Werris Creek Coal Pty Limited
ABN:69 107 169 103

Proposed Modification to the Werris Creek Coal Mine

Groundwater Impact Assessment

Prepared by

Robert Carr & Associates Pty Ltd

March, 2009

Specialist Consultant Studies Compendium: Part 1

Groundwater Impact Assessment

of the

Proposed Modification to the Werris Creek Coal Mine

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Report No 7131-301

March, 2009

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APPENDICES

Glossary

AHD	Australian Height Datum.
ANZECC	Australian and New Zealand Environmental Conservation Council.
BOM	Bureau of Meteorology.
DoP	Department of Planning.
DNR	Department of Natural Resources.
DP	Deposited Plan.
DWE	Department of Water and Energy.
GPS	Global Position System.
ha	hectare, 10 000m2.
km	kilometre, 1000m.
L	Litres.
L/s	Litres per second.
m	metre.
mg/L	milligram per litre.
ML/year	megalitres (1000L) per year.
mm	millimetre, 0.001m.
mm/year	millimetres per year.
MGA	Map Grid Australia.
m^3/day	cubic metres per day.
m/s	metres per second.
PQL	Practical Quantitation Limit.
RMS	Root Mean Squared.
SWL	Standing Water Level.
WAL	Water Allocation Licence.
WSP	Water Sharing Plan.
˚C	degrees Celsius.
%	percentage.

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EXECUTIVE SUMMARY

Werris Creek Coal Pty Limited ("the Proponent") proposes to modify the area of its existing open cut and associated overburden emplacement. The proposed modification would involve additional disturbance to approximately 21 hectares within the existing mining lease (ML 1563) ("the mine site") and would require mining through, and dewatering of the underground workings of the former Werris Creek Colliery. The water removed from the underground workings would be stored within one of two large dams ("underground water dams") constructed in the southwestern corner of the mine site and the water used for dust suppression.

This report presents a groundwater impact assessment ("the assessment") of the proposed modification to the Werris Creek Coal Mine. The assessment builds on a previous groundwater impact assessment completed as part of the initial development application for the Werris Creek Coal Mine (prior to the commencement of mining operations) in 2004. The impact of a modified open cut area design and dewatering of the underground workings of the former Werris Creek Colliery on the local and regional groundwater table, and inflows to the open cut itself, is considered.

The assessment was based on the collection and review of data from the operation of the Werris Creek Coal Mine, a review of data applicable to the mine site and surrounds, revision of an existing three dimensional groundwater model, modelling of the proposed open cut coal mine development and mining operations (including dewatering of the underground workings of the former Werris Creek Coal Mine) and assessment of impact on the mine site and surrounds.

The groundwater impact assessment has considered the following.

- The impact(s) of the modified open cut coal mining operations on water table levels surrounding the mine site.
- The impact(s) of dewatering the underground workings.
- The impact(s) of the modified open cut coal mining operations on groundwater bores surrounding the mine site.
- The predicted groundwater inflow to the modified open cut mining area.
- Appropriate mitigation measures to compensate for any predicted impact(s) on groundwater level or availability arising from the proposed modification.

Groundwater modelling has predicted a drawdown of up to 0.5m, up to 2km from the open cut and drawdown of approximately 20m in the vicinity of the underground workings to the northeast of the mine site. A reduction in saturated thickness above the adopted trigger criteria (10% reduction in the saturated thickness) was predicted for bores located on the 'Old Colliery', 'Preston Park' and 'Eurunderee' properties. Notably, all three properties are owned by the Proponent with the impact on groundwater availability considered acceptable. Saturated thickness reductions in bores on all other properties are predicted to be negligible and within the naturally occurring variation. Modelling of the current approved mine plan was undertaken in 2004. This modelling predicted a drawdown of 0.2m occurring up to 2km of the open cut. The results indicate that the proposed modification has a marginally greater drawdown when compared to the approved mine plan.

Should groundwater drawdown attributable to the proposed modification result in a reduction in yield or availability of water to the owners of bores on properties not owned by the Proponent, mitigation measures such as the deepening of bores to intercept groundwater lower in the aquifer and re-establish the previous yield would be undertaken by the Proponent. Available geological information for the mine site and surrounds indicates that a suitable groundwater aquifer is present at depth within fractured rock.

Groundwater inflows into the coal mine were predicted to reach a maximum of approximately 212ML/year. The predicted rate of inflow is below the average evaporative rate for the area and the mine is expected to generally remain dry. Variations in climatic conditions may result in water make within the open cut from time to time with this water either pumped to one of two void water dams approved and constructed at surface or the proposed underground water dams (the water then being used for dust suppression across the mine site).

The assessment predicts the modified mining area would result in a reduction in groundwater flow to Quipolly Creek of an estimated at 58ML/year. Modelling of the approved mine plan predicted a loss in groundwater flow to Quipolly Creek of 36ML/year. The modelling indicates that the proposed modification represents an incremental decrease in groundwater discharge to the creek system. Quipolly Creek is within a Water Sharing Area and a licence under the Water Management Act 2000 will be required for this groundwater interference.

In conclusion, the impacts of the proposed modification to the Werris Creek Coal Mine upon the groundwater resources in the area are predicted to be localised. It is considered possible for the Proponent to mitigate the likely impacts and replace any predicted reduction in resource utility through the installation of new and/or deeper groundwater bores on its properties and surrounding the mine site.

1. INTRODUCTION

This report presents the findings of a groundwater impact assessment ("the assessment") undertaken for RW Corkery & Co Pty Ltd on behalf of Werris Creek Coal Pty Limited ("the Proponent"), to assess the impacts of a proposed modification to the mining area of the Werris Creek Coal Mine ("the proposed modification"). Werris Creek Coal Mine is an existing open cut coal mine located within a 679ha Mining Lease (ML 1653) ("the mine site") approximately 4km south of the township of Werris Creek and 11km north of Quirindi, NSW (see **Figure 1**). Open cut coal mining over an area of approximately 80ha commenced in 2004.

The existing mine design creates a narrowing highwall face (from which the coal is mined) which will eventually reduce the production rate as the area of exposed coal is reduced. The proposed modification incorporates changes to the open cut and overburden emplacement design, including a widening of the advancing highwall, which would maximise the area of exposed coal and therefore improve the efficiency of coal recovery for a period of 3 years, ie. up until April 2012 (see **Figure 2**). The modified open cut area would also better accommodate a possible continuation of mining to the north (the Werris Creek Coal resource extends beyond the currently approved northern limit of the mine) should this be proposed and approved. Of note, the modified open cut mine area would intersect the completed underground workings of the former Werris Creek Colliery (contained with the E Seam). These workings are filled with water and would require complete dewatering prior to the open cut encroaching within 50m of these workings.

The report has been prepared to assist in the preparation of, and accompany, a Statement of Environmental Effects for the proposed modification.

The objectives of the assessment were to:

- predict the impact(s) of the proposed modification on groundwater levels on the mine site and surrounds;
- predict the impact of the proposed modification on known groundwater bores surrounding the mine site;
- assess the extent of groundwater inflow to the open cut mining area over the life of the proposed modification and in the final landform; and
- consider and recommend appropriate mitigation measures as necessary.

The scope of work undertaken to fulfil these objectives included the following:

- Review of a geological model for the mine site and surrounds on the basis of:
  - a review of previous work undertaken by Robert Carr & Associates Pty Limited, "*Groundwater Assessment, Werris Creek Coal Mine, July 2004*"; and
  - mapping of the existing underground workings prepared by the Proponent.

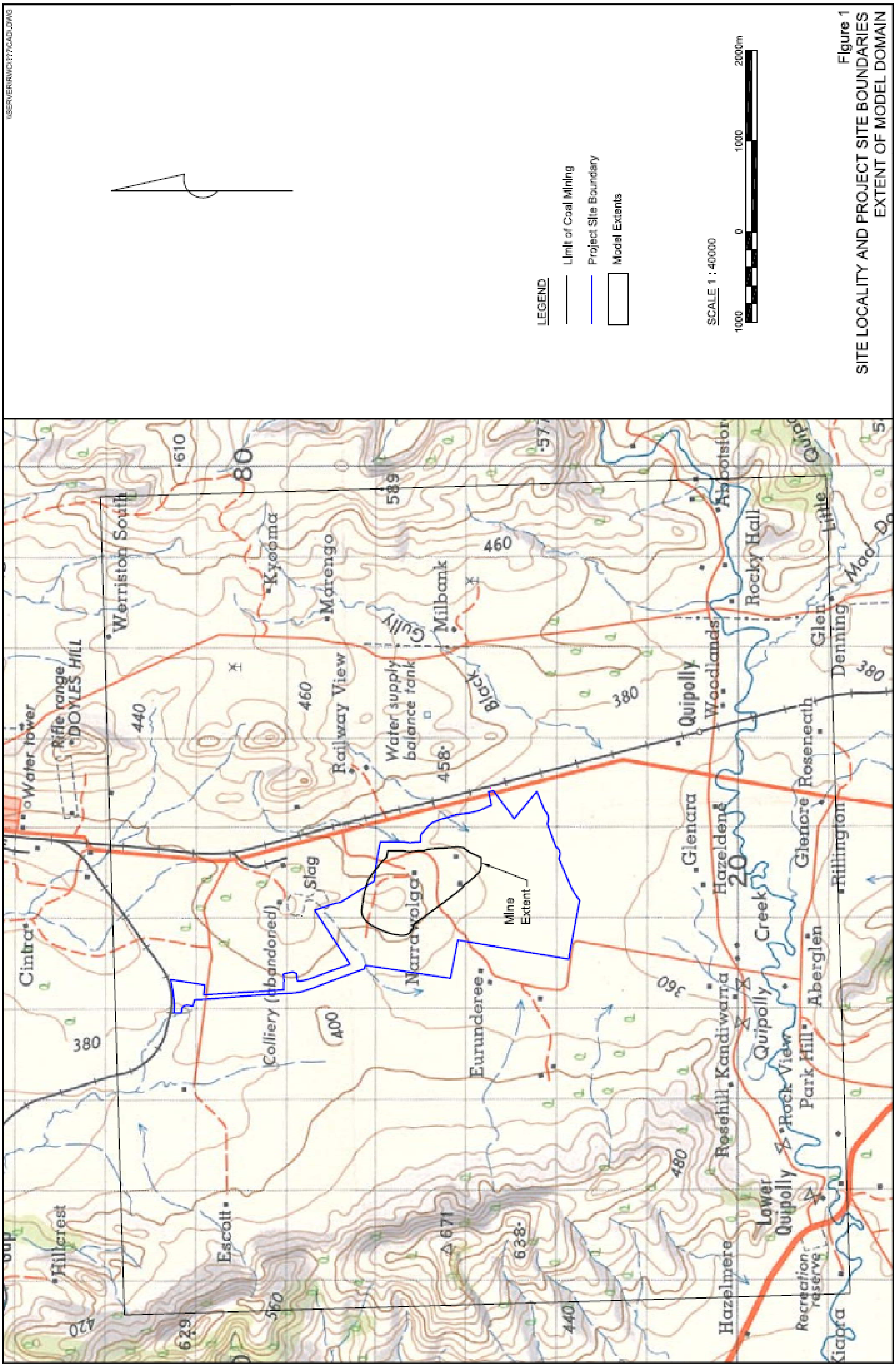
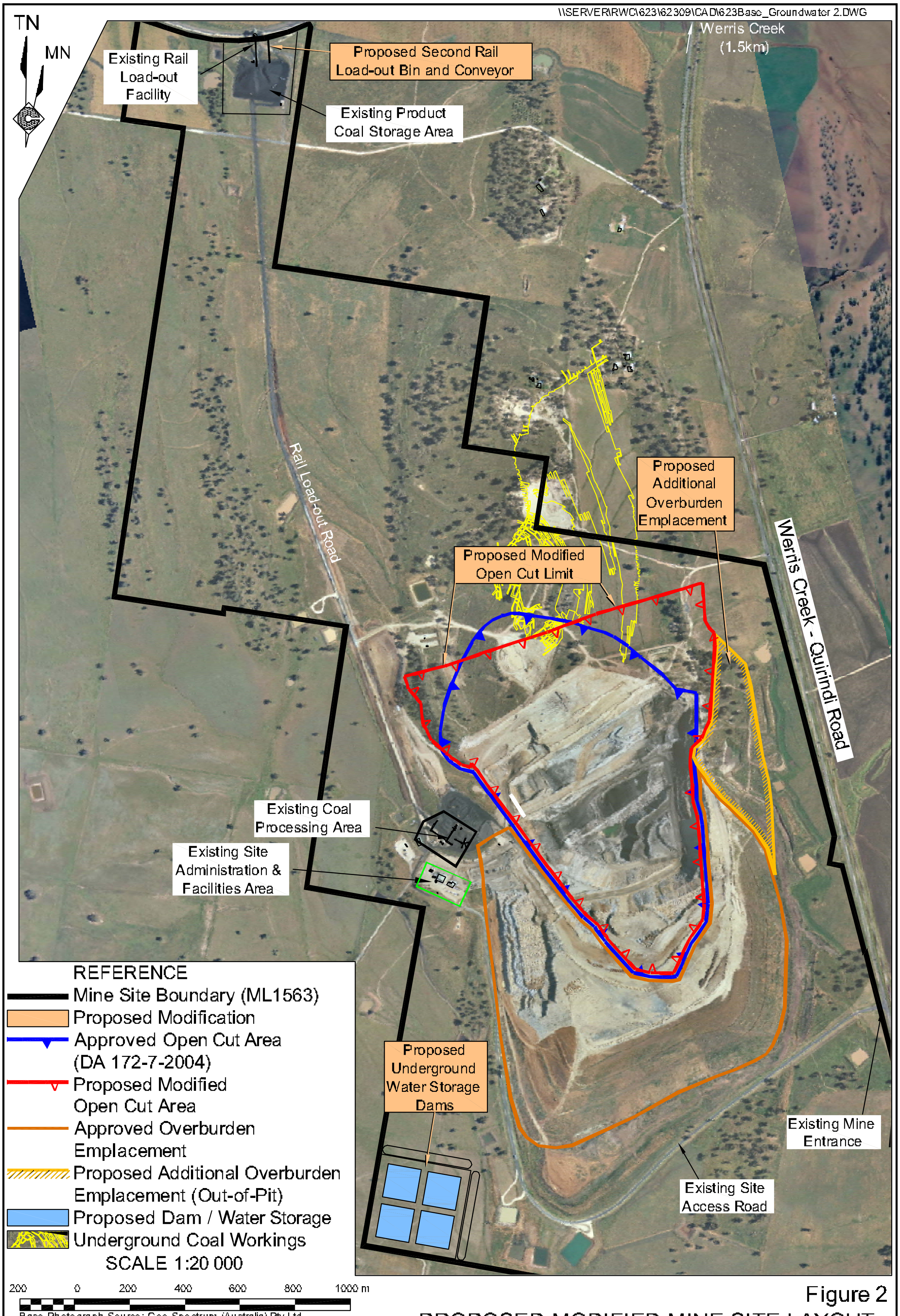


Figure 1
SITE LOCALITY AND PROJECT SITE BOUNDARIES
EXTENT OF MODEL DOMAIN

Note: A colour version of this figure is included on the Project CD



Base Photograph Source: Geo-Spectrum (Australia) Pty Ltd
Date of Photo 13 November 2008

Figure 2
PROPOSED MODIFIED MINE SITE LAYOUT

- Groundwater modelling of the mine site and surrounds and an assessment of impact from the proposed modification through:
  - review of water level gauging undertaken by GeoTerra and presented in "*Werris Creek Coal Mine, Groundwater and Surface Water Monitoring 2007/2008 Annual Review, April 2008*";
  - calibration of the model against measured water levels in groundwater bores;
  - review and recalibration of the existing groundwater model to simulate groundwater conditions based on water level data collated; and
  - groundwater modelling to simulate impacts on groundwater at the mine site and surrounds during and at completion of the proposed modification.

2. SITE IDENTIFICATION AND DESCRIPTION OF THE PROPOSED MODIFICATION

2.1 Site Description

The open cut mine site is centred on the Narrawolga property and part of the Eurunderee property. Part of an internal rail load-out road and the rail load-out facility are located on sections of the Cintra property to the immediate south of a disused rail siding (referred to as the Werris Creek rail siding) (see **Figure 2**). These sections of the Narrawolga, Eurunderee and Cintra properties are all owned by the Proponent, cover an area of 679ha and fall within mining lease (ML 1563). The Proponent also owns the properties of 'Old Colliery', 'Preston Park', 'Hillview' and 'Railway View' which surround the mine site to the north and east.

All of the proposed modifications to the layout of the Werris Creek Coal Mine would remain with the confines of ML 1563, the mine site.

Figure 2 presents the layout of the mine site. The modified components of the mine site layout are identified in orange.

2.2 Description of the Proposed Modification

The proposed modification, if approved, would involve the following activities, the locations of which are shown on **Figure 2**.

- Modification to the open cut area. The northern extent of the open cut area would be widened such that the eastern perimeter corresponds with the eastern extent of the sub-cropping coal seams.
- Dewatering the underground workings of the former Werris Creek Colliery to enable open cut mining through part of these workings.
- Construction of two surface dams to store the water pumped from the underground workings (identified as Underground Water Dams on **Figure 2**).
- Extension of the out-of-pit overburden emplacement to the north along the modified eastern perimeter of the open cut area.
- Modification to the overall shape of the overburden emplacement, with the height increased to approximately 445m AHD to accommodate the increased volume of overburden and revised mine plan associated with the modified open cut design.

- Construction of an additional train loading bin at the rail load-out facility to facilitate the separation of product coal for specific markets and therefore increase the efficiency of train loading.

The rehabilitation objectives and methods would remain consistent within those currently implemented at the Werris Creek Coal Mine, although the proposed sequence of rehabilitation, and designated land use on the final landform has been modified slightly to provide for additional areas of native woodland establishment and conservation.

3. GROUNDWATER LEGISLATION

An evaluation of groundwater legislation that is relevant to the mine site and the proposed modification has been completed. The legislation (and other regulatory instruments) that have been considered in the preparation of this document are outlined below. A summary of the relevant application of the legislation is also provided.

- Guidelines for Fresh and Marine Water Quality (ANZECC 2000). These guidelines were adopted for the evaluation of potential impacts on groundwater quality as a consequence of the proposed modification. The relevant criteria are considered further in **Appendix A**.
- State Groundwater Policy documents, Department of Water and Energy (DWE) and the Water Management Act 2000. Groundwater extraction or groundwater interference at the mine site is currently regulated under Part 5 of the Water Act 1912. Revisions are currently being made within DWE to incorporate management of groundwater across NSW within the Water Management Act 2000. When these changes are enforced, the mine site will be regulated under this Act.
- The Water Sharing Plan (WSP) for the Phillips Creek, Mooki River, Quirindi Creek and Warrah Creek Water Sources 2004. This WSP identifies and regulates groundwater sources within the alluvium aquifer of each water source. Quipolly Creek, is located approximately 2.7km from the mine site boundary and is situated with the Quirindi Creek Water Source. The water source is identified to have a highly variable flow with a 50th percentile flow volume of 2ML/day. The identified alluvium of Quipolly Creek is located 2.6km to the south of the project boundary as shown on **Figure 3**.

  A conceptual hydrogeological regime for the mine site and surrounds is presented in **Section 6.0** and shows that the proposed modification impacts will be limited to within the hard rock aquifer with minimal connection to the alluvium identified at the site. On this basis the proposed site activities and impacts are not regulated under the WSP.
- Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC). These guidelines have been utilised in the sampling of groundwater for water quality analysis presented in **Appendix A.**
- NSW Groundwater Dependent Ecosystem Policy (DWE). No groundwater dependent ecosystems have been identified at the mine site and surrounds. Further detail is presented in **Section 9.3.3**.

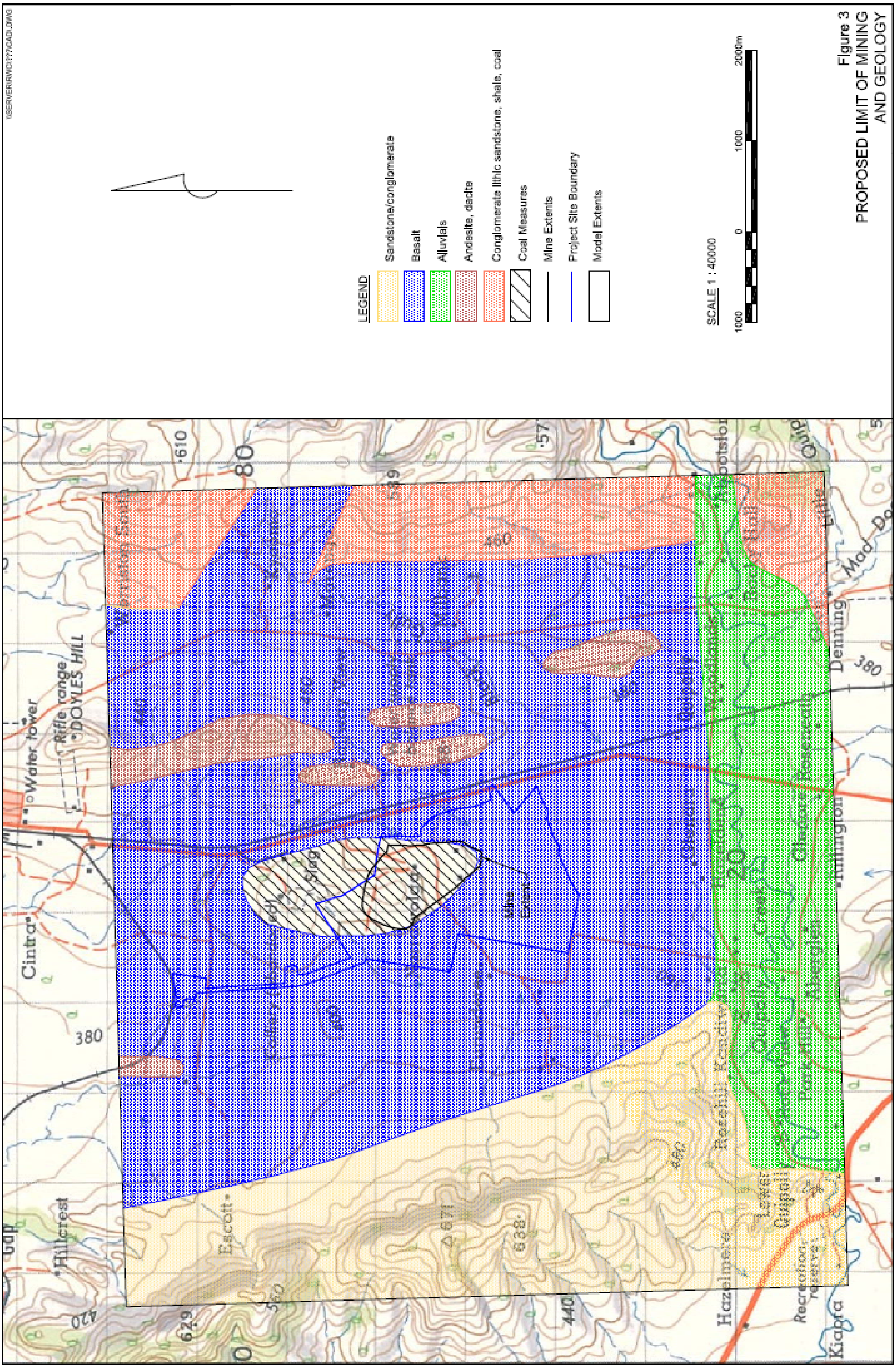


Figure 3
PROPOSED LIMIT OF MINING
AND GEOLOGY

4. BACKGROUND INFORMATION

Prior to the commencement of mining operations at the site an Environmental Impact Statement was completed and included the following Groundwater Assessment.

- Groundwater Assessment, Werris Creek Coal Mine, March 2004, prepared by Robert Carr & Associates Pty Ltd (RCA 2004).

This report was reviewed and relevant data included in the preparation of the assessment.

Also reviewed in the preparation of the assessment were the following documents:

- Werris Creek Coal Mine, Surface Water and Groundwater Monitoring 2006/2007, May 2007, prepared by GeoTerra Pty Ltd (GeoTerra 2007).
- Werris Creek Coal Mine, Surface Water and Groundwater Monitoring 2007/2008, April 2008, prepared by GeoTerra Pty Ltd (GeoTerra 2008).

The RCA (2004) report included development of a geological model from which a three dimensional hydrogeological model was developed. This hydrogeological model forms the basis for the modelling undertaken for the proposed modification. The modelling of RCA (2004) (for the previously proposed mine plan) predicted a groundwater drawdown of up to 11m at the mine site boundary and up to 2m within 5km of the proposed extent of mining. A reduction in saturated thickness was only identified in three bores (on the Eurunderee [4.9%], Railway View [0.6%] and Hillview [0.9%] properties), with none above the 10% reduction criteria considered to be outside the scope of natural variation.

GeoTerra was engaged by the Proponent to undertake independent groundwater quality and water level monitoring of a nominated bore field on and surrounding the mine site. The bore field is identified as monitoring bores MW1 to MW14 on **Figure 4**. Water level monitoring commenced in December 2005 and is undertaken quarterly. A period of monthly monitoring was undertaken for an initial six months' period. The water level monitoring in bores MW1 to MW14 has not identified observable impacts on water levels from the current mining operations (GeoTerra 2007 and 2008).

An average of the last three water level readings at each monitoring bore was taken as a representation of the current water level heights and a representation of the hydrogeological regime. Using the surveyed monitoring bore elevations the hydrogeological regime was predicted for groundwater modelling purpose (see **Figure 4**). The hydrogeological regime identifies groundwater to flow in south easterly direction toward Quipolly Creek.

5. SITE CONDITIONS AND SURROUNDING ENVIRONMENT

5.1 Topography

The mine site grades from 380m AHD on the northern boundary to radial hill feature with maximum elevation of 445m in the midsection of the site and then down to 355m at the southern boundary. The topography of the mine site as shown on the 1:25000 topographic sheet is reproduced in **Figure 4**.

The mine site comprises an elevated topographical region within a wide valley formation. The topography to the east of the site comprises a broken ridge line. To the west the topography rises steeply to a maximum elevation of 638m AHD. Quipolly Creek is located to the south of the site and flows in a westerly direction.

5.2 Local Meteorology

Information on local rainfall was sourced from the Quirindi Meteorology Station No. 055049, located approximately 11km to the south-southwest at an elevation of 390m AHD. The total average rainfall for the area is 683mm/year.

Information on evaporative rates was sourced from the Tamworth Meteorology Station No. 055049, located approximately 40km to the north. The total average evaporation for the area is 1 976mm/year, ie, almost three times the average rainfall rate.

5.3 Stratigraphy

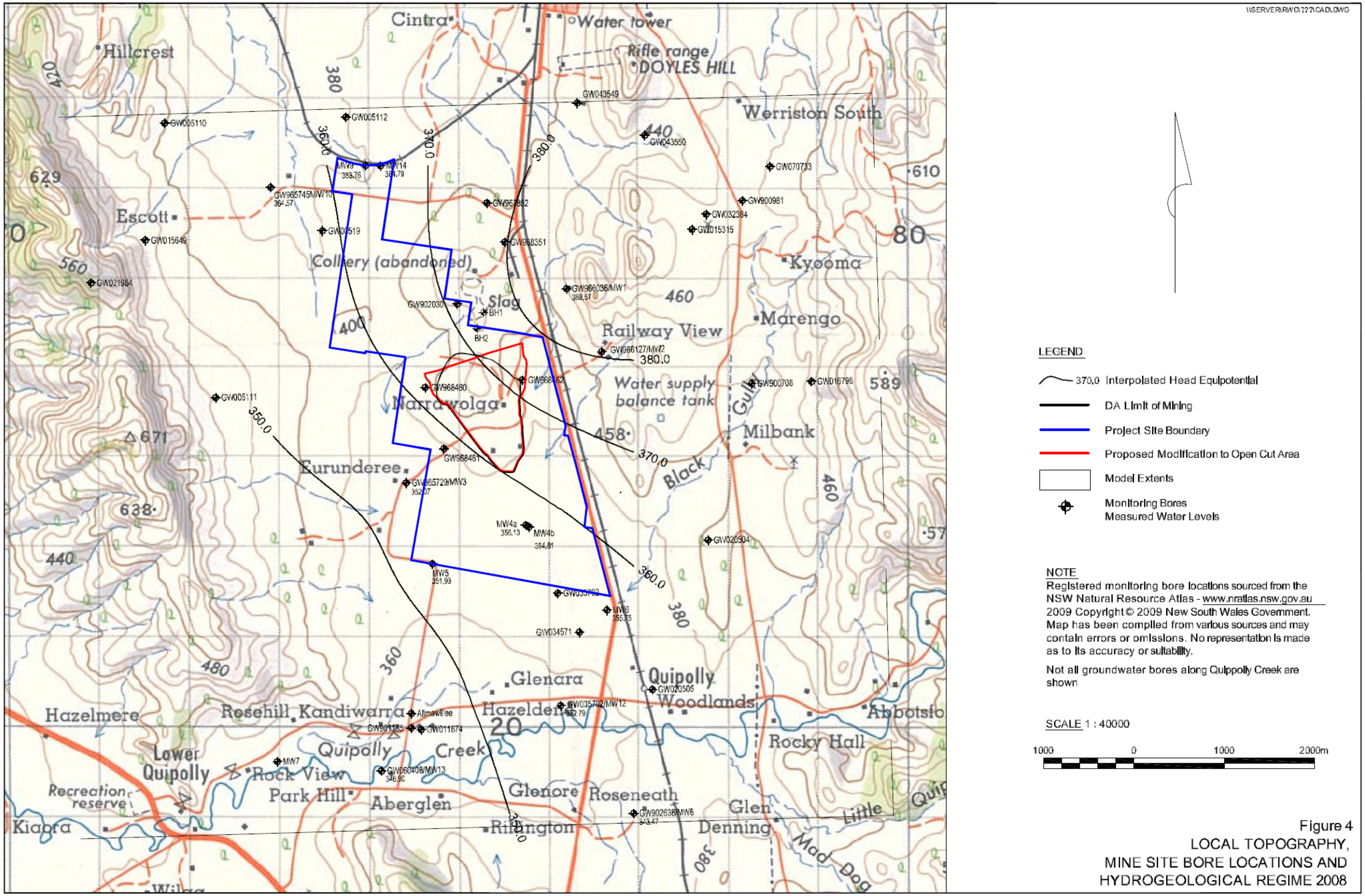
The general stratigraphic sequence in the vicinity of the mine site is presented in **Table 1** with the strata listed from youngest to oldest.

