AshtonCoal

Appendix 5

Groundwater Assessment

South East Open Cut Project
&
Modification to the
Existing ACP Consent

Water and Environment

ASHTON SOUTH EAST OPEN CUT PROJECT: HYDROGEOLOGICAL IMPACT ASSESSMENT

Prepared for	Ashton Coal Operations
Date of Issue	2 July 2009
Our Reference	S36/B2/063

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	Name	Position	Signature	Date
Originator	J van den Akker	Project Hydrogeologist		02/07/09
	A Fulton	Senior Hydrogeologist		02/07/09
Reviewer	P Dundon	Senior Principal Hydrogeologist		02/07/09

	Location	Address
Issuing Office	Sydney	Suite 9, 1051 Pacific Highway, Pymble NSW 2073 Tel +61 2 9440 2666 Fax +61 2 9449 3193

EXECUTIVE SUMMARY

BACKGROUND

This report presents the results of a hydrogeological impact assessment of the proposed Ashton South East Open Cut Coal Project undertaken by Aquaterra Consulting Pty Ltd for Ashton Coal Operations Pty Ltd.

The Ashton Coal Project (ACP) is located 14 km north west of Singleton in the Hunter Valley of NSW within the Hunter Coalfields of the Sydney Basin, and comprises an open cut, underground mine, coal processing plant and other infrastructure. The South East Open Cut (SEOC) is a proposed new open cut located approximately 2.5km south east of the ACP coal processing plant.

The overall objective of this report is to provide sufficient information on the state of the groundwater environment within the SEOC area and immediate surrounds, and to assess the potential impacts on groundwater levels and quality from development of the SEOC. This has been done to address any concerns regarding groundwater and surface water resources, groundwater dependant ecosystems and existing groundwater users, to the satisfaction of the Minister for Planning.

The proposed SEOC pit high wall lies close to Glennies Creek and its associated alluvium. A comprehensive understanding of the nature of the Glennies Creek alluvium and its hydraulic interaction with Glennies Creek has been undertaken to enable a robust prediction of the proposed SEOC impact on Glennies Creek.

GROUNDWATER INVESTIGATIONS AND FINDINGS

Drilling investigations at the site revealed unconsolidated materials above the Permian coal measures extending eastwards from the creek into the proposed mining area. These unconsolidated clays, silts, sands and gravels include alluvium associated with the current Glennies Creek, as well as older alluvium and colluvium that are not associated with the current Glennies Creek.

The base of the unconsolidated materials rises quite quickly away from Glennies Creek adjacent to the northern part of SEOC pit, and at the proposed pit boundary the unconsolidated sediments are dry. In parts of the central and southern sections of the pit, saturated unconsolidated materials extend inside the proposed SEOC pit boundary.

The alluvium associated with Glennies Creek occurs on a lower terrace adjacent to the creek, and then merges into older unconnected alluvium and colluvium to the east. Hydraulic testing in the unconsolidated materials revealed highly variable hydraulic conductivity (permeability), ranging from 0.01 to over 100 m/d. This reflects both the highly variable nature of the alluvium, and in particular the variable nature of the sand and gravel layer that lies towards the base of the alluvial deposits and makes up most of the permeability. In many areas these sands and gravels are very poorly sorted, with considerable clay and silt content, and high permeability only occurs where the sands and gravel are ‘clean’. The geometric mean permeability is much lower than the arithmetic mean, which reflects the highly variable nature of the alluvium and indicates that the permeable zones are relatively small and discontinuous.

Hydraulic connection between the alluvium and the colluvium to the east appears to be poor, and is shown by a very marked increase in salinity away from the connected alluvium, as discussed below. The demarcation between the connected saturated alluvium associated with Glennies Creek, and the alluvium/colluvium of the upper terrace and eastern slopes, is difficult to define from drilling results alone, as the drilling disturbance causes the sand and gravel material from both sources to have a similar composition and appearance.

This boundary was initially assessed using a combination of aerial photography, ground mapping, and hydraulic conductivity properties of the sediments, and ultimately was based primarily on the basis of groundwater salinity. Further investigations were then carried out to examine the extent and nature of the more permeable zones that were encountered in the lower alluvium. Some zones of higher permeability were encountered within the alluvium, which appear to be associated with paleo- surface drainage and paleo-geomorphological factors that existed during and after the deposition of the alluvium, but are not related to the present surface drainage.

Groundwater chemistry was also used to help define boundaries and differences in the hydrogeology of the alluvium. In particular it was found that salinity contours generally provided a good indication of the transition from alluvium to colluvium. Groundwater salinity increases sharply (up to 15,000 µS/cm EC) away from Glennies Creek, reflecting the transition from highly permeable, connected alluvium beneath the lower terrace levels, to poorly permeable colluvium and unconnected alluvium on the flanks of the flood plain.

The findings of the studies were used to provide a site specific assessment of hydraulic conductivity within the unconsolidated sediments, and identify the boundary between the 'connected' alluvium of Glennies Creek and the poorly connected alluvium/colluvium to the east. In general it was found that the 3,000 µS/cm EC contour represented a good demarcation of the boundary of the hydraulically connected Glennies Creek alluvium. The only exception to this was an area just to the north of Mrs Bowman's farmhouse, where unusually low EC values were found to extend further to the east than elsewhere in the alluvium. In this area the boundary is marked by the edge of the higher permeability basal sand/gravel layer (about 100m west of the proposed SEOC pit shell).

PREDICTED GROUNDWATER IMPACTS

Potential impacts of the proposed SEOC on groundwater and surface water resources, groundwater and surface water quality, groundwater dependent ecosystems and other groundwater users, were determined on the basis of groundwater modelling.

A transient groundwater flow model was designed to predict the cumulative impacts from all three Ashton mines – NEOC, Underground and SEOC, each operating concurrently in accordance with their respective mine plans. The model predictions were made using assessed parameters from investigations undertaken onsite. This included a complex, conservative representation of the hydraulic conductivity of the alluvium, including zones of high permeability and a general demarcation between the connected Glennies Creek alluvium and the unconnected alluvium/ colluvium to the east.

During the mining of SEOC, the maximum drawdown in the Glennies Creek alluvium predicted by the model is 1.5m. This maximum drawdown would occur in a localised area on the western margin of the SEOC where there is a basement low and where saturated thickness of alluvium/colluvium is greatest. The majority of the alluvium should experience drawdowns of 0.5m or less, and the predicted overall reduction in saturated storage within the alluvium is only 3%.

The lowering of groundwater levels in the alluvium and other unconsolidated materials will result in some reduction in baseflow to Glennies Creek. The net predicted impact of the SEOC on baseflows in Glennies Creek is around 0.5 L/s (0.047 ML/d). This causes the Creek to change from a marginally gaining to a marginally losing stream in this reach. This impact is very small in relation to the flows in Glennies Creek, representing around 0.03% of the average flow and 0.3% of the minimum 5 percentile sustained flow in this section of the creek. These impacts are transient and will recover back to pre-mining conditions within 100 years of the end of mining.

Larger impacts to groundwater levels are predicted to occur within the Permian coal measures, which will be dewatered during mining. The extent of predicted drawdowns as a result of dewatering the coal measures is predicted to be quite localised, and will be generally contained within the project boundary.

Although hydraulic connectivity between the alluvium and colluvium on the western side of the pit is limited, some water does flow through to the pit. Inflows from the alluvium to the pit on this western side are predicted to start in Year 3 of mining and then increase to a maximum of 24 m^3/d by year 7 of mining. However, flows from the Glennies Creek alluvium only constitute around 10-15% of the total groundwater flows that are predicted for the pit, with up to 200m^3/d entering the pit from recharge to the backfill material, the Permian strata and other superficial deposits.

Post mining, water levels within the alluvium are expected to return to pre-mining levels within 100 years. Some minor residual impacts (<1m) may remain within the Permian coal measures, but this will have a negligible impact on surface water tables or river baseflows. There is therefore no long term risk of stream capture or significant loss from this project.

Because groundwater flows will be towards the pit, no groundwater quality impacts are expected on aquifers outside of the pit shell during operation. There is little difference between average composite groundwater quality within the Permian strata, and the quality of the water table aquifers in the pit area. This, and the fact that the long term post mining flow regime should be very similar to pre-mining conditions, mean that long term impacts on water quality from the pit should be minimal.

One licensed bore exists within Camberwell village, north of the New England Highway, and about 1km north of the SEOC. The bore intercepts alluvium and is not expected to be impacted by the proposed mining of the SEOC. There are no other known licensed or unlicensed groundwater production bores within the predicted zone of influence.

MONITORING AND CONTINGENCY PLANS

Monitoring of groundwater levels, pit inflows and groundwater quality is recommended, as detailed in Section 8 of this report. Because of the risk that may exist to Glennies Creek and its alluvium, a contingency/response plan that includes trigger values, procedures for review and the derivation of appropriate response action plans has been included in Section 9 of this report. This includes a recommendation for modelling post audits following the second and fourth years of the mine programme.

The staged mine plan allows time to implement mitigation measures should the inflows be higher than anticipated. Potential mitigation measures might include the construction of a low permeability cut-off wall, possibly comprising bentonite or natural clays emplaced in a trench keyed into the underlying low permeability Permian rocks. Such a trench would not be required at the start of mining as the northern section of the proposed mine does not intersect saturated unconsolidated sediments.

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1 INTRODUCTION

1.1 BACKGROUND

This report presents the results of a hydrogeological impact assessment of the proposed Ashton South East Open Cut Coal Project undertaken by Aquaterra Consulting Pty Ltd for Ashton Coal Operations Pty Ltd.

The Ashton Coal Project (ACP) is located 14 km north west of Singleton in the Hunter Valley of NSW within the Hunter Coalfields of the Sydney Basin, and comprises an open cut, underground mine, coal processing plant and other infrastructure. The South East Open Cut (SEOC) is a proposed new open cut located approximately 2.5km south east of the ACP coal processing plant. The village of Camberwell is located approximately 400m to the north of the SEOC. The locations of the ACP and the SEOC are shown on **Figure 1.1** and **Figure 1.2**

The existing Ashton operations are located within ML1533 and are situated on the northern side of the Hunter River, mostly between Bowmans Creek and Glennies Creek which are tributaries of the Hunter River. The lease straddles the New England Highway, with the existing Ashton open cut operations (now termed the North East Open Cut – NEOC) located north of the highway, and the underground mine south of the highway. The proposed SEOC is located to the south of the New England Highway to the east of the underground mine and is indicated on **Figure 1.2**.

The SEOC is proposed for development within Exploration Licences EL 4918 and EL 5860 (**Figure 1.2**). Authorisation 81 held by Navidale (Camberwell Mine) lies to the east of EL5860 where it is proposed to construct out of pit emplacements and infrastructure.

EL 4918 covers an area of 370ha and EL 2860 an area of 272ha, comprising rural lands, freehold land, Crown Land and land owned by ACOL. It is characterised by mostly cleared grazing lands with little topographical relief, with land elevation ranging from 50m AHD (Australian Height Datum) in the west adjacent to Glennies Creek (or Fal Brook) and 100 m AHD to the east.

1.2 SITE DESCRIPTION

The surface topography within the vicinity of the SEOC generally dips to the west and is gently undulating over most of the SEOC area. Surface elevation varies between about 100m AHD along the eastern ridge line near the New England Highway to around 50m AHD near the southern end of the SEOC adjacent to Glennies Creek.

The main natural features of the area are the creeks and the alluvium flats associated with the Hunter River, Glennies Creek and Bowmans Creek. There are minor ephemeral tributaries or natural drainage features which dissect the proposed SEOC area and discharge to Glennies Creek, but they have no associated alluvium.

1.3 SCOPE OF THIS REPORT

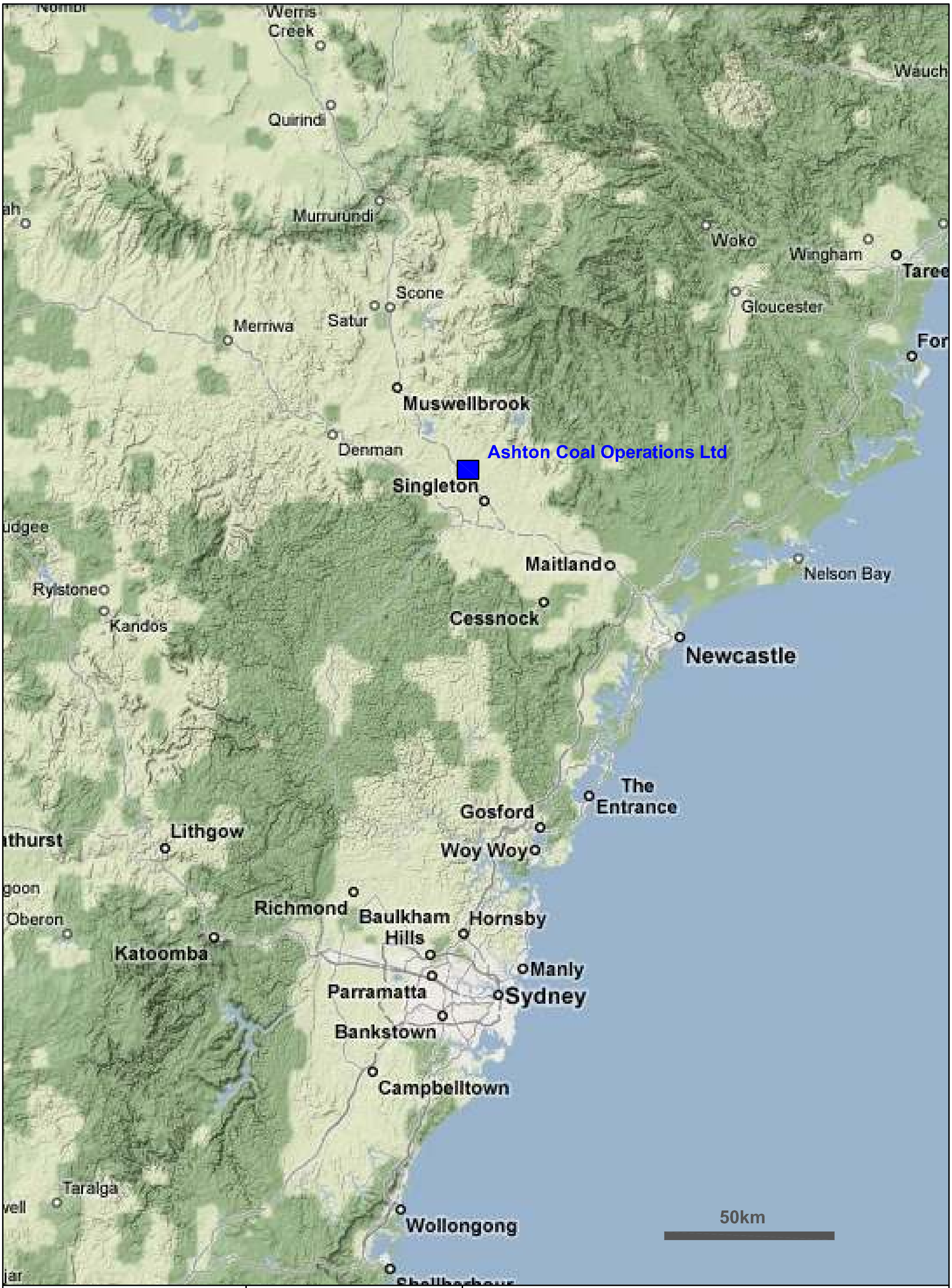
The overall objective of this report is to provide sufficient information on the state of the groundwater environment within the SEOC area and immediate surrounds, and to assess the potential impacts on groundwater levels and quality from development of the SEOC. This has been done to address any concerns regarding groundwater and surface water resources, groundwater dependant ecosystems and existing groundwater users, to the satisfaction of the Minister for Planning.

The proposed SEOC pit high wall lies close to Glennies Creek and its associated alluvium. A comprehensive understanding of the nature of the Glennies Creek alluvium and its hydraulic interaction with Glennies Creek has been undertaken to enable a robust prediction of the proposed SEOC impact on Glennies Creek.

This report is structured as follows:

- Section 2 addresses the statutory requirements, policies and guidelines relevant to the SEOC project.

- Section 3 contains a summary of groundwater investigations undertaken, including relevant summary details of previous groundwater investigations undertaken on the Ashton Project.
- Section 4 reports on the existing State of the Environment within the proposed project area, and includes available information on climate, topography, land use (including existing mining activities), and an evaluation of the current groundwater environment based on available groundwater levels and groundwater quality, and groundwater-surface water interactions.
- Section 5 outlines the mining proposal and gives a brief summary of the proposed operations.
- Section 6 details the groundwater modelling work undertaken to assess the potential impacts of the proposal.
- Section 7 contains details of the potential groundwater impacts of the proposed project on groundwater and surface water resources, groundwater and surface water quality, groundwater dependant ecosystems (GDEs), and other groundwater users.
- Section 8 details proposed monitoring, mitigation and management strategies in relation to potential impacts on the groundwater resources.
- Section 9 presents recommendations for contingency response plans to address any unforeseen adverse impacts on groundwater and/or surface water.
- Section 10 provides a summary and conclusions on groundwater and surface water evaluation work undertaken.
- Section 11 provides a list of references.



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Scale: as indicated

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Job No: S36

Drawing No: S36-004a

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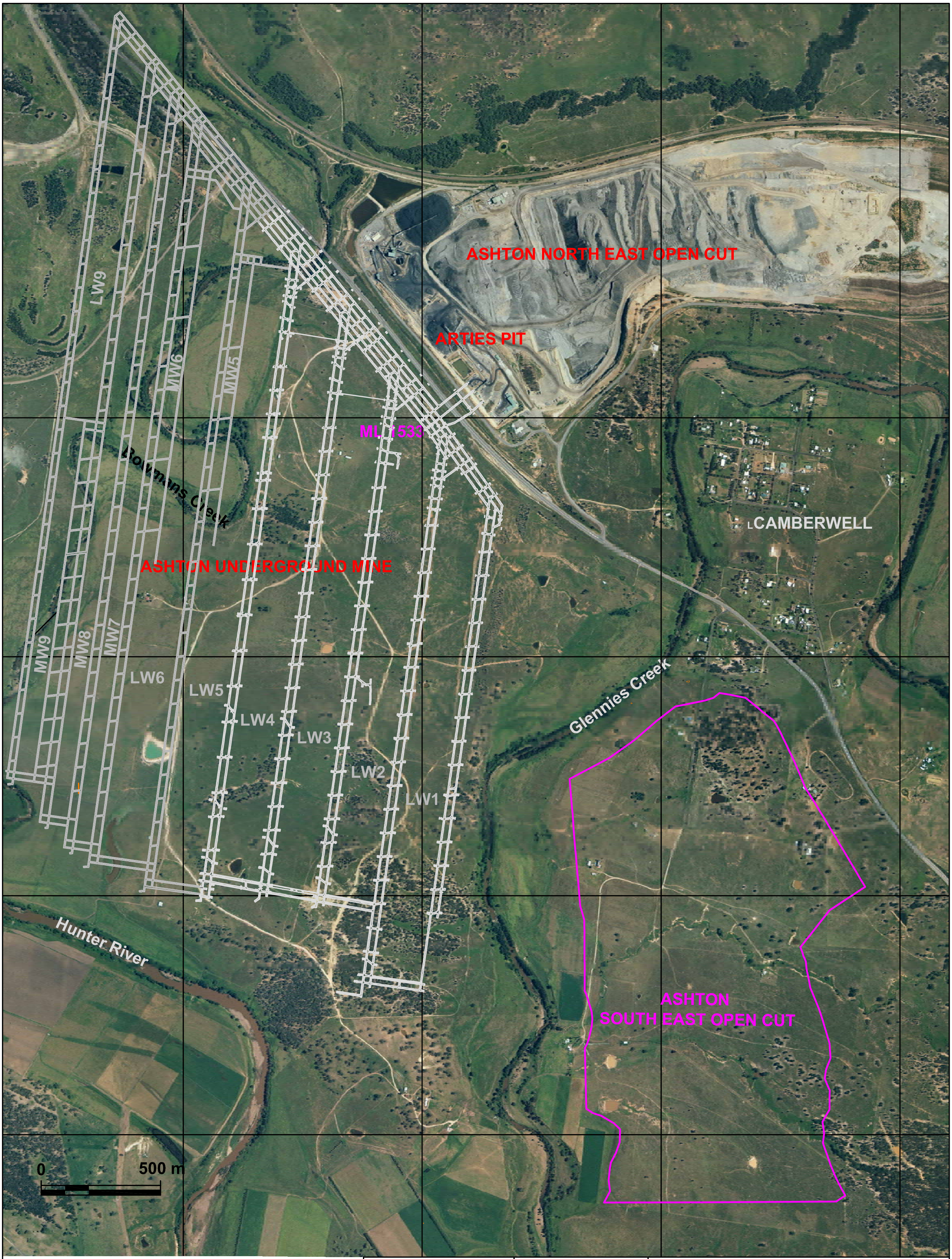
LOCALITY PLAN
ASHTON COAL OPERATIONS

Figure 1.1



Legend

South Eastern Open Cut Outline

Underground Mine Workings

Date: 11 May 2009

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ASHTON PROJECT AREA

Figure 1.2

2 STATUTORY REQUIREMENTS

2.1 DIRECTOR GENERAL'S REQUIREMENTS

In accordance with Section 75F of the EP&A Act, the Director General of the Department of Planning has issued requirements for the preparation of the Environmental Assessment for the proposed SEOC coal project. Specific requirements have been provided by the DGR and relevant consulted public authorities in relation to this project. The requirements relating to groundwater have been addressed within this report as detailed in **Table 2.1**.

Table 2.1: Director – General's Requirements

Director General's Requirement	**Relevant Section of Report**
A description of the existing environment	Section 4
Assessment of the potential impacts of all stages of the project including any cumulative impacts associated with the concurrent operation of the project with any other existing or approved mining operation, taking into consideration any relevant guidelines, policies, plans and statutory provisions - Assessment of the potential impacts on the quantity, quality and long-term integrity of the groundwater resources.	Sections 6, 7
Description of the measures that would be implemented to avoid, minimize, mitigate, rehabilitate/remediate, monitor and/or offset the potential impacts of the project including detailed contingency plans for managing any significant risks to the environment.	Sections 8, 9
Key Issues (soil & water:	
• A detailed assessment of the potential impacts of the project, using quantitative modelling, on;	Sections 6, 7
o The quantity and quality of both surface and ground water resources	Section 7
o Water users, both in the vicinity of and downstream of the project	Section 7
• … a clear demonstration that there would be no adverse effects on the integrity of the watercourses to the west of the pit boundary	
Department of Water and Energy Comments	**Relevant Section of Report**
Outcomes: …demonstrate that the proposed mining operation will achieve the following:	
1. no hydraulic connection between the mining operation and surface water sources, including connected alluvium to the Glennies Creek regulated river (Zone 3 of the Hunter River water source)	Section 4
2. no impact on adjacent licensed water users, basic landholder rights, or minimum base flows in Zone 3 of the regulated Hunter River water source, downstream within Zone3 of the Hunter River water source, embargoed alluvium or groundwater dependent ecosystems	Section 7
3. no long term risk of capture or riverine migration into backfilled mine spoils or other degradation of the regulated river system	Section 7
The EA must consider a range of scenarios of groundwater drawdown and impacts… Glennies Creek water source is not to be affected, nor any regulated	Section 7

river water drained to the workings or any induced fracturing .	
Water Supply and Water Balance The EA must include assessment of water supply and/or water inception and extraction against any Water Sharing Plan in force affecting the site or potential water supply to the proposal	Section 7
Groundwater Resource Protection …include demonstration that the project is consistent with the NSW Sate Groundwater Policy Framework Document, the NSW State Groundwater Protection Policy, the NSW State Groundwater Dependent Ecosystems Policy and the Draft NSW State Groundwater Quantity Management Policy. This must include: • identification of surrounding water users and any groundwater dependent ecosystems • detailed explanation of potential groundwater volume, piezometric level, water table heights and the direction of flow and quality, through the mine life and projections into post mine period, applying to the connected alluvium to Glennies Creek, any identified aquicludes/aquitards underlying the connected alluvial water source and all seams targeted for extraction • detailed explanation of groundwater drawdown or other impacts upon connected groundwaters associated with Glennies Creek water source, compared with all predicted seepage flow migrating from fractured hard rock into the proposed [underground] mine workings • explanation of the site water balance… including any changes to water balance inputs from rainfall runoff and/or groundwater seepage into the open cut extension • detailed analysis of the impacts of dewatering if required for the project • measures to prevent contamination of either the Glennies Creek regulated water source, or its connected alluvium resulting from changes in groundwater tables	Section 4, 7 Section 6, 7 Section 6, 7 Section 7 Section 5 Section 7
Rehabilitation, Final Landform and Final Void Management • justification of the proposed final landform with regard to its impact on local and regional groundwater systems • detailed modelling of potential groundwater volume, flow and quality impacts of the presence of an inundated final void on identified receptors • the measures that would be established for the long-term protection of local and regional aquifer systems… following cessation of the project	Section 7 Section 7 Section 7 and 8
Other Departmental Comments	**Relevant Section of Report**
Department of Primary Industries • ..provide particular rigour in the monitoring, prediction and assessment of surface and groundwater impacts on Glennies Creek alluvial systems	Sections 6, 7 and 8

Department of Environment and Climate Change DECC considers that the key environmental aspects of this proposal are: • Potential impacts on surface water (Glennies Creek and Bowmans Creek) and the management of surface waters on site • Potential for adverse impacts on the water quality of Glennies Creek and Bowmans Creek due to their close proximity to the proposed mining area • Potential impacts on integrated surface water and groundwater systems	
Singleton Council The following key issues should be considered: • An assessment of impact on the integrity of Glennies Creek and the riverine environment, particularly any potential loss of water quality and flow	

2.2 RELEVANT STATE POLICIES AND GUIDELINES

There are a number of guidance documents for groundwater protection and assessment in NSW. The key policy document is the NSW State Groundwater Policy Framework Document released by the then Department of Land and Water Conservation (DLWC, now DWE) in 1998. This document outlines the policy objectives relating to groundwater management and implementation strategies. The NSW State Groundwater Policy refers to three component policies.

- The NSW Groundwater Quality Protection Policy produced by DLWC in 1998 which outlines the beneficial use classification system applicable to all aquifer systems in NSW. The policy states that all groundwater systems should be managed to maintain the most sensitive identified beneficial use. The beneficial uses adopted in this policy include ecosystem protection, recreation and aesthetics, raw water for drinking water supplies, agricultural water and industrial water. For new developments, the policy also outlines the scale and scope of work required to demonstrate adequate groundwater protection which shall be commensurate with the risk the development poses to a groundwater system and the value of the groundwater resource.
- The NSW State Groundwater Dependent Ecosystem Policy (DLWC, 2002) provides guidance on how to protect and manage ecosystems that rely on groundwater for their survival for the benefit of present and future generations. Groundwater dependent ecosystems (GDE’s) may include terrestrial vegetation supported by shallow groundwater such as red gum forests, wetlands, ecosystems in streams fed by groundwater discharge and aquifer and cave ecosystems.
- The policy on Groundwater Quantity Management has not been released but the principles and objectives are outlined in State Groundwater Policy and include the efficient, equitable and sustainable use of the State’s groundwater resources. Groundwater access must be managed such that it does not cause unacceptable local impacts.

Water sharing plans are being developed for the Hunter Region and are designed to provide long term environmental protection and sustainability of the groundwater resources as well as directing how water will be allocated and shared among the various water users. Water Sharing Plans are statutory instruments created under the Water Management Act 2000 and apply the goals and principles of the State Groundwater Policy at a local and regional level.

The water sharing plans identify the recharge component to each groundwater source or zone and direct how the recharge component will be allocated and shared among different water users. The water sharing plans also outline the management of local impacts, including groundwater interference, and list beneficial uses of the groundwater to be protected and occurrence of any groundwater dependent ecosystems within the groundwater source or zone.

The draft guideline Management of Stream / Aquifer Systems in Coal Mining Developments (Hunter Region) has been developed to address potential impact on groundwater and rivers in the Hunter region. The objectives of the draft guideline include protection of river systems which includes channels, stream beds and banks, connected alluvial groundwater and perched groundwater.

The water sharing plans refer to the National Health and Medical Research Council (NHMRC) 1996 Drinking Water Guidelines for drinking water beneficial use. Other beneficial uses are defined by the Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 Water Quality Guidelines.

This report has also been prepared with due consideration of relevant state policies and guidelines including:

- Murray-Darling Basin Groundwater Quality. Sampling Guidelines. Technical Report 3 (MDBC 1993);
- Murray-Darling Basin Commission. Groundwater Flow Modelling Guideline (MDBC, 2001);
- Hunter River Groundwater Water Sharing Plan Draft (DWE);
- Management of Stream / Aquifer Systems in Coal Mining Developments (Hunter Region) Draft (DIPNR, 2005).

2.3 WATER LICENSING

Groundwater licences under Part 5 of the Water Act 1912 will be required for any of the following activities relating to the SEOC:

- Extraction of water from open cut mining;
- Production bores; and
- Monitoring piezometers (for the purposes of water level and quality monitoring and test pumping).

It should be noted that Part 5 licences will be required for the extraction of groundwater. In addition the extraction of any groundwater from alluvium systems will likely be subject to conditions and management in accordance with the ‘Draft Hunter Unregulated and Alluvium Water Sources Water Sharing Plan’ (DWSP). This document is, at the time of writing, under consideration by the Department of Water and Energy (DWE), pending finalization in early-mid 2009. Until the DWSP is commenced, licensing of activities, water use, water works and approvals are governed by the Water Act 1912.

Any discharge of surplus water volumes to the environment will be managed in accordance with the site’s Environmental Protection Licence, under the Protection of the Environment Operations Act 1997.

3 GROUNDWATER INVESTIGATIONS

3.1 PREVIOUS INVESTIGATIONS

Several previous investigations on groundwater, surface water and geology have been undertaken in the area within and surrounding EL4918 and EL2860.

3.1.1 EIS INVESTIGATIONS

Groundwater studies were undertaken during the period 2000 to 2003 to support the Environmental Impact Statement for approval to develop the Ashton coal mining operations (HLA, 2001). The investigations were undertaken in support of both the North East Open Cut (NEOC) operations north of the New England Highway and the underground operations south of the highway.

The investigations focused particularly on impacts associated with the underground mining of the Pikes Gully Seam and deeper seams to the west of Glennies Creek.

HLA (2001) recognised two distinct aquifer systems in the Ashton project area, namely a fractured rock aquifer system within the coal measures, and a shallow porous media aquifer system in the unconsolidated alluvium.

3.1.2 INVESTIGATIONS ASSOCIATED WITH THE UNDERGROUND MINE

Ongoing investigations supporting operational and regulatory requirements have been undertaken over the period 2004-2008. These studies include:

- Ashton Coal Mine Longwall Panels 1-4, Subsidence Management Plan, Groundwater Assessment. (PDA, 2006);
- Ashton Coal - End of Panel 1 Groundwater Report (Aquaterra, 2008a);
- Ashton Underground Mine – Bowmans Creek Alluvium Investigation (Aquaterra, 2008b);
- Ashton Underground Mine, LW/MW5-9 Pikes Gully Seam, Groundwater Impact Assessment (Aquaterra, 2008c).
- Ashton Coal – End of Panel 2 Groundwater Report (Aquaterra, 2009).

A key conclusion of these investigations was that groundwater in the coal measures is saline, with electrical conductivities (EC) in the range 2,000 to more than 10,000 µS/cm, but usually between 5,000 and 8,000 µS/cm. Groundwater in the alluvium aquifer system commonly has lower salinity, but still varying over a wide range. EC in the alluvium is usually below 2,000 µS/cm, although there are some locations where salinity is higher, up to 6,000 µS/cm EC, possibly due to mixing with saline groundwater from the underlying coal measures. Both alluvium and coal measures groundwater have a near-neutral pH.

Surface flow in Glennies Creek has much lower salinity than both the alluvium and the coal measures, with EC generally below 500 µS/cm. The measured water quality of surface flow in Hunter River during the period 2002 to 2009 has ranged from 200 to 1100 µS/cm.

Although the primary focus of the earlier studies has been the mining of the Pikes Gully Seam underground to the west of Glennies Creek, the hydrogeological conditions are expected to be generally similar within the deeper seams to be mined in the proposed SEOC.

Hydraulic conductivity in the coal seams has been revealed by the results of hydraulic testing to be generally in the range 0.01 to 10m/d, with the values at the high end of the range occurring close to outcrop. The interburden is much less permeable than the coal seams, and would have a horizontal hydraulic conductivity in the order of 0.001 m/d or less, and vertical conductivity much less than 0.0001 m/d.

A study of alluvial sediments associated with Bowmans Creek (Aquaterra, 2008b) revealed somewhat variable alluvium hydraulic conductivity, but generally within the range 0.1 to 10 m/d.

3.2 BASELINE MONITORING

A baseline monitoring program for the SEOC project commenced during the EIS studies, and is ongoing. This program includes monitoring results from the pre-existing Ashton underground mine and North East Open Cut (NEOC) network, supported by a large number of piezometers that have been installed specifically to investigate the potential impacts of the SEOC project. The pre-existing monitoring network related mostly to locations outside the probable area of impact of the proposed SEOC, and was focused on underground mining of the Pikes Gully seam and mining activities associated with the NEOC. A small number of monitoring bores between Glennies Creek and the underground mine were included in the network as well as one multilevel piezometer east of Glennies Creek.

The installation of piezometers specifically for the SEOC project started in November 2008, resulting in the addition of boreholes WML239-WML253 to the monitoring network. Six more piezometers (AP 242–247) were then installed in April and May 2009 to further investigate the hydraulic properties and electrical conductivity (EC) of the alluvium between the proposed pit shell and Glennies Creek to the west. Monitoring comprises monitoring of discharge volumes (dewatering from the underground mine), groundwater levels in monitoring bores, and periodic sampling from monitoring bores and the streams for field and/or laboratory analysis of water quality.

The drilling programmes carried out for this investigation (detailed under **Section 3.3** of this report) have focused on establishing a groundwater monitoring network east of Glennies Creek, within the area designated as the proposed SEOC. This network includes alluvium groundwater levels and quality from 22 standpipe piezometers, and groundwater pressures within the Permian coal measures from two multi-level vibrating wire piezometer bores. The locations of current groundwater monitoring bores are shown in **Figure 3.1**.

3.2.1 EXPLORATION DRILLING AND PIEZOMETER INSTALLATION

Permian Coal Measures

An additional monitoring bore (WML245) was drilled in the north of the SEOC, with vibrating wire piezometers installed into targeted coal seams to monitor groundwater pressures within the Permian Coal measures. Piezometers are located in the Upper Liddell, Middle Liddell and Upper Barrett Seams, and in the Lower Barrett-Hebden Seam interburden.

Alluvium and Colluvium

Groundwater and surface water interaction with Glennies Creek and the potential for groundwater inflows to the SEOC pit via connection with alluvium was a primary consideration for this investigation. Delineation of the extent and nature of saturated, connected alluvium through the drilling of investigation holes was therefore an important part of this study.

Three drilling programs were undertaken in 2007, 2008 and 2009. All exploration/investigation holes were drilled to Permian bedrock where possible. The primary purposes of this drilling program were to:

- Delineate the extent of saturated alluvium associated with Glennies Creek, along the full extent of the proposed SEOC western pit margin, and to determine the surface profile of the underlying Permian sediments (upon which the alluvium sits) relative to water levels in Glennies Creek under normal flow conditions.
- Determine the properties of the alluvium aquifer system, by determining spatial distribution of groundwater salinity/chemistry and hydraulic conductivity of the alluvium/colluvial sediments.
- Explore the location and nature of zones of high hydraulic permeability within the alluvium.

A series of shallow exploration holes (WML145-169) was drilled by ACOL along 3 east-west transects during the period September to October 2007, to provide preliminary indications of the depth to fresh bedrock across the SEOC area. Temporary casing was installed in the holes and they were monitored for water levels and quality until they were all cemented and rehabilitated in January 2009. Due to the method of drilling (air rotary), hole instabilities and caving meant that not all holes were able to reach the top of fresh bedrock. Locations of these transects, which include bores WML145 – WML169, are shown on **Figure 3.2.**

During October to December 2008, a focussed exploration program was undertaken in the area east of Glennies Creek, extending across the floodplain into the SEOC area. Drilling was undertaken under the direction and supervision of Aquaterra. A total of 57 exploration/investigation holes (WML237-294) were drilled into the Glennies Creek alluvium and/or the flanking colluvium, across the western boundary of the SEOC (**Figure 3.2**). Twelve of these exploration/investigation holes were completed as piezometers. The remainder were backfilled and abandoned, but the drilling information obtained from all bores was used to provide detail on the depth to the base of the unconsolidated sediments and salinity (EC) of groundwater where intersected.

During April and May 2009, a further 6 boreholes (AP 242-247) were drilled in areas of the alluvium that had been identified with higher permeabilities in previous programmes. These were drilled at a larger diameter to allow higher rate pumping tests to be carried out to investigate aquifer properties.

Air drilling was used in preference to mud drilling, as it allows the identification of groundwater intersections during drilling. Where boreholes had to be kept stable for piezometer installation, the Tubex sleeve casing method was used.

All holes were generally drilled until intersection of the Permian coal measures was identified in the drill cuttings, so the holes penetrated at most 0.2 to 0.5m into the Permian. The holes selected for completion as piezometers were cased with 50mm PVC casing including a 3m section of factory-slotted screen. The screens were designed to be placed in the lowermost section of the alluvium or colluvium.

As part of previous groundwater investigations associated with longwall mining of Pikes Gully Seam to the west of the proposed SEOC, groundwater bores WML119 and WML120A (Pikes Gully Seam) and WML120B and WML129 (alluvium) were installed adjacent to and on the western side of Glennies Creek (**Figure 3.1**), to assess and monitor for potential impacts on saturated alluvium along the creek alignment nearest to longwall panel 1 (Aquaterra, 2008b).

