



**NEWNES KAOLIN ANNUAL -  
GROUNDWATER MONITORING REPORT**







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Prepared by:

**RPS Water & Environment**

Level 9, 17 York Street, Sydney NSW 2007  
GPO Box 4401 Sydney NSW 2001

T: 61 2 8270 8388

F: 61 2 8270 8399

E: [water@rpsgroup.com.au](mailto:water@rpsgroup.com.au)

W: [rpsgroup.com.au](http://rpsgroup.com.au)

Our ref: WS0092D/001a

Date: 22 March 2016

Prepared for:

**T/A Sydney Construction Materials Pty Ltd**

3 Karingal Court  
Marsfield NSW 2122



**Document Status**

	Issue Date	Purpose of Document
Revision A	22/03/2016	2015 Groundwater AEMR

	Name	Position	Signature	Date
Author	Jonathon Tait	Environmental Engineer		22/03/2016
Reviewer	Jason Carr	Senior Hydrogeologist		22/03/2016

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## 1. Introduction

### 1.1 Background

Newnes Kaolin Pty Limited (NKPL) proposes to develop an open pit operation to extract friable sandstone at Newnes Junction (Newnes), on the Newnes Plateau some 10km east of Lithgow, between the existing Clarence Colliery and Rocla Quarry.

The proposed open cut operation covers an area of 25ha, adjacent to three existing quarry / mine operations. An estimated 23.7Mt of reserves will be extracted over the next 21 years.

Mine planning is based on a gradual increase over the initial ten years of pit operation until full production is reached in approximately year 11. Extraction will proceed in a north to south direction, to a reduced level (RL) of 990m.

A final void will remain at the end of mining and will contain a large number of small benches forming a terraced, vegetated landscape. The base of the pit will be graded, in order to be free-draining with all disturbed areas to be topsoiled and re-vegetated. The final retention pond will form part of a small wetland area (International Environmental Consultants, 2005).

The quarry design enables all water flows (at completion of quarrying) to be contained within the quarry void. When the final rehabilitation stage is complete, the vegetation cover established and the landform stable, it will be possible to place a channel from the near quarry floor to the small creek channel in the north and re-establish flows directly to the water course (International Environmental Consultants, 2005).

### 1.2 Objectives

The following report presents the latest groundwater level and groundwater quality data and includes data from previous monitoring periods to aid in the identification of long term trends. An interpretation of the 2015 data is provided that aims to highlight anomalies and environmental changes that might have occurred during the 2015 monitoring period and recommendations provided to improve the monitoring program.

### 1.3 Reporting Period

This report presents a summary of the groundwater level and quality monitoring results from September 2014 to September 2015. Data from groundwater level loggers was last downloaded on the 1<sup>st</sup> September 2015 and water quality was also sampled on the same date.

### 1.4 Existing Environment

#### 1.4.1 Rainfall

Rainfall data is sourced from the Bureau of Meteorology's rain gauge Maddox Lane, Lithgow. Table 1.1 shows basic statistical analysis of rainfall at Maddox Lane to December 2015.

The highest daily rainfall was 60.6mm on the 21<sup>st</sup> April 2015. Additionally, December 2014 was the highest total monthly rainfall for the reporting period with a total of 160.4 mm of rain.

**Table 1.1: 2015 Maddox Lane 2015 Rainfall Data**

Statistic	Sep 14	Oct 14	Nov 14	Dec 14	Jan 15	Feb 15	Mar 15	Apr 15	May 15	Jun 15	Jul 15	Aug 15	Sep 15
Monthly Total (mm)	35.2	51.6	36.8	160.4	156.2	21.2	39.4	158.2	25.2	24.8	44.6	43.8	9.8
Average* (mm)	52.4	67.1	72.5	73.6	86.1	79.1	65.0	44.6	49.4	49.0	50.9	64.2	52.4
Median* (mm)	48.4	67.6	63.0	61.2	76.8	71.1	50.4	32.6	42.8	40.0	43.2	51.0	48.4

\* Rainfall statistics data for all years 1959 - 2015.

## 1.5 Newnes Kaolin Groundwater Monitoring Network

The Newnes monitoring program was developed in November 2004 and comprises 6 piezometers across 3 sites (Figure 1 and Table 2.1). The piezometers were terminated in the Narrabeen Sandstone unit in order to target groundwater levels and water quality within future mined lithology. Paired monitoring sites (NW, NE and S) were installed around the periphery of the proposed pit area (Figure 1). Two piezometers (S54 and S17.5) were installed between the proposed Newnes Pit and the existing Rocla Quarry, with the primary intention of monitoring the potential cumulative impacts from both mining operations.

**Table 1.2: Newnes Monitoring Network Summary**

Bore ID	Easting (WGS84)	Northing (WGS84)	Surface RL (mAHD)	Installation Date	Total Depth (m)	Screen Interval (mbgl)	Monitoring Data
NW60	244563	6293686	1037	2004	59.93	15-18, 21-24, 27-30, 33-36, 39-42, 45-48, 51-54, 57-60	17/06/2010 - Present
NW17.5				2004	17.55	14.5-17.5	17/06/2010 - Present
NE60	245066	6293569	995	2004	60.35	15-18, 21-24, 27-30, 33-36, 39-42, 45-48, 51-54, 57-60	17/06/2010 - Present
NE17.5				2004	17.53	14.5-17.5	17/06/2010 - Present
S54	244668	6292930	1059	2004	53.91	24-30, 36-42, 48-54	17/06/2010 - Present
S17.5				2004	17.02	14.5-17.5	17/06/2010 - Present

### 1.5.1 Baseline Groundwater Monitoring

The routine groundwater monitoring program at Newnes commenced in June 2010. The key components and objectives of the program are to:

- Record daily water levels at all piezometers and to continue this monitoring monitor program through the life of the project.
- Collect quarterly groundwater samples from all piezometers and any pit sump/seepages (during excavation), for field based analysis of electrical conductivity (EC), total dissolved solids (TDS) and pH.
- Collect representative groundwater samples biannually (twice yearly) from all piezometers and any pit sump/seepages (that occur during excavation) and schedule for laboratory analysis of a suite of parameters, to include; physical properties (EC, TDS and pH), major cations and anions (Ca, Mg, Na, K, Cl, SO<sub>4</sub>, HCO<sub>3</sub> and CO<sub>3</sub>), nutrients and dissolved metals (aluminum, arsenic, barium, cadmium, chromium, copper, lead, manganese, nickel, zinc, boron and iron).

A summary of the groundwater monitoring program is detailed in Table 2.2.

