



Australasian Groundwater and
Environmental Consultants Pty Ltd



Report on

Ulan Mine

Annual Groundwater Review - 2016

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Report on

Ulan Mine

Annual Groundwater Review - 2016

1 Introduction

Ulan Coal Mine Complex (Ulan Mine) is operated by Ulan Coal Mines Limited (UCML), which is a joint venture between Glencore Coal Assets Australia (Glencore) and Mitsubishi Development. The Ulan Mine is located in the central west of New South Wales near the town of Ulan, which is approximately 38 km north-northeast of Mudgee. Ulan Mine is within EPL 394, and was first assessed under Part 3A of the *Environmental Planning & Assessment Act 1979* (EP&A Act) and approved on 15 November, 2010. Routine groundwater monitoring is undertaken at Ulan Mine as part of the conditions of the project approval (PA 08_0184), which was last updated in March 2016.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) were commissioned by Ulan Coal Mine Limited (UCML) to prepare this annual groundwater review for the 2016 monitoring period, which extends from January to December 2016. The annual groundwater review has been prepared to address Schedule 5 (Environmental Management, Reporting and Auditing) of PA 08_0184. The 2016 groundwater results are assessed against the UCML (2016a) Ulan Groundwater Monitoring Program (GWMP) and statements of commitments under PA 08_0184 (Appendix 9, Section 6.4.1 to Section 6.4.6).

2 Objectives and scope of work

The objective of the monitoring program is to assess the potential impact of the Ulan Mine on the groundwater regime. The scope of work to achieve this objective included monitoring as required under the conditions of approval, and additional monitoring at the site, and on properties adjacent to the mine. Tasks undertaken over the monitoring period included:

1. manual measurement of groundwater water levels in the monitoring network;
2. downloading of electronic water level loggers; and
3. collecting groundwater samples for field and laboratory analysis.

The objective of this report is to present the groundwater monitoring results and analysis for the 2016 monitoring period.

3 Background

3.1 Geology

Ulan Mine is within the western limit of the Sydney Basin, and at the southern end of the Gunnedah Sub-basin. The stratigraphic sequence across the mine area comprises Permian Illawarra Coal Measures, Triassic Narrabeen Group and Jurassic Pilliga sandstone (Figure 3.1 and Table 3.1). Tertiary volcanics and Quaternary sediments are also present in localised areas around the site.

The Permian and Triassic strata are largely stratified and dip towards the north-east at a shallow angle (less than 2 degrees). Each of the key geological units and their hydrogeological characteristics are discussed further in Section 3.1.1 to Section 3.1.5.

Table 3.1 Summary of site stratigraphy

Age	Unit	Description
Quaternary	-	Alluvium/colluvium – comprising soil, silt, clay, sand and gravel
Tertiary	-	Alluvium (palaeochannels) Weathered basalts
Jurassic	Pilliga sandstone Purlewaugh Siltstone	Coarse grained quartzose sandstone, lithic sandstone, conglomerates, claystone and shale
Triassic	Wollar Sandstone (Narrabeen Group equivalent)	Quartzose and lithic sandstone, conglomerates and claystone
Permian	Illawarra Coal Measures	Interbedded claystones, siltstones, sandstones (fine to coarse grained) and coal seams

3.1.1 Quaternary and Tertiary alluvium/colluvium

Quaternary alluvium is restricted to areas along creeks, including Mona Creek, Ulan Creek, Bobadeen Creek and an unnamed tributary of Cockabutta Creek. The alluvium comprises fine to coarse grained sands and gravels within a silt/clay matrix. Thicker sequences of alluvium are present at the confluence of Ulan Creek and the Goulburn River, and to the northwest in areas adjacent to the Talbragar River.

A study conducted for Moolarben Mine indicates the presence of Tertiary palaeochannels south of the Goulburn River Diversion (Dundon Consulting 2015). The palaeochannels apparently comprise poorly sorted sands and gravels within a clayey matrix, and are up to 50 m thick (Dundon Consulting 2015).

3.1.2 Tertiary volcanics

Tertiary volcanics are present in isolated areas across the northern limits of Ulan Mine. The volcanics are present as deeply weathered, clay rich tertiary basalts that are present from surface to approximately 30 m depth. Minor volcanic intrusions have also been identified within the area.

3.1.3 Jurassic sediments

The Jurassic sediments are present at the northern limits of Ulan Mine. The Jurassic sediments comprise the Pilliga Sandstone and Purlewaugh Siltstone. The Pilliga Sandstone comprises cross-bedded sequences of ferruginous, coarse grained quartzose sandstone, conglomerates, claystone and shale. The Pilliga Sandstone is relatively permeable and forms a groundwater aquifer where it is present.

The underlying Purlewaugh Siltstone comprises siltstone, mudstone and fine to medium grained lithic sandstone. The Purlewaugh Siltstone is a low permeability unit that likely forms an aquitard (MER 2009). At Ulan Mine the Jurassic sediments are largely unsaturated.

3.1.4 Triassic Wollar Sandstone (Narrabeen Group)

The Triassic aged Wollar Sandstone, which is equivalent to the Narrabeen Group, is present across Ulan Mine. The unit thickens towards the north, and ranges between 10 m and 120 m thick across Ulan Mine. The Wollar Sandstone comprises two depositional units, a shallower quartzose unit and the deeper lithic unit. The quartzose unit comprises thick sequence (i.e. 90 m thick) of cream to yellow, cross-bedded porous sandstone, conglomerates and claystone. The lithic unit is thinner (i.e. 35 m) and comprises light grey/green, poorly sorted sandstone.

The Wollar Sandstone is largely a stratified/bedded unit with variable hydraulic properties. As documented for the Narrabeen Group, the coarser grained sandstone units can form aquifers and claystone units can form aquitards (Australian Government 2016). At Ulan Mine the Triassic sediments are variably saturated.

3.1.5 Permian Illawarra Coal Measures

The Permian aged Illawarra Coal Measures are present across Ulan Mine and are around 145 m thick. The coal measures conformably underlie the Triassic Wollar Sandstone and comprise interbedded claystones, siltstones, sandstones (fine to coarse grained) and coal seams. The coal seams include Middle River, Moolarben, Glen Davis, Irondale and Ulan seams. Ulan Seam is the main economic seam at site and is around 10 m thick and occurs approximately 90 m below the base of Triassic. Underlying the Ulan Seam is the Marrangaroo Conglomerate, which comprises weakly cemented conglomerates and medium to coarse grained sandstones.

Groundwater storage and movement occurs within the coal seam cleats and fissures, and to a lesser degree within fractures associated with faults intersecting the seams. Other sediments in the coal overburden and interburden sequence are relatively impermeable and form aquitards. Some Permian sandstones yield minor groundwater, although in the mined section of the coal measures, these are rare.

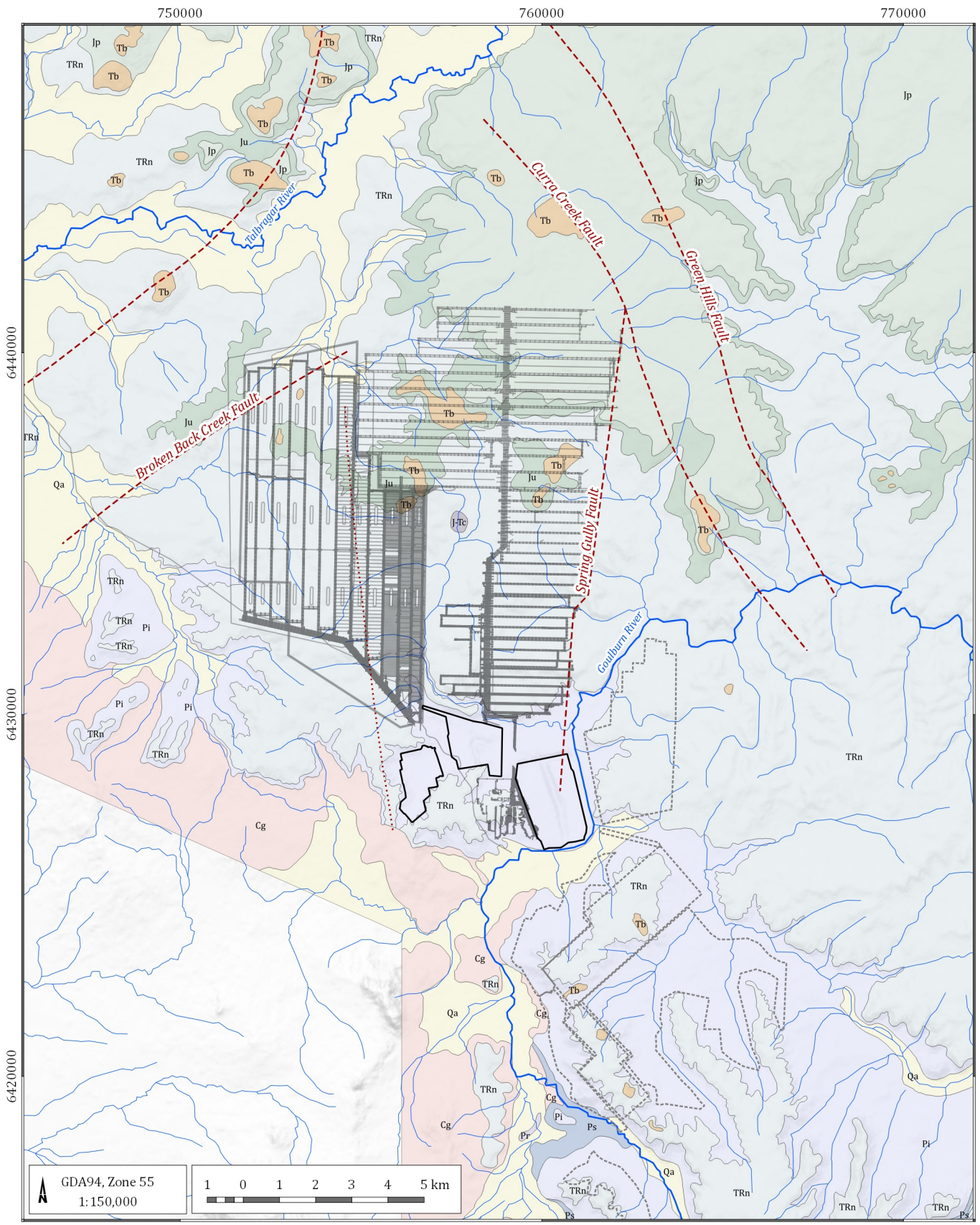
The Permian strata is therefore categorised into the following hydrogeological units:

- hydrogeologically “tight” and hence very low yielding to essentially dry (when drilling) sandstone and siltstone that comprise the majority of the Permian interburden / overburden; and
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

The Permian coal measures are confined to semi-confined within the region. However, the coal measures are depressurised locally due to historic and current mining activities.

3.1.6 Structural geology

A north to north-east trending fault (Spring Gully Fault) is present on the eastern extent of Ulan Mine (Figure 3.1). The fault is near vertical, with an approximate 8 m displacement in Permian and Triassic sediments. Two north-west trending faults are also mapped east of Spring Gully Fault, and a north-east trending fault is present west of Ulan West Underground, near Broken Back Creek.



LEGEND

- Ulan underground
- ▭ Ulan open cut
- ▭ Moolarben mine area
- Major drainage
- Minor drainage

Western Coalfield (north) Regional Geology (1:100k)

- Qa - Quaternary alluvium
- Tb - Tertiary basalts
- J-Tc - Jura-Tertiary volcanics
- Jp - Pilliga Sandstone
- Ju - Purlawaugh Formation
- Ma - Late triassic intrusions, phonolite
- TRn - Narrabeen Group
- Pi - Illawarra Coal Measures
- Ps - Shoalhaven Group
- Pr - Rylstone Volcanics
- Cg - Carboniferous granite
- - - Fault
- Hingeline

Ulan Mine
Annual Groundwater Review (G1844E)

Site geology



DATE
21/03/2017

FIGURE No:
3-1

3.2 Mine activities

The Ulan Mine has a long history of open-cut and underground mining dating back to the 1920's. Currently, underground mining is active within Ulan No. 3 and Ulan West Underground (Figure 3.2). Mining commenced at Ulan No. 3 around 1986 and progressed in a northerly direction. During 2016, mining was active within Ulan No. 3 in longwall panels LW29 and LWW3, and headings development commenced for LWW4, LWW5, LW30 and LW31.

Mining commenced at Ulan West Underground around 2012 and will progress in a westerly direction until 2031. Over 2016, mining was active within the Ulan West Underground in longwall panel LWUW3, and headings development commenced for LWUW4 to LWUW6. Historic underground mining also occurred at Underground No. 2 until 1983.

Open cut mining occurred at East Pit until 2008. Mining at West Pit commenced in 2012 and ceased in 2016; however, mining in West Pit is approved until 2031. East Pit is has been used for tailings storage since the 1990's, and is approved for use until 2018. Tailings were also stored within South 5 Tailings Dam until around 2011, and within West Pit (Barrier Pit) between 2012 and 2016.

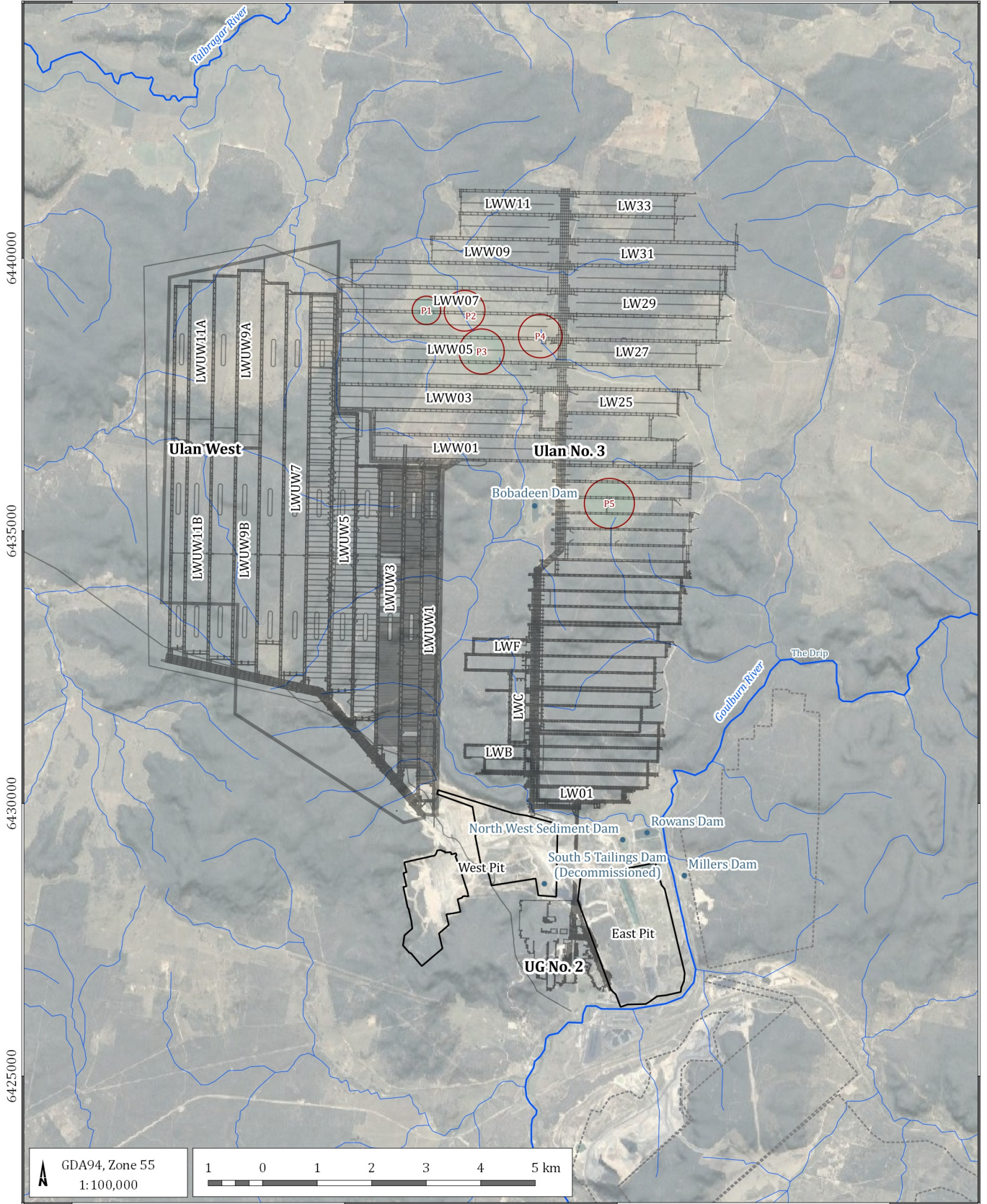
There are also several water storage dams across Ulan Mine, including North West Sediment Dam, Bobadeen Dam and Rowans Dam that store underground mine water. Water is treated at Bobadeen and Rowans dams, with the water utilised on site and/or released from licensed discharge points along Ulan Creek. Potable water is abstracted from bore PB1C (Bore license 20BL168008) at a rate of around 50 ML/year, treated and then stored at Millers Dam for dust suppression.

750000

755000

760000

765000



LEGEND

- Ulan underground
- ▭ Ulan open cut
- ▭ Moolarben mine area
- ◻ Bobadeen Irrigation System (P1 - P5)
- Major drainage
- Minor drainage

Ulan Mine
 Annual Groundwater Review (G1844E)
Mine area



DATE
 21/03/2017

FIGURE No:
3-2

4 Monitoring network

4.1 Monitoring bores

The monitoring bore network at Ulan Mine has been installed over a number of different campaigns since 1997. General construction details for the Ulan Mine groundwater monitoring network is listed in Appendix A, and locations are shown in Figure 4.1. Ulan Mine has three main monitoring networks, the North Monitoring Network (NMN), Bobadeen Monitoring Network (BMN) and Pleuger Monitoring Network (PMN).

The NMN is the largest network, currently comprising 35 monitoring standpipes at 14 locations, as well as nine vibrating wire piezometer (VWP) locations with a total of 38 sensors in operation. The currently monitored NMN intersects all key hydrogeological units except alluvium, as presented in Table 4.1. VWP PZ36 was installed in 2016, and construction details are detailed in Section 4.2.

Table 4.1 NMN active network target lithology (2016)

Lithology	Open standpipes	VWP sensors	No.
Tertiary basalt	R752	-	1
Jurassic sediments	PZ09D, PZ10B, PZ14C, PZ26D, PZ28B	R894_119, PZ36_018	7
Triassic sediments	PZ01A, PZ04A, PZ06C, PZ07C, PZ08C, PZ09C, PZ10A, PZ11B, PZ12C, PZ14B, PZ24B, PZ26C, PZ28A, R755A	DDH266_084, R894_219, R894_255, TAL1_028, TAL1_045, UW2_050, PZ36_050, PZ36_072, PZ36_090, PZ36_122	24
Permian coal measures	PZ06B, PZ08B	TAL1_061, TAL1_097, TAL2_050, TAL2_090, TAL2_110, UW1_022, UW1_035, UW1_051, UW2_090, UW3_040, UW3_060, UW3_075, UW4_041, UW4_063, UW4_087, PZ36_143, PZ36_183	19
Permian coal seam (Ulan Seam)	PZ06B, PZ07B, PZ09B, PZ11A, PZ12B, PZ14A, PZ24A, PZ26B	DDH266_189, TAL1_140, TAL2_128, UW1_061, UW2_110, UW3_098, UW4_122, PZ36_243	16
Permian coal measures beneath Ulan Seam	PZ06A, PZ07A, PZ09A, PZ12A, PZ26A	DDH266_192	6
No.	35	38	73

Notes: R753A is included in the GWMP but no data is available for this bore.

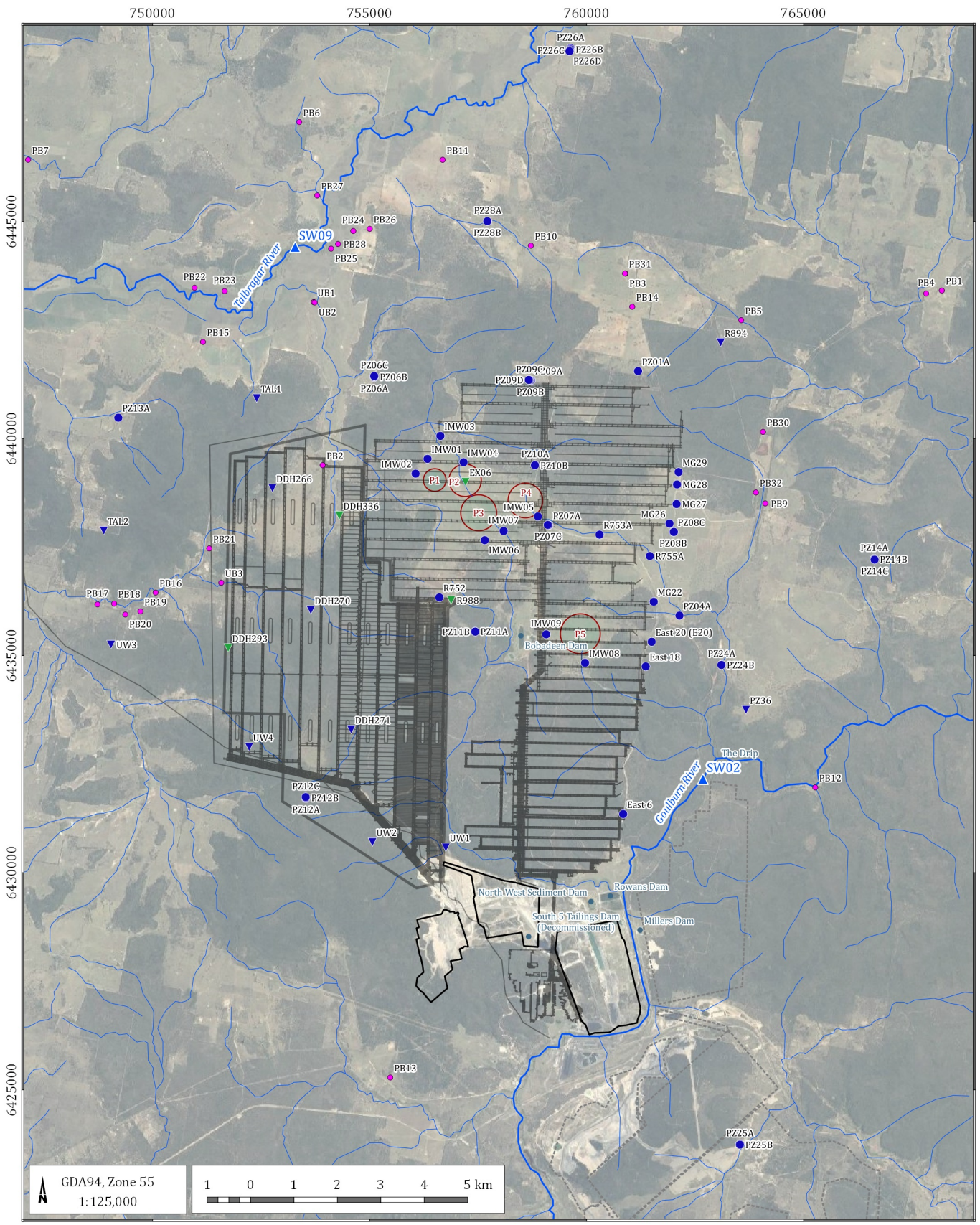
DDH270 and DDH271 are in the GWMP but have not been functioning since 2014

An additional four VWP locations (DDH293, DDH336, R855 and R988) are monitored but not included in the NMN under the GWMP.

The BMN comprises nine open standpipes (IMW01 to IMW09) that intersect unconsolidated sediments within the upper catchments of Mona Creek, Ulan Creek, and Spring Gully Creek (in the vicinity of the Bobadeen Irrigation Scheme).

The PMN comprises seven active dewatering bores (E20, MG22, MG26, MG27, MG28 and MG29 and UW TG1). As well as six decommissioned dewatering stations that are used for monitoring (East 7, East 9, East10, East 15, East 18 and MG21). Note, the GWMP incorrectly states East 6 instead of East 7 (pers. coms. UCML staff); East 7 is no longer used for groundwater abstraction.

Private landholder bores (PB bores) are also monitored, where access is granted. Little is known about the construction of the bores; however available details and estimated target lithology is presented in Appendix A. The location of the PB bores is also presented in Figure 4.1.



LEGEND

- Ulan underground
- ▭ Ulan open cut
- - - Moolarben mine area
- ▭ Bobadeem Irrigation System (P1 - P5)
- Major drainage
- Minor drainage
- ▲ Surface water monitoring points
- Private bore
- Groundwater monitoring network**
- Monitoring bore in GWMP
- ▼ VWP in GWMP
- Monitoring bore
- ▼ VWP

Ulan Mine
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Groundwater monitoring network

 DATE 21/03/2017 FIGURE No: **4-1**

4.2 Bore condition

Three monitoring bores (PZ13A, PZ25A, PZ25B and R753A) and two VWPs (DDH270 and DDH271) are listed within the GWMP for the NMN, but are no longer monitored due to access restrictions (PZ13A, PZ25A, PZ25B, R753A and DDH271) and faulty sensors (DDH270). In addition, VWP R894 has recorded erroneous data for one sensor since establishment in 2006, this sensor intersects the Jurassic sediments at a depth of 90 m below surface.

Over 2016, a program commenced to drill and construct a series of VWPs across the site and surrounds, which is continuing into 2017. The program includes installation of additional VWPs to address data gaps and monitor changes in the groundwater regime as the mine progresses north and west. The program also includes the collection of core samples to be laboratory tested to obtain hydraulic properties of various key stratigraphic units.

In 2016, two VWPs were drilled and constructed, EX06 and PZ36. The location of both VWPs is shown in Figure 4.1, and construction details are discussed below. Core samples were not collected for hydraulic testing, but samples are planned to be collected at one location to be drilled in 2017.

VWP PZ36 was constructed approximately 1.3 km north of The Drip in February 2016. The purpose of the VWP was to monitor the groundwater level trends and gradients between the Jurassic, Triassic and Permian coal measures. The data will build upon the existing monitoring program, which aims to understand The Drip recharge source and hydraulic connection to the regional groundwater system. The datalogger has been set to record groundwater pressures/levels at 12 hourly intervals. The VWP comprises six sensors intersecting the Jurassic, Triassic and Permian stratigraphy, as outlined in Table 4.2. During construction the Jurassic sediments intersected by the shallowest sensor (18 m below surface) were unsaturated. Further data and results for the VWP are presented in Section 5.7.

Table 4.2 PZ36 construction details

Drill ID	Easting	Northing	Top of casing elevation (mAHD)	Sensor depth (mbgl)	Target unit	Lithological description
PZ36	763673.2	6433747.4	443.6	18	Jurassic	Conglomerate (base of Jurassic) - dry
				72	Triassic	Conglomerate
				90	Triassic	Conglomerate
				122	Triassic	Sandstone, coarse grained, lithic
				143	Permian	Coal (Goulburn) – sensor failed
				183	Permian	Carbonaceous claystone – sensor failed
				243	Permian	Coal (Ulan DWS floor)

VWP EX06 was constructed in December 2016 in the middle of the Bobadeen Irrigation System (BIS) – pivot P2. The purpose of the VWP was to monitor the change in hydrostatic pressure between the Jurassic, Triassic and Permian coal measures in that region. The datalogger has been set to record groundwater pressures/levels on a 6 hourly frequency. The VWP comprises eight sensors intersecting the Jurassic, Triassic and Permian stratigraphy, as outlined in Table 4.3. Due to difficult ground conditions, EX06 was constructed within three drill holes, spaced approximately 2 m apart. Due to EX06 being constructed late in the monitoring period, there is insufficient data to present in this annual review. However, the VWP will be included in the BMN monitoring program for 2017.

Table 4.3 EX06 construction details

Drill ID	Easting	Northing	Ground elevation (mAHD)	Sensor depth (mbgl)	Target unit	Lithological description
R1217	757210.38	6438998.44	498.30	8.5	Jurassic	Basic / Mafic volcanics
				27.5	Base of Jurassic	Sandstone – fine to coarse grained - quartzose
R1216	757210.04	6439001.25	498.30	55.5	Triassic	Conglomerate
				70.5	Triassic	Sandstone – medium to coarse grained - quartzose
				94.5	Triassic	Sandstone – medium to coarse grained - quartzose
DDH560	757207.96	6438999.59	498.10	120.5	Base of Triassic	Conglomerate
				185	Permian coal measures	Sandstone – medium grained - lithic
				226.5	Ulan Seam	Ulan seam

4.3 Monitoring program

Groundwater monitoring is undertaken in accordance with the GWMP. As outlined within the GWMP, there are four key monitoring programs, the NMN, BMN, PMN and monitoring at The Drip. Each of the monitoring programs are summarised below.

The NMN standpipes are monitored quarterly for groundwater levels and field parameters of pH and electrical conductivity (EC). VWP data is also downloaded on a quarterly basis. On an annual basis all standpipes are sampled and sent to the laboratory to analysis for:

- physical parameters: pH, EC, temperature, silica and total dissolved solids (TDS);
- major ions: Ca, Cl, K, Na, Mg, SO₄;
- nutrients: nitrates, nitrites and nitrogen ammonia;
- fluoride (note, incorrectly stated as fluorine in GWMP);
- total alkalinity as CaCO₃, HCO₃, CO₃; and
- dissolved metals: As, Al, B, Ba, Cd, Cr, Cu, Fe, Hg, Li, Mn, Mo, Ni, Pb, Sb, Se, Sr and Zn.

The BMN is monitored quarterly for standing water level, depth to ground and depth to standpipe. On a quarterly basis all standpipes with water present are sampled and the samples sent to the laboratory to analyse for:

- physical parameters: pH and EC;
- major ions: Ca, Cl, K, Na, Mg, SO₄;
- total alkalinity as CaCO₃, HCO₃, CO₃ and CaCO₃ saturation index;
- acidity and hardness;
- sodium absorption ratio; and
- total metals: Fe, Mn and Zn.

The PMN is monitored monthly for water levels in six decommissioned dewatering bores, East 7 (incorrectly stated as East 6 in GWMP), East 9, East 10, East 15, East 18 and MG21. Water quality sampling is also conducted on a fortnightly basis for seven active dewatering bores, E20, MG22, MG26, MG27, MG28, MG29, UW TG1. The seven bores are sampled and sent to the laboratory to analyse for:

- physical parameters: pH, EC and total suspended solids (TSS);
- major ion: SO₄;
- total alkalinity as CaCO₃; and
- total and dissolved metals: Fe, Mn.

The Drip monitoring program involves sampling of surface water expressed from the cliff face on a two monthly basis and following significant rainfall events. The samples are analysed for:

- physical parameters (field): pH, EC and temperature;
- major ions: Ca, Cl, K, Na, Mg, SO₄;
- total alkalinity as CaCO₃, HCO₃, CO₃;
- total metals: Al, As, B, Ba, Li, Mn, Se, Si, Sr and Zn; and
- dissolved metals: Fe.

The Environmental Assessment (EA) identified private bores within the predicted zone of drawdown for Ulan Mine. Since 2009, a private bore monitoring program has been in place, which has expanded over time to include 32 private bores (see Appendix A). Groundwater levels and quality (EC and pH) are monitored at all private monitoring bores on an annual basis, subject to voluntary access arrangements to the private property and the relevant bore.

4.4 Methodology

4.4.1 Sampling methodology

The following field observations were recorded on a field data sheet during sampling:

- date and time of sampling for each monitoring location;
- depth to groundwater from the top of casing;
- field measurements of pH and electrical conductivity (EC); and
- observations of sample water, where relevant.

The depth to groundwater is recorded manually using an electronic dip-meter within the open standpipes. VWP water levels are recorded at a 10 minute to 12 hourly frequency.

Prior to purging, the depth to groundwater was measured with an electronic dip meter. For the shallower bores (i.e. BMN), purging and sampling was undertaken with a submersible (high flow) pump, with samples taken after three well volumes were purged from the well, and / or once water parameters (EC and pH) had stabilised. The deeper wells were sampled with a hand bailer.

To comply with Australian Standards Water Quality - Sampling AS 5667 (1998), samples were collected in laboratory supplied containers. Samples requiring heavy metal analysis were filtered in the field and stored in laboratory-supplied nitric acid preserved bottles. Whilst in the field, samples were kept in an esky chilled with ice, and itemised on a Chain of Custody Form that accompanied the samples to the analytical laboratory. The groundwater samples were analysed by ALS, a National Association of Testing Authorities (NATA) accredited laboratory.

4.4.2 Quality assurance and quality control methodology

The following quality assurance and quality control (QA / QC) procedures were followed during the field sampling and monitoring:

- calibration of field water quality meter on a monthly basis; and
- rinsing of monitoring equipment between bores with town water.

In addition, the NATA accredited laboratory undertake quality control measures, including reagent blanks, replicate analysis, recovery checks, internal standards and surrogate spikes.

4.5 Trigger levels

4.5.1 Site monitoring bores (NMN, BMN and PMN)

The EA predicts the complete dewatering of Triassic strata above all mine longwall panels, with depressurisation extending up to 5 km from site. Trigger levels are not required to be developed for all UCML groundwater monitoring bores above the mined longwall panels, as the majority of these monitoring bores are predicted to become dry within the life of the mine.

For NMN bores outside of the immediate mine footprint (PZ01, PZ04, PZ06, PZ08, PZ09, PZ12, PZ14, PZ24, PZ26, PZ28, R755A, R894, TAL1, TAL2, UW2 and UW3), groundwater trends are compared against model predictions to identify any deviations. While no set trigger levels have been prescribed, any significant deviations from model predictions that are due to Ulan Mine operations will trigger an investigation into the cause and implications.

No groundwater quality triggers have been prescribed for site monitoring bores. However, all water quality data is reviewed by a qualified hydrogeologist on an annual basis in order to identify any adverse changes in groundwater quality that require further investigation.

4.5.2 Private bores

Seven of the bores on private land are predicted to experience groundwater level drawdowns in excess of 2 m (PB2, PB8, PB9, PB14, PB21 and PB30). Annual water level data is compared to groundwater drawdown predictions by a qualified hydrogeologist on an annual basis.

Within the UCML (2016b) Surface Water Groundwater Response Plan (SWGWRP), Table 3.5 provides reference criteria ranges for pH of of 6.5 to 8.0 and EC range of 30 $\mu\text{S}/\text{cm}$ to 350 $\mu\text{S}/\text{cm}$. However, as outlined within the GWMP, historic monitoring indicates that water quality in the privately owned bores varies widely, with average EC concentrations ranging from 172 $\mu\text{S}/\text{cm}$ to 4,760 $\mu\text{S}/\text{cm}$, and average pH levels ranging from pH 4.5 to pH 7.6.

As detailed within the GWMP, adequate baseline data is required in order to establish effective trigger levels for the privately owned bores. Collection of baseline data will continue, subject to voluntary access arrangements to the private property and the relevant bore. As outlined within the SWGWRP, the water level and quality triggers for private bores predicted to be impacted (PB2, PB8, PB9, PB14, PB21, PB30 and PB32) will be based on:

- \pm 10% deviation from baseline data;
- greater depressurisation than that predicted by numerical groundwater modelling; and
- complaint received from private landholder.

For all other private bores not predicted to be impacted, but included in the private bore monitoring network (Section 4.1), the trigger is based on a \pm 15% deviation from baseline data or complaint received from the private landholder.

5 Monitoring results

5.1 Rainfall data

Rainfall data has been collected at Ulan Mine on a daily basis since 2013, and at nearby Bureau of Meteorology (BoM) station 62036 (Ulan Water) since 1906. Table 5.1 presents the average monthly rainfall data as measured at site over 2016, and historic average data collected by BoM at station 62036. Note, no data was recorded at station 62036 between April 2007 and January 2014, therefore data from BoM station 62013 (Gulgong Post Office) was used for this period.

Table 5.1 Monthly rainfall data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average monthly rainfall (mm)†	74.0	61.9	52.3	40.1	44.8	46.5	47.4	47.1	44.3	54.6	58.8	71.0	642.8
2016 Rainfall (mm)	111.0	2.0	9.0	26.0	52.0	65.0	70.0	44.0	144.0	55.0	56.0	59.0	693.0

Note: † Based on BoM station 62036 data from 1906, in-filled with data from station 62013 between 2007 and 2014

Rainfall patterns over 2016 were highly variable, with above average rainfall in January, negligible rainfall from February to April then above average rainfall over winter (June, July and September). The rainfall in January and September largely relate to peak rainfall events, where over 30 mm rainfall fell in a day. In addition, while November recorded below average rainfall, 48 mm fell in one day (12 November).

5.2 Stream flow

The Ulan Mine Complex is located at the headwaters of both the Goulburn River system and the Talbragar River system. The Talbragar River flows in a south-westerly direction across the northern extent of Ulan Mine. Mona Creek and Cockabutta Creek are ephemeral tributaries of the Talbragar River system.

The Goulburn River flows in an easterly to northerly direction along the southern boundary of Ulan Mine. The Goulburn River has been modified as a component of previous mining activities on the site, known as the Goulburn River Diversion. Several natural ephemeral creeks are present across the mine feeding into the Goulburn River during periods of peak rainfall. These include Spring Gully, Ulan Creek, Bobadeen Creek, Curra Creek, Sportsman's Hollow Creek and Moolarben Creek. Ulan Creek currently has more perennial flows due to controlled discharge of treated water from Bobadeen Dam.

UCML monitor stream flow and quality at various locations across and surrounding the mine. Water levels within the Goulburn River. Figure 5.1 shows Goulburn River stream flow compared against the cumulative rainfall departure (CRD), which is based on averaged rainfall data collected at BoM station 62036. The CRD shows trends in rainfall relative to the long term average, and provides a historical record of relatively wet periods and droughts. A rising trend in slope in the CRD plot indicates periods of above average rainfall, whilst a declining slope indicates periods when rainfall is below average. As shown in Figure 5.1, the area experienced below average rainfall and low stream flow (less than 90 ML/day) between 2013 and 2014. Over 2016, the area experienced above average rainfall and peak stream flow (up to 1,014 ML/day) events between July and September.

As outlined within the GWMP, the Goulburn River stream levels rapidly recede after peak flow events due to poor catchment water storage. Baseflow analysis conducted by MER (2009) indicates that the Goulburn River receives baseflow contributions from the hardrock system during extended dry periods, when flows are frequently less than 0.5 ML/day. Over the 2016 monitoring period, stream flow ranged between 6 ML/day and 1,014 ML/day, indicating baseflow was not a significant contributor to stream flow during this period.

Goulburn River stream flow is also compared against EC and pH in Figure 5.2 for the 2016 monitoring period. Over 2016, average EC within the Goulburn River ranged between 329 $\mu\text{S}/\text{cm}$ and 838 $\mu\text{S}/\text{cm}$, and average pH ranged between 7.0 and 8.9. As shown in Figure 5.2, each peak stream flow event resulted in a reduction in EC and a reduction in pH to more neutral conditions. This correlates with the observed above average rainfall over these periods, indicating the peak flows relate to natural recharge events.

