LIDSDALE SIDING UPGRADE PROJECT - GROUNDWATER ASSESSMENT

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EXECUTIVE SUMMARY

RPS on behalf of Centennial Coal Pty Limited has commissioned RPS Aquaterra to prepare a Groundwater Assessment for the Lidsdale Siding Upgrade Project (Project). The Project is located approximately 1km north of the township of Wallerawang off the main western railway line. Wallerawang is approximately 9km north-west of Lithgow in the Lithgow Council local government area (LGA) of New South Wales.

This study forms an appendix to the main Environmental Assessment Report prepared by RPS.

Project Description

The purpose of this assessment is to form part of a Environmental Assessment being prepared by RPS to support the application for Project Approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to facilitate the development of a reclaim tunnel and infrastructure upgrade.

The Lidsdale Siding Upgrade Project will enable coal loading automation by establishing a main elongated conical stockpile with underground reclaimers feeding a ground conveyor elevating to a train loading bin.

Hydrogeological Background

The unconsolidated alluvium/colluvium material covers most of the site and is generally 2-6m thick. It is underlain by shale which is weathered in the top section (approximately 7m) and fresh below this depth. The Shoalhaven Group outcrops over most of the study area mainly to the south and west, while to the north and east of the project site, the Shoalhaven Group is overlain by the Illawarra Coal Measures. The Illawarra Coal Measures contain four sub-groups and five main coal seams as outlined in Table 3.4 (listed in order of descending stratigraphy). The Permian sediments unconformably overlie Carboniferous granite.

The primary water bearing zones on site are associated with the weathered shale and shallow alluvium. The fresh shale is known to be of low permeability and is not classified as aquifer. Elsewhere in the study area, groundwater is known to occur within the weathered sandstone, siltstone and shale of the basement Shoalhaven group although low yields are recorded. The thickness of the Shoalhaven group sediments is greater than 50m.

Baseline monitoring comprises quarterly measurement of water levels at all site bores and quarterly sampling of groundwater for laboratory analysis of water quality which is routinely undertaken at all monitoring sites.

Predicted Impacts

As a result of the shallow excavation and the low inflow volumes, the impact to the groundwater system from the Project will be minor and the recovery will occur quickly following the cessation of development. Predictive analytical modelling has indicated that groundwater inflow to the shallow excavation would reduce from 76m^3/day after the first 2 months of excavation to 2.3m^3/day at the end of initial 3 months of excavation. After this time, the construction of the concrete lined tunnel will be underway and the development would intercept insignificant groundwater inflow. The total inflow would reach negligible 3.8 x 10^{-7}m^3/day (0.00038 L/day) by the end of the six months of construction.

In general, the predicted impact of the Project on the groundwater sources in the vicinity (up to 2km) of Project can be summarised as follows:

- It is assessed that the Project would not impact on any groundwater users in the area. Extraction of groundwater by dewatering would lower the water levels of the shallow alluvial aquifer within and close to the trench area. The maximum lowering of the water levels is predicted to be approximately 0.3m at the site boundary. There would be negligible drawdown outside of this area when the tunnel is concrete lined.
- There is only very minor change in the overall baseflow contribution to Pipers Creek with a maximum loss of 0.2m^3/day during construction period.

- Apart from minor and very local drawdown in the alluvial aquifer during the construction of the reclaim tunnel, there will be no impacts to other deeper aquifer systems.
- Once the site is operational, there would be a neutral effect on receiving groundwater and surface water quality. The tunnel will be concrete lined and the predicted seepage is negligible (in order of 0.1L/year).
- There would be no impact of dewatering on the other aquifers and on water quantity and quality of the Coxs River downstream.
- No sensitive groundwater dependent ecosystems have been identified within the Lidsdale Siding area.

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1. INTRODUCTION

1.1 Introduction

Centennial Coal Pty Limited commissioned RPS Aquaterra to prepare a Groundwater Assessment for the Lidsdale Siding Upgrade Project (Project). The Project is located approximately 1km north of the township of Wallerawang off the main western railway line. Wallerawang is approximately 9km north-west of Lithgow in the Lithgow Council local government area (LGA) of New South Wales.

This study forms an appendix to the main Environmental Assessment Report prepared by RPS.

1.2 Project Context

Lidsdale Siding is managed by Ivanhoe Coal Pty Limited, a full subsidiary of Centennial Coal Company Ltd (Centennial). It is strategically located within Centennial Western Mines region to facilitate transport of coal from the region to Port Kembla Coal Terminal. It supplies the domestic and international markets with thermal and coking coal. The Lidsdale Siding Upgrade is designed to meet the site requirements to automate the train loading facility. The automation would significantly reduce the need for mobile plant and equipment to load rail wagons.

Centennial commenced work on the Project in 2008. However, due to operational considerations, all work ceased on the Project in late 2009. The Project has now recommenced with minor changes to the original project description. The NSW Department of Planning (now Department of Planning & Infrastructure (DP&I)) issued the Project application number MP09_0223, for the project to be determined pursuant to Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act 1979).

Revised DGRs were issued by DP&I on 31 January 2012. The revised DGRs removed the need for a groundwater assessment from the previous DGRs of July 2011. This study has been prepared to address the original Director General's Requirements (DGRs) issued on 21 November 2008, as discussed further in Sections 1.5 and 1.6.

1.3 Project Description

The Lidsdale Siding Upgrade Project will enable coal loading automation by establishing a main elongated conical stockpile with underground reclaimers feeding a ground conveyor elevating to a train loading bin.

The Project occupies an area of approximately 1.2km^2 with the key aspects outlined in Figure 1. For a more detailed project description refer to Volume 1, Section 4 of the EA Report.

1.4 Project Location

The Project is located approximately 1km northeast of the township of Wallerawang, and by road it is 9km northwest of Lithgow NSW. The Lidsdale Siding joins the main western railway line on the southern side of Wallerawang Power Station.

The Project is located on the cleared flat area with Pipers Flat Creek flowing from west to east close to its northern boundary. The site is just downstream of the confluence of Pipers Flat Creek and Coxs River. About 700m to the south, Coxs River flows past the power station into Lake Wallace.

1.5 Report Objectives

This report has been compiled in order to address groundwater related issues that may arise as a result of project proposed activities and will support and form part of the Environmental Assessment (EA).

This report is designed to provide sufficient information on the existing groundwater environment within the Lidsdale Siding area and its immediate surrounds to assess the potential impacts of the project on groundwater, surface water, groundwater dependent ecosystems (GDEs) and existing groundwater users, and to develop appropriate management and mitigation strategies.

For the purpose of this report Lidsdale Siding upgrade project (Project) comprises the proposed stockpile upgrade, auxiliary stockpile, underground reclaim tunnel, track extension to rail siding and other associated loading structure and services. The Study Area for the groundwater impact assessment includes the wider area comprising the Lake Wallace to the south, Kerosene Vale and Sawyers Swamp to the northeast and Blackmans Flat to the north (Figure 1).

1.6 Environmental Assessment Requirements

The Lidsdale siding upgrade project is a 'Major Development' as defined in State Environmental Planning Policy (SEPP) Major Development 2005, and in accordance with the Environmental Planning and Assessment Act, 1979 (EP&A Act 1979) requires approval of the NSW Minister for Planning to proceed under Part 3a of the EP&A Act.

Issues relating to groundwater for the EA have been outlined in Table 1.1, which also shows the relevant report section that deals with that specific requirement. These relate to the original DGRs issued in 2008, however the revised DRGs issued in January 2012 DGRs contain no specific requirement to assess groundwater.

Table 1.1: DGRs specific to Groundwater Resources

Issues Specific to Groundwater	Relevant Report Section
Existing groundwater management and monitoring regime on site	Section 2.5 and 2.6
Risk assessment of potential groundwater impacts of the project	Section 6
Description of existing environment using sufficient baseline data	Section 3
Assessment of potential impacts of the Project and any cumulative impacts of the current operation of the Project with any other existing or approved mining operations in the region during all stages of the project	Section 6.2
The measures that would be implemented to avoid, minimise and mitigate potential impacts of the project including detailed contingency plans for managing significant risk to the environment	Section 7
Modelling and assessment of the potential groundwater impacts of the project	Section 5
Outline all the proposed environmental management and monitoring measures	Section 7

1.6.1 Groundwater Dependent Ecosystems

This report also addresses the potential for the project to lead to impacts to Groundwater Dependent Ecosystems (GDEs). In accordance with the NSW State Groundwater Dependant Ecosystems Policy, the GDEs are those ecosystems which are deemed to be at least partly dependent on groundwater, and GDEs identified in the project area are detailed in the ecology specialist report (Appendix to the EA).

Potential impacts of the project on the identified GDEs are described in Section 3.11.

1.6.2 Contingency Measures

Where potential impacts from the operation have been identified (refer to Section 6) this study has attempted to quantify the limits of impact and provide suitable measures that could be implemented to reduce or manage potential impacts to sensitive receptors i.e. stream baseflows, GDEs and other water users. Section 7 provides details of a recommended groundwater monitoring program and includes recommendations on suitable time intervals for water level monitoring, representative sampling and associated field and laboratory analysis.

1.6.3 Operation Mitigation Measures

This assessment has also considered appropriate operation mitigation measures and a series of options for the management of these measures. Section 8 of this report addresses the following:

- Measures that would need to be established in order to minimise the potential impacts on the local and regional groundwater resources and surface water systems and for the ongoing management of the site during the operational stage; and

- Detailed description of the measures to be put in place to ensure that sufficient resources are available to implement the proposed rehabilitation of water related impacts.

1.6.4 Relevant State Policies and Guidelines

This report has addressed (as applicable) policies and procedures from the relevant state policies and guidelines;

- National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia (ARMCANZ / ANZECC);
- NSW Inland Groundwater Shortage Zones Order No.2 (2008);
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000);
- Australian and New Zealand Guidelines for Water Quality Monitoring;
- NSW State Groundwater Policy Framework Document (DLWC, 1997);
- NSW State Groundwater Quantity Management Policy (1998);
- NSW State Groundwater Quality Protection Policy (DLWC, 1998);
- NSW DECC, 2007. Guidelines for the Assessment and Management of Groundwater Contamination;
- Murray-Darling Basin Groundwater Quality Sampling Guidelines. Technical Report No. 3 (MDBC);
- Murray-Darling Basin Commission Groundwater Flow Modelling Guideline (Aquaterra Consulting Pty Ltd, 2001);
- Guidelines for the Assessment and Management of Groundwater Contamination (DECC, 2007);
- NSW State Groundwater Dependent Ecosystem Policy (2002);
- Guidelines for Groundwater Protection in Australia (1995);
- Managing Land Contamination – Planning Guidelines SEPP 55- Remediation of Land (DOP);
- Aquifer interference regulation (NSW Office of Water, 30 June 2011); and
- Water Sharing Plan for Greater Metropolitan Region Groundwater Sources and Unregulated River Water Sources (July, 2011).

The Water Management Act (2000) regulates the extraction of surface water and groundwater and any associated interception and interference with water sources in the Project and wider study area.

The extraction of any surface water from Coxs River and groundwater from any of the aquifer systems will be subject to conditions and management in accordance with the Water Sharing Plan for Greater Metropolitan Region Groundwater Sources and the Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources, as the Project area is located within or close to the Coxs River Source. These water sharing plans were gazetted in July 2011.

Under the Water Sharing Plans, water licences will be required for any of the following activities affecting groundwater and/or surface water:

- Incidental extraction of water from shallow alluvium due to construction activities;
- Installation of production bores (for water supply and/or dewatering);
- Extraction of water from production bores located in alluvium; and
- Extraction of surface water.

2. GROUNDWATER INVESTIGATIONS AND TESTING

2.1 Scope of Groundwater Investigations

The following field and desktop groundwater investigations were carried out at Lidsdale Siding area since 2009:

- Drilling and installation of six groundwater monitoring bores (piezometers) in shallow alluvial aquifer;
- Standard penetrometer test on four boreholes;
- Drilling and installation of a test bore; and conversion to a production bore;
- Groundwater level monitoring (quarterly manual monitoring of groundwater levels and quarterly groundwater quality monitoring);
- Aquifer hydraulic testing of existing piezometers in the shallow alluvial aquifer;
- Review of hydrogeological and other relevant reports produced for Angus Place Colliery, Mt Piper Power Station, Yarraboldy Extension 1, Waste Disposal Facility at Blackmans Flat and Springvale Mine; and
- Construction of a numerical groundwater model for assessing potential impacts of the proposed Lidsdale Siding upgrade.

The results of the investigations are presented below.

2.2 Monitoring Bore Drilling and Installation

The monitoring bore installation program included the drilling and installation of 6 monitoring bores. Bores were drilled to depths between 0.4m and 5.7m. The investigations were aimed primarily at understanding the groundwater system on site and potential contamination in the shallow aquifer.

The bores were drilled and constructed by AECOM in April 2008 to assess potential site contamination. The bores were drilled using the Geoprobe® drill rig using 125mm diameter hollow stem flight augers and push tubes. All holes were drilled to refusal.

The monitoring bore sites included sites within the Project area, with the aim of testing, sampling and monitoring groundwater in the shallow alluvium. All monitoring bores are installed in shallow alluvium as their original purpose was to assess the potential contamination on site. Locations and depths were selected to provide good spatial coverage in the aquifer, and to allow identification of groundwater gradients, as well as potential contamination from disused underground storage tanks.

The monitoring bore locations are shown on Figure 2.

Groundwater licences for bore construction under Part 5A of the *Water Act 1912* were applied for all monitoring bores.

2.2.1 Standpipe Piezometers

All groundwater monitoring bores were completed as single piezometers (i.e. not multi-level piezometers) with screen lengths varying from 1.5m to 3m. The monitoring bores were cased and screened with screwed and 'O' ring-sealed 50mm Class 18 PVC casing. Machine slotted screens with 0.4mm horizontal apertures were installed with a screwed end cap. Well construction including screen lengths were based on observations made during the drilling at each location.

The bore annulus was backfilled with rounded gravel pack (3-5mm graded) to just above the screened section. A bentonite plug was placed above the gravel pack to prevent leakage of groundwater into the bore from overlying water bearing zones. The annulus above the bentonite plug was back-filled to surface.

Monitoring well construction details are provided in Appendix A.

Bore development was conducted by airlifting following piezometer construction to remove 'fines' and to ensure production of groundwater from the screened interval. Bores were completed with headworks consisting of steel casing protector (monument) cemented into the ground and capped with a locked cover.

Newly installed groundwater monitoring wells (MW01 to MW06) were surveyed by Anderson Surveying Pty Ltd, relative to local AHD benchmarks. The construction summary details for standpipe piezometers are presented in Table 2.1.

Table 2.1: Summary details of site monitoring bores

Piezometer	**MGA Coordinates**		**Top of Casing Elevation**	**Depth Drilled**	**Aquifer Screened**	**Screen Interval**	**Water Quality (June 11)**		**Water Level Sep-11**	
	Easting	**Northing**	**(m AHD)**	**(m)**		**(m below GL)**	**EC (uS/L)**	**pH**	**(m below TOC)**	**(m AHD)**
MW1	0228141	6300631	881.15	4.7	Alluvium	1-4.7	557	6.67	4	877.157
MW2	0228020	6300613	878.62	4.7	Alluvium	1-4	1520	6.27	1.37	877.259
MW3	0228150	6300502	884.09	3.7	Alluvium	1-3	311	5.04	2.48	881.619
MW4	0228007	6300853	876.41	2.9	Alluvium	0.8 - 2.3	523	4.23	1.47	874.946
MW5	0227780	6300647	879.21	3.5	Alluvium	0.8 -2.8	146	5.6	2.65	876.564
MW6	0227575	6300440	879.21	3.6	Alluvium	0.7 - 3	572	6.29	1.68	877.534

2.2.2 Test Bore

Two test bores were drilled and installed on site (Figure 2).

- GW110520 test bore was drilled and installed in March 2009. The bore was drilled for industrial purpose to a depth of 38m below ground. The driller's log from the NSW Office of Water database indicates that the gravel and clays extend to 6m below ground, and are underlain by 2m of soft and weathered shale. Fresh shale is found below this depth to the bottom of the hole. The hole was drilled to 15.9m with 203mm diameter, followed by a smaller diameter hole at 168mm from 15.9m to 38m depth. The hole was installed with Class 9 PVC casing and screens with 1mm wide slotted apertures to a depth of 15.9m. The location of the screen is at 2m to 8m depth and the annulus was backfilled with graded 5mm-7mm gravel. Below 15.9m the bore is an open hole to 38m; and
- GW110437 test bore was drilled and installed in April 2009 to a depth of 90m. It intersected 4m of clay and gravel at the top, and then shale from 4m to 90m below ground level. The driller's log (NSW Office of Water database) indicates that the water bearing zones were identified between 3m and 4m below ground with an estimated yield of 0.06L/s. The 203mm diameter surface casing was installed to 9.75m depth, and the test bore was subsequently drilled to 83m with 168mm diameter. The hole was telescopically advanced to 90m using a 127mm diameter bit. The installation details are not provided on the log, however it is believed that the screen was installed at 83m to 90m depth. This bore was abandoned due to insufficient yield.

The location of the test bores is provided in Figure 2, the summary provided in Table 2.2 and the borelogs are given in Appendix A. GW110520 was later converted to production bore (licence number 10WA116403).

Table 2.2: Summary details of test bores

Test bore	MGA Coordinates		Aquifer Screened	Screen Interval	Airlift yield	Water Quality (June 11)		Water Level
								Jun-09
	Easting	Northing		(m below GL)	(l/s)	EC (uS/L)	pH	(m below TOC)
GW110520	228107	6300646	Alluvium and weathered rock	2-8	0.5	619	5.89	1.2
			Fractured rock	15.9-38				
GW110437	227895	6300507	fractured rock	83-90	0.06			

The licences for test bores were granted under Part 5 of the Water Act 1912, and a production bore licence was converted to Water access licence under the Water Management Act (2000) on 5 February 2011.

2.3 Hydraulic Testing

Information on hydraulic properties of the aquifers has been derived from the hydraulic slug testing on all piezometers except MW4 which was not accessible. The testing was conducted and interpreted by RPS Aquaterra during December 2011.

Airlift yield was measured on the test bore in 2009 during drilling and test bore installation. The results are given in Table 2.2. No pumping test was undertaken on the production bore.

The hydraulic testing results are summarised in Tables 2.3. For reference, the results of all tests are presented graphically in Appendix B.

During December 2011 each piezometer was hydraulically tested by a falling head slug test to determine values of average aquifer hydraulic conductivity.

Results have provided sufficient data to derive site specific aquifer hydraulic conductivities for the shallow alluvial aquifer. The test results have been analysed using the Hvorslev method. The results are summarised in Table 2.3 with the detailed results from all tests presented in Appendix B.

Table 2.3: Summary of hydraulic testing results

Piezometer	Hydraulic conductivity (m/d)	Comments
MW1	0.17	
MW2	0.57	
MW3	0.0004	
MW4		Not tested
MW5	0.2	
MW6	0.51	

2.4 Existing Groundwater Occurrence and Use

As part of the groundwater investigations, information on registered groundwater users within and close to the proposed development were collated through a search of the NSW Office of Water groundwater bore database.

The database revealed 38 registered bores and wells within a 5km radius of the Project. The bores are mostly private bores, installed for domestic and stock purposes and monitoring. Six bores are installed for power generation, recreational and water conservation use. The water quality is not recorded except in nine bores and it is mainly reported as being good. The bore yield reported for a limited number of bores is relatively low and in the range of 0.5L/s to 2.5L/s.

These sites are shown on Figure 3, along with information on their depth where available. Summary construction details and other information such as groundwater quality where available for each registered bore are presented in Table 2.5.

Most sites had bores and wells installed in sandstone and shale, with a small number installed in diorite, granite and coal. Over 70% of private bores are shallow (<50m depth), with a small number installed to depths between 50 and 90m below ground.

The locations of groundwater bores (with the screened aquifer records) identified through the database search are shown on Figure 4. This figure also shows the measured groundwater level and the measured EC where available at the time of bore installation.

The complete records for each site, including details, and the results of any water quality analysis, are presented in Appendix C.

2.5 Groundwater Levels

2.5.1 Monitoring Network and Monitoring Program

The groundwater monitoring network comprises six standpipe piezometers which have been manually monitored for groundwater levels on a quarterly basis since the installation from August 2009 onwards.

Composite water level hydrographs are shown in Figure 5, while individual hydrographs have been produced for each site and are included for reference in Appendix D.

2.5.2 Groundwater Level Trends

Water levels in individual bores range between approximately 874.18mAHD and 882.23mAHD.

Bores MW1-6 are screened through the shallow alluvial aquifer/backfill material and show rises in water level of several metres in response to rainfall.

All bores show an active recharge and discharge pattern, with clear rises in water level following significant rainfall followed by recession until the next rainfall recharge event. Rainfall data has been included on Figure 5. Natural recession continued following December 2010 rainfall events and reached equilibrium in the early part of 2011. By late 2011, the hydrographs show a rising trend suggesting a response to recharge, consistent with the rainfall data.

The changes in water levels over time follow the similar trend in all bores, with fluctuation of around 1-2m over time.

2.5.3 Groundwater Contours

Contour plans of groundwater levels within shallow hydrogeological unit across the Lidsdale Siding are presented in Figure 7.

The contours have been constructed from data available from shallow piezometers and very limited information available from the NSW Office of Water groundwater database. Groundwater levels across the site typically range between 881mAHD and 875mAHD (Figure 7). The shallow groundwater contour pattern shows a general conformance with surface topography, and is disconnected from the groundwater contour pattern in the deeper hydrogeology units. Locally within the site area the flow is from the south to north and northeast towards the Pipers Flat Creek. The likely disconnection between the shallow and deep units is due to the low inherent vertical hydraulic conductivity of the strata.

The groundwater levels in the deep aquifer (Illawarra coal measures) follow the regional groundwater gradient which is from the southwest to northeast. Groundwater level data from the underlying basement units (granites and volcanics and Shoalhaven Group) is sparse, but where available indicates limited vertical interconnection with the overlying shallow hydrogeology unit.

2.6 Groundwater Quality

Field measurements of pH and EC collected during drilling and bore installation are recorded on the borelogs in Appendix A. Following completion, each bore was purged in accordance with AS5667 (Standards Australia, 1998) prior to collection of an initial water sample for laboratory analysis of major cations and anions, and selected heavy metals.

To show the distribution of field water quality, salinity values (as EC uS/cm) and pH data from July 2009 to December 2011 have been plotted and are presented in Appendix D.

A summary of the groundwater chemistry based on sampling from bores in main hydrogeological units is shown in Table 2.4. Geochemical data has been plotted on a Piper Diagram to distinguish between different type waters and is presented in Figure 9.

Trends in heavy metal concentration over time from the ongoing monitoring program are provided for information in Appendix E.

Table 2.4: Summary of Groundwater Chemistry - Groundwater Monitoring Piezometers

Aquifer Screened	Water Quality				
	EC (uS/cm)		pH		Data Points
	Range	Median	Range	Median	
Shallow alluvium	96-1570	459	4.24-6.83	6.07	41
Fractured rock	426-647	480	5.89-6.26	6.21	5

Groundwater on site is generally slightly acidic, and the salinity values indicate groundwater is generally fresh, with some samples being brackish.

The current groundwater sampling program includes quarterly water level gauging and sampling from six monitoring bores and one production bore. The sampling schedule is shown in Table 2.5

Table 2.5: Water quality sampling program

Piezometer	Monitoring Frequency	Monitoring Parameters	Location Description
MW1	Quarterly	Major cations & anions, pH, EC, DO, TOG, SWL, NO3, Mn, Fe, Cd, Cu, Ni, TPH & BTEX	About 5m northeast of Diesel fuel tank bunker
MW2			About 50m east of Conveyor Coal Stockpile
MW3			Between Weighbridge and Main St next to fence
MW4			Northwest of Sediment Pond No2 on other side of railway line, inside of fence.
MW5			Just inside fence adjacent to DG7 on western side of railway line.
MW6			On northern side of railway line opposite Coates and outside of fence.
PB1			About 10m east of the Dirty Water Dam

2.7 Surface Water Quality

Surface water sampling locations are shown on Figure 2. Surface water quality is addressed in the Surface Water Impact Assessment and only the basic field parameters (electrical conductivity and pH) are discussed here. Salinity (expressed as EC) can be used as a general indicator of water quality, and is an important parameter in the assessment of environmental value, particularly in relation to ecological communities and, therefore, the development and distribution of groundwater dependent ecosystems (GDEs), and surface-groundwater interactions. The summarised results are shown in Table 2.6.

Table 2.6: Summary of surface water quality results

Location/site ID	Water Quality				
	EC (µS/cm)		pH		Number of Data Points
	Range	Average	Range	Average	
Dirty water dam	96-910	512	6.86-8.21	7.38	
LDP004	275-275	275	7.37	7.37	
Pipers Flat Creek u/s	247-575	469	6.74-7.22	7.03	
Wang STP Monitoring Point no1	241-539	420	6.18-7.19	6.9	

Surface water quality samples show less variability in electrical conductivity than groundwater samples, and mostly fresh quality, while the values of pH are generally slightly acidic to neutral.

3. DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Regional Setting

The Lidsdale Siding Project is located approximately 500m north of the township of Wallerawang, and by road it is 9km northwest of Lithgow NSW. The site joins the main western railway line on the southern side of Wallerawang Power Station.

The main drainage from the project area is Pipers Flat Creek which drains from the area west of Lidsdale Siding and flows along the northern site boundary to join the Coxs River just east of the site. About 700m to the south, Coxs River flows past the Wallerawang power station into Lake Wallace. The Coxs River Catchment contributes flows to Lake Burragorang (Warragamba Dam).

3.2 Summary of Other Developments and Industries in the Area

A literature review was undertaken in order to provide a regional understanding of the groundwater system, as well as other developments in the area that may need to be considered in the context of a cumulative impact assessment. This included a review of publicly available Environmental Assessments and AEMR’s for Angus Place Colliery, Springvale Mine, Centennial Coal Services Site, Lamberts Gully Open Cut, Kerosene Vale, Mt Piper power station and Ash Emplacements, Yarraboldy Extension 1, and Blackmans Flat Waste Management Facility. While details are provided below, it is clear from this analysis that it is not necessary to undertake a cumulative impact assessment for the Lidsdale Siding project as there is no interaction of water-related impacts on a semi-regional scale between the various developments.

3.2.1 Angus Place Colliery

Angus Place Colliery is owned and operated by Centennial Angus Place Pty Ltd. It is situated, approximately 18km north-west of Lithgow. Longwall mining methods have been in used here since 1979, working the Lithgow Seam. Previous approvals included the extraction of 2.3million tonnes of coal per annum (Mtpa) and involving equipment such as conveyors, coal sizers and screens, coal stockpiles, workshops and offices. In 2010, Angus Place Colliery obtained approval to increase their production limit to 4mtpa and for two new longwalls. In January 2012, DGRs were issued for a further modification of the proposed ventilation facility project. Angus Place holds a contract with Delta Electricity for coal supply until 2014. Angus Place currently holds a contract with Delta Electricity for 4Mtpa coal supply.

It was predicted (Aurecon, 2010) that there would be no impact on the most important aquifer zone in the region, the Clarence Aquifer. This is because there is no hydraulic connection between the Clarence Aquifer at Clarence and the aquifer horizon at Angus Place, as Farmers Creek valley acts to truncate the aquifer between the two sites. Along with the analysis of previous impacts of mining in the area, it was concluded that any impact from the proposed extraction of panels is minimal. Although it was predicted that there would be drainage of the lower coal measure aquifers into the goaf, this would not widely impact the hydrogeological regime. There are also no recorded users of the groundwater resources in these aquifers

The available piezometric data indicated that the hydrogeological regime, which consists of overburden aquifers in the proposed extraction, had been largely unaffected or had mainly recovered from coal extraction in the surrounding area. Groundwater had, however, been significantly depleted in the Lithgow seam. The impact of the proposed mining at Angus Place included the likelihood that the lower two aquifers will be drained into the goaf. It was considered in 2006 that continuous pumping over the next 15 years in both Angus Place and Springvale Collieries may extend the downdraw slightly, from the 1200m radius. It was concluded that the regional hydrogeological regime at Angus Place would be restored in the long term (International Environmental Consultants, 2006).

Based on previous mining, it is assumed that once mining ceases, hydrogeological conditions will return to their pre-mining state. The recovery of aquifer systems is predicted to be accelerated due to increased permeability of the coal measure strata as a result of previous mining activity. It is therefore proposed that the hydrogeological regime at Angus Place will restore itself over several decades.

3.2.2 Kerosene Vale

Kerosene Vale is a licensed stockpile area, allowing stockpiling of up to 500,000 tonnes of coal, with the average being 350,000 tonnes. The staging of pipes for water supply, a licensed discharge point and settling ponds are also located at Kerosene Vale. In 2006, it was projected that there may be future extraction of shallow coal reserves at the site.

3.2.3 Centennial Coal Services Site

Centennial Coal Services Site is situated approximately 4.5km to the north-west of Lidsdale Siding and provides coal handling, processing and reject disposal activities. Coal is delivered from the Springvale Mine via an overland conveyor which can then be either washed and conveyed using the return belt to Lidsdale Siding or conveyed to Mount Piper Power Station.

Initial underground and current open cut mining caused the Lithgow Seam within the Western Main mine to become dewatered, with the underground workings being free draining. A dam located to the north of the entrance of the Springvale Coal Services Site acted as storage to collect all seepage through the seams. This groundwater seepage returned to the natural environment via the licensed discharge point into Neubecks Creek, meeting the conditions stated in the Environment Protection Licence. Since underground extraction ceased, old workings which had been intersected by the existing open cut have been largely dry, however, there has been some minor local recharge.

3.2.4 Mt Piper Power station

Mt Piper Power Station is owned and operated by Delta Electricity and is located approximately 17km north-west of Lithgow. The proposed project site (SKM, 2009) is located adjacent to the current power station. The townships of Blackmans Flat, Wallerawang and Portland are located within a 6km radius of the project site. The Mt Piper Extension Project (SKM, 2009) consisted of the installation of CCGT or USC generation located adjacent to and to the west of the existing plant. Electrical power output for the generators was proposed to be delivered via step transformers, and water was projected to be sourced from the existing Coxs River supply for the existing power station. The proposal stated that the power station would have a zero discharge status for water, similar to the original station. Fuel for the plant was planned to be brought from off-site and coal would be sourced from local mines and suppliers. It was projected that the coal would be delivered via rail to a proposed rail unloader at Pipers Flat and then conveyed to the Power Station.

Mt Piper Power Station is located in the upper catchment of the western arm of Neubecks Creek, which flows east and south to join the Coxs River. Low bore yields is indicative of the poor groundwater prospects in the coal measures rocks in the Sydney Basin. The seams within the Basin are classified as semi-confined aquifers and have moderate to high salinity and low hydraulic conductivity. Small amounts of sulphide minerals are found in the underlying Shoalhaven Group rocks, which generate acid when exposed in road cuttings.

Two separate catchment areas supply the Wallerawang and Mt Piper Power Stations: the Coxs River and Fish River, which are tributaries of Nepean and Macquarie Rivers respectively. Under the then current regulations of the *Water Act 1912,* Delta had permission to extract up to 23,000ML/year from the Coxs River system. The water management licence (WML 00002) was issued in July 2000 and is reviewed every 5 years.

Under the Fish River Water Supply Agreement (Agreement Concerning the Supply of Water from the Fish River Water Supply Scheme – State Water Corporation, 2008), Delta may extract up to 8184ML/year, however this was reduced to 40% of that value in drought conditions. The Duckmaloi River Diversion was re-commissioned in June 2009 by the State Water Corporation.

The need for water uptake from the Coxs River by Wallerawang Power Station has been reduced as a result of a mine water transfer system. This was enabled by an agreement in 2006 between Delta Electricity and Centennial Coal for water to be transferred from Springvale/ Angus Place to Wallerawang pipeline. Mt Piper is supplied from Lake Lyell and Thompsons Creek Dam, whilst Wallerawang is supplied by Lake Wallace. Fish River supplies both power stations. The power stations combined extract water at the rate of 1.64ML/GWh.

Overall, the high water demands of the Mt Piper Power Station were kept within the requirements of the then current Water Management Licence. Extra water requirements, regardless of the coal or gas option, were projected be no more than 1,100ML/year, and mine water exchange would ensure no additional drawing from the surrounding waterways. Water quality of the surrounding catchments was projected to be assured by the ongoing policy of 'zero discharge'.

3.2.5 Blackmans Flat Waste Management Facility

The Development Report Assessment was prepared by Geolyse Pty Ltd for the City of Lithgow Council as part of an assessment of the Development Application of Blackmans Flat Waste Management Facility (HLA 2005). The location of the proposed site is to the west of the Castlereagh Highway, directly north of Blackmans Flat, and encompasses an area of approximately 46ha. Geographically, it is situated adjacent to the Centennial Coal Services Site, 16km north of Lithgow and 8km from the Wallerawang Power Station. This site contained a void in the northern part, as a result of previous underground and open cut mining operations, and a dam, known as the DML Dam, in the north eastern part of the site. An area of stockpiled overburden, surrounded by an area of remnant vegetation was located to the south of both the void and the dam. Vegetation was limited on the site, with only occasional areas of rehabilitation plantings. The site is accessible from the Castlereagh Highway via the Centennial Coal Services site access road.

The development of Blackmans Flat Waste Management Facility encompassed the preparation of the mine void for landfilling, weighbridge and road access. It included the construction of a waste transfer and recycling facility which would have enabled the storage and transfer of recyclable waste, including scrap metal, glass, plastic and paper. The proposed development required landfilling of 35,000 to 40,000 tonnes per annum of solid and inert waste, for the duration of approximately 15 years. This facility was projected to cater for approximately 750,000m^3 of waste after the perimeter wall stabilization works and placement of the required landfill lining system would be completed.

3.3 Climate

The area around Lithgow has a cool-temperate climate characterised by mild summers and cold winters. Rainfall is distributed throughout the year, often with higher falls during the summer months (November – February). Locally the climate is influenced by topography, altitude, and aspect. Maximum daily temperatures typically range between 10 and 25 degrees. Frosts are common, particularly between May and September. Rainfall exceeds evaporation only during the winter months.

3.3.1 Rainfall

Based on data collected by several Bureau of Meteorology (BoM) climate monitoring stations the average annual rainfall of the area is approximately 774.6 millimetres (Table 3.1):

- Lidsdale (Maddox Lane), Station 63132. Data record from 01/08/1959 to present;
- Wallerawang Power Station, Station 63176. Data record from 01/12/1902 to 31/10/1973;
- Lithgow (Cooerwull), Station 63226. Data record from 01/01/1878 to present;
- Lithgow (Birdwood St), Station 63224. Data record from 01/04/1889 to 30/06/2006;
- Lithgow (Kylie Park), Station 63164. Data record from 01/09/1959 to 31/09/2009; and
- Lithgow (Newnes Forest Centre), Station 63062. Data record from 01/04/1938 to 30/11/1999).

In addition, Lidsdale siding site has a rainfall gauge on site which has been monitoring rainfall data since 2010. Due to the short period of data availability from this station, the data from Lithgow and Lidsdale was used and is presented in Table 3.1

The distribution of the rainfall throughout the year is relatively uniform, but slightly higher during the warmer months (October through to March). Rainfall intensity is locally affected by the orographic influence of the Great Dividing Range.

Table 3.1: Long-term Average Monthly Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	80.5	75.3	69.4	53.7	51.4	63.3	59.5	61.3	55.2	64.6	69.0	71.4	774.6
Min	0.0	1.3	0.8	1.2	0.0	2.6	0.0	1.5	0.0	2.4	3.1	0.0	329.8
Max	213.6	294.5	411.4	202.6	183.8	258.7	319.0	363.8	255.0	228.4	207.7	255.9	1687.4

3.3.2 Evaporation/Evapotranspiration

The closest BoM climate monitoring station to the Project area that collates evaporation data is Bathurst Agricultural Centre (Station No. 063005) approximately 65km west of Lidsdale Siding (Table 3.2). From data collected between 1966 and 2009, the total average annual potential evaporation for the area is approximately 1,353mm.

Table 3.2: Long-term Average Monthly Potential Evaporation Rates (mm)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bathurst (1966-2006)	210.8	168.2	139.5	87	52.7	33	37.2	55.8	84	124	156	204.6	1353

A comparison between long-term monthly average rainfall and monthly average potential evaporation indicates that the area has excess evaporative capacity over rainfall over most of the year and can therefore be classified as having a semi-arid climate. There is, however, variability in monthly rainfall totals and there are periods when rainfall may exceed evaporation rates, particularly during the cooler winter months.

3.4 Regional Geology

The Project area lies within the Western Coalfield of NSW. The area is covered by the Bathurst-Sydney 1:250,000 geological maps.

The uppermost geological unit across the area is the Narrabeen Group, comprising shale, sandstone and conglomerates of freshwater origin of the Caley Formation and Grose Sub-Group The Triassic Narrabeen Group is underlain by the Permian Illawarra Coal Measures, which is turn are underlain by the Berry Formation of the Shoalhaven Group. The basement rocks of the region comprise early-mid Devonian age quartzites, limestones and shales that have been locally intruded by Carboniferous granites. The regional stratigraphy of the area is shown in (Figure 6) and summarised in Table 3.3.

Table 3.3: Regional Geology

Lithological Age	Stratigraphic Group	Sub-Group/Formation Lithology
Triassic Narrabeen Group	Grose Sub-Group	Quartz sandstone, conglomerate, minor red-brown and grey shale
	Caley Formation	Grey shale, quartz-lithic sandstone
Permian Illawarra Coal Measures	Wallerawang Sub-Group	Shale, claystone, coal; minor sandstone
	Charbon Sub-Group	Coal, shale and sandstone
	Cullen Bullen Sub-Group	Coal, shale, sandstone and conglomerate
	Shoalhaven Group (Berry Formation)	Siltstone
Carboniferous		Granite
Devonian		Quartzite, hornfels, slate

3.5 Local Geology

The unconsolidated alluvium/colluvium material covers most of the site and is generally 2-6m thick. It is underlain by shale which is weathered in the top section (approximately 7m) and fresh below this depth. The Shoalhaven Group outcrops over most of the study area mainly to the south and west, while to the north and east of the project site, the Shoalhaven Group is overlain by the Illawarra Coal Measures. The Illawarra Coal Measures contain four sub-groups and five main coal seams as outlined in Table 3.4 (listed in order of descending stratigraphy). The Permian sediments unconformably overlie Carboniferous granite.

Table 3.4: Illawarra Coal Measures and Units to the north of the site

Formation	Lithological unit
Katoomba Seam	Coal
Middle River Seam	Coal
Glen Davies Formation (Upper Irondale Seam)	Coal, shale, sandstone
Irondale Seam	Coal
Long Swamp Formation	Shale and sandstone
Lidsdale Seam	Coal
Blackmans Flat	Conglomerate
Lithgow Seam	Coal
Marrangaroo Formation	Sandstone, conglomerate

Angus Place and Springvale mining operations to the north and east of the site extract coal from the Lithgow seam. The Irondale Seam, Lidsdale Seam and Lithgow Seam vary in thickness and have a general dip at 1 to 3 degrees to the northeast.

Conformably overlying the Illawarra Coal Measures is the Triassic Narrabeen Group sandstone to the north and east of the Lidsdale Siding. It generally dips to the northeast at around 1.5 degrees. Drilling data indicates that the weathered profile varies in depth from around 4m to 18m, but is generally restricted to depths of less than 10m.

3.6 Hydrogeology

3.6.1 Regional Hydrogeological Units

The main hydrogeological units identified within the study are as follows.

- Quaternary alluvium associated with Coxs River and minor creeks (Pipers Flat Creek);
- Triassic Sandstone;
- Coal seams within the Permian Illawarra Coal Measures – Katoomba Seam, Middle River Seam, Irondale Seam, Lidsdale Seam and Lithgow Seam; and
- Basal unit comprising the Shoalhaven Group (siltstone, shale).

The regional distribution of these hydrogeological units is based mainly on the published geological map and notes for Western Coalfields (Yoo, et al, 2001) as shown on Figure 6.

Relatively higher permeability occurs in alluvium and in the coal seams, with lower permeability in the interburden and overburden. Minor zones of relatively higher permeability also occur in the Triassic sandstone and weathered parts of the Shoalhaven Group. All other units have low permeability.

3.6.2 Groundwater Occurrence within the Project Area

The primary water bearing zones on site are associated with the weathered shale and shallow alluvium. The fresh shale is known to be of low permeability and is not classified as aquifer.

Elsewhere in the study area, groundwater is known to occur within the weathered sandstone, siltstone and shale of the basement Shoalhaven group although low yields are recorded. The thickness of the Shoalhaven group sediments is greater than 50m.

No groundwater dependent ecosystems have been identified in the proposed Lidsdale Siding area.

3.6.3 Quaternary Alluvium

The alluvial sediments were deposited in a strongly fluvial environment and are dominated by channel sand and clay levee and overbank deposits, resulting in a highly heterogeneous aquifer.