Table 1
General Stratigraphic Sequence

Age	Rock/Sediment Type	Strata Type	Occurrence
Quaternary	Unconsolidated sediments	Sands and gravel	Along Quipolly Creek 2.5km from the site
Permian	Coal Measures	Seven coal seams and interburden strata of sandstones/siltstone and shales	The proposed open cut mine site covers most of this strata
Permian	Werrie Basalt	Basaltic lave flows with a significant weathered profile of clay. Underlying the coal measures, the clay forms claystone.	Directly underneath the coal measures and completely surrounding them in all directions in most of the valley and lower lying areas
Permian	Acid Volcanics	Andesite, dacite and rhyolite	This occurs in a limited zone and forms the ridges immediately to the east of the site and also occurs to the north
Permian	Conglomerates	Conglomerates and lithic sandstones	These strata form the dominant N-S trending ridges to the east
Carboniferous	Rossmore Formation	Conglomerates and sandstones, siltstones and mudstones	These strata form the dominant N-S trending ridges to the west.

The occurrence of each of these rock or sediment types listed in **Table 1** are shown on **Figure 3**. A summary of the local geology and stratigraphy is as follows:

- The Coal Measures lie approximately 2.5km to the east of the Mooki Thrust Fault. The coal measures have been structurally deformed to form an intact closed basin (syncline) that is wholly surrounded by the Werrie Basalt. The upper most weathered section of the basalt is overlain by a thin claystone capping of approximate 3m thickness.
- The Warragundi intrusives form a series of north south oriented acid volcanics are located to the east and north of the coal measures



NOTE
Registered monitoring bore locations sourced from the NSW Natural Resource Atlas - www.nratlas.nsw.gov.au 2009 Copyright © 2009 New South Wales Government. Map has been compiled from various sources and may contain errors or omissions. No representation is made as to its accuracy or suitability.

Not all groundwater bores along Quipolly Creek are shown

Figure 4
LOCAL TOPOGRAPHY, MINE SITE BORE LOCATIONS AND HYDROGEOLOGICAL REGIME 2008

- Available data shows that north south oriented faulting occurs in the vicinity and possibly within the coal measures.
- The type of stratigraphy, combined with structural elements such as faulting and folding (which can disrupt stratigraphy over short distances) and existence of intrusive bodies are reasonable explanations for variances in water levels seen in the current data set.
- The coal measures have in part been previously mined by underground methods to the north of the proposed open cut mine. The base RL of these workings extends from 390mAHD in the north west to 280mAHD in the south west.

5.4 Mine Site Aquifer Data

Aquifer data for the mine site was collated in RCA (2004) and comprised permeability testing within five existing exploration holes, a windmill on the Narrawolga property and the five bores/wells on surrounding properties. The location of these bores is shown on **Figure 4** and the results are summarised in **Table 2**.

Table 2
Results of Permeability Testing, RCA 2004

Bore Number	Permeability (m/s)	Strata Screened
WC28	$2x10^{-6}$	Coal Measures – G Seam
WC31	$2x10^{-6}$	Coal Measures – C Seam
WC32	$3x10^{-7}$	Coal Measures - Interburden above G seam
WC43	$1x10^{-9}$	Claystone underlying the coal measures
WC57	$3 x 10^{-9}$	Claystone underlying the coal measures
WM1	$2x10^{-6}$	Werrie Basalt
MW1 – Hillview	$6x10^{-6}$	Werrie Basalt
MW13 – Park Hill	$2x10^{-3}$	Quaternary Sand/Gravel Alluvials
MV1 – Mountain View	$2x10^{-4}$	Quaternary Sand/Gravel Alluvials
GH1 – Gedhurst	$3x10^{-3}$	Quaternary Sand/Gravel Alluvials
A1 – Allmawille	Recovery too fast to measure	Quaternary Sand/Gravel Alluvials

Source: Modified after RCA (2004) – Table 2

5.5 Groundwater Data of the Mine Site and Surrounds

A summary of available groundwater data for the mine site and surrounds has been collated from mine site data, DWE records and field assessment of critical bores.

A total of seventeen (17) registered bores were identified within 5km of the mine site and are shown on **Figure 4**.

A review of DWE Groundwater Works Summary records found that groundwater bores located within the model domain were generally utilised for rural purposes and located within the basalt or unconsolidated alluvial strata. Available data is tabulated in **Table 3**.

Table 3
Summary of Water Bores within 5km of the Mine Site

Registered Number	Property	Aquifer	Usage
GW965729	Eurunderee	Basalt	Stock
GW034571	NK	Basalt	NK
GW020504	NK	Basalt	Stock
GW035702	NK	Alluvial/Basalt	NK
GW055108	NK	Sandstone	NK
GW020505	NK	Alluvial/Basalt	Stock
GW005111	NK	Sandstone	NK
#	Allmawillee	Alluvial	Domestic & Irrigation
GW902030	Old Colliery	Coal Measures	Domestic
#	Gedhurst	Alluvial	Domestic & Irrigation
#	Mountain View	Alluvial	Domestic & Irrigation
GW900708	NK	Basalt	Domestic & Stock
GW966036 (MW1)	Hillview	Basalt	Domestic & Stock
GW966127 (MW2)	Railway View	Basalt	Domestic & Stock
965729 (MW3)	Eurunderee	Basalt	Domestic & Stock
MW4	WCC Pty Ltd	Basalt	Monitoring
MW5	WCC Pty Ltd	Basalt	Monitoring
MW6	WCC Pty Ltd	Basalt	Monitoring
966349 (MW7)	Rosehill	Alluvial	Domestic & Stock
902638 (MW8)	Roseneath	Basalt	Domestic & Stock
MW9	WCC Pty Ltd	Basalt	Monitoring
965745 (MW10)	Turnbulls	Basalt	Domestic
MW11	Turnbulls Gap	Sandstone	NK
35072 (MW12)	Hazeldene	Alluvial	Stock
60408 (MW13)	Parkhill	Alluvial	Irrigation
MW14	WCC Pty Ltd	Basalt	Monitoring

See **Figure 4**.
NA – not available, NT – not tested, NK – not known.
not registered.

Static water levels have been measured in the MW series bores by GeoTerra (2008). The groundwater contour diagram interpolated using this data is presented on **Figure 4**.

Groundwater is contained with the underground mine workings. One groundwater pumping bore is present within these workings and is used to pump water for use within mine operations. In December 2008 RCA installed two additional groundwater monitoring bores (BH1 and BH2) in the workings to evaluate water quality and to assess water levels (RCA 2009). Detailed information is contained in **Appendix A**. The location of the two bores is identified on **Figure 4** and recorded water level tabulated in **Table 4**.

The results indicated a 4m difference in water level between BH1 and BH2 and suggest that the water bodies intercepted by the two bores may not be connected.

Table 4
Water Levels in Old Workings

Well	Bore depth from surface (m)	Depth to water table below t.o.p (m)	Survey t.o.p mAHD	RL of water table mAHD
BH1	122	76.09	420.64	344.55
BH2	105	78.28	418.41	340.13
t.o.p = top of pipe.				

5.6 Groundwater Quality

5.6.1 Mine Site

Groundwater samples taken from the mine site and within the mine workings by RCA (2004) found groundwater to be slightly acidic with low salinity. The low salinity (brackish) was considered unusual for coal measures and attributed to the close proximity of the recharge point (the subcrop).

With three exceptions (WC28, WC33 and WC41), which displayed slightly elevated Zinc or Nickel concentrations, the metals analysed were all below the accepted limits for irrigation purposes. In all cases, these slightly elevated results were well under the accepted limits for livestock use.

Analysis of groundwater collected from BH1, BH2 and the mine site production bore found similar water quality characteristics (RCA 2009). Concentrations of other analytes tested indicated the water is suitable for the purpose of irrigation or re-use in site operations.

5.6.2 Basalt Aquifer

Water quality sampling in the basalt aquifer was undertaken in 2004 and ongoing routine monitoring is undertaken by GeoTerra. The basalt aquifer has slightly acidic to neutral pH and is fresh to slightly brackish. Sampling of other analytes indicate the water body is suitable for irrigation or stock use.

5.6.3 Alluvial Aquifer

Water quality sampling in the alluvial aquifer was undertaken in 2004 and ongoing routine monitoring is undertaken by GeoTerra. The alluvial aquifer is of neutral pH and is fresh to slightly brackish. Sampling of other analytes found the water body is suitable for irrigation or stock use.

5.7 Hydrogeological Regime, Mine Site and Surrounds

Background data, mine site data and data from the area surrounding the mine site has been collated to construct a conceptual hydrogeological model for the mine site and surrounds.

Groundwater occurs in three main strata in the vicinity of the mine site, Permian Coal Measures, Werrie Basalt and Quaternary Sediments.

The coal measures strata within the open cut area of the mine site contains a closed basin of groundwater that is surrounded by a low permeability claystone. Therefore, apart from short-term flow from storage, little long-term inflow to the open cut would be expected when mining occurs below the water table. Groundwater occurs between 10m and 30m below the surface (GeoTerra 2008).

Groundwater in the Werrie Basalt flows to the southwest and is recharged by rainfall and runoff from the surrounding sandstone ridges. Groundwater bore monitoring data indicates the water occurs within this aquifer between 8m and 52.1m below ground level (GeoTerra 2008). Only minor interaction between the basalt and coal measures is expected as the claystone/upper weathered basalt in the vicinity of the syncline structure acts as a low permeability barrier, thereby minimising groundwater interaction.

The Quaternary Sediments alluvial aquifer contains strata of high permeability and is recharged by the upper reaches of the Quipolly Creek catchment as well as by direct infiltration. This causes a westerly flow in this aquifer. Minor interaction between the Werrie basalt and alluvial aquifer is expected to occur. Water levels within this aquifer occur approximately 4.4m to 8.7m below ground level (GeoTerra 2008).

In addition to the above, sandstone and tight volcanic formations have been identified to the north-east and west of the mine site.

6. GROUNDWATER MODELLING

6.1 Model Design and Boundary Conditions

Groundwater flow modelling was undertaken using Visual Modflow 3.1, a three dimensional modular finite difference groundwater flow model. Visual Modflow 3.1 utilises the Modflow - 2000 numeric engine developed by the US Army Corps of Engineers in 2000. The model is based on Modflow – 83, Modflow – 88 and Modflow – 96 which have been widely used by the profession for over 20 years.

The model domain comprised an area of 9km in the easterly direction by 8km, as shown on **Figure 1**, in which the proposed limit of open cut mining was located towards the centre of the model. The model origin was Easting 232800 and Northing 6587800 (in MGA coordinate system). The cell size adopted was 10m by 10m in the vicinity of the mine site and increased to 400m by 400m towards the model boundaries. This cell size is considered to give sufficient resolution to model impacts from the proposed coal mining operations.

Boundary conditions adopted for the mine site are shown on **Figure 5** and can be described as follows:

- In the centre of the mine site a constant head boundary of 346mAHD was input to represent the groundwater present within the underground workings. This figure was recorded for the mine workings for the 2008 monitoring period.
- To the southwest a stream function was input along Quipolly Creek. Quipolly Creek flows from an elevation of approximately 370m AHD in the east to 335mAHD in the west of the model domain. Stream heights were approximated from the topographic map.

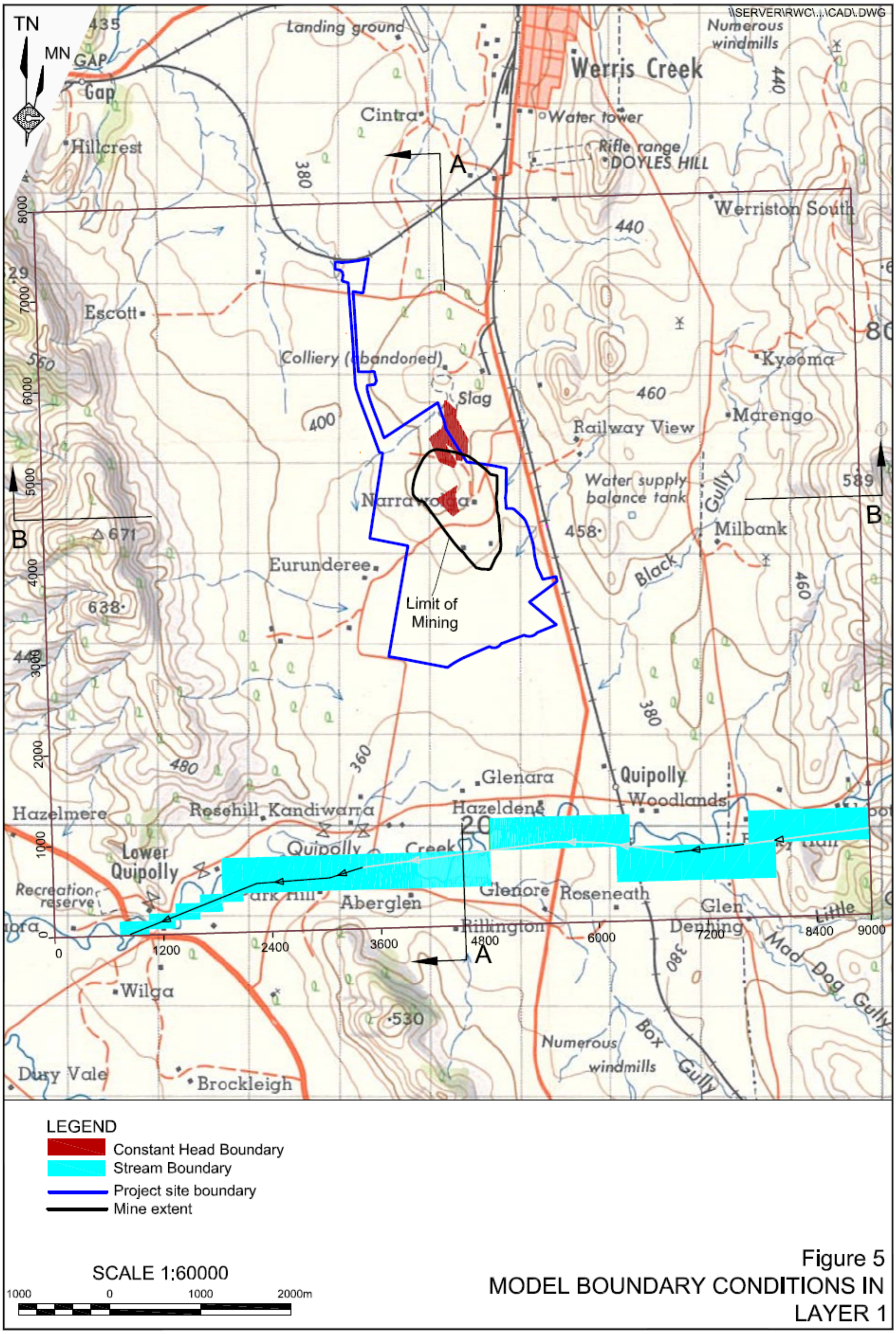


Figure 5
MODEL BOUNDARY CONDITIONS IN LAYER 1

Note: A colour version of this figure is included on the Project CD

Several small creeks occur within the model domain including Black Gully Creek in the central east of the model domain. Due to the depth of groundwater observed in the aquifers likely to be affected by the proposed modification (approximately 35m bgl), interaction of surface water and groundwater within these deeper aquifers is unlikely and therefore these creeks have not been incorporated in the model boundary conditions.

6.2 Model Assumptions

6.2.1 Model Layer

The model has been constructed as four layers. Layer 1 represents the coal seams and interburden strata. Layer 2 represents the weathered basalt layer. Layers 3 and 4 represent the basalt, tight volcanic and sandstone surrounding strata and Permian alluvium.

The model surface for the mine site and surrounds was developed as a contour plot interpolated from the 1:250000 topographic map for the region. A 500m grid was applied across the model domain and elevations determined. This data was combined with a surface survey across the mine site and contoured using ‘Surfer’, a commercially available contouring software package. This approach is not as accurate as using the topographic map contour plan but is sufficient for the purposes of this model.

Layer interfaces were determined from geological information collated from mine exploratory bore holes. Based on available data, the base of the weathered basalt was assumed to extend to 2m below the base of the coal deposit. The interpolated isopleths were constructed using ‘Surfer’.

Each layer was imported to the model and a minimum layer thickness of 1m was assigned. The minimum layer thickness is required to ensure model convergence as model instability can occur where cells become too small relative to the surrounding cells. The ‘lensing out’ of coal seams away from the mine site was simulated through permeability assignment and is discussed in **Section 6.3**. North-south and east-west cross-sections through the model are shown on **Figure 6** (Sections A and B).

6.2.2 Aquifer Parameters

Initial hydraulic conductivity parameters are presented in **Table 5**.

Table 5
Initial Permeability Assignments

Layer	Permeability (m/s)	Effective Porosity[1] %	Storativity[2] (1/m)
Coal Seams	1.0E-06	0.15	1×10^{-5}
Claystone Underlying Lowest Coal Seam (Coal G)	1.0E-09	0.01	1×10^{-5}
Basalt	6.0E-06	0.01	1×10^{-5}
Alluvial Strata	5.0E-04	0.15	1×10^{-5}
Sandstone/conglomerate	1.0E-07	0.01	1×10^{-5}
Volcanics	1.0E-08	0.01	1×10^{-5}

Note 1: Freeze and Cherry (1979).
Note 2: Fetter (1988).

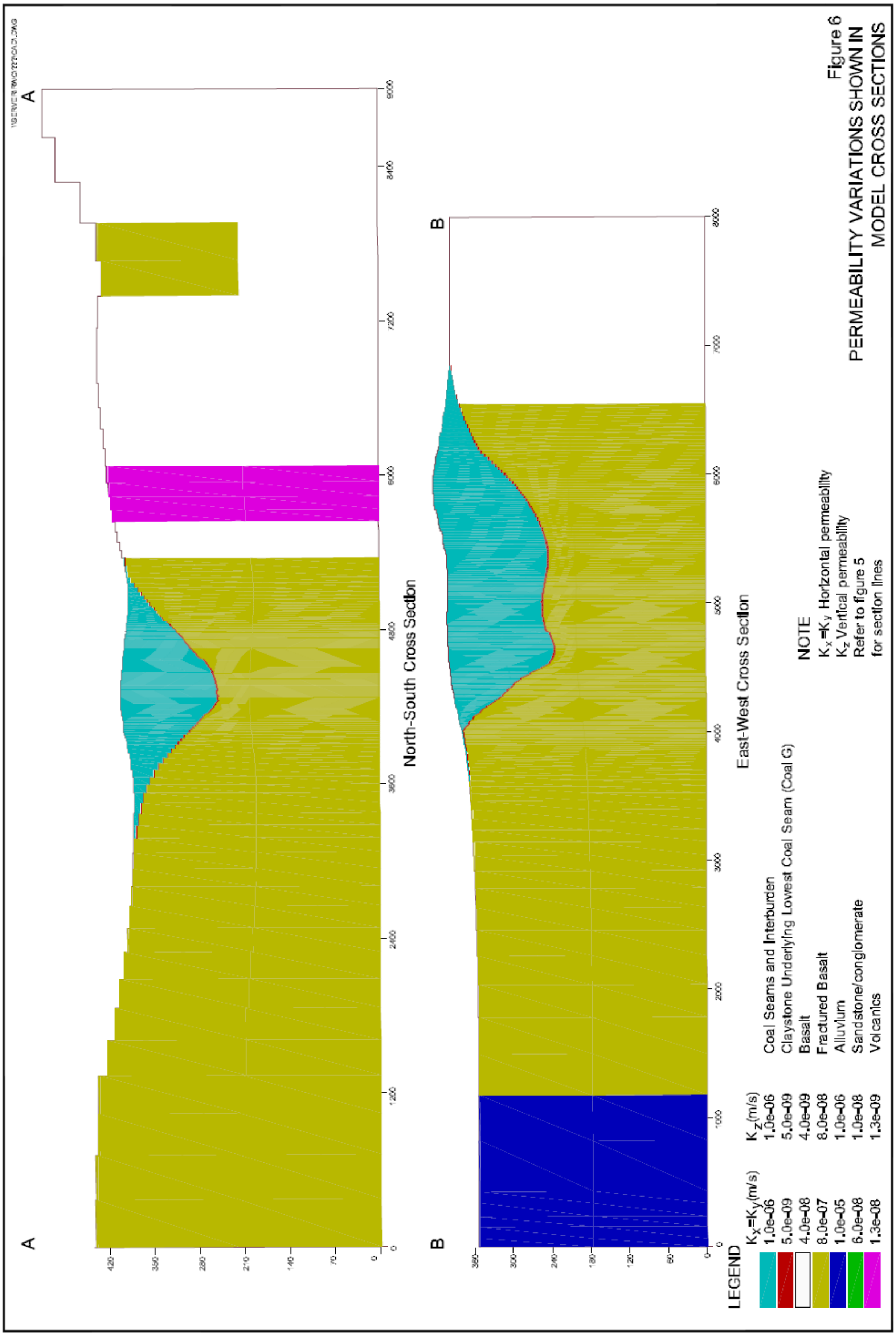


Figure 6

PERMEABILITY VARIATIONS SHOWN IN MODEL CROSS SECTIONS

Note: A colour version of this figure is included on the Project CD

Anecdotal evidence during bore data review found that secondary porosity was present within the strata, particularly the coal seams, due to fracturing, and yields in zones of fracturing can be significantly higher. Secondary fracturing was incorporated in the macro permeability through the model calibration process. Site specific variation in yields that result from fractures within the strata are beyond the scope of the current modelling. An assessment of the impact on yield from the proposed modification can be undertaken through an evaluation of water level impact.

Specific yields and porosity values were based on available published data for similar material (Fetter 1988). Specific yields were used for the transient model analysis, which was conducted to assess impact from the proposed modification. An evaluation of the sensitivity of the model to this parameter is presented in **Section 8.2**. Initial parameters adopted are presented in **Table 5**.

7. MODEL CALIBRATION AND VALIDATION

7.1 Calibration Criteria

The objective of the model calibration was to ensure the model predicted the observed groundwater levels identified in groundwater bores surrounding the mine site. These groundwater levels would be accepted as the steady-state pre-coal removal groundwater head condition. Accepted criteria to ensure a representative model calibration was adopted as follows:

- simulated water table levels are within the water table measurement error of the bore field and/or the Normalised Root Mean Squared (RMS) of calibration is less than 10% (accepted in the industry); and
- the simulated water balance error is less than 2%.

Water table levels identified in the 2008 water level gauging survey were adopted to represent the hydrogeological regime of the aquifer. These groundwater bores, their location and elevation are presented in **Table 6**.

Some of the groundwater bores listed in **Table 6** were not surveyed and therefore the top of the bore is estimated from the relevant 1:25 000 topographic map with 10m contour intervals. For the mine site and surrounds this methodology results in an uncertainty of about ± 5m in the surface elevation and consequently there will be a similar error associated with calculated water table level. This ± 5m error has been adopted as the water table measurement error for the purpose of calibration assessment.

The measured water table levels shown in **Table 6** were assumed to represent steady state pre-coal removal conditions as well as representing the current site conditions. Water level gauging undertaken by GeoTerra since 2005 has not identified a response in groundwater levels from the site operations. As such, the water levels are considered to be representative of both site conditions.

Table 6
Water Table Levels to be used for initial Model Calibration

Bore No[1]	**Easting**[2]	**Northing**[2]	**Approximate Surface Elevation** [3] **(m AHD)**	**Water Table Depth** [5] **(m)**	**Water Table Level Calculated (m AHD)**
MW1	276380	6525100	435 [4]	51.1	383.9
MW2	276770	6524400	410 [4]	27.3	382.7
MW3	274598.6	6522941	367.316	15.2	352.1
MW4A	275940.4	6522469	365.044	8.9	356.1
MW4B	275896.4	6522327	364.143	9.3	354.8
MW5	274899.5	6522046	360.166	8.2	351.9
MW6	276810.3	6521544	366.879	11.1	355.7
MW7	273180.6	6519844	347.877	4.4	343.5
MW8	277124	6519282	369.752	16.0	353.8
MW9	274164.7	6526458	378.059	13.5	364.6
MW10	273130.6	6526225	371.458	18.2	353.3
MW11	272279.7	6528596	347.557	NK	NK
MW12	276311.8	6520486	360.414	7.6	352.8
MW13	274326.8	6519750	352.018	5.1	346.9
MW14	274322.6	6526454	379.99	15.2	364.8

Note 1: See **Figure 4** for bore locations.
Note 2: Coordinate system (MGA).
Note 3: Surveyed.
Note 4: Estimated from 1:25 000 topographic map.
Note 5: Average of 2008 groundwater levels, GeoTerra 2008.
NK – not known.

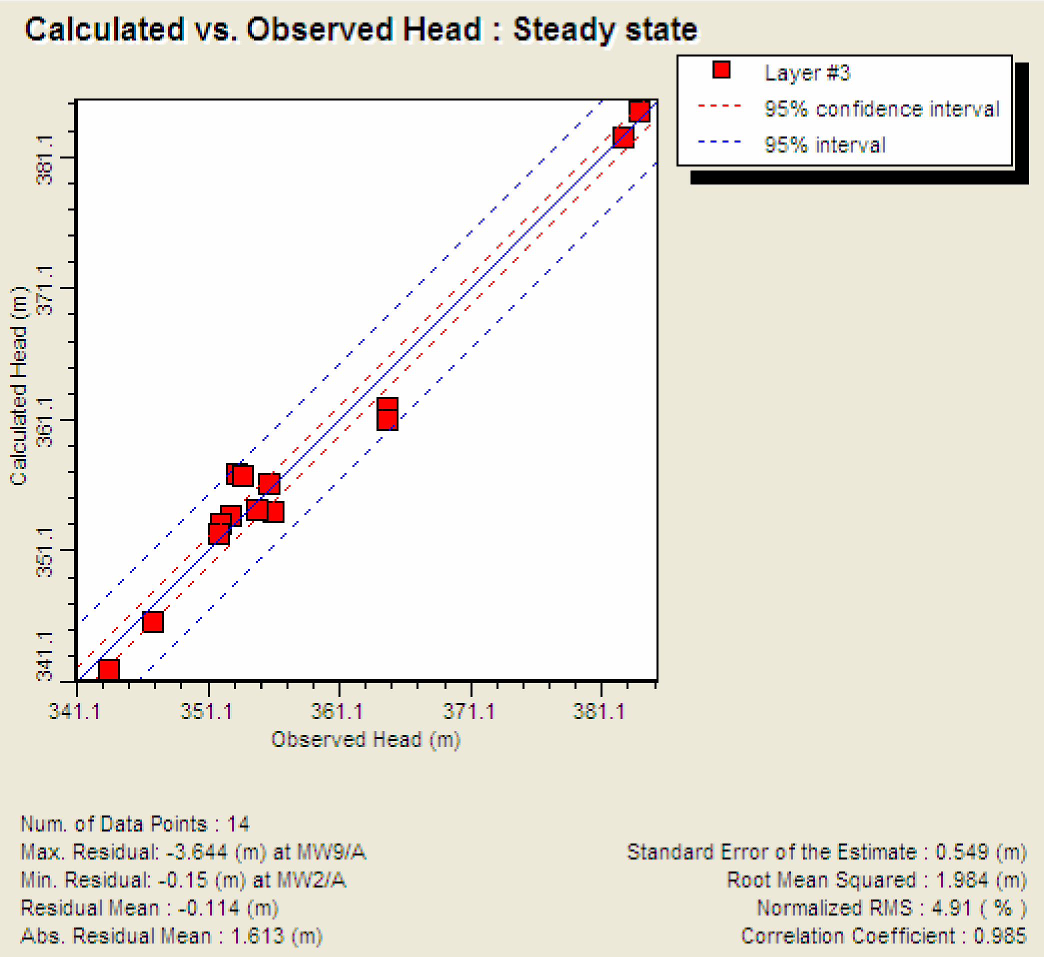
7.2 Current Site Conditions Calibration Methodology

Model calibration under steady state conditions was achieved by systematically changing recharge and the hydraulic conductivity values. Initially, recharge was adopted as 5% of the annual rainfall.