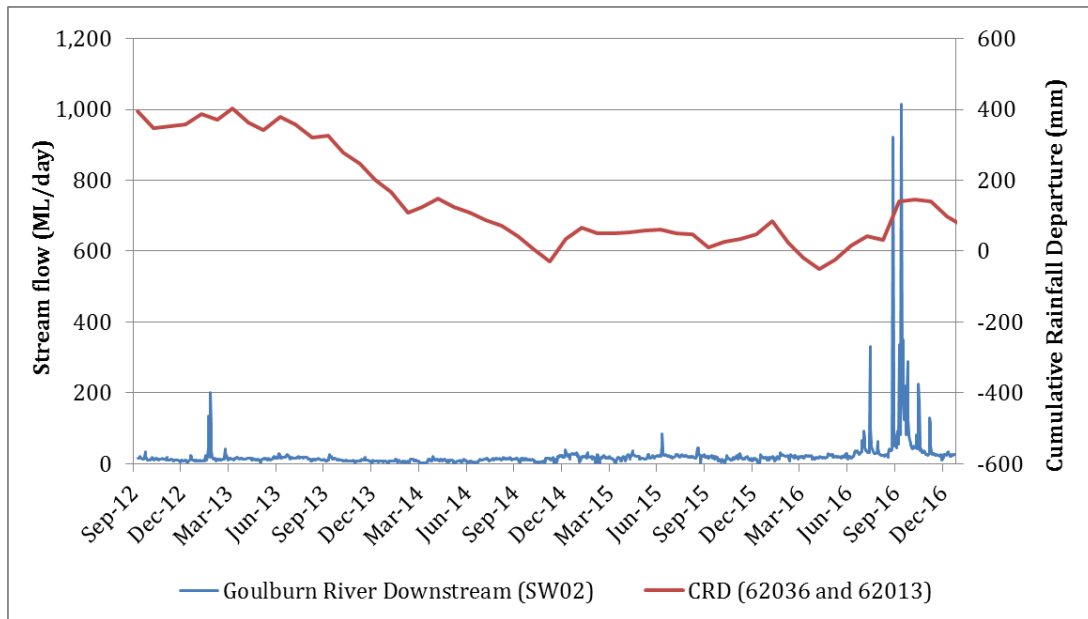


Figure 5.1 Goulburn River stream flow vs CRD

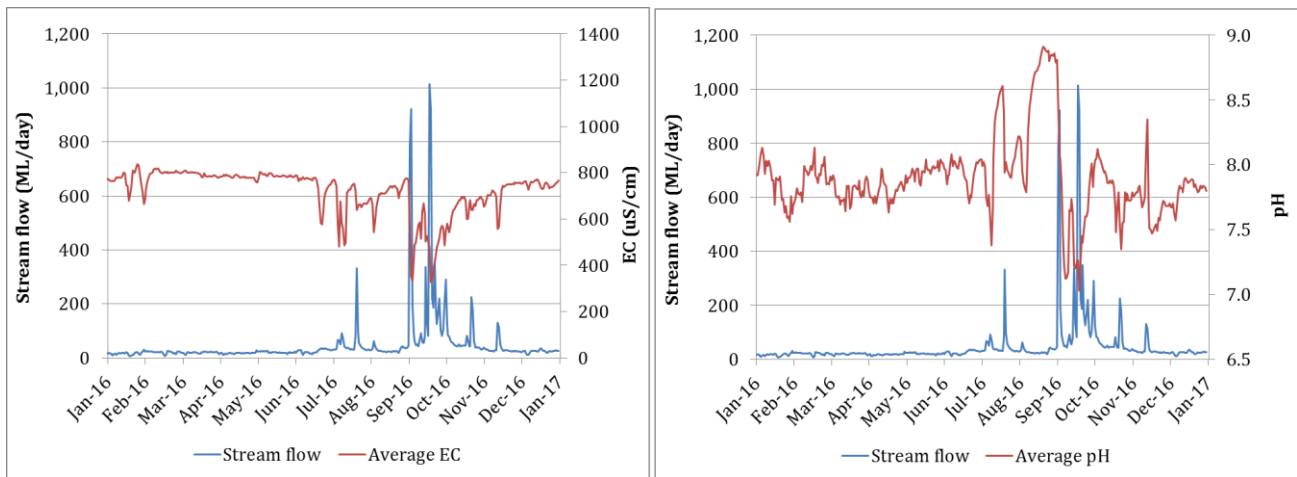


Figure 5.2 2016 Goulburn River stream flow vs EC (left) and pH (right)

5.3 Irrigation

Land above Ulan No. 3 is irrigated with recycled mine water as part of the BIS. The BIS has been in place since 2003 and includes five central pivots (P1 to P5), as shown in Figure 4.1. The rate of water pumped to the pivots is monitored and recorded at station Farm 1 (for pivot P5) and Farm 2 (for pivots P1 to P4). Figure 5.3 presents daily site rainfall data compared to total monthly irrigation volumes, as recorded at Farm 1 and Farm 2.

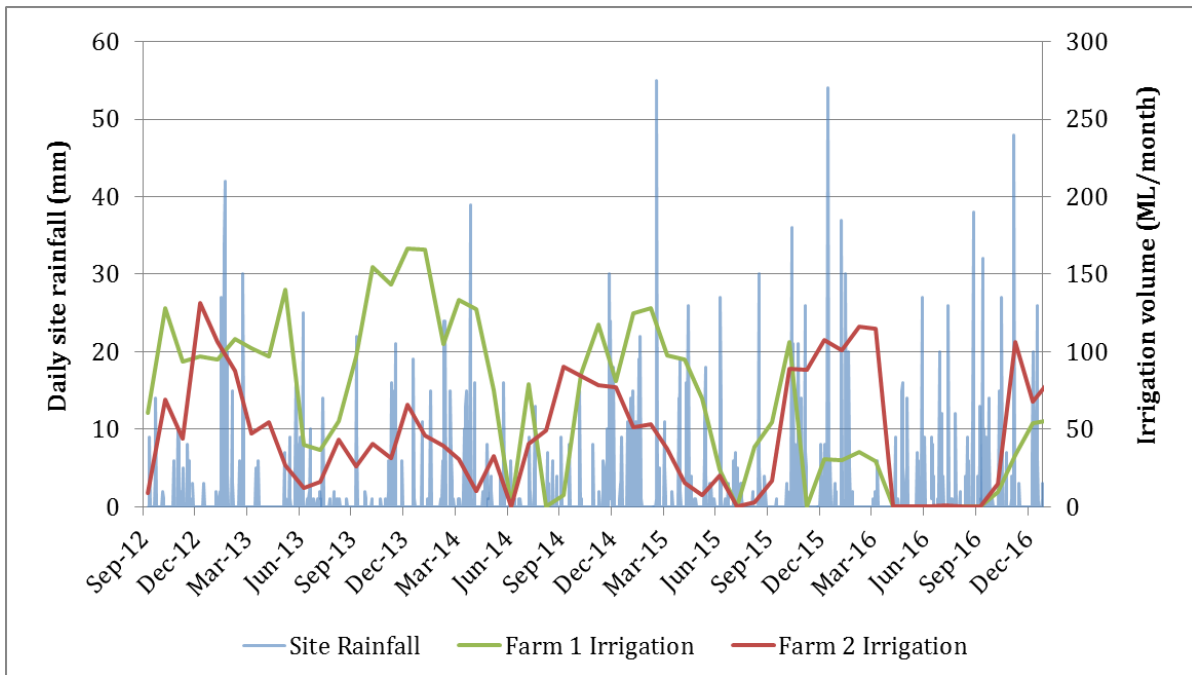


Figure 5.3 Site rainfall and irrigation trends

As shown in Figure 5.3, the P5 (Farm 1) was not operated between April and September of 2016. When P5 was operational, approximately 32 ML of water was used per month to irrigate a 70.6 hectare area. Pivots P1 to P4 (Farm 2) was also not operated, or had negligible use between April and September 2016. When operational, approximately 101 ML or water was used per month to irrigate the combined 174.7 hectare area covered by the four pivots.

5.4 Groundwater levels

5.4.1 North Monitoring Network

As outlined within the GWMP, groundwater levels for standpipes are dipped manually, and VWP data is downloaded on a quarterly basis. Table 5.2 shows the quarterly manual dipped water levels for the standpipes. Hydrographs for the standpipes compared to CRD are presented in Appendix B. Daily groundwater level data for the NMN VWPs are also presented in Appendix B.

Table 5.2 NMN water level data - 2016

Bore ID	Within mine footprint	Ground elevation (mAHD)	Q1 SWL (mAHD)	Q2 SWL (mAHD)	Q3 SWL (mAHD)	Q4 SWL (mAHD)	Lithology
PZ01A	No	534.3*	417.5	417.5	417.4	417.3	Triassic
PZ04A	No	440.7*	399.2	-	-	398.9	Triassic
PZ06A	No	449.7	381.6	381.0	380.5	380.1	Lower-PCM
PZ06B	No	449.8	368.0	367.7	367.3	367.0	Ulan Seam
PZ06C	No	449.7	431.7	431.8	431.8	431.8	Triassic
PZ07A	Yes	502.4	252.2	252.3	252.4	252.7	Lower-PCM
PZ07B	Yes	502.1	252.1	252.2	252.3	252.5	Ulan-Seam

Bore ID	Within mine footprint	Ground elevation (mAHD)	Q1 SWL (mAHD)	Q2 SWL (mAHD)	Q3 SWL (mAHD)	Q4 SWL (mAHD)	Lithology
PZ07C	Yes	501.9	397.1	397.0	396.7	366.5	Triassic
PZ08B	No	481.1	-	304.8	311.8	-	Permian
PZ08C	No	482	399.7	399.5	399.1	398.8	Triassic
PZ09A	No	541.8	362.1	361.3	360.5	359.8	Lower-PCM
PZ09B	No	541.6	350.2	349.8	349.3	349.0	Ulan-Seam
PZ09C	No	541	423.2	423.2	423.2	423.1	Triassic
PZ09D	No	540.6	479.2	479.2	479.8	479.2	Jurassic
PZ10A	Yes	513.8	384.0	388.1	386.8	385.1	Triassic
PZ10B	Yes	514.1	476.6	478.5	476.8	477.4	Jurassic
PZ11A	Yes	476.7	311.0	311.1	-	311.3	Ulan-Seam
PZ11B	Yes	476.5	399.2	398.7	-	398.5	Triassic
PZ12A	No	571.8	-	386.4	388.7	386.4	Lower-PCM
PZ12B	No	571.3	405.7	405.7	405.9	405.8	Ulan-Seam
PZ12C	No	570.6	510.6	510.7	510.7	510.6	Triassic
PZ14A	No	453.37	421.0	416.3	421.3	421.3	Ulan Seam
PZ14B	No	453.7	389.0	389.2	389.1	389.0	Triassic
PZ14C	No	454.2	421.5	421.5	421.5	421.5	Jurassic
PZ24A	No	420.8	329.3	328.9	328.6	328.3	Ulan Seam
PZ24B	No	420.6	400.1	400.1	400.1	400.0	Triassic
PZ26A	Yes	448.3	-	-	-	-	Lower PCM
PZ26B	No	448.2	-	-	-	-	Ulan Seam
PZ26C	No	447.9	-	-	-	-	Triassic
PZ26D	No	447.6	-	-	-	-	Jurassic
PZ28A	No	475.4	428.0	428.0	428.1	427.8	Triassic
PZ28B	No	475.2	460.4	460.5	460.6	460.6	Jurassic
R752	Yes	549.1*	507.9	507.5	514.6	508.5	Basalt
R755A	No	462.42*	391.4	391.3	-	390.6	Triassic

Notes: * average monthly water level
PCM – Permian Coal Measures

Over the 2016 monitoring period, most bores were monitored on a quarterly basis. Bores PZ13A and PZ26 (A-D) were not monitored due to access restrictions (on private land). One to two quarterly readings were not taken for bores PZ04A, PZ08B, PZ11 (A -B), PZ12A and R755A over the 2016 monitoring period. These readings were not taken due access restrictions (i.e. inaccessible tracks).

Comparison of observed groundwater levels to predicted levels generally indicates the model predictions are conservative, with predicted groundwater levels below observed. Two exceptions to this are bores PZ11B and PZ12A. Bore PZ11B records similar trends but a slightly lower groundwater elevation, which is likely a function of the model layers within this area. Bore PZ12A has historically recorded comparable groundwater elevations to model predictions. Since June 2015, groundwater levels at PZ12A have steadily declined, which is not predicted within the model. Bore PZ12A intersects the lower Permian coal measures and is located approximately 1 km south-west of LWUW6. The trend is not visible in the Ulan Seam or Triassic sediments at bore PZ12; therefore, further review of the condition of the bore and lithological logs is required.

5.4.1.1 Tertiary basalt

Bore R752 intersects the Tertiary basalt and recorded groundwater levels over 40m below surface at the start of the year. However, groundwater levels rapidly rose 7m between June and September (to 514.6 mAHD), and rapidly declined by 6m in December (to 508.5 mAHD). This spike coincides with a peak rainfall period where over 30mm rainfall fell in a day approximately a week prior to sampling.

5.4.1.2 Jurassic sediments

Over the 2016 monitoring period, the bores intersecting Jurassic sediments recorded relatively stable groundwater levels, indicating no mine related impacts. VWP R894 is located north-east of Ulan No.3 and has sensors within the Jurassic sediments (R894_119), and within the quartzose (R984_219) and lithic (R984_255) Triassic aged sediments. Over 2016, VWP sensor R894_119 recorded stable to slightly declining groundwater levels (0.4m decline), at around 412.8 mAHD by December 2016. Long-term groundwater trends for R894 indicate a general decline in groundwater levels for the Jurassic sediments and a rise in groundwater levels for the Triassic sediments.

Spatial representation of the most recent (December) groundwater level data is presented in Figure 5.4. Figure 5.4 shows that groundwater within the Jurassic sediments generally flows in a north-easterly direction.

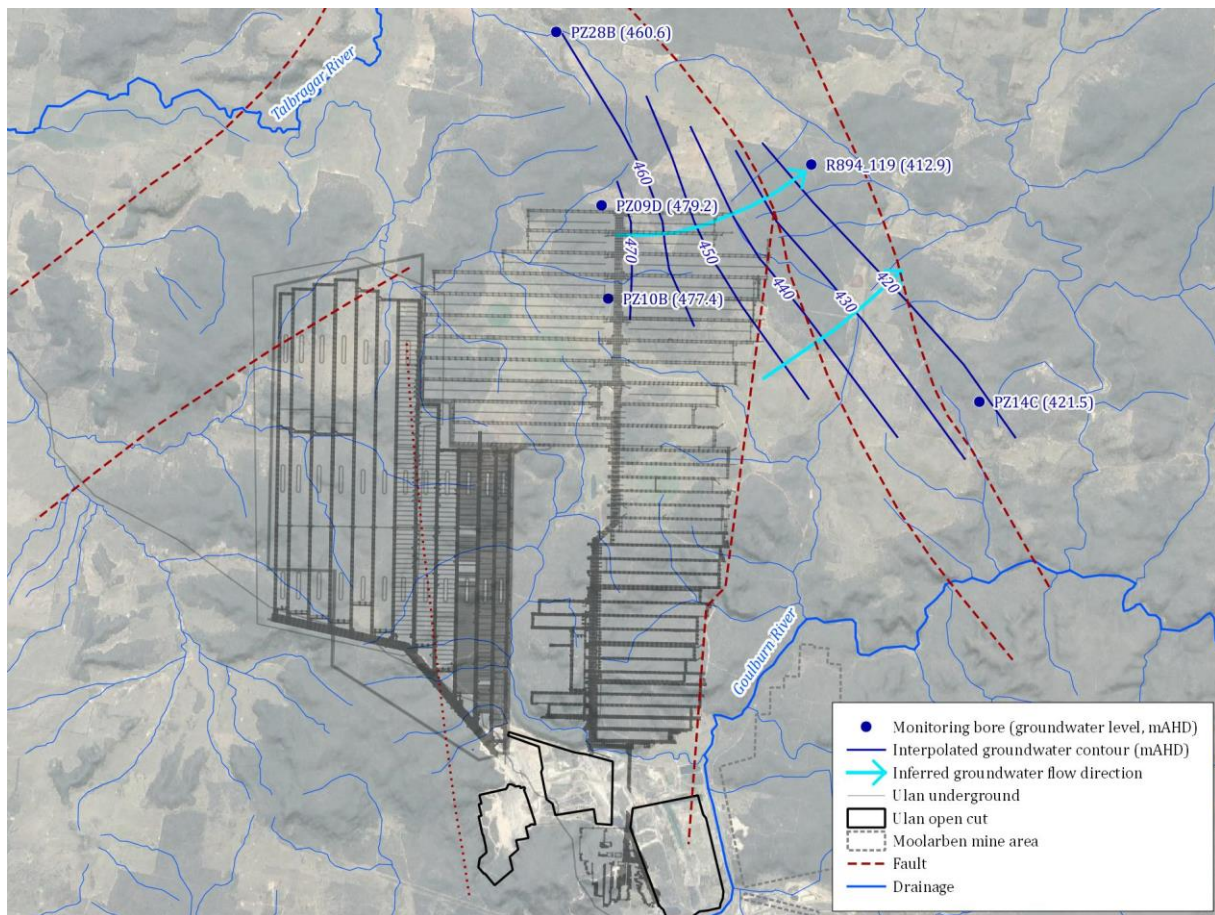


Figure 5.4 Interpolated groundwater contours - Jurassic sediments December 2016

5.4.1.3 Triassic sediments

Bores and VWPs intersecting Triassic sediments over 2 km from the mine area (PZ14B, PZ24B, PZ28A, PZ29 and R894) have recorded relatively stable groundwater levels over the 2016 monitoring period. Bores intersecting the Triassic sediments within 1 km of the mine area recorded less than a 1 m decline in groundwater levels between March and December 2016. A decline of greater than 1 m was recorded for bore PZ07C and no water was measured in it in December 2016. This bore is located immediately above active mine area. It is noted that bores PZ01A, PZ04A and R755A record a gradual decline in groundwater levels over time (<5 m over five years). The greatest decline in groundwater levels, of up to 11 m, was recorded at VWP DDH336_102. DDH336 is located near LWW03 and the decline coincides with commencement of mining along this panel in May 2016.

As outlined earlier, VWP R984 has two sensors intersecting the Jurassic sandstone, as well as the Triassic quartzose sandstone (R984_219) and the Triassic lithic sandstone (R984_219). Results from the VWP indicate the lithic sandstone has the highest piezometric level (413.4m AHD) and more confined conditions compared to the shallower quartzose sandstone and Jurassic sediments. This aligns with previous findings relating to the stratified nature of the Triassic sediments, and the presence of 'aquitards'.

Spatial representation of the most recent (December 2016) groundwater level data is presented in Figure 5.5. Figure 5.5 shows that groundwater within the Triassic sediments at the mine area flow towards active mining. However, east of the mine area, the groundwater gradient is relatively flat.

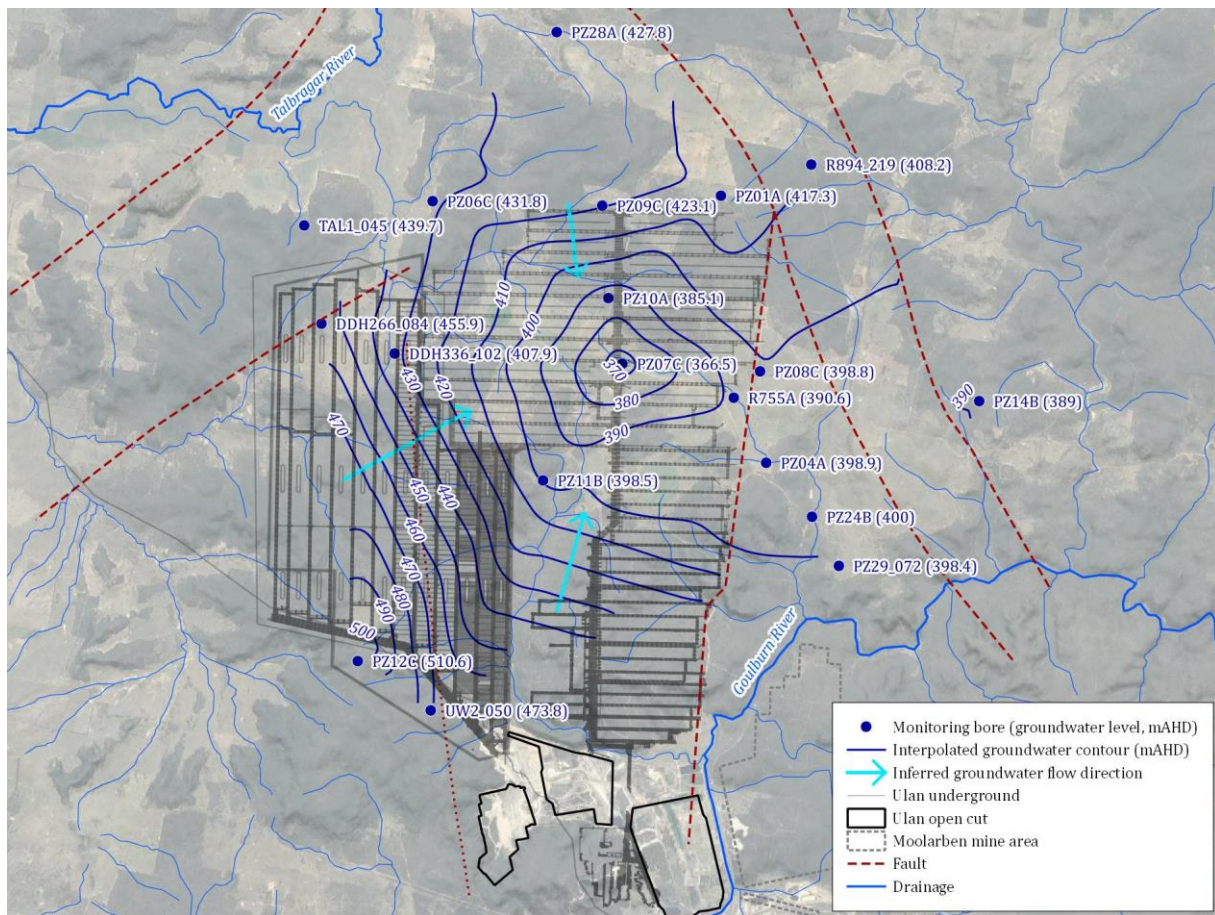


Figure 5.5 Interpolated groundwater contours - Triassic sediments December 2016

5.4.1.4 Permian coal measures

Bores intersecting the Ulan Seam and Permian coal measures underlying the Ulan Seam generally recorded a 1 m to 5 m decline in groundwater levels between March and December 2016. The greatest decline in groundwater levels within the Permian coal seams (up to 10.4 m) was recorded at VWP DDH336. DDH336 is located near LWW03 and the decline coincides with commencement of mining of this panel in May 2016.

VWP's intersecting the Permian coal measures immediately overlying the Ulan Seam recorded a general decline in groundwater levels, while groundwater levels remained relatively stable within the shallower strata. The stable shallow groundwater levels relate to the presence of hydrogeologically "tight" interburden units that exhibit low vertical hydraulic conductivity (see Section 3.1). This trend is visible for VWP's TAL1 and TAL2, which are located 2.5 km north-west and 5.5 km west of LWUW6. The VWP's recorded a 4 m and 3 m decline (respectively) in groundwater levels within the Permian coal measures directly overlying the Ulan Seam over 2016. However, groundwater levels within the Triassic sediments at TAL1 (28 m and 45 m below ground) and shallow Permian coal measures at TAL2 (50 m and 90 m below ground) remained stable.

Spatial representation of the most recent (December) groundwater level data for the Ulan Seam is presented in Figure 5.6. Figure 5.6 shows groundwater drawdown within the Ulan Seam towards the active mine area in Ulan No. 3, as predicted within the EA.

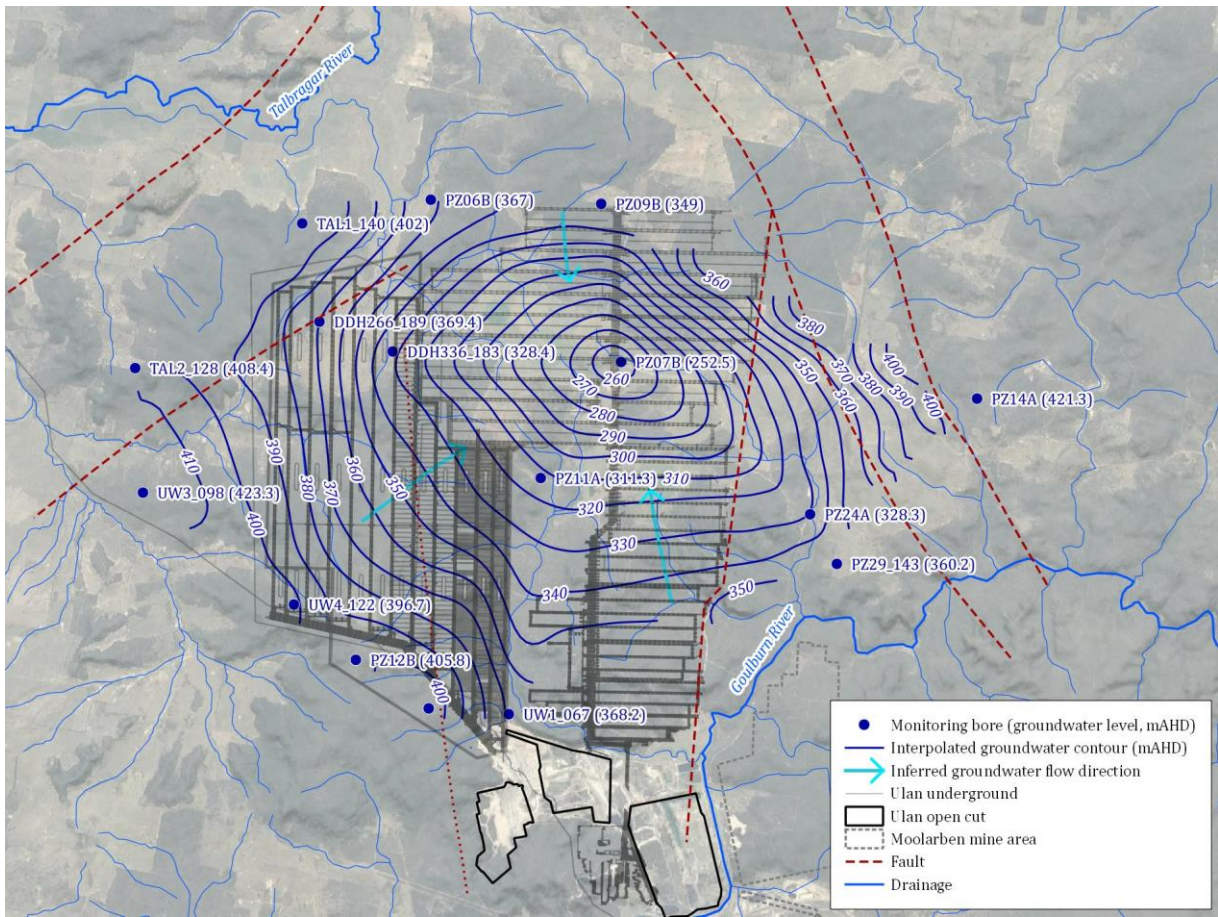


Figure 5.6 Interpolated groundwater contours – Ulan Seam December 2016

5.4.2 Bobadeen Monitoring Network

The quarterly water level readings for each of the BMN bores is presented in Table 5.3, and groundwater level trends are presented in Appendix C compared to irrigation volumes.

Table 5.3 BMN water level data - 2016

Site ID	Screened to (mbgl)	Q1			Q2			Q3			Q4		
		SWL (mAHD)	DtG (m)	DtS (m)	SWL (mAHD)	DtG (m)	DtS (m)	SWL (mAHD)	DtG (m)	DtS (m)	SWL (mAHD)	DtG (m)	DtS (m)
IMW01	2.2	dry	-	-	467.2	NR	1.53	dry	-	-	dry	-	-
IMW02	4	dry	-	-	481.0	NR	2.72	dry	-	-	NR	NR	NR
IMW03	7.3	dry	-	-	dry	-	-	dry	-	-	dry	-	-
IMW04	2.6	dry	-	-	470.0	NR	0.73	NR	NR	NR	dry	-	-
IMW05	11.4	NR	NR	NR	473.0	NR	10.7	NR	NR	NR	NR	NR	NR
IMW06	7.5	NR	NR	NR	467.4	NR	5.3	NR	NR	NR	NR	NR	NR
IMW07	3.4	dry	-	-	dry	-	-	dry	-	-	NR	NR	NR
IMW08	1	dry	-	-	dry	-	-	dry	-	-	dry	-	-
IMW09	2.7	-	-	-	dry	-	-	-	-	-	-	-	-

Notes: SWL – standing water level
DtG – depth to ground
DtS – depth to standpipe
NR – not recorded in the field

As shown in Table 5.3, bores IMW03, IMW08 and IMW09 were recorded as dry over the 2016 monitoring period. IMW08 and IMW09 are located at BIS pivot P5, and as shown in the hydrographs in Appendix C, levels have been dry since early 2015. This coincides with a reduction in irrigation volume and shows no correlation to the above average rainfall trends in 2016. Bore IMW03 is located over 850m north of P1 and P2, indicating enhanced recharge to the regolith is localised to the immediate pivot area.

Bores IMW05 and IMW06 were the only two bores that recorded the presence of groundwater each quarter, with groundwater present around 10.7 m and 5.3 m below the top of casing, respectively. Bores IMW05 and IMW06 are both located along drainage lines and downslope of P4 and P3, respectively. Two small surface water dams are also located adjacent to IMW05. Groundwater levels recorded at IMW05 show a good correlation to changes in irrigation volumes from Farm 2. In contrast, groundwater levels have been gradually declining at IMW06. A similar trend is visible for IMW07, which was recorded as dry between March 2015 and September 2016. Both bores are located south of P3 and overlie Ulan No. 3 LWW4.

Over 2016, bore IMW02 was recorded as dry in March and September, but recorded groundwater 2.71 mbTOC in June. A similar spike in groundwater level was also observed in bores IMW01 and IMW04, and coincides with a period when the BIS pivots were inactive. The three bores are located within 300 m north-west to north of P1 and P2. The area experienced slightly above average rainfall in June; however no peak rainfall events (i.e. over 30mm within one day) occurred at this time.

5.4.3 Pleuger Monitoring Network

Monthly water level readings for each of the decommissioned dewatering bores within the PMN are presented in Table 5.4, and long term trends are shown in Figure 5.7.

Table 5.4 Pleuger groundwater elevation (mAHD) - 2016

Month	East 7	East 9	East 10	East 15	East 18
January	-	-	-	-	-
February	306.4	306.2	285.8	268.1	254.1
March	306.7	306.6	285.9	268.1	254.1
April	305.7	306.1	285.8	268.1	254.1
May	305.7	306.0	285.8	268.1	254.1
June	305.5	305.3	285.9	268.2	254.1
July	305.7	306.2	285.8	267.5	254.2
August	-	-	-	-	-
September	306.1	305.9	285.9	268.3	254.1
October	-	-	-	-	-
November	305.8	305.2	285.9	268.1	254.0
December	-	-	-	-	-

Groundwater levels were not measured for all bores in January, August, October and December due to access restrictions. Groundwater levels were not monitored at bore MG21 over the reporting period. As shown in Table 5.4 and Figure 5.7, groundwater levels for the PMN bores remained relatively stable over the 2016 monitoring period. At the start of the year (January to March) bore East 7 recorded a 1 m decline in groundwater levels.

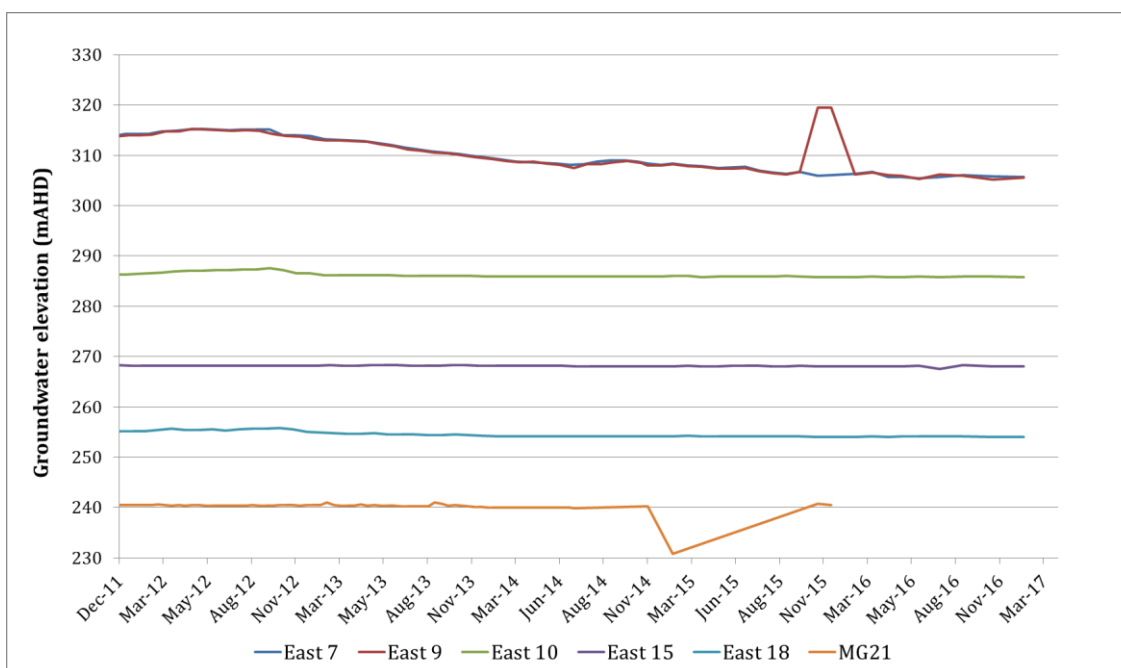


Figure 5.7 PMN hydrographs

5.4.4 Private bores

Monitoring of the private bores is conducted annually, dependent on whether access is granted by the private landholder. Over the 2016 monitoring period, 20 of the 32 private bores were visited.

Over 2016, no complaints were received from private landholders regarding their bores. The monitored private bores predicted to experience groundwater level drawdowns in excess of 2 m (PB2, PB8, PB9, PB14 and PB30), recorded groundwater levels in line with available historic levels for each bore. The remaining private bores, not predicted to be impacted, also recorded groundwater levels in line with available historic levels. One exception is bore PB7, which exceeded the $\pm 15\%$ divergence criteria as identified in the SWGWMP during the 2016 monitoring round.

In response, an investigation into PB7 has been undertaken, as well as of proximal monitoring points inclusive of PB15 and TAL1. Bore PB7 is located over 10 km north-west of the mine area and is positioned along Cainbil Creek. While construction details could not be sourced, proximity of the bore to the creek and mapped geology (Figure 3.1) indicates the bore intersects Quaternary alluvium. It is important to note that only two historic water level readings are available for the bore, which means seasonal variations common to unconfined aquifers have not been captured. In addition, the bore is equipped with a pump that is used intermittently, and according to field records, was in use within 24 hours of the 2016 monitoring event.

Bore PB15 is located closer to the mine (approximately 4 km north-west) compared to PB7, and appears to intersect alluvium along Talbragar River. In 2016, bore PB15 recorded groundwater levels in line with historic levels. In addition, historic trends indicate groundwater level fluctuations of up to 33% between years. In addition, the site monitoring VWP located within 3 km north-west of the mine area (TAL1), recorded stable ground levels within the shallow Triassic strata over 2016 (Appendix B).

The change in groundwater levels at PB7 is unlikely to be due to mine activities, and likely relates to natural variation within the Quaternary alluvium and bore usage. However, confirmation of the construction details of the bore, and more frequent in 2017 is recommended.

5.5 Water quality

5.5.1 North Monitoring Network

As outlined within the GWMP, field water quality parameters are tested on a quarterly basis. The bores are also tested for a full suite of analytes on an annual basis, as outlined in Section 4.3. The full suite of water quality results are presented in Appendix D along with the laboratory reports. The samples were tested for most analytes as outlined within the GWMP, except for temperature, total alkalinity, and molybdenum. Discussion on the results for physical parameters, major ions and metals is included in Section 5.5.1.1 to Section 5.5.1.3, below.

5.5.1.1 Physical parameters – EC and pH

Table 5.5 presented the field water quality results for EC and pH recorded for the NMN over the 2016 monitoring period. Long term trends in EC and pH are presented in Appendix D.

Table 5.5 NMN field water quality data - 2016

Bore ID	Q1 (Mar)		Q2 (Jun)		Q3 (Sep)		Q4 (Dec)		Lithology
	EC (µS/cm)	pH	EC (µS/cm)	pH	EC (µS/cm)	pH	EC (µS/cm)	pH	
PZ01A	438	6.1	-	-	434	6.8	-	-	Triassic
PZ04A	320	6.3	-	-	-	-	-	-	Triassic
PZ06A	1,550	8.1	-	-	1,578	8.2	-	-	Lower-PCM
PZ06B	1,130	7.3	-	-	1,239	7.8	-	-	Ulan Seam
PZ06C	271	9.6	-	-	278	9.0	-	-	Triassic
PZ07A	1,543	11.8	-	-	1,559	11.5	-	-	Lower-PCM
PZ07B	408	8.7	-	-	495	8.5	-	-	Ulan-Seam
PZ07C	674	6.8	-	-	-	-	-	-	Triassic
PZ08B	-	-	-	-	-	-	-	-	Permian
PZ08C	879*	6.4	-	-	995	6.7	-	-	Triassic
PZ09A	1,017	9.3	-	-	972	9.6	-	-	Lower-PCM
PZ09B	1,198	8.1	-	-	1,214	7.8	-	-	Ulan-Seam
PZ09C	380	8.2	-	-	384	8.3	-	-	Triassic
PZ09D	1,571	7.5	-	-	1,509	7.6	-	-	Jurassic
PZ10A	361	6.6	-	-	259	8.4	-	-	Triassic
PZ10B	2,867	5.9	-	-	2,585	6.5	-	-	Jurassic
PZ11A	843	6.8	-	-	-	-	-	-	Ulan-Seam
PZ11B	180	6.2	-	-	-	-	-	-	Triassic
PZ12A			-	-	-	-	-	-	Lower-PCM
PZ12B	465	6.1	-	-	406	6.7	-	-	Ulan-Seam
PZ12C	191	4.6	-	-	196	7.6	-	-	Triassic

Bore ID	Q1 (Mar)		Q2 (Jun)		Q3 (Sep)		Q4 (Dec)		Lithology
	EC (µS/cm)	pH	EC (µS/cm)	pH	EC (µS/cm)	pH	EC (µS/cm)	pH	
PZ14A	819	9.6	-	-	924	9.4	-	-	Ulan Seam
PZ14B	896	11.3	-	-	993	11.6	-	-	Triassic
PZ14C	1,315	6.6	-	-	1,230	7.0	-	-	Jurassic
PZ24A	804	8.2	-	-	826	8.3	-	-	Ulan Seam
PZ24B	256	9.5	-	-	257	8.7	-	-	Triassic
PZ26A	-	-	-	-	-	-	-	-	Lower PCM
PZ26B	-	-	-	-	-	-	-	-	Ulan Seam
PZ26C	-	-	-	-	-	-	-	-	Triassic
PZ26D	-	-	-	-	-	-	-	-	Jurassic
PZ28A	491	9.1	-	-	509	9.3	-	-	Triassic
PZ28B	-	-	-	-	2,640	8.8	-	-	Jurassic
PZ32	-	-	-	-			-	-	Spoil
R752	746	7.2	-	-	593	7.2	-	-	Basalt
R755A	-	-	-	-	-	-	-	-	Triassic

Notes: * laboratory reading

PCM – Permian coal measures

Over the 2016 monitoring period, EC declined slightly for all bores within the Jurassic sediments. EC remained stable to slightly rising for most bores intersecting Triassic and Permian stratigraphy. Bores PZ06B, PZ07A, PZ07B, PZ08C and PZ14A and recorded a slight rise in EC of up to 110 µS/cm, over 2016. It is noted that in Q1 of 2016, bores PZ10B (Jurassic) and PZ12C (Triassic) recorded pH of 5.9 and 4.6, respectively; however, both bores recorded a more neutral pH when sampled in September.

A summary of the average EC and pH for the various stratigraphic units is presented in Table 5.6, compared to historic averages derived from the GWMP. The results in Table 5.6 indicate minimal change in EC and pH compared to historic levels, taking into account the variation inherent in EC and pH.

Table 5.6 NMN field water quality data statistics - 2016

		Jurassic sediments	Triassic sediments	Permian coal measures	Ulan Seam
EC ($\mu\text{S}/\text{cm}$)	Historic average (standard deviation)*	2,554 (1148)	471 (326)	1,151 (626)	1,310 (1739)
	2016 average (standard deviation)	1,960 (705)	438 (257)	1370 (291)	829 (310)
pH (pH unit)	Historic average (standard deviation)*	7.6 (1.2)	7.5 (1.6)	9.5 (1.6)	6.5 (0.3)
	2016 average (standard deviation)	7.1 (0.9)	7.9 (1.8)	9.7 (1.6)	7.9 (1.0)

5.5.1.2 Major ions and alkalinity

The proportions of the major anions and cations were used to determine the hydrochemical facies of the groundwaters sampled over the monitoring period. The anion-cation balance is shown on the Piper diagram in Figure 5.8. The results indicate that in general:

- Tertiary basalts (R752) exhibit Mg-Na-Ca-HCO₃ type water;
- Jurassic to Triassic sediments exhibit Na-Mg-Cl type water;
- Triassic sediments exhibit Na-Cl and Na-Ca-HCO₃-Cl type water; and
- Permian coal measures, including the Ulan Seam, exhibit Na-HCO₃ and Na-CO₃ type water.

