Rio Tinto

IODMS

RTIO-PDE-0071209

Yandicoogina Hydrogeological Field Program Report

Bore Installation and Test pumping 2008/09

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Distribution: RTIO Internal

Issue Date:

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EXECUTIVE SUMMARY

A hydrogeological investigation into new mining deposits Oxbow and Junction South West (JSW), as well as accelerated mining of Junction South East (JSE) was carried out as part of the Order of Magnitude (OoM) Study for the proposed expansion of the RTIO Yandicoogina operations from 52Mta to 60Mta. The principal objective of the study was to gain a better understanding of the hydrogeological setting of the Yandicoogina region, to facilitate government approvals and provide information to support a Public Environmental Review (PER). The OoM hydrogeological investigation focused on obtaining aquifer parameters at the new mining deposits principally Oxbow and JSW, surface water groundwater interaction, and estimates of dewatering volumes for the proposed expansion sites.

Conceptually to date the Channel Iron Deposit (CID) orebody is believed to represent a relatively narrow throughflow aquifer incised into low permeability bedrock (Weeli Wolli Formation). Recharge occurs from intense rainfall events and more recently from Marillana Creek surface water flow which recharges the CID aquifer where the creek crosses over the palaeochannel. The hydraulic gradient for groundwater throughout the region is from west to east.

The result of drilling outside the CID in the flood plain of Marillana Creek revealed that the material surrounding the CID aquifer in the flood plain is unconsolidated alluvium or in situ weathered Weeli Wolli Formation bedrock. Regardless of the weathering history and origin of the deposits, the material is characterised by higher hydraulic properties than previously anticipated. The minimum thickness for the flood plain material estimated from drilling at JSE is 37 m that occurs adjacent to the deposit. The thickness of the flood plain material at JSW and Oxbow is variable (20 - >50 m) depending on elevation and proximity to Marillana Creek. The drilling also suggests that the flood plain/weathered bedrock material outside the CID boundary (denoted in this report as alluvium/insitu weathered bedrock aquifer) is characterised by relatively high storage and hydraulically connected to the CID aquifer.

The findings of the drilling program were corroborated during a test pumping program were nine production bores were pumped from two days to 15 days. The results of constant rate test pumping shows that the bores installed in the alluvium aquifer responded to the dewatering in the CID aquifer. This suggests good hydraulic connection between the alluvium and CID aquifers.

Well efficiencies and hydraulic parameters such as hydraulic conductivity (K) and specific yield (Sy) for the CID aquifer were calculated from different monitoring bores. The average K and Sy for the CID are 25 m/d and 1×10^{-2} respectively.

The extent of the CID and flood plain alluvial boundary with the Weeli Wolli Formation was evident on most of the drawdown versus time tests. Using the Theis distance drawdown method, predictions were made to the lateral extent of drawdown for each pumping bore. Conceptual transects for each production bore and the associated monitoring bores were illustrated to show the extent of drawdown during test pumping. The figures show the impact of drawdown in the CID on the water table in the adjacent alluvium aquifer as well as the relationship with Marillana Creek surface water.

Groundwater chemistry data was collected during drilling for environmental monitoring and at the end of test pumping for government requirements and analysis. EC, DO, pH, redox and temperature were all logged at 10 min intervals throughout the pumping tests to supplement the understanding of recharge from Marillana Creek surface water flow. The concentration of DO in groundwater and surface water in particular proved to be a very useful tool in determining boundary conditions during test pumping. The results of dissolved oxygen monitoring during test pumping has helped to define the boundary between CID and Alluvium.

The results of the interference drawdown analysis suggests that designing borefields with clusters of bores are more efficient than locating multiple bores on a straight line perpendicular to the axes of the CID aquifer. The relatively high transmissivity of the alluvium may provide opportunity to partially dewater the pits from the alluvium (i.e. ex-pit). However, more work and drilling is required to confirm the depth of the alluvium and the hydraulic properties of the deeper sections of the alluvium aquifer. The test pumping of the shallow (37 m) bore in the alluvium at JSE area has shown that this option might be possible particularly on the boundary between CID and the alluvium.

The high yield from the constant rate pumping tests that ranged from 60L/s up to 100 L/s suggests that the dewatering of the pits are possible with fewer bores than previously anticipated. The high end of the pumping was only limited to ~ 100 L/s because of the capacity of the pumps, and the diameter and length of the discharge pipe. Discharge with higher rates up to 150 L/s is possible from several production bores if the discharge outlet were designed to handle higher volumes.

This programme has improved the conceptual understanding of the hydrogeological characteristics of the CID, flood plain alluvium/insitu weathered bedrock aquifers and relationship with Marillana Creek surface water. From this study a large scale regional CID groundwater model, including all deposits (BHPB and RTIO) will be constructed to predict dewatering requirements, manage current dewatering borefields and help in the understanding for mine closure.

1. INTRODUCTION

Hydrogeological investigations have been ongoing at RTIO Yandicoogina mine site since late 1970. The focus of early investigations was at Junction Central (JC) deposit, which commenced mining in 1998, followed by Junction South East (JSE) deposit, which commenced mining in 2005. In 2008 RTIO undertook an Order of Magnitude study (OoM) to obtain a better understanding of the hydrogeological setting of the Yandicoogina mine site and to gain government approvals to extend production beyond 52Mta.

The proposed expansion included accelerated mining of JSE deposit in a northerly direction and mining new deposits comprising Junction South West (JSW), and Oxbow. The aim of the OoM study was to obtain aquifer parameters at the proposed new pits, define surface water groundwater interaction, and estimates of dewatering volumes for the proposed expansion sites. The work was carried out internally by the Resource Development, Technical Projects, Hydrogeological team.

Based on the current mine schedule, mining of the Channel Iron Deposits of the JSW and Oxbow deposits is due to commence in 2013, and 2014 respectively.

A hydrogeological drilling and testing program comprised of drilling and testing of seven production bores and 22 monitoring bores in JSW, one production bore and seven monitoring bores in Oxbow and one production bore, one alluvial testing bore and five monitoring bores in JSE. The borefields were designed after a review of previous works including test pumping programs conducted at JC and JSE deposits. The results of the drilling, test pumping and hydrochemical sampling undertaken during the investigation will be used to update the Yandi groundwater and water balance models to predict impacts and optimise requirements for water management against the developing mine schedule.

The drilling program was undertaken from September 2008 through to April 2009 by Nudrill Pty Ltd and supervised by Hydrogeologists from RTIO. The exploration program was drilled by Nudrill's Rotamac Rig 3, with the production bores drilled with the Drilltech Rig 1 and 2. Test pumping was undertaken in June through to September 2009 by Test Pumping Australia Pty Ltd.

2. LOCATION AND ACCESS

The Yandicoogina mine site is located approximately 85 km northwest of Newman and 145 km east of Tom Price in the Central Pilbara. The 54 km Yandicoogina access road is 135 km northwest of Newman on the Great Northern Highway. Yandicoogina deposit, within the mining lease 274SA is divided into two active mining areas JC and JSE. The primary focus of the study is up gradient, adjacent to the west of the main mining areas in JSW and Oxbow, with a component of the investigations in JSE.

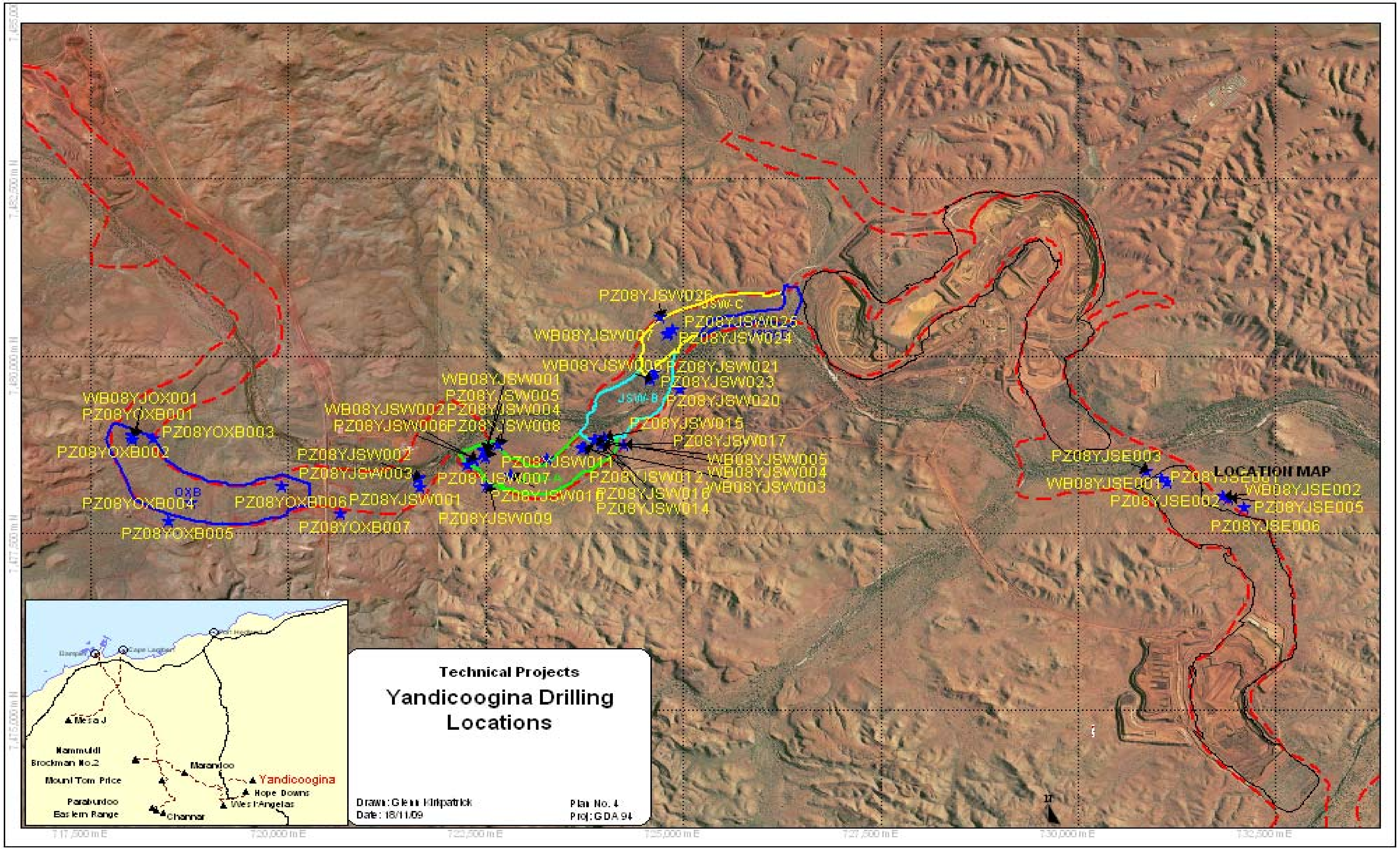

Figure 1 Location of Yandicoogina Pits with study drilling locations

3. TOPOGRAPHY AND DRAINAGE

The Yandicoogina CID deposit is located within the Marillana Creek regional catchment and occurs within a broad structural basin of the Yandicoogina Syncline, formed by synclinal folding of the Lower Proterozoic Brockman Iron Formation, which is conformably overlain by the Weeli Wolli Formation. The total length of the CID is over 80 km, but within the RTIO lease it is 26 km long, approximately 500 m wide and average thickness of 60 m. The Marillana Creek catchment originates 20 km to the east of the Great Northern Highway, and runs predominately east-west draining into the Weeli Wolli Creek system downstream of RTIO's Yandicoogina mine operations. Two tributaries, Phil's Creek and Yandicoogina Creek drain into Marillana Creek in the vicinity of RTIO mine site.

The CID is located in the central part of a broad, east-trending drainage basin with the Hamersley Range to the north and an unnamed range to the south (PPK, 1998). The CID where it outcrops resulting from recent dissection from modern day drainages, forms a series of characteristic 'mesas' which are generally orientated with the present day drainage, with surface gradients of 1.5 m/km along the axis of the basin (PPK, 1998).

The creeks in the region are dry for most of the year and are prone to flooding during the wet season, where stream flow is ephemeral. In recent times the two mining operations of BHP BILLITON and RTIO in the area the Marillana and Weeli Wolli Creek systems have been impacted by surplus water discharges, resulting in permanent surface water flow in parts of the drainage lines.

4. GEOLOGY

The Yandicoogina area consists of Proterozoic basement rocks of the Weeli Wolli Formation, overlain by relatively thin Tertiary and Quaternary sediments. The basement rocks comprise Banded Iron Formation (BIF), chert, shale and volcanic rocks. The thin alluvium and colluvium cover consists of valley fill and drainage deposits, which include the Channel Iron Deposits (CID) and are restricted to areas close to present drainages.

The Proterozoic basement rocks have been faulted and folded into a gently synclinal structure called the Yandicoogina Syncline which controls the geomorphology and ultimately the location of the CID and present drainage system. Fractured, siliceous rocks underlie and enclose the CID and are hydraulically connected to the CID aquifer.

The Tertiary Pisolite, commonly known as the Channel Iron Deposit or Robe Pisolite, is an iron rich sedimentary deposit which infilled the ancient river channels. The CID is a continuous, mineralised, pisolitic iron ore that occurs adjacent to the present day Marillana, Yandicoogina and Weeli Wolli Creek systems. The thickest sections of the CID occur close to the centre of the palaeochannel in long, straight sections but on meanders, the thickest section occurs close to the outer bend of the meander (PPK, 1998).

The CID consists of pisolitic clasts of goethite-hematite, clay and fossil wood fragments with an approximately average thickness of 60 m. The CID clasts (peloids) are typically irregular or subangular to subrounded in shape. These iron rich peloids are interpreted to represent the end product of detrital weathering via sheet wash processes deposited in low lying areas (Ramanaidou, et al, 2003).

A detailed 1:10,000 investigation into the geology of the Yandicoogina area was undertaken by Youngman, 1997, where the lithologies have been divided into four main groups:

- Basement rocks of Archaean and Proterozoic age consisting of Banded Iron Formation (BIF), shale, dolerite and dolomite (Wittenoom Formation found further upstream of the study area). Several dolerite dykes cut through these BIF sequences throughout the area.
- Altered basement rocks of the Proterozoic consisting of lateritic profiles and basement rocks of various weathered states. This Basal Clay Conglomerate (BCC) consists of clasts of BIF, chert and shale in a yellow-white clay matrix.
- Early Tertiary Channel Iron Deposits comprise chemically enriched weathered BIF and fluvial deposits. The CID consists of iron oxide spheroids that have formed insitu by chemical precipitation of hydrated iron oxides around hematite nuclei. The outer coating of the nuclei is composed of goethite and the matrix is a mixture of goethite, limonite and ferruginised wood fragments. The CID is divided into two parts; a clayey basal zone and an upper economic pisolite zone. The basal zone or Limonitic Goethite Channel (LGC) overlies the Basal Conglomerate and consists of limonite, clay and goethite often with the CID texture altered. The Pisolitic zone consists of two parts the bottom high grade ore (GVL), and the lower grade ore (GVU).
- Tertiary and Quaternary overburden material is a mixture of lateritic pisolite, poorly sorted angular to sub angular BIF, chert and dolomite gravels in a sandy matrix. Overlying the main ore deposit is a Weathered Channel Horizon (WCH) consisting of pisolitic material with low iron content and contains various amounts of clay.

5. HYDROGEOLOGY

There are three main aquifers recognised in this study in the Yandicoogina region. They comprise the fractured basement aquifer, the overlying fractured CID aquifer and the surfical unconfined alluvial aquifer. These aquifer systems are recharged by direct infiltration of rainfall and through creek beds. The CID is recharged primarily by the leakage through the alluvium in areas where the creeks overly the CID. Exceptionally high water levels in the creek from rainfall and discharge of surplus mine water flood areas beyond the alluvium resulting in direct infiltration to the CID. Groundwater can discharge from the aquifers to the Marillana Creek after a flood event. Recharge may also occur by groundwater inflow from the basement rocks where upward hydraulic gradients occur.

The CID aquifer is relative narrow meandering palaeochannel imbedded in the basement Weeli Wolli Formation. The heterogeneous aquifer exhibits a variable but overall increasing permeability with depth, related to secondary porosity developed in discrete zones formed by fractures, solution channels and cavity features (MWH, 2006). The development of solution features has largely superseded the primary porosity of the interstitial pore space. Permeability is generally lowest within the main ore zone, particularly the upper zone and highest in sections of the limonite-goethite clay zone where large voids are often encountered. However the LGC is highly variable and may exhibit very low permeability in clay zones.

The alluvial/insitu weathered bedrock flood plain deposits that overlie the CID and basement aquifers and the river gravel in the beds of Marillana and Weeli Wolli Creek systems consist of mixtures of poorly sorted gravels, sand, silt and clay. These alluvial deposits are predominantly saturated due to the surface water discharge from mining operations located up gradient of the Yandicoogina mine site. The alluvium deposit underlying the creek beds is primarily recharged by creek flow, usually following/during a rainfall event. Discharge of surplus water from mining operations to Marillana Creek has resulted in greater recharge and increased storage within the creek alluvium. Transmissivity is variable within the alluvial aquifer. Groundwater moves freely within the coarser less clayey sediments but flow may slow within the underlying clayey sections of the alluvium. The coarse river gravels of the upper alluvium of the creek bed are generally highly permeable and if thick over a larger area has the ability to transmit large volumes of groundwater (Peck, 1998).

The basement aquifer is a fractured rock aquifer which consists of inter-bedded banded iron formation, banded chert, shale and dolerite. It underlies and surrounds the CID and alluvial aquifers. The aquifer permeability is variable and largely dependent on the development of structural features. Monitoring bores screened in basement lithologies demonstrate hydraulic connection with the CID following dewatering abstraction. Groundwater in the basement rocks occurs in secondary porosity of the weathered zone and within fractures in the bedrock, with lower hydraulic conductivities than the CID and flood plain alluvium. However, local and regional fracture systems within the basement rocks are capable of providing significant water yields.

The hydraulic connection between the alluvium and the CID is likely to be variable depending on the presence of clay or coarse sediment at the base of the alluvium and the presence of solution paths locally in the CID. The natural depth to groundwater varies from 3 to 20 m below surface with the groundwater flow direction to the east and southeast in the west and to the northeast in the east.

6. LICENSING AND APPROVALS

An Approvals Request (AR-08-03254) was submitted for the overall drilling program covering JSW, JSE and Oxbow. AR-08-03254 covered drilling locations within areas inside and outside Marillana Creek. Due to extra restrictions and the time constraints of drilling within the creek, the AR was split into two, AR-08-03254A (outside the creek) & AR-08-03254B (inside the creek).

AR-08-03254A was the permit issued for the drilling program and drill pads of 50 m x 50 m were constructed for each site. AR-08-03254B, due to company priorities, funding and logistics was not issued and the creek bores were not drilled. The request was issued on 1 August, 2008 for the construction of drill pads and sumps and expired in August 2009. A licence to construct or alter wells CAW166698 (1) was obtained as part of this process.

7. RESULTS

7.1 Drilling and Bore Completion

7.1.1 Overview

Bore locations were designed based on the information collected from previous groundwater investigations, and Resource Evaluation geological models. Location of some of the drill sites was constrained by approvals due to heritage, bed and banks permits and access.

Production bores where designed to be drilled on the up gradient edge of each proposed pit to obtain aquifer hydraulic parameters and to be then incorporated into future dewatering borefield designs. Each production bore targeted the centre of the CID to maximise the full extent of the aquifer. Observation bores were designed to optimise the results obtained from test pumping such as determining the extent of the cone of depression and connection between CID and the alluvium and basement aquifers.

The drilling program, contracted to Nudrill Pty Ltd commenced in early September 2008 with the company using their Rotamac 1302, (Rig 3) initially to do all the exploration work. A second drill rig (Drilltech Rig 1) was introduced in late September to capitalise on available resources. The program was about 75% completed by the 18th of December when drilling ceased for the Christmas and wet season break. The program recommenced in March 2009, with Nudrill using Drilltech (Rig2) to conclude the program in April.

During the program, drilling was conducted over three locations; Junction South West, Junction South East and Oxbow where a total of nine production bores, one testing bore and 34 monitoring bores were successfully installed. Drilling was undertaken by conventional air/percussion methods with some unconsolidated alluvial material being drilled by mud/rotary techniques. The project was supervised by RTIO hydrogeologists. Summary details of all monitoring and production bores completed during this programme are listed in Table 1 through to Table 6.

7.1.2 Monitoring bores

The exploration drill program consisted of drilling 22 monitoring bores in Junction South West, seven in Oxbow and five in Junction South East (Figures 2-4). Monitoring bores where designed down gradient of the production bore, and placed approximately 10, 100, 500 m away in the CID. Additional 50 m deep bores were completed in the alluvial flood plain and river gravel adjacent to the CID channel. The monitoring bores were required for observing future dewatering impacts and groundwater responses to abstraction.

All CID bores were drilled by rotary air blast hammer drilling techniques. These holes were drilled into the BCC or Weeli Wolli Formation depending on the thickness of the BCC, to allow for sufficient drawdown below the base of the LGC. Alluvial bores drilled into the flood plain adjacent to the CID and Marillana Creek river gravels had nominal depths of 50 m to monitor hydraulic connections between the alluvial and the CID aquifer.

The bores were drilled conventionally to 5.7 m using a 317 mm bit. Steel surface casing (219 mm OD) was cemented allowing 700 mm above ground level. A 203 mm hole was drilled through the surface casing to the basement Weeli Wolli Formation or greater than 10 m below the LGC depending on thickness of the BCC lithology. The monitoring bores were then cased with slotted 50 mm PVC to the water table and blank casing then to surface. The annulus was gravel packed to approximately 6 m above the slotted PVC casing with 3.2 to 6.4 mm graded gravel. All monitoring bores were sealed with cement or A & B foam to prevent foreign objects, and create a water tight seal.

Four 50 m alluvial/insitu weathered bedrock holes were drilled using 152 mm mud/rotary techniques of which two (PZ09YJSW011 and PZ09YJSW020) where drilled in JSW (Figure 2) and two (PZ08YJSE005 and PZ08YJSE006) in JSE (Figure 3). Bores were drilled to 4 m using 317 mm tri cone then 203 mm (OD) steel surface casing was placed and cemented in the hole. The holes were then drilled and cased with slotted 50 mm Cl12 PVC to the water table and blank casing to surface.

Two monitoring bores, PZ08YJSW002 and PZ08YJSW003, where constructed in Marillana Creek river gravels at the western end of the JSW-A pit (Figure 2). The rationale behind was to establish head differences, chemistry and response to discharge from permanent surface water flow. Mud/rotary drilling techniques were used to drill up to 14 m in the unconsolidated coarse river gravels. PZ08YJSW002 was drilled to 28 m and cased with 203 mm (OD) diameter steel surface casing then 203 mm air/hammer through to 72 m. PZ08YJSW003 was drilled 311 mm mud /rotary to 8 m into the river gravels cased with slotted 50 mm Cl12 PVC to surface.

A prefix of ‘PZ’ was used to describe monitoring bores, followed by the year drilled; a four letter description of the site, and the last three digits reflected the order in which they were designed. A summary of monitoring bores is presented in Table 1, 3 and 6. Bore completion diagrams can be found in Appendix 1.

7.1.3 Production bores

Seven production bores were constructed in clusters at JSW. Bores where drilled up gradient of the proposed pit location taken from the 2008 long term mine plan design (Figure 2). Two bores were drilled on the western edge of pit JSW-A where mining is due to commence in 2015. A cluster of three bores was drilled on the up gradient edge of pit JSW-B where no mining is planned in the near future due to the ore body crossing Marillana Creek. Two bores were drilled up gradient of JSW-C which is due to commence mining in 2012.

One production bore was drilled on the northern edge of the Oxbow pit near the BHP Billiton mining lease boundary, where mining is due to commence in 2018. In JSE one production bore was drilled on the north western edge near the Marillana Creek and a test bore was drilled in the flood plain alluvials to the east on JSE pit (Figure 3). All production bores were located in the middle on the palaeochannel and were open the full extent of the CID aquifer and will be used for future dewatering.

Production bores where drilled 445 mm air/hammer down to 6 m, reamed out with a 609 mm air/roller and positioned 508 (OD) steel surface casing. The hole was then drilled 444 mm (OD) air/hammer into the BCC or Weeli Wolli Formation. The shallow, 37 m (WB08YJSE002) bore was drilled in the flood plain alluvials for testing aquifer characteristics. It was drilled 371 mm air/roller to 1.5 m and cased with 254 mm (OD) steel surface casing and cemented in place. The hole was drilled to the Weeli Wolli Formation with a 311 mm mud/rotary bit. The annulus was gravel packed, from the total drilled depth to the surface, using 3.2 to 6.4 mm graded gravel.

Bores drilled in the CID were constructed with 324 mm (OD) steel casing with the mineralised high permeability zones screened with stainless steel wire wound screens. Blank casing was set from surface to the water table followed by slotted casing to the 6 m sump at the bottom. Twelve meters of stainless steel screens were set over the lower most permeable zones. Bores were developed from 4 hours to 16 hours till continuous clean, silt and sand free water was obtained.

Bore WB08YJSE002 was drilled via mud/rotary methods due to the unconsolidated fine silt clay material. The bore was cased to 37 m with 200 mm (OD) PVC slotted casing with one 6 m blank length at the surface. All bore head works were capped with a lockable steel cap and a concrete plinth placed around each bore. A summary of all the production bores can be found in

Table 2, 4 and 6. Bore completion diagrams are presented in Appendix 1. The location of the bore is shown by Figure 2-3.

7.2 WELL DEVELOPMENT and GROUNDWATER SAMPLING

Well development was achieved by airlifting using the rig mounted compressor coupled to the truck mounted auxiliary compressors. Once constructed, the production bores were developed anywhere from four hours up to 15 hours, until a clean water sample was observed. At the end of airlifting, a water sample was taken and field tested for pH, Electrical Conductivity (EC) and temperature. Flow rates were measured using a 90° V-Notch weir. Holes drilled via mud/rotary techniques were developed using auxiliary compressor with poly pipe inserted in the 50 mm casing. Field water chemistry was taken at the end of each rod to monitor pH, EC and Temperature in different lithological units. A final measurement of the field parameters was taken and recorded at the end of airlifting (Tables 1-6).

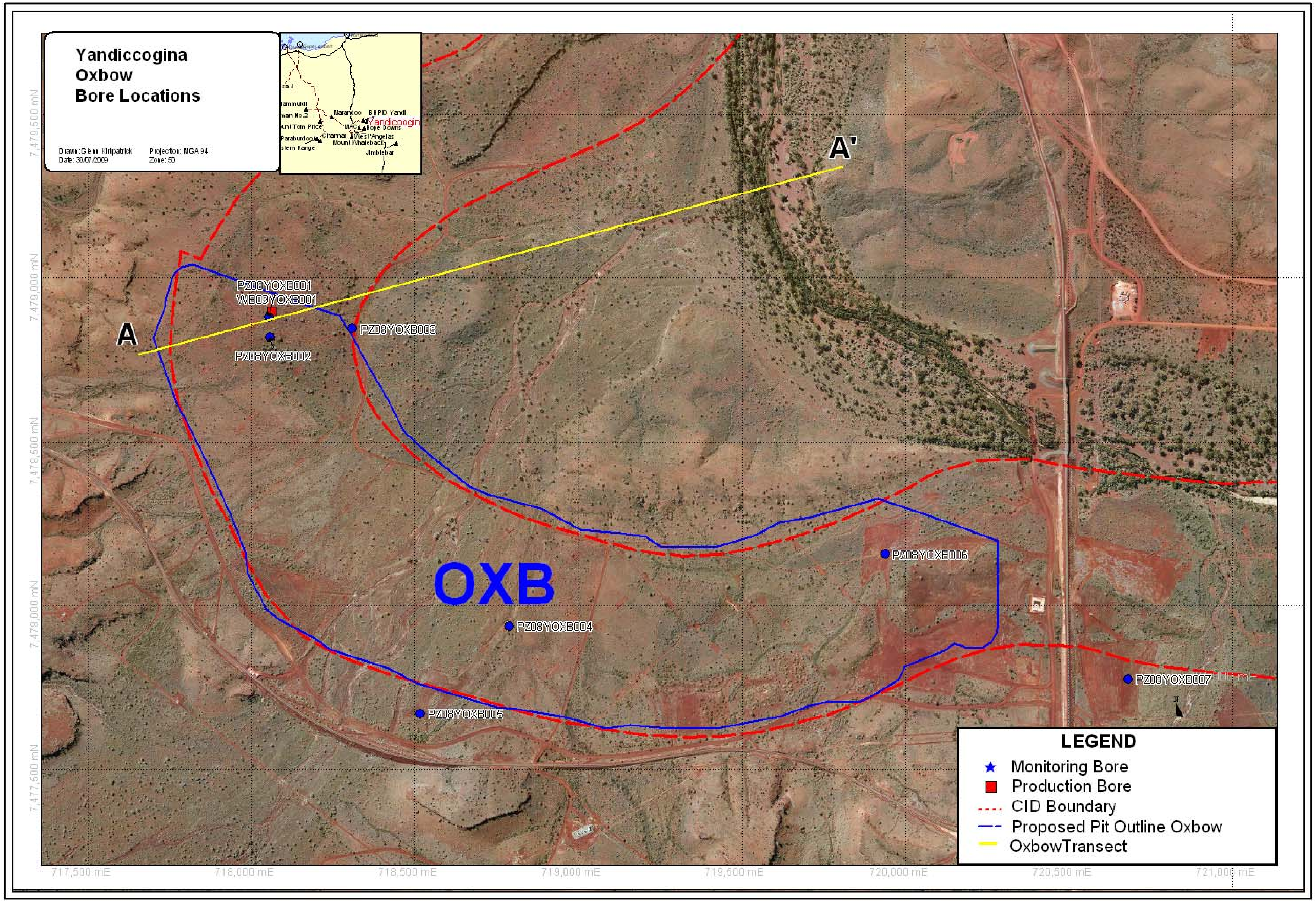

Figure 2 Location of bores drilled at Oxbow with superimposed transect line

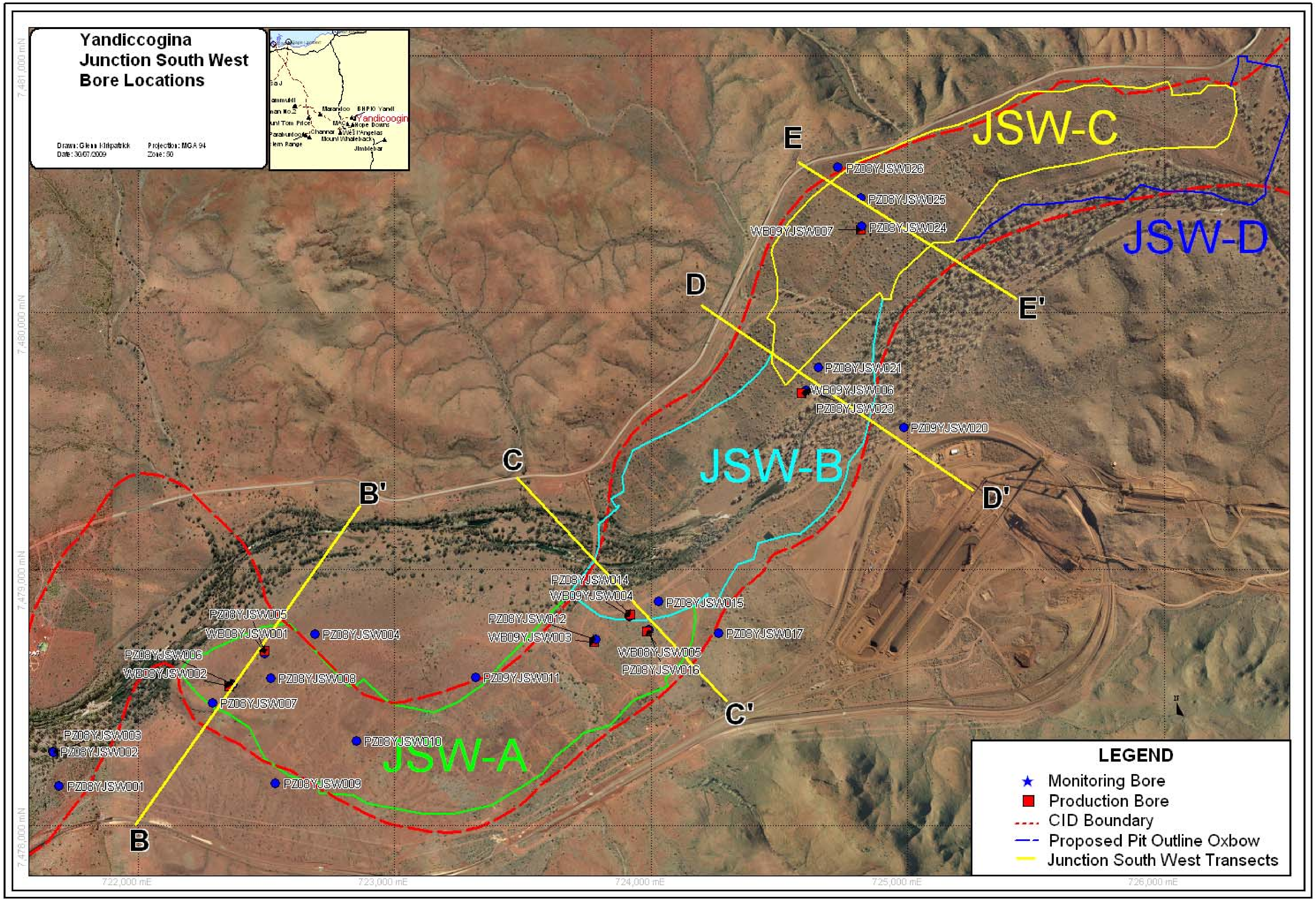

Figure 3 Location of bores drilled at Junction South West with superimposed transect line

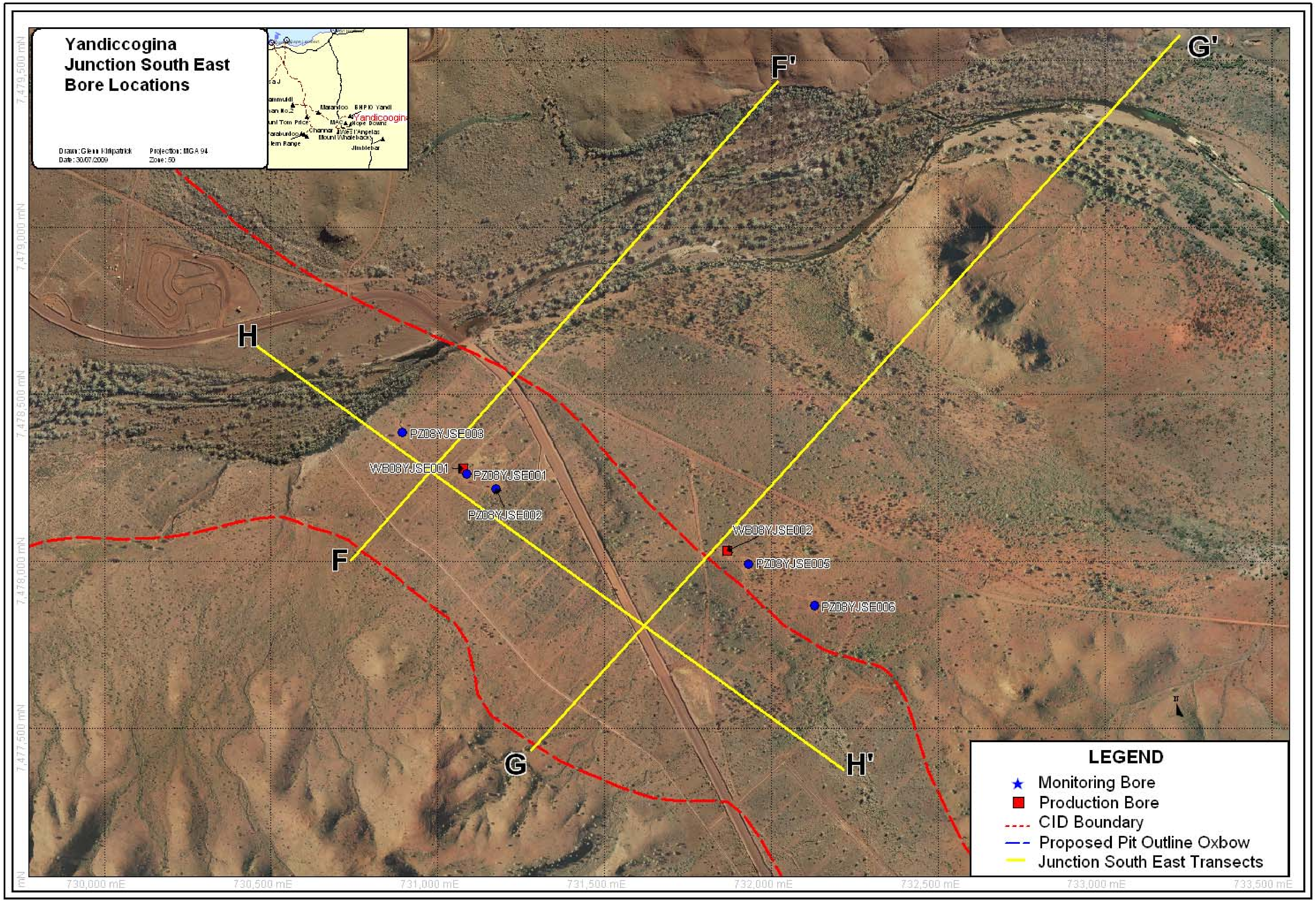

Figure 4 Location of bores drilled at Junction South East with superimposed transect line

Table 1 Junction South West Monitoring Bore Completion Data

Bore number	Mine grid		MGA94		Top of Casing (RL)	Drill depth (m)	PVC Casing type (Cl12) (mm)	Slotted interval (m bgl)	Airlift Yield (L/sec)	pH	EC (µS/cm)	Screened Formation	Water level (RL)
	Easting	Northing	Easting	Northing									
PZ08YJSW001	55554.08	8000.97	721690.89	7478156.29	531.82	77	50	11 - 77	2	8.24	875	CID	522.11
PZ08YJSW002	55531	8134.60	721667.81	7478289.94	525.97	72	50	24 - 72	N/A	N/A	N/A	CID	522.01
PZ08YJSW003	55533.12	8132.06	721669.93	7478287.40	526.02	8	50	0 - 8	N/A	N/A	N/A	Alluvium	523.94
PZ08YJSW004	56550.98	8590.94	722687.95	7478746.36	528.29	50	50	30 - 50	<0.1	N/A	N/A	Alluvium	519.64
PZ08YJSW005	56357.92	8515.59	722494.86	7478671	530.46	92	50	16 - 88	21.5	7.71	967	CID	519.80
PZ08YJSW006	56231.17	8394.98	722368.1	7478550.36	538.77	95	50	19 - 91	29.3	7.31	858	CID	519.15
PZ08YJSW007	56153.06	8324.59	722289.98	7478479.96	540.19	90	50	23 - 89	1	8.09	966	CID	519.66
PZ08YJSW008	56380.51	8420.86	722517.46	7478576.25	530.09	92	50	9 - 87	30	7.87	921	CID	519.34
PZ08YJSW009	56396.59	8011.22	722533.54	7478166.54	532.86	50	50	22 - 46	0.5	7.76	1223	Alluvium	520.56
PZ08YJSW010	56715.94	8174.55	722852.95	7478329.91	532.14	104	50	18.5 – 102.5	29.3	7.89	916	CID	519.03
PZ08YJSW012	57647.25	8569.74	723784.41	7478725.17	531.49	94	50	0 - 73	31	7.73	925	CID	517.33
PZ08YJSW014	57781.27	8668.19	723918.46	7478823.64	528.51	100	32	35 - 95	36.5	7.94	924	CID	517.05
PZ08YJSW015	57892.04	8718.47	724029.24	7478873.93	532.20	98	50	26 - 98	42.7	7.59	896	CID	517.01
PZ08YJSW016	57852.841	8610.43	723990.04	7478765.87	533.34	96	50	17.5 – 89.5	38.5	8.02	955	CID	517.1
PZ08YJSW017	58125.26	8594.25	724262.50	7478749.68	535.38	50	50	20 - 50	2	7.83	987	Alluvium	516.14
PZ08YJSW021	58512.74	9631.27	724650.04	7479786.9	523.98	92	50	14 - 86	18.8	7.20	1050	CID	513

Bore number	Mine grid		MGA94		Top of Casing (RL)	Drill depth (m)	PVC Casing type (Cl12) (mm)	Slotted interval (m bgl)	Airlift Yield (L/sec)	pH	EC (µS/cm)	Screened Formation	Water level (RL)
	Easting	Northing	Easting	Northing									
PZ08YJSW023	58466.37	9542	724603.66	7479697.6	524.06	94	50	20 - 92	32.8	7.77	912	CID	513.2
PZ08YJSW024	58681.29	10182.55	724818.62	7480338.26	524.18	100	50	26 - 98	15	7.85	973	CID	508.05
PZ08YJSW025	58678.31	10290.95	724815.64	7480446.68	525.74	86	50	19 - 85	18.8	7.75	960	CID	508.72
PZ08YJSW026	58591.09	10411.72	724728.41	7480567.46	533.08	50	50	21 - 48	1	8.03	1106	Weeli Wolli	507.5
PZ09YJSW011	57179.97	8423.47	723317.05	7478578.87	526.46	50	50	14 - 50	5	N/A	N/A	Alluvium	519.58
PZ09YJSW020	58847.65	9397.23	724985.01	7479552.81	519.95	50	50	14 - 50	2	7.93	843	Alluvium	513.35
Total metres drilled						**1690**							

Table 2 Junction South West Production Bore Completion Data

Bore number	Mine grid		MGA94		Top of Casing (RL)	Drill depth (m)	Steel Casing (324OD mm)	Slotted interval (m bgl)	Airlift Yield (L/sec)	pH	EC (µS/cm)	Screened Formation	Water level (RL)
	Easting	Northing	Easting	Northing									
WB08YJSW001	56358.09	8526.54	722495.03	7478681.95	530.6	88	324	15 - 75	31	8.02	995	CID	519.93
WB08YJSW002	56217.9	8387.27	722354.82	7478542.66	539.14	90	324	17.5 – 83.5	37	7.86	948	CID	519.65
WB08YJSW005	57848.18	8601.48	723985.38	7478756.92	533.41	80	324	20 - 74	31	7.82	767	CID	516.99
WB09YJSW003	57641	8558.97	723778.16	7478714.4	531.26	94	324	18 - 90	34.6	7.67	762	CID	517.05
WB09YJSW004	57778.02	8661.28	723915.21	7478816.72	528.94	89	324	11 - 83	34	7.75	1007	CID	517.13
WB09YJSW006	58448.7	9529.58	724586	7479685.17	524.16	90	324	18 - 84	35	7.74	670	CID	512.67
WB09YJSW007	58679.21	10166.07	724816.54	7480321.78	524.06	83	324	17 - 77	39	8.44	841	CID	508.34
Total metres drilled						**614**							

Table 3 Oxbow Monitoring Bore Completion Data

Bore number	Mine grid		MGA94		Top of Casing (RL)	Drill depth (m)	PVC Casing type (Cl12) (mm)	Slotted interval (m bgl)	Airlift Yield (L/sec)	pH	EC (µS/cm)	Screened Formation	Water level (RL)
	Easting	Northing	Easting	Northing									
PZ08YOXB001	51916.81	8727.81	718053	7478883.22	551.52	102	50	35 - 101	20	7.95	1005	CID	517.12
PZ08YOXB002	51918.56	8665	718054.75	7478820.4	550.55	102	50	34 - 100	18.8	7.92	940	CID	517.47
PZ08YOXB003	52171.85	8691.19	718308.08	7478846.6	544.45	56	50	31 - 55	N/A	N/A	N/A	Alluvium	518.13
PZ08YOXB004	52651.23	7781.62	718787.55	7477936.88	545.58	104	50	29 - 101	10.9	7.84	671	CID	520.52
PZ08YOXB005	52377.59	7514.63	718513.86	7477669.84	547.85	50	50	20 - 50	0.4	8.49	992	Alluvium	531.49
PZ08YOXB006	53799.93	8002.74	719936.45	7478158.04	534.15	90	50	18 - 90	11.9	7.88	871	CID	521.65
PZ08YOXB007	54544.78	7621.38	720681.42	7477776.62	538.33	56	50	26 - 56	0.76	8.04	1106	CID	522.48
Total metres drilled						**560**							

Table 4 Oxbow Production Bore Completion Data

Bore number	Mine grid		MGA94		Top of Casing (RL)	Drill depth (m)	Steel Casing (324OD mm)	Slotted interval (m bgl)	Airlift Yield (L/sec)	pH	EC (µS/cm)	Screened Formation	Water level (RL)
	Easting	Northing	Easting	Northing									
WB09YOXB001	51924.45	8742.11	718060.63	7478897.52	551.54	105	324	30 - 96	20	7.96	884	CID	516.32
Total metres drilled						**105**							

Table 5 Junction South East Monitoring Bore Completion Data

Bore number	Mine grid		MGA94		Top of Casing (RL)	Drill depth (m)	PVC Casing type (Cl12) (mm)	Slotted interval (m bgl)	Airlift Yield (L/sec)	pH	EC (µS/cm)	Screened Formation	Water level (RL)
	Easting	Northing	Easting	Northing									
PZ08YJSE001	64947.14	8106.06	731085.55	7478261.46	508.99	98	50	20 - 98	11	7.77	1043	CID	484.89
PZ08YJSE002	65034.63	8061.47	731173.06	7478216.86	508.65	92	50	20 - 92	12	7.85	1016	CID	486.62
PZ08YJSE003	64755.82	8230.52	730894.2	7478385.95	507.72	100	50	22 - 100	21.5	7.73	1085	CID	486.04
PZ08YJSE005	65793.4	7837.46	731931.96	7477992.82	499.69	39.1	50	9.1 – 39.1	2	8.5	1096	Alluvium	489.06
PZ08YJSE006	65989.89	7711.05	732128.48	7477866.39	500.18	48	50	24 - 48	2	8.48	1030	Alluvium	489.4
Total metres drilled						**377.1**							

Table 6 Junction South East Production Bore Completion Data

Bore number	Mine grid		MGA94		Top of Casing (RL)	Drill depth (m)	Steel Casing (324OD mm)	Slotted interval (m bgl)	Airlift Yield (L/sec)	pH	EC (µS/cm)	Screened Formation	Water level (RL)
	Easting	Northing	Easting	Northing									
WB08YJSE001	64936.18	8122.94	731074.59	7478278.34	508.84	98	324	25 - 91	18	7.67	996	CID	484.22
WB08YJSE002	65728.83	7875.77	731867.37	7478031.14	499.47	37	200 mm CL12 PVC	0 - 37	5	8.49	1007	Alluvium	488.52
Total metres drilled						**135**							

7.3 TEST PUMPING

7.3.1 Test pumping contract

Test pumping was conducted on nine bores between the 14th June and 1st October. The work was contracted to Test Pumping Australia Pty Ltd and supervised by RTIO hydrogeologists. Test pumping was carried using a vertical turbine Everflow 250FHM submersible pump rated in excess of 100 L/sec for higher yielding CID bores, and a vertical turbine Pomona 6HC rated to 25 L/sec for the lower yielding alluvial bore.

7.3.2 Test Procedures

Step rate tests were conducted on all the production bores to establish the pumping capacity of the bore and the capacity of the submersible pump. Each test comprised of three to five steps depending on the available drawdown. The step tests were conducted for 60 mins. Following recovery from the step test, production bores were subject to a constant rate test, with discharge rates selected based on the step test data.

Controlled constant rate discharge tests were conducted from two days up to 15 days. The tests were conducted to estimate aquifer hydraulics, and possibly determine boundary conditions. Aquifer characteristics obtained from test pumping included hydraulic conductivity (K), transmissivity (T), specific yield (Sy) and storage coefficient (S). Conventional manual curve matching methods were used to determine parameters followed by estimation of the same parameters by computer program (Aquifer Test Pro V 2.5).

The methods selected for analysis of the hydraulic properties of the unconfined aquifer depend primarily on the hydrogeological conditions at the test site, and includes several assumptions;

- The aquifer is homogenous, isotropic, uniform thickness and of infinite extent.
- The production bore fully penetrates the aquifer.
- The discharge from the pumping bore is constant throughout the pumping test.
- The flow to the aquifer is laminar.
- Transmissivity is constant with time.
- The aquifer is unconfined
- Sy/S >10
- An observation bore screened over its entire length penetrates the full thickness of the aquifer
- The diameters of the pumped and observations bores are small, i.e. storage in them can be neglected

Calculations of hydraulic properties from the production bores were carried out using various monitoring bores by the Neuman method. The Neuman (1972) method of analysing the CID and alluvial monitoring bores was selected due to the unconfined delayed yield response and geology of the aquifer. A comparison to the unconfined aquifer analysis to the standard confined aquifer analysis of Cooper-Jacob (Time Drawdown) method and Theis method was conducted for the CID, giving representative results within the same order of magnitude. The results are tabulated in Appendix 5.