During initial simulations, calculated heads in registered bores MW1, MW2, MW9 and MW14 were significantly lower (up to 30m) than measured data, whereas calculated heads surrounding the mine site and in the valley were consistent with measured data. A normalised RMS error of 19% was identified. Of particular note was the observed head at MW10 is approximately 10m lower than MW9 and MW14 which are in close proximity. The variation suggests a structural change in strata occurring between the monitoring locations.

Various strata options were evaluated in combination with recharge variation. The most realistic of these introduces a lower permeability zone within the eastern portion of the basalt commencing in a north-south trending zone through the approximate middle of the syncline. The higher permeability of the basalt to the west of this line suggests fracturing within the basalt which could occur from the Mooki Fault structure. The permeability values adopted represent macro permeability and are representative of combined primary and secondary permeability.

Adjustments in permeability values and locations were made within each layer until the hydrogeological condition was consistent with that observed. The normalised RMS determined for the final permeability combination is presented in **Figure 7**.



Num. of Data Points : 14
Max. Residual: -3.644 (m) at MW9/A
Min. Residual: -0.15 (m) at MW2/A
Residual Mean : -0.114 (m)
Abs. Residual Mean : 1.613 (m)

Standard Error of the Estimate : 0.549 (m)
Root Mean Squared : 1.984 (m)
Normalized RMS : 4.91 (%)
Correlation Coefficient : 0.985

Figure 7 **Calibration Output for Iterated Recharge and Permeability Combination**

The normalised RMS is within the acceptable range and the maximum residual head is also acceptable.

The water balance error was also reviewed to assess model stability. The water balance error for the simulation is presented in **Figure 8** and shows an error of <0.1% in the water balance. This low water balance error indicates robustness and stability within the model.

7.3 Calibration Summary

The steady state model calibration to simulate observed site conditions has identified that the groundwater system was best represented by areas of varying permeability and recharge as shown on **Figure 9** to **Figure 13**.

In summary, the recharge of 2mm/year was applied to the majority of the model domain and represents approximately 0.5% of the annual rainfall. Localised recharge of 9mm/year was applied to the higher regions and represents 1.5% of the annual rainfall. There is no obvious reason why higher recharge is required in this area to calibrate the model, but some increases could be attributed to the ephemeral drainage channels within the valley, a higher permeability within the unsaturated zone, lower runoff due to vegetation on the slopes or lower evapo-transpiration resulting from a deeper water table in these areas. An increased infiltration along Quipolly Creek alluvium was also introduced to represent the increased recharge that would occur in this area due to increased surface permeability and reduced surface gradients. The recharge distribution adopted is presented in **Figure 9**.

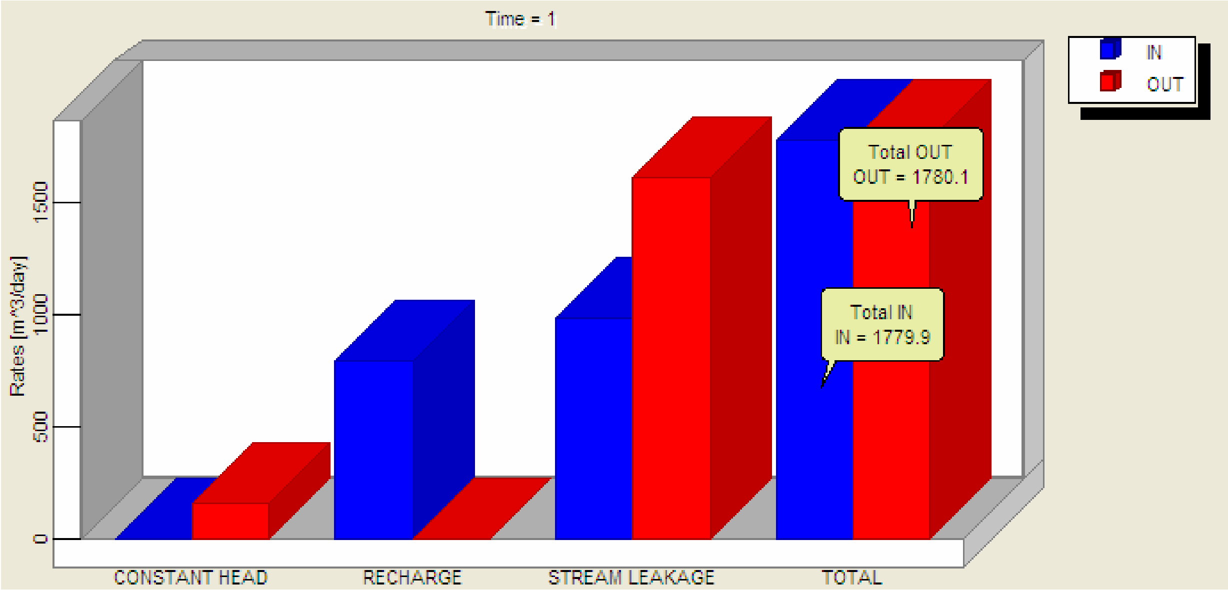


Figure 8 **Water Balance Error**

The final permeability distributions for each layer are presented in **Table 7**.

Table 7
Adopted Permeability Distribution

Layer	**Permeability adopted (m/s)**		**Range of Field Measured Data (m/s)**
	$K_x = K_y$	K_z	$K_x = K_y$
Coal Seams and interburden	1.0E-06	1.0E-06	3.0E-07 to 2.0E-06
Claystone Underlying Lowest Coal Seam (Coal G)	5.0E-09	5.0E-09	1.0E-09 to 3.0E-09
Basalt	4.0E-08	4.0E-09	2.0E-06 to 6.0E-06
Fractured Basalt	8.0E-07	8.0E-08	
Alluvium	1.0E-05	1.0E-06	2.0E-04 to 2.0E-03
Sandstone/conglomerate	6.0E-08	1.0E-08	No data
Volcanics	1.3E-08	1.3E-09	No data
K_x=K_y horizontal permeability. K_z = vertical permeability. K represents permeability in all directions.			

The permeability values adopted for basalt and alluvium are lower than the permeability values adopted in the model. This is a result of permeability tests being undertaken in pumping bores where bores are strategically located in zones of high permeability within the strata in order to maximise groundwater flow. The permeability values adopted are representative of the macro permeability for the strata and represent areas of both high and low flow. On this basis the values adopted appear reasonable. A higher than measured permeability for the claystone was adopted. Simulations using a lower permeability failed to converge. The use of a higher permeability is a conservative approach as it allows greater interaction between groundwater within the coal measures and the basalt strata.

This combination of recharge and permeability is considered plausible for the mine site and surrounds although is not likely to be a unique solution. It is possible that other combinations of recharge and permeability are available that can provide a similar approximation to the steady state condition.

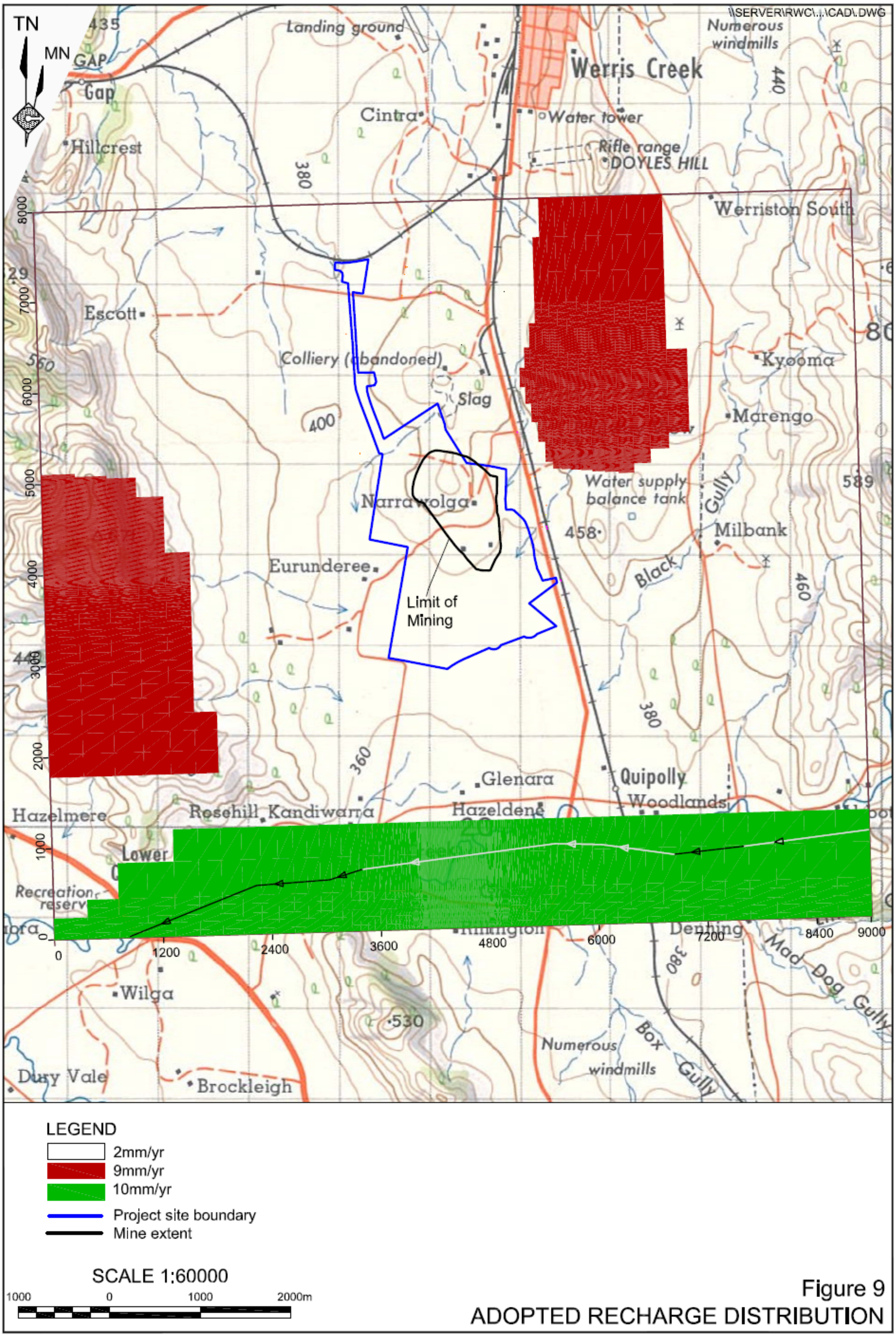
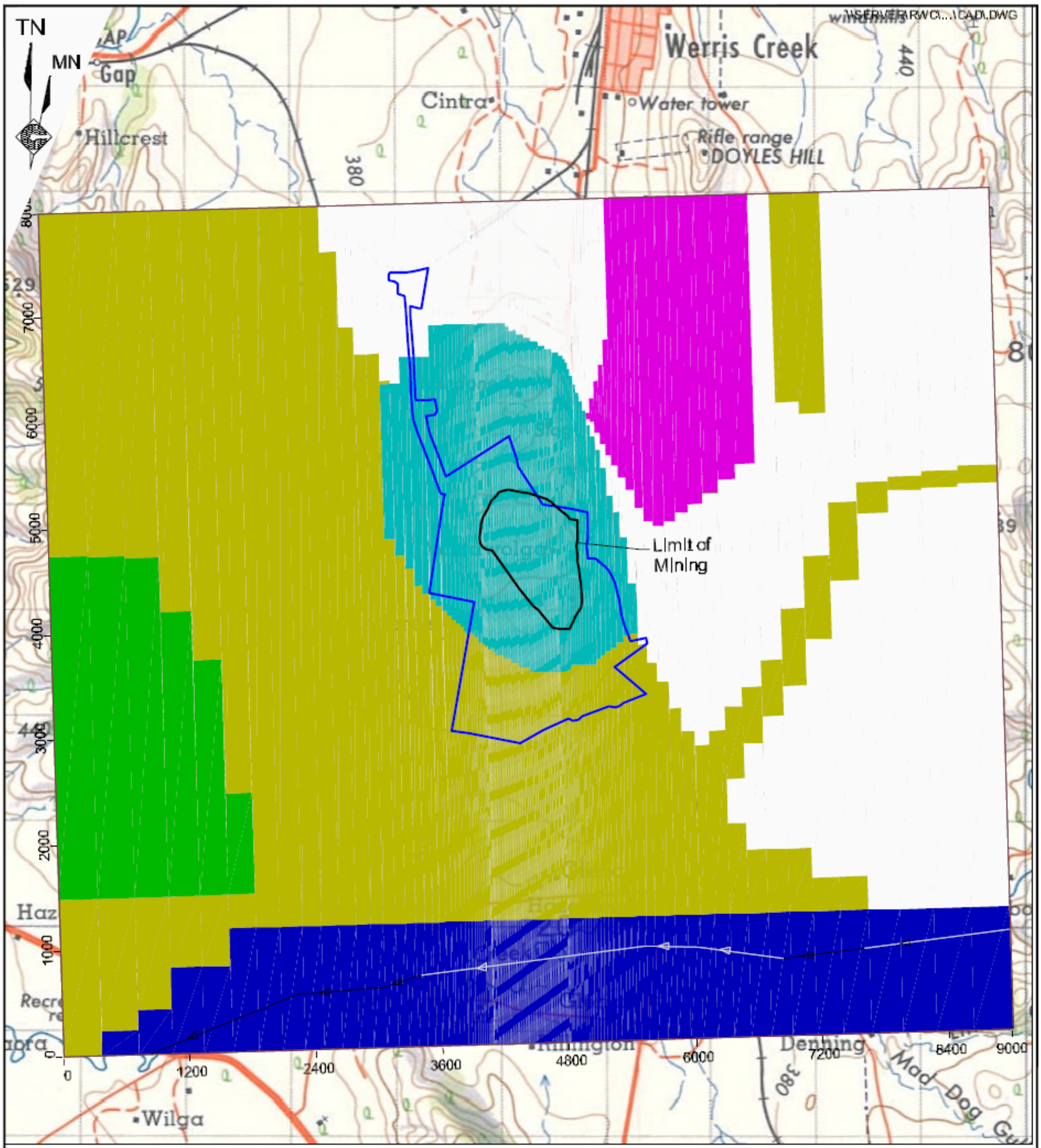


Figure 9
ADOPTED RECHARGE DISTRIBUTION

Note: A colour version of this figure is included on the Project CD



LEGEND

	K_x=K_y(m/s)	K_z(m/s)	
▨	1.0e-06	1.0e-06	Coal Seams and Interburden
🟥	5.0e-09	5.0e-09	Claystone Underlying Lowest Coal Seam (Coal G)
⬜	4.0e-08	4.0e-09	Basalt
🟨	8.0e-07	8.0e-08	Fractured Basalt
🟦	1.0e-05	1.0e-06	Alluvium
🟩	6.0e-08	1.0e-08	Sandstone/conglomerate
🟪	1.3e-08	1.3e-09	Volcanics

— Project site boundary
— Mining extent

NOTE
K_x=K_y Horizontal permeability
K_z Vertical permeability

SCALE 1:60000
1000 0 1000 2000m

Figure 10
LAYER 1
ADOPTED PERMEABILITY DISTRIBUTION

Note: A colour version of this figure is included on the Project CD

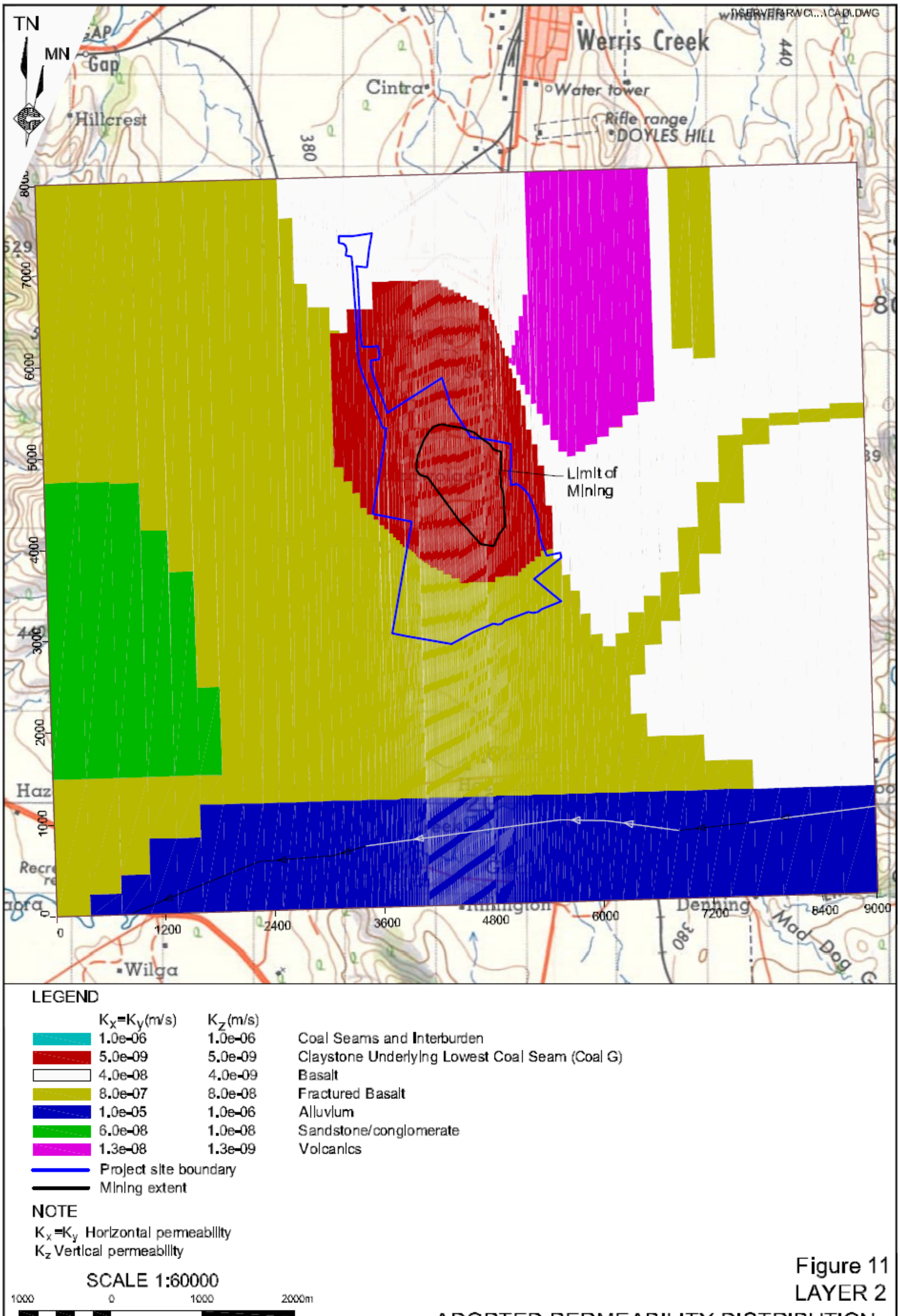
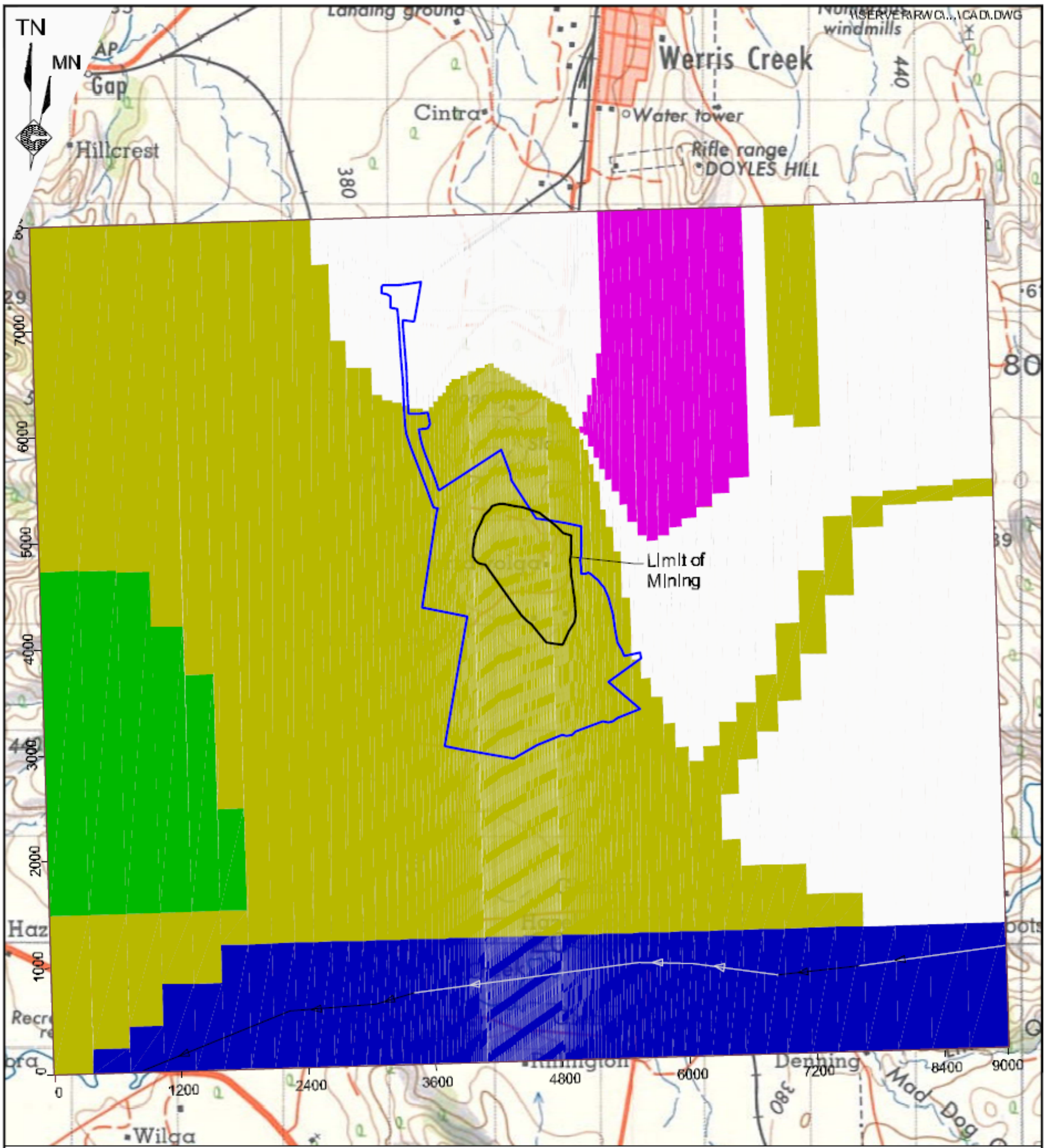


Figure 11
LAYER 2
ADOPTED PERMEABILITY DISTRIBUTION

Note: A colour version of this figure is included on the Project CD



LEGEND

	K_x=K_y(m/s)	K_z(m/s)	
🟦	1.0e-06	1.0e-06	Coal Seams and Interburden
🟥	5.0e-09	5.0e-09	Claystone Underlying Lowest Coal Seam (Coal G)
⬜	4.0e-08	4.0e-09	Basalt
🟨	8.0e-07	8.0e-08	Fractured Basalt
🟦	1.0e-05	1.0e-06	Alluvium
🟩	6.0e-08	1.0e-08	Sandstone/conglomerate
🟪	1.3e-08	1.3e-09	Volcanics
—	Project site boundary		
—	Mining extent		

NOTE

K_x=K_y Horizontal permeability
K_z Vertical permeability

SCALE 1:60000

1000 0 1000 2000m

Figure 12
LAYER 3
ADOPTED PERMEABILITY DISTRIBUTION

Note: A colour version of this figure is included on the Project CD

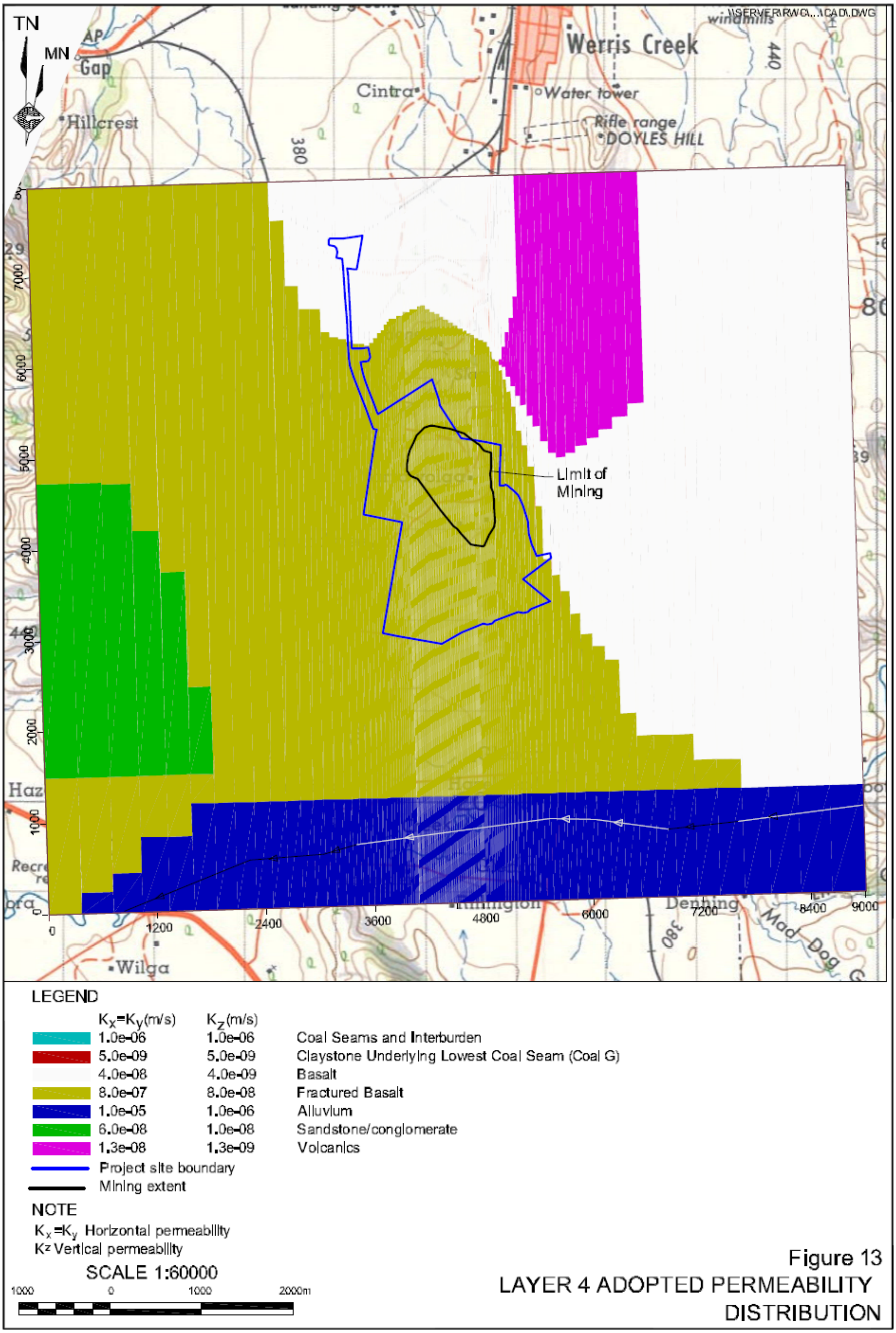


Figure 13
LAYER 4 ADOPTED PERMEABILITY DISTRIBUTION

Note: A colour version of this figure is included on the Project CD

The closest approximate solution resulted in a maximum and minimum residual of the water table after calibration of -3.6m and 0.2m at MW9 and MW2 respectively. The absolute residual mean and RMS were found to be 1.6m and 2.0m respectively with a normalised RMS of 4.9% and a correlation coefficient approaching 1. The calibration results indicate that the model is a good representation of the regional recharge and permeability distribution and is a suitable starting condition for transient analysis to determine drawdown created by the proposed modification.

Based on a low RMS value of <10%, the low water balance error of <0.1%, and all residual head values within the calibration target, it can be concluded that the model has been calibrated.

7.4 Initial Groundwater Head Condition

The initial steady state groundwater condition was determined for each layer. The groundwater condition for Layer 3 is presented in **Figure 14** and is representative of the groundwater condition outside of the syncline.