The results presented in Figure 5.8 also show a degree of groundwater mixing between the units. Bore PZ08C has a high proportion of magnesium, similar to the Tertiary basalt type water and may reflect rainfall recharge. In addition, bore PZ14A (Ulan Seam) has a higher proportion of magnesium and chloride, similar to the Triassic sediments. In contrast bore PZ14B (Triassic) exhibits similar results to the Permian coal measures. This indicates the bore nomenclature may be mismatched for the PZ14 bores, and requires further review.

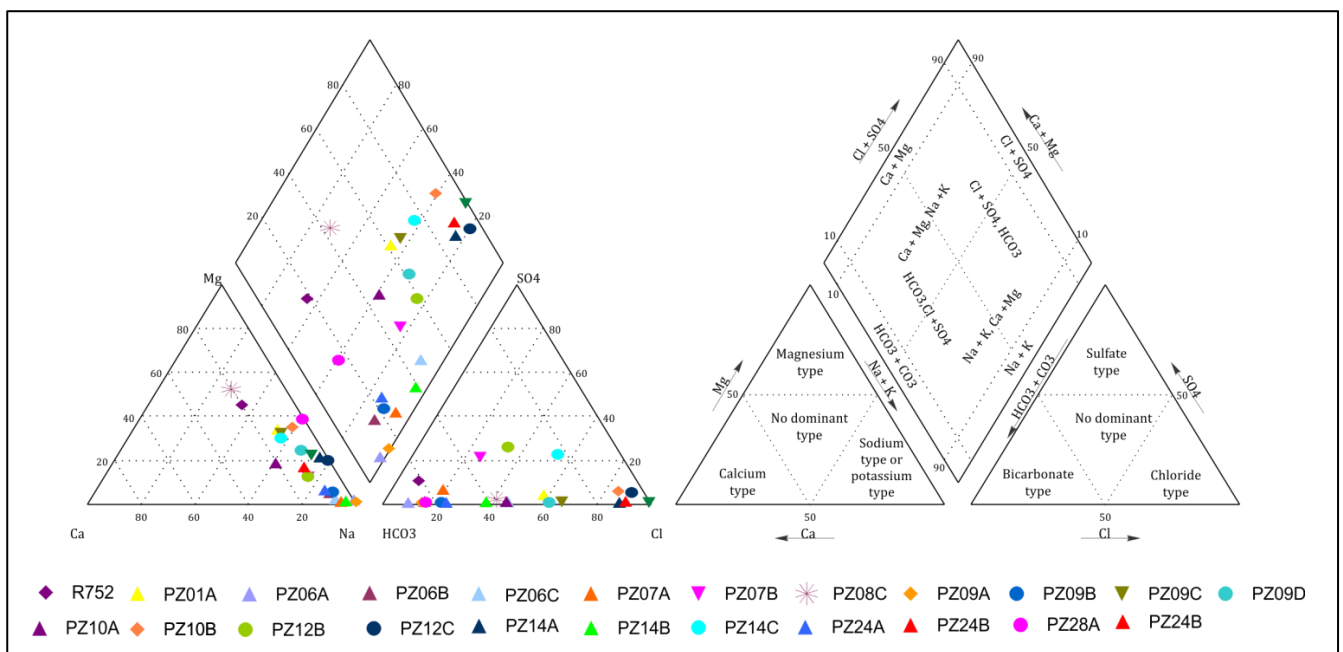


Figure 5.8 Piper plot for NMN 2016 data

5.5.1.3 Metals

Over 2016, the NMN bores were sampled and tested for dissolved metals (Al, As, B, Ba, Cd, Cr, Cu, Fe, Hg, Li, Mn, Ni, Pb, Sb, Se, Sr and Zn). Water quality trigger levels have not been established for the NMN and are therefore not assessed as part of the annual review. However, general observations of the 2016 results are included below:

- all bores recorded concentrations below the limit of reporting for dissolved metals cadmium, mercury, lead and selenium;
- concentration of dissolved manganese below 1.1 mg/L, with all results below the ANZECC (2000) guideline level for fresh water aquatic and short term irrigation;
- concentration of dissolved aluminium, barium, boron, lithium, strontium and zinc below 1 mg/L, with all results below the ANZECC (2000) guideline level for short term irrigation and stock water;
- concentration of dissolved copper and nickel below 0.05 mg/L, with all results below the ANZECC (2000) guideline level for short term irrigation and stock water; and
- concentration of dissolved arsenic and chromium below 0.01 mg/L, with all results below the ANZECC (2000) guideline level for short term irrigation and stock water.

For the metals analysed, all bores recorded concentrations within acceptable limits under the ANZECC (2000) short term irrigation and stock water guidelines.

Trends for three of the main metal (dissolved aluminium and barium and manganese), are shown in Appendix D, and indicate relatively stable concentrations over the 2016 monitoring period. Bores PZ07A, PZ07B, PZ10B are located immediately over the mine area and near the BIS, and recorded a less than 0.1 mg/L increase in dissolved barium over 2016. Bores PZ10B and PZ14C recorded an increase in dissolved manganese by 0.2 mg/L and 0.02 mg/L, respectively. Bore PZ10B is located immediately over the mine area; however PZ14C is located over 5km east of the mine area. Both bores intersect the shallow Jurassic sediment, and the trend may relate to peak rainfall events over September 2016.

5.5.2 Bobadeen Monitoring Network

Over the 2016 monitoring period, where water was present, the Bobadeen monitoring bores (IMW01 to IMW09) were sampled and water quality analysed on a quarterly basis. Over 2016, water quality analysis was conducted in accordance with the GWMP, with the samples tested for pH, EC, acidity, alkalinity, hardness, CaCO₃ saturation index, calcium, chloride, magnesium, potassium, sodium, sodium absorption ratio, sulphate and total metals (Fe, Mn and Zn). The water quality results are presented in Appendix E. Field parameters for EC and pH were not collected at each sampling event.

As discussed in Section 5.4.2, IMW03, IMW08 and IMW09 were recorded as dry over the 2016 monitoring period. A water quality sample was collected for IMW09 in June 2016, which may represent water within the bore sump. Bores IMW05 and IMW06 were the only two bores that recorded the presence of groundwater each quarter, and both are located downslope of BIS P4 and P3, respectively. Water quality results for the 2016 monitoring period (Appendix E) and a summary of the average EC and pH statistics is presented in Table 5.7.

Table 5.7 BMN field water quality data statistics - 2016

		Q1 (Mar)	Q2 (Jun)	Q3 (Sep)	Q4 (Dec)
Field EC ($\mu\text{S/cm}$)	2016 average	-	1,799	-	-
	2016 standard deviation	-	2,088	-	-
Field pH (pH unit)	2016 average	-	6.6	-	-
	2016 standard deviation	-	0.7	-	-
Population		0	5	0	0

The results in Table 5.7 and Appendix E indicate most bores contain brackish quality water, and that salinity levels remained relatively stable or declined compared to previous results. In contrast, bore IMW06 recorded a general rise in salinity, to 5,240 $\mu\text{S/cm}$ (moderately saline) in June 2016. Field pH ranged between 5.9 and 7.6, with most bores recording stable to slightly rising pH levels compared to previous results. Bores IMW01 and IMW04 recorded a decline in pH to 6.0 and 6.4 (respectively) since previous readings (i.e. since 2013). However, it is noted that these levels are similar to historic readings.

Major ions and metals were also analysed as part of the routine monitoring, with the results summarised below:

- Sodium concentrations remained relatively stable for most bores, but generally increased for IMW05 and IMW07, and IMW06 recorded a spike of up to 920 mg/L in June 2016.
- The sodium absorption ration (SAR) was recorded at 10 or above for samples from IMW01, IMW05, IMW06 and IMW07, indicating potential dispersive soil properties that may lead to decreased infiltration of water, and increased surface water flow.
- Sulphate concentrations remained relatively stable for most bores, but IMW02 and IMW05 recorded spikes in sulphate (up to 298 mg/L) in June and December, respectively.
- Total iron concentrations rose slightly for bores IMW02, IMW05 and IMW07, with IMW02 recording the highest concentration of 134 mg/L in December. Prior observations noted iron oscillates frequently and can range between 0.1 mg/L and 1000 mg/L.
- Total zinc concentrations generally remained stable, but IMW02 recorded an increase in December (1.2mg/L).

For the metals analysed, all bores within the BMN recorded concentrations within acceptable limits under the ANZECC (2000) short term irrigation and stock water guidelines. However, bore IMW06 recorded chloride concentrations above the ANZECC (2000) guideline level for stock water.

The BMN bores generally contain Na-Cl or Na-Mg-Cl type water, and trends in EC and sodium appear highly correlated. As outlined within the 2015 annual review (Coffey 2015), there is approximately a one month lag between increased irrigation/ rainfall and rising groundwater levels. Peak rainfall events have also been found to result in a reduction in EC in the short term, while sustained irrigation and rainfall can increase EC over the long-term due to flushing of salts. Bore IMW06 is located near P4, which utilises approximately 28% of the water fed by the Farm 2 irrigation line (Coffey 2015). The increased EC recorded at IMW06 may relate to consistent and above average irrigation rates (88 ML/day to 116 ML/day) applied from Farm 2 between October 2015 and March 2016.

5.5.3 Pleuger Monitoring Network

As outlined within the GWMP, the PMN comprises seven active dewatering bores (E20, MG22, MG26, MG27, MG28, MG29, UW TG1) that have their water quality tested on a fortnightly basis, as outlined in Section 4.3. The water quality results for the 2016 monitoring period are presented in Appendix F.

Over the 2016 monitoring period, over 20 water quality samples were collected (per bore) for E20, MG26 and MG29. Due to access restrictions, six or less readings were recorded for bores MG22, MG26, MG28, UW TG1 over the 2016 monitoring period.

Review of water quality trends indicates EC, pH, sulphate and manganese (total and dissolved) frequently fluctuated, but generally remained within historic levels. For the 2016 results, it was also observed that:

- EC ranged between 728 $\mu\text{S}/\text{cm}$ and 1,790 $\mu\text{S}/\text{cm}$;
- pH ranged between 6.2 and 7.9;
- most bores recorded sulphate concentrations in line with historic levels, with the exception of bore E20 and MG28, which recorded a general decline in sulphate over 2016; and
- most bores recorded iron (total and dissolved) concentrations in line with historic levels, with the exception of bores MG27, MG28 and UG TW1, that recorded a slight increase.

For the metals analysed, most bores recorded concentrations within acceptable limits under the ANZECC (2000) short term irrigation guidelines. However, bore E20 consistently recorded iron and manganese concentrations above the ANZECC (2000) short term irrigation guideline level.

Over the 2016 monitoring period there are no marked changes in water quality for any of the Pleuger bores. However, the slight increase in iron for bores MG27, MG28 and UG TW1 may indicate bore deterioration and requires further investigation.

5.5.4 Private bores

Over the 2016 monitoring period, 20 of the 32 private bores were visited. Of the 20 bores visited, 16 were monitored for water quality, with the remaining four bores not sampled due to bores being in active use or inaccessible. The monitored private bores recorded groundwater quality (EC and pH) in line with available historic results for each bore. The results were below the trigger level deviation from baseline data ($\pm 10\%$ and $\pm 15\%$), and no complaints related to groundwater quality were received from private landholders over 2016.

5.5.5 Laboratory QA/QC

AGE were provided with laboratory reports for samples collected from the NMN in September 2016 and from the BMN each quarter. The full laboratory reports are presented in Appendix D for NMN and Appendix E for BMN, and laboratory QA/QC results are summarised below.

Quality control

Laboratory quality control includes assessment of laboratory duplicates, method blanks and matrix spikes, detailing the relative percentage difference (RPD) and acceptance limits. Laboratory duplicates provide information regarding method precision and sample heterogeneity.

The majority of RPD for laboratory duplicate samples analysed over the 2016 monitoring period were all less than 20%. Acidity as CaCO₃ (ME1601095 Aug 2016 for BMN) recorded a RPD of 20.2%; however, this is considered to be acceptable. Method blanks are tested to monitor potential laboratory contamination, and matrix spikes are used to monitor potential matrix effects on analyte recoveries. Most quality control reports for samples submitted to ALS recorded method blank, groundwater matrix and surrogate spike recoveries within the acceptable limits.

Matrix spike recoveries were not determined for analyte test ED041G (sulphate) for BMN results from March (ME1600359), August (ME1601095) and December (ME1601780). Matrix spike recoveries were not determined for analyte test ED045G (chloride) for BMN results from March (ME1600359). For all samples, no elevated concentrations were recorded, so this does not appear to have impacted the water quality results.

Holding times

For the 2016 monitoring period, most samples were extracted and analysed within the prescribed holding times, with the exception of pH for all sampling rounds. Field pH is generally recorded for each sample using calibrated equipment, which ensures a representative reading is recorded. However, field readings were not collected at all sampling events in 2016.

5.6 Model verification

The most recent calibrated model for approved operations at Ulan Mine was developed in 2015 as part of the Modification 3 groundwater impact assessment by MER (2015). The model was developed to predict future groundwater inflows to Ulan No. 3 and the Ulan West Mine. Figure 5.9 shows the modelled inflows combined for the two mine areas. The predicted inflows are compared to the estimated inflows from the site water balance, which are presented as the monthly average. It should be noted that the water balance values are based on the water year, therefore values for the second half of 2016 have not yet been documented for use in the annual review.

For data available for the 2016 monitoring period, the water balance estimated combined average monthly inflows for No.3 UG and Ulan West of 16.1 ML/day on average, ranging between 5.5 ML/day and 29 ML/day. Over the 2016 period, the numerical model predicted combined average monthly inflows of 22.6 ML/day on average, ranging between 21.3 ML/day and 23.7 ML/day. Overall, available estimated groundwater inflows from the water balance were lower than predicted for 2016.

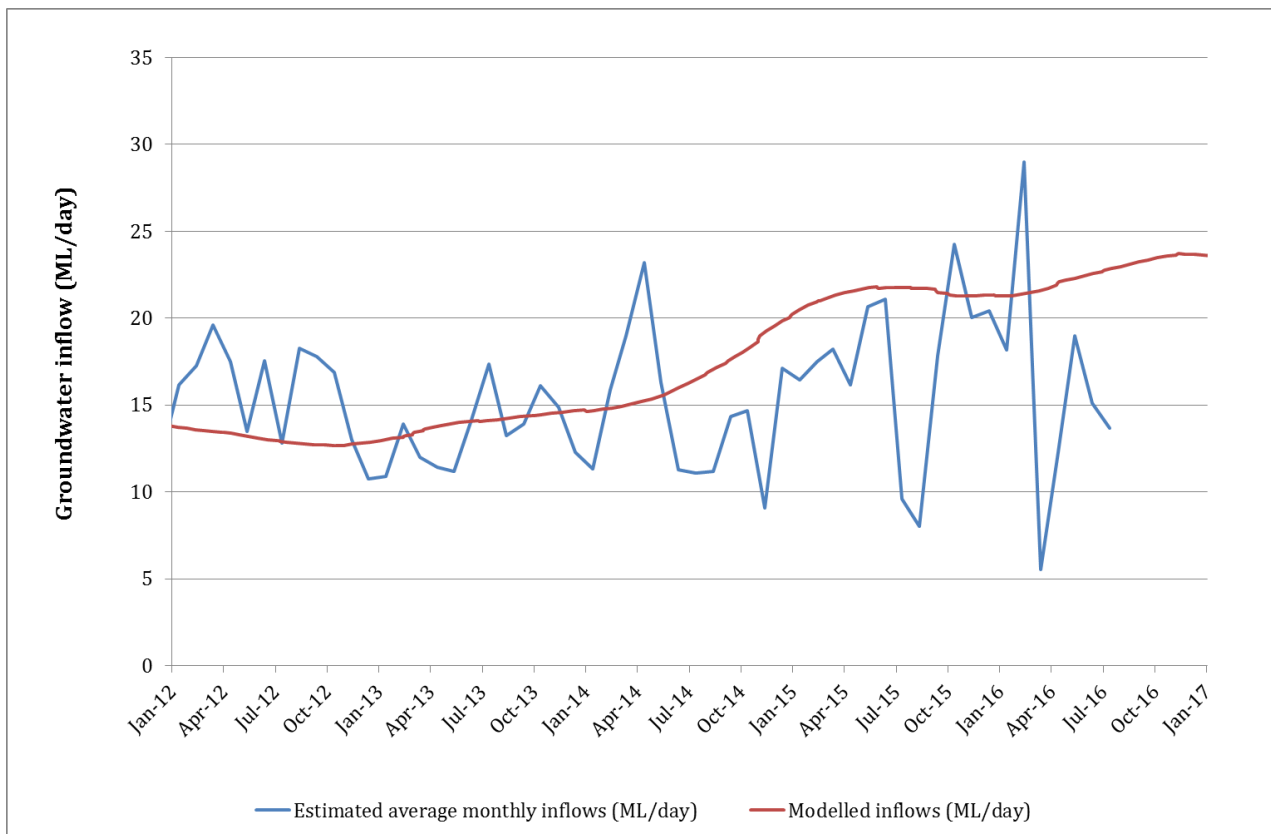


Figure 5.9 Comparison of modelled and calculated groundwater inflows to underground workings

5.7 The Drip assessment

Triassic sandstone gorge along the Goulburn River, known as The Drip, is recognised for its cultural significance and potential to sustain groundwater dependent ecosystems. The Drip is located to the east of Ulan, on the northern banks of the Goulburn River. Due to the incised nature of the gorge, it acts as a discharge area for the Triassic sandstone.

The Triassic sandstone has been documented as having confined groundwater conditions within the region. Previous studies have proposed that the weathered sequences near the cliff face and at surface act as shallow perched groundwater systems, based on available data. Groundwater monitoring and management commitments require that UCML collect field data in order to assess this assumption and subsequently model predictions. This includes water quality testing of water expressed at The Drip and installation of multi-level piezometers. The purpose of this data is to help identify if The Drip is a perched system fed by rainfall, or a groundwater fed spring. This distinction is important for predicting potential impacts on The Drip.

Water expressed from The Drip cliff face was collected on a two monthly (or more frequent) basis over 2016. The samples were collected by UCML staff by funnelling dripping water into a sample container. The samples were tested for most analytes outlined within Section 4.3. However, bores were not tested for temperature and silicon, also samples were tested for dissolved concentrations of aluminium, arsenic, barium and boron instead of total concentrations as per the GWMP. The water quality results are presented in Appendix G. Field parameters for EC and pH were not collected at each sampling event.

Based on the laboratory results for EC, the samples indicate fresh water quality, with an EC of between 496 $\mu\text{S}/\text{cm}$ and 621 $\mu\text{S}/\text{cm}$, which is above the ANZECC (2000) freshwater aquatic guideline level of 300 $\mu\text{S}/\text{cm}$. The laboratory results also indicate neutral to slightly alkaline pH, of between 7.2 and 8.4. Compared to the results for the NMN, The Drip water quality results have a similar EC and pH to historical and recent averages for the Triassic sediments.

The proportions of the major anions and cations was analysed to determine the hydrochemical facies of the groundwaters sampled over the monitoring period. The anion-cation balance is shown on the Piper diagram in Figure 5.10.

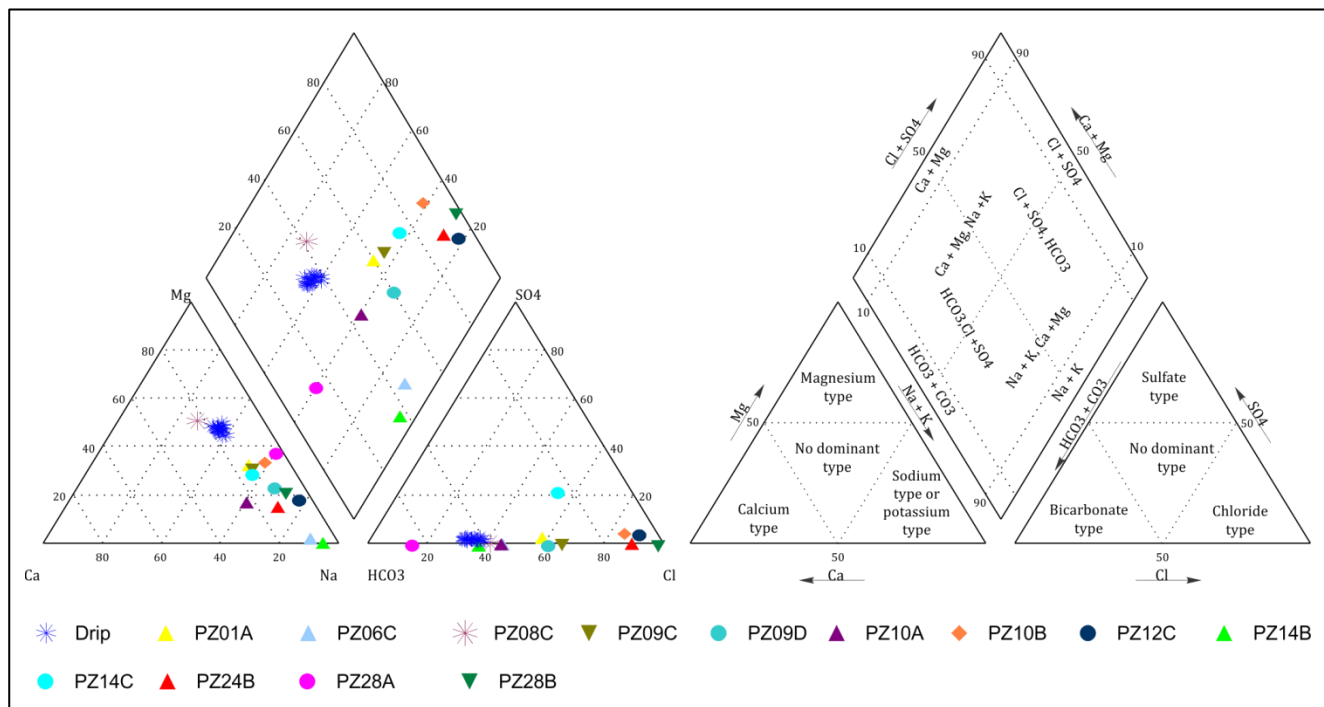


Figure 5.10 Piper plot for The Drip compared to NMN Triassic bore data - 2016

As shown, The Drip consistently recorded a Mg-Ca- HCO_3 -Cl water type over 2016. This indicates a lower proportion of sodium and higher proportion of manganese compared to the Jurassic and Triassic sediments, which generally have a Na-Mg-Cl, Na-Cl and Na-Ca- HCO_3 -Cl water types, as discussed in Section 5.5.1.

The Drip samples were also tested for metals, with the results summarised below:

- dissolved arsenic, boron and iron concentrations below the limit of reporting;
- total selenium and total aluminium concentrations below the limit of reporting (<0.01 mg/L);
- dissolved aluminium generally below the limit of reporting (<0.01 mg/L), except for two readings of 0.02 mg/L;
- dissolved barium, total lithium and total manganese concentrations of below 0.05 mg/L;
- total strontium concentrations of below 0.2 mg/L; and
- dissolved selenium concentration of between 44 mg/L and 53 mg/L.

For most metals analysed, samples recorded concentrations within acceptable limits under the ANZECC (2000) freshwater aquatic, short term irrigation and stock water guidelines. However, most samples recorded concentrations of total Zinc above the ANZECC (2000) freshwater aquatic guideline level of 0.008 mg/L. The metals concentrations for The Drip water are generally lower than recorded for the NMN bores intersecting the Triassic sediments. With the exception of total zinc, which is generally below the limit of reporting (<0.005 mg/L) for the NMN bores.

Overall, The Drip water quality exhibits a different proportion of major ions (different water type) and metals compared to the Triassic sediments away from the cliff exposure, indicating the influence of a different recharge source.

As outlined in Section 4.2, a VWP (PZ36) was installed 1.3 km north of The Drip for the purpose of assessing groundwater gradients and trends around The Drip. The time-series data from the VWP is presented in Figure 5.11.

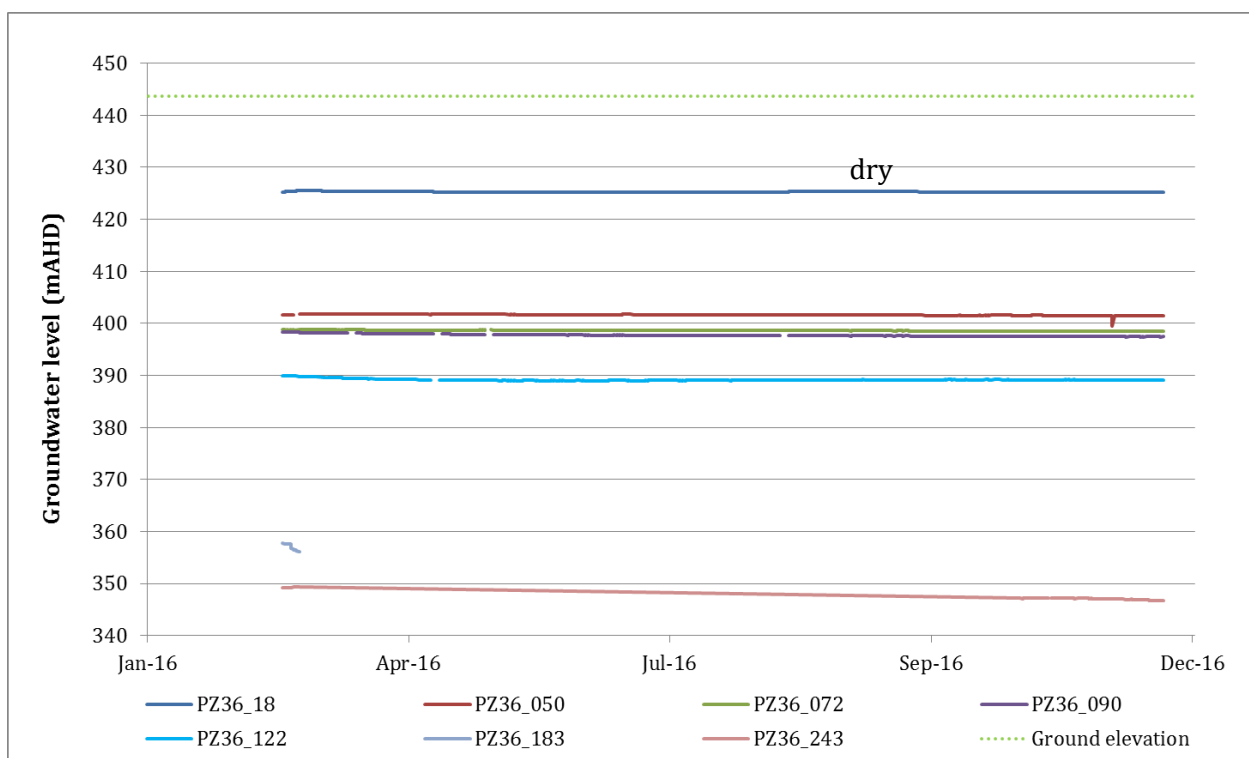


Figure 5.11 PZ36 hydrographs

During construction, the Jurassic sediments intersected by the shallowest sensor (18 m below surface) were unsaturated and results indicate they have remained unsaturated over 2016. The Triassic sediments extend to approximately 130 m below surface. The results show a downward gradient within the Triassic sediments, with the shallowest Triassic sensor (50 mbgl) recorded a piezometric surface at around 410 mAHD, down to the deepest sensor (122 mbgl) recording a piezometric surface at around 389 mAHD. Groundwater levels for all sensors within the Triassic sediments remained relatively stable over the 2016 monitoring period. Only one of two sensors within the Permian coal measures, PZ36_243, appears to be operating (243 mbgl), which intersects the Ulan Seam. The results indicate that the Ulan Seam has a lower piezometric surface compared to the Triassic sediments. In addition, groundwater levels have gradually declined by 2 m over the 2016 monitoring period. Overall, the results indicate a degree of hydraulic separation (i.e. aquitard) between the Permian coal measures and the Triassic sediments.

6 Discussion and project approval conditions

Project approval was granted for the Ulan Coal – Continued Operations Project by the Minister for Planning on 10 November 2010 for Modification 2 and March 2016 for Modification 3 (PA 08_0184). Requirements under the project approval include a groundwater monitoring program (Condition 39). In addition, under Appendix 9 of the project approval (PA 08_0184) are the statements of commitments required of UCML. Commitments specific to groundwater are stipulated under Sections 6.4.1 to 6.4.6.

Table 6.1 details the individual commitments, a short summary of findings from the 2016 review, and refers to the sections where full details are provided.

Table 6.1 Project approval conditions

Project approval conditions	2016 Groundwater assessment
39. The Groundwater Monitoring Program must include:	
b) a program to augment the baseline data over the life of the project;	See Section 4 Monitoring of NMN, BMN and PMN.
c) groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts;	See Section 4.5 No triggers for bores immediately above mine workings, and additional data required to establish other triggers.
d) a program to monitor and/or validate: groundwater inflows to the open cut and underground mining operations;	See Section 5.6 Overall, available estimated groundwater inflows from the water balance were lower than predicted for 2016.
a program to monitor and/or validate the impacts of the project on: the alluvial, Triassic, coal seam and interburden aquifers;	See Section 4 Monitoring of NMN, BMN and PMN covers Triassic, coal seam and interburden aquifers. No actively monitored bores intersect alluvium.
base flows to the Goulburn and Talbragar Rivers and associated creeks;	See Section 5.2 and Section 5.6 Over the 2016 monitoring period, flow within the Goulburn River ranged between 6 ML/day and 1,014 ML/day, indicating baseflow was not a significant contributor to stream flow during this period. The observed groundwater levels were also found to match predictions within this region, indicating the modelled predictions remain valid.
any groundwater bores, springs and seeps on privately-owned land;	See Section 5.4.4. 20 identified privately owned bores were monitored in 2016. Most recorded groundwater levels in line with historic levels and model predictions. However, one bore (PB7) recorded a decline in groundwater levels beyond the two historic readings. The bore appears to intersect Quaternary alluvium and is equipped with a bore that was in use within 24 hours of the 2016 monitoring event. Bores closer to the mine do not show a decline, and the trend is believed to be due to natural variation and bore usage. However, further investigation is recommended, including assessing the construction details of PB7 and increase the monitoring frequency.

Project approval conditions	2016 Groundwater assessment
the 'Drip'; and	<p>See Section 5.7</p> <p>Water samples were collected from The Drip cliff face on a two monthly, or more frequent, basis over the 2016 monitoring period. Analysis of the water quality results indicate The Drip water quality exhibits a different proportion of major ions (different water type) and metals compared to the Triassic sediments away from the cliff exposure. Indicating the influence of a different recharge source.</p> <p>In 2016 a VWP was installed 1.3 km north of The Drip. The results from the VWP indicated the shallow Jurassic sediments are unsaturated, that groundwater levels remained stable within the Triassic sediments over 2016 and groundwater levels declined by 2m within the Ulan Seam. Comparison of groundwater levels between the various stratigraphic units indicates a general downward flow gradient and/or potential hydraulic barrier (i.e. aquitard) between the Triassic sediments and Ulan Seam of the Permian coal measures.</p>
the seepage/leachate from any tailings dams, water storages or backfilled voids on site; and	<p>See Section 5.4 and Section 5.5</p> <p>Monitoring of potential seepage from Bobadeen Dam and the BIS is captured by the BMN. Seepage from backfilled voids is captured by the PMN. No adverse changes in water levels or water quality were observed for either monitoring network.</p> <p>The GWMP does not include any actively monitored bores positioned around the East Pit tailings storage.</p>
6.4.1 A Continued measurement of groundwater levels, pressures and water quality within the existing regional network of monitoring bores and an expanded network as underground mining progresses to the north and west, specifically considering:	<p>See Section 4.1 and Section 4.2</p> <p>Over 2016, the NMN, BMN and PMN were all monitored. A drill program was commenced in 2016 and will continue into 2017, installing additional bores where key data gaps have been identified, specifically where the mine is progressing north and west.</p> <p>In 2016, two additional VWPs were also installed as part of the drill program. One is located near The Drip (PZ36) and one within the BIS area (EX06).</p>
<ul style="list-style-type: none"> ▪ depressurisation monitoring of at least three multi-level piezometer strings equipped with vibrating wire transducers (or equivalent) and distributed within the Permian-Triassic strata; 	<p>See Section 4.1 and Section 4.2</p> <p>Most bores and VWPs remained functional over the 2016 monitoring period, with the NMN comprising 38 monitoring standpipes at 16 locations, as well as nine VWP locations with a total of 38 sensors in operation. The currently monitored NMN intersects all key hydrogeological units, as presented in Table 4.1.</p>
<ul style="list-style-type: none"> ▪ strata hydraulic conductivity measurement on rock core obtained at these above noted piezometer locations; 	<p>Over 2016, a program commenced to drill and construct a series of VWPs across the site and surrounds, which is continuing into 2017. As part of the program two VWPs were installed, PZ36 and EX06. Core samples were not collected from PZ36 or EX06 for hydraulic testing; however, samples are planned to be collected at one of the drill locations planned for 2017.</p>
<ul style="list-style-type: none"> ▪ daily or more frequent monitoring of pore pressures and piezometric elevations by installed auto recorders in selected new piezometers. 	<p>See Section 5.4.1 and Appendix B.</p> <p>Time series water level data was collected from the eight NMN VWP locations, as well as the additional four VWP locations (DDH293, DDH336, R855 and R988).</p>

Project approval conditions	2016 Groundwater assessment
<p>Groundwater monitoring will include:</p> <ul style="list-style-type: none"> monthly monitoring of basic water quality parameters pH and EC in pumped mine water. 	<p>See Section 5.5.3</p> <p>Water quality data was collected on a fortnightly basis for three of the active dewatering bores within the PMN. The remaining four bores were sampled less than six times over 2016 due to access restrictions.</p>
<ul style="list-style-type: none"> six monthly monitoring of pH and EC in the regional monitoring network. 	<p>See Section 5.5.1</p> <p>Field parameters of pH and EC were recorded for the NMN in March and September 2016. It is noted that the GWMP currently states that these results will be collected on a quarterly basis. The program will be reviewed to ensure the GWMP and field activities align.</p> <p>The results indicate minimal change in EC and pH between sampling rounds over 2016, taking into account the variation inherent in EC and pH. It was noted that bores PZ10B (Jurassic) and PZ12C (Triassic) recorded pH of 5.9 and 4.6, respectively in March. However, both bores recorded a more neutral pH when next sampled in September, of 6.5 (PZ10B) and 7.6 (PZ12C).</p>
<ul style="list-style-type: none"> annual measurement of total dissolved solids (TDS) and speciation of water samples in selected piezometers to support identification of mixing of groundwater types. 	<p>Section 5.5.1</p> <p>Analysis of major ions is presented as a Piper diagram and discussed in Section 5.5.1. The results indicate water types for each of the stratigraphic units (Tertiary basalt, Jurassic sediments, Triassic sediments and Permian coal measures).</p> <p>The results also show a degree of groundwater mixing between the units. Bore PZ08C has a high proportion of magnesium, similar to the Tertiary basalt type water. In addition, bore PZ14A (Ulan Seam) has a higher proportion of magnesium and chloride, similar to the Triassic sediments. In contrast bore PZ14B (Triassic) exhibits similar results to the Permian coal measures. This indicates the bore nomenclature may be mismatched for the PZ14 bores, and requires further review.</p>
<ul style="list-style-type: none"> graphical plotting of basic water quality parameters and identification of trend lines and statistics including mean and standard deviation calculated quarterly. Comparison of trends with rainfall and any other identifiable processes that may influence such trends. 	<p>Section 5.5, Appendix D and Appendix E.</p> <p>Water quality trends and statistics are presented for the water quality results from the NMN and BMN.</p> <p>The results for NMN and BMN bores indicate change in EC and pH compared to historic levels, taking into account the variation inherent in EC and pH. However, it is noted that the salinity in BMN bore IMW06 rose to 5240 $\mu\text{S}/\text{cm}$ (moderately saline) in 2016, which may be due to flushing of salts following a period of above average BIS irrigation rates.</p> <p>All NMN and BMN samples collected over 2016 recorded metals concentrations within acceptable limits (for the metals analysed) under the ANZECC (2000) short term irrigation and stock water guidelines. Metals concentrations were generally consistent with historic levels. However a rise in iron concentrations was observed for three active dewatering bores (MG27, MG28 and UG TW1) that may relate to bore deterioration.</p>
<p>The monitoring network and monitoring programme will be reviewed on an annual basis to determine ongoing suitability and any proposed changes will be discussed in the annual review of monitoring results.</p>	<p>See Section 4.2 and recommendations included within Section 7</p> <p>The groundwater monitoring network at Ulan Mine is extensive and a program is in place to install additional bores as the mine progresses. However, further work is required to document the construction details of all site bores, and to gain greater understanding of the construction and target lithology for all private bores.</p>

Project approval conditions	2016 Groundwater assessment
<p>6.4.2</p> <p>The results of groundwater monitoring and a comparison of measured and predicted impacts will be reported in the annual review required by the project approval conditions.</p>	<p>See Section 5.4.1 and Section 5.6</p> <p>The NMN observed groundwater levels were compared to predicted levels as part of the annual review. Review indicates the model predictions are generally conservative, with predicted groundwater levels below observed. One bore recorded a decline in groundwater levels not captured by the model, bore PZ12A, which is located approximately 1 km south-west of LWUW6. As part of the model recalibration process planned for 2017, further review will be required to understand the trend at PZ12A.</p>
<p>6.4.3</p> <p>Impacts on the privately owned licensed bores identified in Section 5.3 as being potentially affected, will be assessed by monitoring and in the event that any utilised privately owned bore is significantly adversely affected, an alternative water supply will be provided by UCML until such time as the bore is re-established or replaced, or appropriate compensation established, in accordance with project approval requirements.</p>	<p>See Section 5.4.4</p>
<p>6.4.4</p> <p>The groundwater monitoring results will be analysed (graphically and statistically) as new results become available i.e. quarterly or six monthly. In addition, a monitoring review and verification process will be established as part of the Water Management Plan process, to verify regional groundwater losses as necessary to refine groundwater mitigation strategies.</p>	<p>Section 5.4 (water levels) and Section 5.5 (water quality), as well as hydrographs included in the appendices.</p>
<p>6.4.5</p> <p>Identification of any changes or long term trends in groundwater outside the predicted impacts will result in an investigation to determine if the trend is a result of the Project operations and if so, identify management strategies to be implemented to address the identified issues as per UCML's Internal TARP process (T – trigger; A – Action; R – response; P – Plan).</p>	<p>Section 5.4.1 and Section 5.6</p> <p>Overall, available estimated groundwater inflows from the water were lower than predicted for 2016.</p> <p>Groundwater levels within the NMN matched predicted trends for all bores except one, PZ12A. PZ12A intersects the lower Permian coal measures and records declining trends that are not observed within the shallower bores intersecting the Ulan Seam and Triassic sediments at the same location. Further work will be undertaken to investigate the trend, with findings to be incorporated into the planned model recalibration for 2017.</p>

7 Summary and recommendations

The groundwater monitoring network covers much of the project area and surrounds and intersects all key groundwater bearing units except alluvium. A drill program commenced in 2016 to install additional bores to address data gaps and mine progression. The program will continue into 2017 and will include collection of core samples for testing of hydraulic properties. To address data gaps, the proposed monitoring locations should include installation of VWPs north and west of the mine area, as well as installation of bores within alluvium at and surrounding the mine. The monitoring network should also be reviewed to ensure groundwater monitoring around key water storage facilities (i.e. East Pit).