**Table 1.3: Groundwater monitoring frequency.**

Bore ID	Installed	Depth (m)	Screen Interval (m)	Monitoring	Groundwater monitoring frequency	Water quality monitoring frequency	Purpose	
NW60	2004	59.93	15 - 60	17/06/2010	Daily (logger)	Quarterly: TDS, EC, pH	Obtain baseline data (including possible existing groundwater influences from the Clarence Colliery to the North) and monitor drawdown/water quality impacts within the predicted zone of influence.	
						Biannual: Major ions, Metals, Nutrients		
NW17.5	2004	17.55	14.5-17.5	17/06/2010	Daily (logger)	Quarterly: TDS, EC, pH		
						Biannual: Major ions, Metals, Nutrients		
NE60	2004	60.35	15 - 60	17/06/2010	Daily (Logger)	Quarterly: TDS, EC, pH		
						Biannual: Major ions, Metals, Nutrients		
NE17.5	2004	17.53	14.5-17.5	17/06/2010	Daily (logger)	Quarterly: TDS, EC, pH		
						Biannual: Major ions, Metals, Nutrients		
S54	2004	53.91	24 - 54	17/06/2010	Daily (logger)	Quarterly: TDS, EC, pH		Obtain baseline data (including possible existing groundwater influences from the Rocla Quarry to the south) and monitor drawdown/water quality impacts within the predicted zone of influence.
						Biannual: Major ions, Metals, Nutrients		
S17.5	2004	17.02	14.5-17.5	17/06/2010	Daily (logger)	Quarterly: TDS, EC, pH		
						Biannual: Major ions, Metals, Nutrients		

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## 2. Groundwater Response Plan

### 2.1 Contingency Measures

In the event of any adverse impacts or water quality degradation compared to the baseline groundwater quality, as defined in the Groundwater Management Plan (RPS 2013), or groundwater table fluctuations not attributed to climatic conditions, Newnes Kaolin Pty Ltd will:

- Commission an assessment of the causes;
- Develop a staged response program satisfactory to DPI Water to mitigate the adverse impacts; and
- Attempt to establish and implement measures to limit further adverse impact.

The identification process and response protocols to potential adverse outcomes are provided in the trigger action response plan (TARP) outlined in Table 3.1. The responses proposed incorporate a staged assessment and development of management measures deemed appropriate for each individual event should it occur.

### 2.2 Trigger Action Response Plan

The Trigger Action Response Plan (TARP) provides appropriate triggers and corresponding response actions for prevention or mitigation of adverse impacts to nearby water users or the natural environment as a result of mining. The baseline monitoring program that has been assessed in Section 2 of the Ground Water Management Plan (GWMP) has been designed to detect changes to groundwater levels, groundwater quality or inflow rates, or to indicate that an abnormal condition relating to mining activity may have developed.

The trigger level criteria for groundwater quality nominated in the GWMP have been derived from a dataset spanning approximately 18 months. The dataset describing groundwater levels at the project site cover a timeframe of 69 months.

As the duration of monitoring and the size of the data sets increases the suitability of the trigger criteria long term should be reviewed as part of the AEMR reporting procedure outlined in Section 2.5 of the GWMP. Aspects assessed to be at risk are summarised in Section 1.3 of the GWMP and fully explored in the Hydrogeological Assessment Report (Kalf and Associates, 2004) and the EIS (International Environmental Consultants, 2005). These include both predicted and unpredicted impacts, and include:

- Groundwater level;
- Groundwater quality;
- Base flow and vegetation;
- Groundwater users (private bores); and
- Cumulative impacts.

### 2.3 Response Action

In the event of sustained exceedances in baseline criteria detailed in Sections 2.4.1 to 2.4.6 of the GWMP, the following response action would be initiated:

- Initiate immediate review of circumstances leading to exceedance event, including results of monitoring;
- Assessment undertaken to determine the likely reason(s) for the exceedance;

- If assessed as being caused by the mining operation, and it is further assessed to be likely to cause an adverse impact on an existing beneficial or environmental use of surface water or groundwater, then an appropriate preventative and/or remedial strategy would be recommended, which may comprise:
  - Additional monitoring;
  - Provision of alternative water supply or other negotiated agreement with landholders if found to be adversely impacted; or
  - (if appropriate) no change to operations.

The above response program would be carried out in consultation with DPI Water and DII-Minerals.



**Table 2.1: Trigger Action Response Plan (TARP)**

Aspect	Parameter	Frequency	Purpose	Trigger	Action	Responsibility	Timing	Purpose
Groundwater monitoring	Groundwater level in piezometers	Daily: data logger, quarterly downloads	To provide baseline groundwater level data and to identify any water level impacts that might develop as a result of mining activity.	<u>Piezometers S, NW and NE:</u> An additional drawdown of 5 m relative to the predicted EIS drawdown, which is not attributed to climatic conditions	Repeat water level monitoring to confirm. Refer the matter to an independent hydrogeologist for review.	Newnes Kaolin Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week.	Inform agencies of baseline assessment and monitoring. Identify, investigate and report on impacts to groundwater levels.
		Weekly: manual measurements						
Groundwater monitoring	Groundwater quality in piezometers	Quarterly: pH, EC, TDS	To provide baseline water quality data characteristics and to identify any degenerative groundwater quality impacts as a result of mining activity.	<u>Piezometers S, NW and NE:</u> Exceedances of the default ANZECC 2000 Guidelines Values (Table 2.6 and 2.7) should be routinely reported on. In addition departures from the ranges observed in the baseline monitoring should be assessed and the statistically nominated site-specific trigger levels be used to support the assessment .	Evaluate magnitude of shift between the 50 <sup>th</sup> and 80 <sup>th</sup> percent-tiles of dataset. Repeat groundwater sampling to confirm. Refer the matter to an independent hydrogeologist for review.	Newnes Kaolin Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week	Inform agencies of baseline assessment and monitoring. Identify, investigate and report on impacts to groundwater quality.
		Biannual: Major Cations and Anions, Nutrients & Dissolved metals						