8. MODEL SIMULATION OF THE PROJECT

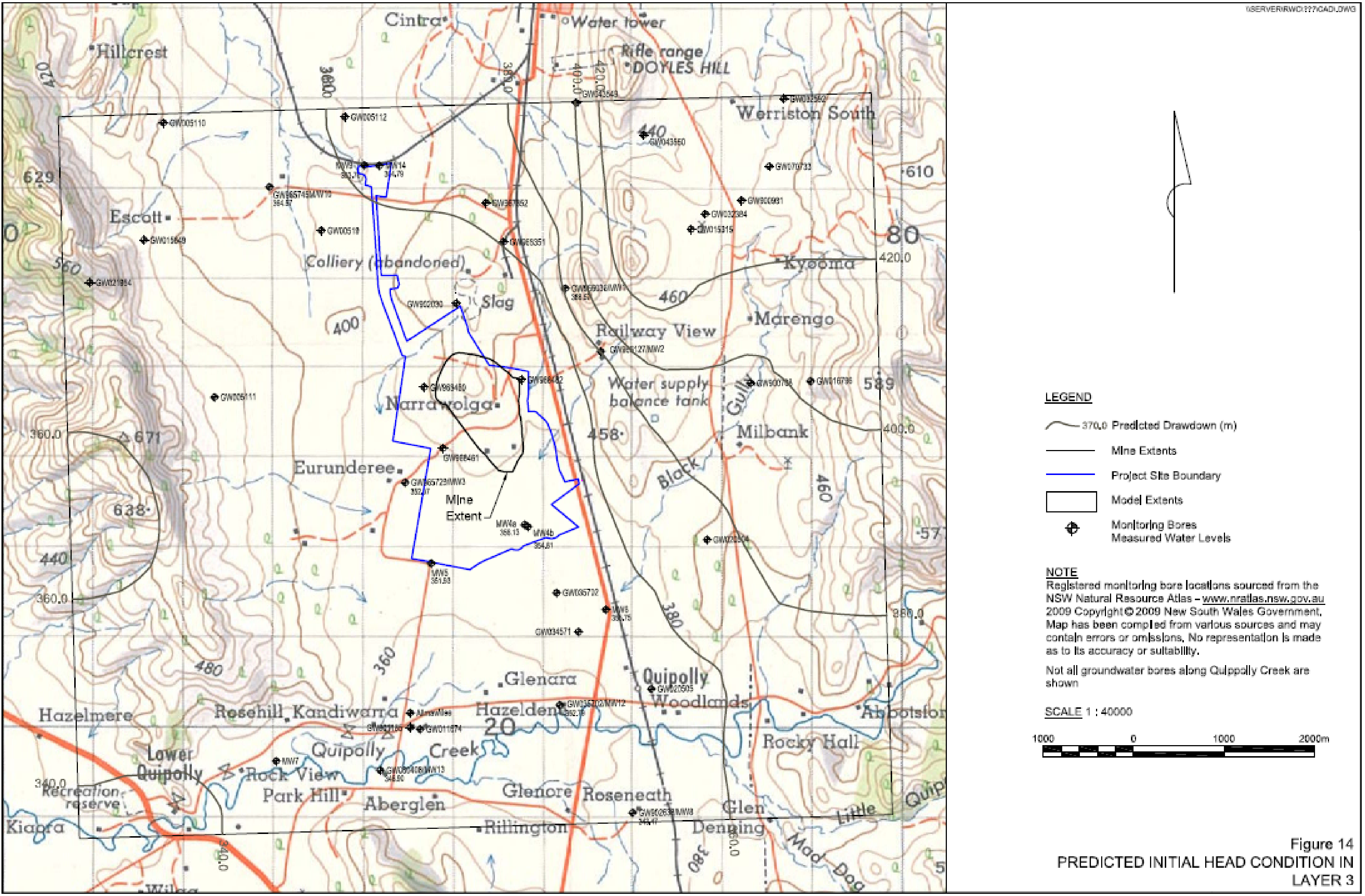
8.1 Calibrated/Validated Model Simulation

Modelling the impact to groundwater of the proposed modification was undertaken to provide an indication of the likely groundwater table response to the modified open cut area layout and dewatering of the underground workings. The modelling considers existing data, local and regional site conditions, the proposed modification and resulting impacts surrounding the mine site.

The initial water table condition for the transient modelling was simulated under steady state conditions, which are assumed to be representative of long-term climatic conditions but also representative of the current site conditions. To predict the drawdown effect created by the progressive open cut mining activities, a transient simulation was necessary.

The limit of the open cut mining area was simulated by applying constant head values at the depth of the open cut. The head was assigned for a period of three years, the proposed life of the proposed modification. The proposed sequence of open cut development that was modelled is presented in **Figure 15**. Additionally, for the proposed modification to proceed, dewatering of the underground mine voids is required. The groundwater within the mine voids is represented as a constant head of 346m AHD. The dewatering of the mine voids was simulated by decreasing this constant head value from 346m AHD to the base of the mine workings (290m AHD) over Year 1.

The long-term groundwater condition following completion of the proposed modification was simulated by removing the constant head boundary and varying the permeability of the layers within the void to represent backfilled overburden/interburden. The backfilled overburden/interburden was modelled as a uniform mass with permeability of 1E-5m/s and a specific yield of 0.01. This permeability was adopted on the assumption that the void will be loosely backfilled.



NOTE
Registered monitoring bore locations sourced from the NSW Natural Resource Atlas – www.nratlas.nsw.gov.au 2009 Copyright © 2009 New South Wales Government. Map has been compiled from various sources and may contain errors or omissions. No representation is made as to its accuracy or suitability.

Not all groundwater bores along Quipolly Creek are shown

Figure 14
PREDICTED INITIAL HEAD CONDITION IN LAYER 3

Note: A colour version of this figure is included on the Project CD

8.3 Sensitivity Analysis

8.3.1 Introduction

A sensitivity analysis of the model was undertaken to determine the impact of chosen parameters on model behaviour. Recharge, permeability and storage coefficients are the main parameters that can impact on model predictions. The sensitivity of the model to recharge and permeability is addressed in the calibration process outlined in **Section 7.2**. Further analysis of the sensitivity of the model to storage coefficients was undertaken and is presented in **Section 8.2.2.**

8.3.2 Storage Coefficient

Sensitivity of the model to storage coefficients was undertaken by adopting a maximum and minimum specific yield range to evaluate the unconfined aquifers. The model predictions were then assessed in comparison to the adopted specific yield values. Typical values range from 0.01 to 0.3, however values toward the low end of the range are considered appropriate for basalt (Freeze and Cherry 1979).

Modelling of the final year of the proposed modification (see **Figure 15**) was undertaken using specific yield values of 0.005, 0.01 and 0.05 for the basalt and fractured basalt zones, with all other parameters remaining constant. Model simulation found that convergence was not achieved with specific yield values below 0.005 and therefore this was the lowest specific yield value adopted. The basalt strata was chosen for the sensitivity analysis as this represents the largest rock structure within the model domain.

An evaluation of the predicted drawdown at three groundwater bores within the predicted impact zone, MW1, MW5 and MW12, was evaluated and provided the following results:

Bore ID	Specific yield			Maximum change (m)
	0.005	0.01	0.05	
GW902030	17.5m	15m	12.5m	2.5m
MW5	2.0m	1.1m	0.1m	1.0m
MW12	0.15m	0.05m	<0.05m	0.1m

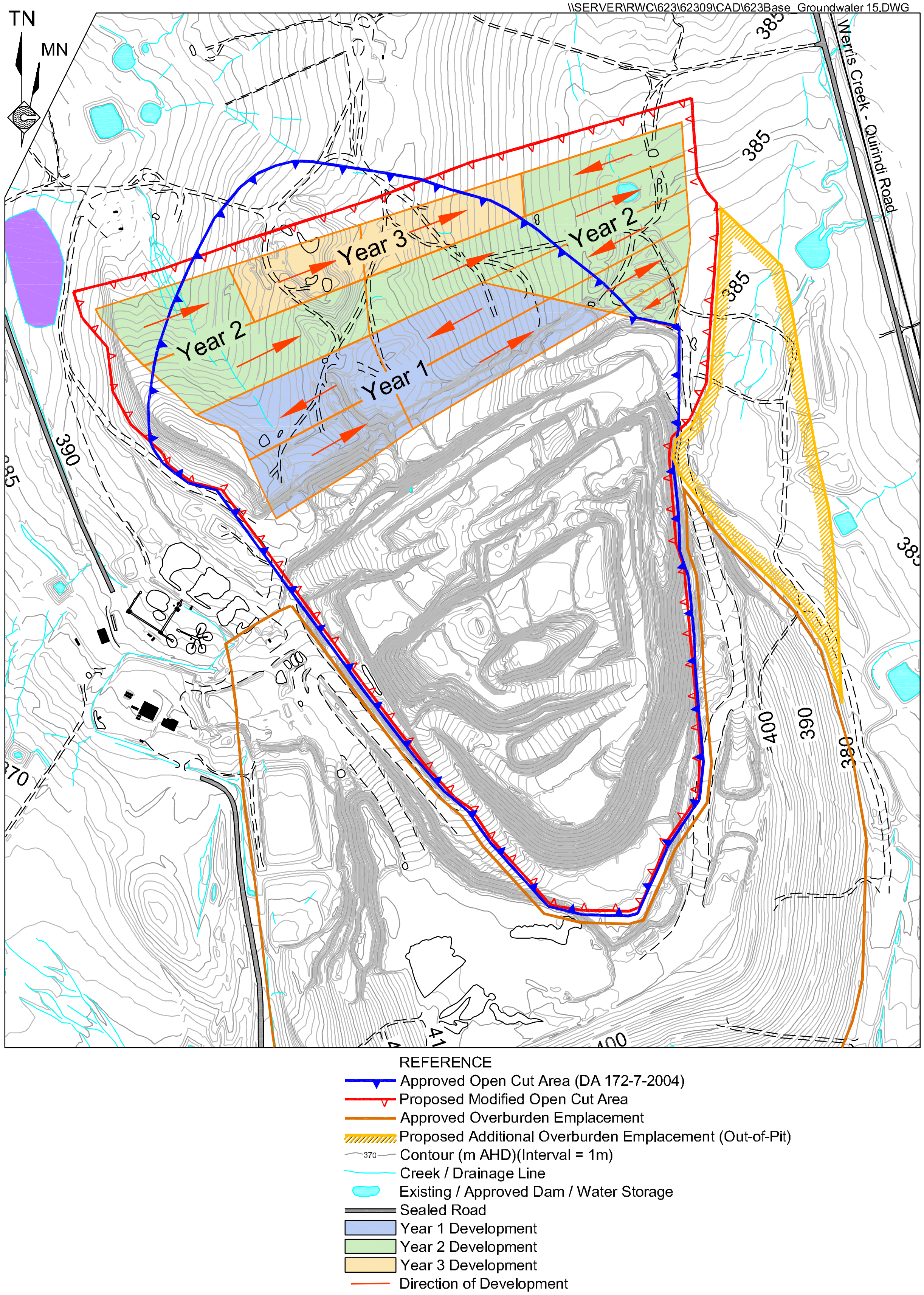
The results indicate that the model is sensitive to the specific yield value adopted for the basalt rock strata. The adoption of 0.01 for model simulation is considered reasonable and is in the mid-range of the possible values.

9. PREDICTED IMPACTS OF THE PROPOSED MODIFICATION

9.1 Predicted Drawdown on the Regional Water Table

9.1.1 Calibrated Model Predictions

The drawdown in the regional water table predicted by the model at the completion of Year 1 and Year 3 is presented in **Figure 16** and **Figure 17**. These figures reflect drawdown in Layer 3 of the model which is representative of most groundwater bores in the local area. The predicted impact on groundwater bores surrounding the mine site is tabulated in **Table 8**. Drawdown at bores can be expressed as a reduction in saturated thickness which provides a useful relationship between the drawdown and the depth of water within the bore (saturated thickness). Reduction in saturated thickness can impact on bore yield by reducing the head of water available for pumping.

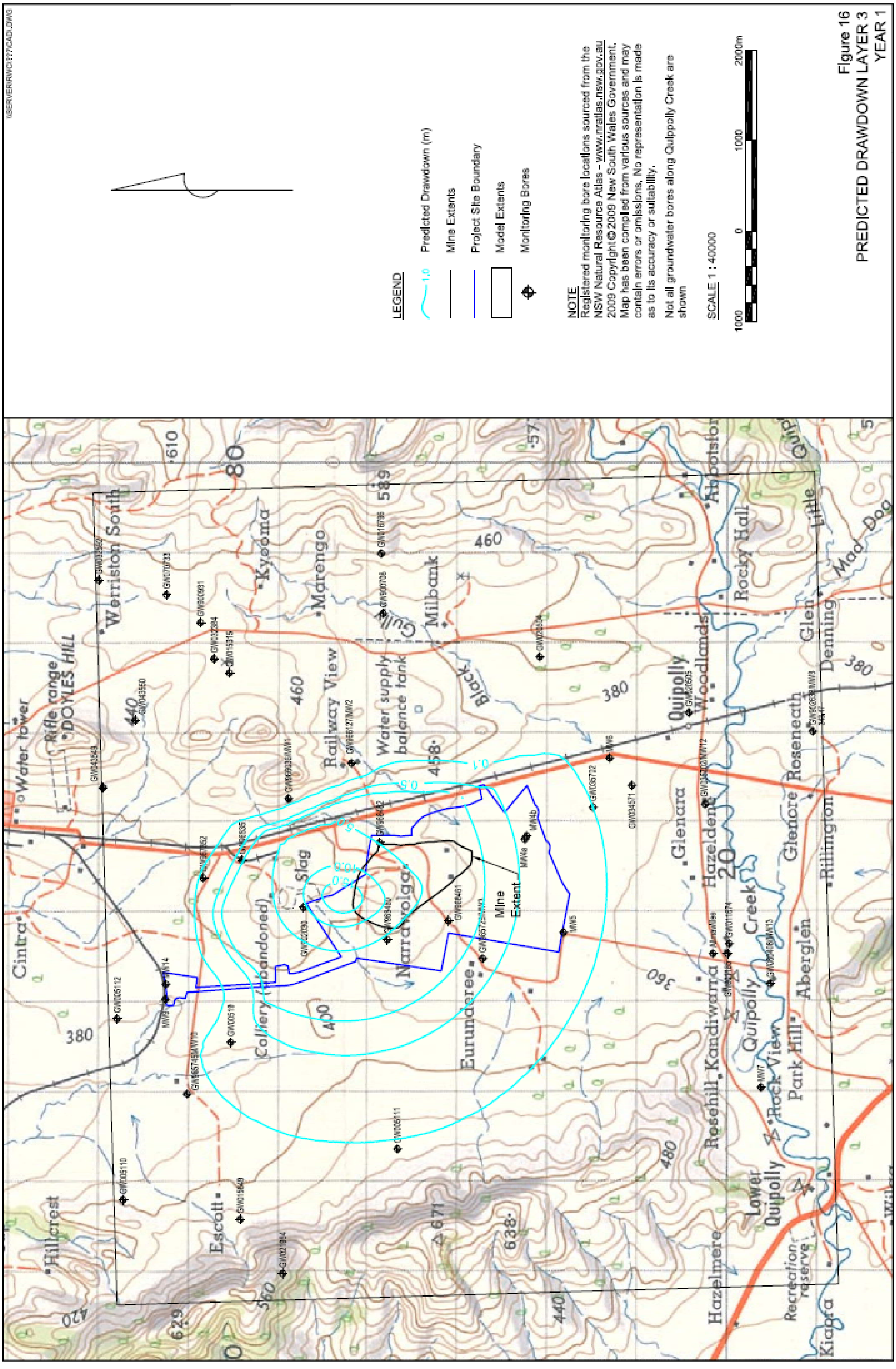


SCALE 1:10 000

100 0 100 200 300 400 500 m

Mine Design Source: Roche Mining

Figure 15
OPERATIONAL SEQUENCE

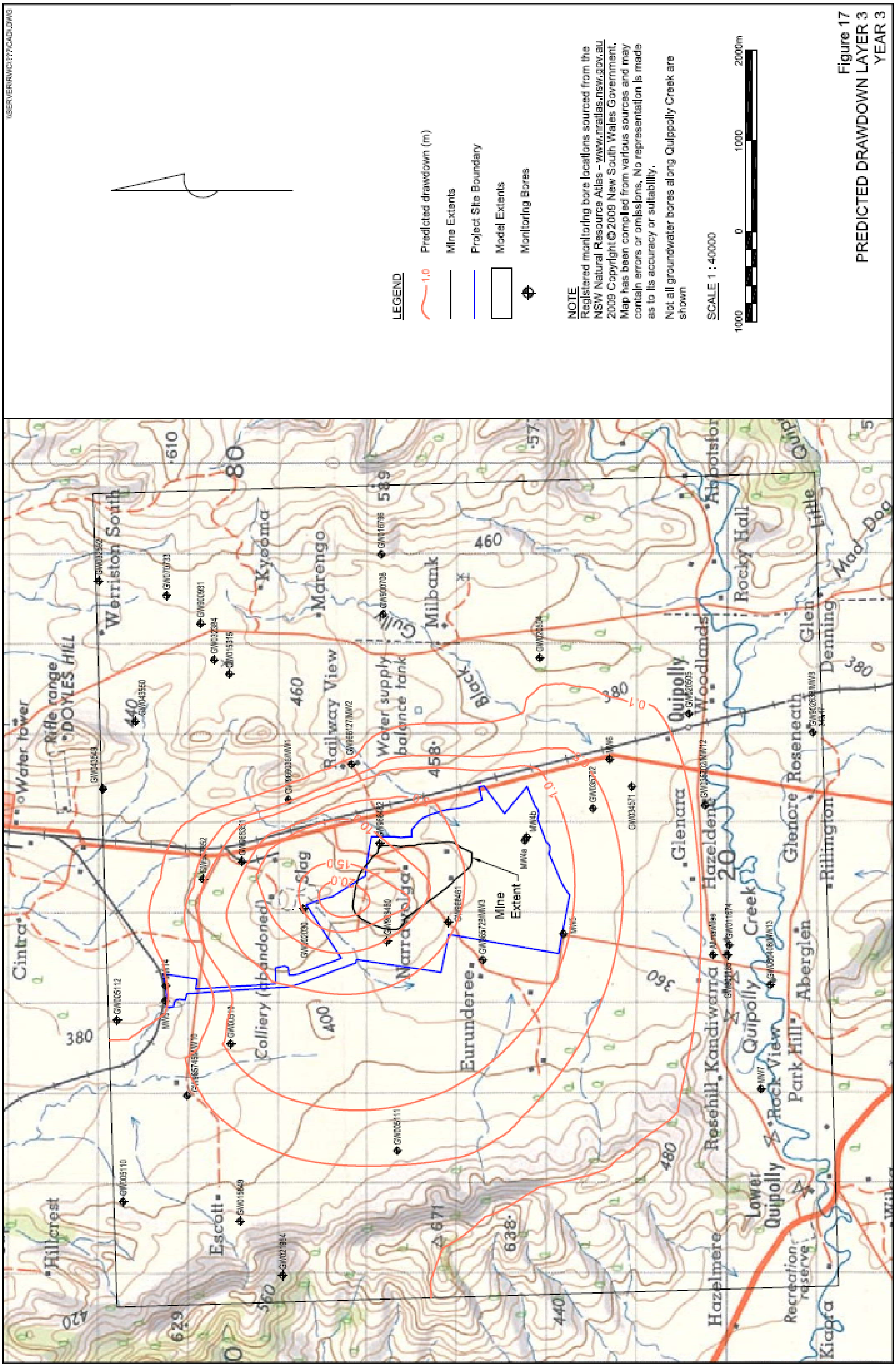


NOTE
Registered monitoring bore locations sourced from the NSW Natural Resource Atlas - www.nratlas.nsw.gov.au 2009 Copyright ©2009 New South Wales Government. Map has been compiled from various sources and may contain errors or omissions. No representation is made as to its accuracy or suitability.

Not all groundwater bores along Quipolly Creek are shown

Figure 16
PREDICTED DRAWDOWN LAYER 3
YEAR 1

Note: A colour version of this figure is included on the Project CD



NOTE
Registered monitoring bore locations sourced from the NSW Natural Resource Atlas – www.nratlas.nsw.gov.au 2009 Copyright © 2009 New South Wales Government. Map has been compiled from various sources and may contain errors or omissions. No representation is made as to its accuracy or suitability.

Not all groundwater bores along Quipolly Creek are shown

Figure 17
PREDICTED DRAWDOWN LAYER 3
YEAR 3

Note: A colour version of this figure is included on the Project CD

Modelling has predicted that drawdown of greater than 20m may occur as a result of dewatering the underground mine workings. The drawdown is the greatest to the north east of the mine extents as a consequence of this dewatering. Drawdown of up 0.5m is predicted to occur up to 2km from the open cut and is predicted to be greatest to the west of the mine site through the area of higher permeability. Modelling undertaken in 2004 for the previously approved mine plan predicted a drawdown of 0.2m up to 2km from the open cut.

At the completion of operations, the mine site is to be rehabilitated to a final landform (see **Figure 18**). To predict the final landform groundwater regime and the time taken to reach this regime, the model allowed re-saturation of the mine void and underground mine workings. The mine void was backfilled with overburden. Modelling indicates that complete recovery of the water table occurs. The transient model analysis shows that approximately 75% of the recovery occurs within 24 years.

The predicted long-term groundwater condition compared to the initial condition is shown on **Figure 19**.

9.1.2 Predicted Groundwater Seepage to Operation Area

Based on the model simulations, the seepage to the void at the completion of mining stages is presented in **Table 9**.

Table 9
Total Seepage to the Void

Time Period	Year 1	Year 3
Flow Total (m^3/day)	580	215
Annual In-flow (ML/year)	211.7	78.5

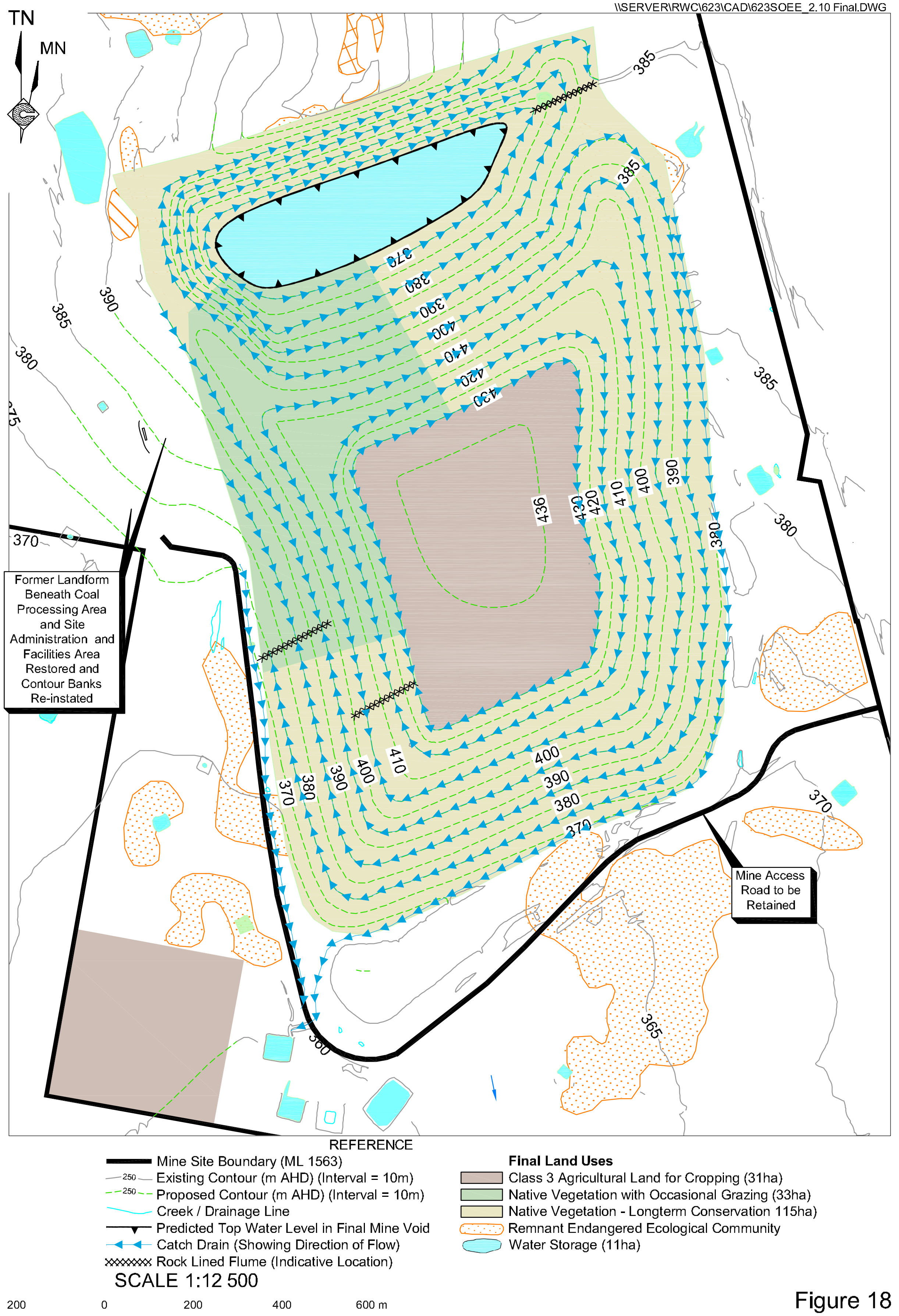
The flow to the mine void is expected to decrease from current operations over the first year as a result of dewatering the adjacent mine workings. Groundwater flow through the coal measures from the underground workings currently occurs and provides continual seepage to the open cut operations. The lowering of the water table will reduce this seepage, as evidence by the Year 3 inflow prediction. The inflow rates determined are comparable with previous approximations (RCA 2004).

The evaporation rate for the area is approximately 1.9m/year (see **Section 5.2**). Multiplying this evaporation rate over the footprint of the mining extent indicates that the evaporation rate is in excess of the mine inflow rate. This suggests that little water is expected to remain within the void and the mine will be generally operate as a dry mine, as is the case with other coal mines in the area. Variations in climatic conditions may result in water make within the open cut from time to time with this water either pumped to one of two void water dams approved and constructed at surface or the proposed underground water dams (the water then being used for dust suppression across the mine site).

A Water Access Licence (WAL) is required for the interception of the groundwater table during operations. The predicted maximum groundwater make during operations is 212ML/year (see **Table 9**). This groundwater make is termed incidental water make by DWE and an aquifer interference licence is required. The DWE have identified that the site is located within the Phillips Creek, Mooki River, Quirindi Creek and Warrah Creek Water Sources 2004 Water Sharing Plan and therefore a water access licence for this water make is required. There is currently an embargo in place on the issuing of new licences however, the there is an exemption that allows the Minister to grant a new licence in certain circumstances. The exemption states:

“Water supply for a person where the Minister determines that a failure to supply the water would cause a prohibitively high social, economic or national security cost and the supply of the water will cause no more harm than minimal environmental harm to any aquifer, or its dependent ecosystems”.

An incidental water make licence is subjected to fees and charges by the DWE. The aquifer interference licence is issued for the life of the proposed modification, is relinquished at the proposed modification completion and is not transferable.



Former Landform Beneath Coal Processing Area and Site Administration and Facilities Area Restored and Contour Banks Re-instated

Mine Access Road to be Retained

Base Map Source: Geo-Spectrum (Australia) Pty Ltd

Figure 18
FINAL LANDFORM

9.2 Criteria for the Assessment of Groundwater Impact

The parameter adopted to assess groundwater impact is the percentage reduction in saturated thickness predicted at bores surrounding the mine site. This parameter represents the reduction of standing water within each monitoring or extraction bore. A typically accepted change in saturated thickness is 10% and is considered to be representative of variation from seasonal fluctuations.

Impacts on saturated thickness have been adopted to provide trigger levels to identify bores that are predicted to be impacted, and for which further evaluation will then be undertaken. A trigger level of 10% reduction in saturated thickness has been adopted to represent variations that are outside naturally occurring seasonal fluctuations. Note that this evaluation does not consider the available drawdown within the bore as this can vary from saturated thickness depending on the location of the pump within the well. Therefore, evaluation of available drawdown for bores identified by the above trigger levels will be undertaken as part of the baseline monitoring programme outlined in a Water Management Plan. Further evaluation also includes a determination of yield.

9.3 Assessment of Impacts

9.3.1 Groundwater Bores

The impacts on the groundwater regime surrounding the mine site from the proposed modification were assessed using the calibrated groundwater model.

Modelling predicts that a 0.5m drawdown in the water table occurs up to 2km from the maximum extent of mining. A decrease in the water table of in excess of 20m may occur in the vicinity of the underground workings, to the northeast of the extent of mining.

The predicted reduction in saturated thickness was calculated for bores surrounding the mine site (see **Table 8**). A variation in saturated thickness of 10% was considered to represent a variation outside of naturally occurring variations and is the adopted trigger criteria for the evaluation of bore impact.

Reductions exceeding the adopted trigger criteria were observed at bores located on the ‘Old Colliery’, ‘Preston Park’, ‘Eurunderee’, ‘Escott’, ‘Mountain View’ and ‘Parkhill’ properties refer to **Table 8**.

Losses exceeding the adopted trigger criteria were observed at bores located on the ‘Old Colliery’, ‘Preston Park’, ‘Eurunderee’, ‘Escott’, ‘Mountain View’ and ‘Parkhill’ Properties.

The higher reductions in saturated thickness at bores on the ‘Escott’, ‘Mountain View’ and ‘Park Hill’ properties is related to the very low initial saturated thickness of these bores. The predicted loss in head at these bores is 0.4m, <0.1m and <0.1m respectively. The predicted loss in head is small and within expected seasonal levels of variation. Whilst the predicted loss in saturated thickness meets the trigger criteria, it is unlikely that any observable impacts will occur at these locations. These bores are therefore not considered to be impacted by the operations.