Details of the piezometers installed within the Glennies Creek floodplain area during the 2007, 2008 and 2009 drilling programs are presented in **Appendix A.1** and drill hole logs in **Appendix A.2.** The piezometers installed comply with the minimum construction requirements for water bores in Australia (National Minimum Bore Specifications Committee, 2003).

The locations of all installed monitoring bores and exploration holes are shown on **Figure 3.2**. This figure also indicates transect lines which were used to depict cross sections across the floodplain and SEOC areas.

3.2.2 HYDRAULIC TESTING

Testing of aquifer characteristics in the SEOC piezometers was conducted by Aquaterra in October 2008 and January 2009. The bores west of Glennies Creek were tested in June 2006 and November 2007 as part of groundwater investigations associated with longwall mining (LW1-4) of the Pikes Gully seam to the west of the proposed SEOC (PDA, 2006).

Falling head slug tests were carried out on 19 exploratory holes piezometers to obtain estimates of average hydraulic conductivity of the saturated alluvium and colluvium. The procedure involved adding a slug of water to each piezometer/bore and then recording water-level recovery back to a static level using a downhole pressure transducer.

The slug test data were analysed using the Bouwer-Rice method (Bouwer and Rice, 1976) for the tests on unconsolidated sediments (alluvium and colluvium), and the Hvorslev Method (Hvorslev, 1951) for tests on the hard rock units, which are suitable for providing 'near well' estimates of aquifer hydraulic conductivity (K). These methods of analysis assume that the entire length of the screened interval in the test well is saturated; however in some cases this condition was not met. In such cases, an adaptation of the Bouwer and Rice Method was applied. The results are summarised in **Table 3.5** and the data and solutions from which these values were derived are shown in **Appendix B.1.**

The limitation in this method is that disturbance to the formation caused during drilling can result in elevated K values in the immediate vicinity of the borehole. Hence, where there was sufficient depth of water in the bore, a Constant Rate Test (CRT) was also conducted using a low capacity sampling pump. The drawdown and pumping rate data obtained from a CRT can provide the basis for estimating a broader range of hydraulic parameters than is achievable from falling head tests. In some cases it can also provide a better representation of the wider aquifer characteristics beyond the immediate vicinity of the borehole.

The constant rate test data were analysed using the Cooper-Jacob method (Cooper and Jacob, 1946) to determine a value of transmissivity, from which a value of average hydraulic conductivity (permeability) can be calculated. A summary of the derived hydraulic conductivity (K) and transmissivity values (K x aquifer thickness) is presented in **Table 3.5**. Data plots and solutions derived for each CRT test are included for reference in **Appendix B.2**

In some cases prior to the 2009 investigations, the CRT tests were only partially successful because the diameter of the borehole only allowed for small capacity pumps that were not able to produce sufficient drawdown curves to be analysed with confidence.

The April-May 2009 drilling programme was carried out to address this issue. It targeted suspected higher permeability zones with larger diameter boreholes that would allow appropriate pump sizes and hence CRTs to be carried out at higher yields than with the smaller capacity pump. These were all analysed using the Cooper-Jacob method. Derived hydraulic conductivity and transmissivity values are also contained in **Table 3.5.**

3.2.3 GROUNDWATER SAMPLING

Where groundwater samples were taken, each piezometer was purged in accordance with AS/NZS 5667 (Standards Australia, 1998) and water samples were collected for field analysis of pH, electrical conductivity (EC) and temperature, and for laboratory testing of a comprehensive suite of analytes, viz

- pH, electrical conductivity (EC) and total dissolved solids (TDS),
- Major cations and anions, and
- Dissolved metals (As, B, Cd, Cr, Cu, Fe, Ni, Pb, Mn, Se, Zn, Hg).

The laboratory analysis was undertaken by ALS Environmental, a NATA-accredited laboratory based in Sydney. A summary of the major ions taken from the laboratory analysis report are presented in **Table 3.2.**

3.2.4 GROUNDWATER QUALITY

Water samples collected from selected monitoring bores were tested for pH, electrical conductivity (EC), total dissolved solids (TDS), suspended solids (TSS) and alkalinity as CaCO3 on a quarterly basis. Water samples were also collected from existing and newly installed piezometers (WML239-WML253) for full chemical analysis (major ions and dissolved metals). Sampling for the further alluvium investigations in April and May 2009 was confined to on-site EC readings. Some water samples were also collected from exploration drillholes, prior to being backfilled and cemented up.

The historic range of water quality data collected over the period 2000 to 2009, along with the more recent water quality data obtained from newly installed piezometers WML239-WML253, and AP242-247 is summarised in **Table 3.1.** In addition, groundwater produced during the drilling of some exploration holes was analysed on site for EC (See **Appendix A.1**).

Table 3.1: Baseline Groundwater Quality Data Summary – 2000 to 2009

Aquifer Screened	Piezometers	pH	Electrical Conductivity (µS/cm)	
		Range	Mean	Range
Alluvium & Colluvium	WML120B	6.87-7.24	1360	1020-1930
	WML129	7.06-7.27	517	396-577
	WML148	6.94	2610	2610
	WML155	6.74	915	915
	WML157	7.23	803	803
	WML158	7.14	705	705
	WML239	7.01	1000	1000
	WML240	6.72	1660	1660
	WML241	7.34	829	829
	WML243	6.97	5570	5570
	WML247	7.92	14200	14200
	WML248	7.53	18400	18400
	WML249	8.00	15300	15300
	WML250	7.10	1200	1200
	WML252	6.73	4710	4710
	WML253	7.87	345	345
	AP242	7 – 7.13	1045	1045
	AP243	7	1938	1938
	AP244	7	600	600
	AP245	7.2	2500	2500
	AP246	7.10	5250	5250
	AP247	7.38	6080	6080
Pikes Gully Seam	WML20, WML21, WML119, WML120A, WML181-186	6.44-8.27	4380	387-8680
Upper Liddell Seam	GM1	6.81-8.38	5740	4920-9370
Lower Barrett Seam	GM2	6.76-7.18	5504	1460-8600
Other Permian coal measures (Upper Barrett Seam, Bayswater Seam, weathered coal measures, etc)	RSGM1, RM05, G3A, OC1, OC2, WML108B-115B	6.65-8.66	6095	875-14700

Overall, the average water quality from the alluvium/colluvium boreholes is slightly better (EC 4,400 µS/cm) than the average water quality of the coal measures (5,400 µS/cm).

A summary of the major ions in water samples taken from former exploration holes (WML148-157) and newly installed piezometers (WML239-253) piezometers within the Glennies Creek floodplain are presented in **Table 3.2.** TDSs were in the range 236 to 12,000 mg/L.

Table 3.2: Glennies Creek Alluvium Groundwater and Surface Water Quality

Source	Sample date	pH	EC	TDS	Ca	Mg	Na	K	Cl	HCO3	SO4
			µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WML148	21/11/2008	6.85	3340	2800	191	90	401	<1	1010	210	34
WML155	21/11/2008	7.25	1160	967	96	36	90	1	260	128	114
WML157	21/11/2008	7.2	701	500	56	22	59	<1	104	201	24
WML239	07/11/2008	7.01	1000	690	62	29	93	2	221	152	19
WML240	06/11/2008	6.72	1660	1400	98	56	138	2	466	91	31
WML241	07/11/2008	7.34	829	539	18	10	156	1	163	190	6
WML243	07/11/2008	6.97	5570	3310	162	143	917	2	1530	598	195
WML247	06/11/2008	7.92	14200	8320	30	80	2940	21	4180	1320	38
WML248	06/11/2008	7.53	18400	12000	293	556	3210	18	6230	781	1080
WML249	06/11/2008	8	15300	9480	61	150	3130	10	4580	1050	747
WML250	06/11/2008	7.1	1200	754	58	30	141	<1	258	170	20
WML252	21/11/2008	6.73	4710	2640	90	106	832	2	1250	331	259
WML253	21/11/2008	7.87	345	236	28	13	27	<1	46	118	6
GLENNIES CREEK	21/11/2008	6.98	310	176	18	9	31	2	45	75	14
SM7	31/08/2007	7.15	570	348	30	15	57	3	87	103	33
SM8	30/08/2007	7.18	538	344	29	14	52	3	78	115	33

3.2.5 SURFACE WATER QUALITY

Surface water quality for Glennies Creek has been monitored monthly for pH, EC and TSS. Three monitoring stations are located on Glennies Creek (shown as SM7, SM8 and SM11 on **Figure 3.1**). The range of Electrical conductivity (EC) measured across all stations is summarised in **Table 3.3**.

Table 3.3: Baseline Surface Water Quality Summary- 2000-2008

Water Source	Stations	pH	Electrical Conductivity (µS/cm)	
		Range	Mean	Range
Glennies Creek	SM7, SM8, SM11	7.20 – 8.45	376	230 – 903
Hunter River	SM9, SM10, SM12, SM13	7.62 - 8.52	699	236 – 1290

3.2.6 GROUNDWATER LEVELS

Monitoring of groundwater levels has been undertaken by ACOL in accordance with the draft Groundwater Monitoring Plan (Ashton, 2009), commencing in some piezometers in 2001. As described above, the monitoring network comprises a series of shallow alluvium/colluvium piezometers and two upper Permian piezometers (WML144 and WML245), located in the

Glennies Creek flood plain, and along the western boundary of the proposed SEOC pit (**Figure 3.1**).

Piezometer WML144, near the western boundary of the proposed SEOC has vibrating wire piezometers set within the Upper Liddell, Upper Lower Liddell and Lower Barrett seams, as well as a number of minor seams and splits (Middle Liddell 1 and 2, Lower Lower Liddell and Upper Barrett). Newly installed piezometer WML245 on the northern boundary of the proposed SEOC has vibrating wires set within the Upper Liddell, Middle Liddell and Upper Barrett Seams, and in the Lower Barrett-Hebden Seam interburden.

Groundwater levels are recorded at least monthly in all designated monitoring piezometers. A summary of the current groundwater monitoring piezometers is presented in **Table 3.4**

Table 3.4: Current Groundwater Monitoring Piezometers

Bore	Coordinates		Ground Level	Drilled Depth	Screened Interval	Aquifer Screened	Current Status	Water Level Nov 08 – May 09	
	Easting	Northing	(m AHD)	(m bgl)	(m bgl)			m bgl	m AHD
WML119	319255	6403930	61.12	27	18-21	PG seam	Piezometer	11.70	50.15
WML120A	319291	6404579	60.27	18	12-15	PG seam	Piezometer	10.24	50.71
WML120B	319292	6404587	60.01	8.5	5.5-8.5	Alluvium	Piezometer	8.56	51.95
WML129	319467	6403548	54.94	9.5	7-9	Alluvium	Piezometer	4.61	50.73
WMLC144	319500	6404170	59.26	98m +	VW 26m	ULD seam	VW Piezometer	8.58	50.68
					VW 32m	ML1 seam	VW Piezometer	9.82	49.44
					VW 45m	ML2 seam	VW Piezometer	10.90	48.36
					VW 50m	ULLD seam	VW Piezometer	8.94	50.32
					VW 58m	LLLD seam	VW Piezometer	11.2	48.06
					VW 81m	UB seam	VW Piezometer	8.98	50.28
					VW 98m	LB seam	VW Piezometer	8.5	50.76
WML239	319345	6404045	60.142	13.5	10.5-13.5	Alluvium	Piezometer	8.00	52.14
WML240	319500	6404000	58.816	11	8-11	Alluvium	Piezometer	7.50	51.36
WML241	319475	6403222	57.831	14.5	11.5-14.5	Alluvium	Piezometer	7.50	51.36
WML243	319643	6403226	59.055	15	12-15	Alluvium	Piezometer	6.97	52.09
WML245	320035	6404835	65.642	101	VW 55m	ULD seam	VW Piezometer	29.49	36.15
					VW 65m	MLD seam	VW Piezometer	24.19	41.45
					VW 70m	UB seam	VW Piezometer	27.76	37.89

Bore	**Coordinates**		**Ground Level**	**Drilled Depth**	**Screened Interval**	**Aquifer Screened**	**Current Status**	**Water Level Nov 08 – May 09**	
	Easting	**Northing**	**(m AHD)**	**(m bgl)**	**(m bgl)**			**m bgl**	**m AHD**
					VW 110	LB-Heb interburden	VW Piezometer	40	25.59
WML246	319893	6404592	64.9	10	7 – 10	Alluvium	Piezometer	Dry	-
WML247	319734	6404472	63.4	13	10 – 13	Alluvium	Piezometer	10.60	52.76
WML249	319577	6404300	62.3	13	10 – 13	Alluvium	Piezometer	10.23	51.08
WML250	319454	6404301	60.4	13	10 – 13	Alluvium	Piezometer	7.8	52.64
WML252	319621	6403684	60.2	10.9	7.9 –10.9	Alluvium	Piezometer	8.00	52.24
WML253	319555	6403707	60.2	12.5	9.5 –12.5	Alluvium	Piezometer	9.00	51.16
WML256	319723	6402774	….	7.55	4.5 – 7.5	Alluvium	Piezometer	4.65	-
WML294	….	….	….	12.5	9.46 - 12.46	Colluvium	Piezometer	5.58	-
AP242	319455	6404320		17.3	9.3-11.3	Alluvium	Piezometer	7.83	
AP243	319592	6403473	….	10.3	7.3 – 10.3	Alluvium	Piezometer	7.0	-
AP244	319662	6403472	….	7.8	5.8 – 7.8	Alluvium	Piezometer	5.28	-
AP245	319724	6403483	….	6	4? – 6	Alluvium	Piezometer	6.12	-
AP246	319647	6403249	…	11	7.9-10.9	Alluvium	Piezometer	7.9	
AP247	319635	6403699	…	11	8-11	Alluvium	Piezometer	8.4	

….To be surveyed

3.3 DWE REGISTERED BORES

A search was conducted of the DWE groundwater bore database. No registered water supply bores occur in the coal measures within the areas where the predicted draw downs are significant. However, there is one registered groundwater bore in the Glennies Creek alluvium in the township of Camberwell. This bore is not expected to be impacted by the proposed mining of the SEOC.

Table 3.5: Summary of Results from Hydraulic Testing Programme

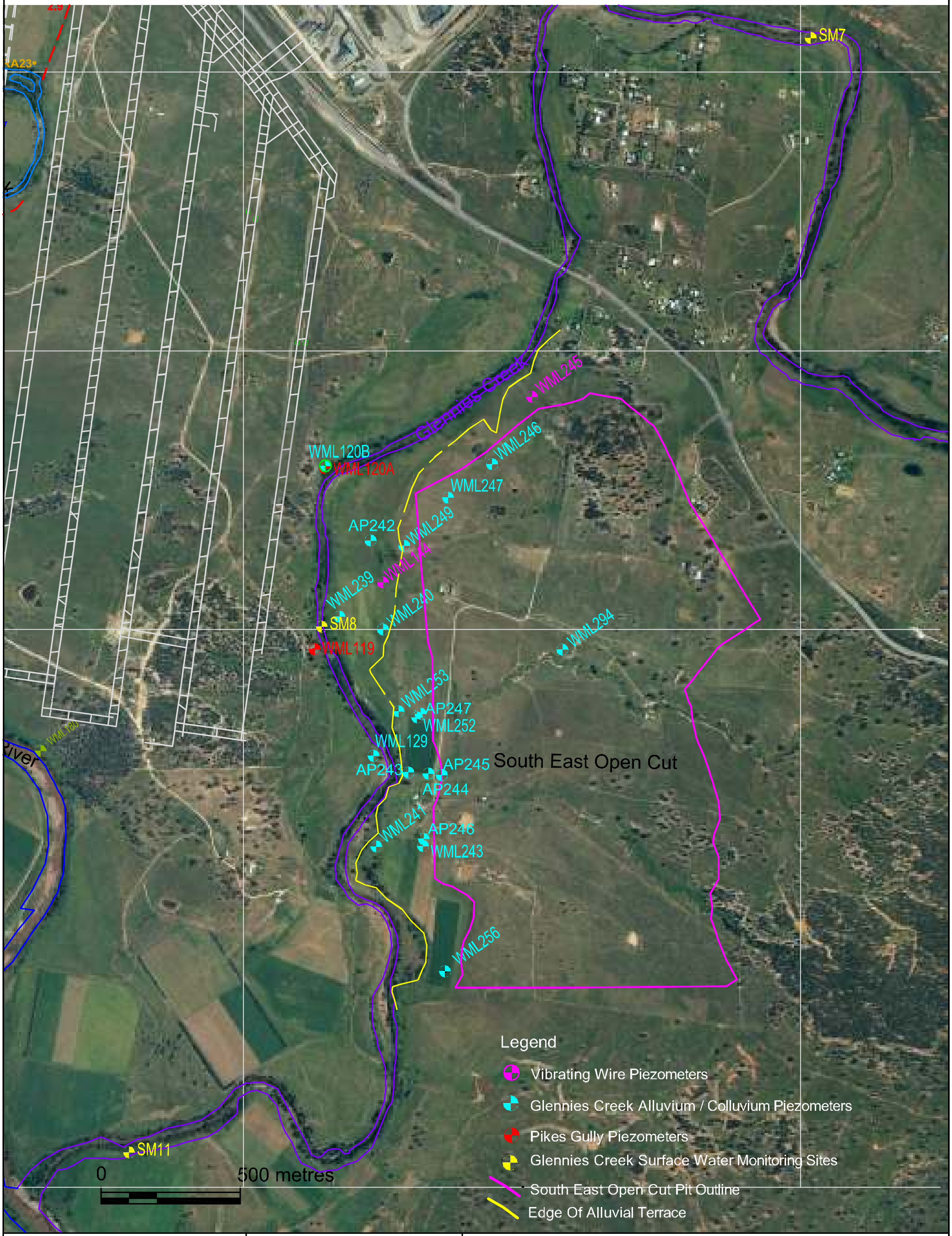
Bore	Aquifer Screened	Screened Interval (m bgl)	Test Date	Type of Test	Duration (min)	Pumping rate (kL/day)	Transmissivity, T (m^2/day)	Hydraulic Conductivity, K (m/day)	Comments
WML119*	PG seam	18-21	15/06/2006	CRT	120	8.30	0.30	0.10	Western side of creek
			23/06/2007	CRT	65	4.90	0.75	0.04	
			06/11/2007	CRT	65	10.80	0.40		
WML120A*	PG seam	12-15	15/06/2006	CRT	125	13.50	20.00	7.00	Western side of creek
			27/11/2007	CRT	35	13.90	50.00	7.00	
WML120B*	Alluvium	5.5-8.5	14/06/2006	CRT	12	7.70	17.00	5.00	Western side of creek
			20/12/2007	Slug	-	-	-	0.20	
WML129*	Alluvium	7-9.5	23/06/2007	CRT	1	6.50	2.30	0.70	Western side of creek
			19/12/2007	Slug	-	-	-	0.40	
WML145*^	Alluvium	11.8 – 14.8	20/12/2007	Slug	12	-	-	0.26	
			21/11/2008	Slug		-		0.30	
WML148*	Alluvium	7.9 – 10.9	20/12/2007	Slug	46	-		0.42	
WML155*^	Alluvium	6.9 – 9.9	20/12/2007	Slug	47	-	0.21	0.07	
			21/11/2008	Slug		-	0.15	0.05	
WML157*^	Alluvium	6.0 – 9.0	20/03/2008	Slug	41	-	0.54	0.18	
			21/11/2008	Slug		-	0.30	0.10	
WML158*	Alluvium	2.5 – 5.5	20/12/2007	Slug	48	-		0.70	
WML239^	Alluvium	11.5-13.5	15/10/2008	Slug	6	-	0.77	0.20	Early time data
			15/10/2008	Slug	13	-	1.41	0.16	Late time data
WML240^	Alluvium	8.0-11.1	15/10/2008	Slug	5	-	0.30	0.10	Early time data
			15/10/2008	Slug	11	-	0.30	0.10	Late time data
			06/11/2008	CRT	30		1.2	0.4	Late time data
WML241^	Alluvium	11.5-14.5	14/10/2008	Slug	2		3.84	0.60	Early time data

Bore	Aquifer Screened	Screened Interval (m bgl)	Test Date	Type of Test	Duration (min)	Pumping rate (kL/day)	Transmissivity, T (m^2/day)	Hydraulic Conductivity, K (m/day)	Comments
			14/10/2008	Slug	17		0.58	0.09	Late time data
WML243^	Alluvium	12-15	07/11/2008	CRT	20	14.20	-	-	Test duration too short and drawdown too small to be reliable
			14/10/2008	Slug	15	-	0.14	0.05	Early time data
			14/10/2008	Slug	25	-	0.49	0.17	Late time data
			05/02/2009	Slug	6	-	10.08	3.50	
WML248^	Alluvium	6-9	06/11/2008	Slug	60	-	0.01	0.01	
WML249^	Alluvium	10-13	21/11/2008	Slug	58	-	0.06	0.02	
WML250^	Alluvium	8 –11	16/10/2008	Slug	-	-			Recovery too rapid to analyse
			20/01/2008	CRT	35	19.00	20.00	6.67	Early time data
							115.00	38.33	Late time data
			27/01/2009	CRT	310	34.00	150.00	50.00	Early time data -based on 3m sat thickness
							240.00	80.00	Late time data - based on 3m sat thickness
WML252^	Alluvium	7.9-10.9	21/11/2008	Slug	15	-	2.5 - 6	1 - 2.4	
			30/01/2009	CRT	8	16.4	4.29	2.14	Test duration too short and drawdown too small to be reliable
WML253^	Alluvium	9.5 - 12.5	21/11/2008	Slug	-	-	6.72	1.60	
			28/01/2009	CRT	260	36.00	22.00	5	Early time data
							66.00	15.00	Late time data
WML294^	Alluvium	8-11	30/01/2009	Slug	66	-	0.08	0.03	
AP242^	Alluvium	9.3 - 11.3	14/05/2009	CRT	240	147	448	180	
AP243^	Alluvium	7.3-10.3	12/05/2009	CRT	40	12.96	13.00	6.00	early data
							1.60	0.75	late data
			22/05/2009	CRT	65	12.10	13.00	6.00	early data
							6.00	2.80	late data

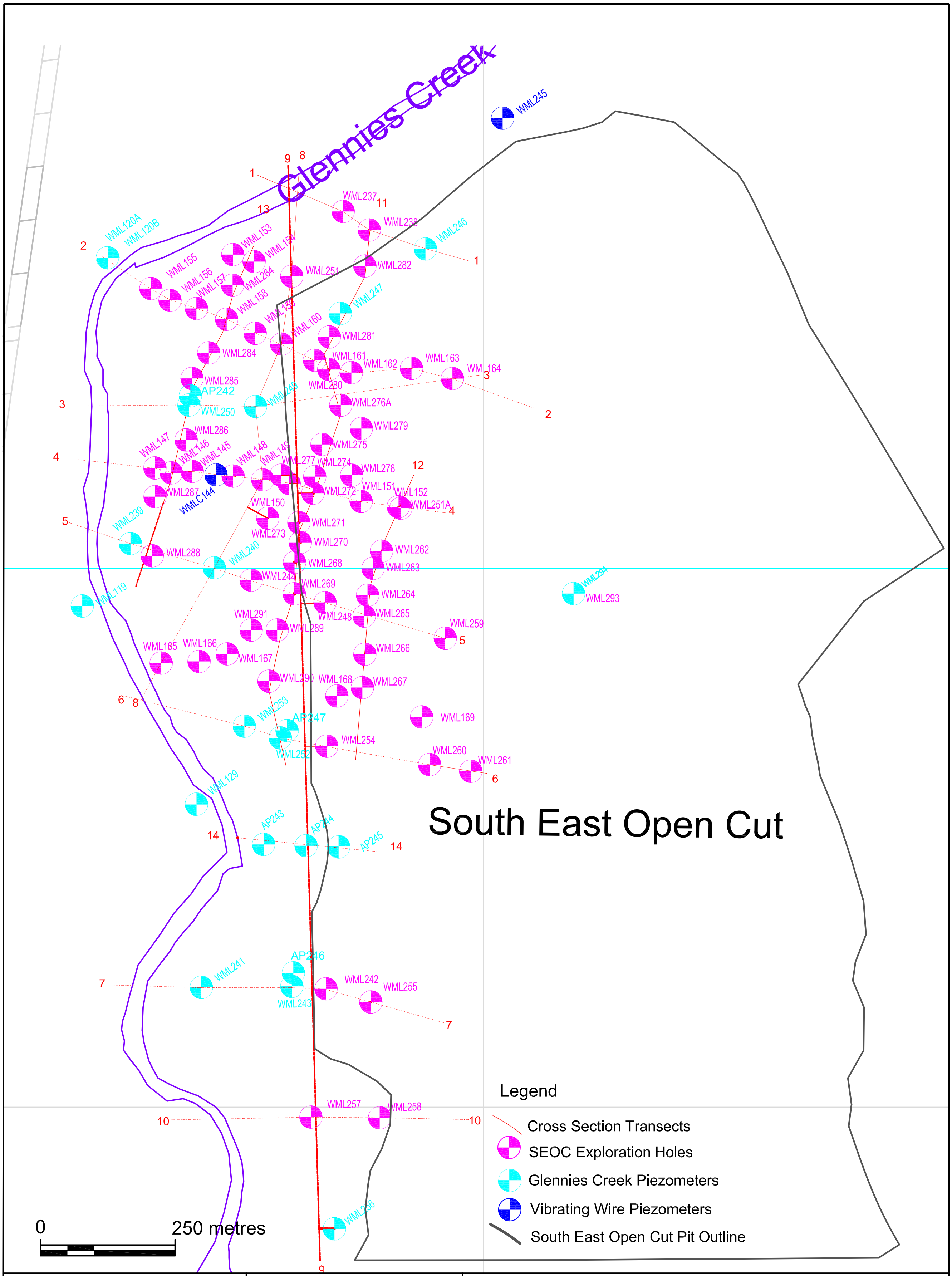
Bore	Aquifer Screened	Screened Interval	Test Date	Type of Test	Duration (min)	Pumping rate	Transmissivity, T	Hydraulic Conductivity, K	Comments
		(m bgl)				(kL/day)	(m^2/day)	(m/day)	
AP 246^	Alluvium	7.9-10.9	21/05/2009	CRT	400	116.00	60.00	28.00	early data
							29.00	13.80	late data
AP 247^	Alluvium	8.0-11.0	22/05/2009	CRT	8	25.92	9.80	6.00	early data
							1.00	0.62	late data
AP244^	Alluvium	5.8 – 7.8	29/05/2009	CRT	15	8.6	0.9	0.37	
WML256	Alluvium	4.55 -7.55	05/05/2009	Slug	-	-	0.1	0.036	slug out

^ Hydraulic testing undertaken as part of SEOC groundwater impact assessment

* Hydraulic testing undertaken as part of previous hydrogeological investigations (PDA, 2006)



Date:	29 May 2009	Scale:	as shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT SEOC GROUNDWATER AND SURFACE WATER MONITORING SITES**
Drawing No:	S36-027b	Rev:	B	
aquaterra				**Figure 3.1**



Date: 1 July 2009

Scale: as shown

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Job No: S36

Drawing No: S36-003f

Rev: F

aquaterra

Ashton Coal Operations Ltd

ASHTON COAL PROJECT
SEOC
BOREHOLE LOCATION PLAN

Figure 3.2

4 DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 SITE DESCRIPTION

The SEOC area is located on the northern side of the Hunter River, to the east of Glennies Creek which is a tributary of the Hunter River. The SEOC lies to the east of Ashton's current mining lease ML1533. This mining lease straddles the New England Highway, and incorporates the existing Ashton open cut operations (NEOC) on the northern side of the highway, and the underground operations on the southern side (**Figure 1.2**).

4.2 TOPOGRAPHICAL SETTING

The SEOC Project is located within EL 4918 (which covers an area of 370ha) and EL 2860 (272ha). It includes rural lands under the ownership of private holders, Crown Land and land owned by ACOL. It consists mostly of cleared grazing lands with little topographical relief, with land elevation ranging from 50m AHD (Australian Height Datum) in the west adjacent to Glennies Creek and 100m AHD to the east.

While the topography of the Project Site generally dips to the west towards Glennies Creek, the surface contours exhibit gentle undulations with a number of tributary streams draining across the site in a westerly direction towards Glennies Creek.

4.3 CLIMATE

4.3.1 RAINFALL AND EVAPORATION

The climate of the region is temperate with hot summers and cool winters. The average daily maximum temperature ranges from 31.7 ºC in January to 17.4 ºC in July.

Table 4.1 summarises rainfall data from the Jerry's Plains weather station, situated approximately 14 km to the southwest of the Ashton Project. The table lists the mean monthly rainfall and mean annual rainfall, based on more than 100 years of rainfall data since 1884. Evaporation data are available from Scone, approximately 100km west of Ashton. **Table 4.1** shows that there is an excess of evaporation over rainfall in all months, although rainfall and potential evaporation are close to being in balance in the winter months (June and July).

Table 4.1: Long-term Average Monthly Rainfall at Jerry's Plains and Evaporation at Scone (mm)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall*	80.3	69.7	58.4	43.9	41.2	47.7	43.7	36.7	42.1	51.7	57.1	66.8	639
Evaporation#	220	169	154	118	89	56	69	81	112	164	195	204	1630
Balance	-140	-99	-96	-74	-48	-8	-25	-44	-70	-112	-138	-137	-991

Source: Bureau of Meteorology (2008)

*BOM Jerry's Plains Meteorological Station

BOM Scone SCS Meteorological Station

4.4 SURFACE WATER

The main surface water feature of interest in the area is Glennies Creek. This is a 6th order stream (according to the Strahler classification), that flows into the Hunter River. It is a Schedule 3 stream according to the Draft DIPNR Stream/Aquifer Guidelines for the Hunter Region (DIPNR, 2005).

Glennies Creek flows are around 152 ML/day on average, with a minimum 5 percentile sustained flow of approximately 14 ML/day. Flows are regulated by the Glennies Creek Dam which is located in the upper part of the catchment.

Ephemeral flows occur via natural surface drainage features that run east-west across the proposed pit area. These are all first or second order (ie Schedule 1) streams.

4.5 GEOLOGY

4.5.1 REGIONAL GEOLOGY

The study area is located within the Hunter Coalfield of the Sydney Basin. The Permian aged coal reserves within the Ashton Coal Project mining lease are mostly within the Foybrook Formation of the Vane Sub-Group (Hebden to Lemington seams). There is a limited occurrence of the Bayswater Seam which is the basal unit of the Jerry's Plains Sub-Group, in the south-western corner of the Ashton underground mine area. Both sub-groups are part of the Whittingham Coal Measures, the basal coal-bearing sequence of the Singleton Supergroup. Regional surface geology is shown on **Figure 4.1**.

The major mineable coal seams identified in the SEOC area are (in descending stratigraphic order) the Upper Liddell, Upper Lower Liddell, Lower Barrett, Upper Hebden and Lower Hebden Seams. Subcropping to the west of the proposed SEOC are the Pikes Gully Seam, the Lemington Seams 1-19, and the Bayswater Seam. The Pikes Gully Seam is currently being mined in the Ashton underground mine.

A range of seams from the Lower Barrett up to the Pikes Gully Seam and some from the lower Lemingtons are mined in the current NEOC. The Bayswater Seam is stratigraphically higher than the Pikes Gully and Lemington seams, and was previously mined in the former Bayswater open cut and the Narama Pit, both to the west of the project area.

4.5.2 LOCAL GEOLOGY

The target coal seams are separated by interburden sediments which comprise alternating sandstone, siltstone, conglomerate, mudstone and shale, as well as occasional minor coal seams.

The main regional geological structures in the area are the Bayswater Syncline, the axis of which is located to the west of Ashton in the Ravensworth South and Narama mines; the Camberwell Anticline, the axis of which passes just to the east of the proposed SEOC; and, further to the east, the Glennies Creek Syncline. The axes of these structures run from N to S or NNW to SSE. The coal seams to be mined at Ashton's proposed SEOC outcrop in the study area on the western and north-eastern limbs of the Camberwell anticline and within the proposed SEOC footprint. The geology used for the groundwater model was based on the subcrop patterns for the seams derived from the Ashton geological model. These were extrapolated out to the groundwater model boundary based on published mapping and geological references in various public company reports.

The most important seams in the SEOC are the Liddell, Barrett, and Hebden Seams and associated splits, with the upper levels of the Foybrook Formation weathered in the SEOC area. The seam thicknesses vary generally between 2m and 4m. The interburdens between the seams vary in thickness between 7m and 63m.

The Hebden Seam, which is the deepest seam considered for mining within the SEOC, occurs at depths ranging from 20m to more than 90m below ground (+50 to -25m AHD) at the northern end of the proposed SEOC pit and from 40m to more than 110m below ground (+50 to -60m AHD) at the southern end.

4.5.3 ALLUVIAL DEPOSITS

Within the project area, alluvium occurs in association with the deposition of paleo-sediments by Glennies Creek. These deposits occur within two main terraces, a lower terrace adjacent to the river, and an upper terrace that merges with colluvium and finally regolith associated with the slopes of the rising Permian subcrop to the east. The areal extents of the alluvial terraces can be defined visually. The terraces are tiered, with an elevation change between terraces in the order of 1-3 m.

A representative geological cross section through the shallow superficial deposits in the area is presented in **Figure 4.2.** This shows both the east-west transition from Glennies Creek to the Permian sub-crop, and a north-south cross section near the line of the proposed western pit wall. These relate to borehole transects 5 and 9, as shown on **Figure 3.2.**

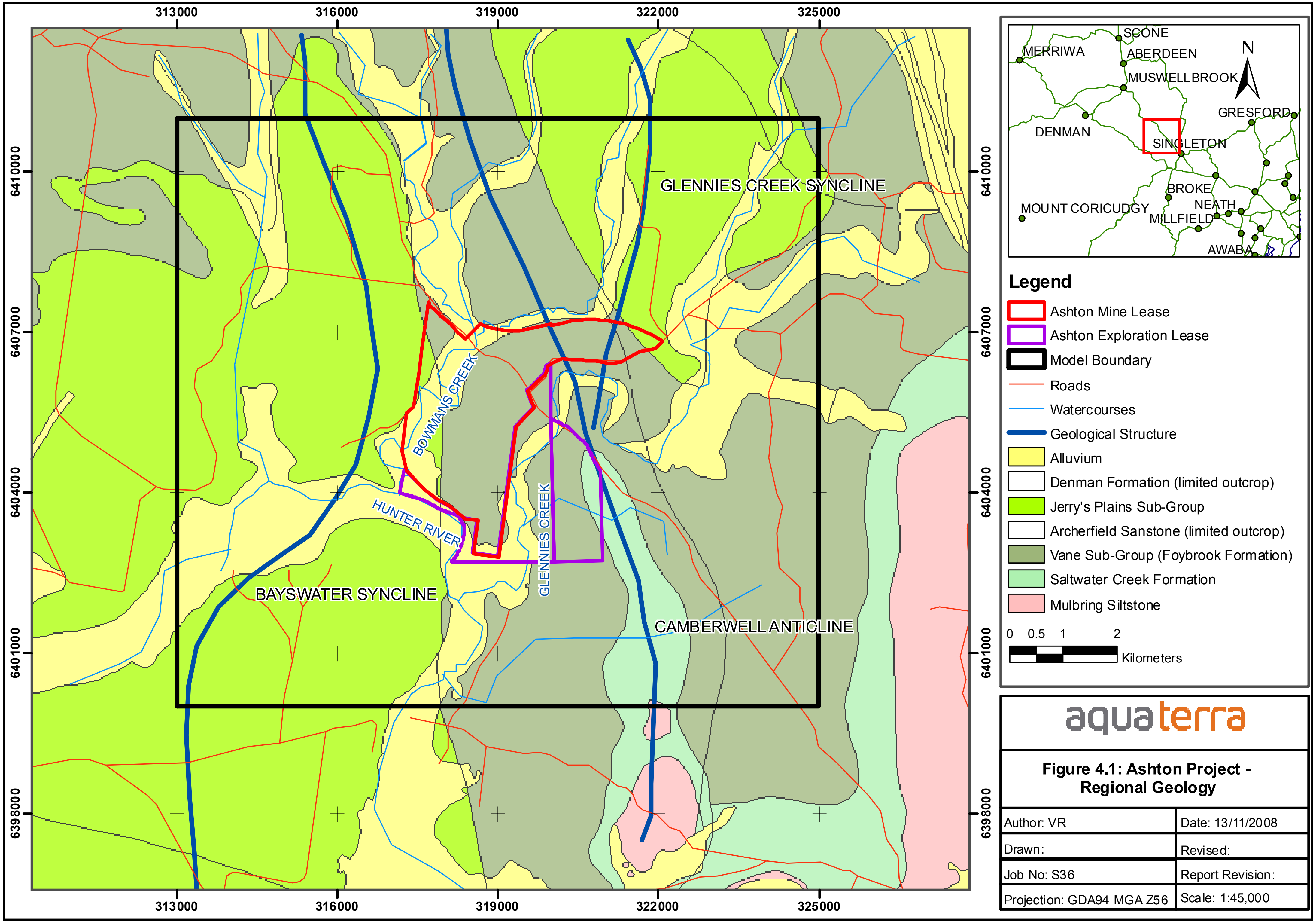

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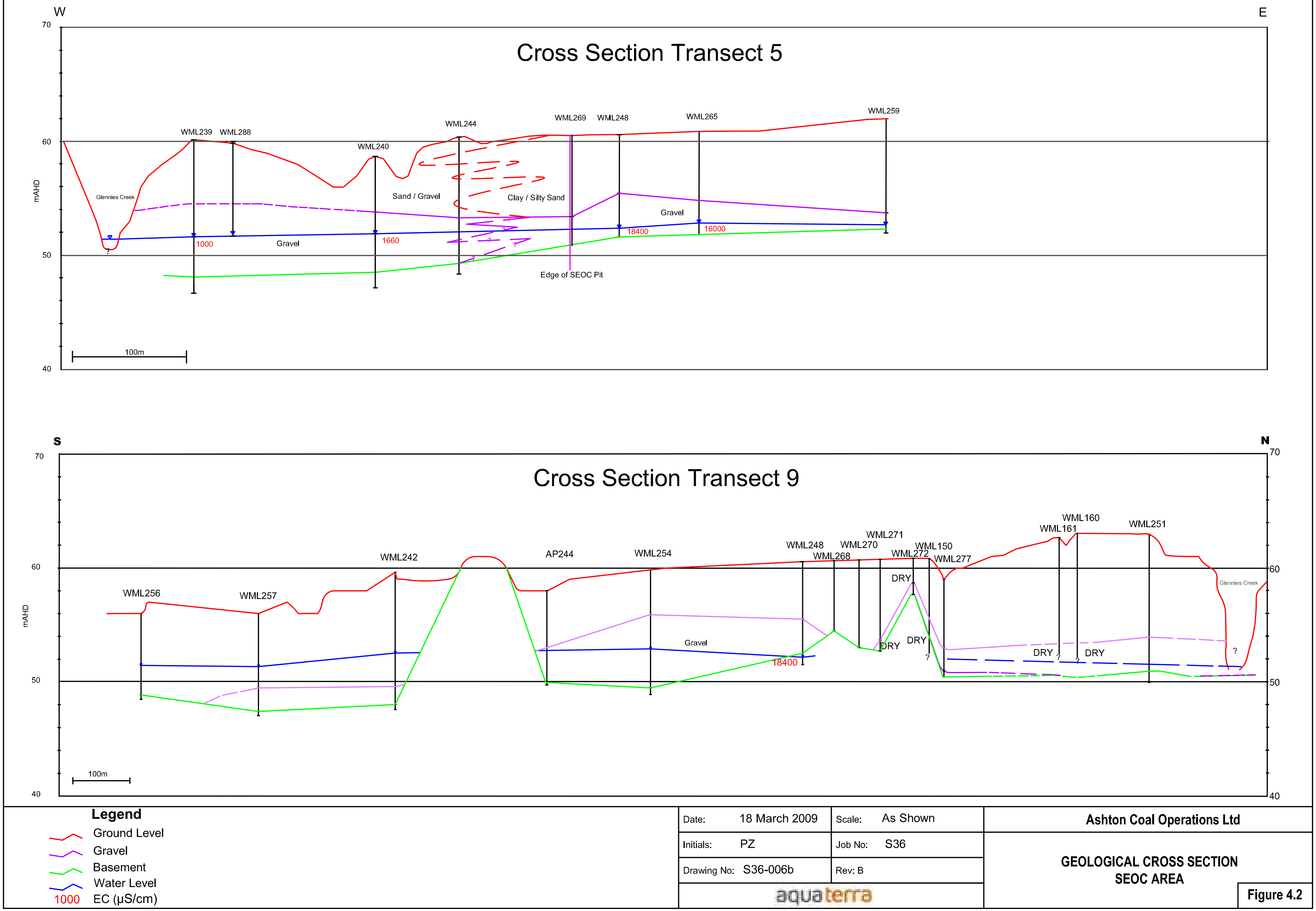
Figure 4.1: Ashton Project - Regional Geology

Author: VR	Date: 13/11/2008
Drawn:	Revised:
Job No: S36	Report Revision:
Projection: GDA94 MGA Z56	Scale: 1:45,000



Date:	18 March 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**GEOLOGICAL CROSS SECTION SEOC AREA**
Drawing No:	S36-006b	Rev: B		
aquaterra				**Figure 4.2**

Investigation drilling of the Glennies Creek floodplain and regolith indicated up to about 8 -10 m of sandy silts, silts and silty clays, generally overlying coarse sandy gravels. Maximum recorded saturated thickness is 6m.