Aspect	Parameter	Frequency	Purpose	Trigger	Action	Responsibility	Timing	Purpose
Base flow	Groundwater level in piezometers	Daily: data logger, quarterly download	To identify any baseflow impacts to the streams	<u>Piezometers S, NW and NE:</u> An additional drawdown of 5 m relative to the predicted EIS drawdown, which is not attributed to climatic conditions	Repeat water level monitoring to confirm. Refer the matter to an independent hydrogeologist for review.	Newnes Kaolin Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week	Identify, investigate and report on potential impacts to stream flow.
		Weekly: manual measurements		<u>Piezometer W:</u> An additional drawdown of 5 m (not attributed to climatic variation) relative to the lowest groundwater level observed following no less than 12 months of monitoring data after installation.				
	Groundwater quality in piezometers	Quarterly: pH, EC, TDS	To identify any water quality impacts to the streams	<u>Piezometers S, NW and NE:</u> Exceedances of the default ANZECC 2000 Guidelines Values (Table 2.6 and 2.7) should be routinely reported on. In addition departures from the ranges observed in the baseline monitoring should be assessed and the statistically nominated site-specific trigger levels be used to support the assessment	Evaluate magnitude of shift between the 50 <sup>th</sup> and 80 <sup>th</sup> percent-tiles of dataset. Repeat groundwater sampling to confirm. Refer the matter to an independent hydrogeologist for review	Newnes Kaolin Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week	Identify, investigate and report on potential impacts to stream water quality.
		Biannual: Cations, Anions, Nutrients & Dissolved metals		<u>Piezometer W:</u> The same approach to apply following the collation and analysis of no less that 12 months of groundwater quality data				



Aspect	Parameter	Frequency	Purpose	Trigger	Action	Responsibility	Timing	Purpose
Existing licensed groundwater bores	Groundwater level in piezometers	Daily: logger quarterly download Weekly: manual measurements	To identify any water level impacts to existing users	<p><u>Piezometers S, NW and NE:</u> An additional drawdown of 5 m relative to the predicted EIS drawdown, which is not attributed to climatic conditions</p> <p><u>Piezometer W:</u> An additional drawdown of 5 m (not attributed to climatic variation) relative to the lowest groundwater level observed following no less than 12 months of monitoring data after installation.</p> <p><u>CLRP Bore Series</u> Data obtained from the colliery network located &gt;1km away may be assessed if available. If a declining trend is observed further investigation should be considered.</p>	Repeat water level monitoring to confirm. Refer the matter to an independent hydrogeologist for review	Newnes Kaolin Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week	Ensure adequate groundwater levels are maintained for existing users
	Groundwater quality in piezometers	Quarterly: pH, EC, TDS Biannual: Cations, Anions, Nutrients & Dissolved metals	Identify any water quality impacts to existing groundwater users	<p><u>Piezometers S, NW and NE:</u> Exceedances of the default ANZECC 2000 Guidelines Values (Table 2.6 and 2.7) should be routinely reported on. In addition departures from the ranges observed in the baseline monitoring should be assessed and the statistically nominated site-specific trigger levels be used to support the assessment</p>	Evaluate magnitude of shift between the 50 <sup>th</sup> and 80 <sup>th</sup> percent-tiles of dataset. Repeat groundwater sampling to confirm. Refer the matter to an independent hydrogeologist for review	Newnes Kaolin Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week	Identify, investigate and report on potential water quality impacts to existing users

Aspect	Parameter	Frequency	Purpose	Trigger	Action	Responsibility	Timing	Purpose
				<p><u>Piezometer W:</u> The same approach to apply following the collation and analysis of 12 months of groundwater quality data</p> <p><u>CLRP Bore Series</u> Data obtained from the colliery network located &gt;1km away may be assessed if available. If a declining trend is observed further investigation should be considered.</p>				
Mine inflows	Flow rate	Record duration, rate and volume of pump events, prepare weekly summaries of pumped volumes	Identify unexpected high mine inflows and determine whether this will impact on groundwater levels off site	An observed inflow rate 100% in excess of the predicted EIS inflow rate at any stage during the mine life sustained for 3 consecutive months	Refer the matter to an independent hydrogeologist for review.	Newnes Kaolin Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week	Identify, investigate and report on drawdown impacts to existing users and creeks.
	Water quality	Quarterly: pH, EC, TDS	Identify whether a new source of groundwater inflows has been intercepted	Exceedances of the default ANZECC 2000 Guidelines Values (Table 2.6 and 2.7) should be routinely reported on. In addition departures from the ranges observed in the baseline monitoring should be assessed and the statistically nominated site-specific trigger levels be used to support the assessment	Refer the matter to an independent hydrogeologist for review	Newnes Kaolin Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week	Identify, investigate and report on water quality impacts and determine whether a new source of inflows has occurred
Biannual, unless a sudden increase in flows are encountered): Cations, Anions, Nutrients & Dissolved metals								

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### 3. Groundwater Levels

Groundwater levels are compared with daily Cumulative Rainfall Deviation (CRD) in order to quantify groundwater level responses to recharge aiding in the identification and differentiation between natural fluctuations in groundwater and mining induced impacts. Given that no active mining has occurred at Newnes, groundwater levels are reflections of natural conditions. During the 2015 reporting period no anomalous variations in water levels were observed and is expected given no mining.

In general, groundwater flows in a NE direction on site. This is evident in Figure 2 with water levels highest in S17.5 and S54 and lowest in NE17.5 and NE60. A continuing minor drop in water levels can be seen in S17.5 and S54 during the reporting period which is a delayed response to high rainfall during 2012 and 2013. A minor increase in groundwater levels is observed approximately three months after intense rainfall during December 2014 and January 2015. Similarly, but to lesser gradients, NW17.5, NW60, NE17.5 and NE60 show similar responses.

The relationship between CRD and groundwater levels shows that water levels respond to rainfall in a dampened manner. The dampened recharge response is also a consequence of the moderate permeability of the sandstone causing rainfall to slowly recharge the aquifer as it moves through the unsaturated zone. Water level change is a combination of rainfall intensity, rainfall runoff and evapotranspiration whereby above average rainfall is required to overcome these factors in order for aquifer recharge to occur.

## 4. Groundwater Quality

Groundwater samples were collected from the Newnes monitoring network and submitted under chain-of-custody conditions to NATA accredited laboratory ALS Laboratory Group for detailed chemical analysis.

The groundwater quality data set was divided into two data sets, one for the shallow piezometers (NW17.5, NE17.5 and S17.5) and one for the deeper piezometers (NW60, NE60 and S54). Although the shallow and deep piezometers are inferred to represent the same aquifer unit, the groundwater quality is not homogenous across the intersected aquifer.

The summary and analysis of the groundwater quality data of the shallow piezometers is presented in Table 5.1. Table 5.2 comprises the water quality results of the deep piezometers. Both tables show the observed range of groundwater quality parameters, the mean and median concentrations as well as the 20<sup>th</sup> and 80<sup>th</sup> percentile of the baseline dataset. The observed ranges and site specific trigger values (SSTV's) represent the minimum and maximum concentrations recorded and trigger value for that parameter from four laboratory data sets (June 2010 to March 2013) and seven field observations of pH, EC and TDS.

The water quality results were compared to SSTV's which were nominated in the GWMP (RPS 2013). For comparison, the ANZECC (2000) 95% protection of species trigger are also presented in Tables 5.1 and 5.2.