The permeability of the formation is dependent on grain size distribution and is higher in the cleaner sand and gravel layers than in the clayey sand or clayey gravel layers. The hydraulic conductivity of the alluvium across the site ranges from less than 0.004m/d up to about 0.57m/day with the lower values associated with clay facies and compacted site soils and the higher values with cleaner sands. The site investigations had reported yields from only two bores developed in the alluvial aquifer in the assessment area. The reported yields ranged from 0.06 to 0.5L/sec with an average of 0.28L/sec.

3.6.4 Narrabeen Group sediments

The Narrabeen Group sediments stratigraphically overlay the Illawarra Group but are not present in the Project area. This sedimentary sequence outcrops to the east and north.

The hydraulic parameters of sandstone aquifers can vary considerably due to varying nature of their deposition, fracturing and formation, which leads to an anisotropic and heterogeneous nature.

3.6.5 Illawarra Coal Measures

The Permian Illawarra coal measures overlay the Shoalhaven Group sediments and outcrop to the north and east of the Project area. This sedimentary sequence has variable permeability and storativity. Permeability is generally higher in the coal seams and occasionally in the interburden sediments (generally sandstone, siltstone and mudstone) due to localised fracturing. The coal seams are classified as aquifers due to their relative higher permeability in comparison to the properties of the interburden sediments.

3.6.6 Weathered and fresh shale (Shoalhaven Group)

The shale and siltstone in the Shoalhaven Group outcrop over the Project area and to the west and vary from relatively fresh to highly weathered. The hydrogeology of shale is complex due to the stratification and texture, the random distribution of joints and fractures and the degree of weathering. The shales can be weathered to silts and clay, which has high porosity but low permeability.

The fresh (unweathered) shale can form fractured rock type aquifers but this depends on the nature of their formation. The shale aquifers tend to have low permeability and produce low yields. The bore yields in the government groundwater databases range from 0.5 to 2.5L/sec with an average of 1L/sec. The groundwater bore installed on site (GW110520) in weathered and fresh shale has a yield of 0.5L/s.

The reported salinity of groundwater from the shale in the assessment area is reported in three bores as good to fair.

3.7 Aquifer Parameters – Estimates of Hydraulic Conductivity

Table 3.5 details, for the principal hydrogeological units, the range and mean values of hydraulic conductivity obtained from analysis of the hydraulic test data and information from other studies in the area.

The hydraulic testing program was discussed in Section 2.3. The results of all tests are presented in Appendix B.

Table 3.5: Major Hydrogeological Units - Hydraulic Conductivity

Unit	Hydraulic Conductivity range (m/d)
Quaternary Alluvium/Residual Soil (Regolith)	0.001 -5
Triassic Narrabeen sediments	0.04 - 7.2
Permian coal measures and overburden	0.0003 -14
Weathered shale (Shoalhaven Group)	0.01 - 0.18
Fresh rock (Shoalhaven group)	0.06 - 1.1

3.8 Groundwater Levels and Flow Patterns

3.8.1 General Flow Patterns

Groundwater levels have been routinely monitored across the Lidsdale Siding area since late 2009, and a baseline dataset now exists. The composite hydrographs presented in Figure 5, and individual hydrographs in Appendix D, show the changes in groundwater levels with time. Groundwater level contours have also been constructed (Figure 7) to show spatial local groundwater level patterns, and give an indication of groundwater flow direction.

The generated contours infer that groundwater flow in the surficial water-table aquifers (alluvium, colluvium, weathered bedrock) generally follows the local topography, mirroring the local surface drainage pattern, with higher groundwater levels in areas of elevated terrain and lower levels in the valley (Figure 7). The southern side of the site is topographically elevated, which means the water levels are also elevated. Groundwater therefore moves from the site area to the Pipers Flat Creek and Coxs River valley areas to the north and northeast.

The water level in deeper hydrogeology unit are based on the recorded spot heights, as shown, and on groundwater levels in the steady state calibrated groundwater model, as described in Section 5. The generated contours show that groundwater is flowing through the deeper (Permian) hydrogeological units in a north-easterly direction, in the direction of strata dip. This flow pattern would be influenced by the recharge process which occurs predominantly in areas where units outcrop.

The site piezometers all show a gradual increase in groundwater levels, associated with higher rainfall events throughout 2010 following the very dry mid-winter period in 2009. Both piezometers located along the Pipers Flat Creek (MW4, MW5 and MW) and the piezometers on the upgradient side of site away from the creek (MW1, MW2 and MW3) show a similar response to rainfall. The rainfall in December 2010 causes an increase in water levels across the site with rise of around 1m. The subsequent decline in water levels is due to natural regional groundwater throughflow and discharge.

Extraction from production bore occurs sporadically throughout the year. At the current pumping rate of approximately 4ML/year the pumping from the production bore does not appear to have any impact on the shallow aquifer.

The locations of registered private bores within the area are provided in Figure 4. All of the bores that are near the site, and where the screened formation is known, are indicated as abstracting from the sandstone and shale aquifer (Figure 4). Inspection of the bore logs and the records of water strike for all bores within 2km of the site showed that all of the water bearing horizons were recorded within the weathered zone immediately above the top of the shale, and all of the bores have been screened within this horizon.

In addition to shallow alluvial aquifer, the aquifer within the investigation area occurs within the bottom of the weathered horizon immediately above the fresh shale/sandstone or within fresh rock. This acts as the water source for the bores in the area. This layer is of variable thickness, depending on the degree and nature of the weathering, but is generally in the order of 2 – 7m. It is semi-confined by the overlying clay materials, although there will be some connectivity with the lower part of the weathered sequence.

3.8.2 Quaternary Alluvium/Colluvium/Weathered Bedrock (Regolith Layer)

Groundwater levels in the surficial (near-surface) groundwater system range between 874.18mAHD and 882.23mAHD, but are closely related to surface topography rather than being a regional flow system, as shown by the groundwater contours in Figure 7. Groundwater within this layer is derived from local infiltration of rainfall into the near-surface alluvium, colluvium and/or highly weathered bedrock zone, with down-gradient flow towards and along topographic lows, generally the valley floor. Groundwater flow patterns within the shallow groundwater system are believed to be largely unrelated to flow systems in the deeper Shoalhaven group sediments.

Shallow alluvial groundwater flow generally follows the surface drainage systems, with similar flow directions and flow patterns to surface runoff. Groundwater discharges locally as baseflow to the stream system. As the groundwater table is typically shallow, losses also occur via evapotranspiration with little deep percolation to the underlying weathered hard rock units of the Shoalhaven group.

3.8.3 Permian Fractured Rock Aquifer

Permian strata are not present within the Project area but outcrop generally to the north. The groundwater flow is to northeast in the direction of the sedimentary sequence dip direction.

Registered bores installed mainly in shale, siltstone and coal are located to the northeast of the Project site however they are no recorded groundwater level measurements for these bores. Nevertheless, the groundwater unit is considered to become saturated at depth in the north east direction.

3.9 Recharge and Discharge

3.9.1 Recharge

Recharge occurs by direct infiltration of rainfall and local runoff into the unconsolidated surficial material, comprising alluvium in low-lying areas, and into the weathered zone of the bedrock (regolith layer) in more elevated areas. Water percolates downwards until reaching a zone of reduced permeability (top of bedrock beneath the alluvium, or the base of weathering in other areas), and then flows laterally above the less permeable layer. Recharge rates are a function of rainfall intensity, evaporation, vegetation coverage and density, topography and soil properties of the surficial aquifer material.

A water-table aquifer generally forms as an extensive unconfined aquifer, within surficial unconsolidated material, although there may be isolated occurrences of localised perched water tables.

Regionally, the Shoalhaven group aquifer is primarily recharged at outcrop. Where the aquifer is overlain by highly weathered material, recharge may also occur to the permeable parts of the hard rocks that subcrop beneath the unconsolidated surficial material.

3.9.2 Discharge

Natural groundwater discharge occurs through evapotranspiration, and through baseflow contributions to creeks and rivers, including discharge to the alluvium in some locations. Local discharges may take place wherever the water level in that unit is higher than the ground surface.

Baseflow contributions to river and stream features are also a primary natural groundwater discharge process with relative contribution rates proportionately increasing during the recession period of surface runoff after a rainfall event. Pipers Flat creek in the Lidsdale Siding area is considered to be ephemeral from natural processes, but receives discharge contributions from sewage treatment plant upgradient of the Project site. In the Lidsdale siding area the creek is “gaining” for the reaches upstream and downstream of the site which means that groundwater drains from the aquifer into the creek.

3.10 Groundwater Use

Records of the registered groundwater use from bores in the study area (within 5km) were extracted from the NSW Office of Water database, which contains records for 38 registered bores in the Lidsdale Siding area.

About 45 per cent of the bores are registered for stock and/or domestic supply uses with one bore licensed for irrigation. Around 30 per cent of bores found on the database are installed for monitoring purposes and 25 per cent are installed for power generation purposes.

Where possible, these bores have been identified according to aquifer type using available bore logs and construction details. Aquifer characterisation by nine registered bores (about 23%) was unable to be reliably determined from the information in the various state groundwater databases because of incomplete bore records; missing information included bore depths, construction details and/or lithologic logs. The locations of the bores in the different categories are plotted on geological base maps in Figure 8. This shows that there are a significant number of stock and domestic bores in the area, nearly all of which abstract from the shale and sandstone and older volcanics basement.

The salinity of the alluvium and sandstone/shale groundwater implies that it is suitable for most of the identified beneficial uses, although it is reported in relatively small number of bores (20%).

3.11 Groundwater Quality

Groundwater quality is discussed in detail within this section, and is based on the results of groundwater quality monitoring program presented in Section 2.6 and other information from the region.

Table 3.5 presents a summary of the ranges of key water quality parameters for groundwater derived from the main hydrogeological units. For reference, the table compares the values to the ANZECC (2000) guideline values for freshwater ecosystem protection.

Information on registered groundwater users within a 5km radius of the Lidsdale Siding Project area provided limited information on basic water quality, mainly salinity. Figure 4 shows the spatial distribution of groundwater salinity, using information collected from NSW Office of Water registered bores in the greater area.

Table 3.6: Summary of Water Quality Results

	Bore Name		**MW1**			**MW2**			**MW3**			**MW4**			**MW5**			**MW6**			**PB1**		
	Aquifer		**Alluvium Aquifer**			**Alluvium Aquifer**			**Alluvium Aquifer**			**Alluvium Aquifer**			**Alluvium Aquifer**			**Alluvium Aquifer**					
Parameter	**Units**	**ANZECC guidelines for 95% protection of species**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**
pH Value (lab)		6.5-8	6.62	6.71	6.83	5.78	6.12	6.44	4.98	5.33	5.78	4.23	4.40	4.71	5.60	5.96	6.74	6.24	6.36	6.56	5.63	5.98	6.26
Conductivity @ 25°C	μS/cm		389.00	516.57	686.00	517.00	1253.00	1570.00	228.00	340.00	460.00	343.00	501.78	604.00	96.00	143.75	191.00	276.00	399.00	572.00	426.00	563.00	689.00
Calcium	mg/L		34.00	38.57	42.00	64.00	159.60	221.00	3.00	7.80	18.00	15.00	22.67	34.00	5.00	8.00	13.00	23.00	32.60	44.00	29.00	34.80	40.00
Magnesium	mg/L		22.00	27.00	31.00	16.00	31.00	37.00	2.00	5.60	10.00	17.00	26.88	40.00	5.00	6.70	11.00	14.00	19.38	26.00	17.00	20.00	23.00
Sodium	mg/L		8.00	9.29	13.00	42.00	70.44	87.00	44.00	49.20	55.00	39.00	41.78	45.00	5.00	7.50	10.00	16.00	20.80	27.00	41.00	50.50	68.00
Potassium	mg/L		2.00	3.43	6.00	5.00	8.11	10.00	1.00	1.33	2.00	4.00	4.67	7.00	1.00	1.71	2.00	3.00	3.89	5.00	4.00	5.13	6.00
Carbonate as CaCO3	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate as CaCO3	mg/L		190	227.7143	256	55	164.88	268.00	3.00	12.00	26.00	<1	2.00	3.00	3.00	8.38	20.00	43.00	52.75	63.00	13.00	27.25	52.00
Chloride	mg/L		3.05	4.042857	5	13.1	18.17	22.80	36.00	46.40	52.00	12.00	15.69	19.40	2.00	4.25	5.67	22.00	31.52	45.00	14.00	21.13	29.00
Sulphate	mg/L		1	5.002	16	240	481.3333	622	27	63.4	116	167	227.8	312	34	48.71375	78.7	88.1	115.0111	145	43	200	276
Cadmium - Filtered	mg/L	0.0009	<0.0001	**0.002**	0.01	0.0001	**0.001**	0.006	<0.0001	0.0005	0.0013	0.0003	0.0007	0.0016	<0.0001	0.0009	0.0021	<0.0001	0.0005	0.002	0.0002	0.0002	0.0004
Copper - Filtered	mg/L	0.0062	0.001	**0.044**	0.149	0.002	**0.022**	0.112	0.003	**0.071**	0.287	0.008	**0.073**	0.455	0.002	**0.009**	0.026	0.002	**0.008**	0.02	0.001	**0.038**	0.277
Nitrate as N	mg/L	0.7	0.01	0.028333	0.06	0.020	0.177	0.730	2.860	**3.854**	4.980	0.320	0.792	1.310	0.290	**1.549**	4.430	0.070	0.480	1.090	0.020	0.059	0.120

3.11.1 Salinity

The overall values of salinity range from 96µS/cm measured in MW5 located close to the Pipers Flat Creek to 1570µS/cm in the MW2 located in the middle of the site. Overall, bores MW5 and MW3 located on the southern and northern end of site have the lowest average salinity of 144µS/cm and 340µS/cm respectively. The highest average salinity occurs in bore MW2 with 1253µS/cm. Other bores on site including the production bore have relatively low salinity and are typically fresh waters with the average around 500µS/cm.

The fluctuation in EC is generally 200-300µS/cm, except MW2 which shows fluctuations of around 1000µS/cm.

This is similar to other registered bores where the water was reported as good or fair.

3.11.2 pH

In general, pH values in the groundwater are acidic to neutral and vary from 4.2 to 6.8. The lowest average pH is recorded in MW4 (4.4) located upstream near the Pipers Flat Creek and the highest average pH was recorded in MW1 (6.7) in the centre of the site. All other average values are slightly acidic in the range from 6.1 to 6.6.

3.11.3 Dissolved Metals

In general, all samples have elevated heavy metals and exceed the ANZECC (2000) guidelines for 95% protection of freshwater species for cadmium and copper. .Comparison of the analysis results for dissolved metals was undertaken against the ANZECC (2000) guideline values for 95% protection of species (ANZECC, 2000). Since the cadmium and copper were elevated above the guidelines, the guideline trigger value was modified by calculating a site specific guideline. This was done by correcting a guideline for hardness and testing a new value as per ANZECC (2000) guidelines. Heavy metals in bore samples show exceedances of the corrected guideline values, as follows:

- In general, cadmium concentrations are low, but the guideline value (maximum) is exceeded in four monitoring bores and the production bore but not in MW4 and MW6. The highest concentration is found in bore MW1 located in the center of the site where the maximum value of 0.01 mg/L was recorded; and
- Levels of copper in the groundwater are exceeded in all bores and the production bore, with the highest concentrations recorded in MW4 of 0.45mg/L. Other bores have average values that exceed the guidelines by one or two orders of magnitude.

3.11.4 Nutrients

All samples were submitted for the analysis of nitrate. Nitrate concentrations are above the ANZECC (2000) guideline value in MW3, MW4 and MW5 The highest concentration of nitrate is found in bore MW3 with concentrations of up to 4.9mg/L (compared to the guideline value of 0.7mg/L).

3.11.5 Major Ion Composition

The groundwater in unconsolidated sediments is typically sulphate enriched in terms of anions and has no dominant cation. Sulphate makes up over 60-70% of all anions. Surface water has similar sulphate dominance but is more enriched with Mg and Ca.

The major ion chemistry classifications were prepared by using the Piper plots for September 2011 sampling periods separately and are presented in Figure 9. This sampling round was selected as it provides latest and the most comprehensive set of data.

Groundwater mainly falls into no dominant group where dissolution and mixing occurs. A small number of samples are SO_4 and Cl and Na dominant and represent the end point water where mixing had already occurred along the flow path, as shown on Piper diagrams Figure 9.

3.11.6 Groundwater-Surface Water Interaction

The study area has moderate annual long term average rainfall of about 770mm. This rainfall is not sufficient to support perennial streams except in the largest catchments and the surface water supplies are therefore limited.

Local groundwater flow is generally towards the river, and thus groundwater contribution to streams is possible. This relationship depends on the elevation of the creek. Since the creek is receiving additional recharge from the sewage treatment plant upstream, the water levels are artificially raised and therefore any natural patterns may be reversed.

3.11.7 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are defined by ARMCANZ/ANZECC (1996) as ecosystems which have their species composition and their natural ecological processes determined by groundwater. A detailed ecological assessment report, which includes discussion of the occurrence and distribution of GDEs within the Lidsdale Siding area, has been prepared by Paul Anink.

No groundwater dependent ecosystems have been identified during field inspection undertaken in December 2011.

4. DEVELOPMENT PROPOSAL

4.1 Proposal

The Lidsdale Siding project comprises a proposed infrastructure development in which coal will be loaded and transported from the existing overland conveyor onto trains by automatic handling system. The project has been developed to allow loading the coal for transport by rail to export and domestic markets. The development will include the construction of above and below ground facilities. Below ground facility will require the excavation of a 4m deep trench, which will be used to lay the prefabricated concrete blocks. These will form part of the reclaim tunnel. Excavation and construction of the reclaim tunnel will take 3-6 months to complete. The base of the proposed reclaim tunnel would be approximately 4m below ground. The tunnel would be approximately 150m in length and 5.5m wide.

For the purpose of this study and groundwater impact assessment, the development schedule (reclaim tunnel excavation and construction) for the Lidsdale Siding has been assumed to begin in 2012 but will actually depend on the final approval date.

4.2 Schedule

Although the detail design for the excavation and development of the reclaim tunnel has not been developed yet, the general construction periods and techniques have been used. It is anticipated that construction will commence in December 2012 and the site will be fully operational by December 2013. For the purpose of this groundwater study, the excavation of the trench will take three months and during the first month soil will be removed to depth of 1.4m over the area of 50m x 100m. Over the second month the soil will be removed to 2.8m depth, and during the third month the excavation will reach 4.2m below ground.

Following the excavation, the prefabricated concrete blocks will be lowered in the trench and connected so to form the reclaim tunnel. During this period the trench will be open and any water inflow will be managed by pumping. The waste will be used on site for bunding and other purposes. This will provide the advantages of reduced cost of material disposal.

4.3 Water Supply

Water supply on site will be provided from various sources:

- Groundwater from production bore (8.5ML/year licence);
- Surface water from Pipers Flat Creek(1ML/year licence);
- Dirty water dam with over 4ML capacity to store surface water and runoff; and
- Clean water supply from Lithgow Council (negotiations are on the currently being undertaken).

The overall water balance is given in the Surface Water assessment for this EA.

5. GROUNDWATER MODELLING

5.1 Background

A numerical model was set up as part of the groundwater assessment for the Lidsdale Siding project.

There are no known groundwater models that cover this area. This semi-regional scale model has been developed by RPS Aquaterra to include all naturally occurring features in the area and to assess the local groundwater impact from Lidsdale Siding project. The cumulative impact from other industries is considered without reference to the model due to the remoteness of the other sites and the lack of interference with groundwater.

The semi-regional model was set up to simulate groundwater conditions over a 64km^2 area, to encompass the area of potential impact from the Lidsdale Siding project and allow for potential future cumulative impact assessments. The model structure, modelling approach, model calibration, results of simulations and the assessment of potential impacts to the groundwater environment are discussed in detail in the following sections.

5.2 The Groundwater Model

5.2.1 Modelling Software

A 3-dimensional finite difference model has been built using the MODFLOW code (McDonald and Harbaugh, 1988) coupled with the MODFLOW SURFACT (Version 4) code to allow for both saturated and unsaturated flow conditions. The modelling has been undertaken using the Groundwater Vistas (Version 6.07) pre/post-processor software package.

The model was set up to simulate groundwater conditions over the study area in order to include all naturally occurring features. The model also encompasses the area of potential impact from the Lidsdale Siding project.

The model structure, modelling approach, model calibration, results of simulations and the assessment of potential impacts to the groundwater environment are discussed in detail in the following sections.

5.2.2 Conceptual Model Design

The conceptual model is a simplified representation of the real system, identifying the most important geological units and hydrogeological processes, while acknowledging that the real system is hydrologically and geologically more complex than can be rendered in a model. The conceptual model forms the basis for the computational groundwater flow model.

The key conceptual model features of the Lidsdale Siding model are described below, and are graphically illustrated in the following figures:

- Figure 11 shows the model domain and key model features including boundary conditions and conceptual groundwater flow patterns for the shallow alluvial and deeper fractured rock aquifers; and
- Figure 13 shows a North-South cross-section through the reclaim tunnel, showing the model structure.

5.2.3 Model Layers

The hydrogeological units of relevance have been represented in the groundwater model by three model layers, as detailed below in Table 5.3.

The occasional presence of volcanic intrusive rocks (basalt) has not been represented specifically, as the basalt is not regionally continuous, and is deemed in the model to be included in the enclosing or adjacent lithology.

Table 5.1: Lidsdale Siding Model Layers

Layer	Lithology	Aquifer/Aquitard	Comments
1	Quaternary alluvium	Locally minor aquifer	Limited to valley areas of active streams, and rivers
	Colluvium / weathered bedrock / regolith	Locally aquifer	Regolith is generally present across the model
2	Weathered bedrock, Shoalhaven Group, Triassic sandstone and Illawarra Coal Measures at the outcrop	Minor aquifer	Poor to moderate horizontal permeability, but low vertical permeability
3	Shoalhaven Group, Illawarra Coal Measures	Minor aquifer	Low permeability generally, except where associated with fractured zones and moderate permeability associated with coal seams.

Within the model, all layers were designated as MODFLOW SURFACT 'Type 3' layers, which allows for each to behave as unconfined or confined dependent on water levels relative to layer elevations. Model simulations involved variably-saturated flow conditions using the van Genuchten function as an unsaturated flow modelling option provided by the MODFLOW SURFACT BCF4 package.

5.2.4 Model Domain and Boundary Conditions

The model domain, boundary conditions and grid design are shown in Figure 12.

The model boundary conditions have been assigned to represent the regional groundwater flow system in a realistic manner, taking into account stratigraphic and topographic controls. The model boundary condition maps for each layer are illustrated in more detail in Appendix F.

Model covers an area of 8km x 8km (64km^2), with a regular grid size of 50m x 50m over the majority of the model domain (refer to Figure 12) and mesh refinement to 25m x 25m in the vicinity of the reclaim tunnel and centre of the site. This gives a grid mesh of 180 rows and 180 columns, a total of 32,400 cells per layer, or 97,200 cells for the full 3-layer model.

The 25m x 25m grid cell size aligns with the proposed trench alignment which similarly has dimensions of 25m x 100m, which allows for accurate representation. It also provides the capability for accurate modelling of impacts, particularly stream-aquifer interaction processes in the areas where greatest impacts are expected to occur.

The model contains three layers, with areas at the eastern and western sections of the model domain specified as a no-flow boundary in each layer. General head (or head-dependent flow) boundaries were included in the all three model layers in the north-eastern corner (representing regional outflow) of the model, and in layer three in the south-western corner (representing regional inflow). These are the only areas and hydrogeological units that would allow for significant regional groundwater throughflow. This boundary was not applied in the upper two layers as the flow in the Coxs River and water elevation of Lake Wallace (constant head boundary) control the groundwater flow to the northeast in the upper layers.

5.2.5 Model Layer Elevations

Layer surface elevation contours are presented in Appendix G.

The top elevation of Layer 1 was specified from the surface topography Digital Elevation Model using 1m contouring over the site and 50m contouring over the areas to the south and west.

The layer elevations were taken from the groundwater bore logs within the site, and have been extended regionally using information from the regional Western Coalfields geological data. The regional structure of the Permian Coal Seams was based on general dip information provided by the 1:100,000 geological map (E.K. Yoo, et al, 1998). Layer surface elevation contours are presented in Appendix G.

Layer thicknesses in the model vary from around 1m to 6m in Layer 1 (Alluvium and Regolith) to 6m in Layer 2 (weathered host material sandstone and shale). Regionally, the thicknesses of layers 1 and 2 are assumed at 6m and 7m respectively; unless otherwise effected by outcropping, where layer thickness are reduced to a minimum cell thickness of 1m to ensure numerical stability. The thickness of Layer 3 is about 90m.

5.2.6 Aquifer Properties

Representative aquifer properties of the lithological units in the study area, as determined from field testing and hydrogeological assessment, are listed in Table 5.2. Through the calibration process, some adjustments have been made to these values. Model Layer 1 parameter distribution was undertaken in accordance with the interpreted distribution of alluvium, colluvium and regolith.

The extent of the alluvium has been regionally based on the published 1:100,000 geological mapping, and locally refined near the Project site based on the results of drilling and analysis of topography.

The aquifer parameters are based on the results of the field investigations and testing and from reference to studies undertaken by others for the nearby coal projects.

Table 5.2: Representative Modelled Aquifer Parameters

Layer	Lithologies	K_h (m/d)	K_v (m/d)	Unconfined Sy (-)	Confined S (-)
1	Weathered regolith, alluvial and colluvial deposits	0.0012-5	0.0007-0.5	0.01	n/a
2	Weathered bedrock, Shoalhaven Group, Triassic sandstone and Illawarra Coal Measures at the outcrop	0.0068 – 5	0.004- 0.05	0.01	0.01
3	Shoalhaven Group, Illawarra Coal Measures	0.001	0.0001	0.01	0.01

5.2.7 Groundwater Flow Pattern

The shallow groundwater flow pattern (for groundwater within the alluvium and regolith units) is generally from the south to the north, but is locally controlled by the surface topography and stream systems.

Groundwater flow in the Narrabeen Group, the Illawarra Coal Measures and locally outcropping Shoalhaven Group is not directly related to the local topography. The general flow direction in these hydrogeology units is to the north-east, in the direction of the dip of the strata, but under the influence of regional recharge where each unit outcrops/subcrops and discharge at remote locations downdip to the north-east.

5.2.8 Surface Drainage

Groundwater baseflow contributions to river and stream features represent one of the primary natural groundwater discharge processes (the other main natural discharge processes being evapotranspiration from shallow water tables and some regional groundwater throughflow). Baseflow is groundwater that discharges into a stream system, and is a continuing process whenever the head differences between the groundwater and the stream are favourable, but with contribution rates often increasing during the recession phase after a rainfall event has recharged the aquifer system and raised groundwater levels relative to the stream bed level. Although Pipers Flat Creek naturally is an ephemeral creek, its current status is perennial due to discharge from the upstream industry. Ephemeral creek characteristics are apparent where the baseflow is insufficient to maintain permanent (perennial) creek flow.

In areas where the groundwater levels may be lower than the creek system, the creeks may be “losing” streams i.e. they may lose water by seepage to adjacent or underlying aquifers. It is possible for larger river/creek systems to provide some recharge to the aquifer under natural conditions at least at some times, when river and creek levels may be temporarily higher than the groundwater following heavy rainfall events

The numerical model design incorporates river/aquifer interaction features to represent both baseflow (groundwater discharge to streams) and leakage (from the streams to the groundwater), as well as quantification of the impacts of groundwater pumping on surface water features. It is considered that the tributary stream (Pipers Flat Creek) in the study is naturally ephemeral because groundwater baseflow discharge is insufficient to sustain continuous flow, and extensive periods of no-flow naturally occur. This creek however receives the recharge from the upstream sewage treatment plant, and is therefore flowing most of the time.

Surface drainages have been represented in the model using the River (RIV) package of the MODFLOW software. River cells allow flow in both directions between the groundwater and the stream, depending on relative heads at any time in a simulation.

The river stage elevations were set to 1m below the river bank elevation (in the absence of surveyed data), and river bed levels set up to 1m below the stage in the Coxs Creek and 0.5m below the stage of Pipers Flat Creek. The river stages in the model were not varied at any time during simulations (calibration or prediction).

The river conductance parameter varies as it depends on the length of the river reach in the cell. An average river conductance was set to 250m^2/day for the Pipers Flat Creek in the vicinity of the site, and 500m^2/day for Coxs River.

5.2.9 Rainfall Recharge

The water table is recharged by rainfall, with the spatial variations in the assumed percentage values of rainfall recharge rate depending on the type and extent of surficial outcrop, and local topography.

For the steady-state (long term average) model, the annual average recharge rate has been modelled by applying a spatially-variable effective rainfall percentage recharge rate to two specific areas, reflecting the presence (or absence) of alluvium in the area. Modelled recharge to alluvium is set at 11% of annual average rainfall. Elsewhere, recharge is set to 1.5% of annual average rainfall for the steady state model.

The same percentage recharge rates have been carried forward to the transient (time-varying) calibration model, but are applied to the monthly rainfall averages over the calibration period. For the prediction during 6 months of excavation and tunnel development, the adopted recharge rates over the trench area are conservatively set to 100% of rainfall. For the recovery (post-construction) model, long term average annual rainfall was used with the specified recharge rates.

5.2.10 Evapotranspiration

Evapotranspiration (EVT) has been included in the model using the Evapotranspiration package of MODFLOW. A uniform maximum rate of 600 mm/yr was assumed (approximately 40% of the average long-term pan EVT, and equivalent to BoM estimates for actual EVT in the Lidsdale Siding area). An extinction depth of 3m has been used adopted over the model domain, meaning that EVT in the model will occur predominantly in areas of shallow depth to the water table (usually in the riparian and floodplain zones of surface drainage features).

5.2.11 Other Discharge Features

Discharge occurs from the model as a result of pumping from production bores. The site holds a licence for 8.5ML/year extraction, however less than half of this allocation is used. The pumping was applied in the model to occur at the past extraction rates and pumping is assigned to Layer 3.

5.3 Simulation of Development

The overall objective of the groundwater modelling was to assess the potential impacts of the Lidsdale Siding project on the groundwater environment, specifically with regard to:

- Predicted inflow into the reclaim tunnel during excavation and development (and dewatering) rates;
- Regional changes in groundwater levels during construction and operation;
- Changes in baseflow contributions to surface watercourses; and
- Potential impacts on any existing beneficial groundwater users and GDEs.

The progression of the excavation and tunnel development has been simulated by setting Modflow drain (DRN) cells to all parts of the trench that are excavated at a particular stage of the project, in accordance with the development schedule provided by Centennial Ivanhoe. Dewatering occurs in three stages of one-month duration each associated with three excavation levels 1.4, 2.8 and 4.2mbgl (metres below ground level).

During laying of the concrete blocks, the hydraulic parameter of the trench (K) has been changed to represent the nature of the concrete material. This has been accomplished by setting up time slice models, with parameters set to in-situ conditions for the first time slice model that represents the excavation, and parameters representing the laying of concrete and backfilling for the second slice. Drain cells are kept active in the trench during the excavation and laying of concrete blocks, which each takes three months to complete. The drain cells are then switched off after the tunnel is completed and trench backfilled.

The drain conductance value reflects the resistance to flow between the surrounding material and the void. This is a key model parameter which determines the simulated seepage inflow into the trench. The drain cell conductance parameter used in the trench was 5m^2/day reducing to 0.1m^2/day during the placement of the concrete lined tunnel in the trench. The sensitivity to this parameter was assessed by increasing the drain conductance as reported in Section 5.9.

A 10 year recovery run post development simulates the recovery to both the regional and local groundwater levels and also provides data to assess the changes to the water balance.

5.4 Model Calibration

Calibration is the process by which the independent variables (parameters and boundary conditions) of a model are adjusted, within realistic limits, to produce the best match between simulated and measured data. The realistic limits on parameter values are constrained by the range of measured values from pumping tests and other hydrogeological investigations.

An initial steady state calibration was run, to obtain the parameters for the transient calibration and to define the model parameters.

Transient records are available from September 2009 from six bores. A transient calibration has been run for the period September 2009 to September 2011. The stress periods during transient model calibration was set to three-monthly periods, while for the predictive time slice model a one-monthly stress period was used, to correspond with the excavation and tunnel development.

5.4.1 Steady State Calibration

The overall groundwater balance for the steady state Lidsdale Siding model is summarised in Table 7.6.

The total inflow over the entire modelled area is around 7.3ML/d, comprising river recharge (43%), leakage into the aquifer from Lake Wallace (35%) plus lateral regional inflow (20%).

The total outflow of the aquifer system (7.3ML/d) comprises baseflow to rivers and creeks (41%), groundwater recharge to Lake Wallace (37%) and lateral groundwater outflow (20%).

Table 5.3: Groundwater Budget for the Lidsdale Siding Model Steady State Calibration

Component	**Groundwater Inflow**	**Groundwater Outflow**
	(ML/d)	**(ML/d)**
Rainfall Recharge	0.015	
Evapotranspiration (EVT)		0.010
Lateral regional groundwater inflow	1.47	1.54
River- ephemeral creeks and streams	3.2	3.06
Lake Wallace	2.59	2.76
Pumping –dewatering bore		0.006
TOTAL	7.35	7.351

5.4.2 Transient Model Calibration

The aim of the transient calibration was to achieve a history match to the observed groundwater level impacts during the period 2009 to 2011, which included the varying recharge conditions in response to actual rainfall. The pumping bore was omitted from the transient calibration run as detailed pumping bore data was not available and the steady state run and monitoring data indicated there was no influence on the shallow aquifer due to pumping.

Data from all observation bores within the Lidsdale Siding area which have a two year period of monitoring were used in the model.

The initial conditions in the transient model calibration were based on the heads generated by the steady state model. The calibration process involved initial running of PEST followed by manual calibration due to long running times. The process involved changing aquifer parameter values (hydraulic conductivity, unconfined specific yield and confined storage coefficient) within reasonable limits (constrained by available data and hydrogeological knowledge of the area), until reasonable matches were obtained between the observed and simulated hydrographs, and between reported and simulated inflow rates.

The calibrated aquifer hydraulic parameters resulting from the steady and transient model calibration are summarised in Table 5.2. Detailed maps for the hydraulic parameter zones for each layer are presented in Appendix H and the simulated versus observed hydrographs for each of the bores used during calibration are included in Appendix I.

The groundwater balance for 2009 -2011 transient model at the end of the 2-year calibration period in September 2011 is summarised in Table 5.4.

Table 5.4: Groundwater Budget for the Transient Model at September 2011

Component	**Groundwater Inflow**	**Groundwater Outflow**
	(ML/d)	**(ML/d)**
Rainfall Recharge	0.087	
Evapotranspiration (EVT)		0
River - ephemeral creeks and streams	5.35	5.06
Lateral groundwater inflow/outflow	2.35	2.42
Lake Wallace	5.19	5.48
Storage	0.018	0.032
TOTAL	13.01	13.01
% Error	0.01	

The calibration performance of the model for the two year history match period to 2011 has been demonstrated in quantitative terms (potentiometric head matches and statistical measures) and qualitative terms (pattern-matching), by:

- Scatter plots of modelled versus measured potentiometric head in Figure 14, and the associated statistical measure of the scaled root mean square (SRMS) value (Table 5.5); and
- Hydrographs of modelled and measured potentiometric head (Appendix I).

The modelled results (hydrographs in Appendix I) match very well with the actual hydrographs, including the response to seasonal rainfall recharge (and noting that the model did not include variations in stream stage levels), confirming the model as a good predictive tool to simulate the aquifer system

The SRMS value is the key quantitative performance indicator, calculated as the RMS value divided by the range of measured heads across the model. Given the uncertainties in the overall water balance volumes (e.g. it is difficult to directly measure evaporation, or baseflow into the creeks), it was considered that a 10% SRMS value on aquifer water levels would be an appropriate target for this project, consistent with the Australian best practice modelling guideline (MDBC, 2001).

The scatter diagram of measured versus modelled potentiometric head targets is plotted in Figure 14.

Table 5.5: Steady State Calibration Performance in the Model

Calibration Parameters		Value	
Count	n	6	-
Scaled Mean Sum of Residuals	SMSR	2.55	%
Root Mean Square	RMS	0.11	m
Scaled RMS	SRMS	2.96	%
Root Mean Fraction Square	RMFS	0.01	%
Scaled RMFS	SRMFS	2.96	%
Coefficient of Determination	CD	0.95	-

5.5 Prediction of Construction Dewatering

Having achieved acceptable calibration of the model, the model was then applied to predictive transient modelling.

The groundwater conditions at 2011 derived from results of the transient calibration were used as the initial conditions for prediction modelling, predictive model was run using two time slice models for the period of three months each, with a one-month stress period for each three-month time slice.

The predicted inflow rates are shown graphically in Figure 15 and are summarised in Table 5.6.

Table 5.6: Predicted Reclaim Tunnel Inflow Rates

Excavation and tunnel development (month)	Average Inflow (m^3/day)	Cumulative Volume (m^3)
1	7.2	218
2	12.4	591
3	26.9	1400
4	<0.1	1400
5	<0.1	1400
6	<0.1	1400

During the initial 3 months of excavation there is predicted to be an increase in the water inflow into the trench as it progresses deeper and intercepts groundwater. Once the construction of the tunnel commences the hydraulic conductivity will decrease due to concrete blocks and backfill, and the inflow will subsequently cease.

The highest water inflows are predicted to occur in the second and third month, as excavation continues deeper.

5.6 Predicted Water Level Drawdown

The predicted water level drawdown has been calculated for Layer 1 only as all the dewatering activity occurs in this layer.

The drawdown impacts due to Lidsdale Siding project are discussed below in Section 6.2.

5.7 Post Construction Groundwater Recovery

The post-construction recovery run was conducted using the results from the end of the dewatering predictions, i.e. conditions at the end of six months of construction, as the initial conditions. The recovery period was set as 10 years.

All excavation drain cells were deactivated and the average long term rainfall applied for the recovery simulation. The results from the end of modeling run are given in Figure 20 for the shallow aquifer.

At the end of the 10 year recovery period, water levels in Layer 1 are predicted to be essentially the same as pre-construction levels. Layer 2 is not affected by activities in Layer 1, and Layer 3 is affected to a very small degree by pumping dewatering which is scheduled to continue throughout the recovery period.

5.8 Baseflow

The Pipers Flat Creek was divided into 'reaches' in order to evaluate the groundwater discharge (baseflow) contributions to the groundwater system. Figure 16 shows the location of these reaches (numbered R1 to R6). Reach 1 is the upstream reach and reach 6 is the downstream, all other reaches are along the Project boundary.

Table 5.7 summarises the predicted river/creek baseflow and predicted river leakage volumes at key stages prior to construction activities.

Upstream of the site and along the northern site boundary, predicted baseflows are negligible in the order of 1m^3/d (i.e. from the upstream catchment) and increase to 62m^3/day for the reach downstream of the site, which also registers some leakage to the aquifer in this area.

Modelling of river / creek flows to groundwater (by leakage) along the various reaches predicts that change in baseflow contribution (post construction) to Pipers Flat Creek from groundwater is negligible (0.1m^3/day). No creek losses are predicted in the zones close to the site.

Table 5.7: Baseflow contribution to the Pipers Flat Creek pre-construction

River zone	River leakage(m^3/day)	Baseflow contribution (m^3/day)
1	563.9	0.9
2	1.9	0.1
3	1.8	0.0
4	2.6	0.0
5	0.0	0.5
6	53.7	62.1

Table 5.8: Change in baseflow contribution from pre-construction to post-construction of reclaim tunnel development

River zone	River leakage(m^3/day)	Baseflow contribution (m^3/day)
1	0.8	18.5
2	0.0	0.2
3	0.0	0.2
4	0.0	-0.2
5	0.5	-0.5
6	9.8	-5.9

5.9 Uncertainty Analysis

Uncertainty analysis is the process of assessing the impacts on model predictions of variations in critical parameters.

During the calibration process, it was found that the critical parameter that will most likely affect model reliability is the drain conductance parameter that governs the dewatering volumes.

For the uncertainty analysis, the model was set up with high drain conductance (enhanced by a factor of 10).

Table 5.9 lists a summary of the results following the uncertainty analysis parameter changes

Table 5.9: Uncertainty analysis results

Parameter changed	Layer	Time (days)	Change in inflow rate (m^3/day)
Drain conductance	1	30	-0.67
		60	107
		90	-0.81
		120	0
		150	0
		180	0

Table 5.9 illustrates the predicted change in dewatering rates with increased drain cell conductance in Layer 1 compared with the base case prediction. The overall total increase in inflow is around 1.4ML, which would double the total inflow for the period of construction to 2.8ML. This is still a very small volume and the model results can be classified as not sensitive in a semi-regional or even a local context.

5.10 Future Groundwater Extraction and Licensing

The existing groundwater-related licences held by the Proponent are listed in Section 2.2. These licences would be retained.

In addition to the existing licences, a Water Access Licence under Section 115 of the Water Act 1912 may be required for the proposed Lidsdale Siding to account for the interception of the aquifer. Despite the introduction of the Water Management 2000 on 1 July 2011, applications for dewatering are required to be made under the Water Act, 1912.

Future groundwater extraction based on the maximum groundwater levels will be in the range from 6m^3/day to 76 m^3/day for the period of three months with the total 1.4ML predicted to be intercepted over the construction period of 6 months. As advised by NSW Office of Water, Centennial Ivanhoe will apply for the temporary dewatering licence for construction purpose for the aquifer interception during development under the Water Act 1912. Following the completion of development, this licence will be cancelled. This licence will be assessed independently from the Project.