The location of exploration holes and corresponding transect lines used to construct the cross sections across the study area have been shown previously in **Figure 3.2**. Cross sections 1 to 12 are presented in **Appendix B** and the geological logs (WML237-294) from which these cross sections were created are presented in **Appendix A.2**. The results of drilling are discussed in the following section.

4.5.4 DISCUSSION OF DRILLING RESULTS

Site inspection and aerial photography indicates that there are raised terrace levels at the site. Topography indicates that, although there are a number of channels and ridges associated with the floodplain/lower terrace, there is a distinct, continuous scarp slope demarcation between this and the upper terrace. The main/upper terrace level is typically around 60 m AHD. It comprises floodplain alluvium in the upper parts that merges with colluvial soils associated with the rising terrain to the east and partly encroaches on the SEOC boundary within and just north of the W. Bowman homestead. The lower terrace level is around 55-60m AHD in the floodplain area. The interpreted boundary of the main (upper) terrace is shown in **Figure 4.3.** This shows that the lower terrace is much wider to the north west of the site, where it forms a wide floodplain with Glennies Creek. On the west and south-west side the floodplain and associated lower terrace is more closely confined to the river.

Observations made during drilling across the boundary of the main (upper) terrace tended to show a change in soil texture. Although saturated gravels are observed at the base of drill holes on the upper terrace, the sediments appear to be colluvial as well as fluvial, suggesting intercalated alluvium and colluvium. The drilling was too coarse to accurately define the extent of this zone, but this boundary does delineate the margin of the terraced alluvial sediments deposited by Glennies Creek in the past.

These terraces are elevated well above the present Glennies Creek drainage, and are considered to be related to an ancient (higher) creek level than prevails today. The upper terrace may become inundated during extreme flooding events.

Comments on the cross sections contained in **Appendix B** are as follows.

Transect 1

Drilling in this northern area of the proposed SEOC revealed either shallow basement, or unsaturated gravels overlying the Permian coal measures. Here the water table intercepts the elevated basement, west of the SEOC pit wall and hence there is no hydraulic connection with Glennies Creek in this area.

Transects 2-4

South of Transect 1, the lower alluvial terrace widens significantly across the Glennies Creek Valley which has been infilled with alluvial sediments, up to 7m thick (Transects 2-3). There is a trend to increased angularity in the gravels away from Glennies Creek to the east, suggesting that they have been transported less distance (possibly from higher terrain immediately to the east). These gravels are more colluvial in nature, and there is a gradual transition from alluvium in the creek to colluvium in the east.

East of the physical surface feature designating the extent of the lower terrace, basement levels rise with topography. East of the terrace, the proposed SEOC western batter intercepts up to 2 m of saturated colluvial gravels, however south of Transect 3 (around bores WML275, WML271 and WML251), gravels are absent over areas of elevated basement (Transect 4). Here the majority of drill holes within the SEOC pit were dry and the water table intercepts elevated basement, 60m west of the SEOC wall.

Transects 5-6

Transects 5 and 6 showed similar soil structure patterns during drilling with a gradual decrease in both basement elevation and reduction in gravel thickness (from 5m to 2m) is noted in a easterly direction. The gravels encountered within drill holes located on the lower terrace along Transect 5 were typically well rounded, which is consistent with gravels that had been transported some distance. Moving east up on to the higher terrace level, drill holes revealed thinner gravels with a greater proportion of more angular clasts, consistent with shorter transport distances than that seen closer to the river.

Also typical of these two transects is an increased clay content in the gravel matrix, and a thicker overlying clay cover above the lower matrix. Similar features can be seen in this part of the north-south transect 9.

As with other transects, salinity shows a marked increase from the alluvium of the lower terrace near Glennies Creek to the colluvium of the upper terrace and upper slopes further east.

Transect 7

The terrace feature south of the W Bowman homestead was investigated via drilling along Transect 7. The terrace escarpment is very close to the creek at this point, and the alluvium/colluvium sediments rapidly thin towards the east from Glennies Creek as in other areas.

Transect 7 shows the same topographical trend as seen in other east west transects of elevating basement to the east. Adjacent to the creek in WML241, thick rounded to sub-rounded gravels were overlain by silty sand. WML 243 to the east shows thinner gravels overlain by similar silty sand which became finer at shallower depths. Electrical Conductivities show a similar pattern to that seen further north with salinity rapidly changing from 829 uS/cm at WML241 to 5570 uS/cm at WML243.

The saturated gravels encroach inside the proposed pit outline in this area, with drilling revealing that the upper surface of the Permian coal measures is well beneath the current level of Glennies Creek in this area. The creek banks in this area broaden in comparison to creek morphology seen in areas adjacent to northern end of the proposed SEOC. WML255 also supports the trend of rising basement levels correlating with the rise in topography which occurs at this site and elsewhere. No gravels were observed at this area, with silty sand overlying the Permian coal measures at this location suggesting that alluvium and colluvial sediments are intercalated.

Transects 8, 9, 11, 12 and 13

These north-south trending transects confirm the findings of the west-east transect descriptions provided above. They show that gravels become unsaturated to the north of the site and that alluvium/colluvium pinches out with the rising basement to the east. A comparison between transect 13 and the other transects shows the difference between the alluvial sediments and the colluvial/basement regolith to the east. Because transects 8, 9, 11, and 12 are located within either the intercalcated alluvium/colluvium of the upper terrace, or the colluvium above the Permian within the pit shell, saturated depth in the gravels is variable, and EC values are high (greater than 5000 μS/cm).

Transect 9 runs just to the west of the entire length of the western pit shell. This shows that there is a ridge of Permian sub-crop that runs almost to the creek near the Bowmans farmhouse, which effectively separates the alluvium to the north and south of this structure.

Transect 10

This transect shows that the rising Permian basement in the south western corner of the site results in a narrower band of alluvium next to the river. Gravels are therefore absent in WML 258 and the superficial alluvial/colluvial sediments are unsaturated at the edge of the pit shell.

Transect 14

Transect 14 shows that the river is much closer to the edge of the paleo floodplain in this area, so the west-east trend shows a rapidly rising basement and thinning out of gravel layers. The gravel is only just saturated (<30cm) and less than 1.5m thick in the eastern borehole next to the proposed pit shell (AP245).

4.6 HYDROGEOLOGY

4.6.1 AQUIFER SYSTEMS

The drilling results and interpretation of water levels and geology show that two main aquifer systems occur within the Ashton SEOC area:

- A hard rock aquifer system in the Permian coal measures. Because of the impermeable nature of the interburden sediments, groundwater flow within the hard rock is predominantly confined to the cleat fractures in the coal seams. This means the coal seams themselves form the main aquifer within the hard rock system; and
- A shallow porous media aquifer system in the unconsolidated sediments of the alluvium associated with Glennies Creek (and the Hunter River to the south), merging into colluvium and residual soil (extremely weathered coal measures).

Groundwater flow in the Permian rocks is dominated by fracture flow, particularly in the coal seams. The hydraulic conductivity (permeability) of the coal seams is generally low, usually one to two orders of magnitude lower than the alluvium, but higher seam permeabilities are found in some areas close to outcrop. The hydraulic conductivity of the coal seams declines rapidly with greater depth of cover.

The most important coal seams in the SEOC are the Liddell, Barrett, and Hebden Seams and associated splits. The upper levels of the Foybrook Formation are weathered in the SEOC area. Many of the seams outcrop within or adjacent to the SEOC pit limits.

Hydraulic testing of the coal seams indicated that horizontal hydraulic conductivities (Kh) in the order of 1 to 10 m/d may apply to parts of the Pikes Gully Seam within the weathered zone close to outcrop, whereas typical values for the seam in the unweathered zone are in the order of 0.01 to 0.05 m/d. The results of hydraulic testing of bores in the area between Glennies Creek and the underground mine have confirmed that the higher permeabilities of the outcrop zone persist to less than 100m from outcrop. It is expected that a similar pattern of relatively high Kh close to outcrop and much lower Kh away from outcrop will also be observed in the other coal seams targeted in the SEOC.

The unconsolidated alluvium/colluvium/regolith comprises clay-bound and silt-bound sands and gravels, with occasional lenses or coarser horizons where sands and gravels have been concentrated. The alluvium aquifer associated with Glennies Creek has been found to be generally poorly permeable, with hydraulic conductivity values less than 0.5 m/d. However, the basal coarse gravels are much more permeable, with tested Kh values ranging up to more than 100 m/d. The hydrogeology of the alluvium is complex and variable, and has been interpreted based on surface topography, borehole logs, hydraulic tests, and groundwater quality. It is more fully discussed in **Section 4.6.6**.

4.6.2 GROUNDWATER LEVELS AND FLOW REGIME

Groundwater level contours for the Glennies Creek alluvium / colluvium have been produced on the basis of groundwater levels measured in November 2008 (**Figure 4.3**). The contours show a gradient from east to west, towards Glennies Creek. Groundwater elevations range from around 53 mAHD at the up gradient end to around 50.5 mAHD within the Glennies Creek flood plain.

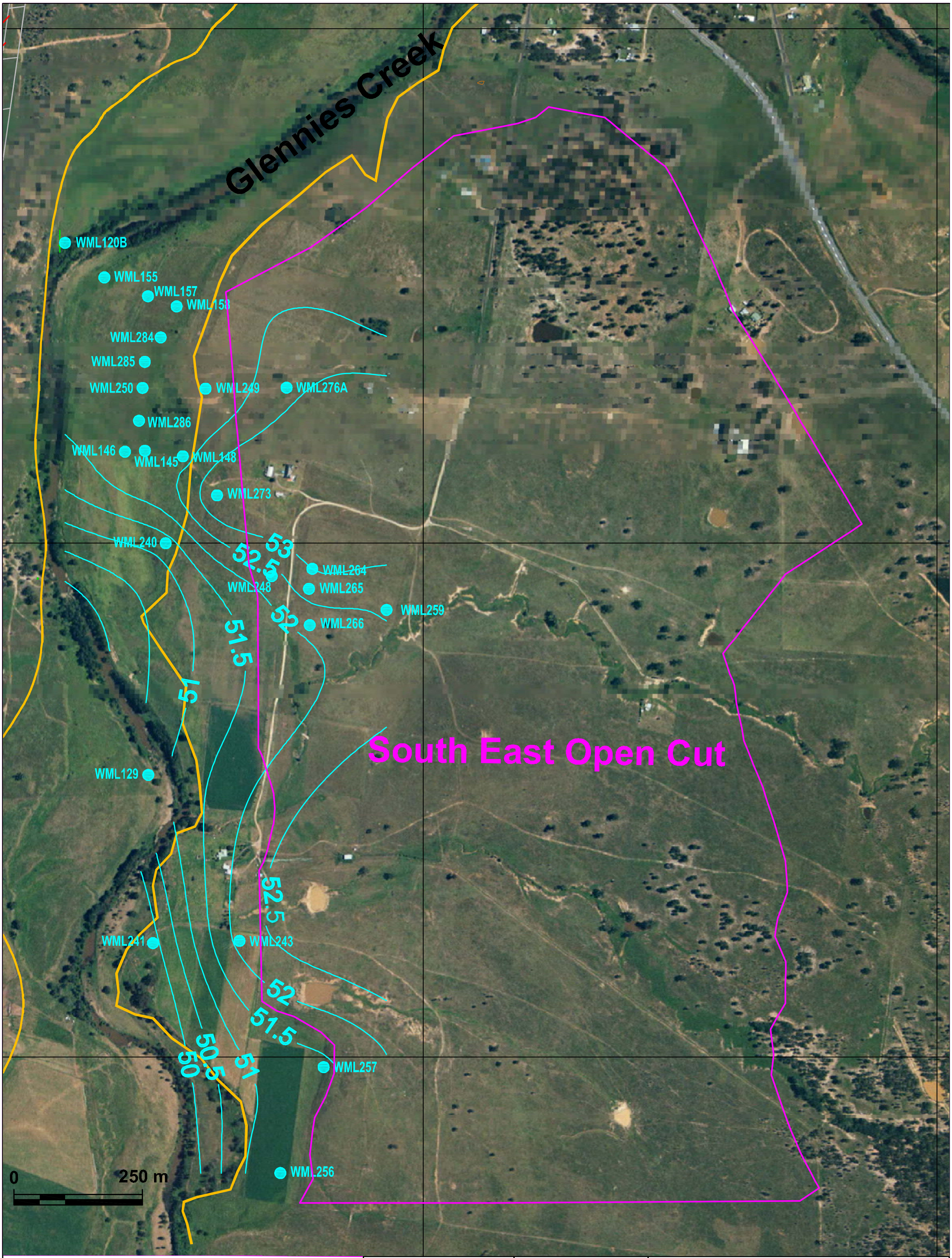
Groundwater levels in the upper part of the Permian coal measures tend to reflect the local topography, with higher groundwater levels in elevated areas and lower levels in the valleys. Groundwater levels within the alluvial sediments associated with Glennies Creek and the regolith also reflect local topography, with higher groundwater levels in elevated areas and lower levels within the floodplain. Groundwater flow direction follows the form of the topography, generally flowing towards Glennies Creek, although the gradients are relatively flat.

Groundwater levels at depth in the coal measures below the weathered zone are more regionally-controlled, and are independent of the local topography. Under current day conditions they are generally at or below those in the alluvium.

A potentiometric surface for the coal measures before the commencement of the Ashton mining operation was established by HLA for the EIS (HLA, 2001) on the basis of water levels measured in open holes drilled to the base of the Barrett Seam. This composite water level map of the coal measures indicated that in the study area groundwater flowed mainly to the southwest, believed to be under the influence of past or present nearby mining activity. Based on the earliest measurements of water levels in the baseline monitoring program, it appears that pre-mining groundwater levels in the coal measures would have been higher than water levels in the creeks and the associated alluvium. The multi-level vibrating wire piezometer bore WMLC144 located between the SEOC and Glennies Creek (**Figure 3.1**) had a water level about 6m higher than Glennies Creek (i.e. water level 58.5 mAHD compared with the creek water level of 52.5 mAHD) before it was grouted prior to installation. After installation of piezometers and grouting of the hole, the recorded pressures in the lower seams (Upper and Lower Barrett Seams) were initially higher than Glennies Creek, and also higher than alluvium groundwater levels, although they have subsequently fallen due to regional dewatering effects. The Permian water levels have been reduced as a result of dewatering impacts from the NEOC, and possibly other neighbouring mines. Total drawdowns of around 2m have been observed in most seams over the past year, but smaller drawdowns have occurred in the Upper Liddell and Upper Lower Liddell Seams over that time. The Pikes Gully Seam is absent from the SEOC area, so any influence from Ashton's underground mine is minimal.

The hydrostatic head profiles developed for WMLC144 and the newly installed piezometer WML245, located in the north of the SEOC pit boundary are shown on **Figure 4.4**. The plots represent a snapshot of recent groundwater pressures in relation to the elevation for each piezometer. Generally, under pre-mining conditions, in the Ashton area, pressures plot close to the 45° "hydrostatic line", although there is a slight shift from the line due to the upward head gradient. Slight deviations from the hydrostatic line seen in WML245 are due to the depressurisation effects from historical mining in the area.

Groundwater levels in the Permian coal measures may have been influenced to some extent by historical mining, but it is clear that prior to commencement of mining at Ashton, the groundwater levels in the Permian were higher than in both the alluvium and in the streams. The higher groundwater heads in the Permian meant that under natural conditions, groundwater discharged from the Permian to the alluvium and to the surface streams. This is still occurring in some places, and is reflected in occasional relatively higher salinities in the alluvium, and also in the surface flow at times of low rainfall and runoff.



Legend

- ● Glennnies Creek Exploration holes / Piezometers
- WaterTable Contour (mAHD)
- Edge of Terraces
- South Eastern Open Cut Outline

Date:	3 April 2009	Scale:	as shown
Initials:	JVDA	Job No:	S36
Drawing No:	S36-008b	Revision:	B

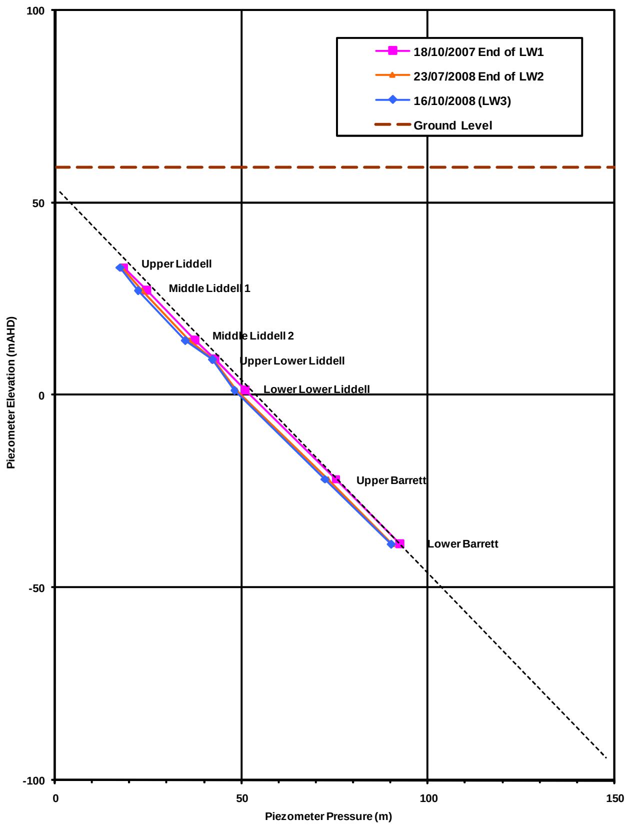
aquaterra

Ashton Coal Operations Ltd

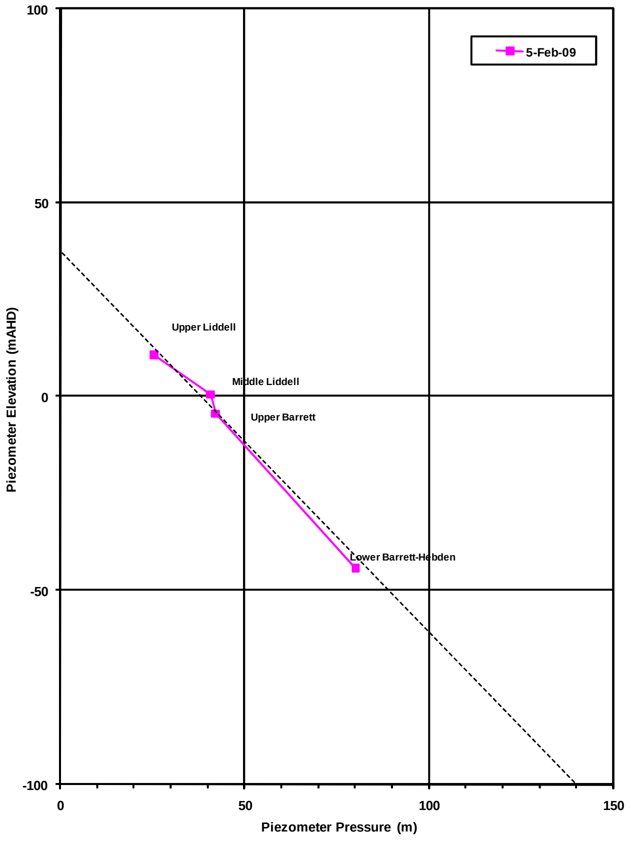
GLENNIES CREEK ALLUVIUM / COLLUVIUM
WATER TABLE CONTOURS
(November 2008)

Figure 4.3

Hydrostatic Head Profile - WML144



Hydrostatic Head Profile - WML245



Date: 18 March 2009	Scale: as indicated	**Ashton Coal Operations Ltd**
Initials: PZ	Job No: S36	**HYDROSTATIC HEAD PROFILES WML144 and WML245**
Drawing No: S36-017a	Rev: A	
aquaterra		**Figure 4.4**

4.6.3 RECHARGE AND DISCHARGE

Recharge to the aquifers occurs by the infiltration of rainfall and local runoff. It is likely that recharge to the colluvium / alluvium system occurs by rainfall infiltration on the higher colluvial slopes east of the creek, possibly augmented by local runoff within the tributary drainage channels which flow westwards towards Glennies Creek. Groundwater gradients indicate a groundwater flow direction following topography and slope to the west although the gradient is generally very flat.

The primary mode of recharge to the Permian coal seam aquifers is by direct recharge where the various seams outcrop or subcrop beneath the alluvium or regolith layer. It is considered that recharge via downward leakage through overburden and interburden layers subject to head differences is a very minor or negligible component of recharge due to the very low vertical permeability of the interburden layers. The alluvium and regolith aquifers are recharged by direct infiltration of rainfall and local runoff.

Table 4.1 shows that average monthly evaporation generally exceeds rainfall, indicating that a soil water balance deficit occurs most of the time and only a small percentage of the rainfall is available for runoff and/or recharge of groundwater.

Regional studies suggest approximately 0.5% to 1.0 % of the annual rainfall percolates to the coal measures groundwater system (HLA, 2001). Based on observation of responses to rainfall in the Ashton project area, we consider that recharge rates are likely to be highest in areas where the coal seams either outcrop or subcrop beneath alluvium or colluvium, and a recharge rate of 1.7% has been assigned to these areas in the modelling studies. Conversely, recharge rates into weathered coal measures is generally quite low, probably in the order of 0.2% of rainfall. This would result in overall coal measures recharge rates similar to those suggested by HLA (2001) in previous groundwater investigations within the immediate area.

4.6.4 GROUNDWATER QUALITY

Groundwater Salinity

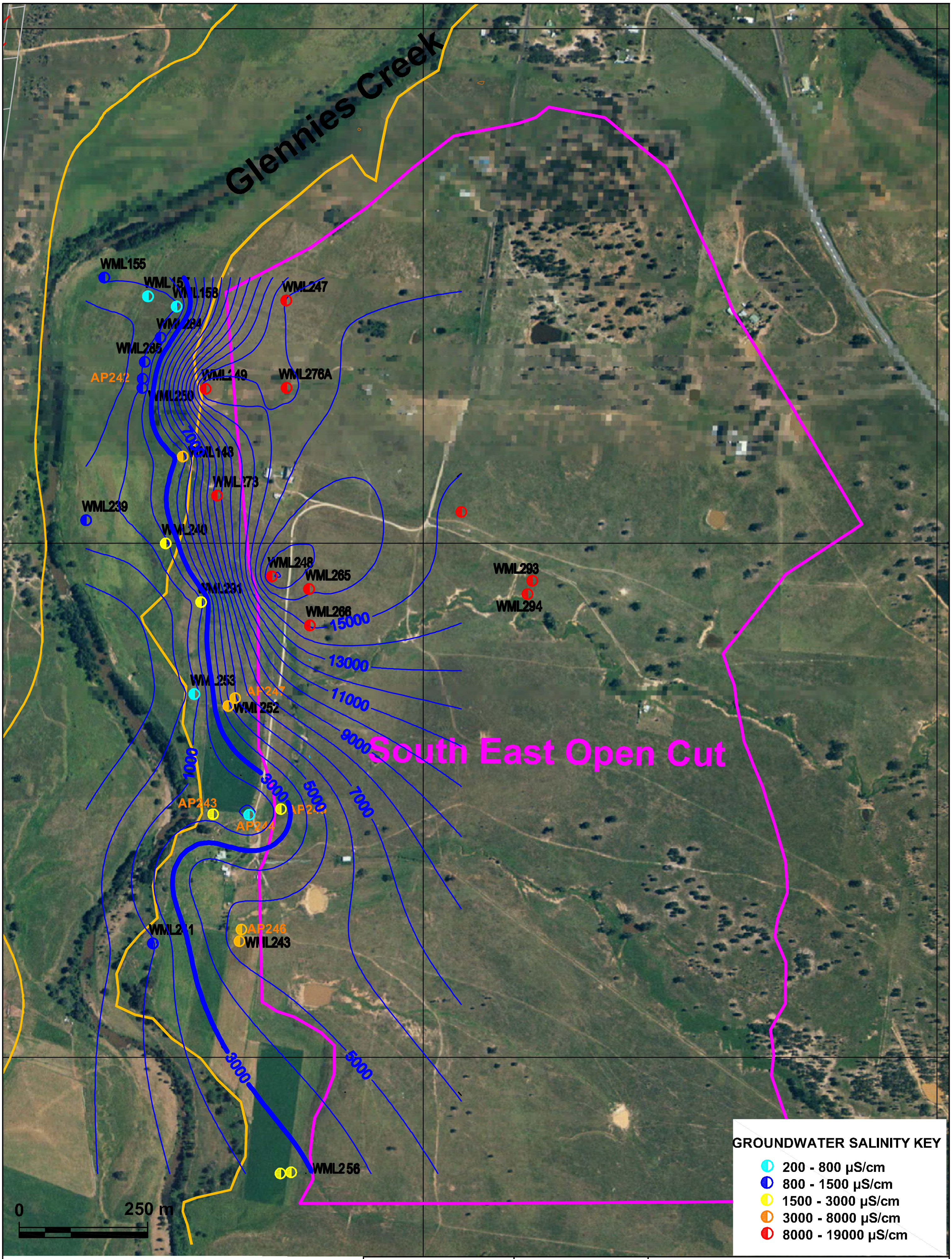
The spatial distribution of groundwater salinity (EC) collected from exploration drill holes and piezometers is shown on **Figure 4.5**. Salinity contours (EC) produced on the basis of this data are also presented and show an abruptly increasing EC trend (approximately +4000μS/cm/ 100m) with distance from Glennies Creek. This increase is believed to reflect the proximity to Glennies Creek as well as the transition from alluvium deposits (within the terrace) to the colluvial deposits on the eastern side of the terrace.

Salinity of the alluvial groundwater varies, but it is generally less saline than the coal measures. Within the flood plain/lower terrace, groundwater salinity is typically less than 1500 μS/cm EC. The low groundwater salinities here are slightly higher than the salinity range of Glennies Creek (230-903 μS/cm) and reflect the combined influence of recharge (from rainfall) and influx of more saline water from the underlying Permian and/or from the colluvium to the east.

Much higher salinities, ranging from 8,000 to 17,000 μS/cm EC, were recorded in exploration holes drilled further east from Glennies Creek. The high salinities encountered here are generally associated with colluvium and/or weathered Permian. There is a zone of transition between the alluvium and the colluvium that generally occurs around the terrace boundary described previously. This zone has higher salinity than the lower alluvium, which is considered to be due to a greater dominance of leakage from the more saline Permian groundwater, and minimal connectivity to Glennies Creek. These higher salinities tend to occur in the area where colluvium (or other silt/clay deposits) has become intercalated with the alluvial sands and gravels. This reduces hydraulic continuity with the creek and reduces the amount of rainfall recharge entering the superficial deposits.

A zone of low salinity (bores AP243-245) was encountered in drilling close to the northern side of the ridge of Permian outcrop that occurs in the area of Bowman’s farm house. The interpretation of this low salinity zone, and the implications it may have on hydrogeology of the alluvium are discussed in **Section 4.6.6**.

The groundwater in the coal measures aquifer system is saline. Typical salinities range up to more than 8,000 μS/cm EC (electrical conductivity), or more than 6,000 mg/L TDS (total dissolved solids).



Legend

- ● Glennies Creek Piezometers / Exploration holes
- Groundwater Salinity Contour (EC µS/cm)
- Edge of Terraces
- South Eastern Open Cut Outline

Date:	1 July 2009	Scale:	as shown
Initials:	PZ	Job No:	S36
Drawing No:	S36-009c	Revision:	c

aquaterra

Ashton Coal Operations Ltd

ASHTON COAL MINE
GLENNIES CREEK ALLUVIUM / COLLUVIUM
GROUNDWATER SALINTY CONTOURS
(Electrical Conductivity µS/cm)

Figure 4.5

Major Ion Chemistry

The major ion chemistry can assist with comparing natural waters to identify whether they are derived from the same or different sources, or mixtures of sources. The Piper Trilinear Diagram and ratio plots of major ions are useful for this purpose, as they enable each groundwater sample to be graphically plotted at a unique point on the basis of the relative concentrations of the major ions typically found in solution – ie the cations calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K); and the anions chloride (Cl), carbonate (CO_3), bicarbonate (HCO_3) and sulphate (SO_4).

A Piper trilinear plot of the groundwater samples from the Glennies Creek floodplain, together with one sample from Glennies Creek surface flow is shown in **Figure 4.6** and supporting ratio plots are presented in **Appendix D**.

The Piper trilinear plot shows all groundwater samples from bores located within the general vicinity of the Glennies Creek floodplain. They include samples of groundwater from the alluvium, colluvium and deeper coal measures (Pikes Gully Seam), with each source identified by a different colour.

In general, natural waters that are close to recharge sources (or intake areas) have calcium and bicarbonate as the dominant ions in solution, and these waters plot in the left or central parts of the diamond field on the Piper Trilinear Diagram. Waters that are not from an active recharge environment or remote from a recharge source tend to have sodium and chloride as the dominant ions, and these waters plot on the right side of the diamond field. Hence the higher salinity samples, sourced from drill holes further up gradient from Glennies Creek (i.e WML246, WML247 and WML248 located inside the proposed SEOC pit), tend to plot near the right hand side of the diamond field on **Figure 4.6**. The November 2008 low salinity Glennies Creek surface flow sample plots near the centre of the diamond field, along with a number of low salinity alluvium groundwater samples taken from the flood plain area, close to recent recharge rainfall.

The cluster of the colluvium and deep coal measures groundwaters near the right hand side of the Piper Diagram on **Figure 4.6** suggests a lower dominance of rainfall recharge and closer association with 'older' waters within the Permian.

A combination of ionic weight ratios of groundwater (HCO_3/Cl^- v Cl^-, Cl^-/Na, Ca/Cl and Mg/Cl) were also used to determine whether groundwaters sourced from the alluvium and flanking colluvium are derived from the same or different sources, or mixtures of sources. Overall, groundwaters tend to plot along a mixing line between two end members which represent i) fresher, recently recharged groundwaters within the alluvium terrace and ii) older, more saline groundwaters (remote from recharge) further up gradient (from piezometers inside the SEOC pit wall). Interpretations of the individual plots are provided below, but they generally support the conclusion that alluvial waters to the west tend to contain a greater proportion of more recent, recharge sourced groundwater (either due to connection with the creek or higher rainfall recharge rates).

Ratio plots are presented in **Appendix D** and the interpretation of each plot is summarised below:

- The plot of HCO_3/Cl^- v Cl^- shows a general trend of reducing HCO_3/Cl ratios with an increase in both Cl^- and distance from Glennies Creek. Alluvium boreholes located within the flood plain exhibit high HCO_3/Cl^- ratios (dominance of HCO_3), which is a reflection of fresh water recharge. Colluvial boreholes located further to the east have lower HCO_3/Cl^- ratios (dominance of Cl^-) and therefore represent older groundwaters, which are not readily recharged and/or are remote from recharge zones.
- The molar weight ratios of Cl^-/Na illustrate a strong correlation between Cl^- and Na, with the two end members being identified as: i) groundwater close to Glennies Creek (within the flood plain alluvium) and ii) groundwater from colluvium up gradient. All samples plot along a mixing line, with lower molar ratios (<1) corresponding to fresher groundwater associated with Glennies Creek flood plain (mixing with recent recharge), and higher molar ratios (>1) representing more saline, older groundwater up gradient.

- Ratios of Ca/Cl and Mg/Cl both exhibited a good negative correlation with salinity (Cl). They increase as Ca/Cl and Mg/Cl decreased, which is derived from Cl freshening (via recently recharged groundwater) in close proximity to Glennies Creek.

pH

pH for all samples was near neutral or slightly alkaline, indicating a lack of acid forming conditions in the area. There is some correlation between higher pH and higher salinity within the alluvial samples, but this is relatively weak. pH in groundwater from Permian strata, including coal seams, shows a fairly wide variation and no discernable relationship between pH and salinity.

Dissolved Metals

Comparison of the analysis results for dissolved metals against the ANZECC guideline values for Freshwater Ecosystem Protection (ANZECC, 2000) shows a number of exceedences of the guideline values (**Appendix E**) as follows:

- The guideline value for **cadmium** (0.0002 mg/L) is exceeded at alluvium bore WML252.
- The **copper** guideline value (0.0014 mg/L) is exceeded at alluvium bore WML248.
- The **zinc** guideline value (0.008 mg/L) was exceeded in alluvium bores WML248, WML249, and WML250.

4.6.5 HYDRAULIC PARAMETERS

The hydraulic conductivity values determined from the hydraulic testing program are summarised in **Table 4.2** below. Average K values are presented for each investigation hole on **Figure 4.7**, overlain on aerial photography.

Table 4.2: Summary of Hydraulic Conductivity Values from Hydraulic Testing

Aquifer	Hydraulic conductivity (m/d)			Number of Piezometers tested
	min	max	mean	
Pikes Gully Seam	0.04	7	3.54	2
Alluvium	0.04	80*	4.3*	14
Colluvium	0.007	0.025	0.02	3

**Note – 2007 & 2008 data only, see comments below*

Glennies Creek Alluvium

Hydraulic testing of Glennies Creek Alluvium during 2007 and 2008 revealed a high variability in hydraulic conductivity, with values in the range of 0.1 to 80m/d, and a mean value of 4.3 m/d. However, very high values were found to be very localised and unrepresentative of the alluvium as a whole, and the geometric mean was found to be much lower, at only 0.6m/d. The values at the higher end of the range are believed to be reflecting the presence of localized lenses of cleaner coarse gravels, while the very low values are typical of the clay-silt matrix which encloses the gravels over most of the floodplain area. Further investigations into the nature of the high permeability zones were carried out in 2009, as discussed in **Section 4.6.6**.

Colluvium

Three tests conducted on colluvium piezometers indicated much lower hydraulic conductivity values (0.007m/d to 0.025m/d).

