GROUNDWATER IMPACT ASSESSMENT REPORT

Dolwendee Quarry, Hollydeen

Prepared for KMH Environmental

Prepared by RCA Australia

RCA ref 9325-204/2

October 2015

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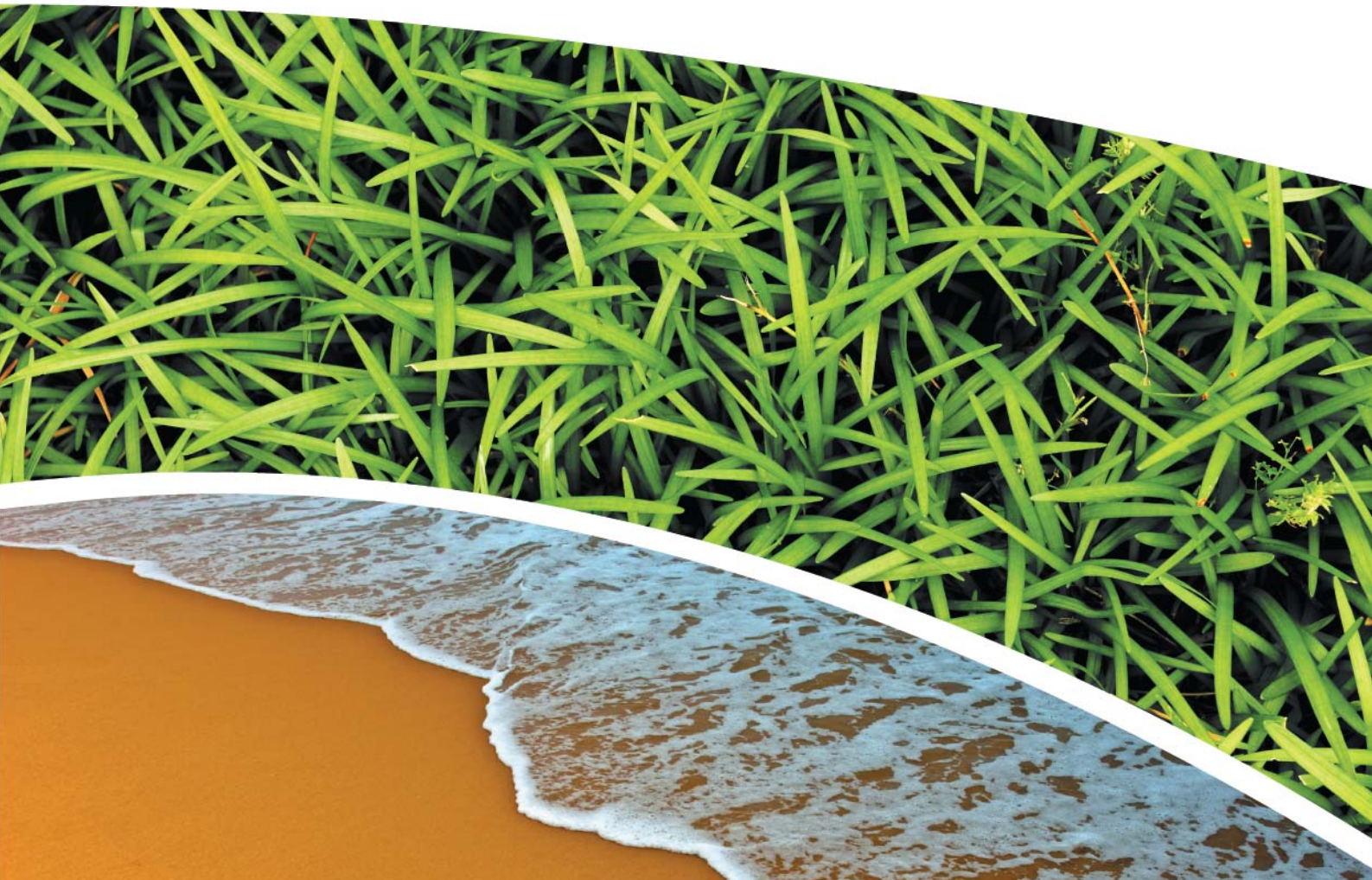

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DOCUMENT STATUS						
Rev No	**Comment**	**Author**	**Reviewer**	**Approved for Issue (Project Manager)**		
				Name	**Signature**	**Date**
/0	Draft	R Carr	C Mickan	R Carr		31.07.15
/1	Draft	R Carr	C Mickan	R Carr		29.09.15
/2	Final	R Carr	C Mickan	R Carr		23.10.15

DOCUMENT DISTRIBUTION				
Rev No	**Copies**	**Format**	**Issued to**	**Date**
/0	1	Electronic (email)	KMH Environmental – Adam Bishop – Abishop@kmh.com.au	31.07.15
/0	1	Electronic report	RCA – job archive	31.07.15
/1	1	Electronic (email)	KMH Environmental – Adam Bishop – Abishop@kmh.com.au	29.09.15
/1	1	Electronic report	RCA – job archive	29.09.15
/2	1	Electronic (email)	KMH Environmental – Adam Bishop – Abishop@kmh.com.au	23.10.15
/2	1	Electronic report	RCA – job archive	23.10.15

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RCA ref 9325-204/2

23 October 2015

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GROUNDWATER IMPACT ASESSMENT REPORT
DOLWENDEE QUARRY PROJECT, HOLLYDEEN

1 INTRODUCTION

This report presents the results of a review of the impacts of the proposed Dolwendee Quarry Project, Hollydeen, on the groundwater system. The report has been undertaken at the request of Mr Adam Bishop of KMH Environmental. The purpose of the assessment is to address the NSW Office of Water comments (in regard to groundwater) in response to Dolwendee Quarry Project (SSD_6519) Request for input into Secretary's Environmental Assessment Requirements (SEARs) (Ref [1]).

RCA have previously issued a Baseline Groundwater Monitoring report for Dolwendee Quarry (Ref [3]). This report is reproduced with minor modifications as part of this report.

2 SITE LOCATION AND GEOLOGICAL SETTING

2.1 LOCATION

The site is described as 930 Golden Highway, Hollydeen, NSW, Lot 2 in DP 1160936. The site is currently used as agricultural farmland. The site is proposed to be used as a quarry.

The site is surrounded by agricultural farmland, with extensive mining operations being undertaken within the wider Denman and Muswellbrook regions. To the northwest of the site is Wybong Creek. Based on topographic considerations groundwater is expected to flow towards the Wybong Creek and its tributary streams.

2.2 GEOLOGICAL SETTING

Reference to NSW Geological Survey 1:100,000 Hunter Coalfield Regional Geology map indicates that the proposed quarry area overlies the Narrabeen Group Widden Brook Conglomerate, and is in close proximity to the subcrop of the boundary with the underlying Wollombi Coal Measures. It is planned that the proposed quarry will win the Widden Brook Conglomerate for construction material (Ref [2]) with the notional base of the quarry above the Greigs Creek Coal member (top of the Wollombi Coal Measures).

The Geological setting is shown on **Drawing 4** in **Appendix A** and tabulated on **Table 1**.

Drilling carried out for the quarry investigation and planning (Ref [2]) has intersected the sequence shown on **Table 1** down to the Hobden Gully Coal member.

Table 1 *Geological setting*

<table>
<tr><th>Age</th><th>Group</th><th>Sub Group</th><th>Formation</th><th>Member</th></tr>
<tr><td>Triassic</td><td>Narrabeen Group</td><td>Widden Brook Conglomerate</td><td></td><td></td></tr>
<tr><td rowspan="6">Permian</td><td rowspan="6">Wollombi Coal Measures</td><td rowspan="5">Glen Gallic Subgroup</td><td colspan="2">Greigs Creek Coal</td></tr>
<tr><td colspan="2">Redmanvale Creek Formation</td></tr>
<tr><td rowspan="3">Dight Creek Coal</td><td>Hillsdale Coal</td></tr>
<tr><td>Nalleen Tuff</td></tr>
<tr><td>Hobden Gully Coal member</td></tr>
<tr><td>Doyles Creek Subgroup</td><td colspan="2">Waterfall Gully Formation</td></tr>
</table>

Note: Not all subgroups shown in table.

The nearest cross-section on the NSW GS 1: 100,000 Hunter Coalfield Regional Geology sheet indicates the base of the Wollombi Coal Measures dips in a westerly direction.

Reference to NSW DMR notes for the Hunter Coalfield indicates the Widden Brook Conglomerate directly overlies the Greigs Creek Coal Seam (the uppermost coal seam in the Wollombi Coal Measures) and states that “In many places conglomerate directly overlie the Greigs Creek seam with little evidence of any washout or erosion.” Thus inferring that the boundary is likely to represent a true bedding surface rather than an erosional unconformity, the latter being expected to be an irregular and un-predictable interface.

The geotechnical bore holes drilled for Ref [2] indicate that the boundary between the Widden Brook Conglomerate and the Greigs Creek Coal Seam (the uppermost coal seam in the Wollombi Coal Measures) dips at about 3.5^{o} to the northwest.

The groundwater table surface has been measured (Ref [2] and Ref [2]) within the Wollombi Coal Measures (beneath the proposed quarry base) and has been subject to baseline groundwater monitoring to inform the project on the groundwater system. Details of the baseline groundwater monitoring are presented in Section 7.

3 PROPOSED DEVELOPMENT

It is proposed to develop a quarry on the site in a number of stages.

The nominal maximum depth of the quarry is the top of the Greigs Creek Coal Seam.