Groundwater level monitoring was conducted in accordance with the GWMP, where the bores were accessible. Over 2016, the monitoring bore intersecting Tertiary basalt showed a rapid response to rainfall. Monitoring bores, intersecting Jurassic sediments, recorded relatively stable groundwater levels, indicating no mine related impacts. Bores and VWPs intersecting Triassic units over 2 km from the mine recorded relatively stable groundwater levels over the 2016 monitoring period. Bores intersecting the Triassic units within 1 km of the mine area recorded less than a 1 m decline in groundwater levels between March and December 2016. These observed changes align with model predictions. Groundwater within the Permian coal measures generally declined over the monitoring period, in line with model predictions. One bore within the Permian coal measures beneath the Ulan Seam (PZ12A) recorded a greater level of drawdown than predicted. Further work will be undertaken to investigate this trend, with findings to be incorporated into the planned model recalibration for 2017. Groundwater level decline has been observed for one private bore; however, the level of decline exceeds that observed at a monitoring bore closer to the mine, therefore local factors (i.e. bore usage and seasonality) need to be considered.

Groundwater quality monitoring was largely conducted in accordance with the GWMP; however, field parameters were not recorded during all sampling events and not all analytes were tested as per the GWMP. Despite these omissions, it is considered sufficient data was collected to enable assessment of potential changes in groundwater quality within the prescribed monitoring networks over the 2016 monitoring period. Action will be taken to review the groundwater monitoring program and techniques to ensure compliance with the GWMP for the 2017 monitoring period. Groundwater quality data is largely within the range of historic results, with no adverse impacts identified. However, it is noted that the salinity in BMN bore IMW06 rose to 5240 $\mu\text{S}/\text{cm}$ (moderately saline) in 2016, which may be due to flushing of salts following a period of above average BIS irrigation rates. Iron concentrations within three pumping bores increased over 2016, potentially indicating deterioration of the bores. In addition, four private bores recorded pH outside of historic range of data. However, readings remained within the ANZECC (2000) drinking water, fresh water aquatic and irrigation water guideline range of 6.0 to 8.5.

Overall, available estimated groundwater inflows from the water balance were lower than predicted for 2016.

The 2016 groundwater monitoring period was generally conducted in accordance with the GWMP and conditions of approval for all accessible bores. However, areas for further improvement are detailed below:

- Installation of additional monitoring points with expansion of the Ulan No. 3 towards the north, and collection of data on hydraulic properties as part of the drill program.
- Continue to review suitability of current groundwater monitoring program.
- Continued monitoring of the recently installed VWPs PZ29 and EX06, and inclusion of EX06 into the BMN.
- Record purge volumes and field water quality parameters on field sheets to ensure three well volumes are purged and field parameters stabilise prior to sampling, or alternatively low-flow or in-situ sampling techniques should be used for deep bores.
- To ensure consistency between measurements, it is recommended that the standpipe height for all BMN bores be measured and documented within a database. In addition, the GWMP should be amended to require only the depth to standpipe be recorded.
- Collection of field parameters of EC and pH during all water quality sampling events (i.e. NMN, BMN and PMN).
- Collection of field duplicates, to assess the precision of the laboratory analysis.
- Review the construction details and total depths of nested bores PZ14A and PZ14B, to ensure they are correctly labelled.
- Review construction details and lithological logs for bore PZ12 to identify cause of decline in groundwater levels at bore.
- Update GWMP to more clearly specify:
 - dissolved and total metals analysis;
 - fluoride for the NMN (not fluorine);
 - PZ36 within the NMN Table 4.1 (not PZ32); and
 - verify PMN bores (i.e. East 6 and MG21).
- Conduct an investigation into the change in groundwater levels at private bore PB7. This should aim to gather information about the construction of the bore, target lithology, bore usage and temporal changes in groundwater levels.

8 References

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Ulan Coal Mines Limited 2016b, *Surface Water Groundwater Response Plan*, prepared for Ulan Coal Mines Limited, ULN SD PLN 0057, March 2016.

Appendix A Existing monitoring bore details

Ulan Mine Site Monitoring Bore Network Details

Network	Name	Easting (mMGA)	Northing (mMGA)	Ground elevation (mAHD)	Total Depth (mbgl)	Screen from (mbgl)	Screen to (mbgl)	Screened strata
NMN	PZ01A	761186	6441552	534.3*	165	144	159	Triassic
NMN	PZ04A	762140	6435921	440.7*	55	42	54	Triassic
NMN	PZ06A	755106	6441412	449.7	169	161	169	Lower-PCM
NMN	PZ06B	755109	6441425	449.8	159	147	159	Ulan-Seam
NMN	PZ06C	755105	6441437	449.7	71	58	71	Triassic
NMN	PZ07A	759136	6438002	502.4	274	262	274	Lower-PCM
NMN	PZ07B	759122	6438005	502.1	255	240	255	Ulan-Seam
NMN	PZ07C	759105	6438009	501.9	121	102	121	Triassic
NMN	PZ08B	761995	6437847	481.1	265	170	265	Permian
NMN	PZ08C	762011	6437848	482.0	130	90	130	Triassic
NMN	PZ09A	758720	6441337	541.8	330	314	330	Lower-PCM
NMN	PZ09B	758702	6441339	541.6	310	290	310	Ulan-Seam
NMN	PZ09C	758683	6441343	541.0	165	150	165	Triassic
NMN	PZ09D	758668	6441348	540.6	80	50	80	Jurassic
NMN	PZ10A	758812	6439393	513.8	165	150	165	Triassic
NMN	PZ10B	758808	6439383	514.1	46	26	46	Jurassic
NMN	PZ11A	757426	6435557	476.7	175	160	175	Ulan-Seam
NMN	PZ11B	757434	6435550	476.5	82	68	82	Triassic
NMN	PZ12A	753529	6431711	571.8	187	176	187	Lower-PCM
NMN	PZ12B	753528	6431725	571.3	172	158	172	Ulan-Seam
NMN	PZ12C	753526	6431739	570.6	75	55	75	Triassic
NMN	PZ13A†	749207	6440479	445.8	73	65	73	Ulan-Seam
NMN	PZ14B	766633	6437221	453.7	182	140	182	Triassic
NMN	PZ14C	766637	6437208	454.2	56	32	56	Jurassic
NMN	PZ24A	763109	6434793	420.8	236	208	236	Ulan Seam
NMN	PZ24B	763107	6434783	420.6	74	44	74	Triassic
NMN	PZ25A	763535	6423746	430.8	86	78	86	Lower PCM
NMN	PZ25B	763533	6423732	430.7	78	60	78	Ulan Seam
NMN	PZ26A	759629	6448988	448.3	265	248^	265*	Lower PCM
NMN	PZ26B	759621	6448966	448.2	243	225*	240*	Ulan Seam
NMN	PZ26C	759613	6448943	447.9	130	60*	90*	Triassic
NMN	PZ26D	759605	6448921	447.6	22	16*	22*	Jurassic

Network	Name	Easting (mMGA)	Northing (mMGA)	Ground elevation (mAHD)	Total Depth (mbgl)	Screen from (mbgl)	Screen to (mbgl)	Screened strata
NMN	PZ28A	757722	6445002	475.4	130	108	130	Triassic
NMN	PZ28B	757712	6445005	475.2	44	38	44	Jurassic
NMN	R752	756607	6436339	549.1*	46	31	43	Basalt
	R753A	760299	6437786	482.12*	91	78	90	Triassic
	R755A	761457	6437292	462.42*	91	78	90	Triassic
NMN	DDH266	752760	6438854	494	192		84	Lithic Triassic
							189	Ulan Seam
							192	Lower Permian
NMN	DDH270	753643	6436046	491	173		76	Lithic Triassic
							171	Lower Permian
NMN	DDH271	754574	6433293	508	156		47	Lithic Triassic
							147	Ulan Seam
							156	Lower Permian
NMN	R894	763091	6442209	487	261		90†	Jurassic (Purlewaugh SS)
							119	Jurassic (Purlewaugh SS)
							219	Quartzose Triassic
NMN	TAL1	752396.9 752370 (C2015)	6440925.1 6440925 (C2015)	465	150		28	Quartzose Triassic
							45	Lithic Triassic
							61	Permian
							97	Permian
							140	Ulan Seam
NMN	TAL2	748873* 749274 (C2015)	6437875* 6438170 (C2015)	498	138		50	Permian
							90	Permian
							110	Permian
							128	Ulan Seam
NMN	UW1	756754.1	6430579	436	80		22	Permian
							35	Permian
							51	Permian
							67	Ulan Seam
NMN	UW2	755064* 755051 (C2015)	6430700* 643069 (C2015)	520	132		50	Lithic Triassic/ Permian
							90	Permian
							110	Ulan Seam
NMN	UW3	749037*	6435250*	474	108		40	Permian

Network	Name	Easting (mMGA)	Northing (mMGA)	Ground elevation (mAHD)	Total Depth (mbgl)	Screen from (mbgl)	Screen to (mbgl)	Screened strata
		749126 (C2015)	6435273 (C2015)				60	Permian
							75	Permian
							98	Ulan Seam
NMN	UW4	752221.7	6432892	519	132		41	Permian
							63	Permian
							87	Permian
							122	Ulan Seam
NMN	PZ36	763673.2	6433747.4	443.6	243		18 ^t	<i>Conglomerate (base of Jurassic)</i>
							50	Triassic Sandstone, coarse grained
							72	Conglomerate
							90	Conglomerate
							122	Sandstone, coarse grained, lithic
							143	<i>Coal (Goulburn)</i>
							183	Siltstone / claystone
							243	Coal (Ulan DWS floor)
-	DDH293	751740	6435175	517	169		40	Quartzose Triassic
							111	Permian
							155	Ulan Seam
							167	Lower Permian
-	DDH336	754303	6438225	488	197		42	Quartzose Triassic
							62	Quartzose Triassic
							82	-
							102	Lithic Triassic
							122	Permian (MLB Seam)
							146	Permian (IRD Seam)
							167	-
							183	Ulan Seam
-	R855	761195	6436392	492	264		44	Quartzose Triassic
							70	Quartzose Triassic
							100 ^t	<i>Lithic Triassic</i>
							130 ^t	<i>Lithic Triassic</i>

Network	Name	Easting (mMGA)	Northing (mMGA)	Ground elevation (mAHD)	Total Depth (mbgl)	Screen from (mbgl)	Screen to (mbgl)	Screened strata
							180	Permian
							253 [†]	Ulan Seam
							265 [†]	Lower Permian
-	R933	756381	6435863	545	236		40	Jurassic (Purlewaugh SS)
							115	Lithic Triassic
							125	Lithic Triassic
							145	Lithic Triassic
							165	Permian
-	R936	756011	6435376	533	218		130	Lithic Triassic
							170	Permian
							190	Permian
							210	Ulan Seam
-	R988	756877	6436276	527	193		130	Lithic Triassic
							150	Permian
							170	Permian
							192	Permian
BMN	IMW01	756334	6439529	468.0	2.2	0.5	2.2	Regolith/colluvium
BMN	IMW02	756059	6439190	483.0	3.5	1	4	Regolith/colluvium
BMN	IMW03	756630	6440058	450.0	7.4	0.3	7.3	Regolith/colluvium
BMN	IMW04	757165	6439453	470.0	2.7	0.3	2.6	Regolith/colluvium
BMN	IMW05	758879	6438205	483.0	11.4	0.5	11.4	Regolith/colluvium
BMN	IMW06	757653	6437657	472.0	7.5	1.5	7.5	Regolith/colluvium
BMN	IMW07	758087	6437869	479.0	3.4	0.5	3.4	Regolith/colluvium
BMN	IMW08	759964	6434831	464.0	1.1	0.2	1	Regolith/colluvium
BMN	IMW09	759068	6435489	470.0	2.8	0.3	2.7	Regolith/colluvium
BMN	EX06	757210.4	6438998.4	498.3	34		8.5	Jurassic volcanics
							27.5	Jurassic sandstone
		757210.0	6439001.3	498.3	108		55.5	Triassic conglomerate
							70.5	Triassic sandstone
							94.5	Triassic sandstone
		757207.9	6438999.6	498.1	237		120.5	Triassic conglomerate
							185	Permian overburden
							226.5	Ulan Seam

Network	Name	Easting (mMGA)	Northing (mMGA)	Ground elevation (mAHD)	Total Depth (mbgl)	Screen from (mbgl)	Screen to (mbgl)	Screened strata
PMN	East 6	760842.8	6431348.8	-	-	-	-	Permian coal measures
PMN	East 7	760843.3	6431460.9	468.5	-	-	-	Permian coal measures
PMN	East 9	760819.9	6432099.3	454.9	-	-	-	Permian coal measures
PMN	East 10	760834.4	6432410.8	443.6	-	-	-	Permian coal measures
PMN	East 15	761221.8	6433960.2	441.3	-	-	-	Permian coal measures
PMN	East 18	761362.2	6434749.6	483.0	-	-	-	Permian coal measures
PMN	E20	761499.8	6435315.8	-	-	-	-	Permian coal measures
PMN	MG22	761547.4	6436238.7	460.1	-	-	-	Permian coal measures
PMN	MG26	761910.6	6438041.0	-	-	-	-	Permian coal measures
PMN	MG27	762073.0	6438490.1	516.8	-	-	-	Permian coal measures
PMN	MG28	762083.8	6438940.9	-	-	-	-	Permian coal measures
PMN	MG29	762119.5	6439226.7	-	-	-	-	Permian coal measures
PMN	UW TG1	756991.2	6436120.6	-	-	-	-	Permian coal measures

Notes: Coordinates in MGA94 Zone 55

* Ground elevations are approximate only and need to be surveyed

† Monitoring point not monitored or erroneous (i.e. dry or faulty VWP sensor)

Private bore details

Site ID	Bore ID	Land Owner	Easting (mMGA)	Northing (mMGA)	Ground elevation (mAHD)*	Total Depth (mbgl)	Screen from (mbgl)	Screen to (mbgl)	Screened strata
PB1	Ardgowan	E. Power	768187	6443408	429.2	36.5	-	-	Jurassic SS?
PB2	Petzel	Petzel	753917	6439385	466.1	37.51	-	-	Triassic SS?
PB3	Power 01	P. Power	760895	6443799	515.9	AR	-	-	-
PB4	Power 02	P. Power	767827	6443340	420.8	20	-	-	Regolith? Weathered Jurassic
PB5	Crown Land 01	Crown Land	763563	6442725	465.1	46.73	-	-	Jurassic SS?
PB6	Fergusson 01	Fergusson	753377	6447290	487.5	38.35	-	-	Jurassic SS?
PB7	Fergusson 02	Fergusson	747127	6446421	428.1	AR	-	-	Alluvium
PB8	80BL245863	Mitchell	745138	6438804	436.0	~ 67	-	-	Ulan Seam?
PB9	GW064580	Cundy ¹	764120	6438504	477.1	43	30	36.5	Jurassic SS?
PB10	GW065222	Hensley	758716	6444442	510.3	AR	-	-	-
PB11	McMaster 01	McMaster	756683	6446419	465.4	24.5	-	-	Jurassic SS?

Site ID	Bore ID	Land Owner	Easting (mMGA)	Northing (mMGA)	Ground elevation (mAHD)*	Total Depth (mbgl)	Screen from (mbgl)	Screen to (mbgl)	Screened strata
PB12	GW800279	Imrie	765270	6431962	381.9	28.38	9.1	21.03	Triassic SS
PB13	GW080355	Cap	755475	6425279	457.2	24	-	-	Ulan Seam?
PB14	Archer 01	Archer ¹	761051	6443035	508.2	17.19	-	-	Regolith?
PB15	Rouse 01	Rouse	751158	6442224	429.3	26.5	-	-	Alluvium?
PB16	GW048604	Page	750066	6436450	450.2	-	10	18	CM
PB17	GW803206	Mc Caffrey	748728	6436179	445.1	>30	20	58	CM
PB18	Loughrey 01	Loughrey	749112	6436196	445.0	AR	-	-	-
PB19	Clarke 01	Clarke	749718	6436017	453.9	AR	-	-	-
PB20	Bottyan 01	Bottyan	749369	6435945	452.4	22.19	-	-	Triassic SS?
PB21	GW066553	McGrath	751303	6437467	470.1	-	-	70	SS & CM
PB22	GW803062	Haynes	750965	6443472	423.8	12.62	-	-	Alluvium
PB23	GW803063	Haynes	751657	6443395	426.3	14.16	-	-	Alluvium
PB24	GW803064	Haynes	754623	6444780	437.2	>30	-	-	Triassic SS?
PB25	GW803065	Haynes	754112	6444373	430.6	25.73	-	-	Triassic SS?
PB26	Haynes 01	Haynes	755002	6444829	445.1	42	-	-	Triassic SS?
PB27	Haynes 02	Haynes	753792	6445598	435.7	AR	-	-	-
PB28	Haynes 03	Haynes	754272	6444480	432.1	AR	-	-	-
PB29	GW073385	Colin Seis	742070	6436332	484.4	-	-	-	-
PB30	McDonald 01	McDonald	764066	6440151	490.2	-	-	-	-
PB31	Power 03	P. Power	760886	6443801	515.9	-	-	-	-
PB32	Kalastien 01	UCML	763901	6438757	494.8	-	-	-	-
UB1	GW801625(1)	UCML	753710	6443142	436.8	10.4	-	Open	Triassic SS
UB2	GW801625(2)	UCML	753733	6443133	436.8	>30	-	Open	Triassic SS?
UB3	Jannesse	UCML	751580	6436677	462.9	AR	-	-	-

Notes: * ground elevation indicative only - based on interpolated topographic surface from groundwater model

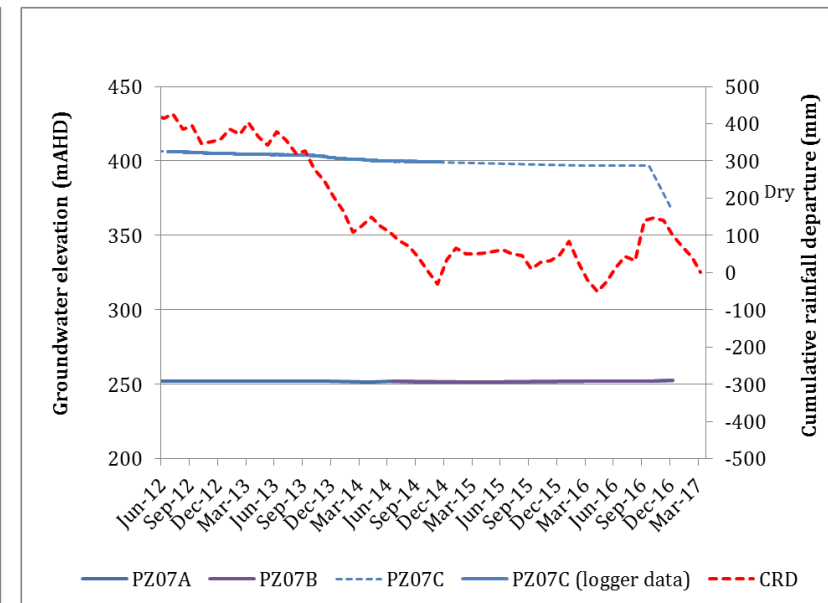
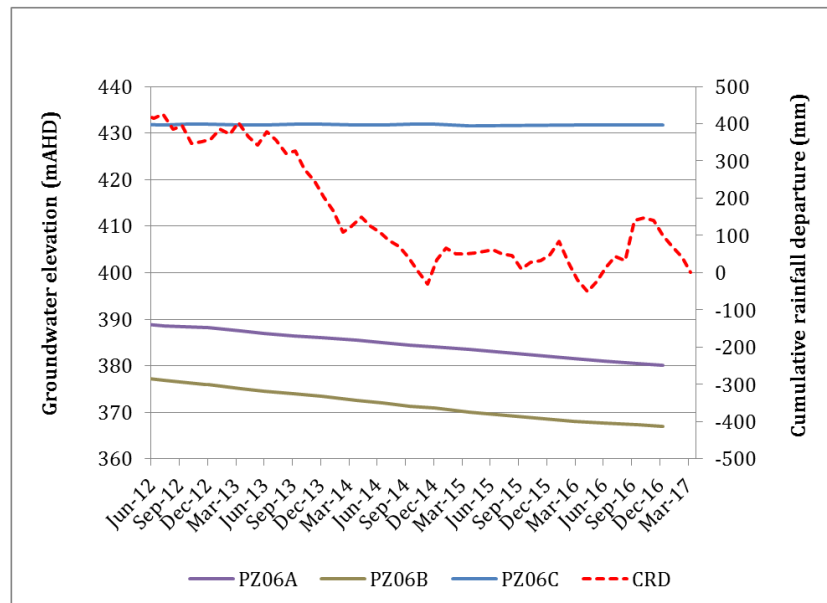
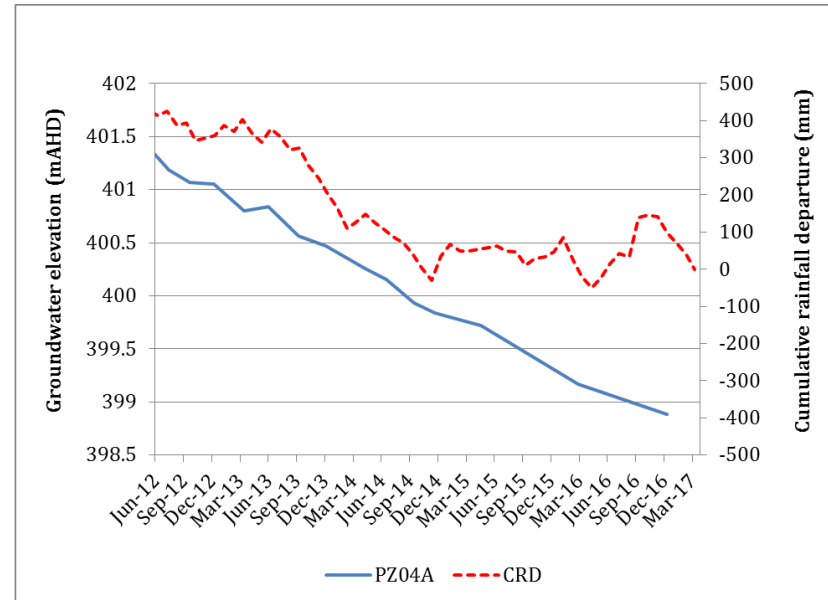
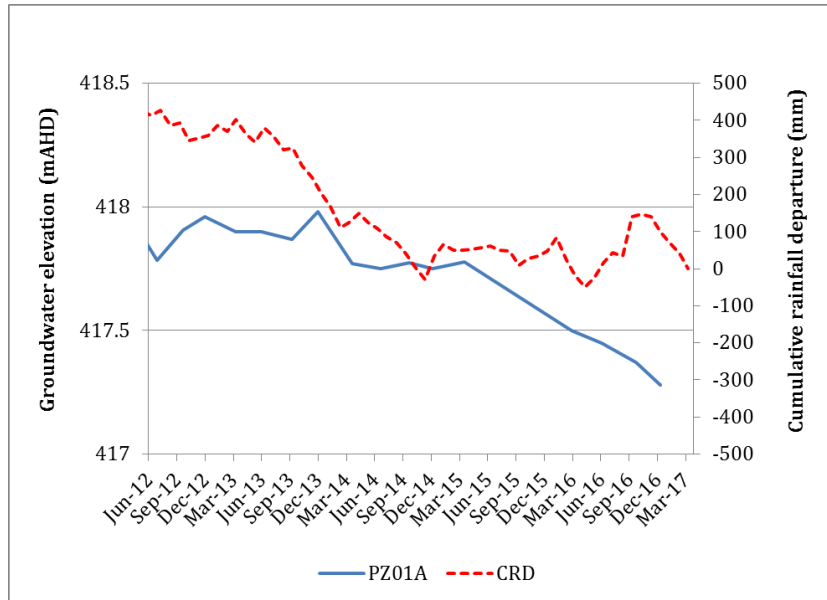
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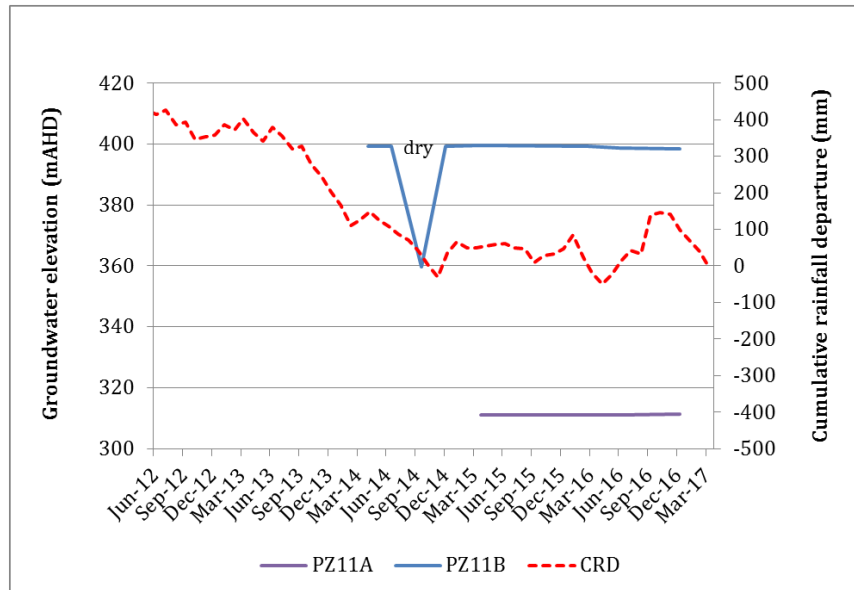
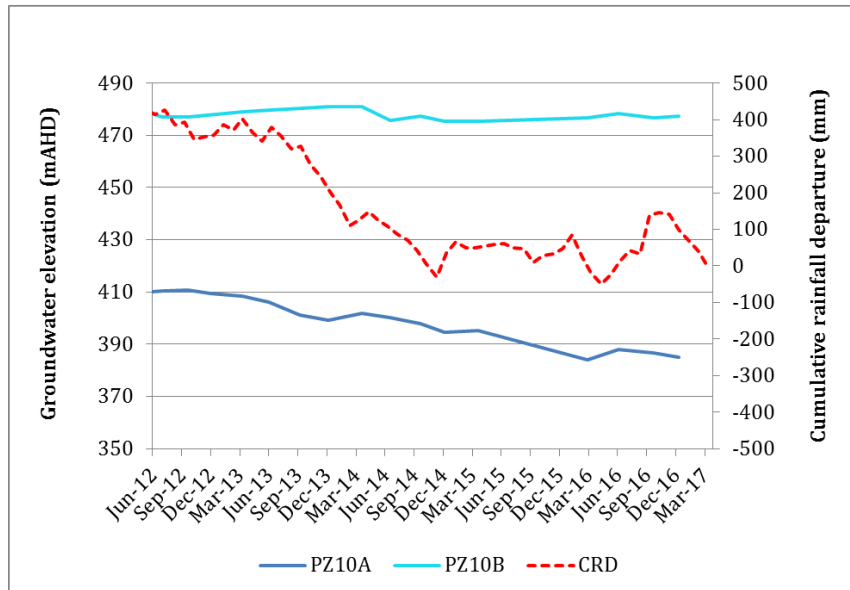
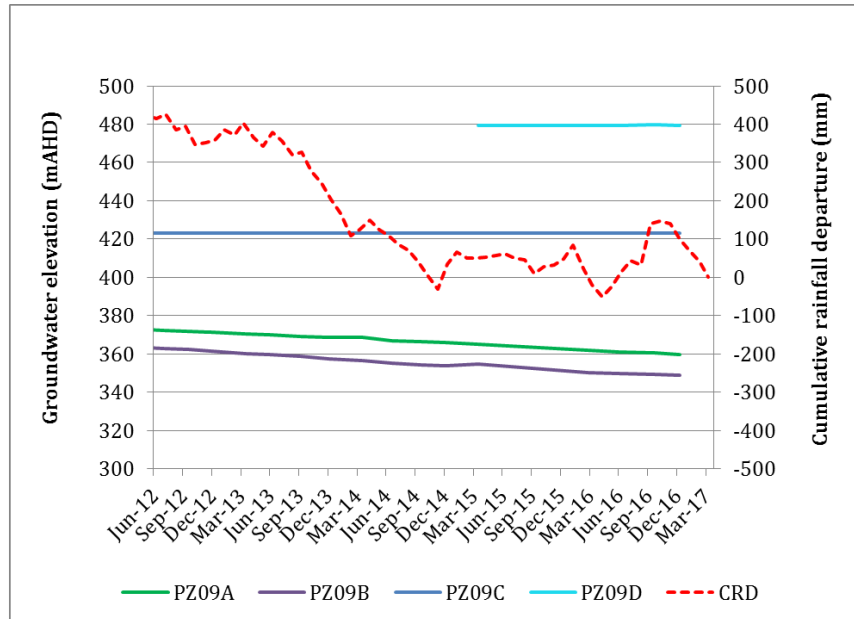
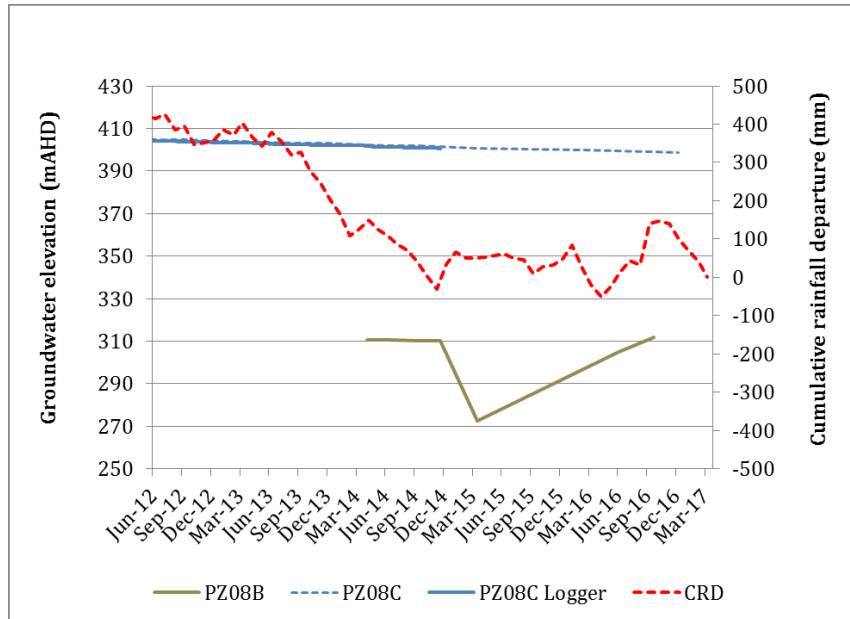
SS – sandstone

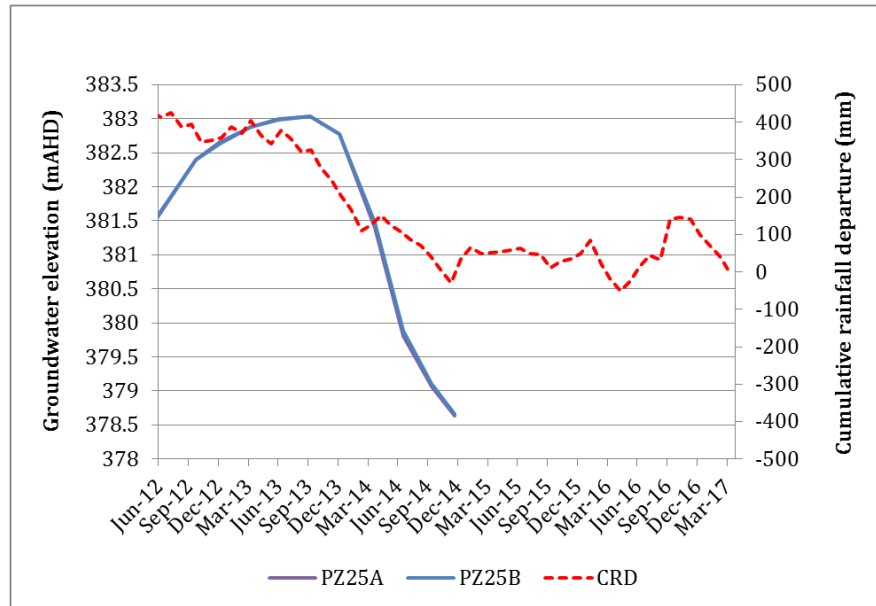
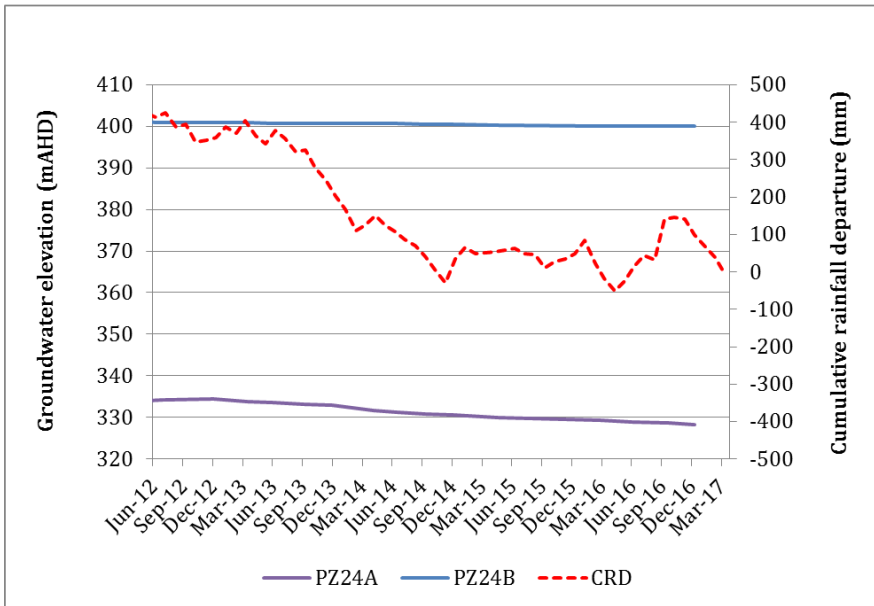
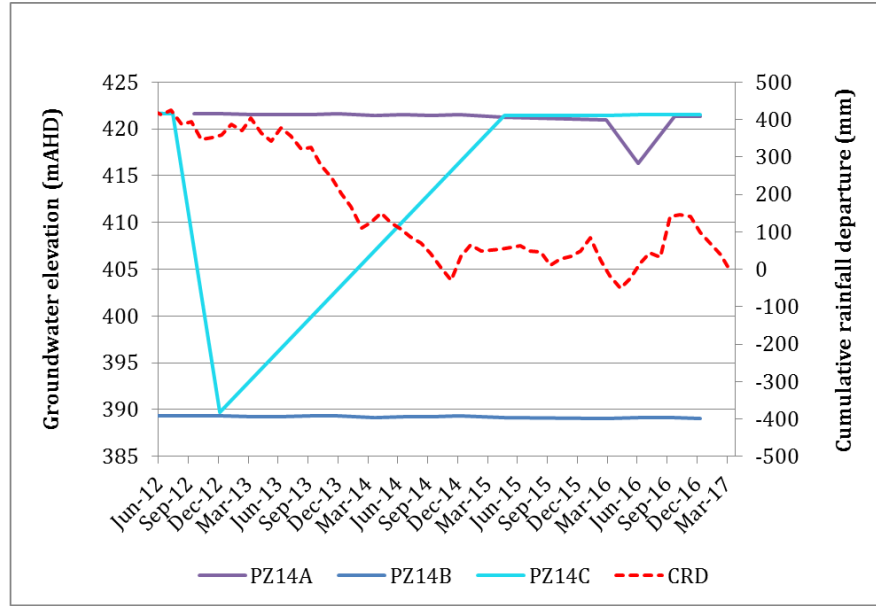
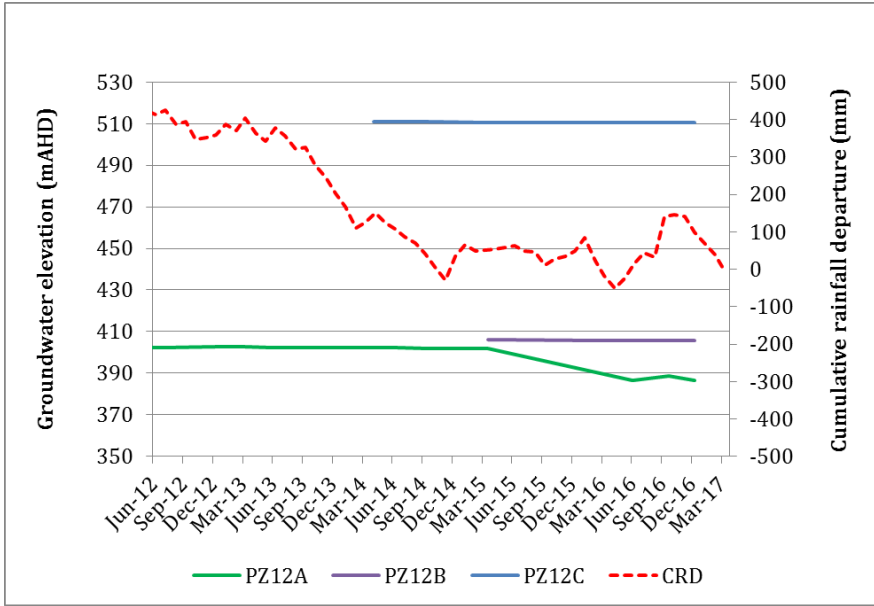
CM – coal measures