Permian Coal Measures

The coal measures strata have little primary or intergranular permeability, but joints and fissures result in secondary or fracture permeability. Generally, the coal seams are more brittle and more densely fractured than the interburden strata and therefore have a relatively higher hydraulic conductivity, typically one to two orders of magnitude higher than the interburden material. Within the coal seams, the groundwater flows predominantly through cleat fractures, with very little evidence of structure-related fracturing. Vertical permeability is significantly lower than horizontal (typically 3 or more orders of magnitude lower).

No hydraulic testing of Permian coal measures has occurred in the proposed footprint of the SEOC, however, hydraulic testing of the Permian measures undertaken as part of previous investigations in the area indicated the following:

- The upper, weathered parts of the Permian coal measures (generally free of coal seams), within the underground SMP area, showed hydraulic conductivities in the range 0.01 to 3.3 m/d with a median value of 0.1 m/d (Aquaterra, 2008b). In most cases the tested section was within the weathered zone, which has properties more akin to alluvium or colluvium than fractured rock.
- Packer testing over seventeen intervals within the Permian coal measures in borehole WMLC213 located southwest of the underground mine area showed that most permeability results were in the order of 10^{-4}m/d. Some test results in the depth range 50m to 100m, where there was very little fracturing, indicated permeabilities less than 10^{-6}m/d. Some permeabilities in the shallow, upper sections of the Permian were in the order of 10^{-3} to 10^{-2}m/d (SCT, 2008b).
- Several hydraulic tests indicated that the hydraulic conductivity of the Pikes Gully seam, which subcrops to the west of the Proposed SEOC, ,is consistently around 0.02-0.05 m/d, except in the upper weathered zone near outcrop/subcrop, where higher values of hydraulic conductivity were measured (up to 7m/d). Similar hydraulic conductivities would apply to other coal seams in the sequence although hydraulic conductivity is typically lower with increasing depth of cover.

Vertical hydraulic conductivities are considered to be 2-3 or more orders of magnitude lower than the horizontal hydraulic conductivity for all units, based on the very strongly bedded nature of all units and the role of bedding plane features in controlling groundwater flow. This applies both to the coal seams (which are broken up by interbeds of siltstone/sandstone/claystone) and especially to the interburden sediments which comprise interbedded siltstones, sandstones, claystones and shale.

4.6.6 HYDROGEOLOGY AND HYDRAULIC CONNECTIVITY OF ALLUVIAL DEPOSITS

The lateral, saturated extent of the Glennies Creek alluvium has been determined from a combination of aerial photography, ground mapping, the results of exploration drilling, groundwater levels and groundwater salinity. The alluvium merges with colluvium along the flanks of the floodplain. Generally speaking the permeable layers are associated with sands and gravels at the base of the sequence, which grade to low permeability silts and clays nearer the surface. Within the basal alluvium there is a general transition from higher permeability, lower EC sands and gravels that are hydraulically connected to Glennies Creek, to silt- and clay-bound alluvial gravels that may be intercalated with colluvium closer to the pit shell.

Contours of the base of gravels are plotted on **Figure 4.8**. These contours are based on the results of exploration drilling. The contours show a region of elevated gravels (>52mAHD) along the north western margin of the SEOC pit wall. The base of the alluvium reduces in a southward direction (towards W. Bowman's homestead, 48mAHD), and westward direction (towards Glennies Creek, 50mAHD).

The limits of saturated alluvium are shown on cross sections 1-12 (**Appendix B**). Plots showing the saturated thickness of alluvium for each exploration hole are shown on **Figure 4.9**. These are based on the groundwater levels collected during November-December 2008 and the base of alluvium as depicted on **Figure 4.8**.

Saturated Extent of Alluvium in the North of SEOC

In the northern area and the northern part of the alluvium to the west of the pit shell, extensive areas of the alluvium are dry to the full depth, where the upper surface of the underlying Permian rises above the water table in the north of the proposed SEOC. This means that the terraces and the groundwater contained in the alluvium adjacent to the pit are not in direct hydraulic connection with Glennies Creek and its associated alluvium.

Characterisation of the Alluvium to the West of the Pit Shell

Along the western and southern portion of the SEOC, the basement elevation decreases and saturated thickness increases to a maximum of 6m (**Figure 4.9**). Borehole samples indicated that there is significant intercalating of alluvium and colluvial sediments in this area, which makes it hard to delineate the boundary of alluvial gravels associated with Glennies Creek based simply on the drill cuttings. The potential for inflow from the alluvium is significantly reduced by the presence of silt and clays, so demarcation of the boundary between the higher permeability alluvium that is connected to Glennies Creek was necessary in this area.

Because of the uncertainties in the interpretation of lithology, groundwater chemistry indicators have been used to help identify this boundary. The chemical analyses described previously indicate that there is a general relationship between EC and the occurrence of lower permeabilities and limited connectivity associated with the colluvium. While the alluvium and colluvium are both recharged primarily by infiltration of rainfall, the highly connected alluvium drains readily to Glennies Creek, whereas the poorly connected alluvium and colluvium does not, leading to the higher groundwater salinities.

Figure 4.5 shows the transition in groundwater salinity from the higher salinities associated with colluvium in the east to the lower salinities associated with the alluvium within the floodplain (and lower terrace in the north western area). It can be seen that the EC contours generally provide a good indication of the transition from higher permeabilities associated with the lower terrace, to lower permeabilities associated with the higher terrace and colluvium.

Geochemical signatures also help to identify the origins of groundwater and further differences can be seen between the alluvial and colluvial groundwaters when ionic ratios are compared. The Piper Trilinear diagram described in **Section 4.6.4** demonstrates the transition from colluvium to alluvium, with water changing from a sodium chloride type to a calcium bicarbonate type.

The fact that these EC and chemical differences exist indicates that there is poor horizontal mixing of groundwater between the alluvium and colluvium, confirming that there is a lack of hydraulic continuity between the two aquifer bodies.

Hydraulic tests showed that there were a number of localised, high permeability areas within the alluvium. These higher permeability areas, as shown in **Figure 4.10**, coincide with the points where surface drainages from the east reach the edge of the alluvium. Surface topography in relation to the higher permeability zones is sown in **Figure 4.11.** These high permeability zones do not extend inside the proposed SEOC pit shell.

These permeable zones reflect historic relationships between the topography/drainage of the Permian outcrop and the depositional environment of Glennies Creek. They are not simply associated with current surface drainage across the alluvium (which mainly occurs over a layer of surface clay).

Based on borehole logs, topographical interpretation and hydraulic testing, it appears that the areas of higher permeability within the alluvium have been caused by number of factors:

- Structural features within the Permian. These control topographical features and hence the direction of historical surface flows, as described below. They will also have affected weathering patterns and hydrogeology within the Permian, regolith and alluvium.
- The geomorphological effects of paleo- surface drainage during the period when the gravels were being laid down.
- ‘Washing out’ of the lower terrace gravels by Glennies Creek, both during the period of deposition, and subsequent geomorphological activity.
- More recent weathering effects caused by surface drainage since the gravels were laid down.

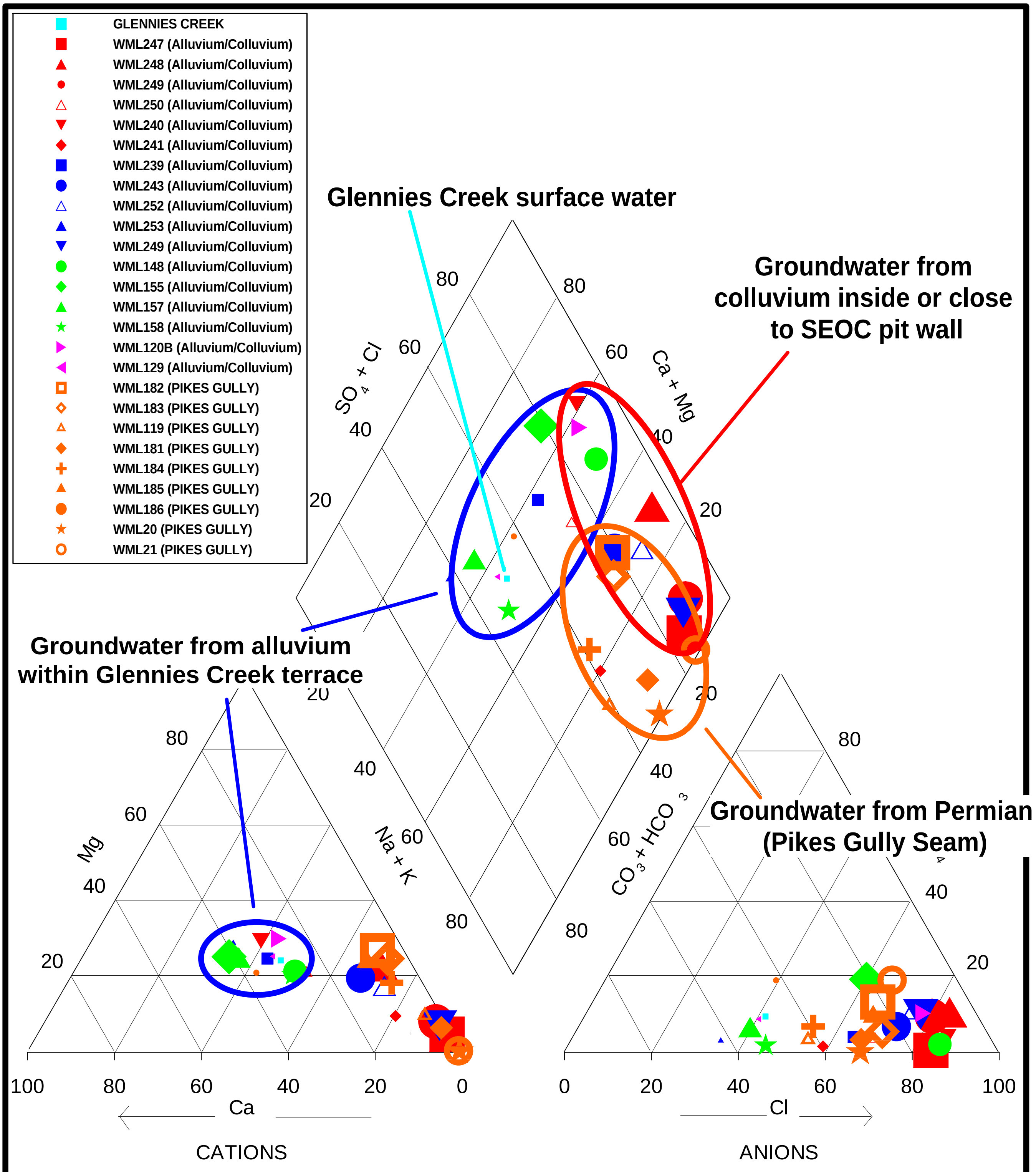
Based on these controls, there may be a fourth area of higher hydraulic conductivity, as indicated in **Figure 4.10**. This was not tested due to limited access, but logically there may be a risk of a high permeability zone in that area.

Field observations and the topography in **Figure 4.11**, indicate that there is a notable Permian outcrop beneath the Bowman's farm just to the south of the centre line of the western pit shell. This forms a ridge of bedrock that extends out to the Creek, and influences east-west surface water drainage in that area. There is a localised area of low EC just to the north of this outcrop (boreholes AP243 – 245), which is associated with the current ephemeral stream where it crosses onto the lower terrace. This is the only area on the site where a current drainage channel that crosses the alluvium is likely to have been in place for some time, largely due to the presence of the Permian outcrop. Visual inspection has shown that there are large 'holes' and deep erosion within the surface alluvial clays in this area. This weathering allows surface runoff and recharge to penetrate through the overlying clays and into the underlying sands and gravels, causing the low EC values that have been recorded near the drainage channel. These low EC values are not necessarily associated with high permeability, as borehole AP244 has an EC of only 600µS/cm, but a permeability of only 0.4m/d.

There is also an area of enhanced permeability that is associated with surface drainage running along the southern side of the Permian outcrop. However, this is very localised, and permeability varies significantly between boreholes that are located less than 50m apart in this area. EC values are unusually high (>5,000µS/cm EC) for the permeable alluvium, and increased steadily during testing. Pump tests showed a steadily declining transmissivity during the test, which also indicates there is a limited extent to the permeable zone. This indicates that, whilst there are some permeable gravels in this area, they are limited in extent and tend to drain groundwater from the surrounding colluvium and Permian strata. These gravels are not therefore well connected with Glennies Creek or its alluvium.

Based on the above assessment, it is considered that the EC contours represents the best method for defining the boundary between the alluvium that is directly hydraulically connected to Glennies Creek, and the poorly connected, clay- and silt-bound alluvium to the east. Overall it is considered that the 3,000µS/cm EC contour provides the best representation of this boundary. This value was chosen as it represents the inflection point in the salinity gradient between the unconnected alluvium/colluvium to the east, and the Glennies Creek alluvium to the west. The only exception to this is in the area just to the north of the Permian outcrop at Mrs Bowman's house, where there is localised occurrence of low groundwater salinity in poorly permeable unconnected alluvium/colluvium (bore AP244). The edge of the connected alluvium in this area is considered to be to the west of borehole AP244, which is around 100m outside the proposed pit shell.

The boundary of the hydraulically connected alluvium has been used within the groundwater model described in Section 6. Hydraulic properties within the alluvium have been modified to allow for the higher permeability zones described above, which have been included as specific areas in the predictive model.



Glennies Creek surface water

Groundwater from colluvium inside or close to SEOC pit wall

Groundwater from alluvium within Glennies Creek terrace

Groundwater from Permian (Pikes Gully Seam)

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CLIENT
Ashton Coal Operations Ltd

DRAWN **JV/SRD**
DATE **30 March 2009**

CHECKED
DATE

SCALE **As Shown**
S36-010a
A4

PROJECT
ASHTON COAL PROJECT

TITLE
PIPER TRILINEAR DIAGRAM
ASHTON BORES

PROJECT No **S36**
Figure 4.6

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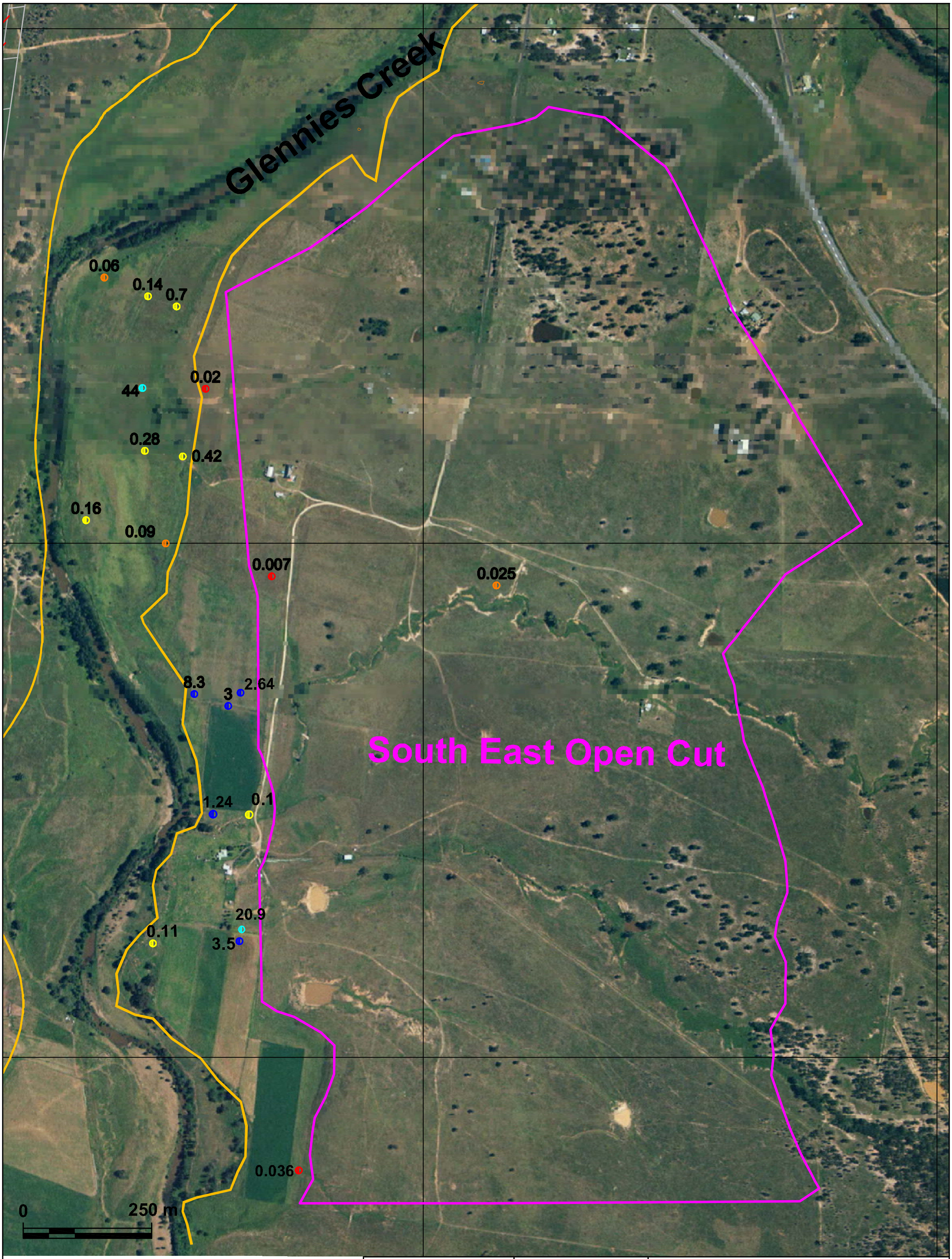

Legend

◐ Glennies Creek Piezometers / Drill holes

Edge of Terraces

South Eastern Open Cut Outline

Hydraulic Conductivity (m/d)

- ◐ > 10
- ◐ 1 - 10
- ◐ 0.1 - 1
- ◐ 0.01 - 0.1
- ◐ 0.001 - 0.01

Date: 1 July 2009
Scale: as shown
Initials: PZ
Job No: S36
Drawing No: S36-011a
Revision: A

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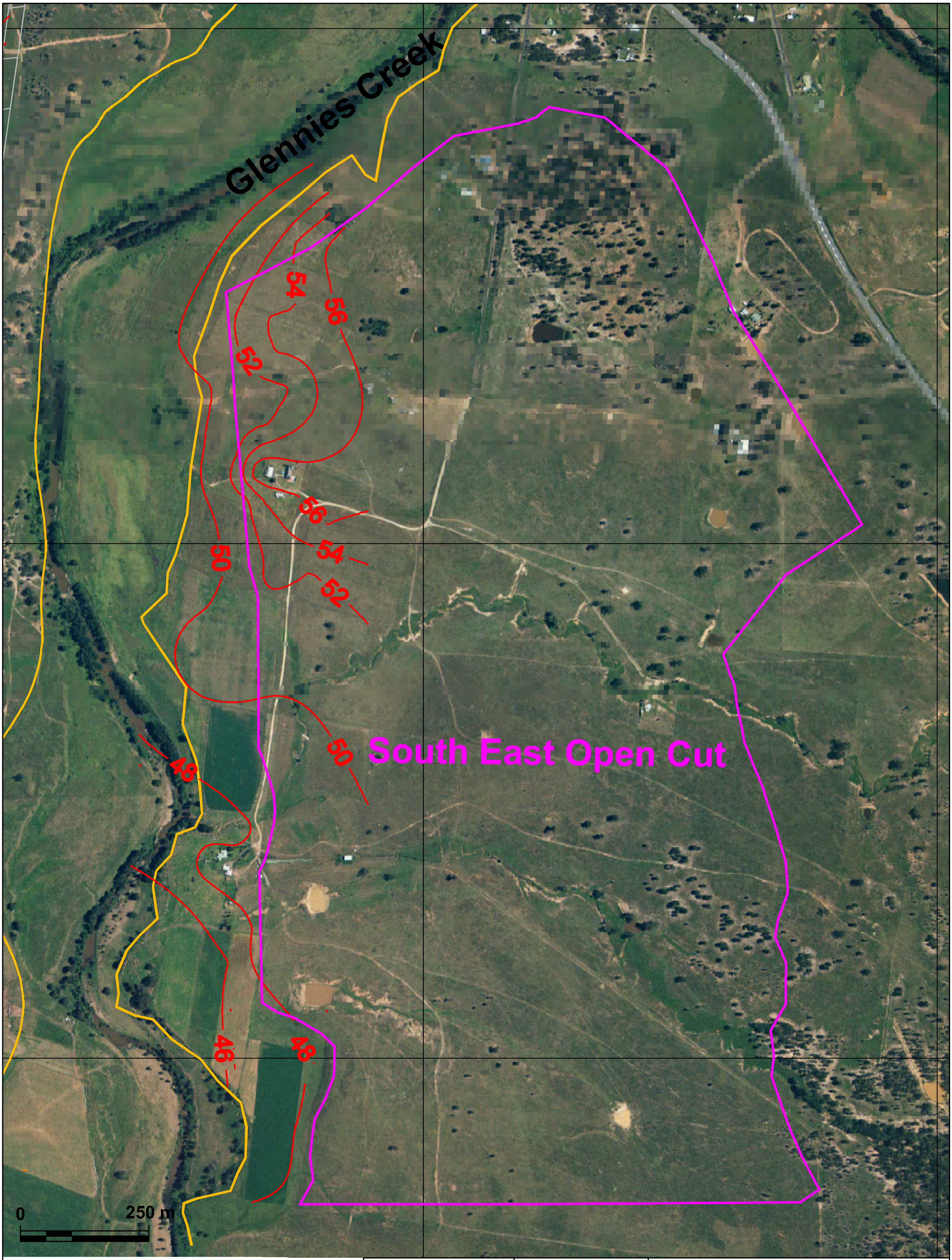
ASHTON COAL MINE
GLENNIES CREEK ALLUVIUM / COLLUVIUM
AVERAGE HYDRAULIC CONDUCTIVITY (m/d)

Figure 4.7



Legend

Edge of Terraces
South Eastern Open Cut Outline
Contour - Base of Gravels (mAHD)

Date: 11 May 2009
Scale: as shown
Initials: JVDA
Job No: S36
Drawing No: S36-012e
Revision: C

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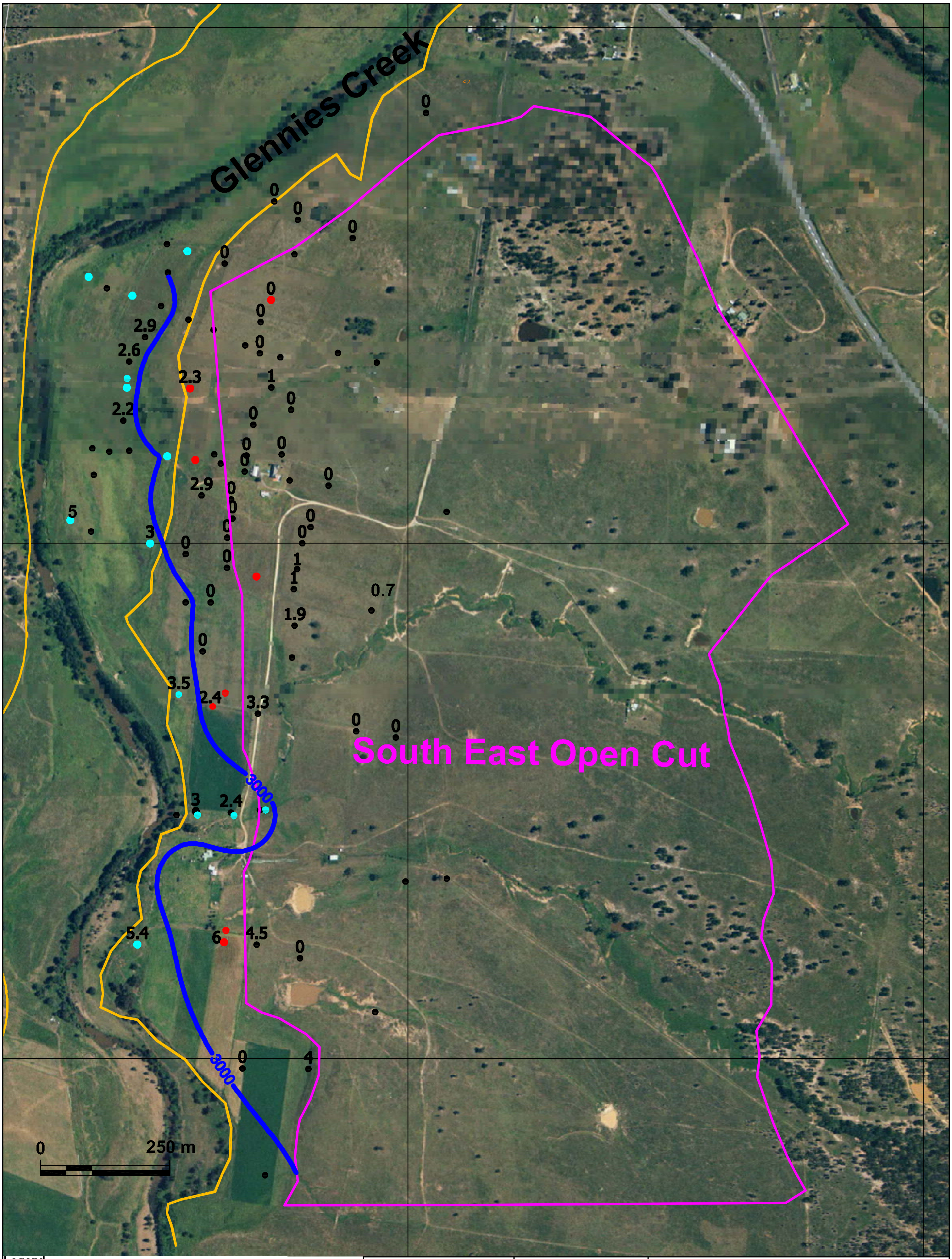
CONTOURS OF BASE OF ALLUVIUM / COLLUVIUM
(mAHD)

Figure 4.8



Legend

2 ● . Saturated thickness of Alluvial/Colluvial (m)

3000uS/cm EC contour line

● Groundwater Dominant in Na & Cl ● Groundwater dominant in HCO_3 & Ca

Edge of Terraces

South Eastern Open Cut Outline

Date:	27 May 2009	Scale:	as shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**GLENNIES CREEK ALLUVIUM / COLLUVIUM SATURATED THICKNESS & CHEMISTRY**
Drawing No:	S36-013d	Revision:	D	

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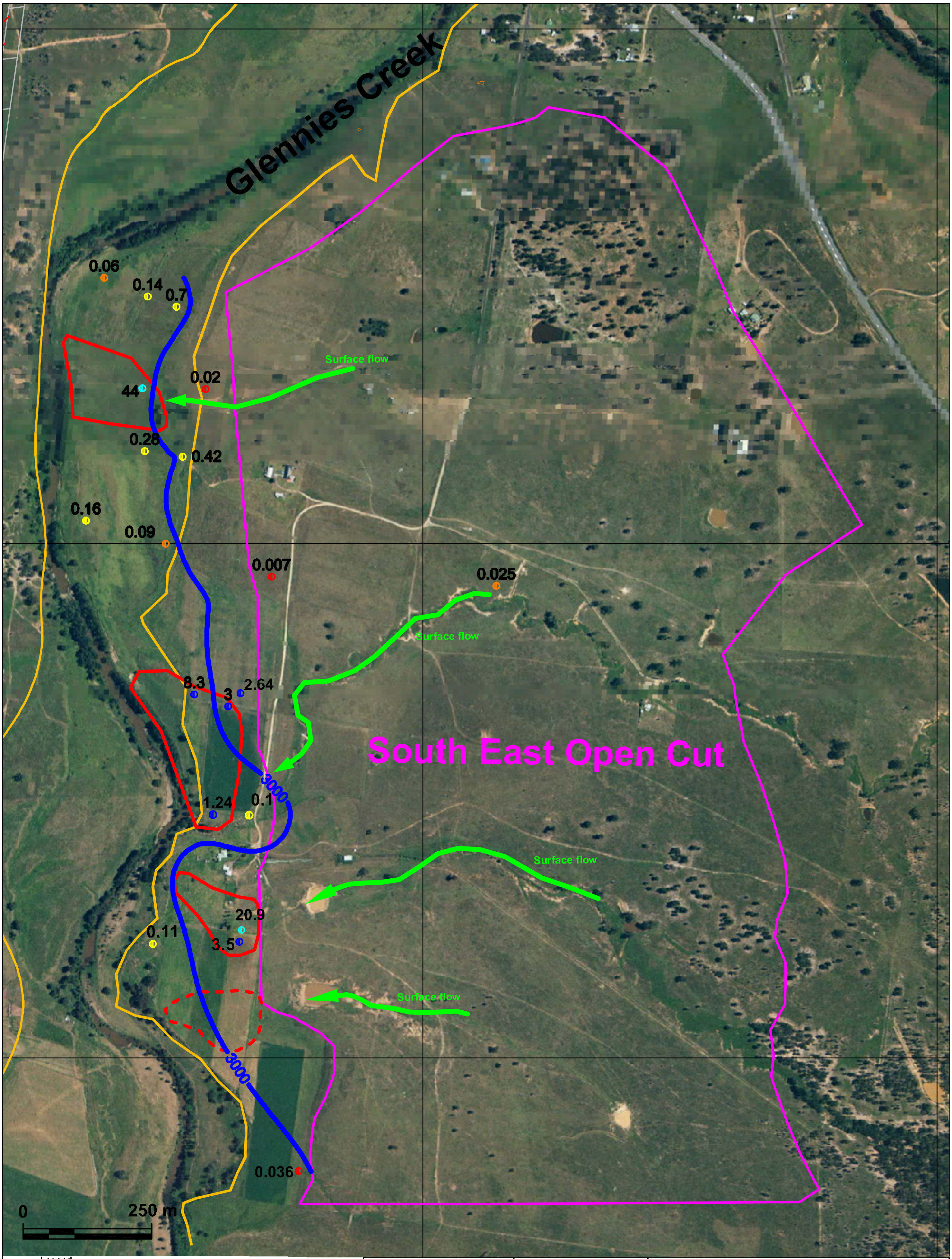
Figure 4.9



Legend

- Inferred Areas of High Permeability
- Areas of High Permeability
- Groundwater 3000µS/cm EC Contour
- Edge of Terraces
- South Eastern Open Cut Outline
- Surface Flow Across Permian

Hydraulic Conductivity (m/d)

- > 10
- 1 - 10
- 0.1 - 1
- 0.01 - 0.1
- 0.001 - 0.01

Date:	1 July 2009	Scale:	as shown
Initials:	PZ	Job No:	S36
Drawing No:	S36-011d	Revision:	D

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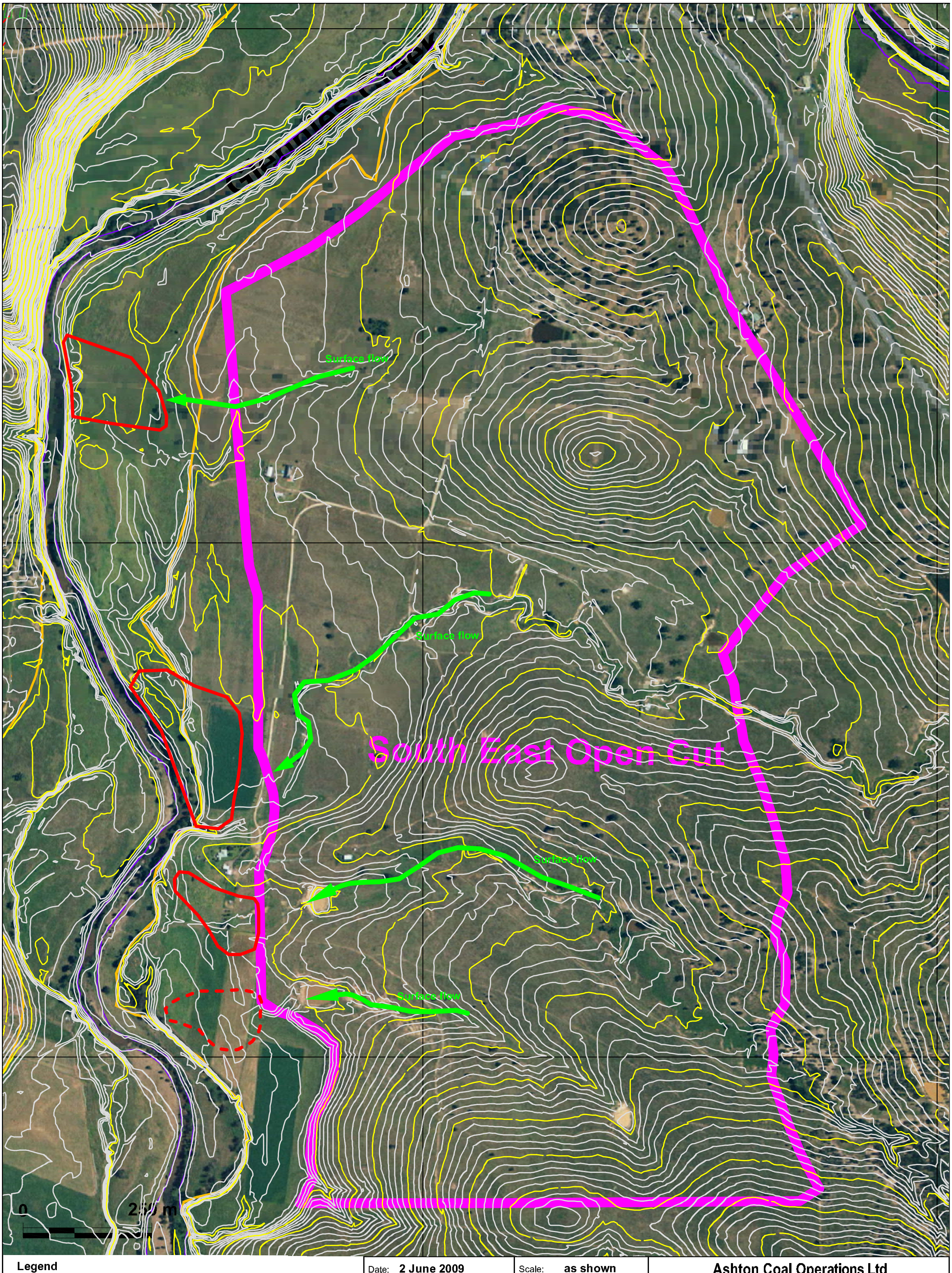
ASHTON COAL MINE

Location of Piezometer and Zones of High Permeability

Figure 4.10



Legend

- Areas of High Permeability
- Edge of Terraces
- South Eastern Open Cut Outline
- Surface Flow Across Permian

Date: 2 June 2009	Scale: as shown	**Ashton Coal Operations Ltd**
Initials: PZ	Job No: S36	**ASHTON COAL MINE** **Surface Topography and Drainage from Permian Sub-crop Areas**
Drawing No: S36-011b	Revision: 0	
aquaterra		**Figure 4.11**

5 MINING PROPOSAL

5.1 MINE PIT

The most important seams to be mined in the SEOC are the Liddell, Barrett, and Hebden Seams and associated splits, with the upper levels of the Foybrook Formation weathered in the SEOC area, many of the seams crop within or adjacent to the SEOC pit limits.

The proposed pit shell will cover an area of approximately 194ha, and extraction will be carried out to the base of the Lower Hebden seam. Because of the location on the western limb of the Camberwell Anticline, the depth of extraction therefore varies from around 20m in the north eastern corner of the pit, to around 110m in the south western corner.

The mine will be backfilled with waste overburden as the extraction proceeds and the height of the backfill will generally be at, or slightly above, the pre-existing topography.

5.2 MINING SCHEDULE

Production from SEOC will start at the end of 2009 or early 2010. It will reach a maximum production of approximately 3.6Mtpa ROM coal and run for approximately 6 years at full extraction rates.

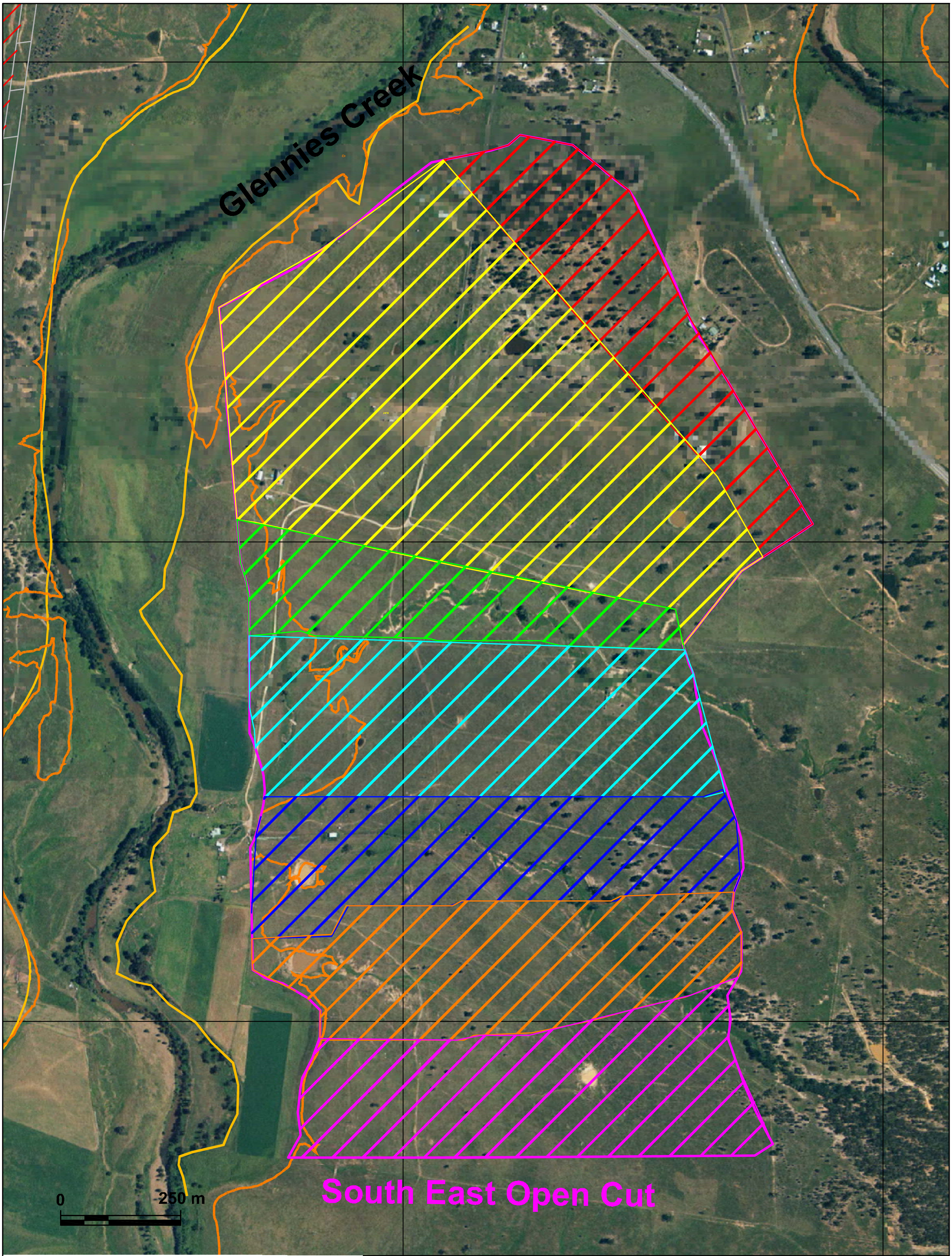
Mining in the SEOC will commence in the north and progress to the south. The mining schedule (for the period 2010-2016) for the SEOC plan is shown on **Figure 5.1**. Mining is limited to the Lower Barrett Seam in Year 1 after which time, progressive mining down to the Hebden Seams will occur after Year 2.