Field parameters were also measured and recorded at the time of the sampling. The results of the 2015 field and laboratory measurements are summarised in Tables 5.1 and 5.2.

**Table 4.1: Groundwater Chemistry Summary - Shallow Piezometers (NW17.5, NE17.5 and S17.5)**

Parameter	Units	Baseline Range	2015 Range	2015 Mean	2015 Median	2015 20 <sup>th</sup> Percentile	2015 80 <sup>th</sup> Percentile	ANZECC Values <sup>(3)</sup> (2000) Trigger	Site Specific Values <sup>(4)</sup> Trigger
pH <sup>(1)</sup>	pH unit	4.17 – 6.45	4.74 – 6.64	5.46	5.63	4.96	5.70	6.5 – 8	4.73 – 5.28
EC <sup>(1)</sup>	µS/cm	25.3 – 296	24 – 47.3	36.4	37.0	30.3	42.2	30 - 350	50
TDS <sup>(2)</sup>	mg/L	13 – 216	29 – 75	44.0	40.5	37.0	42.0	–	87
Calcium	mg/L	<1 – 3	<1 - 2	1.00	1.33	1.00	2.00	–	2.00
Magnesium	mg/L	<1	<1	<1	<1	<1	<1	–	N/A
Sodium	mg/L	3 – 7	2 – 5	3.83	4.00	4.00	4.00	–	5.00
Potassium	mg/L	<1 – 2	<1	<1	<1	<1	<1	–	N/A
Hydroxide Alkalinity	mg/L	<1	<1	<1	<1	<1	<1	–	N/A
Carbonate Alkalinity	mg/L	<1	<1	<1	<1	<1	<1	–	N/A
Bicarbonate Alkalinity	mg/L	<1 – 12	<1 – 5	3.5	4.0	2.8	4.4	–	9.0
Chloride	mg/L	4 – 7	4 – 7	5.16	5.00	4.00	6.00	–	6.88
Sulphate	mg/L	0.61 – 1.17	<1	<1	<1	<1	<1	–	1
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.024	N/A
Barium	mg/L	<0.001 – 0.015	0.006 – 0.012	0.009	0.010	0.008	0.012	–	0.012
Cadmium	mg/L	<0.0001	<0.001 – 0.001	0.001	0.001	0.001	0.001	0.0002	N/A
Chromium	Mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	N/A
Copper	mg/L	<0.001 – 0.038	0.001 – 0.009	0.003	0.001	0.001	0.001	0.014	0.003
Manganese	mg/L	0.008 – 0.095	0.007 – 0.087	0.054	0.070	0.011	0.078	1.90	0.072
Nickel	mg/L	<0.001	0.001 – 0.003	0.0020	0.0020	0.0014	0.0026	0.011	N/A
Lead	mg/L	<0.001 – 0.016	<0.001 – 0.001	0.001	0.001	0.001	0.001	0.0034	0.006
Zinc	mg/L	0.007 – 0.041	0.013 – 0.088	0.055	0.061	0.026	0.080	0.008	0.041
Iron	mg/L	<0.01 – 9.72	<0.05	<0.05	<0.05	<0.05	<0.05	–	6.82
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006	N/A

Parameter	Units	Baseline Range	2015 Range	2015 Mean	2015 Median	2015 20 <sup>th</sup> Percentile	2015 80 <sup>th</sup> Percentile	ANZECC (2000) Trigger Values <sup>(3)</sup>	Site Specific Trigger Values <sup>(4)</sup>
Ammonia	mg/L	0.01 – 0.06	<0.01 – 0.08	0.08	0.08	0.08	0.08	0.90	–
Nitrite	mg/L	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01	–	–
Nitrate	mg/L	0.05 – 0.24	0.09 – 0.25	0.170	0.160	0.118	0.214	0.70	0.3
Nitrite + Nitrate	mg/L	0.05 – 0.24	0.09 – 0.26	0.18	0.16	0.13	0.25	–	0.3
Total Nitrogen	mg/L	0.1 – 1.6	<0.10 – 0.30	0.22	0.20	0.20	0.22	0.35	0.4
Total Phosphorous	mg/L	0.01 – 1.72	<0.01 – 0.06	0.220	0.120	0.060	0.024	0.01	0.53

<sup>(1)</sup>: pH and EC values obtained from field observations

<sup>(2)</sup>: TDS ranges obtained from field observations and laboratory results

<sup>(3)</sup>: Taken from trigger values for toxicants for freshwater for 95% protection of species (Table 3.3.2 & 3.4.1 – ANZECC, 2000)

<sup>(4)</sup>: Site Specific Trigger Values (SSTV's) derived from data June 2010 – March 2013.

**Table 4.2: Groundwater Chemistry Summary - Deep Piezometers (NW60, NE60 and S54)**

Parameter	Units	Baseline Range	2015 Range	2015 Mean	2015 Median	2015 Percentile 20 <sup>th</sup>	2015 Percentile 80 <sup>th</sup>	ANZECC Trigger Values <sup>(3)</sup> (2000)	Site Specific Trigger Values <sup>(4)</sup>
pH <sup>(1)</sup>	pH unit	4.2 – 5.8	4.77 – 6.07	5.22	5.08	4.95	5.49	6.5 – 8	4.8 – 5.5
EC <sup>(1)</sup>	µS/cm	18.2 – 141.6	24 – 61.3	39.4	33.0	28.4	50.4	30 - 350	58
TDS <sup>(2)</sup>	mg/L	26 – 98	11 – 62	42.3	46.5	34.0	54.0	–	59
Calcium	mg/L	<1 – 2	<1 – 1	1	1	1	1	–	0.9
Magnesium	mg/L	<1	<1	<1	<1	<1	<1	–	N/A
Sodium	mg/L	<1 – 7	3 – 6	4.0	3.5	3.0	5.0	–	5.0
Potassium	mg/L	<1 – 1	<1	<1	<1	<1	<1	–	N/A
Hydroxide Alkalinity	mg/L	<1	<1	<1	<1	<1	<1	–	N/A
Carbonate Alkalinity	mg/L	<1 – 3	<1	<1	<1	<1	<1	–	N/A
Bicarbonate Alkalinity	mg/L	<1 – 12	<1	<1	<1	<1	<1	–	6.6
Chloride	mg/L	4 – 7	4 – 6	5.16	5.00	5.00	6.00	–	6.0
Sulphate	mg/L	<0.5 – 7	<1	<1	<1	<1	<1	–	0.67
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.024	N/A
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	N/A
Chromium	Mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	N/A
Copper	mg/L	<0.001 – 0.002	0.001 – 0.004	0.002	0.002	0.001	0.003	0.014	0.002
Manganese	mg/L	0.008 – 0.045	0.008 – 0.032	0.018	0.013	0.010	0.031	1.9	0.024
Nickel	mg/L	<0.001	<0.001 – 0.002	0.002	0.002	0.002	0.002	0.011	N/A
Lead	mg/L	<0.001 – 0.064	<0.001	<0.001	<0.001	<0.001	<0.001	0.0034	0.0056
Zinc	mg/L	<0.005 – 0.049	0.028 – 0.078	0.046	0.043	0.038	0.047	0.008	0.017
Iron	mg/L	<0.05 – 0.82	<0.05 – 0.16	0.16	0.16	0.16	0.16		0.174
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006	N/A
Ammonia	mg/L	<0.01 – 0.68	<0.01	<0.01	<0.01	<0.01	<0.01	0.9	>0.01