The disposal of water during construction of the tunnel will be into the dirty water dam on-site. If any overflow occurs from the Dirty water dam, it will be discharged under the current EPA discharge licence and monitored at licensed discharge point LDP004.

6. POTENTIAL GROUNDWATER IMPACTS

This section of the report discusses the potential hydrogeological impacts of the proposed Lidsdale Siding Project and the proposed mitigation measures where adverse impacts are identified.

The impact of ground disturbance due to subsidence and vibration from the Project and any changes in hydrology and GDEs due to subsidence have not been discussed as the proposed Project is a shallow (<2m) open excavation development which would not cause ground subsidence.

With regards to the potential impact on future water supply, no groundwater sources or aquifers have been identified that would require sterilisation from future water supply use as a consequence of the Project.

6.1 Overview of Potential Impacts on the Groundwater System

Groundwater inflow into the proposed development of the Lidsdale Siding would occur from the groundwater intercepted during the excavation and construction of the reclaim tunnel.

Predictive analytical modelling has indicated that groundwater inflow to the shallow excavation would reduce from 76m^3/day after the first 2 months of excavation to 2.3m^3/day at the end of initial 3 months of excavation. After this time, the construction of the concrete lined tunnel will be underway and the development would intercept insignificant groundwater inflow. The total inflow would reach negligible 3.8 x 10^{-7}m^3/day (0.00038L/day) by the end of the six months of construction. Groundwater inflow control strategies, such as a strategically located sump pump in the trench would be required during the first three months of excavation. No advanced dewatering would be required and no groundwater treatment and disposal would be required as a result of this Project.

6.2 Cumulative Impact on Groundwater from Surrounding Industries

As a result of the shallow excavation and the low inflow volumes, the impact to the groundwater system from the Project will be minor and the recovery will occur quickly following the cessation of development. The sewage treatment facility upstream of the site and Wallerawang Power Station downstream of the site are not affecting the groundwater system. However, they are impacting on the surface water and its quality.

The additional dewatering and discharge from excavation and laying of the reclaim tunnel is predicted to add 1.4ML to the surface water system, which will be disposed off in the dirty water dam on site. This water will be used on site and recycled as part of the site water balance.

It is considered that the additional 1.4ML of water that will enter the surface water system over the main construction period is negligible compared to the flow in the Pipers Flat Creek and Coxs River and overall site water balance. Other mines such as Angus Place, Springvale Colliery and Yarraboldy Extension 1 are intercepting overlaying aquifers and are located at such a significant distance from the proposed Project that there would be no influence on the groundwater system.

6.3 Impact on Licensed Water Users

Extraction of groundwater by dewatering would lower the water levels of the shallow alluvial aquifer within and close to the trench area. The maximum lowering of the water levels is predicted to be approximately 0.3m at the site boundary. There would be negligible drawdown outside of this area when the tunnel is concrete lined.

Therefore, only those bores that are either directly at the site boundary (GW053071) could be impacted by the temporary dewatering prior to concrete lining. As shown in Figure 3, privately owned bores within a 5km radius are beyond the extent of the temporary dewatering, except GW053071, which is just outside of the northern site boundary and is used for domestic purposes. The maximum expected drawdown in this bore is predicted to be 0.3m and only for a short period, which only marginally reduces the available drawdown from this bore. There are no other bores in the 1km radius form the site. It is therefore assessed that the Project would not impact on any groundwater users in the area.

6.4 Impact on Surface Water

The closest surface water system is the Pipers Flat Creek. The water levels after 3 months excavation when the inflow is highest show that the extent of dewatering will not reach the creek.

The baseflow analysis was undertaken to assess the recharge and discharge to the Pipers Flat Creek for 6 zones stating from the upgradient area of the site to downgradient of the site, as shown on Figure 16. The results are reported in Table 5.9. There is only very minor change in the overall baseflow contribution with a maximum loss of 0.2m^3/day.

6.5 Impact on Groundwater System

Apart from minor and very local drawdown in the alluvial aquifer during the construction of the reclaim tunnel, there will be no impacts to other deeper aquifer systems. The recovery will occur following the construction of the tunnel, and the gravel envelope would be placed around the concrete tunnel to allow groundwater to flow around the tunnel and thus prevent any backup of water on the upgradient southern side.

6.6 Potential Impacts during Construction

During the initial construction period of the Project, it is proposed to excavate the trench in stages and then progress with placement of the concrete lining.

During this period there would be interception of groundwater in particular as the excavation progress below the water table at around 1.5m depth. The inflows will mainly occur during the first three months of excavation and will reduce to minor seepage following the placement of the concrete lining. There would be a neutral impact on surface water quality and quantity. In relation to potential impacts during the construction phase of the project these are assessed as being in accordance with the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 as having a neutral effect and NSW State Groundwater Policy Framework Document (DLWC, 1997).

Groundwater volumes collected in the sump would range from 6m^3/day to 67m^3/day, as predicted by numerical modelling (with an uncertainty factor of 2). This water would be effectively managed on site and disposed off in the Dirty Water Dam. This means that there would be no offsite discharge and therefore no impact on the water levels or water quality of the Pipers Flat Creek, except in the event of ongoing or significant rainfall events. In that case any groundwater stored would be mixed with surface water and only be discharged through licensed discharge points if water quality met the parameters set out in the Lidsdale Siding Environmental Protection Licence (Discharge of water is discussed within the Surface Water Assessment for the Project).

No groundwater users would be affected during the operational stage of the Project, as the decline in the water level is not likely to propagate for more than 50m outside the Lidsdale Siding boundary.

In terms of impacts on groundwater chemistry, care needs to be taken in relation to site management practices. Oils, fuels and lubricants should be stored in an appropriate manner and any spillages/leaks should be managed and reported in line with a suitable environmental management plan and in accordance with Guidelines for the Assessment and Management of Groundwater Contamination (DECC, 2007).

6.7 Potential Impacts during Operation

Once the site is operational, additional minor seepage is possible, but there would be a neutral effect on receiving groundwater and surface water quality State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 as previously mentioned. The tunnel will be concrete lined and the predicted seepage is negligible (in order of 0.1L/year).

There would be no impact of dewatering on the other aquifers and on water quantity and quality of the Coxs River downstream.

Regarding the impacts on groundwater chemistry, care needs to be taken in relation to site management practices. Oils, fuels and lubricants should be stored in an appropriate manner and any spillages/leaks should be managed and reported in line with a suitable environmental management plan. This would provide the protection of groundwater in accordance with NSW State Groundwater Policy (DLWC, 1997), the NSW Groundwater Quality Protection Policy (DLWC, 1998) and the Guidelines for the Assessment and Management of Groundwater Contamination (DECC, 2007).

During operations, any surface water from the catchment would be diverted away from disturbed areas thereby preventing any potential mixing with groundwater. Moreover, the clean runoff would be of a better water quality than the groundwater contained within the shallow aquifer.

6.8 Impact to Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDE's) are defined by ARMCANZ/ ANZECC (1996) and NSW Groundwater Dependent Ecosystem Policy (DECCW, 2002) as ecosystems which have their species composition and their natural ecological processes determined by groundwater.

No sensitive groundwater dependent ecosystems have been identified within the Lidsdale Siding area. Any potential ecosystems associated with the Pipers Flat Creek would not be impacted by the proposed Project both in relation to water quality and quantity. This is ensured by efficient site management and groundwater reuse and storage in on site dams.

Further detailed discussion on ecosystems is provided in aquatic ecology assessment (Section of EA).

7. MONITORING AND MANAGEMENT

7.1 General

The impact assessment has indicated that the existing and future operation of the proposed Lidsdale Siding pose a very low risk to groundwater systems. As such, additional monitoring will be required only during construction, reverting to current monitoring and groundwater management requirements during operation.

Following receipt of Lidsdale Siding approval, the Proponent would need to develop a Water Management Plan, and update the existing Groundwater Monitoring and Response Program. This should outline the proposed monitoring procedures and verify the impacts of the development on groundwater during construction.

The program would be developed in consultation with the and Department of Environment, Climate Change and Water (DECCW) and the results reported as required in the Annual Environmental Management Report (AEMR).

The on-ground protection measures and management practices during the construction, operation and decommissioning stages of the Project will be based on the Current Recommended Practices (CRPs) and Standards (where applicable) endorsed by the Sydney Catchment Authority (SCA). However, the protection measures and management practices during all Project stages would be based on the NSW State Groundwater Policy Framework Document (DLWC, 1997), NSW State Groundwater Quality Protection Policy (DLWC1998), NSW State Groundwater Quantity Management Policy (DLWC, 1998) , ANZECC (2000) and National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia (ARMCANZ & ANZECC, 1995).

7.2 Requirements during Construction

It is recommended that groundwater inflows be monitored closely throughout the development of the Project. This would include recording the volume and quality of water discharged from the trench and pumped from the sump pump.

It is recommended that the proposed Lidsdale Siding monitoring program includes recording of the following.

- Groundwater inflow volumes – monthly totals of water pumped from trench sump; and
- Groundwater quality –
    - Weekly measurements on site of the EC and pH of sump pumps.
    - One water quality sample taken during the second month of trench development when highest inflows are expected. The sample should be sent to the laboratory for analysis on major ions, EC, dissolved arsenic, cadmium, chromium, copper, iron, lead, nickel and zinc.

Due to relatively short period of dewatering (6 months) no additional groundwater quality sampling will be required. If the EC and pH recording shows the values that exceed 20% of average value for the site bores, full water quality analysis will be required.

7.3 Requirements during Operation

Due to future operation of the proposed Lidsdale Siding posing a very low risk to groundwater system, no additional monitoring or reporting is required during the operation. The current ongoing monitoring will continue as described in section 7.4 below.

7.4 Monitoring and Reporting

It is recommended that the current baseline groundwater monitoring program be continued. In addition, it is recommended that additional metals be added to the sampling suite to include arsenic, chromium, iron, lead, nickel and zinc.

The following is recommended relating to the groundwater monitoring network and ongoing monitoring during the operation:

- Quarterly monitoring of water levels from the network of monitoring bores following the completion of construction; and
- Quarterly sampling of representative monitoring bores for laboratory analysis on major ions, EC, dissolved arsenic, cadmium, chromium, copper, iron, lead, nickel and zinc.

It is suggested that all results of the monitoring program be reviewed by the Proponent as they are received, with all results and interpretations subsequently reported. The monitoring program would be re-assessed by the Proponent during preparation of the annual reports if required and may be modified subject to agreement with the relevant government agencies once the variability of the groundwater system is established.

8. REFERENCES

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9. GLOSSARY

Alluvium-Sediment (gravel, sand, silt, clay) transported by water (i.e. deposits in a stream channel or floodplain)

Aquifer- Water-bearing layer of permeable rock or unconsolidated materials (gravel, sand, or silt) through which groundwater flows.

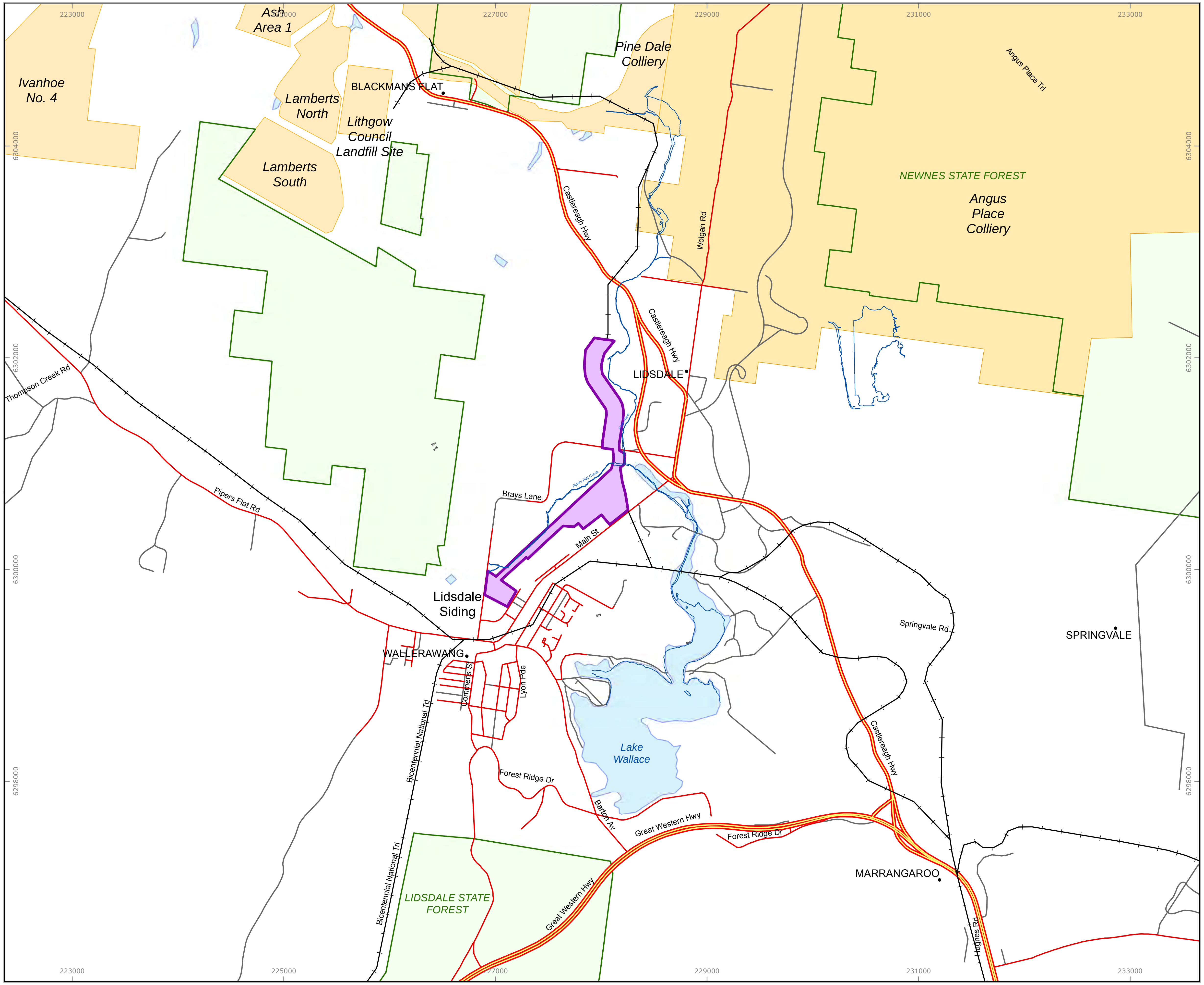
Hydraulic conductivity- A measure of the rate at which water moves through a soil/rock mass. It is the volume of water that moves within a unit cross-sectional area perpendicular to the direction of flow under unit hydraulic gradient in a unit of time

Hydraulic test (slug test) – A test made by the instantaneous addition or removal of a known volume of water from a well. The subsequent well recovery in measured

Storativity- The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer , per unit change in head

Transmissivity- A measure of the rate at which water moves through an aquifer of unit width under a unit hydraulic gradient.

FIGURES



LEGEND

•	Town
┼─┼	Railway
═	Highway
─	Major Road
─	Minor Road
─	Contour
▨	Lidsdale Siding Upgrade Study Area
🟧	Nearby Features
🟦	Waterbody
🟩	State Forest

N

0 500 1,000 2,000
Metres
SCALE 1:35,000 @ A3

GDA 1994 MGA Zone 56

DATA SOURCES
RPS Aquaterra Sydney

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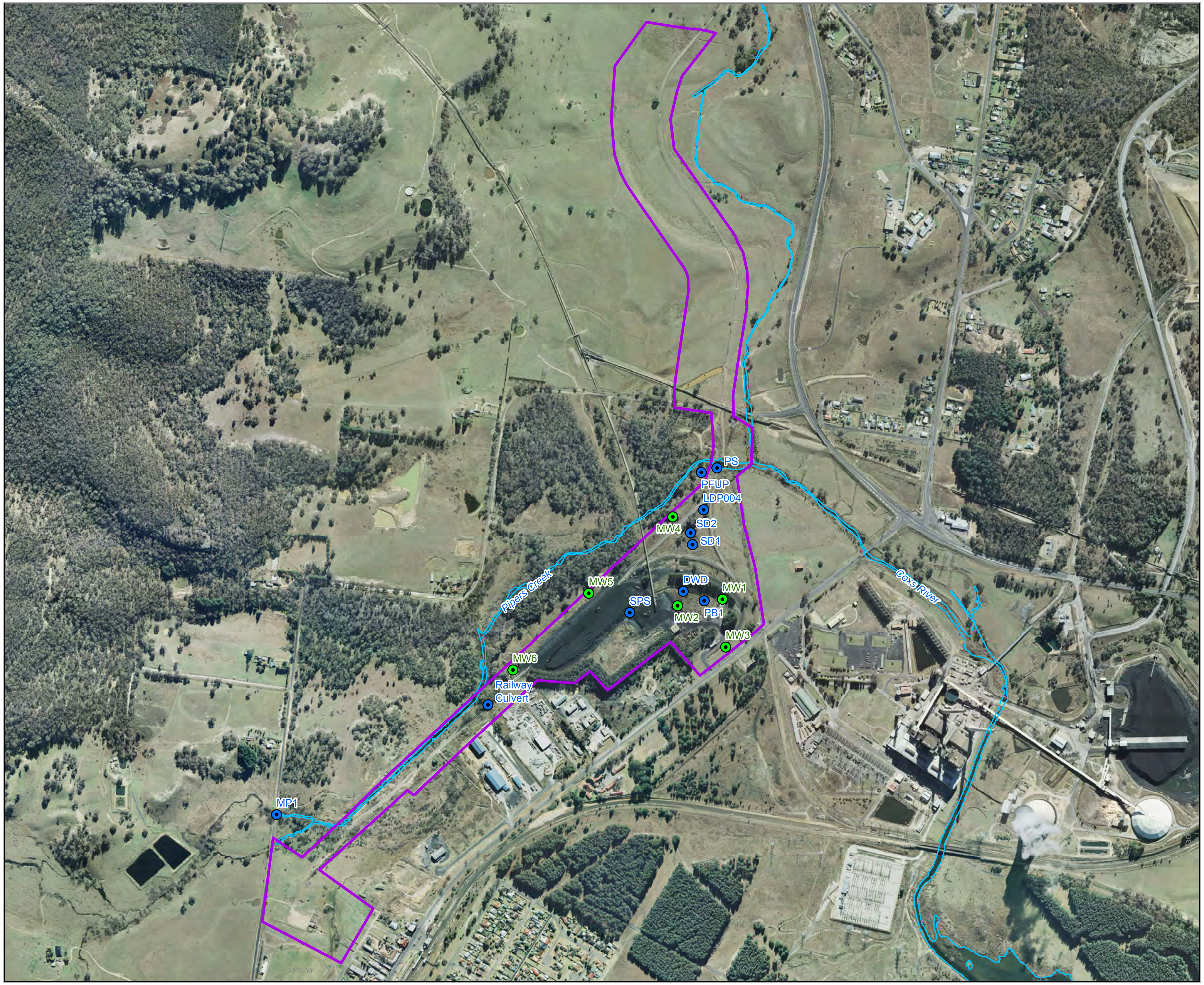
FIGURE 1
Location Map

AUTHOR	KD	REPORT NO	R001
DRAWN	TW	REVISION	C
DATE	16/08/2012	JOB NO.	S168B

MapID: 11-3719-007d - Published 16 August 2012



LEGEND

- ● Monitoring Bores
- ● Surface Water Monitoring Points
- — Watercourse
- ▭ Lidsdale Siding Upgrade Study Area

N

0 100 200 400
Metres
SCALE 1:10,000 @ A3

GDA 1994 MGA Zone 56

DATA SOURCES

RPS Aquaterra Sydney

FIGURE 2

Location of monitoring and production site bores and surface water monitoring points

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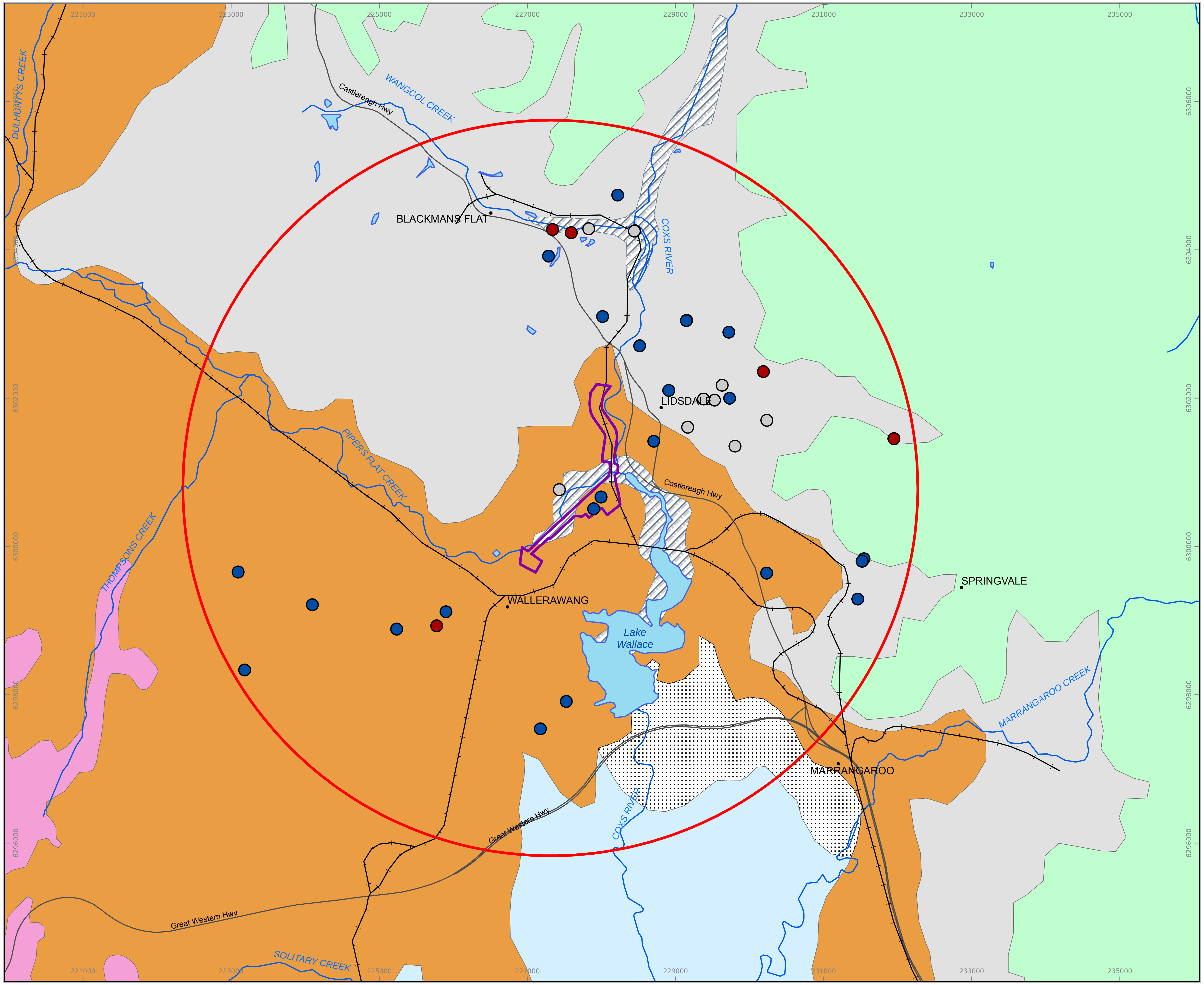
DRAWN	TW	REVISION	C
DATE	16/08/2012	JOB NO.	S168B

MapID: 11-3719-023a - Published 16 August 2012



DATA SOURCES

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FIGURE 3

Location of NSW Office of Water registered bores and their depths

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DRAWN	TW	REVISION	C
DATE	17/08/2012	JOB NO.	S168B

MapID: 11-3719-024a - Published 17 August 2012

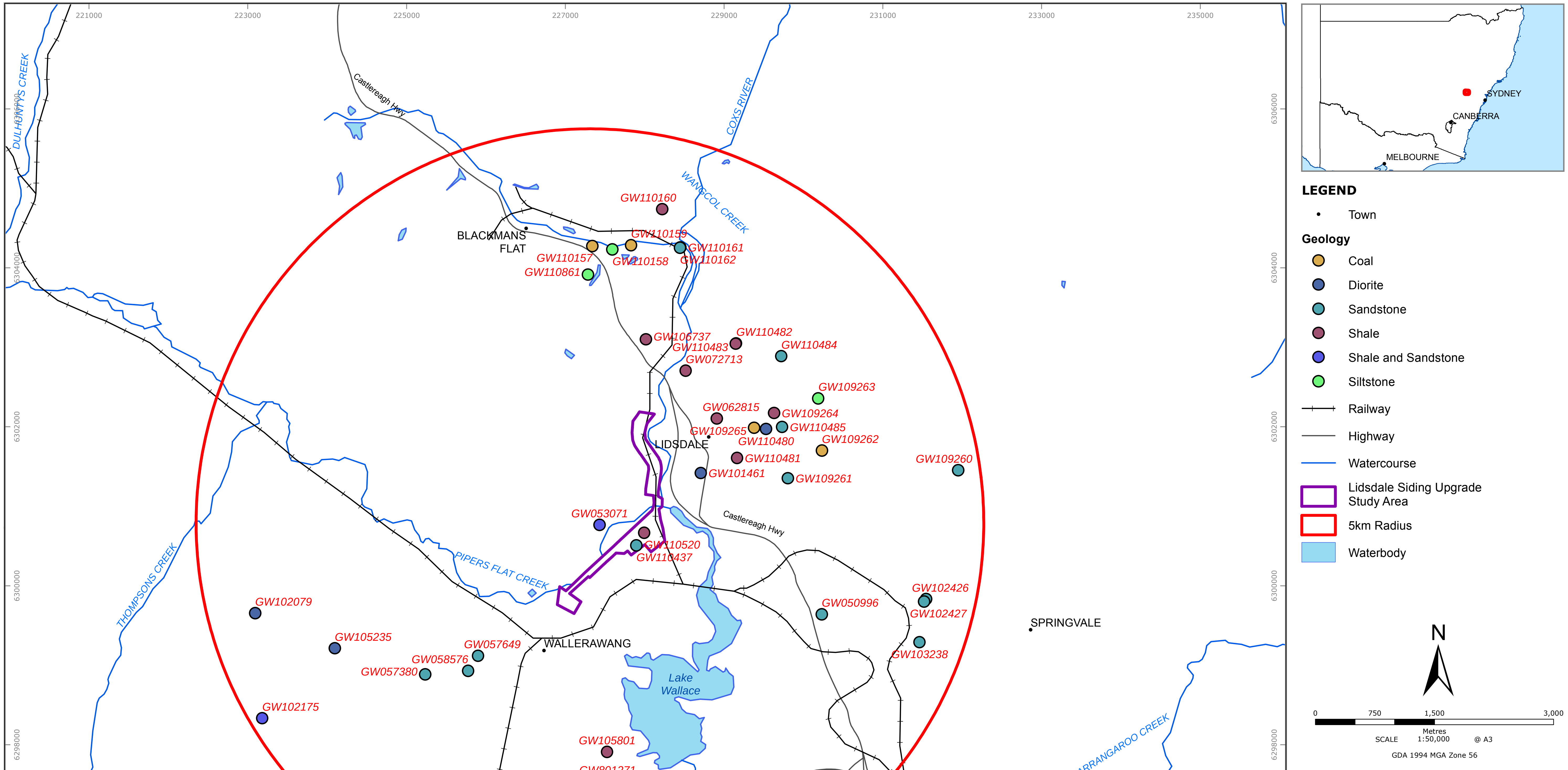

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FIGURE 4

Aquifer type for NSW Office of Water registered bores

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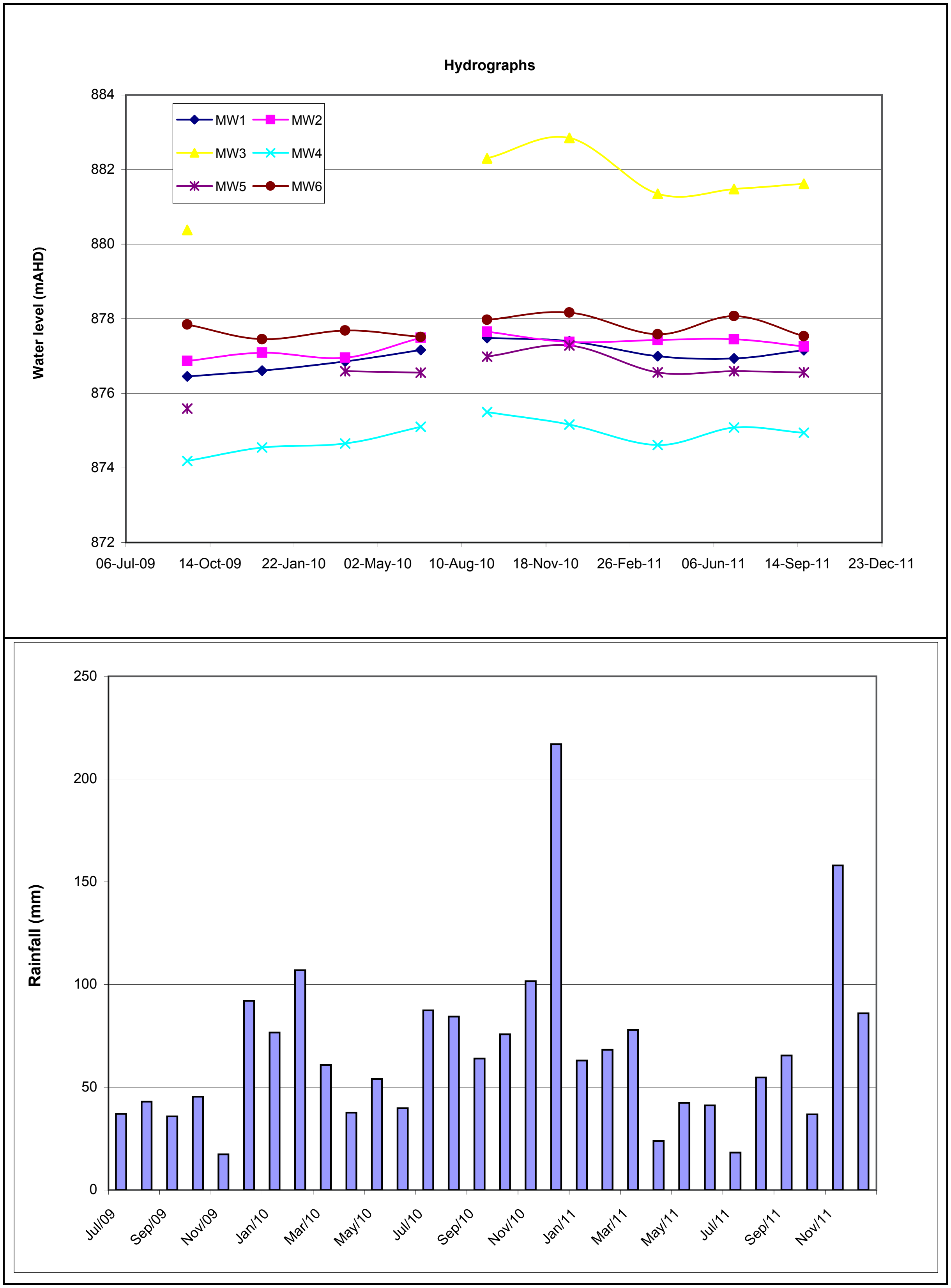
MapID: 11-3719-025a - Published 17 August 2012



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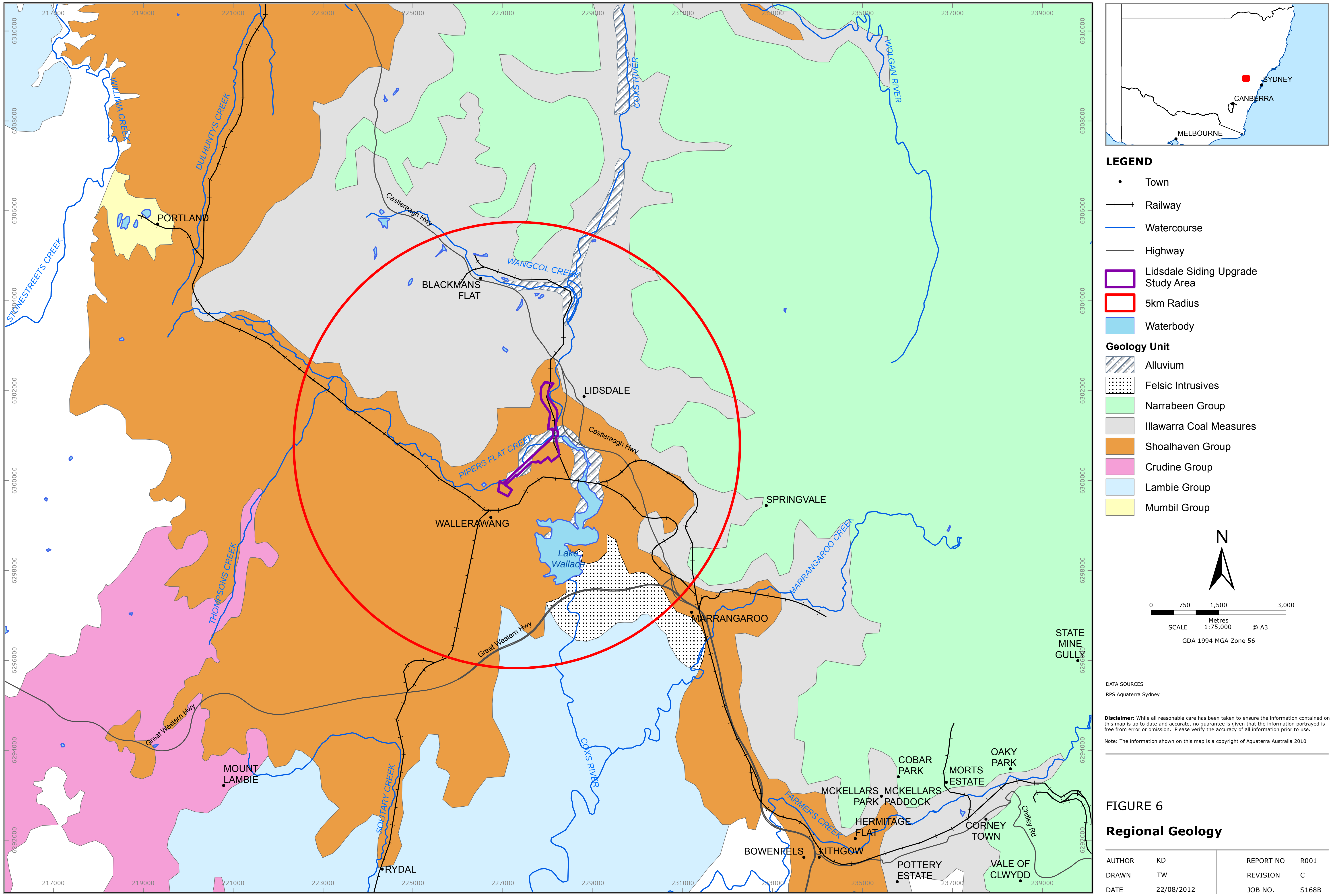
Composite Hydrographs for Site Bores FIGURE 5

F:\Jobs\S168B\300\Water levels\[029e Lisdale water + graphs UPDATE up til 01 2012.xls]2graphs



DATA SOURCES

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FIGURE 6

Regional Geology

AUTHOR	KD	REPORT NO	R001
DRAWN	TW	REVISION	C
DATE	22/08/2012	JOB NO.	S168B

MapID: 11-3719-024b - Published 22 August 2012

DATA SOURCES

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FIGURE 7

Interpreted Groundwater Contour Map For Shallow Aquifer

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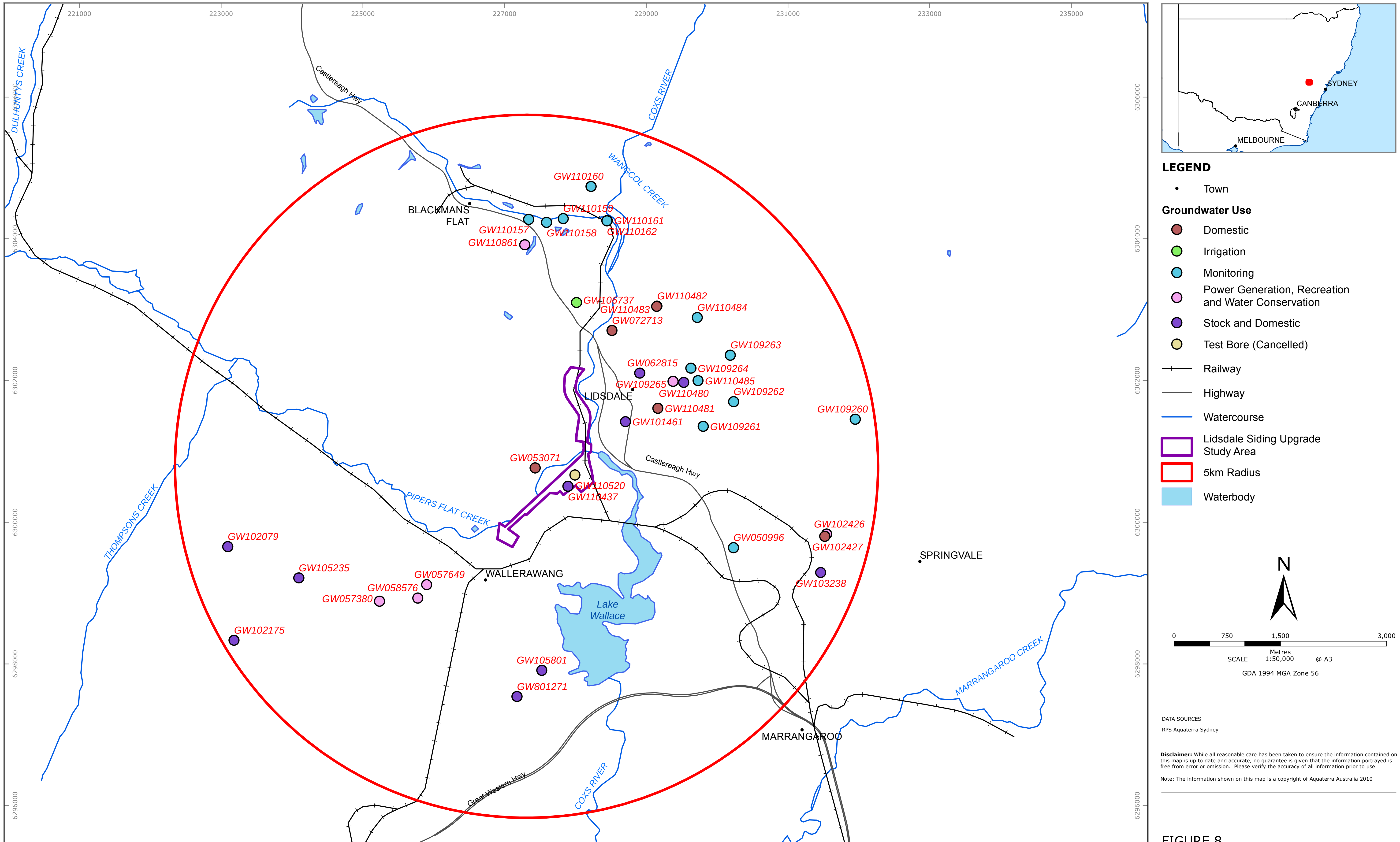
DRAWN	TW	REVISION	C
DATE	16/08/2012	JOB NO.	S168B

MapID: 11-3719-008d - Published 16 August 2012



DATA SOURCES
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FIGURE 8

Groundwater use (Registered groundwater bores)