The final void of the SEOC will be located in the southern corner of the open cut. The location of this void allows potential for continued open cut mining of coal reserves to the south.

5.3 MINE WATER MANAGEMENT

Groundwater entering the mine will be collected and pumped to the mine water management system. The design and operation of that system is outside of the scope of the report, but anticipated pit inflows are outlined in Section 6.7.2 and Section 7.

It is not anticipated that dewatering outside of the pit shell will be required for this project.



Legend

Glennies Creek Flood Extent (Worley Parsons, pers comm)

South Eastern Open Cut Outline

Edge of Terraces

Mine Plan - Year: 2010 ▨ 2011 ▨ 2012 ▨ 2013 ▨ 2014 ▨ 2015 ▨ 2016 ▨

Date: 29 May 2009	Scale: as shown	Ashton Coal Operations Ltd
Initials: PZ	Job No: S36	ASHTON SEOC MINE PLAN 2010 - 2016
Drawing No: S36 - 007b	Revision: B	

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Figure 5.1

6 GROUNDWATER MODELLING- ASSESSMENT OF GROUNDWATER IMPACTS

6.1 BACKGROUND

6.1.1 MODELLING SOFTWARE AND SET-UP

Model Selection

The MODFLOW numerical groundwater flow modelling package has been used for this study with the SURFACT module (SURFACT Version 3, HydroGeoLogic, Inc., 2006), operating under the Groundwater Vistas Version 5 graphic interface software package (Environmental Simulations, Inc., 2005).

The MODFLOW package has industry-leading modules for simulating surface water and groundwater interaction which enable assessment of impacts on creeks and rivers. The SURFACT module enables simulation of saturated/unsaturated flow conditions and provides for more stable drying and re-wetting of cells in thin model layers (such as coal seams).

The hydrogeological investigations (including modelling) were undertaken with reference to the 'Guidelines for Management of Stream/Aquifer Systems in Coal Mining Developments – Hunter Region' (DIPNR, 2005), with the model developed in accordance with the best practice guideline on groundwater flow modelling (MDBC, 2001). The degree of model complexity required to accomplish the study objectives is a medium complexity model (MDBC, 2001).

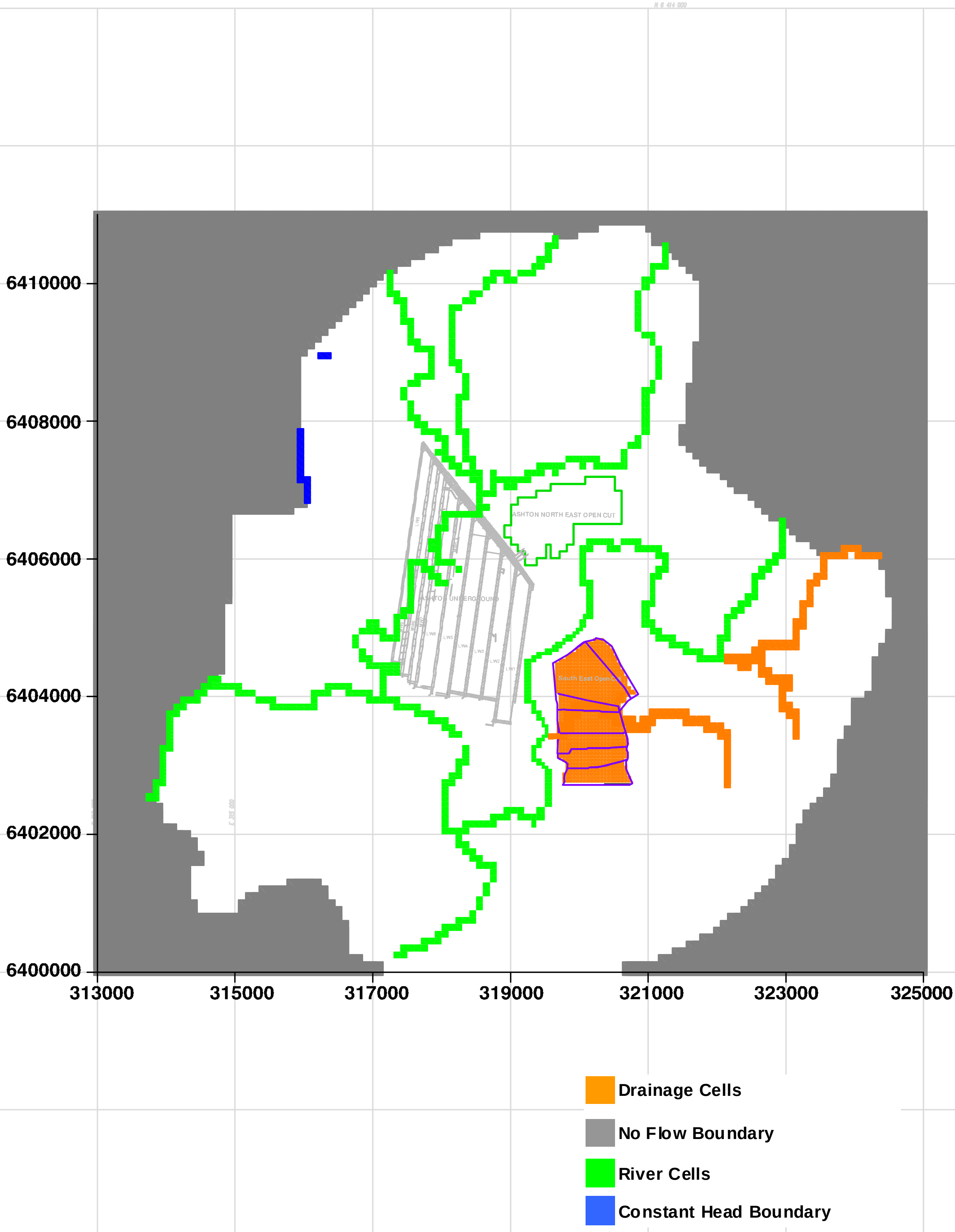
Groundwater Model Origin

The groundwater model utilised for this project is based on the model constructed for assessment of impacts from Ashton underground mine to the west of Glennies Creek (Aquaterra, 2008). Several modifications have been made to the model structure and parameters to improve the representation of the groundwater and geological environment for the SEOC Project Site. The changes involved extension of the model domain to the south east to provide a boundary which is not impacted by SEOC operations, and also redefining of the structure and parameters for the Glennies Creek alluvium.

6.1.2 MODEL DESIGN AND CONCEPTUAL HYDROGEOLOGY

The groundwater model that was used for this study is largely based on the model that was created by Aquaterra (2008) for the Ashton underground mine. A full model description, including calibration results, is presented in the report for that mine.

The model domain and boundary conditions for the extended SEOC model are graphically presented in **Figure 6.1.** Relevant notes on conceptual model features and changes to the model structure are given in the following sections.



Date: 13 May 2009

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Job No: S36

Drawing No: S36-001b

Rev: B

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Groundwater Model Domain
Layer 1

Figure 6.1

6.2 MODEL EXTENTS

The domain and boundaries of the model are shown in **Figure 6.1**.

The SEOC (South East Open Cut) model closely follows the model from the previous study undertaken for underground mining of the Pikes Gully Seam (Aquaterra 2008c), but with a number of modifications to suit the needs of the SEOC project as detailed in the following sections. The principal changes were the introduction of additional layers and changes to the model cell size and amount. Where new information is available, for instance changed mine plans or updated geological unit elevation data, the new data has been incorporated in the model set-up.

The model domain, which covers an area of around 132 km^2, is shown in **Figure 6.1**. It includes both the underground and NEOC mining areas, and extends to the south east open cut at Ashton. **Figure 6.2** shows a typical section through the model – at model row 158 (equivalent to 6404460m S).

6.2.1 MODEL GRID

The model has cell sizes of 100m by 100m on the outer edges of the model reducing to 50m by 50m over the SEOC mine area. Smaller cells have been implemented in the SEOC mine area to more accurately represent the geometry of the coal seams and the mining operation, and to simulate the steep groundwater level gradients expected to occur from open cut mining. A total of 136 rows and 136 columns were used.

6.2.2 MODEL LAYERS

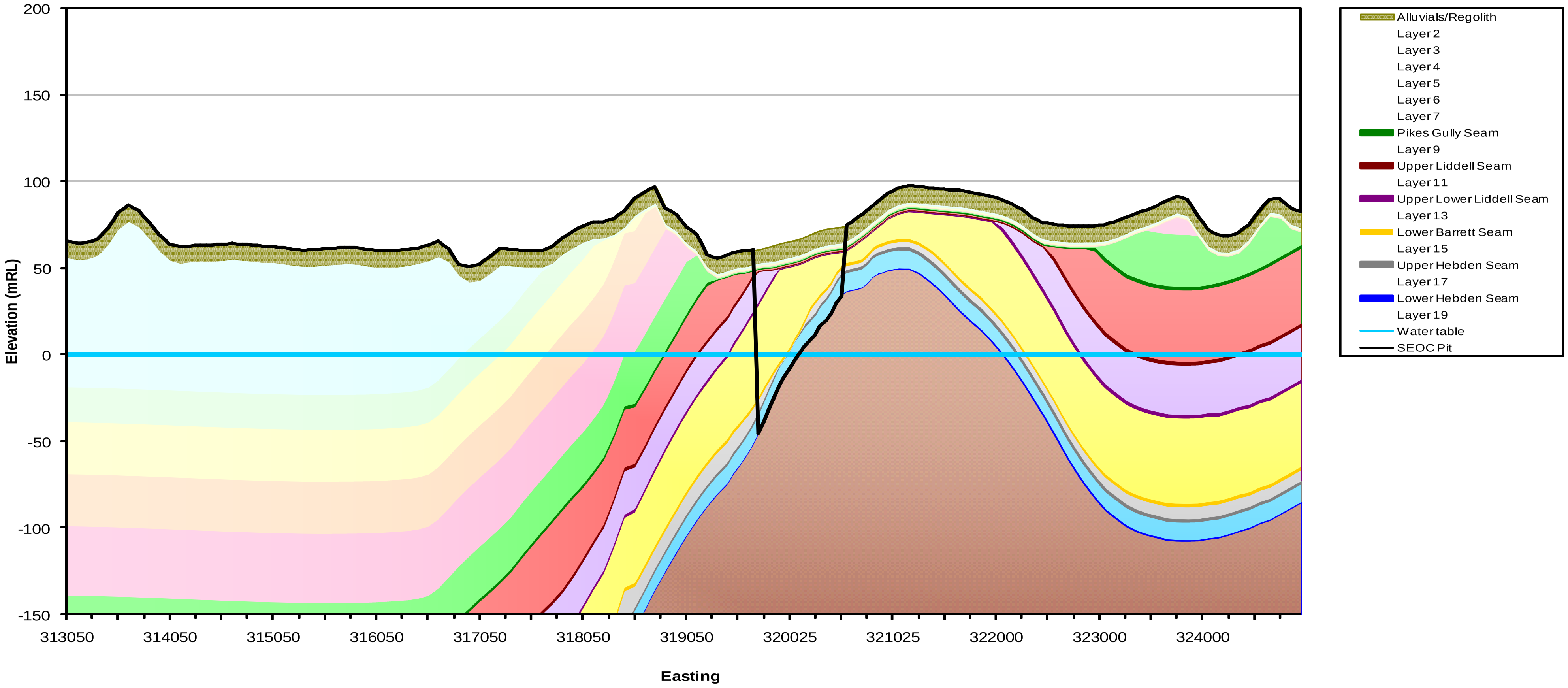
The local hydrogeology has been represented by 19 model layers, where coal seams and interburden are represented independently:

Layer 1: Bowmans Creek, Glennies Creek and Hunter River alluvium, colluvium, weathered Permian overburden (regolith) and Ravensworth spoil (backfill in the old Ravensworth open cut).

Layers 2, 3, 4, 5, 6 and 7: Pikes Gully Seam overburden – split into a number of layers to allow the simulation of fracturing extending to different heights above the coal seam during mining impact assessment. These layers include the full range of coal measures lithologies, including the Lemington coal seams (1 to 19), and in the very western part of the area the Bayswater 1 and 2 seams.

- Layer 8: Pikes Gully Seam.
- Layer 9: Pikes Gully – Upper Liddell interburden.
- Layer 10: Upper Liddell Seam.
- Layer 11: Upper Liddell – Upper Lower Liddell interburden.
- Layer 12: Upper Lower Liddell Seam.
- Layer 13: Upper Lower Liddell – Lower Barrett interburden.
- Layer 14: Lower Barrett Seam.
- Layer 15: Lower Barrett – Upper Hebden Seam interburden.
- Layer 16: Upper Hebden Seam.
- Layer 17: Upper Hebden – Lower Hebden Seam interburden.
- Layer 18: Lower Hebden Seam.
- Layer 19: Everything below.

The model layers above were specified for the full proposed four seam extraction mine plan. For the calibration and predictive impact assessment modelling of SEOC, all Layers were active in the model.



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Initials:	PZ	Job No:	S36
Drawing No:	S36-036a	Rev:	A

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SCHEMATIC GEOLOGICAL
MODEL CROSS SECTION

Figure 6.2

6.3 REFINED BOUNDARY CONDITIONS

The model boundary conditions in the SEOC model have been assigned to represent the regional groundwater flow system in a realistic manner, taking into account stratigraphic, topographic controls and neighbouring mines.

6.3.1 CONSTANT HEAD BOUNDARIES

Only Constant Head boundary conditions were changed in the SEOC model, other boundary conditions were the same as the underground mine model. The changes to the Constant Head boundary conditions are entirely associated with the changes to the model layers discussed previously. Conceptually there is no real difference in boundary conditions between this model and the model developed for the underground mine.

6.3.2 SURFACE DRAINAGE

The main rivers in the model domain (including Glennies Creek) have been represented by MODFLOW river cell boundaries. These allow baseflow from groundwater to the river, or recharge from the river to the model groundwater cells, depending on the relative position of groundwater heads in the surrounding aquifer cells. Because of the importance of baseflow impacts and effects on the Glennies Creek alluvium, the river cells for Glennies Creek were re-checked and refined against the GIS map.

The main ephemeral site drainage that crosses east-west across the middle of the proposed area has been represented by drain cells in the model. This drainage is generally only associated with storm runoff and is of little significance to the groundwater model.

6.4 REFINED AQUIFER PARAMETERS FOR THE STEADY STATE MODEL

The only significant change to aquifer parameters occurred in Layer 1 (the surface layer), and related to the detailed investigations into the hydrogeology of the Glennies Creek alluvium/colluvium referred to in Section 4. Based on the drilling and testing investigations, hydraulic conductivity for the alluvium (as defined by the 3,000 µS/cm ‘boundary’ defined in Section 4.6.6) was altered in two stages. For the steady state model and model sensitivity analysis, a simple approach was used whereby the alluvium was separated into two zones, with the alluvium close to and in contact with Glennies Creek assigned a permeability of 1.5m/d, and the alluvium/colluvium to the east of the 3,000µS/cm contour assigned a permeability of 0.5m/d. This was simpler than the distribution used for the predictive model, and was primarily carried out to examine model sensitivity and stability prior to the predictive modelling exercise.

6.5 MODEL CALIBRATION

The SEOC model was not calibrated directly, as it was based on the model developed for the LW/MW5-9 Pikes Gully Seam groundwater impact assessment (Aquaterra, 2008c) which had already been calibrated.

The model used previously for assessment of the impacts associated with underground mining of the Pikes Gully seam had undergone a lengthy transient calibration process utilising the early impacts of LW1 and LW2 mining.

As changes were made to the model domain and to Glennies Creek alluvium for the SEOC study, verification was undertaken to ensure that the minor changes to the model domain did not significantly affect model results for the pre SEOC mining condition. This validation exercise confirmed that results from the underground model correlated well with the updated SEOC model. Because the underground model was rigorously calibrated, and changes in calibration parameters from this were insignificant for the SEOC model, it is considered that the SEOC model is adequately calibrated for the purposes of this study.

6.6 SENSITIVITY AND UNCERTAINTY ANALYSIS

Sensitivity analysis was undertaken on the steady state model to examine the sensitivity of the steady state model to parameters within the alluvial aquifer (Zones 10, 13 and 41 in Layer 1). since the drawdown in the alluvium aquifers and baseflow impacts on Glennies Creek are the key groundwater issues in relation to agency requirements for the project.

As noted previously, a simpler distribution of horizontal hydraulic conductivity was used at this stage, as the main purpose of the exercise was to confirm consistency with the previous model, and check for calibration stability when the parameters in the alluvium were changed. The sensitivity to each parameter was analysed by first decreasing, and then increasing its value, by the multipliers shown in **Table 6.1**. Parameters that resulted in a change to the scaled RMS statistics by a significant amount indicate that the model is sensitive to that parameter.

Because the primary focus of this assessment was the impacts on Glennies Creek alluvium, sensitivities were carried out on recharge, hydraulic horizontal conductivity (kh) and vertical conductivity (kv) in this layer.

These results show that the steady model is relatively insensitive to Kh and Kv of the Glennies Creek alluvium. This shows that the model is relatively stable for these parameters, and indicates that a range of values may be plausible in modelling terms. This was important, as it indicated that the distribution and extent of hydraulic permeability within the alluvium had to be defined by primary investigations (as described in **Section 4),** rather than steady state model calibration. Because the model was sensitive to values of recharge, this parameter was not varied for uncertainty analysis during the predictive model runs

Assessment of uncertainty during the subsequent predictive model runs indicated that the predicted level of impact of the SEOC mine on Glennies Creek is sensitive to horizontal hydraulic permeability, but not to vertical hydraulic conductivity. Uncertainty analysis for the impact assessment therefore concentrated upon the impact of changing values of kh in the alluvium and colluvium associated with Glennies Creek.

Table 6.1: Steady State Model Sensitivity Analysis - Parameters, Zones and Multipliers

Parameter	Zone	Calibrated Value (m/day)	Multiplier
Recharge	10	1 x 10^{-5}	0.1, 0.5, 2, 5
Horizontal Hydraulic Conductivity	13	0.5 m/d	0.5, 2
	41	1.5 m/d	0.5, 2
Vertical Hydraulic Conductivity	13	5×10^{-6} m/d	0.1, 10

Table 6.2: Steady State Model Sensitivity Analysis for Recharge, Horizontal Hydraulic Conductivity and Vertical Hydraulic Conductivity

Zone	Calibrated Value	Multiplier	SRMS (%)
Sensitivity to Recharge			
10	1 x 10^{-5}	0.1	30.6
		0.5	19.3
		1	10.2
		2	9.7
		5	18.1
Sensitivity to Horizontal Hydraulic Conductivity (m/d)			
13	0.5	0.5	9.88
		1	**10.14**
		2	10.37
41		0.5	10.11

Zone	Calibrated Value	Multiplier	SRMS (%)
		1	**10.14**
		2	10.17
Sensitivity to Vertical Hydraulic Conductivity (m/d)			
13	5×10^{-6} m/d	0.1	10.19
		1	**10.14**
		10	10.08

6.7 PREDICTED GROUNDWATER IMPACTS OF SEOC MINE PLAN

6.7.1 PREDICTION METHOD

The mining schedule for the SEOC plan is shown on **Figure 5.1**. Within the model, two 'time slices' are run prior to the start of SEOC mining in order to allow for the impacts of other mining activities in the area, and allow the initial conditions to stabilise before SEOC mining starts. Mining of the SEOC then starts at Year 6 (January 2010). The model then runs for the 7 years of the mine plan. There are 7 mining stages, each representing 1 year in SEOC. Excavations corresponding to each mining period are shown by a common colour. **Table 6.3** shows the stress-period setup used to simulate the proposed mine schedule. **Figure 5.1** shows the modelled drain cell progressions which were used to simulate the mine plan schedules.

The SEOC Model has been used for predictive transient modelling to assess the potential impact of progressive SEOC mining on the groundwater and surface water resources. Transient calibration verification period included open cut mining and underground mining up to July 2008. The transient model was designed to predict the impact from all three projects- NEOC, LW/MW 1-9 and SEOC, each operating concurrently in accordance with their respective mine plans. However, modelling has also been undertaken to assess the impacts of the SEOC in isolation.

Table 6.3: Stress Period Set-up for Life of Mine Simulation

Period	Stress Period	Model Year	Mine year	length (days)	From	To
NO SEOC PIT	1	1-5	-4 to 0	912	01/01/2004	31/6/2006
	2			912	01/07/2006	31/12/2009
SEOC PREDICTION	3	6	1	365	01/01/2010	31/12/2010
	4	7	2	365	01/01/2011	31/12/2011
	5	8	3	365	01/01/2012	31/12/2012
	6	9	4	366	01/01/2013	31/12/2013
	7	10	5	365	01/01/2014	31/12/2014
	8	11	6	365	01/01/2015	31/12/2015
	9	12	7	365	01/01/2016	31/12/2016

Steady state heads pre-mining were used as the initial head for the prediction run. Drawdown caused by the underground mine and the NEOC prior to mining were then added by running two stress periods with those mines in place prior to the start of the SEOC mining.

6.7.2 MODELLED HYDRAULIC PARAMETERS

For the predictive model, the values of hydraulic conductivity within the alluvium were carefully selected in order to reflect the permeability values and zones described in **Section 4.6.6**. An overview of the hydraulic parameters used in Layer 1 of the predictive model (the alluvium/colluvium/regolith) is provided in **Figure 6.3.**

It can be seen that the approach that was adopted was deliberately conservative, particularly in relation to high permeability Zones 3 and 4. Because the alluvium at the pit shell boundary is in Zone 1, it was found that baseflow impacts and pit inflows from the alluvium were not sensitive to the extent or hydraulic parameters within this Zone. However, because the alluvium has a greater depth of saturation at the pit shell boundary, the model is sensitive to the extent and nature of Zones 2 and 3. Therefore, the higher permeability area for Zone 3 has been assumed to extend to the creek, and has been assigned a value (10m/d) based on the simple average of the two boreholes drilled in that area.

6.7.3 PREDICTION RESULTS

The following is a summary of the results of the life of mine predictions.

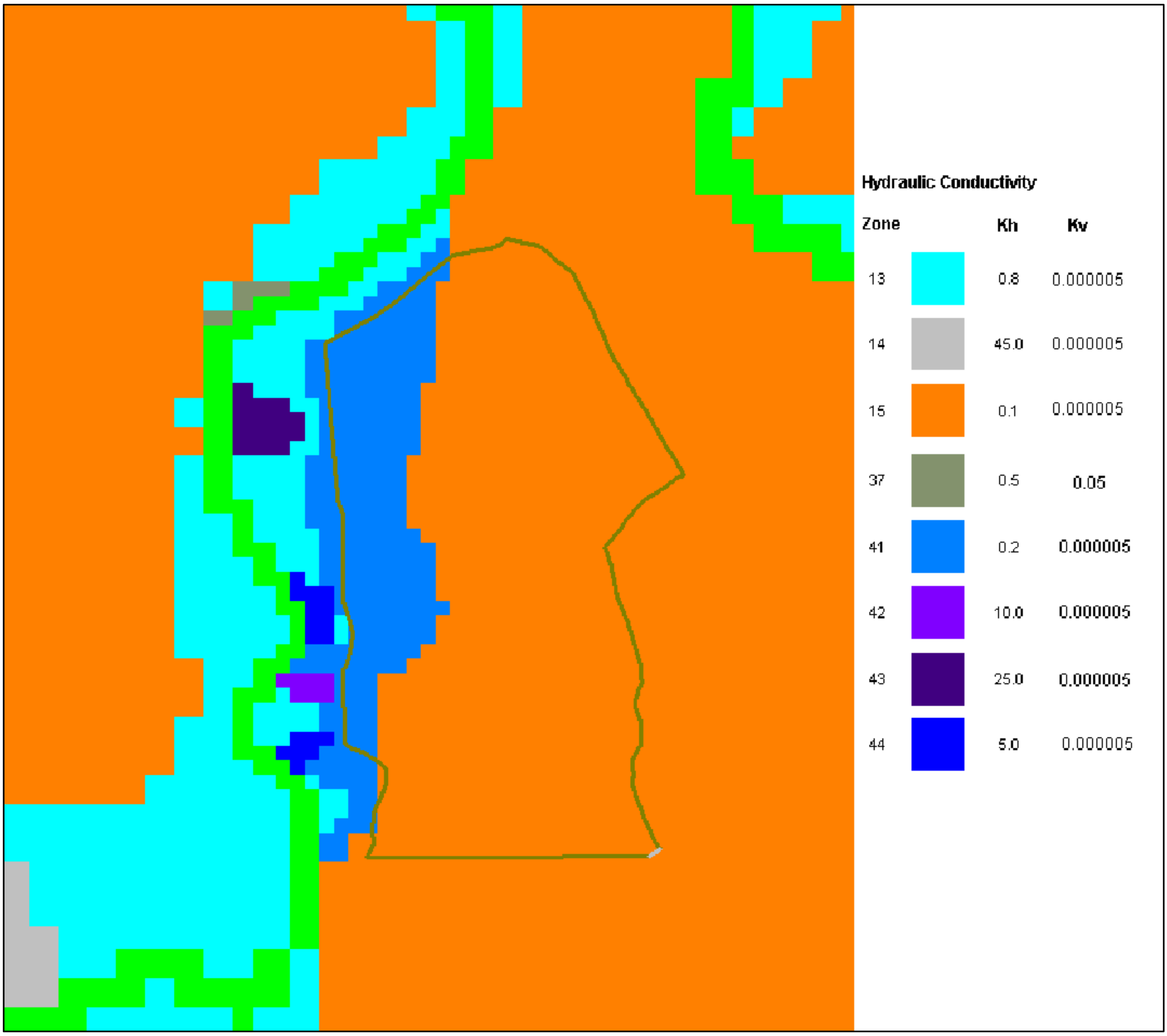
Mine Inflow Rates

Mine inflow comes from three sources:

- Flow to the pit shell from the alluvium/colluvium (layer 1) associated with Glennies Creek to the west
- Flow from the Permian strata (layers 2 to 17) and other superficial deposits (layer 1) to the pit shell.
- Direct rainfall recharge to the pit area.

Figure 6.4 shows the model-predicted mine inflow rates, separated into flow from the Glennies Creek alluvium/colluvium to the west (layer 1), direct recharge, and other groundwater sources, including the Permian and regolith/colluvium to the north, south and east (all other model layers). Model uncertainty for the inflows from the Glennies Creek alluvium has also been assessed by separate prediction runs with Kh halved and doubled for all zones within the alluvial area.. The following observations are made:

- Total predicted groundwater inflow to the pit shell ranges from 56 m^3/d in year 1 to around $200m^3$/annum for mine years 2 to 7. The direct recharge component of this increases as the area of the pit increases. Groundwater flow net of direct recharge peaks at years 2 to 4, at around 120 – $140m^3$/annum.
- Groundwater inflow mostly occurs from the Permian coal measures and colluvium/ weathered overburden intersected by the open cut. By year 7, only 24 m^3/d of the inflow that is entering the pit originates from the alluvium associated with Glennies Creek to the west.
- The prediction of inflow rates from the alluvium associated with Glennies Creek is relatively sensitive to values of Kh for the alluvium. Doubling Kh increases pit inflows from the alluvium on the western side of the pit by about 35% to a maximum rate of 33 m^3/d in Year 7. Halving Kh similarly reduces maximum inflow by about 28%, reducing it to a maximum of $18m^3/d$.



Date: 2 June 2009

Scale: As Shown

Ashton Coal Operations Ltd

Initials: PZ

Job No: S36

Drawing No: S36-076b

Rev: B

Groundwater Model Hydraulic Conductivity

aquaterra

Figure 6.3

Creek Baseflow Impacts

Figure 6.5 shows the total model predicted baseflow impacts for Glennies Creek as a result of both SEOC and underground mining and net additional baseflows impacts as a result of SEOC mining only. As with pit inflows, the sensitivity of baseflow predictions to the hydraulic conductivity (kh) of the Glennies Creek alluvium is also shown.

The following observations can be made:

- During the SEOC mining period, baseflow in Glennies Creek is anticipated to reduce by around 57 m^3/d due to all mining activities (including the underground mine).
- The maximum net predicted impact on Glennies Creek as a result of SEOC mining alone is a reduction in baseflow of 47 m^3/day (0.5 L/s).
- The prediction of impact on baseflow is less sensitive to changes in Kh for the alluvium associated with Glennies Creek. Doubling Kh in layer 1 for zones 13 and 41 increases the final leakage rate from Glennies Creek to the alluvium by around 9 m^3/d. The majority of this increase would be associated with impacts from the SEOC.

Impacts on Alluvium Aquifer Storage

One of the objectives of this assessment was to determine the potential impact of the proposed mining of SEOC on groundwater storage within the Glennies Creek alluvium.

The change in saturated volume in the Glennies Creek alluvium over the period of mining was calculated using the contouring and 3D surface mapping software package SURFER. The initial volume of groundwater storage was calculated based on the starting water table levels adopted for the beginning of the transient calibration, and the topography of the base of the alluvium, within the extent of saturated alluvium in Glennies Creek. The volume at the completion of mining was calculated using the modelled final water table distribution within the same area.

The results of this analysis are as follows:

- Starting saturated alluvium aquifer volume was 10.7 Mm^3 within the groundwater model domain.
- The predicted reduction in groundwater storage volume within the Glennies Creek, based on drawdown in Year 7, is 0.3Mm^3, or less than 3 % of the total storage.

Groundwater Levels

A selection of modelled versus observed hydrographs over the prediction period are shown in **Figure 6.6 and Figure 6.7.**

These hydrographs show the following:

- Predicted heads were slightly higher than observed heads for multi-level piezometer WMW144, located approximately 150m west of the SEOC pit (**Figure 6.6)**. Here, substantial water level declines ranging from 15m to 57m are predicted in all coal seams, with deeper seams (Upper and Lower Barrett), showing a larger drawdown and cone of depression. It is expected that over the project life, all seams will become fully dewatered across the SEOC pit area.
- The calibration between predicted and observed water levels is generally good for piezometers in the Glennies Creek alluvium (Layer 1). Drawdowns up to 1m are predicted at some sites, although more than half of this is associated with mining impacts prior to the start of the SEOC. Impacts due to the SEOC mining (2010 onwards) are generally very small, at between 0.2m and 0.4m.
- Total de-saturation of Layer 1 is predicted in areas outside the Glennies Creek floodplain, adjacent to the pit wall, where Layer 1 represents intercalated alluvium/colluvium, colluvium and/or weathered coal measures (regolith).

Glennies Creek Alluvium Drawdown Impacts

Contours of predicted drawdown in the Glennies Creek alluvium in mining years 5 and 7 are shown in **Figures 6.8 and 6.9**.

The following observations can be made:

- No drawdowns are expected to occur in the first 2 years of SEOC mining, as mining will be occurring at the northern end of the SEOC, where there is no hydraulic connection to Glennies Creek alluvium.
- The largest drawdowns are predicted to occur directly adjacent to the southern parts of the SEOC, where saturated thickness of alluvium/colluvium is greatest.
- Maximum drawdown tends to occur around years 4 – 7, when inflows to the pit occur and the active pit is closest to the saturated alluvium. The maximum drawdown is less than 1.5m and this only occurs in a area around Zones 2 and 3 close to the pit shell. Drawdown greater than 0.5m is confined to a relatively small area in the alluvium around the middle of the westerns side of the pit.

Coal Seam Drawdown Impacts

Contours of predicted drawdown in selected coal seams (Upper Liddell and Upper and Lower Hebden) by the completion of mining in year 2017 (Mine Year 7) are shown on **Figures 6.10 and 6.11**. Progressive drawdown contours predicted for years 2010-2016 are presented in **Appendix F.**

The following observations can be made:

- The maximum predicted drawdown in the Upper Liddell Seam (Layer 12) predicted by the model is 20-30m. The drawdown is limited to the western side of the SEOC and influenced from an expansion of the cone of depression emanating from the underground mining of LW/MW 1-9, suggesting impacts of underground and SEOC mining mutually interfere **(Figure 6.10).** However, because the model does not include direct dewatering by the Ashton underground mine of seams below Pikes Gulley, the modelled impact from the SEOC can be considered conservative. In reality the proportional impact from the underground mining would be greater once the lower seams are mined, which would reduce the relative level of impact from the SEOC.
- The maximum predicted drawdown in the Upper and Lower Hebden Seam (Layer 17) predicted by the model is 70m. A cone of depression extends over some of the underground mining area as well as the SEOC **(Figure 6.11)**.
- The drawdown impacts of all seams are generally contained within the Project Boundary.

6.8 RECOVERY SIMULATION

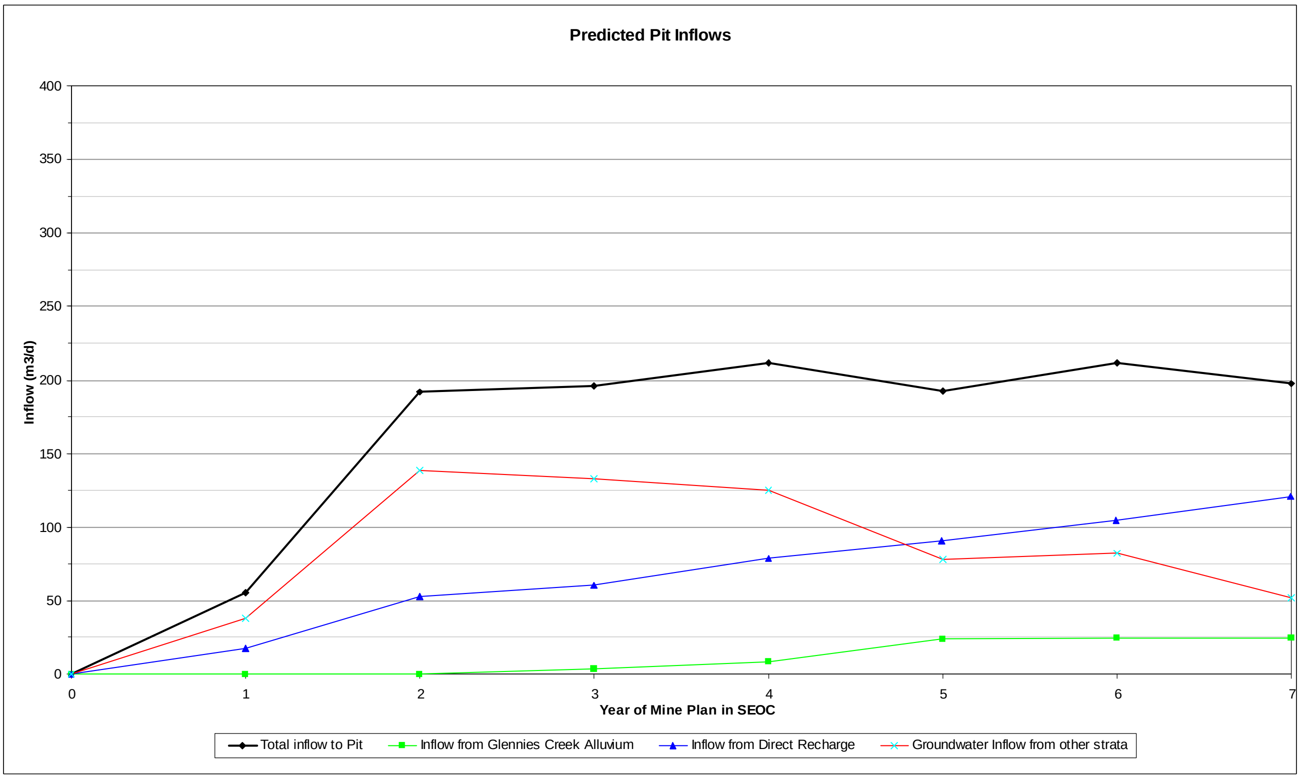
The post-mining recovery run was conducted using the results from the end of the SEOC mine dewatering predictions, i.e. conditions at the end of Mining Year 7, as the initial conditions. The recovery period was set as 100 years.