Parameter	Units	Baseline Range	2015 Range	2015 Mean	2015 Median	2015 20 <sup>th</sup> Percentile	2015 80 <sup>th</sup> Percentile	ANZECC Trigger Values <sup>(3)</sup> (2000)	Site Specific Trigger Values <sup>(4)</sup>
Nitrite	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	–	N/A
Nitrate	mg/L	0.03 – 2.31	0.08 – 3.21	1.13	0.10	0.09	1.97	0.7	1.806
Nitrite +Nitrate	mg/L	0.03 – 2.31	0.08 – 3.21	1.08	0.12	0.10	2.87	–	1.806
Total Nitrogen	mg/L	<0.1 – 4.3	0.10 – 3.20	1.30	0.20	0.10	2.96	0.35	2.44
Total Phosphorous	mg/L	<0.01 – 0.16	<0.01 – 0.06	0.06	0.06	0.06	0.06	0.01	0.092

<sup>(1)</sup>: pH and EC values obtained from field observations

<sup>(2)</sup>: TDS ranges obtained from field observations and laboratory results

<sup>(3)</sup>: Taken from trigger values for toxicants for freshwater for 95% protection of species (Table 3.3.2 & 3.4.1 – ANZECC, 2000)

<sup>(4)</sup>: Site Specific Trigger Values (SSTV's) derived from data June 2010 – March 2013.

### Total Dissolved Solids (TDS)

TDS ranged from 29 – 75 and 11 – 62 mg/L for shallow and deep piezometers respectively. Both mean and median values for shallow and deep piezometers were below the SSTV's for shallow and deep piezometers.

### Electrical Conductivity (EC)

EC ranged from 24 – 47.3 and 24 – 61.3  $\mu\text{S}/\text{cm}$  for shallow and deep piezometers respectively. The high value 61.3  $\mu\text{S}/\text{cm}$  was measured on the 1 April 2014 was short lived with a reading of 30  $\mu\text{S}/\text{cm}$  the following monitoring round.

Both mean and median values for shallow and deep piezometers were below the SSTV's of 50 and 58  $\mu\text{S}/\text{cm}$  respectively.

The low EC's are consistent with the low TDS concentrations and indicate low groundwater salinity and are attributed to high rainfall recharge and potentially low residence times in the system.

### pH

pH ranged from 4.74 – 6.64 and 4.77 – 6.07 for shallow and deep piezometers respectively. The mean for shallow piezometers was above the upper limit of pH at pH 5.63 but the median value for pH was between trigger values. A pH reading of 6.64 on the 1 April 2015 has skewed the mean towards the upper limits of the SSTV trigger value.

pH was exceeded in deep piezometers on the lower and upper scales of the SSTV during the monitoring period but mean and median values were between SSTV trigger values. If exceedances continue, the SSTV's will need to be reestablished. However, the observed slightly acidic pH range is consistent with aquifers low in carbonate content.

### Major Anions

A Piper Diagram (Figure 3) has been generated to categorize the groundwater types across the site. The diagram is useful in showing the degree of variation in hydrochemical signatures at each monitoring point. Figure 3 contains the groundwater quality results at each monitoring location in the upper (NW17.5, NE17.5 and S17.5) and lower aquifer depths (NW60, NE60 and S54).

The projection on to the diamond shaped portion of the diagram shows a clustering of points from each monitoring location. In summary, the dominant anion in shallow groundwater is chloride and bicarbonate ( $\text{Cl}$  and  $\text{HCO}_3$ ) and deep groundwater chloride ( $\text{Cl}$ ). The cation signature trends towards a sodium dominant type in both shallow and deep groundwater. Generally, the cation and anion concentrations are low correlating with the low EC and TDS.

### Dissolved Metals

Majority of dissolved metal concentrations were below trigger values or detection limits. Zinc is the only dissolved metal where by mean and median values exceeded trigger values for both shallow and deep piezometers.

Exceeding on all occasions in the deeper piezometers, zinc ranged from 0.013 – 0.088 and 0.028 – 0.078 mg/L for shallow and deep piezometers respectively. Given the high concentrations of zinc since project inception, it is fair to assume the chemical composition of the local sandstone naturally high concentrations of dissolved zinc.

### Nutrients

Nutrients were below SSTV's for Total Nitrogen (TN) and Total Phosphorus (TP). It's observed that TN and TP are higher in concentration in the shallow piezometers than deeper piezometers. This is likely due to leaching of nutrients from surface from decaying biomass.

## 5. Recommendations

The aquifer in the vicinity of the proposed operation has been shown to behave as a single aquifer unit and is therefore suitable to monitor groundwater levels before, during and after mining. Given no active mining, the TARP is not applicable and variations and exceedances in groundwater levels and quality are seen to be natural variation. Furthermore, the following salient points summarise improvements to the current monitoring program -

- Deep piezometers are screened in several horizons in the Narrabeen Sandstone formation and piezometers NE60 and NW60 are screened across the same horizons as their adjacent shallow piezometers NE17.5 and NW17.5 (Appendix A). Given that the sandstone aquifer behaves as a single aquifer unit, NW17.5 and NW60 have similar water levels, are screened in the same stratigraphy and give very similar groundwater quality results it is recommended that only NW60 be sampled.
- Diligence to the GWMP is required to meet compliance. Between September 2014 and September 2015 only 3 sets of field parameters were taken when 4 sets of field parameters are required. Furthermore, one water quality sample was taken in 2015 when 2 per year are necessary. At this point in time, Newnes is not compliant with regulatory requirements.
- If concentrations of dissolved zinc continue to exceed SSTV's it is recommended that SSTV's be re-evaluated in the 2016 AEMR.