The main assumption for the calculation of specific yield by Newman equation is that the ratio of specific yield (Sy) to that of storage (S) should be greater than 10 (Sy/S>10). Where this assumption is satisfied the calculated Sy values for CID aquifer ranges from 0.1 to 0.01. The few analysis where the assumption of Sy/S>10 were not satisfied, the Sy values were relatively low and therefore the result were not considered.

The Theis non-equilibrium distance drawdown flow equation was used to determine the extent of cone of depression or the permissible drawdown. The Theis equation assumes that flow towards the pumping bore would almost certainly be from the throughflow in the ore body and therefore be in a non-equilibrium or transient state.

$$h - h_0 = \frac{Q}{4\pi T} W(u) \quad (1)$$

$$S = \frac{4Tut}{r^2} \quad (2)$$

Where $h-h_0$ is drawdown, Q is flow, T is transmissivity, and W(u) is the well function, t is time since pumping, S is the dimensionless storativity of the aquifer, r the radial distance from the discharge point and u is a dimensionless constant.

In addition to water levels and pumping rates, groundwater temperature, pH, dissolved oxygen (DO), and oxidation potential were monitored using a through flow cell attached to the pump in the production bore. Data was collected at 10 min intervals during step rate and constant rate tests using an In-situ Multi Parameter Troll 9500 water quality meter. The DO concentration was measured during test pumping by electrode and meter. The electrode measures the partial pressure of oxygen in the water, which is converted to oxygen mass weight concentration. The objective of using chemical and physical parameters is to identify geological and recharge boundary conditions. In particular, boundaries to the CID and recharge from the Marillana Creek alluvium aquifer during the long term pumping test. These parameters can provide information regarding boundary condition and inter-aquifer connections. The same parameters were recorded for Oxbow and Junction South East production bores.

7.3.3 The use of dissolved oxygen as tracer during pumping testing

Field parameters such as electrical conductivity and pH measured for the CID, and alluvium/insitu weathered bedrock groundwaters during test pumping and Marillana Creek surface water were similar. Therefore identifying the source of recharge into the production bore using these parameters was not possible. The DO concentration is relatively higher in the Marillana Creek and the upper parts of the alluvium/insitu weathered bedrock and CID aquifers (~ 20 below water table) compared to groundwater in the deeper part of the aquifers (Figure 5).

The higher level of DO in the top 20 m of alluvium/insitu weathered bedrock and CID aquifer is due to the recharge of oxygenated water and equilibrium with atmospheric oxygen. The down hole profile of DO throughout the study area shows a decreasing trend from ~ 8 mg/L at the water table to close to zero in deeper (> 30 m below watertable) parts of CID and alluvium/insitu weathered bedrock aquifers. It is therefore anticipated that the DO concentration will change in the later part of the test pumping due to groundwater mixing between the deep and shallow groundwater.

Furthermore, the measured DO concentration in the Marillana Creek is in equilibrium with atmospheric O_2. The DO concentration of the flowing Marillana Creek water is ~ 8 mg/L indicating equilibrium with atmospheric O_2. The increased leakage and recharge from Marillana Creek during test pumping may result in increased levels of DO in groundwater due to mixing of stagnant water from deeper parts of the CID with oxygenated water from Marillana Creek.

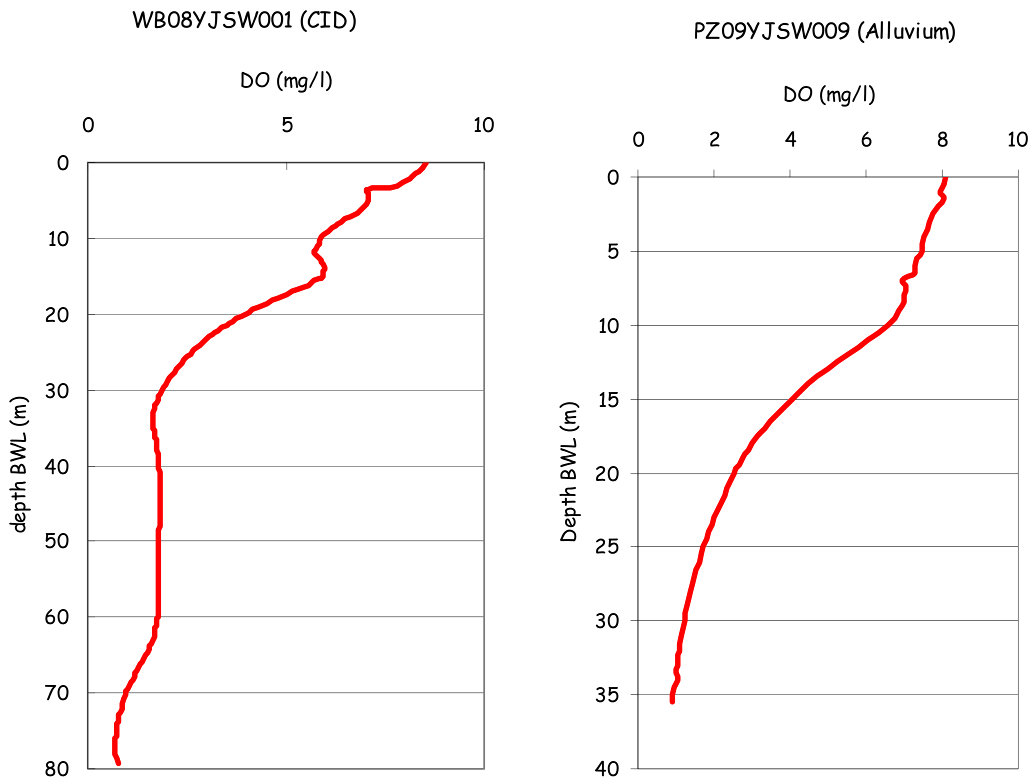

Figure 5. The DO concentration below the water table in a CID and an alluvium monitoring bore.

7.3.4 WB09YOXB001

One hour duration step tests were conducted on bore WB09YOXB001 for four different discharge rates; 24, 35, 45 and 60 L/sec respectively, to obtain the apparent well efficiency in the production bore performance and a rate for the constant discharge test. Drawdown for the four steps stabilised well within the hour. A constant discharge rate of 60 L/sec was selected based on the results of the step test analysis.

The apparent efficiency in the production bore performance ranges from 60-80% which indicates a reasonably efficient bore, with only a modest component of well loss in the pumping well. The negligible inefficiencies are likely the result of well loss as an effect of turbulent flow related to the relatively high pumping rates. The step test was analysed using Rorabaugh's equation and presented in Appendix 4.

Production bore WB09YOXB001, with a standing water level of 37.79 mbtc (meters below the top of the casing) was pumped at 60 L/sec for five days with the water level declining 19.66 m to 57.45 m. The time drawdown curve on the log-linear graph (Appendix 5) resembles the theoretical unconfined aquifer curve with a delayed yield or recharge boundary.

Early time data up to six minutes indicates water is released from storage within the bore. Then there appears to be a large low gradient response in the drawdown curve where the hydraulic head partially stabilises, indicating withdrawal of groundwater from available storage in the CID. After 17 hours pumping the drawdown trend steepened. The steeper slope may indicate the boundary between the CID and the adjacent flood plain alluvial/insitu weathered bedrock aquifer. This may also explain the slight increase in the dissolved oxygen concentration in the groundwater. As the percentage of groundwater mixing from alluvial/insitu weathered bedrock aquifer to that of CID aquifer increases, the dissolved oxygen level increases with time.

The rise in water levels at approximately three and a half days was a result of faulty equipment which was rectified and pumping continued. The drawdown in the CID monitoring bores, ranged from 0.5 to 4.5 m depending on their distance from the production bore. The drawdown in the monitoring bore PZ08YOXB001 10 m from the production bore was 4.5 m indicating moderately transmissive material and no influence of recharge from Marillana Creek surface flow.

Water levels in PZ08YOXB003 and PZ08YOXB005 located 258 m and 1308 m from the pumping bore (Figure 2) drew down 0.7 m and 0.14 m respectively, indicating high transmissive material and good connection to the CID. Monitoring bore PZ08YOXB004, approximately 1200 m from the pumping bore, had 0.5 m drawdown showing the high transmissive nature of the CID.

A schematic cross section of the production and monitoring bores was drawn to show the water table elevation across the valley floor (Figure 7). The test pumping results and the response of the alluvium bore to the production bore suggest a well connected flood plain alluvium/insitu weathered bedrock to the CID aquifer. The Theis non-equilibrium distance drawdown flow equation was used to determine the extent of the cone of depression or the permissible drawdown. The hydraulic parameters used in the equation were obtained from the constant rate test pumping analysis (T=2000 m^2/d and S= 0.01). The results shows that at a distance of 260 m from the production bore drawdown should be approximately 0.7 m, which is what is observed in PZ08YOXB003. Due to the distance of Marillana Creek from the production bore no water table response can be expected in the Marillana creek. The non-equilibrium distance drawdown analysis also suggests that the boundary between the alluvium and Weeli Wolli Formation cannot be reached with the discharge rate used in five day test pumping.

The DO concentration during the test pumping is plotted against drawdown (Appendix 5). The DO content of groundwater in the CID aquifer is approximately 0.5 - 1 mg/L. The down hole DO profiles (Figure 6) for the two alluvium monitoring bores PX08YOXB003 and PZ08YOXB005 show higher concentration compared to that measured in the CID. The DO concentration after approximately one day of test pumping, where the CID/alluvial boundary was reached increased to ~ 1.5 mg/L indicating the increased percentage of mixing from groundwater derived from the alluvium. The redox potential mimics the dissolved oxygen concentration and increases from low potential of -86 mv to164 mv at the end of the test pumping were groundwater is sourced from the dewatering of the upper sections of CID aquifer with a small percentage of alluvial/insitu weathered bedrock groundwater (Appendix 3). There is no apparent change in EC (averaging 900 µS/cm) during the test pumping because both aquifers are characterised by similar EC. The pH averaged 6.65 throughout the test.

The results for the drawdown versus time was analysed using the Theis recovery, Logan's formula and Neuman method. The values of T, K and Sy, using the described methods are given in Appendix 5. The values for T for the CID range from 600 to 3000 m^2/d adopting 2000 m^2/d. The values for Sy range from 0.1 to 0.001, adopting 0.01. The adopted values were based on averages for the CID and comparisons with previous work for the area. The hydraulic conductivity, calculated by dividing the transmissivity by the 60 m aquifer thickness of the bore is 50 m/d. The flood plain alluvial/insitu weathered bedrock has a higher transmissivity of 3500 m^2/d due to the unconsolidated nature of the material. The calculated specific yield from monitoring bores observations installed in the alluvial/insitu weathered bedrock aquifer provide higher values compared to the monitoring bores installed in the CID aquifer. The connection between the aquifers was further illustrated by the measured dissolved oxygen (DO) concentration during pumping test.

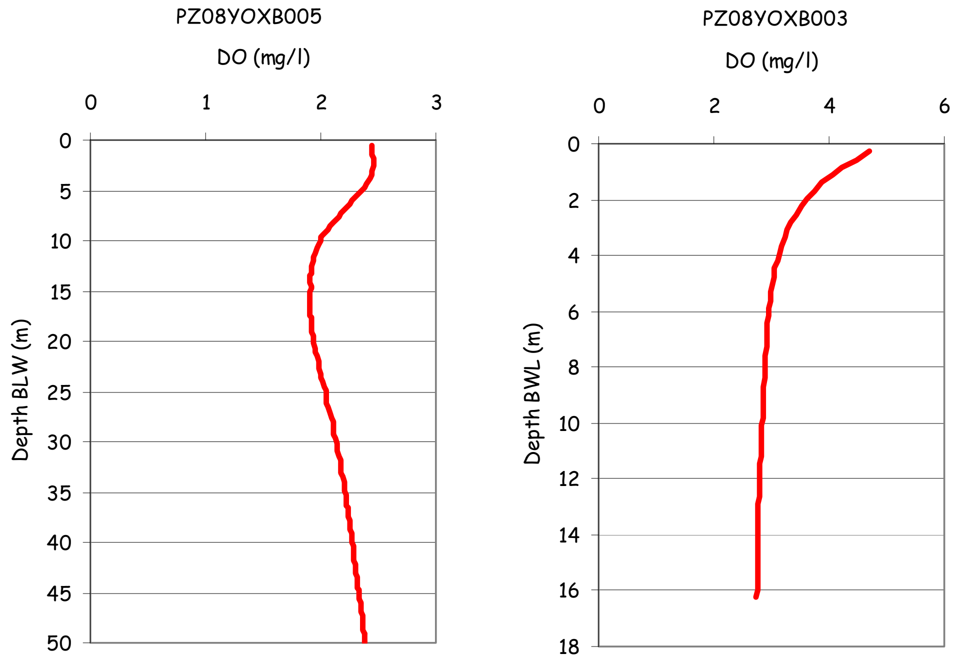

Figure 6 The down hole DO concentration in two alluvium bores located at the flanks of CID

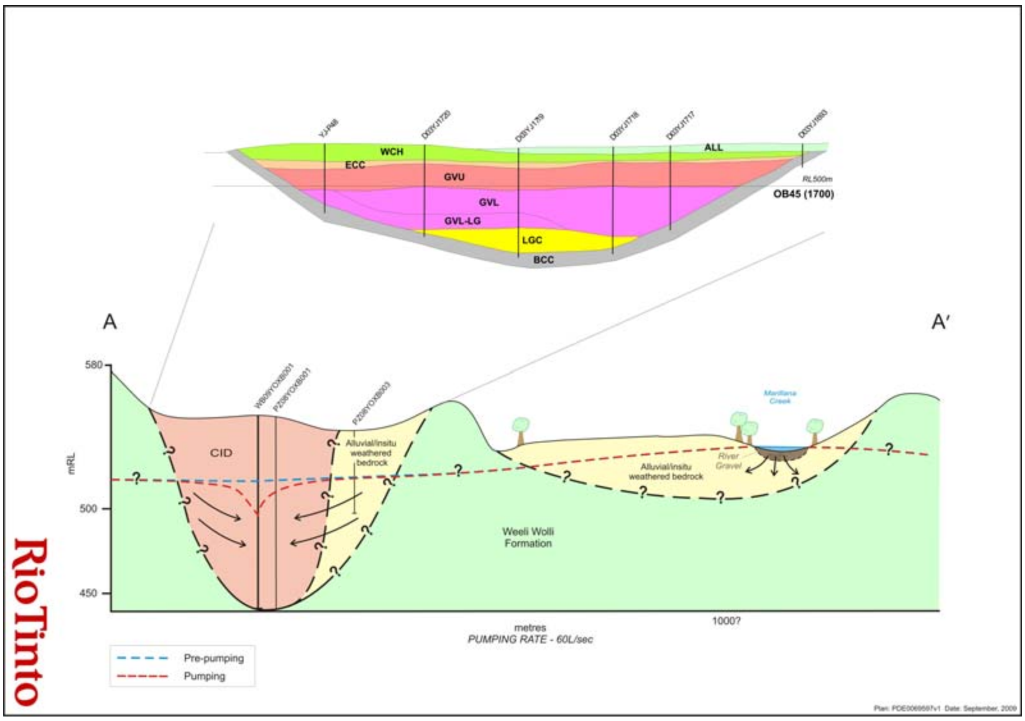

Figure 7 Schematic cross section of Oxbow pumping test.

7.3.5 WB08YJSW001

Four one hour duration step tests were conducted on bore WB08YJSW001 at discharge rates 32, 45, 60 and 80 L/sec respectively. Drawdown for the first three steps stabilised within the hour, but increasing the discharge to 80 L/sec did not stabilise and continued to decline. A constant discharge rate of 65 L/sec was selected based on the results of the step test analysis.

The apparent efficiency in the production bore performance ranges from 40-60% which indicates a significant component of well loss in the pumping well. The low efficiencies are likely the result of turbulent flow related to higher pumping rates. The step test was analysed by using Rorabaugh's equation and presented in Appendix 4.

Production bore WB08YJSW001, was pumped at 65 L/sec for five days. The groundwater level declined 47.85 m from the pre-pumping level of 11.15 mbtc to 59 mbtc. The time drawdown curve on the log-linear graph (Appendix 5) resembles the theoretical unconfined aquifer curve with a delayed yield.

Early time data up to 10 mins indicates the water is released from well storage. Then the curve partially stabilises, indicating withdrawal of groundwater from available storage in the CID. After approximately one and quarter days of pumping, the late time observations steepened indicating a decrease of flow through the CID aquifer. This response and an increase in dissolved oxygen suggests a boundary condition of the CID and flood plain alluvial/insitu weathered bedrock was reached. A further 10 m decline in drawdown after approximately 4.2 days was measured. A similar response was measured in all CID monitoring bores and may represent the extent of the palaeochannel and indicate the low permeability boundary of the Weeli Wolli Formation. The water level draw down in the CID monitoring bores, ranged from 5 to 10 m depending on distance from the production bore. 10 m of drawdown in the monitoring bore PZ08YJSW005, located 10 m from the production bore indicates relatively transmissive material and the influence of recharge from Marillana Creek surface flow.

Water level in PZ08YJSW004 and PZ08YJSW009 located 207 m and 516 m from the pumping bore (Figure 3) drew down 1 m and 1.8 m respectively, indicating high recharge influence from Marillana Creek and connection to the CID. Alluvial/insitu weathered bedrock monitoring bore PZ08YJSW004 located between Marillana Creek and the CID, had less drawdown compared to the alluvial/insitu weathered bedrock monitoring bore PZ08YJSW009 on the opposite flank of the CID. This may be due to the continuous recharge from the proximal Marillana Creek (despite the former being closer to the actual pumping bore).

The Theis non-equilibrium distance drawdown equation was used to determine the extent of the cone of depression or the permissible drawdown. The hydraulic parameters (T=450 m^2/d and S= 0.01) used in the equation were obtained from the constant rate test pumping analysis. The equation shows that at a distance of 550 m from the production bore drawdown should be approximately 2 m, which would result in the Marillana Creek surface water flow delinking with the underlying alluvial/insitu weathered bedrock aquifer. Groundwater levels in PZ08YJSW009, 400 m from the production bore, would theoretically be drawn down 2.2 m which is close to what was observed. The theoretical drawdown of 4 m in PZ08YJSW004, drilled into the flood plain alluvials close to Marillana Creek was greater than observed due to the recharge from Marillana Creek.

Figure 8 illustrates the old conceptual model whereby the CID was interpreted to be flanked by impermeable basement Weeli Wolli Formation with a thin veneer of alluvial cover. A revised schematic cross section across the flood plain based on the results of drilling and test pumping was prepared. It illustrates the drawdown across the CID, alluvial/insitu weathered bedrock and Marillana Creek (Figure 9). The test results showed the flood plain alluvium/insitu weathered bedrock and Marillana Creek gravels are well connected to the CID aquifer. It also demonstrates the delinking of the surface water flow from Marillana Creek from the underlying aquifer towards the end of pumping.

Dissolved oxygen, pH, electrical conductivity, temperature and redox potential were logged at 10 min intervals. The concentration of dissolved oxygen is plotted against drawdown (Appendix 5). The oxygen content of groundwater in the CID aquifer is approximately 2-3 mg/L at the start of the pumping test, and after approximately 1.5 days, increased to 7 mg/L when the CID/alluvial boundary was reached. This may be due to the mixing of shallow groundwater from the alluvium and potentially surface water from Marillana Creek. A percentage of Marillana Creek surface flow may recharge the CID aquifer where it crosses the CID palaeochannel 140 m up gradient. The measured redox potential mimics the dissolved oxygen concentration and increases steadily from 5 mv to 100 mv (end of the test pumping) where most of the groundwater is from the alluvium underlying Marillana Creek. There is no change in EC during the test pumping as the surface water from Marillana creek and groundwater of the CID and alluvium has similar EC[1] values.

The results for the production bore of drawdown data were analysed using the Theis recovery, Logan's formula and Neuman method. Transmissivity values ranged from 222 to 558 m^2/d. The adopted value was 250 m^2/d (from Neuman). The values of T, K and Sy, using the described methods are given in Appendix 5. These values for the CID range from 319 to 631 m^2/d adopting 500 m^2/d. The values for Sy range from 0.1 to 0.0001, adopting 0.01. The hydraulic conductivity, calculated by dividing the transmissivity by the 70 m aquifer thickness of the bore is 6.4 m/d. The flood plain alluvial/insitu weathered bedrock aquifer has a higher transmissivity of 1500 m^2/d due to the unconsolidated nature of the material. Calculated specific yield in the alluvium gives similar values as the CID.

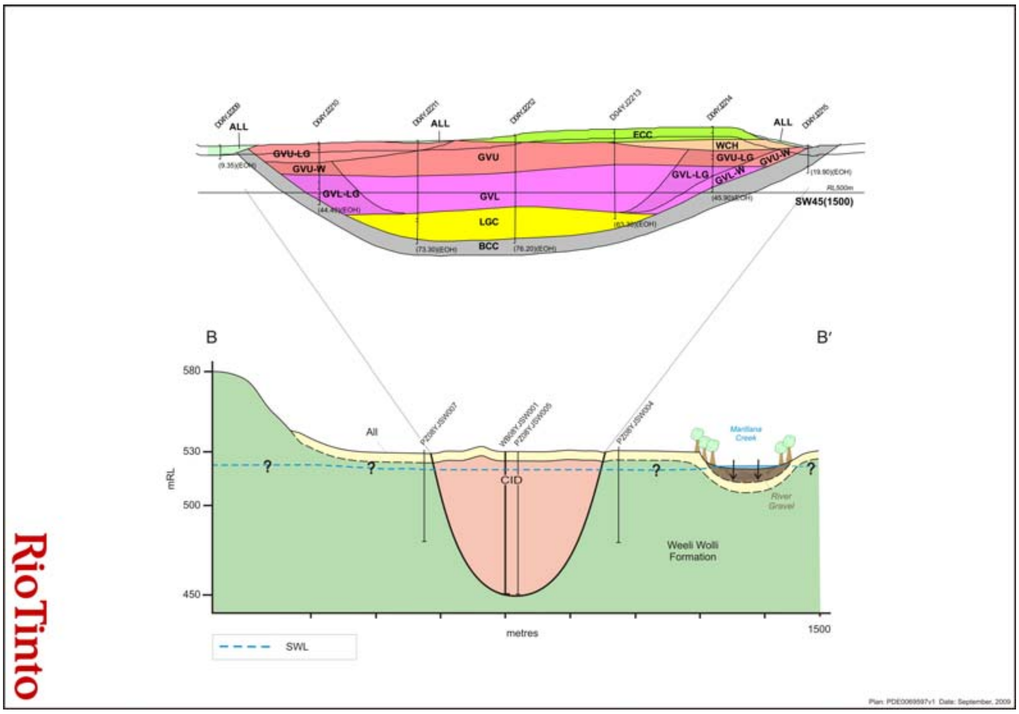

Figure 8 Conceptual model of cross section across the flood plain encompassing WB08YJSW001 bore prior to this study

[1] This to be expected as most surface water in Marillana Creek is actually derived from groundwater discharged as a result of BHPB dewatering operations upstream of RTIO Yandicoogina

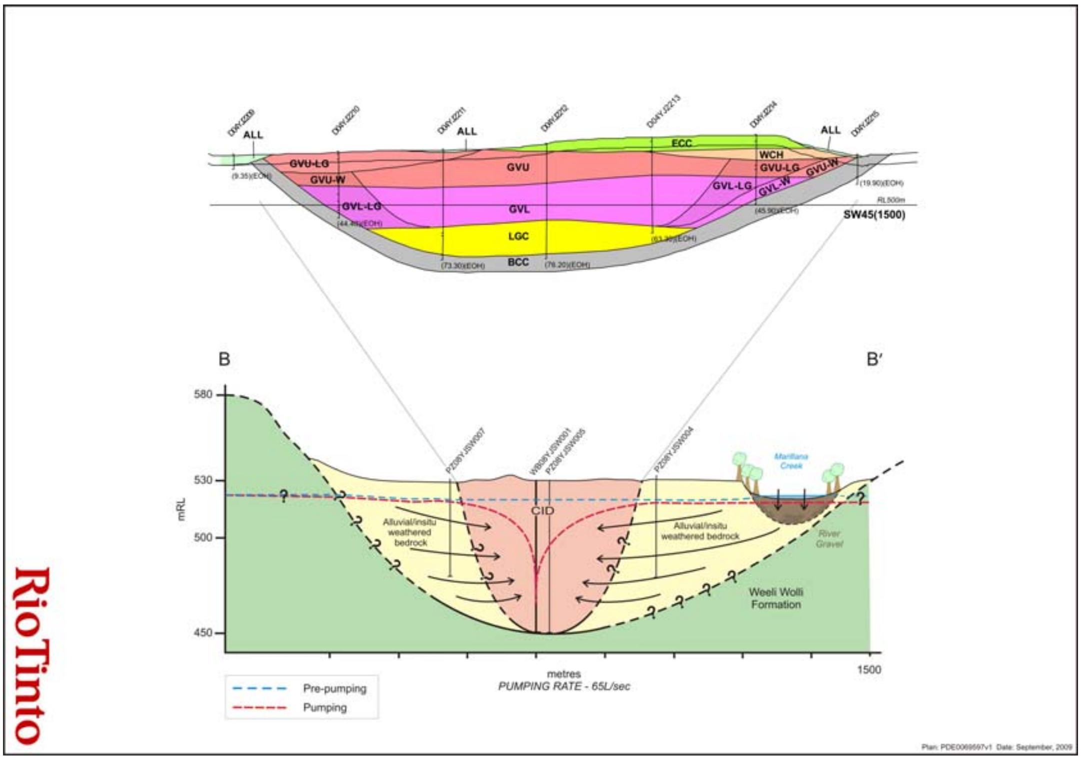

Figure 9 Conceptual model of cross section across the flood plain encompassing WB08YJSW001 drawn based on the results of this study

7.3.6 WB08YJSW002

Three one hour duration step tests were conducted on bore WB08YJSW002 at discharge rates 40, 50 and 80 L/sec respectively. Drawdown for the first two steps went close to stabilising within the hour, but increasing the discharge to 80 L/sec steepened the drawdown curve which only started to slightly stabilise towards the end of the test hour. The water level after the three steps at high pumping rates was lowered in the bore column to 43 m below standing water level. Based on the results of the step test analysis and comparison with adjacent production bore WB08YJSE001 a constant discharge rate of 60 L/sec was chosen.

The apparent efficiency in the production bore performance ranges from 23-37% which indicates there to be a significant component of well loss in the pumping well. The low efficiencies are likely the result of turbulent flow related to higher pumping rates. The step test was analysed by using Rorabaugh's equation and presented in Appendix 4.

Production bore WB08YJSW002, was pumped at 60 L/sec for two days. The groundwater level declined 38.19 m from the pre-pumping level of 20.78 mbtc to 58.97 mbtc. The time drawdown curve on the log-linear graph (Appendix 5) resembles the theoretical unconfined aquifer curve with a delayed yield At early time data up to six minutes, water is released from well storage. Then there appears to be a slight decline in drawdown where water is released from storage within the CID to the point where the boundary of the flood plain alluvial/insitu weathered bedrock and the CID is reached. After 13 hours of pumping, the steeper decline in the drawdown curve, up (~8 m) to two days, indicates where the groundwater is obtained from the mixed storage of the CID and alluvial aquifers.

WB08YJSW002 was tested for a short duration for comparison with the adjacent production bore (WB08YJSW001). The two day constant rate test did not reach the boundary condition of the alluvial and Weeli Wolli Formation. The steepened slope of the curve suggests a decrease in the flow to the production bore for the latter part of the test. The approximate 1 m drawdown in the flood plain alluvial bores after two days suggests that the water level was not lowered below the Marillana Creek bed.

The Theis non-equilibrium distance drawdown equation was used to determine the extent of the cone of depression or the permissible drawdown. The hydraulic parameters used in the equation were obtained from the constant rate test pumping analysis (T=500 m^2/d and S= 0.01). The equation shows that at a distance of 250 m (the distance of Marillana creek to the production bore) the water level will be lowered by approximately 3 m. This suggests that after two days of pumping, the Marillana Creek surface flow will be delinked from the underlying aquifer along the elongated palaeochannel.

Water level in PZ08YJSW004 and PZYJSW009 located 390 m and 512 m from production had approximately 1 m of drawdown after two days of pumping suggesting a good hydraulic connection between the alluvial/insitu weathered bedrock and the CID. The proximal monitoring bore to Marillana Creek had less drawdown due to the recharge from Marillana creek to the alluvium aquifer/insitu weathered bedrock.

The DO content of groundwater in the CID aquifer is approximately 2 mg/L for the first 300 minutes then sharply increases to approximately 8 mg/L, indicating that the water is sourced from the well connected alluvium/insitu weathered bedrock aquifer that is recharged by surface water from Marillana creek. The DO content in groundwater at the end of pumping resembles that of surface water in equilibrium with atmosphere, suggesting recharge from shallow alluvium and potentially surface water from Marillana Creek. The measured redox potential increases rapidly from -40 mv to 60 mv by the end of the test pumping were most of the discharge water is sourced from the adjacent alluvium/insitu weathered bedrock. There is a slight increase in EC during test pumping, but averaging 800 µS/cm because the surface water from Marillana creek and groundwater of the CID and alluvium/insitu weathered bedrock has similar EC. The high concentration of DO corroborates the test pumping results that both production bores WB08YJSW001 and WB08YJSW002 are recharged mainly by shallow alluvium/insitu weathered bedrock aquifer by the end of test pumping.

The results for production bore WB08YJSW002 of drawdown versus time was analysed using the Theis recovery, Logan's formula and Neuman method giving an adopted transmissivity of 150 m^2/d. The values of T, K and Sy, using these methods are given in Appendix 4. The values for T using the Neuman method for the CID range from 300 to 600 m^2/d adopting 500m^2/d. The values for Sy range from 0.0001 to 0.1, adopting 0.01. The hydraulic conductivity, calculated by dividing the transmissivity by the 60 m aquifer thickness of the bore is 8.3 m/d.

7.3.7 WB09YJSW004

Four one hour duration step tests were conducted on bore WB09YJSW004 at discharge rates 50, 70, 90 and 110 L/sec respectively. Drawdown for the first two steps went close to stabilising within the hour, but increasing the discharge to 90 L/sec and 110 L/sec continued to decline which resulted in a steepened drawdown curve which started to stabilise towards the end of each test hour. The fourth step was close to the pumps maximum pumping rate and lowered the water level in the bore column to 14.46 m below standing water level. Based on the results of the step testing a constant discharge rate of 95 L/sec was chosen.
The apparent efficiency in production bore performance ranges from 25-42% which indicates there to be a significant component of well loss in the pumping well. The efficiencies are likely the result of turbulent flow related to higher pumping rates. The step test was analysed by using Rorabaugh's equation and presented in Appendix 4.

Production bore WB09YJSW004, was pumped at 95 L/sec for 15 days. The groundwater level declined 16.53 m from the pre-pumping level of 13 mbtc to 29.61 mbtc. The time drawdown curve on the log-linear graph (Appendix 5) resembles close to the theoretical unconfined aquifer curve with a recharge boundary. The open cone of depression interpreted from the pumping data also suggests that the CID aquifer is unconfined.

At early time data up to two minutes on the drawdown curve, water is released from storage within the bore. Then a continued decrease in the slope of drawdown curve where water is released from storage within the CID to the point where the flood plain alluvial/insitu weathered bedrock and the CID boundary are reached after one hour of pumping. From this point a steeper constant decline in drawdown (~9 m) to 15 days, where the water is drawn from the CID, alluvial/insitu weathered bedrock and from the Marillana Creek surface water flow.

The drawdown versus time slope in the monitoring bores begins to stabilise suggesting a continuous recharge from the alluvium/insitu weathered bedrock aquifer. The proximity of the saturated Marillana Creek crossing the palaeochannel with the potential to recharge the CID 200 m down gradient provides the explanation for the minimal drawdown observed in the production bore. Mixing of the CID groundwater with that of the surface water from Marillana Creek and the underlying alluvium/insitu weathered bedrock aquifer is apparent in the graph of DO for the test duration. The constant dissolved oxygen data (~4 mg/L) measured throughout the whole test representing an aquifer readily recharged by oxygenated surface water.

The water level drawdown in the CID monitoring bores located in a 150 m radius of the pumping bore, ranged from 8.5 to 9.5 m depending on distance from the production bore. Drawdown of 9 m in the monitoring bores PZ08YJSW014 (7.5 m) and PZ08YJSW016 (92 m) from production bore was similar representing relatively homogenous transmissive material. After 15 days no apparent boundary with the Weeli Wolli Formation was reached, owing to the recharge from the alluvium/insitu weathered bedrock and nearby saturated river gravels.

The Theis non-equilibrium distance drawdown equation was used to determine the extent of the cone of depression or the permissible drawdown. The hydraulic parameters used in the equation were obtained from the constant rate test pumping analysis (T=600 m2/d and S= 0.1). The equation shows that at a distance of 300 (distance Marillana creek to the production bore) the water level will be lowered by approximately 3.5 m. This suggests that after 15 days of pumping duration the Marillana Creek surface flow will be delinked from the underlying aquifer adjacent to the palaeochannel.

Water levels in PZ08YJSW017, PZ09YJSW011 and PZ09YJSW020 located 352 m, 650 m and 1291 m respectively, from the pumping bore parallel to Marillana Creek (Figure 2), had drawdowns of approximately 0.5 m, demonstrating again the connection between the flood plain alluvial/insitu weathered bedrock and the CID. PZ09YJSW020, over 1 km distance from the pumping bore had 0.4 m of drawdown demonstrating the highly transmissive material of the flood plain alluvial/insitu weathered bedrock.

Figure 10 illustrates the old conceptual model whereby the CID was interpreted to be flanked by impermeable basement Weeli Wolli Formation with a thin veneer of alluvial cover. Schematic section across the flood plain drawn from the production and monitoring bore logs illustrates the aquifer setting, the water level and drawdown during the test pumping (Figure 11). The test pumping results and the response of the alluvium/insitu weathered bedrock bores to the production bore suggest a well connected flood plain alluvium/insitu weathered bedrock and Marillana river bed gravel to the CID aquifer. The diagram also demonstrates the delinking of the surface water flow from Marillana Creek from the underlying aquifer towards the end of pumping.

The results for the production bore of drawdown versus time was analysed using the Theis recovery, Logan's formula and Neuman method giving an adopted T of 500 m^2/d. The values of T, K and Sy, using these methods are given in Appendix 4. The values for the Neuman method for T for the CID range from 500 to 600 m^2/d adopting 600 m^2/d. The values for Sy range from 0.001 to 0.1, adopting 0.1. The hydraulic conductivity, calculated by dividing the transmissivity by the 70 m aquifer thickness of the bore is 7.8 m/d.

The hydraulic properties calculated using the three 50 m deep monitoring alluvial bores (PZ09YJSW011, PZ09YJSW017 & PZ09YJSW020), which were close to the margins of Marillana Creek, provide higher transmissivities of average 3000 m^2/d than CID monitoring bores. This is due to the larger distance of the alluvium/insitu weathered bedrock monitoring bores from the production bore utilised in test pumping equations.

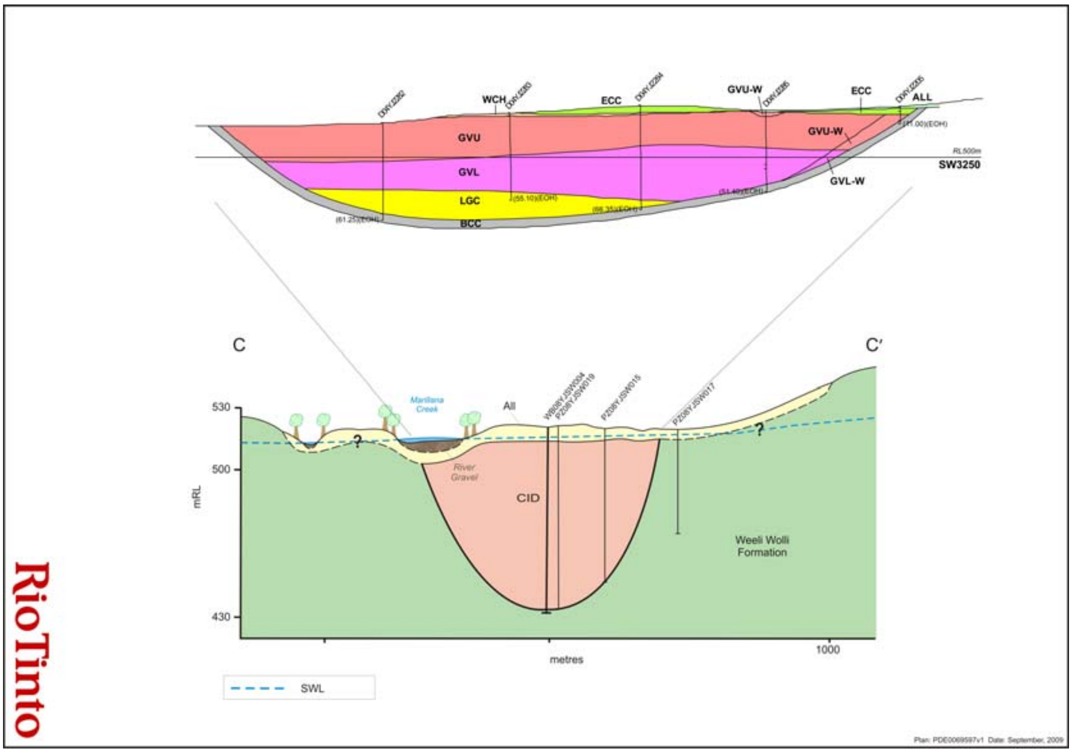

Figure 10 Conceptual model of cross section across the flood plain encompassing WB08YJSW001 bore prior to this study

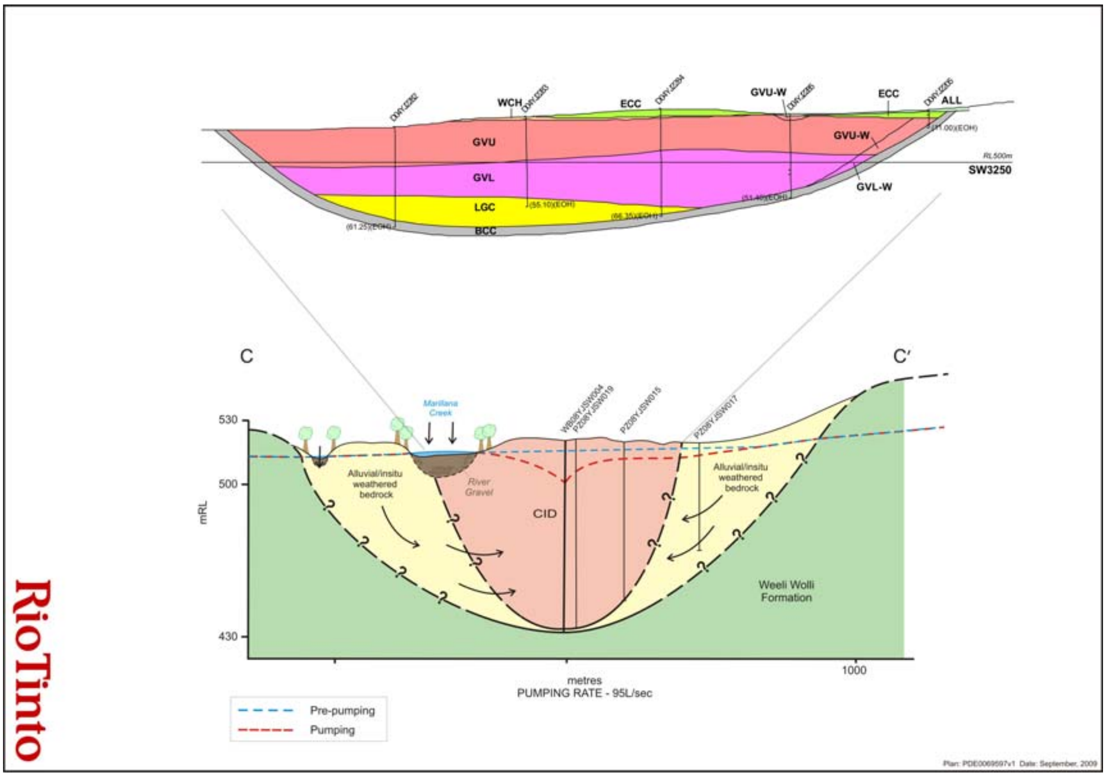

Figure 11 Schematic section across flood plain encompassing WB09YJSW004 production bore and associated monitoring bores. The geological model of CID is shown to illustrate width of CID compared to flood plain alluvium/insitu weathered bedrock.

7.3.8 WB09YJSW005

Four one hour duration step tests were conducted on bore WB09YJSW005 at discharge rates 50, 70, 90 and 110 L/sec respectively. Drawdown for the first three steps practically stabilised within the hour, but increasing the discharge to the pumps maximum pumping rate of 110 L/sec continued to decline the drawdown curve which only started to slightly stabilise towards the end of the test hour. Based on the results of the step test analysis a constant discharge rate of 100 L/sec was chosen.

The apparent efficiency in production bore performance ranges from 29-48% which indicates a component of well loss in the pumping well. The low efficiencies are the result of turbulent flow related to higher pumping rates. The step test was analysed by using Rorabaugh's equation and presented in Appendix 4.

Production bore WB09YJSW005, was pumped at 100 L/sec for three days. The groundwater level declined 37.55 m from the pre-pumping level of 17.82 mbtc to 55.37 mbtc. The time drawdown curve on the log-linear graph (Appendix 5) resembles close to the theoretical unconfined aquifer curve with a recharge boundary.

The early time data show that the water is release from storage within the well. Then there appears to be a decrease in drawdown versus time where water is released from storage within the CID to the point where the boundary of the flood plain alluvial/insitu weathered bedrock and the CID is likely to be reached. After ten hours of pumping a steeper decline in drawdown (~7

m) to three days, where the groundwater is obtained from the mixed storage of the CID and alluvial/insitu weathered bedrock aquifers.

The steep slope of the curve suggests decrease in flow to the production bore for the latter part of the test. The drawdown in all CID monitoring bores is approximately 8 m indicating a reasonably homogenous aquifer in the vicinity of the production bore. The alluvial bore PZ08YJSW017, located 277 m from the production bore had little to no drawdown due to the short duration of the test. However, the results of the three days of test pumping mimics that measured for the adjacent production bore WB09YJSW004.

Unlike the DO concentration in the adjacent WB09YJSW004 production bore, the DO content of groundwater in WB09YJSW005 increases from ~ 2 mg/l to 8 mg/L by the end of the three day constant rate test whereby more recharge from Marillana Creek is evident. The concentration represents a well mixed shallow groundwater from alluvium/insitu weathered bedrock and potentially surface water from Marillana Creek with the CID groundwater. The measured redox potential increases rapidly from -30 mv to 40 mv by the end of test pumping were most of the discharge water is sourced from the alluvium/insitu weathered bedrock underlying Marillana creek (Appendix 3).

Comparison of DO to the adjacent production bore (WB09YJSW004) suggests that the recharge boundary with the alluvium/insitu weathered bedrock was reached in a relatively shorter time. This is due to the dewatering of the aquifer by the WB09YJSW004 bore pumping testing. The 15 day test showed that the discharge water was derived from a well mixed CID and alluvial/insitu weathered bedrock aquifer where the DO was consistent throughout the test at approximately 4 mg/L. The results of DO concentration in the subsequent three day test of WB09YJSW005 shows water initially was derived from the deep CID aquifer to a point approximately 10 hours into the test, when the CID and alluvial/insitu weathered bedrock boundary was reached and the DO increased sharply to 8 mg/L.

The Theis non-equilibrium distance drawdown equation was used to determine the extent of the cone of depression or the permissible drawdown. The hydraulic parameters used in the equation were obtained from the constant test pumping analysis (T=600 m2/d and S= 0.1). The equation shows that at a distance of 400 (the distance from Marillana Creek to the production bore) the water level will be lowered by 2 m. This suggests that after three days of pumping the Marillana Creek surface flow will be delinked from the underlying aquifer.

The results of drawdown versus time was analysed using the Theis recovery, Logan's formula and Neuman method giving an average transmissivity of 400 m^2/d The values of T, K and Sy, using these methods are given in Appendix 5. The values for T for the CID range from 300 to 650 m^2/d adopting 600m^2/d. The values for Sy range from 0.1 to 0.01, adopting 0.1. The hydraulic conductivity, calculated by dividing the transmissivity by the 65 m aquifer thickness of the bore is 9.2 m/d.

7.3.9 WB09YJSW006

Five one hour step tests of discharge rates of 40, 50, 60, 75 and 105 L/ were conducted on bore WB09YJSW006 respectively. Drawdown for the all steps began to stabilise within the hour, with overall drawdown after the five hours only 15 m. To be able to sustain a long term constant rate within the pump capacity 80 L/sec was chosen for a five day constant rate test.

The apparent efficiency in production bore performance ranges from 56-77% which indicates there to be a slight component of well loss in the pumping well. The inefficiencies are likely the result of turbulent flow related to high pumping rates. The step test was analysed by using Rorabaugh's equation and presented in Appendix 4.

Production bore WB09YJSW006, was pumped at 80 L/sec for five days. The groundwater level declined 14.15 m from the pre-pumping level of 12.2 mbtc to 26.35 mbtc. The time drawdown curve on the log-linear graph (Appendix 5) resembles close to the theoretical unconfined aquifer curve with a recharge boundary. The open cone of depression interpreted from the pumping data also suggests that the CID aquifer is unconfined.

At early time data up to five minutes, water is release from storage. This is supported by relatively low concentration of dissolved oxygen values of 2 -2.5 mg/L in the CID aquifer. Then there appears a change of the slope of the drawdown curve, indicating withdrawal of groundwater from aquifer storage.

At approximately 16 hours after pumping commenced a slight steepening in drawdown gradients is observed in the production bore and all monitoring bores. This coincides with a slight decrease in the dissolved oxygen indicating the decline in available volume of storage in the CID and pumping is sourced from a relatively deeper part of the aquifer. The late relatively steep decline in drawdown in the pumping bore at approximately four days after the commencement of the test is similar to that observed in WB08YJSW001 production bore. This may suggest the boundary of the palaeochannel and the Weeli Wolli Formation.

The water level draw down in the CID monitoring bores, ranged from 2 - 8 m depending on distance from the production bore. Drawdown of 7.9 m in the monitoring bore PZ08YJSW021, located 21m from production bore indicates relatively transmissive material. The Theis non-equilibrium distance drawdown equation was used to determine the extent of the cone of depression or the permissible drawdown. The hydraulic parameters used in the equation were obtained from the constant rate test pumping analysis (T=800 m2/d and S= 0.01). The equation shows that at a distance of 120 m (the distance from Marillana Creek to the production bore) the water level will be lowered by 2.8 m. This suggests that after five days of pumping the Marillana Creek surface flow will be delinked from the underlying aquifer.

The distance between Marillana Creek and WB09YJSW006 is only 120 m. The pre testing Marillana Creek water level is ~ 1m higher than the water level in the production bore, suggesting a loosing stream and potential for leakage from alluvium/insitu weathered bedrock into the CID aquifer. The response in the alluvial/insitu weathered bedrock monitoring bore PZ09YJSW020 which was located on the eastern side of the Marillana Creek is minimal due the continuous recharge from Marillana Creek. The recharge from Marillana Creek towards the production bore creates a hydraulic divide that potentially drives the groundwater from the eastern side of the Marillana Creek towards the creek and not the production bore. Therefore the response of the groundwater on the opposite side of Marillana Creek to the production bore is minimal during the pumping test.

A Schematic cross section showing the production and monitoring bores illustrates the drawdown across flood plain including Marillana Creek (Figure 12), with minimal drawdown in the alluvial/insitu weathered bedrock bore on the opposite side of Marillana Creek. The test pumping results, and that the concentration of dissolved oxygen, the redox potential, pH, electrical conductivity and temperature of pumped groundwater remains constant throughout five days of pumping, suggests a well mixed groundwater derived from the CID and Marillana Creek surface water flow. The diagram also demonstrates the delinking of the surface water flow from Marillana Creek from the underlying aquifer towards the end of pumping.

The results for the production bore of drawdown versus time was analysed using the Theis recovery, Logan's formula and Neuman method giving an adopted T of 450 m^2/d. The values of T, K and Sy, using these methods are given in Appendix 5. The values using the Neuman method for T for the CID range from 550 to 1600 m^2/d adopting 800 m^2/d for prediction analysis.

The values for Sy range from 0.001 to 0.01, adopting 0.01. The hydraulic conductivity, calculated by dividing the Transmissivity by the 70 m aquifer thickness of the bore is 14.3 m/d. Due to the recharge from Marillana Creek surface flow, there was very minimal drawdown in the adjoining flood plain in the 50 m deep bore and therefore aquifer parameters could not be obtained using the alluvium/insitu weathered bedrock monitoring bore.