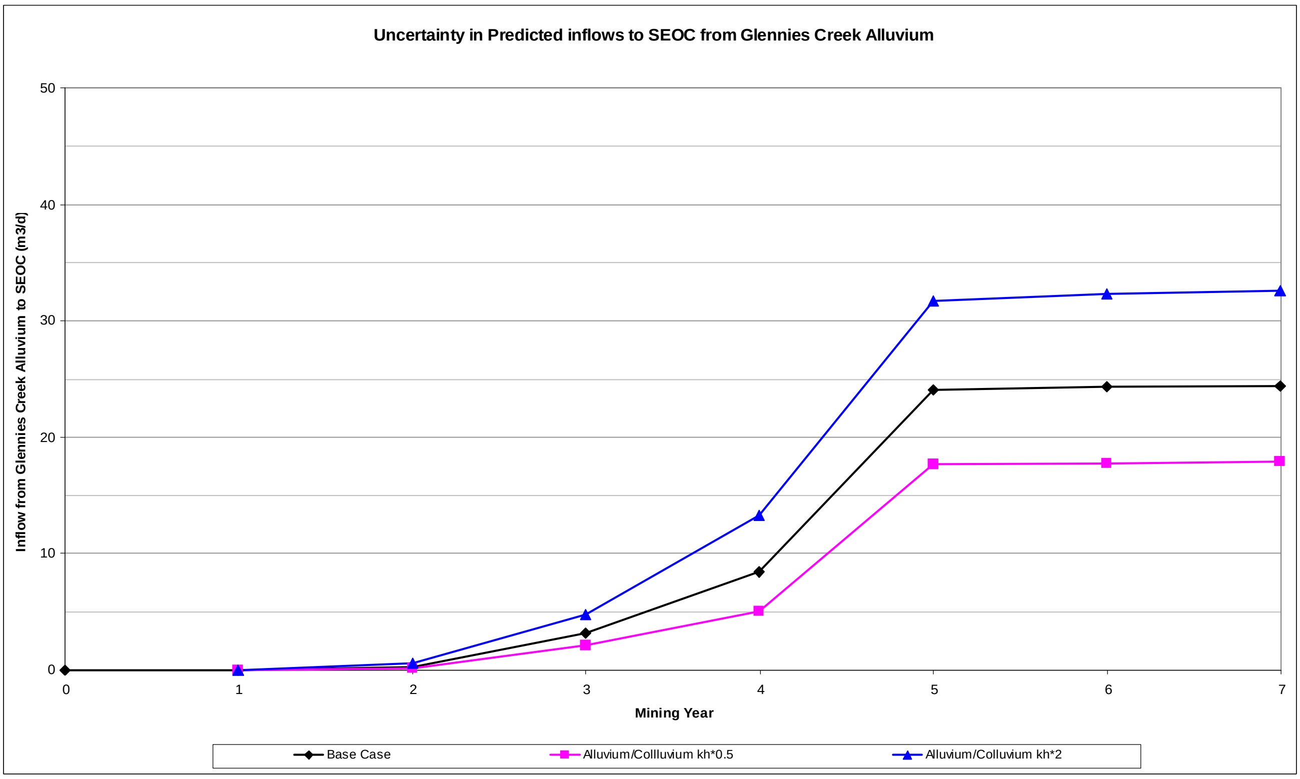
Aquifer parameters representing backfill were applied in the SEOC, and the goaf and fracture zone parameters in Ashton underground mine areas were retained in the model throughout the recovery period. It was assumed that the open-cuts would be backfilled to above the pre-mining water table.

Figures 6.12 and 6.13 show predicted water level drawdown in Model Layer 1 (Alluvium) and Layer 12 (Upper Liddell Seam) at the end of the recovery period (Mining Year 107).

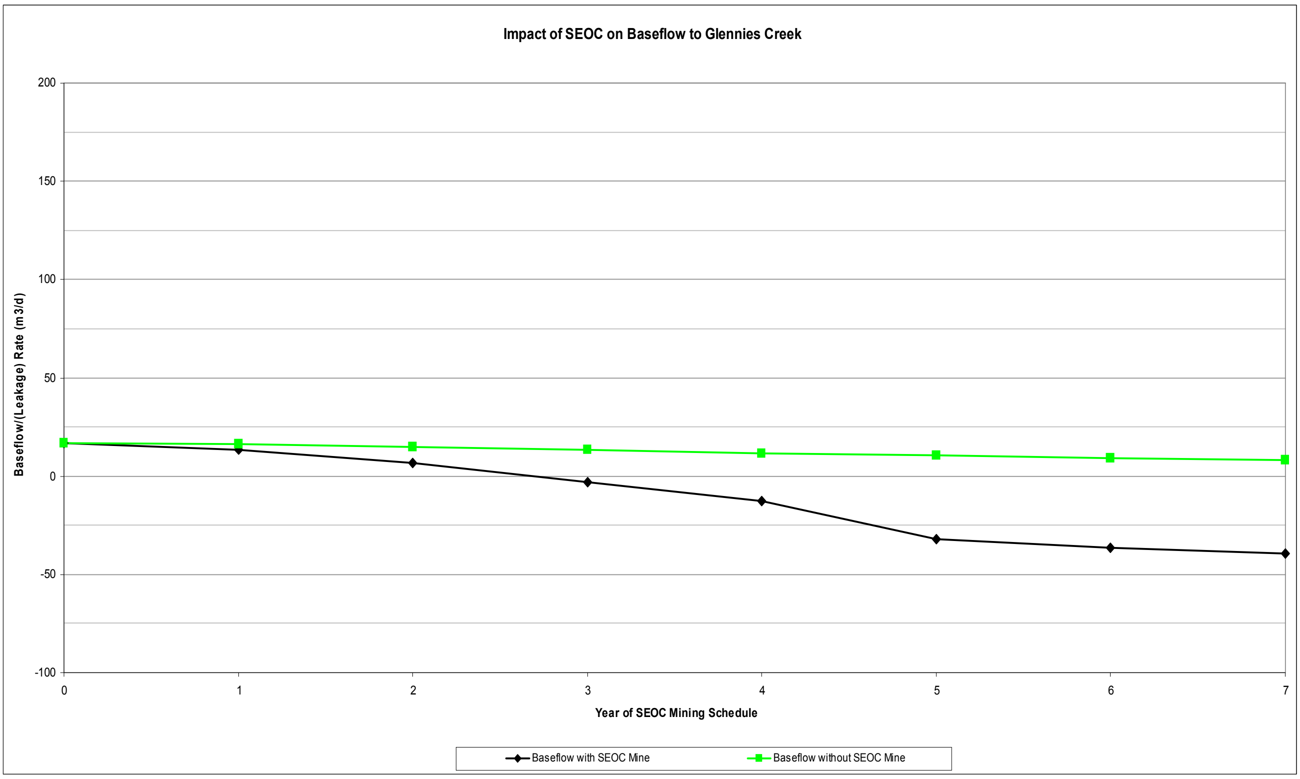
In summary, the drawdown plots and hydrographs show the following:

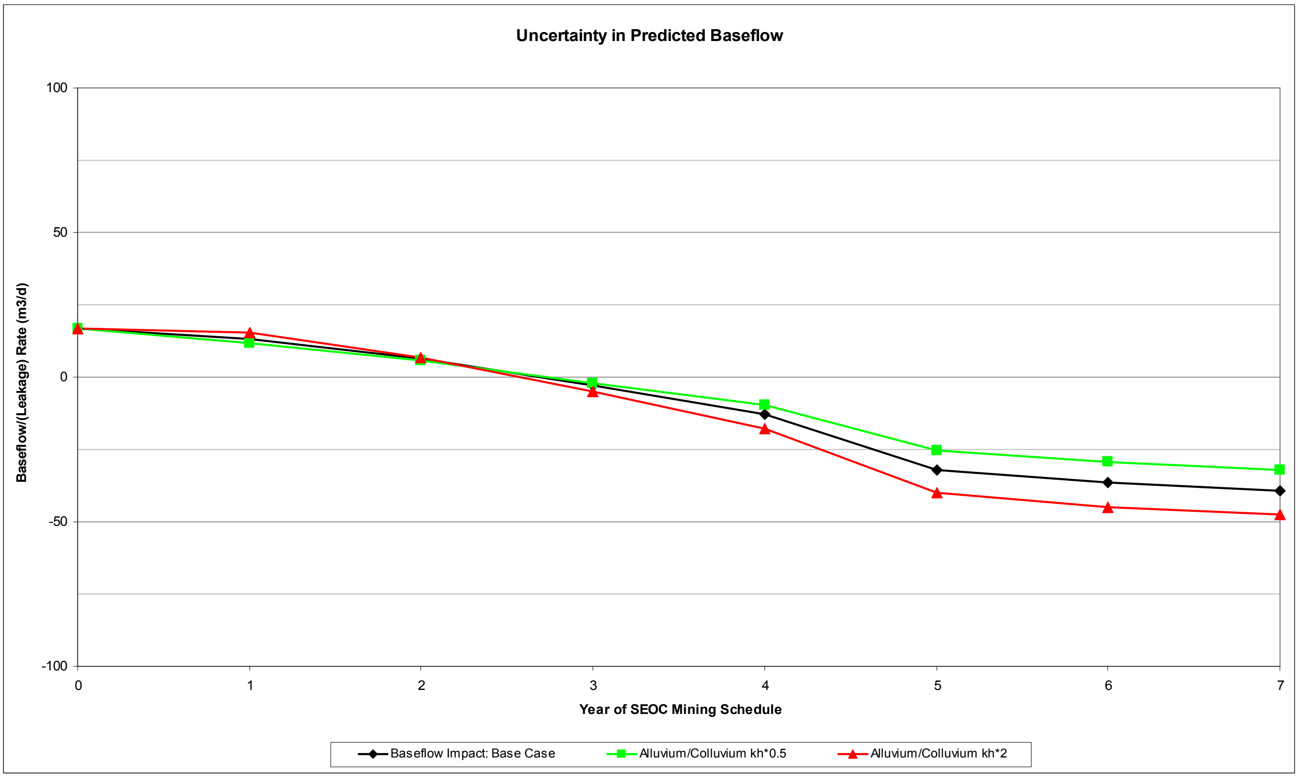
- There is no residual impact in Layer 1 (the alluvium) due to the SEOC operation.
- Residual impacts as a result of underground mining do persist in the coal seam layers, but these are limited to within the mine pit area and are generally less than 1m.



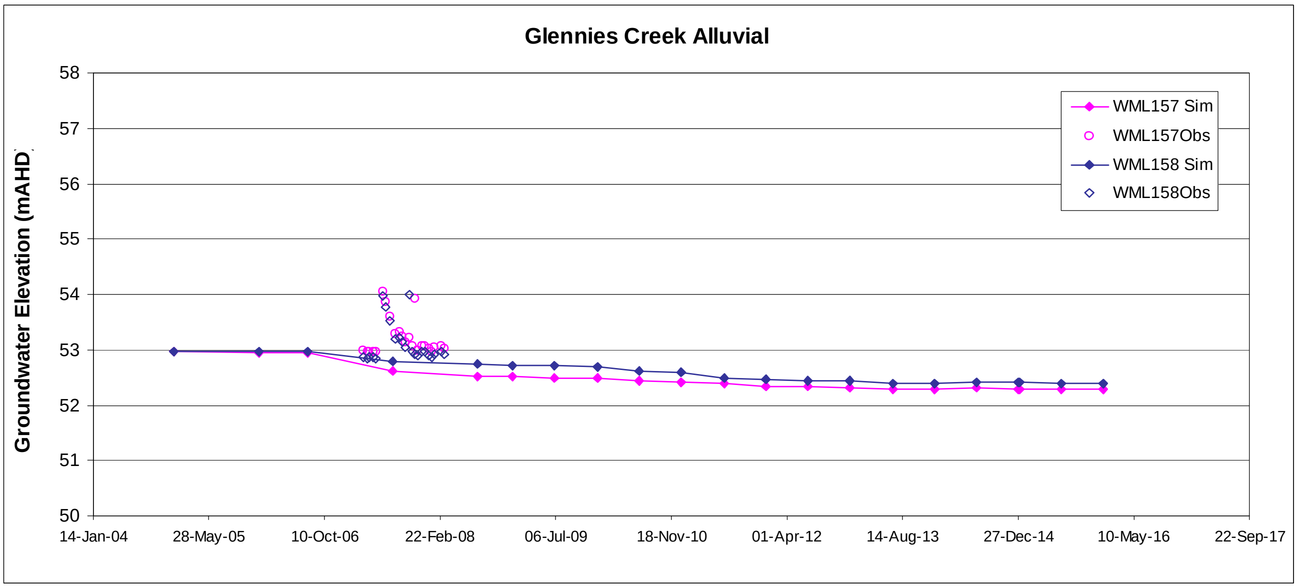


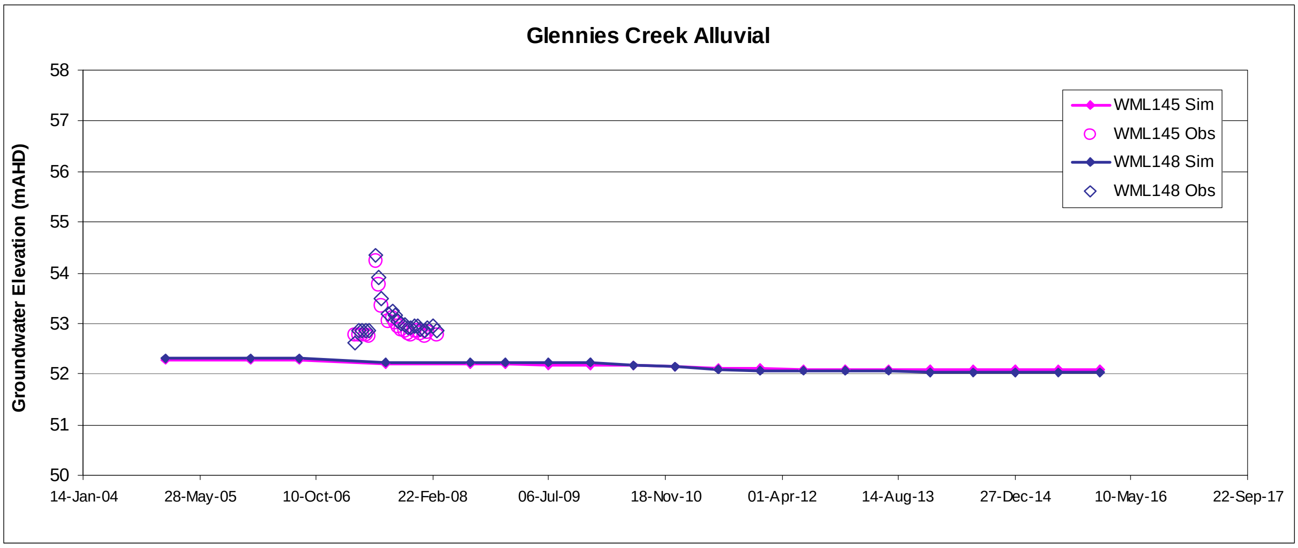
Date: 2 June 2009	Scale: As Shown	**Ashton Coal Operations Pty Ltd**
Initials: PZ	Job No: S36	**ASHTON COAL PROJECT** **PREDICTED MINE INFLOW RATES** **m^3/day**
Drawing No: S36-024b	Rev: B	
aquaterra		**Figure 6.4**

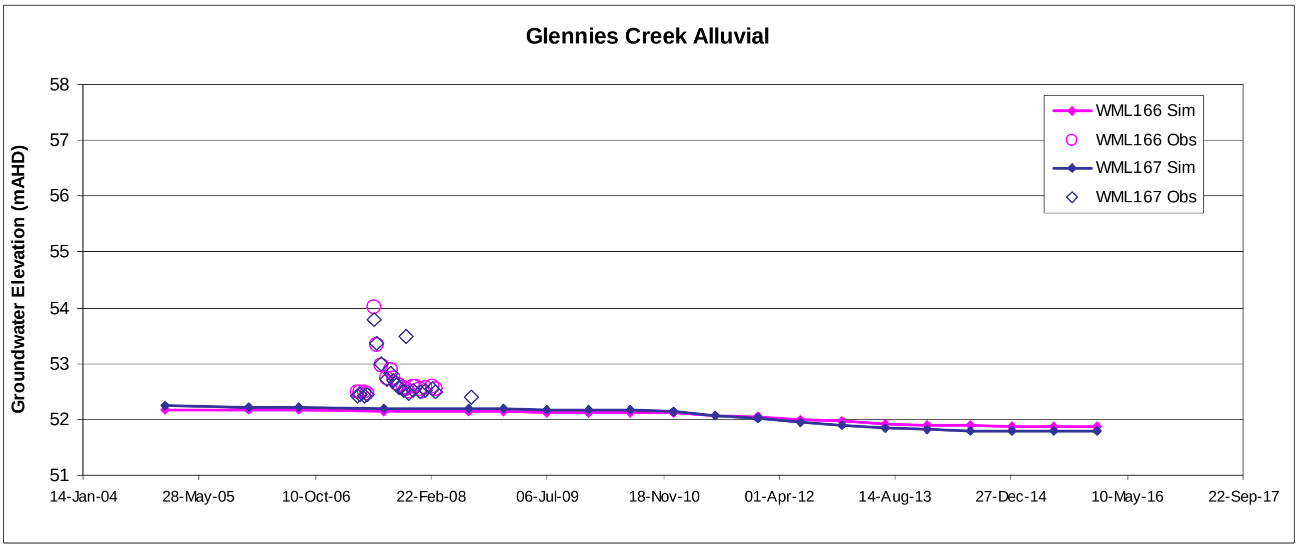

Impact of SEOC on Baseflow to Glennies Creek


Uncertainty in Predicted Baseflow

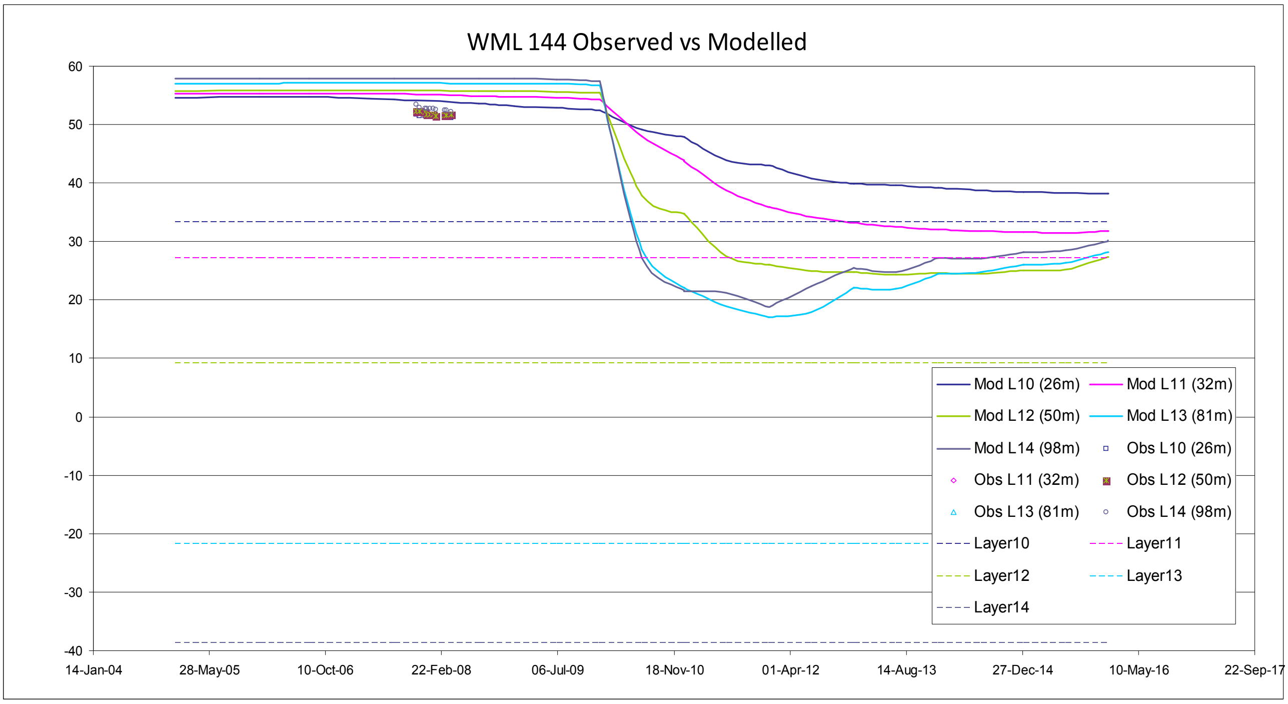
Date:	2 June 2009	Scale:	As Shown	**Ashton Coal Operations Pty Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT** **SEOC** **BASEFLOW IMPACTS TO GLENNIES CREEK**
Drawing No:	S36-015b	Rev:	B	
aquaterra				**Figure 6.5**



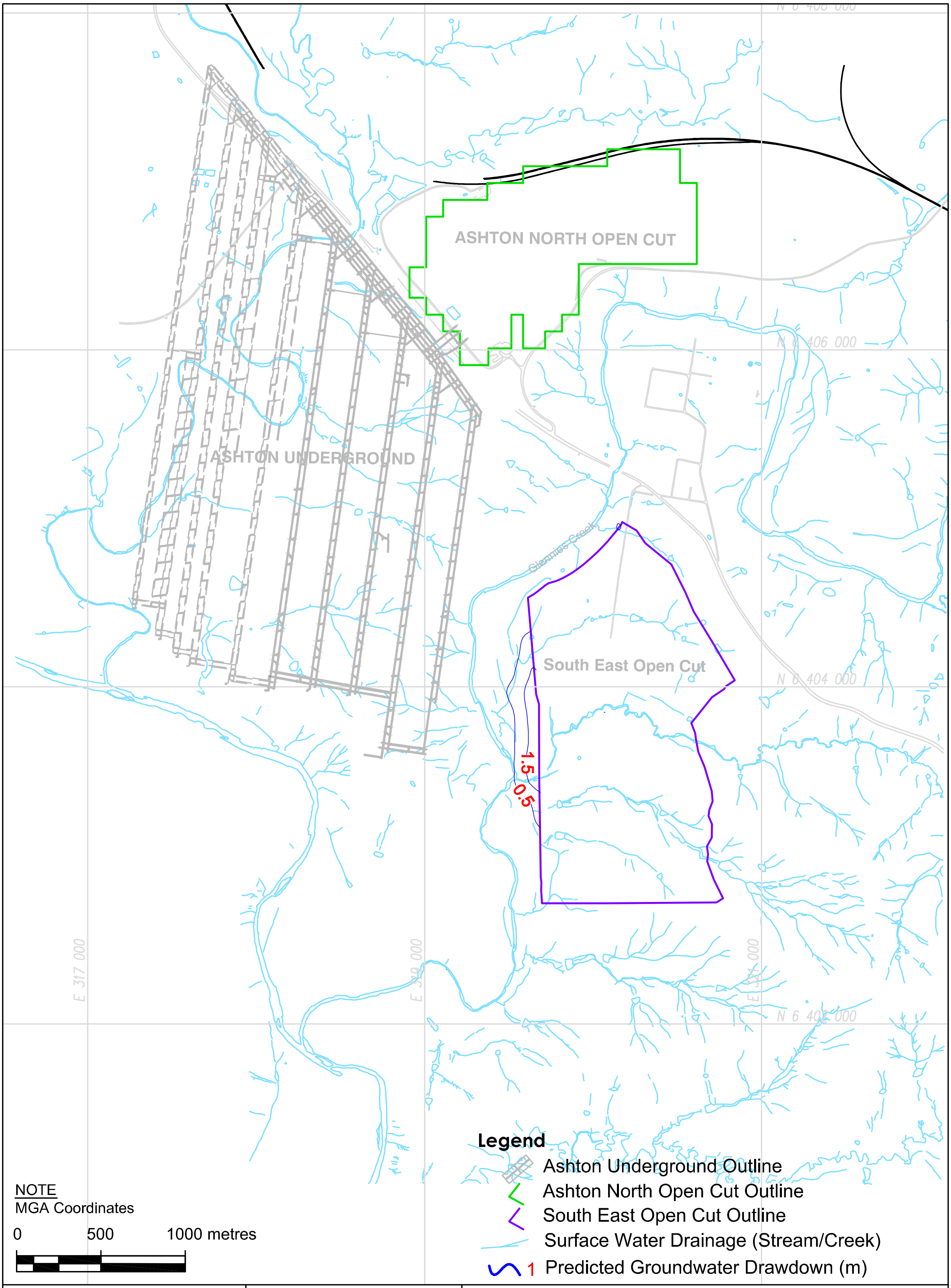




Date:	2 June 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT - SEOC MODELED VS OBSERVED HYGROGRAPHS GLENNIES CREEK ALLUVIUM / COLLUVIUM**
Drawing No:	S36-016d	Rev:	D	
aquaterra				**Figure 6.6**



Date:	2 June 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT - SEOC MODELLED VS OBSERVED HYDROGRAPHS PERMIAN - WML 144**
Drawing No:	S36-019c	Rev:	C	
aquaterra				**Figure 6.7**



Date: 08 July 2009	Scale: As Show	**Ashton Coal Operations Pty Ltd**
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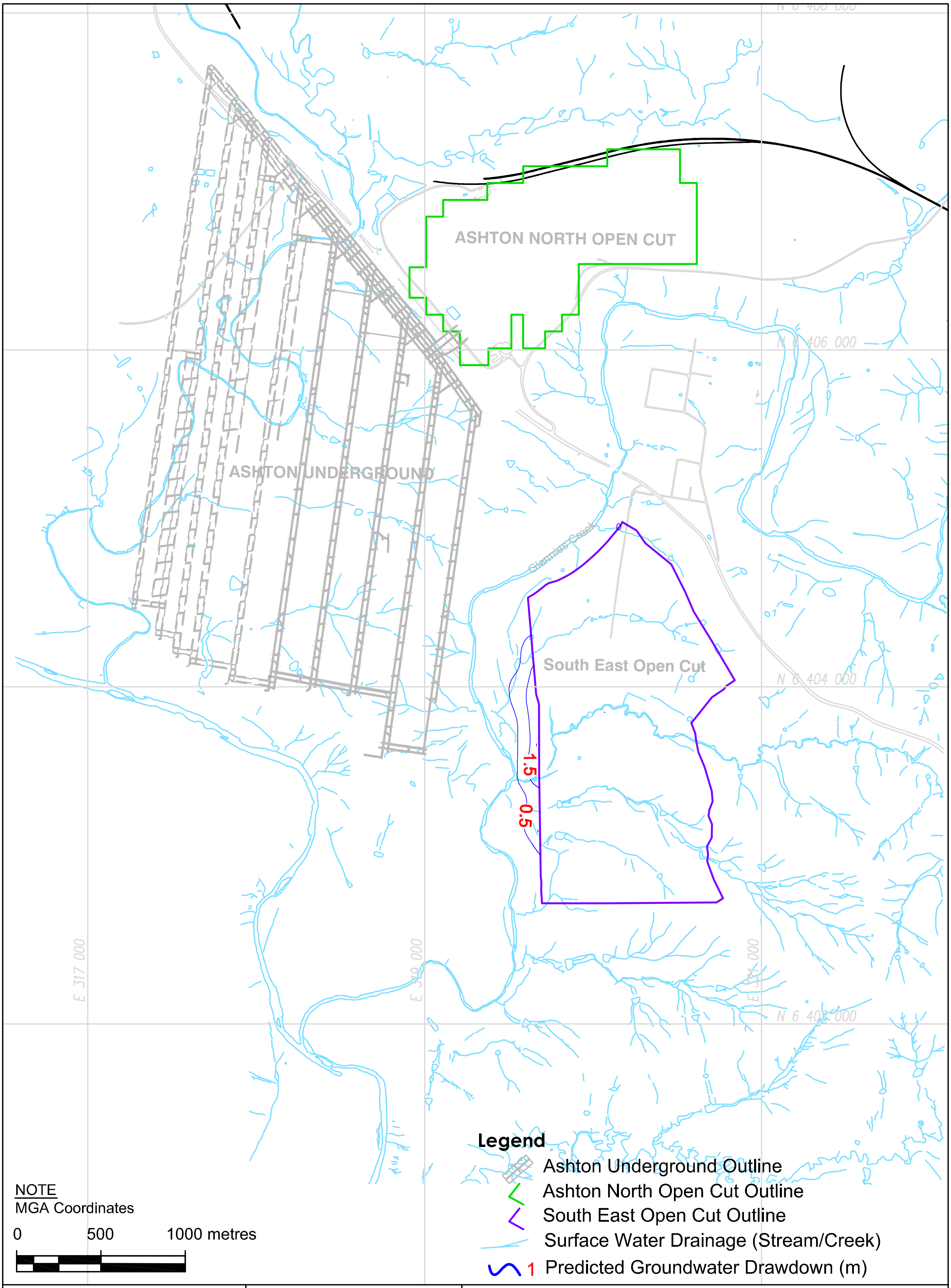
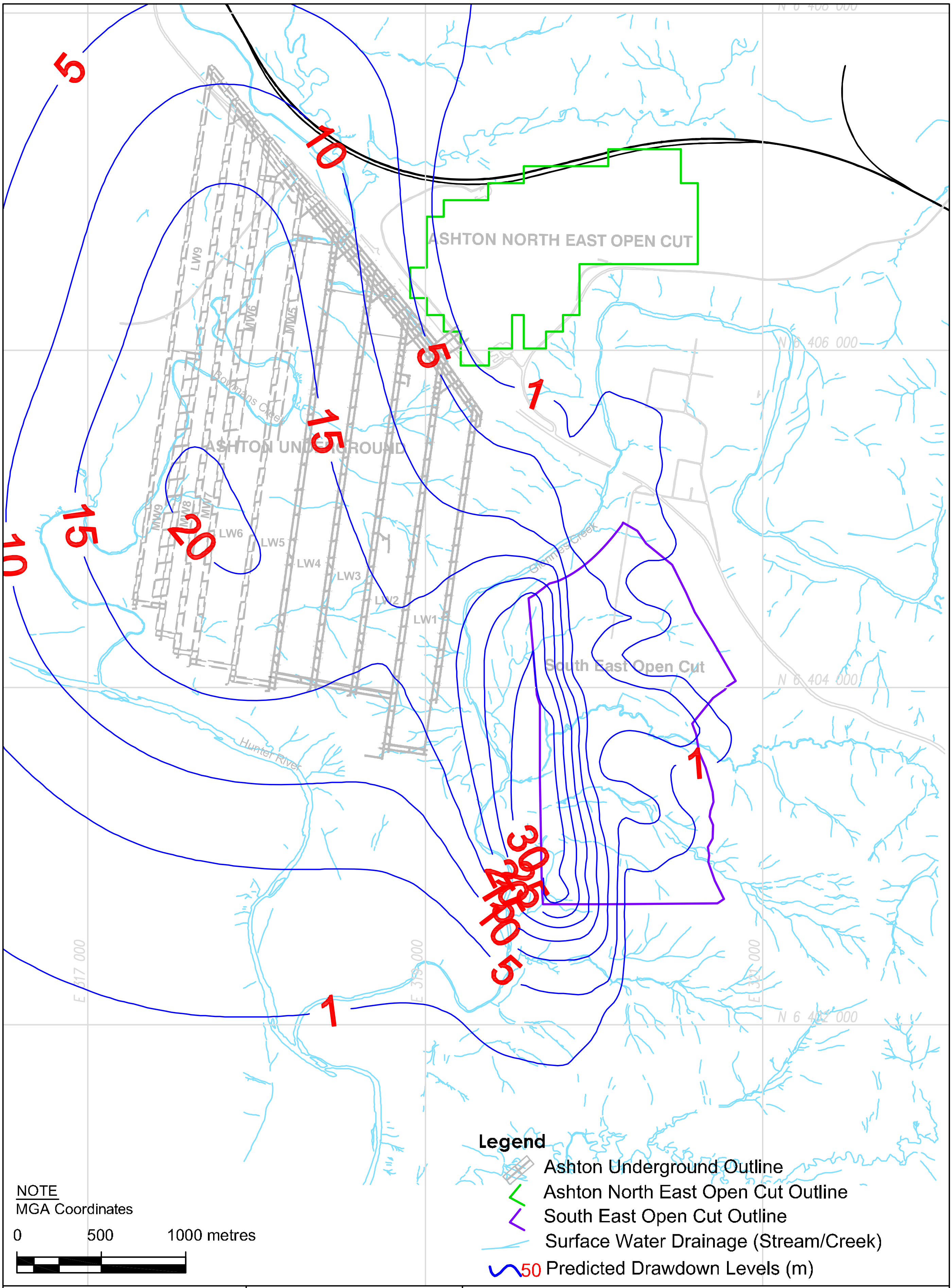
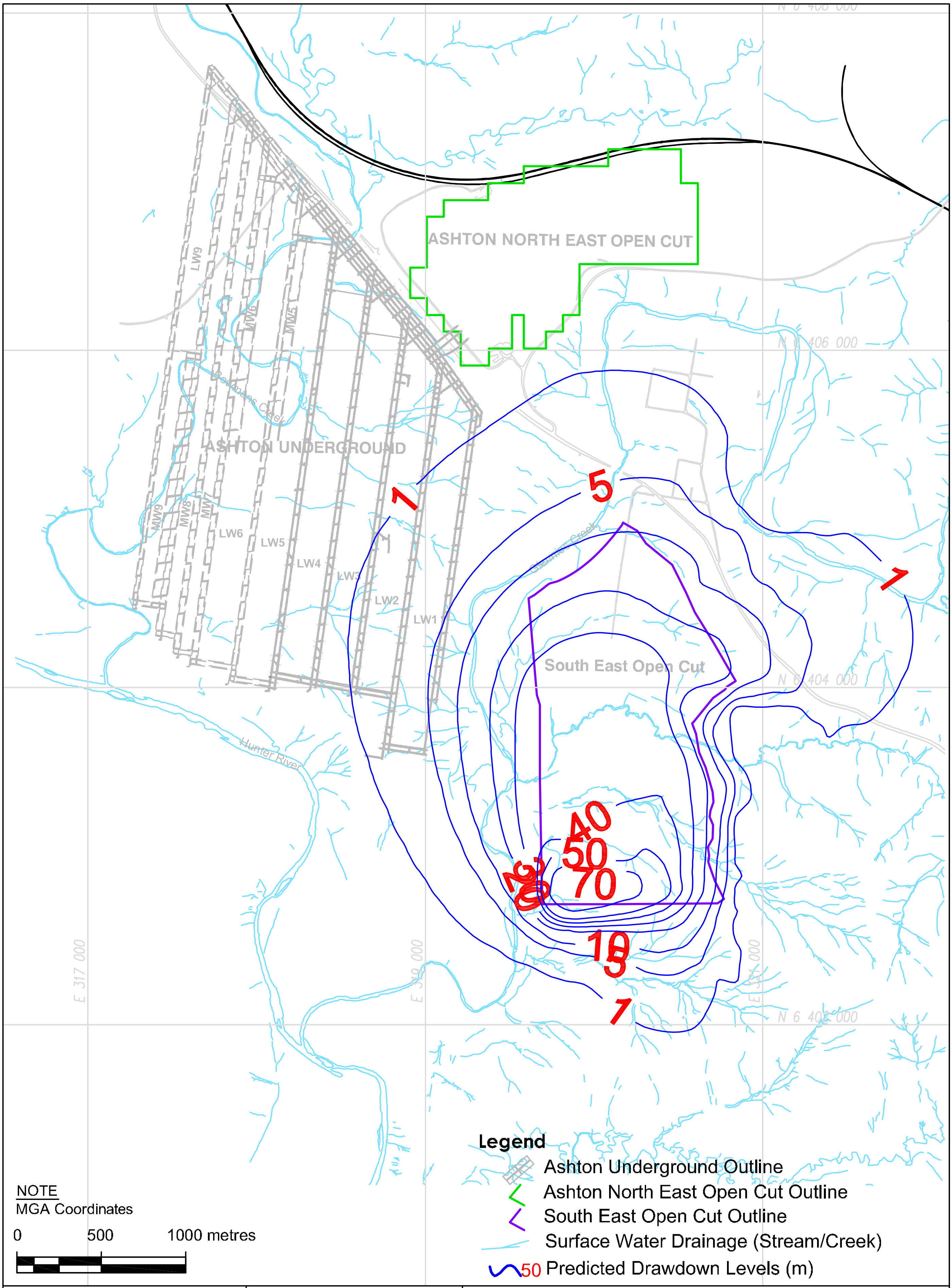
Drawing No: S36-051a	Rev: B	
aquaterra		**Figure 6.8**



Date: 08 July 2009	Scale: As Show	**Ashton Coal Operations Pty Ltd**
Initials: JVDA	Job No: S36	**Predicted Drawdown Levels in Alluvium After 7 Years Mining**
Drawing No: S36-051	Rev: B	
aquaterra		**Figure 6.9**



Date:	26 June 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**Predicted Drawdown Levels in Upper Lower Liddell Seam after 7 Years Mining**
Drawing No:	S36-077b	Rev:	B	
aquaterra				**Figure 6.10**