Activities during the quarry are understood to include:

- Digging, ripping and blasting of rock.
- Processing of the won excavated rock including:
  - screening,
  - stockpiling.
- Exporting of material from site by:
  - loading from stockpile and quarry face,
  - trucking out of pit and from site.

It is understood that:

- Water for the quarrying activities will be imported from off-site surface water storages. Groundwater will not be harvested.
- Dirty water would be contained treated and recycled within the quarry.
- Sewage effluent would be managed out of pit with suitably designed domestic wastewater treatment and irrigation system.
- It is proposed that the quarry site will be left as a closed void at the end of the extraction period.

4 GROUNDWATER USERS

The groundwater works/users on the NSW Office of Water (NOW) data base are shown on **Figure 1**. The closest groundwater works are clustered on the alluvial aquifer associated with Wybong Creek.

With reference to the NOW data base the nearest groundwater works (GW028313 and GW028314) are in the order of one kilometer away from the proposed Dolwendee Quarry site.

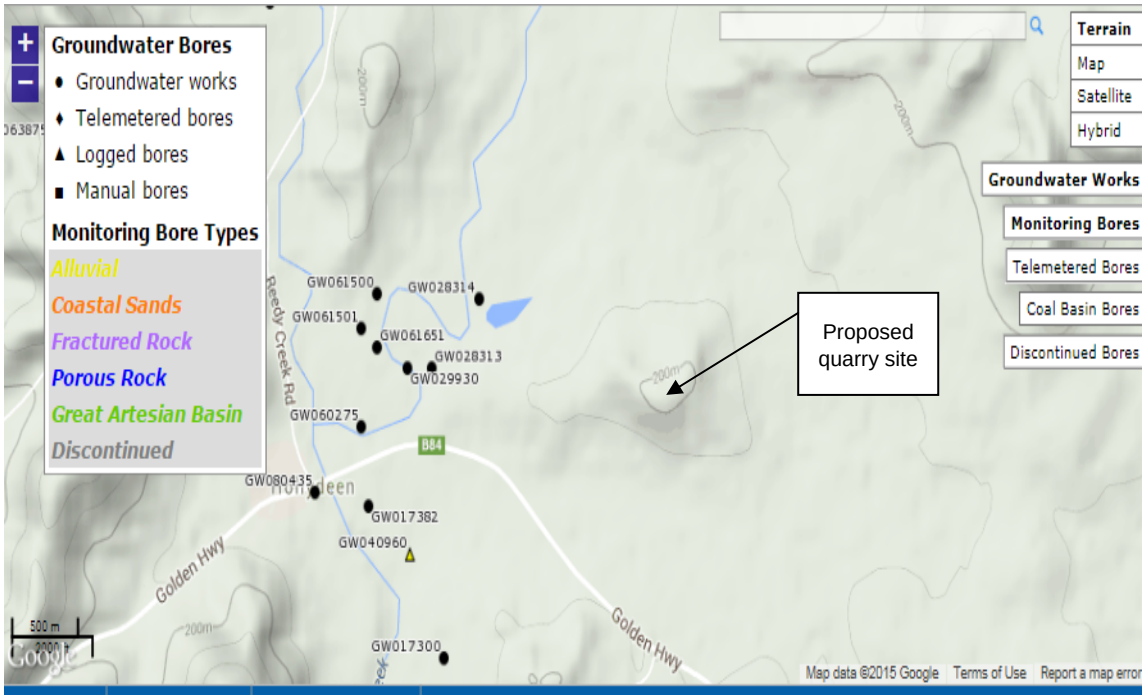


Figure 1 *Groundwater works in the environs of the proposed Dolwendee Quarry (Ref NOW Website)*

The salinity description on the works sheet for GW028313 indicates that the groundwater is of good quality with respect to salinity. GW028314 has a blank field in regard to salinity description. Both ground water works GW028313 and GW02314 work summary sheets indicate yields of 25.26l/s.

Based on the yields stated on the works sheet the Wybong Creek alluvial aquifer would be regarded as a *highly productive groundwater source* (Ref [9]) however it is noted that water quality in terms of salinity is reported (Ref [10]) to be highly variable. Ref [10] hypothesizes that the cause of the high salinity in the alluvial aquifer is leakage from coal seam aquifers into the alluvial aquifer by fracture systems in the rock.

As such the existing groundwater users take the groundwater from the alluvial aquifer with no licensed groundwater work indicated in the Wollombi Coal Measures in the environs of the proposed quarry.

It is noted however, that the degree of connectivity between the Wollombi Coal Measures aquifer and the Wybong Creek alluvial aquifer is not quantified and, as noted above, significant leakage from one to the other may occur where fracture zones facilitate such.

5 INVESTIGATION WORK

RCA Australia (RCA) undertook geotechnical investigations at the site in April 2012 and September 2014 (Ref [2]) In summary, the investigations included the rock coring drilling of four (4) bore holes (BH1, BH2, BH3 and BH4) and the installation and measuring of groundwater depths in four (4) piezometers established in BH5, BH6, BH7 and BH8. The location of these groundwater monitoring piezometers is shown on **Drawing 1** in **Appendix A**. The interval over which the piezometers is sealed is shown on **Drawings 5** and **6** in **Appendix B**.

The position and level of the bore holes were surveyed by a registered surveyor.

No groundwater was observed prior to rock coring water recirculation drilling techniques commencing in BH1 to BH4 which were drilled in April 2012. At the request of RCA the client dipped the boreholes in June 2013 to determine if there was any standing groundwater in the boreholes. The groundwater observations from the client borehole inspection are presented in **Table 2**.

Table 2 *Summary of client groundwater observations in BH1 to BH4 June 2013*

BH No.	Surveyed Collar RL (m AHD)	BH drilled depth (m)	BH inspected to depth (m)	Comments
BH1	173.00	30	16	No free water encountered. BH had collapsed below inspection depth.
BH2	181.90	30.1	25	As above
BH3	168.14	30	11	As above
BH4	177.84	27.15	20	As above

Groundwater levels in piezometers at BH5, BH6, BH7 and BH8 were measured on 6 November 2014 and are shown in **Table 3**.

Table 3 *Measured Groundwater Levels, 6 November 2014.*

Monitoring well	RL of top of PVC pipe (m AHD)	Depth to bottom of bore from top of PVC pipe (m)	PVC pipe stickup above ground surface (m)	Groundwater surface depth from top of pipe (m)	RL of Groundwater surface (m AHD)
				6/11/14	
BH5	176.38	61.5	0.622	45.51	130.87
BH6	161.80	45.0	0.69	30.83	130.97
BH7	167.12	40.2	0.565	34.91	132.21
BH8	158.71	40.1	0.645	36.13	122.58

The regional geological setting, and selected geotechnical sections through the site together with the logs of bores BH1 to BH8 are contained in **Appendix B**.

With reference to the Drawings in **Appendix B** it is understood that it is proposed to Quarry the Widden Brook Conglomerate which overlies the Greigs Creek Coal Seam which is at the top of the Wollombi Coal Measures. As such, the notional base of the quarry would be at the top of the coal seam.

Groundwater bore licence applications for monitoring wells in BH5 to BH8 have been lodged with NOW.

6 HYDROLOGY

The closest available annual rainfall statistics to the site are from the Bureau of Meteorology (BoM) for the Denman meteorological station (station number 61016) approximately 8.5km to the southeast of the site.

Available rainfall data for the Denman meteorological station number 61016 included the years 1883 to 2013 and part of the year 2014. No data is available beyond September 2014. The mean annual rainfall from 1883 to 2013/2014 at Denman is 591.8mm.

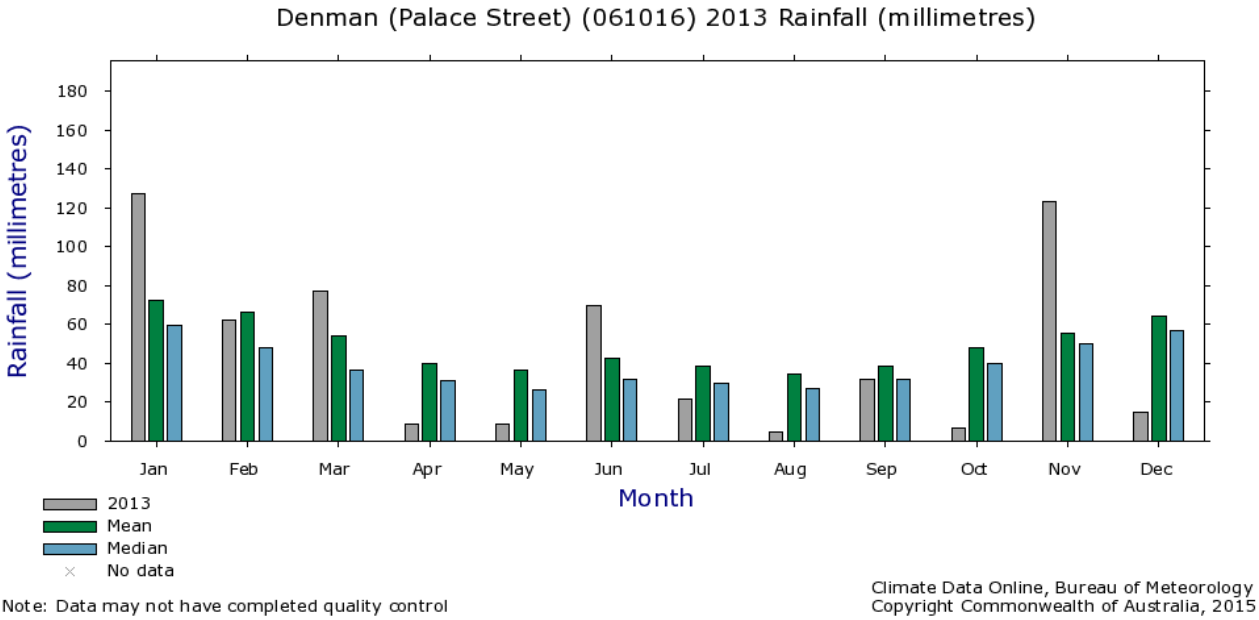


Figure 2 *Comparison of Monthly Rainfall for 2013 and the Mean Monthly Rainfall for Period from 1883 to 2013/2014.*

As noted above the data for 2014 is incomplete and no data is available for 2015 from Denman. The closest up to date available daily rainfall data on the BoM website is from Baerami (The Old Dairy) station number 061423 which is approximately 18kms south west of the site. Historical daily rainfall data is available from 2010 to 2015 and across the piezometer monitoring period.