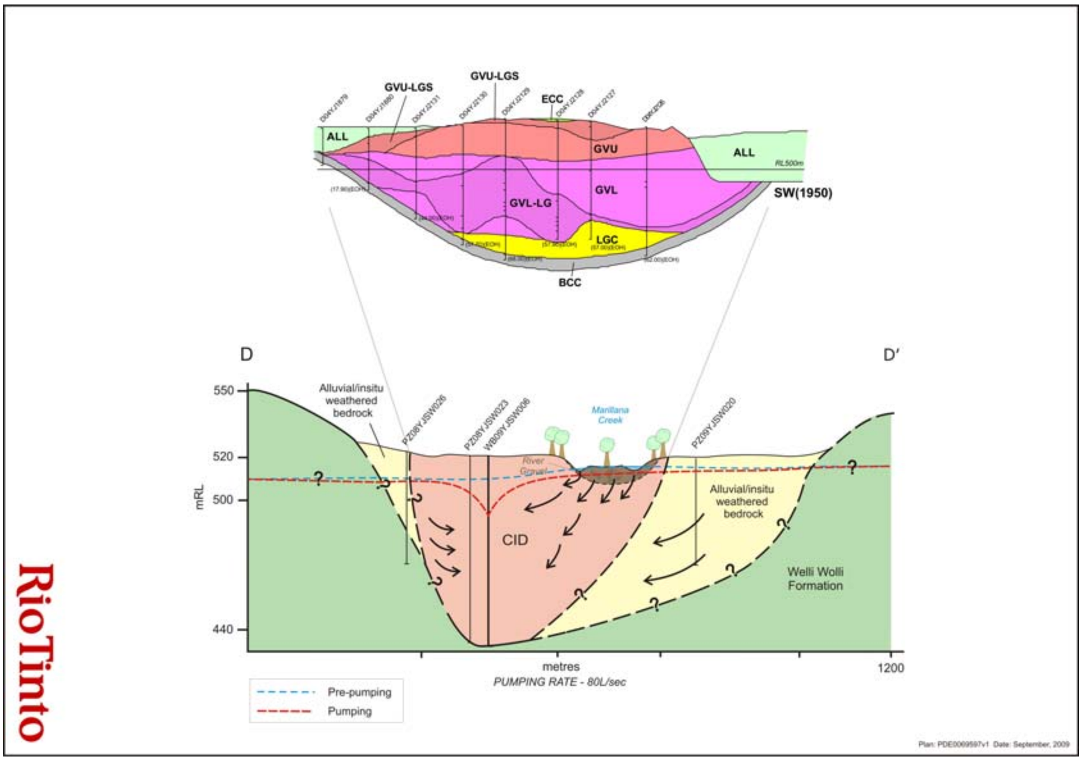

Figure 12 Schematic section across flood plain encompassing WB09YJSW006 production bore and associated monitoring bores. The geological model of CID is shown to illustrate width of CID compared to flood plain alluvium/insitu weathered bedrock.

7.3.10 WB09YJSW007

Four one hour duration step tests were conducted on bore WB09YJSW007 at discharge rates 50, 70, 90 and 110 L/sec respectively. Drawdown for the first two steps went close to stabilising within the hour, but increasing the discharge to 90 L/sec and 110 L/sec, close to the pumps maximum pumping capacity, continued to decline which only started to partially stabilise towards the end of each test hour. Based on the results of the step test analysis a constant discharge rate of 100 L/sec was chosen. The apparent efficiency in the production bore performance ranges from 43-62% which indicates there to be a reasonable component of well loss in the pumping well. The low efficiencies are likely the result of turbulent flow related to higher pumping rates. The step test was analysed by using Rorabaugh's equation and presented in Appendix 4.

Production bore WB09YJSW007, was pumped at 100 L/sec for five days. The groundwater level declined 21.35 m from the pre-pumping level of 25.4 mbtc to 37.18 mbtc. The time drawdown curve on the log-linear graph (Appendix 5) resembles the theoretical unconfined aquifer curve with a recharge boundary. The open cone of depression interpreted from the pumping data also suggests that the CID aquifer is unconfined.

The early time data up to four mins of the drawdown curve show a steep decline of water level suggesting that water is released from storage within the well. Then the slope of the drawdown time curve decreases indicating that the water is released from storage within the CID aquifer to the point where the boundary of the flood plain alluvial/insitu weathered bedrock and the CID is likely to be reached. After six hours of pumping the steeper decline in drawdown (~7.5 m) to 3.5 days results from, the groundwater being obtained from the mixed storage of the CID and alluvial/insitu weathered bedrock aquifers.

The sharp decrease in the slope of drawdown at approximately three and a half days represents the boundary between the well connected alluvial/CID aquifer and the Weeli Wolli Formation. The steep slope of the curve suggests decrease in flow to the production bore for the latter part of the test. The 2 m drawdown at 262 m in the basement monitoring bore PZ08YJSW026 suggests that the water level was lowered below the Marillana Creek bed.

The Theis non-equilibrium distance drawdown equation was used to determine the extent of cone of depression or the permissible drawdown. The hydraulic parameters used in the equation were obtained from constant test pumping analysis (T=500 m2/d and S= 0.001). The equation shows that at a distance of 340 (distance Marillana creek to the production bore) the water level will be lowered by 5 m. This suggests that after 5 days of pumping the Marillana Creek surface flow will be delinked from the underlying aquifer.

Water level in PZ08YJSW026 located 262 m from the pumping bore on the northern border of the CID ore body, (Figure 3), had drawdown approximately 2 m indicating a high rate of flow from the basement to the CID aquifer.

The oxygen content of groundwater in the CID aquifer is approximately 3 mg/L throughout the five day test with a slight increase at two and a half days whereby more recharge from Marillana Creek is evident. The concentration represents well mixed shallow groundwater from the alluvium/insitu weathered bedrock and potentially surface water from Marillana Creek with the CID aquifer. The measured redox potential increases rapidly from 74 mv to 329 mv by the end of test pumping were most of the discharge water is sourced from alluvium/insitu weathered bedrock aquifer underlying Marillana creek. There is no apparent change in EC during the test pumping because the two end members (i.e. surface water from Marillana creek and groundwater of the CID and alluvium/insitu weathered bedrock) have similar EC.

A Schematic cross section showing the production and monitoring bores illustrates the relative water level and drawdown in the CID, flood plain and the Weeli Wolli Formation (Figure 13). The test pumping results and the response of the bores to the production bore suggest a reasonably well connected alluvium/insitu weathered bedrock and basement to the CID aquifer. The diagram also demonstrates the connection and influence of recharge from Marillana Creek to the CID aquifer. The results of drawdown versus time was analysed using the Theis recovery, Logan's formula and Neuman method giving an average T of 500 m^2/d. The values of T, K and Sy, using these methods are given in Appendix 4. The values for T for the CID range from 550 to 500 m^2/d adopting 500m^2/d. The values for Sy range from 0.001 to 0.1, adopting 0.01. The hydraulic conductivity, calculated by dividing the transmissivity by the 60 m aquifer thickness of the bore is 13 m/d.

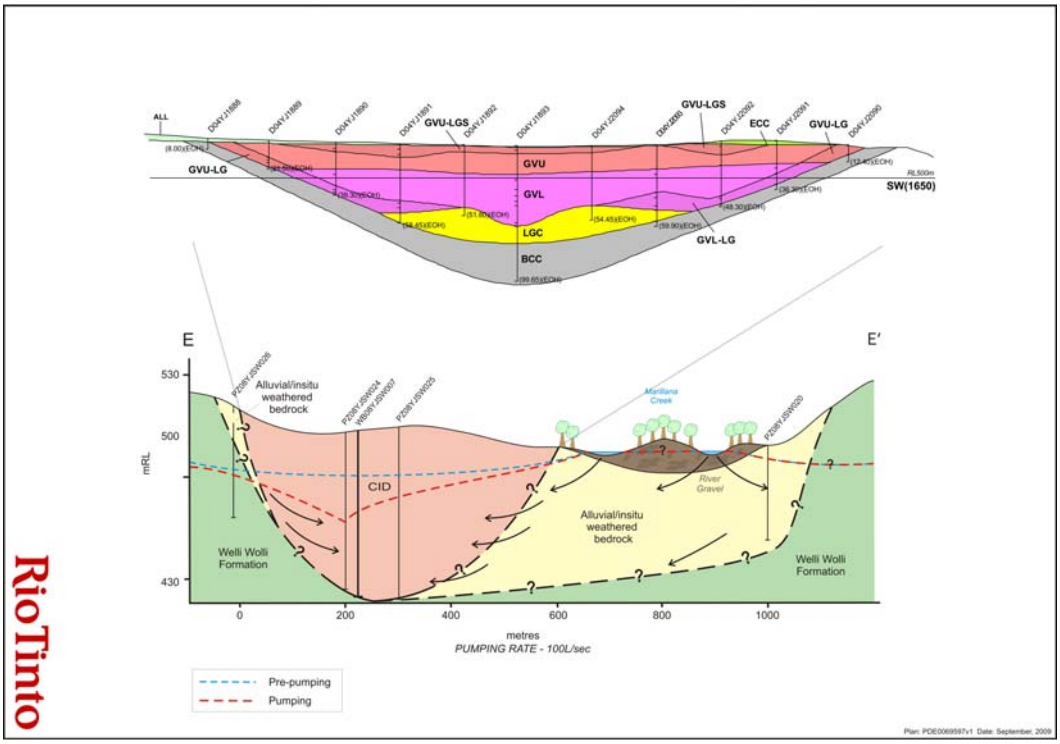

Figure 13. Schematic section across flood plain encompassing WB09YJSW007 production bore and associated monitoring bores. The geological model of CID is shown to illustrate width of CID compared to flood plain alluvium/insitu weathered bedrock.

7.3.11 WB08YJSE001

Four one hour duration step tests were conducted on bore WB08YJSE001 at discharge rates 43, 53, 65 and 80 L/sec respectively. Drawdown for the first three steps stabilised within the hour, but increasing the discharge to 80 L/sec did not stabilise and lowered the water level in the bore column to 32 m below standing water table. A constant discharge rate of 77 L/sec was selected based on the results of the step test analysis.

The apparent efficiency in production bore performance ranges from 13-21% which indicates there to be a significant component of well loss in the pumping well. The low efficiencies are likely to be the result of turbulent flow related to higher pumping rates. The step test was analysed by using Rorabaugh's equation and presented in Appendix 4.

Production bore WB08YJSE001, was pumped at 77 L/sec for five days. The groundwater level declined 32.62 m from the pre-pumping level of 25.4 mbtc to 58 mbtc. The time drawdown curve on the log-linear graph (Appendix 5) resembles the theoretical unconfined aquifer curve with a recharge boundary. The open cone of depression interpreted from the pumping data also suggests that the CID aquifer is unconfined.

At early time data up to five minutes, the water is released from storage in the water column (Appendix 5). Then the slope of drawdown versus time decreases suggesting that the water is released from storage in the CID aquifer where the drawdown is lowered by 10 m. The drawdown stabilises after five hours, indicating constant recharge into the CID by throughflow. The Production bore is located 300m down gradient from Marillana Creek crossing the CID aquifer. Therefore the constant recharge of the CID aquifer is due to the seepage from Marillana Creek to the alluvium/insitu weathered bedrock and mixing with groundwater in the

CID. This is corroborated by the increasing concentrations of dissolved oxygen in groundwater in the middle part of the curve. The higher than expected level of DO concentration during this part of the pump testing is likely to be due to the mixing between CID and shallow alluvium/insitu weathered bedrock groundwater. In the latter part of the curve where oxygen concentration stabilised at 7 mg/L resembling that of open water in equilibrium with atmosphere indicate the constant input from Marillana creek surface water into underlying CID aquifer.

The water level drawdown in the CID monitoring bores, ranged from 3.3 to 5.5 m depending on the distance from the production bore. Drawdown of 4.4 m in the monitoring bore PZ08YJSE001, located 20 m from production bore indicates relatively transmissive material and the influence of recharge from Marillana Creek surface flow. The response in the up gradient two monitoring bores PZ08YJSE003 and D03YJ1653, located between Marillana creek and the production bores are 3.3 m and 5.5 m. Unlike the down gradient monitoring bores the response of relatively more distant monitoring bore D03YJ1653 is higher (5.5 m) than the closer monitoring bore PZ08YJSE003 (3.3 m) by one fold.

The Theis non-equilibrium distance drawdown equation was used to determine the extent of cone of depression or the permissible drawdown. The hydraulic parameters used in the equation were obtained from the constant rate test pumping analysis (T=1100 m2/d and S= 0.001). The equation shows that at a distance of 430 m (the distance from Marillana Creek to the production bore) the water level will be lowered by 1.3 m. This suggests that after five days of pumping the Marillana Creek surface flow will be delinked from the underlying aquifer.

The relatively smaller drawdown in PZ08YJSE003 bore is due to the higher rate of surface flow in the adjacent Marillana creek. The monitoring bore PZ08YJSE003 is located up gradient from D05 (Yandi operation discharge site) which discharges 3000 m^3/d into the creek. The higher rate of recharge from the creek results in the higher flow into the underlying aquifer and lower response in the monitoring bore. The discharge of surplus water into Marillana Creek at DO5 will create a localised higher head down gradient with potentially higher flow into the underlying aquifer, therefore maintaining higher water levels compared to up gradient section of the CID aquifer.

A Schematic cross section showing the production and monitoring bores illustrates the water level and drawdown across the CID, alluvial/insitu weathered bedrock flood plain and Marillana Creek (Figure 14). The test pumping results and the response of the alluvium/insitu weathered bedrock bores to the production bore suggest a well connected flood plain alluvium/insitu weathered bedrock and Marillana river bed gravel to the CID aquifer. The diagram also demonstrates the connection and influence of recharge from Marillana Creek. A second schematic section was drawn along the strike of CID palaeochannel (Figure 15) illustrates the drawdown along the CID and potential recharge from the proximal Marillana Creek.

The results of drawdown versus time was analysed using the Theis recovery, Logan's formula and Neuman method giving an adopted T of 300 m^2/d The values of T, K and Sy, using these methods are given in Appendix 4. The values obtained from the Neuman method for T for the CID range from 700 to 200 m^2/d adopting1100 m^2/d. The values for Sy range from 0.5 to 0.01, adopting 0.1. The hydraulic conductivity, calculated by dividing the transmissivity by the 65 m aquifer thickness of the bore is 23 m/d.

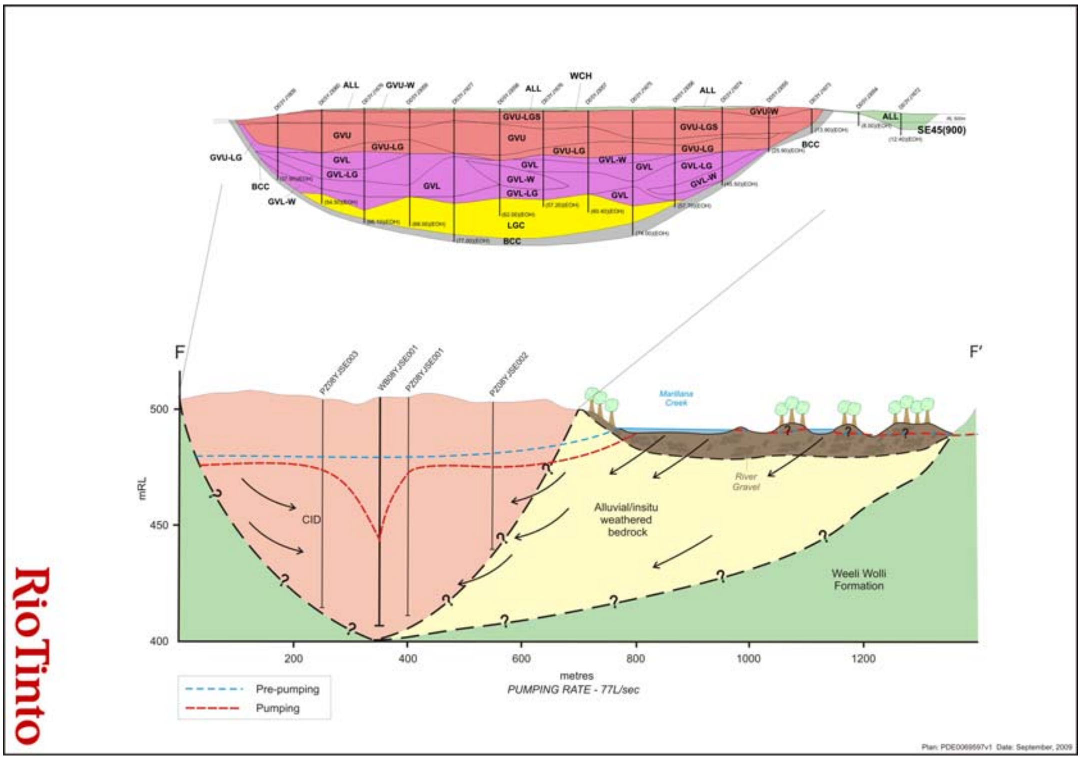

Figure 14 Schematic section across flood plain encompassing WB09YJSE001 production bore and associated monitoring bores. The geological model of CID is shown to illustrate width of CID compared to flood plain alluvium/insitu weathered bedrock.

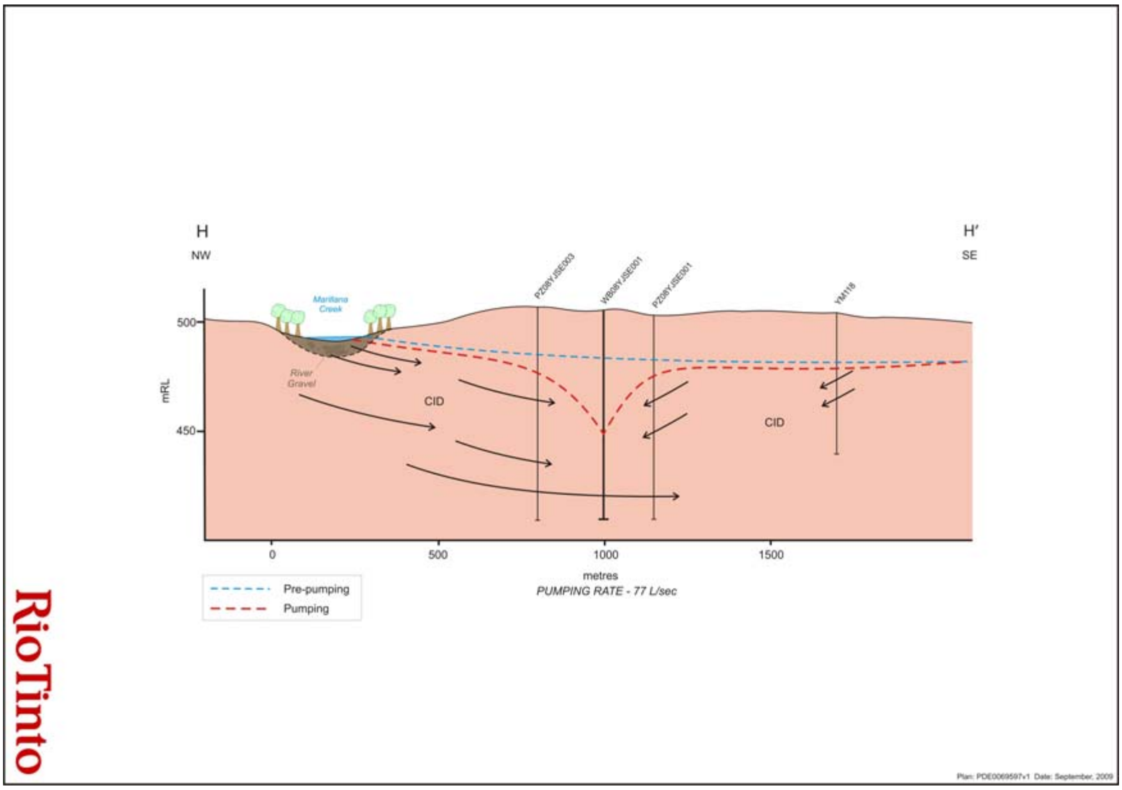

Figure 15 Schematic cross section along strike of the CID for the WB08YJSE001 test pumping.

7.3.12 WB08YJSE002

Four one hour duration step tests were conducted on the flood plain alluvial/insitu weathered bedrock testing bore WB08YJSE002 at discharge rates 5, 7, 10 and 13 down to 11 L/sec respectively. Drawdown for the first three steps stabilised within the hour, but increasing the discharge to 13 L/sec did not stabilise within the hour and had to be regulated back to 11 L/sec. With only 26 m of available drawdown, increasing the rate from 10 L/sec to 13 L/sec brought the water in the bore column down an extra 12 m to 32.7 m, close to the pump intake at 33 m. The fourth step test was therefore carried out by reducing the discharge rate to 11 L/sec. Based on the step test data, a constant discharge rate of 10 L/sec was selected.

The apparent efficiency in production bore performance ranges from 36-60% which indicates there to be a significant component of well loss in the pumping well. The low efficiencies are likely the result of turbulent flow related to higher pumping rates. The step test was analysed by using Rorabaugh's equation and presented in Appendix 4.

The flood plain alluvial testing bore WB08YJSE002, was pumped at 10 L/sec for 36 hours. The groundwater level declined 9 m from the pre-pumping level of 10.8 mbtc to 19.8 mbtc. The time drawdown curve on the log-linear graph (Appendix 5) resembles the theoretical unconfined aquifer curve with a recharge boundary. The open cone of depression interpreted from the pumping data also suggests that the CID aquifer is unconfined.

At early time data up to six minutes, water is released from storage within the bore. The drawdown curve then stabilises, indicating withdrawal of groundwater from available storage in the flood plain alluvium. At approximately 36 hours after pumping commenced the discharge rate was increased lowering the drawdown by 6.5 m with an instant response. The rapid response of the water level to higher discharge coincides with the significant increase in the concentration of dissolved oxygen in pumped groundwater (Appendix 5).

The water level drawdown in the flood plain alluvial/insitu weathered bedrock monitoring bores, ranged from 0.25 at a distance of 310 m and to 0.52 m at a distance of 75 m. The drawdown in the CID 507 m away showed response of 4 mm over the two day test. The rapid response of the alluvium bores to the discharge from production bore despite the relatively shallow bores (37m) indicates reasonable transmissive alluvial/insitu weathered bedrock material. The results of the test pumping also suggests that the boundary between alluvium/insitu weathered bedrock aquifer and Marillana Creek has not been reached probably due to low pumping rates and the distance of the Creek from the production bore. The layout of the bores and the drawdown across the alluvial/insitu weathered bedrock flood plain and the adjacent CID is shown in Figure 3.

The Theis non-equilibrium distance drawdown equation was used to determine the extent of cone of depression or the permissible drawdown. The hydraulic parameters used in the equation were obtained from constant test pumping analysis (T=700 m2/d and S= 0.01). The equation shows that at a distance of 180 (distance from alluvial bore to monitored CID bore) the water level will be lowered by 0.3 m. No apparent drawdown was observed after two days of continuous pumping of the flood plain alluvial/insitu weathered bedrock aquifer, suggesting a high hydraulic connection to the Marillana Creek 900 m away.

The concentration of dissolved oxygen is plotted against drawdown (Appendix 5). The oxygen content of groundwater in the alluvial/insitu weathered bedrock aquifer is approximately 2.8 mg/L and is constant throughout the test. Following 36 hours after pumping commenced the discharge rate was increased with an immediate response in the dissolved oxygen content to 7 mg/L. This reflects a greater influence from the shallower alluvium/insitu weathered bedrock aquifer water. This is also corroborated by an increase in the redox potential from 60 mV to 110 mV mimicking the dissolved oxygen. There is no apparent change in EC (Averaging 1100 µS/cm) during the test pumping which is reasonably higher than in the CID and the pH at 6.5 starts to increase slightly with the increase in discharge representing the influence of shallower water.

The results of drawdown versus time was analysed using the Theis recovery, Logan's formula and Neuman method giving an adopted T of 150 m^2/d The values of T, K and Sy, using these methods are given in Appendix 4. The values obtained from the Neuman method for T for the CID range from 600 to 800 m^2/d adopting 700 m^2/d. The values for Sy range from 0.01 to 0.001, adopting 0.01. The hydraulic conductivity, calculated by dividing the transmissivity by the 30 m aquifer thickness of the bore is 23 m/d.

7.4 GROUNDWATER CHEMISTRY

Water samples were collected for each bore at the end of test pumping (Appendix 2). Total Dissolved Solids (TDS) in groundwater ranges from 548 mg/L to 630 mg/L throughout the CID aquifer. Chloride concentrations for the surface water in Marillana Creek are higher than that in the CID groundwater due to evaporation. The concentration of Cl in the Marillana Creek ranges from 90 mg/l at the BHP discharge point to 140 mg/l approximately 16 km down gradient from discharge point. The Cl concentration of the groundwater analysed at the end of pumping test is slightly elevated due to the mixing with the Marillana Creek surface water. This corroborates the pumping test analysis and the dissolved oxygen concentrations showing that the groundwater is a mixture of the two end members namely surface water of Marillana Creek with average Cl concentrations of 130 m/L and CID groundwater with average Cl concentration of 85 mg/L.

7.5 BOREFIELD DESIGN

Optimum dewatering rates in the vicinity of the production bore were calculated using a source reliable output spread sheet. The number of production bores, and distances between production bores were determined. The input parameters to the model used in the spread sheet were obtained from test pumping analysis. To achieve dry mining conditions in the vicinity around each bore six months was assumed. This analysis aims to predict the impact of interference effects of adjacent production bores and subsequent drawdown. Borefields configurations were designed either in a straight line up gradient perpendicular to the channel or as clusters around the centre of the CID. The optimal design to yield maximum drawdown is a cluster bore field in the centre of palaeochannel. Here the deepest part of the channel is located in the centre of CID. The model was run for six sites to calculate the rate of pumping to achieve maximum drawdown. The modelling results indicate a cluster of five production bores will be needed to achieve required drawdown (200 m radius) from the borefield.

The calculations assume transient radial flow, laminar flow and apparent well loss and utilises the parameters obtained from the step test analysis. Assuming constant distances between the bores and using a constant discharge rate for the bore field, the interference effects are calculated using T and S derived from the test pumping analysis. Table 7 shows the recommended pumping rates for each borefield around the initial production bore. For a five cluster borefield around the initial oxbow production bore (WB09YOXB001), with the pump inlet set at 93 m below ground level, a rate of 7500 m^3/d per bore will be required to achieve maximum drawdown. The estimates obtained from this method should be considered indicative only as the equation used does not account for the increased recharge from surface water flow where interference effects may be greater than estimated. The recommended discharge rates are presented in Table 7.

Borefield	SWL (mbgl)	Pump Setting (mbgl)	Pumping Water Level (mbgl)	Recommended Rate (ML/d)
WB09YOXB001	35.2	93	90	37.5
WB08YJSW001	10.6	72	65	25
WB09YJSW004	11.8	77	75	50
WB09YJSW006	11.5	78	75	62.5
WB09YJSW007	15.7	71	69	60
WB08YJSE001	24.6	91	90	43.5

Table 7 Production Borefield optimum dewatering rates after 6 months

The optimum borefield design to dewater pits JSW-B and JSW-C on the northern side of Marillana Creek included three cluster borefields each comprising of three production bores. The three cluster borefields along the axis of palaeochannel each 600 m apart. To achieve dry mining conditions a pumping rate of 45,000 m^3/d (16.4GL/a) was calculated. The capacity of the production bores drilled in this area range from 70 – 100 L/sec. Taking a conservative pumping rate of 60L/sec, and using variable speed driven pumps the drawdown to the base of ore body can be achieved within 12 months. The abstraction volumes of 16.4 GL/a obtained from this method is comparable to the results derived from empirical modelling used for Yandicoogina Order of Magnitude study.

7.6 PROJECT COSTS

Project costs were recorded from the daily plod sheets and confirmed during project invoicing. A breakdown of major costs within the project is provided in Table 8 below. Some of the ancillary costs associated with the program such as flights, accommodation and supervision were not recorded for this report as only drilling costs were measured for an average cost per metre.

Description	**Actual Costs** (based on invoices)
Drilling	$ 640,149.00
Work time	$ 643,440.00
Standby	$ 151,072.00
Mobilisation	$ 23,625.00
Supply and deliver materials	$ 601,033.25
Muds and chemicals	$ 55,462.76
Other	$ 45,500.00
Test pumping	$ 236,000.00
Total	$ 2,396,282.01

*Note: Other includes the use of auxiliary equipment.

Table 8 Break down of the project costs.

The calculated cost per metre for the program was $621/m (3,481.1 m at $2,160,282.01). The cost per metre is high, largely due to the cost average which does not take into account the hole diameter, materials for production bores and the amount of production bores drilled. The average cost of the step and constant rate discharge tests per bore was approximately $26,000.

8. SUMMARY

This investigation comprised exploration drilling, bore construction, test pumping and hydrochemical sampling. The hydrogeological drilling programme of 34 monitoring and 10 production bores was completed throughout the expanding Yandicoogina deposits. Drilling was carried out using conventional air/percussion methods with a number of bores in unconsolidated alluvials drilled using mud/rotary techniques. Monitoring bores were constructed with 50 mm PVC, and production bores cased with 324 mm steel casing.

The test pumping results of the nine production bores along the Marillana Creek indicate a good hydraulic connection between CID and alluvium/insitu weathered bedrock aquifers. The average distance of the production bores and alluvium/insitu weathered bedrock monitoring bores installed outside the CID boundary is 250 m. Despite this considerable distance, water levels in the monitoring bores responded within two days of continuous pumping. Furthermore, the data on the drawdown versus time plot for most of the monitoring bores mimics that of the production bore suggesting similar hydraulic characteristics in the CID and alluvium/insitu weathered bedrock.

Based on the information obtained from test pumping the hydraulic properties of the CID and alluvium aquifer, and the conceptual model for the groundwater flow system underlying the flood plains of Marillana Creek was updated. The new conceptual model comprises a CID that is surrounded by relatively transmissive alluvium/insitu weathered bedrock that is in direct connection with the CID. The river gravel underlying Marillana Creek and overlying the alluvium/insitu weathered bedrock contributes a significant volume of water to the CID aquifer. The new conceptual outline of the flood plain of Marillana creek is shown in figures (5 to14). The combined width of the CID and alluvium/insitu weathered bedrock aquifers range from ~1000 to ~2000 m. The maximum depth is 110 m in the middle of the CID channel diminishing towards the flanks of the flood plain.

The updated model has important implications for the dewatering of proposed and existing pits at JSW, Oxbow and JSE. The direct contribution of Marillana Creek surface water to the CID and the relatively large storage capacity of the alluvium/insitu weathered bedrock surrounding CID indicate that drawdown in the CID aquifer during dewatering results in considerable leakage from the saturated alluvium/insitu weathered bedrock and creek bed. The prediction of the dewatering volume to achieve dry mining conditions will be accomplished by using the updated conceptual model of the flood plain to carry out groundwater modelling for the whole RTIO Yandicoogina mining area.

The results of the source reliable output suggests that borefields in clusters are more efficient than locating multiple bores perpendicular to the axes of CID aquifer. The relatively high transmissivity of the alluvium may provide opportunity to partially dewater the pits from the alluvium (i.e. ex-pit). However more drilling is required to confirm the depth of the alluvium and the hydraulic properties of the deeper sections of the alluvium aquifer. The pump testing of the shallow (37 m) bore in the alluvium/insitu weathered bedrock at JSE area has shown that this option might be possible particularly on the boundary between CID and the alluvium/insitu weathered bedrock.

The DO concentration and redox potential measured during test pumping provide valuable information on the degree of hydraulic connection and mixing of CID and alluvium/insitu weathered bedrock aquifers. The increased trend of DO concentration during most of the test pumping suggests direct contribution from Marillana Creek surface water to the underlying alluvium and CID aquifers. This was particularly evident in the two production bores immediately down gradient from Marillana Creek at WB08YJSW001 and WB08YJSE001. The distance of these bores from Marillana Creek is ~ 250 m and recharge from Marillana Creek was observed after 18 hours of pumping.

The high yield from the constant rate test pumping ranged from 60L/s up to 100 L/s suggests that the dewatering of the pits is possible with fewer bores than previously anticipated. The high end of the pumping was limited to ~ 100 L/s because of the capacity of the pump, the diameter and length of the discharge pipe. Discharge with higher rates up to 150 L/s is possible from several production bores if the discharge outlet were designed to handle higher volumes.

9. REFERENCES

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Appendix 1: Bore logs

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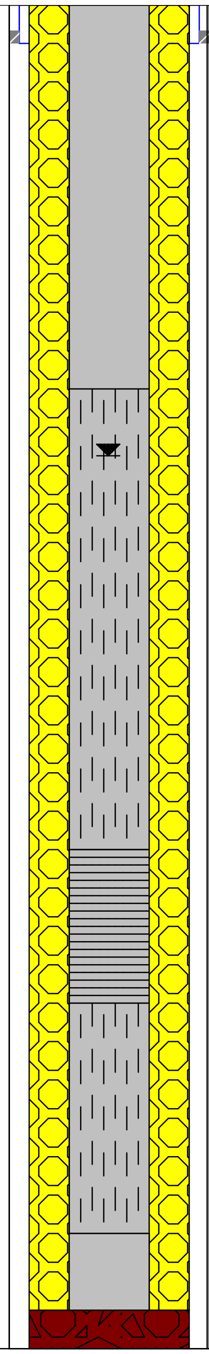
Well Completion Details - WB09YOXB001

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Oxbow	**DRILLER:** Michael Larkman	**EASTING:** 718060.63
DATE COMMENCED: 25-Mar-09	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478897.52
DATE COMPLETED: 28-Mar-09	**HYDROGEOLOGIST(s):** Niall Inverarity	**ELEVATION:** 551.54 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-3 m, 17.5 inch air/hammer 3-105 m.

Depth (mbgl)	Geology	Lithological Description	Field Notes
0 - 12	CID	ECC: Light brown, moderately hard laterite. Vitreous goethite matrix clast supported. Denatured CID, angular clasts with limonitic goethite. Minor clay present.	
12 - 16	CID	ECC: White/yellow clay, mottled, soft with limonitic clay present.	
16 - 38	CID	GVU: Dark grey/brown, angular to subangular, hard vitreous goethite matrix with clast supported hematite goethite peloids. Minor limonitic goethite.	Gravel 44 x 500 kg bags. Intial WL 35.22 mbtoc (2/04/09)
38 - 64	CID	GVL: Dark grey/brown angular to subangular CID. Limonitic goethite matrix with clast supported hematite/goethite peloids. Minor white clay present.	Airlift (after construction) 20 L/s after 4 hrs.
64 - 82	CID	LGC: Yellow /grey hard, angular to subangular denatured CID. Moderately hard, subangular limonite and vitreous goethite. Minor limonitic clays present.	Field chemistry: pH = 7.96, EC = 884 uS/cm, temp = 26.6 C.
82 - 98	CID	BCC: Grey brown angular to subangular hard, CID, BIF and silica. Limonitic clay present.	
98 - 105	WW Fm	WW: Brown/grey, hard angular BIF and chert. Some jasperitic BIF present with minor shale.	

Well Design



Well Construction

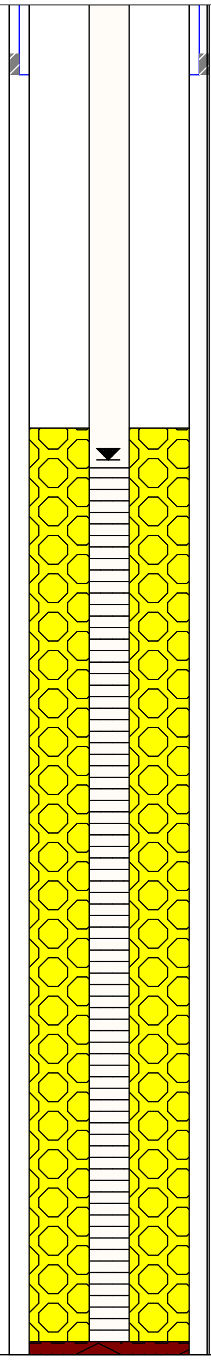
- +0.1 - 3 m Steel 508 mm (OD) collar cemented
- +0.2 - 30 m, 324 mm (OD), 305 (ID) steel blank casing
- 0 - 102 m Gravel pack (graded 3.2-6.4 mm)
- 30 - 66 m, 324 mm (OD), 305 mm (ID) steel slotted casing, 3 mm aperture.
- 66 - 78 m, 324 mm (OD), 305 mm (ID) stainless steel screen casing
- 78 - 96 m, 324 mm (OD), 305 mm (ID) steel slotted casing, 3 mm aperture.
- 96- 102 m, 324 mm (OD), 305 mm (ID) steel blank casing
- 102 - 105 m Natural packing

Well Completion Details - PZ08YOXB001

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Oxbow	**DRILLER:** Andrew McInerney	**EASTING:** 718053.0
DATE COMMENCED: 8-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478883.22
DATE COMPLETED: 9-Sept-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 551.52 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-102m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 – 6	ALL		ALLUVIUM: Light earthy brown, hardcap of CID and denatured ferricrete. Vitreous clasts with minor limonitic coating. Hydrated, CID, texture denatured, angular clasts. Minor clays at the base of the unit.			+0.7 - 5.3 m Steel 219 mm (8") collar cemented
6 – 12	CID					
12 – 18	CID		ECC: Yellow, cream, brown, mottled, massive soft to medium clay. Minor hard, angular, hardcap chips			+0.5 - 35 m, Cl12, 50 mm PVC blank casing
18 – 44	CID		WCH: Weathered, light brown CID with some denatured chips. Limonitic and soft white clay. Hydrated with some silicified samples. Pisolites present with limonitic coating, subrounded to angular clasts.			
			GVU: Red earthy brown, hard rounded to subrounded hematite goethite peloids in a vitreous goethite matrix. Clast supported. Size range from fine sand to pebble. Minor clays present.	Intial WL 34.4 mbtoc (12/9/08)		
44 – 68	CID		GVL: Yellow/brown, rounded to subrounded peloids in a vitreous, limonitic goethite matrix. Soft to stiff limonitic clay present. Minor fossil wood and pisolites with silica.	Field chemistry: pH = 7.95, EC = 1005 uS/cm, temp = 23.9 C.		35 - 101 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
68 – 92	CID		LGC: Yellow/brown, hard limonitie and vitreous goethite. With CID becoming denatured with limonitic clay zones.	Gravel 8 x 500 kg bags Airlift of bore 20 L/s.		32 - 101 m Gravel pack (graded 3.2-6.4 mm)
92 – 102	CID		BCC: Grey/brown, hard, angular, vitreous goethite and chert.			101-102 m Natural packing



Depth scale (mbgl): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

Well Completion Details - PZ08YOXB002

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Oxbow	**DRILLER:** Andrew McInerney	**EASTING:** 718054.74
DATE COMMENCED: 9-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478820.39
DATE COMPLETED: 11-Sept-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 550.55 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-102m.

Geology	Lithological Description
ALL	ALLUVIUM: Yellow to red brown. lateritic, hard, angular massive ferricrete. Minor CID, pisolites present.
CID	ECC: Mottled clay zone, yellow to white clays, soft to moderately stiff.
CID	WCH: Red brown small hard angular to subangular chips of hydrated CID. Minor white clays, silicified in hydrated zones.
CID	GVU: Brown, hard angular chips of rounded to subrounded peloids in a vitreous goethite matrix. Minor limonitic clays throughout.
CID	GVL: Brown subrounded peloids of goethite and hematite in a vitreous limonitic goethite matrix. Sizing from fine sand to fine gravel. Minor clays and fossil wood throughout. Clay pod at 58 m.
CID	LGC: Yellow grey, hard limonite and goethite. Hard to medium stiff limonitic clay. Denatured CID and vitreous goethite chips. Minor silica.
CID	BCC: Yellow brown, hard, angular chert, vitreous goethite. Subrounded clasts of sand to pebble in size. Clay throughout.
WW Fm	WW: Grey, hard, fresh BIF, chert and silica. Subangular to subrounded, becoming fresher with depth.

Depth (mbgl): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

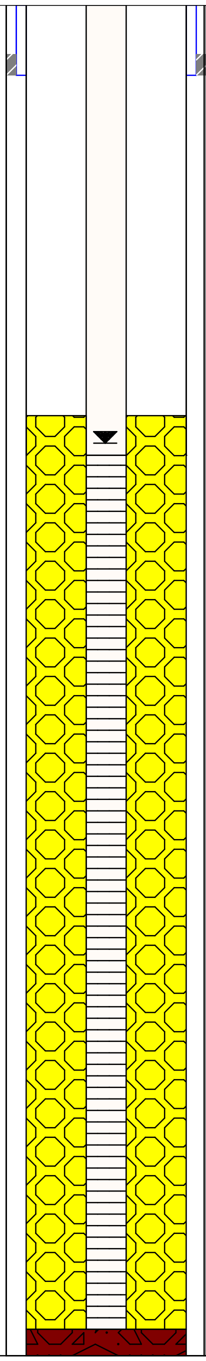
Field Notes

Intial WL 33.08 mbtoc (12/9/08)

Field chemistry: pH = 7.92, EC = 940 uS/cm, temp = 26.8 C.

Airlift of bore 18.8 L/s.

Well Design



Well Construction

+0.7 - 5.3 m Steel 219 mm (8") collar cemented

+0.5 - 34 m, Cl12, 50 mm PVC blank casing

34 - 100 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture

31 - 100 m Gravel pack (graded 3.2-6.4 mm)

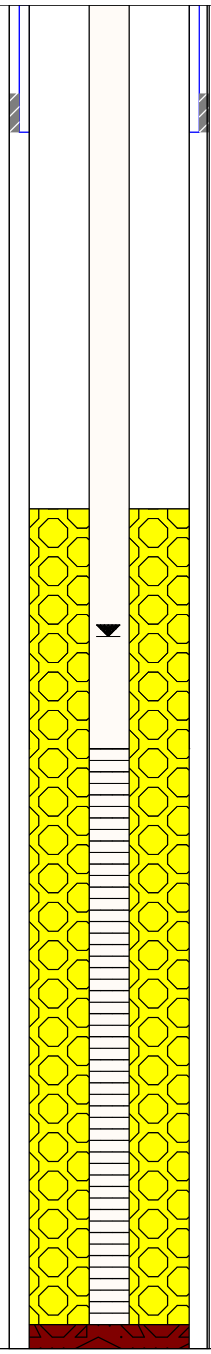
100-102 m Natural packing

Well Completion Details - PZ08YOXB003

HOLE DETAILS	**DRILLING DETAILS**	**LOCATION**
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Oxbow	**DRILLER:** Ross Pendelbury	**EASTING:** 718308.08
DATE COMMENCED: 11-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478846.6
DATE COMPLETED: 12-Sept-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 544.45 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-56m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 – 8	ALL		ALLUVIUM: Light brown, weathered BIF, pisolites and soft red clay. Rounded and magnetic BIF, Pisolites.			+0.7 - 5.3 m Steel 219 mm (8") collar cemented
8 – 14	ALL		BIF WITH INTERBEDDED SHALE: Red/brown, angular to subangular BIF. Red, white and yellow clay present. Minor siliceous and vitreous material present.			
14 – 18	ALL		CLAY AND SILT: White and yellow clay. Minor angular brown BIF.	Airlift of bore dry.		+0.5 - 31 m, Cl12, 50 mm PVC blank casing
18 – 30	ALL		BIF: Red, brown, grey fine grained laminated BIF. Minor shale.	Intial WL 26.32 mbtoc (14/9/08)		
30 – 56	ALL		CLAY AND SILT: White and red clay with minor opaque chert and BIF.	Field chemistry: dry bore on drilling.		31 - 55 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture 21 - 55 m Gravel pack (graded 3.2-6.4 mm) 55-56 m Natural packing



RioTinto

Well Completion Details - PZ08YOXB004

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Oxbow	**DRILLER:** Ross Pendelbury	**EASTING:** 718787.55
DATE COMMENCED: 12-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7477936.88
DATE COMPLETED: 14-Sept-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 545.58 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-104m.

Depth (mbgl): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

Geology	Lithological Description
ALL	ALLUVIUM: Red brown angular to subrounded, siliceous chert. Minor hematite and pisolites.
CID	WCH: Yellow white clay. Some angular to subRounded CID material and red shale.
CID	GVU: Dark red brown angular hematite goethite peloids in a vitreous goethite matrix. Minor yellow clay.
CID	GVL: Dark grey subangular, hard, hematite goethite peloids in a vitreous limonitic goethite matrix. Minor soft red and yellow shale.
CID	LGC: Yellow, red and white clay. Vuggy vitreous material, grey CID. Minor siliceous material.
CID	BCC: Red/ grey subrounded to rounded, siliceous material. Soft, red, white and yellow clay.
WW Fr	WW: Blue/grey, angular to subangular chert opaque. White and green shale/clay.

Field Notes

- Gravel 12 x 500 kg bags
- Intial WL 25.06 mbtoc (16/9/08)
- Field chemistry: pH = 7.84, EC = 671 uS/cm, temp = 24.7 C.
- Airlift of bore 10.9 L/s.

Well Design

Well Construction

- +0.7 - 5.3 m Steel 219 mm (8") collar cemented
- +0.5 - 29 m, Cl12, 50 mm PVC blank casing
- 29 - 101 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
- 29 - 101 m Gravel pack (graded 3.2-6.4 mm)
- 101-104 m Natural packing

RioTinto

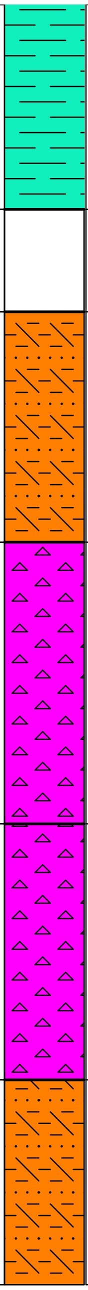
Well Completion Details - PZ08YOXB005

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Oxbow	**DRILLER:** Ross Pendelbury	**EASTING:** 718513.86
DATE COMMENCED: 14-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7477669.84
DATE COMPLETED: 17-Sept-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 547.85 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-11.3m, 7&7/8 inch hammer 11.3-50m.

Depth (mbgl): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

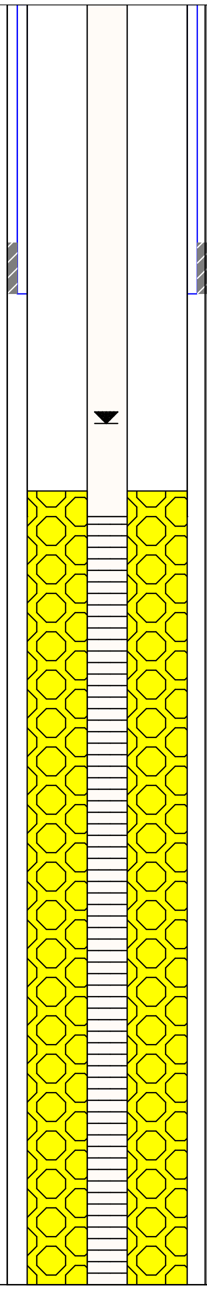
Geology	Lithological Description
ALL	ALLUVIUM: BIF, reg/grey, sub rounded. Some pisolite material, magnetic. Green/grey chert, opaque, sub angular. Minor red shale. Loose material.
No Sample	NO SAMPLE: No sample as collar blew out due to loose material or cavity.
ALL	BIF: Red/grey BIF, sub angular chips. Minor yellow brown clay. Green chert band from 14-16m.
WW Fm	CHERT: Grey, opaque chert with rare green chert, sub angular. BIF, blue/grey/red. Light brown clay.
WW Fm	CHERT: Grey/green/white chert. Minor red and orange shale. Minor red/grey BIF. Red siliceous shale from 38-40m. Minor orange clay 40-42m.
WW Fm	BIF: Dark grey, siliceous fresh BIF. Red BIF. Grey/white chert. Minor red siliceous shale and grey/green shale.



Field Notes

- Intial WL 16.36 mbtoc (18/9/08)
- Airlift of bore 0.4 L/s.
- Field chemistry: pH = 8.49, EC = 992 uS/cm, temp = 25.7 C.

Well Design



Well Construction

- +0.7 - 11.3 m Steel 219 mm (8") collar cemented
- +0.5 - 20 m, Cl12, 50 mm PVC blank casing
- 20 - 50 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
- 19 -50 m Gravel pack (graded 3.2-6.4 mm)

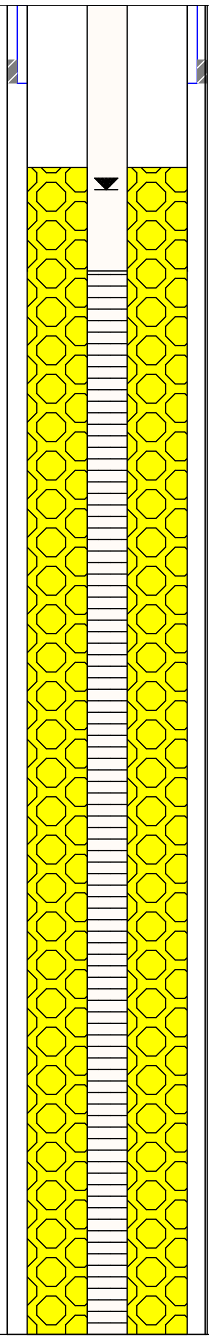
Well Completion Details - PZ08YOXB006

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Oxbow	**DRILLER:** Andrew McInerney	**EASTING:** 719936.45
DATE COMMENCED: 5-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478158.04
DATE COMPLETED: 7-Sept-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 534.15 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-90m.

Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0–2	ALL	ALLUVIUM: Large 20 mm clasts of BIF and CID. BIF is bedded partly mineralised. Minor pisolites		+0.7 - 5.3 m Steel 252 mm (10") collar cemented
2–8	CID	WCH: Some BIF clasts from the alluvial unit above. Hydrated massive vitreous clasts. Minor clays present		
8–26	CID	GVU: Clast supported hematite peliods ranging in size from sand to pebble. Minor limonitic clays with a clay pod at 14 - 18 m	Intial WL 12.5 mbtoc (9/9/08) Airlift of bore 11.9 L/s.	+0.5 - 18 m, Cl12, 50 mm PVC blank casing
26–63	CID	GVL: Limonitic and hematitic peloids, clast supported ranging in size from fine sand to very coarse sand size. Vitreous goethite matrix. Minor clays present	Field chemistry: pH = 7.88, EC = 871 uS/cm, temp = 25.4 C.	18 - 90 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
63–68	CID	LGC: Goethite and limonitic coated clasts with the CID structure denatured.	Gravel 9 x 500 kg bags	
68–74	CID	BCC: Cream colour clays with minor CID denatured clasts.		
74–90	WW Fm	WW: Fresh BIF, hard and fine grained with micro bedding. Some minor shale present.		11 - 90 m Gravel pack (graded 3.2-6.4 mm)

Well Design



Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90

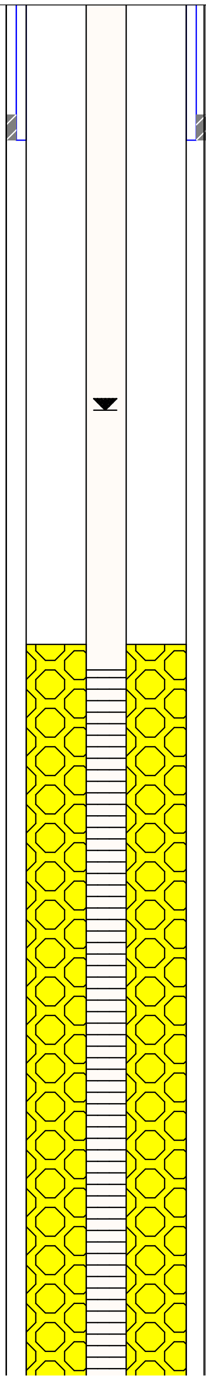
Rio Tinto

Well Completion Details - PZ08YOXB007

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Oxbow	**DRILLER:** Andrew McInerney	**EASTING:** 720681.42
DATE COMMENCED: 17-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7477776.62
DATE COMPLETED: 19-Sept-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 538.33 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-56m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0	ALL		ALLUVIUM: Bedded, fine grained, hard chips. Some rounded pisolites and minor limonitic goethite.			
5	ALL		ALLUVIUM: Clay soft with minor pisolites.			+0.7 - 5.3 m Steel 219 mm (8") collar cemented
	ALL		ALLUVIUM: Moderately soft clay, denatured CID and bedded, hard, angular BIF			
10	CID		GVU: Hematite goethite peloids with a clast supported matrix. Moderately soft soil and clay.			
15				Intial WL 15.85 mbtoc (20/9/08)		+0.5 - 26 m, Cl12, 50 mm PVC blank casing
25				Gravel 3 x 500 kg bags		26 - 56 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
30	CID		GVL: Small soil fragments and CID, unconsolidated.			
				Airlift of bore 0.76 L/s.		
35	CID		BCC: Yellow clay, chert and BIF with some minor silica fragments present.			
40				Field chemistry: pH = 8.04, EC = 1106 uS/cm, temp = 26.0 C.		25 -56 m Gravel pack (graded 3.2-6.4 mm)
45						
50						



Well Completion Details - WB08YJSW001

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 23-Nov-08
DATE COMPLETED: 30-Nov-08

DRILLING DETAILS

DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Lee Martin
DRILLING METHOD: Air/Hammer
HYDROGEOLOGIST(s): Glenn Kirkpatrick

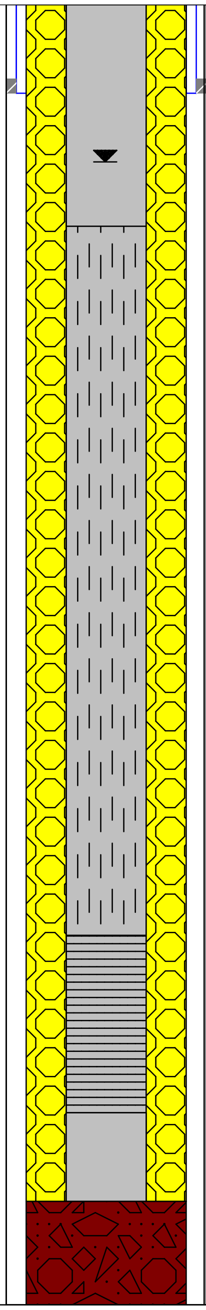
LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 731867.37
NORTHING: 7478031.14
ELEVATION: 499.46 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-6 m, 17.5 inch air/hammer 6-88 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes
0–8	ALL		ALLUVIUM: Light red brown, hard, sub rounded BIF, CID and pisolites. Chip size ranges from fine sand to pebble in size.	
8–28	CID		GVU: Red brown, vitreous goethite matrix with clast supported hematite goethite peloids. Hard, sub angular with minor clay throughout.	Intial WL 10.65 mbtoc (18/11/08)
28–50	CID		GVL: Yellow to red brown. Hard, angular hematite goethite peloids in a vitreous goethite and limonitic goethite matrix, clast supported. Limonitic and white clay throughout.	Gravel 30 x 500 kg bags Airlift of bore after construction 31 L/s. Airlift conducted for 5.5 hrs.
50–68	CID		LGC: Yellow/grey hard limonite and goethite, denatured in places. Limonitic clay present.	
68–78	CID		BCC: Grey/red, sub rounded, hard, BIF, limonitic clay, shale and vitreous goethite present. Minor pisolites.	Field chemistry: pH = 8.02, EC = 995 uS/cm, temp = 23.4 C.
78–88	WW Fm		WW: Grey, fresh, hard, angular, medium grained dolerite. Yellow/white clay present with some jasperitic BIF.	

Well Design



Well Construction

- +0.1 - 5.9 m Steel 508 mm (20") collar cemented
- +0.2 - 15 m, 324 mm (12") steel blank casing
- 15 - 63 m, 324 mm (12") steel slotted casing, 3 mm aperture, 9.2 mm wall thickness
- 0 to 81 m graded gravel (3.2 to 6.4 mm)
- 63 - 75 m, 324 mm (12") stainless steel screen casing
- 75 - 81 m, 324 mm (12") steel blank casing
- 81 - 88 m Natural packing

Well Completion Details - WB08YJSW002

RioTinto

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Lee Martin/Shaun McGinley	**EASTING:** 722354.82
DATE COMMENCED: 5-Nov-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478542.66
DATE COMPLETED: 14-Nov-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 539.14 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-6 m, 17.5 inch air/hammer 6-90 m.

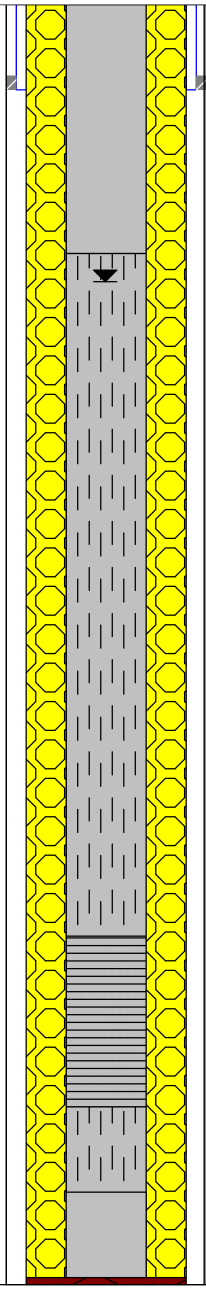
Depth (mbgl): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90

Geology	Lithological Description
ALL	ALLUVIUM: Yellow brown, hard BIF, hydrated CID, vitreous, pisolitic with limonitic clay.
CID	ALLUVIUM: Cream/white clay and laterised, hydrated BIF.
CID	GVU: Grey vitreous goethite matrix with clast supported hematite goethite peloids. Hard, subangular with minor yellow/cream clay throughout.
CID	GVL: Yellow to grey, hard, angular hematite goethite peloids in a vitreous / limonitic goethite matrix.
CID	LGC: Yellow /grey, hard limonitie and goethite, denatured in places. Limonitic clay present.
CID	BCC: Yellow/grey, subangular, hard, BIF and chert. Limonitic clay and CID present.
WW Fm	WW: Grey/Brown, fresh, hard, angular, BIF and chert. Shale and clay present.

Field Notes

- Intial WL 19.49 mbtoc (19/11/08)
- Gravel 32 x 500 kg bags
- Airlift of bore after construction 37 L/s. Airlifted for 4hrs.
- Field chemistry: pH = 7.86, EC = 948 uS/cm, temp = 25.6 C.

Well Design



Well Construction

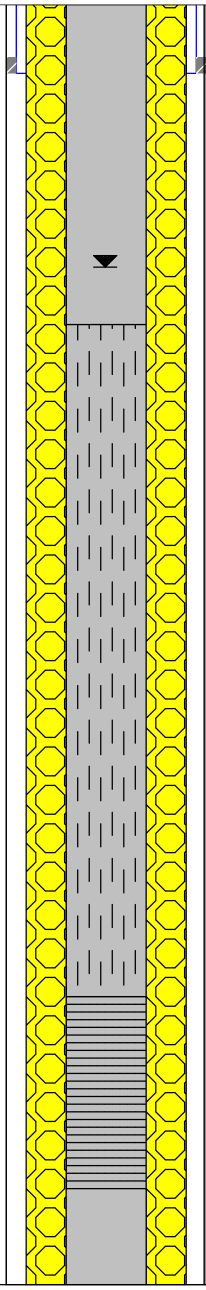
- +0.1 - 5.9 m Steel 508 mm (20") collar cemented
- +0.2 - 17.5 m, 324 mm (12") steel blank casing
- 17.5 - 65.5 m, 324 mm (12") steel slotted casing, 3 mm aperture, 9.2 mm wall thickness
- 0 to 89.5 m graded gravel (3.2 to 6.4 mm)
- 65.5 - 77.5 m, 324 mm (12") stainless steel screen casing
- 77.5 - 83.5 m, 324 mm (12") steel slotted casing, 3 mm aperture, 9.2 mm wall thickness
- 83.5 - 89.5 m, 324 mm (12") steel blank casing
- 89.5 - 90 m Natural packing

Well Completion Details - WB08YJSW005

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Lee Martin/Shaun McGinley	**EASTING:** 723985.37
DATE COMMENCED: 14-Nov-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478756.92
DATE COMPLETED: 23-Nov-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 533.4 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-4.3 m, 17.5 inch air/hammer 4.3-80 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 - 6	CID		ECC: Brown, lateritic, hard, angular to subangular limonitic and vitreous goethite. Minor stiff red clay present, hydrated CID, porus.			+0.1 - 4.3 m Steel 508 mm (20") collar cemented
6 - 26	CID		GVU: Red brown, hard, angular, hematite goethite peloids in a vitreous goethite matrix, clast supported. White soft clay present throughout. Fe-staining on hydrated and fracture surfaces. Minor hard limonitic clay.	Intial WL 16.41 mbtoc (24/11/08)		+0.2 - 20 m, 324 mm (OD), 305 (ID) steel blank casing
26 - 56	CID		GVL: Yellow to grey, hard, angular hematite goethite peloids in a vitreous/limonitic goethite matrix, clast supported. Limonitic and white clay throughout.	Gravel 36 x 500 kg bags. Airlift of bore after construction 31 L/s. 4 hrs airlift		20 - 62 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture.
56 - 72	CID		LGC: Yellow /grey hard, denatured CID. Moderately hard, subangular limonite and vitreous goethite. Soft to hard limonitic clay present. Minor stiff white clays present.	Field chemistry: pH = 7.82, EC = 1007 uS/cm, temp = 24.1 C.		62 - 74 m, 324 mm (OD) stainless steel screen casing
72 - 80	CID		BCC: Yellow/brown, angular to subangular, hard, BIF and chert. Clay matrix, yellow clay pod at 76 m.			74 - 80 m, 324 mm (OD) steel blank casing



Well Completion Details - WB09YJSW003

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 19-Mar-09
DATE COMPLETED: 23-Mar-09

DRILLING DETAILS

DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Michael Larkman
DRILLING METHOD: Air/Hammer
HYDROGEOLOGIST(s): Niall Inverarity

LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 723778.16
NORTHING: 7478714.39
ELEVATION: 531.26 mRL (TOC)

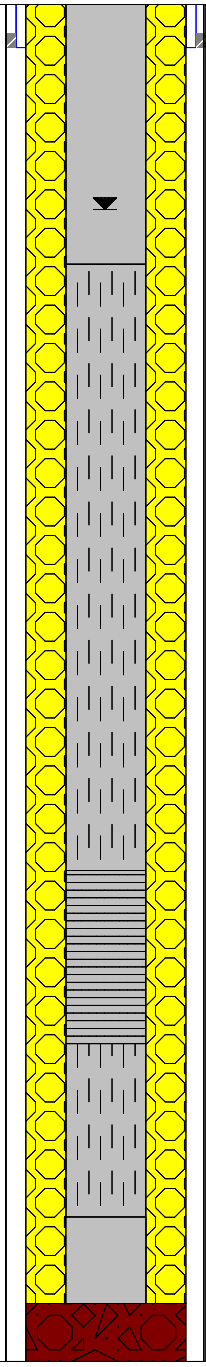
Well Notes: Hole diameter 24 inch air/roller 0-3 m, 17.5 inch air/hammer 3-94m.

Depth (mbgl)	Geology	Lithology	Lithological Description
0 – 6	ECC		ECC: Red brown to grey cemented pisolites, clay and shale. Hard, angular limontic goethite and earthy goethite.
6 – 38	CID		GVU: Dark grey hard vitreous goethite matrix with hematite peloids. Some limonitic goethite with occasional white clay.
38 – 60	CID		GVL: Dark grey and yellow vitreous goethite matrix, with hematite peloids. Prominant limonitic goethite, with white clay present throughout.
60 – 78	CID		LGC: Yellow light grey limonitic goethite matrix with hematite and goethite clasts. White clay throughout.
78 – 86	CID		BCC: Dark brown grey, angular to sub angular clasts and pisolites. Clay throughout with vitreous and earthy goethite.
86 – 94	WW Fm		WW: Dark light grey medium grained dolerite.

Field Notes

- Intial WL 14.21 mbtoc (28/03/09)
- Gravel 38 x 500kg bags
- Airlift of bore after construction 34.6 L/s. 8 hrs airlifting. V-notch eroded away during airlifting yields still rising.
- Field chemistry: pH = 7.67, EC = 767 uS/cm, temp = 26.2 C.

Well Design



Well Construction

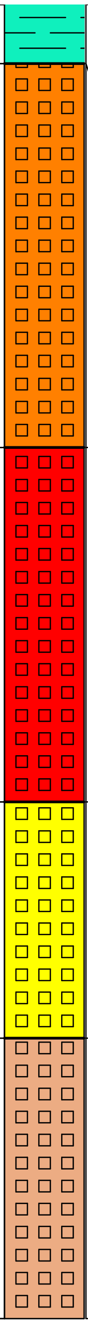
- +0.1 - 3 m Steel 508 mm (20") collar cemented
- +0.2 - 18 m, 324 mm (OD), 305 (ID) steel blank casing
- 18 - 60 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture.
- 60 - 72 m, 324 mm (OD), stainless steel screen casing
- 72 - 84 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture.
- 84 - 90 m, 324 mm (12") steel blank casing
- 90 - 94 m Natural Packing

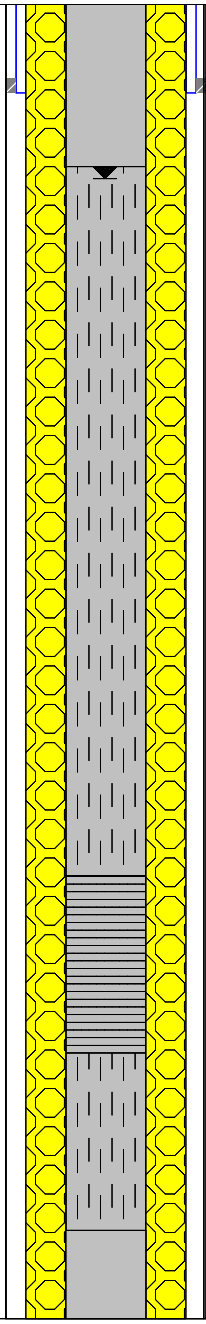
Well Completion Details - WB09YJSW004

RioTinto

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Richard Attard	**EASTING:** 723915.21
DATE COMMENCED: 8-Mar-09	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478816.72
DATE COMPLETED: 16-Mar-09	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 528.94 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-6 m, 17.5 inch air/hammer 6-89m.





Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0–4	ALL	ALLUVIUM: Light brown, hard, angular to subangular silty soil,clay, limonitic goethite, hematite and hydrated CID.		+0.1 - 5.9 m Steel 508 mm (20") collar cemented
4–30	CID	GVU: Brown, hard, angular hematite goethite peloids in a vitreous goethite matrix. Clast supported with limonitic clay present throughout.	Intial WL 11.81 mbtoc (19/03/09)	+0.2 - 11 m, 324 mm (12") steel blank casing 11 - 59 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture.
30–54	CID	GVL: Yellow brown, had angular chips of hematite and goethite in a vitreous/limonitic goethite matrix. Limonitic and white clay present throughout. Limonitic clay pod through 30 -34m	Gravel 34 x 500 kg bags Airlift of bore after construction 34 L/s. 4 hrs airlifting	
54–70	CID	LGC: Yellow light grey limonitic goethite matrix with hematite and goethite clasts. Denatured CID, with white clay throughout.		59 - 71 m, 324 mm (12") stainless steel screen casing
70–89	CID	BCC: Dark brown to yellow brown, angular to subangular clasts, limonite and pisolites. Clay throughout with vitreous goethite.	Field chemistry: pH = 7.75, EC = 762 uS/cm, temp = 26 C. 78 m recovering gravel from 7 m away obs bore.	71 - 83 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture. 83 - 89 m, 324 mm (12") steel blank casing

Well Completion Details - WB09YJSW006

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 5-April-09
DATE COMPLETED: 13-April-09

DRILLING DETAILS

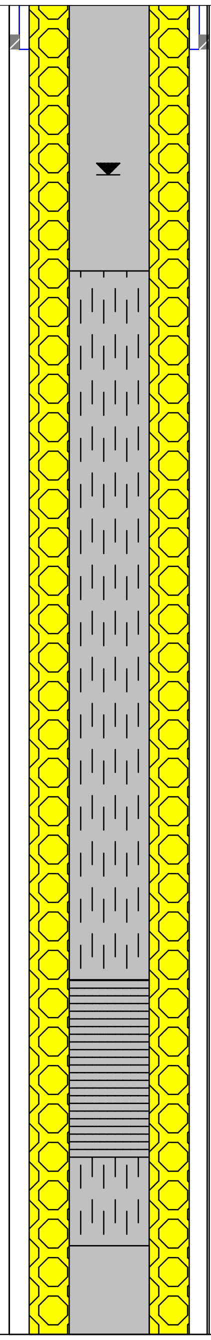
DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Richad Attard
DRILLING METHOD: Air/Hammer
HYDROGEOLOGIST(s): Niall Inveraity

LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 724585.99
NORTHING: 7479685.17
ELEVATION: 524.16 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-3 m, 17.5 inch air/hammer 6-90 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 – 30	CID		GVU: Brown/grey, hard, angular, hematite - goethite peliods in a vitreous goethite matrix, clast supported. Minor clay present.	Intial WL 11.49 mbtoc (14/04/09)		+0.1 - 3 m Steel 508 mm (20") collar cemented +0.2 - 18 m, 324 mm (12") steel blank casing 18 - 66 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture. 0 - 90 m graded gravel 3.2 mm to 6.5 mm
30 – 54	CID		GVL: Yellow to grey. Hard, angular hematite goethite peloids in a vitreous goethite and limonitic goethite matrix, clast supported. Limonitic and white clay throughout.	Gravel 41 x 500 kg bags. Airlift of bore after construction 35 L/s. Airlifted for 5.5 hrs.		
54 – 72	CID		LGC: Yellow /grey hard, denatured CID. Moderately hard, subangular limonite and vitreous goethite. Minor stiff white clays present.			66 - 78 m, 324 mm (12") stainless steel screen casing
72 – 90	CID		BCC: Yellow/brown, angular to subangular, hard, BIF and chert. Clay matrix.	Field chemistry: pH = 7.74, EC = 670 uS/cm, temp = 24.9 C.		78 - 84 m, 324 mm (OD) 305 (ID) steel slotted casing, 3 mm aperture. 84 - 90 m, 324 mm (12") steel blank casing



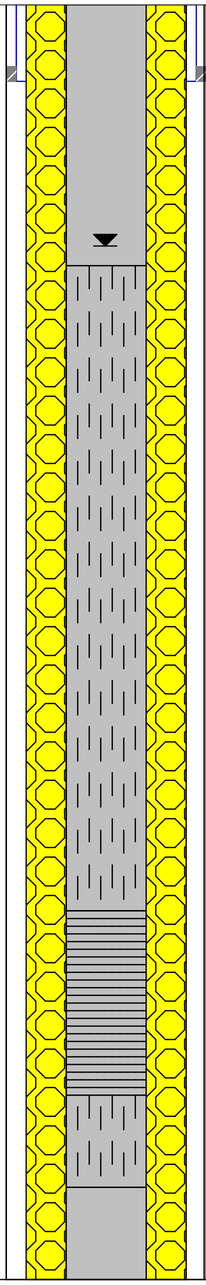
Well Completion Details - WB09YJSW007

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Michael Larkman	**EASTING:** 724816.54
DATE COMMENCED: 29-Mar-09	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7480321.78
DATE COMPLETED: 2-April-09	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 524.06 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-5 m, 17.5 inch air/hammer 5-83 m.

Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0 - 2	ALL	ALLUVIUM: Soil unconsolidated, hematitic CID, pisolites and BIF scree. Angular to subrounded.		+0.1 - 5 m Steel 508 mm (20") collar cemented
2 - 24	CID	GVU: Red Brown, hard, angular, hematite - goethite peliods in a vitreous goethite matrix, clast supported. Minor clay present.	Intial WL 15.72 mbtoc (6/04/09)	+0.2 - 17 m, 324 mm (12") steel blank casing; 17 - 59 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture.
24 - 49	CID	GVL: Yellow to grey. Hard, angular to subangular hematite goethite peloids in a vitreous goethite and limonitic goethite matrix, clast supported. Limonitic and white clay throughout.	Gravel 33 x 500 kg bags. Airlift of bore after construction 39 L/s. Airlifted 8.5 hrs.	
49 - 65	CID	LGC: Yellow /grey hard, denatured CID. Moderately hard, subangular limonite and vitreous goethite. Minor limonitic clays present.		59 - 71 m, 324 mm (12") stainless steel screen casing
65 - 83	CID	BCC: Yellow/brown, angular to subangular, hard, BIF, pisolites and chert. Clay matrix. Minor quartz present.	Field chemistry: pH = 8.44, EC = 841 uS/cm, temp = 25.3 C.	71 - 77 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture. 77 - 83 m, 324 mm (12") steel blank casing

Well Design



Well Completion Details - PZ08YJSW001

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 21-Sept-08
DATE COMPLETED: 22-Sept-08

DRILLING DETAILS

DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Shaun McGinley
DRILLING METHOD: Air/Hammer
HYDROGEOLOGIST(s): Glenn Kirkpatrick

LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 721690.89
NORTHING: 7478156.28
ELEVATION: 531.82 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-77 m.

Depth (mbgl)	Geology	Lithological Description
0 – 24	CID	GVU: GVU - Hard hematite goethite peloids clast supported vitreous matrix. Minor Moderate stiff clay, fossil wood, pisolites and limonite.
24 – 36	CID	GVL: GVL - hematite goethite peloids in a vitreous/limonitic goethite matrix.
36 – 40	CID	LGC: LGC - Denatured CID limonite and goethite, pitted with minor clay present. Some opaline silica
40 – 54	CID	BCC: BCC - Vitreous goethite with minor silica and red chert. White clay at the base of the unit.
54 – 65	CID	BCC: Unconsolidated soft clay
65 – 71	WW Fm	WW: Stiff consolidated clay and altered basement (dolertie)
71 – 77	WW Fm	WW: Medium grained fresh basement

Field Notes

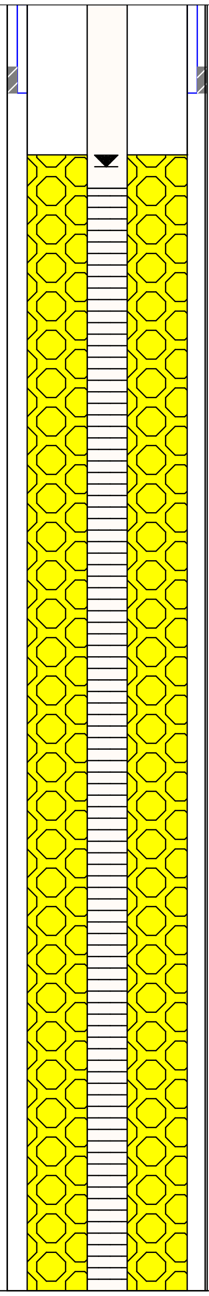
Intial WL 9.71 mbtoc (28/9/08)

Airlift of bore 2 L/s.

Field chemistry: pH = 8.24, EC = 875 uS/cm, temp = 23.8 C.

Gravel 4 x 500 kg bags

Well Design



Well Construction

+0.7 - 5.3 m Steel 219 mm (8") collar cemented

+0.5 - 11 m, Cl12, 50 mm PVC blank casing

11 - 77 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture

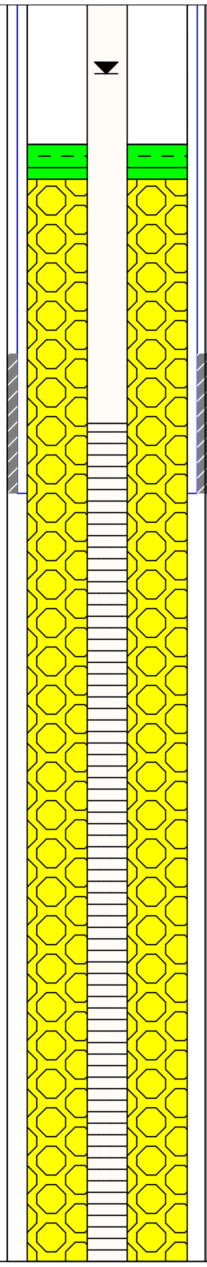
9 - 77 m Gravel pack (graded 3.2-6.4 mm)

Well Completion Details - PZ08YJSW002

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Shaun McGinley	**EASTING:** 721667.81
DATE COMMENCED: 8-Dec-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478289.94
DATE COMPLETED: 17-Dec-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 525.96 mRL (TOC)

Well Notes: Hole diameter 12 inch mud/rotary 0-28m, 6 inch mud/rotary 28-72 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 – 4	ALL		ALLUVIUM: Coarse to very coarse gravel and pebbles. Weathered BIF, chert and CID	Intial WL 3.96 mbtoc (22/1/09)		+0.1 - 28 m Steel 219 mm (8") collar cemented
4 – 14	ALL		ALLUVIUM: Clay present throughtout. Pisolites also present.	Attempted to drill air/hammer, unsuccessful (ground did not hold up)		Bentonite Seal
14 – 26	CID		GVU: GVU - hard hydrated towards the top of the unit, hematite goethite peloids, VG matrix. Minor clay and pisolites present.	No airlift as drilled with mud		0 - 24 m, Cl12, 50 mm PVC blank casing
26 – 40	CID		GVL: GVL - hard fractured hematite goethite peloids, VG/Limonitic matrix. Limonitic clay present.			
40 – 54	CID		LGC: LGC - limonite and goethite. 3m Cavity no sample return at 48m.	Field chemistry: no water returns during mud drilling.		24 - 72 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
54 – 64	CID		BCC: BCC - lateritic in sections, pisolites, BIF, CID and chert. (sliceous) gravel size.	Gravel 4 x 500 kg bags		
64 – 72	CID		BCC: solf yellow/brown clay.			8 - 72 m Gravel pack (graded 3.2-6.4 mm)



Well Completion Details - PZ08YJSW003

RioTinto

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 17-Dec-08
DATE COMPLETED: 17-Dec-08

DRILLING DETAILS

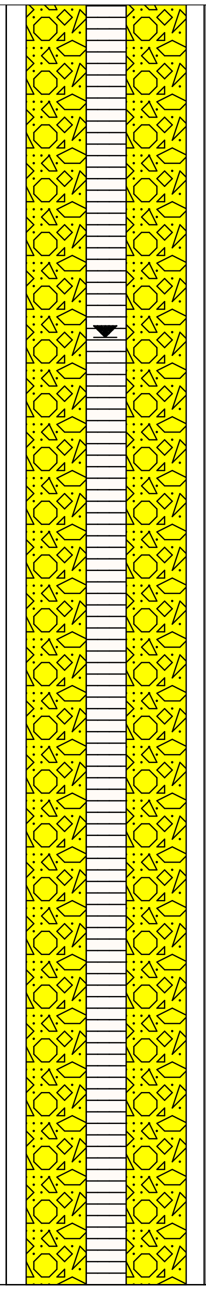
DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Shaun McGinley
DRILLING METHOD: Air/Hammer
HYDROGEOLOGIST(s): Glenn Kirkpatrick

LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 721669.93
NORTHING: 7478287.4
ELEVATION: 526.02 mRL (TOC)

Well Notes: Hole diameter 12 inch mud/rotary 0-8m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0	ALL		ALLUVIUM: Hard, rounded gravel to pebble size BIF. Clay present throughout.	No airlift as drilled with mud		
				Intial WL 2.08 mbtoc (22/1/09)		0 - 8 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
				Field chemistry: no water returns during mud drilling.		
				Gravel 4 x 500 kg bags		
5						0 - 8 m Gravel pack (graded 3.2- 6.4 mm)
				Attempted to 6 inch mud/rotary, unsuccessful (ground did not hold up)., went to 12 inch		

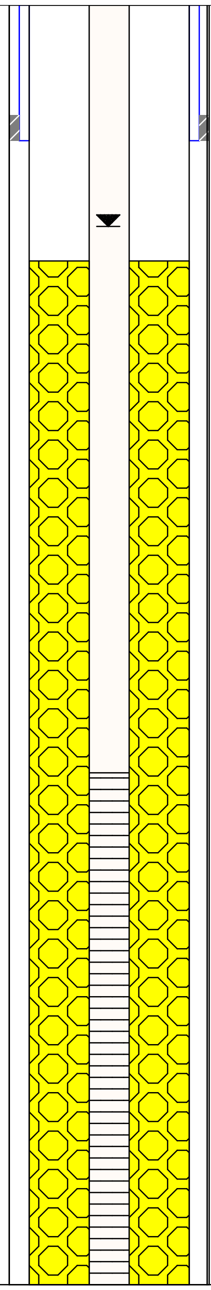


Well Completion Details - PZ08YJSW004

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Andrew McInerney	**EASTING:** 722687.95
DATE COMMENCED: 14-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478746.36
DATE COMPLETED: 17-Sept-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 528.29 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-50m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0	ALL		ALLUVIUM: Light brown, some pisolites present, bedded chips, fine grained. Some moderately stiff clay			+0.7 - 5.3 m Steel 219 mm (8") collar cemented
5	BIF		ALLUVIUM: Brown BIF, some silica present, with minor stiff white clay	Intial WL 8.65 mbtoc (28/9/08)		
10						
15	CLAY		ALLUVIUM: Yellow, white, soft clay with minor BIF			+0.5 - 30 m, Cl12, 50 mm PVC blank casing
20	BIF		ALLUVIUM: Limonite and chert present with some minor white clay			
25	BIF		ALLUVIUM: Brown, pebble size chips, fresh, fine grained hard BIF with micro banding. Some FE staining on small fractures	Airlift of bore <0.1 L/s.		30 - 50 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
30						
35						
40	BIF		ALLUVIUM: Minor silica present, some pitted fracture surfaces. Jasperitic BIF red discharge colour.	Field chemistry: not sufficient water discharge on drilling.		10 -50 m Gravel pack (graded 3.2-6.4 mm)
45	CLAY		ALLUVIUM: Soft yellow clay.	Gravel 4 x 500 kg bags		
50						



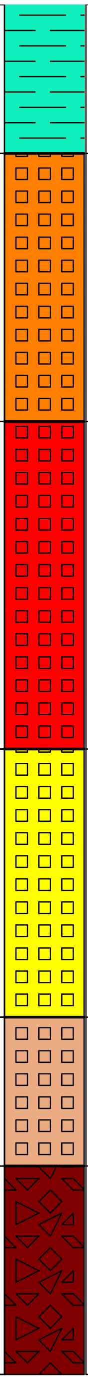
RioTinto

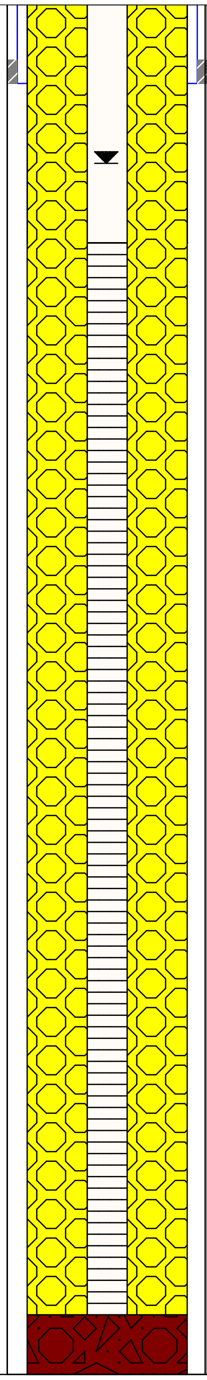
Well Completion Details - PZ08YJSW005

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Lee Martin	**EASTING:** 722494.86
DATE COMMENCED: 25-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478671
DATE COMPLETED: 26-Sept-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 530.46 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-92 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 – 10	ALL		ALLUVIUM: Alluvium, CID material, BIF, pisolites, red/grey.	Intial WL 10.66 mbtoc (30/9/08)		+0.7 - 5.3 m Steel 219 mm (8") collar cemented
10 – 28	CID		GVU: GVU. Vitreous goethite matrix, grey with red and yellow peloids.	Airlift of bore 21.5 L/s.		+0.5 - 16 m, Cl12, 50 mm PVC blank casing
28 – 50	CID		GVL: GVL. Vitreous goethite matrix, grey with red and yellow peloids. Rare orange clay. 38-40m yellow clay pod.			
50 – 68	CID		LGC: LGC. Yellow clay matrix. Some CID and vitreous goethite.	Field chemistry: pH = 7.71, EC = 967 uS/cm, temp = 25.3 C.		16 - 88 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
68 – 78	CID		BCC: BCC. Yellow clay/shale. Some CID material. Red/grey BIF. White clay 74-78m.	Gravel 12 x 500 kg bags		0 - 88 m Gravel pack (graded 3.2-6.4 mm)
78 – 92	WW Fm		WW: Blue, medium grained hard material. Yellow clay, white clay and red BIF.			88 - 92 m Natural fall back





Well Completion Details - PZ08YJSW006

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 23-Sept-08
DATE COMPLETED: 25-Sept-08

DRILLING DETAILS

DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Lee Martin
DRILLING METHOD: Air/Hammer
HYDROGEOLOGIST(s): Glenn Kirkpatrick

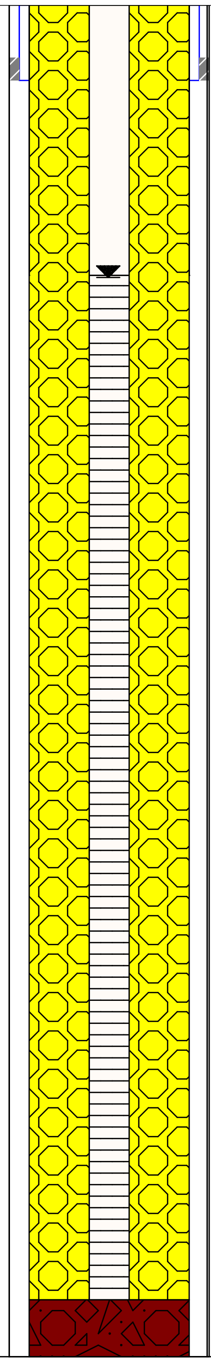
LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 722368.09
NORTHING: 7478550.36
ELEVATION: 538.77 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-95 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Construction
0 – 6	ALL		ALLUVIUM: Hard, hydrated vitreous CID also present with minor pisolites, limonite and clay		+0.7 - 5.3 m Steel 219 mm (8") collar cemented
6 – 12	CID		WCH: Cream/white moderately hard clay and lateritised, hydrated CID		
12 – 28	CID		GVU: GVU- hard hematite goethite peloids clast supported.	Intial WL 19.15 mbtoc (30/9/08) Airlift of bore 29.3 L/s.	+0.5 - 19 m, Cl12, 50 mm PVC blank casing
28 – 60	CID		GVL: GVL-Hard, vitreous goethite and limonitic coated matrix, hematite goethite peloids	Field chemistry: pH = 7.31, EC = 858 uS/cm, temp = 24.5 C.	19 - 91 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
60 – 68	CID		LGC: LGC- denatured CID and soft to hard clay.		
68 – 80	CID		BCC: BCC- hard sand to pebble size clasts with limonitic clay present.	Gravel 13 x 500 kg bags	0 - 91 m Gravel pack (graded 3.2-6.4 mm)
80 – 95	WW Fm		WW: Hard, fresh angular basement		91 - 95 m Natural fall back

Well Design



Well Completion Details - PZ08YJSW007

RioTinto

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 22-Sept-08
DATE COMPLETED: 23-Sept-08

DRILLING DETAILS

DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Andrew McInerney
DRILLING METHOD: Air/Hammer
HYDROGEOLOGIST(s): Glenn Kirkpatrick

LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 722289.97
NORTHING: 7478479.96
ELEVATION: 540.19 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-90 m.

Depth (mbgl): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90

Geology	Lithological Description
ALL	ALLUVIUM: Light brown, hard BIF and vitreous goethite. Angular to subangular, pisolites and limonite.
ALL	ALLUVIUM: Cream yellow predominately white soft clay. Minor subangular BIF, pisolites and limonite.
CID	GVU: Brown, hard, angular hematite goethite peloids in a vitreous goethite matrix. Size ranging from sand to coarse sand.
CID	GVL: Light brown hematite goethite peloids in a limonitic, vitreous goethite matrix, clast supported. Moderately hard limonitic clay throughout.
CID	LGC: Light yellow brown, very stiff denatured CID and limonitic clay. Some minor soft clay.
CID	BCC: Brown, soft clay and weathered, subangular BIF, CID. Minor chert.
CID	BCC: Red brown soft clay
CID	BCC: Red brown clay with hard, angular BIF and chert.
WW Fm	WW: Green, grey, hard fresh medium grained siliceous dolerite.

Field Notes

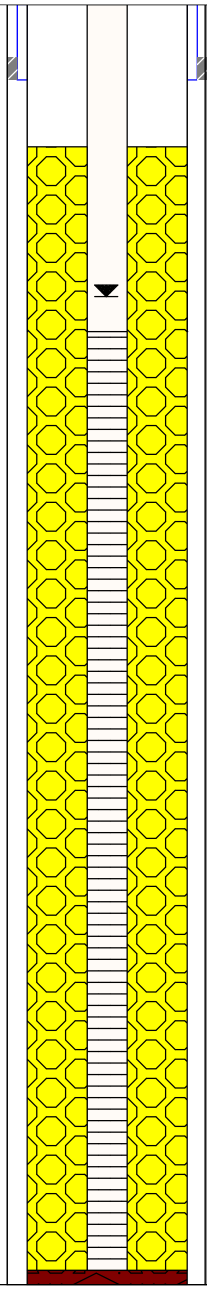
Intial WL 20.53 mbtoc (28/9/08)

Field chemistry: pH = 8.09, EC = 966 uS/cm, temp = 21.8 C.

Gravel 8 x 500 kg bags

Airlift of bore 1 L/s.

Well Design



Well Construction

+0.7 - 5.3 m Steel 219 mm (8") collar cemented

+0.5 - 23 m, Cl12, 50 mm PVC blank casing

23 - 89 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture

10 - 89 m Gravel pack (graded 3.2-6.4 mm)

89-90 m Natural packing

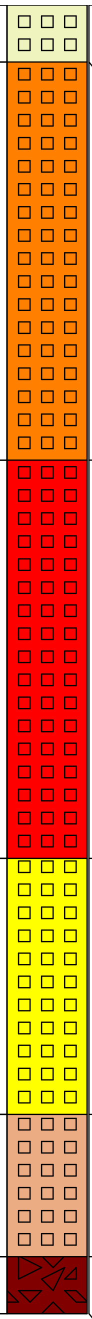
Well Completion Details - PZ08YJSW008

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Andrew McInerney	**EASTING:** 722517.46
DATE COMMENCED: 20-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478576.25
DATE COMPLETED: 22-Sept-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 530.09 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-92 m.

Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0	CID	WCH: Brown, Denatured CID and Alluvial BIF, hydrated with minor pisolites		+0.7 - 5.3 m Steel 219 mm (8") collar cemented
5	CID	GVU: Brown, hematite - goethite peloids in a clast supported vitreous goethite matrix. Limonite and wood fragments present. Minor white clay	Intial WL 10.75 mbtoc (22/9/08)	+0.5 - 9 m, Cl12, 50 mm PVC blank casing
33	CID	GVL: Yellow/brown, Limonite and vitreous goethite. Clay throughout. Some pitted fracture surfaces	Field chemistry: pH = 7.87, EC = 921 uS/cm, temp = 24.8 C.	9 - 87 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
60	CID	LGC: Yellow brown, Limonite and vitreous goethite, CID denatured with clay throughout		5 - 87 m Gravel pack (graded 3.2-6.4 mm)
78	CID	BCC: Yellow, brown, Limonite and chert, soft clays and minor silica.	Airlift of bore 30 L/s.	
88	WW Fm	WW: Grey, green, brown fresh, hard, medium grained		87-92 m Natural packing

Lithology:



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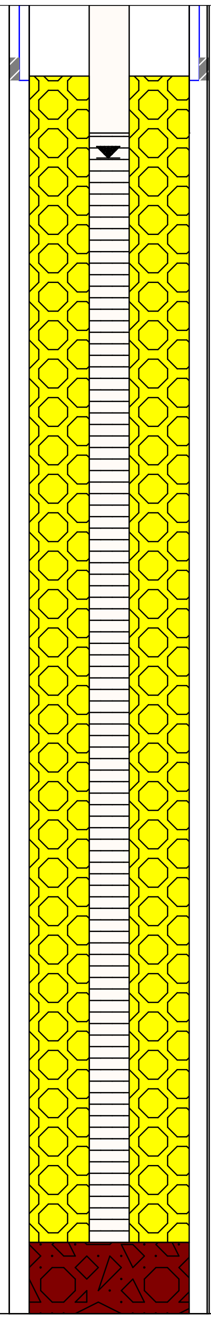


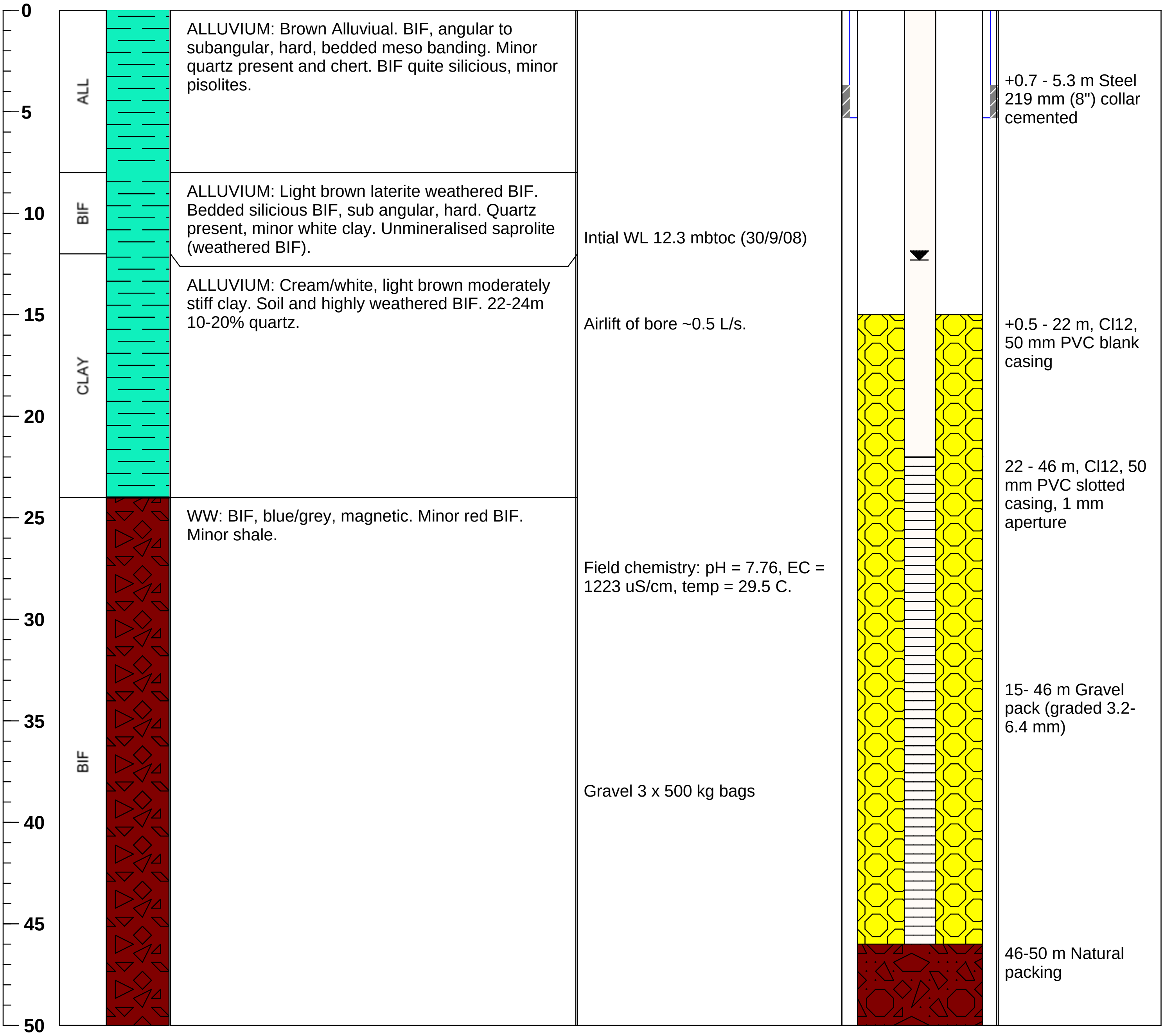
Well Completion Details - PZ08YJSW009

RioTinto

HOLE DETAILS		DRILLING DETAILS		LOCATION	
PROJECT:	Yandicoogina	**DRILLING COMPANY:**	Nudrill Pty Ltd	**GRID NAME:**	MGA94 Zone 50
LOCATION:	Junction South West	**DRILLER:**	Andrew McInerney	**EASTING:**	722533.54
DATE COMMENCED:	23-Sept-08	**DRILLING METHOD:**	Air/Hammer	**NORTHING:**	7478166.54
DATE COMPLETED:	25-Sept-08	**HYDROGEOLOGIST(s):**	Emma McGiven	**ELEVATION:**	532.86 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 7&7/8 inch hammer 5.3-50 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0–8	ALL		ALLUVIUM: Brown Alluviual. BIF, angular to subangular, hard, bedded meso banding. Minor quartz present and chert. BIF quite silicious, minor pisolites.			+0.7 - 5.3 m Steel 219 mm (8") collar cemented
8–12	BIF		ALLUVIUM: Light brown laterite weathered BIF. Bedded silicious BIF, sub angular, hard. Quartz present, minor white clay. Unmineralised saprolite (weathered BIF).	Intial WL 12.3 mbtoc (30/9/08)		
12–24	CLAY		ALLUVIUM: Cream/white, light brown moderately stiff clay. Soil and highly weathered BIF. 22-24m 10-20% quartz.	Airlift of bore ~0.5 L/s.		+0.5 - 22 m, Cl12, 50 mm PVC blank casing 22 - 46 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
24–50	BIF		WW: BIF, blue/grey, magnetic. Minor red BIF. Minor shale.	Field chemistry: pH = 7.76, EC = 1223 uS/cm, temp = 29.5 C. Gravel 3 x 500 kg bags		15- 46 m Gravel pack (graded 3.2-6.4 mm) 46-50 m Natural packing



RioTinto

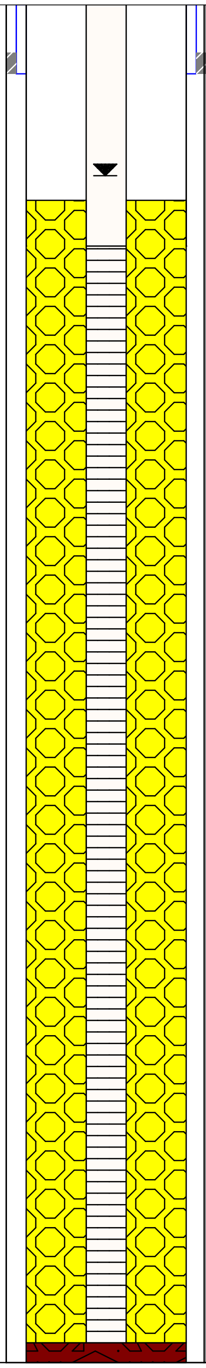
Well Completion Details - PZ08YJSW010

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Andrew McInerney	**EASTING:** 722852.94
DATE COMMENCED: 25-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478329.91
DATE COMPLETED: 28-Sept-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 532.14 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 7&7/8 inch hammer 5.3-104 m.

Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0–5	ALL	ALLUVIUM: BIF, red/grey, magnetic. Red shale. Subangular chips.		+0.7 - 5.3 m Steel 219 mm (8") collar cemented
5–28	CID	GVU: Dark grey vitreous goethite matrix with red and yellow peloids, magnetic. 14-16 m orange clay pod. Subrounded to subangular chips.	Intial WL 13.11 mbtoc (1/10/08) Airlift 29.3 L/s.	+0.5 - 18.5 m, Cl12, 50 mm PVC blank casing
28–64	CID	GVL: Dark grey vitreous goethite matrix with red and yellow peliods. Limonitic clay. Increased yellow/orange clay from 54 m increasing with depth.	Field chemistry: pH = 7.89, EC = 916 uS/cm, temp = 25.6 C.	18.5 - 102.5 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
64–78	CID	LGC: Orange clay, white clay, some CID material, Grey BIF. 78-80 m quartz present.		15- 102.5 m Gravel pack (graded 3.2-6.4 mm)
78–86	CID	BCC: Red, white and orange clay. Poor sample return.	Gravel 12 x 500 kg bags	
86–98	CID	BCC: BIF, red/grey. Orange and red shale. Grey, opaque chert from 86m. Minor quartz. Minor CID material.		
98–104	WW Fm	WW: Blue/green dolerite. Minor orange clay		102.5-104 m Natural packing

Well Design



RioTinto

Well Completion Details - PZ09YJSW011

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 3-April-09
DATE COMPLETED: 4-April-09

DRILLING DETAILS

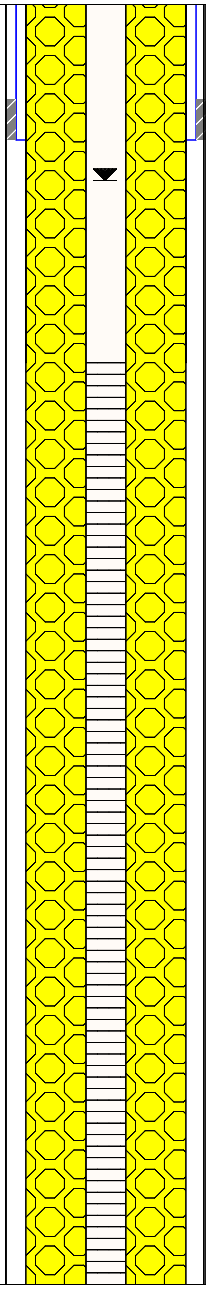
DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Richard Attard
DRILLING METHOD: Mud/Rotary
HYDROGEOLOGIST(s): Niall Inverarity

LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 723317.05
NORTHING: 7478578.87
ELEVATION: 526.46 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 6 inch mud/rotary 5.3-50 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0	ALL		ALLUVIUM: Angular to rounded chips. Predominantly BIF, chert and shale. Some clay			
5						+0.7 - 5.3 m Steel 219 mm (8") collar cemented
				Intial WL 6.88 mbtoc (10/4/09)		
10						
15				Airlift of bore 5 L/s.		+0.5 - 14 m, Cl12, 50 mm PVC blank casing
20	CID		BCC: Possibly BCC. Small, subrounded chips of GOV, HEM, much GOL. Some LMC			
25	WW Fm		WW: Chert and cherty BIF. Quite large, subangular chips. May be fractured. Thin GOL layers evident. Large clay pod intersected at 28-30m.			
30				Gravel 3 x 500 kg bags		
35						
40				Field chemistry: no chemistry due to mud drilling.		
45						
50						



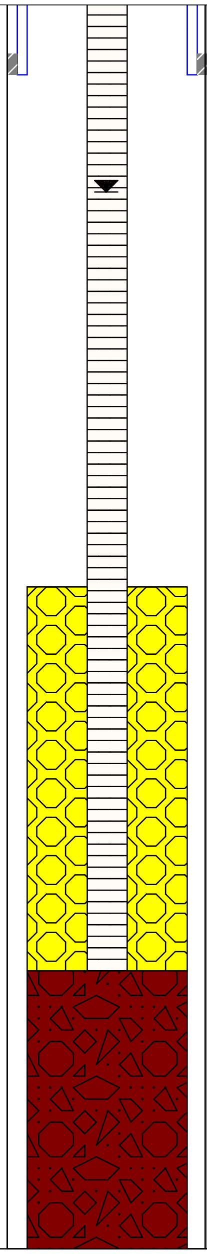
Well Completion Details - PZ08YJSW012

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Ross Pendelbury	**EASTING:** 723784.41
DATE COMMENCED: 9-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478725.17
DATE COMPLETED: 11-Oct-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 531.49 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 7&7/8 inch hammer 5.3-94 m.

Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0 - 5	CID	ECC: Light brown, pisolite material, cemented, brown clay/shale.		+0.7 - 5.3 m Steel 219 mm (8") collar cemented
5 - 20	CID	GVU: Vitreous goethite matrix, dark grey, CID, red and yellow peliods. 8-10m light brown clay.	Intial WL 14.16 mbtoc (12/10/08)	
20 - 52	CID	GVL: Vitreous goethite matrix, dark grey CID, red and yellow peloids. Minor brown/yellow clay. Rare fossilised wood. 26-30m yellow clay. 36-38m White/yellow clay.	Airlift of bore 31 L/s.	0 - 73 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
			Field chemistry: pH = 7.73, EC = 925 uS/cm, temp = 26.4 C.	
52 - 68	CID	LGC: Yellow/brown clay, limonitic, CID material. Rare red shale and quartz.		44 - 73m Gravel pack (graded 3.2-6.4 mm)
68 - 86	CID	BCC: Orange, white clay. Minor red shale. Minor chert, white. Minor grey BIF. Pisolites, rounded, red/brown	Gravel 8 x 500 kg bags	73 - 94 m Natural packing
86 - 90	WW Fm	WW: Chert, grey, opaque. Red/grey BIF. Yellow clay.		
90 - 94	WW Fm	WW: Grey/green dolerite. Minor red shale and BIF.		

Well Design



Well Completion Details - PZ08YJSW014

HOLE DETAILS		DRILLING DETAILS		LOCATION	
PROJECT:	Yandicoogina	**DRILLING COMPANY:**	Nudrill Pty Ltd	**GRID NAME:**	MGA94 Zone 50
LOCATION:	Junction South West	**DRILLER:**	Ross Pendelbury	**EASTING:**	723918.46
DATE COMMENCED:	6-Oct-08	**DRILLING METHOD:**	Air/Hammer	**NORTHING:**	7478823.63
DATE COMPLETED:	8-Oct-08	**HYDROGEOLOGIST(s):**	Glenn Kirkpatrick	**ELEVATION:**	528.51 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 7&7/8 inch hammer 5.3-100 m.

Geology	Lithological Description
CID	ECC: hard denatured CID, lateritic in parts with minor soft white clay and quartz.
CID	GVU: hard hematite goethite peloids in a vitreous goethite matrix, clast supported. Soft white clays present throughout
CID	GVL: Hematite goethite peloids in a vitreous goethite/limonitic matrix. Moderately stiff white and limonitic clay throughout.
CID	LGC: limonite and goethite. Denatured CID Minor silica present
CID	BCC: sand size pisolites with some white clay and goethite present.
CID	BCC: Clay dominated (yellow and white soft clays) Remenant CID and some bedded BIF
WW Fm	WW: Hard, fresh BIF and jaspilitic BIF, siliceous.

Depth (mbgl): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

Field Notes

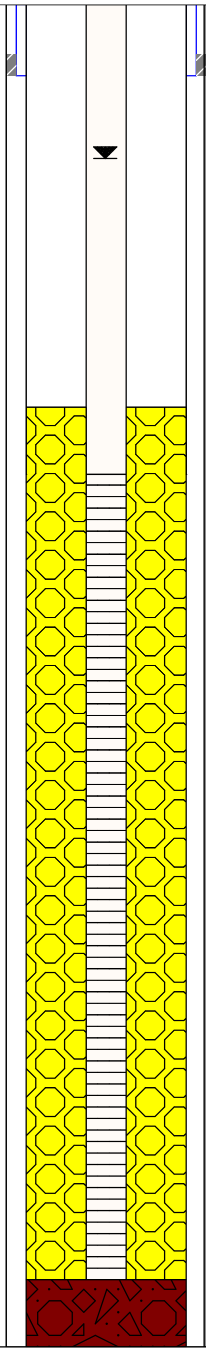
Intial WL 11.46 mbtoc (11/10/08)

Airlift 36.5 L/s.

Field chemistry: pH = 7.94, EC = 924 uS/cm, temp = 25.6 C.

Gravel 16 x 500 kg bags

Well Design



Well Construction

+0.7 - 5.3 m Steel 219 mm (8") collar cemented

+0.5 - 35 m, Cl12, 32 mm PVC blank casing

35 - 95 m, Cl12, 32 mm PVC slotted casing, manual holes drilled every 10 cm

30- 95 m Gravel pack (graded 3.2-6.4 mm)

95 - 100 m Natural packing

RioTinto

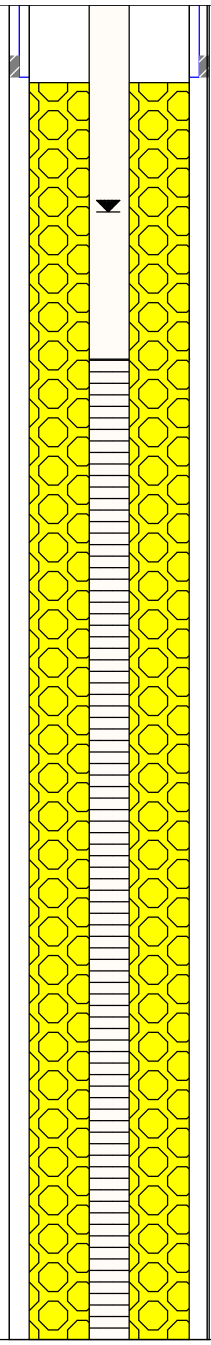
Well Completion Details - PZ08YJSW015

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Ross Pendelbury	**EASTING:** 724029.24
DATE COMMENCED: 30-Sept-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478873.93
DATE COMPLETED: 2-Oct-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 532.2 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-98 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0–5	CID		WCH: Weathered CID material, pisolites, magnetic, grey. BIF, red/grey. Orange shale/clay. Hydrated.			+0.7 - 5.3 m Steel 219 mm (8") collar cemented
5–26	CID		GVU: Vitreous goethite matrix, dark grey, red and yellow peloids. Minor clay, white and yellow. Increased orange clay 22-24m	Intial WL 15.19 mbtoc (11/10/08)		+0.5 - 26 m, Cl12, 50 mm PVC blank casing
26–56	CID		GVL: Vireous goethite matrix, dark grey, red and yellow peloids, rounded. Minor clay. White clay 38-42m. Yeloow clay 48-52m.	Field chemistry: pH = 7.59, EC = 896 uS/cm, temp = 25.9 C.		26 - 98 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
56–70	CID		LGC: Limonitic clay, come CID material, white clay, fossilised wood fragments.			
70–92	CID		BCC: Orange and white clay. Red shale. Red/grey BIF. Fossilised wood fragments.	Airlift 42.7 L/s.		5.7 - 98 m Gravel pack (graded 3.2-6.4 mm)
92–98	WW Fm		WW: Dark grey and red BIF, hard, fresh. Orange/yelow clay.			

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95

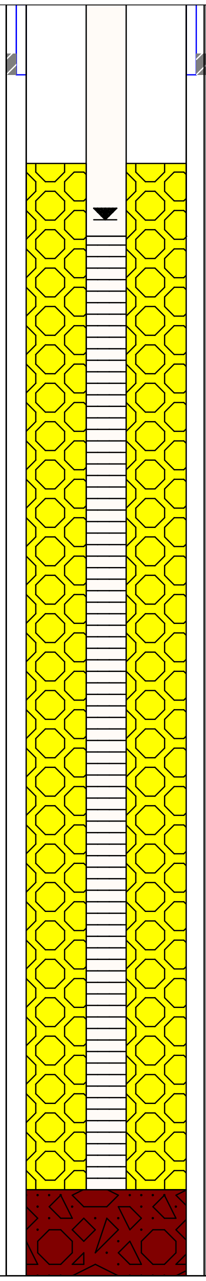


Well Completion Details - PZ08YJSW016

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Ross Pendelbury	**EASTING:** 723990.04
DATE COMMENCED: 5-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478765.97
DATE COMPLETED: 6-Oct-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 533.34 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 7&7/8 inch hammer 5.3-96 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 – 6	CID		ECC: Lateritic hard limonitic goethite weathered and vitreous goethite porous with minor red stiff clay present.			+0.7 - 5.3 m Steel 219 mm (8") collar cemented
6 – 26	CID		GVU: Hematite goethite peloids in a vitreous goethite matrix, clast supported, hard with white soft clays present throughtout. Fe staining on some fracture surfaces. Hard limonitic clay present.	Airlift of bore 38.5 L/s. Intial WL 16.25 mbtoc (11/10/08)		+0.5 - 17.5 m, Cl12, 50 mm PVC blank casing
26 – 52	CID		GVL: Hard goethite hematite peloids in a limonitic and vitreous goethite matrix. Clast supported	Field chemistry: pH = 8.02, EC = 955 uS/cm, temp = 24.8 C.		17.5 - 89.5 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
52 – 66	CID		LGC: Denatured CID witreous and limonitic goethite. Moderately hard white clays pitted on fracture surfaces.			12- 96 m Gravel pack (graded 3.2-6.4 mm)
66 – 92	CID		BCC: Dominated by limonitic and white clay. Minor quartz, bedded BIF in parts	Gravel 10 x 500 kg bags		89.5 - 96 m Natural packing
92 – 96	WW Fn		WW: Hard Fresh BIF, siliceous and fine grained .			



Well Completion Details - PZ08YJSW017

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Andrew McInerney	**EASTING:** 724262.5
DATE COMMENCED: 2-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478749.68
DATE COMPLETED: 4-Oct-08	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 535.37 mRL (TOC)

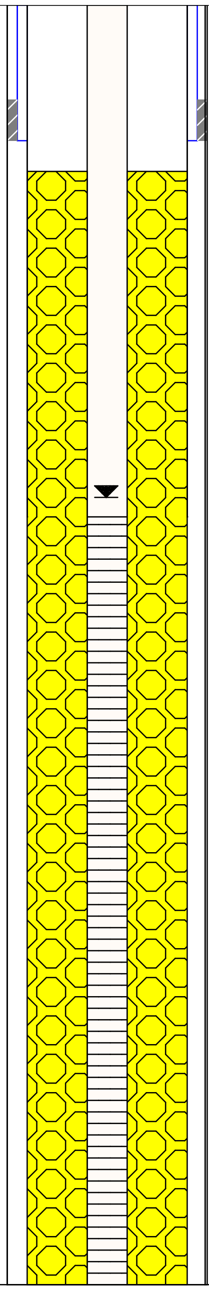
Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 7&7/8 inch hammer 5.3-50 m.

Depth (mbgl)	Geology	Lithological Description
0 – 2	ALL	ALLUVIUM: hard, siliceous, pebble chip size with meso banding. Minor chert
2 – 10	ALL	ALLUVIUM: hard, with minor hydrated pitted fracture surfaces. Quartz present, minor clay
10 – 24	ALL	ALLUVIUM: hard, with jaspilitic BIF, minor moderately stiff clay
24 – 36	WW Fm	WW: hard platy chips with minor chert
36 – 42	WW Fm	WW: Fe stained soft yellow clay present
42 – 50	WW Fm	DOLERITE: pitted, siliceous medium grained with alteration on fracture surfaces.

Field Notes

- Airlift of bore ~2 L/s.
- Intial WL 19.24 mbtoc (11/10/08)
- Field chemistry: pH = 7.83, EC = 987 uS/cm, temp = 25.4 C.
- Gravel 4 x 500 kg bags

Well Design



Well Construction

- +0.7 - 5.3 m Steel 219 mm (8") collar cemented
- +0.5 - 20 m, Cl12, 50 mm PVC blank casing
- 20 - 50 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
- 6.5- 50 m Gravel pack (graded 3.2-6.4 mm)

Well Completion Details - PZ09YJSW020

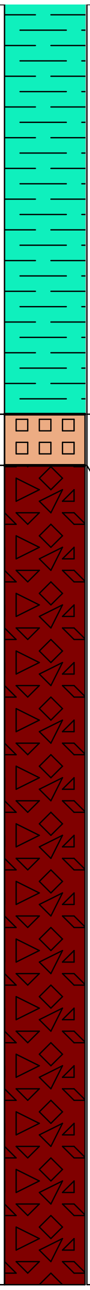
Rio Tinto

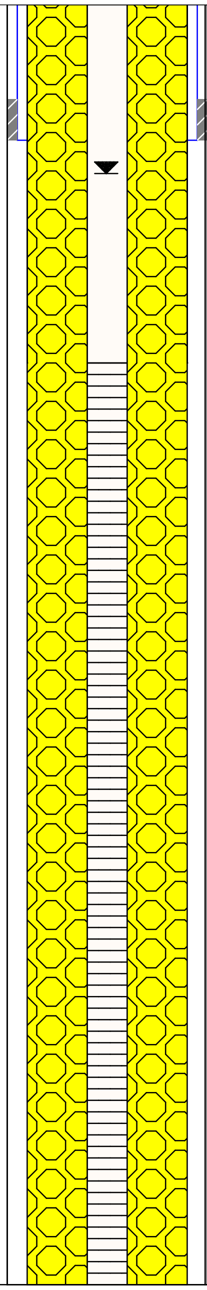
HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Richard Attard	**EASTING:** 724985.01
DATE COMMENCED: 4-April-09	**DRILLING METHOD:** Mud/Rotary	**NORTHING:** 7479552.8
DATE COMPLETED: 5-April-09	**HYDROGEOLOGIST(s):** Niall Inverarity	**ELEVATION:** 519.95 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 6 inch mud/rotary 5.3-50 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 – 16	ALL		ALLUVIUM: Gravel to pebble-sized clasts of GOV, BIF and SHL. Clay matrix with minor WH CLA.	Intial WL 6.60 mbtoc (12/4/09)		+0.7 - 5.3 m Steel 219 mm (8") collar cemented
16 – 18	CID		BCC: Small angular chips of GOV, GOL, HEM pisolites. Some BIF chips.	Airlift 5 L/s.		+0.5 - 14 m, Cl12, 50 mm PVC blank casing
18 – 50	WW Fm		WW: BIF and SHL. Finely laminated BIF. Small chips of chert. Some SHL present. Occasional Jasperlitic BIF.	Gravel 3 x 500 kg bags		14 - 50 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
				Field chemistry: no chemistry due to mud drilling.		0- 50 m Gravel pack (graded 3.2-6.4 mm)

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50





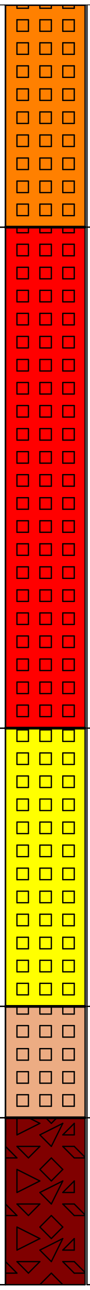
Well Completion Details - PZ08YJSW021

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Ross Pendlebury	**EASTING:** 724650.04
DATE COMMENCED: 13-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7479786.9
DATE COMPLETED: 15-Oct-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 523.97 mRL (TOC)

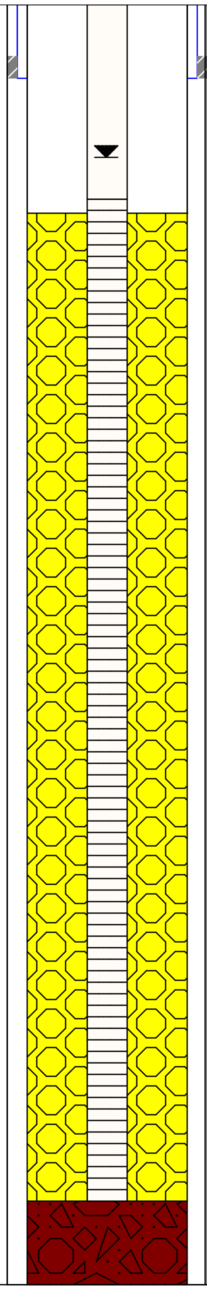
Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-92 m.

Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0 - 16	ALL	GVU: Dark grey vitreous goetite matrix with red and yellow peloids. Minor light brown clay.	Intial WL 10.98 mbtoc (16/10/08)	+0.7 - 5.3 m Steel 219 mm (8") collar cemented +0.5 - 14 m, Cl12, 50 mm PVC blank casing
16 - 52	CID	GVL: Dark grey vitreous goethite matrix with red and yellow peloids. Minor yelow clay. 22 - 24m red and yellow clay. 26 - 30m yellow brown and whiite clay. 32 - 34m yellow and white clay	Gravel 12 x 500 kg bags	
52 - 72	CID	LGC: Yellow limonitic clay. CID material, vitreus goethite.	Field chemistry: pH = 7.20, EC = 1050 uS/cm, temp = 25.5 C.	14 - 86 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
72 - 80	CID	BCC: Yellow/orange clay. Red shale. Minor CID material. Minor BIF.	Airlift 18.8 L/s.	15 - 86 m Gravel pack (graded 3.2-6.4 mm)
80 - 92	CID	WW: Red/grey/brown BIF. Minor chert, grey, opaque, increasing with depth. Minor yellow clay. 88-90m rare green chert. 90-92m grey/green dolerite.		86 - 92 m Natural packing

Lithology:



Well Design:



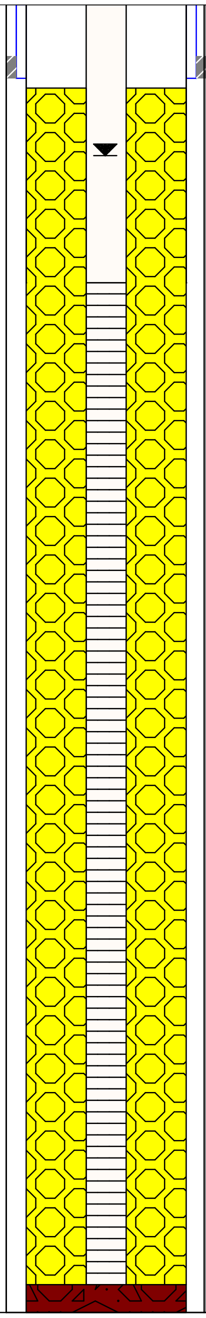
Well Completion Details - PZ08YJSW023

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Andrew McInerney	**EASTING:** 724603.66
DATE COMMENCED: 11-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7479697.6
DATE COMPLETED: 13-Oct-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 524.06 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-94 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes
0	ALL		ALLUVIUM: Pisolites, dark grey, weakly cemented. CID, vitreous goethite. Minor light brown clay	
5	CID		GVU: Vitreous goethite matrix, dark grey, pisolites. Minor light brown/yellow clay. 16-18m light brown clay pod.	Intial WL 10.86 mbtoc (14/10/08)
20	CID		GVL: Vitreous goethite matrix, dark grey, red and yellow peloids. minor clay. 32-40m increased white, yellow and red clay.	
52	CID		LGC: Orange/yellow limonitic clay. Some dark grey vitreous goethite. Red shale.	Field chemistry: pH = 7.77, EC = 912 uS/cm, temp = 26.4 C.
76	CID		BCC: Yellow/orange clay. White clay. Red shale. Rare BIF, grey. Some CID material.	Airlift 32.8 L/s.
82	WW Fm		WW: Red/grey/brown BIF. Green/grey opaque chert increasing with depth. Red shale, yellow clay.	

Well Design



Well Construction

+0.7 - 5.3 m Steel 219 mm (8") collar cemented

+0.5 - 20 m, Cl12, 50 mm PVC blank casing

20 - 92 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture

6 - 92 m Gravel pack (graded 3.2-6.4 mm)

92 - 94 m Natural packing

Well Completion Details - PZ08YJSW024

HOLE DETAILS

PROJECT: Yandicoogina
LOCATION: Junction South West
DATE COMMENCED: 15-Oct-08
DATE COMPLETED: 17-Oct-08

DRILLING DETAILS

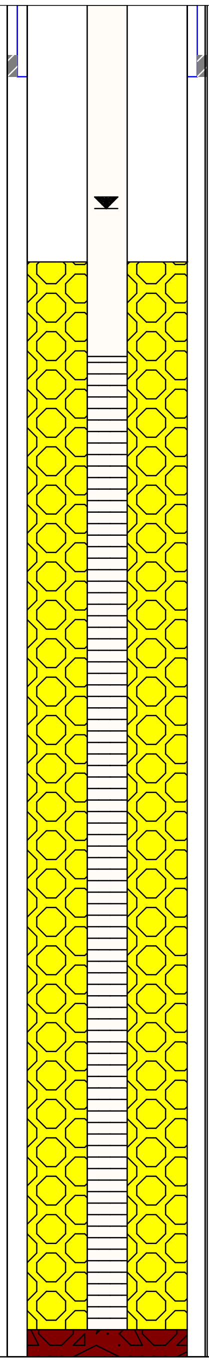
DRILLING COMPANY: Nudrill Pty Ltd
DRILLER: Andrew McInerney
DRILLING METHOD: Air/Hammer
HYDROGEOLOGIST(s): Glenn Kirkpatrick

LOCATION

GRID NAME: MGA94 Zone 50
EASTING: 724818.83
NORTHING: 7480338.17
ELEVATION: 523.75 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-100 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0	L		ALLUVIUM: Shales, pisolites and BIF present.			
5	CID		GVU: Hematite goethite peloids in a vitreous goethite matrix, with minor light brown clay			+0.7 - 5.3 m Steel 219 mm (8") collar cemented
15				Intial WL 15.05 mbtoc (21/10/08)		+0.5 - 26 m, Cl12, 50 mm PVC blank casing
20	CID		GVL: Goethite and limonitic matrix, soft white clay present throughout			
30				Gravel 11 x 500 kg bags		
50						26 - 98 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
55	CID		LGC: Limonite and vitreous goethite with some denatured CID. Moderately stiff limonitic clay.	Field chemistry: pH = 7.85, EC = 973 uS/cm, temp = 26.0 C.		
75				Airlift 15 L/s.		19 - 98 m Gravel pack (graded 3.2-6.4 mm)
80	CID		BCC: Hard BIF/Chert and CID with minor silica, soft white clays and limonitic clays present.			
90	WW Fm		WW: Hard unmineralised, fresh basement with minor quartz present.			
100						98 -1 00 m Natural packing



Depth scale (mbgl): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

Well Completion Details - PZ08YJSW025

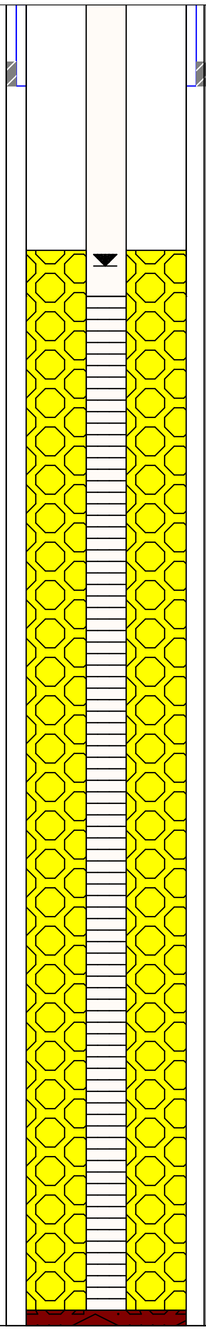
Rio Tinto

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Andrew McInerney	**EASTING:** 724815.64
DATE COMMENCED: 25-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7480446.67
DATE COMPLETED: 27-Oct-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 525.73 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-86 m.

Depth (mbgl)	Geology	Lithological Description	Field Notes
0 - 5	ALL	ALLUVIUM: Alluvial material. Red/grey BIF. Red shale. Pisolite material.	
5 - 20	CID	GVU: Dark grey vitreous goethite matrix with red and yellow peloids. Minor light brown/yellow clay.	Intial WL 17.02 mbtoc (30/10/08)
20 - 50	CID	GVL: Dark grey vitreous goethite matrix with red and yellow peloids. 26-30 m increased yellow limonitic clay 10-20%. 32-36 m and 44-50 m increased yellow/white clay 20-30%. 38-42 m cavity. 42-44 m yellow limonitic clay pod.	Airlift 18.8 L/s.
50 - 66	CID	LGC: Yellow limonitic clay. Red and white clay. Dark grey vitreous goethite.	Field chemistry: pH = 7.75, EC = 960 uS/cm, temp = 26.0 C.
66 - 74	CID	BCC: Red, yellow and white clay. Some vitreous goethite material. minor light brown BIF. Minor grey/green chert.	
74 - 86	WW Fm	WW: Green, grey, opaque orange chert. White clay. Red, grey and light brown BIF.	Gravel 11 x 500 kg bags

Well Design



Well Construction

- +0.7 - 5.3 m Steel 219 mm (8") collar cemented
- +0.5 - 19 m, Cl12, 50 mm PVC blank casing
- 19 - 85 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
- 16 - 85 m Gravel pack (graded 3.2-6.4 mm)
- 85 - 86 m Natural packing

Well Completion Details - PZ08YJSW026

RioTinto

HOLE DETAILS		DRILLING DETAILS		LOCATION	
PROJECT:	Yandicoogina	**DRILLING COMPANY:**	Nudrill Pty Ltd	**GRID NAME:**	MGA94 Zone 50
LOCATION:	Junction South West	**DRILLER:**	Andrew McInerney	**EASTING:**	724728.41
DATE COMMENCED:	24-Oct-08	**DRILLING METHOD:**	Air/Hammer	**NORTHING:**	7480567.46
DATE COMPLETED:	25-Oct-08	**HYDROGEOLOGIST(s):**	Emma McGiven	**ELEVATION:**	533.08 mRL (TOC)

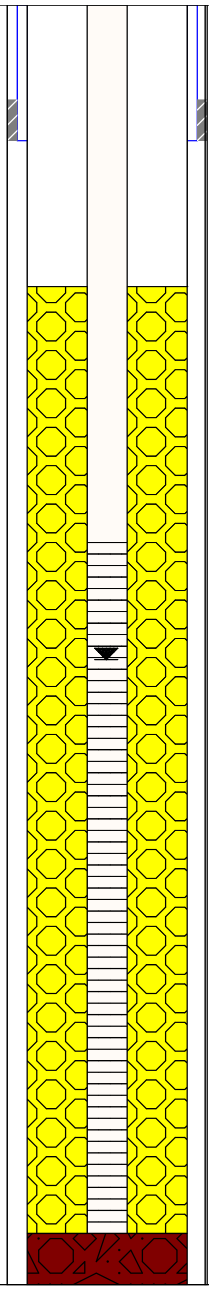
Well Notes: Hole diameter 12 inch hammer 0-5.3 m, 7&7/8 inch hammer 5.3-50 m.

Depth (mbgl)	Geology	Lithological Description
0 – ~2	ALL	ALLUVIUM: Alluvial material. BIF, dark grey. Red shale.
~2 – 8	ALL Fm	ALLUVIUM: BIF, dark grey. Red shale. Orange and white clay.
8 – 34	WW Fm	WW: BIF, blue grey. Red and orange shale. Minor grey opaque chert. 14-16m increased orange shale ~40%. Fracture at 18m. 26-34m increased orange/light brown clay.
34 – 44	WW Fm	WW: Dark grey BIF, red streak, red BIF, silicious material. Minor orange/yellow shale. Rare chert
44 – 50	WW Fm	WW: Red/grey BIF. Orange, opaque and clear chert ~10-20%. Orange shale ~20-30%,

Field Notes

- Airlift of bore ~1 - 1.5 L/s.
- Intial WL 25.58 mbtoc (29/10/08)
- Field chemistry: pH = 8.03, EC = 1106 uS/cm, temp = 26.7 C.
- Gravel 4 x 500 kg bags

Well Design



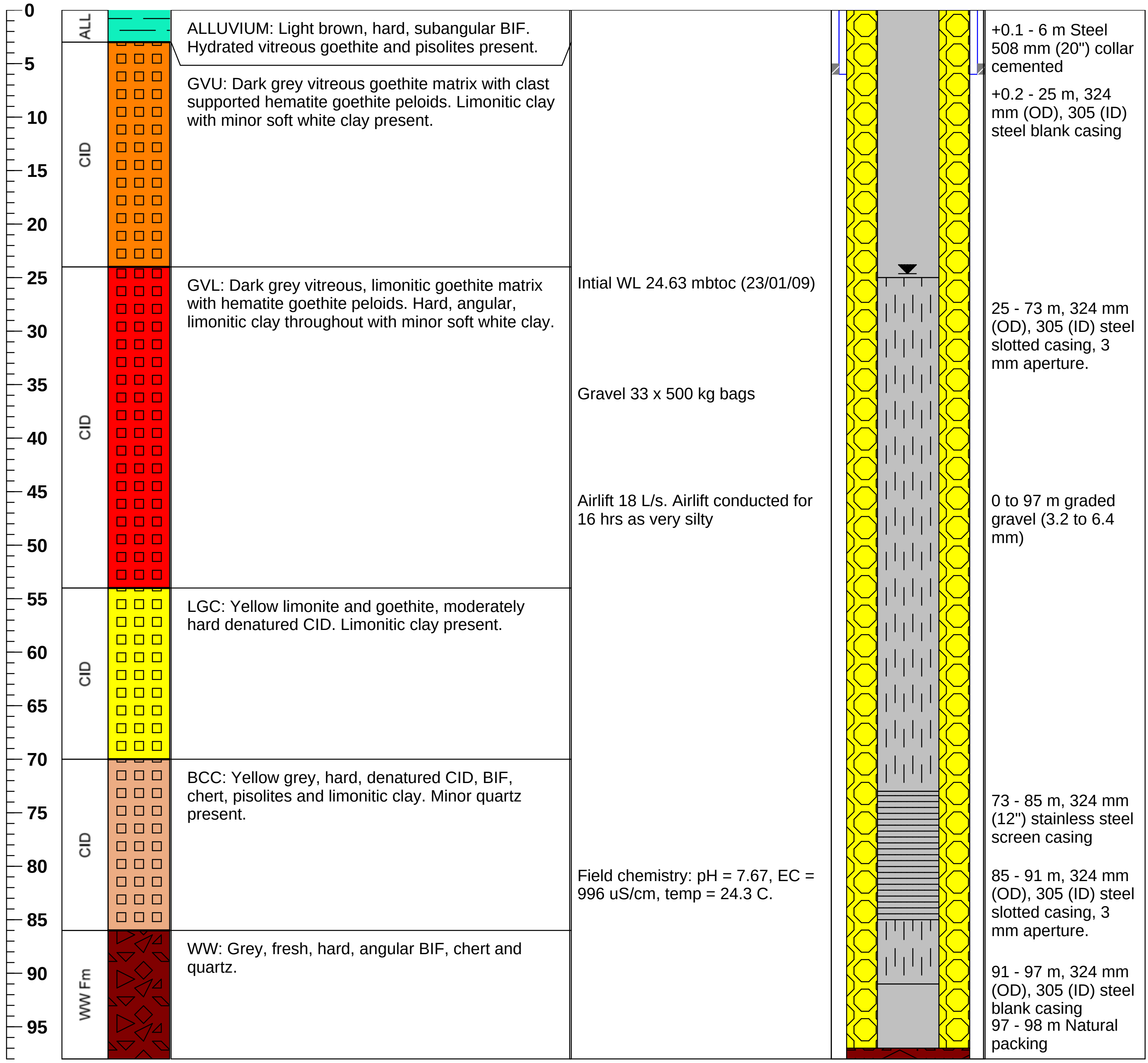
Well Construction

- +0.7 - 5.3 m Steel 219 mm (8") collar cemented
- +0.5 - 21 m, Cl12, 50 mm PVC blank casing
- 21 - 48 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
- 11- 48 m Gravel pack (graded 3.2-6.4 mm)
- 48-50 m Natural packing

Well Completion Details - WB08YJSE001

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South East	**DRILLER:** Lee Martin	**EASTING:** 731074.59
DATE COMMENCED: 23-Nov-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478278.34
DATE COMPLETED: 30-Nov-08	**HYDROGEOLOGIST(s):** Emma McGiven	**ELEVATION:** 508.84 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-6 m, 17.5 inch air/hammer 6-98 m.



Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0–3	ALL		ALLUVIUM: Light brown, hard, subangular BIF. Hydrated vitreous goethite and pisolites present.			+0.1 - 6 m Steel 508 mm (20") collar cemented
3–24	CID		GVU: Dark grey vitreous goethite matrix with clast supported hematite goethite peloids. Limonitic clay with minor soft white clay present.			+0.2 - 25 m, 324 mm (OD), 305 (ID) steel blank casing
24–54	CID		GVL: Dark grey vitreous, limonitic goethite matrix with hematite goethite peloids. Hard, angular, limonitic clay throughout with minor soft white clay.	Intial WL 24.63 mbtoc (23/01/09) Gravel 33 x 500 kg bags Airlift 18 L/s. Airlift conducted for 16 hrs as very silty		25 - 73 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture. 0 to 97 m graded gravel (3.2 to 6.4 mm)
54–70	CID		LGC: Yellow limonite and goethite, moderately hard denatured CID. Limonitic clay present.			
70–86	CID		BCC: Yellow grey, hard, denatured CID, BIF, chert, pisolites and limonitic clay. Minor quartz present.	Field chemistry: pH = 7.67, EC = 996 uS/cm, temp = 24.3 C.		73 - 85 m, 324 mm (12") stainless steel screen casing 85 - 91 m, 324 mm (OD), 305 (ID) steel slotted casing, 3 mm aperture.
86–98	WW Fm		WW: Grey, fresh, hard, angular BIF, chert and quartz.			91 - 97 m, 324 mm (OD), 305 (ID) steel blank casing 97 - 98 m Natural packing

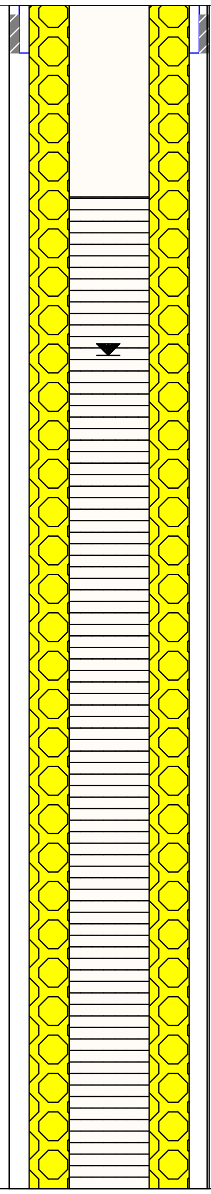
RioTinto

Well Completion Details - WB08YJSE002

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South East	**DRILLER:** Lee Martin	**EASTING:** 731867.37
DATE COMMENCED: 6-Dec-08	**DRILLING METHOD:** Mud/Rotary	**NORTHING:** 7478031.14
DATE COMPLETED: 7-Dec-08	**HYDROGEOLOGIST(s):** Simon Page	**ELEVATION:** 499.46 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-1.5 m, 12.5 inch mud/rotary 1.5-37 m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0	ALL		ALLUVIUM: Red brown unconsolidated soil, angular to subangular bedded BIF, chert and minor pisolite material. Sand to fine pebble size.			+0.7 - 1.5 m Steel 317 mm (14") collar cemented
5	ALL		ALLUVIUM: Red brown clay, angular to subangular BIF, chert and pisolite material. Sand to fine pebble size.			+0.5 - 6 m, Cl12 200 mm PVC blank casing
10	ALL		ALLUVIUM: Red brown clay. Angular to subangular BIF and chert material. Sand to fine pebble size.	Intial WL 10.95 mbtoc (22/01/09)		
15	ALL		ALLUVIUM: Red brown clay, angular to subangular BIF, chert, quartz and pisolitic material. Sand to fine pebble size.	Field chemistry: pH = 8.49, EC = 1007 uS/cm, temp = 24.9 C.		0 to 37 m graded gravel (3.2 to 6.4 mm)
20						
25	ALL		ALLUVIUM: Green brown clay, angular to subangular BIF, dolerite (pitted and weathered green) and chert. Sand to fine pebble size.			
	ALL		ALLUVIUM: Green and brown sandy clay. Angular to subangular BIF and chert. Sand to fine pebble size. Weathered green and pitted dolerite.			6 - 37 m, Cl12 200 mm PVC slotted casing, 3 mm aperture
30	ALL		ALLUVIUM: Green/brown clay, angular to subangular BIF and chert. Weatherd dolerite. Sand to medium pebble size.	Airlift ~5 L/s. Airlift conducted with compressor and 20 mm tremie pipe.		
35	ALL		ALLUVIUM: Green brown clay. Angular to subangular BIF and chert. BIF not weathered, sand to fine pebble size.			



RioTinto

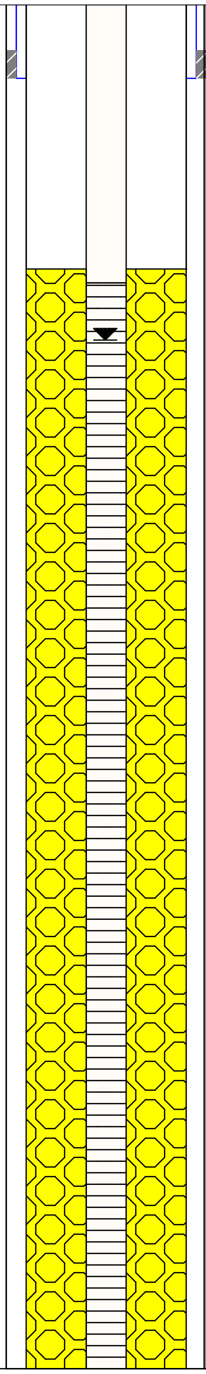
Well Completion Details - PZ08YJSE001

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South East	**DRILLER:** Andrew McInerney	**EASTING:** 731085.55
DATE COMMENCED: 21-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478261.46
DATE COMPLETED: 22-Oct-09	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 508.98 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.3m, 7&7/8 inch hammer 5.3-98m.

Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0 - 5	ALL	ALLUVIUM: unconsolidated, light brown, hard, hydrated, subangular bedded BIF, vitreous goethite, limonite and pisolites		+0.7 - 5.3 m Steel 219 mm (8") collar cemented
5 - 26	CID	GVU: Brown, hard, angular CID. Hematite-goethite peloids in a vitreous goethite matrix, clast supported. Limonitic clay and minor white clay present throughout.	Intial WL 24.10 mbtoc (30/10/08)	+0.5 - 20 m, Cl12, 50 mm PVC blank casing
26 - 56	CID	GVL: Light grey to yellow brown, hard, angular, hematite-goethite peloids in a vitreous goethite, limonitic goethite matrix. Limonitic and white clay pods throughout, minor earthy clay present.	Gravel 11 x 500 kg bags	20 - 98 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
56 - 70	CID	LGC: Yellow, hard, subangular, denatured CID. Soft limonitic clay present throughout.	Field chemistry: pH = 7.77, EC = 1043 uS/cm, temp = 25.5 C.	
70 - 88	CID	BCC: Yellow/grey, hard CID and vitreous goethite. Moderately stiff limonitic clay. White clay, BIF, chert and pisolites also present.	Airlift 11 L/s.	19 - 98 m Gravel pack (graded 3.2-6.4 mm)
88 - 98	WW Fm	WW: Grey,hard, angular, fresh bedded BIF, chert and some quartz.		

Well Design



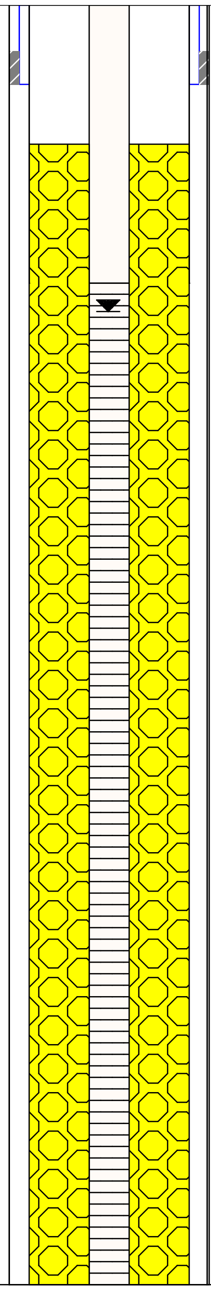
Rio Tinto

Well Completion Details - PZ08YJSE002

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South East	**DRILLER:** Andrew McInerney	**EASTING:** 731173.6
DATE COMMENCED: 19-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478216.87
DATE COMPLETED: 21-Oct-09	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 508.65 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.7m, 7&7/8 inch hammer 5.7-92m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0 – 1	ALL		ALLUVIUM: Alluvium: brown, hard, angular, vitreous goethite chips, limonite and some BIF, CID. Slightly lateritic.			+0.3 - 5.7 m Steel 219 mm (8") collar cemented
1 – 24	CID		GVU: Brown, hard, angular hematite-goethite peloids in a vitreous goethite matrix, clast supported. Limonitic clay present.	Intial WL 22.03 mbtoc (21/10/08)		+0.5 - 20 m, Cl12, 50 mm PVC blank casing
24 – 52	CID		GVL: Yellow brown, hard, angular, hematite-goethite peloids in a vitreous goethite, limonitic goethite matrix. Limonitic and soft white clay throughout, minor earthy clay present.	Gravel 11 x 500 kg bags		20 - 92 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
52 – 62	CID		LGC: Yellow, hard, subangular,limonite and goethite denatured CID. Soft limonitic clay present throughout.	Airlift 12 L/s.		
62 – 74	CID		BCC: Yellow/grey/brown, hard CID and vitreous goethite in a clay matrix. Moderately soft limonitic clay. White clay, BIF, chert and pisolites also present.			
74 – 92	WW Fm		WW: Grey,hard, angular, fresh bedded BIF, chert , jasperitic BIF and vitreous goethite present.	Field chemistry: pH = 7.85, EC = 1016 uS/cm, temp = 25.9 C.		10 - 92 m Gravel pack (graded 3.2-6.4 mm)



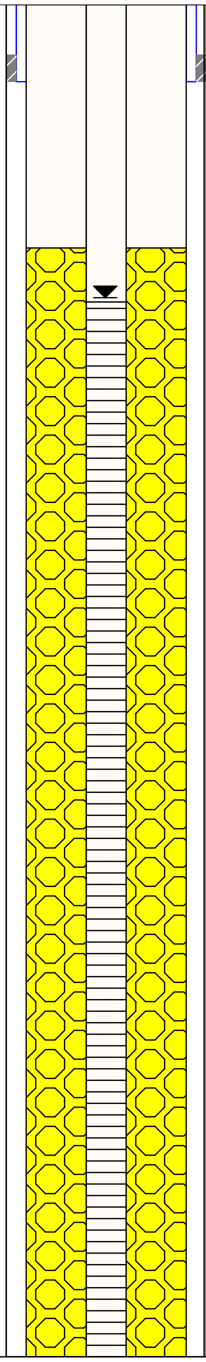
Well Completion Details - PZ08YJSE003

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South East	**DRILLER:** Andrew McInerney	**EASTING:** 730894.2
DATE COMMENCED: 17-Oct-08	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478385.95
DATE COMPLETED: 19-Oct-09	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 507.72 mRL (TOC)

Well Notes: Hole diameter 12 inch hammer 0-5.7m, 7&7/8 inch hammer 5.7-100m.