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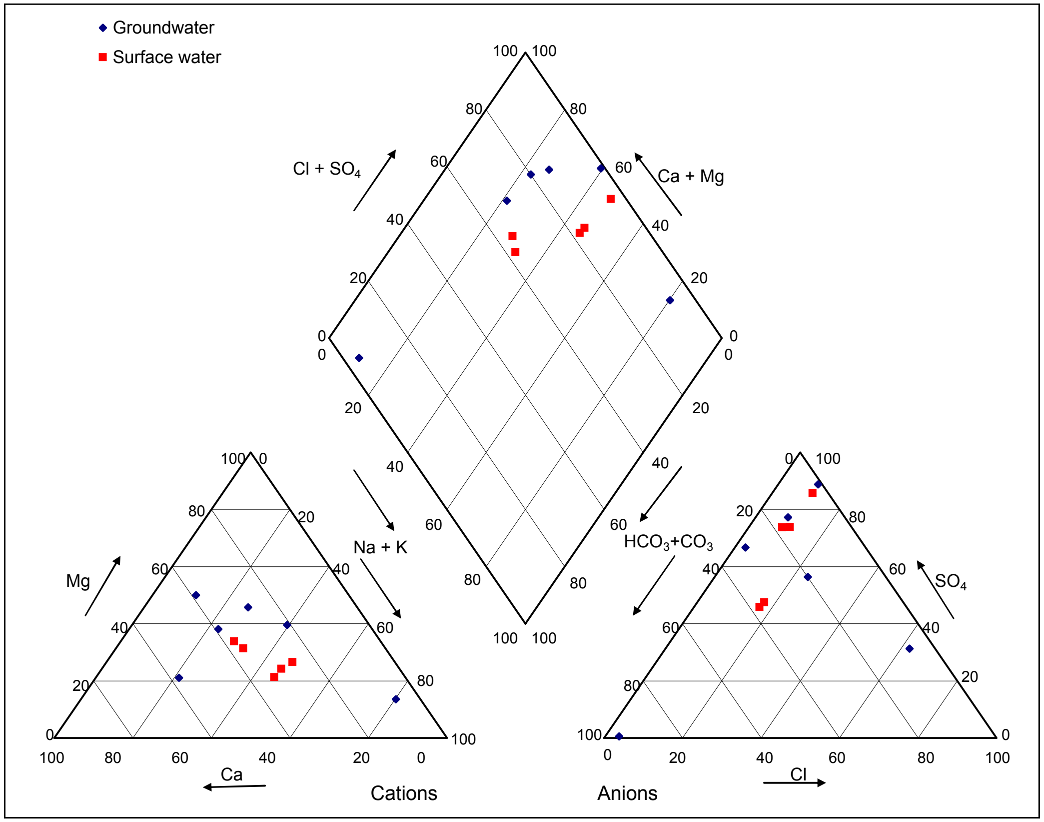
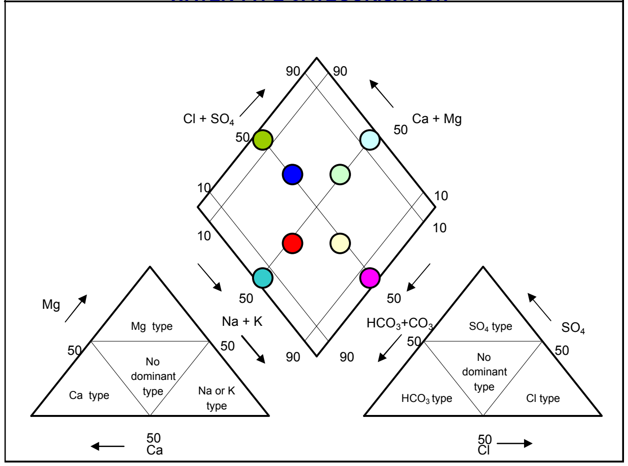


WATER TYPE CATEGORISATION



WATER TYPE SUB-FIELDS

● Ca + Mg, Na + K type	● Ca + Mg type
● HCO$_3$, Cl + SO$_4$ type	● HCO$_3$ + CO$_3$ type
○ Na + K, Ca + Mg type	● Na + K type
○ Cl + SO$_4$, HCO$_3$ type	○ Cl + SO$_4$ type

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Major Ion Chemistry- Piper Diagram

Figure 9

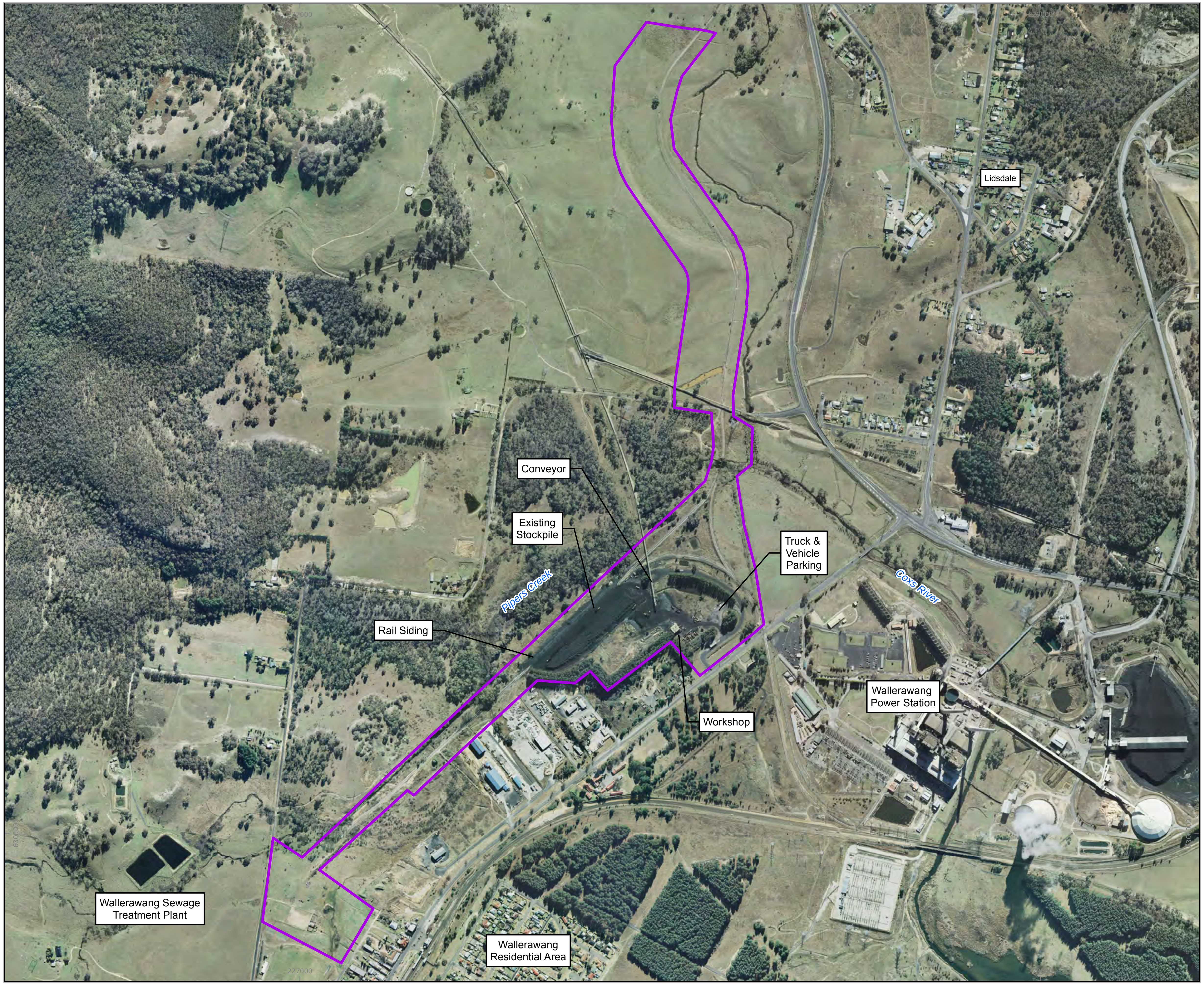
Date: 17/01/12

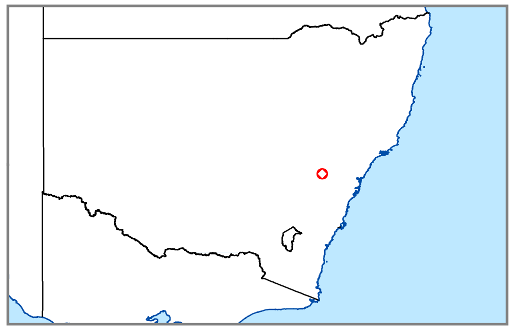
C:\Documents and Settings\david\My Documents\Centennial\Lidsdale\report\figs\[Figure 9 HydroCHEM2.0 all samples.xls]Input Data

Project: Lidsdale Siding
Project No: S168B

Description:
Client: Centennial Coal

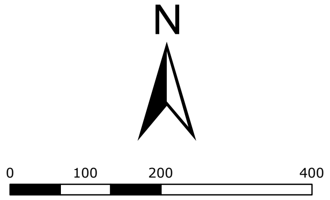
HydroCHEM 2.0





LEGEND

▭ Lidsdale Siding Upgrade Study Area



SCALE 1:10,000 @ A3

GDA 1994 MGA Zone 56

DATA SOURCES

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FIGURE 10

Lidsdale Siding Upgrade Project Area

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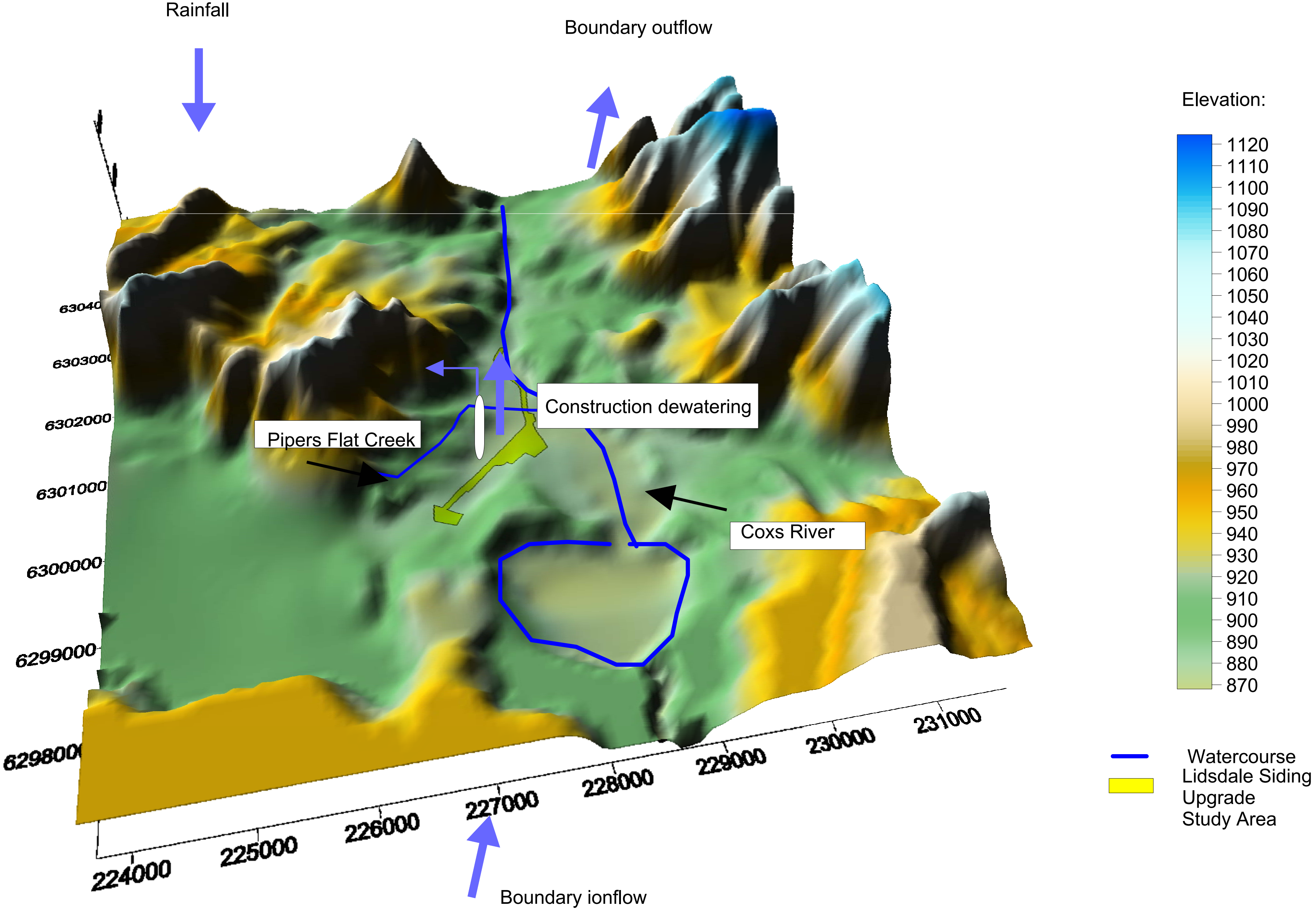

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CONCEPTUAL MODEL AND BOUNDARY CONDITION FIGURE 11

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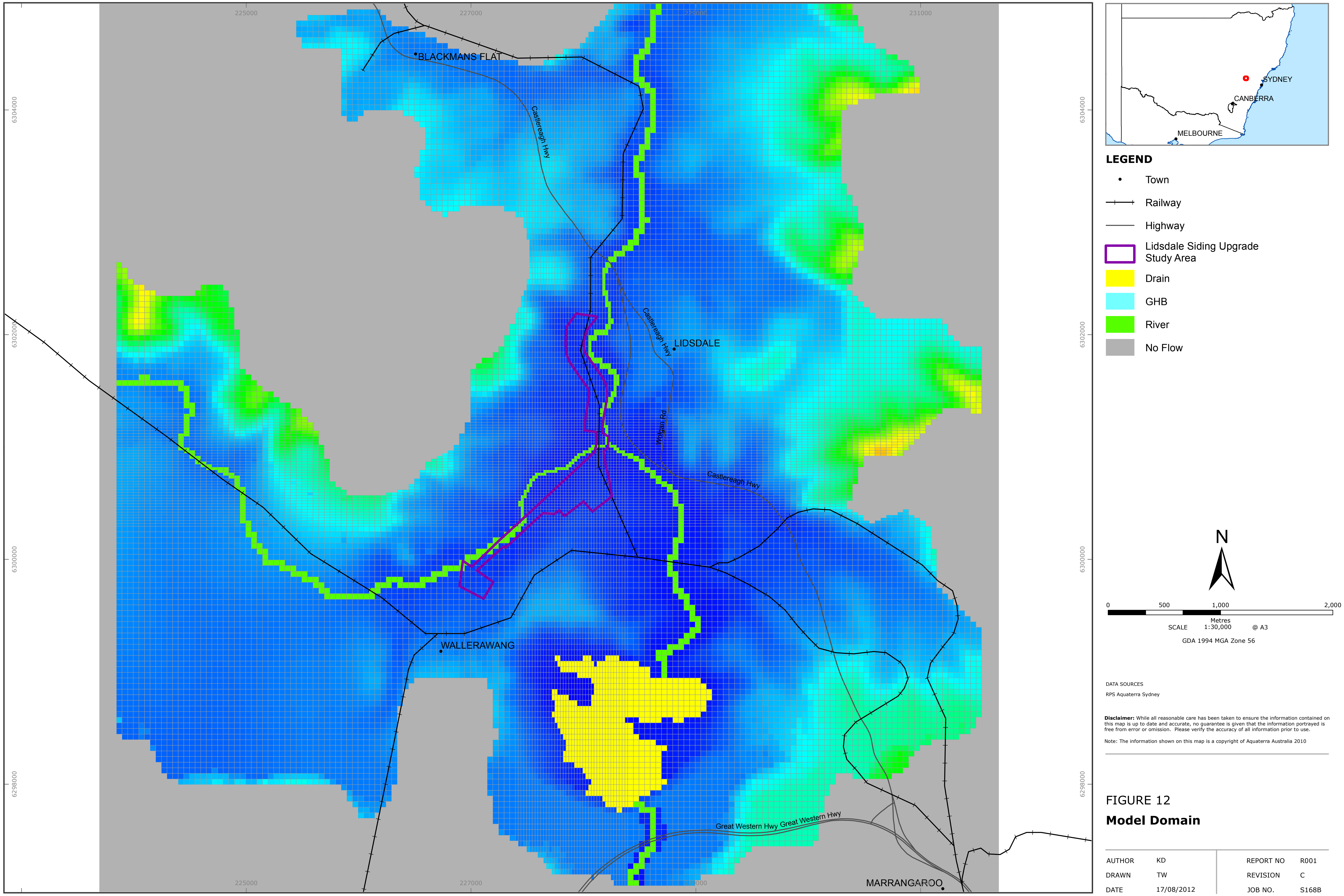

DATA SOURCES

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FIGURE 12

Model Domain

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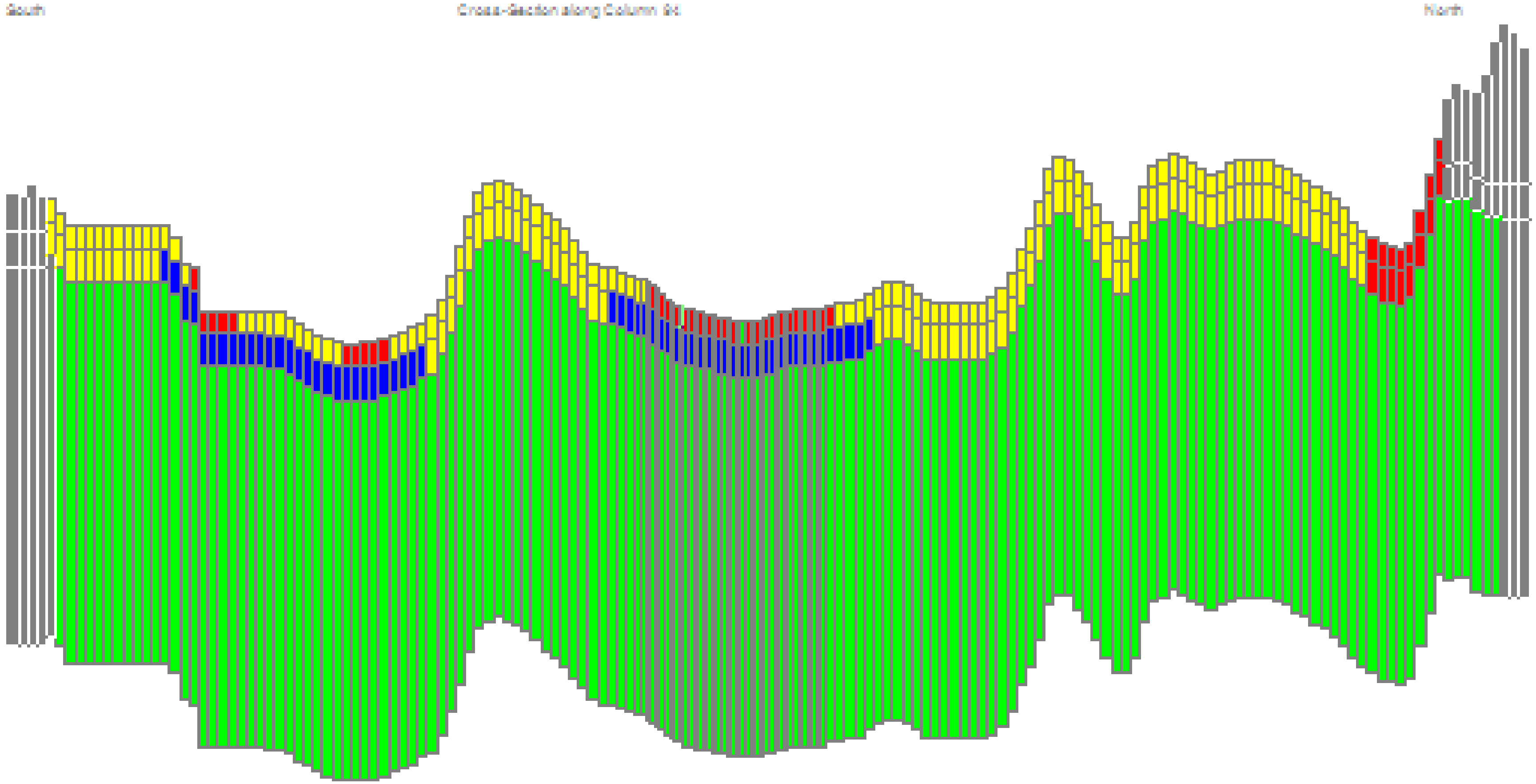

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CONCEPTUAL HYDROGEOLOGICAL CROSS SECTION

FIGURE 13

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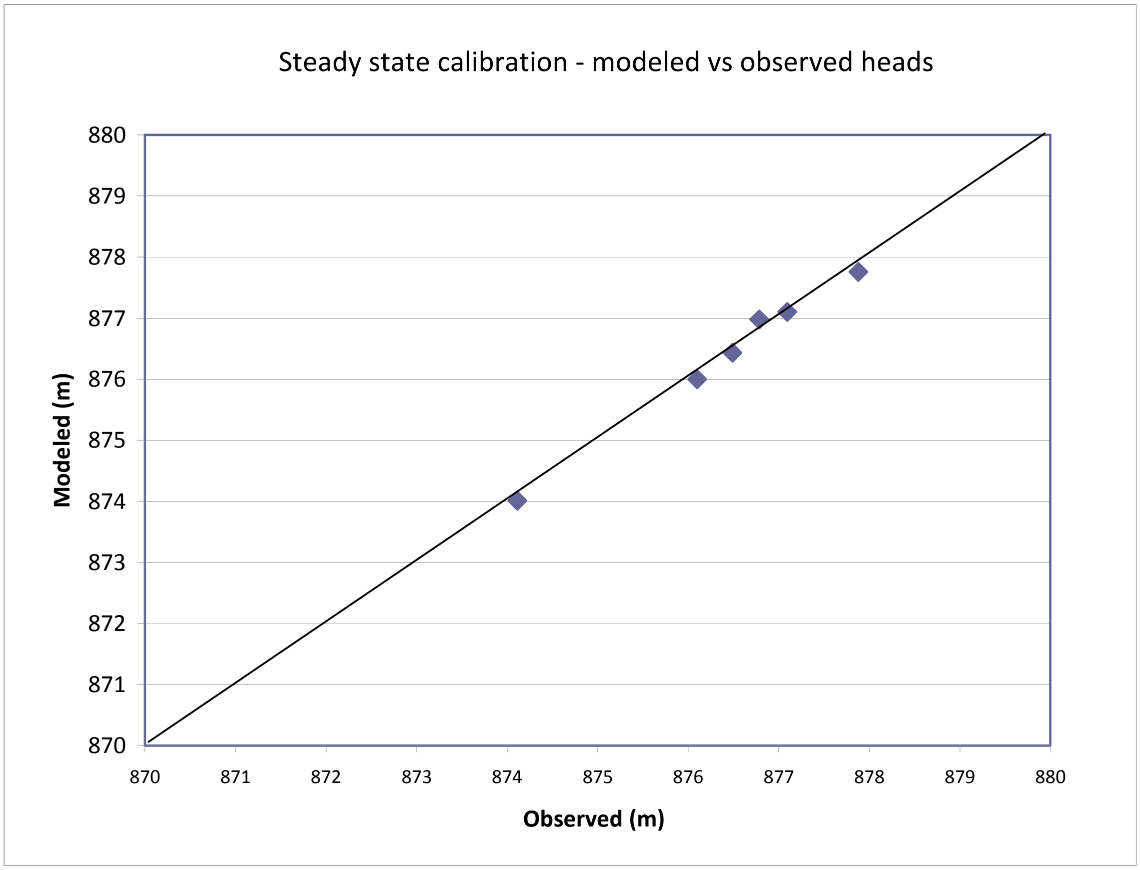
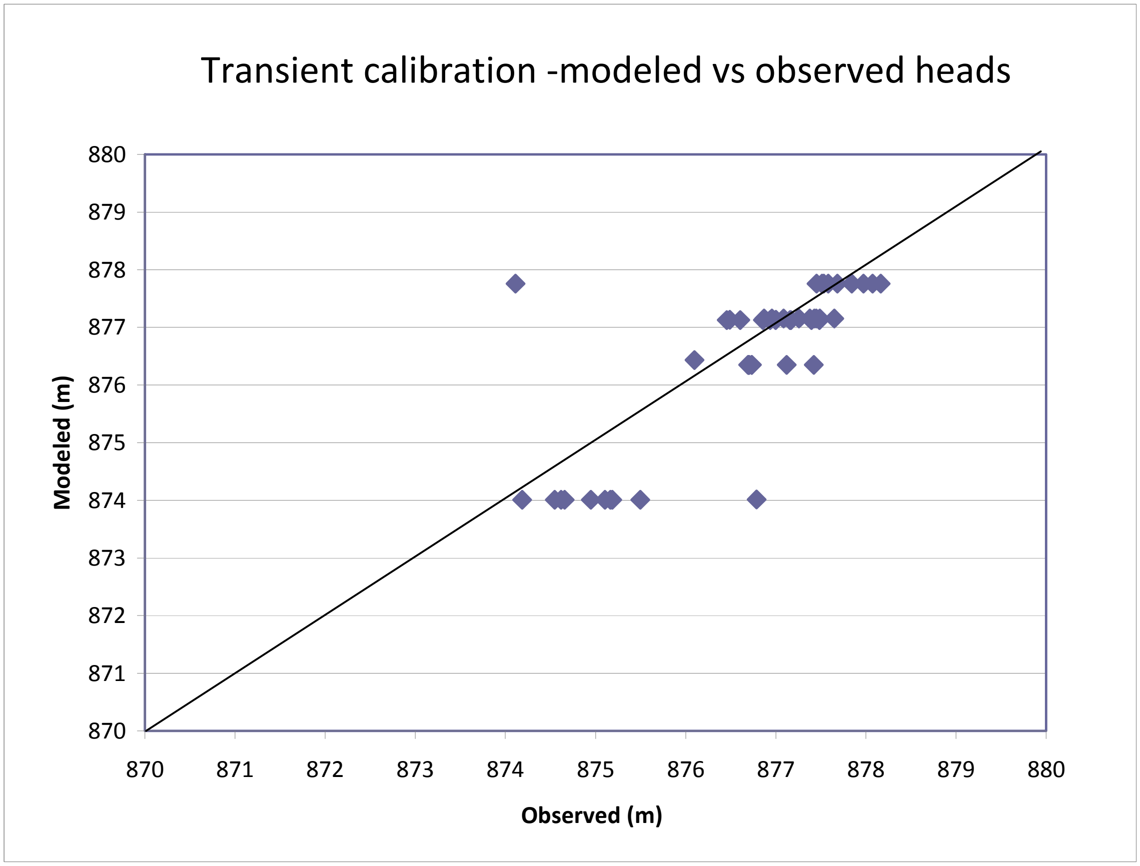
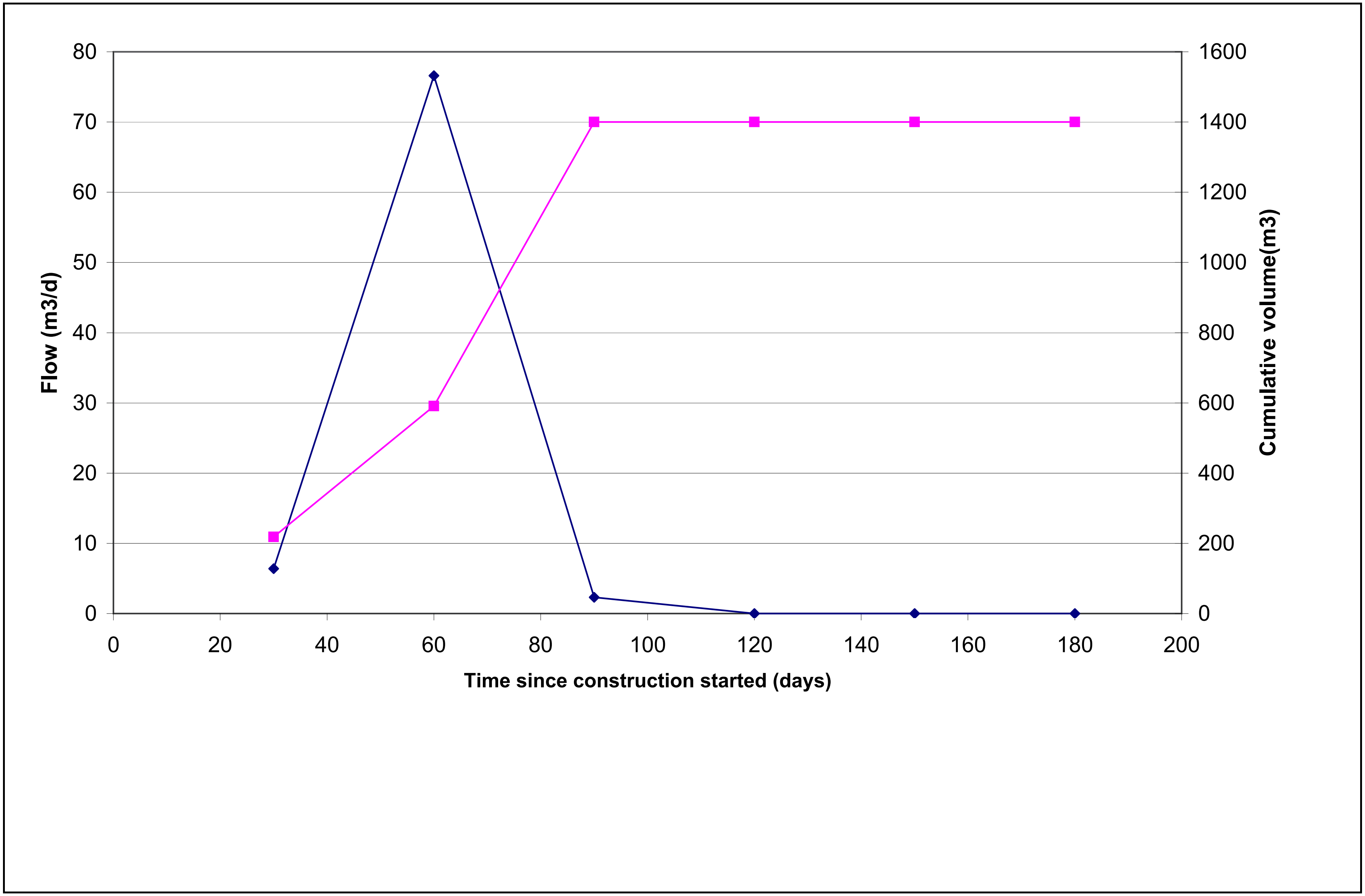

Steady state calibration - modeled vs observed heads


Transient calibration -modeled vs observed heads

SCATTER DIAGRAM FOR STEADY STATE AND TRANSIENT CALIBRATION FIGURE 14



Predicted dewatering during construction FIGURE 15

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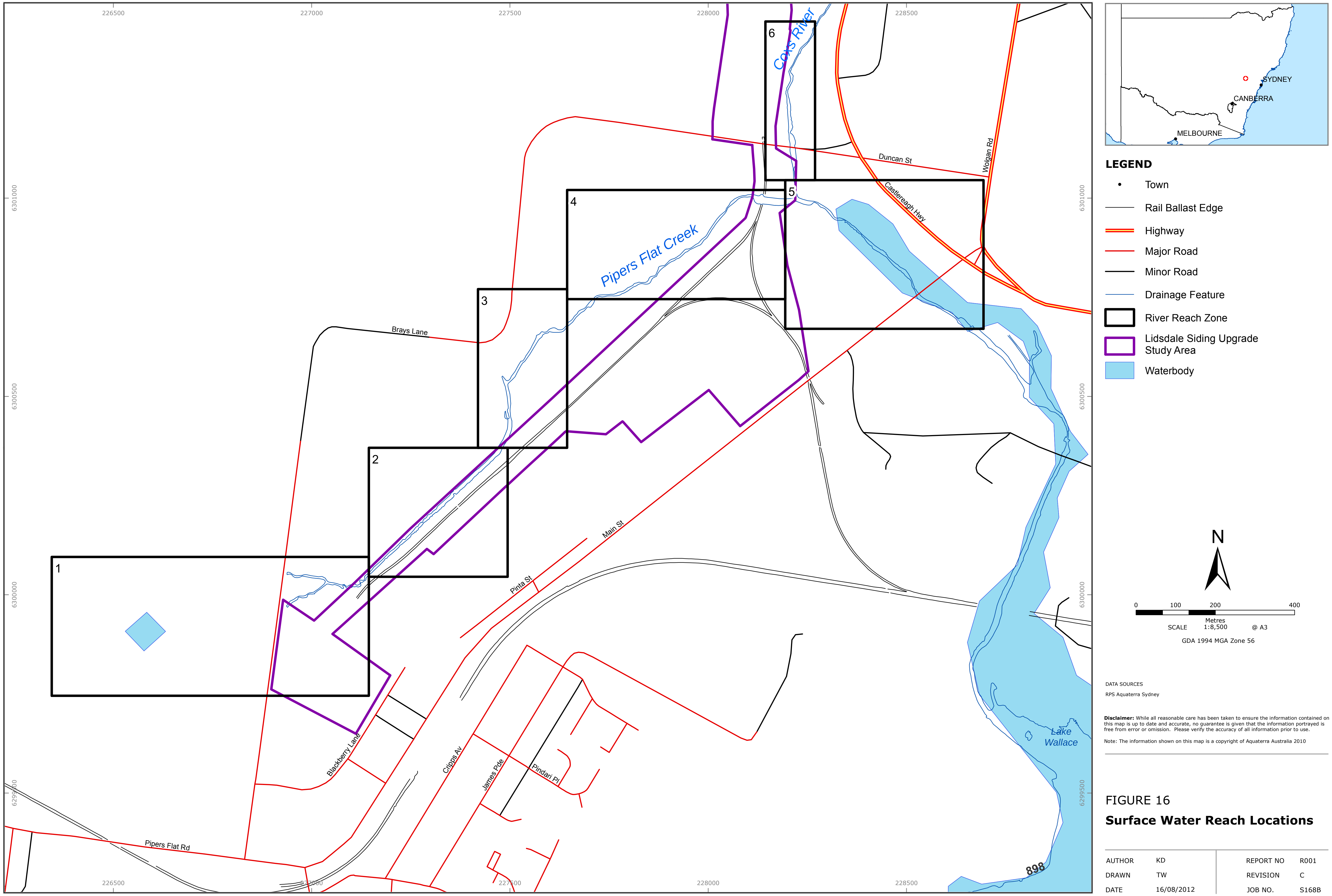

DATA SOURCES

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FIGURE 16

Surface Water Reach Locations

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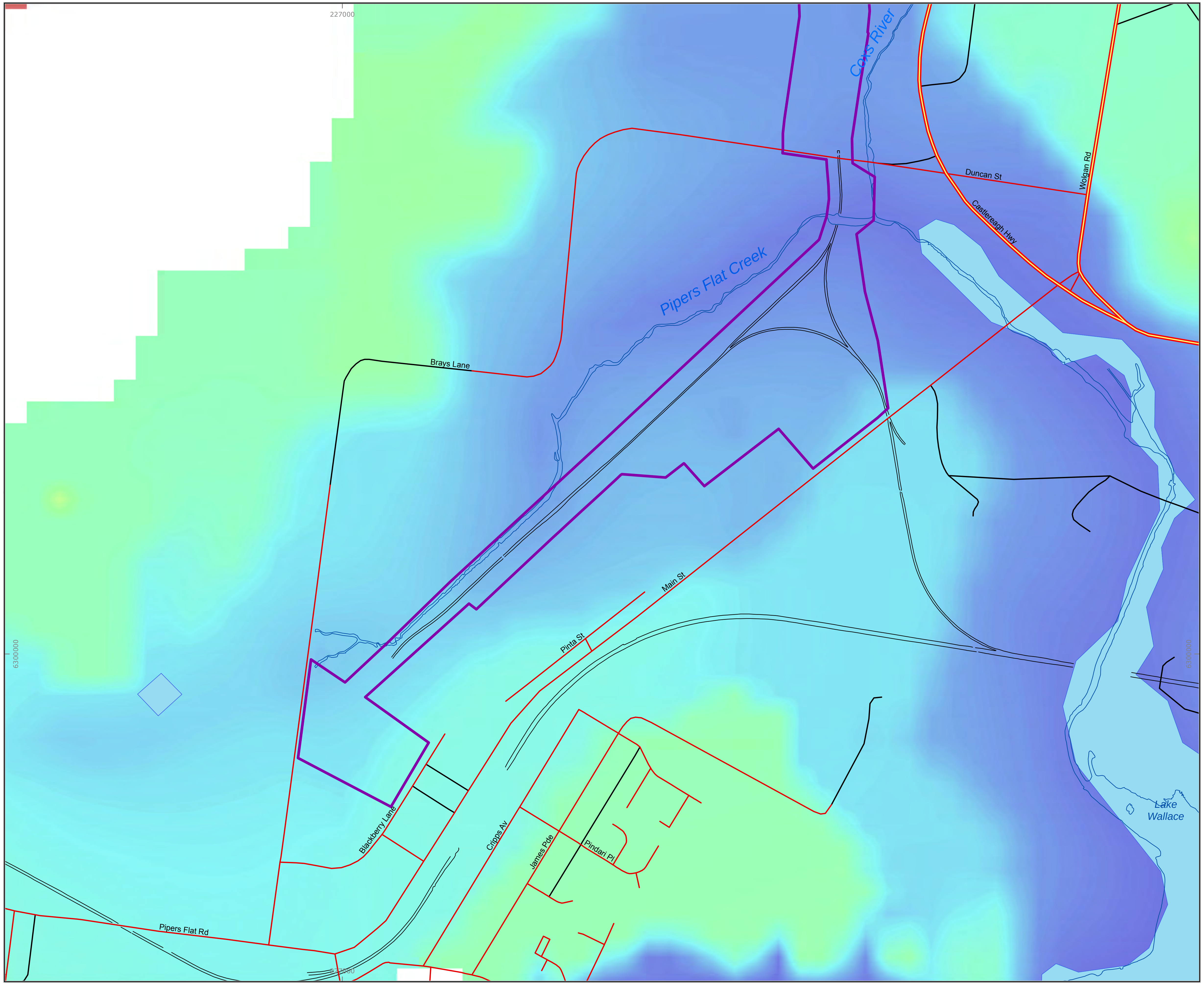

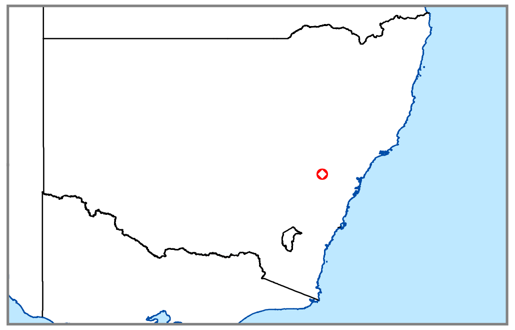

LEGEND

- • Town
- — Rail Ballast Edge
- ═ Highway
- — Major Road
- — Minor Road
- — Drainage Feature
- ☐ Lidsdale Siding Upgrade Study Area
- ▨ Waterbody

Predicted Groundwater Level

- 🟦 860
- 🟦 880
- 🟩 895
- 🟨 915
- 🟥 930

N

0 100 200 400
Metres
SCALE 1:8,500 @ A3

GDA 1994 MGA Zone 56

DATA SOURCES
RPS Aquaterra Sydney

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FIGURE 17a

Predicted groundwater levels in shallov aquifer following three months of construction

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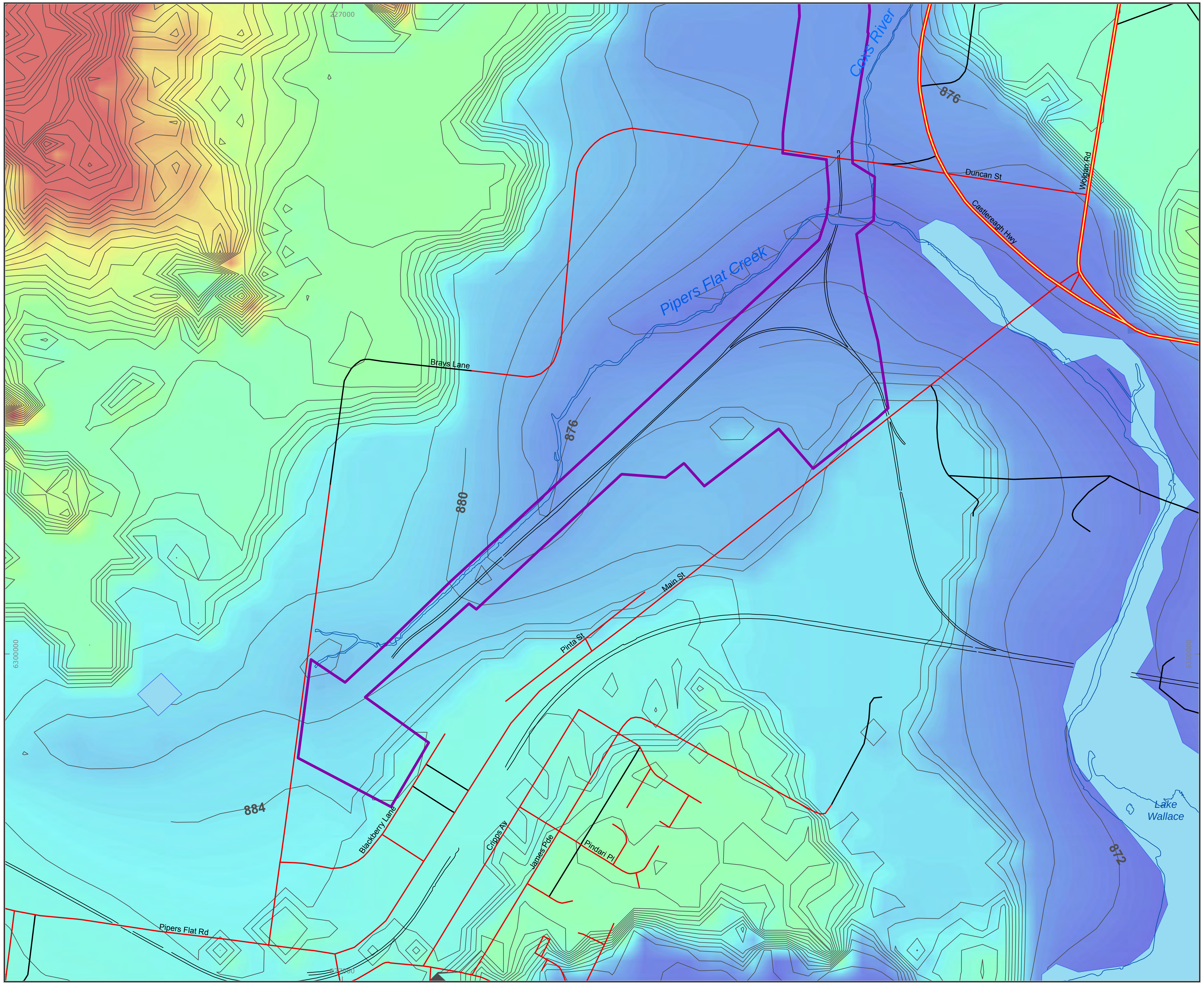
DATE	22/08/2012	JOB NO.	S168B

