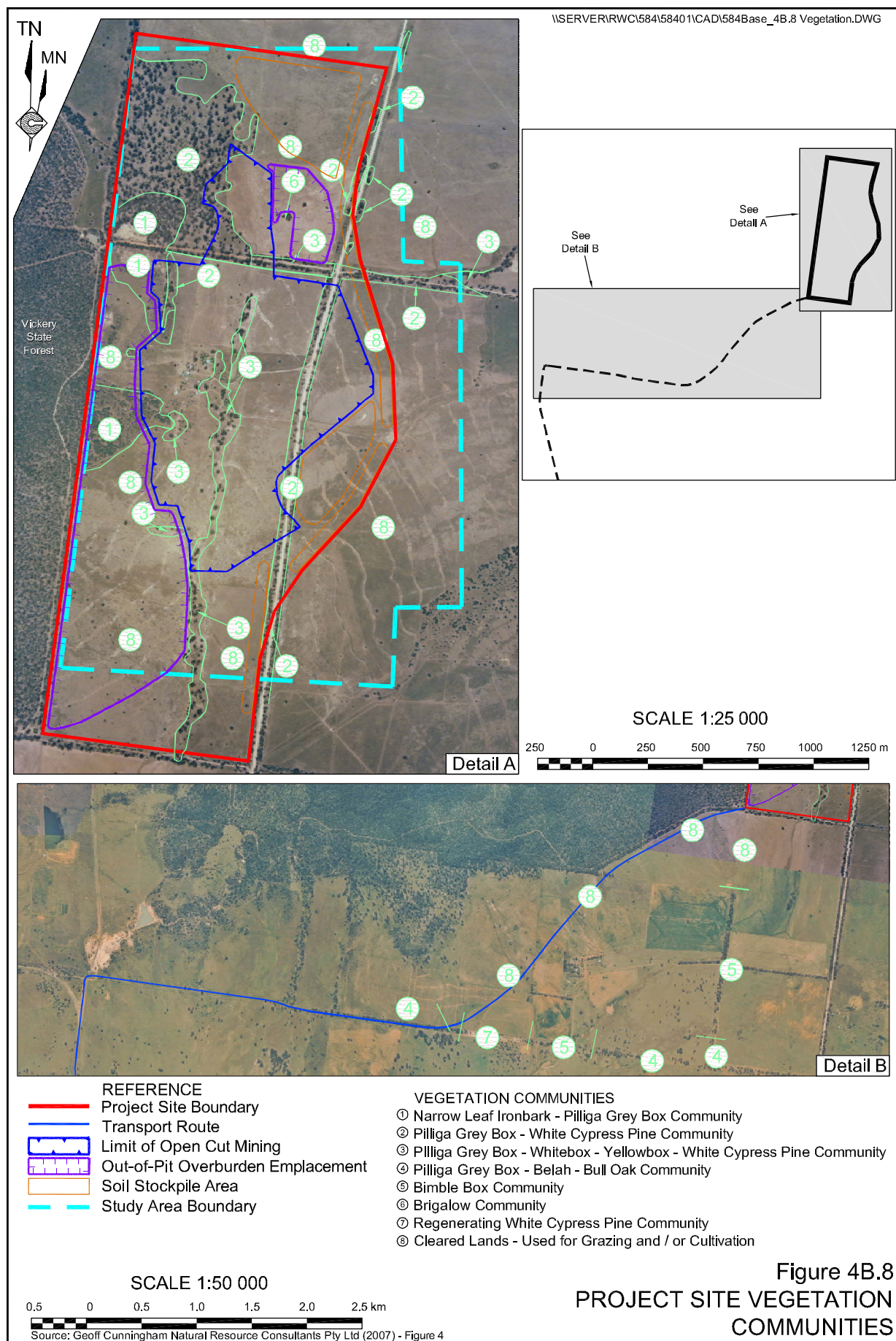
On 15 and 16 December, 2006, each of the 50 sample sites were revisited determine if any substantial changes in community composition or structure had occurred and ensure the assessment was completed in accordance with the DECC's Threatened species assessment guidelines.

Additional detail on the study methodology is provided by GCNRC (2007a) – Part 2 of the *Specialist Consultant Studies Compendium*.

4B.2.2.2 Existing Vegetation

Eight separate vegetation communities were identified on or adjacent to the Project Site and transport route during the 2002 and 2006 field surveys (GCNRC, 2007a - see **Figure 4B.8**), namely:





- **Community 1** - Narrow-leaf Ironbark - Pilliga Grey Box Community;
- **Community 2** - Pilliga Grey Box - White Cypress Pine Community;
- **Community 3** - Pilliga Grey Box - White Box Yellow Box White Cypress Pine Community;
- **Community 4** - Pilliga Grey Box - Belah - Bull Oak Community;
- **Community 5¹** - Bimble Box Community;
- **Community 6** - Brigalow Community;
- **Community 7¹** - Regenerating White Cypress Pine; and
- **Community 8** - Cleared Lands - Used for Grazing and / or Cultivation.

A complete description of each is provided by GCNRC (2007a), however, a brief summary of the communities that occur on the Project Site and/or the transport route is as follows.