A summary of the Baerami monthly rainfall data is presented on **Figure 3**.

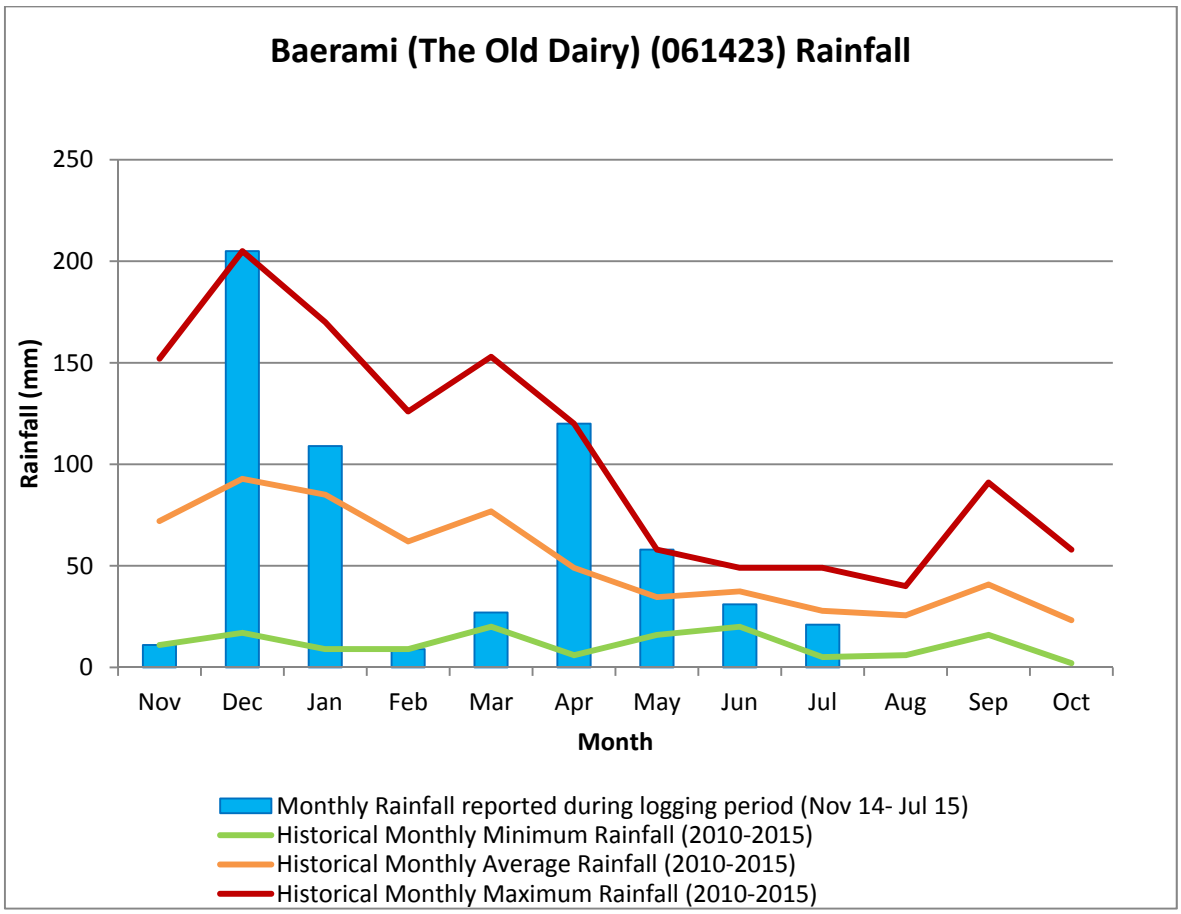


Figure 3 *Comparison of Monthly Rainfall for the Period from 2010 to 2015.*

The mean monthly rainfall distribution for the Denman station is not dissimilar to the average monthly rainfall distribution at the Baerami station.

With reference to **Figure 3** it may be seen that during the groundwater monitoring period statistically significant rainfall monthly totals have occurred. December 2014, April 2015 and May 2015 gave the highest monthly rainfall historically, while November 2014 and February 2015 were the lowest monthly rainfall recorded historically.

The daily rainfalls at the Baerami station are shown on the hydrographs for BH5 and BH8 in **Appendix F** together with the water levels from the data loggers in BH5 and BH8.

7 BASELINE GROUNDWATER MONITORING

Monitoring has been carried out by manually dipping the water level and sampling in 4 boreholes (BH5, 6, 7 and 8 fitted with stand pipe piezometers), during 3 site visits and by automatic water level monitoring (in standpipe piezometers in BH5 and BH8) in the period between the site visits. Site visits were undertaking during the months of January, May and July 2015. The work undertaken during each monitoring site visit is discussed below.

7.1 JANUARY 2015

Fieldwork at the site was undertaken on 22, 23 and 29 January 2015.

On 22 January 2015 the following work was carried out:

- Dipping of bores with a hand held dip meter to measure the depth to groundwater.

- Purging (at least one submerged bore volume) of the bores.
- Installation of two (2) automatic water level loggers (BH5 and BH8) and one (1) automatic barometric logger (BH5).
- Bores were re-dipped within 24 hours of purging.

BH5 was dipped immediately after purging of 80L over a period of 1 hour from the bore. It was observed that the purging of the bore only slightly lowered the groundwater table (by approximately 2cm).

BH6 was dipped on 23 January 2015 after purging of 80L over a period of one hour from the bore. It was observed that the purging of the bore did not lower the groundwater table.

BH7 was dipped on 23 January 2015 after purging of 40L over a period of one hour from the bore. It was observed that the purging of the bore only slightly lowered the groundwater table (by approximately 18cm).

BH8 was dipped on 23 January 2015 after purging the bore dry (approximately 12L purged over a period of one hour from the bore). The groundwater table was not observed to return to initial depth readings in bore BH8 within 24 hours of purging (approximately 1.24m lower than initial readings).

On 29 January 2015 the following was undertaken at the bores:

- Bores were manually dipped by hand held dip meter.
- Groundwater samples were collected by use of a Bennett pump, after pH and EC readings had stabilised.

Groundwater levels in the bores on 29 January 2015 ranged from 122.52m AHD (BH8) to 130.93m AHD (BH7) and was generally clear with some turbidity and trace particles, with the exception of BH8 which was observed to be dark brown/grey and very turbid.

There were no visual or olfactory signs of contamination observed during the inspection.

Samples were sent to a NATA accredited laboratory and analysed for pH, electrical conductivity (EC), dissolved oxygen, total dissolved solids (TDS), major cations and anions, ammonia, nitrates + nitrites and metals (iron, copper, lead, zinc, cadmium, chromium, nickel, manganese, aluminium, arsenic and mercury).

Field sheets are attached in **Appendix C**.

7.2 MAY 2015

Fieldwork at the site was undertaken on 6 May 2015 and included:

- Manual dipping of the four (4) bores on site by hand held dip meter.
- Purging of the sampling bores.
- Groundwater samples were collected by use of a Bennett pump, after pH and EC readings were stabilised. It is noted that BH8 only recovered sufficiently to allow one sample of groundwater to be collected for field testing during the time on site.
- Collection of automatically logged water levels and barometric pressure readings from two (2) water level loggers (located in BH5 and BH8) and one (1) barometric pressure logger (located in BH8).

There were no visual or olfactory signs of contamination observed during the inspection.

Samples were sent to a NATA accredited laboratory and analysed for pH, electrical conductivity (EC), dissolved oxygen, total dissolved solids (TDS), major cations and anions, ammonia, nitrates + nitrites and metals (iron, copper, lead, zinc, cadmium, chromium, nickel, manganese, aluminium, arsenic and mercury).

Filed sheets are attached in **Appendix C**.

7.3 JULY 2015

Fieldwork at the site was undertaken on 16 July 2015 and included:

- Manual dipping of the four (4) bores on site by hand held dip meter.
- Collection of automatically logged water levels and barometric pressure readings from two (2) water level loggers (located in BH5 and BH8) and one (1) barometric pressure logger (located in BH8).

No in situ water quality testing was carried out and no sampling/laboratory testing was carried out.

Field sheets are attached in **Appendix C**.

7.4 QUALITY ASSURANCE/QUALITY CONTROL

The collection of all groundwater samples was undertaken in compliance with RCA methodology. Groundwater sample collection methods comprised extraction by Bennett pump – following stabilisation of bore head and the pH and EC readings (within 0.1) to ensure a representative sample was collected.

These groundwater collection methods were chosen for the site as the Bennett pump was the most appropriate sampling equipment for the depth of groundwater (>30m below ground level (bgl)).