Reductions in saturated thickness above the adopted trigger criteria are also predicted at the ‘Old Colliery’, ‘Preston Park’, ‘Eurunderee’ properties. Notably, all three properties are owned by the Proponent with the impact on groundwater availability considered acceptable. Saturated thickness losses in bores on all other properties are predicted to be negligible and within the naturally occurring variation.

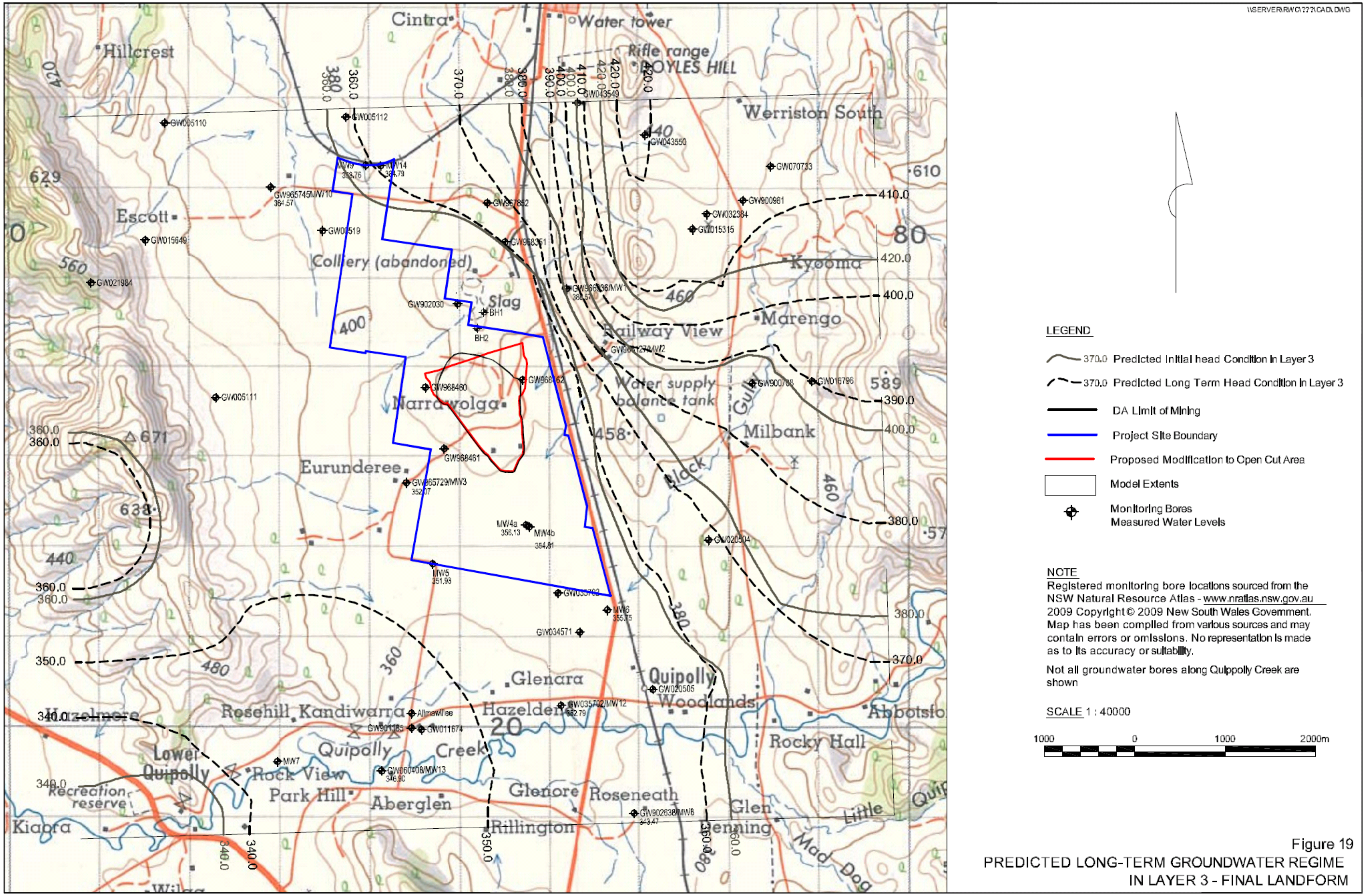


Figure 19
PREDICTED LONG-TERM GROUNDWATER REGIME IN LAYER 3 - FINAL LANDFORM

Table 8
Predicted Drawdown and Reduction in Saturated Thickness within the Model Domain

Bore No	Property	Easting	Northing	Usage	Approx. Distance from limit of proposed mining (m)	Total Depth (m)	Water Bearing Zone Strata	Yield (L/sec)	SWL @ (m)	Saturated Thickness (m)	Predicted reduction in head (m)	% Reduction in Saturated Thickness	Comments
GW902030	Old Colliery	275169	6524932	Domestic	880	96.6	Coal Measures		33.5	63.1	12.0	19.0	Tested 2004
GW968462	The Proponent	275892	6524087	Monitoring	40	61	Basalt	0.2	NK	NK	11	NK	Not Tested
GW968460	The Proponent	274815	6524004	Monitoring	60	42	Basalt	0.3	NK	NK	10	NK	Not Tested
GW968461	The Proponent	275022	6523326	Monitoring	300	25	Basalt	NK	NK	NK	6	NK	Not Tested
GW968351	Preston Park	275696	6525612	Domestic & Stock	1080	76.2	Basalt	1.26	47.8	28.4	3.8	13.3	Not Tested#
GW965729 (MW3)	Eurunderee	274598.573	6522940.562	Stock	600	39.6	Basalt	0.6	15.2	24.4	2.7	11.1	Tested 2008
MW4	The Proponent	275940.406	6522468.663	Monitoring	760	NK	Basalt	NK	8.9	NK	1.6	NK	Tested 2008
MW5	The Proponent	274899.53	6522045.794	Monitoring	1240	28	Basalt	NK	8.2	19.8	1.1	5.6	Tested 2008
GW005109	NK	273671	6525732	Domestic & Stock	1640	79.2	Basalt	NK	NK	NK	1.1	NK	Not Tested
GW967852	Cintra	275501	6526039	Domestic & Stock	1350	80	Shale	NK	NK	NK	0.9	NK	Not Tested
GW005111	NK	272495	6523889	NK	2400	88.4	Basalt	0.9	31.7	56.7	0.5	0.8	Tested 2004
GW966036 (MW1)	Hillview	276380	6525100	Domestic & Stock	1250	68.7	Basalt	0.9	51.1	17.6	0.4	2.3	Tested 2008
GW034571	NK	276516	6521295	NK	1650	14.6	NK	NK	NK	NK	0.4	NK	Not Tested
GW965745 (MW10)	Turnbulls	273130.606	6526225.377	Domestic	2760	22	Basalt	NK	18.2	3.8	0.4	10.5	Tested 2008
MW6	The Proponent	276810.332	6521543.945	Monitoring	1840	16	Basalt	NK	11.1	4.9	0.3	6.2	Tested 2008
GW015649	Escott	271717	6525628	Domestic & Stock	3200	76.2	Green rock	NK	NK	NK	0.25	NK	Not Tested
GW966127 (MW2)	Railway View	276770	6524400	Domestic & Stock	820	65.5	Basalt	0.37	27.3	38.2	0.2	0.5	Tested 2008
GW020505	Woodlands	277320	6520726	Stock	2050	23.8	Alluvial/Basalt	NK	NK	NK	0.2	NK	Not Tested
GW005110	NK	271927	6526927	NK	2300	18.3	Basalt	0.8	15.2	3.1	0.15	4.8	Not Tested#
GW021984	Escott	271120	6525153	Domestic & Stock	3670	42.7	NK	NK	NK	NK	0.15	NK	Not Tested
MW14	The Proponent	274322.59	6526453.984	Monitoring	2240	26	Basalt	NK	15.2	10.8	0.1	0.9	Tested 2008
MW9	The Proponent	274164.662	6526458.431	Monitoring	2280	28	Basalt	NK	13.5	14.5	0.1	0.7	Tested 2008
GW900708	Talavera	278418	6524040	Domestic & Stock	1935	192	Basalt	2.95	1.4	190.6	<0.1	<0.1	Tested 2004
GW020504	Woodlands	277947	6522311	Stock	2260	18.3	NK	NK	NK	NK	<0.1	NK	Not Tested
GW015315	Bill View	277768	6525758	Stock	2560	88.4	Basalt	0.23	9.1	79.3	<0.1	0	Not Tested#
MW11	Turnbulls Gap	272279.663	6528595.694	NK	2600	NK	Sandstone	NK	NK	NK	<0.1	NK	Not Tested
GW035072 (MW12)	Hazeldene	276311.81	6520485.888	Stock	2600	12.1	Alluvial	NK	7.6	4.5	<0.1	<2.2	Tested 2008
GW005112	NK	273935	6527001	NK	2650	48.8	Basalt	NK	NK	NK	<0.1	NK	Not Tested
GW043549	NK	276496	6527149	Stock	2700	21.9	NK	NK	NK	NK	<0.1	NK	Not Tested
#	Allmawillee	NK	NK	Domestic & Irrigation	2750	8.6	Alluvial	High *	5.9	2.7	<0.1	<3.7	Tested 2004
GW032384	Hillview	277923	6525916	Stock	2890	128.6	Basalt	0.2	66.4	62.2	<0.1	0.0	Not Tested#
GW011674	Gedhurst	274768	6520240	Domestic & Irrigation	2900	8.2	Alluvial	High *	7.1	1.1	<0.1	<9.1	Tested 2004
GW043550	NK	277244	6526795	Stock	2920	19.8	NK	NK	NK	NK	<0.1	NK	Not Tested
GW901185	Mountain View	274654	6520233	Domestic & Irrigation	3000	7.9	Alluvial	High *	7.0	0.9	<0.1	<11.1	Tested 2004
GW016796	Galla	279073	6524061	Stock	3220	28	Gravel	0.51	14	14	<0.1	<0.7	Not Tested
GW900981	Kyooma	278327	6526072	Stock	3340	210	Conglomerate	0.4	22	188	<0.1	0	Not Tested#
GW060408 (MW13)	Parkhill	274326.818	6519749.708	Irrigaton	3560	5.5	Alluvial	NK	5.1	0.4	<0.1	<26	Tested 2008
GW070733	Werriston Sth	278634	6526449	Stock	3800	56.3	Basalt	1.76	17	39.3	<0.1	<0.3	Not Tested#
GW902638 (MW8)	Roseneath	277124.049	6519282.16	Domestic & Stock	4000	42.7	Basalt	0.31	16.0	26.7	<0.1	<0.4	Tested 2008
GW966349 (MW7)	Rosehill	273180.55	6519843.721	Domestic & Stock	4040	NK	Alluvial	NK	4.4	NK	<0.1	NK	Tested 2008
GW032592	NK	278795	6527198	Stock	4410	57.9	Basalt	0.8	22.3	35.6	<0.1	<0.3	Not Tested#

@ SWL (Standing Water Level): Not Tested - Testing not attempted, NK – not known # Taken from Department of Natural Resources. ^ Determined from modelling.. * Based on field observations and discussions with owners (2004)

At the completion of the proposed modification, the mine site is to be rehabilitated for a final long-term land use of native vegetation conservation with some agricultural activities. Modelling predicts that a 75% recovery of the water table is achieved within approximately 24 years. The remaining 25% recovery is predicted to occur over a significant timeframe (approximately 100 years) and therefore, when assessing impacts, it should be considered that only a 75% recovery occurs.

9.3.2 Impact on Alluvium of Quipolly Creek

An evaluation of the reduction of groundwater flow to the alluvium of Quipolly Creek was undertaken. Quipolly Creek is assigned a 'stream' function within the model and the reduction to this system can be directly calculated. **Table 10** presents a comparison between flow contribution before and after mining.

Table 10
Groundwater Contribution to Quipolly Creek

Time Period	Flow Total (m^3/day)
Pre mining and current condition	648
Year 1 of mining	583
Year 3 of mining	541
5 years post completion	488
10 years post completion	508
15 years post completion	565
20 years post completion	629
30 years post completion	687
40 years post completion	738
50 years post completion	782

The flow rates presented in **Table 10** indicate that the current contribution of groundwater to Quipolly Creek is 648m^3/day within the model domain. A maximum reduction in groundwater flow to the Creek is predicted to occur approximately five years after completion of mining. Full recovery of the groundwater contribution occurs between 20 and 30 years after the completion of mining.

The maximum reduction in groundwater flow to Quipolly Creek is predicted to be 160m^3/day or 58ML/year. An evaluation of the previously approved mine plan predicted a groundwater flow reduction of 36ML/year to Quipolly Creek. The proposed modification represents an incremental loss to the Quipolly Creek system. Quipolly Creek is a regulated water source under the Water Sharing Plan for the Phillips Creek, Mooki River, Quirindi Creek and Warrah Creek Water Sources 2004. A Water Access Licence for this groundwater consumption will therefore be required.

The long-term groundwater flow predictions indicate that the groundwater contribution to Quipolly Creek will increase in excess of the predicted pre-mining groundwater contribution. This is a consequence of increased infiltration occurring within the replaced overburden.

9.3.3 Impact on Groundwater Dependent Ecosystems

No groundwater dependent ecosystems (GDEs) are identified within the Water Sharing Plan for the Phillips Creek, Mooki River, Quirindi Creek and Warrah Creek Water Sources 2004.

This notwithstanding, the following assessment of impact on groundwater which could contribute to the health of a GDE, is considered.

The proposed modification is predicted to impact on groundwater within the alluvium and fractured rock aquifer. The depth to groundwater in the aquifer at the mine site and surrounds is variable and in the order of between 5m and 50m from the surface. Groundwater in the vicinity of the site has not been observed to form perched water tables or springs and groundwater dependent ecosystems are therefore not likely impacted from drawdown effects within the hard rock aquifer.

Groundwater discharge from the basalt aquifer does impact on groundwater within the alluvium. The predicted reduction in head within the alluvium is <0.1m and is with the expected seasonal fluctuations of the aquifer. A reduction in groundwater discharge of 25% is predicted for Quipolly Creek. This variation is also within seasonal fluctuations as Quipolly Creek is described as a highly variable creek with flows varying from no flow to over 1 000ML/day.

9.3.4 Impact on Water Quality

Groundwater is utilised at sites surrounding the mine site for the purpose of irrigation and stock watering. Changes to water quality can occur as a result of significant movement in the water table resulting in oxidation of some compounds and changes to the chemical composition.

Oxidation of pyritic compounds within the coal seams may occur and could result in a decrease of groundwater pH and subsequent release of metals. Further protection of water quality is discussed in **Section 10**.

9.4 Mitigation Measures

The focus on the mitigation measures relevant to the proposed modification relate principally to the replacement of the quantity of water that is predicted to be “lost” by a landowner as a result of groundwater drawdown caused by the proposed modification.

The principal mitigation measure recommended is the deepening of existing bores to intercept groundwater lower in the aquifer to re-instate the previous yield. In some cases, it may be necessary to drill a new groundwater bore. Confidence in this prediction of bore yield restoration is provided by geological information for the area which has identified the presence of significant depth of hard rock that would be unaffected by the proposed modification.

9.5 Summary of Residual Impacts

The results of the modelling analysis indicate that a 0.5m drawdown of the water table may occur up to 2km from the limit of open cut mining over the life of the proposed modification. Groundwater bores located on ‘Old Colliery’, ‘Preston Park’ and ‘Eurunderee’ properties are located within this zone of impact and are predicted to be impacted above the trigger criteria of a 10% reduction in saturated thickness. However, as these properties are owned by the Proponent, the impact is considered acceptable.

If required, the predicted impacts could be substantially mitigated through the installation of additional or deeper groundwater bores at the impacted properties to replace any reduction in yield from groundwater bores arising from the proposed modification. Geological information for the mine site and surrounds indicates that suitable aquifers occur within the fractured rock and are present at depths able to supply supplementary water supply.

10. PROTECTION OF GROUNDWATER

10.1 Groundwater Management Plan

A groundwater management plan has been prepared for the management of groundwater as part of a Site Water Management Plan. No change in the groundwater component of management plan is considered necessary as a consequence of the proposed modification.

10.2 Groundwater Monitoring

Groundwater monitoring is currently being undertaken by GeoTerra on behalf of the Proponent. No modification to the Groundwater Monitoring Programme is recommended.

11. ASSESSMENT AGAINST DWE REQUIREMENTS AND STATE GROUNDWATER POLICY DOCUMENTS

The mine site is located within an embargoed groundwater resource area. A Water Access Licence is required to be sought under the Water Management Act 2000. **Table 11** identifies the key principles of the Water Act 1912 and the Water Management Act 2000, and directs the reader to the relevant section within this document.

Table 11
Assessment of Proposal in Accordance with the Relevant Acts

Principle	Comments
Identification of the relevant groundwater system	Section 5.7 details the groundwater system that would be encountered by the proposed modification.
Evaluation of the impact on the groundwater system	A hydrogeological study has been completed. The impact assessment is presented in **Section 9**.
Evaluation of the incidental water make by the proposal	The hydrogeological study undertaken included a prediction of incidental water make and is presented in **Section 9.1.2**.
Measures to ensure the protection of groundwater quality during operations	A Water Management Plan has been developed. Ongoing groundwater monitoring in accordance with this plan will continue.
Evaluation of impact on groundwater dependent ecosystems.	There are no groundwater dependent ecosystems identified at the mine site and surrounds. Further details are presented in **Section 8.3.3.**

12. CONCLUSION

A three dimensional model domain has been developed to predict the extent of impact from the proposed modification to the mining area and development of the Werris Creek Coal Mine. Modelling has predicted that a 0.5m drawdown in the water table will occur up to 2km from the limit of open cut mining.

A reduction in saturated thickness above the adopted trigger criteria of 10% was exceeded at bores on three properties not owned by the Proponent. This exceedance of the 10% trigger level was determined to be a consequence of the very low initial saturated thickness and has been assessed as unlikely to have any significant impact on the yield of these bores. Similar impacts were predicted from modelling of the approved mine plan.

It would however, be possible for the Proponent to mitigate predicted reduction in saturated thickness through the installation of new and/or deeper groundwater bores. Available geological information for the mine site and surrounds indicates that a suitable groundwater aquifer is present at depth within fractured rock.

The impacts of groundwater flow to Quipolly Creek indicate a reduction in groundwater flow, estimated at 58ML/year. This is an incremental increase on the predicted loss for the approved mine operation plan. Quipolly Creek is within a Water Sharing Area and a licence the Water Management Act 2000 will be required for this groundwater interference.

13. REFERENCES

ANZECC (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality, October 2000.

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Martin O'Rourke, Personal Correspondence, Department of Water and Energy, Tamworth.

APPENDICES

(No. of pages excluding this page = 29)

Appendix 1: Werris Creek Coal Mine, Groundwater Quality Evaluation, RCA 2009.

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Appendix 1

Werris Creek Coal Mine, Groundwater Quality Evaluation, RCA 2009

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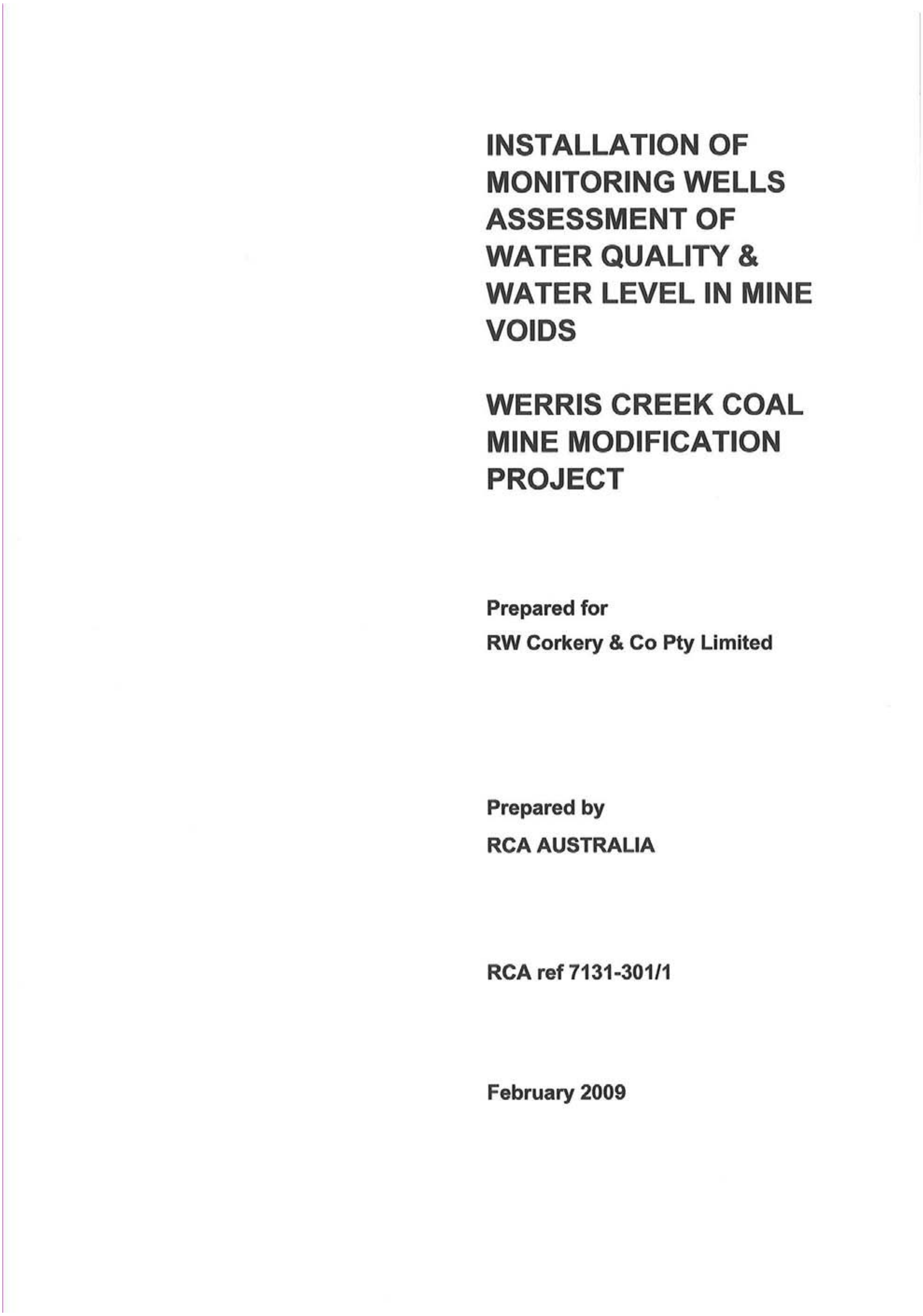

INSTALLATION OF MONITORING WELLS ASSESSMENT OF WATER QUALITY & WATER LEVEL IN MINE VOIDS

WERRIS CREEK COAL MINE MODIFICATION PROJECT

Prepared for
RW Corkery & Co Pty Limited

Prepared by
RCA AUSTRALIA

RCA ref 7131-301/1

February 2009

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DOCUMENT STATUS

Rev No	Comment	Author	Reviewer	Approved for Issue (Project Manager)		
				Name	Signature	Date
/0	Final	C Handebo	F Robinson	F Robinson		23.01.09

DOCUMENT DISTRIBUTION

Rev No	Copies	Format	Issued to	Date
/0	1	Electronic (email)	RW Corkery & Co Limited – Alex Irwin - rob@rwcorkery.com	23.01.09
/0	1	Electronic (CD)	RW Corkery & Co Limited – Alex Irwin	23.01.09
/0	1	Bound report	RW Corkery & Co Limited – Alex Irwin	23.01.09
/0	1	Bound report	RCA – job archive	23.01.09
/0	1	Electronic report	RCA – job archive	23.01.09
/1	1	Electronic (email)	RW Corkery & Co Limited – Alex Irwin – rob@rwcorkery.com	17.02.09
/1	1	Electronic	RCA – job archive	17.02.09

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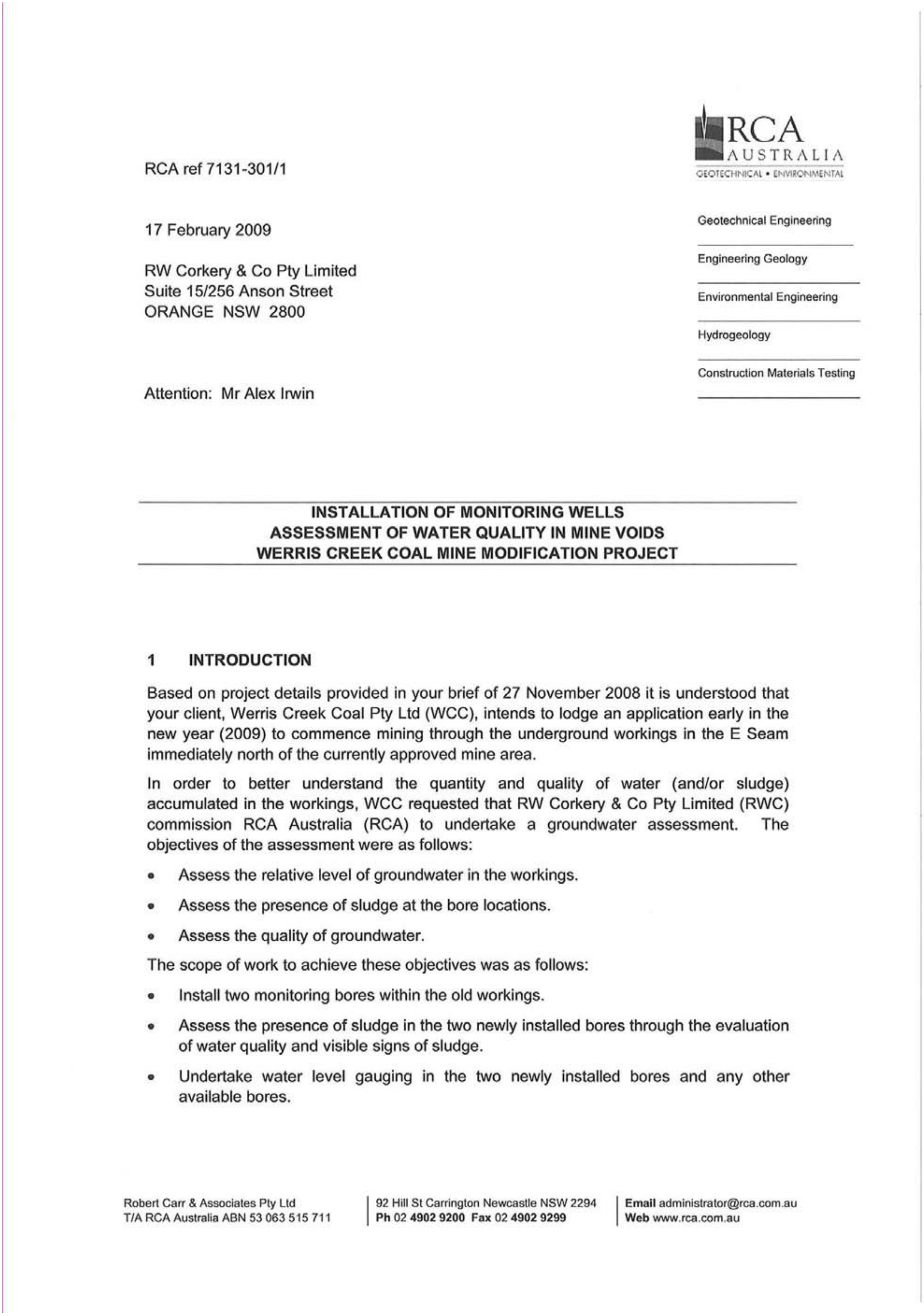

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Geotechnical Engineering
Engineering Geology
Environmental Engineering
Hydrogeology
Construction Materials Testing

RCA ref 7131-301/1

17 February 2009

RW Corkery & Co Pty Limited
Suite 15/256 Anson Street
ORANGE NSW 2800

Attention: Mr Alex Irwin

INSTALLATION OF MONITORING WELLS
ASSESSMENT OF WATER QUALITY IN MINE VOIDS
WERRIS CREEK COAL MINE MODIFICATION PROJECT

1 INTRODUCTION

Based on project details provided in your brief of 27 November 2008 it is understood that your client, Werris Creek Coal Pty Ltd (WCC), intends to lodge an application early in the new year (2009) to commence mining through the underground workings in the E Seam immediately north of the currently approved mine area.

In order to better understand the quantity and quality of water (and/or sludge) accumulated in the workings, WCC requested that RW Corkery & Co Pty Limited (RWC) commission RCA Australia (RCA) to undertake a groundwater assessment. The objectives of the assessment were as follows:

- Assess the relative level of groundwater in the workings.
- Assess the presence of sludge at the bore locations.
- Assess the quality of groundwater.

The scope of work to achieve these objectives was as follows:

- Install two monitoring bores within the old workings.
- Assess the presence of sludge in the two newly installed bores through the evaluation of water quality and visible signs of sludge.
- Undertake water level gauging in the two newly installed bores and any other available bores.

Robert Carr & Associates Pty Ltd
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- Collect water samples from the two newly installed bores and analyse for pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), major cations and anions and thirteen (13) metals.