Community 1 - Narrow-leaf Ironbark - Pilliga Grey Box Community (24.9ha)

This community is located in remnant patches along the western perimeter of the Project Site, adjacent to Vickery State Forest. It is characterised by 1m to 10m spacings of Narrow-leaf Ironbark, Pilliga Grey Box and White Cypress Pine, with other tree species including Rosewood, Wilga, Black Cypress Pine and Butterbush. Shrub species including, Western Boobialla, Western Golden Wattle, Broad-leaf Hopbush, Sticky Wallaby-bush, Shrubby Riceflower, Cough Bush and Silver Wattle are spaced from <1m to 2m apart or may be scattered.

Parts of this area have been used as gravel pits and are regenerating.

Community 2 – Pilliga Grey Box - White Cypress Pine Community (51.5ha)

Found predominantly within the roadside easement of Wean Road, this community is characterised by tree spacings of <2m to 15m of Pilliga Grey Box and White Cypress Pine species with other tree species including Narrow-leaf Ironbark, White Box, Rosewood, Wilga, Wild Orange, Bull Oak and occasional Belah, Yellow Box and Bimble Box. Scattered shrubs of spacings <1m to 15m are present as sub-storey and include Eastern Cottonbush, Gargaloo, Budda, Miljee, Western Boobialla and Native Olive.

Occasional dead plants of African Boxthorn, a classified noxious weed, were noted in roadside locations.

¹ Communities 5 and 7 were identified during the field surveys, however, following the relocation of the transport route, would not be impacted by the Project and are not further considered in this report.



Community 3 – Pilliga Grey Box - White Box Yellow Box White Cypress Pine Community (13.4ha)

This community is found as a remnant patch over the northwestern corner of the Project Site (“Glenroc” property), as roadside remnants and along the main drainage line through the centre of the study area.

Trees are spaced from 2m to 30m apart with the main species being Pilliga Grey Box, White Box, White Cypress Pine, Yellow Box and Bull Oak. Other tree species include Narrow-leaf Ironbark, Wilga, Rosewood, Butterbush and possibly Silver-leaf Ironbark or an Ironbark hybrid. Tumbledown Gum occurs within this community in some midslope areas. Shrub cover varies from relatively dense (<1m to 10m spacings) to scattered. The main species is Eastern Cottonbush with some Miljee, Silver Wattle and Broad-leaf Hopbush.

Community 4 – Pilliga Grey Box - Belah - Bull Oak Community (approximately 3 280m, 4.9ha)

This community is found along the length of Shannon Harbour Road to be upgraded as art of the transport route. It is also found within other remnant patches of native vegetation in other road easements to the south of the Project Site.

It comprises a mixed community of Pilliga Grey Box, Belah and Bull Oak in which all three may be present in a single stand or each may occur in discrete patches. Occasional trees of Rosewood, Wilga and Butterbush are present along with a variable layer of Eastern Cottonbush.

Community 6 – Brigalow Community (0.1ha)

The Brigalow community is represented by a single isolated remnant of about 55 stems of Brigalow although some trees may be multi-stemmed reducing the number of individual trees. The remnant is located in the centre of a heavily grazed cultivation paddock that regularly produces crops and as such the understorey is limited to Eastern Cottonbush shrubs and African Boxthorn plants. The only recognisable ground cover species was Slender Bamboo Grass.

Community 8 – Cleared Lands (276.1ha)

This community is basically treeless although some shade trees, including Pilliga Grey Box Kurrajong, Wilga, White Cypress Pine, Bull Oak, Yellow Box, Rosewood and Narrow-leaf Ironbark, remain in most paddocks.

Eastern Cottonbush is the dominant shrub species and its spacing varies from 5m to 30m, through a scattered distribution, to complete absence on recently cultivated land.

Various native and introduced ground cover species are present.



Noxious Weeds

GCNRC (2007a) identifies a number of weed species within the Project Site and transport route study area which are listed as “noxious” within Gunnedah Shire. The weeds, which occur both in cropped areas and areas of remnant native vegetation, include:

- African Boxthorn *Lycium ferocissimum* – W3²;
- Galvanised Burr *Sclerolaena birchii* – W2³;
- Bathurst Burr *Xanthium spinosum* – W3;
- Paterson's Curse *Echium plantagineum* – W3; and
- Prickly Pear *Opuntia* and *Cylindropuntia* spp. – W4⁴.

Galvanised Burr is the most prevalent, having invaded much of the study area. Prickly Pear is also common within most communities although its density is generally light.

4B.2.2.3 Conservation Significance

4B.2.2.3.1 Threatened Species

In order to identify threatened species previously identified or potentially occurring within the study areas, the NSW DECC's Atlas of NSW Wildlife database, Ayers et al (1996), the schedules of the TSC Act and the EPBC Act online database were reviewed on 7 February 2007 over areas covered by the Boggabri 1:100 000 Map Sheet (for the NSW databases), and a 30km radius surrounding the study areas (for the Commonwealth database). GCNRC (2007a) considered each of these species and **Table 4B.7** presents a summary of those species considered as having the potential to be found on the Project Site or transport route.

None of the species listed in **Table 4B.7** were identified during either the 2002 or 2006 field surveys.

4B.2.2.3.2 Endangered Ecological Communities and Populations

GCNRC (2007a) considered the structure and composition of the vegetation communities present within the study area, comparing these to the listed endangered ecological communities and populations under the TSC Act and the EPBC Act. Reference to NSW Scientific committee findings was also made where relevant.

² The weed must be prevented from spreading and its numbers and distribution reduced.

³ The weed must be fully and continuously suppressed and destroyed.

⁴ The weed must not be sold, propagated or knowingly distributed. Any biological control or other control program directed by the local control authority must be implemented.