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## 6. References

ANZECC, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

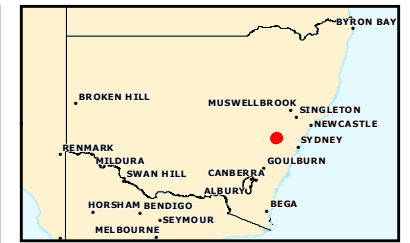
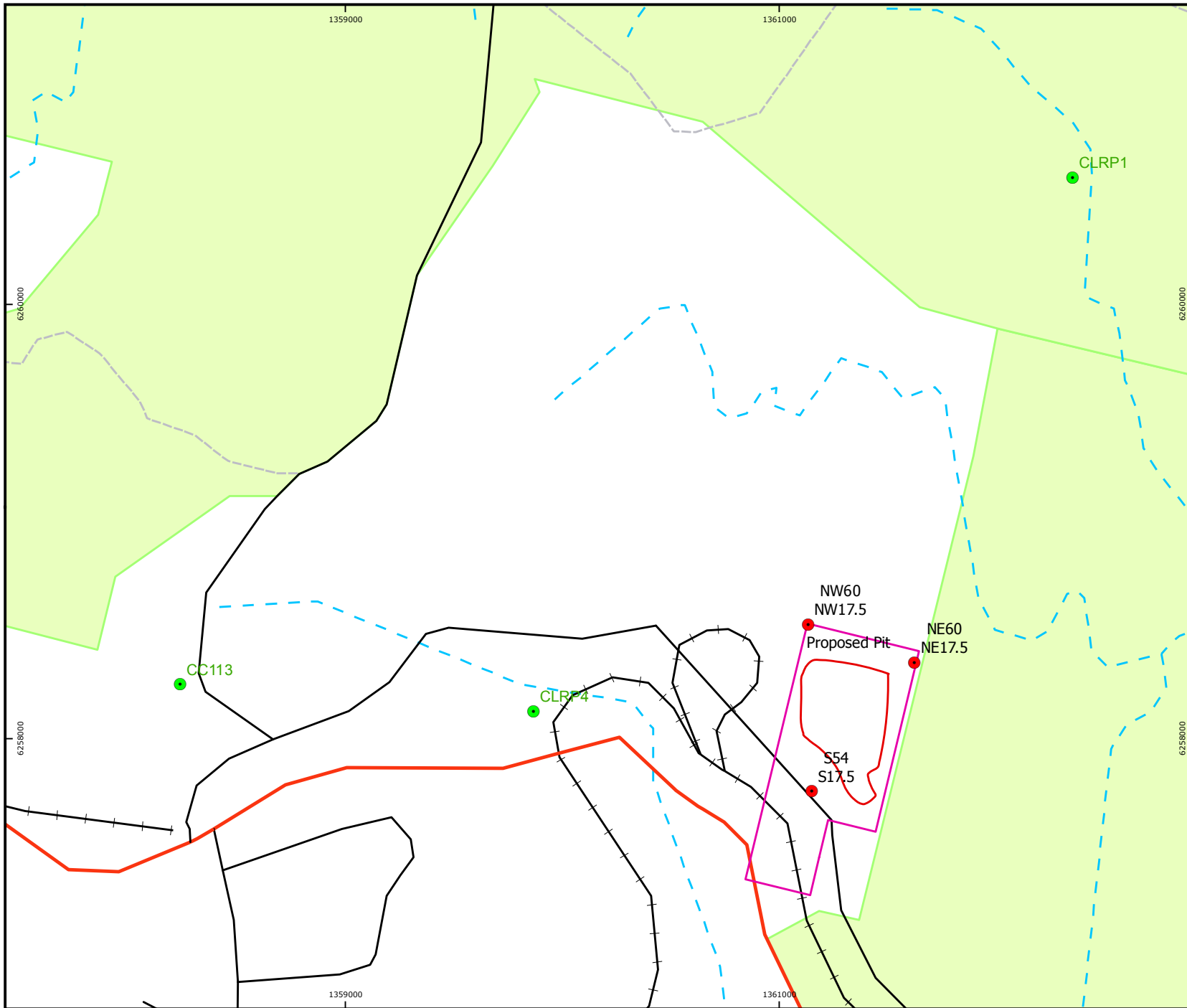
International Environmental Consultants, 2005. Newnes Kaolin Mine Supplementary information. Prepared for the Environmental Impact Statement, 2005.

Kalf and Associates, 2004. Supplementary Information - Hydrogeological Impact Report, 2004.

RPS Aquaterra, 2013, Newnes Junction Sand & Kaolin Extraction Project – Review of Groundwater Monitoring Program, 11 April 2013.

## **FIGURES**

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**LEGEND**

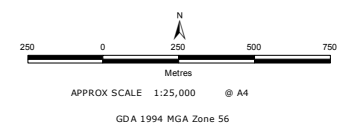
- Clarence Colliery Piezometers
- Newnes Kaolin Piezometers
- Proposed Piezometers
- ML19