No decontamination of the Bennett pump was undertaken, however a new water sampling tube was utilised for each bore and the potential for cross-contamination to occur through the pump is considered to be minimal.

All samples were preserved as recommended by the analytical laboratory and stored in the field in an Esky on ice. Samples were sent to the laboratory within 24 hours of sampling.

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.

RCA omitted quality assurance sampling due to the limited number of samples.

ALS was chosen as the primary laboratory. RCA Laboratories were chosen as a secondary laboratory for analysis of pH, EC, dissolved oxygen and TDS. The laboratories used for analysis are NATA accredited and are experienced in the analytical requirements for potentially contaminated soil and groundwater.

ALS undertook internal quality assurance testing. Results are contained within the laboratory report sheets, **Appendix D**.

Review of the results indicates that ALS has undertaken laboratory quality assurance testing in accordance with the National Environmental Protection Measure (NEPM, Ref [4]).

- Recoveries of surrogates were within acceptance criteria of 70-130%.
- Holding times were within laboratory specified timeframes.
- Recoveries of laboratory control samples were within the acceptance criteria.
- Recoveries of Spikes were within acceptance criteria of 70-130% with the exception of minor departures.
- Relative Percentage Differences (RPD) for laboratory duplicates were within acceptance criteria as defined for duplicates in **Appendix D**.
- No Laboratory Blank result was detected above the PQL.

It is therefore considered that the data obtained from this testing is accurate and reliable in as far as it can be ascertained.

7.5 GROUNDWATER QUALITY SCREENING LEVELS

7.5.1 GROUNDWATER INVESTIGATION LEVELS (GIL)

DECC 2007 (Ref [5]) groundwater quality guidelines introduced by the NSW Department of Environment and Climate Change) recommend that the following are used for the assessment of risk to ecological and human health:

- Australian and New Zealand Environmental Conservation Council (ANZECC 2000, Ref [6]) investigation levels be adopted as groundwater investigation levels (GIL) for aquatic ecosystems; and
- National Health and Medical Research Council (NHMRC) and National Resource Management Ministerial Council (NRMMC, Ref [7]) for drinking water GIL.

ANZECC 2000 are complex guidelines that consider not only the level of protection (eg, 99% or 95%) but also the state of the receiving water (eg, moderately disturbed). For the protection of aquatic ecosystems the DECC recommend the use of 95% protection for all analytes with the exception of carcinogenic analytes for which the 99% protection value should be used. The following comments are additionally made:

- Where the existing generic GIL is below the naturally occurring background concentration of a particular contaminant, the background concentration becomes the default GIL.
- Where PQL are greater than the recommended GIL the PQL is adopted as the GIL. Where background concentrations are proven to be greater than the GIL, the background concentration is adopted as the GIL.
- Where there is insufficient data for the derivation of marine water criteria it is allowable to use fresh water criteria (Section 8.3.4.5, pg 8.3-36, (Ref [6])).

The NHMRC & NRMMC 2011 (Ref [7]) document provides a framework for drinking water quality management and assessment. The framework provided in this document has been adopted for the evaluation of contaminants in groundwater where groundwater can be, or is being, extracted and used for drinking water purpose.

The NHMRC and NMMC 20011 (Ref [7]) provide guidance on total dissolved solids (TDS) concentration for potable water and the National Water Commission (NWC, Ref [8]) detail general TDS values for fresh, brackish and saline waters.

RCA notes that the NEPM (Ref [4]) endorses the guidelines for use as GIL.

7.5.2 APPROPRIATENESS OF THE GUIDELINES

7.5.2.1 ECOLOGICAL GUIDELINES

The DECC guidelines (Ref [5]) is an endorsed guideline and applicable for groundwater.

The gradient on the groundwater surface as measured in BH5 to BH8 (see **Drawing 2** in **Appendix A**) indicates that the receiving water is Wybong Creek and as such the 95% fresh water criteria have been used for the assessment of risk to aquatic ecosystems. It is not considered that groundwater concentrations would be representative of direct contact in Wybong Creek and may not be representative of extracted groundwater off the site.

7.5.2.2 DRINKING WATER GUIDELINES

The Australian drinking water guidelines (Ref [7]) value for total dissolved solids (TDS) is 500mg/L for drinking water.

The NWC (Ref [8]) provides guidelines in terms of TDS for the use of descriptors such as fresh (TDS<500mg/L), brackish (TDS-500mg/L to 30,000mg/L) and saline (>30,000mg/L) for waters. The NWC (Ref [8]) consider that water with TDS values of greater than 500 mg/L are not suitable for use as potable water as the water becomes distasteful at TDS above 500mg/L.

The TDS values for groundwater at the site are have been measured in the laboratory and have been calculated from the field electrical conductivity (EC) values.

Field EC values were converted to TDS values using a multiplication factor of 0.64 as recommended by the Australian drinking water guidelines (Ref [7]).

Based on the measured and calculated TDS results and subsequent comparison to NWC (Ref [8]) guideline TDS values, groundwater at the site would be described as brackish.

Based on the brackish nature of the groundwater RCA considers the groundwater at the site to not be potable without treatment and therefore the Australian drinking water guidelines (Ref [7]) are considered not to be applicable as GILs.

7.6 MONITORING RESULTS

7.6.1 GROUNDWATER LEVELS

Measured groundwater levels during the monitoring events and those obtained during the geotechnical investigation are shown in **Table 4**.

Table 4 *Comparison of measured groundwater levels and top of Greigs Creek seam*

Monitoring Piezometer Location	Elevation of top of pipe (m AHD)	Pipe stickup above ground surface (m)	Depth to water surface level from top of pipe (m)						Groundwater surface level (m AHD)						Level of top of Greigs Creek seam (m AHD)	Minimum distance to GW from top of Greigs Creek seam (m)
			6/11/14	22/1/15	23/1/15	29/1/15	6/5/15	16/7/15	6/11/14	22/1/15	23/1/15	29/1/15	6/5/15	16/7/15	Notional base of quarry	
BH5	176.38	0.622	45.51	45.48	45.50	45.50	45.52	45.51	130.87	130.9	130.88	130.88	131.86	130.87	142.38	10.48
BH6	161.80	0.69	30.83	30.85	30.85	30.89	30.99	30.36	130.97	130.95	130.95	130.91	130.81	131.44	136.5	5.06
BH7	167.12	0.565	34.91	35.99	36.17	36.19	36.05	36.19	132.21	131.13	130.95	130.93	131.07	130.93	143.07	10.86
BH8	158.71	0.645	36.13	36.12	36.36	36.19	36.30	36.16	122.58	122.59	121.35*	122.52	122.41	122.55	129.48	6.89

XXX Highest water level during monitoring period

XXX lowest water level during the monitoring period

*Water level still recovering from pumping on previous day.

Table 4 reports minimal variation in measured groundwater depths. The greatest variation (1.28m) in water depth/level was observed in BH7 which varied from 132.21m AHD in November 2014 to 130.93m AHD in January and July 2015. Hydrographs of measured groundwater levels are shown in **Appendix F**.

The hydrographs as measured from the data logger's in BH5 and BH8 are shown in **Appendix F** with the daily rainfall records from the Baerami meteorological station. The trends are similar to the manual water level readings with little change in water levels over the monitoring period except when water purging/sample pumping occurred at BH8. The piezometer in BH8 is sealed into low permeability strata so pumping resulted in drawdown which took a discernible period to recover. Conversely the piezometer in BH5 is sealed in relatively high permeability strata resulting in no discernible draw down on purging/ water sampling and rapid water level recovery. The hydrographs do not indicate a discernible trend between rainfall and groundwater depth/level.

7.6.2 GROUNDWATER FLOW DIRECTION, GRADIENT AND VELOCITY

Groundwater flow directions were assessed from the groundwater surface contours (based on survey and groundwater depth at the four (4) groundwater monitoring piezometers) as shown on **Drawing 2** in **Appendix A**. Groundwater at the site is interpreted to flow in a general westerly direction with flow along the northeast boundary in a general northerly direction, from the eastern boundary of the site towards the Wybong Creek in the west and its tributaries to north of the site.

With reference to the groundwater contour levels shown on **Drawing 2** in **Appendix A** the overall groundwater surface gradient between BH6 and BH8 is approximately 3.9%.

The results of Packer testing carried out, in the saturated zone below the groundwater table, during the geotechnical investigations for the project, indicate values ranging from no take up to 140 Lugeons indicating permeability's ranging up to 10^{-5}m/sec.

The average of the Lugeon testing indicated a permeability of $3.6x10^{-6}$m/sec.

Adopting the average permeability and the gradient between BH6 and BH8, the lower bound groundwater flow rate through the site is expected to be in the order of 4.5m per year with an upper bound an order of magnitude higher.

7.6.3 GROUNDWATER CHEMISTRY

Groundwater parameters analysed in situ are compared to results reported by the laboratory as shown in **Table 5** and **Table 6**.

Table 5 *Comparison of In Situ Parameters to Reported Laboratory Results (January 2015)*

Location	Average In Situ Value[1]						Laboratory Analysis Value		
	pH	Conductivity (mS/cm)	Turbidity	Dissolved O_2 (mg/L)[2]	Temperature (^{0}C)	Salinity (%)	pH	Conductivity (mS/cm)	Dissolved O_2 (mg/L)
BH5	6.43	8.01	107	2.55	21.4	0.43	6.28	8.690	7.0
BH6	6.27	4.06	18	0.54	21.3	0.20	6.53	4.480	7.5
BH7	6.81	0.89	116	0.25	23.3	0.03	6.83	1.718	7.9
BH8	6.69	2.67	407	0.37	20.9	0.13	6.86	2.840	7.4

[1]Average in situ value represents the average of the last three (3) measured values.