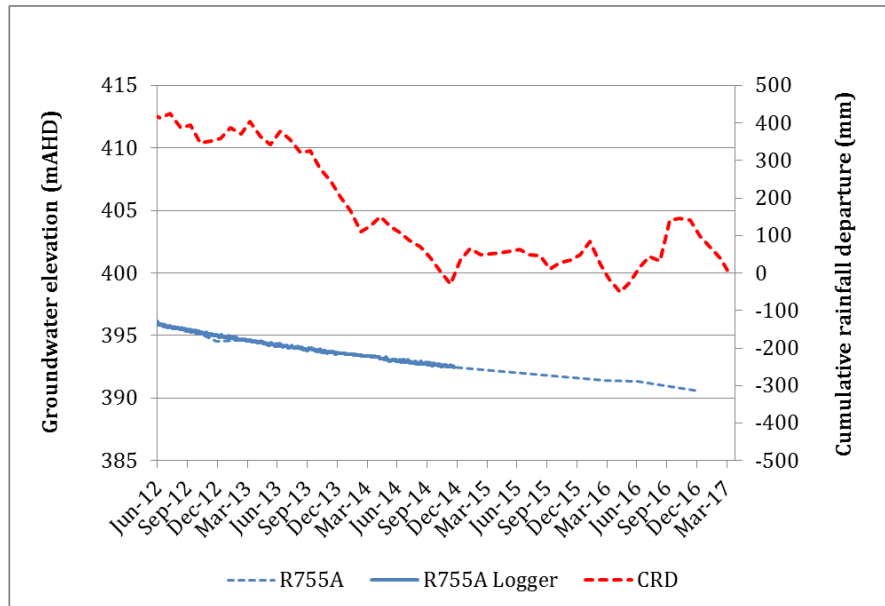
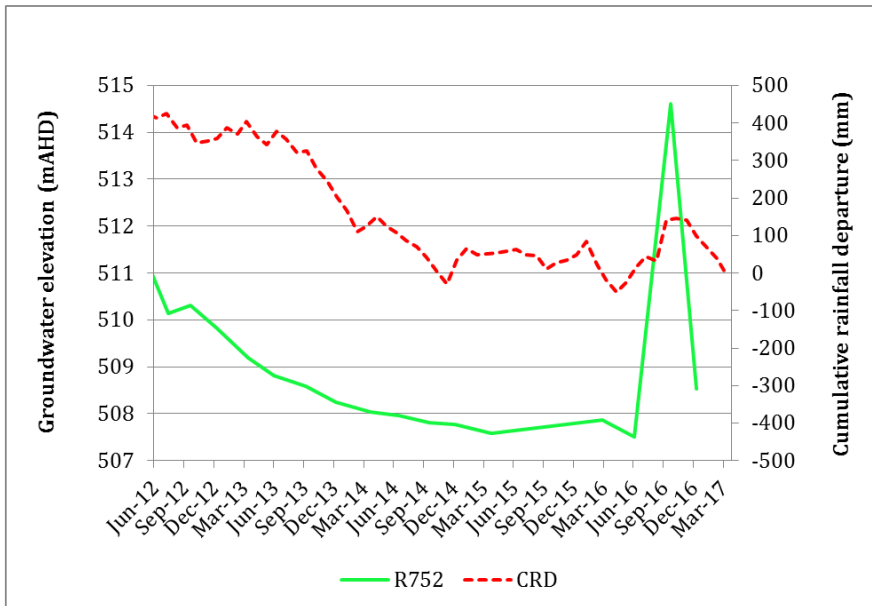
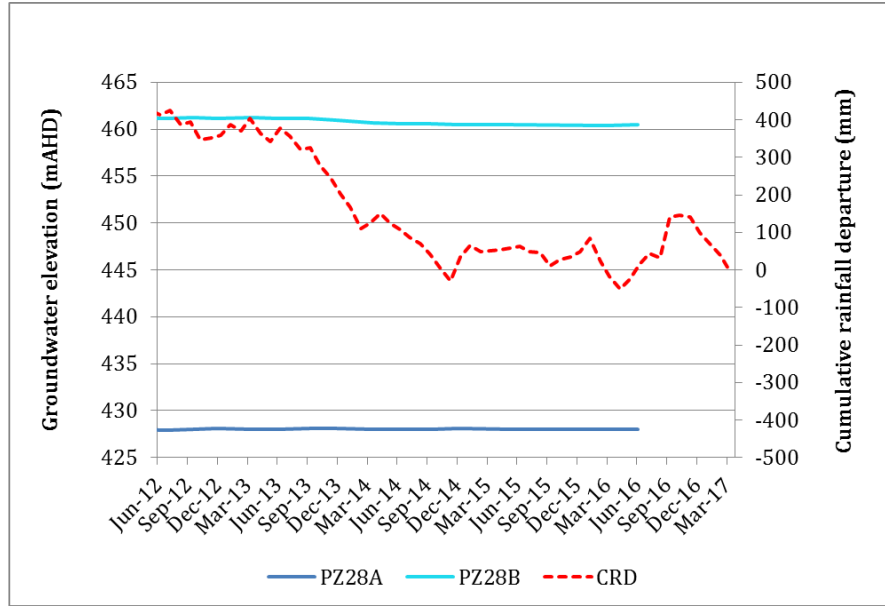
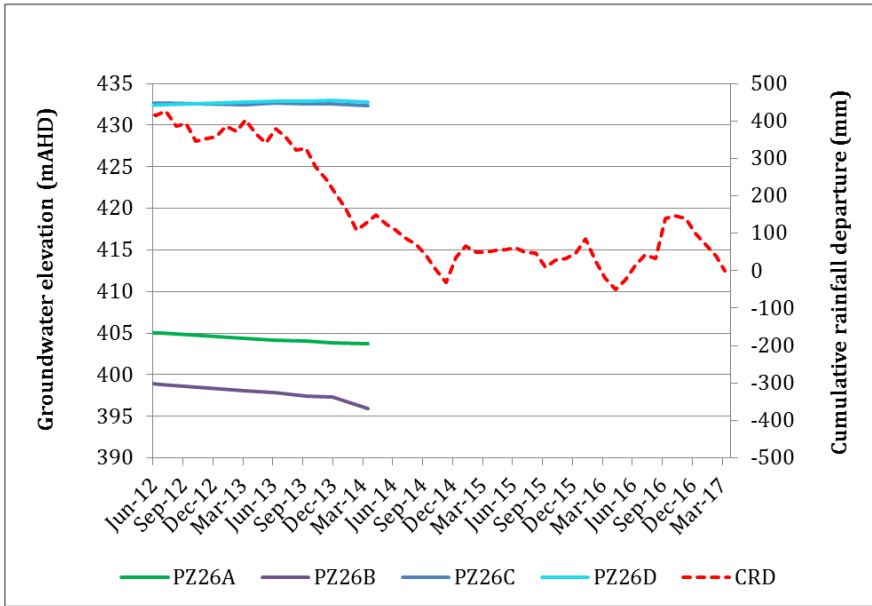
? – screened strata estimated based on bore depth, mapped geology and groundwater model layers

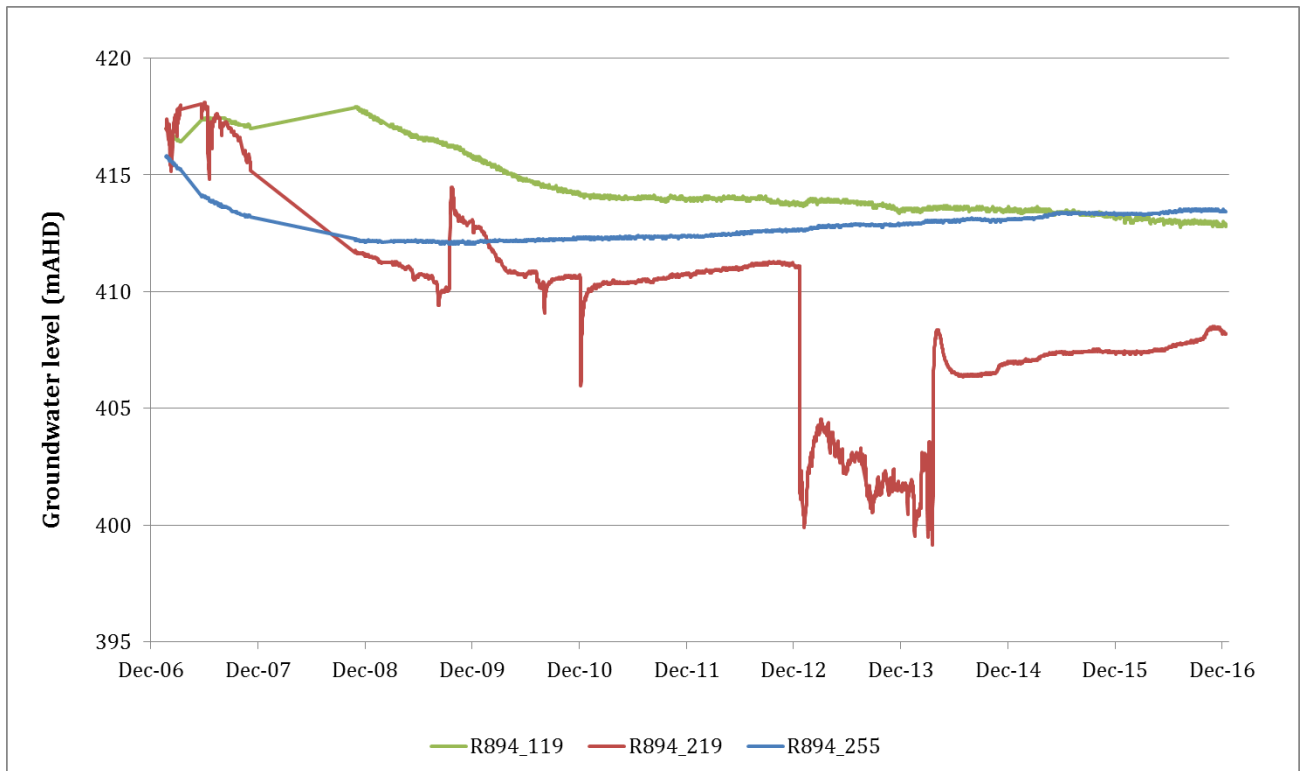
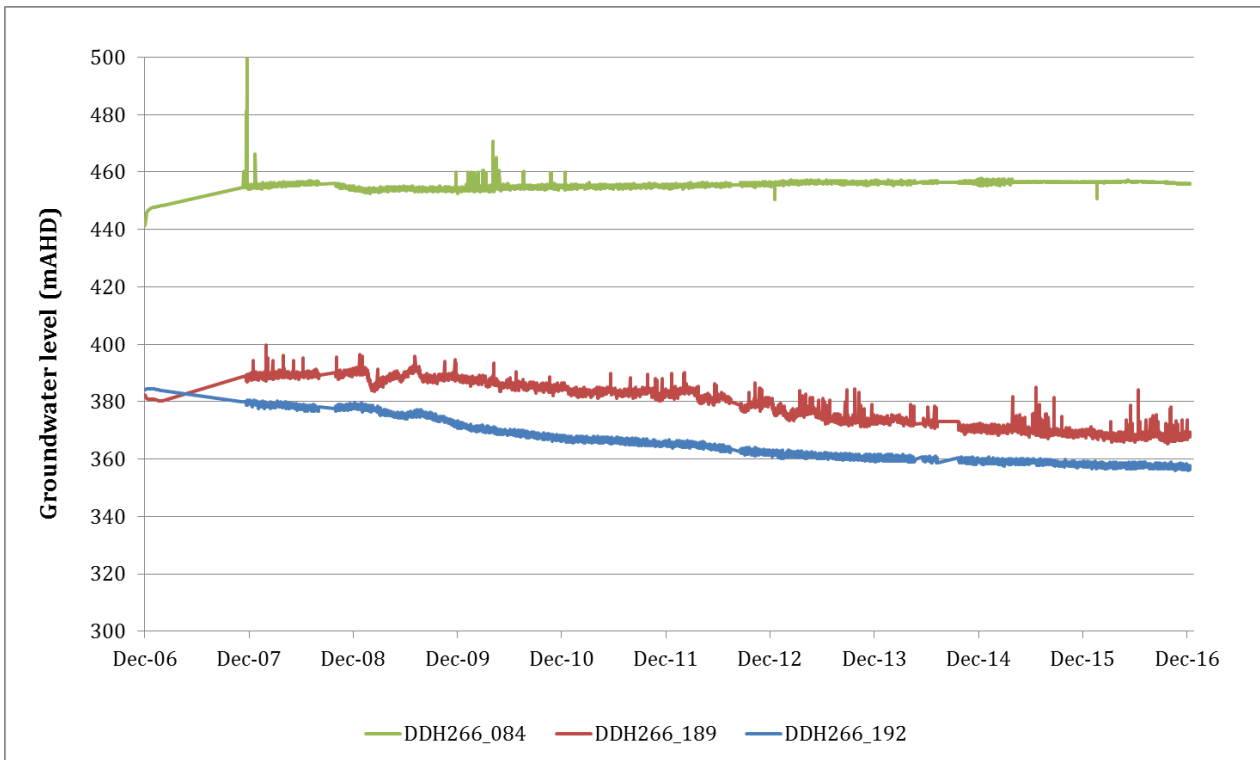
Appendix B **Groundwater level trends – NMN**

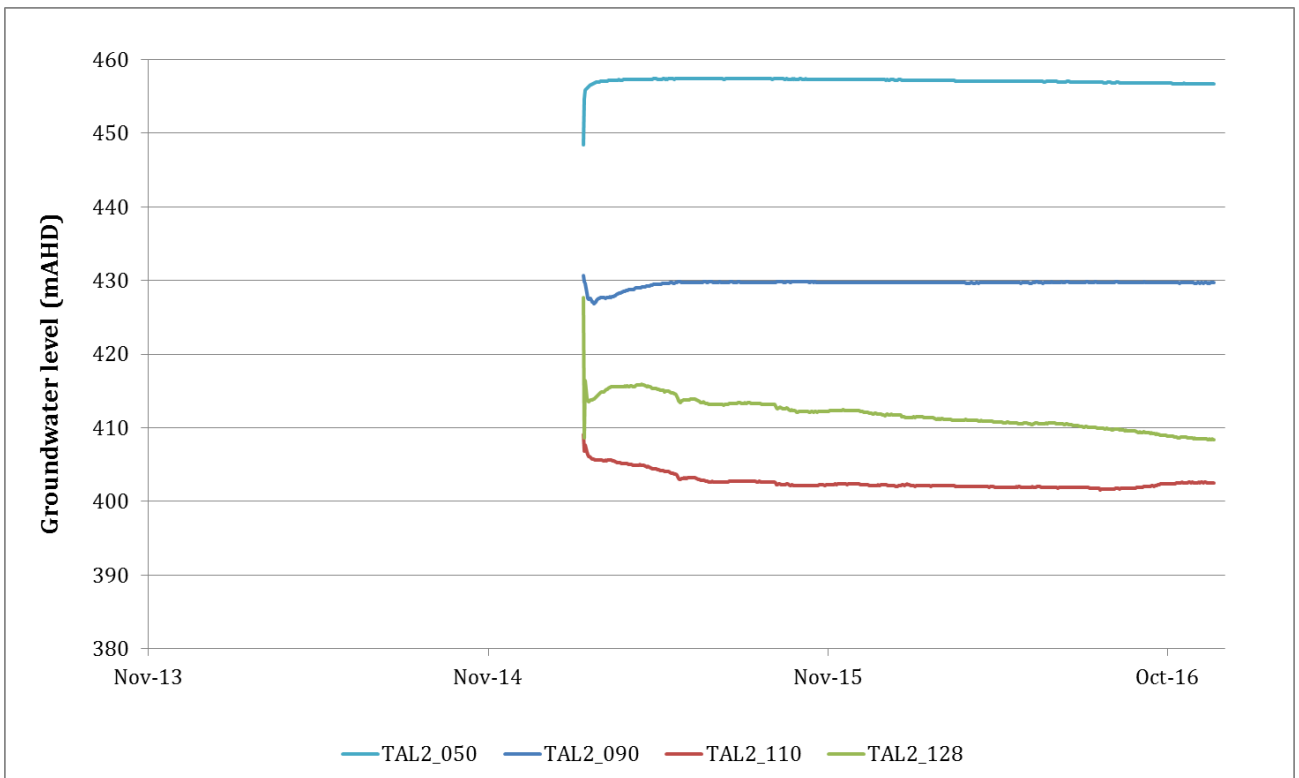
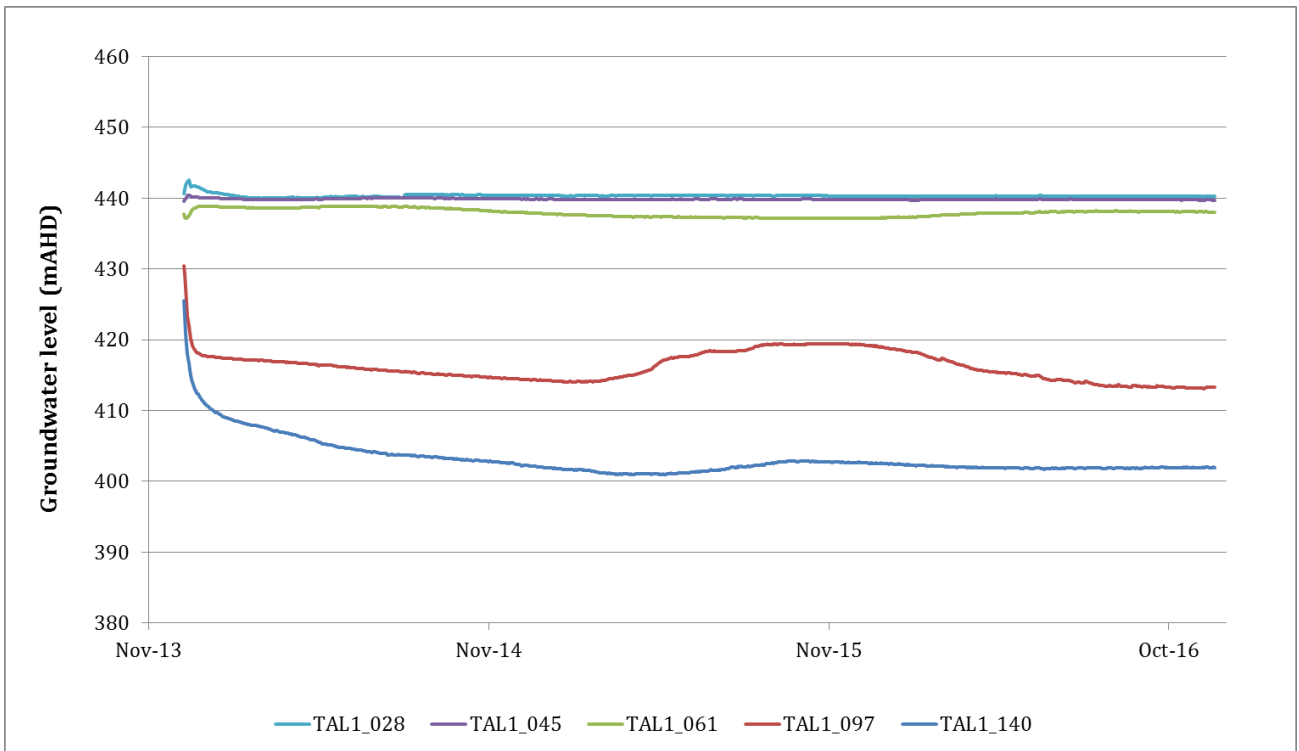


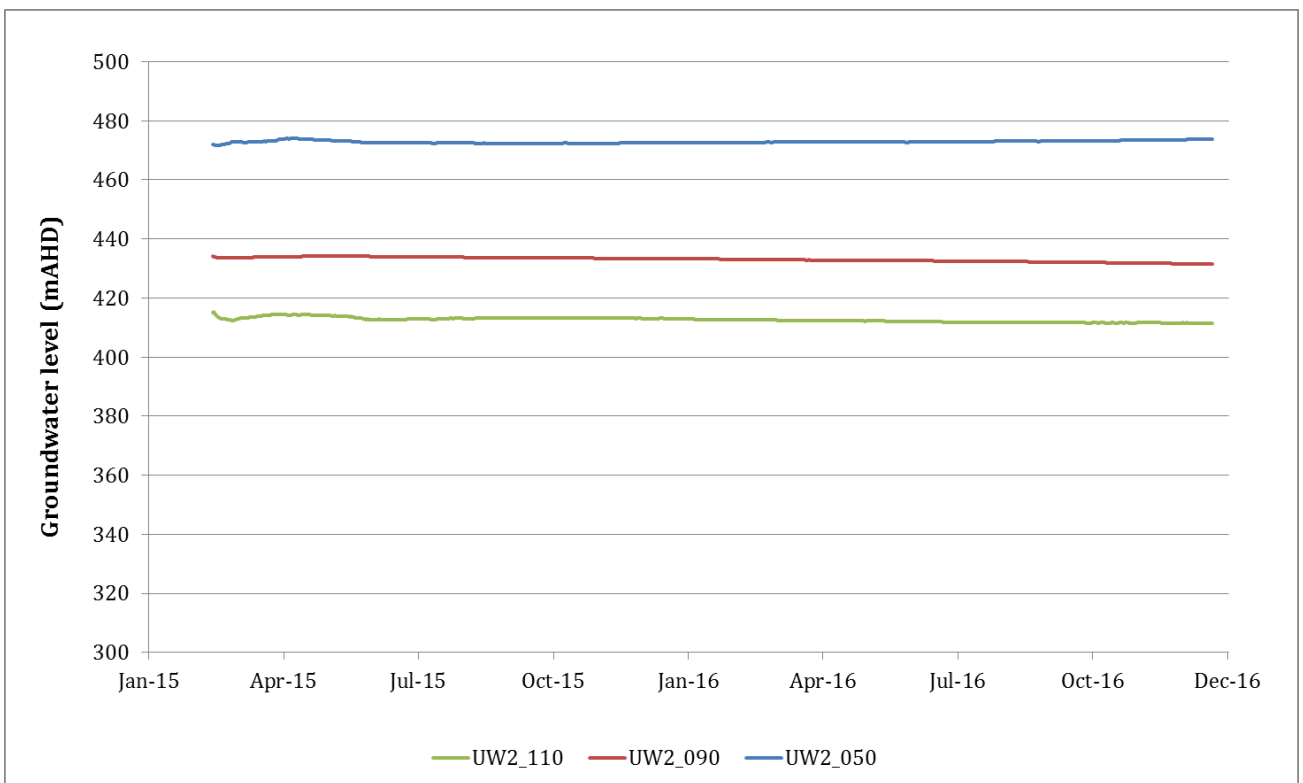
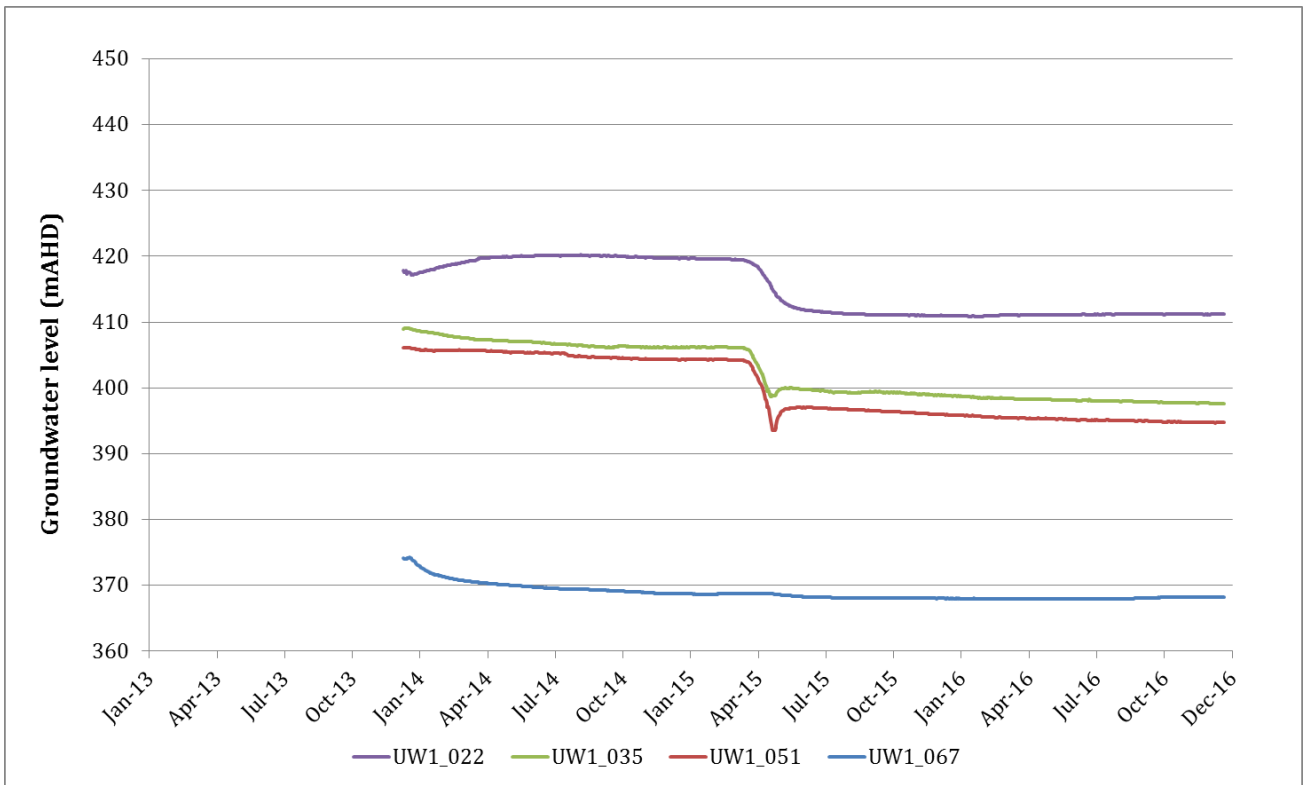


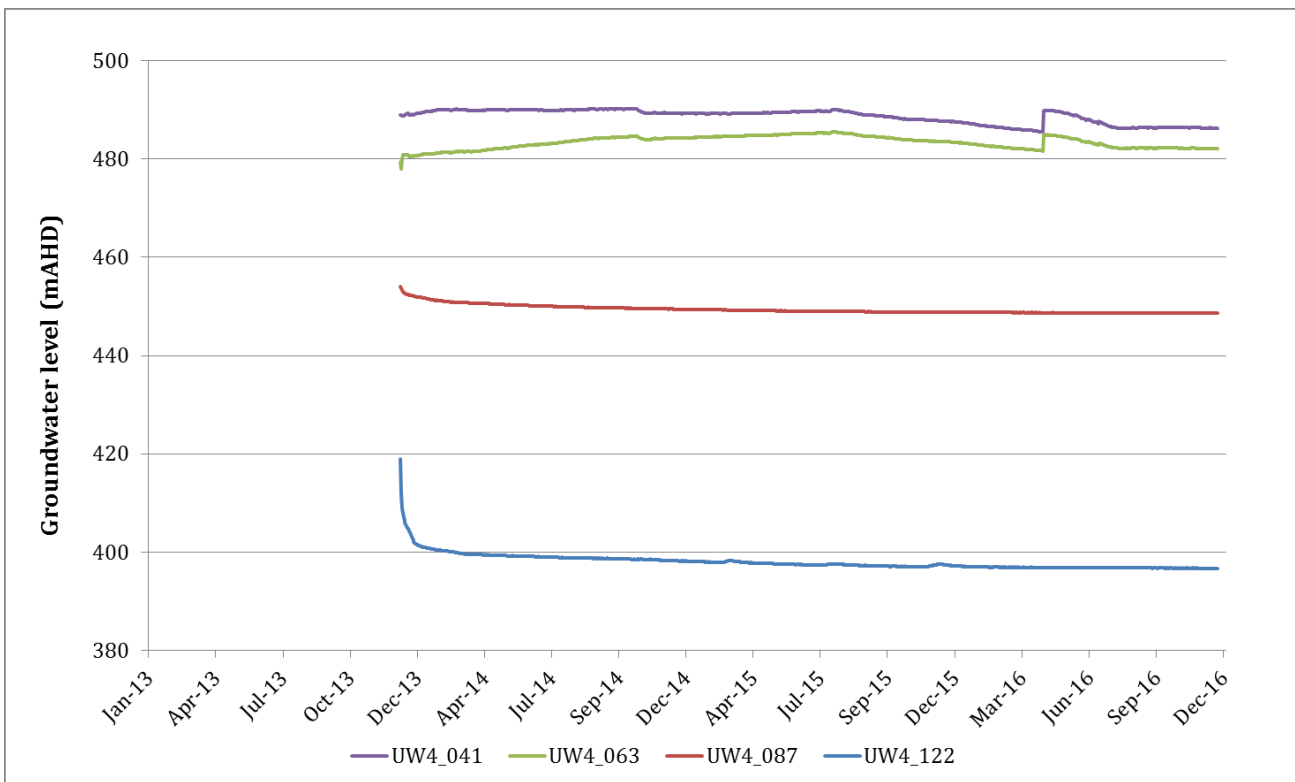
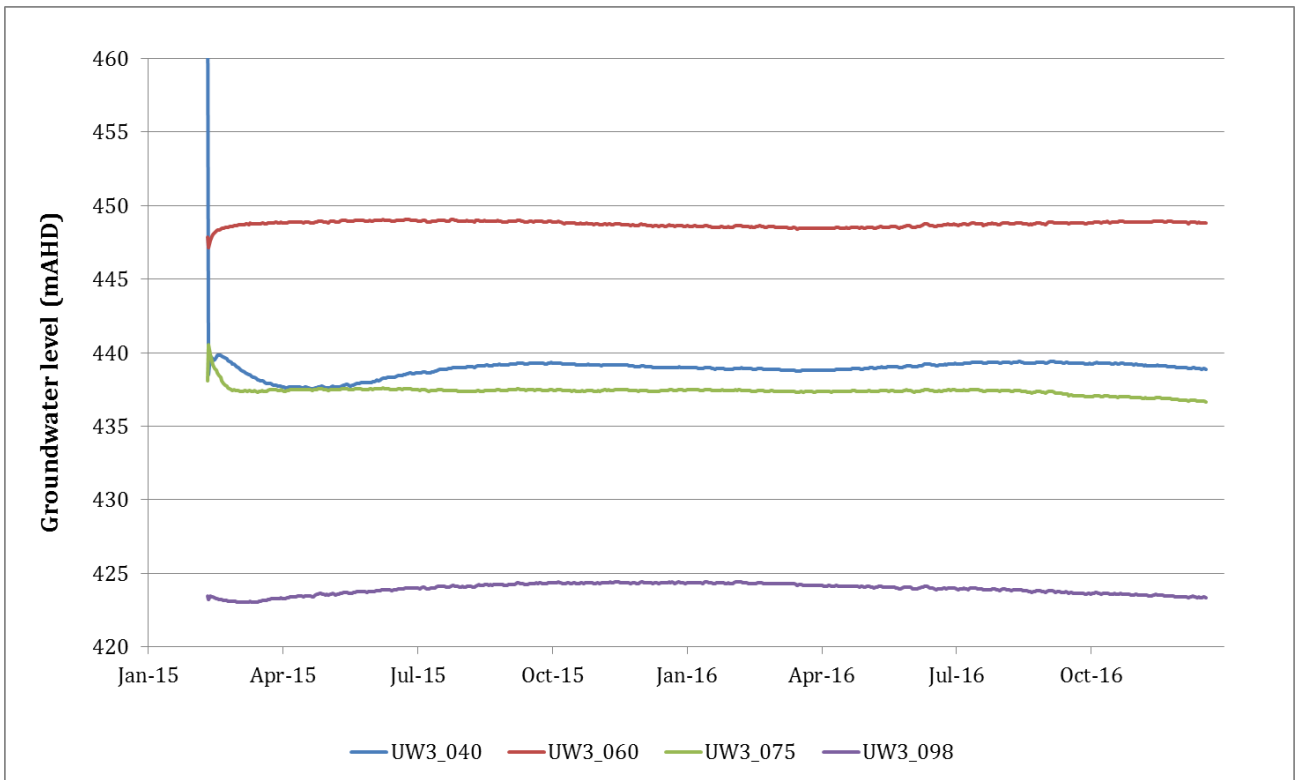


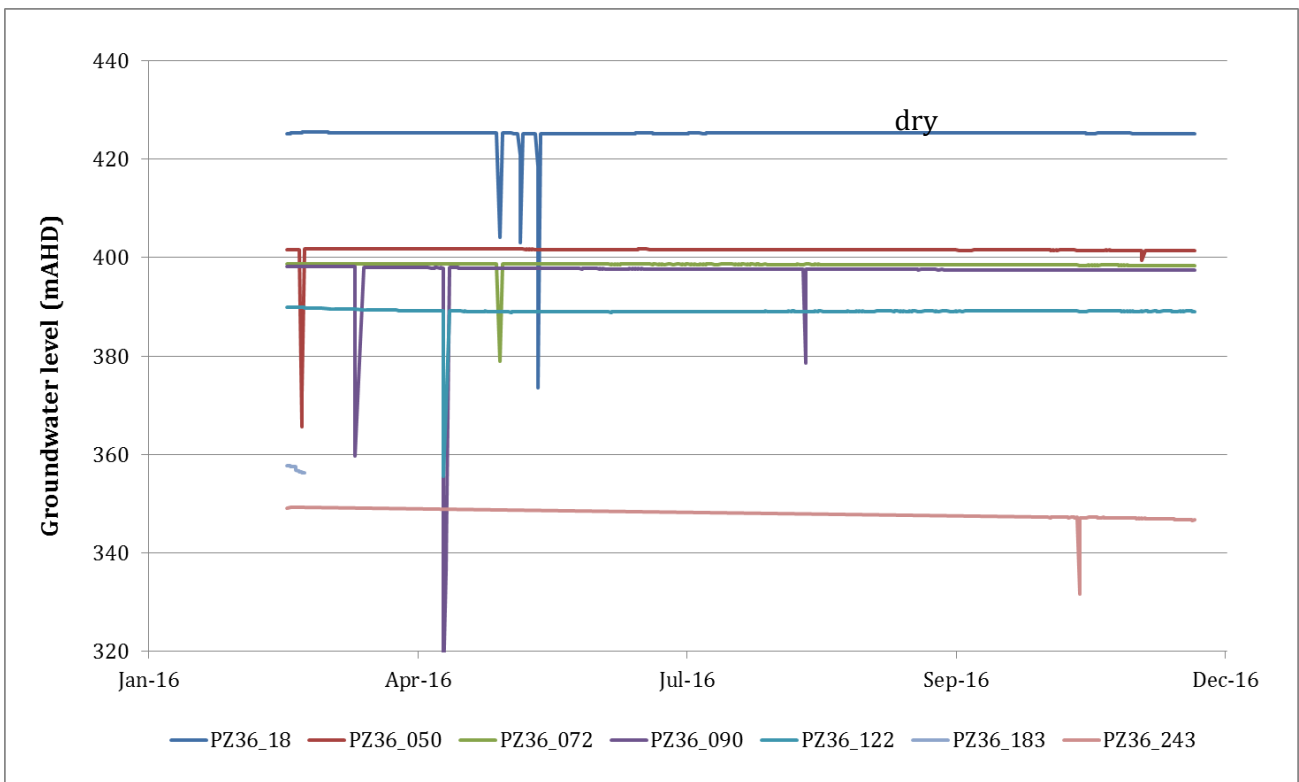
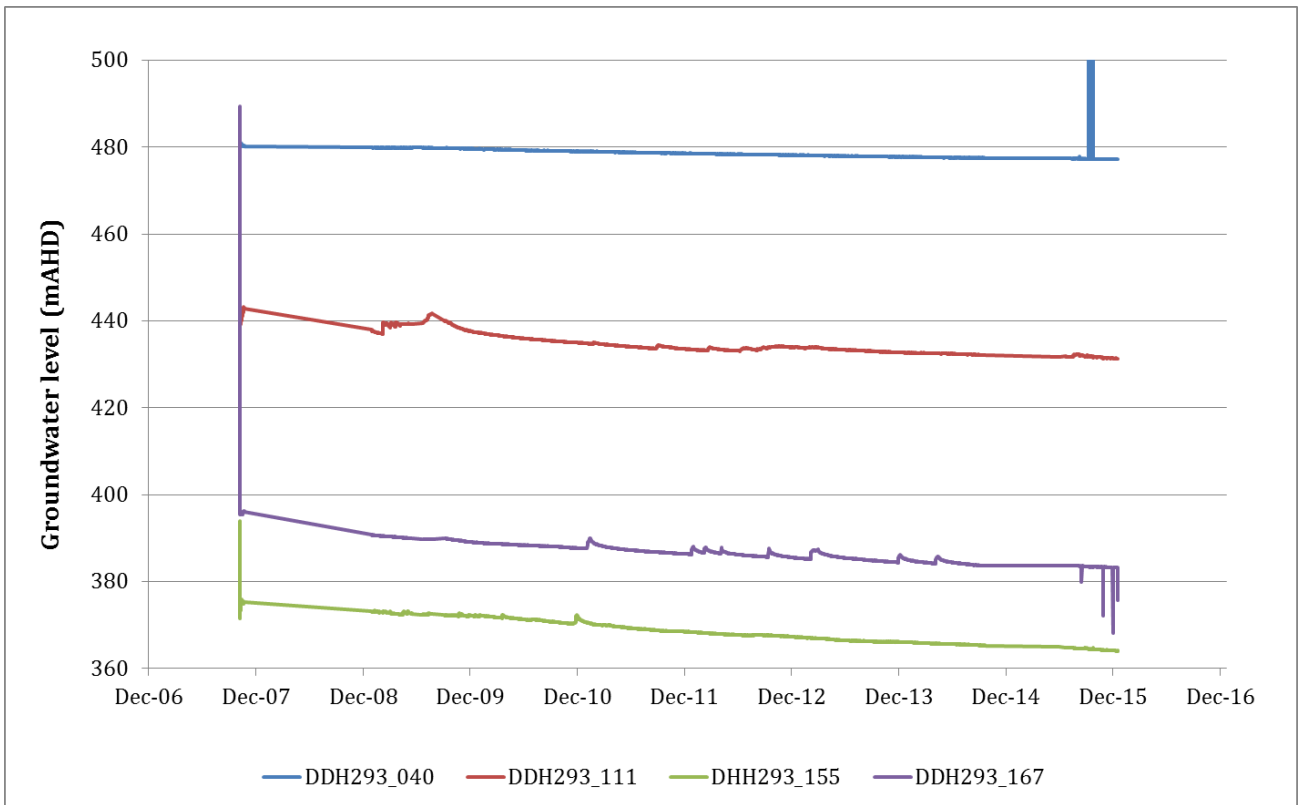




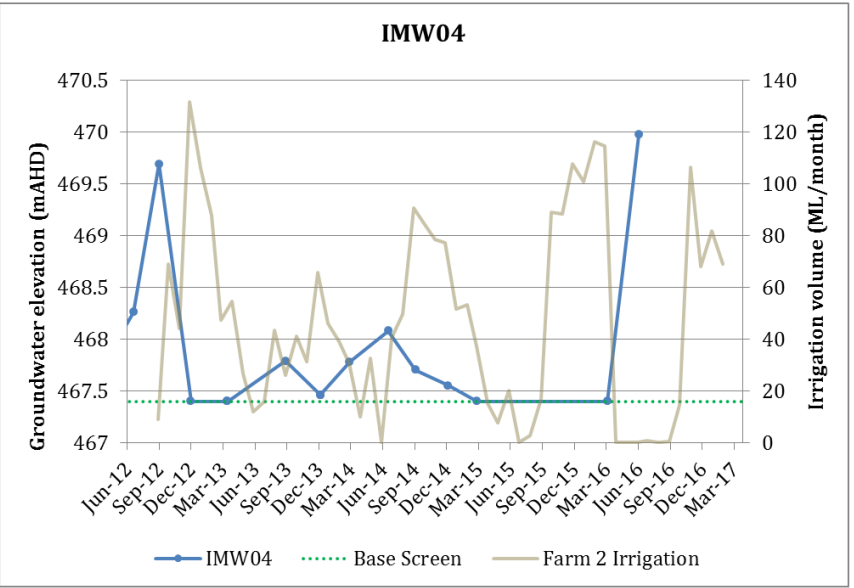
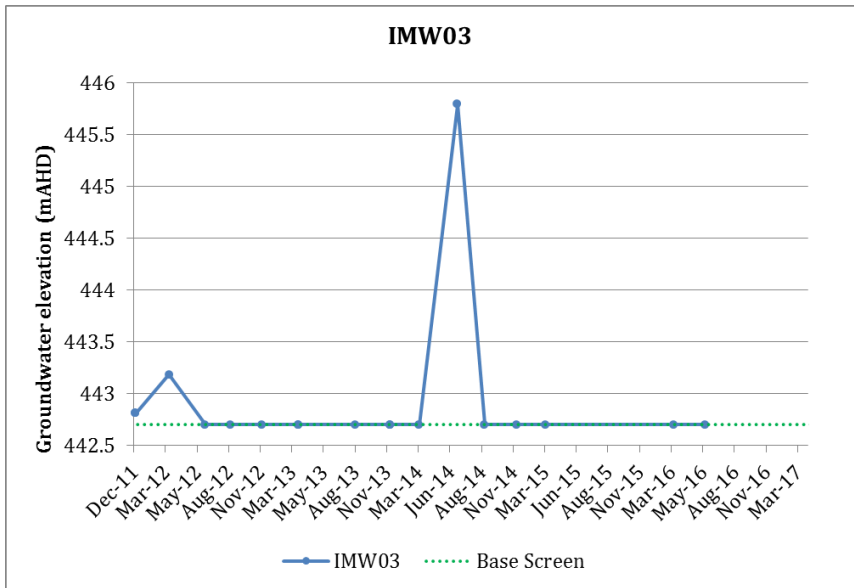
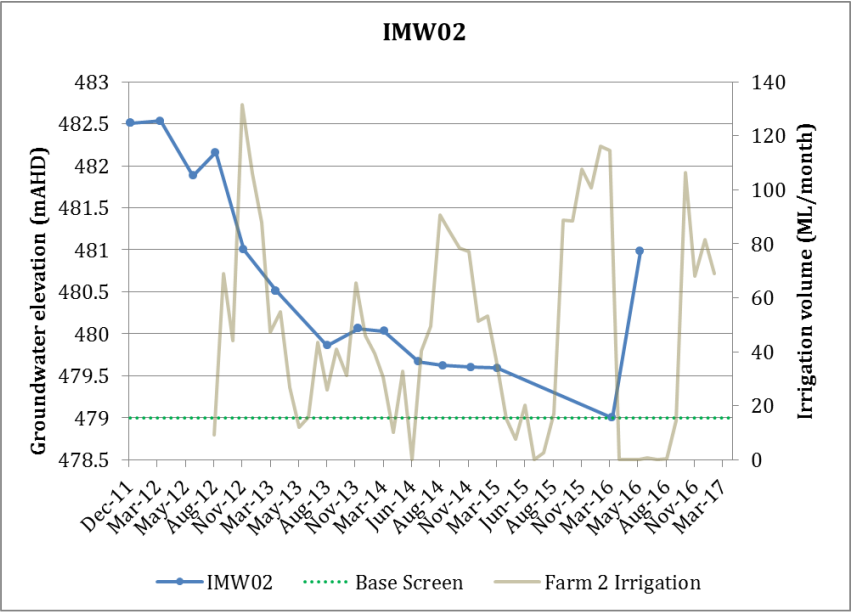
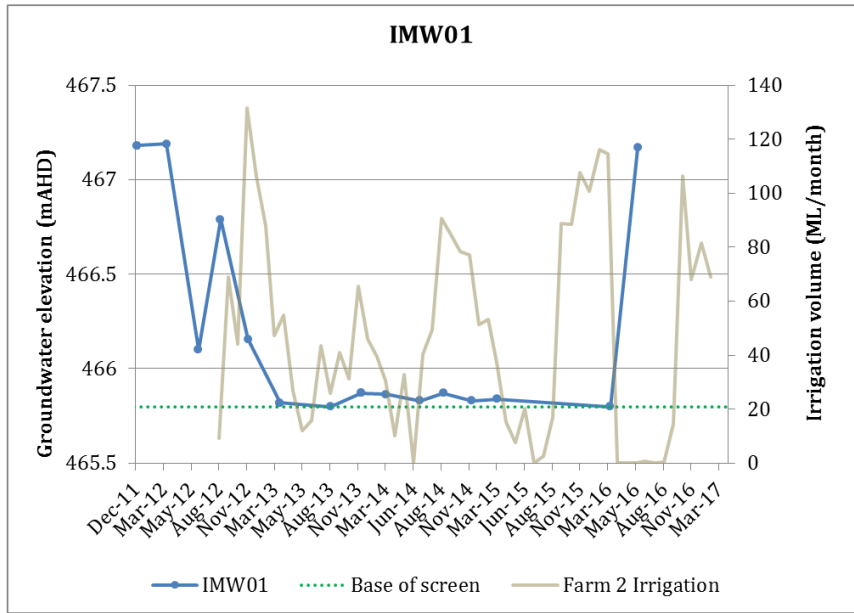