Depth (mbgl)	Geology	Lithological Description	Field Notes	Well Construction
0 - 4	ALL	ALLUVIUM: Brown, hard, angular to sub-angular, hydrated limonite, pisolites, minor bedded BIF and quartz.		+0.3 - 5.7 m Steel 219 mm (8") collar cemented
4 - 30	CID	GVU: Brown/red brown, hard, angular CID. Hematite-goethite peloids in a vitreous goethite matrix, clast supported. Minor limonitic and white clays present throughout. Small white clay pod at 18m.	Intial WL 21.68 mbtoc (20/10/08)	+0.5 - 22 m, Cl12, 50 mm PVC blank casing
30 - 54	CID	GVL: Grey/brown, hard, angular, porus, hematite-goethite peloids in a vitreous limonitic goethite matrix. Limonitic and soft white clay present throughout. Minor fossil wood present.	Gravel 14 x 500 kg bags.	22 - 100 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
54 - 56	CID	LGC: Yellow, soft clay pod. Minor CID present.	Field chemistry: pH = 7.73, EC = 1085 uS/cm, temp = 25.7 C.	
56 - 74	CID	LGC: Yellow, hard, angular, limonitic denatured CID. White and limonitic clays present.		
74 - 84	CID	BCC: Cream/yellow/brown moderately stiff white/limonitic clay matrix, BIF, CID and chert present.	Airlift 21.5 L/s.	18 - 100 m Gravel pack (graded 3.2-6.4 mm)
84 - 100	WW Fm	WW: Grey,hard, angular, fresh, siliceous bedded BIF, chert , jasperitic BIF, quartz and clay present.		

Well Design:



RioTinto

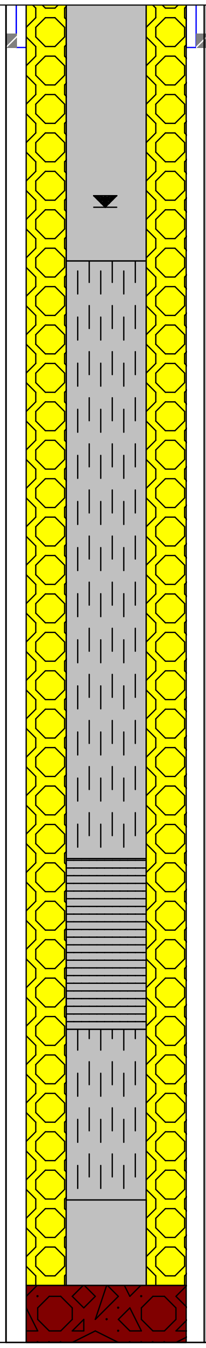
Well Completion Details - WB09YJSW003

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South West	**DRILLER:** Michael Larkman	**EASTING:** 723778.163
DATE COMMENCED: 19-Mar-09	**DRILLING METHOD:** Air/Hammer	**NORTHING:** 7478714.397
DATE COMPLETED: 23-Mar-09	**HYDROGEOLOGIST(s):** Niall Inverarity	**ELEVATION:** 531.26 mRL (TOC)

Well Notes: Hole diameter 24 inch air/roller 0-3 m, 17.5 inch air/hammer 3-94m.

Depth (mbgl)	Geology	Lithological Description	Field Notes
0 – 6	ECC	ECC: Red brown to grey cemented pisolites, clay and shale. Hard, angular limontic goethite and earthy goethite.	
6 – 38	GVU	GVU: Dark grey hard vitreous goethite matrix with hematite peloids. Some limonitic goethite with occasional white clay.	Intial WL 14.21 mbtoc (28/03/09) Gravel 38 x 500kg bags
38 – 60	GVL	GVL: Dark grey and yellow vitreous goethite matrix, with hematite peloids. Prominant limonitic goethite, with white clay present throughout.	Airlift of bore after construction 34.6 L/s. 8 hrs airlifting. V-notch eroded away during airlifting yields still rising.
60 – 78	LGC	LGC: Yellow light grey limonitic goethite matrix with hematite and goethite clasts. White clay throughout.	Field chemistry: pH = 7.67, EC = 767 uS/cm, temp = 26.2 C.
78 – 86	BCC	BCC: Dark brown grey, angular to sub angular clasts and pisolites. Clay throughout with vitreous and earthy goethite.	
86 – 94	WW	WW: Dark light grey medium grained dolerite.	

Well Design



Well Construction

- +0.1 - 3 m Steel 508 mm (20") collar cemented
- +0.2 - 18 m, 324 mm (12") steel blank casing
- 18 - 60 m, 324 mm (12") steel slotted casing, 3 mm aperture, 9.2 mm wall thickness
- 60 - 72 m, 324 mm (12") stainless steel screen casing
- 72 - 84 m, 324 mm (12") steel slotted casing, 3 mm aperture, 9.2 mm wall thickness
- 84 - 90 m, 324 mm (12") steel blank casing
- 90 - 94 m Natural Packing

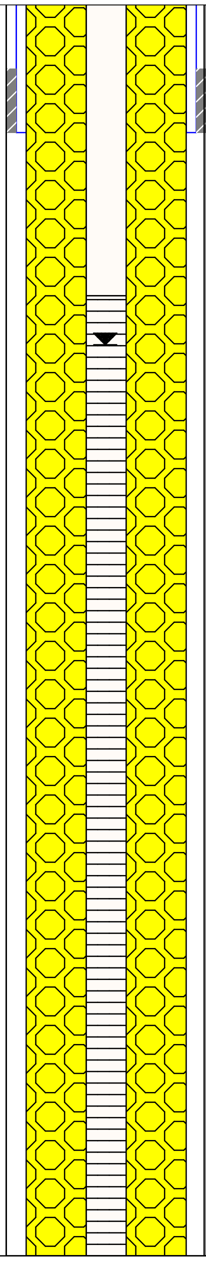
Well Completion Details - PZ08YJSE005

RioTinto

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South East	**DRILLER:** Shaun McGinley	**EASTING:** 731931.96
DATE COMMENCED: 5-Dec-08	**DRILLING METHOD:** Mud/Rotary	**NORTHING:** 7477992.82
DATE COMPLETED: 6-Dec-08	**HYDROGEOLOGIST(s):** Simon Page	**ELEVATION:** 499.69 mRL (TOC)

Well Notes: Hole diameter 10 inch air/hammer 0-4 m, 6 inch mud/rotary 4-39.1m.

Depth (mbgl)	Geology	Lithology	Lithological Description	Field Notes	Well Design	Well Construction
0	ALL		ALLUVIUM: Red brown unconsolidated soil, angular to subangular bedded BIF, chert and minor pisolite material. Sand to fine pebble size.			+0.7 - 4 m Steel 219 mm (8") collar cemented
5	ALL		ALLUVIUM: Brown green clay. Angular to subangular BIF, chert and minor pisolite material. Sand to fine pebble size.			+0.5 - 9.1 m, Cl12, 50 mm PVC blank casing
10	ALL		ALLUVIUM: Red brown clay. Angular to subangular bedded BIF and chert material. Sand to medium pebble size.	Intial WL 10.63 mbtoc (22/01/09)		
15				Field chemistry: pH = 8.5, EC = 1096 uS/cm, temp = 21.1 C.		
20	ALL		ALLUVIUM: Grey brown clay, angular to subangular bedded BIF and chert. Minor pisolite material present. Sand to medium pebble size.			
25	ALL		ALLUVIUM: Green brown clay, angular to subangular BIF, dolerite (pitted and weathered green) and chert. Sand to medium pebble size.			9.1 - 39.1 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture
30	ALL		ALLUVIUM: Purple green and brown clay. Angular to subangular bedded BIF and chert. Sand to medium pebble size.	Airlift ~2 L/s. Airlift conducted with compressor and 20 mm tremie pipe.		0 to 39.1 m graded gravel (3.2 to 6.4 mm)
35	ALL		ALLUVIUM: Purple/green and red in colour, angular to subangular bedded BIF and quartz. Sand to medium pebble size.			



Well Completion Details - PZ08YJSE006

HOLE DETAILS	DRILLING DETAILS	LOCATION
PROJECT: Yandicoogina	**DRILLING COMPANY:** Nudrill Pty Ltd	**GRID NAME:** MGA94 Zone 50
LOCATION: Junction South East	**DRILLER:** Shaun McGinley	**EASTING:** 732128.48
DATE COMMENCED: 3-Dec-08	**DRILLING METHOD:** Mud/Rotary	**NORTHING:** 7477866.39
DATE COMPLETED: 5-Dec-09	**HYDROGEOLOGIST(s):** Glenn Kirkpatrick	**ELEVATION:** 500.18 mRL (TOC)

Well Notes: Hole diameter 12.5 inch mud/rotary 0-4 m, 6 inch mud/rotary 4-48m.

Depth (mbgl)	Geology	Lithological Description
0	ALL	ALLUVIUM: Red brown unconsolidated soil and fill. Clasts of hard angular siliceous BIF, chert and minor pisolites.
5	ALL	ALLUVIUM: Grey/white, hard siliceous BIF and minor chert. Angular to subangular grey still consolidated clay.
10	ALL	ALLUVIUM: Red/brown soft clay with angular bedded BIF.
15	ALL	ALLUVIUM: Brown clay and BIF. BIF is siliceous, subangular with minor chert. Course sand to pebble size.
20	ALL	ALLUVIUM: Brown BIF and clay, pebble size, subrounded, siliceous, bedded with minor chert and quartz. Red soft clay and yellow medium stiff clay present.
25	ALL	ALLUVIUM: Light brown, hard, subrounded to rounded BIF, chert and quartz. Red soft clay present with minor yellow clay throughout. Some pitted fracture surfaces.
30, 35	ALL	ALLUVIUM: Light brown, hard, subangular bedded BIF and chert + quartz. Yellow/red soft clay present throughout. Sand to pebble size range.
40, 45	WW Fm	WW: Grey, fresh, hard, angular. silicious, fine grained BIF, quartz and chert. Minor soft grey clay and black shale.

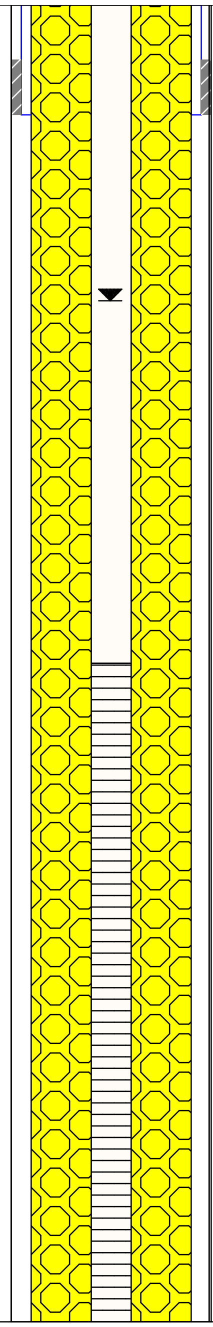
Field Notes

Intial WL 10.78 mbtoc (22/01/09)

Field chemistry: pH = 8.48, EC = 1030 uS/cm, temp = 24.6 C.

Airlift ~2 L/s. Airlift conducted with compressor and 20 mm tremie pipe.

Well Design



Well Construction

+0.7 - 4 m Steel 219 mm (8") collar cemented

+0.5 - 24 m, Cl12, 50 mm PVC blank casing

24 - 48 m, Cl12, 50 mm PVC slotted casing, 1 mm aperture

0 - 48 m graded gravel (3.2 to 6.4 mm)

Appendix 2: Laboratory Analysis of Groundwater

	Units	WB09YOXB001	WB08YJSW001	WB08YJSW02	WB09YJSW004	WB09YJSW05	WB09YJSW006	WB09YJSW007	WB08YJSE001	WB08YJSE002
Chloride, Cl	mg/L	84.9	94.7	94	99	87	98	110	100	110
Sulphate, SO4	mg/L	41.1	41.4	33	41.8	41	38.2	50	49	54
Bicarbonate, HCO3	mg/L	315	261	290	263	310	257	290	350	310
Calcium, Ca	mg/L	42.141	41.012	37	41.643	37	40.723	42	50	44
Magnesium, Mg	mg/L	42.847	40.011	36	40.284	38	39.582	39	44	41
Potassium, K	mg/L	6.049	6.39	5.7	6.213	5.3	6.228	5.8	7.2	6.6
Sodium, Na	mg/L	72.282	63.162	63	62.023	64	60.38	63	73	64
Bromine, Br	mg/L	0.3931	0.447	0.5	0.4311	0.4	0.446	0.5	0.4	0.5
Silica, Si	mg/L	20.76	20.35	22	20.14	22	20.03	23	26	0.42
Soluble Iron, Fe	mg/L	0.031	0.09	< 0.02	< 0.02	< 0.02	< 0.02	0.12	< 0.02	0.39

Appendix 3: Measured redox potential for the production bores during pumping test

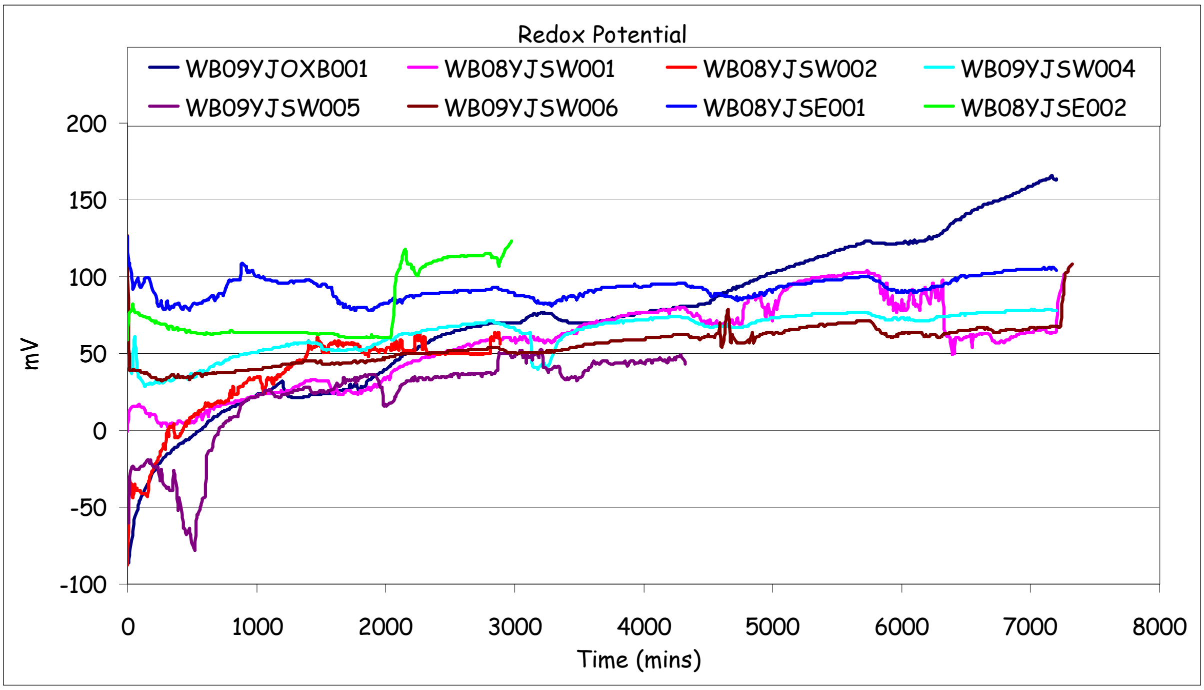
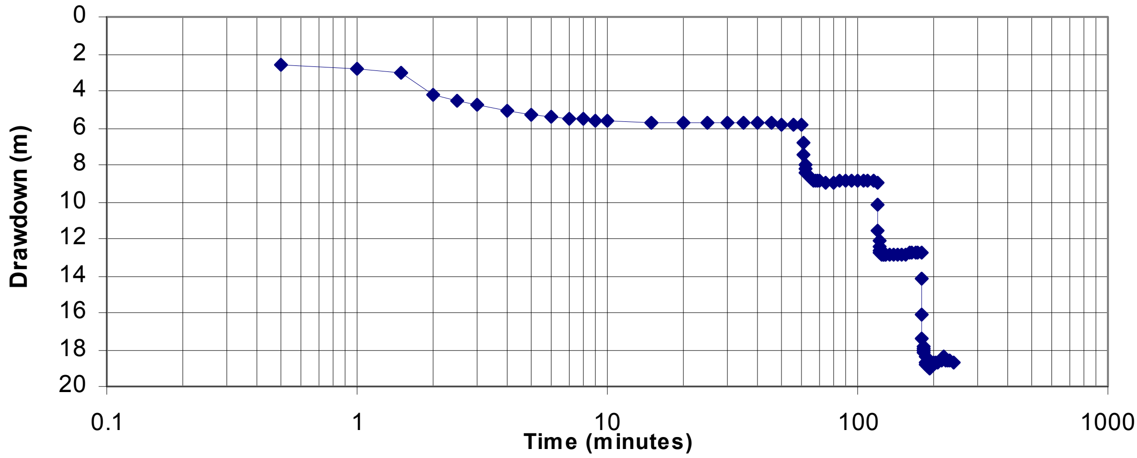


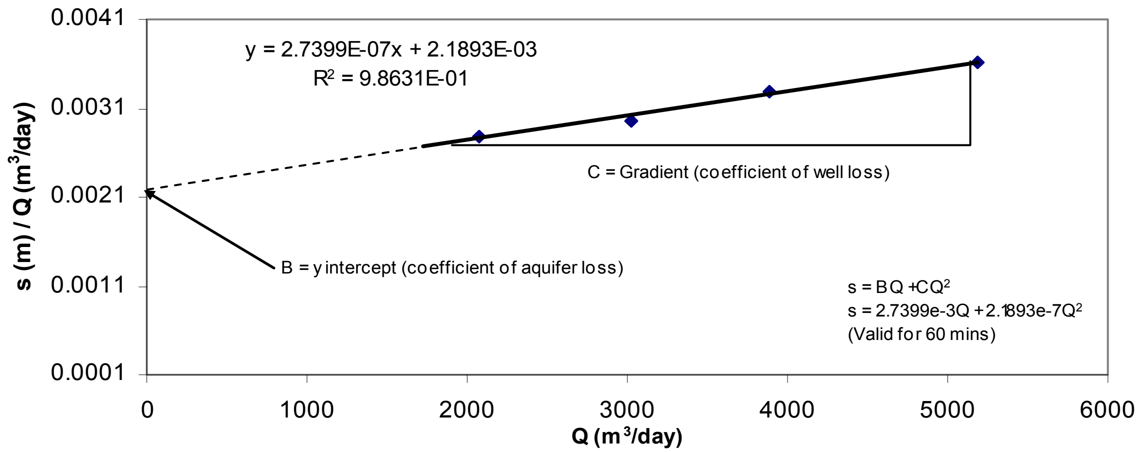
Figure 16 Redox potential measurements for the all test pumping bores

Appendix 4: Step test analysis

WB09YOXB001 Step Discharge Pumping Test (continuous)

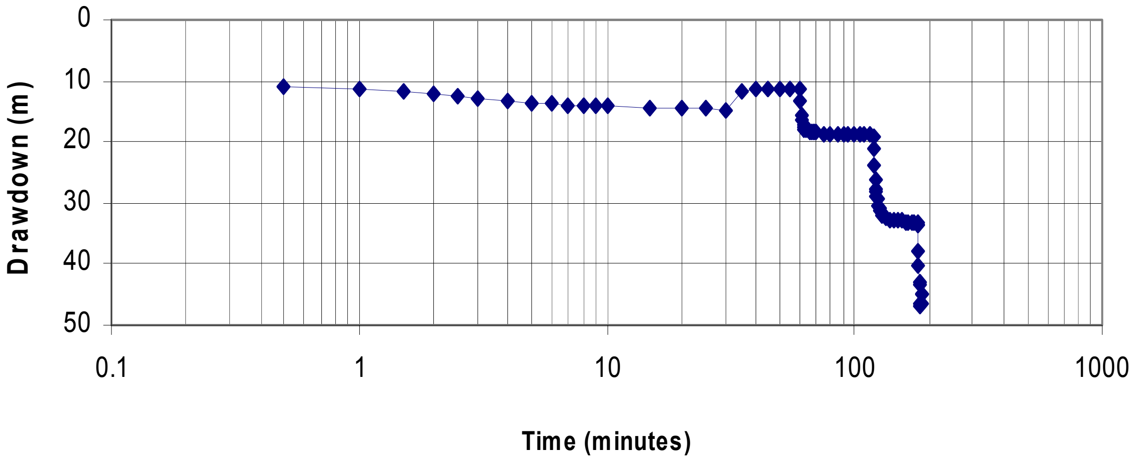


Analytical Plot of s/Q vs Q

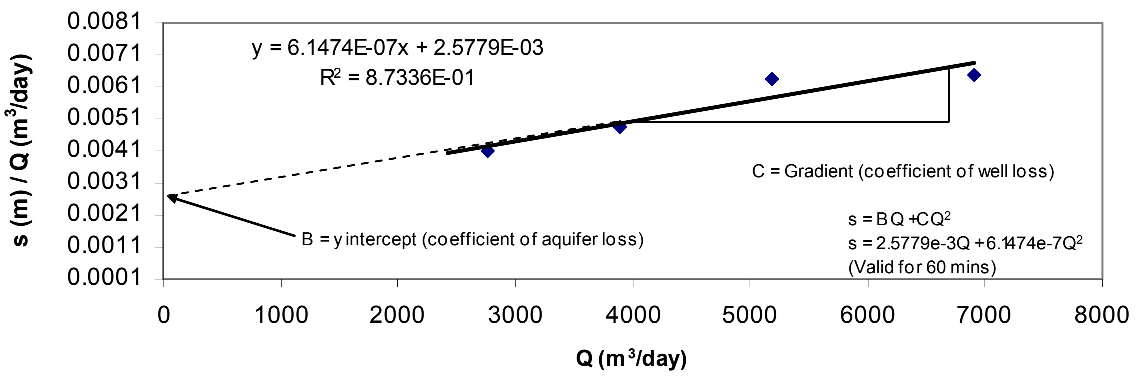


$s_{w(n)} = BQ_n + CQ^P_n$ (Rorabaugh's equation)						
Where, B	= Intercept with y axis (coefficient of aquifer loss or laminar flow)					
C	= Gradient (coefficient of turbulent flow loss or apparent well loss)					
s	= Drawdown in the borehole					
P	= Value determined using Rorabaugh's method of superposition					
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively.						
They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.						
$Ew = (BQ/(BQ + CQ^P) \times 100$						
Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow						
Comparison of Observed and Predicted Drawdowns						
			Observed	Predicted		Apparent
Step	Discharge	Discharge (Q)	Corrected	Drawdown	s/Q	Efficiency (Ew)
(60 min steps)	(L/s)	(m3/d)	Drawdown (s)	(metres)		%
			(metres)			
1	24	2074	5.785	5.72	0.00279	79.40
2	35	3024	8.94	9.13	0.002956	72.55
3	45	3888	12.75	12.65	0.003279	67.27
4	60	5184	18.735	18.71	0.003614	60.65

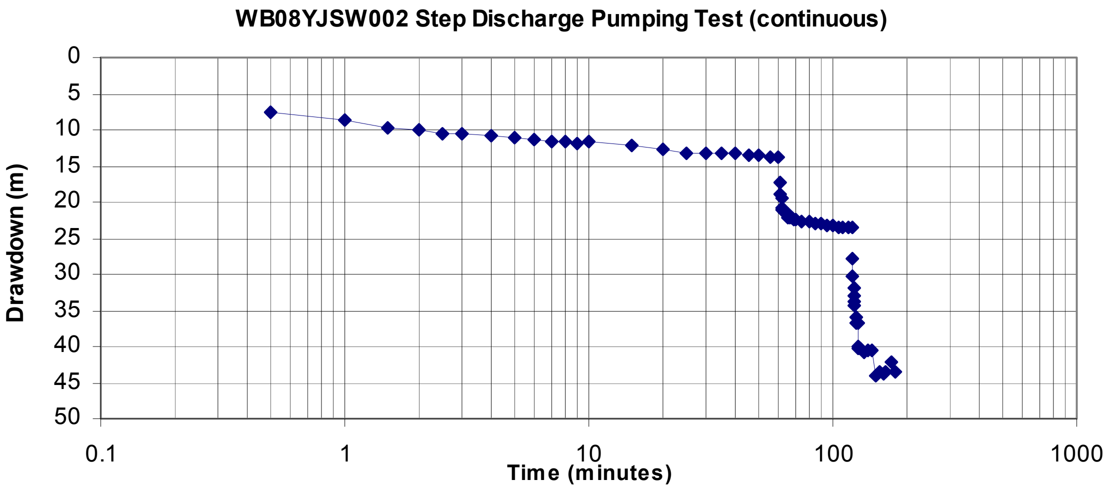
WB08YJSW001 Step Discharge Pumping Test (continuous)

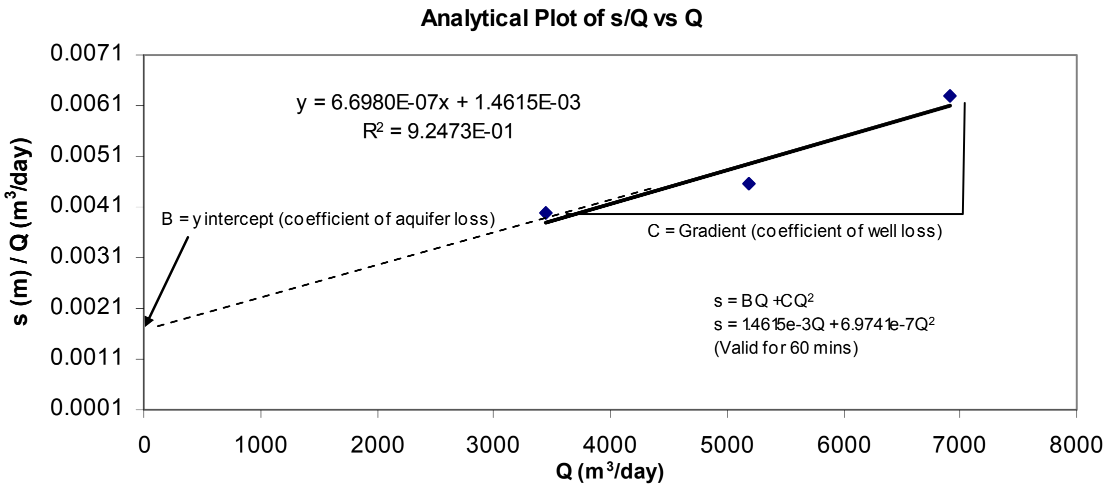


Analytical Plot of s/Q vs Q

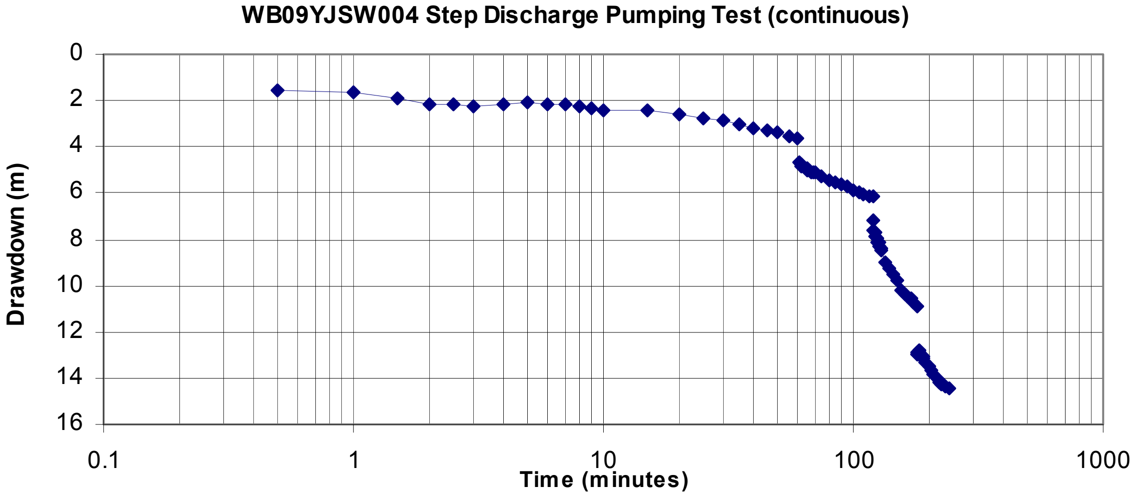


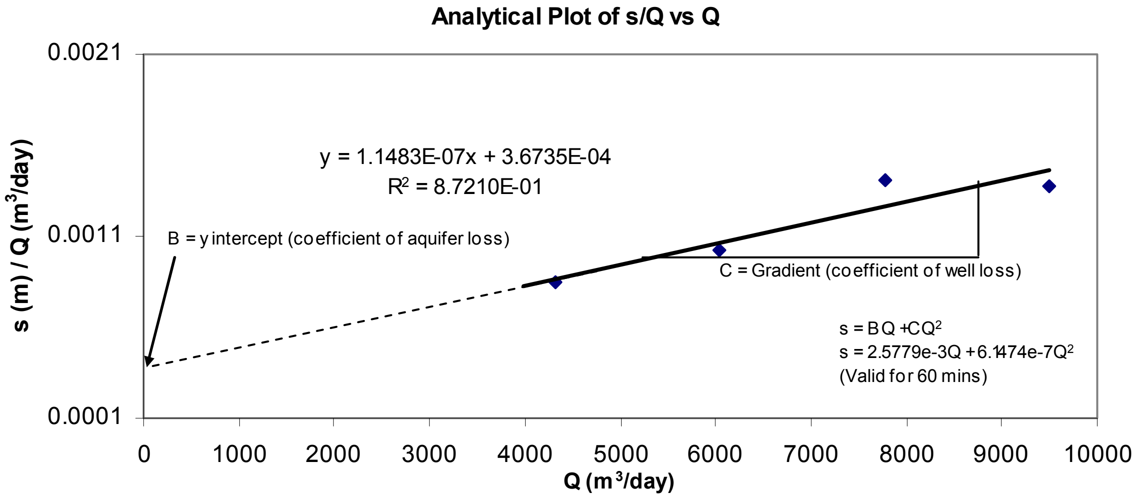
$s_{w(n)} = BQ_n + CQ^P_n$ (Rorabaugh's equation)						
Where, B	= Intercept with y axis (coefficient of aquifer loss or laminar flow)					
C	= Gradient (coefficient of turbulent flow loss or apparent well loss)					
s	= Drawdown in the borehole					
P	= Value determined using Rorabaugh's method of superposition					
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively.						
They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.						
Ew = $(BQ/(BQ + CQ^P) \times 100$						
Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow						
Comparison of Observed and Predicted Drawdowns						
			Observed	Predicted		Apparent
Step	Discharge	Discharge (Q)	Corrected	Drawdown	s/Q	Efficiency (Ew)
(60 min steps)	(L/s)	(m3/d)	Drawdown (s)	(metres)		%
			(metres)			
1	32	2765	11.315	11.83	0.004093	60.27
2	45	3888	18.95	19.32	0.004874	51.89
3	60	5184	33.04	29.88	0.006373	44.72
4	80	6912	44.91	47.19	0.006497	37.76



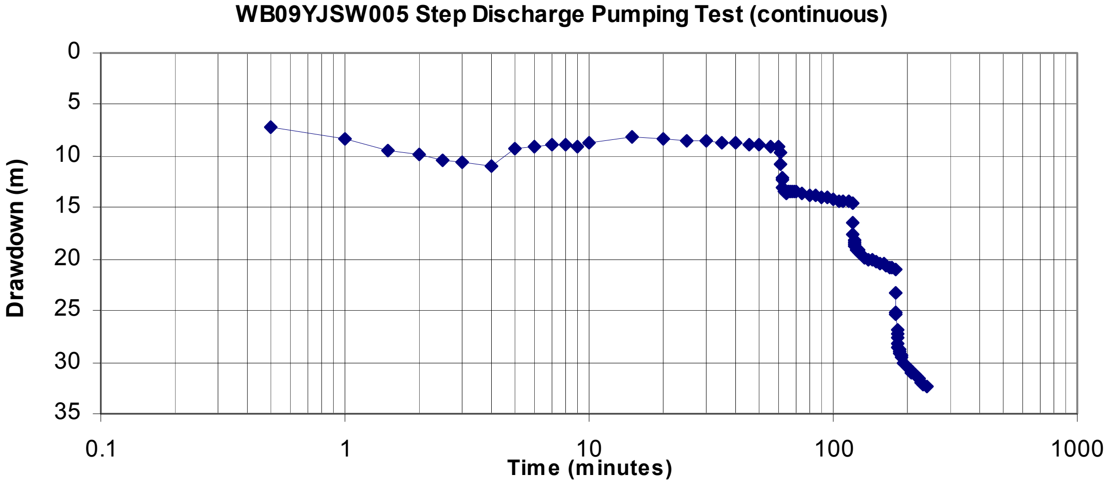


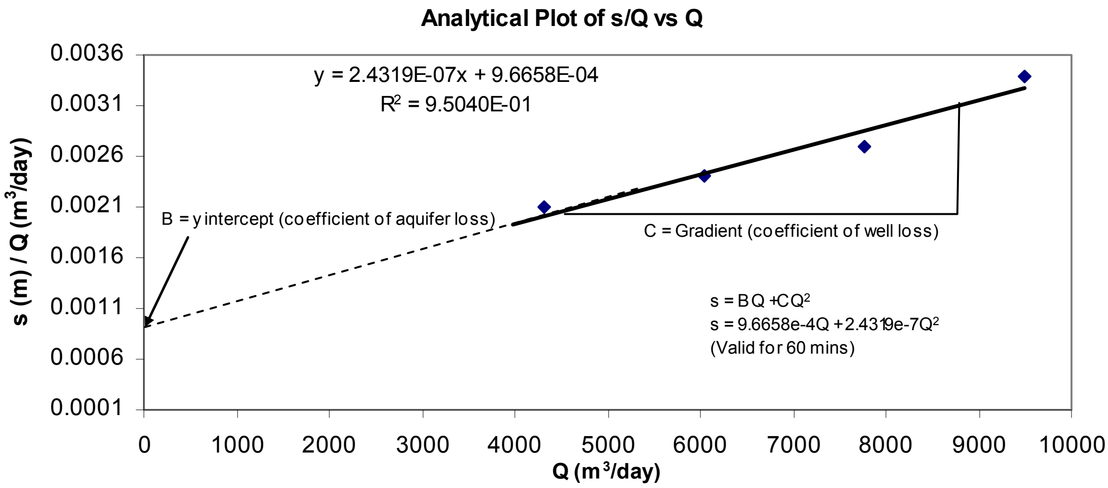
$s_{w(n)} = BQ_n + CQ^P_n$ (Rorabaugh's equation)						
Where, B	= Intercept with y axis (coefficient of aquifer loss or laminar flow)					
C	= Gradient (coefficient of turbulent flow loss or apparent well loss)					
s	= Drawdown in the borehole					
P	= Value determined using Rorabaugh's method of superposition					
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively.						
They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.						
Ew = $(BQ/(BQ + CQ^P) \times 100$						
Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow						
Comparison of Observed and Predicted Drawdowns						
			Observed	Predicted		Apparent
Step	Discharge	Discharge (Q)	Corrected	Drawdown	s/Q	Efficiency (Ew)
(60 min steps)	(L/s)	(m3/d)	Drawdown (s)	(metres)		%
			(metres)			
1	40	3456	13.71	13.38	0.003967	37.75
2	60	5184	23.6	26.32	0.004552	28.79
3	80	6912	43.42	43.42	0.006282	23.26





$s_{w(n)} = BQ_n + CQ^P_n$ (Rorabaugh's equation)						
Where, B	= Intercept with y axis (coefficient of aquifer loss or laminar flow)					
C	= Gradient (coefficient of turbulent flow loss or apparent well loss)					
s	= Drawdown in the borehole					
P	= Value determined using Rorabaugh's method of superposition					
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively.						
They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.						
Ew = (BQ/(BQ + CQ^P) x 100						
Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow						
Comparison of Observed and Predicted Drawdowns						
			Observed	Predicted		Apparent
Step	Discharge	Discharge (Q)	Corrected	Drawdown	s/Q	Efficiency (Ew)
(60 min steps)	(L/s)	(m3/d)	Drawdown (s)	(metres)		%
			(metres)			
1	50	4320	3.65	3.73	0.000845	42.55
2	70	6048	6.16	6.42	0.001019	34.60
3	90	7776	10.905	9.80	0.001402	29.15
4	110	9504	13.1	13.86	0.001378	25.18





$s_{w(n)} = BQ_n + CQ^P{}_n$ (Rorabaugh's equation)

Where, B	= Intercept with y axis (coefficient of aquifer loss or laminar flow)
C	= Gradient (coefficient of turbulent flow loss or apparent well loss)
s	= Drawdown in the borehole
P	= Value determined using Rorabaugh's method of superposition

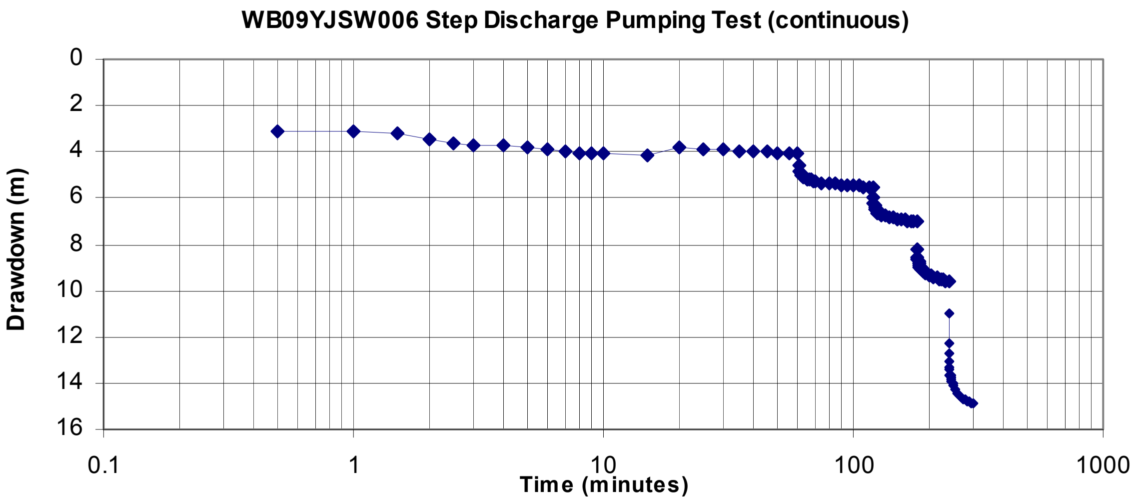
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively. They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.

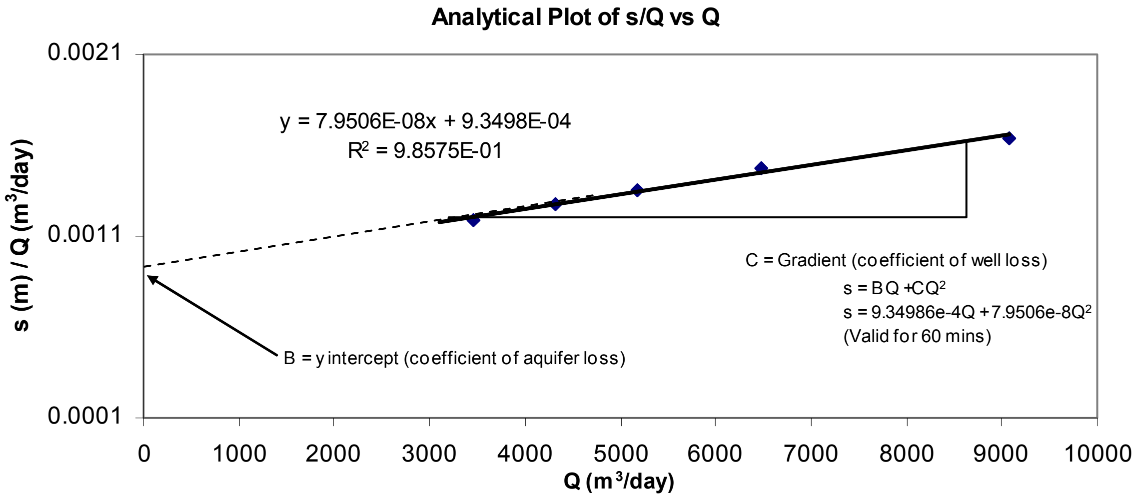
$Ew = (BQ/(BQ + CQ^P) \times 100$

Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow

Comparison of Observed and Predicted Drawdowns

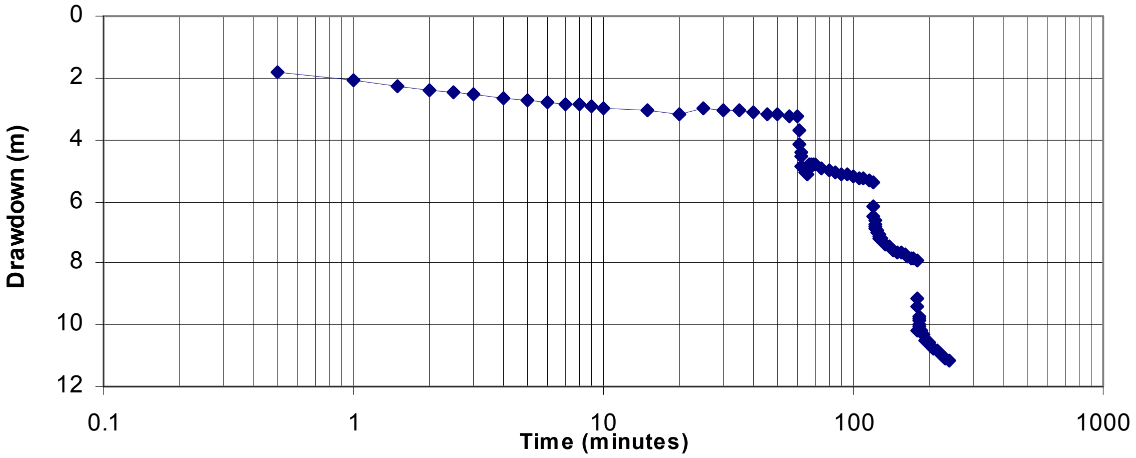
Step (60 min steps)	Discharge (L/s)	Discharge (Q) (m3/d)	Observed Corrected Drawdown (s) (metres)	Predicted Drawdown (metres)	s/Q	Apparent Efficiency (Ew) %
1	50	4320	9.04	8.71	0.002093	47.92
2	70	6048	14.54	14.74	0.002404	39.66
3	90	7776	20.98	22.22	0.002698	33.82
4	110	9504	32.27	31.15	0.003395	29.49



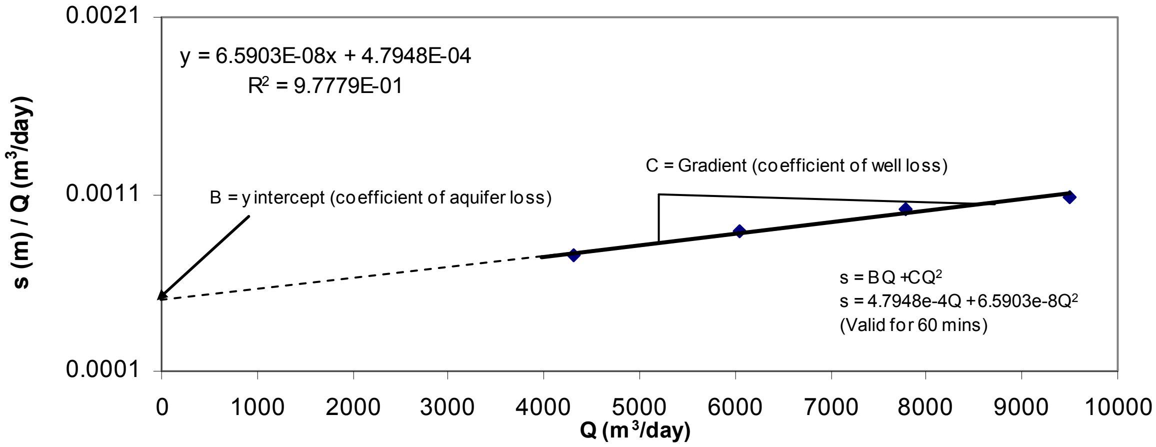


$s_{w(n)} = BQ_n + CQ^P_n$ (Rorabaugh's equation)						
Where, B	= Intercept with y axis (coefficient of aquifer loss or laminar flow)					
C	= Gradient (coefficient of turbulent flow loss or apparent well loss)					
s	= Drawdown in the borehole					
P	= Value determined using Rorabaugh's method of superposition					
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively.						
They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.						
Ew = (BQ/(BQ + CQ^P) x 100						
Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow						
Comparison of Observed and Predicted Drawdowns						
			Observed	Predicted		Apparent
Step	Discharge	Discharge (Q)	Corrected	Drawdown	s/Q	Efficiency (Ew)
(60 min steps)	(L/s)	(m3/d)	Drawdown (s)	(metres)		%
			(metres)			
1	40	3456	4.105	4.18	0.001188	77.29
2	50	4320	5.53	5.52	0.00128	73.13
3	60	5184	7.04	6.98	0.001358	69.40
4	75	6480	9.58	9.40	0.001478	64.47
5	105	9072	14.855	15.03	0.001637	56.45

WB09YJSW007 Step Discharge Pumping Test (continuous)



Analytical Plot of s/Q vs Q



$s_{w(n)} = BQ_n + CQ^P_n$ (Rorabaugh's equation)

Where, B = Intercept with y axis (coefficient of aquifer loss or laminar flow)

C = Gradient (coefficient of turbulent flow loss or apparent well loss)

s = Drawdown in the borehole

P = Value determined using Rorabaugh's method of superposition

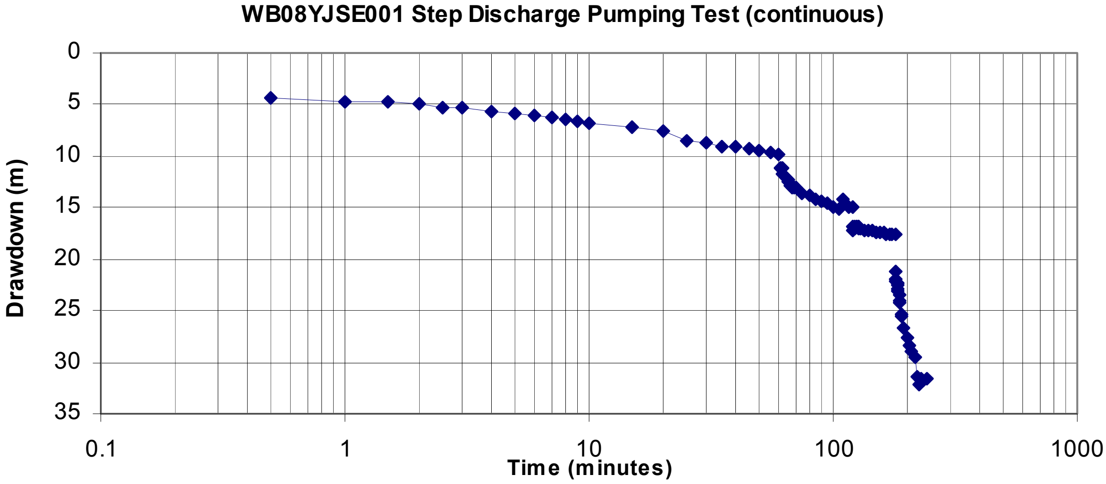
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively. They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.