**Roads**

- Minor Road
- Principal Road
- Secondary Road
- Track
- Rail

**Watercourses**

- Non-perennial
- Perennial
- Reserves



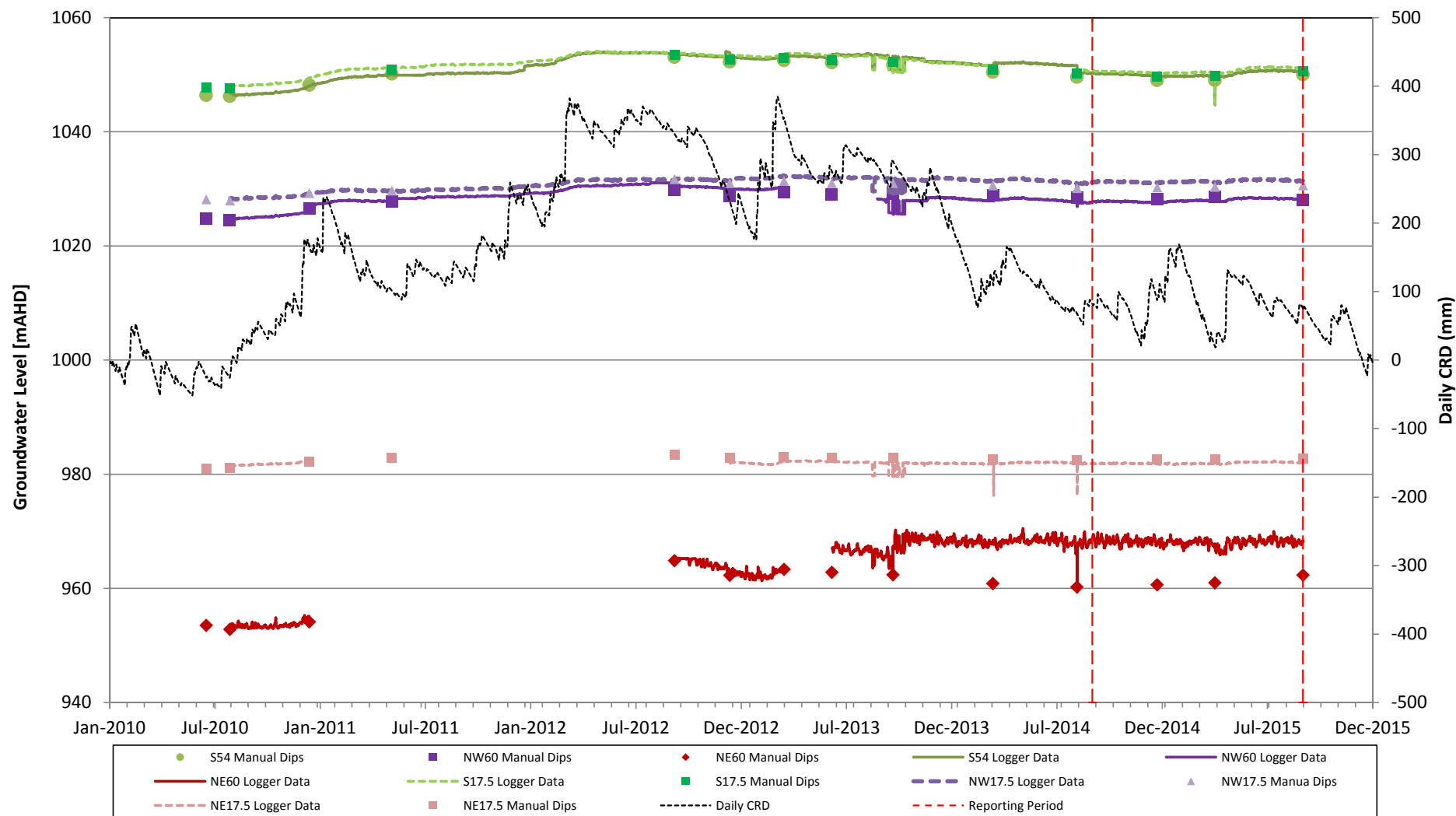
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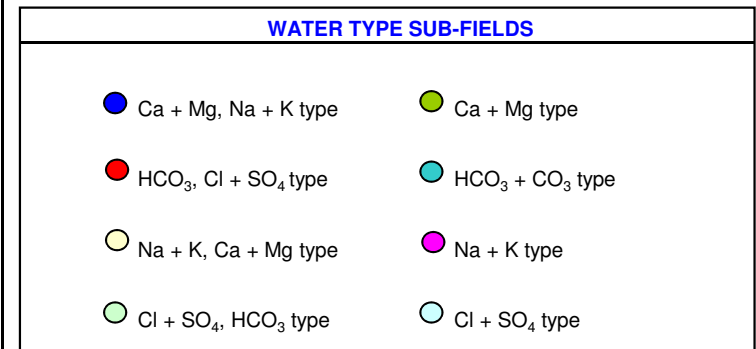
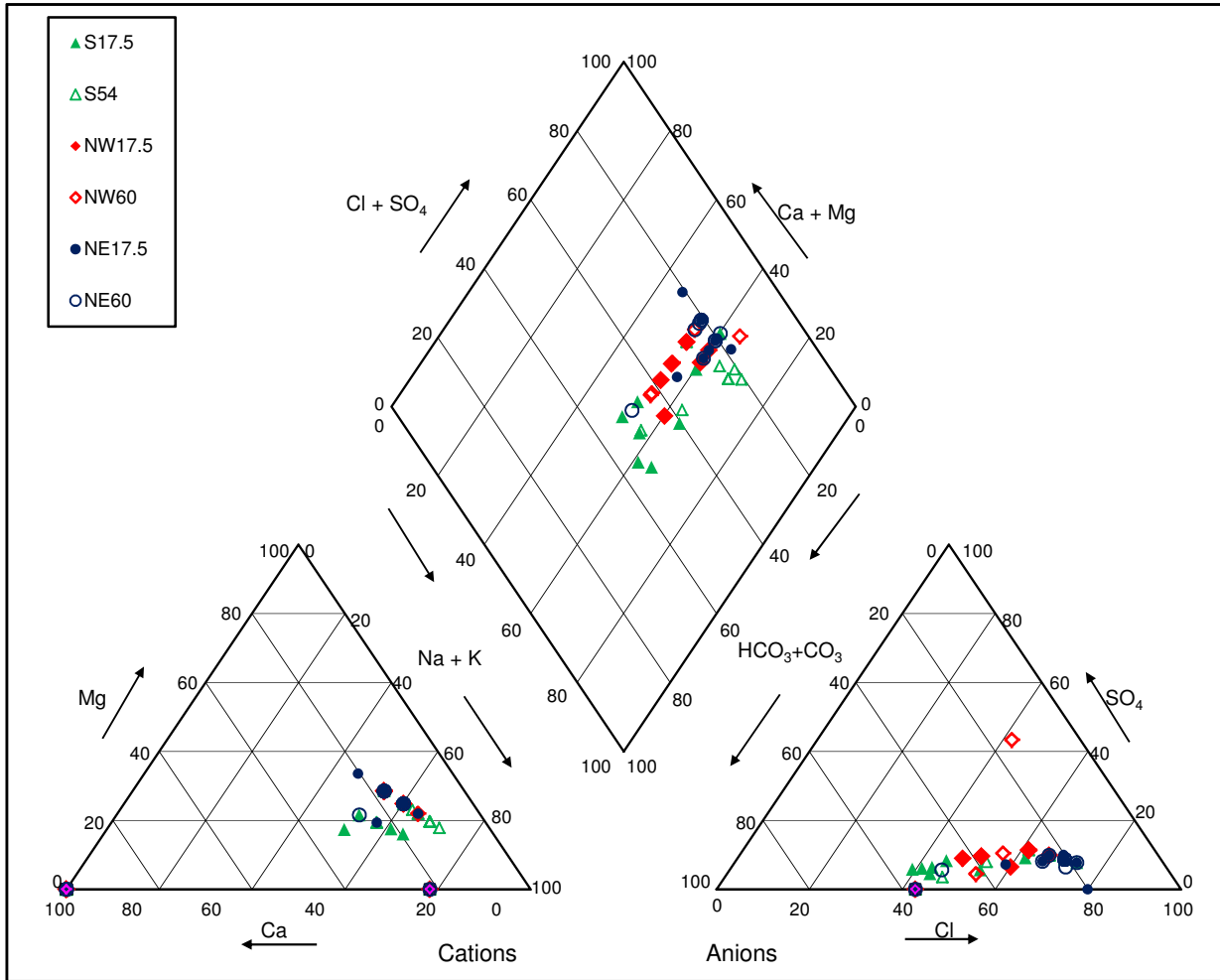
**Disclaimer:** While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.  
Note: The information shown on this map is a copyright of RPS Aquaterra Australia 2012