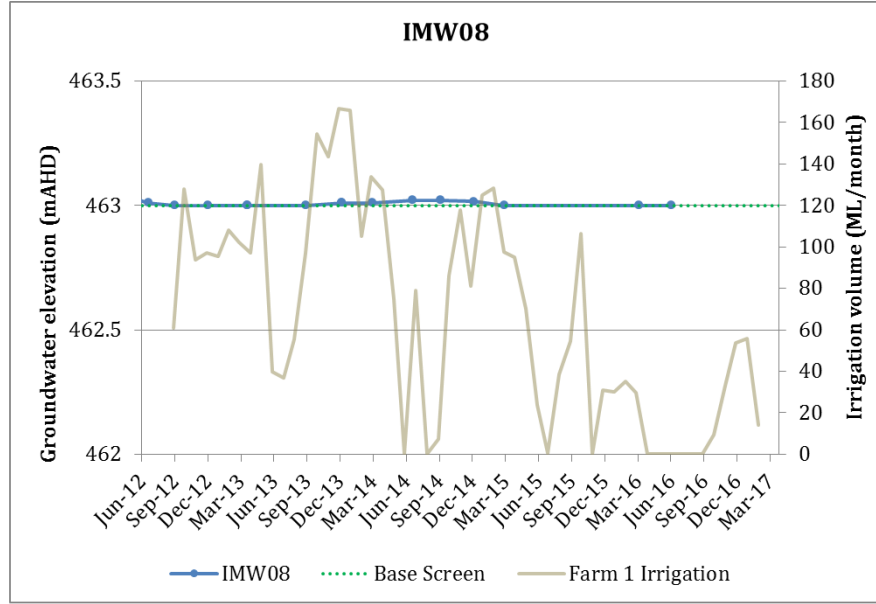
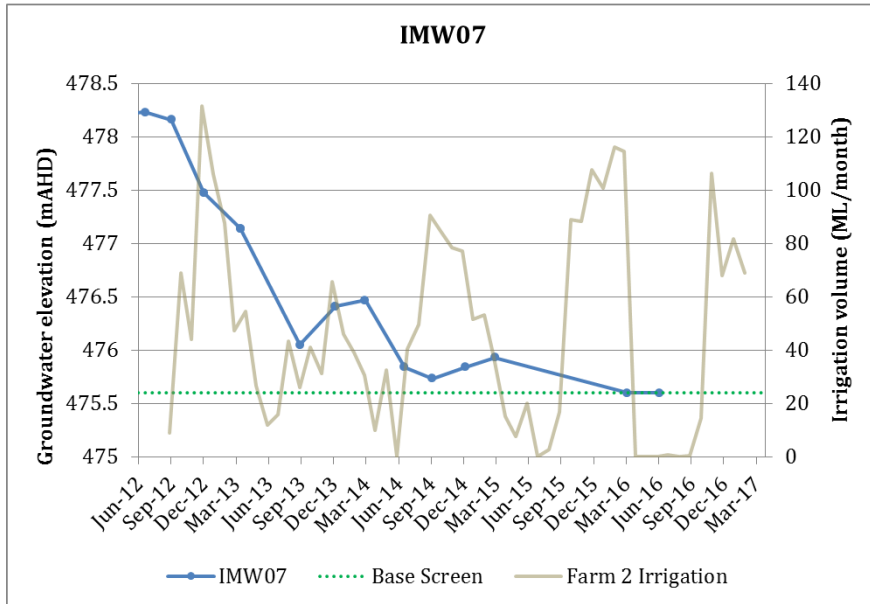
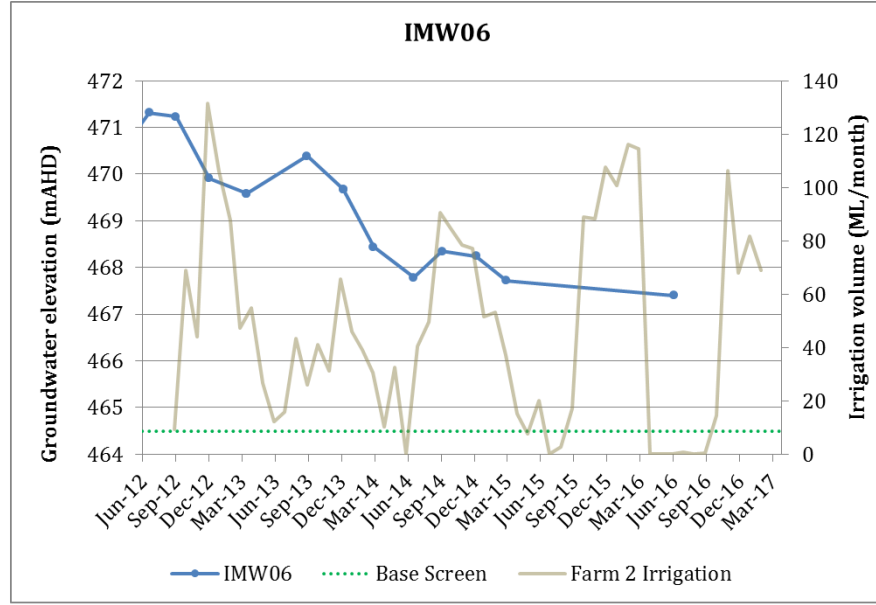
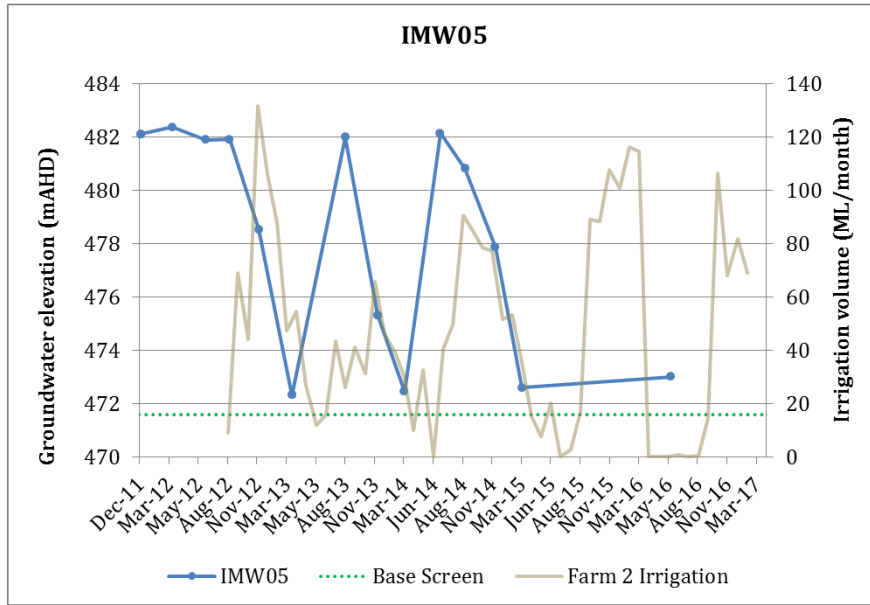


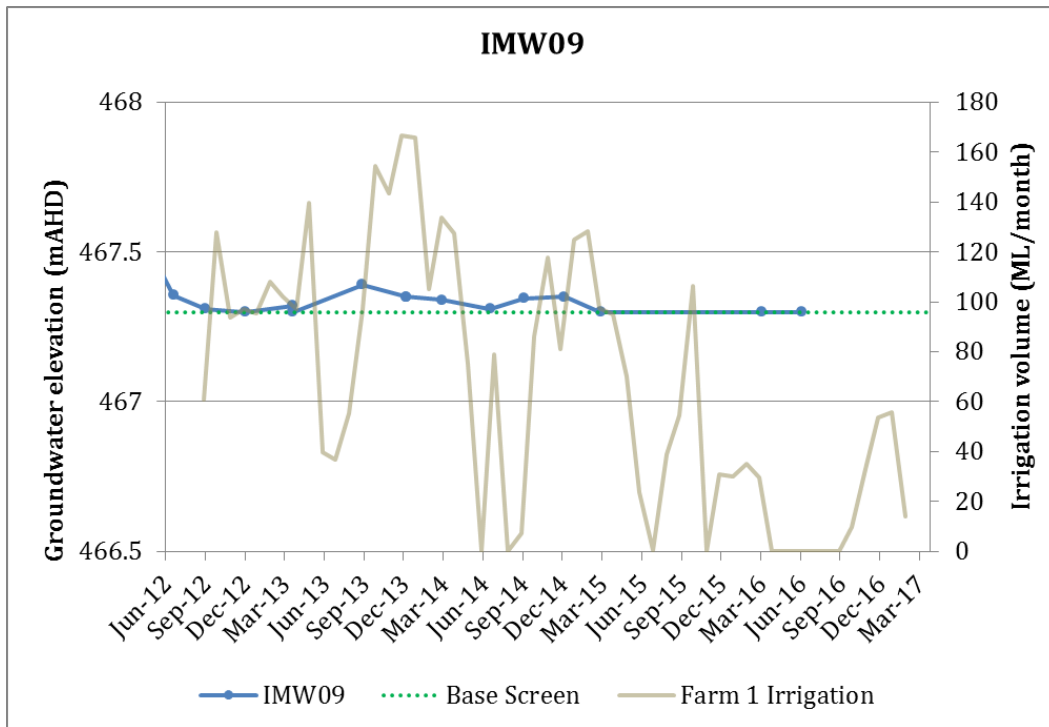




Appendix C **Groundwater level trends – BMN**





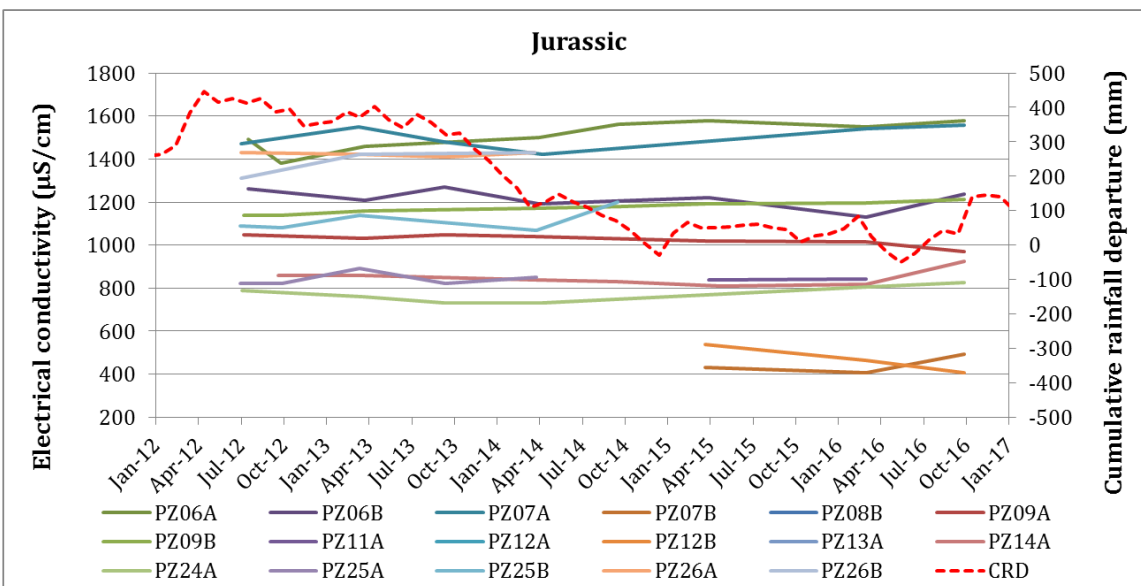
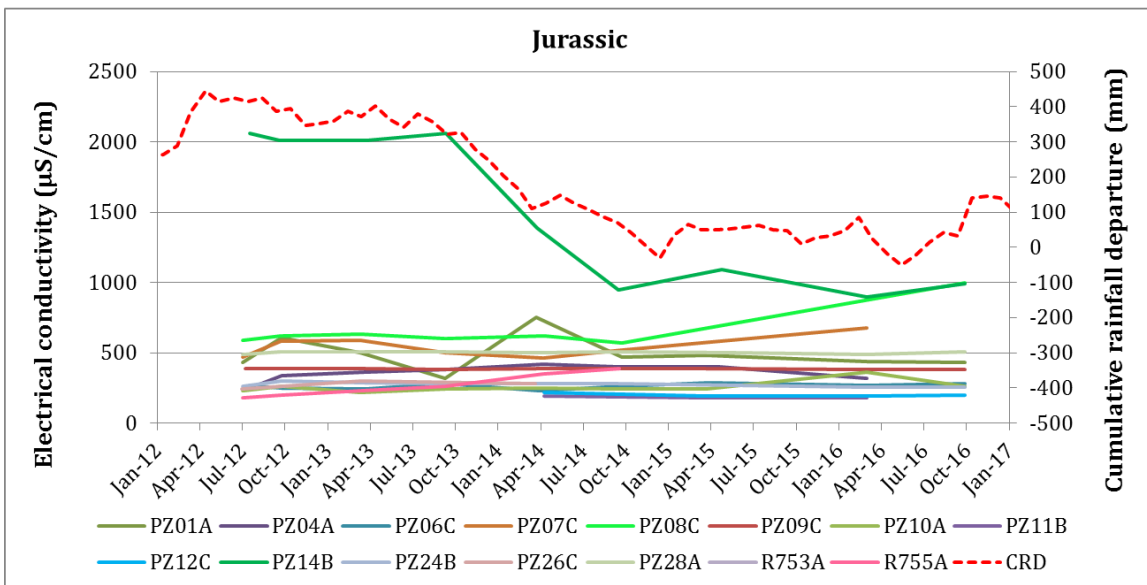
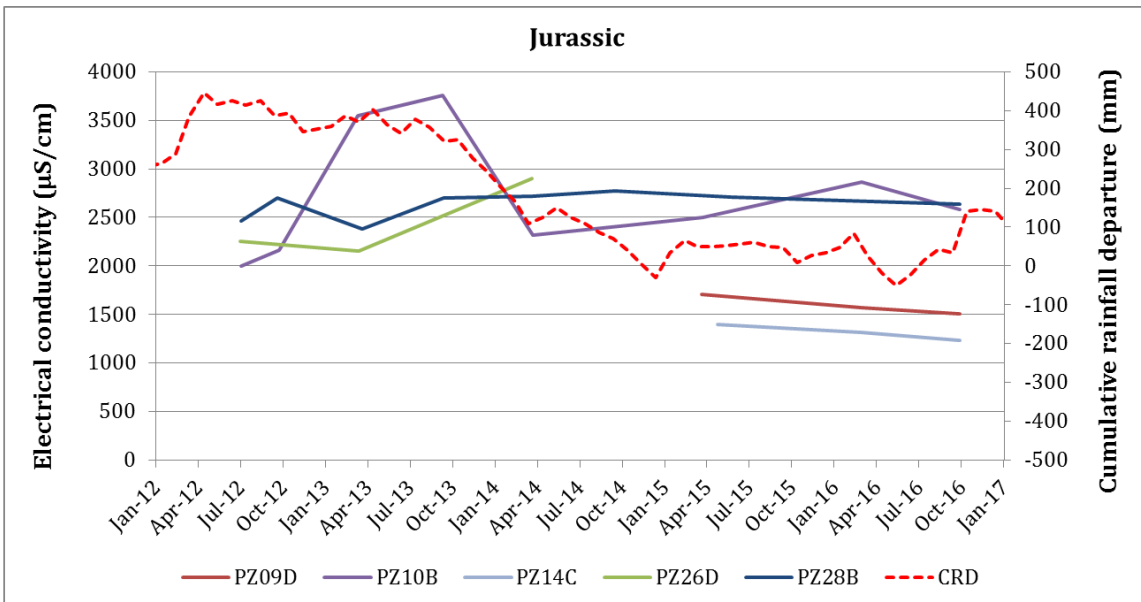


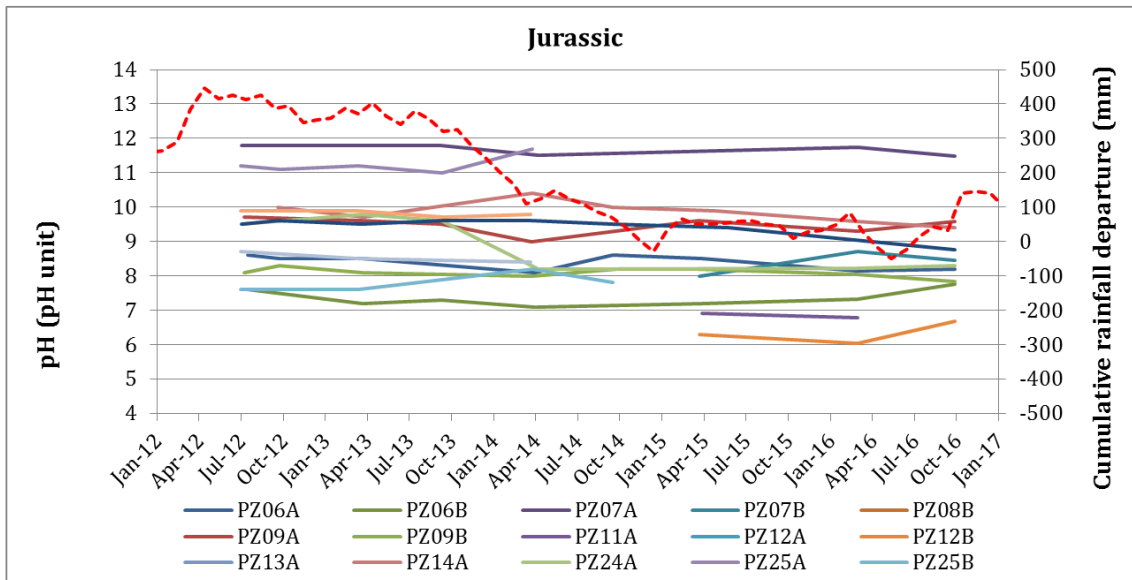
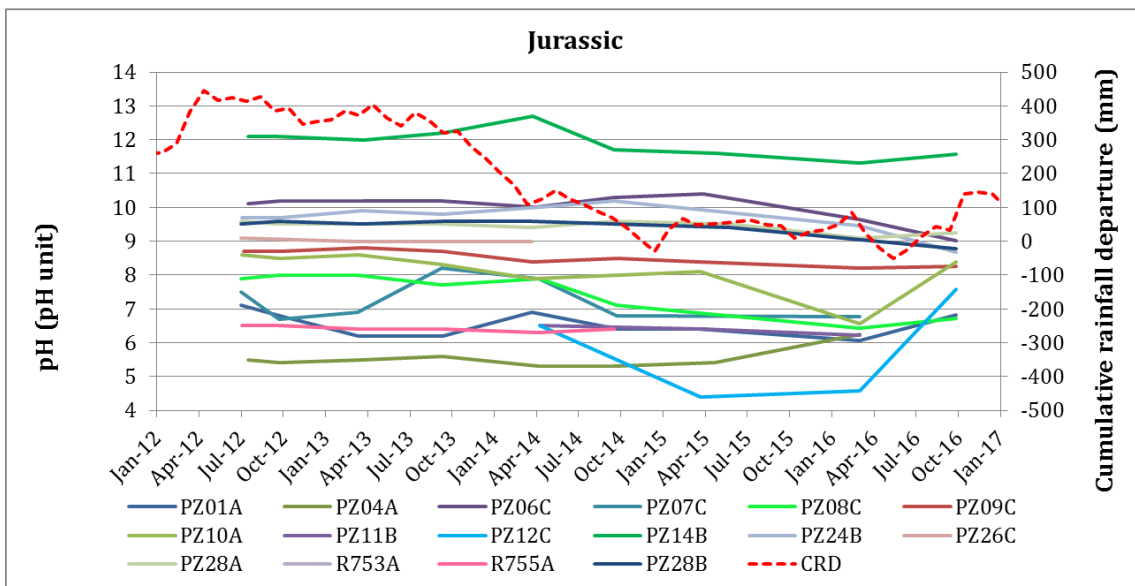
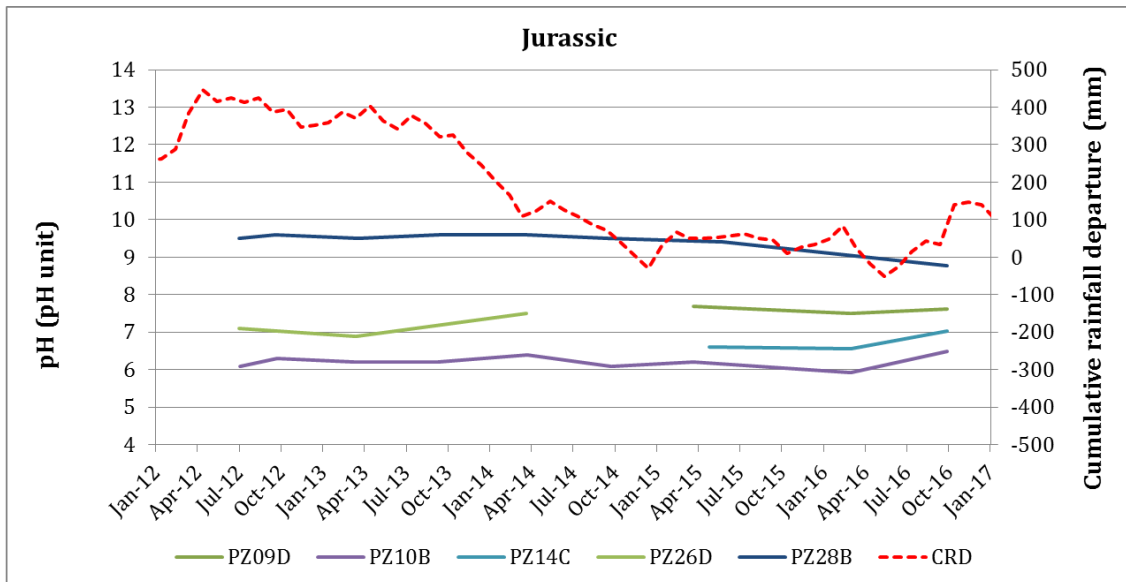
Appendix D **2016 water quality results - NMN**

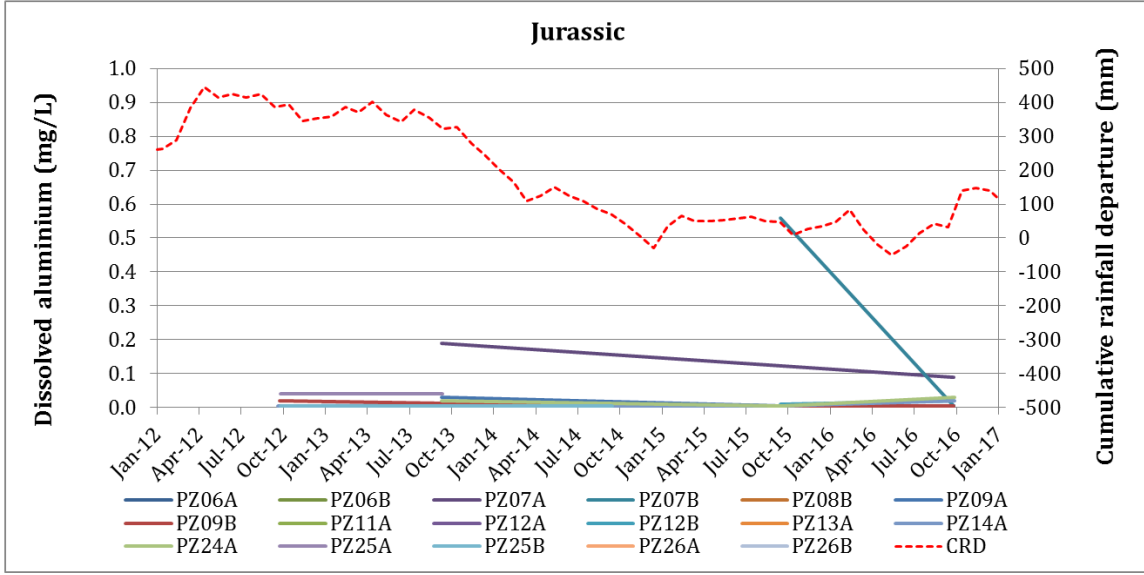
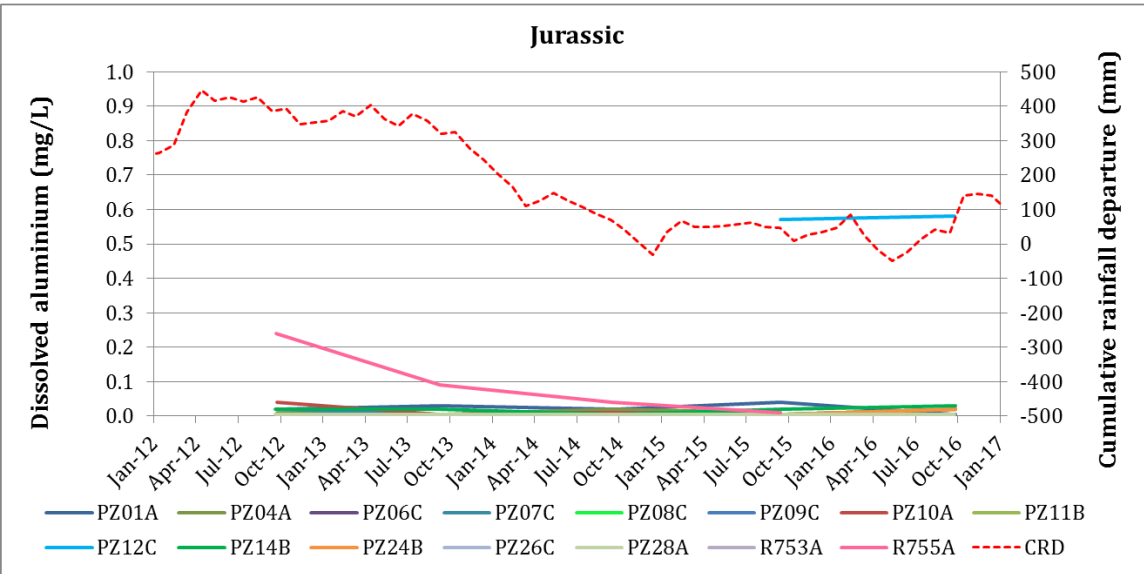
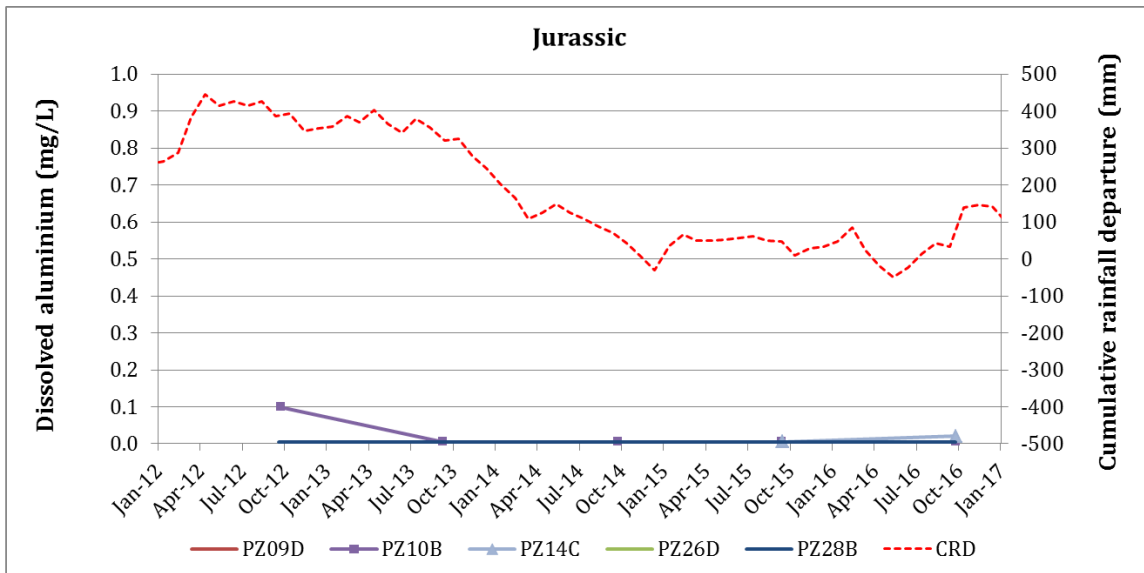
Bore ID	Date	Sample No.	EC µS/cm	pH Lab	Temp °C	Silica mg/L	TDS (Calc.) mg/L	Ca mg/L	Cl mg/L	K mg/L	Na mg/L	Mg mg/L	SO ₄ mg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ammonia as N mg/L	Fluoride mg/L	Total Alkalinity mg/L	CO ₃ mg/L	HCO ₃ mg/L
PZ01A	26/09/201	ME1601357007	438	7.0	-	10.0	295	10	70	3	43	15	6	0.2	<0.01	<0.01	0.1	-	<1	81
PZ04A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ06A	27/09/201	ME1601360007	1550	8.5	-	4.5	1040	5	52	15	423	3	<1	0.1	<0.01	0.7	1.8	-	110	767
PZ06B	27/09/201	ME1601360006	1210	7.6	-	11.4	810	25	58	16	279	8	3	0.1	<0.01	0.7	2.3	-	<1	597
PZ06C	27/09/201	ME1601360005	274	9.1	-	0.2	185	4	38	15	43	<1	<1	<0.01	<0.01	0.1	0.1	-	12	54
PZ07A	26/09/201	ME1601357003	1540	11.5	-	2.5	1030	10	47	17	156	<1	21	<0.01	<0.01	5.4	0.9	-	164	<1
PZ07B	26/09/201	ME1601357004	487	8.2	-	3.5	325	11	37	20	61	6	42	0.1	<0.01	0.04	0.1	-	3	134
PZ07C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ08B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ08C	28/09/201	ME1601367007	962	7.1	-	9.7	645	41	127	2	56	59	6	0.02	<0.01	0.2	0.3	-	<1	310
PZ09A	27/09/201	ME1601360001	981	9.4	-	2.64	656	2	57	8	246	<1	<1	0.01	<0.01	1.72	2.2	-	186	256
PZ09B	27/09/201	ME1601360002	1200	8.1	-	10.1	805	20	86	19	262	8	<1	<0.01	<0.01	1.3	2.4	-	36	496
PZ09C	27/09/201	ME1601360003	371	8.1	-	0.7	250	9	71	3	41	13	<1	<0.01	<0.01	0.0	<0.1	-	<1	62
PZ09D	27/09/201	ME1601360004	1500	7.9	-	4.4	1005	30	292	10	231	45	<1	0.02	<0.01	0.0	<0.1	-	<1	321
PZ10A	27/09/201	ME1601360008	255	8.4	-	1.1	170	10	36	9	26	5	<1	<0.01	<0.01	1.2	0.2	-	<1	74
PZ10B	27/09/201	ME1601360009	3230	6.5	-	9.8	2165	48	799	12	412	132	67	0.04	<0.01	0.4	<0.1	-	<1	174
PZ11A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ11B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ12A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ12B	26/09/201	ME1601357002	458	6.4	-	10.7	305	9	42	14	51	5	44	0.04	<0.01	0.2	0.3	-	<1	90
PZ12C	26/09/201	ME1601357001	189	4.2	-	9.8	125	<1	43	2	22	3	3	0.3	<0.01	<0.01	0.2	-	<1	3
PZ14A	28/09/201	ME1601367004	852	9.0	-	0.2	570	6	236	6	119	18	<1	<0.01	<0.01	0.1	0.1	-	8	44
PZ14B	28/09/201	ME1601367003	982	11.4	-	0.5	660	5	70	6	116	<1	1	0.02	<0.01	0.3	<0.1	-	99	<1
PZ14C	28/09/201	ME1601367002	1200	7.0	-	6.6	805	33	217	8	143	41	122	0.04	<0.01	0.1	0.2	-	<1	173
PZ24A	28/09/201	ME1601367005	822	8.4	-	7.4	550	17	61	14	158	6	<1	0.04	0.11	1.2	1.6	-	18	326
PZ24B	28/09/201	ME1601367006	254	7.7	-	<0.10	170	5	60	2	32	4	<1	<0.01	<0.01	<0.01	0.1	-	<1	10
PZ28A	26/09/201	ME1601357006	515	9.2	-	1.2	345	2	32	9	63	23	<1	<0.01	<0.01	0.2	0.4	-	78	159
PZ28B	26/09/201	ME1601357005	2700	9.1	-	<0.10	1810	31	720	7	363	59	<1	<0.01	<0.01	<0.01	0.2	-	2	20
PZ32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R752	28/09/201	ME1601367001	581	7.7	-	57.6	390	26	14	1	47	33	26	3.5	<0.01	0.1	0.3	-	<1	272
R753A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R755A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