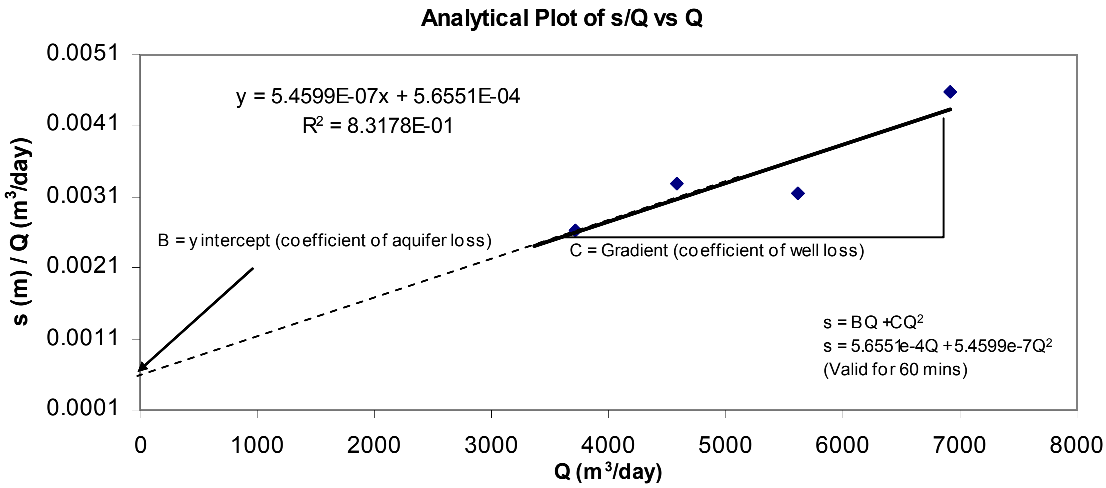
$Ew = (BQ/(BQ + CQ^P) \times 100$

Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow

Comparison of Observed and Predicted Drawdowns

Step (60 min steps)	Discharge (L/s)	Discharge (Q) (m3/d)	Observed Corrected Drawdown (s) (metres)	Predicted Drawdown (metres)	s/Q	Apparent Efficiency (Ew) %
1	50	4320	3.24	3.30	0.00075	62.74
2	70	6048	5.355	5.31	0.000885	54.60
3	90	7776	7.93	7.71	0.00102	48.33
4	110	9504	10.31	10.51	0.001085	43.36





$s_{w(n)} = BQ_n + CQ^r{}_n$ (Rorabaugh's equation)

Where, B	= Intercept with y axis (coefficient of aquifer loss or laminar flow)
C	= Gradient (coefficient of turbulent flow loss or apparent well loss)
s	= Drawdown in the borehole
P	= Value determined using Rorabaugh's method of superposition

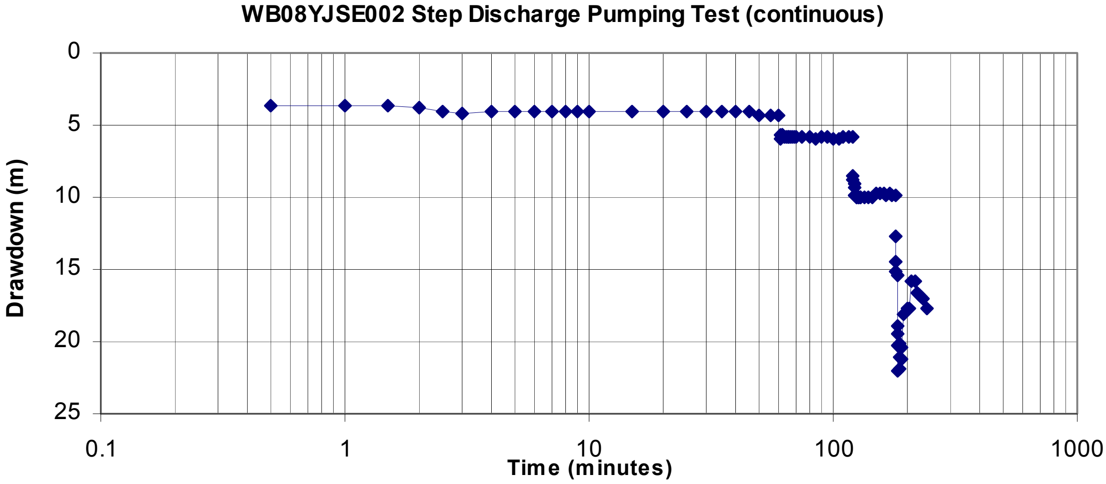
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively. They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.

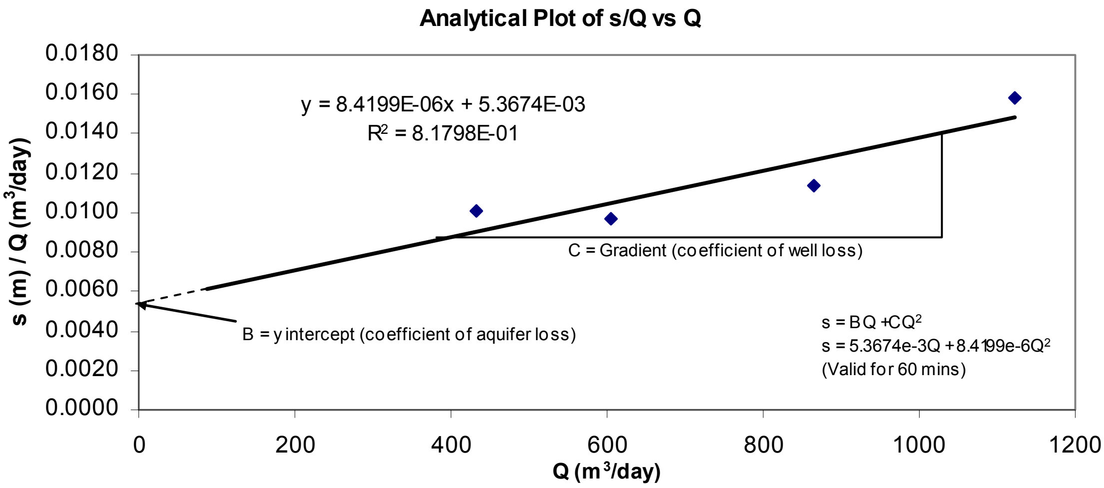
$Ew = (BQ/(BQ + CQ^P) \times 100$

Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow

Comparison of Observed and Predicted Drawdowns

Step (60 min steps)	Discharge (L/s)	Discharge (Q) (m3/d)	Observed Corrected Drawdown (s) (metres)	Predicted Drawdown (metres)	s/Q	Apparent Efficiency (Ew) %
1	43	3715	9.795	9.69	0.002636	21.68
2	53	4579	15.02	14.12	0.00328	18.34
3	65	5616	17.64	20.52	0.003141	15.48
4	80	6912	31.61	30.18	0.004573	12.95





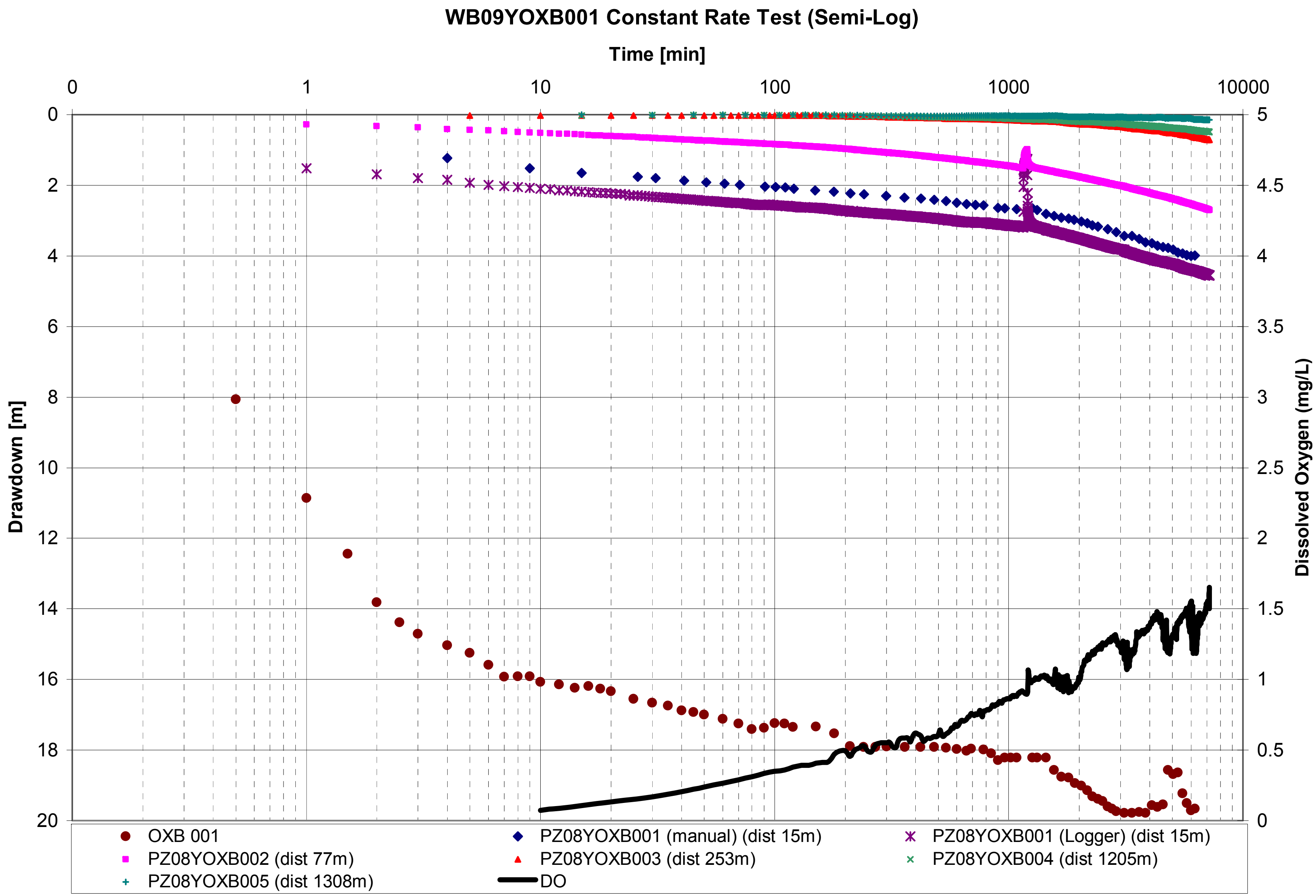
$s_{w(n)} = BQ_n + CQ^P_n$ (Rorabaugh's equation)						
Where, B	= Intercept with y axis (coefficient of aquifer loss or laminar flow)					
C	= Gradient (coefficient of turbulent flow loss or apparent well loss)					
s	= Drawdown in the borehole					
P	= Value determined using Rorabaugh's method of superposition					
Components of the equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively.						
They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.						
Ew = $(BQ/(BQ + CQ^P) \times 100$						
Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow						
Comparison of Observed and Predicted Drawdowns						
			Observed	Predicted		Apparent
Step	Discharge	Discharge (Q)	Corrected	Drawdown	s/Q	Efficiency (Ew)
(60 min steps)	(L/s)	(m3/d)	Drawdown (s)	(metres)		%
			(metres)			
1	5	432	4.35	3.89	0.010069	59.61
2	7	605	5.85	6.33	0.009673	51.31
3	10	864	9.83	10.92	0.011377	42.46
4	13	1123	17.76	16.65	0.015812	36.21

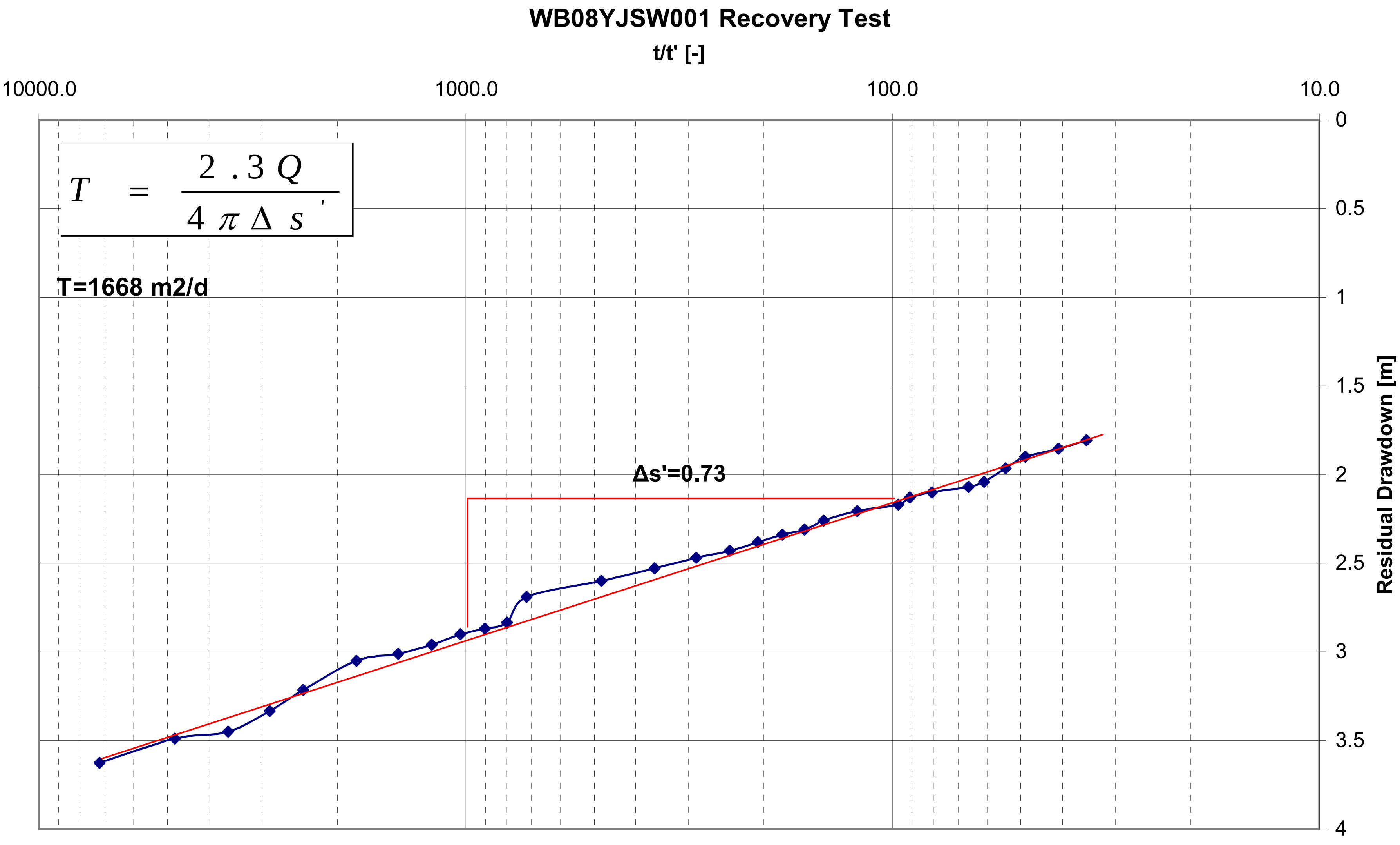
Appendix 5: Test pumping results

WB09YOXB001 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Calculated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Adopted T (m^2/d)
WB09YOXB001	CID	Cooper-Jacob	0	37.79	57.66	-	-	1300	18.5	350
		Logan				-	-	364	5.2	
		Neuman				-	-	369	6.2	
PZ08YOXB001	CID	Neuman	10	10.95	10.21	$8.22x10^{-4}$	$5.2x10^{-1}$	519	8.65	600
		Cooper-Jacob (Middle)				$1.45x10^{-2}$	-	1880	28	
		Cooper-Jacob (Late)				-	-	516	7.7	
		Theis				$2.33x10^{-1}$	-	923	13.7	
PZ08YOXB002	CID	Neuman (manual)	108	10.38	6.293	$3.43x10^{-4}$	$2.04x10^{-3}$	1360	21	1500
		Cooper-Jacob (Middle)				$3.74x10^{-2}$	-	2130	31.9	
		Cooper-Jacob Late)				$1.61x10^{-1}$	-	630	9.4	
		Theis				$1.65x10^{-2}$	-	2600	38	
PZ08YOXB003	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman (manual)	175	18.99	0.713	$8.53x10^{-4}$	$8.53x10^{-2}$	3270	48.9	3500
		Cooper-Jacob (Middle)				$5.73x10^{-2}$	-	5380	80.4	

		Cooper-Jacob Late)				$9.69x10^{-1}$	-	1220	18.3	
		Theis				$6.56x10^{-1}$	-	2920	43.5	
PZ08YOXB004	CID	Neuman	1205	27.55	0.488	$6.84x10^{-4}$	$2.31x10^{-1}$	2920	43.5	3000
		Cooper-Jacob (Middle)				$5.31x10^{-2}$	-	7250	108	
		Cooper-Jacob Late)				$8.88x10^{-2}$	-	1910	28.8	
		Theis				$6.56x10^{-1}$	-	4620	69	
PZ08YOXB005	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman	1308	18.16	0.143	$8.59x10^{-4}$	$3.52x10^{-2}$	2920	61.5	3500
		Cooper-Jacob				$6.24x10^{-2}$	-	9710	144	
		Theis				$5.85x10^{-3}$	-	8230	122	


WB09YOXB001 Constant Rate Test (Semi-Log)
Time [min]
0
1
10
100
1000
10000
Drawdown [m]
0
2
4
6
8
10
12
14
16
18
20
Dissolved Oxygen (mg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
OXB 001
PZ08YOXB001 (manual) (dist 15m)
PZ08YOXB001 (Logger) (dist 15m)
PZ08YOXB002 (dist 77m)
PZ08YOXB003 (dist 253m)
PZ08YOXB004 (dist 1205m)
PZ08YOXB005 (dist 1308m)
DO

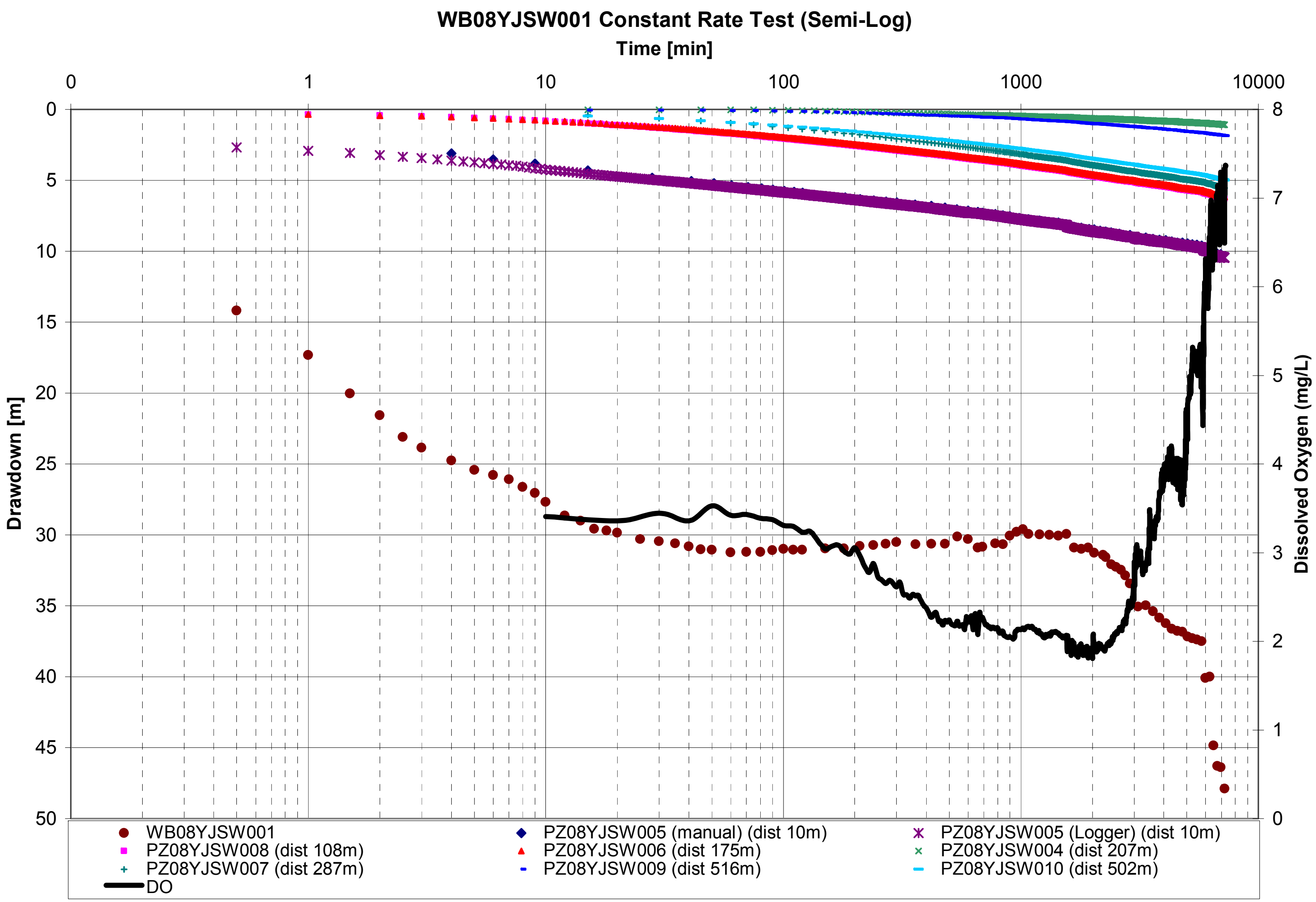


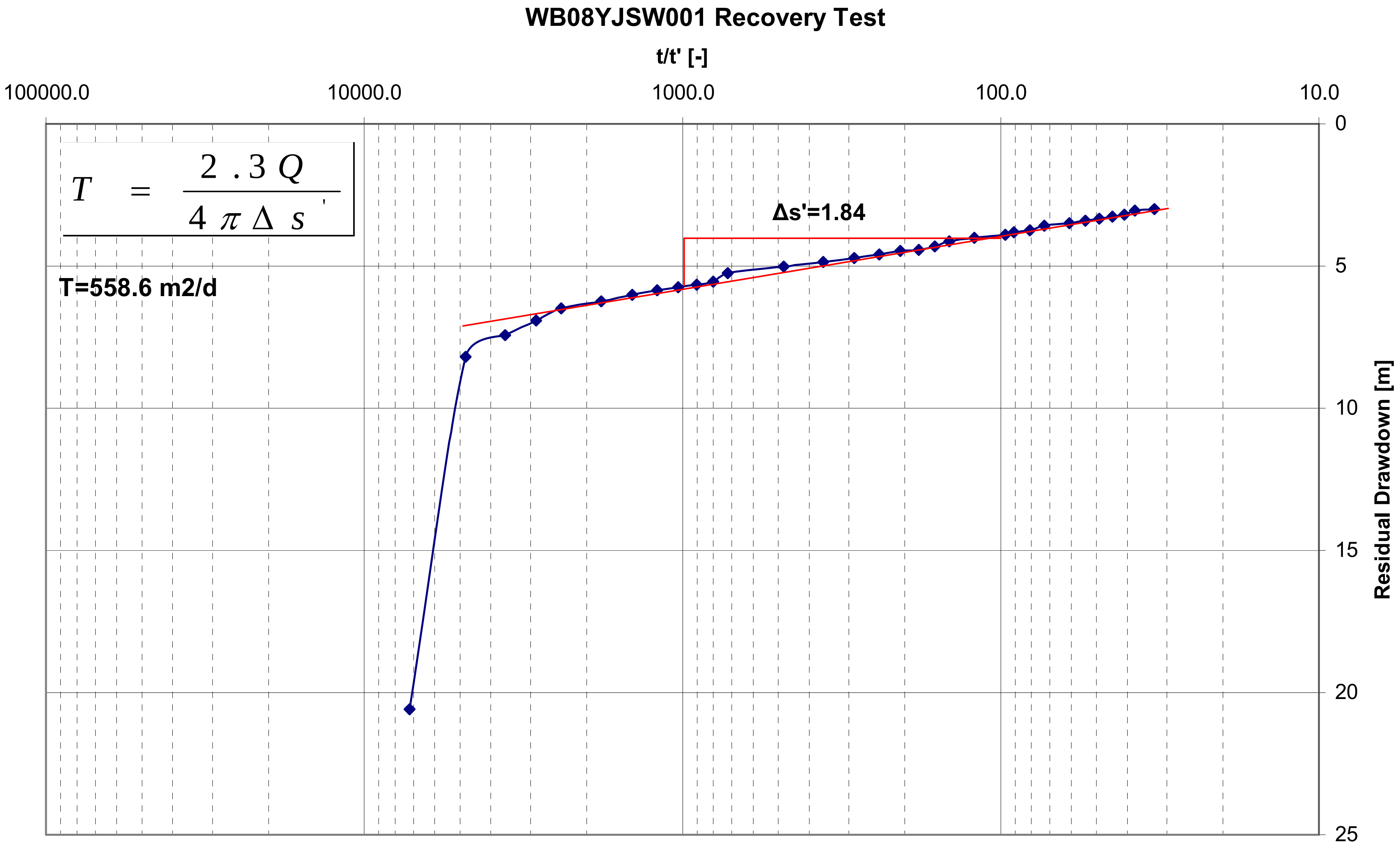
WB08YJSW001 Recovery Test
t/t' [-]
10000.0
1000.0
100.0
10.0
0
0.5
1
1.5
2
2.5
3
3.5
4
Residual Drawdown [m]
$T = \frac{2.3Q}{4\pi\Delta s'}$
T=1668 m2/d
Δs'=0.73

WB08YJSW001 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Calculated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Adopted T (m^2/d)
WB08YJSW001	CID	Cooper-Jacob	0	11.15	47.88	-	-	558	1.3	250
		Logan				-	-	250	3.57	
		Neuman (ATP)				-	-	223	3.18	
PZ08YJSW005	CID	Neuman (manual)	10	10.95	10.21	$9.1x10^{-4}$	$6.2x10^{-3}$	319	4.9	350
		Cooper-Jacob (All)				$2.17x10^{-1}$	-	482	7.2	
		Theis				$3.56x10^{-1}$	-	398	5.94	
PZ08YJSW008	CID	Neuman (manual)	108	10.35	6.29	$1.26x10^{-5}$	$5.25x10^{-4}$	398	5.94	450
		Cooper-Jacob (Middle)				$7.75x10^{-1}$	-	555	8.28	
		Cooper-Jacob Late)				$2.21x10^{-1}$	-	429	6.41	
		Theis				$7.11x10^{-1}$	-	891	13.3	
PZ08YJSW006	CID	Neuman	175	18.99	6.17	$2.37x10^{-4}$	$2.37x10^{-1}$	455	6.50	460
		Cooper-Jacob (Middle)				$2.32x10^{-1}$	-	445	6.36	
		Cooper-Jacob Late)				$4.80x10^{-2}$	-	655	9.36	
		Theis				$5.74x10^{-7}$	-	486	6.94	
PZ08YJSW007	CID	Neuman	287	20.33	5.54	$3.85x10^{-5}$	$3.85x10^{-1}$	501	7.48	500
		Cooper-				$3.98x10^{-1}$		495	7.39	

		Jacob (Middle)								
		Cooper-Jacob Late)				$6.39x10^{-1}$	-	401	5.99	
		Theis				$2.83x10^{-1}$	-	501	7.48	
PZ08YJSW010	CID	Neuman	502	12.66	4.99	$1.0x10^{-5}$	$1.0x10^{-1}$	631	9.42	600
		Cooper-Jacob (Middle)				$1.41x10^{-1}$	-	562	8.4	
		Cooper-Jacob Late)				$2.63x10^{-1}$	-	431	6.44	
		Theis				$1.0x10^{-1}$	-	562	8.39	
PZ08YJSW004	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman (manual)	207	8.10	1.08	$5.77x10^{-3}$	$1.01x10^{-3}$	1990	29.5	1900
		Cooper-Jacob (All)				$1.21x10^{-2}$	-	1970	29.4	
		Theis				$1.41x10^{-2}$	-	1770	26.5	
PZ08YJSW009	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman	516	11.95	1.88	$1.5x10^{-4}$	$1.5x10^{-2}$	1250	18.7	1250
		Cooper-Jacob (Middle)				$1.19x10^{-1}$	-	1333	19.8	
		Cooper-Jacob Late)				$2.24x10^{-1}$	-	754	11.2	
		Theis				$1.26x10^{-1}$	-	1410	21	


WB08YJSW001 Constant Rate Test (Semi-Log)
Time [min]
0
1
10
100
1000
10000
Drawdown [m]
0
5
10
15
20
25
30
35
40
45
50
Dissolved Oxygen (mg/L)
8
7
6
5
4
3
2
1
0
WB08YJSW001
PZ08YJSW005 (manual) (dist 10m)
PZ08YJSW005 (Logger) (dist 10m)
PZ08YJSW008 (dist 108m)
PZ08YJSW006 (dist 175m)
PZ08YJSW004 (dist 207m)
PZ08YJSW007 (dist 287m)
PZ08YJSW009 (dist 516m)
PZ08YJSW010 (dist 502m)
DO

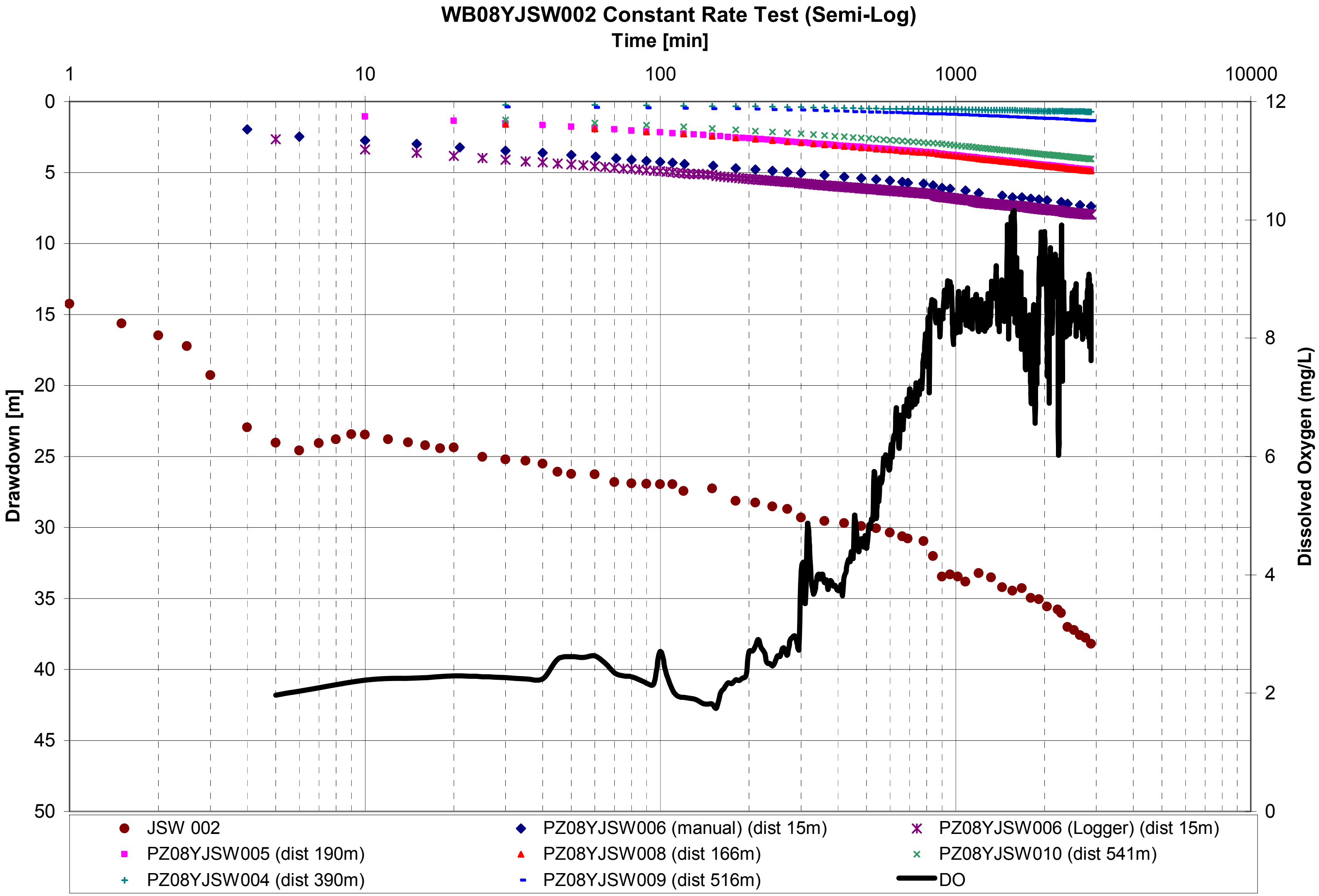


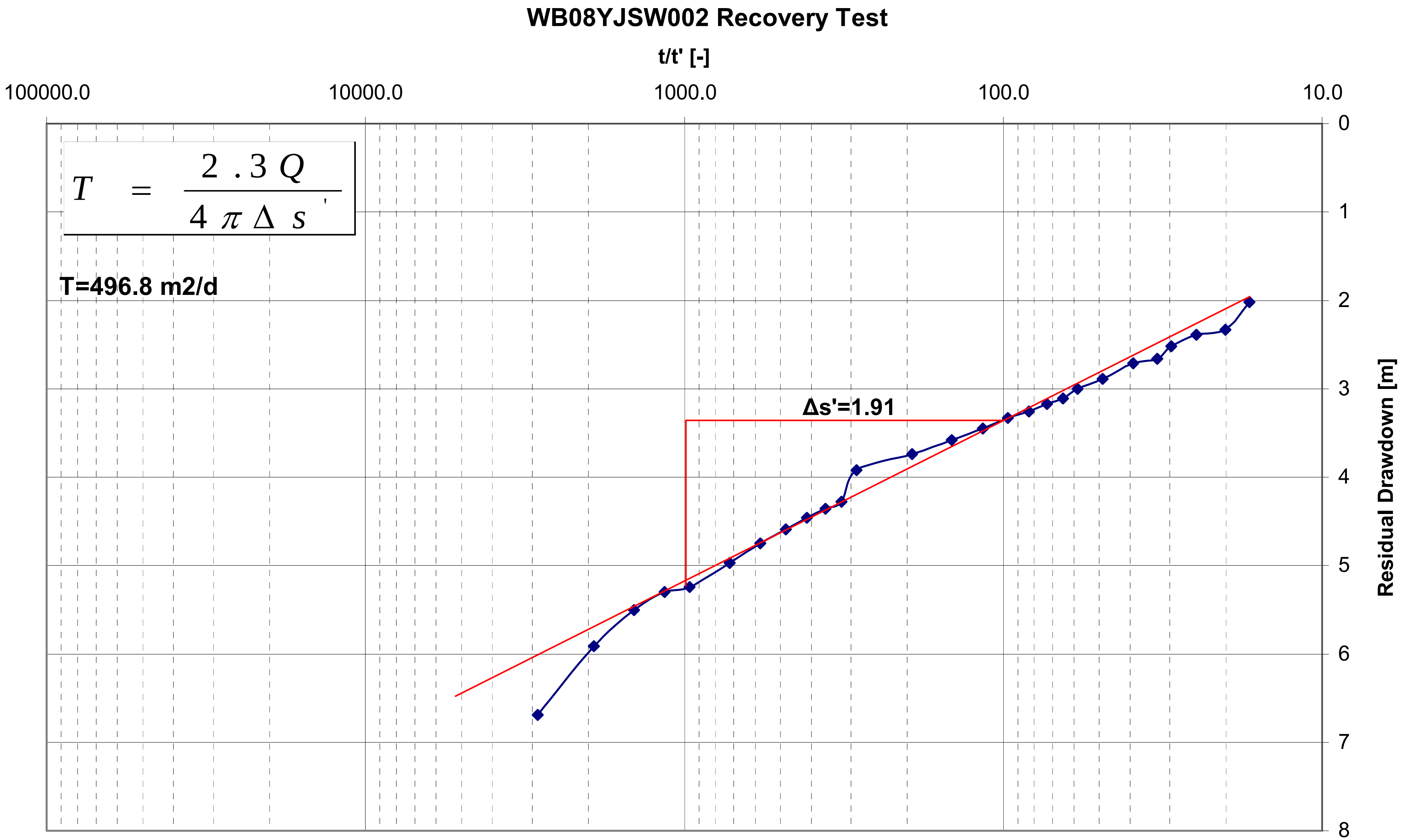
WB08YJSW001 Recovery Test
t/t' [-]
100000.0
10000.0
1000.0
100.0
10.0
0
5
10
15
20
25
Residual Drawdown [m]
$T = \frac{2.3Q}{4\pi\Delta s'}$
T=558.6 m2/d
Δs'=1.84

WB08YJSW002 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Calculated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Adopted T (m^2/d)
WB08YJSW002	CID	Cooper-Jacob (Recovery)	0	20.78	38.19	-	-	497	8.3	250
		Logan				-	-	241	4	
		Neuman (ATP)				-	-	130	2.2	
PZ08YJSW006	CID	Neuman	15	19.62	7.95	7.33×10^{-4}	7.33×10^{-2}	292	4.3	350
		Cooper-Jacob (All)				9.97×10^{-1}	-	527	7.87	
		Theis				2.33×10^{0}	-	412	6.15	
PZ08YJSW005	CID	Neuman	190	11.11	4.8	1.44×10^{-4}	1.62×10^{-1}	589	9.06	600
		Cooper-Jacob (Middle)				1.62×10^{-1}	-	607	9.06	
		Cooper-Jacob Late)				4.55×10^{-1}	-	442	6.6	
		Theis				1.16×10^{-1}	-	653	9.75	
PZ08YJSW008	CID	Neuman (manual)	166	11.02	4.9	2.67×10^{-4}	1.19×10^{-4}	260	3.88	460
		Cooper-Jacob (Middle)				2.41×10^{-1}	-	577	8.61	
		Cooper-Jacob Late)				5.78×10^{-1}	-	438	6.54	
		Theis				2.33×10^{-1}	-	519	7.75	
PZ08YJSW010	CID	Neuman	541	13.45	4.04	3.99×10^{-2}	1.0×10^{-1}	462	6.9	500
		Cooper-				4.87×10^{-2}	-	616	9.19	

		(Middle)								
		Cooper-Jacob Late)				$1.04x10^{-1}$	-	471	7.04	
		Theis				$5.21x10^{-2}$	-	519	7.75	
PZ08YJSW004	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman	390	8.68	0.7	$4.84x10^{-1}$	$9.66x10^{-1}$	2310	34.6	3000
		Cooper-Jacob (All)				$5.6x10^{-1}$	-	3250	48.6	
		Theis				$5.21x10^{-1}$	-	3270	48.9	
PZ08YJSW009	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman	516	12.77	1.35	$2.76x10^{-2}$	$1.55x10^{-1}$	462	6.9	550
		Cooper-Jacob (All)				$5.99x10^{-2}$	-	578	8.63	
		Theis				$4.14x10^{-2}$	-	653	9.75	

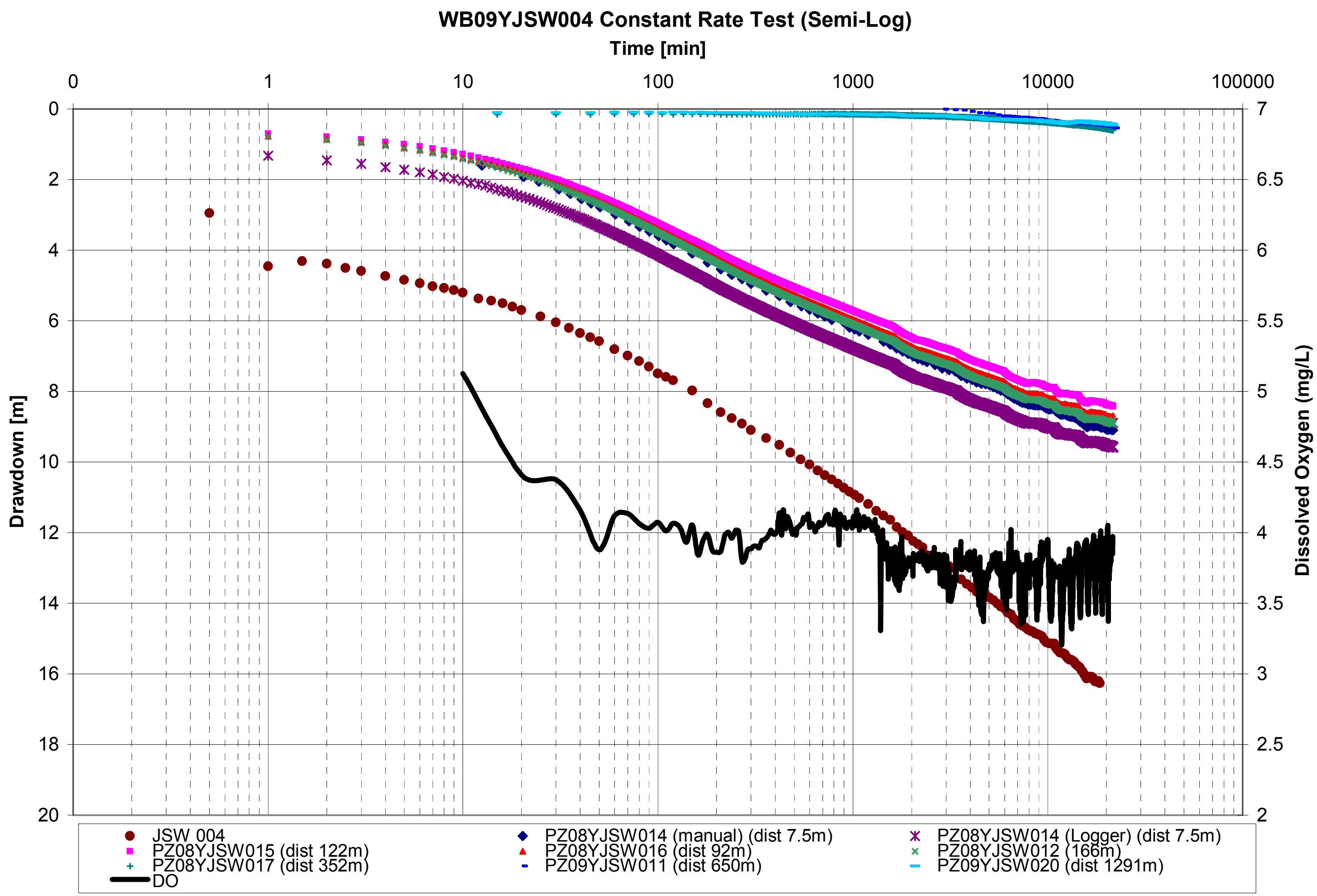

WB08YJSW002 Constant Rate Test (Semi-Log)
Time [min]
1
10
100
1000
10000
Drawdown [m]
0
5
10
15
20
25
30
35
40
45
50
Dissolved Oxygen (mg/L)
12
10
8
6
4
2
0
JSW 002
PZ08YJSW006 (manual) (dist 15m)
PZ08YJSW006 (Logger) (dist 15m)
PZ08YJSW005 (dist 190m)
PZ08YJSW008 (dist 166m)
PZ08YJSW010 (dist 541m)
PZ08YJSW004 (dist 390m)
PZ08YJSW009 (dist 516m)
DO


WB08YJSW002 Recovery Test
t/t' [-]
100000.0
10000.0
1000.0
100.0
10.0
0
1
2
3
4
5
6
7
8
Residual Drawdown [m]
$T = \frac{2.3Q}{4\pi\Delta s'}$
T=496.8 m2/d
Δs'=1.91

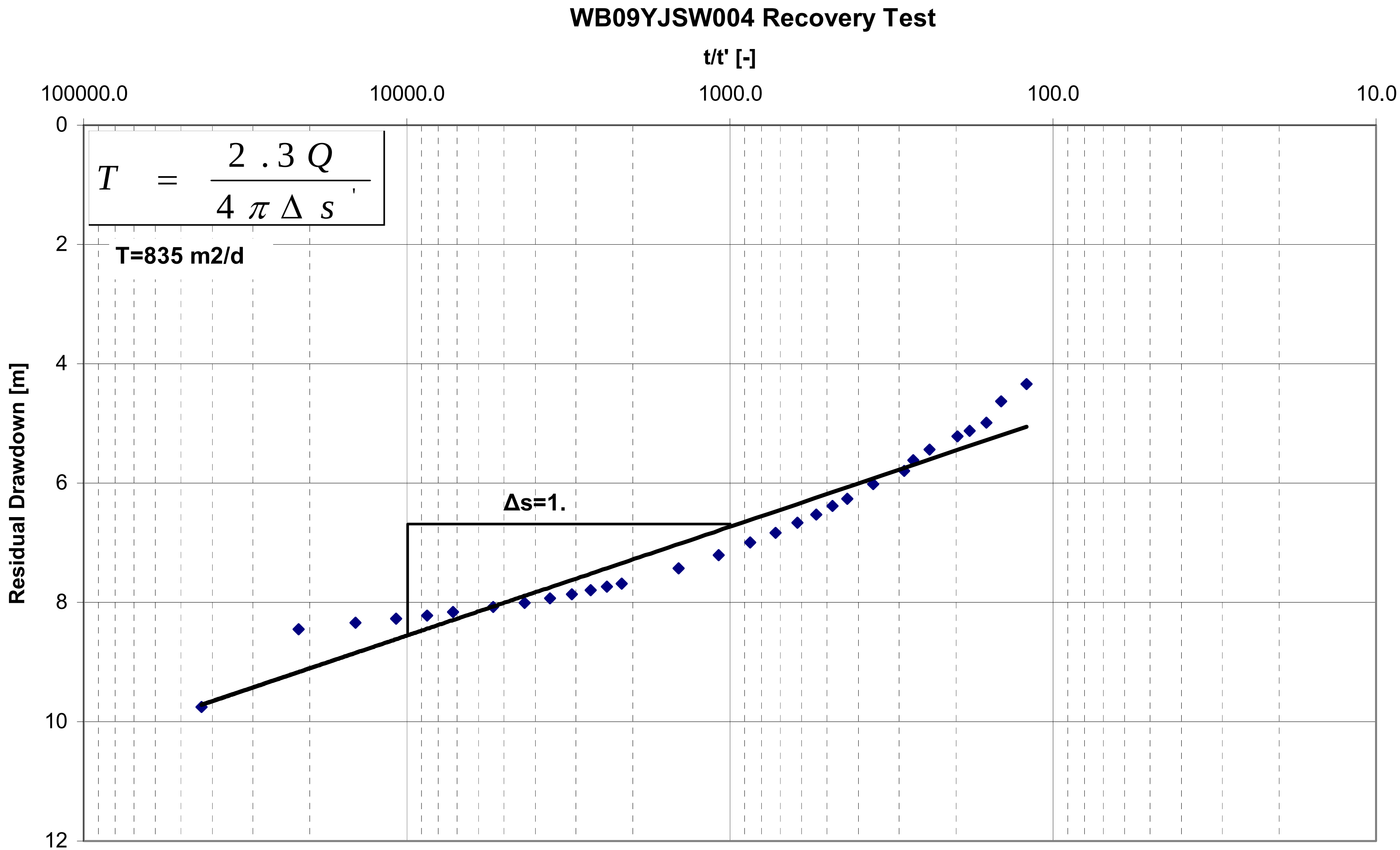
WB09YJSW004 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Calculated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Adopted T (m^2/d)
WB09YJSW004	CID	Cooper-Jacob	0	13.08	16.53	-	-	834	11.9	500
		Logan				-	-	684	9.7	
		Neuman (ATP)				-	-	231	3.3	
PZ08YJSW005	CID	Neuman (manual)	7.5	12.6	9.1	1.66×10^{-2}	3.87×10^{-2}	582	8.68	600
		Cooper-Jacob (All)				7.16×10^{-1}	-	627	9.35	
		Theis				9.27×10^{-1}	-	653	9.74	
PZ08YJSW015	CID	Neuman	108	10.35	6.29	4.98×10^{-5}	1.98×10^{-1}	518	7.74	550
		Cooper-Jacob (All)				4.1×10^{-1}	-	631	9.43	
		Theis				4.14×10^{-1}	-	582	8.68	
PZ08YJSW016	CID	Neuman	92	15.56	8.69	9.76×10^{-5}	9.76×10^{-2}	462	6.9	500
		Cooper-Jacob (All)				6.99×10^{-1}	-	601	8.97	
		Theis				4.64×10^{-1}	-	732	10.9	
PZ08YJSW012	CID	Neuman	166	15.72	8.81	2.12×10^{-5}	2.12×10^{-1}	462	6.9	500
		Cooper-Jacob (Middle)				2.27×10^{-1}	-	562	8.38	
		Cooper-Jacob Late)				8.59×10^{-2}	-	686	10.2	
		Theis				1.46×10^{-1}	-	582	8.68	
PZ08YJSW017	ALLUVIAL/INSITU WEATHERERD	Neuman	502	12.66	4.99	6.32×10^{-3}	6.32×10^{-2}	4620	69	4500

	BEDROCK	Cooper-Jacob (All)				8.2×10^{-1}	-	3900	58.3	
		Theis				8.26×10^{-1}	-	4120	61.5	
PZ09YJSW011	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman	650	7.56	0.538	5.51×10^{-4}	5.51×10^{-3}	1460	21.8	1500
		Cooper-Jacob (All)				-	-	2820	42	
		Theis				-	-	1160	17.3	
PZ09YJSW020	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman	1291	5.93	0.446	9.89×10^{-5}	9.89×10^{-3}	9220	137	10000
		Cooper-Jacob (Middle)				4.71×10^{-1}	-	14800	221	
		Cooper-Jacob Late)				-	-	6760	100	
		Theis				7.36×10^{-1}	-	11600	173	