[2]It was noted that during sampling the Horiba metre (ENV-1037) used for in situ parameter measurements had a split membrane. The membrane is used to measure dissolved oxygen.

Table 6 *Comparison of In Situ Parameters to Reported Laboratory Results (May 2015)*

Location	Average In Situ Value[1]						Laboratory Analysis Value		
	pH	Conductivity (mS/cm)	Turbidity	Dissolved O_2 (mg/L)	Temperature (^{0}C)	Salinity (%)	pH	Conductivity (mS/cm)	Dissolved O_2 (mg/L)
BH5	6.27	8.38	2	1.56	21.2	0.46	6.41	8.75	6.1
BH6	6.20	4.35	6	1.67	21.7	0.22	6.20	4.5	3.8
BH7	6.30	3.52	47	2.61	23.7	0.17	6.46	3.77	5.6
BH8	7.09	3.20	999	5.51	18.5	0.15	6.85	3.39	7.1

[1]Average in situ value represents the average of the last three (3) measured values except for BH8 where slow water level recovery after purging only allowed one water sample to be taken.

The field testing conductivity results indicate that the TDS in all bores is above 500mg/L and in all except BH7 it is above 1500mg/L.

Laboratory test results have been compared to the relevant criteria as shown in **Appendix E**.

Groundwater quality results reported elevated concentrations of arsenic, iron, nickel and zinc above relative guideline criteria. Groundwater results in excess of the relevant criteria are presented in **Table 7**.

Table 7 *Groundwater Results above Relevant Criteria*

Sample Identification	Analyte	Criteria	Concentration Jan/ May 2015
BH5	Iron	0.3[a]	11.3/0.89
	Zinc	0.008[a]	0.021/-
BH6	Iron	0.3[a]	4.32/3.5
	Zinc	0.008[a]	0.025/0.021
BH7	Iron	0.3[a]	1.52/2.65
	Nickel	0.011[a]	0.022/0.012
	Zinc	0.008[a]	0.047/0.034
BH8	Arsenic	0.013[a]	0.04/0.023
	Nickel	0.011[a]	0.051/1
	Zinc	0.008[a]	0.071/0.093

All concentrations in mg/L.

[a] ANZECC 2000 95% Protection Level for fresh water.

Additionally, laboratory results reported the following:

- The major anion in all bores was chloride followed by bicarbonate and sulfate. The major cation in all bores was sodium followed by magnesium, calcium and potassium.
- Cation and anion concentrations were the lowest in BH7 in January 2015 (19.2 meq/L and 19.3 meq/L) and significantly greater in BH5 (98.8/96.7 meq/L and 106/109 meq/L in January/May 2015), with concentrations between these values in BH6 and BH8.
- The pH readings in all bores ranged from 6.2 to 7.09 pH units, indicating slightly acidic to relatively neutral pH conditions.
- Ammonia concentrations were detected below the ANZECC criteria (0.9 mg/L) in all bores.
- Detectable concentrations (below the guideline level) of nitrate + nitrite and phosphorus were identified in one bore (BH8 in January 2015).
- Total dissolved solids varied from 1022mg/L to 5639mg/l (ie, greater than 500mg/L) and only one of the test results for TDS in BH7 (ref summary in **Appendix E**) having a TDS of less than 1500mg/L.

8 HYDROGEOLOGICAL SETTING

8.1 CONCEPTUAL HYDROGEOLOGICAL SETTING

The proposed Dolwendee quarry is located in the Narrabeen Widden Brook Conglomerate above of the Wollombi Coal Measures which contains groundwater.

A schematic conceptual hydrogeological setting is shown by way of an annotated sketch on **Figure 4**.

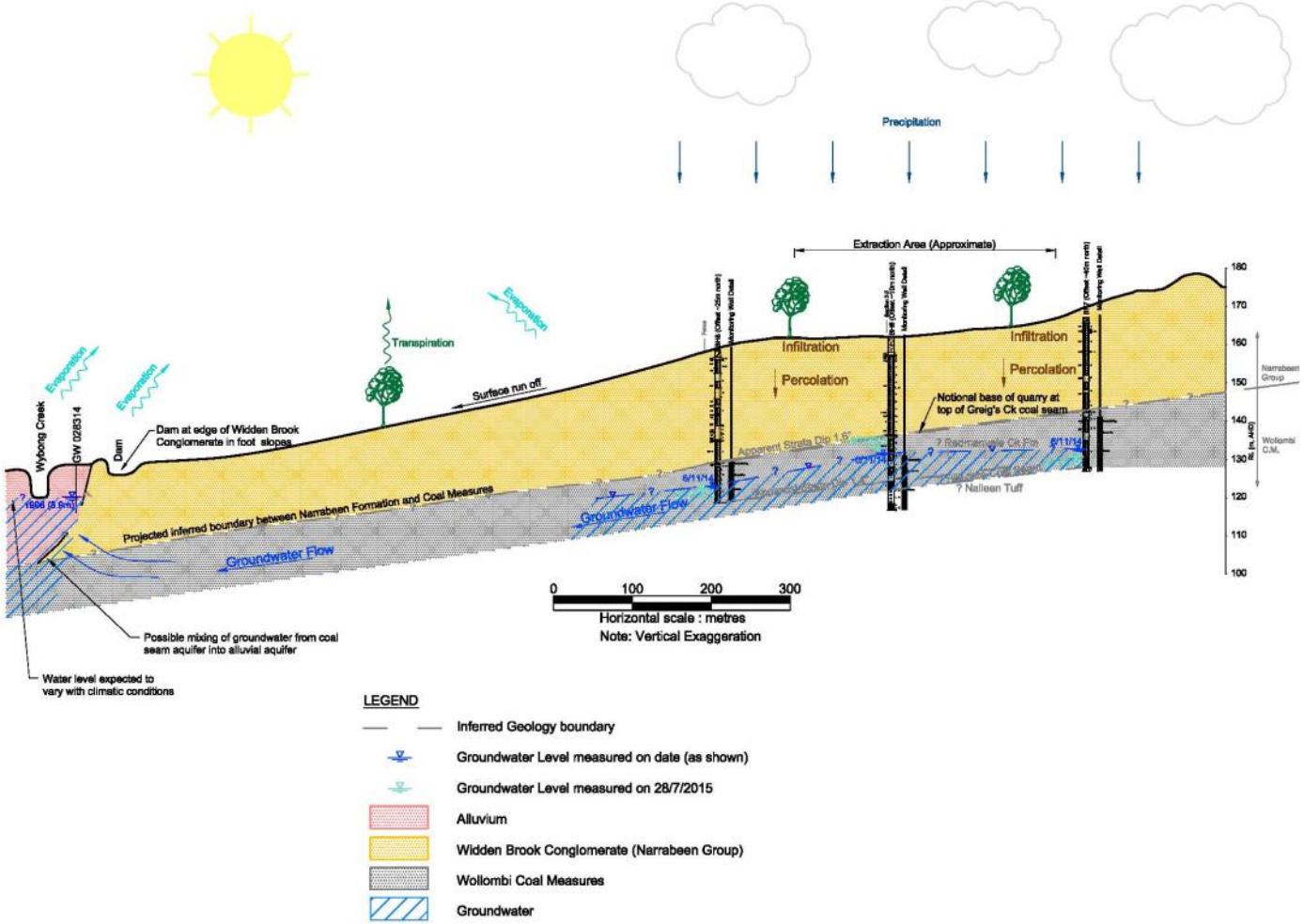


Figure 4 *Conceptual hydrogeological setting*

8.2 GROUNDWATER DEPTH/LEVELS

Monitoring of groundwater depth/levels has been carried out by the following:

- Manual dipping of 4 standpipe piezometers. The depth to groundwater was measured during installation in November 2014 and in January 2015, May 2015, and July 2015.
- Logging of water levels in 2 of the standpipe piezometers by an automatic data logger.
- The data was collected over a period of approximately six months.

In summary, the conclusion of the groundwater depth/level monitoring and comparison with the closest rainfall records was that:

- The greatest variation in groundwater levels measured in any one monitoring piezometer was 1.28m.
- Groundwater levels at the site ranged from 121.35m AHD to 132.21m AHD.
- No discernible trend between rainfall and groundwater depth/level was observed.

8.3 GROUNDWATER FLOW DIRECTION, RATE AND CONNECTIVITY

As noted in Section 7.6.2 groundwater at the site is interpreted to flow in a general westerly direction with flow along the north-east boundary in a general northerly direction, from the eastern boundary of the site towards the Wybong Creek in the west and its tributaries to the north of the site.

As noted in Section 7.6.2 based on the gradient between BH6 and BH8, the lower bound groundwater flow rate through the site is expected to be the order of 4.5m per year with an upper bound an order of magnitude higher.

In regard to connectivity it is likely that there is connectivity between the rock and the Wybong Creek alluvial aquifer. However, as the water quality was noted as good on the driller's log worksheet for GW028313 (one of the closest works – see Section 4) indicating that the connectivity is limited at this location.

8.4 GROUNDWATER QUALITY

The groundwater was sampled in January 2015 and May 2015 and subject to the following analysis:

- In-field testing for pH, conductivity, turbidity, dissolved oxygen, temperature and salinity.
- Analyses for pH, electrical conductivity (EC), dissolved oxygen, total dissolved solids (TDS), major cations and anions, ammonia, nitrates + nitrites and metals (iron, copper, lead, zinc, cadmium, chromium, nickel, manganese, aluminium, arsenic and mercury) by a NATA accredited laboratory.