Data provided in relation to the project was provided to RCA by Lynden Cini of WCC and comprised:

- underground working contour drawing;
- surface contour drawing;
- test drilling report.

2 METHODOLOGY

Bore locations were determined by referencing survey drawings of the underground workings. It was understood that the original survey of the underground workings contained an offset of approximately +/- 10m. Additionally it was understood that there may be discrepancies in the orientation of the plan potentially causing any errors involved to be amplified from north to south.

It was also understood that the eastern arm of the old workings had been previously drained following the encroachment of current open cut mining operations and that the water in the void was contained below the 346m RL contour.

Potential bore locations were determined with regard to constraints and based on access requirements and probability of locating underground workings and are shown on **Drawing 1**, **Appendix A**.

Drilling and well installation was carried out on 17 and 18 December 2008. Drilling was undertaken by Mannion Drilling with a 100mm diameter down hole hammer rig.

Bore positions were located on site with a hand held GPS unit based on coordinates obtained from the underground workings survey supplied.

With reference to relative levels (RLs) indicated on survey drawings provided, it was anticipated that BH1 would encounter the void at approximately 84m below ground level (bgl) and BH2 would encounter the void at approximately 115m (bgl).

BH1 encountered a water filled void from 102m to 105m bgl. BH2 encountered a water filled void from 117m to 122m bgl.

Groundwater monitoring wells were constructed from Class 18 PVC with glued fittings, sealed base and a 6m slotted section extending to 6m above the void floor. The bores were sealed via promoted bridging 12m above the void floor with a bentonite and cement seal. Bores were backfilled with soil and finished at the surface with a lockable steel monument.

Monitoring wells were surveyed following installation to determine well location and relative levels. Monitoring well locations are shown on **Drawing 1** attached.

All holes were logged from drill cuttings and bore logs are attached in **Appendix B**.

An environmental engineer experienced in the handling of potentially contaminated groundwater undertook the sampling on 13 January 2009 with the assistance of a technician. Sampling was undertaken approximately four weeks following bore installation to allow time for bores to equilibrate.

The water levels were gauged using an electronic dip meter and recorded on field sheets. The depth of sludge was estimated by the height of sludge evident on the groundwater pump and the turbidity of the sample collected. The pump had been drawn through a long water column which affects the estimate. However, this is considered to provide a reasonable indication of solids presence.

The collection of all soil and groundwater samples was undertaken in compliance with RCA methodology, which forms part of our accreditation. Groundwater collection was by an air driven pump operated at a low flow rate due to the requirement for limited disturbance in order to sample the water column from within the void. Water quality results were taken with a Horiba U10 Analyser to ensure that a representative sample was collected. Results are recorded on field sheets, **Appendix C**.

No decontamination of the pump was undertaken, however a significant volume of bore water was flushed through the pipe at each bore and the potential for cross-contamination to occur is considered to be minimal.

The laboratory analysis of all groundwater samples for pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), major cations and anions and thirteen (13) metals was undertaken by Labmark, which is NATA accredited and experienced in the analytical requirements for soil and groundwater.

3 QUALITY CONTROL

3.1 QUALITY ASSURANCE

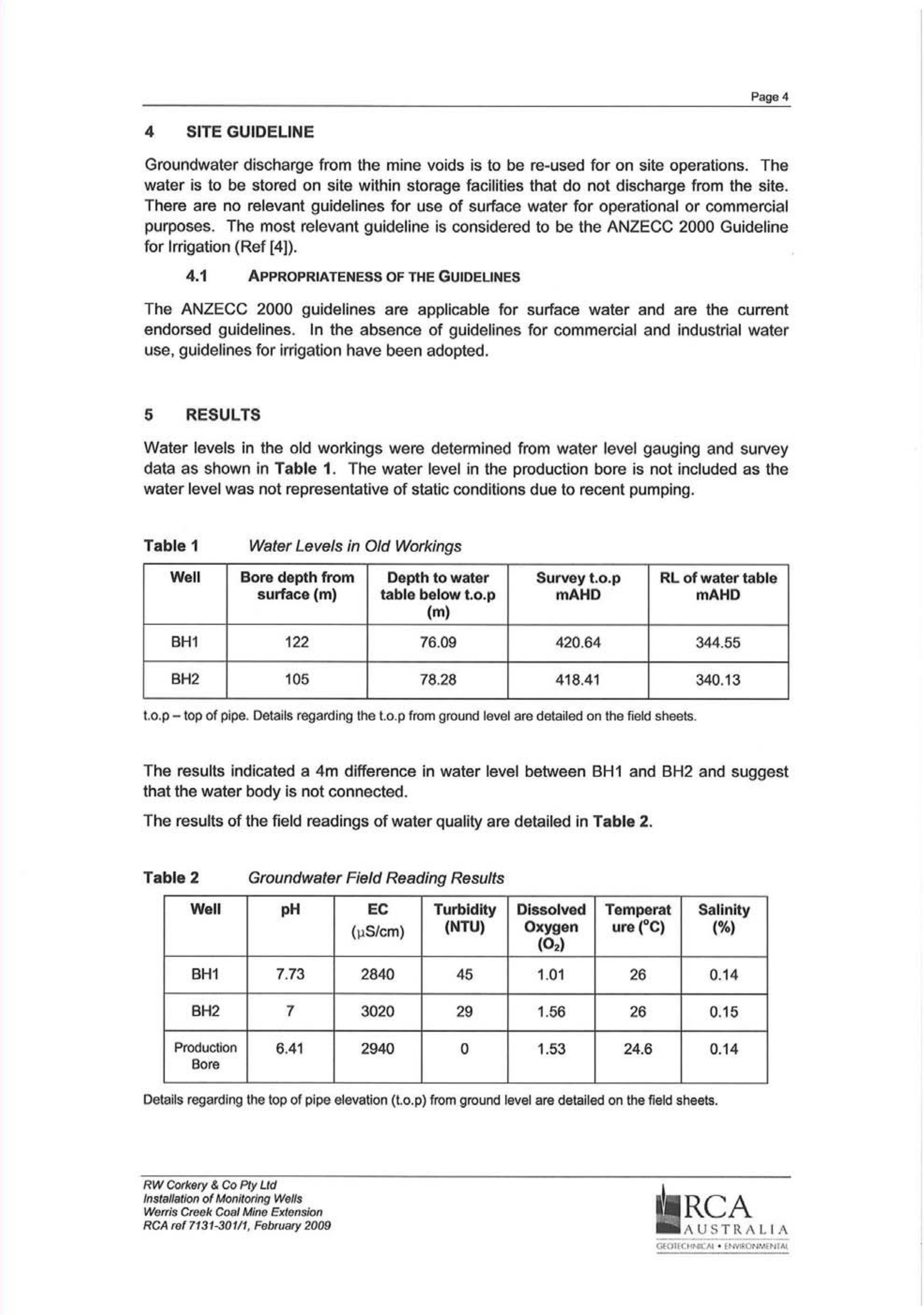
All samples were preserved as recommended by the analytical laboratory and stored in the field in an Esky on ice (at approximately 4°C). Samples were stored in a refrigerator until transport to the laboratory.

All samples were sent under Chain of Custody (COC) documentation detailing the sample identification, required analysis, the name of the sampler and date released from custody. The laboratory acknowledged the receipt of samples by signature and date and returned the COC with a sample receipt notice indicating the condition of the samples received upon receipt.

One (1) groundwater duplicate sample was submitted blind to the laboratory for analysis with the samples. This represents a percentage of greater than 10%, in accordance with the Australian Standard and RCA protocol.

Results indicate no groundwater analyses reported an RPD in excess of the acceptance criteria.

In summary, quality control data for the groundwater samples complied with RCA's quality protocols for the environmental assessment and demonstrates that the results are free of systematic and method biases. The evaluation is presented in, **Appendix D**



4 SITE GUIDELINE

Groundwater discharge from the mine voids is to be re-used for on site operations. The water is to be stored on site within storage facilities that do not discharge from the site. There are no relevant guidelines for use of surface water for operational or commercial purposes. The most relevant guideline is considered to be the ANZECC 2000 Guideline for Irrigation (Ref [4]).

4.1 APPROPRIATENESS OF THE GUIDELINES

The ANZECC 2000 guidelines are applicable for surface water and are the current endorsed guidelines. In the absence of guidelines for commercial and industrial water use, guidelines for irrigation have been adopted.

5 RESULTS

Water levels in the old workings were determined from water level gauging and survey data as shown in **Table 1**. The water level in the production bore is not included as the water level was not representative of static conditions due to recent pumping.

Table 1 *Water Levels in Old Workings*

Well	Bore depth from surface (m)	Depth to water table below t.o.p (m)	Survey t.o.p mAHD	RL of water table mAHD
BH1	122	76.09	420.64	344.55
BH2	105	78.28	418.41	340.13

t.o.p – top of pipe. Details regarding the t.o.p from ground level are detailed on the field sheets.

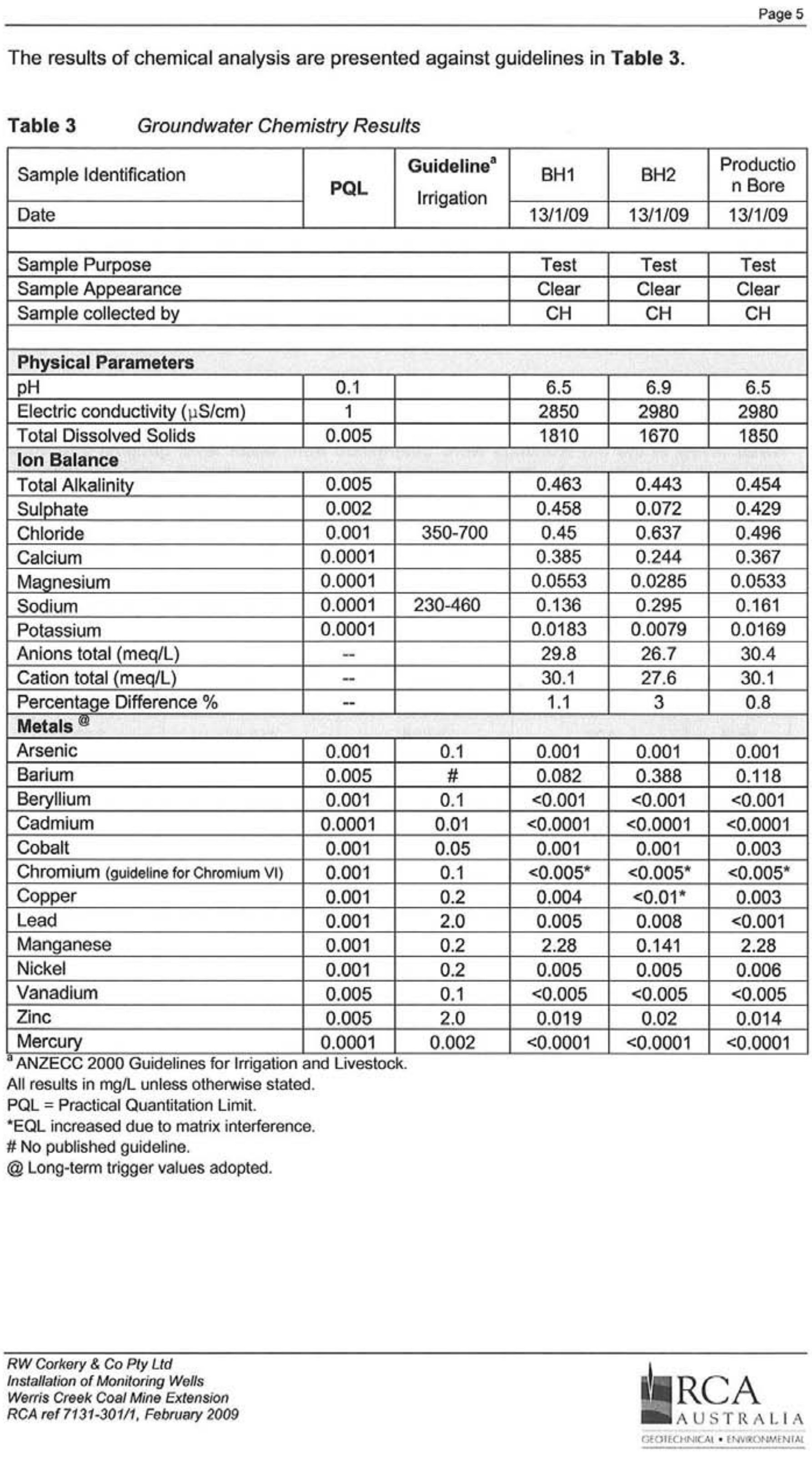
The results indicated a 4m difference in water level between BH1 and BH2 and suggest that the water body is not connected.

The results of the field readings of water quality are detailed in **Table 2**.

Table 2 *Groundwater Field Reading Results*

Well	pH	EC (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (O_2)	Temperature (°C)	Salinity (%)
BH1	7.73	2840	45	1.01	26	0.14
BH2	7	3020	29	1.56	26	0.15
Production Bore	6.41	2940	0	1.53	24.6	0.14

Details regarding the top of pipe elevation (t.o.p) from ground level are detailed on the field sheets.

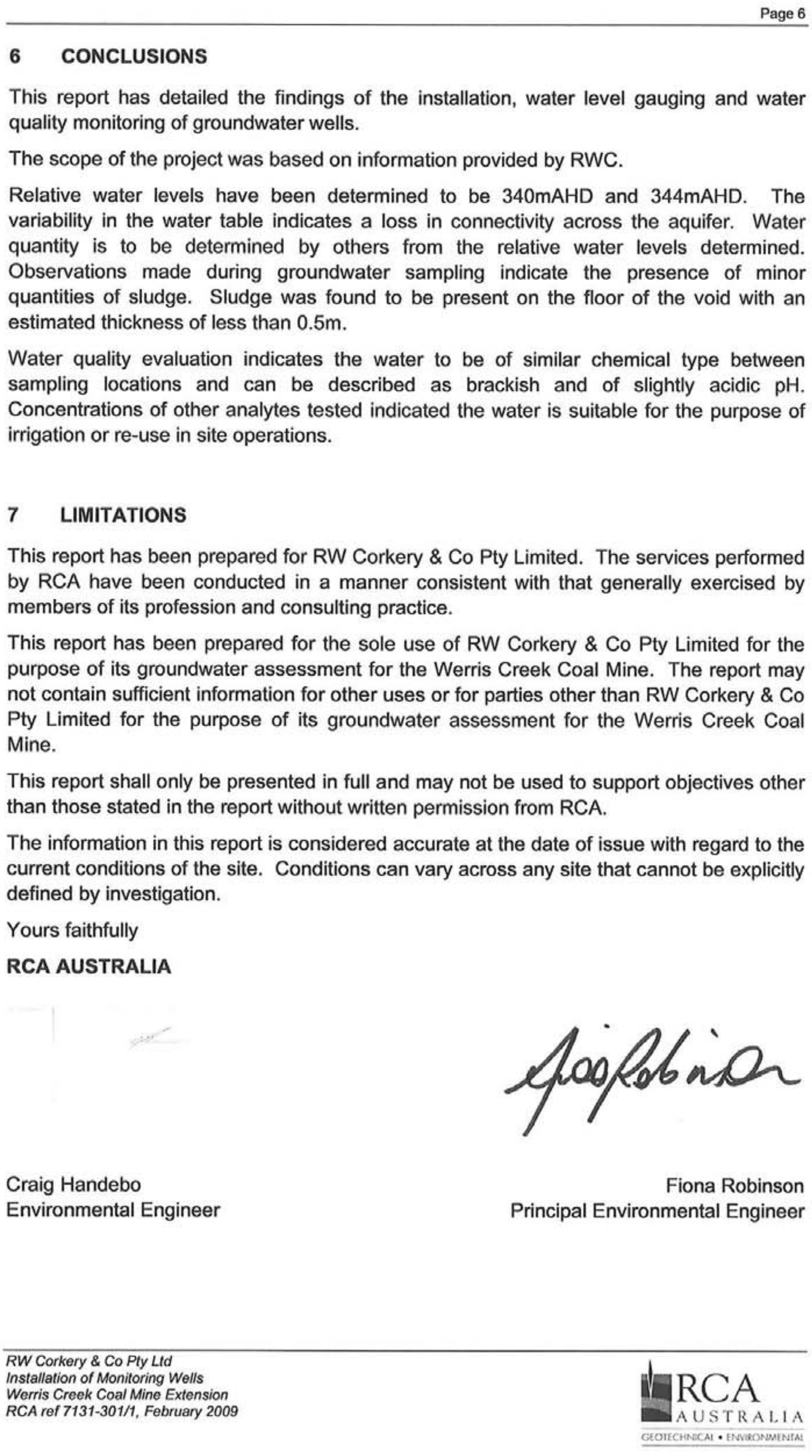


The results of chemical analysis are presented against guidelines in **Table 3**.

Table 3 *Groundwater Chemistry Results*

Sample Identification	**PQL**	**Guideline**[a] Irrigation	BH1	BH2	Production Bore
Date			13/1/09	13/1/09	13/1/09
Sample Purpose			Test	Test	Test
Sample Appearance			Clear	Clear	Clear
Sample collected by			CH	CH	CH
Physical Parameters					
pH	0.1		6.5	6.9	6.5
Electric conductivity (µS/cm)	1		2850	2980	2980
Total Dissolved Solids	0.005		1810	1670	1850
Ion Balance					
Total Alkalinity	0.005		0.463	0.443	0.454
Sulphate	0.002		0.458	0.072	0.429
Chloride	0.001	350-700	0.45	0.637	0.496
Calcium	0.0001		0.385	0.244	0.367
Magnesium	0.0001		0.0553	0.0285	0.0533
Sodium	0.0001	230-460	0.136	0.295	0.161
Potassium	0.0001		0.0183	0.0079	0.0169
Anions total (meq/L)	--		29.8	26.7	30.4
Cation total (meq/L)	--		30.1	27.6	30.1
Percentage Difference %	--		1.1	3	0.8
Metals [@]					
Arsenic	0.001	0.1	0.001	0.001	0.001
Barium	0.005	#	0.082	0.388	0.118
Beryllium	0.001	0.1	<0.001	<0.001	<0.001
Cadmium	0.0001	0.01	<0.0001	<0.0001	<0.0001
Cobalt	0.001	0.05	0.001	0.001	0.003
Chromium (guideline for Chromium VI)	0.001	0.1	<0.005*	<0.005*	<0.005*
Copper	0.001	0.2	0.004	<0.01*	0.003
Lead	0.001	2.0	0.005	0.008	<0.001
Manganese	0.001	0.2	2.28	0.141	2.28
Nickel	0.001	0.2	0.005	0.005	0.006
Vanadium	0.005	0.1	<0.005	<0.005	<0.005
Zinc	0.005	2.0	0.019	0.02	0.014
Mercury	0.0001	0.002	<0.0001	<0.0001	<0.0001

[a] ANZECC 2000 Guidelines for Irrigation and Livestock.
All results in mg/L unless otherwise stated.
PQL = Practical Quantitation Limit.
*EQL increased due to matrix interference.
No published guideline.
@ Long-term trigger values adopted.



6 CONCLUSIONS

This report has detailed the findings of the installation, water level gauging and water quality monitoring of groundwater wells.

The scope of the project was based on information provided by RWC.

Relative water levels have been determined to be 340mAHD and 344mAHD. The variability in the water table indicates a loss in connectivity across the aquifer. Water quantity is to be determined by others from the relative water levels determined. Observations made during groundwater sampling indicate the presence of minor quantities of sludge. Sludge was found to be present on the floor of the void with an estimated thickness of less than 0.5m.

Water quality evaluation indicates the water to be of similar chemical type between sampling locations and can be described as brackish and of slightly acidic pH. Concentrations of other analytes tested indicated the water is suitable for the purpose of irrigation or re-use in site operations.

7 LIMITATIONS

This report has been prepared for RW Corkery & Co Pty Limited. The services performed by RCA have been conducted in a manner consistent with that generally exercised by members of its profession and consulting practice.

This report has been prepared for the sole use of RW Corkery & Co Pty Limited for the purpose of its groundwater assessment for the Werris Creek Coal Mine. The report may not contain sufficient information for other uses or for parties other than RW Corkery & Co Pty Limited for the purpose of its groundwater assessment for the Werris Creek Coal Mine.

This report shall only be presented in full and may not be used to support objectives other than those stated in the report without written permission from RCA.

The information in this report is considered accurate at the date of issue with regard to the current conditions of the site. Conditions can vary across any site that cannot be explicitly defined by investigation.

Yours faithfully

RCA AUSTRALIA

Craig Handebo
Environmental Engineer

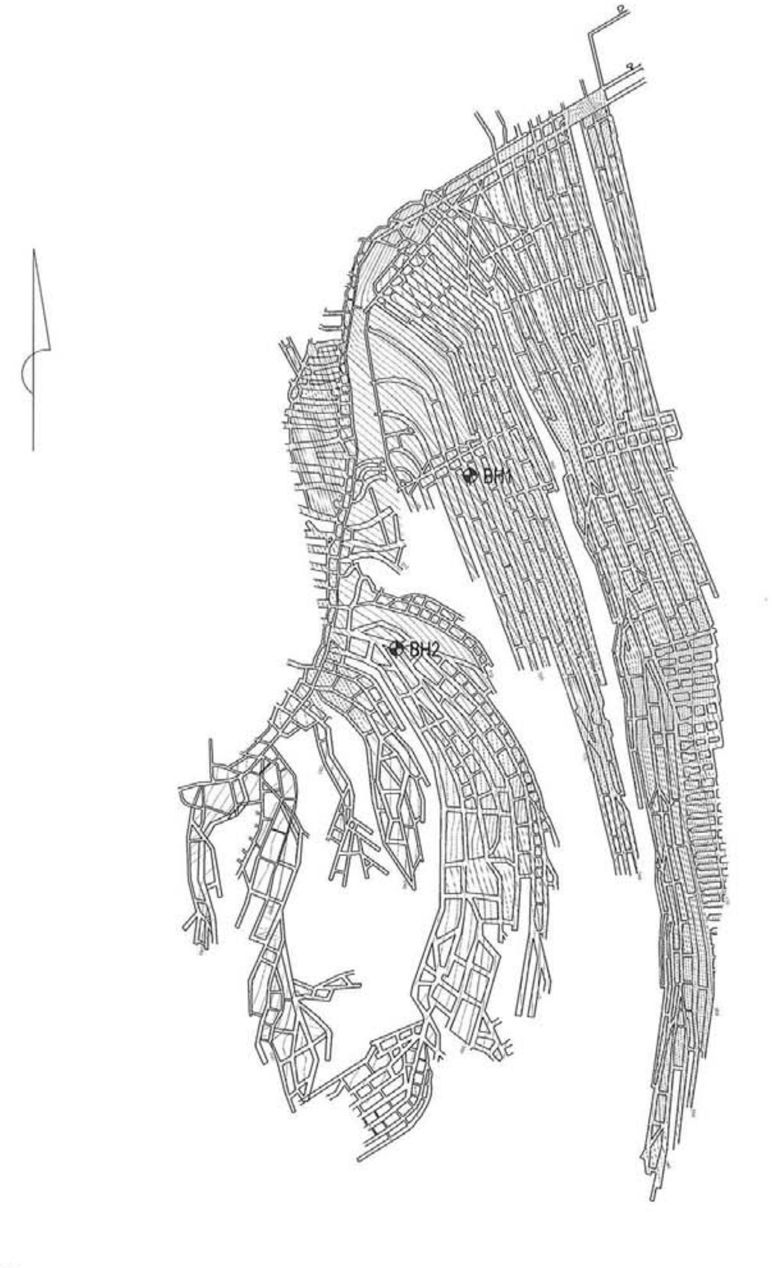
Fiona Robinson
Principal Environmental Engineer

REFERENCES

[1] ANZECC 200), Australian and New Zealand Guidelines for Fresh and Marine Water Quality, October 2000.

Appendix A

Monitoring Well Locations



LEGEND

- ◆ Monitoring well location (located by hand held GPS)
- Mine working
- Inferred high water mark

Note: Drawing adapted from plan supplied by Horizon Surveying
Dwg 0015-58, Date:12/12/07

0 50 100 150 200
metres

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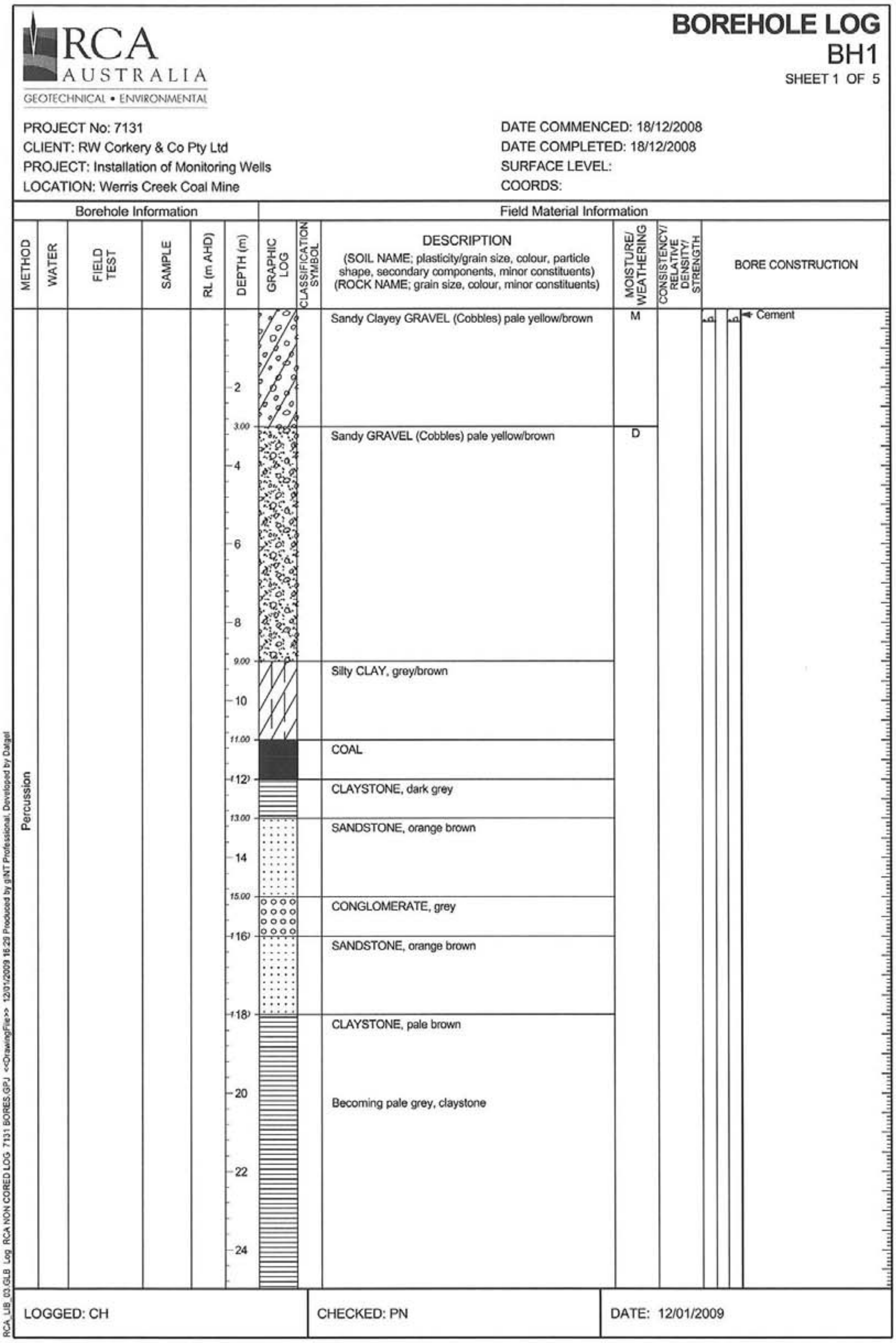
MONITORING WELL LOCATION
ASSESSMENT OF WATER QUALITY
AND QUANTITY IN MINE VOIDS
WERRIS CREEK

CLIENT	RW Corkery & Co Pty Ltd			PROJECT No	7131
DRAWN BY	CH	SCALE	1 : 400	DRAWING No	1 REV 0
APPROVED BY	FR	DATE	23/1/09	OFFICE	NEWCASTLE

Appendix B

Bore Logs



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BOREHOLE LOG
BH1
SHEET 1 OF 5