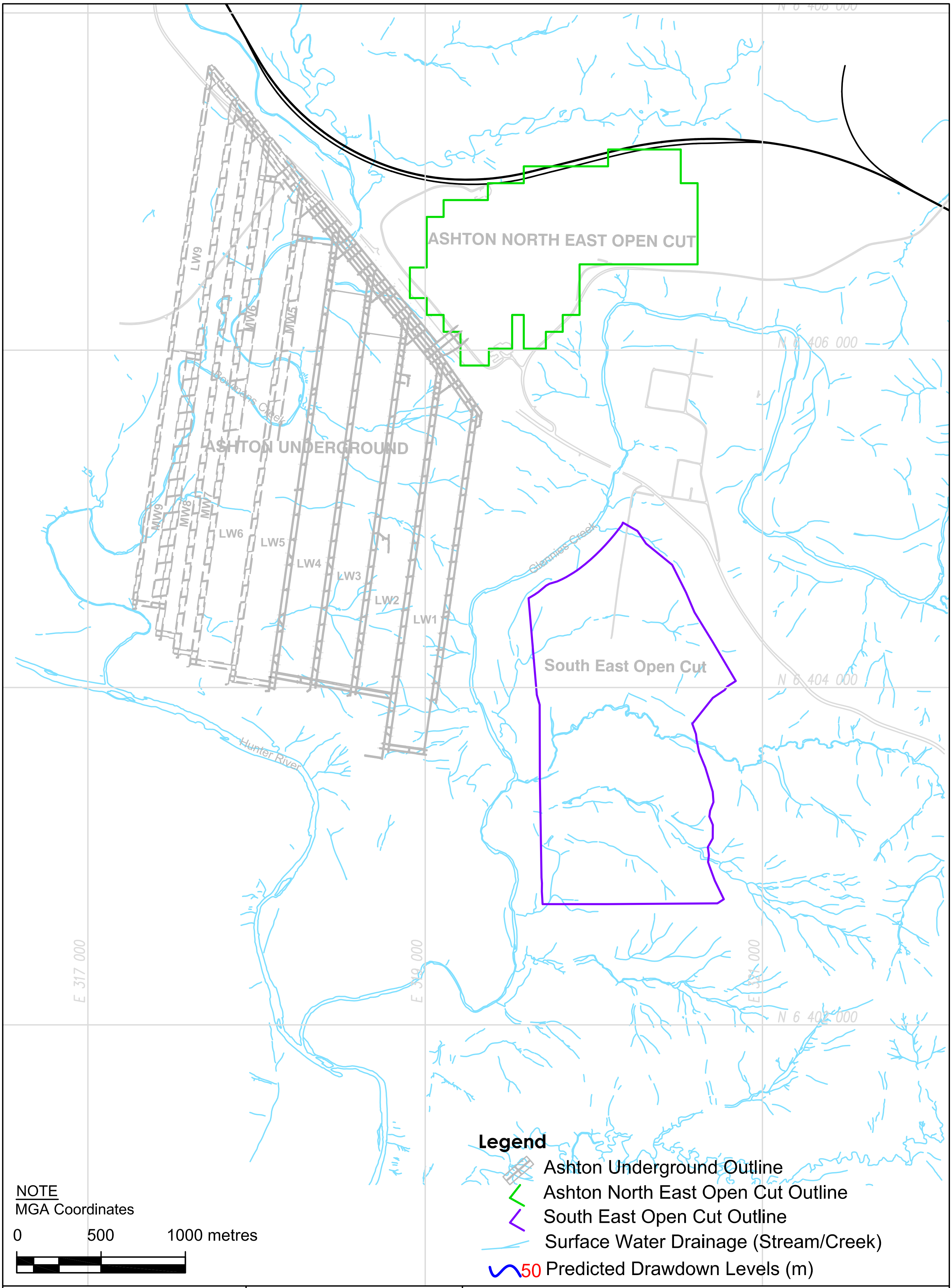
Date: 26 June 2009
Scale: As Shown
Initials: PZ
Job No: S36
Drawing No: S36-079b
Rev: B

aquaterra

Ashton Coal Operations Ltd

Predicted Drawdown Levels in Upper Hebdon to Lower Hebdon Seam after 7 Years Mining

Figure 6.11



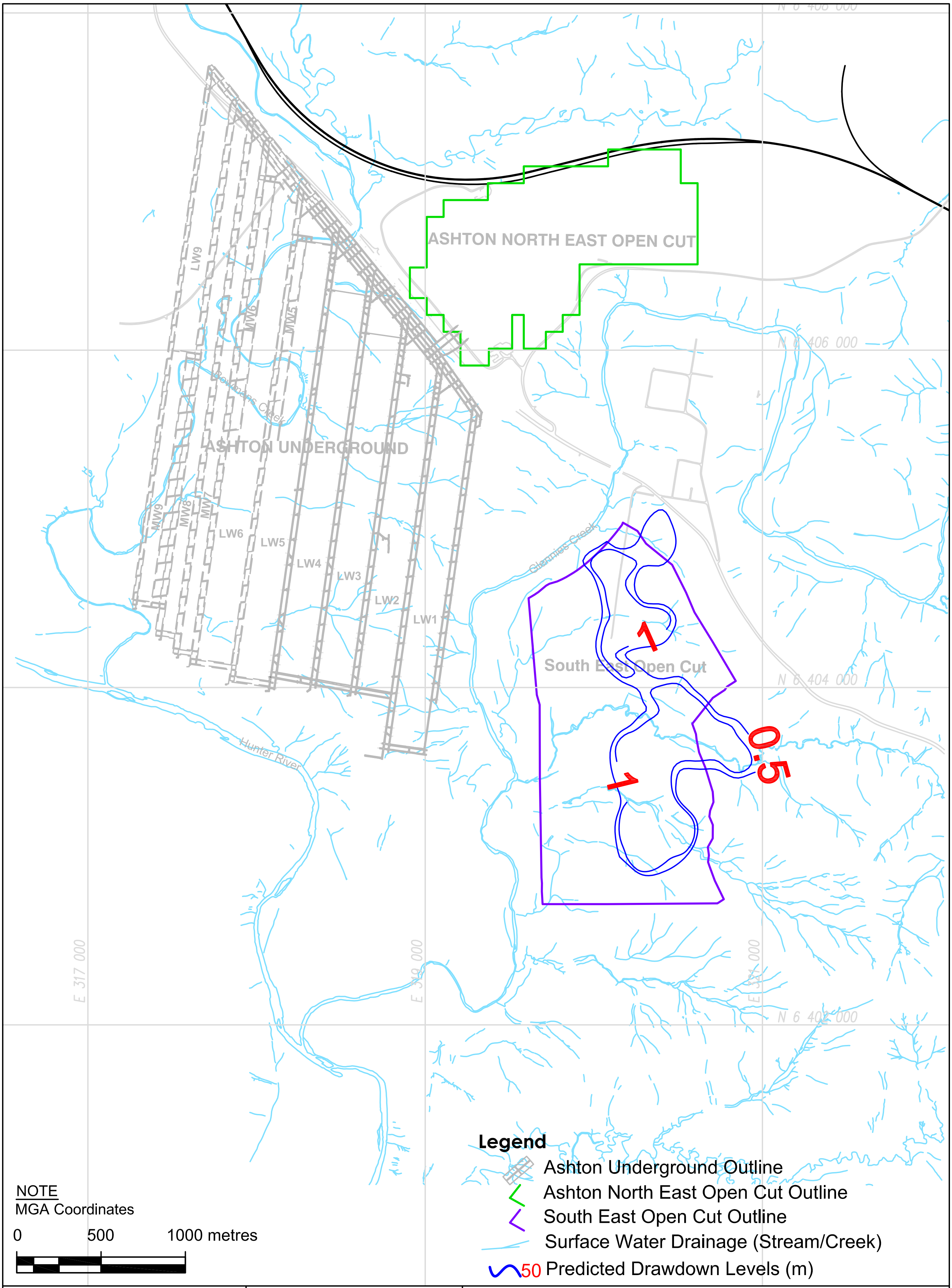
Date:	26 June 2009	Scale:	As Shown
Initials:	PZ	Job No:	S36
Drawing No:	S36-080a	Rev:	A

aquaterra

Ashton Coal Operations Ltd

Predicted Drawdown Levels in Alluvium after 107 Years

Figure 6.12



Date:	26 June 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**Predicted Drawdown Levels in Upper Lower Liddell Seam after 107 Years**
Drawing No:	S36-078a	Rev:	A	
aquaterra				**Figure 6.13**

7 POTENTIAL GROUNDWATER IMPACTS OF THE PROJECT

7.1 OVERVIEW OF POTENTIAL IMPACTS ON THE GROUNDWATER SYSTEM

Mining activities associated with the operation of SEOC will have some impact on the groundwater environment on a local scale and, to a more limited extent, regional scale. Potential impacts to the groundwater system may include the following aspects, each of which is discussed in further detail in the following sections:

- Groundwater level impacts
- Potential impacts on Glennies Creek alluvium and baseflow
- Groundwater quality impacts
- Potential impacts on groundwater users
- Potential impacts on Groundwater Dependant Ecosystems (GDE's).

The base case groundwater model (transient model) was designed to predict the impact from all three projects- NEOC, LW/MW 1-9 and SEOC - each operating concurrently. The NEOC, LW/MW 1-9 and SEOC are in sufficiently close proximity that some impacts of all three mines will mutually interfere. The base-case modelling therefore assessed the cumulative impacts of all three mines operating concurrently, and separated the impact from the SEOC as appropriate.

7.2 GROUNDWATER LEVEL IMPACTS

7.2.1 PREDICTED IMPACTS ON GROUNDWATER LEVELS IN PERMIAN COAL MEASURES

The most significant impacts to groundwater levels are predicted to occur within the Permian coal measures which, as the targeted resource, will undergo dewatering during mining activities. Drawdowns as a result of dewatering the coal measures within the SEOC are predicted to be contained within the project boundary.

7.2.2 PREDICTED IMPACTS ON GROUNDWATER LEVELS IN THE ALLUVIUM

Mining of the SEOC has the potential to influence groundwater levels within the alluvium sediments associated with Glennies Creek. The maximum drawdown in the Glennies Creek alluvium predicted by the model is less than 1.5m. Drawdown of this extent is limited to a small area near the pit shell where the alluvium is intercalated with colluvial sediments. Impacts on the alluvium nearer the Creek are much less, generally less than 0.5m. The predicted reduction in groundwater storage volume within the Glennies Creek alluvium is less than 3 %.

Although hydraulic connectivity between the alluvium and colluvium on the western side of the pit is limited, some water does flow through to the pit. Inflows from the alluvium to the pit on this western side are predicted to start in Year 3 of mining and then increase to a maximum of 24 m^3/d by year 7 of mining. However, flows from the Glennies Creek alluvium only constitute around 10-15% of the total groundwater flows that are predicted for the pit, with up to 200m^3/d entering the pit from the Permian aquifers and other superficial deposits.

As with baseflow impact assessments, impacts on saturated thickness and flows within the alluvium are transient, and will return to the pre-mining condition within 100 years of the end of mining. There is therefore no risk of stream capture or loss in the long term from this project.

7.3 POTENTIAL BASEFLOW IMPACTS ON GLENNIES CREEK

The reach of Glennies Creek next to the proposed SEOC site changes from a slightly gaining stream to a slightly loosing stream (i.e. water flows from the stream to the groundwater) during the SEOC mining period. Some of the impact is caused by other mines during the SEOC mining period, but the net predicted impact of the SEOC on baseflows in Glennies Creek is around 47m^3/d.

This impact is very small in relation to the flows in Glennies Creek, representing around 0.03% of the average flow. Because the Creek flows are regulated by upstream dams, the impact is still only 0.33% of the minimum 5 percentile sustained flow in this section of the creek. These impacts are transient and will recover back to pre-mining conditions within 100 years of the end of mining.

7.4 UNCERTAINTY IMPACT ASSESSMENTS

The key uncertainty in the impact of the SEOC on baseflows to Glennies Creek, and on inflows from the Glennies Creek alluvium to the mine pit relates to the hydraulic conductivity of the alluvium/colluvium between Glennies Creek and the western side of the SEOC. Pit inflows increase almost linearly with horizontal hydraulic conductivity, and baseflow changes are also significant in relation to this parameter. Detailed drilling investigations and a conservative assessment of kh have therefore been used to support the assessment of impacts contained within this report. Some uncertainty will remain, particularly if lenses of 'clean' alluvial gravels remain at or close to the western side of the pit shell. This is reflected in the recommended monitoring and mitigation contained in Sections 8 and 9.

7.5 GROUNDWATER QUALITY IMPACTS

The initial average water quality of mine inflows is expected to be a composite blend of the water qualities from any groundwater intercepted by the mine, however it is anticipated that groundwater quality will be dominated by the main inflow zones, i.e. from the various seams intersected and alluvium sediments. It is expected that there will be some variation in inflowing groundwater quality from year to year within each area as mining progresses. Initially, there is likely to be an increase in salinity as saline groundwater is intersected along the northern end of the mine footprint. Subsequently, salinity may reduce as the mine progresses towards the southern area, where the saturated thickness of alluvium increases, and there is some possible hydraulic connection with Glennies Creek alluvium.

Overall, the average quality of Permian groundwater (based on the conductivity of the main coal seam aquifers) collected within the pit during initial mining operations will be around 5,400 µS/cm. This compares with average alluvial/colluvial water quality of 4,400 µS/cm. This figure is reduced by the presence of alluvial samples taken closer to the creek, so the salinity in the colluvium in and around the pit is very similar to the Permian aquifers. Initial calculations for the long term post mining condition indicate that there should be a reasonable balance between rainfall, recharge and evaporation from the mine pit void and backfill material, so groundwater levels are likely to return to approximately pre-mining conditions. Flows from the pit area to the Glennies Creek alluvium should therefore be similar to pre-mining conditions. This, combined with the fact that the composite groundwater quality within the pit should be very similar to the colluvium/weathered overburden water table that it replaced, means that overall groundwater quality impacts during the post closure phase are expected to be minimal.

7.6 SURFACE WATER QUALITY

The reversal of hydraulic gradient within the alluvium, and hence the reduction in base flow to Glennies Creek, as a result of mining the SEOC, is expected to result in an overall reduction in salt load to the creek and thence to the Hunter River. In the long term, there may be some flow of water from the pit shell to the Creek as the pit void and overburden become saturated, but, as detailed above, this should cause a negligible difference in overall water quality.

7.7 POTENTIAL IMPACTS ON EXISTING GROUNDWATER USERS

A search of the DWE bore data base within the predicted impact zone has been conducted which has revealed no registered groundwater supply bores. The nearest registered water bore is located in Camberwell village, which will not be affected by the SEOC.

7.8 POTENTIAL IMPACTS ON GROUNDWATER DEPENDENT ECOSYSTEMS

Other than the impacts on the baseflow for Glennies Creek, as discussed previously, the only potential GDEs that have been identified are red gums adjacent to Glennies Creek. These are not expected to be affected by temporary reductions in water table level, as the small impacts predicted to occur will be in areas close to the pit and not adjacent to Glennies Creek where the red gums occur.

7.9 GROUNDWATER LICENSING

Mining activities will be undertaken beneath the current water table. Therefore groundwater extraction licences will be required prior to intersection of significant groundwater. A licence should be sought for the impacts on Glennies Creek and the Glennies Creek alluvium.

8 MONITORING AND MANAGEMENT

8.1 IMPACTS OF GROUNDWATER EXTRACTION / DEWATERING

It is recommended that all groundwater discharges be monitored closely through the project life. This would include recording the volume and quality of water discharged from the mine and/or pumped from dewatering, or open-cut sumps. It is also recommended that the current baseline monitoring program be continued, with a modified network of selected monitoring points determined prior to commencement of mining.

Data collected will enable the SEOC to establish and continually assess the impact mining activities have on the groundwater environment. Collection of these data will also enable continual periodic review of any observed impacts against those predicted during numerical modelling, and will allow further refinement of the Model as the mine develops.

It is recommended that the proposed project monitoring program includes recording of the following:

- Groundwater extraction volumes / rates – weekly totals from all open cut sumps.
- Groundwater discharge quality – monthly measurements on site of the EC and pH of water discharged from the mine and/or pumped from dewatering, or open-cut sumps
- Quarterly sampling of water discharged from the mine and/or pumped from dewatering bores, or open-cut sumps for comprehensive hydrochemical analysis as detailed in **Table 8.1.**
- Monthly manual monitoring or continuous automated monitoring of water levels from the network of monitoring bores
- Annual sampling of representative monitoring bores for laboratory analysis (as outlined in **Table 8.1**).

Table 8.1: Recommended Laboratory Analysis Suite for Groundwater Monitoring

Class	**Parameter**
Physical parameters	EC, TDS, TSS and pH
Major cations	calcium, magnesium, sodium and potassium
Major anions	carbonate, bicarbonate, sulphate and chloride
Dissolved metals	aluminium, arsenic, boron, cobalt, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, selenium, zinc
Nutrients	ammonia, nitrate, phosphorus, reactive phosphorus
Others	Fluoride, cyanide

8.2 REVIEW AND REPORTING

The above monitoring data should be subjected to an annual review by an approved experienced Hydrogeologist to assess the impacts of the project on the groundwater resources, and compare impacts with the groundwater model predictions. It is also recommended that two years after commencement of coal production, a modelling post-audit be carried out, in accordance with industry best-practice (MDBC, 2001), and if necessary the model be re-calibrated and confirmatory forward predictions made at that time. Further post-audits should be carried out during the fourth or fifth year of mining, as this represents the most vulnerable time in relation to potential inflows from Glennies Creek.

Should any review or post-audit indicate a significant variance from the model predictions with respect to either water quality or groundwater levels, then the implications of such variance should be assessed, and appropriate response actions should be implemented in consultation with DWE, Department of Primary Industries (DPI) and Department of Environment and Climate Change (DEC) as appropriate.

It is strongly recommended that the monitoring program be part of an integrated monitoring program with the nearby Ashton underground and NEOC projects.

9 CONTINGENCY RESPONSE PLANS

9.1 RECOMMENDATION FOR DEVELOPMENT OF RESPONSE PLANS

It is recommended that a response program be adopted for implementation in the event of unforeseen adverse impacts on either groundwater or surface water from the SEOC. The response plans would be in accordance with those outlined in the Groundwater Management Plan developed (Ashton, 2009).

The sections below detail the proposed approach for the management of groundwater levels and water quality outlining the criteria by which each would be assessed in order to determine the need to implement mitigation actions as outlined in the response plans. It should be noted that, as groundwater levels and quality will naturally vary over time, the setting of specific trigger-levels, for either quality parameters or water-levels, is not considered practical. For example, water levels will vary considerably across the area of the SEOC in response to natural climatic variations and recharge patterns, and due to the impacts of neighbouring mining projects. Likewise seasonal variations in water quality as a result of varying rates of recharge will occur.

It is recommended that the assessment is made based on the variation of levels and quality parameters from their recorded baseline range, combined with the recorded variation from predicted impacts (for those bores within the zone of influence of dewatering).

Trigger levels will be set, for selected sites, to be applied during the initial stage of mine construction and Mining Years 1 to 3, after which time all trigger levels will be reviewed with reference to the baseline data records available at that time, and revised as appropriate through consultation with the Department of Water and Energy.

9.1.1 WATER LEVELS

In the event that groundwater level drawdowns exceed predicted drawdowns by 20% or more for any consecutive three month period, then the monitoring data should immediately be referred to an approved Hydrogeologist for review. The reviewer should assess the data to establish the nature of the exceedence and the reasons for it, and should recommend an appropriate response action plan for implementation in consultation with DWE. The response action may involve one or more of the following:

- Modification to the mining plan, if appropriate
- Continuation of mining, with closer monitoring
- No change to the operations.

9.1.2 PIT INFLOWS

It is recommended that the volume of pit inflows during dry periods should be periodically assessed (at least twice per year), particularly on the western side of the pit. If dry weather inflows exceed anticipated inflows on the western side by more than 50%, then the data should immediately be referred to an approved Hydrogeologist for review, with outcomes and response plans as described for water levels above.

The staged mine plan allows time to implement mitigation measures should the inflows be higher than anticipated. Potential mitigation measures include construction of a low permeability cut-off wall, possibly comprising bentonite or natural clays emplaced in a trench keyed into the underlying low permeability Permian rocks. Such a trench would not be required at the start of mining as the northern section of the proposed mine does not intersect saturated unconsolidated sediments.

9.1.3 GROUNDWATER QUALITY

Salinity decreases noted in either the i) alluvium monitoring bores, ii) mine inflows or iii) dewatering discharge, would suggest dewatering impacts to Glennies Creek Alluvium. The response plan in the current GWM plan doesn't make reference to such salinity triggers, associated with SEOC and hence the GWMP will therefore be updated to account for such triggers.

Should the water quality of the monitoring piezometers (alluvium) mine inflows or dewatering discharge indicate an decrease in salinity of more than 50% from base line levels, it is recommended that the nature of the decrease and all relevant monitoring data be provided to an approved experienced Hydrogeologist for review and assessment of the impact of on the environment.

If remedial action is recommended by the reviewer on the basis of the changes in water quality, the recommended action will be implemented in consultation with DWE, DPI and DECC as appropriate.

It is envisaged that the remedial action may include one or more of the following:

- Modification to the mining plan, if appropriate
- Continuation of mining, with closer monitoring
- No change to the operations.

10 SUMMARY AND CONCLUSIONS

The Ashton Coal Project, located 14km west of Singleton in the Hunter Valley region, currently consists of both open cut and underground mining operations to access a series of coal seams within the Permian Foybrook Formation.

Ashton Coal Operations P/L (ACOL) seeks approval for the construction and operation a new open cut pit, the South East Open Cut, and associated facilities. The SEOC is located east of the Glennies Creek, and south of the New England Highway and will produce up to 3.6 Mtpa ROM coal.

Environmental studies have identified key environmental planning issues concerning possible impacts to groundwater, including those to the Glennies Creek Alluvium, which have been addressed in this report.

Groundwater and surface water interaction with Glennies Creek alluvium is a key environmental issue for this project. Gaining an understanding of the extent and hydraulic properties of the alluvium was an important part of the investigations carried out for this project. These investigations showed that potential hydraulic connection with Glennies Creek along the southern extent of the western SEOC pit wall has the potential to remove some water from the creek due to lowering of water tables in the alluvium and underlying rock strata. Groundwater studies have therefore quantified the amount of water which may be removed from Glennies Creek due to mining activities.

Dewatering outside of the pit shell is not considered necessary for this project, so has not been assessed in this report.

10.1 GROUNDWATER INVESTIGATIONS AND FINDINGS

Investigations comprised drilling of over 60 bores, along with water quality sampling and hydraulic testing. Drilling revealed unconsolidated materials above the Permian coal measures extending eastwards from the creek into the proposed mining area. These unconsolidated clays, silts, sands and gravels include alluvium associated with the current Glennies Creek, as well as older alluvium and colluvium that are not associated with the current Glennies Creek.

Due to elevated basement in the north of SEOC pit, the unconsolidated sediments are dry. In the central section, saturated unconsolidated sediments extend inside the proposed SEOC pit boundary.

The alluvium sediments associated with Glennies Creek occur on the lower terrace adjacent to the creek, and then merge into older unconnected alluvium and colluvium to the east. Hydraulic testing in the unconsolidated alluvial sediments revealed highly variable hydraulic conductivity (permeability), ranging from 0.01 to over 100 m/d. This reflects both the highly variable nature of the alluvium, and in particular the variable nature of the sand and gravel layer that lies towards the base of the alluvial deposits and makes up most of the permeability. In many areas these sands and gravels are very poorly sorted, with considerable clay and silt content, and high permeability only occurs where the sands and gravel are ‘clean’. The geometric mean permeability is much lower than the arithmetic mean, which reflects the highly variable nature of the alluvium and indicates that the permeable zones are relatively small and discontinuous.

Hydraulic connection between the alluvium and the colluvium to the east appears to be poor, and is shown by a very marked increase in salinity away from the connected alluvium, as discussed below. The demarcation between the connected saturated alluvium associated with Glennies Creek, and the alluvium/colluvium of the upper terrace and eastern slopes, is difficult to define from drilling results alone, as the drilling disturbance causes the sand and gravel material from both sources to have a similar composition and appearance.

This boundary was initially assessed using a combination of aerial photography, ground mapping, and hydraulic conductivity properties of the sediments, and ultimately was based primarily on the basis of groundwater salinity. Further investigations were then carried out to examine the extent and nature of the more permeable zones that were encountered in the lower alluvium. Some zones of higher permeability were encountered within the alluvium, which appear to be associated with paleo- surface drainage and paleo-geomorphological factors that existed during and after the deposition of the alluvium, but are not related to the present surface drainage.

Groundwater chemistry was also used to help define boundaries and differences in the hydrogeology of the alluvium. In particular it was found that salinity contours generally provided a good indication of the transition from alluvium to colluvium. Groundwater salinity increases sharply (up to 15,000 µS/cm EC) away from Glennies Creek, reflecting the transition from highly permeable, connected alluvium beneath the lower terrace levels, to poorly permeable colluvium and unconnected alluvium on the flanks of the flood plain.

The findings of the studies were used to provide a site specific assessment of hydraulic conductivity within the unconsolidated sediments, and identify the boundary between the 'connected' alluvium of Glennies Creek and the poorly connected alluvium/colluvium to the east. In general it was found that the 3,000 µS/cm EC contour represented a good demarcation of the boundary of the hydraulically connected Glennies Creek alluvium. The only exception to this was an area just to the north of Mrs Bowman's farmhouse, where unusually low EC values were found to extend further to the east than elsewhere in the alluvium. In this area the boundary is marked by the edge of the higher permeability basal sand/gravel layer (west of borehole AP244, around 100m west of the proposed SEOC pit shell).

10.2 PREDICTED GROUNDWATER IMPACTS

Potential impacts of the proposed SEOC on groundwater and surface water resources, groundwater and surface water quality, groundwater dependent ecosystems and other groundwater users, were determined on the basis of groundwater modelling.

A transient groundwater flow model was designed to predict the cumulative impacts from all three Ashton mines – NEOC, Underground and SEOC, each operating concurrently in accordance with their respective mine plans. The model predictions were made using assessed parameters from investigations undertaken onsite. This included a complex, conservative representation of the hydraulic conductivity of the alluvium, including zones of high permeability and a general demarcation between the connected Glennies Creek alluvium and the alluvium/colluvium to the east.

During the mining of SEOC, the maximum drawdown in the Glennies Creek alluvium predicted by the model is 1.5m. This maximum drawdown would occur in a localised area on the western margin of the SEOC where there is a basement low and where saturated thickness of alluvium/colluvial sediments is greatest. The majority of the alluvium should experience dawdowns of 0.5m or less, and the overall reduction in saturated storage within the alluvium is only 3%.

The lowering of groundwater levels in the alluvium and other unconsolidated materials will result in some reduction in baseflow to Glennies Creek. The net predicted impact of the SEOC on baseflows in Glennies Creek is around 0.5 L/s (0.047 ML/d). This causes the Creek to change from a marginally gaining to a marginally losing stream in this reach. This impact is very small in relation to the flows in Glennies Creek, representing around 0.03% of the average flow. Because the Creek flows are regulated by upstream dams, the impact is still only 0.33% of the minimum 5 percentile sustained flow in this section of the creek. These impacts are transient and will recover back to pre-mining conditions within 100 years of the end of mining.

The most significant impacts to groundwater levels are predicted to occur within the Permian coal measures, which will be dewatered during mining. The extent of predicted drawdowns as a result of dewatering the coal measures within the SEOC is generally contained within the project boundary.

Although hydraulic connectivity between the alluvium and colluvium on the western side of the pit is limited, some water does flow through to the pit. Inflows from the alluvium to the pit on this western side are predicted to start in Year 3 of mining and then increase to a maximum of 24 m^3/d by year 7 of mining. However, flows from the Glennies Creek alluvium only constitute around 10-15% of the total groundwater flows that are predicted for the pit, with up to 200m^3/d entering the pit from recharge to the backfill material, the Permian strata and other superficial deposits.

Post mining, water levels within the alluvium are expected to return to pre-mining levels within 100 years. Some minor residual impacts (<1m) may remain within the Permian coal seams, but this will have a negligible impact on surface water tables or river baseflows. There is therefore no long term risk of stream capture or significant loss from this project.

Because groundwater flows will be towards the pit, no groundwater quality impacts are expected on aquifers outside of the pit shell during operation. There is little difference between average composite groundwater quality within the Permian strata, and the quality of the water table aquifers in the pit area. This, and the fact that the long term post mining flow regime should be very similar to pre-mining conditions, mean that little long term impacts on water quality from the pit should be minimal.

One licensed bore exists within Camberwell village, north of the New England Highway, and about 1km north of the SEOC. The bore intercepts alluvium and is not expected to be impacted by the proposed mining of the SEOC. There are no other known licensed or unlicensed groundwater production bores within the predicted zone of influence.

10.3 MONITORING AND CONTINGENCY PLANS

Monitoring of groundwater levels, pit inflows and groundwater quality is recommended, as detailed in **Section 8** of this report. Because of the risk that may exist to Glennies Creek and its alluvium, a contingency/response plan that includes trigger values, procedures for review and the derivation of appropriate response action plans has been included in Section 9 of this report. This includes a recommendation for modelling post audits following the second and fourth years of the mine programme.

The staged mine plan allows time to implement mitigation measures should the inflows be higher than anticipated. Potential mitigation measures include construction of a low permeability cut-off wall, possibly comprising bentonite or natural clays emplaced in a trench keyed into the underlying low permeability Permian rocks. Such a trench would not be required at the start of mining as the northern section of the proposed mine does not intersect saturated unconsolidated sediments.

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APPENDIX A1 SUMMARY OF PIEZOMETERS AND EXPLORATION HOLES

Glennies Creek Piezometer and exploration holes details

Bore	Ground Level (m AHD)	Drilled Depth (m bgl)	Screened Interval (m bgl)	Aquifer Screened	Current Status	Water Level (Nov 08 - May 09)		EC (Nov 08 – May 09) µS/cm
						m bgl	m AHD	
WML119	61.12	27	18-21	PG seam	Piezometer	10.9	50.22	
WML120A	60.27	18	12-15	PG seam	Piezometer	9.87	50.4	
WML120B	60.01	8.5	5.5-8.5	Alluvium	Piezometer	8.03	51.98	
WML129	54.94	9.5	7-9.5	Alluvium	Piezometer	4.19	50.75	
WML144	59.26	98m +	VW 26m	ULD seam	VW Piezometer		51.16	
			VW 32m	ML1 seam			49.98	
			VW 45m	ML2 seam			49.96	
			VW 50m	ULLD seam			51.6	
			VW 58m	LLLD seam			49.74	
			VW 81m	UB seam			51.19	
			VW 98m	LB seam			51.42	
WML145	60.29	8.80		Alluvium	Cemented, abandoned	7.51	52.78	
WML146	59.15	7.40		Alluvium	Cemented, abandoned	6.76	50.39	
WML147	60.65	9.00		Alluvium	Cemented, abandoned	-	-	
WML148	59.74	8.00		Alluvium	Cemented, abandoned	7.39	52.39	3340
WML149	61.67	7.65		Alluvium	Cemented, abandoned	-	-	
WML150	60.87	6.65		Alluvium	Cemented, abandoned	-	-	
WML151	63.15	8.00		Alluvium	Cemented, abandoned	-	-	
WML152	63.29	5.00		Alluvium	Cemented, abandoned	-	-	
WML153	61.67	8.80		Alluvium	Cemented, abandoned	-	-	
WML154	61.14	8.40		Alluvium	Cemented, abandoned	-	-	
WML155	58.83	6.40		Alluvium	Cemented, abandoned	6.33	52.5	1160
WML156	61.19	8.40		Alluvium	Cemented, abandoned	-	-	
WML157	61.22	8.40		Alluvium	Cemented, abandoned	8.73	52.49	701
WML158	61.1	8.40		Alluvium	Cemented, abandoned	8.61	52.54	745
WML159	62.59	8.40		Alluvium	Cemented, abandoned	-	-	
WML160	63.16	6.66		Alluvium	Cemented, abandoned	-	-	
WML161	62.73	7.40		Alluvium	Cemented, abandoned	-	-	
WML162	63.54	8.80		Alluvium	Cemented, abandoned	-	-	
WML163	64.72	8.40		Alluvium	Cemented, abandoned	-	-	
WML164	65.15	5.70		Alluvium	Cemented, abandoned	-	-	
WML165	58.49	5.70		Alluvium	Cemented, abandoned			
WML166	56.54	5.00		Alluvium	Cemented, abandoned	4.32	52.59	

Bore	Ground Level (m AHD)	Drilled Depth (m bgl)	Screened Interval (m bgl)	Aquifer Screened	Current Status	Water Level (Nov 08 - May 09)		EC (Nov 08 – May 09) µS/cm
						m bgl	m AHD	
WML167	59.26	7.40		Alluvium	Cemented, abandoned	7.06	52.54	
WML168	60.62	6.40		Alluvium	Cemented, abandoned			
WML169	61.45	8.00		Alluvium	Cemented, abandoned			
WML237	61.246	11	-	Alluvium	Uncased, abandoned	9.5	51.75	
WML238	62.549	10	-	Alluvium	Uncased, abandoned	-		
WML239	60.142	13.5	-	Alluvium	Piezometer	8	52.14	1000
WML240	58.816	11	8-11	Alluvium	Piezometer	7.5	51.36	1660
WML241	57.831	14.5	11.5-14.5	Alluvium	Piezometer	8.1	49.7	829
WML242	59.649	12	-	Alluvium	Uncased, abandoned	7	52.65	
WML243	59.055	15	12-15	Alluvium	Piezometer	6.97	52.09	5570
WML244	60.392	12	-	Alluvium	Uncased, abandoned	10	50.39	
WML245	65.642	101	VW 55m	ULD seam	VW Piezometer	29.49	36.15	
			VW 65m	MLD seam		24.19	41.45	
			WV 70m	UB seam		27.76	37.89	
			WV 110m	LB-Heb interburden		30.06	35.59	
WML246	64.885	10	7 – 10	Alluvium	Piezometer	-	-	
WML247	63.361	13	10 – 13	Alluvium	Piezometer	-	-	14200
WML248	60.571	9	-	Alluvium	Uncased, abandoned	8.2	52.37	18400
WML249	62.316	13	10 – 13	Alluvium	Piezometer	10.23	51.08	15300
WML250	60.444	11	8 –11	Alluvium	Uncased, abandoned	7.8	52.64	1200
WML251	62.91	13	10 –13	Alluvium	Uncased, abandoned	-	-	
WML252	60.242	10.9	7.9 –10.9	Alluvium	Piezometer			4710
WML253	60.164	12.5	9.5 –12.5	Alluvium	Piezometer			345
WML254	59.802	11	-	Alluvium	Uncased, abandoned			
WML255		8.15	-	Alluvium	Uncased, abandoned	-	-	
WML256		7.55	4.5 – 7.5	Alluvium	Piezometer	4.65		2550
WML257		8.8	-	Alluvium	Uncased, abandoned	-	-	
WML258		5.2	-	Alluvium	Uncased, abandoned		-	
WML259		10.4	-	Alluvium	Uncased, abandoned	-	-	
WML260		8.8	-	Alluvium	Uncased, abandoned	-	-	
WML261		4.4	-	Alluvium	Uncased, abandoned	-	-	
WML251A	62.746	6	-	Alluvium	Uncased, abandoned	dry	-	
WML262	61.94	6	-	Alluvium	Uncased, abandoned	dry	-	
WML263	*61.5*	9	-	Alluvium	Uncased, abandoned	dry	-	

Bore	**Ground Level (m AHD)**	**Drilled Depth (m bgl)**	**Screened Interval (m bgl)**	**Aquifer Screened**	**Current Status**	**Water Level (Nov 08 - May 09)**		**EC (Nov 08 – May 09) µS/cm**
						m bgl	**m AHD**	
WML264	*61*	10	-	Alluvium	Uncased, abandoned	8.02	*52.98*	
WML265	60.688	9	-	Alluvium	Uncased, abandoned	7.98	52.7	16000
WML266	60.267	10	-	Alluvium	Uncased, abandoned	8.15	52.12	15200
WML267	59.634	9	-	Alluvium	Uncased, abandoned	?	-	
WML268	60.499	6	-	Alluvium	Uncased, abandoned	dry	-	
WML269	60.503	10	-	Alluvium	Uncased, abandoned	dry	-	
WML270	60.538	7.5	-	Alluvium	Uncased, abandoned		-	
WML271	60.673	9	-	Alluvium	Uncased, abandoned	dry	-	
WML272	60.863	4	-	Alluvium	Uncased, abandoned	dry	-	
WML273	60.509	11	-	Alluvium	Uncased, abandoned	7.1	53.4	9600
WML274	60.814	6	-	Alluvium	Uncased, abandoned	dry	-	
WML275	*61*	9	-	Alluvium	Uncased, abandoned	dry	-	
WML276A	61.798	11	-	Alluvium	Uncased, abandoned	9	*52.8*	13560
WML277	58.971	8.5	-	Alluvium	Uncased, abandoned		-	
WML278	62.335	3	-	Alluvium	Uncased, abandoned	dry	-	
WML279	62.694	6	-	Alluvium	Uncased, abandoned	dry	-	
WML280	62.457	9	-	Alluvium	Uncased, abandoned	dry	-	
WML281	62.599	8.5	-	Alluvium	Uncased, abandoned	dry	-	
WML282	63.322	9	-	Alluvium	Uncased, abandoned		-	
WML283	60.714	9.5	-	Alluvium	Uncased, abandoned		-	
WML284	*60.3*	10.5	-	Alluvium	Uncased, abandoned	7.56	*52.7*	1287
WML285	60.044	11	-	Alluvium	Uncased, abandoned	7.86	52.18	1100
WML286	59.962	10	-	Alluvium	Uncased, abandoned	7.82	52.14	
WML287	60.085	8	-	Alluvium	Uncased, abandoned	?	-	
WML288	59.737	8	-	Alluvium	Uncased, abandoned	?	-	
WML289	60.044	9	-	Alluvium	Uncased, abandoned	dry	-	
WML290	60.026	8	-	Alluvium	Uncased, abandoned	dry	-	
WML291	*59.65*	8	-	Alluvium	Uncased, abandoned	collapsed	-	1513
WML292	-	10	-	Alluvium	Uncased, abandoned	dry	-	
WML293	-	9	-	Alluvium	Uncased, abandoned	5.16		14500
WML294	-	11	8 - 11	Alluvium	Piezometer	5.58		11070
AP242	-	17.3	9.3 - 11.3	Alluvium	Test Production Bore	7.83	-	1045
AP243	-	10.7	7.3 - 10.3	Alluvium	Piezometer	6.99	-	1938
AP244	-	7.8	5.8 - 7.8	Alluvium	Piezometer	5.28	-	705