Full details are presented in Section 7.6.3. In summary:

- The pH readings in all bores ranged from 6.2 to 7.09 pH units, indicating slightly acidic to relatively neutral pH conditions.
- The major anion in all bores was chloride followed by bicarbonate and sulfate. The major cation in all bores was sodium followed by magnesium, calcium and potassium.

- The field testing conductivity results indicate that the TDS in all bores is above 500mg/L and in all except one location above 1500mg/L.
- Laboratory total dissolved solids varied from 1022mg/L to 5639mg/L (ie. greater than 500mg/L) with only one of the test results (ref summary in **Appendix E**) having a TDS of less than 1500mg/L. Based on the TDS the water would be regarded as brackish.
- Owing to the brackish nature the groundwater would not be considered potable without treatment and therefore the Australian drinking water guidelines (Ref [7]) are considered not to be applicable as Groundwater Investigation Levels (GILs). The gradient on the groundwater surface as measured in investigation monitoring piezometers (see **Drawing 2** in **Appendix A**) indicates that the receiving water is Wybong Creek and as such the ANZECC 2000, 95% fresh water criteria are considered to be the applicable GILs for the assessment of risk to aquatic ecosystems. It is noted however, that it is considered that groundwater concentrations would not be representative of direct contact in Wybong Creek and may not be representative of extracted groundwater off the site.
- Adopting the ANZECC 2000, 95% Protection Level for fresh water for use as the applicable GILs the water on site chemical testing reported elevated concentrations of arsenic, iron nickel and zinc (See **Appendix E**). The elevated levels are thought to be due to natural causes.

The NOW Aquifer Interference Policy (Ref [9]) divides groundwater into categories of *highly productive* and *less productive* groundwater sources based on the yield and TDS. Groundwater at this site would fall into the category of *a less productive groundwater source* due to the aquifer having the following characteristics:

- A TDS of greater than 1500mg/L; and
- an expected water yield rate of less than 5L/sec.

9 IMPACT OF THE QUARRY ON THE GROUNDWATER SYSTEM

9.1 AQUIFER INTERFERENCE

9.1.1 MAXIMUM GROUNDWATER LEVEL

Groundwater levels measured at the site ranged from 122.41m AHD (BH8) to 132.21 AHD (BH7).

The trace of water levels measured by automatic logger in BH5 and BH8 indicate minor fluctuation of less than 0.5m in groundwater level over the monitoring period despite significant rainfalls. Comparison to available rainfall records indicated that there is minimal variation in groundwater levels in response to rainfall.

The greatest natural fluctuation in water level during the monitoring period was 1.28m in BH7 which was manually monitored by dip meter at discrete times as indicated in **Table 4**.

The notional base of the quarry (the top of the Greigs Creek seam) is more than 5m above the monitored groundwater levels.

The base of the proposed quarry development is:

- above the geological unit (Wollombi Coal Measures) which is acting as an aquifer containing groundwater beneath the site;

- above the surface of the groundwater within the aquifer;
- above the level of the likely fluctuation of the groundwater surface.

With reference to the groundwater monitoring results, it is considered that it is unlikely that quarrying to the top of the Greigs Creek Coal Seam (ref **Drawings 5** and **6** in **Appendix B**) will penetrate the groundwater surface at the site.

Based on the above, the excavation of the quarry is expected not to intersect the coal seam aquifer or groundwater at the site.

Accordingly, groundwater will not be extracted with the winning of the quarry resource.

Consideration of potential aquifer interference is therefore confined to consideration of whether the activities associated with quarrying will impact on the aquifer/groundwater in terms of the following:

- Changing the groundwater water levels due to activity that affects aquifer recharge, ie, by groundwater harvesting or altering the surface infiltration or percolation rates, etc.
- Causing a change in the water quality of the groundwater by the introduction of contaminants during the quarrying operation.

It is expected that the surface rainfall on the plan area of the quarry will infiltrate the subsurface strata in a similar manner pre, during and post quarrying. Taking into account the lack of response of the groundwater level to rainfall indicated by monitoring (see Section 7.6.1) it is expected that the proposed activity is unlikely to have a discernible effect on the groundwater level below the site.

It is understood that water required on site will be imported from elsewhere, contained in site and recycled such that any dirty water is processed and re-used. It is understood that groundwater will not be harvested for quarry activities.

In regard to changing the quality of the groundwater by the introduction of contaminants during quarrying operations this will need to be guarded against by conducting the operations in accordance with a suitably drafted Quarry Environmental Management Plan which would include the following requirements:

- Containment of any chemicals and fuels in lined bunded areas that are designed to safely accommodate the volume of the stored material.
- Containment of sewerage water and treatment out of the quarry in an approved manner.
- Containment of truck wash water and processing water such that they can be processed and re-used.
- Removal of all material, equipment, structures, etc, from the quarry at the completion of the quarrying activity.

As noted in Section 8.4, the aquifer would fall into the category of *a less productive groundwater source* due to water quality and available yields. With reference to the Aquifer Interference Policy (AIP), Table 1, *Minimal Impact Considerations for Aquifer Interference Activities* for a 'Less Productive Groundwater Porous and Fractured Rock Water Source the proposed quarry would fall into the minimal impact category because the quarry is expected:

- not to produce any decline in the water table;

- not to produce any decline in the pressure head;
- not to produce any change in the groundwater quality subject to operation in accordance with an appropriate quarry EMP;
- not to impact on the aquifer/groundwater or any Groundwater Dependent Ecosystems (GDE). Ref [11] indicates that the nearest (GDE) is the river oak woodland along the banks of Wybong Creek over 900m from the site.

9.2 MONITORING

It is proposed to monitor the groundwater level and quality in three monitoring wells in BH5, BH7 and BH8.

The groundwater would be monitored bi-annually for the following:

- Level of the groundwater surface.
- Groundwater quality

The testing results would be tabulated and reported in a working document with comparison to previous monitoring results.

9.2.1 ACTION TRIGGER LEVEL

9.2.1.1 WATER LEVELS

The depth of the quarry will increase with time generally in accordance with the approved quarry plan. This will allow progressive monitoring of water levels with time.

If groundwater levels are found to rise with time the base level of the quarry would be adjusted to maintain the current buffer between the base of the quarry and the groundwater surface. The trigger level for review would be a change in water level of 2m from the previous reading or the base of the quarry being within 5m of the top of the groundwater surface.

9.2.1.2 WATER QUALITY

For contaminants to migrate to the groundwater, would normally occur from contaminated surface water in the quarry. Accordingly, the first line of groundwater protection with the quarry would be the surface water quality monitoring programme.

However, it is suggested that the groundwater be tested for pH, Conductivity, Total Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAH) on a bi-annual basis.

pH and conductivity would be expected remain in the range established by the groundwater baseline monitoring.

TPH and PAH should be monitored and reported against the previous monitoring result and long-term ranges.

10 QUARRY FINAL LANDFORM

It is understood that it is proposed to finish the quarry as a closed void where surface water would be diverted around the quarry and rainfall over the plan area of the void would be collected in the void.

As previously noted it is expected that the quarry will be a dry quarry.

Similarly it is expected that rain falling on the quarry plan area will (less evaporation/transpiration) infiltrate the base of the quarry. As such, the quarry is not expected to pond water.

11 CONSIDERATIONS OF RELEVANT POLICIES AND GUIDELINES

Reference [1] indicates the following relevant policies and guidelines.

The Environmental Impact Statement (EIS) should take into account the following policies (as applicable):

1. NSW Guidelines for Controlled Activities on Waterfront Land (NOW, 2012).
2. NSW Aquifer Interference Policy (NOW, 2012).
3. Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012).
4. Australian Groundwater Modelling Guidelines (NWC, 2012).
5. NSW State Rivers and Estuary Policy (1993).
6. NSW State Groundwater Policy Framework Document (1997).
7. NSW State Groundwater Quality Protection Policy (1998).
8. NSW State Groundwater Dependent Ecosystems Policy (2002).
9. Groundwater Monitoring and Modelling Plans – Information for prospective mining and petroleum exploration activities (NOW, 2014).

The following comments are made on the policies and guidelines with respect to this proposed development:

No 1 is not directly or indirectly relevant as there is no relationship between the development and waterfront land and no controlled activity is proposed on waterfront land associated with the project.

No 2 is directly relevant and addressed within with this report with the proposal considered to fall into the minimal impact/harm category.

No 3 is directly relevant. The presence or otherwise of GDE on the site or surrounds is not addressed by this report. Ref [11] identified the closest GDE as being over 900m from the proposed Quarry. The quarry is not expected to have an adverse impact on this GDE.

No 4 is relevant however, as the activity falls into the minimum impact harm category and no groundwater interference nor harvesting is proposed no detailed modelling is considered warranted.

No 5 is not directly relevant as the development is not in the environs of a river or estuary. It is within the catchment for the Goulburn and Hunter Rivers.

No's 6, 7, 8 are relevant as general policy, principals, management and implementation guidelines on which other issues raised in the SEARs are based and addressed in this report.

No 9 is directly relevant to the proposed development. Based on the investigation work documented within this report the development proposal is considered to fall into the minimal impact/harm category. No groundwater intersection or harvesting is proposed. Accordingly, the baseline monitoring works carried out to date are considered to be sufficient to assess the aquifer impact.