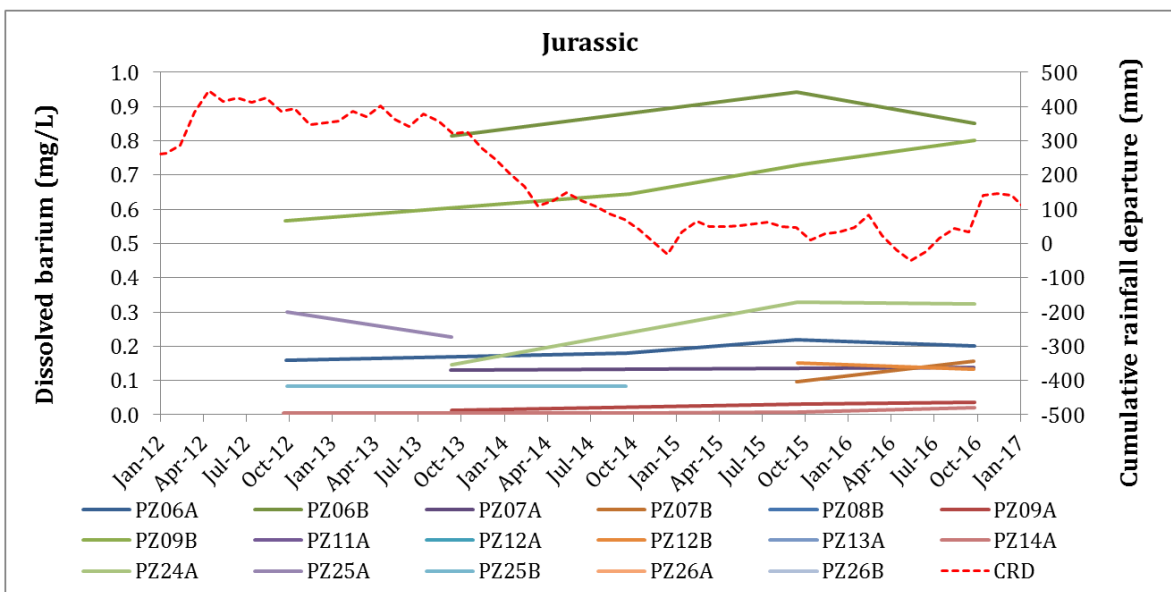
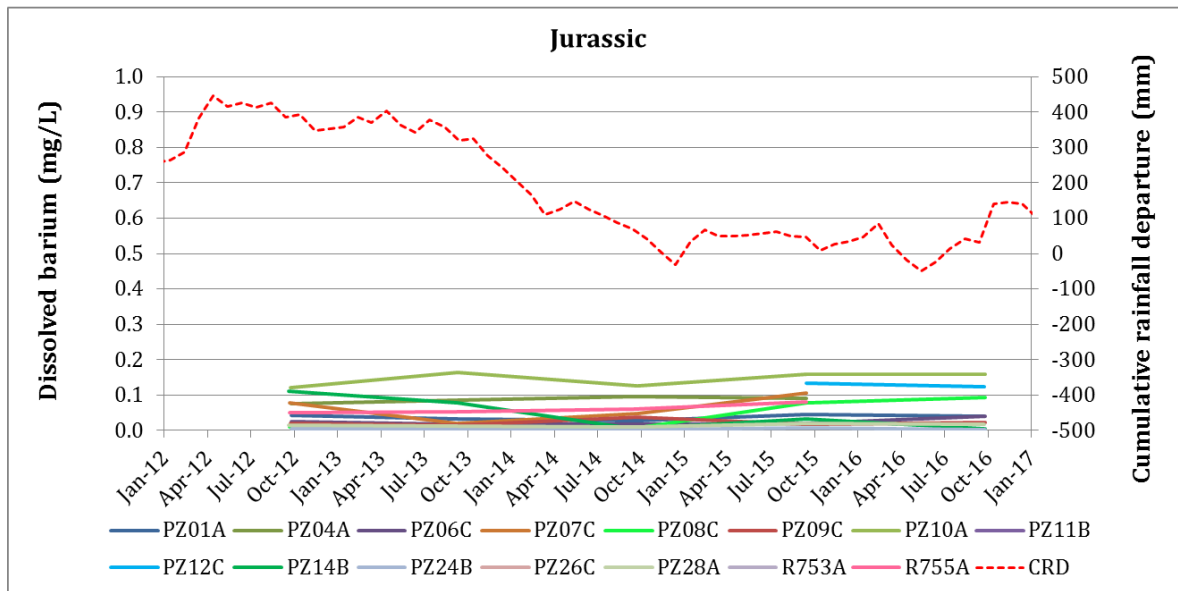
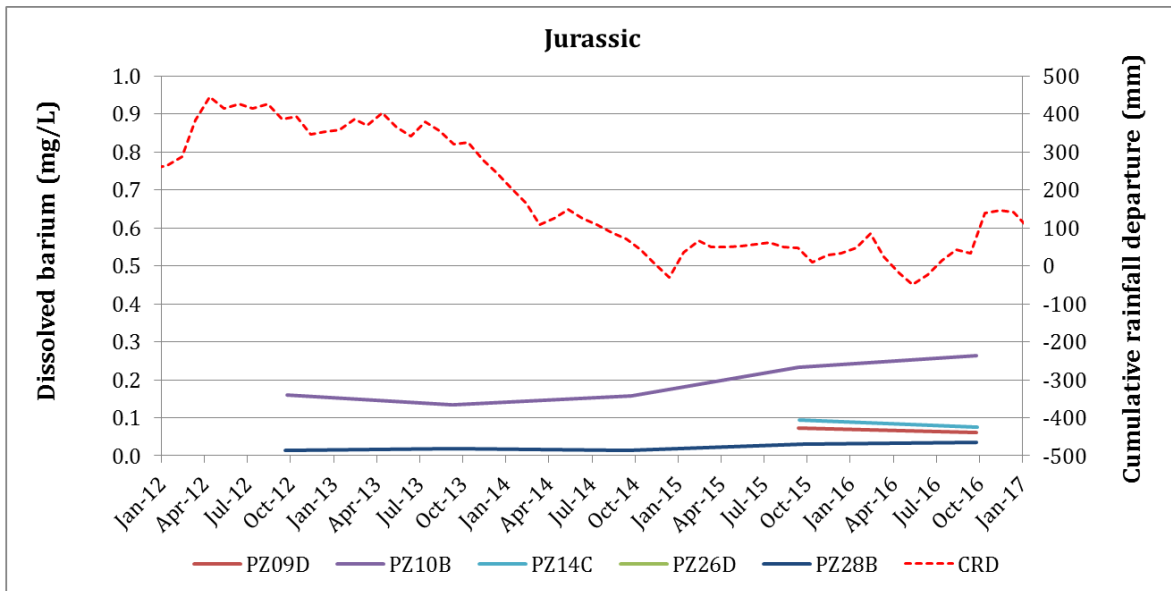
Bore ID	Date	Sample No.	Al (d) mg/L	As (d) mg/L	Ba (d) mg/L	B (d) mg/L	Cd (d) mg/L	Cr (d) mg/L	Cu (d) mg/L	Fe (d) mg/L	Li (d) mg/L	Hg (d) mg/L	Mn (d) mg/L	Mo (d) mg/L	Ni (d) mg/L	Pb (d) mg/L	Se (d) mg/L	Sr (d) mg/L	Zn (d) mg/L
PZ01A	26/09/201	ME1601357007	<0.01	<0.001	0.04	<0.05	<0.0001	0.004	<0.001	<0.05	0.004	<0.0001	0.01	-	0.01	<0.001	<0.01	0.08	0.03
PZ04A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ06A	27/09/201	ME1601360007	<0.01	<0.001	0.20	<0.05	<0.0001	<0.001	<0.001	0.09	0.62	<0.0001	0.01	-	<0.001	<0.001	<0.01	0.05	<0.005
PZ06B	27/09/201	ME1601360006	<0.01	0.001	0.85	<0.05	<0.0001	<0.001	0.003	5.73	0.37	<0.0001	0.03	-	<0.001	<0.001	<0.01	0.19	0.03
PZ06C	27/09/201	ME1601360005	<0.01	<0.001	0.04	<0.05	<0.0001	<0.001	<0.001	<0.05	0.07	<0.0001	0.003	-	<0.001	<0.001	<0.01	0.11	<0.005
PZ07A	26/09/201	ME1601357003	0.09	0.002	0.14	<0.05	<0.0001	<0.001	<0.001	0.05	0.26	<0.0001	<0.001	-	0.004	<0.001	<0.01	0.69	<0.005
PZ07B	26/09/201	ME1601357004	<0.01	<0.001	0.16	0.34	<0.0001	<0.001	<0.001	<0.05	0.19	<0.0001	0.06	-	0.001	<0.001	<0.01	0.16	<0.005
PZ07C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ08B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ08C	28/09/201	ME1601367007	0.02	<0.001	0.09	<0.05	<0.0001	<0.001	<0.001	23.50	0.01	<0.0001	0.16	-	<0.001	<0.001	<0.01	0.13	0.02
PZ09A	27/09/201	ME1601360001	<0.01	0.002	0.036	0.06	<0.0001	<0.001	<0.001	<0.05	0.456	<0.0001	0.006	-	0.002	<0.001	<0.01	0.020	0.009
PZ09B	27/09/201	ME1601360002	<0.01	<0.001	0.80	<0.05	<0.0001	<0.001	<0.001	0.25	0.43	<0.0001	0.01	-	<0.001	<0.001	<0.01	0.21	<0.005
PZ09C	27/09/201	ME1601360003	<0.01	<0.001	0.02	<0.05	<0.0001	<0.001	<0.001	<0.05	0.01	<0.0001	0.05	-	<0.001	<0.001	<0.01	0.05	<0.005
PZ09D	27/09/201	ME1601360004	<0.01	0.002	0.06	<0.05	<0.0001	<0.001	<0.001	2.33	0.08	<0.0001	0.08	-	<0.001	<0.001	<0.01	0.15	0.01
PZ10A	27/09/201	ME1601360008	0.02	<0.001	0.16	<0.05	<0.0001	<0.001	<0.001	<0.05	0.06	<0.0001	0.07	-	<0.001	<0.001	<0.01	0.09	<0.005
PZ10B	27/09/201	ME1601360009	<0.01	<0.001	0.26	<0.05	<0.0001	<0.001	0.004	13.30	0.06	<0.0001	1.08	-	0.002	<0.001	<0.01	0.23	0.11
PZ11A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ11B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ12A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ12B	26/09/201	ME1601357002	0.02	0.001	0.13	0.09	<0.0001	<0.001	0.01	19.80	0.12	<0.0001	0.32	-	0.001	<0.001	<0.01	0.11	0.14
PZ12C	26/09/201	ME1601357001	0.58	0.01	0.12	<0.05	<0.0001	<0.001	0.05	<0.05	0.03	<0.0001	0.74	-	0.02	<0.001	<0.01	0.01	0.10
PZ14A	28/09/201	ME1601367004	0.02	<0.001	0.02	<0.05	<0.0001	<0.001	<0.001	<0.05	0.06	<0.0001	0.03	-	<0.001	<0.001	<0.01	0.03	<0.005
PZ14B	28/09/201	ME1601367003	0.03	<0.001	0.004	<0.05	<0.0001	<0.001	<0.001	<0.05	0.01	<0.0001	<0.001	-	<0.001	<0.001	<0.01	0.02	<0.005
PZ14C	28/09/201	ME1601367002	0.02	<0.001	0.08	<0.05	<0.0001	<0.001	<0.001	1.94	0.06	<0.0001	0.37	-	0.002	<0.001	<0.01	0.14	0.02
PZ24A	28/09/201	ME1601367005	0.03	<0.001	0.32	<0.05	<0.0001	<0.001	<0.001	0.11	0.38	<0.0001	0.03	-	<0.001	<0.001	<0.01	0.27	<0.005
PZ24B	28/09/201	ME1601367006	0.02	<0.001	0.003	<0.05	<0.0001	<0.001	<0.001	<0.05	0.01	<0.0001	0.02	-	<0.001	<0.001	<0.01	0.03	<0.005
PZ28A	26/09/201	ME1601357006	<0.01	<0.001	0.02	<0.05	<0.0001	<0.001	<0.001	<0.05	0.02	<0.0001	0.01	-	<0.001	<0.001	<0.01	0.01	<0.005
PZ28B	26/09/201	ME1601357005	<0.01	<0.001	0.04	<0.05	<0.0001	<0.001	<0.001	<0.05	0.08	<0.0001	0.07	-	<0.001	<0.001	<0.01	0.23	<0.005
PZ32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R752	28/09/201	ME1601367001	0.04	<0.001	0.01	<0.05	<0.0001	<0.001	0.00	<0.05	0.01	<0.0001	0.01	-	0.002	<0.001	<0.01	0.02	0.03
R753A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R755A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

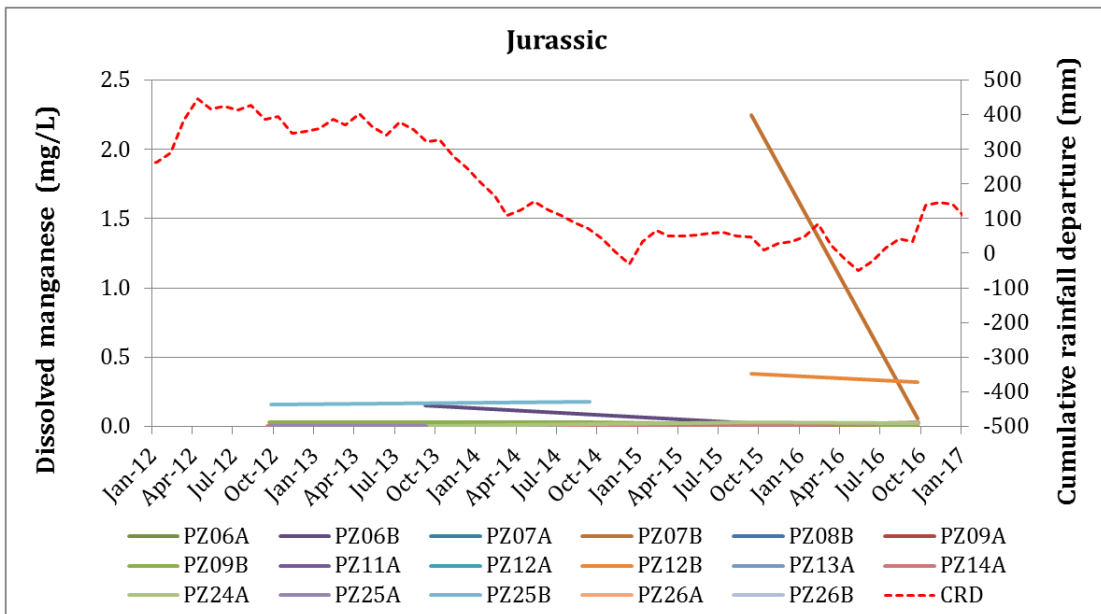
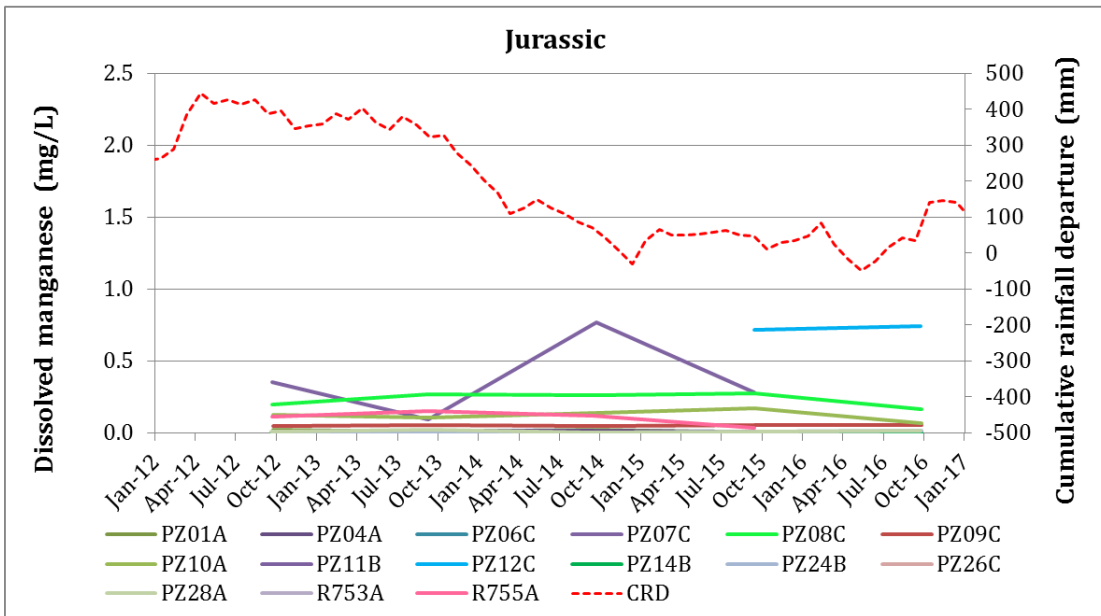
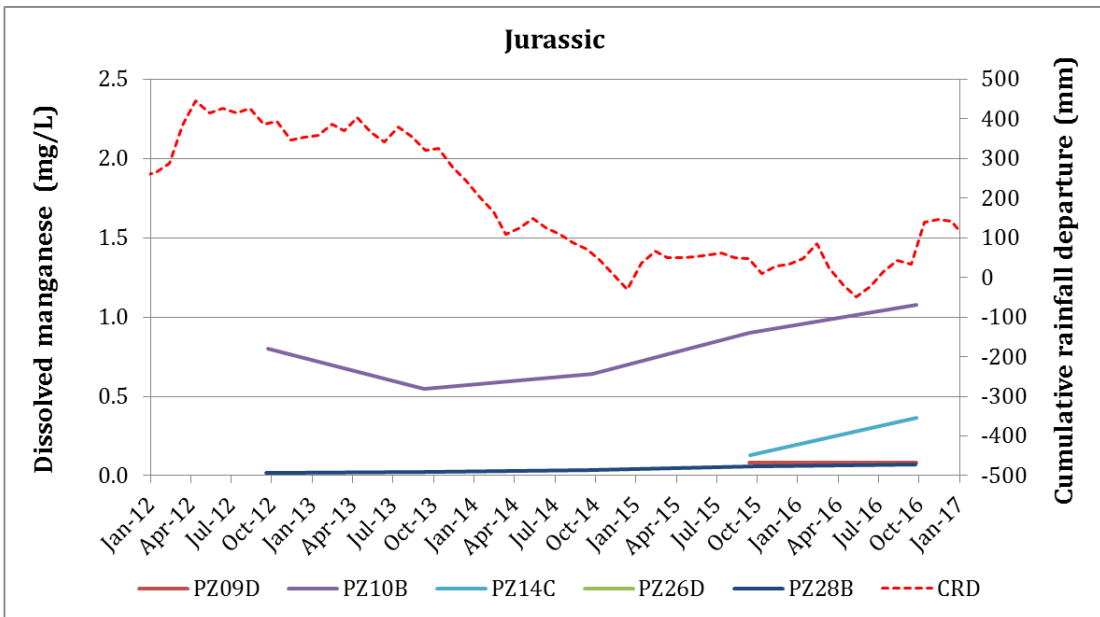
Note: (d) dissolved metals











CERTIFICATE OF ANALYSIS

Work Order	: ME1601357	Page	: 1 of 6
Client	: ULAN COAL MINES LIMITED	Laboratory	: Environmental Division Mudgee
Contact	: Mr Tom Frankham	Contact	: Mary Monds
Address	: Locked Bag 6015 HRMC Newcastle NSW 2310	Address	: 1/29 Sydney Road Mudgee NSW AUSTRALIA 2850
Telephone	: +61 02 6372 5300	Telephone	: 02 6372 6735
Project	: Nth Monitoring Network - Annual	Date Samples Received	: 26-Sep-2016 16:45
Order number	: ----	Date Analysis Commenced	: 28-Sep-2016
C-O-C number	: ----	Issue Date	: 05-Oct-2016 12:20
Sampler	: Neville Buckley		
Site	: ----		
Quote number	: ----		
No. of samples received	: 7		
No. of samples analysed	: 7		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Mary Monds	Environmental Services Representative	Laboratory - Mudgee, Mudgee, NSW



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

∅ = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- Samples were received outside of recommended ALS holding times for analysis of pH. Results should be scrutinised accordingly.
- Ionic Balance out of acceptable limits for samples 2 and 6 due to analytes not quantified in this report.
- Metals by EG020; Mercury by EG035; Silica by EG052; Ammonia by EK055; Nitrite by EK057; Nitrate by EK058; Alkalinity by ED037; Chloride by ED045; Fluoride by EK040; Sulfate by ED041; Major Cations by ED093 and Ionic Balance by EN055 are conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	PZ12C	PZ12B	PZ07A	PZ07B	PZ28B
Client sampling date / time				26-Sep-2016 09:35	26-Sep-2016 10:00	26-Sep-2016 11:20	26-Sep-2016 12:10	26-Sep-2016 13:50	
Compound	CAS Number	LOR	Unit	ME1601357-001	ME1601357-002	ME1601357-003	ME1601357-004	ME1601357-005	
				Result	Result	Result	Result	Result	
EA005: pH									
pH Value	----	0.01	pH Unit	4.2	6.4	11.5	8.2	9.1	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	189	458	1540	487	2700	
ED037P: Alkalinity by PC Titrator									
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	164	3	2	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	3	90	<1	134	20	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3	44	21	42	<1	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	43	42	47	37	720	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	<1	9	10	11	31	
Magnesium	7439-95-4	1	mg/L	3	5	<1	6	59	
Sodium	7440-23-5	1	mg/L	22	51	156	61	363	
Potassium	7440-09-7	1	mg/L	2	14	17	20	7	
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L	0.58	0.02	0.09	<0.01	<0.01	
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Arsenic	7440-38-2	0.001	mg/L	0.005	0.001	0.002	<0.001	<0.001	
Boron	7440-42-8	0.05	mg/L	<0.05	0.09	<0.05	0.34	<0.05	
Strontium	7440-24-6	0.001	mg/L	0.006	0.107	0.692	0.163	0.230	
Barium	7440-39-3	0.001	mg/L	0.124	0.133	0.138	0.157	0.036	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	0.051	0.005	<0.001	<0.001	<0.001	
Lithium	7439-93-2	0.001	mg/L	0.034	0.120	0.256	0.186	0.076	
Manganese	7439-96-5	0.001	mg/L	0.740	0.318	<0.001	0.060	0.073	
Nickel	7440-02-0	0.001	mg/L	0.022	0.001	0.004	0.001	<0.001	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
Zinc	7440-66-6	0.005	mg/L	0.098	0.144	<0.005	<0.005	<0.005	
Iron	7439-89-6	0.05	mg/L	<0.05	19.8	0.05	<0.05	<0.05	
EG035F: Dissolved Mercury by FIMS									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	PZ12C	PZ12B	PZ07A	PZ07B	PZ28B
Client sampling date / time				26-Sep-2016 09:35	26-Sep-2016 10:00	26-Sep-2016 11:20	26-Sep-2016 12:10	26-Sep-2016 13:50	
Compound	CAS Number	LOR	Unit	ME1601357-001	ME1601357-002	ME1601357-003	ME1601357-004	ME1601357-005	
				Result	Result	Result	Result	Result	
EG035F: Dissolved Mercury by FIMS - Continued									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EG052G: Silica by Discrete Analyser									
Reactive Silica	----	0.1	mg/L	9.75	10.7	2.46	3.48	<0.10	
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L	0.2	0.3	0.9	0.1	0.2	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.19	5.43	0.04	<0.01	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.29	0.04	<0.01	0.13	<0.01	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	1.34	3.90	8.18	4.66	20.7	
Total Cations	----	0.01	meq/L	1.26	3.44	7.72	4.21	22.4	
Ionic Balance	----	0.01	%	----	6.32	2.92	5.07	3.75	
MUD-WAT: Total Dissolved Solids - Calculated									
∅ Total Dissolved Solids (Calc.)	----	4	mg/L	125	305	1030	325	1810	



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		PZ28A	PZ01A	----	----	----
Client sampling date / time		26-Sep-2016 14:10		26-Sep-2016 14:50		----	----	----
Compound	CAS Number	LOR	Unit	ME1601357-006	ME1601357-007	-----	-----	-----
				Result	Result	----	----	----
EA005: pH								
pH Value	----	0.01	pH Unit	9.2	7.0	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	515	438	----	----	----
ED037P: Alkalinity by PC Titrator								
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	78	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	159	81	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	6	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	32	70	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	2	10	----	----	----
Magnesium	7439-95-4	1	mg/L	23	15	----	----	----
Sodium	7440-23-5	1	mg/L	63	43	----	----	----
Potassium	7440-09-7	1	mg/L	9	3	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	----	----	----
Strontium	7440-24-6	0.001	mg/L	0.009	0.075	----	----	----
Barium	7440-39-3	0.001	mg/L	0.016	0.039	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	0.004	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Lithium	7439-93-2	0.001	mg/L	0.020	0.004	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.013	0.006	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	0.005	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	0.033	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	----	----	----
EG035F: Dissolved Mercury by FIMS								



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	PZ28A	PZ01A	----	----	----
Client sampling date / time				26-Sep-2016 14:10	26-Sep-2016 14:50	----	----	----	
Compound	CAS Number	LOR	Unit	ME1601357-006	ME1601357-007	-----	-----	-----	
				Result	Result	----	----	----	
EG035F: Dissolved Mercury by FIMS - Continued									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----	
EG052G: Silica by Discrete Analyser									
Reactive Silica	----	0.1	mg/L	1.17	10.0	----	----	----	
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L	0.4	0.1	----	----	----	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.20	<0.01	----	----	----	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	----	----	----	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.23	----	----	----	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	5.64	3.72	----	----	----	
Total Cations	----	0.01	meq/L	4.96	3.68	----	----	----	
Ionic Balance	----	0.01	%	6.41	0.52	----	----	----	
MUD-WAT: Total Dissolved Solids - Calculated									
∅ Total Dissolved Solids (Calc.)	----	4	mg/L	345	295	----	----	----	

CERTIFICATE OF ANALYSIS

Work Order	: ME1601360	Page	: 1 of 6
Client	: ULAN COAL MINES LIMITED	Laboratory	: Environmental Division Mudgee
Contact	: Mr Tom Frankham	Contact	: Mary Monds
Address	: Locked Bag 6015 HRMC Newcastle NSW 2310	Address	: 1/29 Sydney Road Mudgee NSW AUSTRALIA 2850
Telephone	: +61 02 6372 5300	Telephone	: 02 6372 6735
Project	: Nth Monitoring Network - Annual	Date Samples Received	: 27-Sep-2016 17:51
Order number	: ----	Date Analysis Commenced	: 28-Sep-2016
C-O-C number	: ----	Issue Date	: 06-Oct-2016 12:03
Sampler	: Neville Buckley		
Site	: ----		
Quote number	: ----		
No. of samples received	: 9		
No. of samples analysed	: 9		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Mary Monds	Environmental Services Representative	Laboratory - Mudgee, Mudgee, NSW
RICHARD TEA	Lab technician	Sydney Inorganics, Smithfield, NSW



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Samples were received outside of recommended ALS holding times for analysis of pH. Results should be scrutinised accordingly.
- Metals by EG020; Mercury by EG035; Silica by EG052; Ammonia by EK055; Nitrite by EK057; Nitrate by EK058; Alkalinity by ED037; Chloride by ED045; Fluoride by EK040; Sulfate by ED041; Major Cations by ED093 and Ionic Balance by EN055 are conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	PZ09A	PZ09B	PZ09C	PZ09D	PZ06C
Client sampling date / time				27-Sep-2016 09:00	27-Sep-2016 09:45	27-Sep-2016 10:40	27-Sep-2016 11:05	27-Sep-2016 12:00	
Compound	CAS Number	LOR	Unit	ME1601360-001	ME1601360-002	ME1601360-003	ME1601360-004	ME1601360-005	
				Result	Result	Result	Result	Result	
EA005: pH									
pH Value	----	0.01	pH Unit	9.4	8.1	8.1	7.9	9.1	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	981	1200	371	1500	274	
ED037P: Alkalinity by PC Titrator									
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	186	36	<1	<1	12	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	256	496	62	321	54	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	<1	<1	<1	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	57	86	71	292	38	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	2	20	9	30	4	
Magnesium	7439-95-4	1	mg/L	<1	8	13	45	<1	
Sodium	7440-23-5	1	mg/L	246	262	41	231	43	
Potassium	7440-09-7	1	mg/L	8	19	3	10	15	
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Arsenic	7440-38-2	0.001	mg/L	0.002	<0.001	<0.001	0.002	<0.001	
Boron	7440-42-8	0.05	mg/L	0.06	<0.05	<0.05	<0.05	<0.05	
Strontium	7440-24-6	0.001	mg/L	0.020	0.212	0.046	0.146	0.110	
Barium	7440-39-3	0.001	mg/L	0.036	0.801	0.023	0.061	0.040	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Lithium	7439-93-2	0.001	mg/L	0.456	0.426	0.008	0.075	0.074	
Manganese	7439-96-5	0.001	mg/L	0.006	0.013	0.053	0.081	0.003	
Nickel	7440-02-0	0.001	mg/L	0.002	<0.001	<0.001	<0.001	<0.001	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
Zinc	7440-66-6	0.005	mg/L	0.009	<0.005	<0.005	0.005	<0.005	
Iron	7439-89-6	0.05	mg/L	<0.05	0.25	<0.05	2.33	<0.05	
EG035F: Dissolved Mercury by FIMS									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	PZ09A	PZ09B	PZ09C	PZ09D	PZ06C
Client sampling date / time				27-Sep-2016 09:00	27-Sep-2016 09:45	27-Sep-2016 10:40	27-Sep-2016 11:05	27-Sep-2016 12:00	
Compound	CAS Number	LOR	Unit	ME1601360-001	ME1601360-002	ME1601360-003	ME1601360-004	ME1601360-005	
				Result	Result	Result	Result	Result	
EG035F: Dissolved Mercury by FIMS - Continued									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EG052G: Silica by Discrete Analyser									
Reactive Silica	----	0.1	mg/L	2.64	10.1	0.66	4.43	0.17	
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L	2.2	2.4	<0.1	<0.1	0.1	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	1.72	1.32	0.03	0.04	0.05	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.01	<0.01	<0.01	0.02	<0.01	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	10.4	13.1	3.24	14.6	2.37	
Total Cations	----	0.01	meq/L	11.0	13.5	3.38	15.5	2.45	
Ionic Balance	----	0.01	%	2.58	1.69	2.06	2.81	1.70	
MUD-WAT: Total Dissolved Solids - Calculated									
∅ Total Dissolved Solids (Calc.)	----	4	mg/L	656	805	250	1005	185	



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID			PZ06B	PZ06A	PZ10A	PZ10B	----
		Client sampling date / time			27-Sep-2016 12:20	27-Sep-2016 12:45	27-Sep-2016 14:00	27-Sep-2016 14:30	----
Compound	CAS Number	LOR	Unit	ME1601360-006	ME1601360-007	ME1601360-008	ME1601360-009	-----	
				Result	Result	Result	Result	----	
EA005: pH									
pH Value	----	0.01	pH Unit	7.6	8.5	8.4	6.5	----	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	1210	1550	255	3230	----	
ED037P: Alkalinity by PC Titrator									
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	110	<1	<1	----	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	597	767	74	174	----	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3	<1	<1	67	----	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	58	52	36	799	----	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	25	5	10	48	----	
Magnesium	7439-95-4	1	mg/L	8	3	5	132	----	
Sodium	7440-23-5	1	mg/L	279	423	26	412	----	
Potassium	7440-09-7	1	mg/L	16	15	9	12	----	
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.02	<0.01	----	
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----	
Arsenic	7440-38-2	0.001	mg/L	0.001	<0.001	<0.001	<0.001	----	
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	----	
Strontium	7440-24-6	0.001	mg/L	0.186	0.050	0.089	0.228	----	
Barium	7440-39-3	0.001	mg/L	0.850	0.202	0.160	0.264	----	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----	
Copper	7440-50-8	0.001	mg/L	0.003	<0.001	<0.001	0.004	----	
Lithium	7439-93-2	0.001	mg/L	0.369	0.615	0.057	0.058	----	
Manganese	7439-96-5	0.001	mg/L	0.026	0.006	0.068	1.08	----	
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	0.002	----	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----	
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----	
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----	
Zinc	7440-66-6	0.005	mg/L	0.026	<0.005	<0.005	0.105	----	
Iron	7439-89-6	0.05	mg/L	5.73	0.09	<0.05	13.3	----	
EG035F: Dissolved Mercury by FIMS									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	PZ06B	PZ06A	PZ10A	PZ10B	----
Client sampling date / time				27-Sep-2016 12:20	27-Sep-2016 12:45	27-Sep-2016 14:00	27-Sep-2016 14:30	----	
Compound	CAS Number	LOR	Unit	ME1601360-006	ME1601360-007	ME1601360-008	ME1601360-009	-----	
				Result	Result	Result	Result	----	
EG035F: Dissolved Mercury by FIMS - Continued									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----	
EG052G: Silica by Discrete Analyser									
Reactive Silica	----	0.1	mg/L	11.4	4.48	1.06	9.77	----	
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L	2.3	1.8	0.2	<0.1	----	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.69	0.70	1.20	0.42	----	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.09	0.13	<0.01	0.04	----	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	13.6	19.0	2.49	27.4	----	
Total Cations	----	0.01	meq/L	14.4	19.3	2.27	31.5	----	
Ionic Balance	----	0.01	%	2.88	0.69	----	6.91	----	
MUD-WAT: Total Dissolved Solids - Calculated									
∅ Total Dissolved Solids (Calc.)	----	4	mg/L	810	1040	170	2165	----	

CERTIFICATE OF ANALYSIS

Work Order	: ME1601367	Page	: 1 of 6
Client	: ULAN COAL MINES LIMITED	Laboratory	: Environmental Division Mudgee
Contact	: Mr Tom Frankham	Contact	: Mary Monds
Address	: Locked Bag 6015 HRMC Newcastle NSW 2310	Address	: 1/29 Sydney Road Mudgee NSW AUSTRALIA 2850
Telephone	: +61 02 6372 5300	Telephone	: 02 6372 6735
Project	: Nth Monitoring Network - Annual	Date Samples Received	: 29-Sep-2016 07:30
Order number	: ----	Date Analysis Commenced	: 29-Sep-2016
C-O-C number	: ----	Issue Date	: 06-Oct-2016 12:03
Sampler	: Neville Buckley		
Site	: ----		
Quote number	: ----		
No. of samples received	: 7		
No. of samples analysed	: 7		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Mary Monds	Environmental Services Representative	Laboratory - Mudgee, Mudgee, NSW
RICHARD TEA	Lab technician	Sydney Inorganics, Smithfield, NSW



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

∅ = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- Samples were received outside of recommended ALS holding times for analysis of pH. Results should be scrutinised accordingly.
- Metals by EG020; Mercury by EG035; Silica by EG052; Ammonia by EK055; Nitrite by EK057; Nitrate by EK058; Alkalinity by ED037; Chloride by ED045; Fluoride by EK040; Sulfate by ED041; Major Cations by ED093 and Ionic Balance by EN055 are conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	R752	PZ14C	PZ14B	PZ14A	PZ24A
Client sampling date / time				28-Sep-2016 10:30	28-Sep-2016 11:20	28-Sep-2016 11:40	28-Sep-2016 12:00	28-Sep-2016 13:00	
Compound	CAS Number	LOR	Unit	ME1601367-001	ME1601367-002	ME1601367-003	ME1601367-004	ME1601367-005	
				Result	Result	Result	Result	Result	
EA005: pH									
pH Value	----	0.01	pH Unit	7.7	7.0	11.4	9.0	8.4	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	581	1200	982	852	822	
ED037P: Alkalinity by PC Titrator									
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	99	8	18	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	272	173	<1	44	326	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	26	122	1	<1	<1	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	14	217	70	236	61	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	26	33	5	6	17	
Magnesium	7439-95-4	1	mg/L	33	41	<1	18	6	
Sodium	7440-23-5	1	mg/L	47	143	116	119	158	
Potassium	7440-09-7	1	mg/L	1	8	6	6	14	
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L	0.04	0.02	0.03	0.02	0.03	
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	
Strontium	7440-24-6	0.001	mg/L	0.022	0.135	0.018	0.030	0.266	
Barium	7440-39-3	0.001	mg/L	0.013	0.075	0.004	0.020	0.323	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	0.002	<0.001	<0.001	<0.001	<0.001	
Lithium	7439-93-2	0.001	mg/L	0.013	0.062	0.014	0.059	0.382	
Manganese	7439-96-5	0.001	mg/L	0.005	0.367	<0.001	0.029	0.026	
Nickel	7440-02-0	0.001	mg/L	0.002	0.002	<0.001	<0.001	<0.001	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
Zinc	7440-66-6	0.005	mg/L	0.030	0.015	<0.005	<0.005	<0.005	
Iron	7439-89-6	0.05	mg/L	<0.05	1.94	<0.05	<0.05	0.11	
EG035F: Dissolved Mercury by FIMS									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	R752	PZ14C	PZ14B	PZ14A	PZ24A
Client sampling date / time				28-Sep-2016 10:30	28-Sep-2016 11:20	28-Sep-2016 11:40	28-Sep-2016 12:00	28-Sep-2016 13:00	
Compound	CAS Number	LOR	Unit	ME1601367-001	ME1601367-002	ME1601367-003	ME1601367-004	ME1601367-005	
				Result	Result	Result	Result	Result	
EG035F: Dissolved Mercury by FIMS - Continued									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EG052G: Silica by Discrete Analyser									
Reactive Silica	----	0.1	mg/L	57.6	6.62	0.47	0.16	7.36	
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L	0.3	0.2	<0.1	0.1	1.6	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.11	0.05	0.25	0.07	1.15	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.11	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	3.54	0.04	0.02	<0.01	0.04	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	6.37	12.1	5.35	7.70	8.57	
Total Cations	----	0.01	meq/L	6.08	11.4	5.45	7.11	8.57	
Ionic Balance	----	0.01	%	2.34	2.87	0.85	3.97	0.05	
MUD-WAT: Total Dissolved Solids - Calculated									
∅ Total Dissolved Solids (Calc.)	----	4	mg/L	390	805	660	570	550	



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		PZ24B	PZ08C	----	----	----
Client sampling date / time		28-Sep-2016 13:35		28-Sep-2016 14:30		----	----	----
Compound	CAS Number	LOR	Unit	ME1601367-006	ME1601367-007	-----	-----	-----
				Result	Result	----	----	----
EA005: pH								
pH Value	----	0.01	pH Unit	7.7	7.1	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	254	962	----	----	----
ED037P: Alkalinity by PC Titrator								
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	10	310	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	6	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	60	127	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	5	41	----	----	----
Magnesium	7439-95-4	1	mg/L	4	59	----	----	----
Sodium	7440-23-5	1	mg/L	32	56	----	----	----
Potassium	7440-09-7	1	mg/L	2	2	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	0.02	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	----	----	----
Strontium	7440-24-6	0.001	mg/L	0.027	0.128	----	----	----
Barium	7440-39-3	0.001	mg/L	0.003	0.093	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Lithium	7439-93-2	0.001	mg/L	0.006	0.008	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.017	0.160	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	0.023	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	23.5	----	----	----
EG035F: Dissolved Mercury by FIMS								



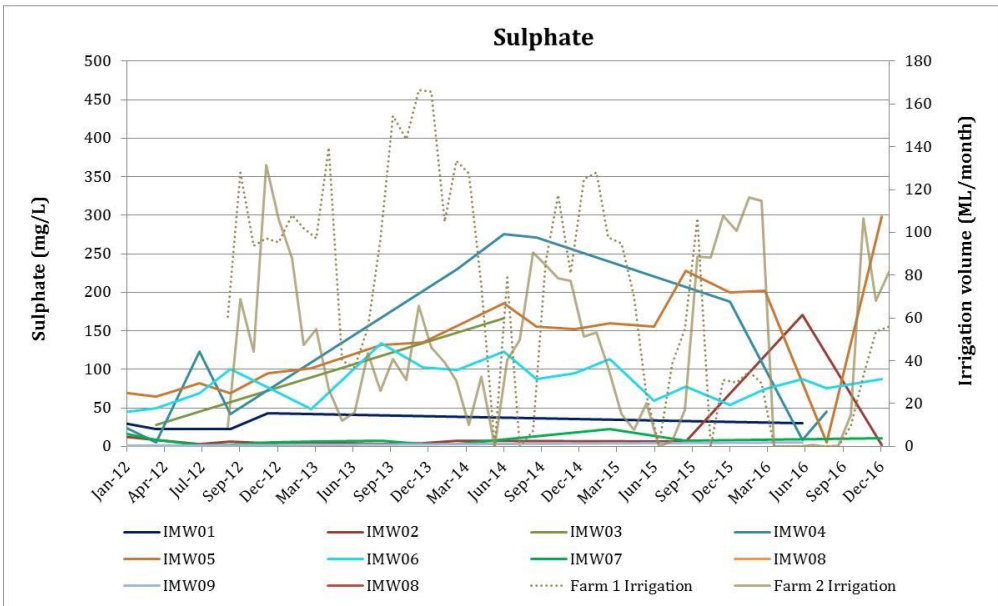
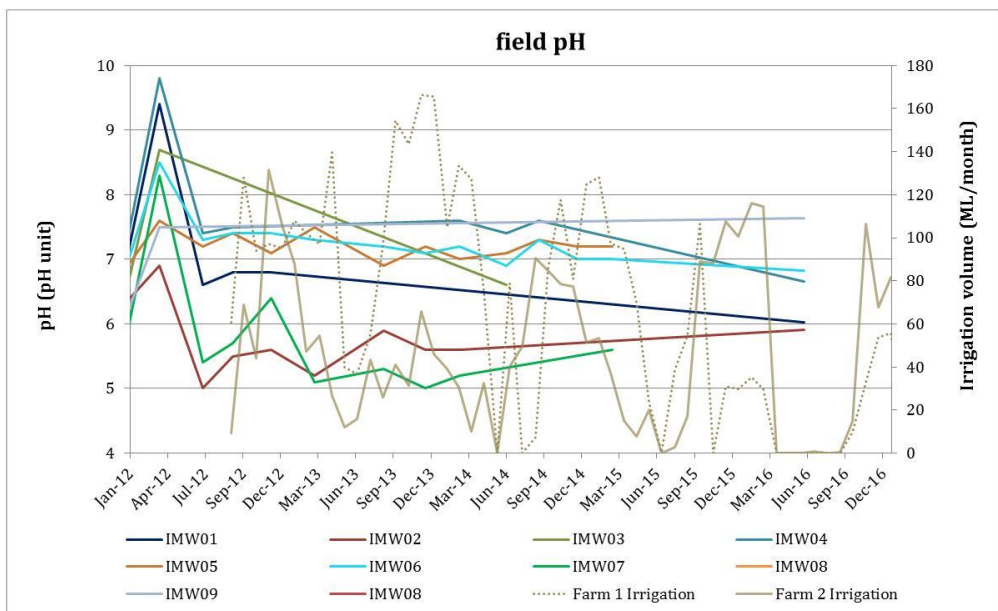
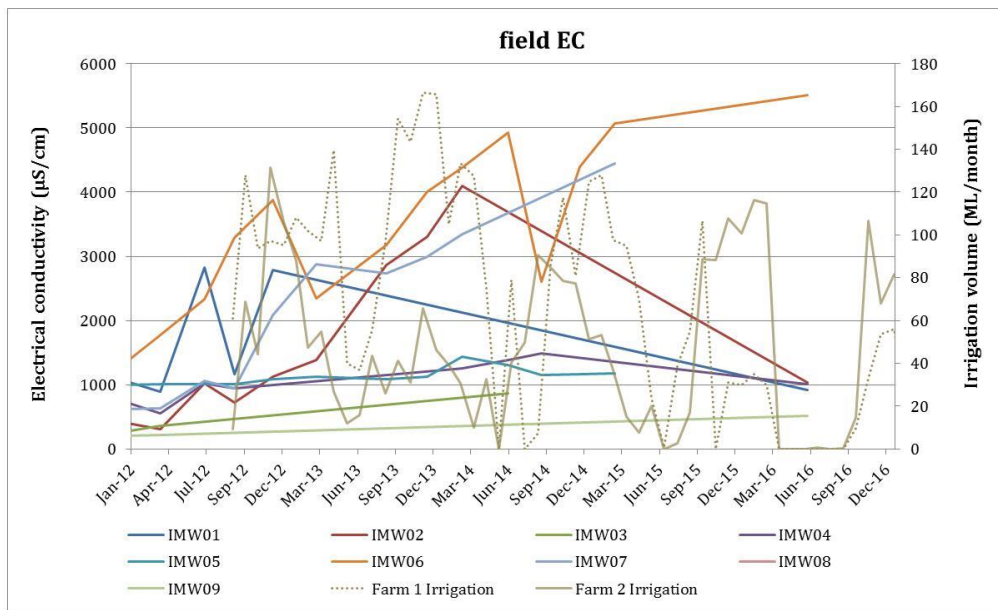
Analytical Results