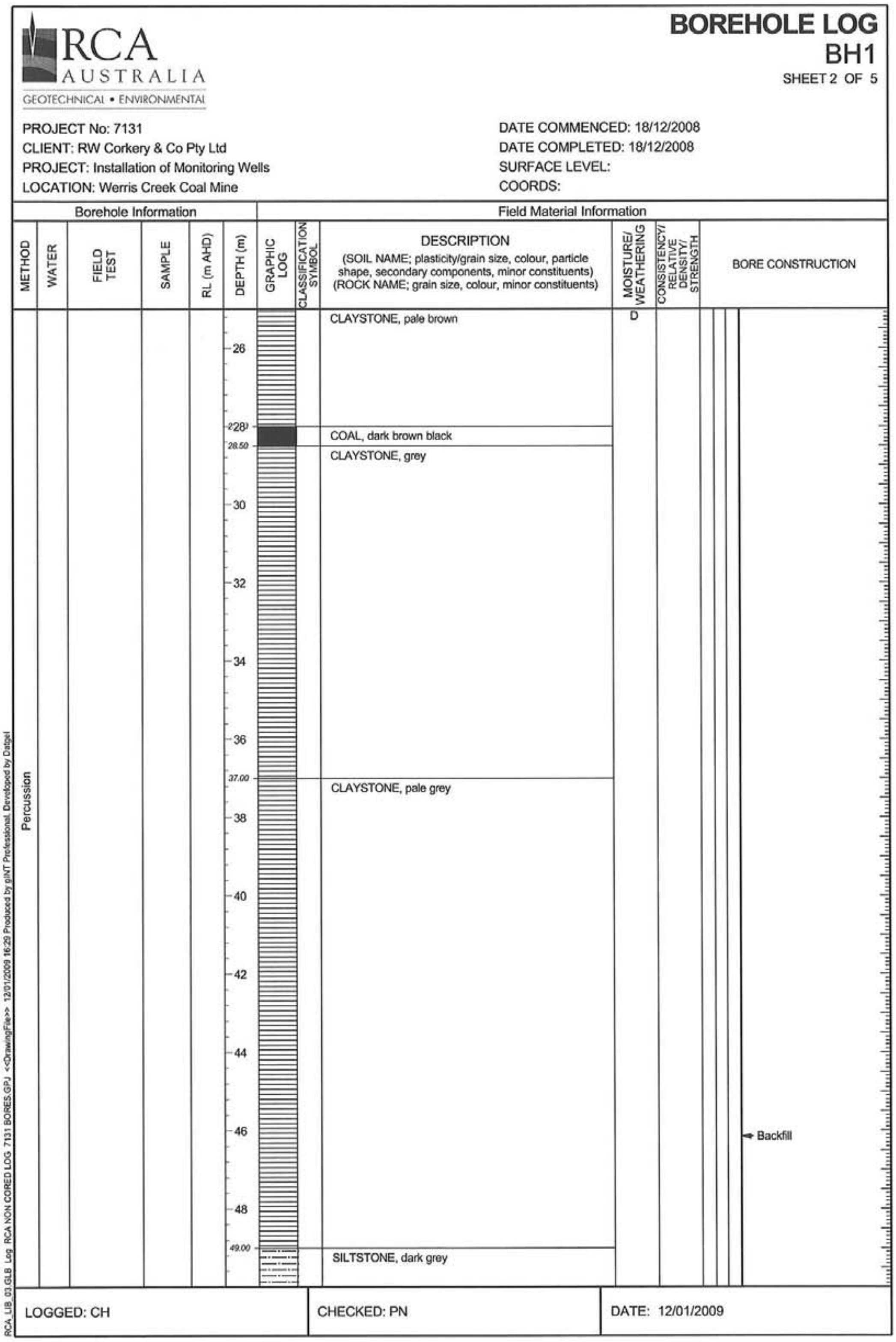
PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

DATE COMMENCED: 18/12/2008
DATE COMPLETED: 18/12/2008
SURFACE LEVEL:
COORDS:

Borehole Information						Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
Percussion								Sandy Clayey GRAVEL (Cobbles) pale yellow/brown	M		Cement
					3.00			Sandy GRAVEL (Cobbles) pale yellow/brown	D		
					9.00			Silty CLAY, grey/brown			
					11.00			COAL			
					12			CLAYSTONE, dark grey			
					13.00			SANDSTONE, orange brown			
					15.00			CONGLOMERATE, grey			
					16			SANDSTONE, orange brown			
					18			CLAYSTONE, pale brown			
					20			Becoming pale grey, claystone			

LOGGED: CH
CHECKED: PN
DATE: 12/01/2009

RCA_LIB_03.GLB Log RCA NON CORED LOG 7131 BORES.GPJ <<DrawingFile>> 12/01/2009 16:29 Produced by gINT Professional, Developed by Datgel



RCA AUSTRALIA
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BOREHOLE LOG
BH1
SHEET 2 OF 5

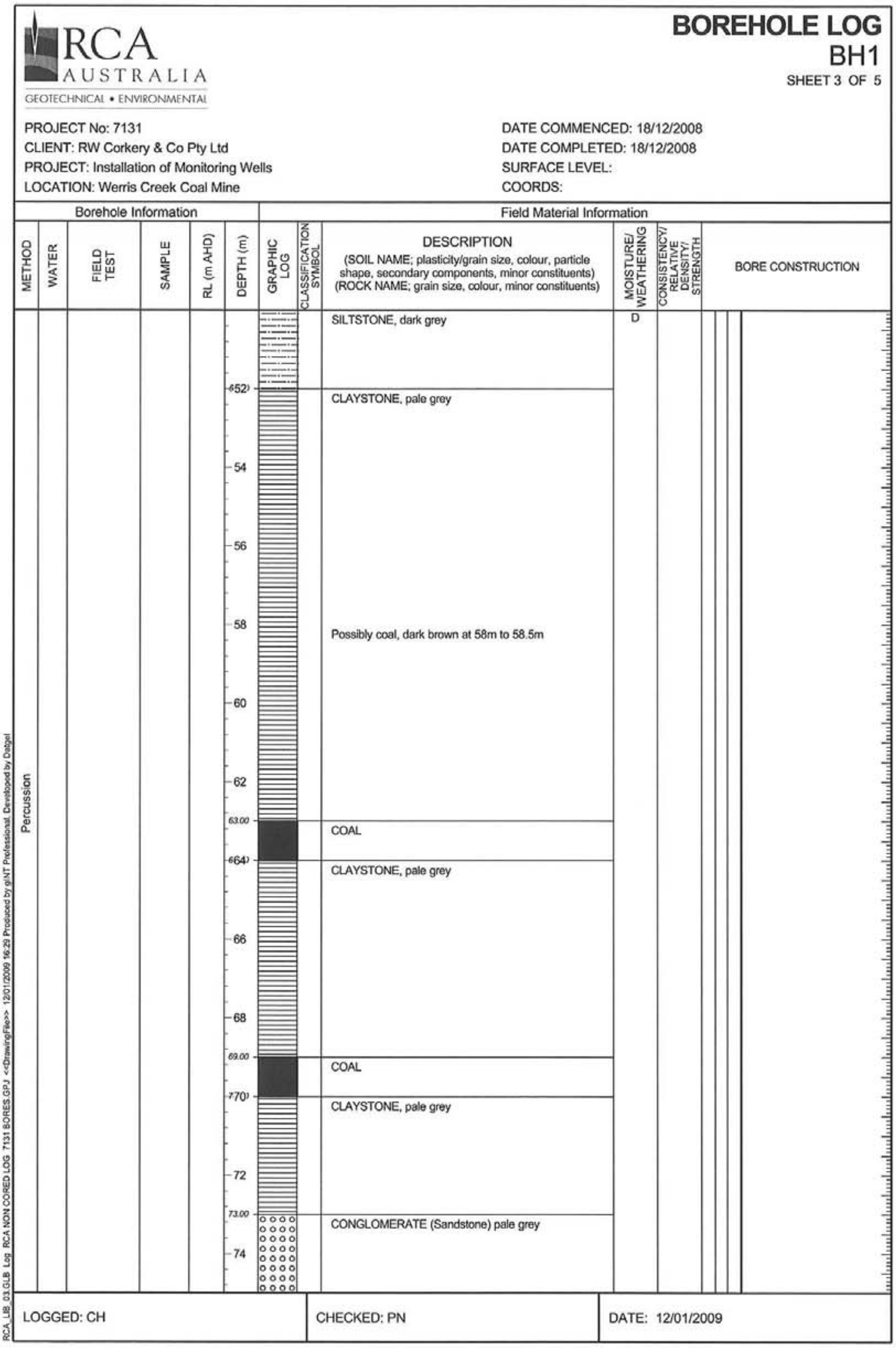
PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

DATE COMMENCED: 18/12/2008
DATE COMPLETED: 18/12/2008
SURFACE LEVEL:
COORDS:

Borehole Information						Field Material Information				
METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
Percussion								CLAYSTONE, pale brown	D		
					28			COAL, dark brown black			
					28.50			CLAYSTONE, grey			
					37.00			CLAYSTONE, pale grey			Backfill
					49.00			SILTSTONE, dark grey			

LOGGED: CH
CHECKED: PN
DATE: 12/01/2009

RCA_LIB_03.GLB Log RCA NON CORED LOG 7131 BORES.GPJ <<DrawingFile>> 12/01/2009 16:29 Produced by gINT Professional, Developed by Datgel



RCA AUSTRALIA
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BOREHOLE LOG
BH1
SHEET 3 OF 5

PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

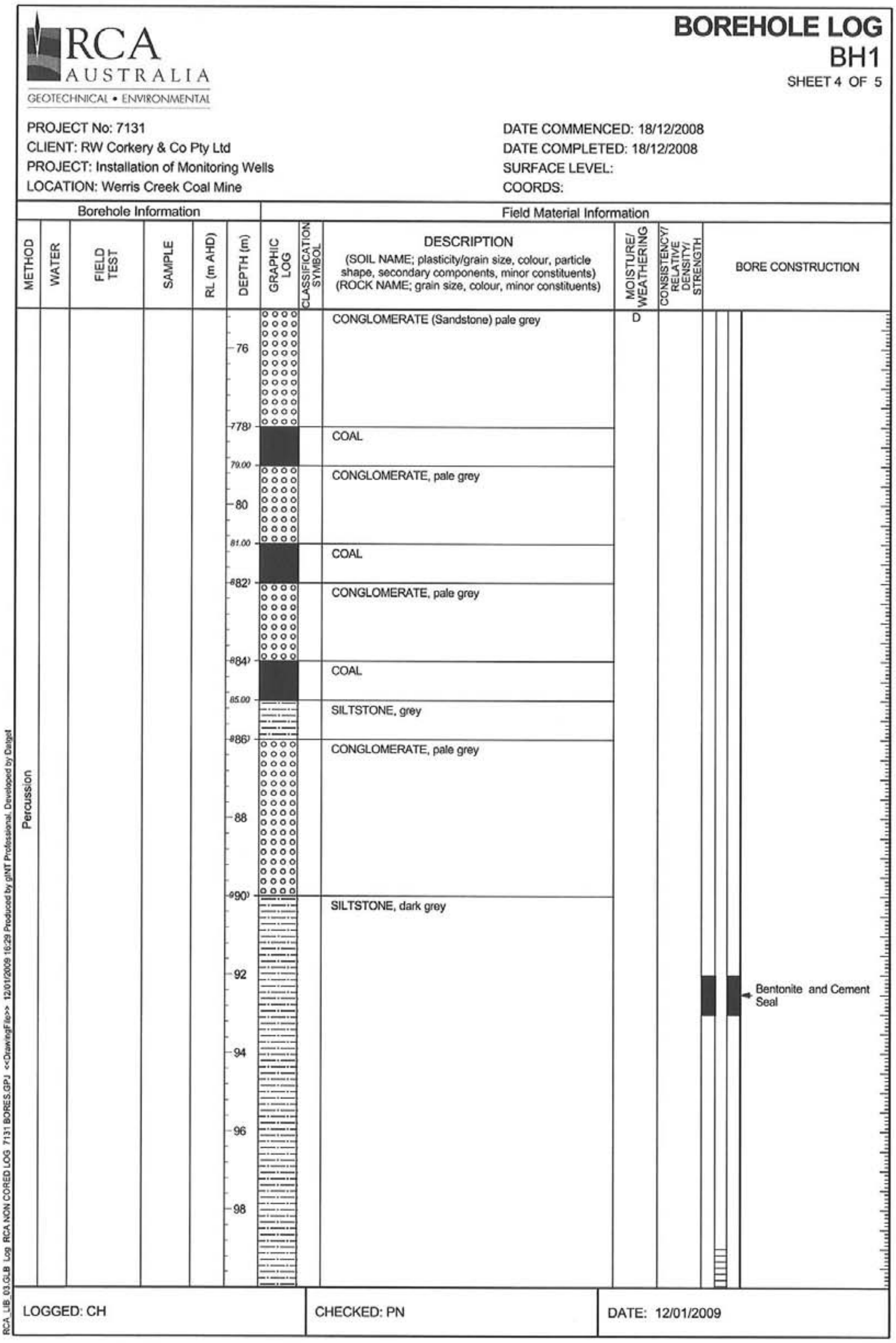
DATE COMMENCED: 18/12/2008
DATE COMPLETED: 18/12/2008
SURFACE LEVEL:
COORDS:

METHOD	DEPTH (m)	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING
Percussion		SILTSTONE, dark grey	D
	52	CLAYSTONE, pale grey	
	58	Possibly coal, dark brown at 58m to 58.5m	
	63.00	COAL	
	64	CLAYSTONE, pale grey	
	69.00	COAL	
	70	CLAYSTONE, pale grey	
	73.00	CONGLOMERATE (Sandstone) pale grey	

Borehole Information: METHOD, WATER, FIELD TEST, SAMPLE, RL (m AHD), DEPTH (m)
Field Material Information: GRAPHIC LOG, CLASSIFICATION SYMBOL, DESCRIPTION, MOISTURE/ WEATHERING, CONSISTENCY/ RELATIVE DENSITY/ STRENGTH, BORE CONSTRUCTION

RCA_LIB_03.GLB Log RCA NON CORED LOG 7131 BORES.GPJ <<DrawingFile>> 12/01/2009 16:29 Produced by gINT Professional, Developed by Datgel

LOGGED: CH CHECKED: PN DATE: 12/01/2009



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BOREHOLE LOG
BH1
SHEET 4 OF 5

PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

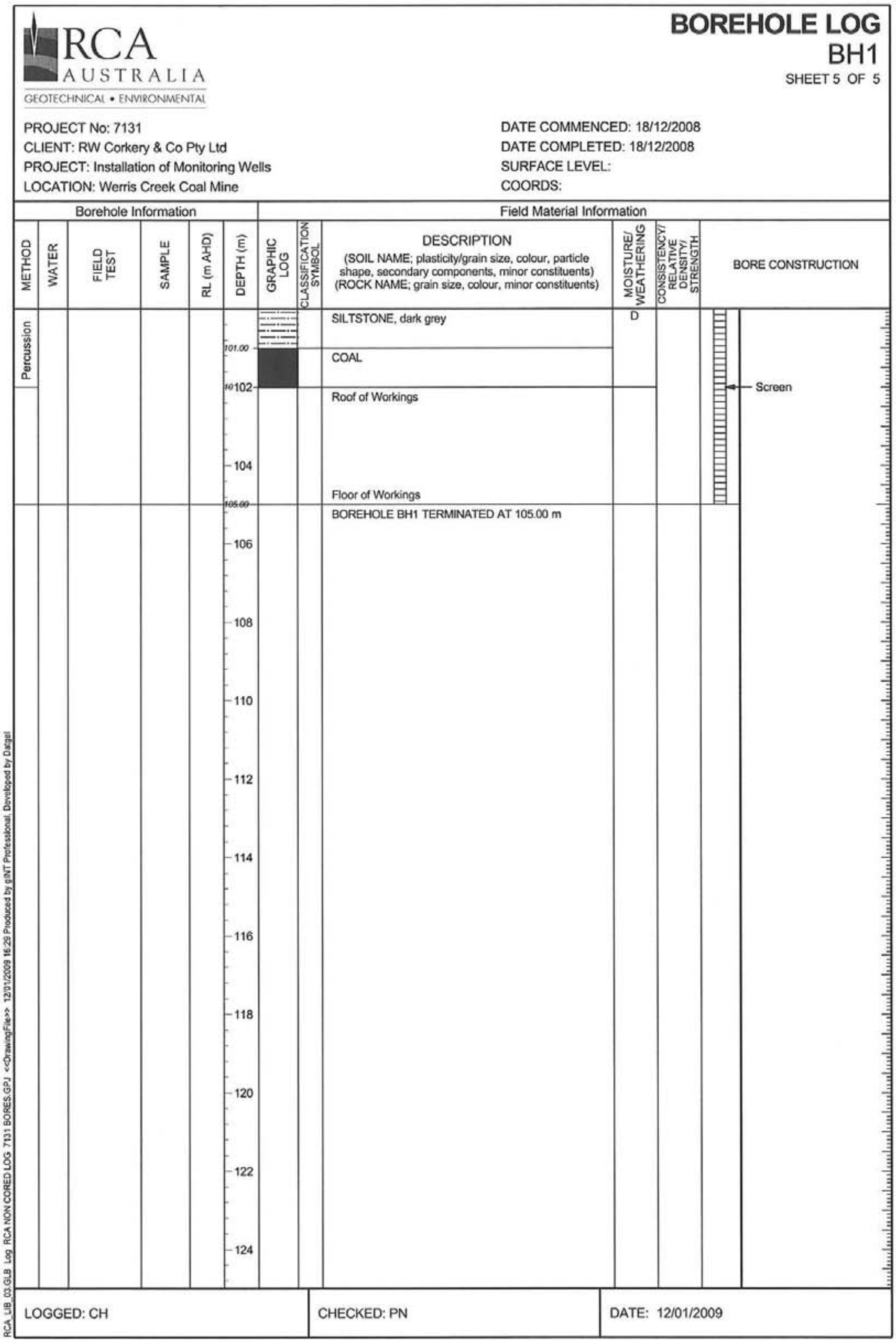
DATE COMMENCED: 18/12/2008
DATE COMPLETED: 18/12/2008
SURFACE LEVEL:
COORDS:

Borehole Information | Field Material Information

METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
Percussion					76	CONGLOMERATE (Sandstone) pale grey	D		
					78	COAL			
					79.00 80	CONGLOMERATE, pale grey			
					81.00	COAL			
					82	CONGLOMERATE, pale grey			
					84	COAL			
					85.00	SILTSTONE, grey			
					86 88	CONGLOMERATE, pale grey			
					90 92 94 96 98	SILTSTONE, dark grey			Bentonite and Cement Seal

RCA_LIB_03.GLB Log RCA NON CORED LOG 7131 BORES.GPJ <<DrawingFile>> 12/01/2009 16:29 Produced by gINT Professional, Developed by Datgel

LOGGED: CH
CHECKED: PN
DATE: 12/01/2009



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BOREHOLE LOG
BH1
SHEET 5 OF 5

PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

DATE COMMENCED: 18/12/2008
DATE COMPLETED: 18/12/2008
SURFACE LEVEL:
COORDS:

Borehole Information						Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
Percussion								SILTSTONE, dark grey	D		Screen
					101.00			COAL			
					102.00 102			Roof of Workings			
					104						
								Floor of Workings			
					105.00			BOREHOLE BH1 TERMINATED AT 105.00 m			
					106						
					108						
					110						
					112						
					114						
					116						
					118						
					120						
					122						
					124						

LOGGED: CH CHECKED: PN DATE: 12/01/2009

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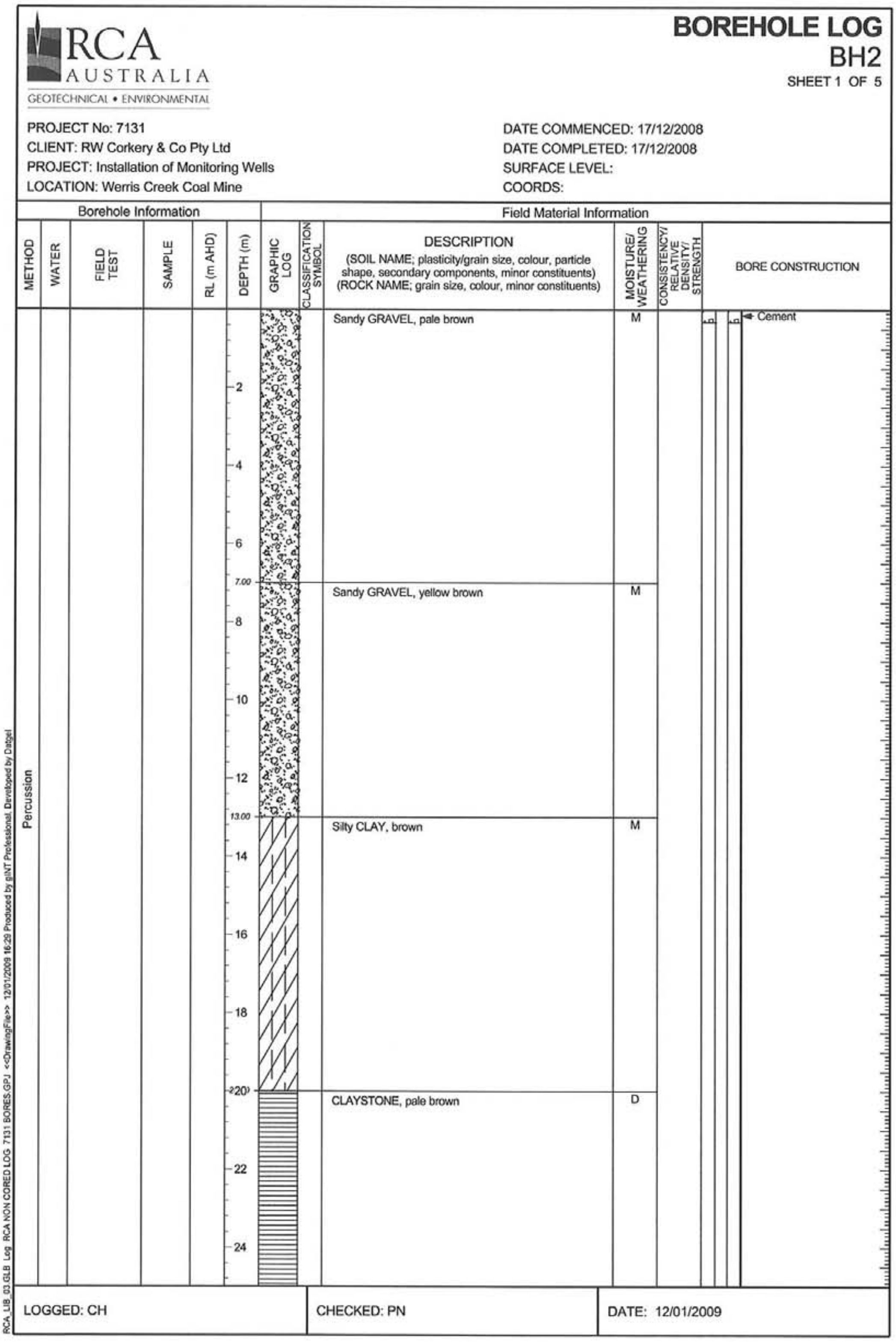

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BOREHOLE LOG
BH2
SHEET 1 OF 5

PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

DATE COMMENCED: 17/12/2008
DATE COMPLETED: 17/12/2008
SURFACE LEVEL:
COORDS:

Borehole Information						Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
Percussion								Sandy GRAVEL, pale brown	M		Cement
					7.00			Sandy GRAVEL, yellow brown	M		
					13.00			Silty CLAY, brown	M		
					20			CLAYSTONE, pale brown	D		

LOGGED: CH
CHECKED: PN
DATE: 12/01/2009

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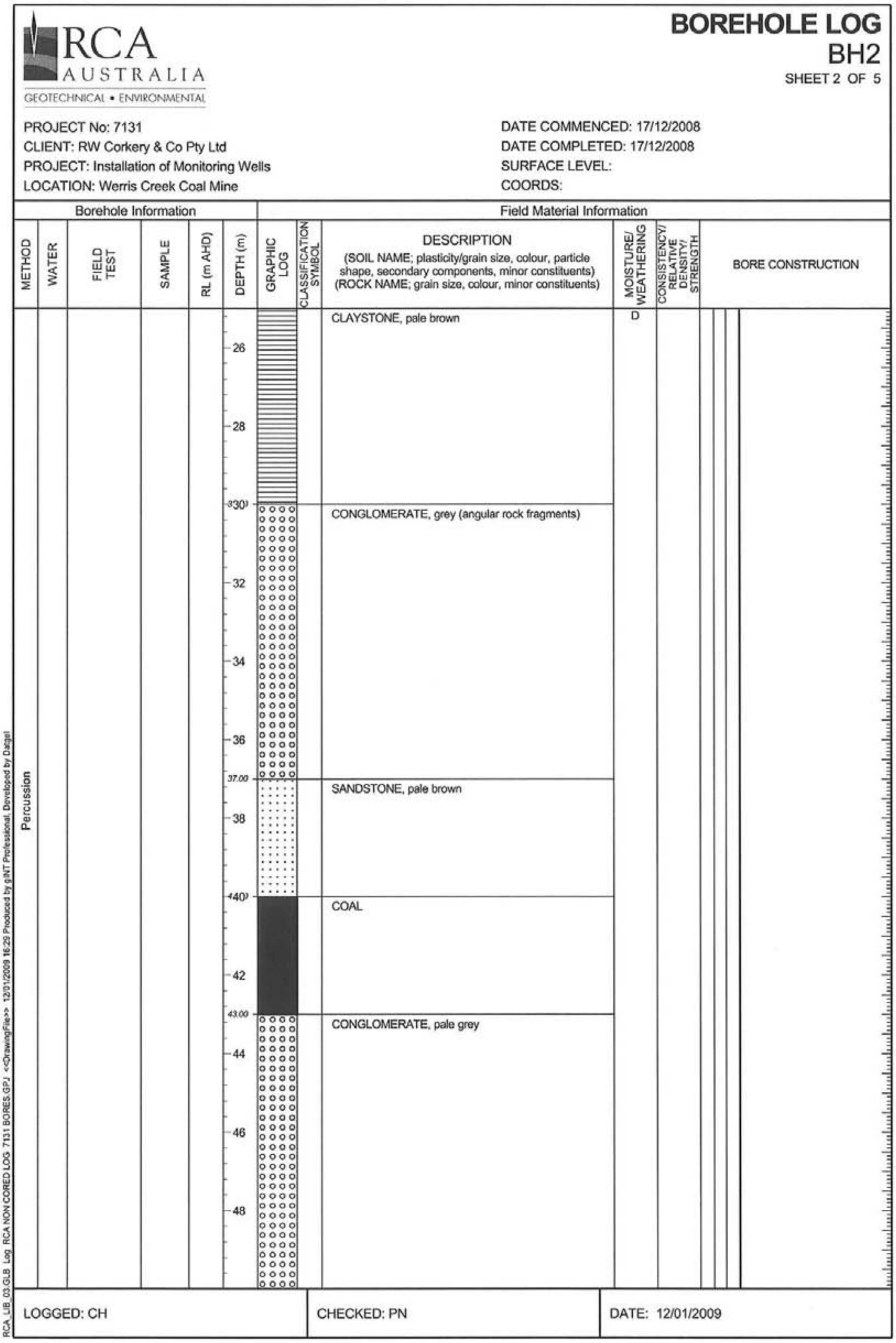

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BOREHOLE LOG
BH2
SHEET 2 OF 5

PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

DATE COMMENCED: 17/12/2008
DATE COMPLETED: 17/12/2008
SURFACE LEVEL:
COORDS:

Borehole Information						Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
Percussion					26 28			CLAYSTONE, pale brown	D		
					30 32 34 36			CONGLOMERATE, grey (angular rock fragments)			
					37.00 38			SANDSTONE, pale brown			
					40 42			COAL			
					43.00 44 46 48			CONGLOMERATE, pale grey			

LOGGED: CH CHECKED: PN DATE: 12/01/2009

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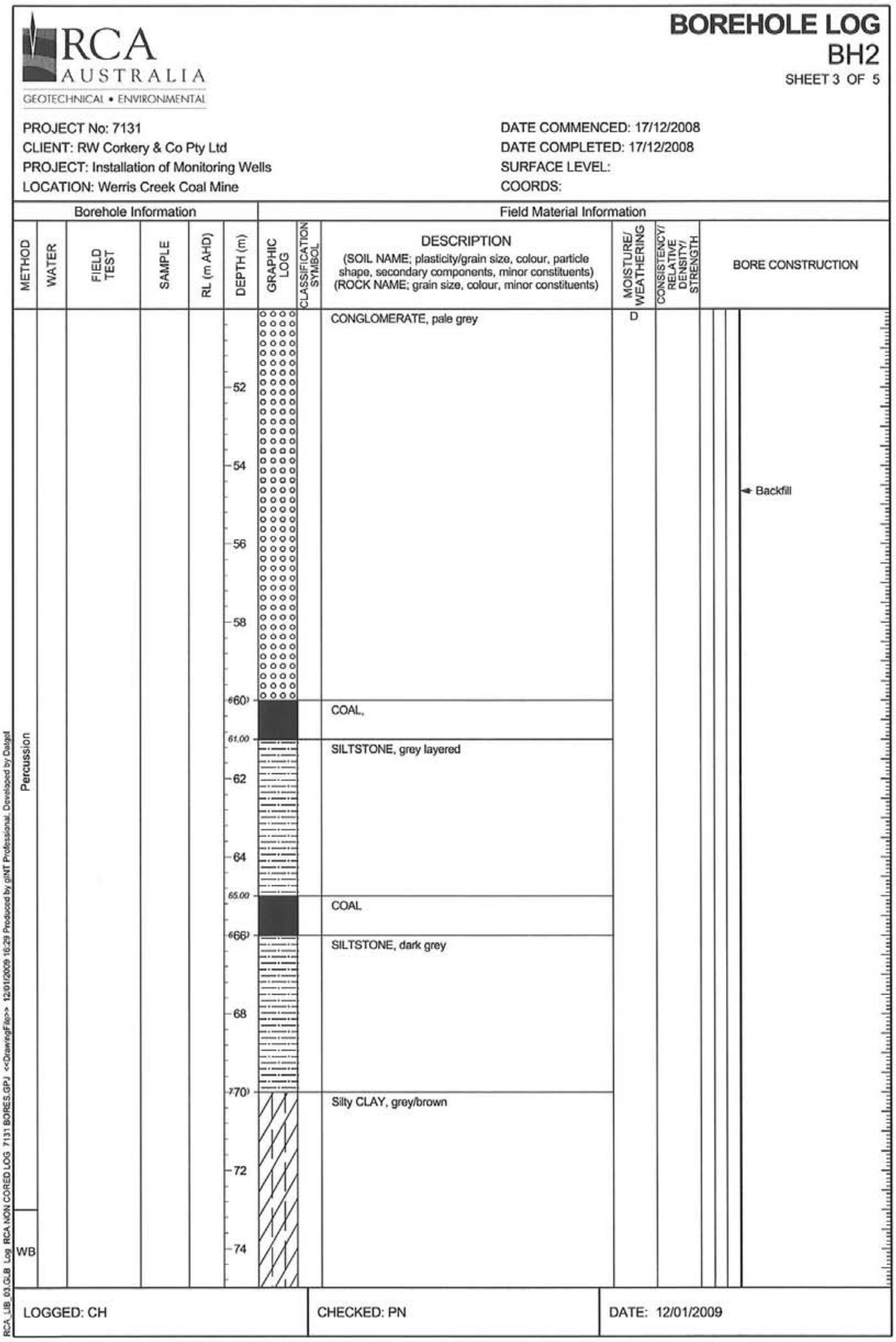