12 WATER SHARING PLAN

The proposed project is located within the *Water Sharing Plan for the Wybong Creek Water Source 2003*, which applies to surface waters and groundwater in the alluvial sediments within the plan area. It is understood from [Ref 1] that this water sharing plan was due for extension/replacement by 1 July 2015 or sooner. At the time of extension/replacement this plan is proposed to be merged with the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources*.

It is also understood from [Ref 1], groundwater contained within the hard rock (porous and fractured rock) aquifers within the project area is currently regulated under the *Water Act 1912*. A water sharing plan covering the porous and fractured rock groundwater within the project area is currently under development, and scheduled for commencement in 2015. Upon commencement of the plan groundwater on site would be regulated under the *Water Management Act 2000*.

It is noted that no groundwater is being taken during the proposed development and, accordingly, the above comments are in passing.

13 RESPONSE TO NOW COMMENTS

The response to the NOW comments as they relate to groundwater impacts are presented in **Table 8**.

Table 8 *NOW comments (SEARs) and reference to the section of the report in which they are addressed*

SEARs NOW comments to be addressed	Comment
Reference 1 Letter dot points beyond the introductory legislative framework summary:	
• A detailed assessment against the NSW Aquifer Interference Policy (2012) using the NSW Office of Water's assessment framework.	See Section 9.1 - 1. Quarrying is defined as an aquifer interference activity. 2. Quarrying under the hydrogeological conditions that prevail at this site is defined as a minimal impact aquifer interference activity according to section 3.3 of the AIP therefore no further assessment against the policy is required.
• Details of water proposed to be taken (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan.	See Section 9.1 - No groundwater is proposed to be intercepted or taken.
• Assessment of any water licensing requirements (including those for ongoing water take following completion of the Project).	See Section 9.1 - No groundwater licence is required as no groundwater is proposed to be intercepted or taken.
• The identification of an adequate and secure water supply for the life of the Project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.	See Section 3 - Groundwater is not proposed to be used as water supply for the Quarry. Water requirements are to be supplied by off quarry site surface water storages.
• Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	See Sections 4 and 9.1 - No impacts are expected as groundwater is not intersected nor taken.
• Proposed surface and groundwater monitoring activities and methodologies.	See Section 9.2 - Proposed groundwater monitoring comprises bi-annual monitoring of three bores for groundwater level, pH and Conductivity, TPH and PAH.

SEARs NOW comments to be addressed	Comment
• Full technical details and data of all surface and groundwater modelling, and an independent peer review.	See Section 9.1 - No modelling is required under the Aquifer Interference assessment Frame Work step by step guide. Accordingly no peer review is required. It is also noted that the aquifer is not intersected nor impacted
• A detailed and consolidated site water balance.	Water balance will be addressed in the Surface Water report.
• Proposed management and disposal of produced or incidental water.	See Section 9.1 - The groundwater table will not be intersected. The quarry is expected to be a dry quarry which will not make water. Water for operations will be imported to the site from surface storages elsewhere. Dirty water in the quarry will be recycled. The discharge of introduced water would be controlled by the **Quarry Environmental Management Plan**.
• Details surrounding the final landform of the site, including final void management (where relevant) and rehabilitation measures.	Ref Quarry Design for details: The final landform is to be a closed void which is not expected to pond water. Only rainwater falling on the plan area of the void would be captured by the void and this less evaporation/transpiration would recharge groundwater in much the same manner that rainfall (less evaporation/transpiration/runoff) on the plan area of the quarry does predevelopment.
• Assessment of any potential cumulative impacts on water resources, and any proposed options to manage cumulative impacts.	See Section 9.1 - Apart from the possibility of contaminant spills there are no potential cumulative impacts on water resources. The risk of contaminant spills will be managed by the appropriate environmental controls in the **Quarry Environmental Management Plan**.
• Consideration of relevant policies and guidelines.	See Section 11.
Reference 1 - Attachment A Comments	
Water Sharing Plan	See Section 12 -There is no proposed groundwater take so a water sharing does not arise
Licencing requirements	See Section 9.1 - There is no proposed groundwater interception or take and therefore no requirement for a licence.

SEARs NOW comments to be addressed	Comment
Groundwater Assessment	
• The predicted highest groundwater table at the site.	See Section 7.6.1 and 8.2 - The highest monitored groundwater level at the site is RL132.21. The groundwater levels do not appear to be responsive to rainfall and a level of RL133m is predicted to be the highest groundwater level likely based on monitoring to date.
• Works likely to intercept, connect with or infiltrate the groundwater sources	See Section 9.1 - No works are likely to intercept, connect or infiltrate the groundwater source.
• Any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes (Office of Water "GW' registration numbers and licence/approval numbers should be supplied).	See Section 3 and 5 - No groundwater extraction is proposed. Groundwater monitoring bores are in place and licence applications have been submitted.
• A description of the flow directions and rates and physical and chemical characteristics of the groundwater source (including connectivity with other groundwater and surface water sources).	See Sections 7 - In summary groundwater flows are to the west and north beneath the site towards Wybong Creek and its tributaries. Flow rates are estimated to be in the order of 4.5m per year. Groundwater is brackish with the dominant cation and anions being sodium and chloride. Unlikely to be connected to surface water flows on the site but possibly connected to the Wybong alluvial aquifer to the west.
• Sufficient baseline monitoring for groundwater quantity and quality for all aquifers and GDEs to establish a baseline incorporating typical temporal and spatial variations.	See Section 7 - Quality and water levels monitored over a period of 6 months. No discernible correlation of water levels with rainfall.
• The predicted impacts of any final landform on the groundwater regime.	See Section 10 - No impacts on the groundwater regime are predicted from the final landform.
• The existing groundwater users within the area (including the environment), any potential impacts on these users and safeguard measures to mitigate impacts.	See Section 4 - No potential impacts are expected on the existing groundwater users.
• An assessment of the quality of the groundwater for the local groundwater catchment.	See Section 8.4 - Groundwater is brackish.

SEARs NOW comments to be addressed	Comment
• An assessment of the potential for groundwater contamination (considering both the impacts of the proposal on groundwater contamination and the impacts of contamination on the proposal).	See Section 9.1 - Minor potential for groundwater contamination exists from spill. It is considered that this potential can be managed by operation in accordance with a suitable structured Quarry **Environmental Management Plan**.
• Measures proposed to protect groundwater quality, both in the short and long-term.	See Section 9.1 - Short term: Containment and safe storage of all potential contaminants (chemicals and fuels) and operation in accordance with the **Quarry Environmental Management Plan**. Long term: demobilisation of all site machinery, equipment storage demolition and removal of all structures to leave only the natural ground surface exposed in the void.
• Measures for preventing groundwater pollution so that remediation is not required	See Section 9.1 - Containment and safe storage of all potential contaminants (chemicals and fuels) and operation in accordance with the **Quarry Environmental Management Plan.**
• Protective measures for any groundwater dependent ecosystems (GDEs).	See Section 9.1 - The groundwater system is not intersected or impacted therefore the quarry is unlikely to have an impact on GDEs
• Proposed methods of the disposal of waste water and approval from the relevant authority	See Section 3 - Dirty stormwater to be retained in pit and reused. The only wastewater would be sewage effluent which would be managed out of pit with suitably designed domestic wastewater treatment and irrigation system.
• The results of any models or predictive tools used.	See Section 7.6.2 - Groundwater direction and flow rate based on interpolation of groundwater levels in bores and interpolated contouring.
Measures that would measure, remediate, reduce or manage potential impacts to the existing groundwater resource, dependent groundwater environment or water users including information on:	
• Any proposed monitoring programs including water levels and quality data.	See Section 9.2 - Proposed bi-annual monitoring of water level, pH and conductivity, TPH and PAH in three groundwater monitoring wells BH5, 7 and 8.

SEARs NOW comments to be addressed	Comment
• Reporting procedures for any monitoring programme including mechanism for transfer of information.	See Section 9.2 - Tabulated results of monitoring in letter format with comment on any significant variation from previous round of monitoring electronic transfer of information.
• An assessment of any groundwater source/aquifer that may be sterilised from future use as a water supply as a consequence of the proposal.	See Section 9.1 - Proposal is unlikely to have an impact on any groundwater source/aquifer present or future.
• Identification of any nominal thresholds as to the level of impact beyond which remedial measures or contingency plans would be initiated (this may include water level trigger or a beneficial use category).	See Section 9.2.1 - Maintain quarry base above groundwater level and confirm absence of contamination by surface water and groundwater monitoring.
• Description of the remedial measures or contingency plans proposed.	See Section 9.2.1 - Review proposed base level of quarry against monitored water levels to ensure that the groundwater is not likely to be intersected.
• Any funding assurance cover in the anticipated post development maintenance cost for example ongoing groundwater monitoring for the nominated period.	None expected to be required. Monitoring will have been ongoing for more than 20 years by the cessation of quarrying. It is expected that groundwater levels would be well understood by that time.
Groundwater Dependent Ecosystems	Ecological investigations by Umwelt indicate that the only GDE within the environs is the river oak woodland community along the banks of Wybong Creek more than 900m from the proposed quarry. The proposed quarry is not expected to have an impact on this GDE.
Water courses and Riparian Lands	Mapping of these carried out by others
Dam Safety	See Section 10 - The void is not expected to hold water. Accordingly, the requirement for referral to the Dam Safety Committee does not arise.
Drill Pad, Well and Access Road Construction	
• Any Construction activity within 40m of a watercourse, should be designed by a suitably qualified person, consistent with the NSW Guidelines for Controlled Activities (July 2012).	Assume that this an advisory note.