FIGURE 1

**Groundwater Monitoring Network**





**RPS** **Piper Diagram** **Figure 3**

Date: 10/03/16 Project: Newnes Kaolin Pty Ltd Description: Dominant Water Type

F:\Jobs\WS0092D\300\Water Quality\PIPER Diagram 6 Piezo\_JT.xls\PIPER Project No: WS0092D Client: T/A Sydney Construction Materials

**HydroCHEM 2.0**

**APPENDIX A:  
NEWNES BORE LOGS**

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University of New South Wales  
School of Civil & Environmental Engineering

Water Research Laboratory

Project: 04039 Newnes Junction

Date: 5th to 7th November 2004

Hole No. NE

Logged By: S.Pells

Driller: McDermott

Drill Hole Diameter: 98mm

Method of Drilling: Rotary Air Hammer

Depth Below Ground (m)	Lithology	Graphic Log	Water Development	Piezometer 60m	Piezometer 17.5m	Well construction comments
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0	Top soil.					lockable steel monument Sand Backfill Using Drill Cuttings
6	Orange.		Very slight moisture			
12	Cream / grey, Orange.					Bentonite Plug
18	Cream / grey. Some fine quartz pieces. Cream / grey. Medium to soft.		Dry			2 to 5 mm Graded Washed Quartz Gravel Pack
24	Orange. Soft. Cream / grey. Some brief orange zones. Orange / yellow. Hard thin ironstone layer.		10 minute pause. No water recovered. Dry Dry and dusty.			
30	White / grey powder. Bright orange / ochre with brief white layer. Soft.		10 minute pause. No water recovered. Dry and dusty.			
36	White / grey powder with alternate orange layers Ironstone layer. Pieces up to 8 mm. Hard.		10 minute pause. No water recovered. Dry and dusty.			
42	White / grey.		Tendency to collaring of drill rods attributed to slight moisture. 10 minute pause. No water recovered.			Class 18 50 mm ID 64 mm OD uPVC Casing & Machine Slotted Screen. No Geotextile Sock Used
48	White / grey with quartz pieces. Occasional ironstone and ochre layers.		Dry and dusty. 2 minute pause. No water recovered. Tendency to collaring of drill rods attributed to slight moisture.			
54	grey / brown slurry.		End drilling 5th Nov 5:00 pm Resume drilling 6th Nov 7:00 am. Airlifted 20 to 30 L water, then dried up.			
60	Very Soft. Some grey high plasticity clay. grey / brown slurry. Very Soft. Some grey high plasticity clay.		Drilling water used from 54 m to counteract collaring. Drilling water used. At 60 m airlifted for 10 minutes to remove all drilling water. Flow appeared to stabilise at 4-5 L/min.			



Project: 04039 Newnes Junction  
 Hole No. NW  
 Driller: McDermott  
 Method of Drilling: Rotary Air Hammer

Date: 2nd to 4th November 2004  
 Logged By: S.Pells  
 Drill Hole Diameter: 98mm

Depth Below Ground (m)	Lithology	Graphic Log	Water Development	Piezometer 60m	Piezometer 17.5m	Well construction comments			
0	Top soil		Very slight moisture			lockable steel monument Sand Backfill Using Drill Cuttings			
	Orange, sandy		Becoming drier with depth						
	Cream, very fine sand		Becoming dry						
6	orange to deep orange		Some moisture Becoming dry			10 minute pause. ~ 1 litre recovered.			Bentonite Plug
	cream / off white		Very slight moisture						2 to 5 mm Graded Washed Quartz Gravel Pack
12	cream / off white, occasional brown/orange					2 minute pause. No water recovered.			
	cream / off white powder with quartz < 2mm pieces. Hard.					Dry and dusty.			
24	layer of Ironstone ~ 50 to 100 mm. Very hard. cream, loose or fractured layer.					Dry Slight moisture 14 minute pause. ~ 30 to 40 L Immediately recovered. Very slight flow stabilising at approximately 0.2 L/min.			
30	cream / off white powder with quartz < 2mm pieces. Hard.					Quickly becoming dry. 13 minute pause. ~ 50 to 60 L Immediately recovered. Stabilising at < 1 L/min			
36						Wet Volumetric test measured < 6 L/min of slurry (spoil included)			
42			Flow rate ~ 1 L/min over v-notch weir. Volumetric testing measures 5-6 L/min of slurry.			Class 18 50 mm ID 64 mm OD uPVC Casing & Machine Slotted Screen. No Geotextile Sock Used			
48	cream / brown slurry. Hard.		Flow rate increasing slightly.						
54			End drilling 2nd Nov 5:40 pm Resume drilling 3rd Nov 6:40 am ~ 100 L immediately recovered. Flow easing.						
60			Flow rate over v-notch weir increasing with depth from 2 L/min to ~ 6-7 L/min.						
			15 minutes airlifting. ~ 5 L/min over v-notch weir.						



University of New South Wales  
 School of Civil & Environmental Engineering  
 Water Research Laboratory

Project: 04039 Newnes Junction  
 Hole No. S  
 Driller: McDermott  
 Method of Drilling: Rotary Air Hammer

Date: 8th to 10th November 2004  
 Logged By: M. Groskops  
 Drill Hole Diameter: 98mm

Depth Below Ground (m)	Lithology	Graphic Log	Water Development	Piezometer 60m	Piezometer 17.5m	Well construction comments
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0	Top soil		Some moisture			lockable steel monument Sand Backfill Using Drill Cuttings
6	Yellow / light coloured sandy spoil with some orange layers. Ground soft with some moisture.		Becoming drier			
12	Orange / brown becoming harder and drier. Yellow with alternate orange/brown and white lenses. Hard. 50mm hard lense at 10 metres		Dry			Bentonite Plug 2 to 5 mm Graded Washed Quartz Gravel Pack
18	Grey / cream light coloured layers, occasional olive band.		Slight moisture			
24	Cream. Slight moisture		Dry			Class 18 50 mm ID 64 mm OD uPVC Casing & Machine Slotted Screen. No Geotextile Sock Used
30	Off white. Cream/brown/light coffee colour. Varying hardness.					
36	Cream. Dusty with some quartz.					
42	Cream. Dusty with some quartz.		End drilling 8th Nov 5:00 pm Resume drilling 9th Nov 6:30 am. Rods retracted and slowly lowered with air on. Water from 31m to 41m. No development of steady flow (< 80L water).			
48	Coffee Colour. Softer.		Very slight moisture			
54	Very hard layer.		Slight moisture			