MapID: 11-3719-017d - Published 22 August 2012



LEGEND

- • Town
- Rail Ballast Edge
- Highway
- Major Road
- Minor Road
- Drainage Feature
- Ground Water Contour
- Lidsdale Siding Upgrade Study Area
- Waterbody

Predicted Groundwater Level

- 🟦 860
- 🟦 880
- 🟩 895
- 🟨 915
- 🟥 930

N

0 100 200 400
Metres
SCALE 1:8,500 @ A3

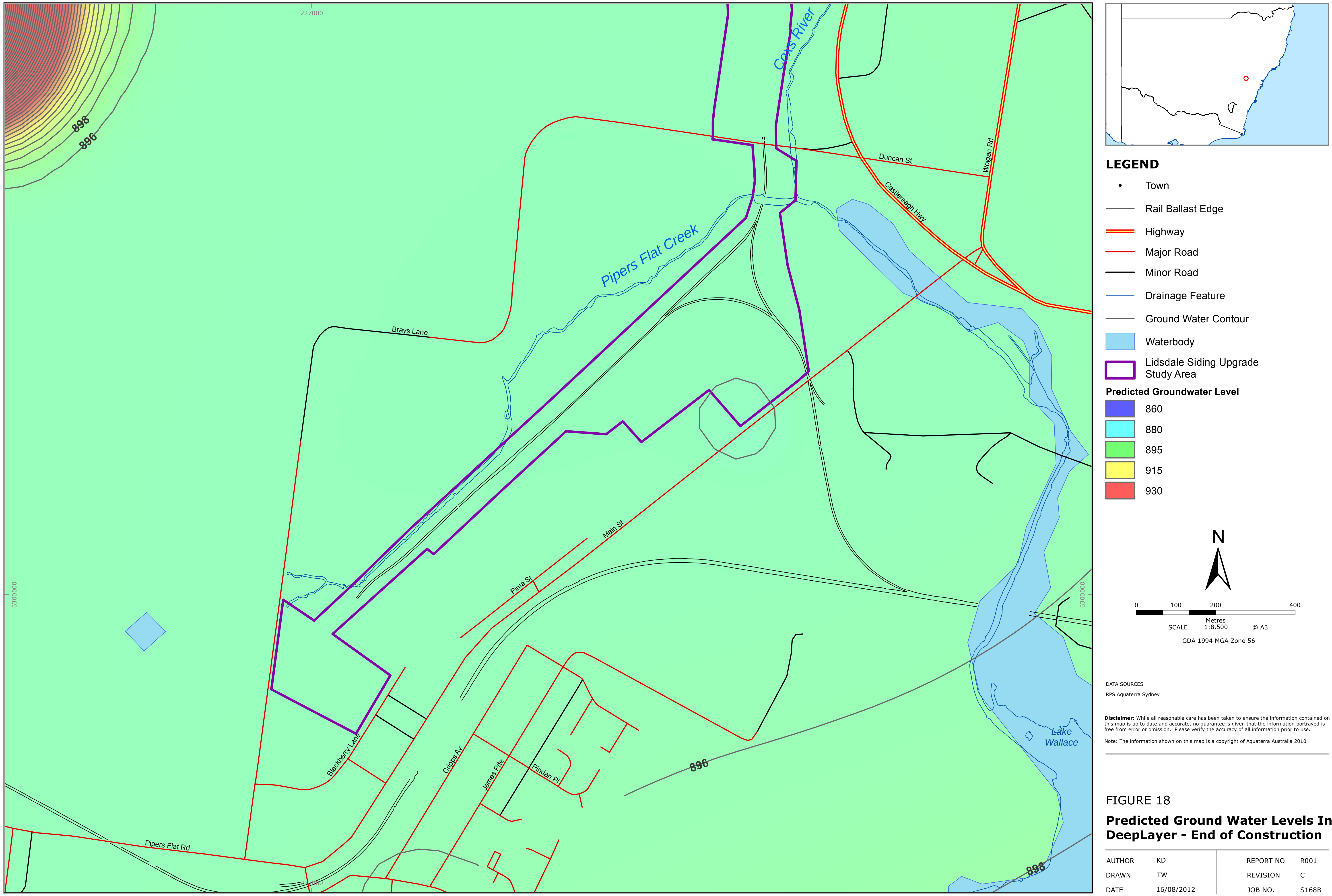
GDA 1994 MGA Zone 56

DATA SOURCES
RPS Aquaterra Sydney

FIGURE 17b

Predicted groundwater levels in shallow aquifer end of construction period

AUTHOR	KD	REPORT NO	R001
DRAWN	TW	REVISION	C
DATE	22/08/2012	JOB NO.	S168B



DATA SOURCES

RPS Aquaterra Sydney

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

Note: The information shown on this map is a copyright of Aquaterra Australia 2010

FIGURE 18

Predicted Ground Water Levels In DeepLayer - End of Construction

AUTHOR	KD	REPORT NO	R001
DRAWN	TW	REVISION	C
DATE	16/08/2012	JOB NO.	S168B

MapID: 11-3719-011d - Published 16 August 2012

DATA SOURCES

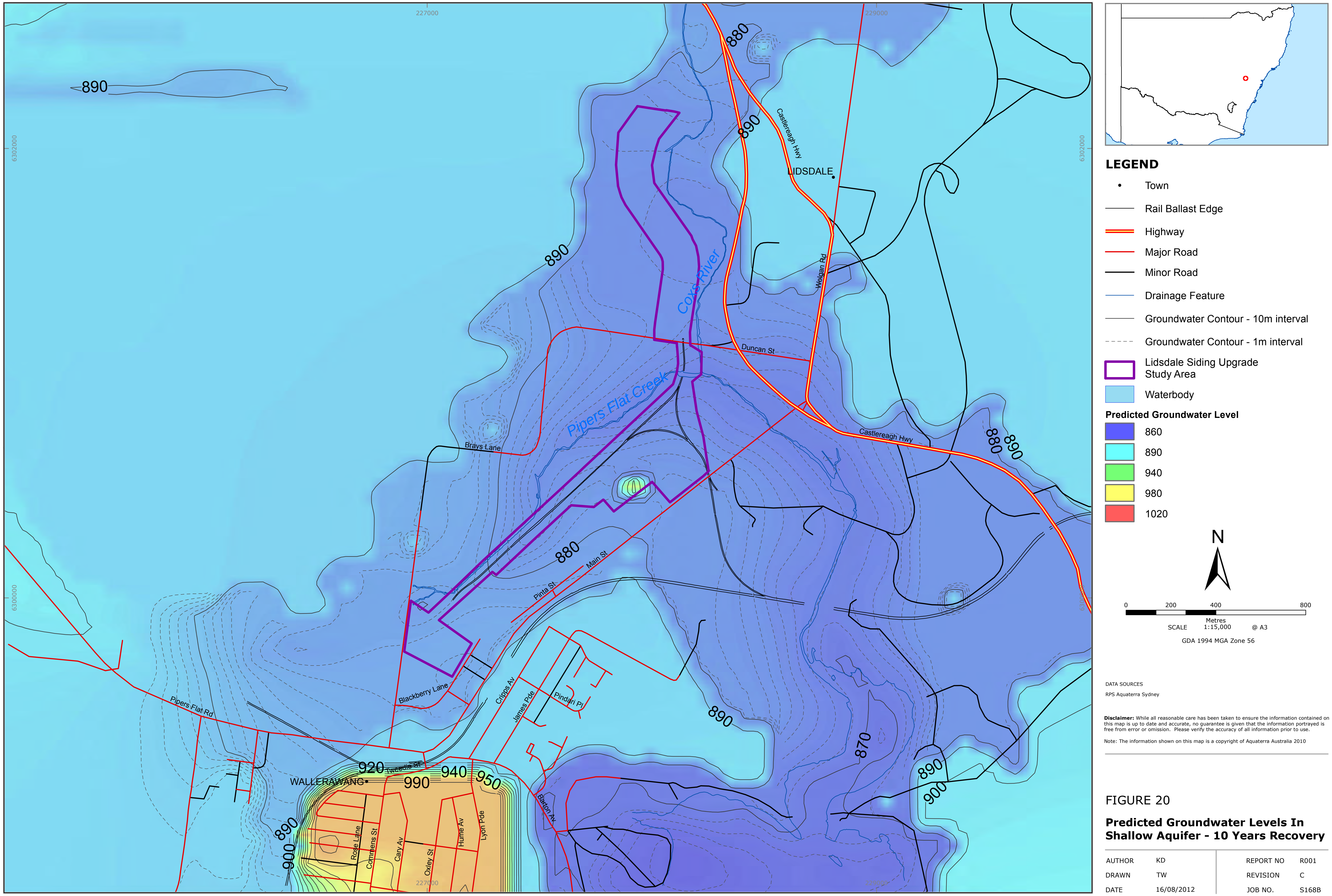
RPS Aquaterra Sydney

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

FIGURE 19

Predicted Drawdown In Shallow Aquifer - End of Construction

AUTHOR	KD	REPORT NO	R001
DRAWN	TW	REVISION	C
DATE	16/08/2012	JOB NO.	S168B



LEGEND

- • Town
- Rail Ballast Edge
- Highway
- Major Road
- Minor Road
- Drainage Feature
- Groundwater Contour - 10m interval
- Groundwater Contour - 1m interval
- Lidsdale Siding Upgrade Study Area
- Waterbody

Predicted Groundwater Level

- 🟦 860
- 🟦 890
- 🟩 940
- 🟨 980
- 🟥 1020

SCALE 1:15,000 @ A3

GDA 1994 MGA Zone 56

DATA SOURCES

RPS Aquaterra Sydney

FIGURE 20

Predicted Groundwater Levels In Shallow Aquifer - 10 Years Recovery

AUTHOR	KD	REPORT NO	R001
DRAWN	TW	REVISION	C
DATE	16/08/2012	JOB NO.	S168B

MapID: 11-3719-013d - Published 16 August 2012

APPENDIX A:
SITE BORE LOGS

AECOM

ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

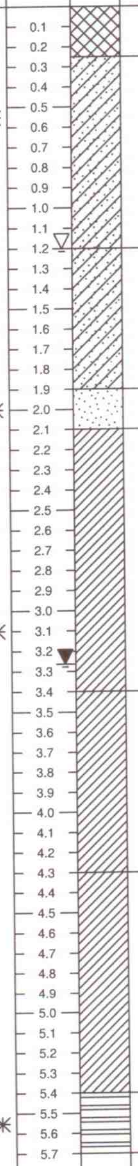
MONITORING WELL LOG BH01/MW01

PROJECT NUMBER S4125101
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube
SURFACE ELEVATION 881.157 m AHD
LOGGED BY Kate O'Brien
COMMENTS

DATE 27 Apr 09
BLANK 50mm Class 18 uPVC Casing
SCREEN 50mm Class 18 uPVC Factory Slotted Screen
GRAVEL PACK 2-3mm graded sand
SANITARY SEAL/BENTONITE Bentonite chips (medium)
STABILISED WATER LEVEL 4.063 m BTOC
GROUND WATER ELEVATION 877.094 m AHD
NORTHING 1212.827
EASTING 867.511

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED
1.5		☒	BH01_0.0-0.2	
72.1		☒	BH01_0.5-0.6	*
91.9		☒	BH01_1.0-1.2	
32.2		☒	BH01_1.4-1.6	
10.6		☒	BH01_1.9-2.1	*
59.2		☒	BH01_3.0-3.2	*
4.4		☒	BH01_4.0-4.2	
2.8		☒	BH01_5.0-5.2	
1.5		☒	BH01_5.5-5.6	*

DEPTH (m BGL) GRAPHIC LOG USCS CLASS



LITHOLOGIC DESCRIPTION

Silty Sandy Gravel (FILL), brown and black, slightly moist, loose, gravel is crushed coal. No odour, staining or potential asbestos containing material (ACM) observed.

0.25

Silty Sandy Clay (SC), pale brownish grey, moist, medium stiff, low plasticity. Hydrocarbon odour noted, no staining observed.

1.20

Silty Sandy Clay (SC), pale brownish grey, saturated, medium stiff, low plasticity, minor inclusions of quartz gravel. Hydrocarbon odour noted, no staining observed.

1.90

Sand (SP), cream/brown/white, saturated, medium dense, sand is coarse river sand, minor silt and fine sand content. Hydrocarbon odour noted, no staining observed.

2.10

Silty Sandy Clay (CL), pale brownish grey, saturated, medium stiff, low plasticity, fine sand, minor coarse angular quartz inclusions. Hydrocarbon odour noted, no staining observed.

3.40

Silty Sandy Clay (CL), mottled pale grey and orange, very moist, very stiff, low plasticity. Slight hydrocarbon odour noted, no staining observed.

4.30

Silty Sandy Clay (CL), mottled pale grey and orange, saturated, stiff, low plasticity. Slight hydrocarbon odour noted, no staining observed.

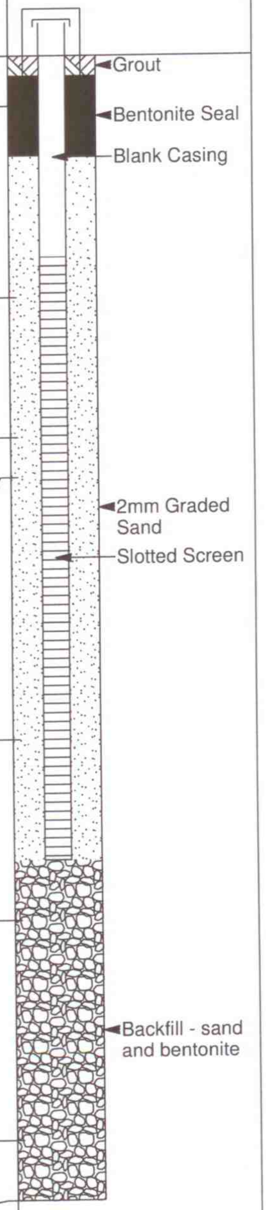
5.40

Weathered Bedrock (Shale), pale grey with orange, moist, very stiff, low plasticity. No obvious odour or staining observed.

5.70

Borehole terminated due to refusal on shale bedrock at 5.7 m bgs.
Total Depth: 5.70 m

WELL DIAGRAM



AECOM
ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

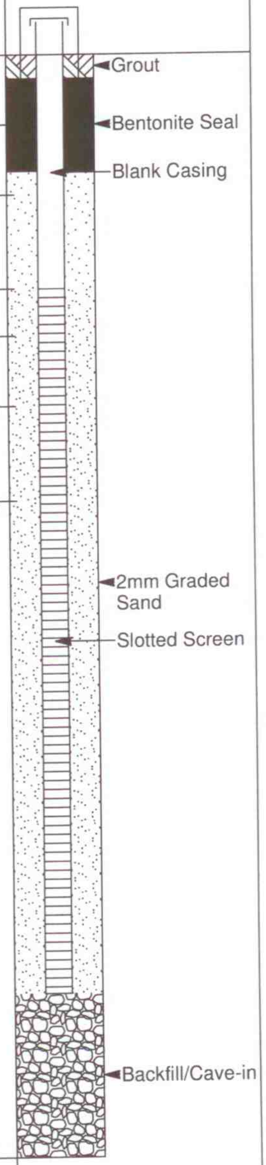
MONITORING WELL LOG BH02/MW02

PROJECT NUMBER S4125101
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube
SURFACE ELEVATION 878.629 m AHD
LOGGED BY Kate O'Brien
COMMENTS

DATE 27 Apr 09
BLANK 50mm Class 18 uPVC Casing
SCREEN 50mm Class 18 uPVC Factory Slotted Screen
GRAVEL PACK 2-3mm graded sand
SANITARY SEAL/BENTONITE Bentonite chips (medium)
STABILISED WATER LEVEL 1.842 m BTOC
GROUND WATER ELEVATION 876.787 m AHD
NORTHING 1095.035
EASTING 858.071

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGIC DESCRIPTION
0.7		☒	BH02_0.0-0.2		0.30			Silty Sand (FILL), black, slightly moist to moist, loose to medium dense, rootlets. No odour noted, stained black by coal wash, no potential ACM observed.
0.5		☒	BH02_0.5-0.6	✳	0.60			Sandy Clay (SC), brown and orange, moist, medium stiff, low plasticity. No odour or staining observed.
					1.00			Sandy Silty Clay (CL), mottled orange and red, moist, medium stiff, low plasticity. No staining or odour observed.
0.5		☒	BH02_1.0-1.2	✳	1.20			Gravelly Silty Clay (CL), mottled orange and red, very moist to saturated, medium stiff, low plasticity, inclusions of quartz gravel. No odour or staining observed.
					1.50			Clayey Gravel (GC), orange/grey/brown, very moist to saturated, medium stiff, low plasticity, fine to medium sized sub-angular and sub-rounded gravels. No odour or staining noted.
0.6		☒	BH02_1.6-1.8		1.90			Sandy Gravel (GP), orange and greys, saturated, medium dense, coarse river sand and sub-rounded and sub-angular fine to medium gravels. No odour or staining observed.
0.5		☒	BH02_2.0-2.2	✳				Silty Clay (CL), mottled pale grey and orange, saturated, stiff, low plasticity. No odour or staining observed.
0.4		☒	BH02_3.0-3.2	✳				Bands of weathered shale between 3 and 4.7 m bgs.
0.2		☒	BH02_4.0-4.2					Moisture decreasing at 4 m bgs.
					4.70			Borehole terminated due to refusal on shale bedrock at 4.7 m bgs. Total Depth: 4.70 m

WELL DIAGRAM



ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

MONITORING WELL LOG BH03/MW03

PROJECT NUMBER S4125101
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube
SURFACE ELEVATION 884.099 m AHD

DATE 28 Apr 09
BLANK 50mm Class 18 uPVC Casing
SCREEN 50mm Class 18 uPVC Factory Slotted Screen
GRAVEL PACK 2-3mm graded sand
SANITARY SEAL/BENTONITE Bentonite chips (medium)

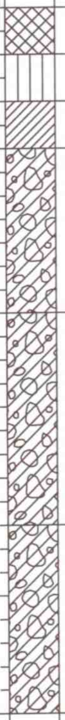
LOGGED BY Kate O'Brien
COMMENTS

NORTHING 1218.764
EASTING 740.231

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED
0.2		☒	BH03_0.0-0.2	
0.1		☒	BH03_0.4-0.5	✳
0.3		☒	BH03_1.0-1.2	✳
0.1		☒	BH03_2.0-2.2	✳
0		☒	BH03_2.8-3.0	

DEPTH (m BGL): 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

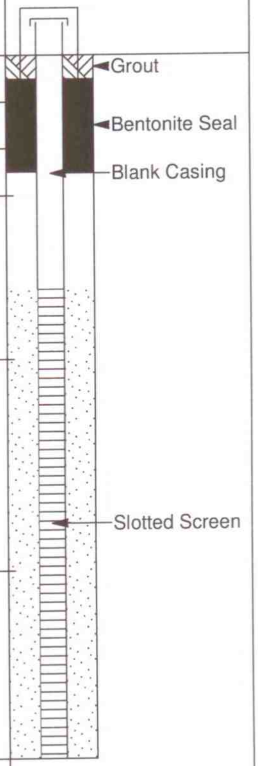
GRAPHIC LOG



USCS CLASS

LITHOLOGIC DESCRIPTION	
Silty Sand (FILL), dark brown, slightly moist, medium dense. No odour or staining observed.	0.20
Gravelly Sandy Silt (ML), pale greyish brown, slightly moist, medium dense, inclusions of angular gravels. No odour or staining observed.	0.40
Silty Clay (CL), mottled grey, red and orange, slightly moist, stiff, low plasticity. No odour or staining observed.	0.60
Gravelly Silty Clay (GC), mottled grey, red and orange, slightly moist, low plasticity, gravels are sub-rounded and sub-angular fined to coarse gravels (quartz, quartzite, shale, siltstone, river stones). No odour or staining observed.	
Hard, grey, very fine grained crystalline stone cobble at 1.2 m bgs	1.30
Gravelly Silty Clay (GC), mottled pale grey and orange, slightly moist to moist, gravels are fine to coarse sized sub-angular and sub-rounded river pebbles and quartz. No odour or staining.	2.20
Clayey Gravelly Sand (GC), orange/grey/red, slightly moist, dense, coarse sand, gravels are fine to coarse sized sub-angular and sub-rounded river pebbles and quartz. No odour or staining observed. Cobble at 2.5 m bgs.	3.00
Borehole terminated due to refusal on shale bedrock at 3 m bgs. Total Depth: 3.00 m	

WELL DIAGRAM



AECOM

ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

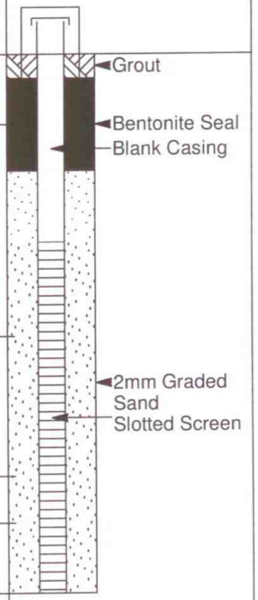
MONITORING WELL LOG BH04/MW04

PROJECT NUMBER S4125101
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube
SURFACE ELEVATION 876.416 m AHD
LOGGED BY Kate O'Brien
COMMENTS

DATE 28 Apr 09
BLANK 50mm Class 18 uPVC Casing
SCREEN 50mm Class 18 uPVC Factory Slotted Screen
GRAVEL PACK 2-3mm graded sand
SANITARY SEAL/BENTONITE Bentonite chips (medium)
STABILISED WATER LEVEL 2.302 m BTOC
GROUND WATER ELEVATION 874.114 m AHD
NORTHING 1081.56
EASTING 1094.119

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGIC DESCRIPTION
0.2		☒	BH04_0.0-0.3	✳	0.1 0.2 0.3			Sandy Silty Clay (CL), dark brown, slightly moist to moist, low plasticity. No odour or staining observed. 0.30
0.1		☒	BH04_0.6-0.8		0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2			Clayey Sandy Gravel (GC), orangish brown, very moist, medium dense. No odour or staining observed. Cobble at 1 m bgs. 1.20
					1.3 1.4 1.5 1.6 1.7 ▼ 1.8			Clayey Sandy Gravel (GC), orange/red/brown, very moist to saturated, gravels include fine sized river pebbles, sub-angular and sub-rounded gravels (quartz, shale, sandstone), coarse grained sand. No odour or staining noted. 1.80
0.2		☒	BH04_1.8-2.0	✳	1.9 2.0			Silty Clay (CL), orangish brown, slightly moist, stiff to very stiff. No odour or staining observed. 2.00
0.1		☒	BH04_2.0-2.2	✳	2.1 2.2 2.3			Weathered Bedrock (Shale), greyish brown, slightly moist, stiff to very stiff. No odour or staining observed. 2.30
								Borehole terminated due to refusal on shale bedrock at 2.3 m bgs. Total Depth: 2.30 m

WELL DIAGRAM



AECOM

ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

MONITORING WELL LOG BH05/MW05

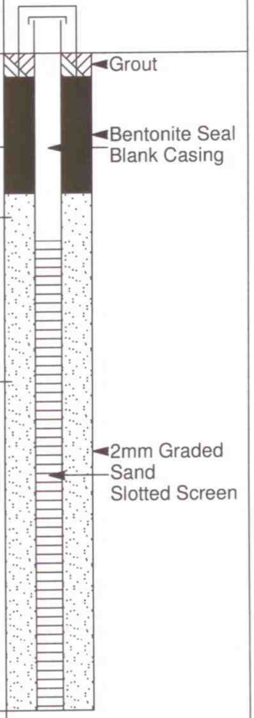
PROJECT NUMBER S4125101
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube
SURFACE ELEVATION 879.353 m AHD

LOGGED BY Kate O'Brien
COMMENTS

DATE 28 Apr 09
BLANK 50mm Class 18 uPVC Casing
SCREEN 50mm Class 18 uPVC Factory Slotted Screen
GRAVEL PACK 2-3mm graded sand
SANITARY SEAL/BENTONITE Bentonite chips (medium)
STABILISED WATER LEVEL 2.726 m BTOC
GROUND WATER ELEVATION 876.488 m AHD
NORTHING 849.595
EASTING 887.3

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGIC DESCRIPTION
0.2		☒	BH05_0.0-0.2		0.1 – 0.40			Clayey Silt (ML), reddish brown, slightly moist, loose to medium dense. No odour or staining observed.
					0.40 – 0.70			Silty Sandy Clay (CL), reddish brown, slightly moist, low plasticity. No odour or staining observed.
					0.70 – 1.40			Silty Clayey Gravel (GC), pinkish orange, dry, gravels are mainly fine to coarse quartzite gravel. No odour or stainig observed.
0.1		☒	BH05_2.0-2.2		1.40 – 2.80 2.0 ▼			Silty Clay (CL), mottled pale grey and orange, slightly moist to moist, low plasticity. No odour or staining observed.
					2.80			Borehole terminated due to refusal on shale bedrock at 2.8 m bgs. Total Depth: 2.80 m

WELL DIAGRAM



AECOM
ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

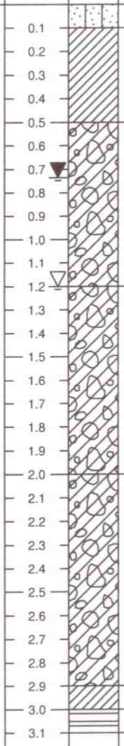
MONITORING WELL LOG BH06/MW06

PROJECT NUMBER S4125101
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube
SURFACE ELEVATION 879.214 m AHD
LOGGED BY Kate O'Brien
COMMENTS

DATE 28 Apr 09
BLANK 50mm Class 18 uPVC Casing
SCREEN 50mm Class 18 uPVC Factory Slotted Screen
GRAVEL PACK 2-3mm graded sand
SANITARY SEAL/BENTONITE Bentonite chips (medium)
STABILISED WATER LEVEL 1.335 m BTOC
GROUND WATER ELEVATION 877.879 m AHD
NORTHING 644.204
EASTING 684.993

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED	USCS CLASS
0		☒	BH06_0.0-0.1		
0.6		☒	BH06_0.8-0.9	*	
0.6		☒	BH06_1.4-1.5	*	
0.1		☒	BH06_2.4-2.5	*	
0.3		☒	BH06_2.9-3.0		

DEPTH (m BGL) / GRAPHIC LOG

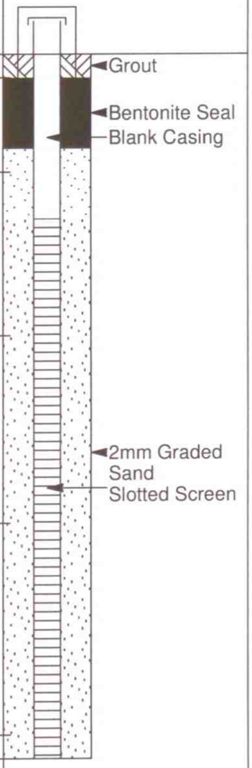


LITHOLOGIC DESCRIPTION

LITHOLOGIC DESCRIPTION	
Silty Sand (SM), brown, moist, loose, rootlets. No odour or staining observed.	0.10
Sandy Clay (CL), orangish brown, moist, medium stiff, low plasticity. No odour or staining observed.	0.50
Sandy Gravel Clay (GC), orangish brown, moist to very moist, medium stiff, low plasticity, inclusions of coarse sandstone, shale and quartz. No odour or staining observed.	1.20
Clayey Sandy Gravel (GC), orangish brown/grey/brown/white, saturated, medium dense, coarse sand, fine to coarse sized quartz and river pebbles, minor cobbles. No odour or staining observed.	2.00
Sandy Clayey Gravel (GC), orangish brown/grey/brown/white, saturated, medium dense, coarse sand, medium to coarse sized quartz and river pebbles, minor cobbles. No odour or staining observed.	2.90
Silty Clay (CL), highly weathered shale, orangish brown, very moist, stiff, low plasticity. No odour or staining observed.	3.00
Slightly Weathered Bedrock (Shale), grey, slightly moist, hard. No odour or staining observed.	3.10

Borehole terminated due to refusal on shale bedrock at 3.1 m bgs.
Total Depth: 3.10 m

WELL DIAGRAM



AECOM
ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

BOREHOLE LOG BH07

PROJECT NUMBER S4125101
DATE 28 Apr 09
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube

LOGGED BY Kate O'Brien
COMMENTS

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGIC DESCRIPTION
					0.1 0.2			Silty Gravel (FILL), black, slightly moist, loose to medium dense, crushed coal. No odour noted.
0.3		☒	BH07_0.2-0.4		0.3 0.4 0.5 0.6			
0.3		☒	BH07_0.6-0.7	✱	0.7			Inclusions of fine gravel sized (10-20mm) slag (dark greenish - yellow) fragments at 0.6 to 0.7 m bgs. 0.70
					0.8 0.9 1.0			0.80 Gravelly Clay (GC), pale cream and orange, dry to slightly moist, stiff, angular to sub-angular fine to medium sized gravels. No odour or staining observed.
0.2		☒	BH07_1.0-1.2	✱	1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0			Gravelly Clay (GC), pale cream and orange, slightly moist, stiff, angular to subangular fine to medium sized gravels. No odour or staining observed.
0.2		☒	BH07_2.0-2.2		2.1 2.2 2.3 2.4			Hard cobble at 2.5 m bgs.
					2.5 2.6 2.7 2.8 2.9 3.0			2.50 Clayey Gravelly Sand (GC), pale orangish brown, saturated, medium dense, coasre sand, fine subangular and subrounded gravel. No odour or staining observed.
0.2		☒	BH07_3.0-3.2	✱	3.1 3.2			
					3.3 3.4 3.5 3.6			3.30 Weathered Bedrock (Shale), pale orangish brown, saturated, medium dense. No odour or staining observed.
0.2		☒	BH07_3.7-3.9		3.7 3.8 3.9			
								3.90 Borehole terminated due to refusal on shale bedrock at 3.9 m bgs. Total Depth: 3.90 m

AECOM
ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

BOREHOLE LOG BH08

PROJECT NUMBER S4125101
DATE 27 Apr 09
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube

LOGGED BY Kate O'Brien
COMMENTS

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGIC DESCRIPTION
80.1		☒	BH08_0.0-0.2		0.1 – 0.5			Sandy Silty Gravel and Clay (FILL), grey and brown, slightly moist, medium dense. Hydrocarbon odour noted, no staining observed.
					0.50			
19		☒	BH08_0.5-0.6		0.6 – 0.9			Gravel (FILL), crushed coal, black, saturated, medium dense. Hydrocarbon odour noted.
					0.90			
31.1		☒	BH08_1.0-1.2	✱	1.0 – 1.3			Silty Clay (FILL), pale brownish grey, very moist to saturated, stiff to medium stiff, rootlets. Hydrocarbon odour noted, no staining observed.
					1.30			
75.5		☒	BH08_2.0-2.2	✱	1.4 – 2.2			Silty Sandy Clay (CL), pale brownish grey, saturated, medium stiff, low plasticity. Hydrocarbon odour noted, no staining observed.
					2.20			
					2.3 – 2.4			Sandy Gravel (GP), dark greys, saturated, medium dense, coarse sand, fine to medium sized subangular/subrounded gravels. Mild hydrocarbon odour noted, no staining observed.
					2.40			
16.7		☒	BH08_2.4-2.6		2.5 – 2.7			Silty Sandy Clay (CL), dark grey, saturated, low plasticity. Mild hydrocarbon odour noted, no staining observed.
					2.70			
12.8		☒	BH08_2.8-3.0	✱	2.8 – 3.1			Clayey Gravel (GC), orange, saturated, medium dense, low plasticity. Mild hydrocarbon odour, no staining observed.
					3.10			
					3.2 – 3.5			Weathered Bedrock (Shale), orange/grey, slightly moist, hard. No odour or staining observed.
					3.50			
								Borehole terminated due to refusal on shale bedrock at 3.5 m bgs. Total Depth: 3.50 m

S4125101_BORELOGS_4MAY09.GPJ 20/05/09

AECOM
ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

BOREHOLE LOG BH09

PROJECT NUMBER S4125101
DATE 27 Apr 09
PROJECT NAME Lidsdale Siding Contaminantion Assessment
LOCATION Lidsdale Siding, Lidsdale, NSW
DRILLING METHOD Push tube
SAMPLING METHOD Push tube

LOGGED BY Kate O'Brien
COMMENTS

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGIC DESCRIPTION
0.8		☒	BH09_0.0-0.1	*	0.1 0.2 0.3	▩		Silty Gravel (FILL), crushed coal, black, dry to slightly moist, medium dense to dense. No obvious odour observed.
0.8		☒	BH09_0.4-0.5	*	0.4 0.5	▩		
0.5		☒	BH09_0.6-0.7	*	0.6	⁘		0.60 Sand (SP), dark orange and yellow, dry to slighlty moist, very dense, fine sand sized quartz inclusions. No odour or staining observed. 0.65
					0.7	≡		0.70 Slightly Weathered Bedrock (Shale), grey, very stiff to hard. No odour or staining observed.

Borehole terminated due to refusal on shale bedrock at 0.7m bgs.
Total Depth: 0.70 m

AECOM
ENSR Australia Pty Ltd. (trading as AECOM)
Level 5, 828 Pacific Highway
Gordon, NSW, 2072

BOREHOLE LOG BH10

PROJECT NUMBER S4125101

DATE 27 Apr 09

PROJECT NAME Lidsdale Siding Contaminantion Assessment

LOCATION Lidsdale Siding, Lidsdale, NSW

DRILLING METHOD Push tube

SAMPLING METHOD Push tube

LOGGED BY Kate O'Brien

COMMENTS

PID (ppm)	PPT (kg/cm2)/ BLOW COUNTS	RECOVERY	SAMPLE NUMBER	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGIC DESCRIPTION	
						▩		Silty Gravel (FILL), pale brown, loose, dry, crushed coal inclusions. No obvious odour noted.	0.05
1		☒	BH10_0.1-0.2		0.1 0.2	▩		Gravel (FILL), crushed coal, black, dry to slightly moist, medium dense. No obvious odour noted.	0.30
					0.3 0.4	☰		Slightly Weathered Bedrock (Shale), grey, dry, hard. No obvious odour or staining noted.	0.40
								Borehole terminated at 0.4 m bgs due to refusal on Shale Bedrock. Total Depth: 0.40 m	

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL 1463
Class of Licence: Cl 4
Driller's Name: E M JONES
Assistant Driller: A. Campbell
Contractor: Watermin Drillers

New bore ☑ Replacement bore ☐
Deepened ☐ Enlarged ☐
Reconditioned ☐ Other (specify)

Final Depth 38 m

2

Work Licence No: 10 B L 602936
Name of Licensee: Ivanhoe Coal Pty Ltd
Intended Use: Test Bore
Completion Date: 6/03/2009

DRILLING DETAILS

3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	15.96	203	5
15.96	38	168	5

WATER BEARING ZONES

4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s)		Test method Code	D D L at end of test (m)	Duration		Salinity (Conductivity or TDS)	
				Individual Aquifer	Cumulative			Hrs	min	Cond. (µS/cm)	TDS (mg/L)
5	8	3	1.2	0.505		1					

CASING / LINER DETAILS

5

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
5	160	6.3	0.3asl	15.96	1

Casing support method Code 1
Type of casing bottom Code 1
Centralisers installed No ☑ Yes ☐ (indicate on sketch)
Sump installed No ☑ Yes ☐ From m To m
Pressure cemented No ☑ Yes ☐ From m To m
Casing Protector cemented in place No ☑ Yes ☐

WATER ENTRY DESIGN

6

General							Screen	Slot Details		
Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type Code	Fixing Code	Aperture (mm)	Length (mm)	Width (mm)	Alignment Code
5	160	6.3	2	8	9	1	1			

GRAVEL PACK

7

Type		Grade		Grain size (mm)		Depth (m)		Quantity	
				From	To	From	To	Litres or	m^3
Rounded	☑	Graded	☑	5	7	15.96	0	200	
Crushed	☐	Ungraded	☐						

Bentonite/Grout seal No ☑ Yes ☐
Method of placement of Gravel Pack Code 1

For D W E use only: G W ☐☐☐☐☐☐

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A ....
PARTICULARS OF COMPLETED WORK

Work Licence No: 10 **B L** 602936

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No ☑ Yes ☐ Name:

Method	Bailing/Surging ☐	Jetting ☐	Airlifting ☑	Backwashing ☐	Pumping ☐	Other:
Duration	hrs	hrs	6 hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery		
								Water level (m)	Time taken (hrs)	(mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)		7/03/09	8	1.2	0.505	6.61	24	5.62	1	30

Height of measuring point above ground level 0.5 m Test Method Code 5 See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: ________ metres Is work partly backfilled: No ☐ Yes ☐

Is work abandoned: No ☐ Yes ☐ Method of abandonment: Backfilled ☐ Plugged ☐ Capped ☐

Has any casing been left in the work No ☐ Yes ☐ From ________ m To ________ m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist ☐ Geologist ☐ Driller ☐ Diviner ☑ Client ☐ Other ________ 12

13

Lot No ________ DP No ________

Work Location Co ordinates Easting ________ Northing ________ Zone ________

GPS: No ☑ Yes ☐ >> AMG/AGD ☐ or MGA/GDA ☐ (See explanation)

Please mark the work site with "X" on the DWE CLID map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: ________

Date: 10/4/09

Licensee: for CENTENNIAL IVANHOE Pty Ltd

Date: 21/4/09

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A ....
PARTICULARS OF COMPLETED WORK

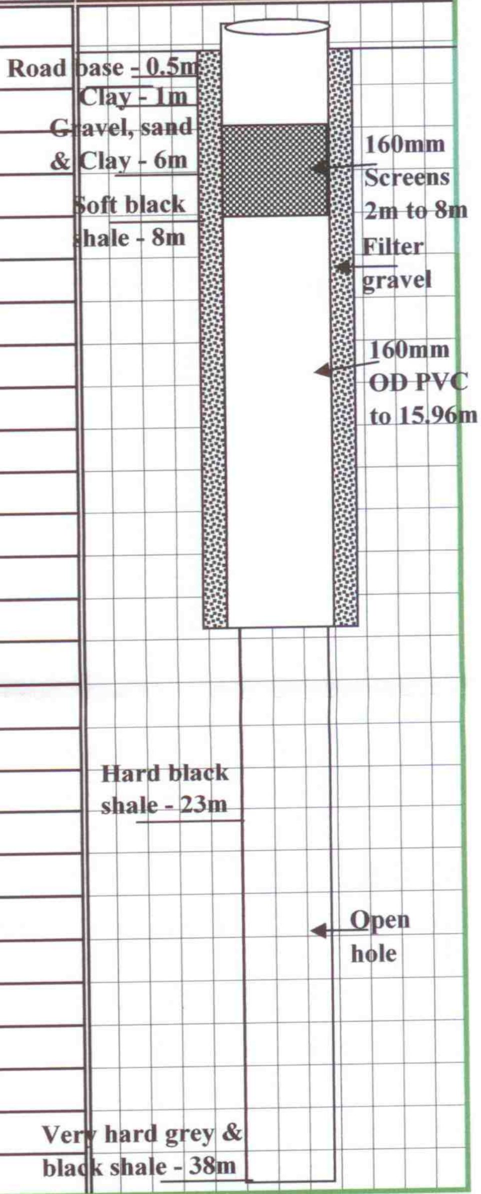
Work Licence No: 10 B L 602936

15

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

Depth		Description
From (m)	To (m)	
0	0.5	Road base
0.5	1	Clay
1	6	Gravel, sand & clay
6	8	Soft black shale
8	23	Hard black shale
23	38	Very hard grey & black shale

WORK CONSTRUCTION SKETCH



16

WORK NOT CONSTRUCTED BY DRILLING RIG

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other ----------------

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (n

17

Please attach copies of the following if available

Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

Page 1

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A
PARTICULARS OF COMPLETED WORK

1

Driller's Licence No: DL 1463
Class of Licence: Cl 4
Driller's Name: E M JONES
Assistant Driller: A. Campbell
Contractor: Watermin Drillers

New bore ☑ Replacement bore ☐
Deepened ☐ Enlarged ☐
Reconditioned ☐ Other (specify)

Final Depth 90 m

2

Work Licence No: 10 B L 602935
Name of Licensee: Ivanhoe Coal Pty Ltd
Intended Use: Test Bore
Completion Date: 9/03/2009