SEARs NOW comments to be addressed	Comment
• Construction of wells must be undertaken by a driller holding a water driller's licence valid in NSW.	Existing monitoring wells have been installed by a driller holding a water driller's licence valid in NSW.
• The length of time that a cored hole is maintained as an open hole should be minimised.	Assume that this an advisory note
Land form rehabilitation or final void management	
• Justification of the proposed final landform with regard to its impact and regional groundwater systems.	See Section 10 - Final landform of the quarry as a void is not expected to have a measurable impact on the regional groundwater system
• A detailed description of how the site would be progressively rehabilitated and integrated into the surrounding landscape.	Refer to quarry design
• Detailed modelling of potential groundwater volume, flow and quality impacts of the presence of an inundated final void on identified receptors specifically considering those environmental systems that are likely to be groundwater dependent.	See Section 10 - Not expected to have a measurable impact on identified receptors.
• A detailed description of the measures to be put into placed to ensure that sufficient resources are available to implement the proposed rehabilitation.	Refer to Quarry Management Plan.

14 LIMITATIONS

This report has been prepared for KMH Environmental in accordance with an agreement with RCA. 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 KMH Environmental. The report may not contain sufficient information for purposes of other uses or for parties other than KMH Environmental. 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.

Environmental conditions including contaminant concentrations can change in a limited period of time. This should be considered if the report is used following a significant period of time after the date of issue.

Yours faithfully

RCA AUSTRALIA

Robert Carr
Principal Geotechnical Engineer

REFERENCES

[1] Letter from the NSW Department of Primary Industries, Ref OUT14/15560 addressed to the Mining Projects, NSW Department of Planning and Environment, Re Dolwendee Quarry Project (SSD_6519) Request for input into Secretary's Environmental Assessment requirements, and Attachment A.

[2] Report titled *Geotechnical Investigation Report for proposed Construction Material Quarry*, Lot 2 "Dalwondee Estate" Golden Highway, Hollydeen prepared by RCA Australia reference 9325-203/0.

[3] Report titled Baseline Groundwater Monitoring, Dolwendee Quarry, Hollydeen, prepared for KMH Environmental by RCA Australia RCA ref 9325-205b/1 dated August 2015.

[4] NEPC, *National Environment Protection (Assessment of Site Contamination) Measure*, 1999 as amended 2013.

[5] DECC, *Contaminated Sites – Guidelines for the Assessment and Management of Contaminated Groundwater*, March 2007.

[6] ANZECC, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, October 2000.

[7] National Health and Medical Research Council, *Australian Drinking Water Guidelines*, 2011.

[8] National Water Commission, *Brackish groundwater: a viable community water supply option*, Waterlines Report Series No 66, December 2011.

[9] NSW Aquifer Interference Policy, NSW Government policy for the licencing and assessment of aquifer interference activity, Department of Primary Industries Office of Water, Sept 2012.

[10] *Origins of salinity and salinisation process in the Wybong Creek Catchment, New South Wales, Australia*, A Thesis by Julia Janson-Smith, submitted for the degree of Doctor of Philosophy of The Australian National University, Research School of Earth Sciences & Fenner School of Environment and Society dated March 2010.

[11] Report titled Ecological Assessment, Dolwendee Quarry prepared for Upper Hunter Holdings Pty Ltd by Umwelt ref 3453_ROI dated September 2015.

GLOSSARY

AHD	Australian height datum, based on a mean sea level.
ANZECC	Australian and New Zealand Environmental Conservation Council.
BoM	Bureau of Meteorology.
DECC	NSW Department of Environment and Climate Change.
GIL	Groundwater investigation levels.
In situ	In place, without excavation.
ISL	Investigation screening levels for soil. Comprised of HIL/EIL and HSL/ESL.
kg	kilogram, 1000 gram.
Leachate	Fluid that has passed through a soil stratum, possibly collects contaminants.
μg	microgram, 1/1000 milligram.
mg	milligram, 1/1000 gram.
NEPC	National Environment Protection Council.
NEPM	National Environment Protection Measure.
NHMRC	National Health and Medical Research Council.
NRMMC	National Resource Management Ministerial Council.
NSWEPA	NSW Environment Protection Authority – formerly a component of DECC, DECCW, OEH but made a separate entity in 2011 to regulate the contaminated land industry.
PQL	Practical Quantitation Limit.
QA	Quality Assurance.
QC	Quality Control.
RPD	Relative Percentage Difference.

Weathering	All physical and chemical changes produced by atmospheric agents.
<u>Chemical Compounds</u>	
EC	Electrical Conductivity.
TDS	Total dissolved solids. Also known as non-filterable residue (NFR).
TSS	Total suspended solids.

Appendix A

Drawings

LEGEND

Project area

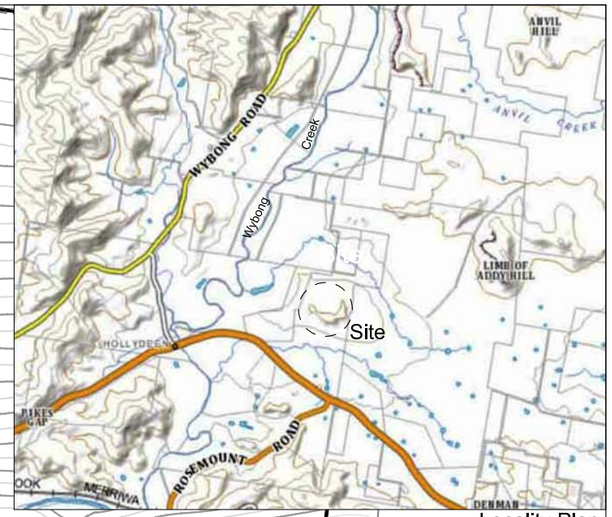
Extraction area

Borehole location BH1 to BH4 drilled April 2012
(no piezometers fitted - dry)

Borehole location BH5 to BH8 drilled September 2014
(piezometers fitted)

NOTE: Drawing adapted from plan supplied by
Boardman Peasley Pty Ltd
Job No. S4953, Plan No. 001, Rev A
Dated February 2013

Project Area and Extraction Area locations
supplied by VGT
Dwg Ref. 1257_DQ_PP_C011_V1_F6.cdr
Version/Date V1 22/07/2015



Locality Plan
N.T.S.

BH8
BH6
BH7
BH1
BH3
BH5
BH4
BH2

2
40 ha

0 25 50 75 100
metres

RCA AUSTRALIA
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BASELINE GROUNDWATER MONITORING
BORE LOCATION PLAN
DOLWENDEE QUARRY
GOLDEN HIGHWAY
HOLLYDEEN

CLIENT	KHM Environmental			RCA Ref	9325-205b/1
DRAWN BY	JG	SCALE	1 : 2500 (A3)	DRAWING No 1	REV 0
APPROVED BY	RJC	DATE	7/8/2015	OFFICE	NEWCASTLE

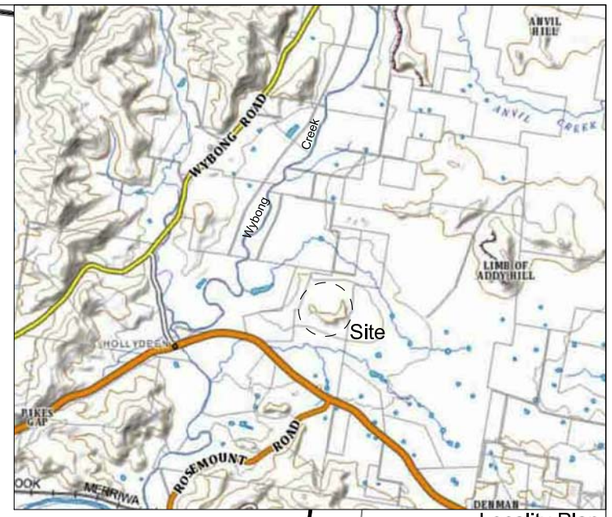
CDT-DWG-A3H-001/1

LEGEND

- Project area
- Extraction area
- Borehole location BH1 to BH4 drilled April 2012 (no piezometers fitted - dry)
- Borehole location BH5 to BH8 drilled September 2014 (piezometers fitted)
- Groundwater contours (m, AHD) (based on piezometers in BH5 to BH8) January 2015
- Groundwater flow direction (inferred from groundwater contours) January 2015
- Groundwater contours (m,AHD) (based on piezometers in BH5 to BH8) July 2015
- Groundwater flow direction (inferred from groundwater contours) July 2015

NOTE: Drawing adapted from plan supplied by Boardman Peasley Pty Ltd
Job No. S4953, Plan No. 001, Rev A
Dated February 2013

Project Area and Extraction Area locations supplied by VGT
Dwg Ref. 1257_DQ_PP_C011_V1_F6.cdr
Version/Date V1 22/07/2015



Locality Plan
N.T.S.

122.52
122.52
BH8

130.91
131.44
BH6

BH7
130.93
130.93

BH1

BH3

BH5
130.88
130.87

BH4

BH2

2
40 ha

0 25 50 75 100
metres

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GROUNDWATER CONTOUR PLAN
DOLWENDEE QUARRY
GOLDEN HIGHWAY
HOLLYDEEN

CLIENT	KHM Environmental			RCA Ref	9325-205b/1	
DRAWN BY	JG	SCALE	1 : 2500 (A3)	DRAWING No	2	REV 0
APPROVED BY	RJC	DATE	7/8/2015	OFFICE	NEWCASTLE	

CDT-DWG-A3H-001/1