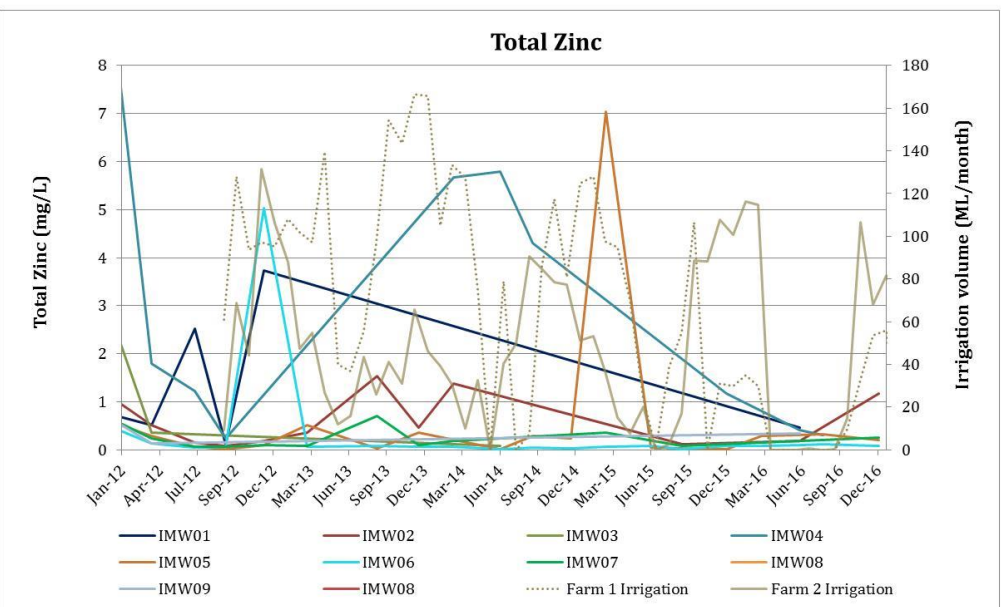
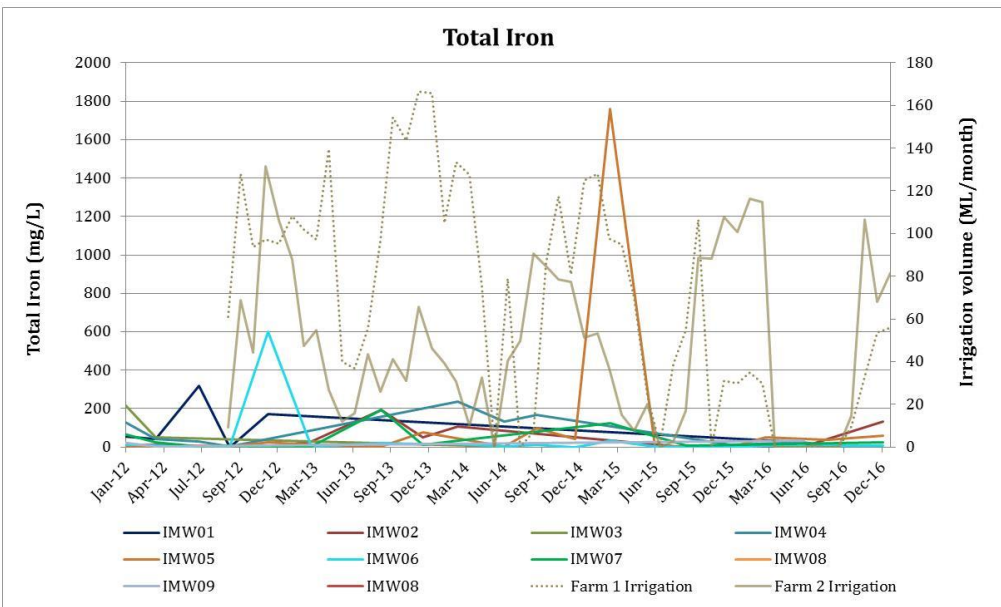
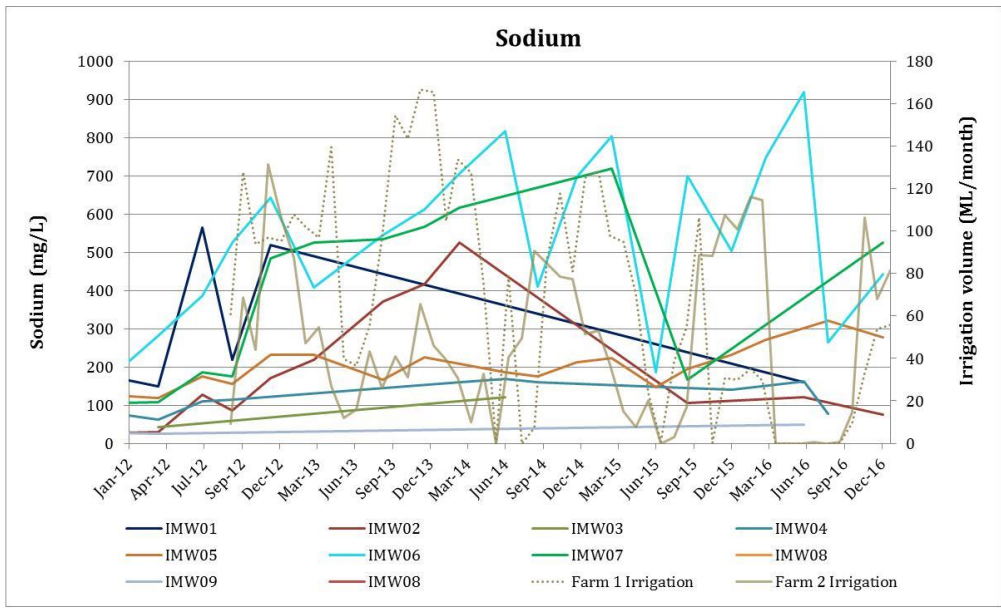
Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	PZ24B	PZ08C	----	----	----
Client sampling date / time				28-Sep-2016 13:35	28-Sep-2016 14:30	----	----	----	
Compound	CAS Number	LOR	Unit	ME1601367-006	ME1601367-007	-----	-----	-----	
				Result	Result	----	----	----	
EG035F: Dissolved Mercury by FIMS - Continued									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----	
EG052G: Silica by Discrete Analyser									
Reactive Silica	----	0.1	mg/L	<0.10	9.66	----	----	----	
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L	0.1	0.3	----	----	----	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.22	----	----	----	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	----	----	----	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.02	----	----	----	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	1.89	9.90	----	----	----	
Total Cations	----	0.01	meq/L	2.02	9.39	----	----	----	
Ionic Balance	----	0.01	%	3.30	2.67	----	----	----	
MUD-WAT: Total Dissolved Solids - Calculated									
∅ Total Dissolved Solids (Calc.)	----	4	mg/L	170	645	----	----	----	

Appendix E **2016 water quality results - BMN**

Bore ID	Date	Sample No.	EC (field) µS/cm	pH (field)	EC (lab) µS/cm	pH (lab)	Ca mg/L	Cl mg/L	K mg/L	Na mg/L	Mg mg/L	SO4 mg/L	Total alkalinity mg/L	CO ₃ alkalinity mg/L	HCO ₃ alkalinity mg/L	CaCO ₃ saturation index	Acidity as CaCO ₃ mg/L	Total Hardness as CaCO ₃ (Calc.) mg/L	SAR	Fe (t) mg/L	Mn (t) mg/L	Zn (t) mg/L
IMW01	9/06/2016	ME1600801001	913	6.0	917	7.6	1	225	<1	160	12	30	18	<1	18	-1.3	4	52	10	25	0.1	0.5
IMW02	9/06/2016	ME1600801002	1041	5.9	1020	7.5	47	73	22	121	35	171	268	<1	268	0.4	9	261	3	4	0.0	0.2
IMW02	16/12/2016	ME1601780001	-	-	440	5.8	2	118	<1	76	8	2	22	<1	22	-3.2	31	38	5	134	0.1	1.2
IMW04	9/06/2016	ME1600801003	1007	6.7	1050	5.7	2	311	<1	162	29	8	2	<1	2	-4.5	10	124	6	24	0.1	0.4
IMW04	5/08/2016	ME1601095001	-	-	641	7.5	25	36	12	78	19	45	257	<1	257	0.2	10	141	3	7	0.1	0.3
IMW05	10/03/2016	ME1600359005	-	-	1420	7.4	4	215	3	272	14	202	145	<1	145	-0.6	4	68	14	51	0.80	0.3
IMW05	5/08/2016	ME1601095002	-	-	1720	7.2	<1	520	2	320	14	5	4	<1	4	-2.3	16	58	18	36	0.1	0.3
IMW05	16/12/2016	ME1601780002	-	-	1490	7.2	9	214	3	278	22	298	153	<1	153	-0.6	12	113	11	59	0.5	0.2
IMW06	10/03/2016	ME1600359006	-	-	4530	7.1	18	1180	<1	748	143	74	278	<1	278	0.2	16	634	13	6	0.2	0.1
IMW06	9/06/2016	ME1600801004	5515	6.8	5240	6.8	22	1480	1	920	193	87	300	<1	300	0.1	16	850	14	3	0.2	0.1
IMW06	5/08/2016	ME1601095003	-	-	1620	7.4	16	286	3	265	44	76	333	<1	333	0.3	14	221	8	8	0.2	0.1
IMW06	16/12/2016	ME1601780003	-	-	2690	7.4	18	622	2	443	72	87	393	<1	393	0.5	18	341	10	8	0.2	0.1
IMW07	16/12/2016	ME1601780004	-	-	2910	4.8	2	905	3	526	32	11	3	<1	3	-5.5	22	137	20	26	0.1	0.3
IMW09	9/06/2016	ME1600801005	520	7.6	326	7.5	1	57	1	49	6	5	10	<1	10	-2.1	4	27	4	33	0.5	0.3

Note: (t) total metals





CERTIFICATE OF ANALYSIS

Work Order	: ME1600359	Page	: 1 of 6
Client	: ULAN COAL MINES LIMITED	Laboratory	: Environmental Division Mudgee
Contact	: Mr Tom Frankham	Contact	: Mary Monds
Address	: Private Mail Bag MUDGEES NSW 2850	Address	: 1/29 Sydney Road Mudgee NSW AUSTRALIA 2850
Telephone	: +61 02 6372 5300	Telephone	: 02 6372 6735
Project	: Bobadeen Groundwaters - Quarterly	Date Samples Received	: 10-Mar-2016 13:15
Order number	: ----	Date Analysis Commenced	: 11-Mar-2016
C-O-C number	: ----	Issue Date	: 22-Mar-2016 14:58
Sampler	: Neville Buckley		
Site	: 10/03/2016		
Quote number	: ----		
No. of samples received	: 9		
No. of samples analysed	: 9		



NATA Accredited Laboratory 825
Accredited for compliance with
ISO/IEC 17025.

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Mary Monds	Environmental Services Representative	Laboratory - Mudgee, Mudgee, NSW



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

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^ = This result is computed from individual analyte detections at or above the level of reporting
∅ = ALS is not NATA accredited for these tests.

- SAR by EA006; Hardness by EA065; Alkalinity by ED037; Acidity by ED038; Sulfate by ED041; Chloride by ED045; Major Cations by ED093; Metals by EG020 and Ionic Balance by EN055 are conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911.
- Test MUD-WAT: NATA accreditation does not cover the performance of this service.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	IMW01	IMW02	IMW03	IMW04	IMW05
Client sampling date / time				[10-Mar-2016]	[10-Mar-2016]	[10-Mar-2016]	[10-Mar-2016]	10-Mar-2016 10:00	
Compound	CAS Number	LOR	Unit	ME1600359-001	ME1600359-002	ME1600359-003	ME1600359-004	ME1600359-005	
				Result	Result	Result	Result	Result	
A EN67-MUD: Field Notes									
Sampler Name	----	-	-	Client	Client	Client	Client	Client	
No Sample	----	-	-	No water	No water	No water	No water	----	
EA005: pH									
pH Value	----	0.01	pH Unit	----	----	----	----	7.4	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	----	----	----	----	1420	
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	----	----	----	----	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	----	----	----	----	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	----	----	----	----	145	
Total Alkalinity as CaCO3	----	1	mg/L	----	----	----	----	145	
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L	----	----	----	----	4	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	----	----	----	202	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	----	----	----	----	215	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	----	----	----	----	4	
Magnesium	7439-95-4	1	mg/L	----	----	----	----	14	
Sodium	7440-23-5	1	mg/L	----	----	----	----	272	
Potassium	7440-09-7	1	mg/L	----	----	----	----	3	
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L	----	----	----	----	68	
Sodium Adsorption Ratio	----	0.01	-	----	----	----	----	14.4	
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L	----	----	----	----	0.802	
Zinc	7440-66-6	0.005	mg/L	----	----	----	----	0.285	
Iron	7439-89-6	0.05	mg/L	----	----	----	----	50.8	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	----	----	----	----	13.2	
Total Cations	----	0.01	meq/L	----	----	----	----	13.2	
Ionic Balance	----	0.01	%	----	----	----	----	0.31	



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	IMW01	IMW02	IMW03	IMW04	IMW05
Client sampling date / time					[10-Mar-2016]	[10-Mar-2016]	[10-Mar-2016]	[10-Mar-2016]	10-Mar-2016 10:00
Compound	CAS Number	LOR	Unit		ME1600359-001	ME1600359-002	ME1600359-003	ME1600359-004	ME1600359-005
					Result	Result	Result	Result	Result
MUD-WAT: Calculated Methods (Department of Agriculture)									
CaCO3 Saturation Index	----	0.1	-		----	----	----	----	-0.6



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	IMW06	IMW07	IMW08	IMW09	----
Client sampling date / time				10-Mar-2016 10:30	[10-Mar-2016]	[10-Mar-2016]	[10-Mar-2016]	----	
Compound	CAS Number	LOR	Unit	ME1600359-006	ME1600359-007	ME1600359-008	ME1600359-009	-----	
				Result	Result	Result	Result	Result	
A EN67-MUD: Field Notes									
Sampler Name	----	-	-	Client	Client	Client	Client	----	
No Sample	----	-	-	----	No water	No water	No water	----	
EA005: pH									
pH Value	----	0.01	pH Unit	7.1	----	----	----	----	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	4530	----	----	----	----	
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	278	----	----	----	----	
Total Alkalinity as CaCO3	----	1	mg/L	278	----	----	----	----	
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L	16	----	----	----	----	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	74	----	----	----	----	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	1180	----	----	----	----	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	18	----	----	----	----	
Magnesium	7439-95-4	1	mg/L	143	----	----	----	----	
Sodium	7440-23-5	1	mg/L	748	----	----	----	----	
Potassium	7440-09-7	1	mg/L	<1	----	----	----	----	
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L	634	----	----	----	----	
Sodium Adsorption Ratio	----	0.01	-	12.9	----	----	----	----	
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L	0.222	----	----	----	----	
Zinc	7440-66-6	0.005	mg/L	0.088	----	----	----	----	
Iron	7439-89-6	0.05	mg/L	5.61	----	----	----	----	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	40.4	----	----	----	----	
Total Cations	----	0.01	meq/L	45.2	----	----	----	----	
Ionic Balance	----	0.01	%	5.61	----	----	----	----	



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	IMW06	IMW07	IMW08	IMW09	----
Client sampling date / time			10-Mar-2016 10:30	[10-Mar-2016]	[10-Mar-2016]	[10-Mar-2016]	----	----
Compound	CAS Number	LOR	Unit	ME1600359-006	ME1600359-007	ME1600359-008	ME1600359-009	-----
				Result	Result	Result	Result	Result
MUD-WAT: Calculated Methods (Department of Agriculture)								
CaCO3 Saturation Index	----	0.1	-	+0.2	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: ME1600801	Page	: 1 of 4
Client	: ULAN COAL MINES LIMITED	Laboratory	: Environmental Division Mudgee
Contact	: Mr Tom Frankham	Contact	: Mary Monds
Address	: Private Mail Bag MUDGEES NSW 2850	Address	: 1/29 Sydney Road Mudgee NSW AUSTRALIA 2850
Telephone	: +61 02 6372 5300	Telephone	: 02 6372 6735
Project	: Bobadeen Groundwaters - Quarterly	Date Samples Received	: 09-Jun-2016 13:45
Order number	: ----	Date Analysis Commenced	: 14-Jun-2016
C-O-C number	: ----	Issue Date	: 21-Jun-2016 10:35
Sampler	: Neville Buckley		
Site	: ----		
Quote number	: ----		
No. of samples received	: 5		
No. of samples analysed	: 5		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

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- Analytical Results

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<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Mary Monds	Environmental Services Representative	Laboratory - Mudgee, Mudgee, NSW
Wisam Marassa	Inorganics Coordinator	Sydney Inorganics, Smithfield, NSW



General Comments

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EN055: Ionic Balance out of acceptable limits for sample 5 due to analytes not quantified in this report.
- SAR by EA006; Hardness by EA065; Alkalinity by ED037; Acidity by ED038; Sulfate by ED041; Chloride by ED045; Major Cations by ED093; Metals by EG020 and Ionic Balance by EN055 are conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911.
- Test MUD-WAT: NATA accreditation does not cover the performance of this service.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	IMW01	IMW02	IMW04	IMW06	IMW09
Client sampling date / time				09-Jun-2016 07:05	09-Jun-2016 08:30	09-Jun-2016 09:00	09-Jun-2016 09:15	09-Jun-2016 09:35	
Compound	CAS Number	LOR	Unit	ME1600801-001	ME1600801-002	ME1600801-003	ME1600801-004	ME1600801-005	
				Result	Result	Result	Result	Result	
A EN67-MUD: Field Notes									
Sampler Name	----	-	-	Client	Client	Client	Client	Client	
EA005: pH									
pH Value	----	0.01	pH Unit	7.6	7.5	5.7	6.8	7.5	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	917	1020	1050	5240	326	
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	18	268	2	300	10	
Total Alkalinity as CaCO3	----	1	mg/L	18	268	2	300	10	
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L	4	9	10	16	4	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	30	171	8	87	5	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	225	73	311	1480	57	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	1	47	2	22	1	
Magnesium	7439-95-4	1	mg/L	12	35	29	193	6	
Sodium	7440-23-5	1	mg/L	160	121	162	920	49	
Potassium	7440-09-7	1	mg/L	<1	22	<1	1	1	
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L	52	261	124	850	27	
Sodium Adsorption Ratio	----	0.01	-	9.66	3.26	6.32	13.7	4.09	
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L	0.120	0.032	0.107	0.221	0.500	
Zinc	7440-66-6	0.005	mg/L	0.461	0.180	0.403	0.096	0.348	
Iron	7439-89-6	0.05	mg/L	24.7	3.65	24.0	2.80	33.4	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	7.33	11.0	8.98	49.6	1.91	
Total Cations	----	0.01	meq/L	8.00	11.0	9.53	57.0	2.70	
Ionic Balance	----	0.01	%	4.32	0.34	2.98	6.99	----	
MUD-WAT: Calculated Methods (Department of Agriculture)									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	IMW01	IMW02	IMW04	IMW06	IMW09
Client sampling date / time				09-Jun-2016 07:05	09-Jun-2016 08:30	09-Jun-2016 09:00	09-Jun-2016 09:15	09-Jun-2016 09:35	
Compound	CAS Number	LOR	Unit	ME1600801-001	ME1600801-002	ME1600801-003	ME1600801-004	ME1600801-005	
				Result	Result	Result	Result	Result	
MUD-WAT: Calculated Methods (Department of Agriculture) - Continued									
∅ CaCO3 Saturation Index	----	0.1	-	-1.3	0.4	-4.5	0.1	-2.1	

CERTIFICATE OF ANALYSIS

Work Order	: ME1601095	Page	: 1 of 3
Client	: ULAN COAL MINES LIMITED	Laboratory	: Environmental Division Mudgee
Contact	: Mr Tom Frankham	Contact	: Mary Monds
Address	: Locked Bag 6015 HRMC Newcastle NSW 2310	Address	: 1/29 Sydney Road Mudgee NSW AUSTRALIA 2850
Telephone	: +61 02 6372 5300	Telephone	: 02 6372 6735
Project	: Bobadeen Groundwaters - Quarterly	Date Samples Received	: 05-Aug-2016 13:50
Order number	: ----	Date Analysis Commenced	: 09-Aug-2016
C-O-C number	: ----	Issue Date	: 15-Aug-2016 11:00
Sampler	: Neville Buckley		
Site	: ----		
Quote number	: ----		
No. of samples received	: 3		
No. of samples analysed	: 3		



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<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ashesh Patel	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Mary Monds	Environmental Services Representative	Laboratory - Mudgee, Mudgee, NSW



General Comments

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~ = Indicates an estimated value.

- SAR by EA006; Hardness by EA065; Alkalinity by ED037; Acidity by ED038; Sulfate by ED041; Chloride by ED045; Major Cations by ED093; Metals by EG020 and Ionic Balance by EN055 are conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911.
- Test MUD-WAT: NATA accreditation does not cover the performance of this service.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		IMW04	IMW05	IMW06	----	----	
Client sampling date / time		05-Aug-2016 09:45		05-Aug-2016 09:25		05-Aug-2016 08:45		----	----
Compound	CAS Number	LOR	Unit	ME1601095-001	ME1601095-002	ME1601095-003	-----	-----	
				Result	Result	Result	----	----	
EA005: pH									
pH Value	----	0.01	pH Unit	7.5	7.2	7.4	----	----	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	641	1720	1620	----	----	
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	257	4	333	----	----	
Total Alkalinity as CaCO3	----	1	mg/L	257	4	333	----	----	
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L	10	16	14	----	----	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	45	5	76	----	----	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	36	520	286	----	----	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	25	<1	16	----	----	
Magnesium	7439-95-4	1	mg/L	19	14	44	----	----	
Sodium	7440-23-5	1	mg/L	78	320	265	----	----	
Potassium	7440-09-7	1	mg/L	12	2	3	----	----	
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L	141	58	221	----	----	
Sodium Adsorption Ratio	----	0.01	-	2.86	18.3	7.75	----	----	
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L	0.060	0.069	0.175	----	----	
Zinc	7440-66-6	0.005	mg/L	0.309	0.319	0.108	----	----	
Iron	7439-89-6	0.05	mg/L	6.50	35.9	8.13	----	----	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	7.09	14.8	16.3	----	----	
Total Cations	----	0.01	meq/L	6.51	15.1	16.0	----	----	
Ionic Balance	----	0.01	%	4.26	0.88	0.90	----	----	
MUD-WAT: Calculated Methods (Department of Agriculture)									
∅ CaCO3 Saturation Index	----	0.1	-	+0.2	-2.3	+0.3	----	----	

CERTIFICATE OF ANALYSIS

Work Order	: ME1601780	Page	: 1 of 3
Client	: ULAN COAL MINES LIMITED	Laboratory	: Environmental Division Mudgee
Contact	: Mr Tom Frankham	Contact	: Mary Monds
Address	: Locked Bag 6015 HRMC Newcastle NSW 2310	Address	: 1/29 Sydney Road Mudgee NSW AUSTRALIA 2850
Telephone	: +61 02 6372 5300	Telephone	: 02 6372 6735
Project	: Bobadeen Groundwaters - Quarterly	Date Samples Received	: 16-Dec-2016 13:23
Order number	: ----	Date Analysis Commenced	: 19-Dec-2016
C-O-C number	: ----	Issue Date	: 28-Dec-2016 16:58
Sampler	: Neville Buckley		
Site	: ----		
Quote number	: MU/044/15		
No. of samples received	: 4		
No. of samples analysed	: 4		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

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- Analytical Results

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Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Mary Monds	Environmental Services Representative	Laboratory - Mudgee, Mudgee, NSW
Raymond Commodore	Instrument Chemist	Sydney Inorganics, Smithfield, NSW



General Comments

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Samples were received outside of recommended ALS holding times for analysis of pH. Results should be scrutinised accordingly.
- SAR by EA006; Hardness by EA065; Alkalinity by ED037; Acidity by ED038; Sulfate by ED041; Chloride by ED045; Major Cations by ED093; Metals by EG020 and Ionic Balance by EN055 are conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911.
- Test MUD-WAT: NATA accreditation does not cover the performance of this service.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID			IMW02	IMW05	IMW06	IMW07	----
		Client sampling date / time			16-Dec-2016 08:05	16-Dec-2016 07:10	16-Dec-2016 07:45	16-Dec-2016 07:25	----
Compound	CAS Number	LOR	Unit	ME1601780-001	ME1601780-002	ME1601780-003	ME1601780-004	-----	
				Result	Result	Result	Result	----	
EA005: pH									
pH Value	----	0.01	pH Unit	5.8	7.2	7.4	4.8	----	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	440	1490	2690	2910	----	
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	22	153	393	3	----	
Total Alkalinity as CaCO3	----	1	mg/L	22	153	393	3	----	
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L	31	12	18	22	----	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2	298	87	11	----	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	118	214	622	905	----	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	2	9	18	2	----	
Magnesium	7439-95-4	1	mg/L	8	22	72	32	----	
Sodium	7440-23-5	1	mg/L	76	278	443	526	----	
Potassium	7440-09-7	1	mg/L	<1	3	2	3	----	
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L	38	113	341	137	----	
Sodium Adsorption Ratio	----	0.01	-	5.37	11.4	10.4	19.6	----	
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L	0.093	0.549	0.227	0.090	----	
Zinc	7440-66-6	0.005	mg/L	1.18	0.195	0.084	0.255	----	
Iron	7439-89-6	0.05	mg/L	134	59.4	7.92	26.0	----	
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	3.81	15.3	27.2	25.8	----	
Total Cations	----	0.01	meq/L	4.06	14.4	26.1	25.7	----	
Ionic Balance	----	0.01	%	3.23	2.92	2.00	0.25	----	
MUD-WAT: Calculated Methods (Department of Agriculture)									
∅ CaCO3 Saturation Index	----	0.1	-	-3.2	-0.6	+0.5	-5.5	----	

Appendix F **2016 water quality results - PMN**

Bore ID	Date	Sample No.	EC (lab) μ S/cm	pH (lab)	TSS mg/L	Sulphate mg/L	Total Alkalinity as CaCO3 mg/L	Fe (t) mg/L	Fe (d) mg/L	Mn (t) mg/L	Mn (d) mg/L
E20	12/01/2016	1	1700	6.4	11	686	92	31.20	31.40	6.18	5.86
E20	3/02/2016	2	1720	6.2	6	711	128	31.70	31.10	6.28	6.12
E20	18/02/2016	3	1780	6.3	20	701	120	33.60	35.70	6.38	6.32
E20	2/03/2016	4	1690	6.3	13	730	118	34.90	31.60	6.85	6.87
E20	14/03/2016	5	1700	6.7	18	318	119	36.30	35.40	6.49	7.06
E20	7/04/2016	6	1730	6.9	6	671	120	36.20	31.90	7.36	7.33
E20	20/04/2016	7	1770	6.6	15	716	124	36.10	36.90	7.07	7.24
E20	5/05/2016	8	1690	6.3	4	625	136	33.30	32.40	6.96	6.81
E20	16/05/2016	9	1680	6.5	10	609	91	32.70	32.10	6.46	6.45
E20	31/05/2016	10	1730	6.4	8	589	144	36.50	33.70	7.02	6.98
E20	14/06/2016	11	1720	6.5	13	697	123	34.00	34.50	6.01	6.26
E20	29/06/2016	12	1790	6.79	10	678	137	34.50	31.10	7.77	6.61
E20	11/07/2016	13	1650	6.8	4	577	124	35.30	34.90	7.35	6.33
E20	25/07/2016	14	1700	6.7	25	571	100	38.80	32.10	7.21	7.34
E20	8/08/2016	15	1790	6.6	8	578	108	36.20	35.10	6.86	6.69
E20	24/08/2016	16	1760	6.5	14	685	140	32.90	29.90	6.15	5.80
E20	5/09/2016	17	1750	6.5	15	596	119	32.10	34.00	6.53	5.95
E20	20/09/2016	18	1740	6.5	26	570	130	30.50	29.90	5.97	6.21
E20	4/10/2016	19	1730	6.4	16	555	110	29.50	29.30	6.38	6.14
E20	17/10/2016	20	1710	6.4	10	568	144	32.60	30.80	6.13	5.91
E20	14/11/2016	21	1760	6.5	22	584	124	29.90	29.50	6.15	6.04
E20	14/12/2016	22	1770	6.5	20	712	110	40.20	39.60	6.36	6.28
MG22	31/05/2016	1	1120	6.8	96	128	353	4.65	3.10	0.42	0.37
MG22	14/06/2016	2	1140	6.7	60	165	345	3.07	14.82	3.36	0.36
MG22	24/08/2016	4	1190	6.7	116	176	350	2.14	2.25	0.35	0.33
MG26	12/01/2016	1	896	6.7	4	43	314	2.39	2.39	0.19	0.18
MG26	3/02/2016	2	955	6.6	3	52	322	2.48	2.54	0.18	0.19
MG26	18/02/2016	3	955	6.7	5	63	293	2.68	2.40	0.20	0.18
MG26	2/03/2016	4	982	6.7	2	73	332	2.52	2.46	0.21	0.23
MG26	14/03/2016	5	980	6.7	6	50	322	0.31	0.16	0.12	0.13
MG26	7/04/2016	6	1000	6.7	5	62	338	2.78	2.41	0.21	0.22
MG26	20/04/2016	7	915	6.8	4	59	332	2.70	2.66	0.20	0.20
MG26	5/05/2016	8	965	6.5	5	40	333	2.43	2.21	0.21	0.19
MG26	16/05/2016	9	936	6.9	5	49	318	2.26	2.19	0.18	0.02
MG26	31/05/2016	10	940	6.7	4	45	330	2.57	2.13	0.20	0.18
MG26	14/06/2016	11	922	7	5	49	319	2.33	2.21	0.17	0.19
MG26	14/06/2016	12	922	7	5	49	319	2.33	2.21	0.17	0.19
MG26	11/07/2016	13	912	7.1	4	46	330	2.36	2.13	0.20	0.19
MG26	25/07/2016	14	946	7.2	6	40	299	2.25	2.20	0.19	0.19
MG26	8/08/2016	15	976	6.8	4	43	299	2.40	2.23	0.20	0.20
MG26	24/08/2016	16	983	6.8	4	42	354	3.73	2.08	0.36	0.20
MG26	5/09/2016	17	954	6.7	5	41	366	2.30	2.10	0.20	0.20
MG26	20/09/2016	18	949	6.7	4	43	352	2.30	1.98	0.20	0.19
MG26	4/10/2016	19	959	6.7	4	40	312	2.26	2.27	0.20	0.19
MG26	17/10/2016	20	939	6.8	5	39	352	2.24	2.16	0.19	0.19
MG26	4/11/2016	21	938	6.8	5	38	343	2.24	1.98	0.18	0.19
MG26	14/11/2016	22	977	6.8	4	36	312	2.44	2.25	0.18	0.17
MG26	14/12/2016	23	981	6.7	4	48	296	2.30	2.19	0.21	0.20
MG27	2/03/2016	1	933	7	7	44	356	2.68	2.44	0.25	0.27

Bore ID	Date	Sample No.	EC (lab) $\mu\text{S}/\text{cm}$	pH (lab)	TSS mg/L	Sulphate mg/L	Total Alkalinity as CaCO ₃ mg/L	Fe (t) mg/L	Fe (d) mg/L	Mn (t) mg/L	Mn (d) mg/L
MG28	20/05/2016	1	1050	7	2	35	441	0.86	0.74	0.25	0.26
MG28	29/06/2016	2	997	7.56	4	21	383	1.61	1.01	0.22	0.20
MG28	8/08/2016	3	977	7.4	2	20	345	1.02	0.76	0.20	0.20
MG28	5/09/2016	4	981	7.1	1	20	411	1.24	0.70	0.19	0.18
MG28	4/11/2016	5	959	7.1	4	18	420	1.37	0.70	0.16	0.17
MG29	3/02/2016	1	728	7.6	12	19	257	0.30	0.05	0.07	0.05
MG29	18/02/2016	2	895	7.4	6	39	310	0.46	0.05	0.20	0.11
MG29	2/03/2016	3	814	7.2	14	30	322	0.24	0.05	0.10	0.08
MG29	14/03/2016	4	983	6.7	6	19	344	0.30	0.15	0.12	0.12
MG29	7/04/2016	5	884	7.4	10	18	358	0.25	0.05	0.10	0.09
MG29	20/04/2016	6	760	7.8	25	21	301	0.32	0.05	0.05	0.04
MG29	5/05/2016	7	828	7.6	16	25	318	0.48	0.05	0.10	0.08
MG29	16/05/2016	8	798	7.8	26	22	291	0.39	0.05	0.04	0.03
MG29	31/05/2016	9	986	7.4	19	59	357	0.53	0.05	0.21	0.04
MG29	14/06/2016	10	860	7.4	13	32	345	0.26	0.05	0.08	0.04
MG29	29/06/2016	11	897	7.94	3	26	341	0.12	0.05	0.07	0.03
MG29	11/07/2016	12	813	7.8	11	22	330	0.34	0.05	0.11	0.08
MG29	25/07/2016	13	803	7.6	20	15	291	0.54	0.05	0.26	0.03
MG29	8/08/2016	14	865	7.3	7	20	307	0.25	0.05	0.04	0.02
MG29	24/08/2016	15	863	7.6	16	22	353	0.25	0.05	0.04	0.03
MG29	5/09/2016	16	865	7.7	11	20	350	0.30	0.05	0.05	0.02
MG29	20/09/2016	17	876	7.4	19	17	342	0.38	0.05	0.05	0.03
MG29	4/10/2016	18	815	7.6	8	17	308	0.26	0.05	0.06	0.02
MG29	17/10/2016	19	905	7.6	4	23	399	0.13	0.05	0.05	0.05
MG29	4/11/2016	20	830	7.4	6	21	339	0.25	0.05	0.06	0.02
MG29	14/11/2016	21	870	7.2	4	20	306	0.24	0.05	0.05	0.03
MG29	14/12/2016	22	888	7.3	2	19	327	0.07	0.05	0.03	0.03
UWTG1	3/02/2016	1	932	7.1	1	110	269	0.93	0.05	0.52	0.52
UWTG1	18/02/2016	2	959	6.8	1	122	234	1.30	0.23	0.64	0.64
UWTG1	20/04/2016	3	1100	7	7	211	250	2.93	1.90	0.68	0.67
UWTG1	16/05/2016	4	925	6.9	12	111	235	2.96	2.14	0.72	0.70
UWTG1	11/07/2016	5	959	7.6	10	133	246	4.24	1.22	0.76	0.74
UWTG1	17/10/2016	6	1150	6.8	14	189	265	4.56	2.43	0.66	0.65
UWTG1	3/02/2016	1	932	7.1	1	110	269	0.93	0.05	0.52	0.52
UWTG1	18/02/2016	2	959	6.8	1	122	234	1.30	0.23	0.64	0.64

Notes: (d) dissolved metals
(t) total metals

Appendix G **2016 water quality results – The Drip**

Sample Location	Sample Date	Sample No.	pH (lab)	EC (lab) $\mu\text{S}/\text{cm}$	HCO ₃ alkalinity mg/L	OH alkalinity mg/L	CO ₃ alkalinity mg/L	Total alkalinity mg/L	Ca mg/L	Cl mg/L	Mg mg/L	K mg/L	Na mg/L	SO ₄ mg/L
East @ Drip	06-Jan-2016	ME1600024001	8.3	520	147	<1	7	154	17	68	32	1	-	4
West @ Drip	06-Jan-2016	ME1600024002	8.4	602	165	<1	18	182	20	79	39	1	-	6
East @ Drip	06-Jan-2016	ME1600024001	8.3	520	147	<1	7	154	17	68	32	1	-	4
West @ Drip	06-Jan-2016	ME1600024002	8.4	602	165	<1	18	182	20	79	39	1	-	6
East @ Drip	02-Feb-2016	ME1600151001	7.9	511	154	<1	<1	154	19	52	32	1	46	3
West @ Drip	02-Feb-2016	ME1600151002	8.1	596	187	<1	7	194	22	63	39	1	57	6
East @ Drip	11-Feb-2016	ME1600210001	8.4	496	152	<1	<1	152	17	56	28	1	45	3
West @ Drip	11-Feb-2016	ME1600210002	8.4	610	180	<1	11	191	19	69	34	1	56	7
East @ Drip	23-Mar-2016	ME1600407001	8.2	553	188	<1	6	195	20	55	34	2	49	6
West @ Drip	23-Mar-2016	ME1600407002	8.3	616	213	<1	7	220	20	64	40	1	56	7
East @ Drip	13-May-2016	ME1600668001	7.2	511	159	<1	6	166	17	57	31	1	-	3
West @ Drip	13-May-2016	ME1600668002	8.3	600	189	<1	13	202	20	66	37	1	-	4
East @ Drip	13-May-2016	ME1600668001	7.2	511	159	<1	6	166	17	57	31	1	-	3
West @ Drip	13-May-2016	ME1600668002	8.3	600	189	<1	13	202	20	66	37	1	-	4
West @ Drip	21-Jun-2016	ME1600864002	8.3	621	212	<1	<1	212	22	60	37	1	47	5
East @ Drip	15-Jul-2016	ME1600994001	8.3	515	162	<1	<1	162	18	54	31	<1	46	4
West @ Drip	15-Jul-2016	ME1600994002	8.3	595	196	<1	<1	196	20	60	36	1	52	5
East @ Drip	05-Aug-2016	ME1601096001	8.1	519	166	<1	<1	166	17	55	30	1	43	3
West @ Drip	05-Aug-2016	ME1601096002	8.3	593	189	<1	<1	189	20	61	35	1	48	5
East @ Drip	16-Sep-2016	ME1601305001	8.3	-	182	<1	<1	182	16	51	29	<1	40	4
West @ Drip	16-Sep-2016	ME1601305002	8.3	-	216	<1	<1	216	19	59	34	1	46	6
East @ Drip	07-Oct-2016	ME1601413001	8.2	523	182	<1	<1	182	17	52	30	<1	42	3
West @ Drip	07-Oct-2016	ME1601413002	8.1	618	223	<1	<1	223	21	61	36	1	51	5
East @ Drip	25-Nov-2016	ME1601668001	8.4	507	166	<1	<1	166	15	58	31	1	44	3
West @ Drip	25-Nov-2016	ME1601668002	8.3	599	195	<1	4	199	18	61	39	1	52	5

Sample Location	Sample Date	Al (d) mg/L	As (d) mg/L	Ba (d) mg/L	B (d) mg/L	Fe (d) mg/L	Se (d) mg/L	Al (t) mg/L	Li (t) mg/L	Mn (t) mg/L	Se (t) mg/L	Sr (t) mg/L	Zn (t) mg/L
East @ Drip	06-Jan-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.005	0.001	<0.01	0.13	0.01
West @ Drip	06-Jan-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.004	<0.001	<0.01	0.14	0.01
East @ Drip	06-Jan-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.005	0.001	<0.01	0.13	0.01
West @ Drip	06-Jan-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.004	<0.001	<0.01	0.14	0.01
East @ Drip	02-Feb-2016	-	<0.001	0.02	<0.05	<0.05	-	<0.01	0.004	0.002	<0.01	0.13	0.01
West @ Drip	02-Feb-2016	-	<0.001	0.03	<0.05	<0.05	-	<0.01	0.003	0.002	<0.01	0.14	0.01
East @ Drip	11-Feb-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.005	-	<0.01	0.13	0.02
West @ Drip	11-Feb-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.004	<0.001	<0.01	0.14	0.02
East @ Drip	23-Mar-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.006	0.007	<0.01	0.13	0.02
West @ Drip	23-Mar-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.004	0.001	<0.01	0.13	0.01
East @ Drip	13-May-2016	0.02	<0.001	0.02	<0.05	<0.05	44	-	0.004	<0.001	<0.01	0.13	0.01
West @ Drip	13-May-2016	<0.01	<0.001	0.03	<0.05	<0.05	53	-	0.004	0.002	<0.01	0.14	0.01
East @ Drip	13-May-2016	0.02	<0.001	0.02	<0.05	<0.05	44	-	0.004	<0.001	<0.01	0.13	0.01
West @ Drip	13-May-2016	<0.01	<0.001	0.03	<0.05	<0.05	53	-	0.004	0.002	<0.01	0.14	0.01
West @ Drip	21-Jun-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.003	0.002	<0.01	0.15	0.28
East @ Drip	15-Jul-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.006	0.001	<0.01	0.12	0.03
West @ Drip	15-Jul-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.004	0.001	<0.01	0.14	0.01
East @ Drip	05-Aug-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.005	0.381	<0.01	0.14	0.05
West @ Drip	05-Aug-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.003	0.001	<0.01	0.14	0.01
East @ Drip	16-Sep-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.002	0.005	<0.01	0.13	0.01
West @ Drip	16-Sep-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.002	0.001	<0.01	0.13	0.01
East @ Drip	07-Oct-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.004	<0.001	<0.01	0.12	0.01
West @ Drip	07-Oct-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.003	0.002	<0.01	0.13	0.01
East @ Drip	25-Nov-2016	<0.01	<0.001	0.02	<0.05	<0.05	-	-	0.004	<0.001	<0.01	0.12	0.01
West @ Drip	25-Nov-2016	<0.01	<0.001	0.03	<0.05	<0.05	-	-	0.004	0.003	<0.01	0.14	0.01

Notes: (d) dissolved metals
(t) total metals