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method Code
0	9.75	203	5
9.75	83	168	5
83	90	127	5

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Cumulative	Test method Code	D D L at end of test (m)	Duration Hrs	min	Salinity (Conductivity or TDS) Cond. (µS/cm)	TDS (mg/L)
3	4	1		0.0631		1					
INSUFFICIENT SUPPLY											

CASING / LINER DETAILS 5

Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code
NO CASING USED					

Casing support method Code
Type of casing bottom Code
Centralisers installed No ☑ Yes ☐ (indicate on sketch)
Sump installed No ☑ Yes ☐ From m To m
Pressure cemented No ☑ Yes ☐ From m To m
Casing Protector cemented in place No ☑ Yes ☐

WATER ENTRY DESIGN 6

General							Screen	Slot Details		
Material Code	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type Code	Fixing Code	Aperture (mm)	Length (mm)	Width (mm)	Alignment Code

GRAVEL PACK 7

Type	Grade	Grain size (mm) From	To	Depth (m) From	To	Quantity Litres or m^3	
Rounded ☐	Graded ☐						
Crushed ☐	Ungraded ☐						

Bentonite/Grout seal No ☐ Yes ☐
Method of placement of Gravel Pack Code

For D W E use only: G W

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A ....
PARTICULARS OF COMPLETED WORK

Work Licence No: 10 B L 602935

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No ☑ Yes ☐ Name:

Method	Bailing/Surging ☐	Jetting ☐	Airlifting ☐	Backwashing ☐	Pumping ☐	Other:
Duration	hrs	hrs	hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical/s used	Quantity applied (litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery		
								Water level (m)	Time taken (hrs)	(mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level ---------- m Test Method **Code** ☐ See Code Table 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: 90 metres Is work partly backfilled: No ☐ Yes ☐

Is work abandoned: No ☐ Yes ☑ Method of abandonment: Backfilled ☑ Plugged ☐ Capped ☐

Has any casing been left in the work No ☑ Yes ☐ From ________ m To ________ m

Sealing / fill type Code	From depth (m)	To depth (m)	Sealing / fill type Code	From depth (m)	To depth (m)
4	90	0			

12

Site chosen by: Hydrogeologist ☐ Geologist ☐ Driller ☐ Diviner ☐ Client ☑ Other ------------

13

Lot No 2 DP No 252472

Work Location Co ordinates Easting ------------------ Northing ------------------ Zone ---------

GPS: No ☑ Yes ☐ >> AMG/AGD ☐ or MGA/GDA ☐ (See explanation)

Please mark the work site with "X" on the DWE CLID map.
Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: ------------------------------------

Date: 10/4/09

Licensee: for CENTENNIAL IVANHOE PTY LTD

Date: 21/4/09

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

FORM A ....
PARTICULARS OF COMPLETED WORK

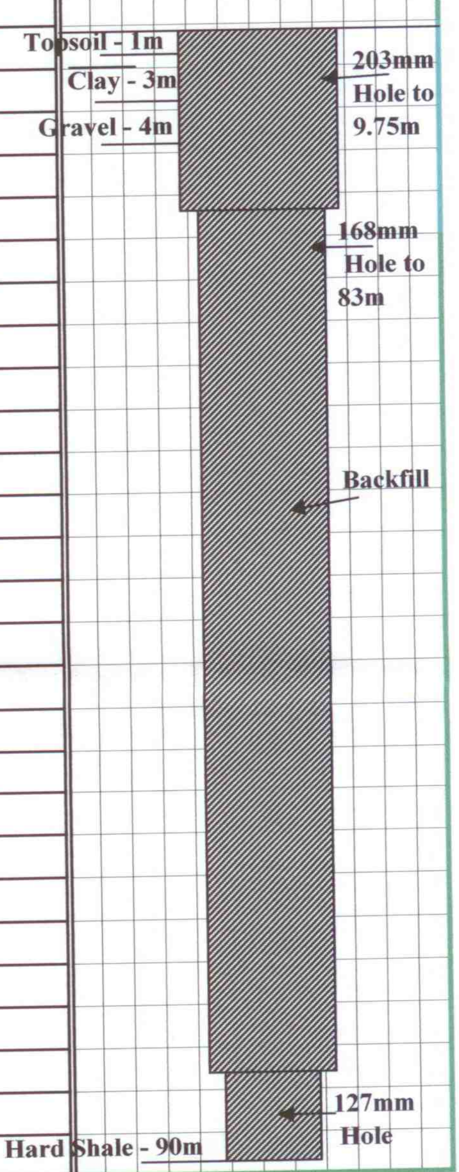
Work Licence No: 10 **B L** 602935

15

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)

Depth From (m)	Depth To (m)	Description
0	1	Topsoil
1	3	Clay
3	4	Gravel
4	90	Hard Shale

WORK CONSTRUCTION SKETCH



16

WORK NOT CONSTRUCTED BY DRILLING RIG

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other ____________

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m

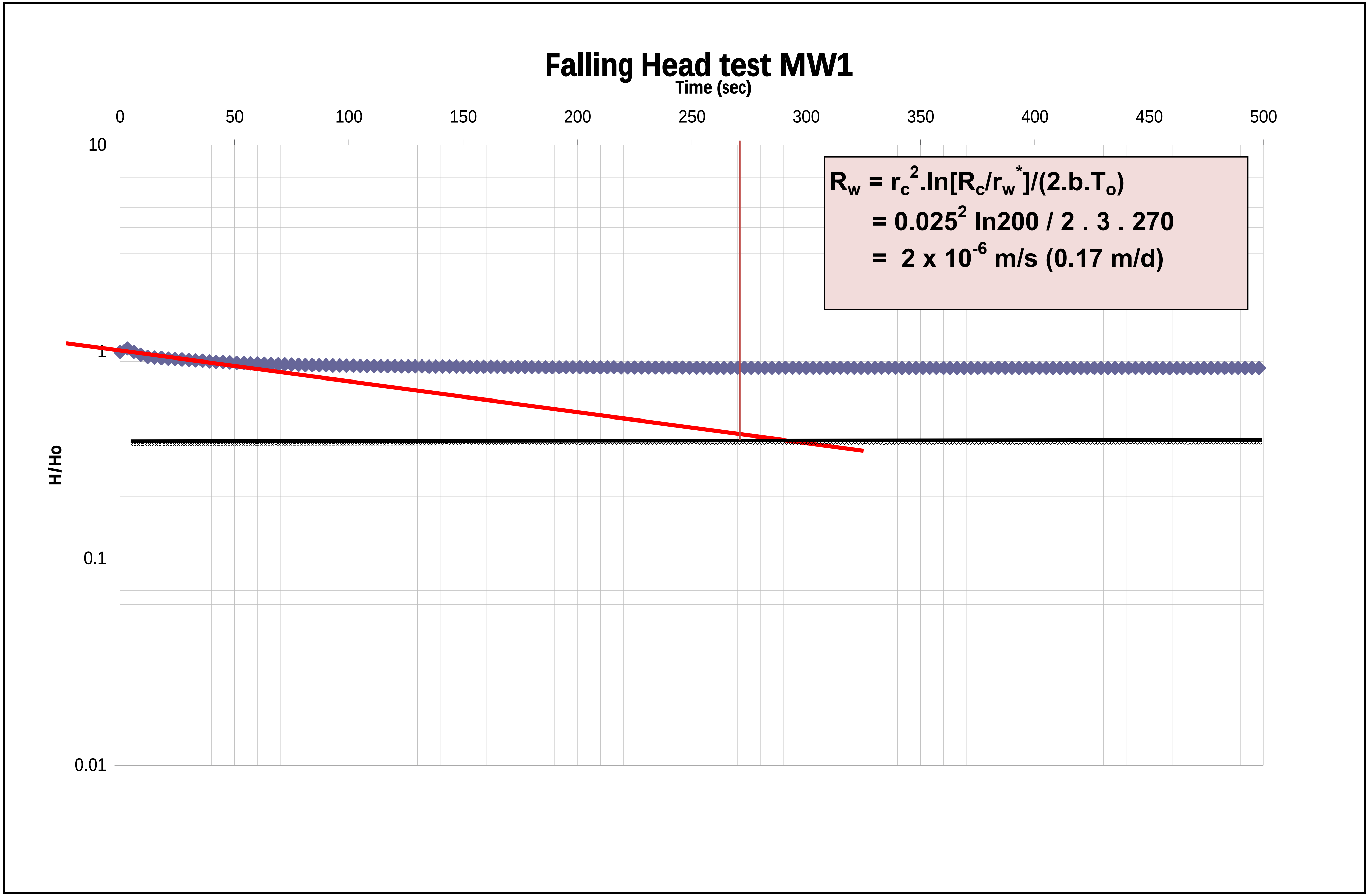
17

Please attach copies of the following if available

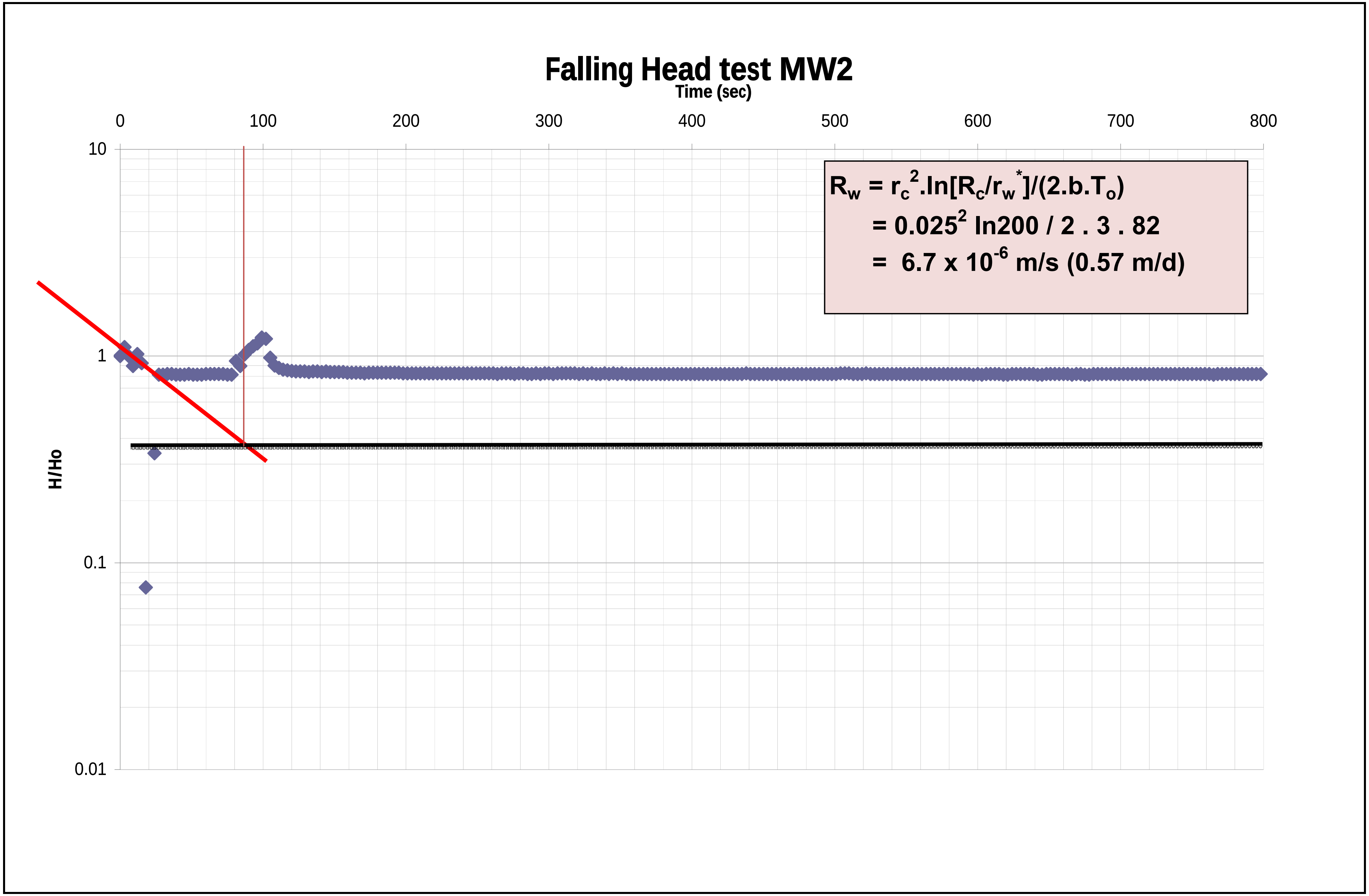
Geologist log No ☐ Yes ☐ Laboratory analysis of water Sample No ☐ Yes ☐ Pumping test(s) No ☐ Yes ☐

Geophysical log No ☐ Yes ☐ Sieve analysis of aquifer material No ☐ Yes ☐ Installed Pump details No ☐ Yes ☐

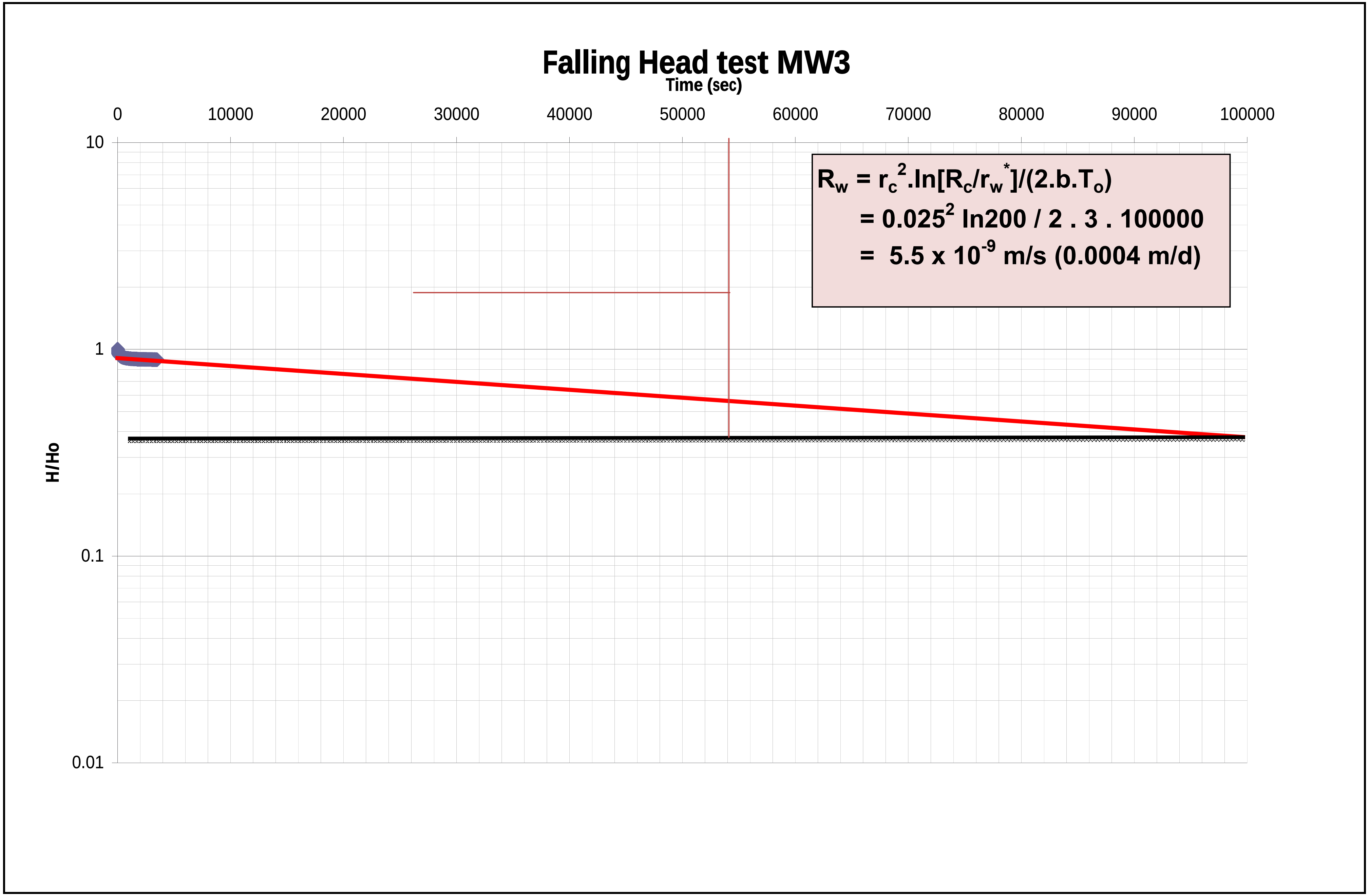
APPENDIX B:
HYDRAULIC TESTING RESULTS



RPS Aquaterra



$$R_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$$
$$= 0.025^2 \ln 200 / 2 . 3 . 82$$
$$= 6.7 \times 10^{-6} \text{ m/s } (0.57 \text{ m/d})$$

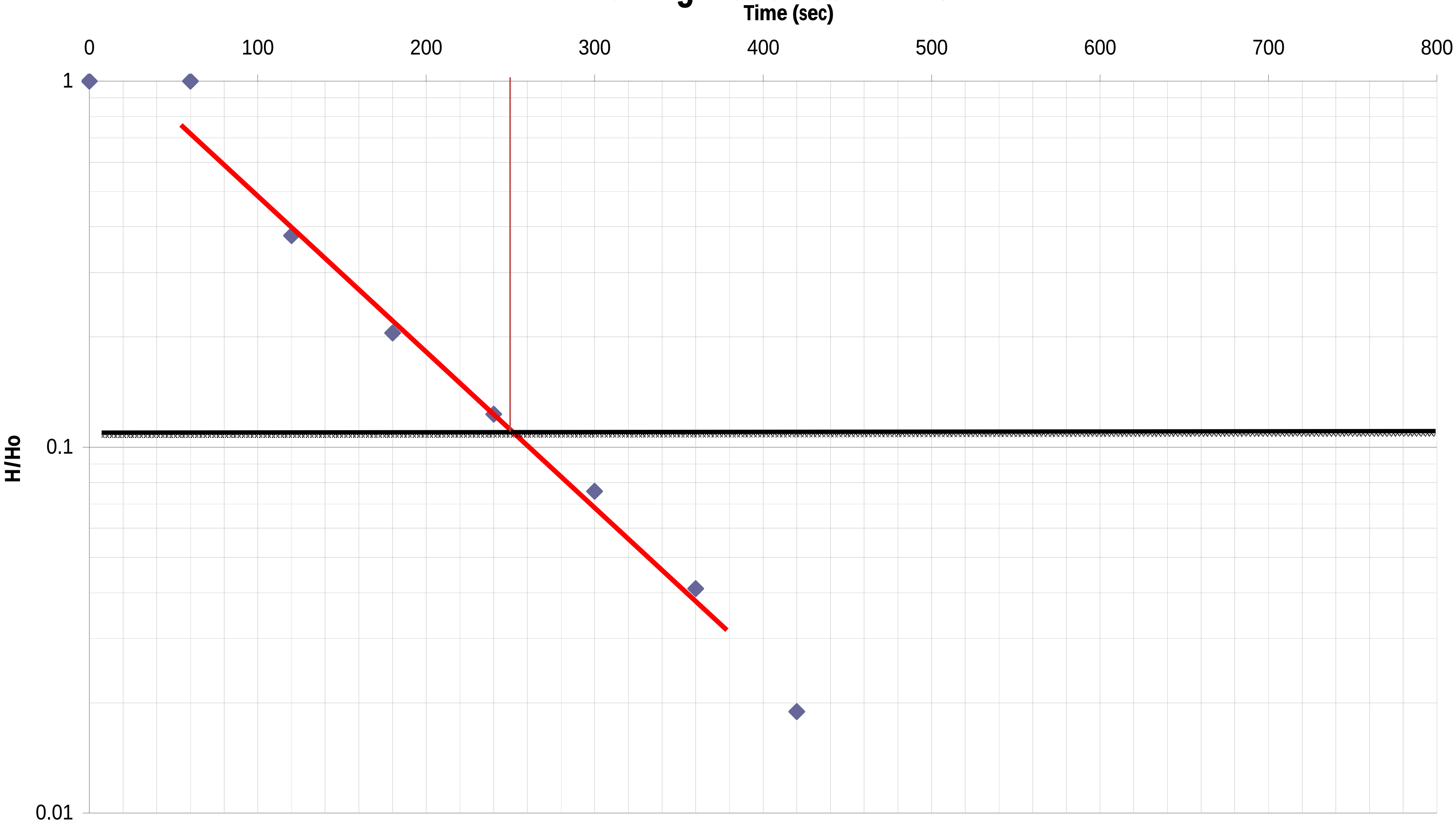


$R_w = r_c^{2}.\ln[R_c/r_w^{*}]/(2.b.T_o)$

$= 0.025^{2} \ln 200 / 2 . 3 . 100000$

$= 5.5 \times 10^{-9}$ m/s (0.0004 m/d)

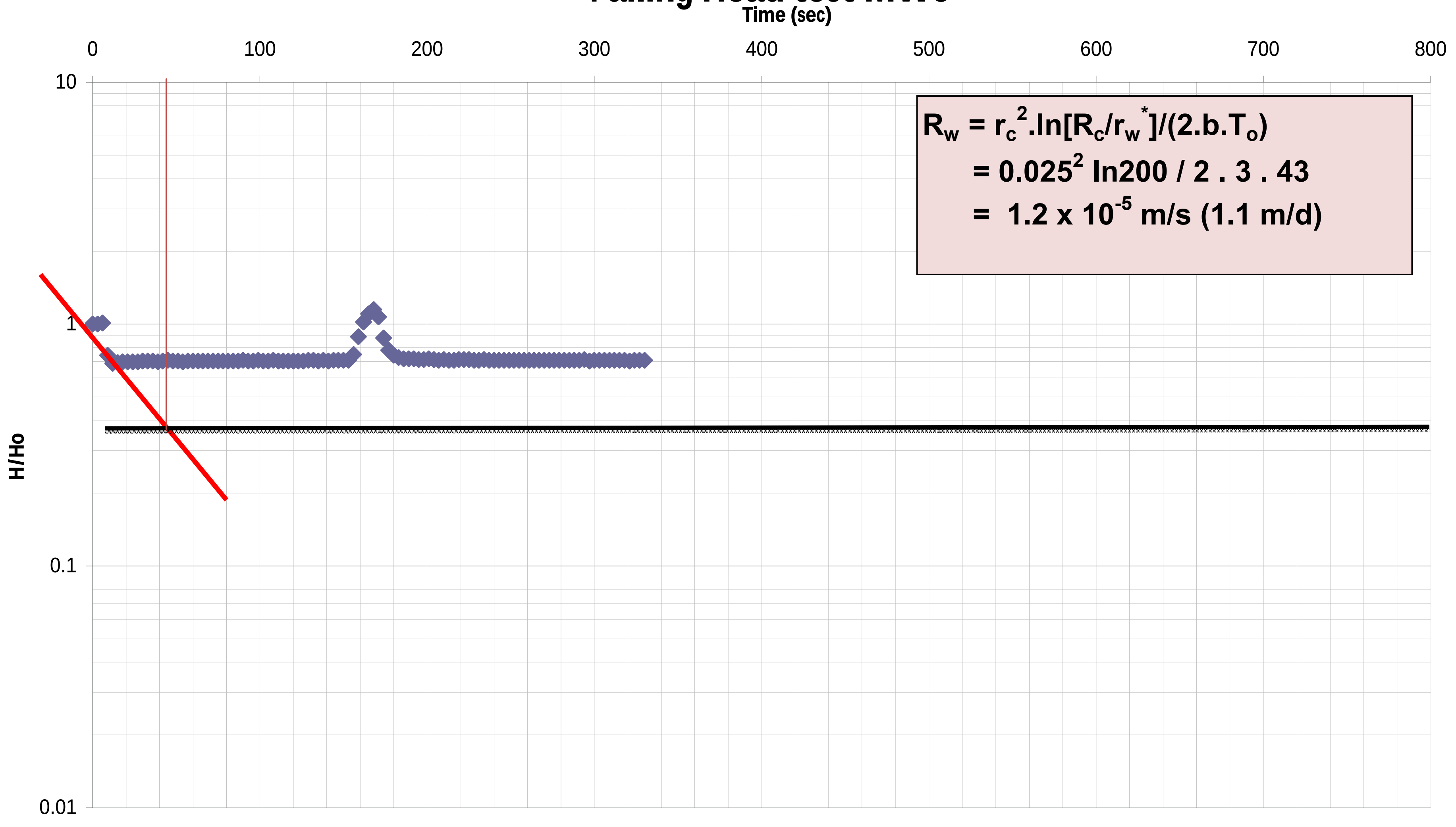
Falling Head test MW5



RPS Aquaterra

FALLING HEAD TEST MW5 HVORSLEV Appendix B4

Falling Head test MW6



$$R_w = r_c^{2}.\ln[R_c/r_w^{*}]/(2.b.T_o)$$

$$= 0.025^{2}\ \ln 200\ /\ 2\ .\ 3\ .\ 43$$

$$= \ 1.2 \times 10^{-5}\ \text{m/s}\ (1.1\ \text{m/d})$$

APPENDIX C:
NSW OFFICE OF WATER DATABASE

Table C1: Registered groundwater users

Work No.	License	Easting	Northing	Bore type	Owner Details	Depth	Date Completed	Salinity	Bore Yield	Standing Water Level	Use
GW050996	10BL111587	1347476.419	6266159.546	Bore open thru rock	Private	45.7	1/02/1980	Good	0.0	0.0	Monitoring
GW058576	10BL128116	1342934.459	6265966.448	Bore	Private	0.0	1/02/1983	(Unknown)	0.0	0.0	Power Generation, Recreation and Water Conservation
GW057380	10BL125180	1342386.723	6265983.295	Bore open thru rock	Private	42.7	1/03/1983	(Unknown)	0.0	0.0	Power Generation, Recreation and Water Conservation
GW057649	10BL126321	1343080.517	6266140.751	Bore	Private	23.5	1/02/1983	Fair	0.0	0.0	Power Generation, Recreation and Water Conservation
GW102426	10BL157246	1348813.888	6266197.467	Bore		70.0	14/08/1995	Good	0.0	0.0	Power Generation, Recreation and Water Conservation
GW102427	10BL157246	1348785.197	6266168.809	Bore		68.5	14/08/1995		0.0	0.0	Domestic
GW101461	10BL158341	1346157.596	6268115.901	Bore		45.0	8/01/1998		0.6	15.0	Stock and Domestic
GW801271	80BL239129	1344172.016	6264410.005	Bore	Private	55.0	8/06/2000	Good	0.0	27.0	Stock and Domestic
GW102079	10BL158928	1340331.634	6267005.196	Bore	Private	43.0	27/01/1999	Good	1.5	3.0	Stock and Domestic
GW053071	10BL134354	1344805.163	6267611.052	Bore open thru rock	Private	15.2	1/12/1980	(Unknown)	0.0	0.0	Domestic
GW102175	10BL158936	1340267.185	6265669.932	Bore	Private	40.0	10/12/1998	Good	2.5	5.0	Stock and Domestic
GW062815	10BL134742	1346439.416	6268779.443	Bore	Private	56.7	1/11/1983	Fair	0.0	0.0	Stock and Domestic
GW105235	10BL161212	1341284.844	6266444.468	Bore	Private	72.0	9/02/2003		1.1	23.5	Stock and Domestic
GW105801	10BL160445	1344567.506	6264740.941	Bore	Private	37.0	1/01/2003		0.5	1.0	Stock and Domestic
GW106737	10BL164509	1345661.615	6269879.93	Bore	Mines	90.0	25/11/2004		0.7	33.0	Irrigation
GW103238	10BL157244	1348667.755	6265663.268	Bore		68.5	14/08/1995	Good	0.0	0.0	Stock and Domestic
GW072713	10BL154771	1346116.631	6269429.031	Bore		21.3	26/05/1994	Good	0.0	0.0	Domestic
GW110437		1345237.748	6267300.282	Bore	Private	90.0	9/03/2009		0.1	0.0	Stock and Domestic
GW110480	10BL603120	1347045.171	6268574.352	Bore	Private	13.0	28/07/2009		0.0	0.0	Stock and Domestic
GW110481	10BL603121	1346638.355	6268253.39	Bore	Private	15.8	28/07/2009		0.0	0.0	Domestic
GW110482	10BL603122	1346793.094	6269696.594	Bore	Private	33.0	29/07/2009		0.0	0.0	Stock and Domestic
GW110483	10BL603122	1346788.546	6269693.087	Bore	Private	21.0	29/07/2009		0.0	0.0	Domestic
GW110520	10BL603501	1345356.275	6267446.677	Bore	Private	38.0	6/03/2009		0.5	1.2	Test Bore
GW110157	10BL165933	1345121.476	6271133.978	Bore	Private	9.0	14/10/2005		0.0	0.0	Monitoring
GW110158	10BL165933	1345370.001	6271063.494	Bore	Private	9.0	14/10/2005		0.0	0.0	Monitoring
GW110159	10BL165933	1345612.438	6271089.084	Bore	Private	10.3	13/10/2005		0.0	0.0	Monitoring
GW110160	10BL165933	1346057.506	6271495.997	Bore	Private	43.0	15/10/2005		0.0	0.0	Monitoring
GW110161	10BL165933	1346229.915	6270988.895	Bore	Private	27.5	13/10/2005		0.0	0.0	Test Bore

Work No.	License	Easting	Northing	Bore type	Owner Details	Depth	Date Completed	Salinity	Bore Yield	Standing Water Level	Use
GW110162	10BL165933	1346224.441	6270985.469	Bore	Private	12.0	13/10/2005		0.0	0.0	Monitoring
GW110484	10BL603123	1347343.955	6269469.181	Bore	Private	59.0	29/07/2009		0.0	0.0	Monitoring
GW110485	10BL603123	1347250.344	6268576.939	Bore	Private	66.6	17/09/2009		0.0	0.0	Monitoring
GW109260	10WM000002	1349406.841	6267775.067	Piezometer	Private	9.0	29/10/1985		0.0	2.2	Monitoring
GW109261	10WM000002	1347247.194	6267921.775	Piezometer	Private	18.0	2/11/1985		0.0	9.8	Monitoring
GW109262	10WM000002	1347718.359	6268221.12	Piezometer	Private	17.5	30/10/1985		0.0	3.6	Monitoring
GW109263	10WM000002	1347748.82	6268884.284	Piezometer	Private	6.0	25/08/2008		0.0	3.5	Monitoring
GW109264	10WM000002	1347169.714	6268764.919	Piezometer	Private	14.3	6/11/1985		0.0	4.5	Monitoring
GW109265	10WM000002	1346896.634	6268606.926	Piezometer	Private	14.9	7/11/1985		0.0	1.0	Power Generation, Recreation and Water Conservation
GW110861	10BL603591	1345025.744	6270781.858	Bore	Private	24.0	19/02/2010		0.0	0.0	Power Generation, Recreation and Water Conservation

APPENDIX D:
HYDROGRAPHS

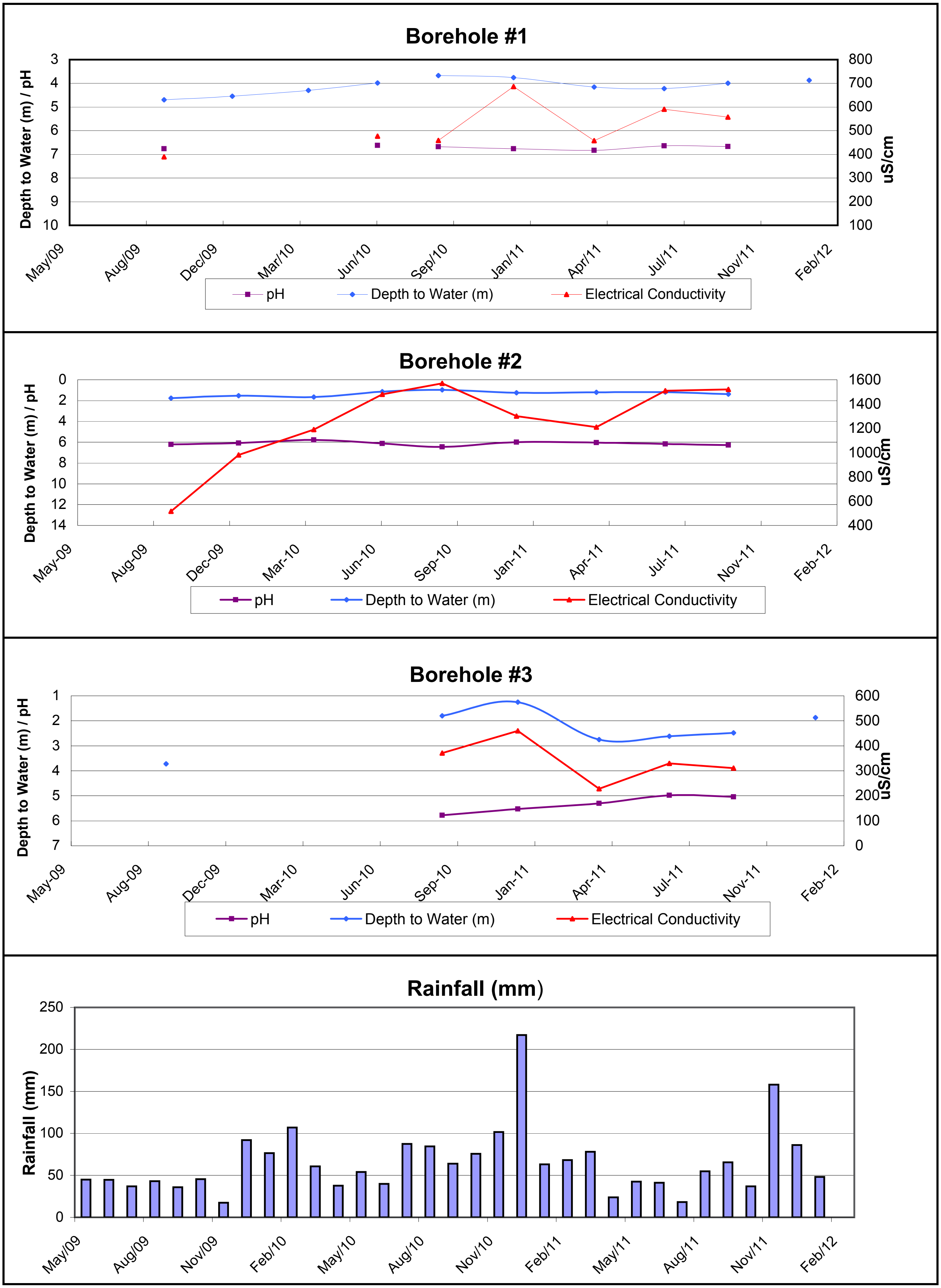


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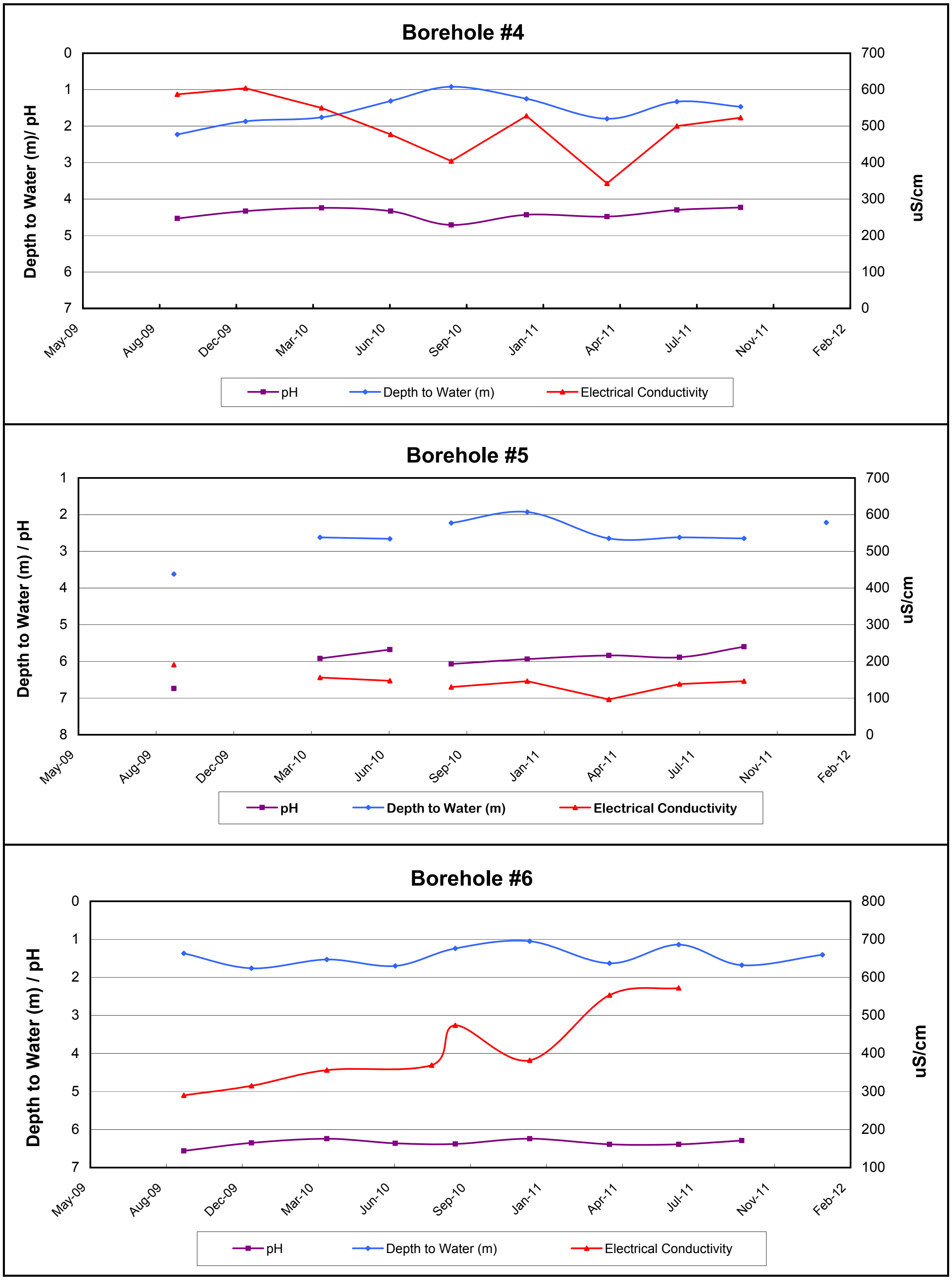
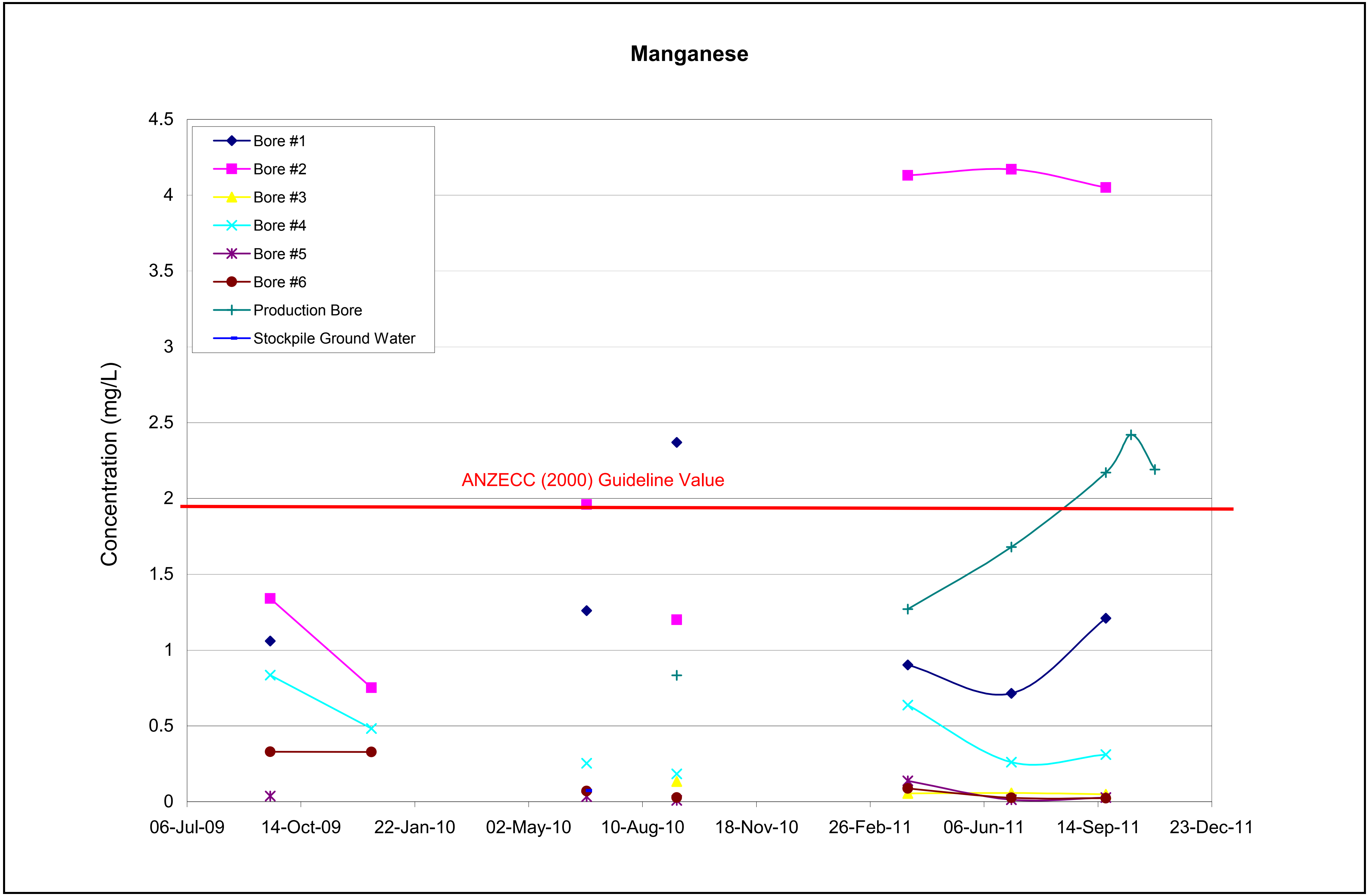
FIGURE MW1,2,3 and rainfall