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BOREHOLE LOG
BH2
SHEET 3 OF 5

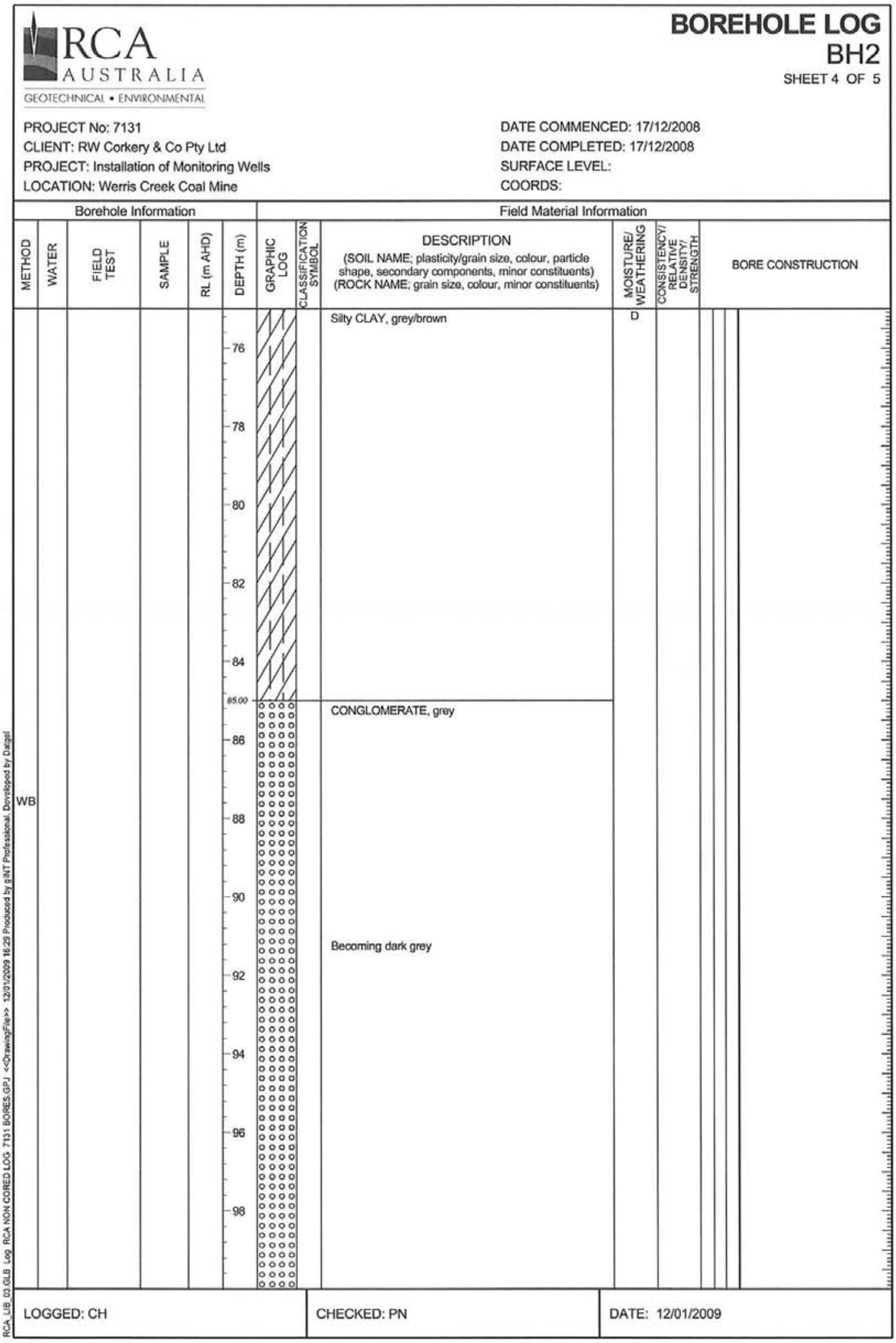
PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

DATE COMMENCED: 17/12/2008
DATE COMPLETED: 17/12/2008
SURFACE LEVEL:
COORDS:

Borehole Information						Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
Percussion								CONGLOMERATE, pale grey	D		
					52						
					54						◄ Backfill
					56						
					58						
					60			COAL,			
					61.00			SILTSTONE, grey layered			
					62						
					64						
					65.00			COAL			
					66			SILTSTONE, dark grey			
					68						
					70			Silty CLAY, grey/brown			
					72						
WB					74						

LOGGED: CH CHECKED: PN DATE: 12/01/2009

RCA_LIB_03.GLB Log RCA NON CORED LOG 7131 BORES.GPJ <<DrawingFile>> 12/01/2009 16:29 Produced by gINT Professional, Developed by Datgel



RCA AUSTRALIA
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BOREHOLE LOG
BH2
SHEET 4 OF 5

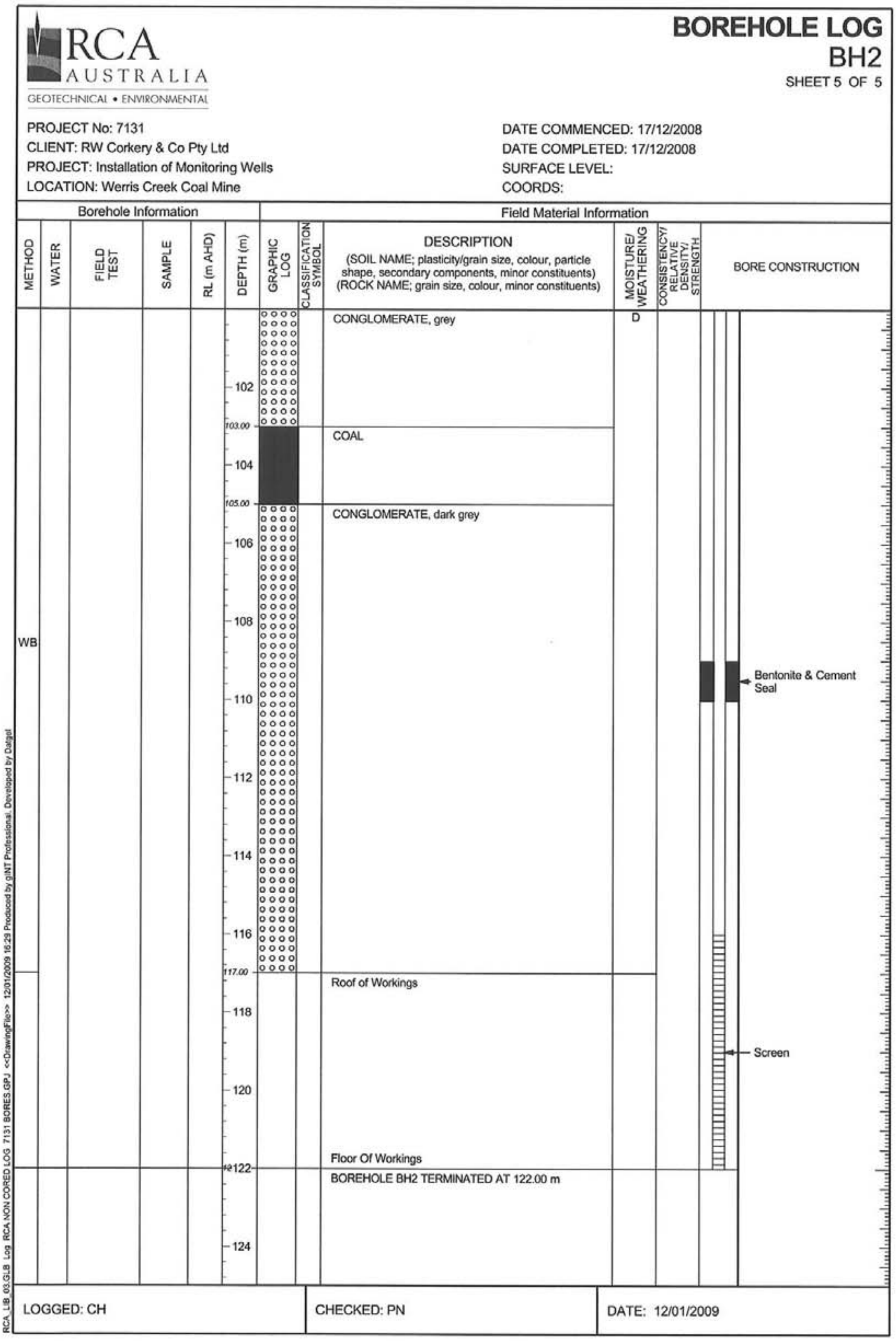
PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

DATE COMMENCED: 17/12/2008
DATE COMPLETED: 17/12/2008
SURFACE LEVEL:
COORDS:

Borehole Information						Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
WB								Silty CLAY, grey/brown	D		
					76						
					78						
					80						
					82						
					84						
					85.00			CONGLOMERATE, grey			
					86						
					88						
					90						
								Becoming dark grey			
					92						
					94						
					96						
					98						

RCA_LIB_03.GLB Log RCA NON CORED LOG 7131 BORES.GPJ <<DrawingFile>> 12/01/2009 16:29 Produced by gINT Professional, Developed by Datgel

LOGGED: CH CHECKED: PN DATE: 12/01/2009



RCA AUSTRALIA
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BOREHOLE LOG
BH2
SHEET 5 OF 5

PROJECT No: 7131
CLIENT: RW Corkery & Co Pty Ltd
PROJECT: Installation of Monitoring Wells
LOCATION: Werris Creek Coal Mine

DATE COMMENCED: 17/12/2008
DATE COMPLETED: 17/12/2008
SURFACE LEVEL:
COORDS:

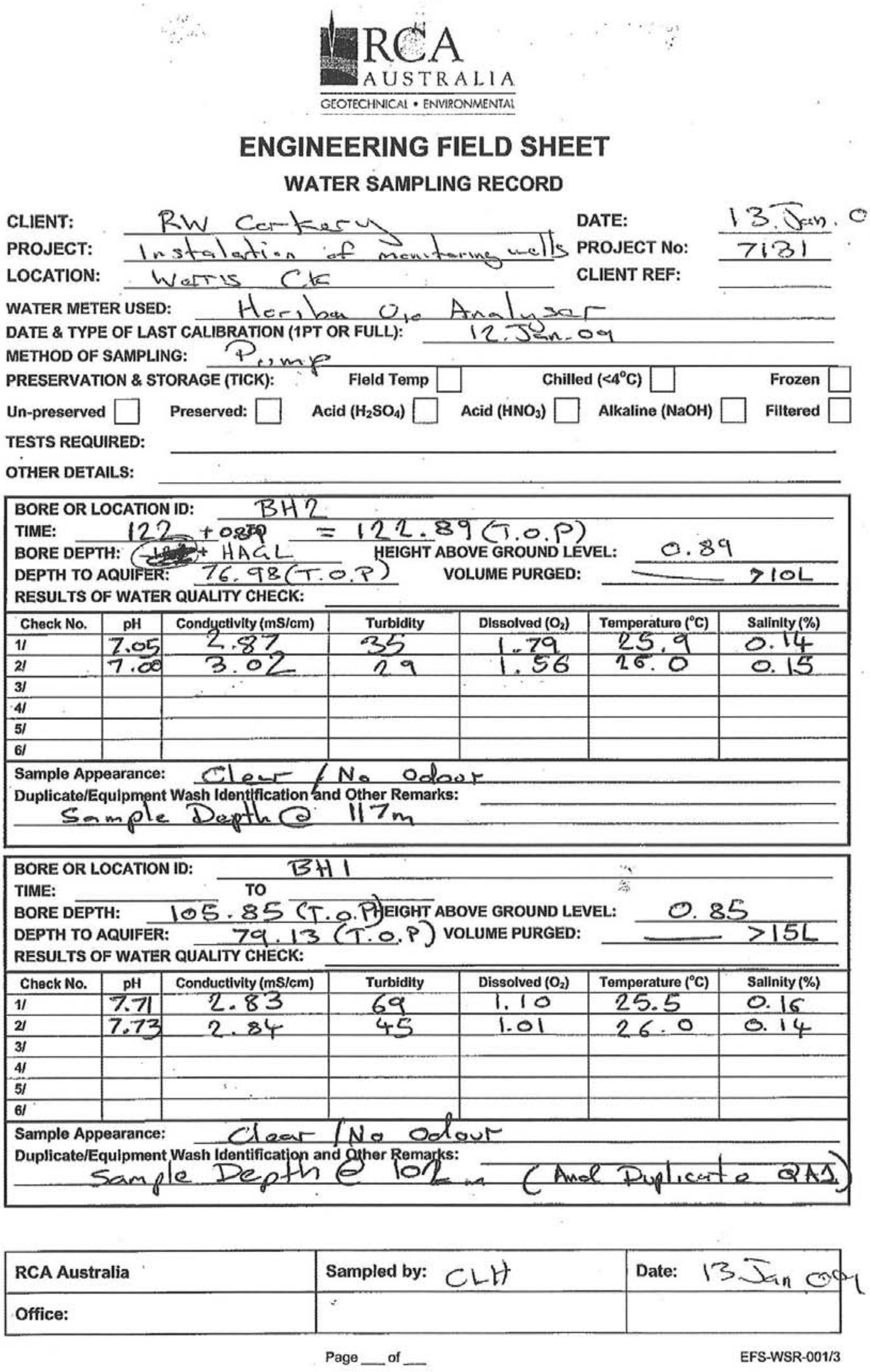
Borehole Information						Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
WB								CONGLOMERATE, grey	D		
					103.00			COAL			
					105.00			CONGLOMERATE, dark grey			Bentonite & Cement Seal
					117.00			Roof of Workings			Screen
								Floor Of Workings			
					122			BOREHOLE BH2 TERMINATED AT 122.00 m			

LOGGED: CH
CHECKED: PN
DATE: 12/01/2009

RCA_LIB_03.GLB Log RCA NON CORED LOG 7131 BORES.GPJ <<DrawingFile>> 12/01/2009 16:29 Produced by gINT Professional, Developed by Datgel

Appendix C

Field Sheets



RCA AUSTRALIA
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ENGINEERING FIELD SHEET

WATER SAMPLING RECORD

CLIENT: RW Corkery **DATE:** 13.Jan.09
PROJECT: Instalation of monitoring wells **PROJECT No:** 7131
LOCATION: Werris Ck **CLIENT REF:**
WATER METER USED: Horiba U10 Analyser
DATE & TYPE OF LAST CALIBRATION (1PT OR FULL): 12.Jan.09
METHOD OF SAMPLING: Pump
PRESERVATION & STORAGE (TICK): **Field Temp** ☐ **Chilled (<4°C)** ☐ **Frozen** ☐
Un-preserved ☐ **Preserved:** ☐ **Acid (H_2SO_4)** ☐ **Acid (HNO_3)** ☐ **Alkaline (NaOH)** ☐ **Filtered** ☐
TESTS REQUIRED:
OTHER DETAILS:

BORE OR LOCATION ID: BH2
TIME: 122 + 0.89 = 122.89 (T.O.P)
BORE DEPTH: ~~[illegible]~~ + HAGL **HEIGHT ABOVE GROUND LEVEL:** 0.89
DEPTH TO AQUIFER: 76.98 (T.O.P) **VOLUME PURGED:** >10L
RESULTS OF WATER QUALITY CHECK:

Check No.	pH	Conductivity (mS/cm)	Turbidity	Dissolved (O_2)	Temperature (°C)	Salinity (%)
1/	7.05	2.87	35	1.79	25.9	0.14
2/	7.00	3.02	29	1.56	26.0	0.15
3/						
4/						
5/						
6/						

Sample Appearance: Clear / No Odour
Duplicate/Equipment Wash Identification and Other Remarks:
Sample Depth @ 117m

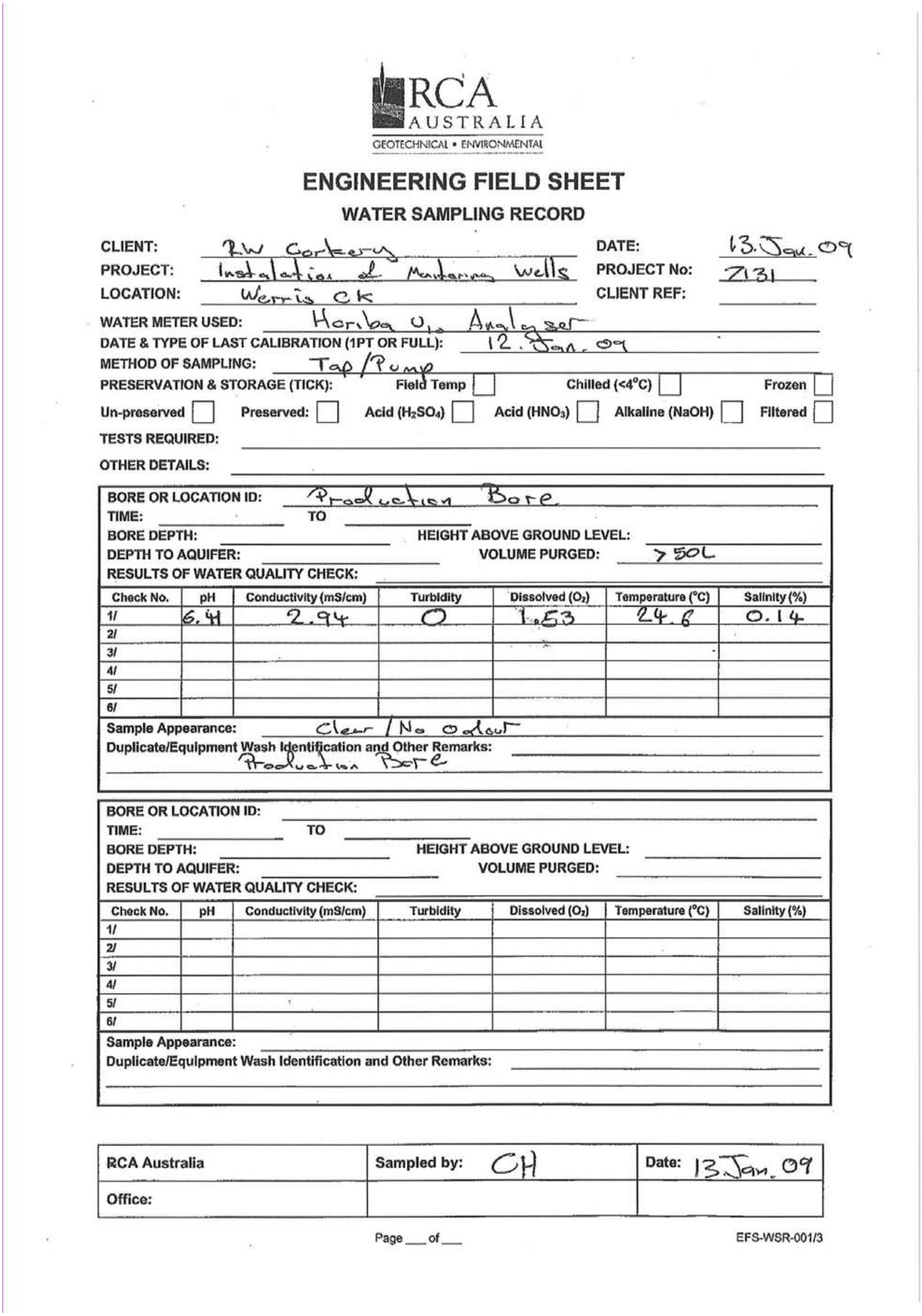
BORE OR LOCATION ID: BH1
TIME: **TO**
BORE DEPTH: 105.85 (T.O.P) **HEIGHT ABOVE GROUND LEVEL:** 0.85
DEPTH TO AQUIFER: 79.13 (T.O.P) **VOLUME PURGED:** >15L
RESULTS OF WATER QUALITY CHECK:

Check No.	pH	Conductivity (mS/cm)	Turbidity	Dissolved (O_2)	Temperature (°C)	Salinity (%)
1/	7.71	2.83	69	1.10	25.5	0.16
2/	7.73	2.84	45	1.01	26.0	0.14
3/						
4/						
5/						
6/						

Sample Appearance: Clear / No Odour
Duplicate/Equipment Wash Identification and Other Remarks:
Sample Depth @ 102m (And Duplicate QA1)

RCA Australia	**Sampled by:** CLH	**Date:** 13 Jan 09
Office:		

Page ___ of ___ EFS-WSR-001/3



RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

ENGINEERING FIELD SHEET

WATER SAMPLING RECORD

CLIENT: R.W Corkery **DATE:** 13.Jan.09
PROJECT: Instalation of Monitoring Wells **PROJECT No:** 7131
LOCATION: Werris Ck **CLIENT REF:**
WATER METER USED: Horiba U10 Analyser
DATE & TYPE OF LAST CALIBRATION (1PT OR FULL): 12. Jan. 09
METHOD OF SAMPLING: Tap/Pump
PRESERVATION & STORAGE (TICK): Field Temp ☐ Chilled (<4°C) ☐ Frozen ☐
Un-preserved ☐ Preserved: ☐ Acid (H_2SO_4) ☐ Acid (HNO_3) ☐ Alkaline (NaOH) ☐ Filtered ☐
TESTS REQUIRED:
OTHER DETAILS:

BORE OR LOCATION ID: Production Bore
TIME: TO
BORE DEPTH: **HEIGHT ABOVE GROUND LEVEL:**
DEPTH TO AQUIFER: **VOLUME PURGED:** >50L
RESULTS OF WATER QUALITY CHECK:

Check No.	pH	Conductivity (mS/cm)	Turbidity	Dissolved (O_2)	Temperature (°C)	Salinity (%)
1/	6.41	2.94	0	1.53	24.6	0.14
2/						
3/						
4/						
5/						
6/						

Sample Appearance: Clear / No odour
Duplicate/Equipment Wash Identification and Other Remarks:
Production Bore

BORE OR LOCATION ID:
TIME: TO
BORE DEPTH: **HEIGHT ABOVE GROUND LEVEL:**
DEPTH TO AQUIFER: **VOLUME PURGED:**
RESULTS OF WATER QUALITY CHECK:

Check No.	pH	Conductivity (mS/cm)	Turbidity	Dissolved (O_2)	Temperature (°C)	Salinity (%)
1/						
2/						
3/						
4/						
5/						
6/						

Sample Appearance:
Duplicate/Equipment Wash Identification and Other Remarks:

RCA Australia	**Sampled by:** CH	**Date:** 13.Jan.09
Office:		

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Appendix D

Quality Assurance

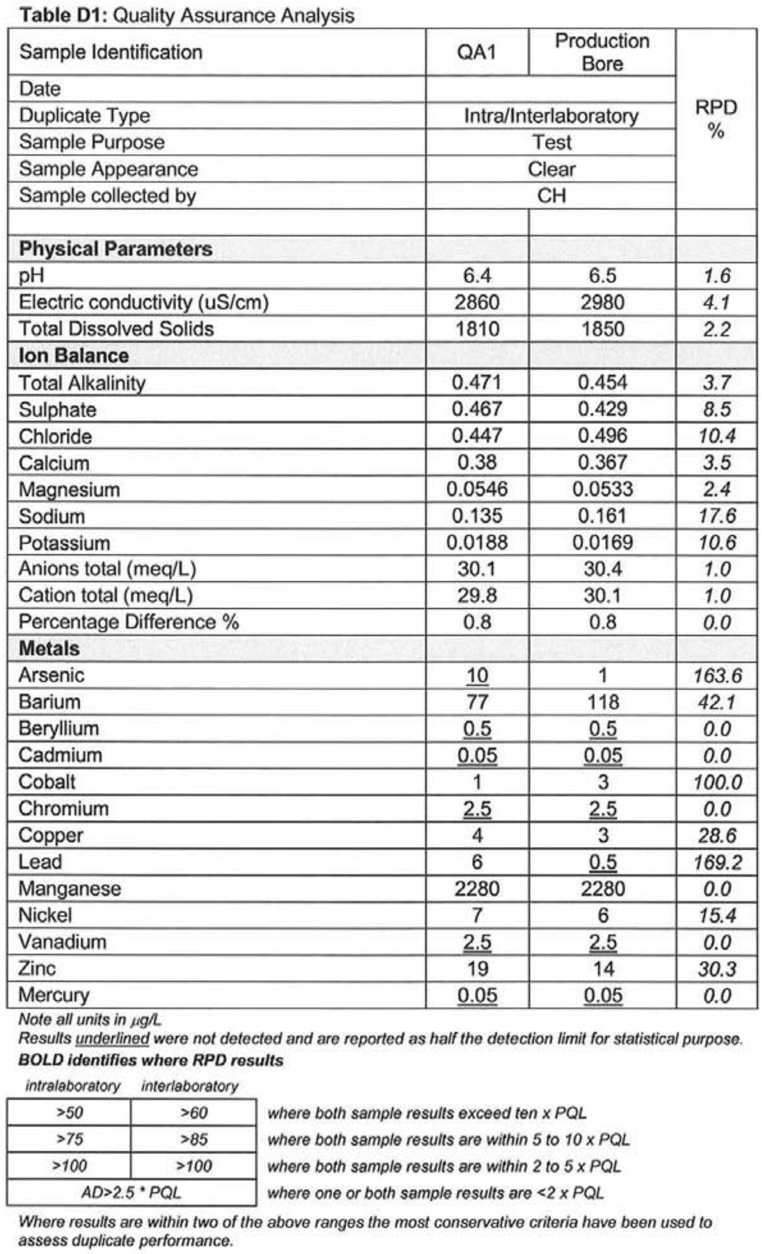

Table D1: Quality Assurance Analysis

Sample Identification	QA1	Production Bore	RPD %
Date			
Duplicate Type	Intra/Interlaboratory		
Sample Purpose	Test		
Sample Appearance	Clear		
Sample collected by	CH		
Physical Parameters			
pH	6.4	6.5	*1.6*
Electric conductivity (uS/cm)	2860	2980	*4.1*
Total Dissolved Solids	1810	1850	*2.2*
Ion Balance			
Total Alkalinity	0.471	0.454	*3.7*
Sulphate	0.467	0.429	*8.5*
Chloride	0.447	0.496	*10.4*
Calcium	0.38	0.367	*3.5*
Magnesium	0.0546	0.0533	*2.4*
Sodium	0.135	0.161	*17.6*
Potassium	0.0188	0.0169	*10.6*
Anions total (meq/L)	30.1	30.4	*1.0*
Cation total (meq/L)	29.8	30.1	*1.0*
Percentage Difference %	0.8	0.8	*0.0*
Metals			
Arsenic	10	1	*163.6*
Barium	77	118	*42.1*
Beryllium	0.5	0.5	*0.0*
Cadmium	0.05	0.05	*0.0*
Cobalt	1	3	*100.0*
Chromium	2.5	2.5	*0.0*
Copper	4	3	*28.6*
Lead	6	0.5	*169.2*
Manganese	2280	2280	*0.0*
Nickel	7	6	*15.4*
Vanadium	2.5	2.5	*0.0*
Zinc	19	14	*30.3*
Mercury	0.05	0.05	*0.0*

Note all units in μg/L
Results underlined were not detected and are reported as half the detection limit for statistical purpose.
BOLD identifies where RPD results

intralaboratory	*interlaboratory*	
>50	*>60*	*where both sample results exceed ten x PQL*
>75	*>85*	*where both sample results are within 5 to 10 x PQL*
>100	*>100*	*where both sample results are within 2 to 5 x PQL*
*AD>2.5 * PQL*		*where one or both sample results are <2 x PQL*

Where results are within two of the above ranges the most conservative criteria have been used to assess duplicate performance.

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