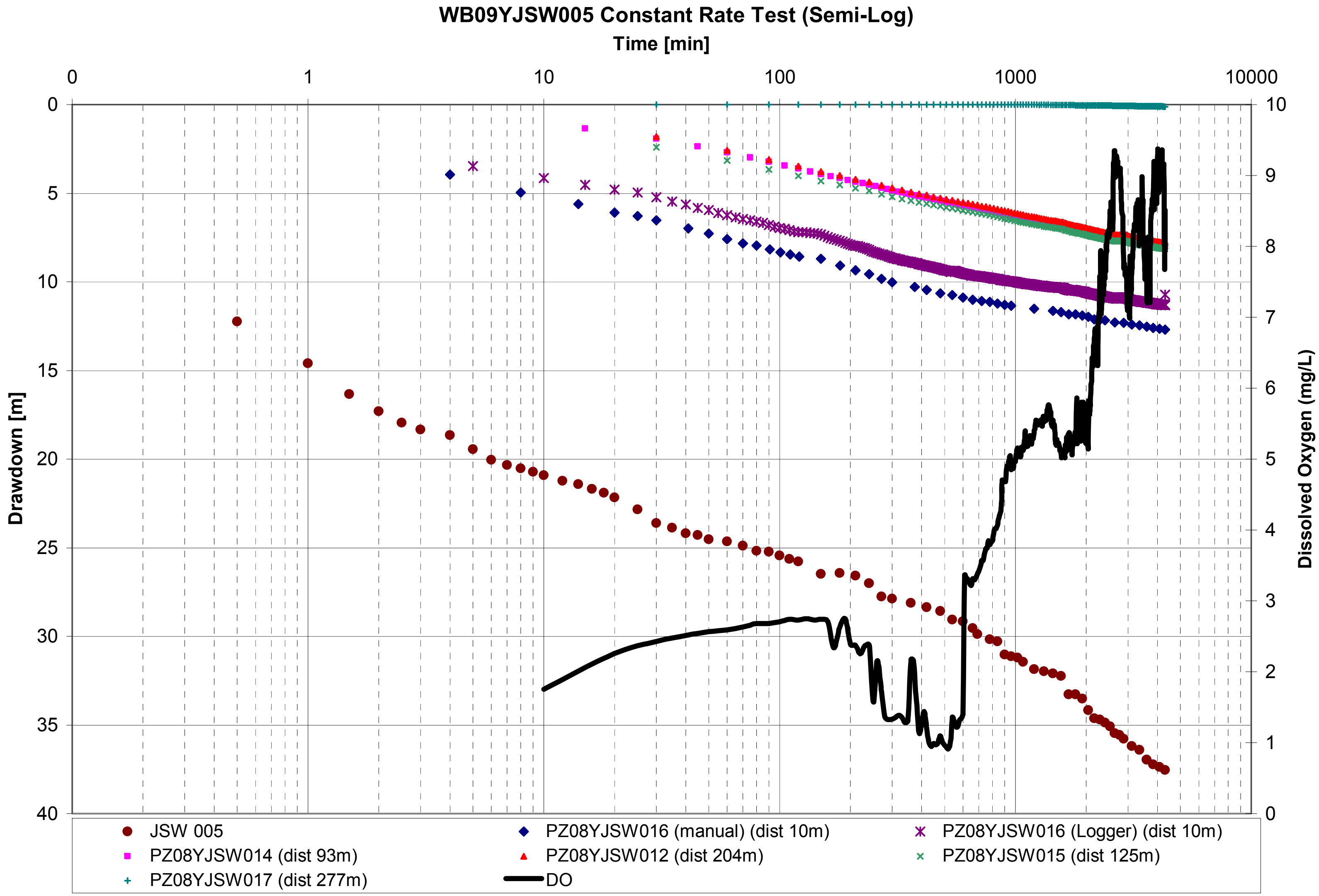


WB09YJSW004 Constant Rate Test (Semi-Log)
Time [min]
0
1
10
100
1000
10000
100000
Drawdown [m]
0
2
4
6
8
10
12
14
16
18
20
Dissolved Oxygen (mg/L)
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
JSW 004
PZ08YJSW014 (manual) (dist 7.5m)
PZ08YJSW014 (Logger) (dist 7.5m)
PZ08YJSW015 (dist 122m)
PZ08YJSW016 (dist 92m)
PZ08YJSW012 (166m)
PZ08YJSW017 (dist 352m)
PZ09YJSW011 (dist 650m)
PZ09YJSW020 (dist 1291m)
DO

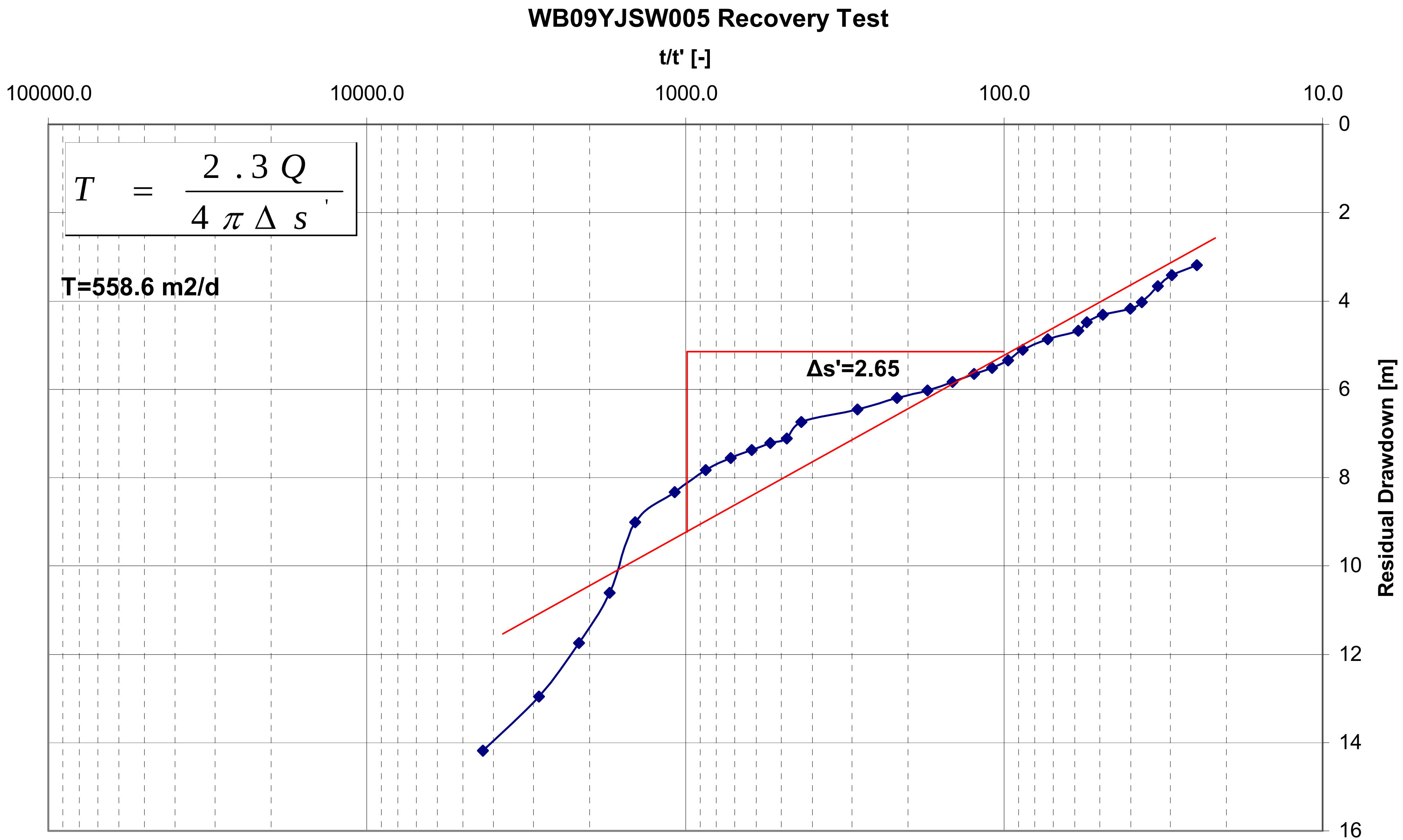

WB09YJSW004 Recovery Test
t/t' [-]
100000.0
10000.0
1000.0
100.0
10.0
0
2
4
6
8
10
12
Residual Drawdown [m]
$T = \frac{2.3Q}{4\pi\Delta s'}$
T=835 m2/d
Δs=1.

WB09YJSW005 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Calculated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Adopted T (m^2/d)
WB09YJSW005	CID	Theis Recovery (manual)	0	17.82	37.55	-	-	597	9.95	400
		Logan (manual)				-	-	406	6.76	
		Neuman					-	365	6.08	
PZ08YJSW016	CID	Neuman (manual)	10	16.79	10.7	7.0×10^{-3}	3.88×10^{-2}	307	4.58	400
		Cooper-Jacob (All)				-	-	615	9.18	
		Theis				-	-	486	6.9	
PZ08YJSW014	CID	Neuman	93	12.2	7.94	7.11×10^{-1}	1.96×10^{-1}	612	9.14	600
		Cooper-Jacob (All)				8.32×10^{-1}	-	567	8.46	
		Theis				9.75×10^{-1}	-	546	8.15	
PZ08YJSW012	CID	Neuman	204	14.74	7.78	3.31×10^{-1}	2.95×10^{-1}	546	8.15	550
		Cooper-Jacob (All)				1.94×10^{-1}	-	569	8.5	
		Theis				2.45×10^{-1}	-	546	8.15	
PZ08YJSW015	CID	Neuman	125	15.55	7.98	5.56×10^{-1}	2.0×10^{-1}	546	8.15	600
		Cooper-Jacob (All)				2.89×10^{-1}	-	598	8.93	
		Theis				3.46×10^{-1}	-	612	9.14	



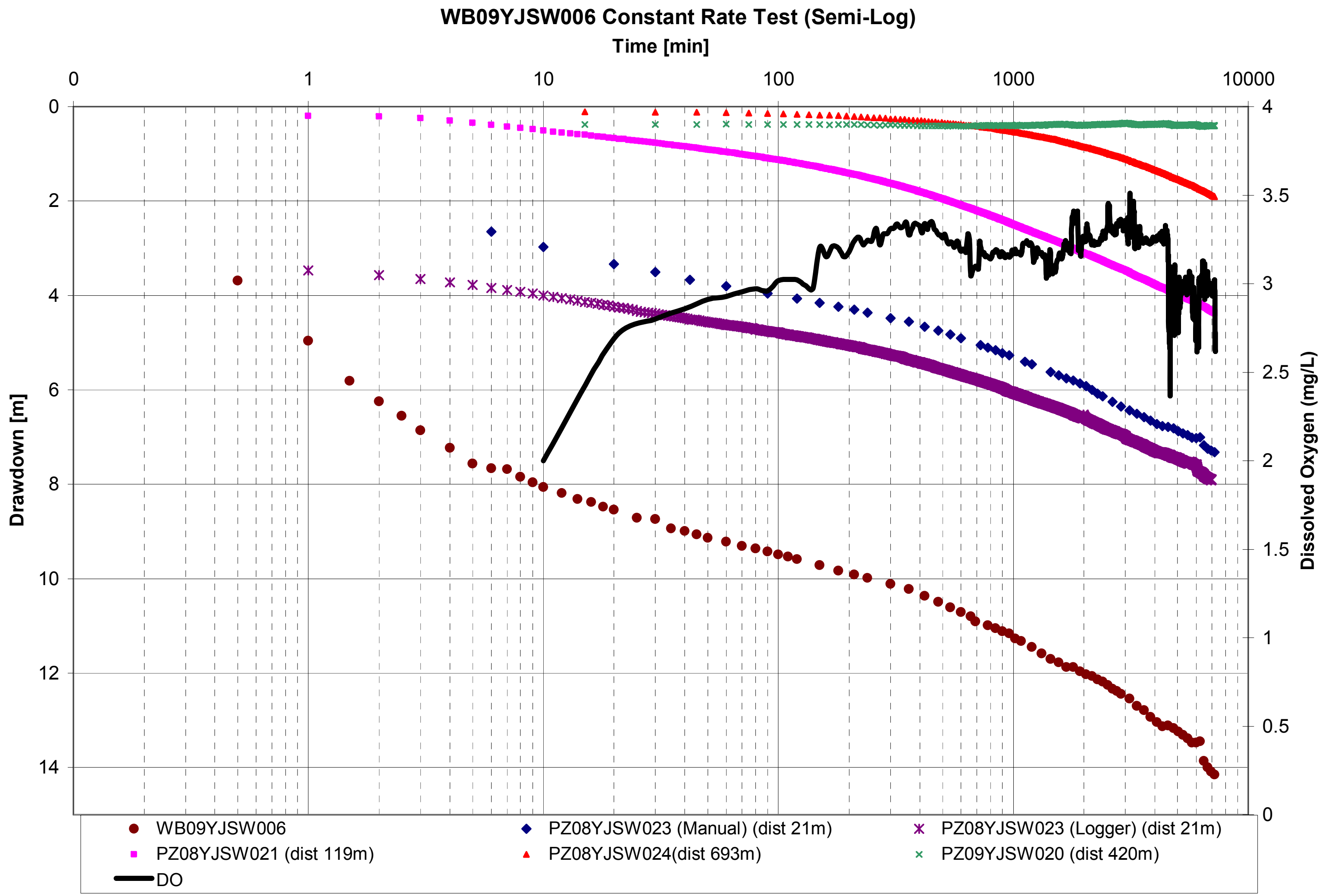
WB09YJSW005 Constant Rate Test (Semi-Log)
Time [min]
0
1
10
100
1000
10000
Drawdown [m]
0
5
10
15
20
25
30
35
40
Dissolved Oxygen (mg/L)
10
9
8
7
6
5
4
3
2
1
0
JSW 005
PZ08YJSW016 (manual) (dist 10m)
PZ08YJSW016 (Logger) (dist 10m)
PZ08YJSW014 (dist 93m)
PZ08YJSW012 (dist 204m)
PZ08YJSW015 (dist 125m)
PZ08YJSW017 (dist 277m)
DO


WB09YJSW005 Recovery Test
t/t' [-]
100000.0
10000.0
1000.0
100.0
10.0
0
2
4
6
8
10
12
14
16
Residual Drawdown [m]
$T = \frac{2.3Q}{4\pi\Delta s'}$
T=558.6 m2/d
Δs'=2.65

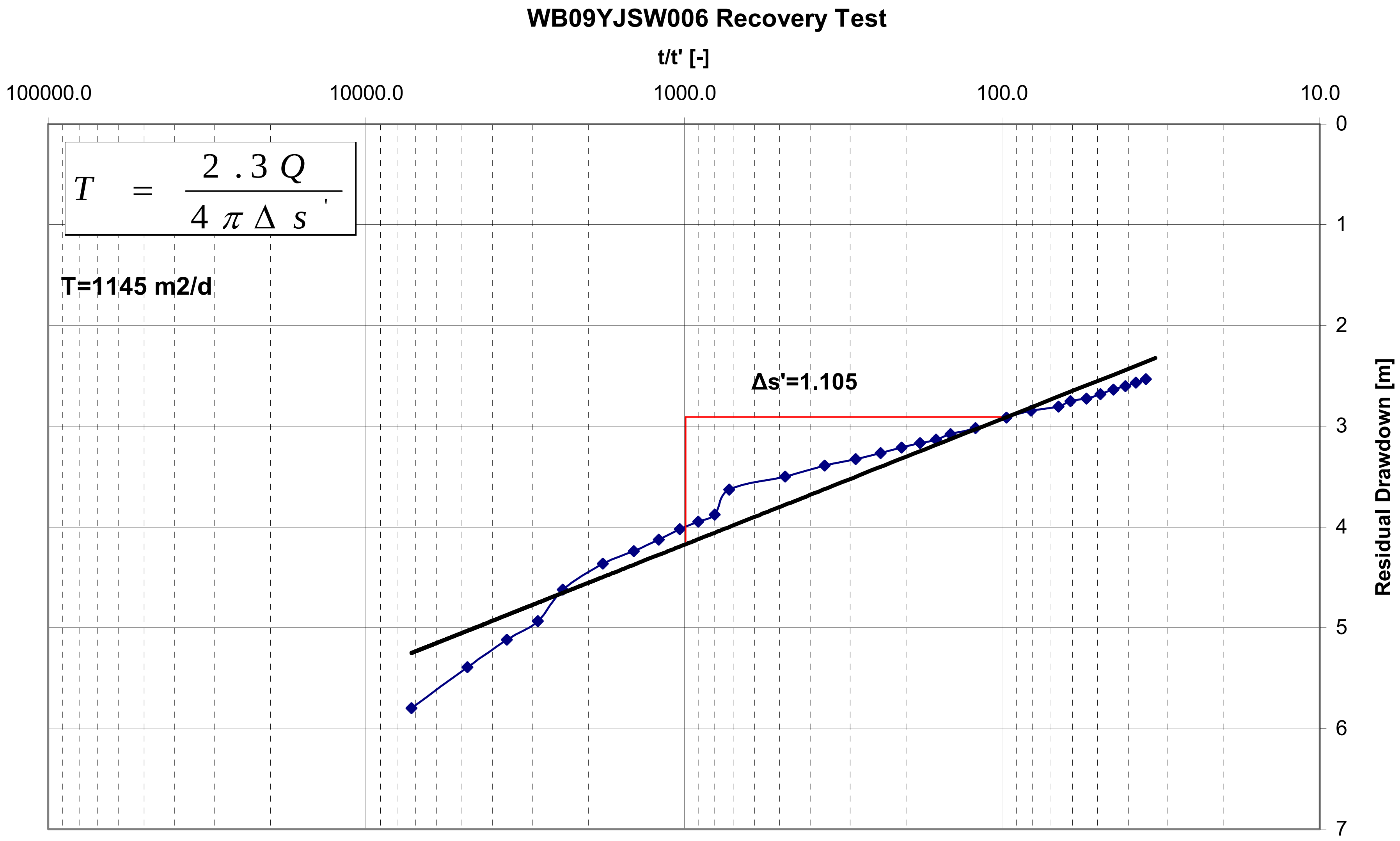
WB09YJSW006 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Estimated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Adopted T (m^2/d)
WB09YJSW006	CID	Theis Recovery (manual)	0	12.2	14.15	-	-	1145	16.3	450
		Logan (manual)				-	-	660	3.57	
		Neuman					-	389	5.56	
PZ08YJSW023	CID	Neuman (manual)	21	10.88	7.32	$6.92x10^{-3}$	$4.99x10^{-3}$	550	4.86	550
		Cooper-Jacob (Middle)				$8.64x10^{-2}$	-	1210	18.1	
		Cooper-Jacob Late)				-	-	592	8.83	
		Theis				-	-	776	11.5	
PZ08YJSW021	CID	Neuman	119	10.85	4.37	$5.51x10^{-5}$	$5.51x10^{-1}$	1550	23.1	1600
		Cooper-Jacob (Middle)				$6.39x10^{-1}$	-	1860	27.7	
		Cooper-Jacob Late)				-	-	631	9.4	
		Theis				$4.38x10^{-1}$	-	2180	32.6	
PZ08YJSW024	CID	Neuman	693	14.97	1.906	$2.89x10^{-4}$	$2.89x10^{-2}$	776	11.5	800
		Cooper-Jacob (Middle)				$9.37x10^{-1}$	-	2130	31.8	
		Cooper-Jacob Late)				-	-	729	10.8	

		Theis				$9.76x10^{-1}$	-	1230	18.3	



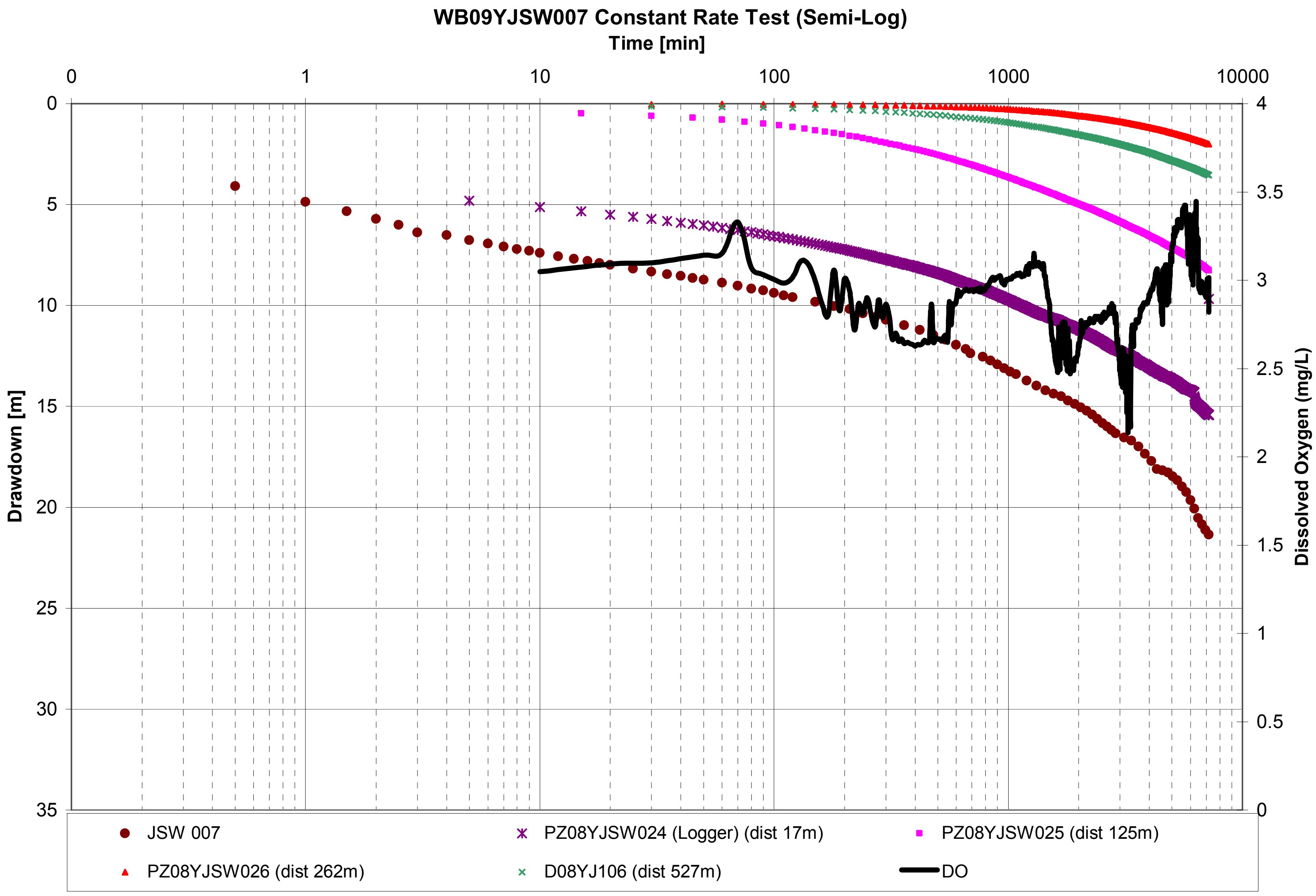
WB09YJSW006 Constant Rate Test (Semi-Log)
Time [min]
0
1
10
100
1000
10000
0
2
4
6
8
10
12
14
Drawdown [m]
4
3.5
3
2.5
2
1.5
1
0.5
0
Dissolved Oxygen (mg/L)
WB09YJSW006
PZ08YJSW023 (Manual) (dist 21m)
PZ08YJSW023 (Logger) (dist 21m)
PZ08YJSW021 (dist 119m)
PZ08YJSW024(dist 693m)
PZ09YJSW020 (dist 420m)
DO

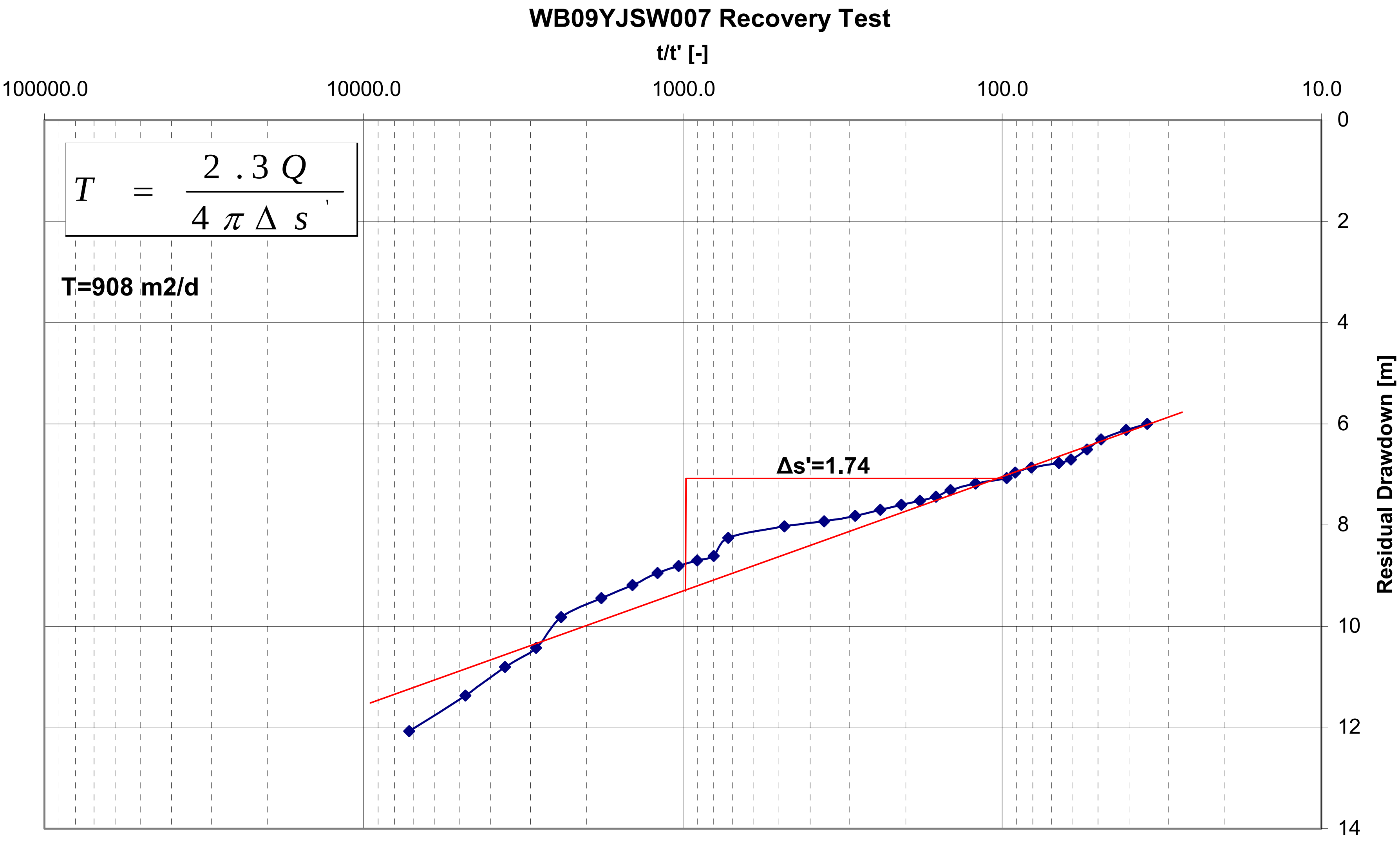

WB09YJSW006 Recovery Test
t/t' [-]
100000.0
10000.0
1000.0
100.0
10.0
0
1
2
3
4
5
6
7
Residual Drawdown [m]
$T = \frac{2.3Q}{4\pi\Delta s'}$
T=1145 m2/d
Δs'=1.105

WB09YJSW007 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Calculated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Adopted T (m^2/d)
WB09YJSW007	CID	Theis Recovery (manual)	0	12.2	14.15	-	-	908	16.3	300
		Logan (manual)				-	-	598	3.57	
		Neuman					-	243	5.56	
PZ08YJSW024	CID	Neuman (manual)	17	15.54	15.71	2.97×10^{-3}	9.99×10^{-3}	343	5.3	350
		Cooper-Jacob (Middle)				3.22×10^{-1}	-	488	7.29	
		Cooper-Jacob Late)				-	-	278	4.16	
		Theis				1.09×10^{-1}	-	612	9.14	
PZ08YJSW025	CID	Neuman	119	10.85	4.37	5.56×10^{-4}	5.56×10^{-4}	486	7.26	500
		Cooper-Jacob (Middle)				4.23×10^{-1}	-	524	4.77	
		Cooper-Jacob Late)				-	-	319	7.83	
		Theis				-	-	433	6.47	
PZ08YJSW026	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman	693	14.97	1.906	5.04×10^{-3}	1.04×10^{-1}	1720	25.7	1500
		Cooper-Jacob (Middle)				2.34×10^{-1}	-	1970	29.4	
		Cooper-Jacob Late)				2.64×10^{-1}	-	595	8.89	

		Theis				$3.08x10^{-1}$	-	971	14.4	
D08YJ106	CID	Neuman	527	18.68	3.546	$2.79x10^{-4}$	$2.79x10^{-2}$	771	11.5	800
		Cooper-Jacob (Middle)				$1.66x10^{-1}$	-	1110	16.6	
		Cooper-Jacob Late)				-	-	486	7.25	
		Theis				-	-	771	11.5	

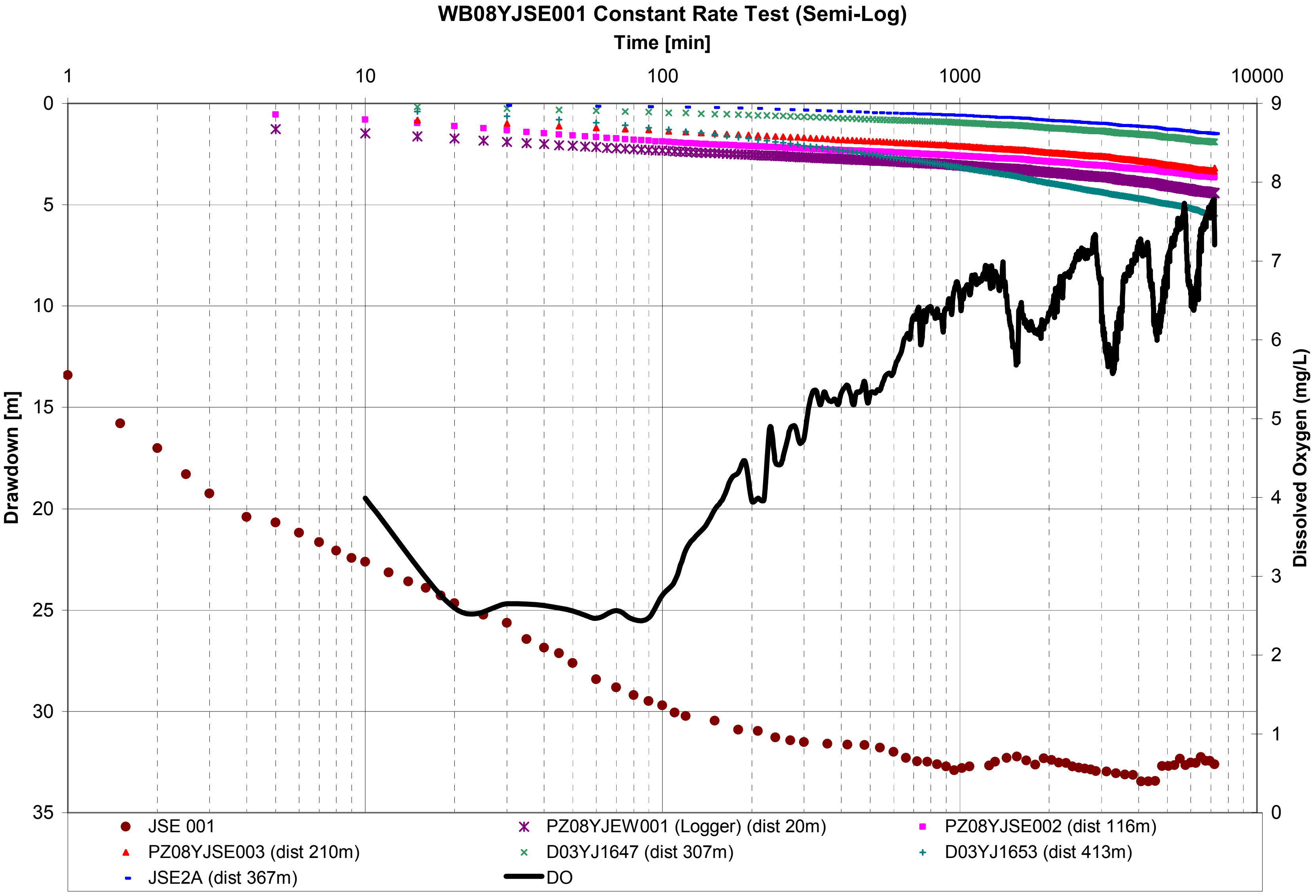

WB09YJSW007 Constant Rate Test (Semi-Log)
Time [min]
0
1
10
100
1000
10000
Drawdown [m]
0
5
10
15
20
25
30
35
Dissolved Oxygen (mg/L)
4
3.5
3
2.5
2
1.5
1
0.5
0
JSW 007
PZ08YJSW024 (Logger) (dist 17m)
PZ08YJSW025 (dist 125m)
PZ08YJSW026 (dist 262m)
D08YJ106 (dist 527m)
DO

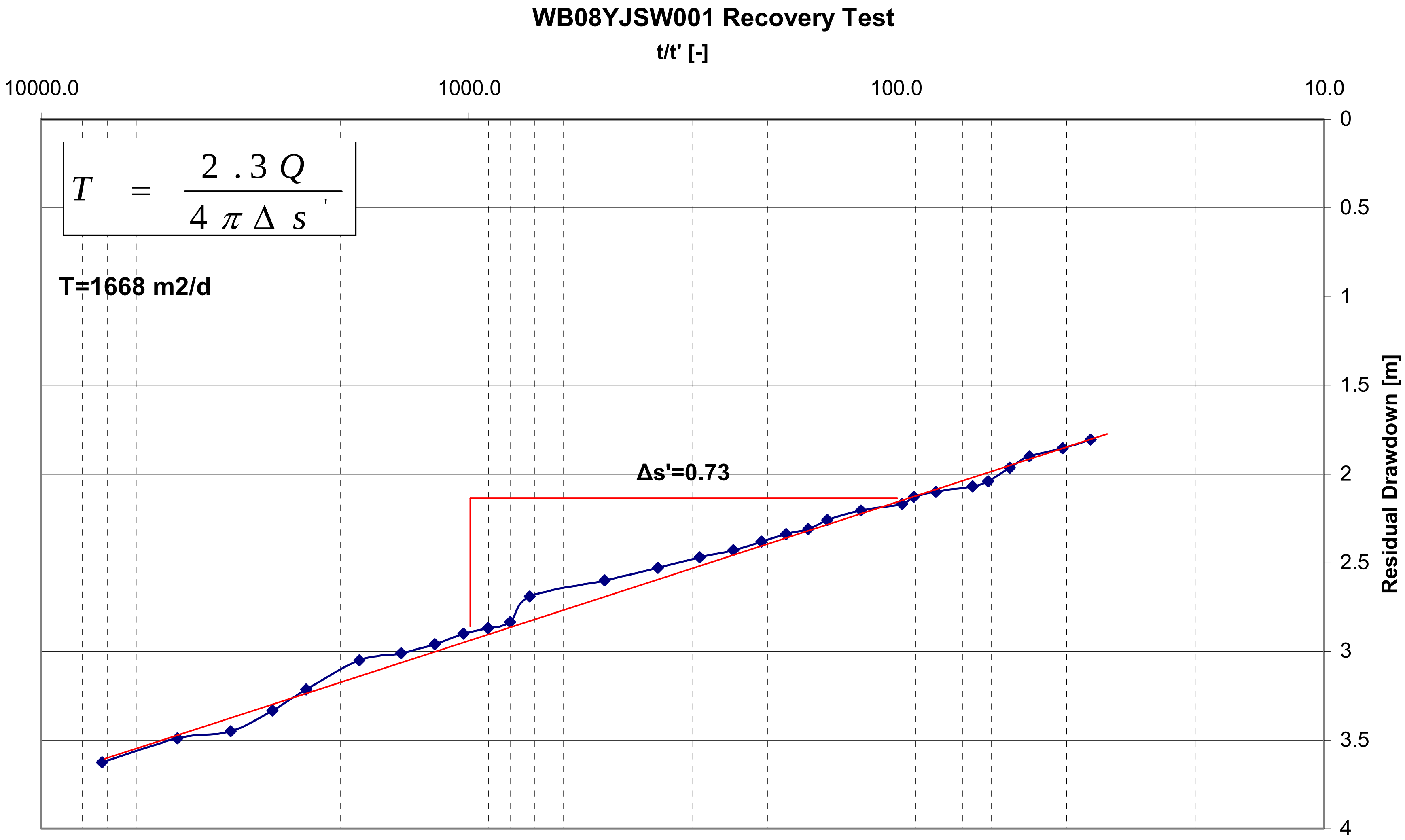

WB09YJSW007 Recovery Test
t/t' [-]
100000.0
10000.0
1000.0
100.0
10.0
0
2
4
6
8
10
12
14
Residual Drawdown [m]
T = 2.3Q / 4πΔs'
T=908 m2/d
Δs'=1.74

WB08YJSE001 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Calculated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Adopted T (m^2/d)
WB08YJSE001	CID	Theis Recovery (manual)	0	25.4	32.62	-	-	1668	25.6	300
		Logan (manual)				-	-	330	5.1	
		Neuman					-	236	3.6	
PZ08YJSE001	CID	Neuman (manual)	20	25.16	4.135	$4.2x10^{-3}$	$1.2x10^{-2}$	882	13.5	700
		Cooper-Jacob (Middle)				$2.2x10^{-1}$	-	1590	23.7	
		Cooper-Jacob Late)				$9.71x10^{-1}$	-	760	11.3	
		Theis				$2.66x10^{-1}$	-	1490	22.2	
PZ08YJSE002	CID	Neuman	116	23.67	3.598	$8.84x10^{-5}$	$1.84x10^{-1}$	941	14	1100
		Cooper-Jacob (Middle)				$1.31x10^{-1}$	-	1510	22.6	
		Cooper-Jacob Late)				$6.75x10^{-1}$	-	1150	17.2	
		Theis				$4.74x10^{-1}$	-	1050	15.7	
PZ08YJSE003	CID	Neuman	210	23.62	3.179	$1.3x10^{-4}$	$2.02x10^{-4}$	1058	16.3	1100
		Cooper-Jacob (All)				-	-	1970	29.4	
		Theis				-	-	971	14.4	
D03YJ1647	CID	Neuman	307	24.93	1.895	$8.94x10^{-5}$	$1.94x10^{-1}$	1870	28	2000

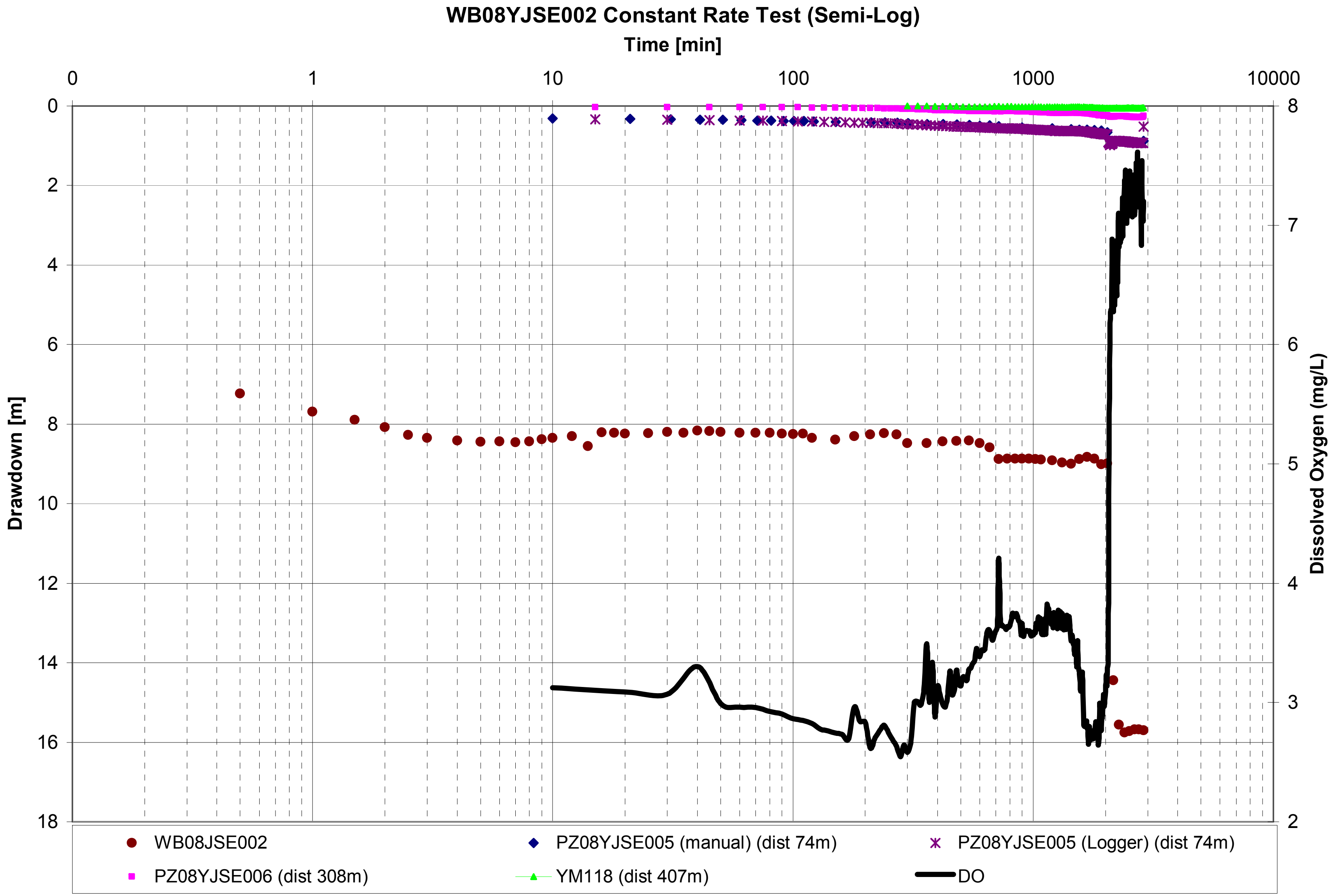
		Cooper-Jacob (Middle)				1.01×10^{-1}	-	2220	33.1	
		Cooper-Jacob Late)				4.13×10^{-1}	-	1110	16.7	
		Theis				5.96×10^{-1}	-	2360	35.2	


WB08YJSE001 Constant Rate Test (Semi-Log)
Time [min]
1
10
100
1000
10000
Drawdown [m]
0
5
10
15
20
25
30
35
Dissolved Oxygen (mg/L)
9
8
7
6
5
4
3
2
1
0
JSE 001
PZ08YJEW001 (Logger) (dist 20m)
PZ08YJSE002 (dist 116m)
PZ08YJSE003 (dist 210m)
D03YJ1647 (dist 307m)
D03YJ1653 (dist 413m)
JSE2A (dist 367m)
DO

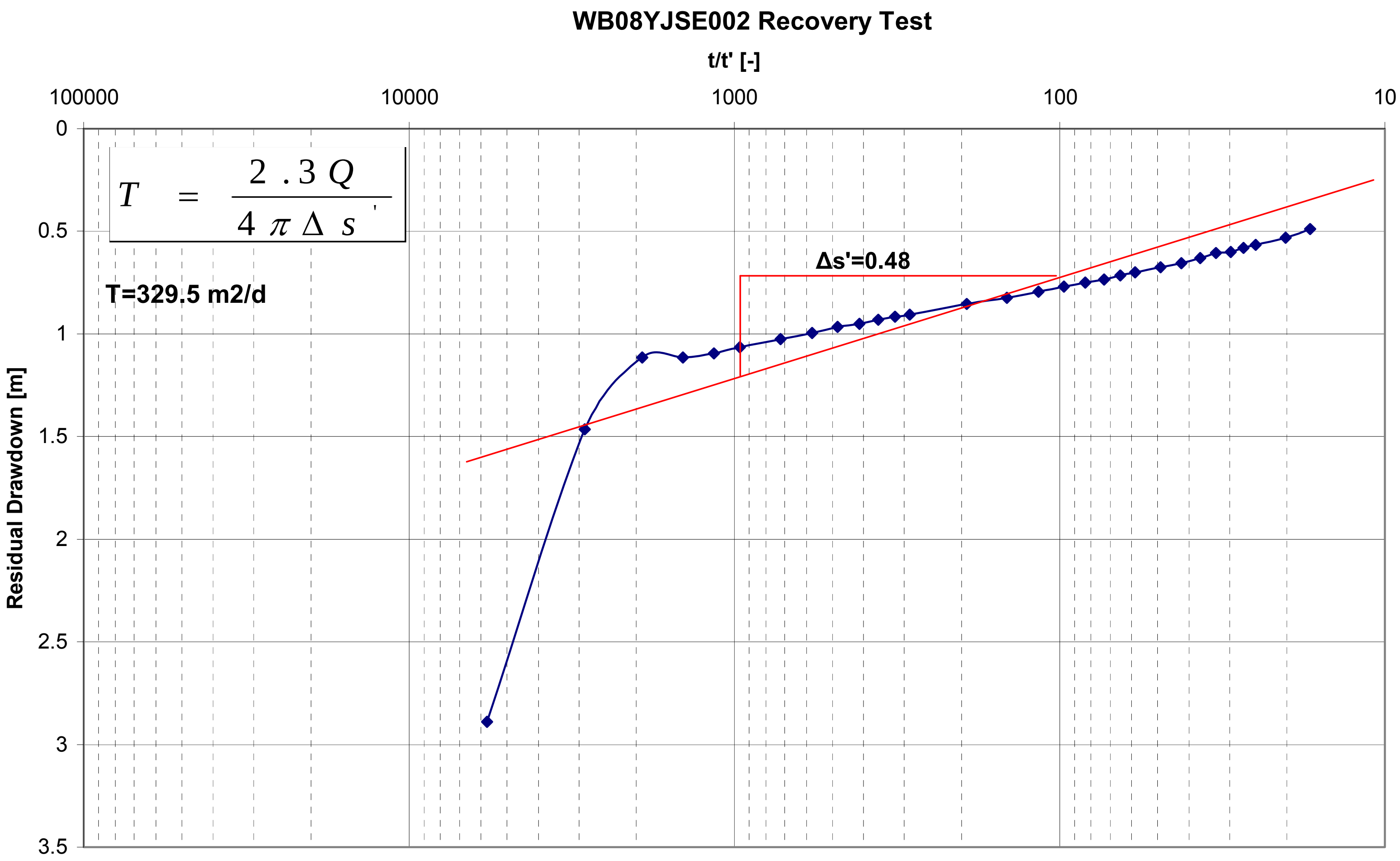

WB08YJSW001 Recovery Test
t/t' [-]
10000.0
1000.0
100.0
10.0
0
0.5
1
1.5
2
2.5
3
3.5
4
Residual Drawdown [m]
$T = \frac{2.3Q}{4\pi\Delta s'}$
T=1668 m2/d
Δs'=0.73

WB08YJSE002 Aquifer Parameters

Bore	Stratigraphical Unit	Analysis Method	Distance from well (m)	Standing water level (mbrp)	Drawdown (m)	Calculated Aquifer Parameters				
						Storativity (S)	Specific Yield (S_y)	T (m^2/d)	K (m/d)	Average T (m^2/d)
WB08YJSE002	ALLUVIAL/INSITU WEATHERERD BEDROCK	Theis Recovery (manual)	0	10.8	9	-	-	329.5	11	150
		Logan (manual)				-	-	137	4.5	
		Neuman				-	-	108	3.6	
PZ08YJSE005	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman	74	10.2	0.523	$8.93x10^{-5}$	$2.16x10^{-3}$	612	9.14	600
		Cooper-Jacob (All)				-	-	589	8.8	
		Theis				$4.31x10^{-1}$	-	687	10.2	
PZ08YJSE006	ALLUVIAL/INSITU WEATHERERD BEDROCK	Neuman (manual)	308	10.05	0.252	$2.89x10^{-4}$	$3.25x10^{-4}$	771	11.5	800
		Cooper-Jacob (All)				$2.2x10^{-1}$	-	1004	15.6	
		Theis				-	-	1008	16.2	



WB08YJSE002 Constant Rate Test (Semi-Log)
Time [min]
0
1
10
100
1000
10000
0
2
4
6
8
10
12
14
16
18
Drawdown [m]
8
7
6
5
4
3
2
Dissolved Oxygen (mg/L)
WB08JSE002
PZ08YJSE005 (manual) (dist 74m)
PZ08YJSE005 (Logger) (dist 74m)
PZ08YJSE006 (dist 308m)
YM118 (dist 407m)
DO


WB08YJSE002 Recovery Test
t/t' [-]
100000
10000
1000
100
10
0
0.5
1
1.5
2
2.5
3
3.5
Residual Drawdown [m]
$T = \frac{2.3Q}{4\pi\Delta s'}$
T=329.5 m2/d
Δs'=0.48