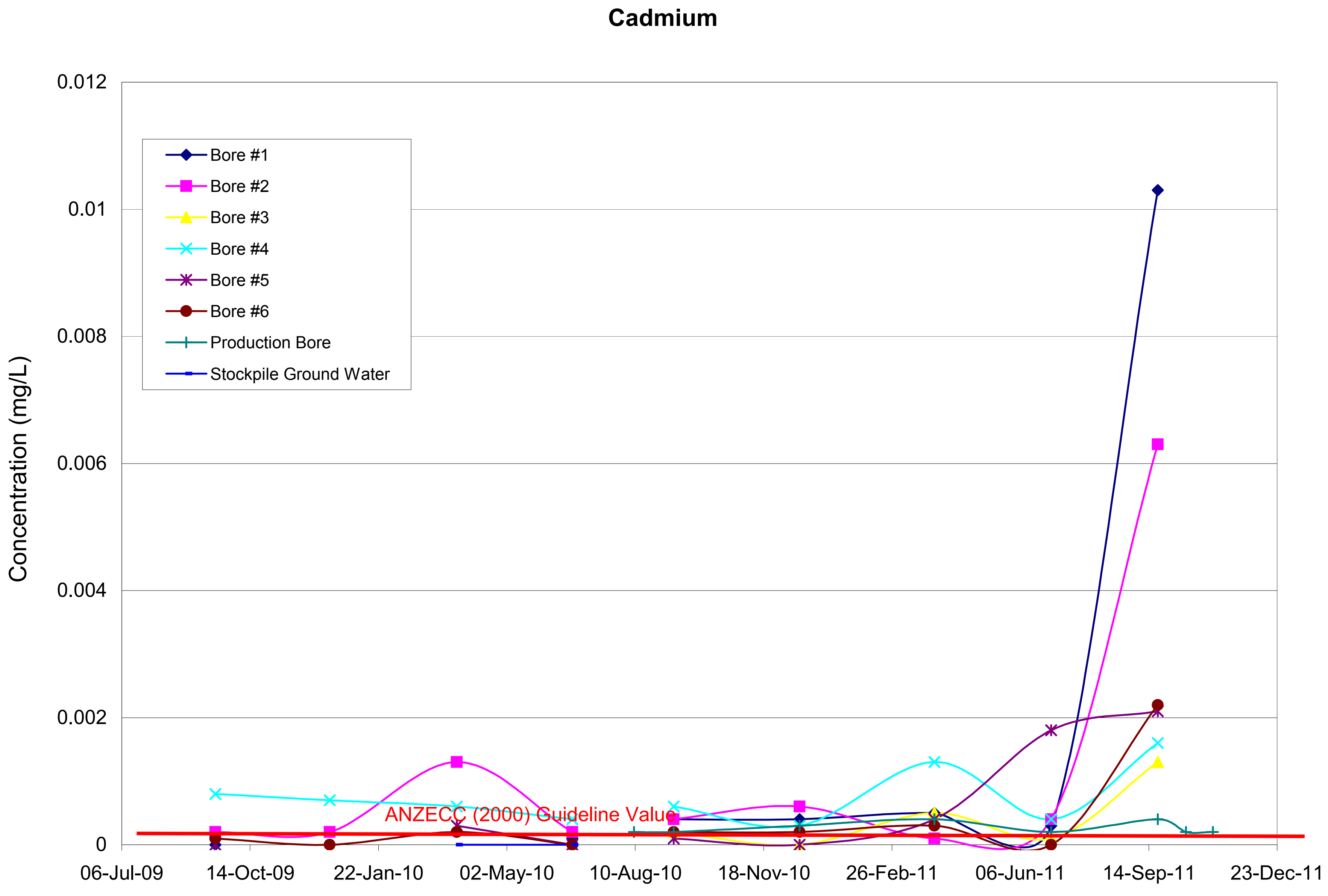


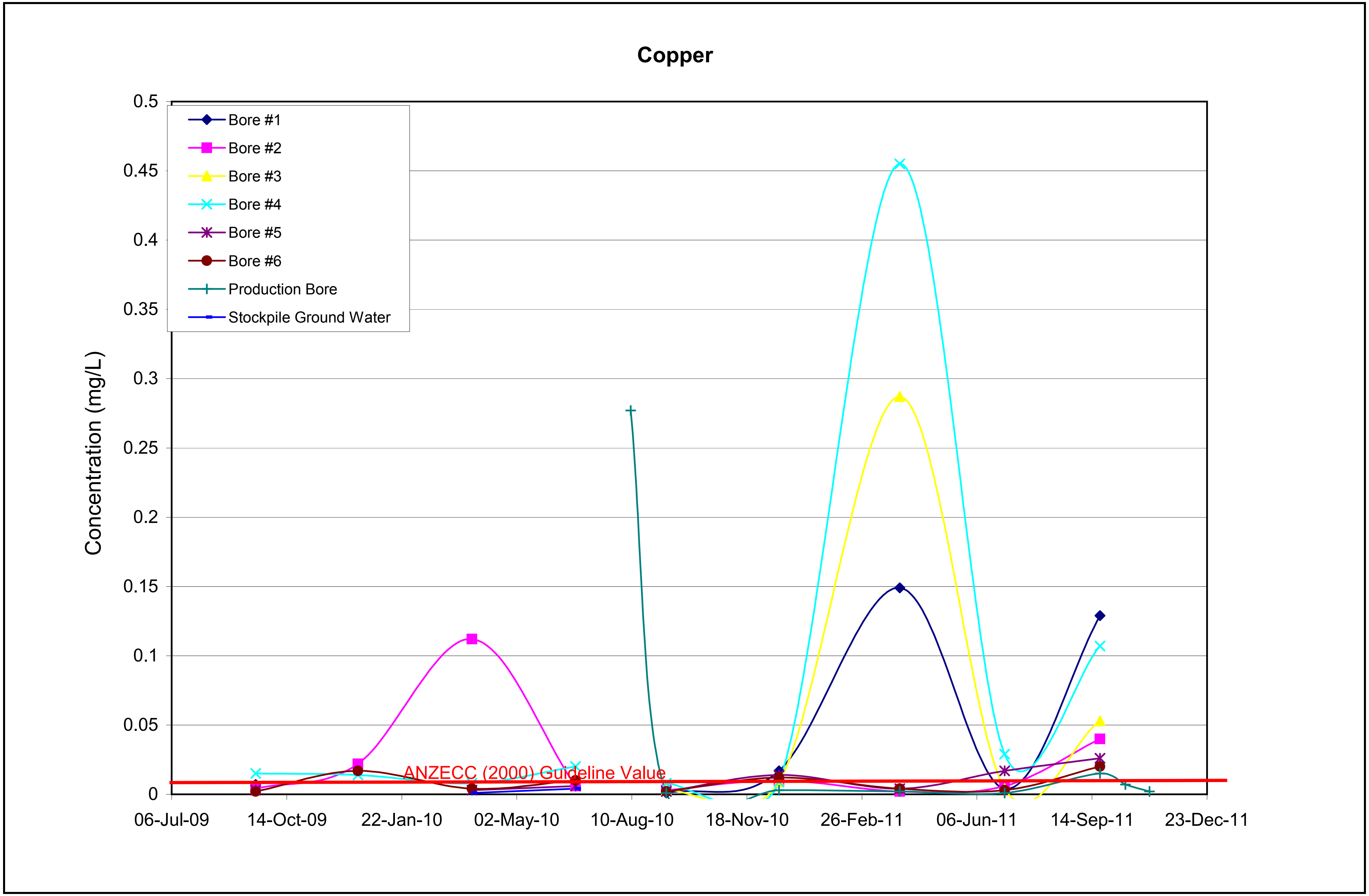
RPS Aquaterra

FIGURE Water levels Bore4,5,6

APPENDIX E:
WATER QUALITY ANALYSIS FROM SITE BORES


Manganese
Bore #1
Bore #2
Bore #3
Bore #4
Bore #5
Bore #6
Production Bore
Stockpile Ground Water
ANZECC (2000) Guideline Value
Concentration (mg/L)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
06-Jul-09
14-Oct-09
22-Jan-10
02-May-10
10-Aug-10
18-Nov-10
26-Feb-11
06-Jun-11
14-Sep-11
23-Dec-11


Cadmium
0.012
0.01
0.008
0.006
0.004
0.002
0
Concentration (mg/L)
Bore #1
Bore #2
Bore #3
Bore #4
Bore #5
Bore #6
Production Bore
Stockpile Ground Water
ANZECC (2000) Guideline Value
06-Jul-09
14-Oct-09
22-Jan-10
02-May-10
10-Aug-10
18-Nov-10
26-Feb-11
06-Jun-11
14-Sep-11
23-Dec-11



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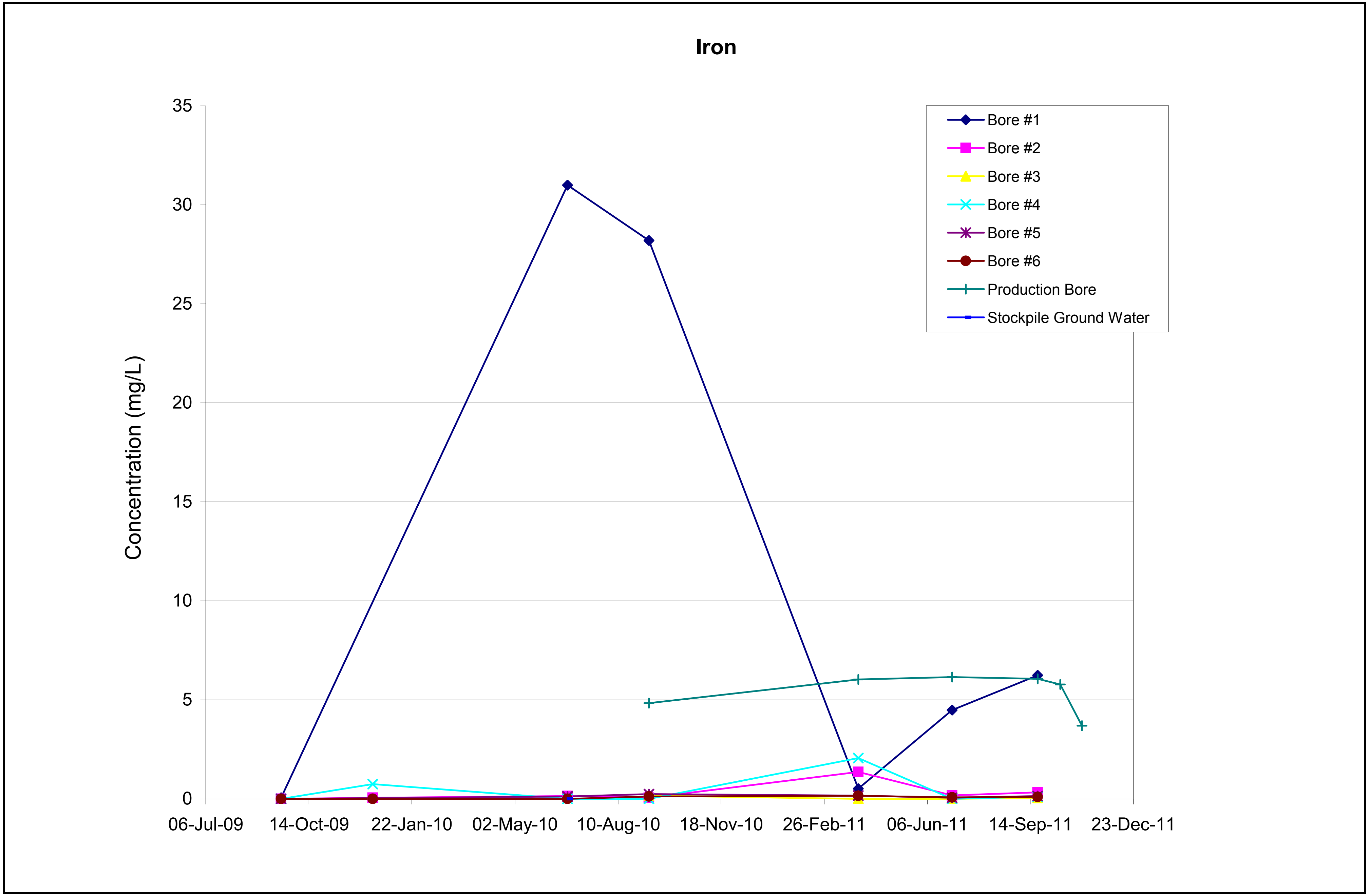
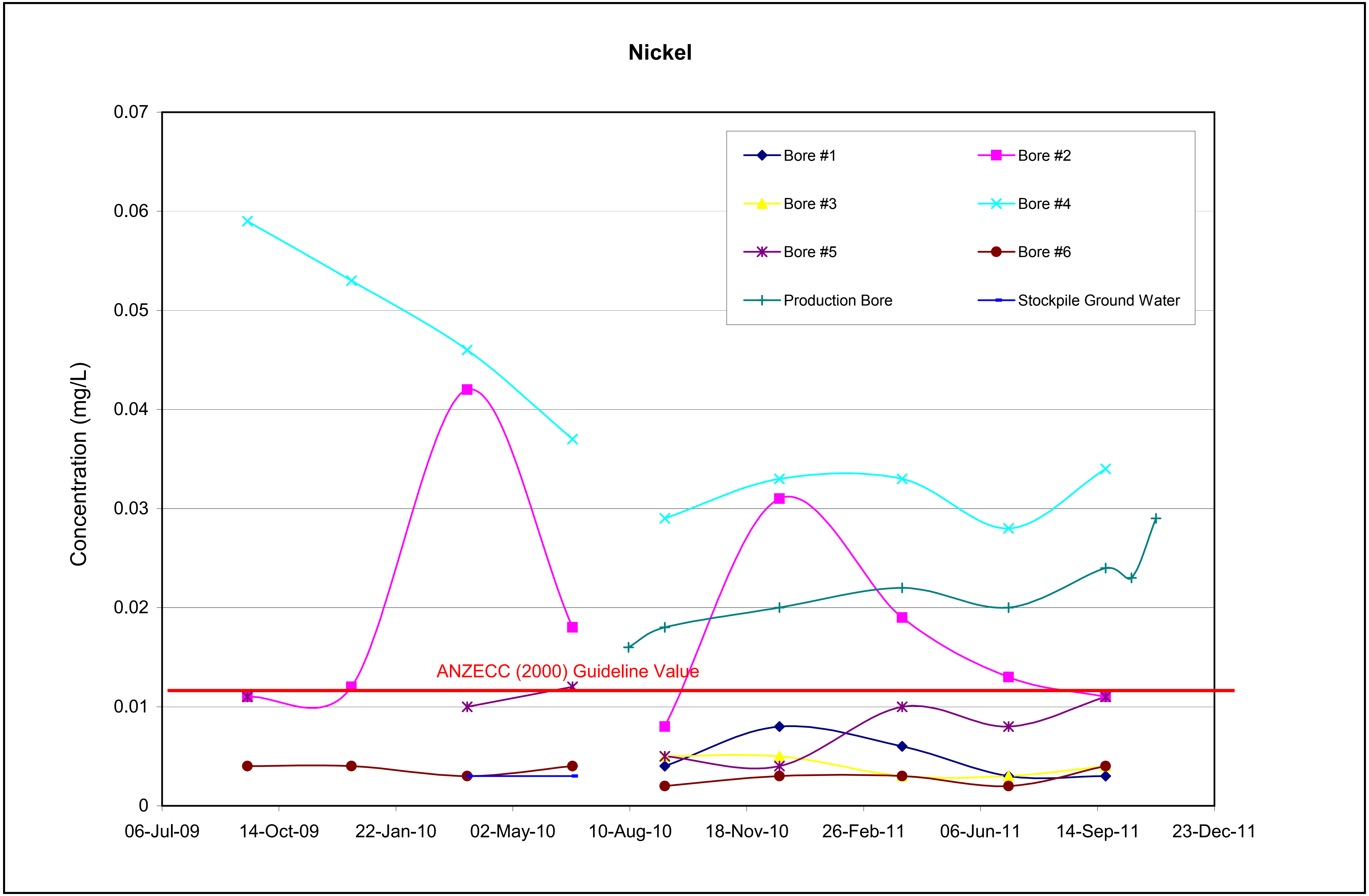
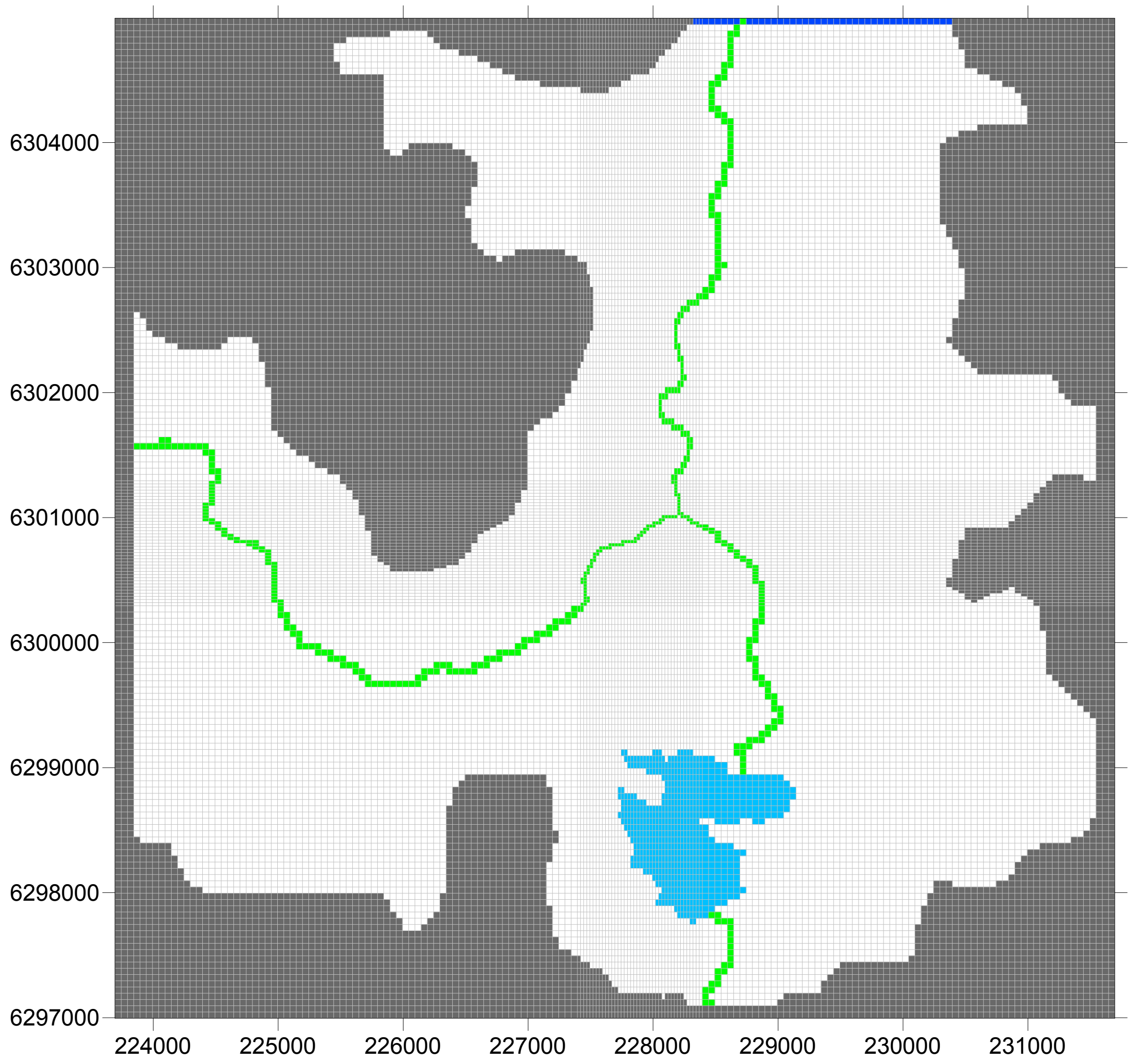

Iron
35
30
25
20
15
10
5
0
Concentration (mg/L)
06-Jul-09
14-Oct-09
22-Jan-10
02-May-10
10-Aug-10
18-Nov-10
26-Feb-11
06-Jun-11
14-Sep-11
23-Dec-11
Bore #1
Bore #2
Bore #3
Bore #4
Bore #5
Bore #6
Production Bore
Stockpile Ground Water


Nickel
Concentration (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
06-Jul-09
14-Oct-09
22-Jan-10
02-May-10
10-Aug-10
18-Nov-10
26-Feb-11
06-Jun-11
14-Sep-11
23-Dec-11
Bore #1
Bore #2
Bore #3
Bore #4
Bore #5
Bore #6
Production Bore
Stockpile Ground Water
ANZECC (2000) Guideline Value

APPENDIX F:
MODEL DOMAIN AND LAYER BOUNDARY CONDITIONS



🟩	River BC	🟦	GHB BC
🟦	Constant Head BC	■	No Flow BC
☐	Model Cells		

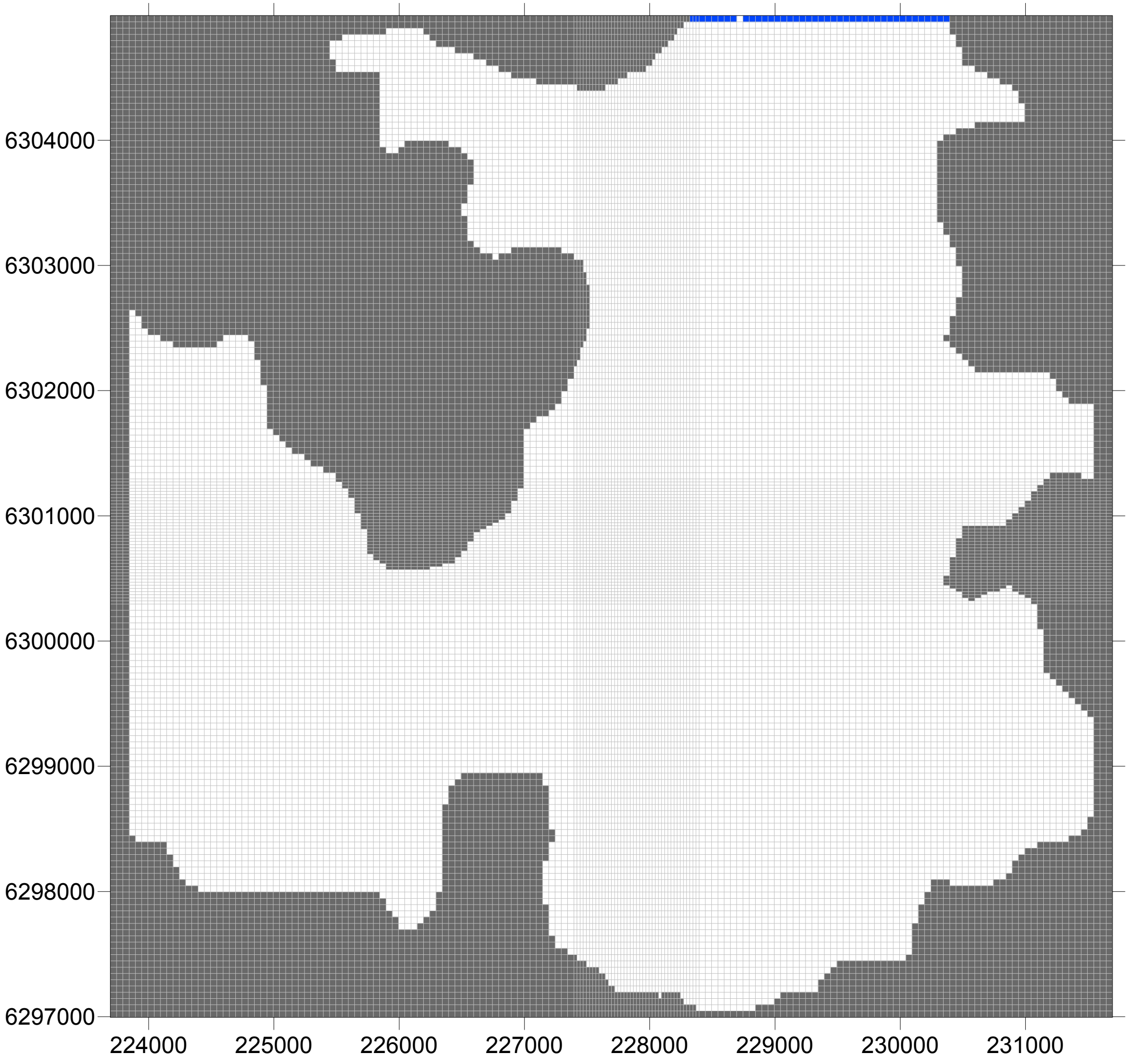
Date	**25 May 2012**	Scale	**As shown**
Initials	**DG**	Project	**S168B**
Drawing Number	**S168B-BC1**	Revision	**A**

RPS Aquaterra

Lidsdale

Model Domain and Boundary Conditions in Layer 1

Appendix F



🟦 GHB BC

⬛ No Flow BC

☐ Model Cells

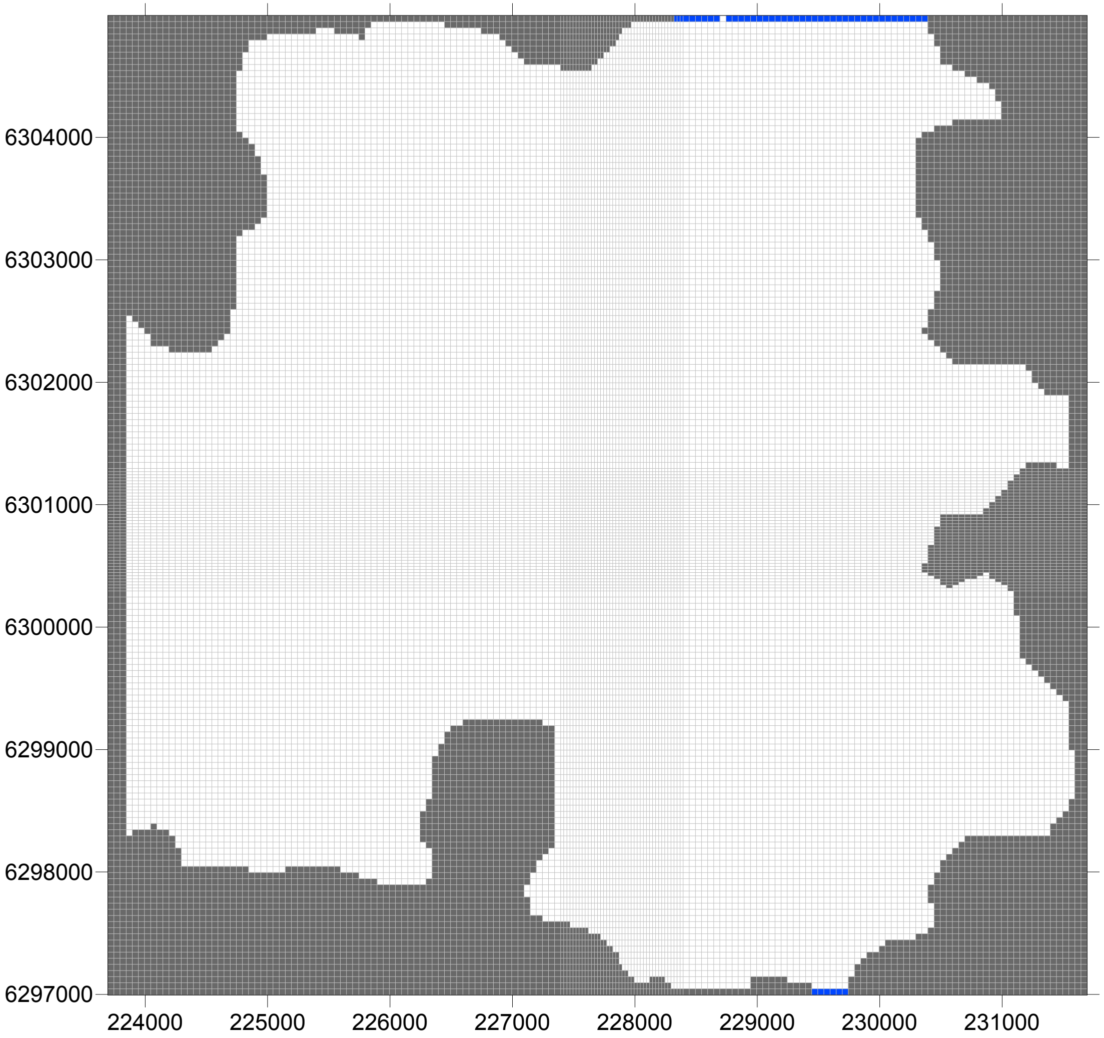
Date	**25 May 2012**	Scale	**As shown**
Initials	**DG**	Project	**S168B**
Drawing Number	**S168B-BC2**	Revision	**A**

RPS Aquaterra

Lidsdale

Model Domain and Boundary Conditions in Layer 2

Appendix F



🟦 GHB BC

■ No Flow BC

☐ Model Cells

Date	**25 May 2012**	Scale	**As shown**
Initials	**DG**	Project	**S168B**
Drawing Number	**S168B-BC3**	Revision	**A**

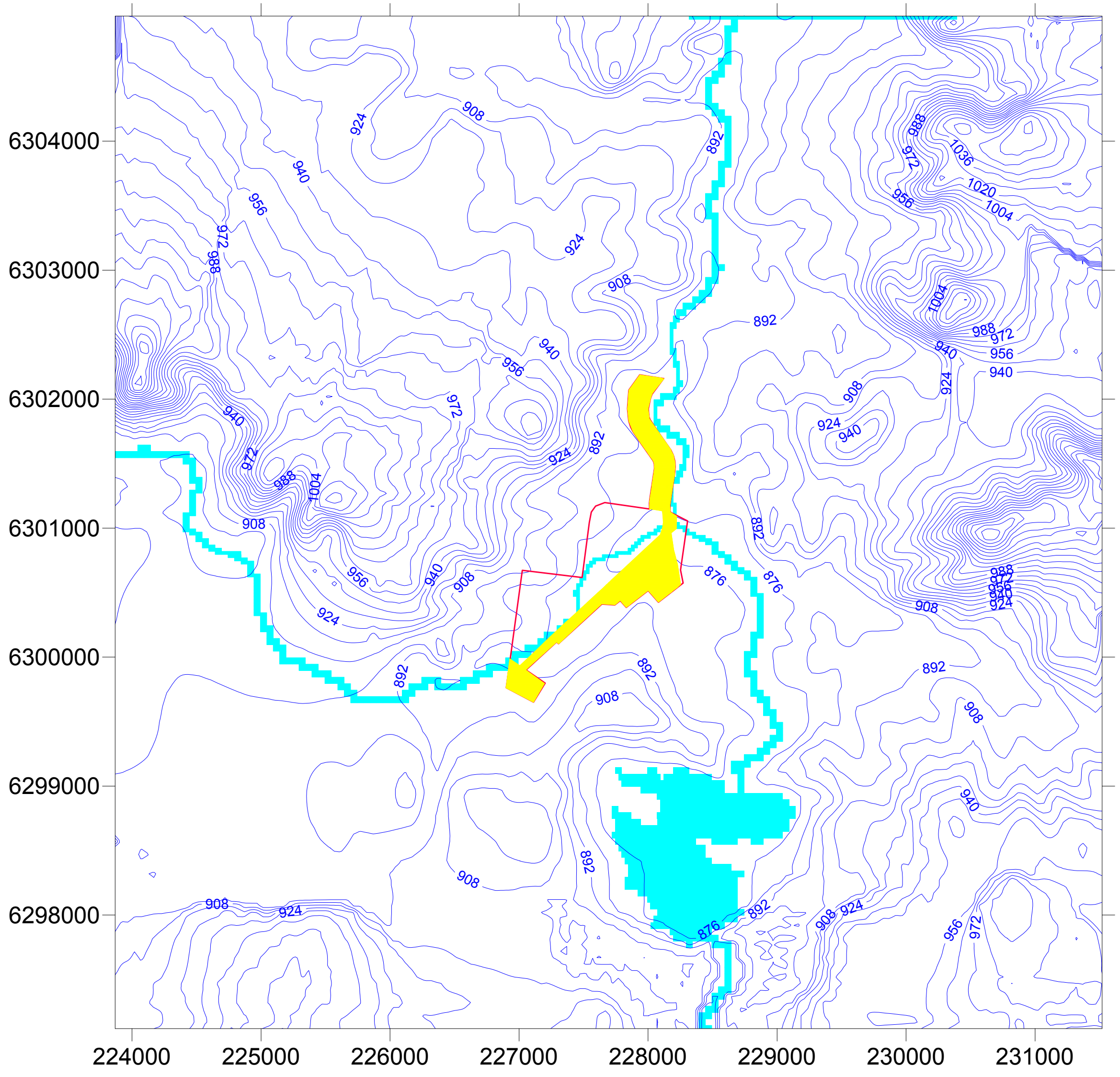
RPS Aquaterra

Lidsdale

Model Domain and Boundary Conditions in Layer 3

Appendix F

APPENDIX G:
MODEL LAYER ELEVATIONS



50	Topography (mAHD)
🟦	Cox River
🟥	Working mine site

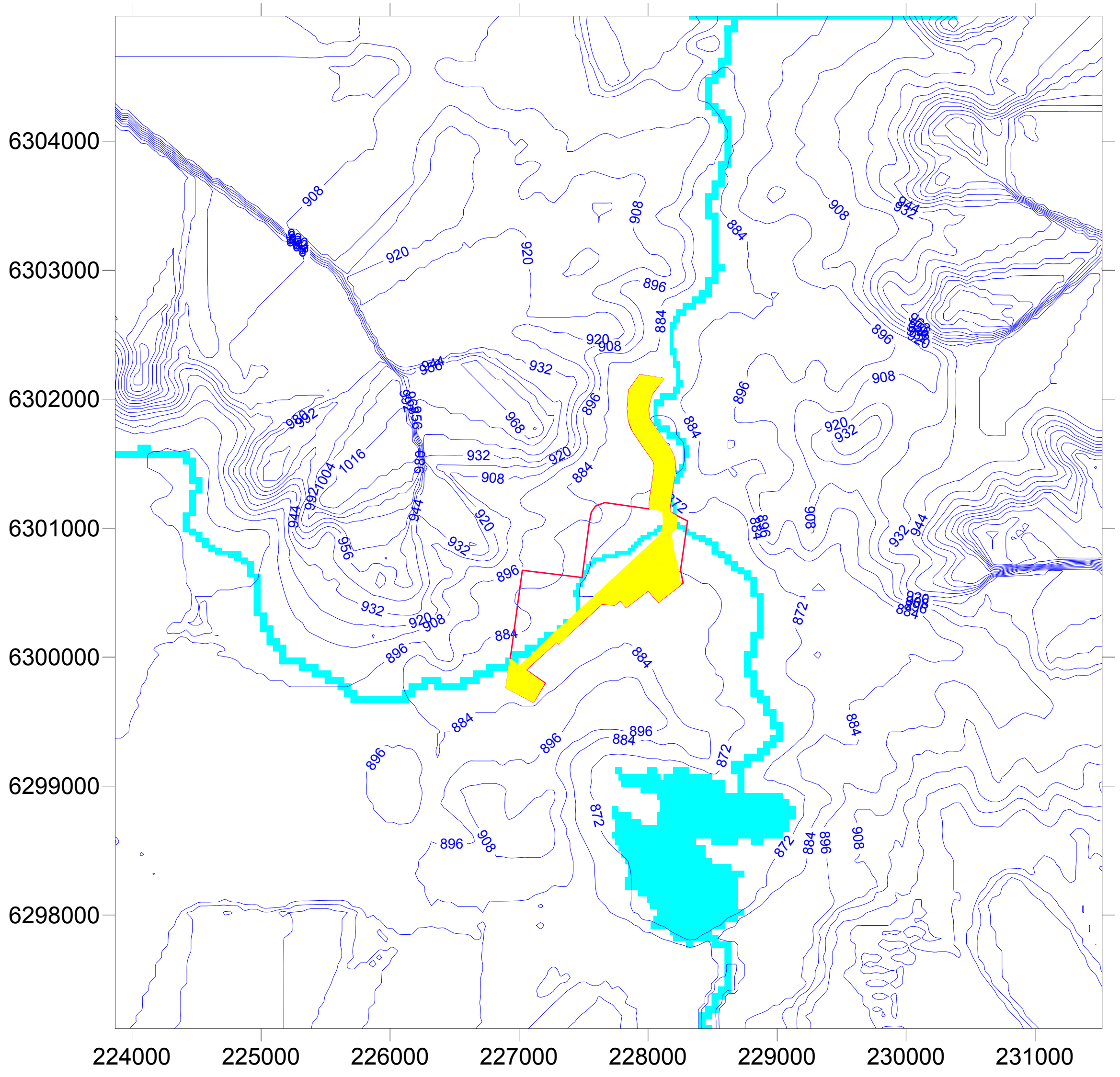
Date	**12 March 2012**	Scale	**As Shown**
Initials	**HZ**	Project	**S168B**
Drawing Number	**S168B-1**	Revision	**A**

RPS Aquaterra

Lidsdale

Model layer elevations for top of layer 1 (mAHD)

Appendix G



∧∕50	Topogrpahy (mAHD)
🟦	Cox River
☐	Working mine site

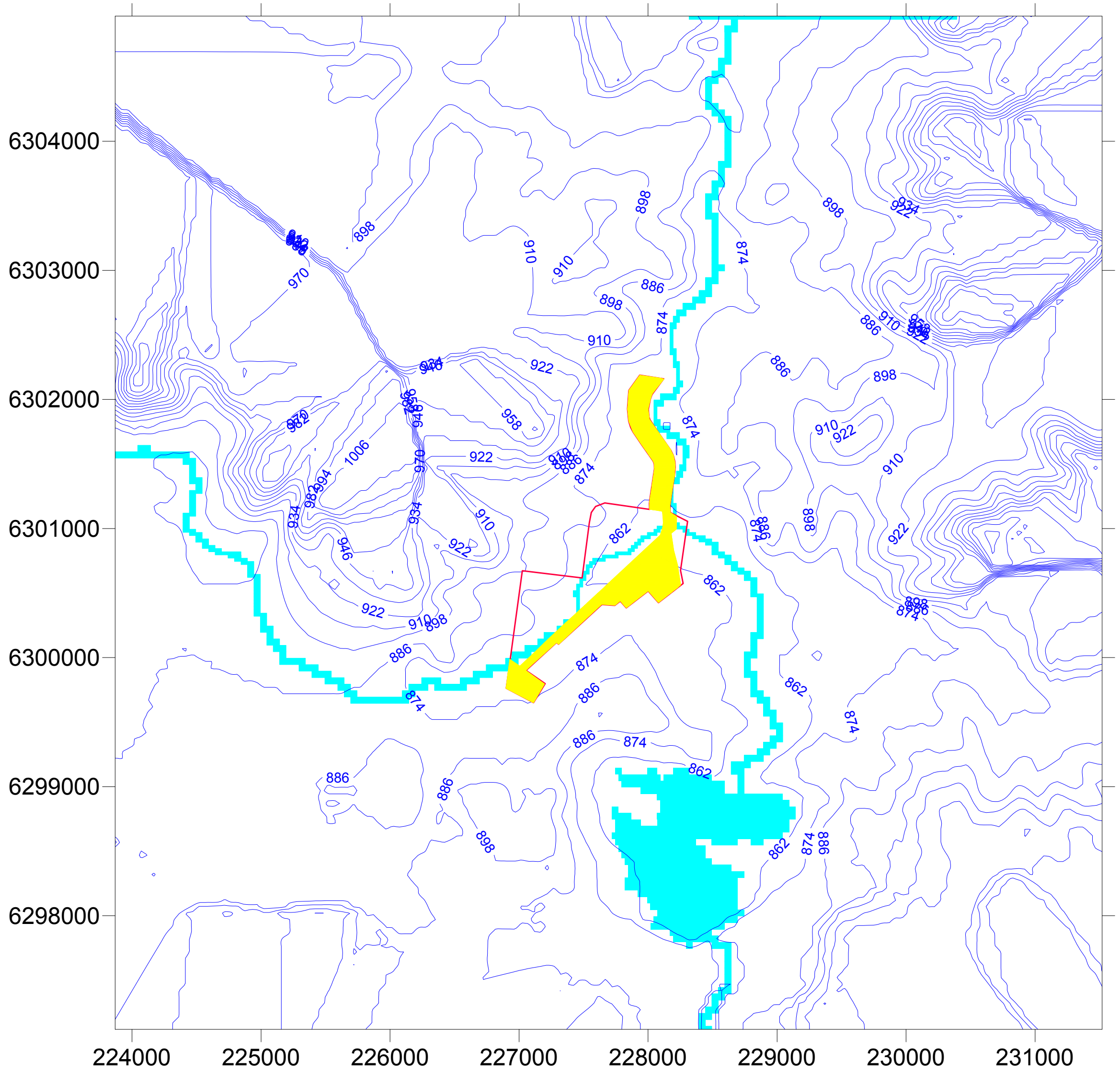
Date **12 March 2012**	Scale **As Shown**
Initials **HZ**	Project **S168B**
Drawing Number **S168B-2**	Revision **A**

RPS Aquaterra

Lidsdale

Model layer elevations for bottom of layer 1 (mAHD)

Appendix G



50 Topography (mAHD)

■ Cox River

□ Working mine site

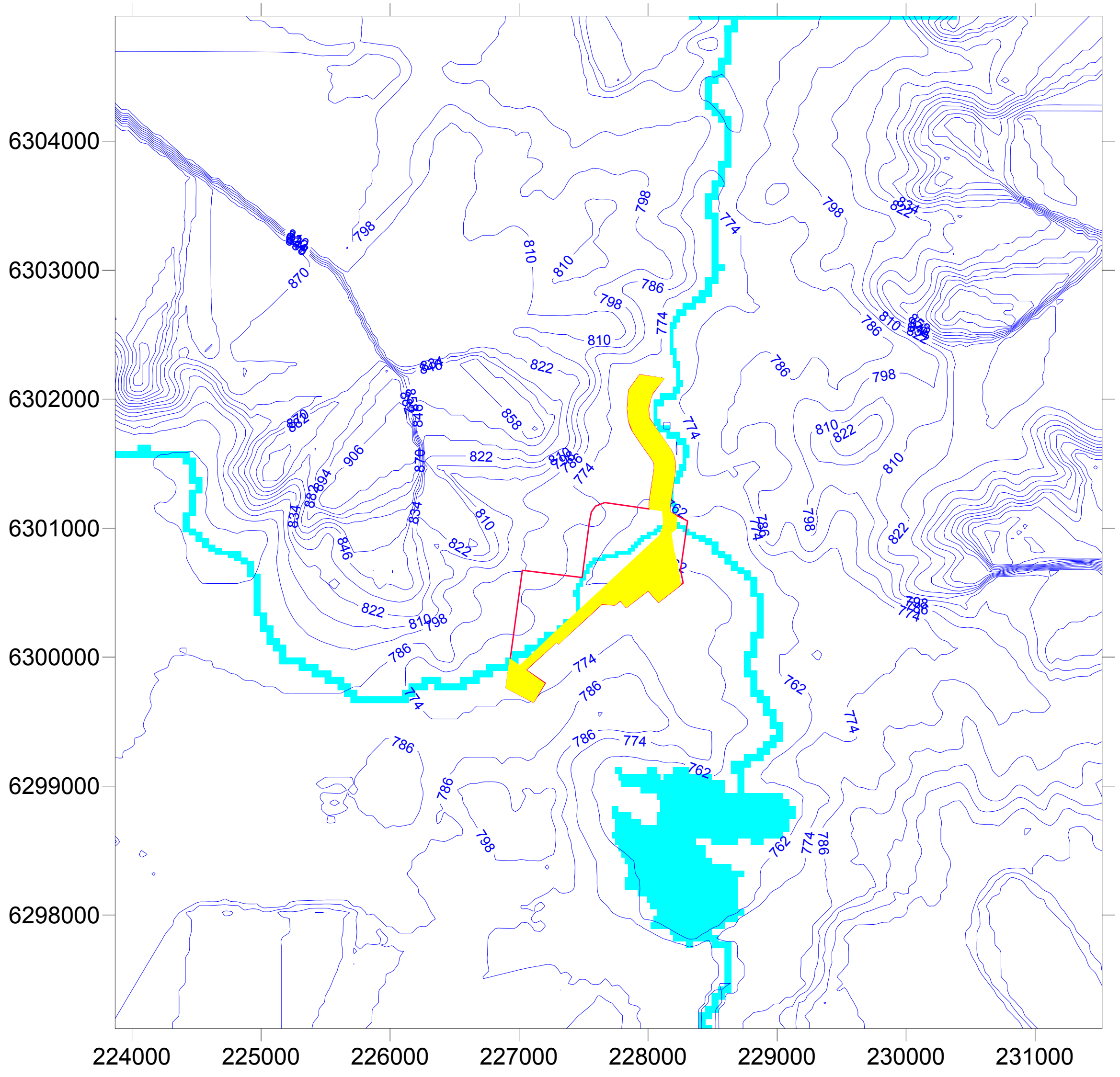
Date	12 March 2012	Scale	As Shown
Initials	HZ	Project	S168B
Drawing Number	S168B-3	Revision	A

RPS Aquaterra

Lidsdale

Model layer elevations for bottom of layer 2 (mAHD)

Appendix G



/\/50	Topography (mAHD)
🟦	Cox River
□	Working mine site

Date	**12 March 2012**	Scale	**As Shown**
Initials	**HZ**	Project	**S168B**
Drawing Number	**S168B-4**	Revision	**A**

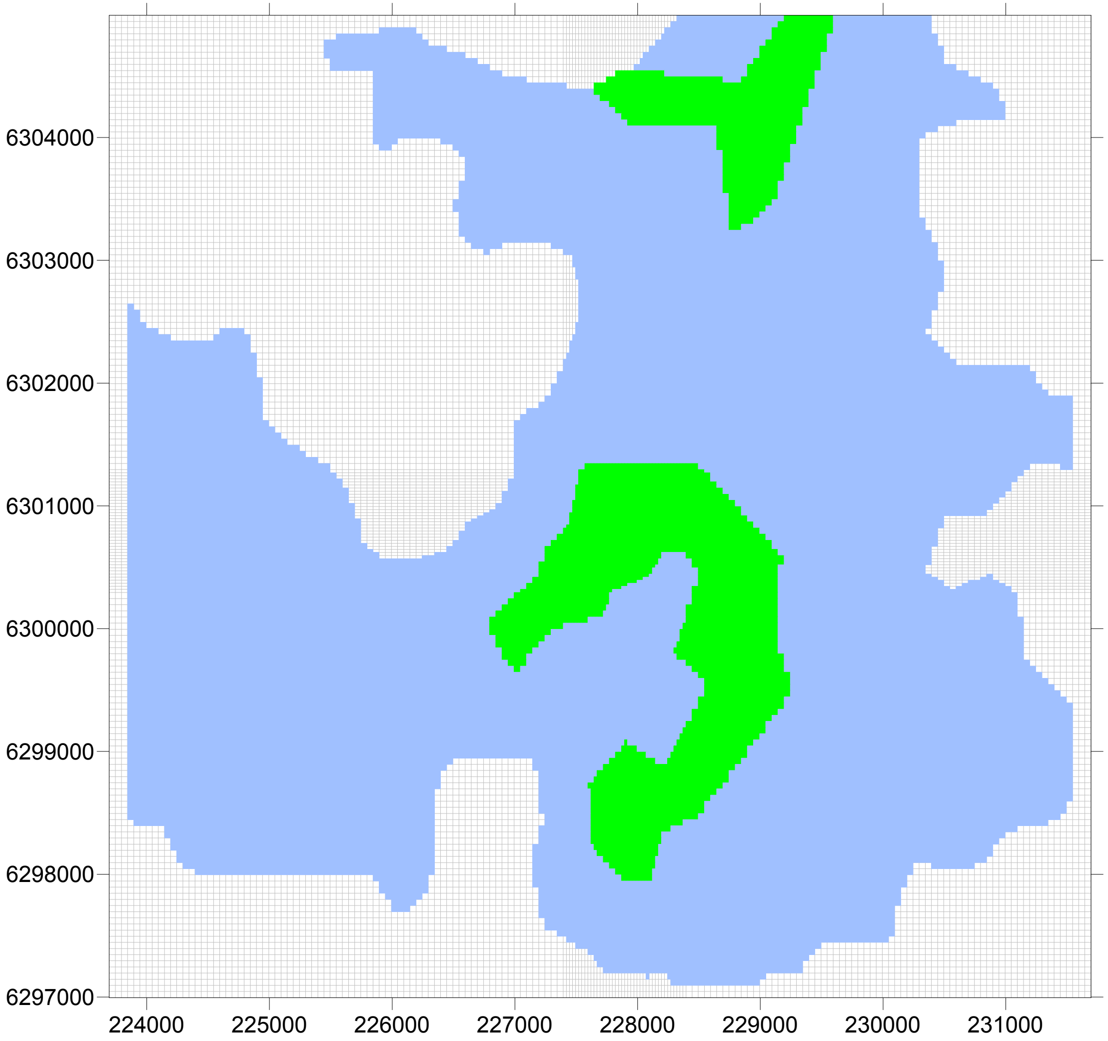
RPS Aquaterra

Lidsdale

Model layer elevations for bottom of layer 3 (mAHD)

Appendix G

APPENDIX H:
CALIBRATED MODEL PARAMETERS



🟩 Kxy = 1.3E-3, Kz = 7.0E-4

🟦 Kxy = 5.0E1, Kz = 5.0E-2

☐ No Flow BC

Date **25 May 2012**

Scale **As shown**

Initials **DG**

Project **S168B**

Drawing Number **S168B-K1**

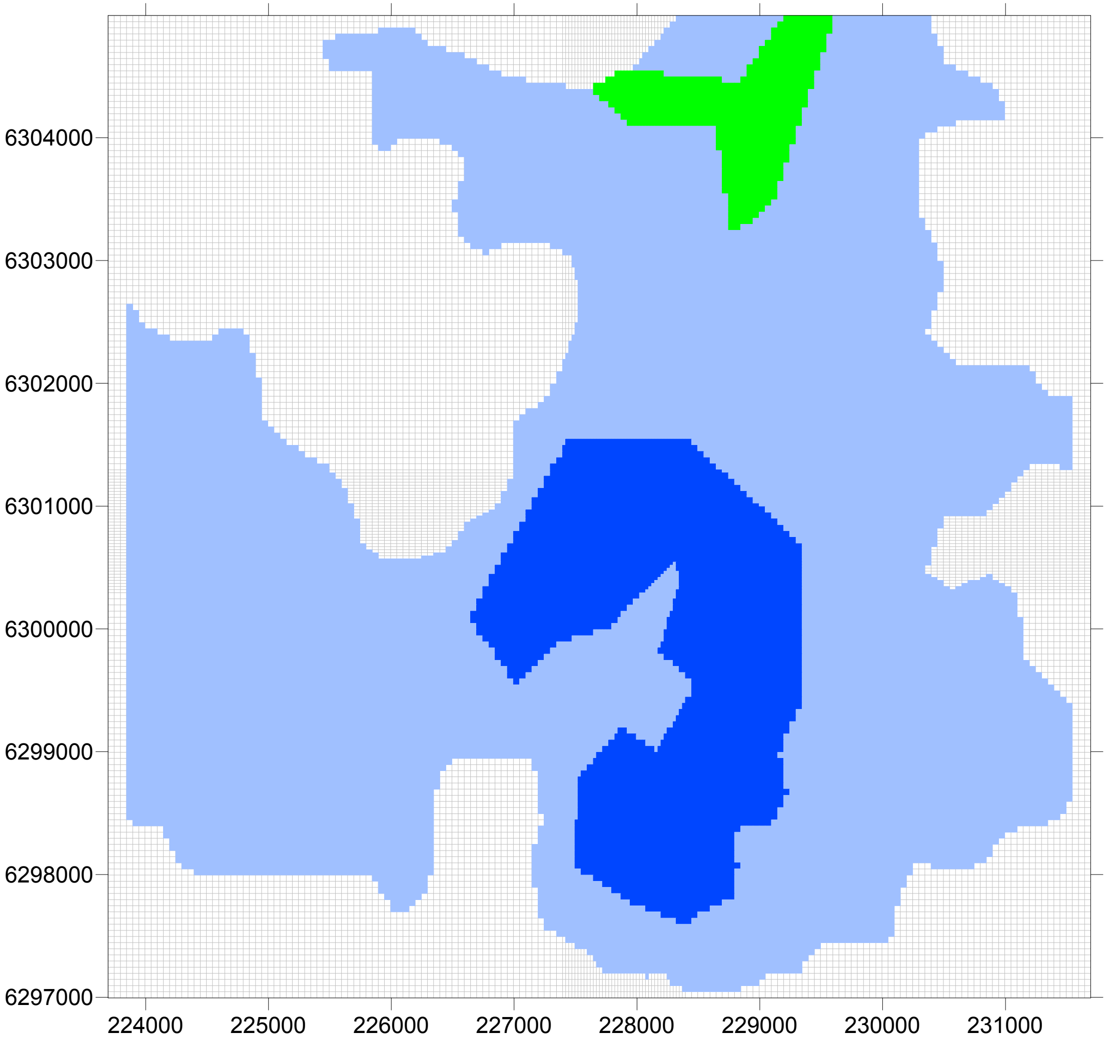
Revision **A**

RPS Aquaterra

Lidsdale

Calibrated Model Parameters in Layer 1

Appendix H



🟩 Kxy = 1.3E-3, Kz = 7.0E-4
🟦 Kxy = 6.8E-3, Kz = 4.0E-3
🟦 Kxy = 5.0E1, Kz = 5.0E-2
⬜ No Flow BC

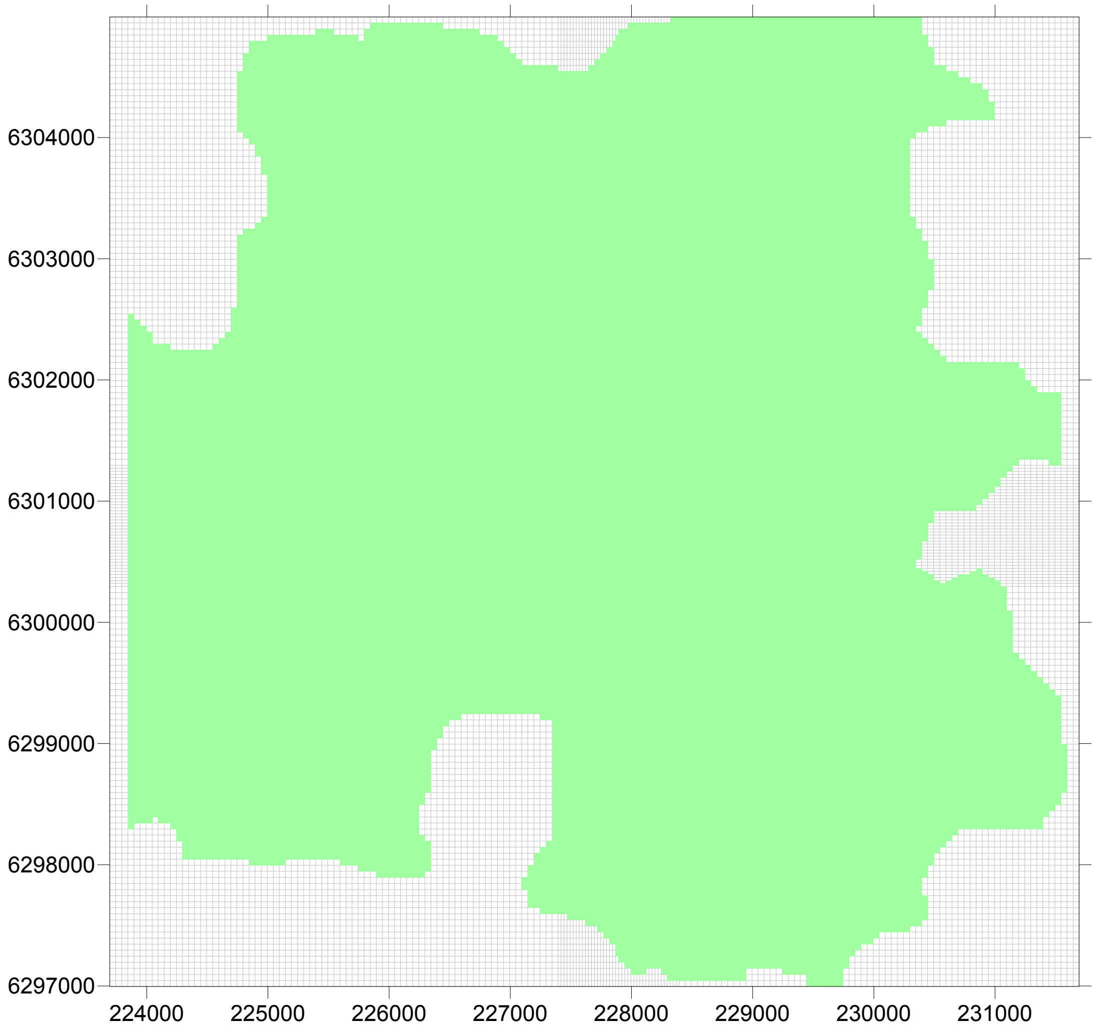
Date	**25 May 2012**	Scale	**As shown**
Initials	**DG**	Project	**S168B**
Drawing Number	**S168B-K2**	Revision	**A**

RPS Aquaterra

Lidsdale

Calibrated Model Parameters in Layer 2

Appendix H



🟩 Kxy = 1.0E-2, Kz = 1.0E-5

☐ No Flow BC

Date	**25 May 2012**	Scale	**As shown**
Initials	**DG**	Project	**S168B**
Drawing Number	**S168B-K3**	Revision	**A**

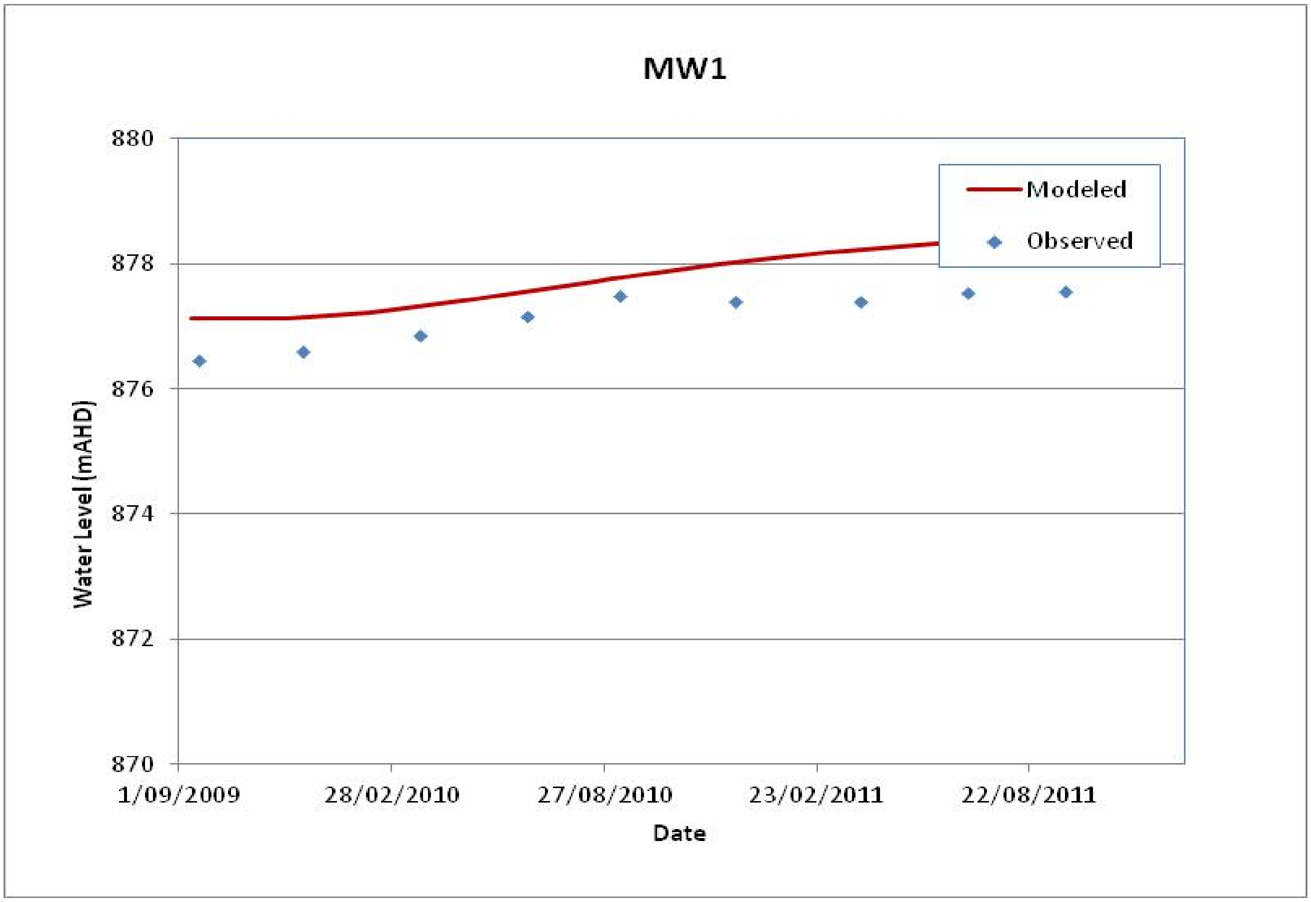
RPS Aquaterra

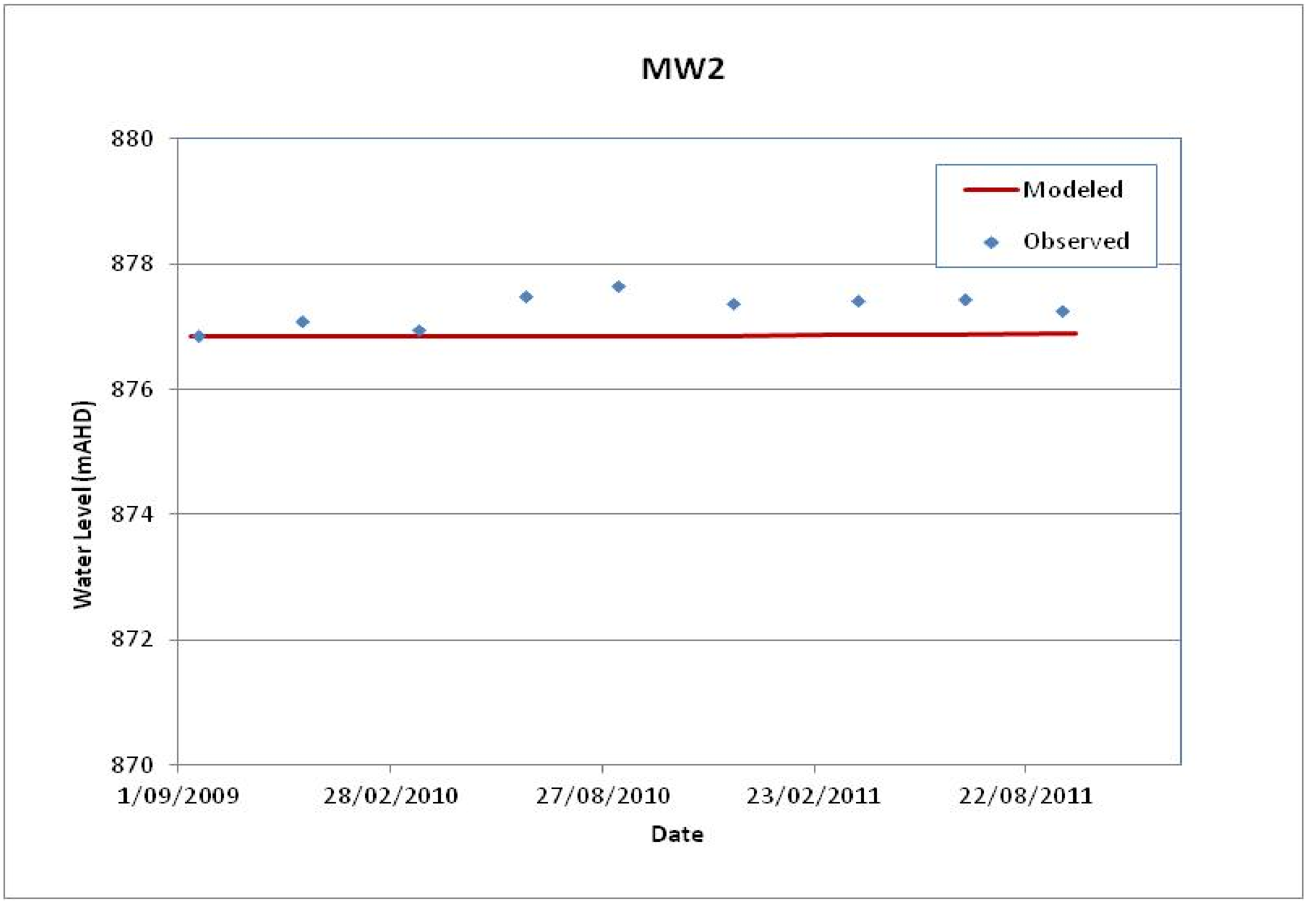
Lidsdale

Calibrated Model Parameters in Layer 3

Appendix H

APPENDIX I:
TRANSIENT CALIBRATION HYDROGRAPHS (SIMULATED VS OBSERVED WATER LEVELS)

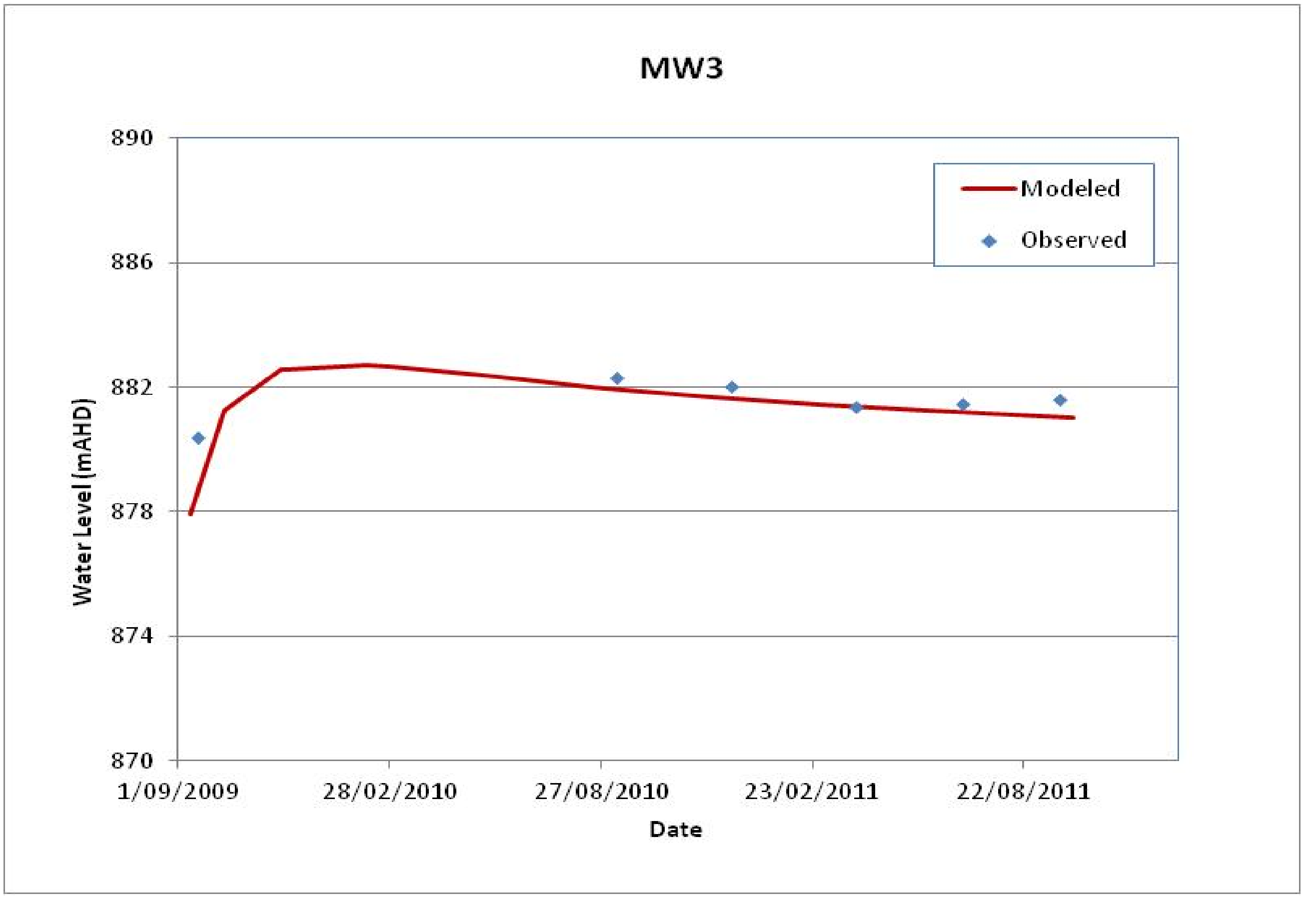


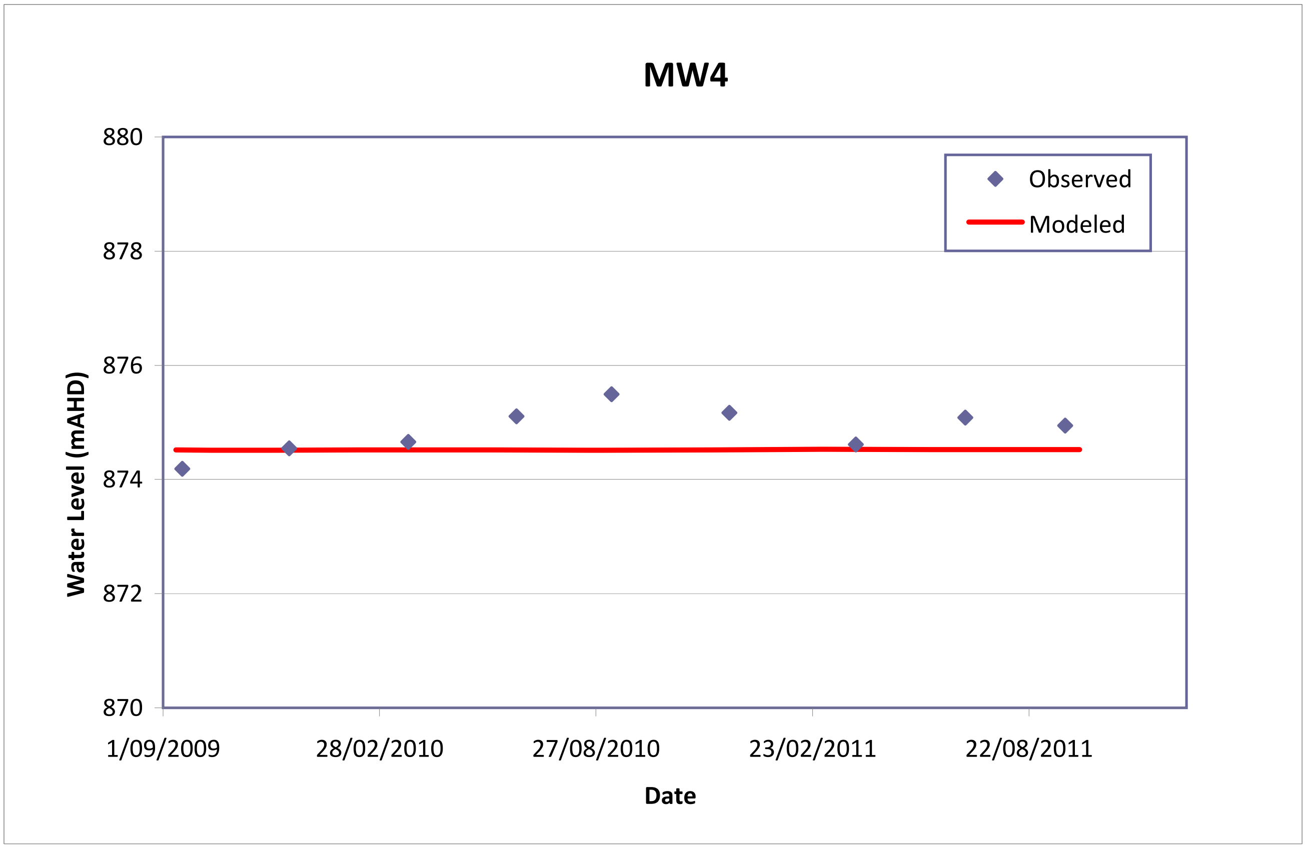


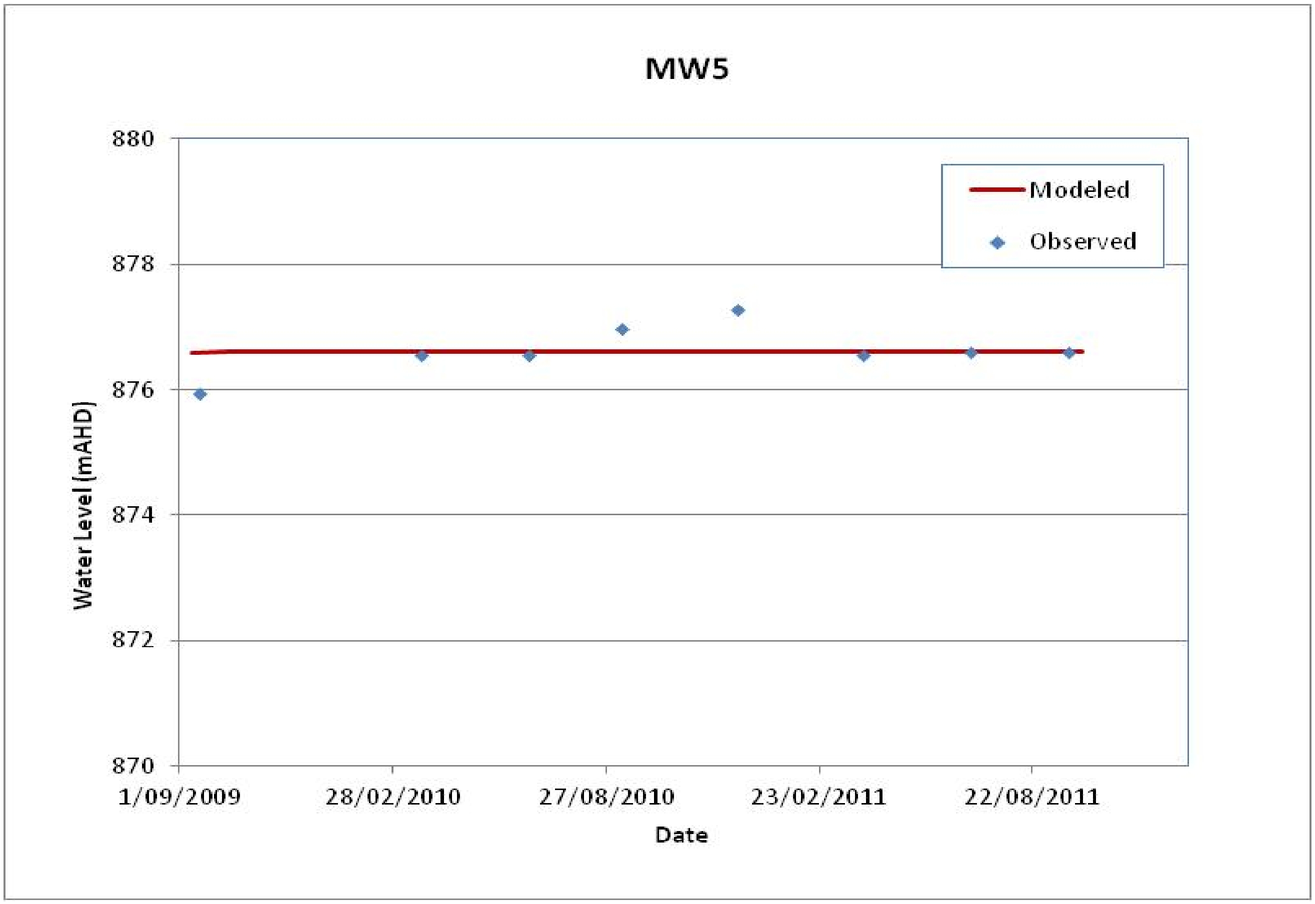
RPS Aquaterra

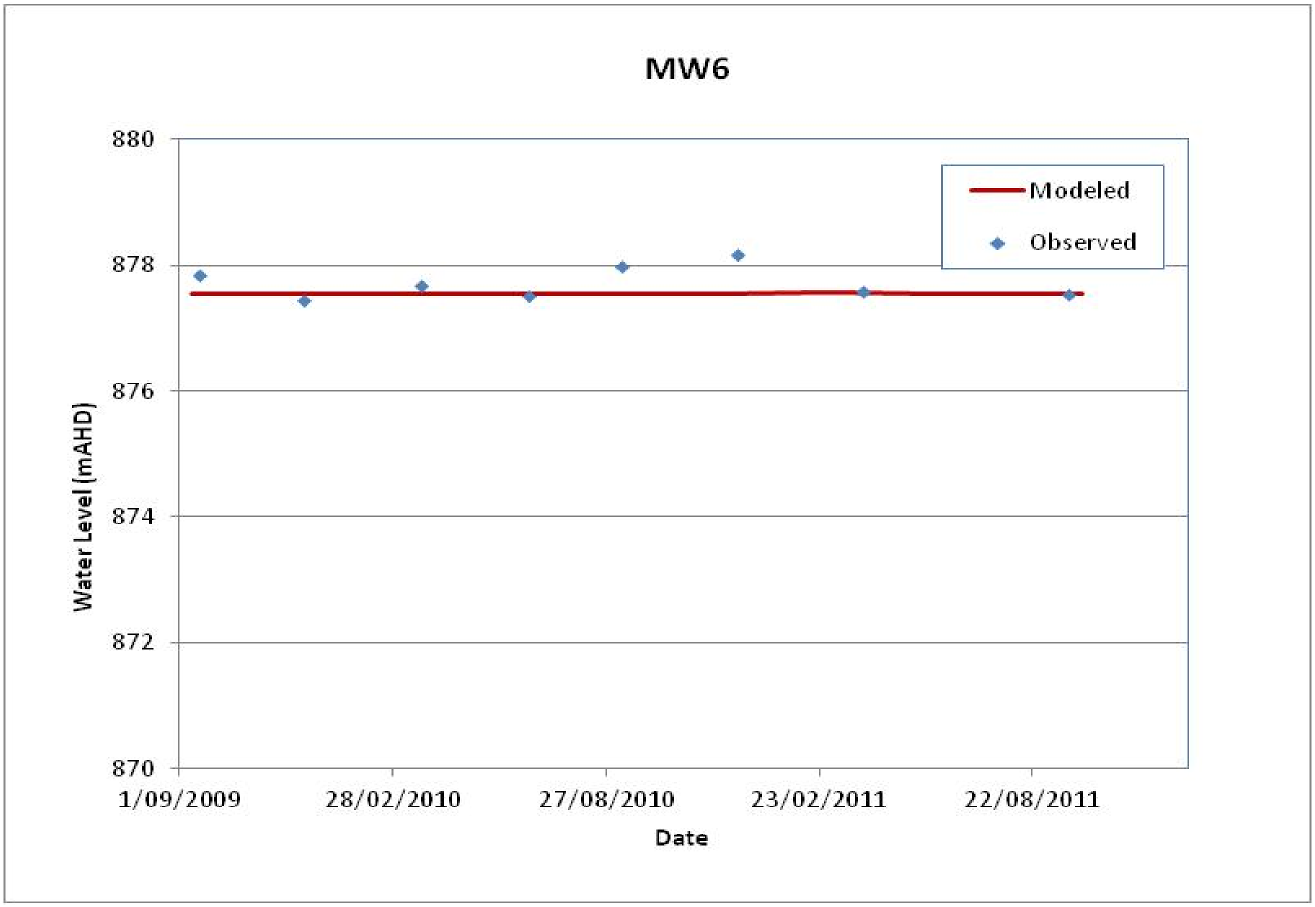
APPENDIX I_1

F:\Jobs\S168B\600\Appendices\[Appendix I.xlsx]Graph1


MW3
Water Level (mAHD)
890
886
882
878
874
870
1/09/2009
28/02/2010
27/08/2010
23/02/2011
22/08/2011
Date
Modeled
Observed


MW4
Water Level (mAHD)
880
878
876
874
872
870
1/09/2009
28/02/2010
27/08/2010
23/02/2011
22/08/2011
Date
Observed
Modeled


MW5
880
878
876
874
872
870
Water Level (mAHD)
1/09/2009
28/02/2010
27/08/2010
23/02/2011
22/08/2011
Date
Modeled
Observed


MW6
880
878
876
874
872
870
Water Level (mAHD)
1/09/2009
28/02/2010
27/08/2010
23/02/2011
22/08/2011
Date
Modeled
Observed