Bore	Ground Level (m AHD)	Drilled Depth (m bgl)	Screened Interval (m bgl)	Aquifer Screened	Current Status	Water Level (Nov 08 - May 09)		EC (Nov 08 – May 09)
						m bgl	m AHD	µS/cm
AP245	-	6	3.94 - 5.94	Alluvium	Piezometer	6.12	-	2500
AP246	-	11	7.9 - 10.9	Alluvium	Test Production Bore	7.9	-	5250
AP247	-	11	8 - 11	Alluvium	Test Production Bore	8.4	-	6080

52.7 Inferred elevation

APPENDIX A2 PIEZOMETER AND EXPLORATION HOLE CONSTRUCTION LOGS

Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: AP242

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

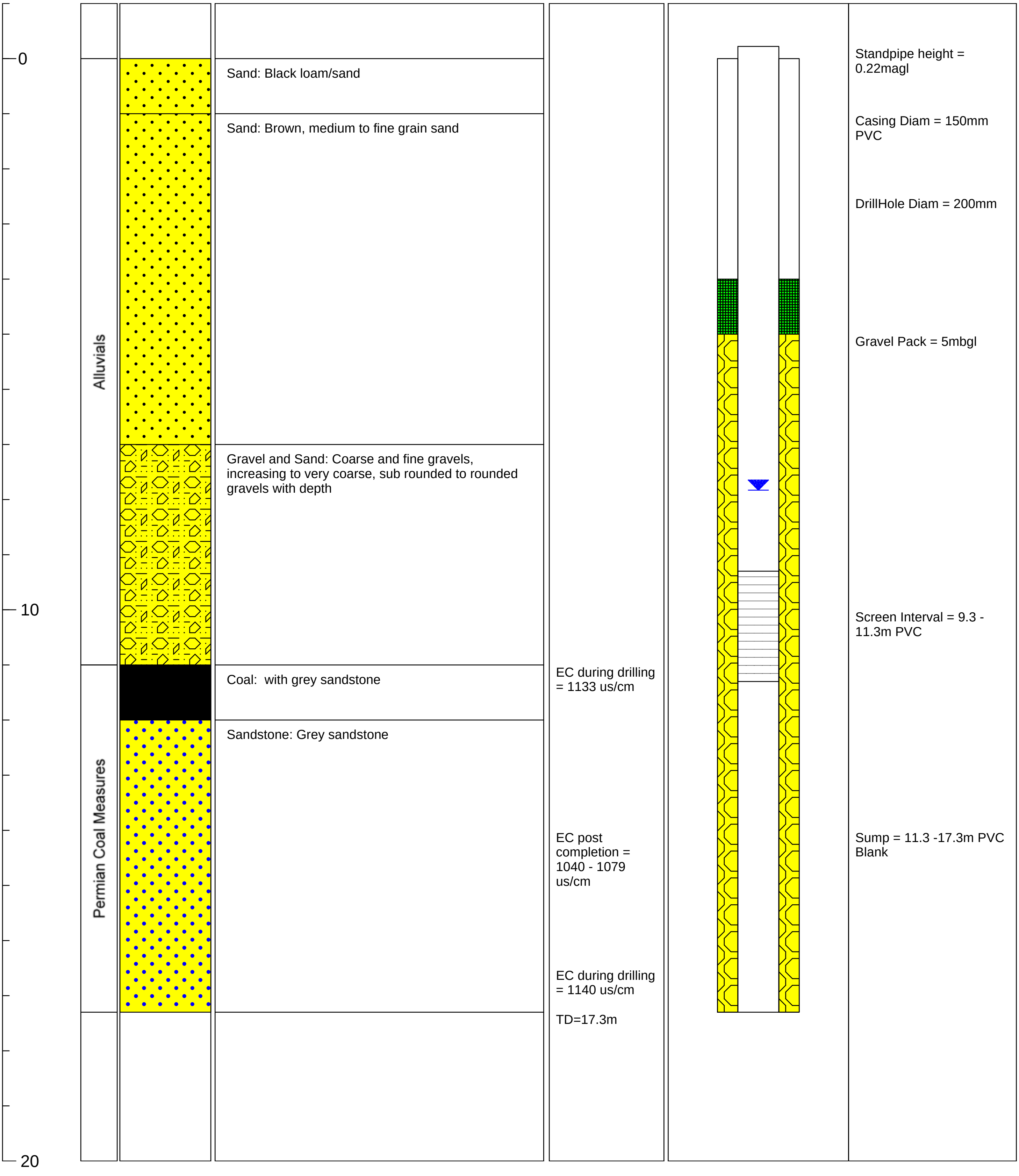
Commenced: 29/04/2009
Completed: 29/04/2009
Drilled: Hunter Drilling
Logged By: JVDA

Method: Rotary Air
Fluid: Air / Foam
Bit Record:

Area:
East: 319455
North: 6404320
Collar (RL):

Static Water Level: 7.83mbgl
Date: 29/04/2009

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Sand: Black loam/sand

Sand: Brown, medium to fine grain sand

Gravel and Sand: Coarse and fine gravels, increasing to very coarse, sub rounded to rounded gravels with depth

Coal: with grey sandstone

Sandstone: Grey sandstone

EC during drilling = 1133 us/cm

EC post completion = 1040 - 1079 us/cm

EC during drilling = 1140 us/cm

TD=17.3m

Standpipe height = 0.22magl

Casing Diam = 150mm PVC

DrillHole Diam = 200mm

Gravel Pack = 5mbgl

Screen Interval = 9.3 - 11.3m PVC

Sump = 11.3 -17.3m PVC Blank

aquaterra

Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: AP243

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

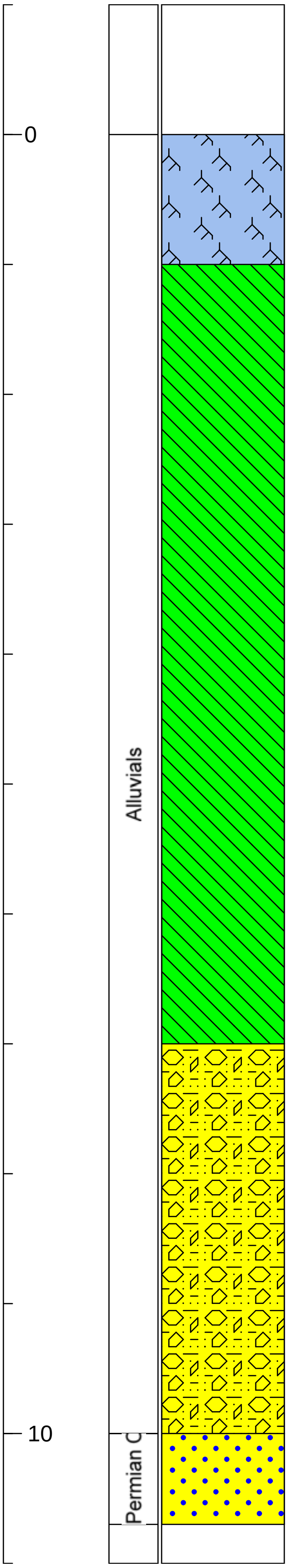
Commenced: 05/05/2009
Completed: 05/05/2009
Drilled: Hunter Drilling
Logged By: JVDA

Method: Rotary Air
Fluid: Air / Foam
Bit Record:

Area:
East: 319592
North: 6403473
Collar (RL):

Static Water Level: 6.99mbgl
Date: 05/05/2009

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Topsoil: Dark brown loam topsoil

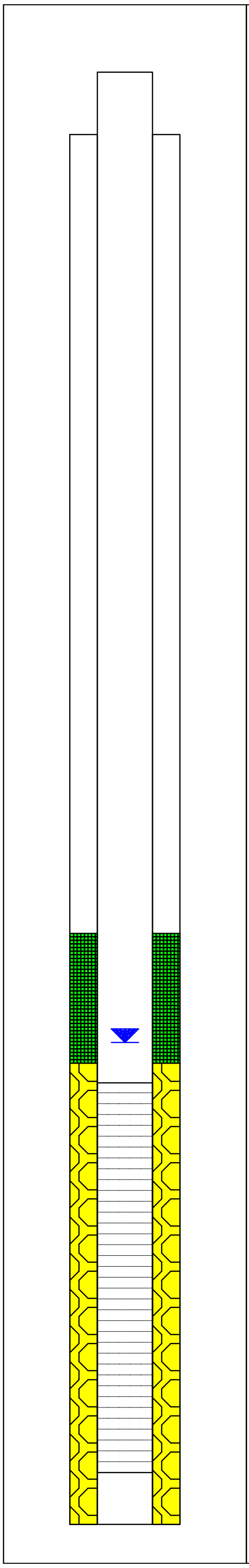
Clay: Brown silty clays

Gravel and Sand: Coarse and gravels, gravels are sub rounded > 15mm in size, well sorted

Sandstone: Grey sandstone, with coal at 10.7

EC post completion = 1856 - 2000 us/cm

TD=10.7m



Standpipe height = 0.48magl

Casing Diam = 50mm PVC

DrillHole Diam = 200mm

Gravel Pack = 7.15mbgl

Screen Interval = 7.3 - 10.3m PVC

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: AP244

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

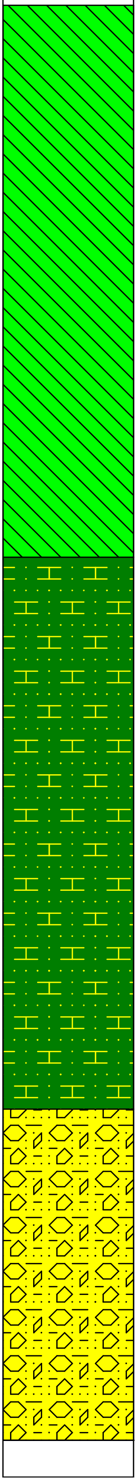
Commenced: 06/05/2009
Completed: 06/05/2009
Drilled: Hunter Drilling
Logged By: JVDA

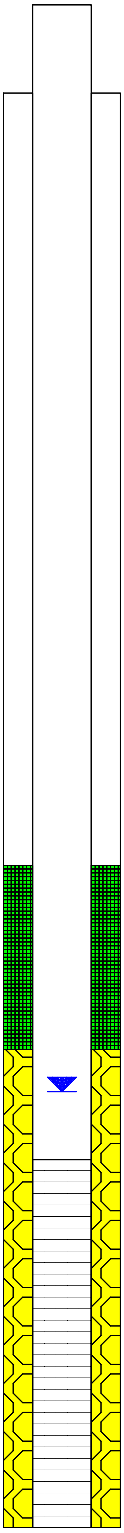
Method: Rotary Air
Fluid: Air / Foam
Bit Record:

Area:
East: 319662
North: 6403472
Collar (RL):

Static Water Level: 5.43mbgl
Date: 06/05/2009

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion Diagram**	**Well Completion Notes**
0	Alluvials		Clay: Dark brown clay			Standpipe height = 0.37magl
			Clay and Silt: Silty clays, brown with some medium gravels, sub rounded to sub angular			Casing Diam = 50mm PVC
			Gravel and Sand: Coarse sands to medium gravels, sub rounded to sub angular			DrillHole Diam = 200mm
			Sandstone: at 7.8m	TD=7.8m		Gravel Pack = 5.2mbgl
						Screen Interval = 5.8 - 7.8m PVC





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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: AP245

Client: Ashton Coal Operations Ltd **Project:** South East Open Cut

Commenced: 08/05/2009
Completed: 08/05/2009
Drilled: Hunter Drilling
Logged By: JVDA

Method: Rotary Air
Fluid: Air / Foam
Bit Record:

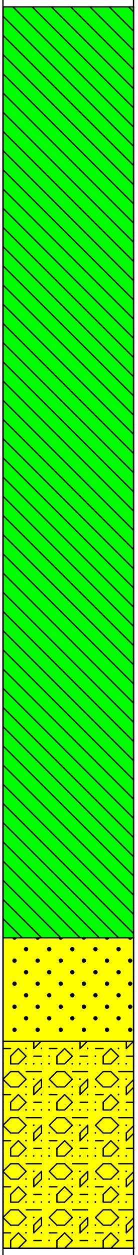
Area:
East: 319724
North: 6403483
Collar (RL):

Static Water Level: 5.76mbgl **Date:** 08/05/2009

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes

0

Alluvials



Clay: Silty dark brown clay

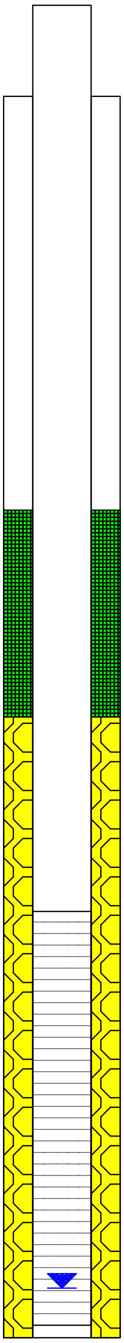
Sand: Coarse sand and some coarse gravels, sub angular to sub round

Gravel and Sand: medium to coarse sands and fine gravels (60% sand : 40% gravel)

Sandstone: between 5.5 and 6m

EC post completion = 2200 us/cm

TD=6.0m



Standpipe height = 0.44magl

Casing Diam = 50mm PVC

DrillHole Diam = 200mm

Gravel Pack = 3mbgl

Screen Interval = 3.94 - 5.94m PVC

Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: AP246

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

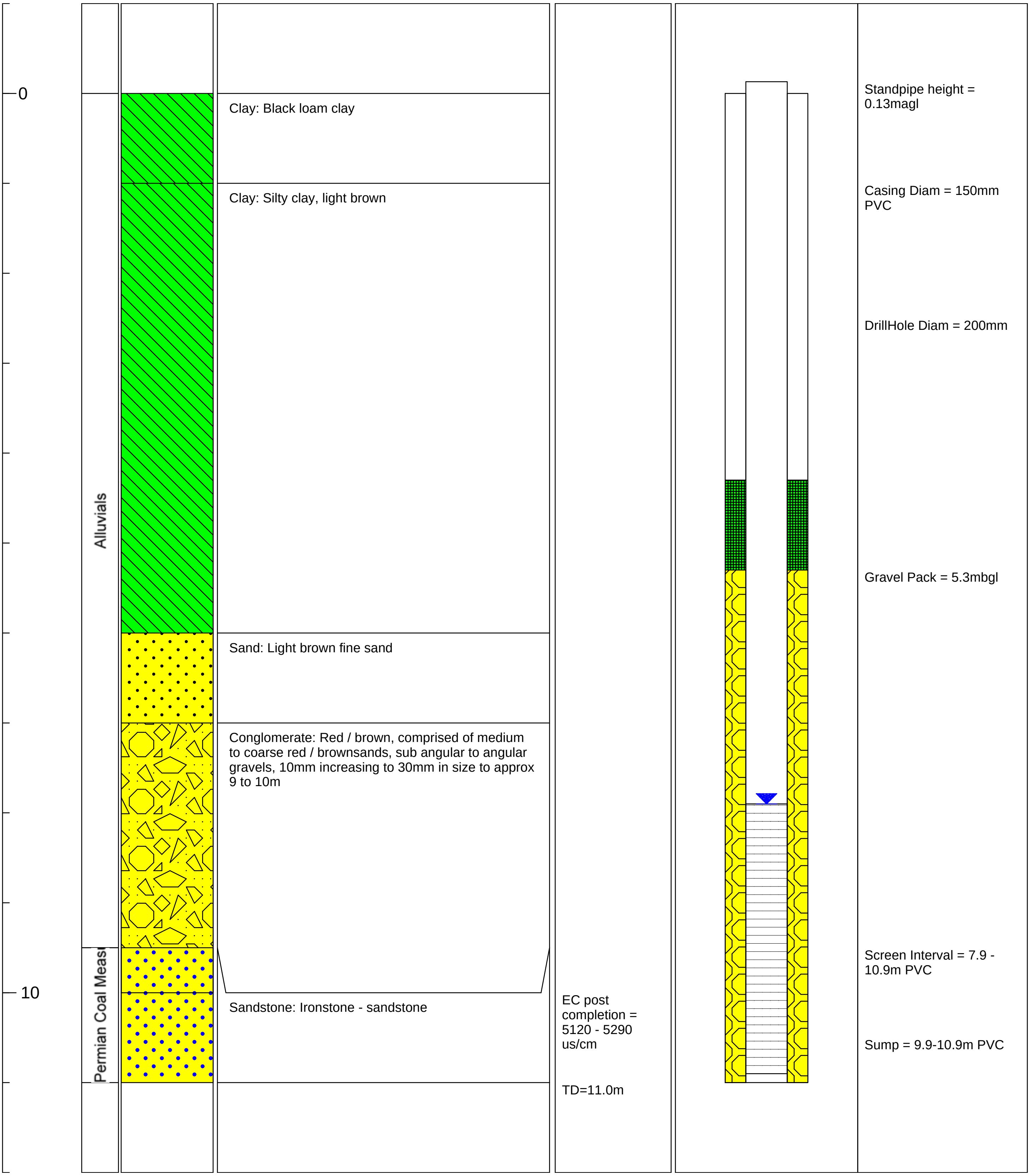
Commenced: 12/05/2009
Completed: 12/05/2009
Drilled: Hunter Drilling
Logged By: JVDA

Method: Rotary Air
Fluid: Air / Foam
Bit Record:

Area:
East: 319647
North: 6403249
Collar (RL):

Static Water Level: 7.9mbgl
Date: 12/05/2009

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay: Black loam clay

Clay: Silty clay, light brown

Sand: Light brown fine sand

Conglomerate: Red / brown, comprised of medium to coarse red / brownsands, sub angular to angular gravels, 10mm increasing to 30mm in size to approx 9 to 10m

Sandstone: Ironstone - sandstone

EC post completion = 5120 - 5290 us/cm

TD=11.0m

Standpipe height = 0.13magl

Casing Diam = 150mm PVC

DrillHole Diam = 200mm

Gravel Pack = 5.3mbgl

Screen Interval = 7.9 - 10.9m PVC

Sump = 9.9-10.9m PVC

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: AP247

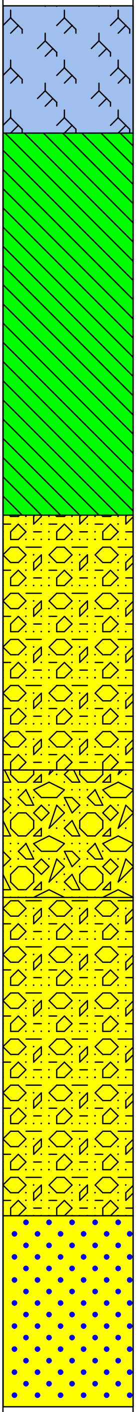
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

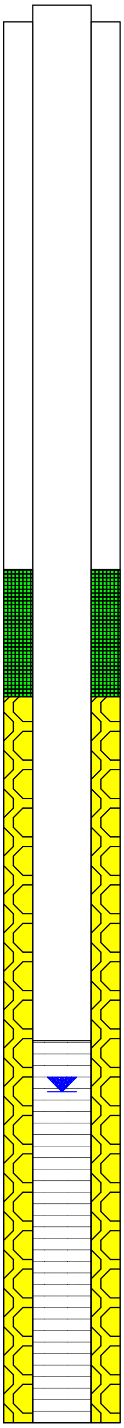
Commenced: 14/05/2009
Completed: 14/05/2009
Drilled: Hunter Drilling
Logged By: JVDA

Method: Rotary Air
Fluid: Air / Foam
Bit Record:

Area:
East: 319635
North: 6403699
Collar (RL):

Static Water Level: 8.4mbgl
Date: 14/05/2009





Depth (mbgl)	**Geology**	**Lithological Description**	**Field Notes**	**Well Completion Notes**
0	Alluvials	Topsoil: Loam, brown topsoil		
		Clay: Silty clay, light brown		Casing Diam = 150mm PVC DrillHole Diam = 200mm
		Gravel and Sand: Coarse sands to fine gravels, sub angular to sub rounded		
		Gravel: Coarse, sub rounded to rounded		
		Gravel and Sand: Gravels and coarse sands, red / brown, gravels up to 30mm in size		Screen Interval = 8 - 11m PVC
10	Permian Coal Meas	Sandstone: Grey sandstone	EC post completion = 6080 us/cm TD=11.0m	Sump = 9.5-11m PVC

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML239

Client: Ashton Coal Operations Ltd **Project:** South East Open Cut

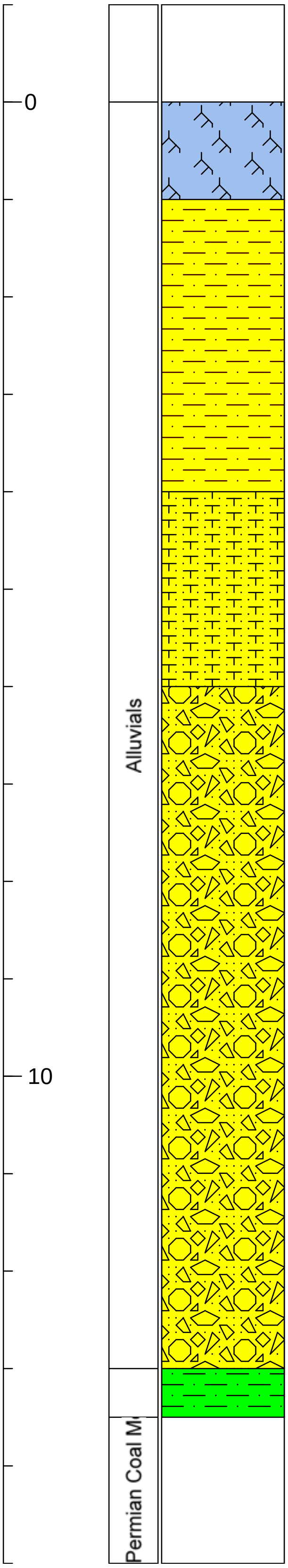
Commenced: 08/11/08
Completed: 08/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record: 5.4
135mm

Area:
East: 319344.998
North: 6404044.823
Collar (RL): 60.142

Static Water Level: 8mbgl **Date:** 08/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Topsoil: Medium brown silty topsoil.

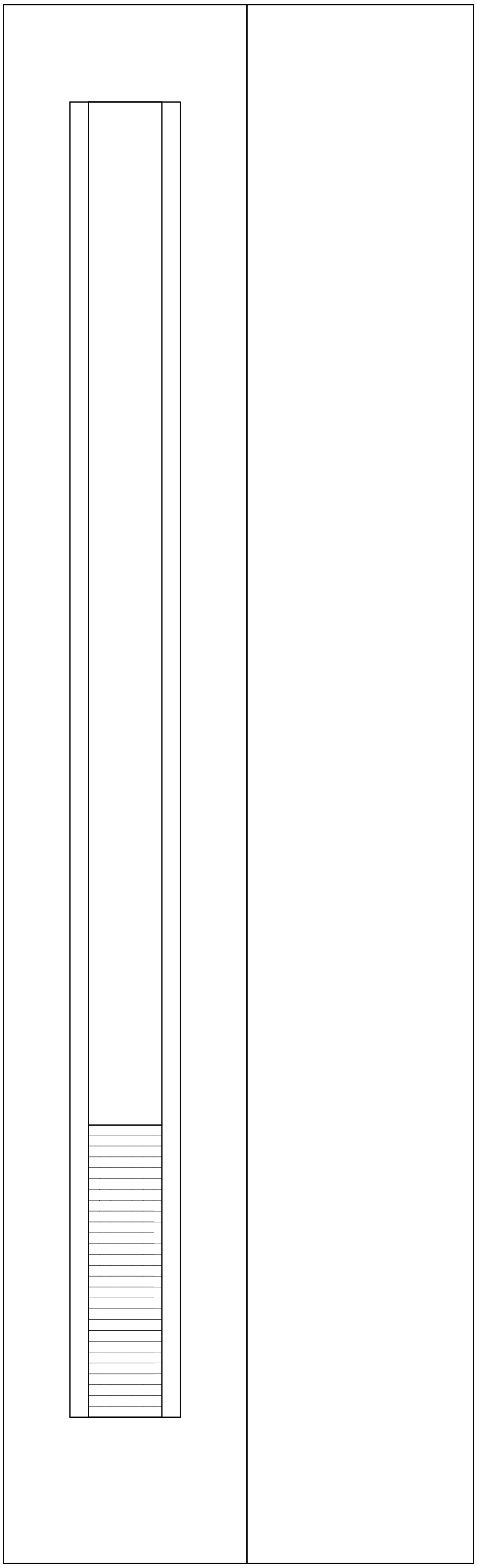
Silt: Medium brown sandy silt, fine sand.

Silty Sand: Light brown silty sand.

Gravel: Medium brown sandy gravel, coarsening down from 10 mm to 20 mm max diam. Sub rounded gravels poorly sorted.

Mudstone: Light grey weathered mudstone.

TD=13.5m



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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML240

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

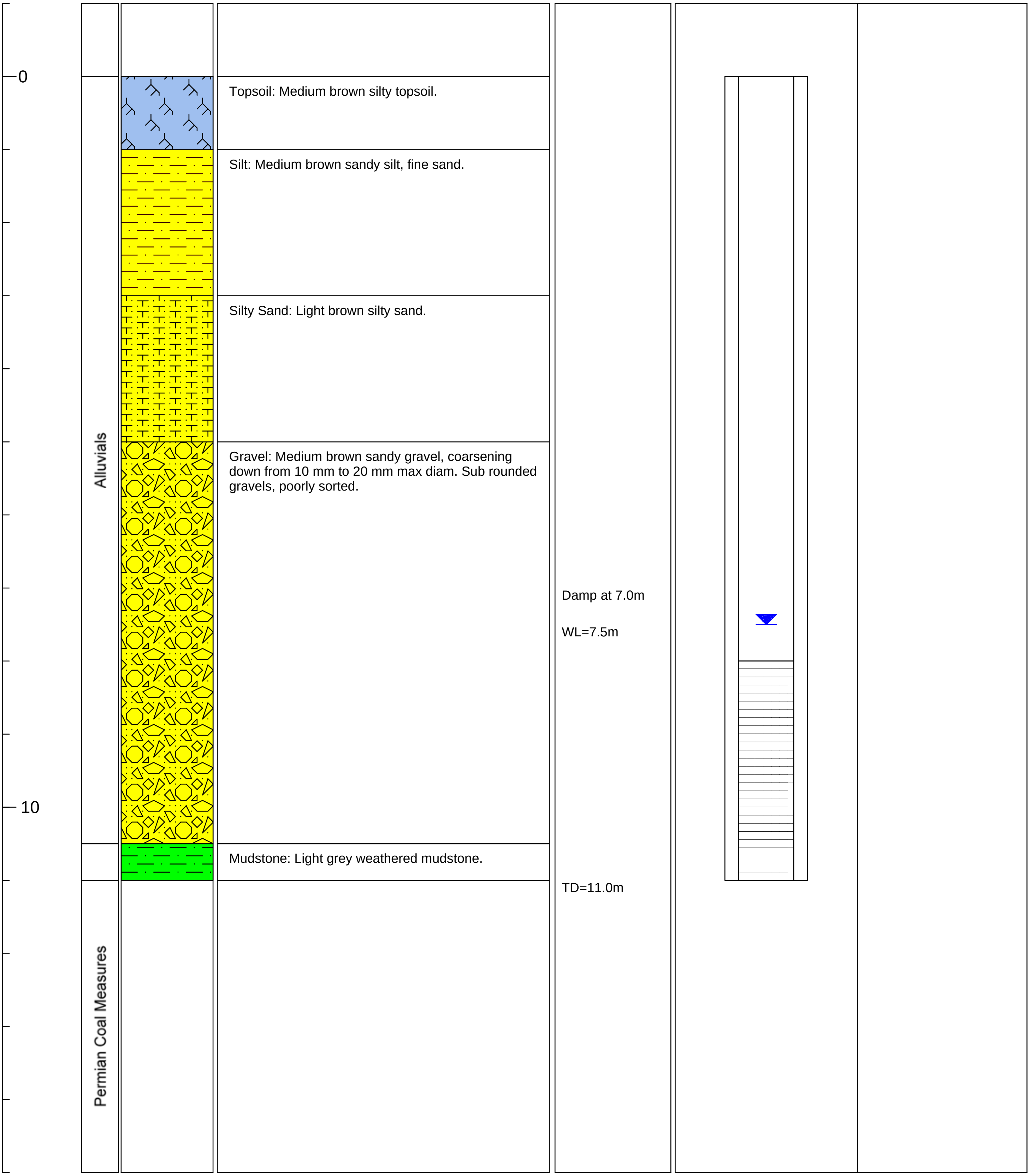
Commenced: 08/11/08
Completed: 08/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record: 5.4
135mm

Area:
East: 319499.876
North: 6403999.67
Collar (RL): 58.816

Static Water Level: 7.5mbgl
Date: 08/11/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Topsoil: Medium brown silty topsoil.

Silt: Medium brown sandy silt, fine sand.

Silty Sand: Light brown silty sand.

Gravel: Medium brown sandy gravel, coarsening down from 10 mm to 20 mm max diam. Sub rounded gravels, poorly sorted.

Mudstone: Light grey weathered mudstone.

Damp at 7.0m

WL=7.5m

TD=11.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML241

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

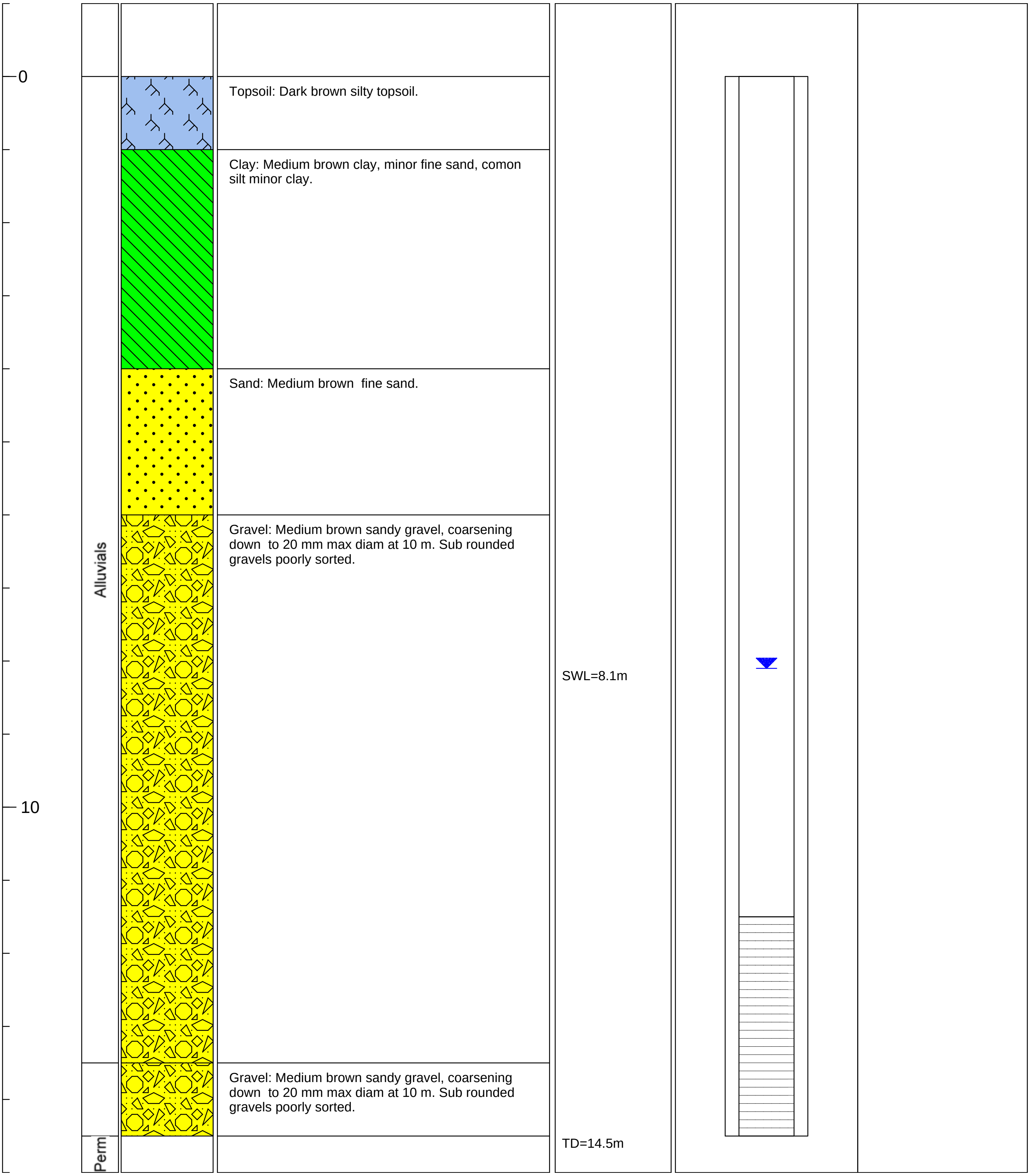
Commenced: 08/11/08
Completed: 08/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record: 6.4
160mm

Area:
East: 319475.005
North: 6403221.786
Collar (RL): 57.831

Static Water Level: 8.1mbgl
Date: 08/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Topsoil: Dark brown silty topsoil.

Clay: Medium brown clay, minor fine sand, comon silt minor clay.

Sand: Medium brown fine sand.

Gravel: Medium brown sandy gravel, coarsening down to 20 mm max diam at 10 m. Sub rounded gravels poorly sorted.

Gravel: Medium brown sandy gravel, coarsening down to 20 mm max diam at 10 m. Sub rounded gravels poorly sorted.

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML242

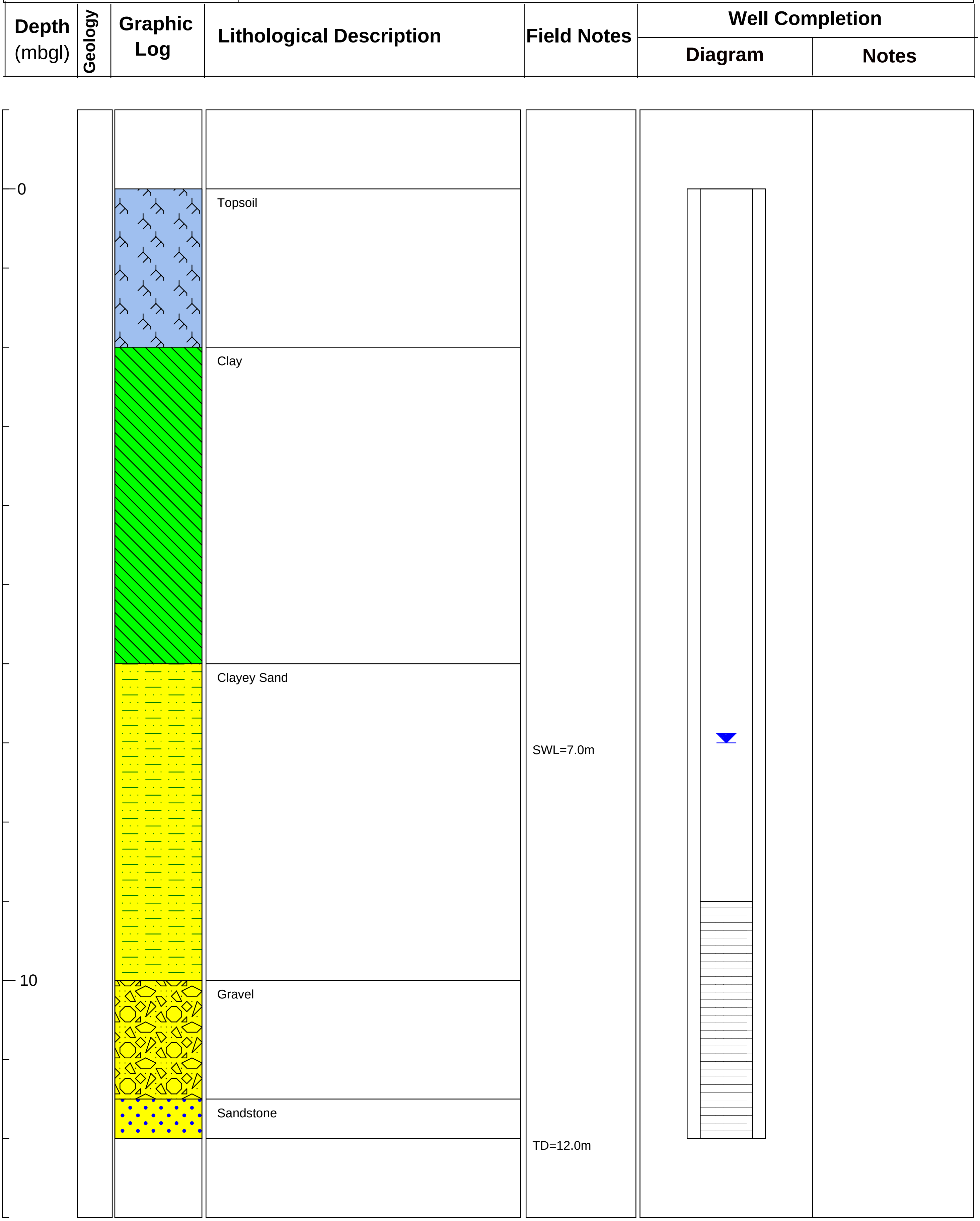
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced: 09/11/08
Completed: 09/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record: 5.4
135mm

Area:
East: 319706.489
North: 6403221.547
Collar (RL): 59.649

Static Water Level: 7.0mbgl
Date: 09/11/08



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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML243

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

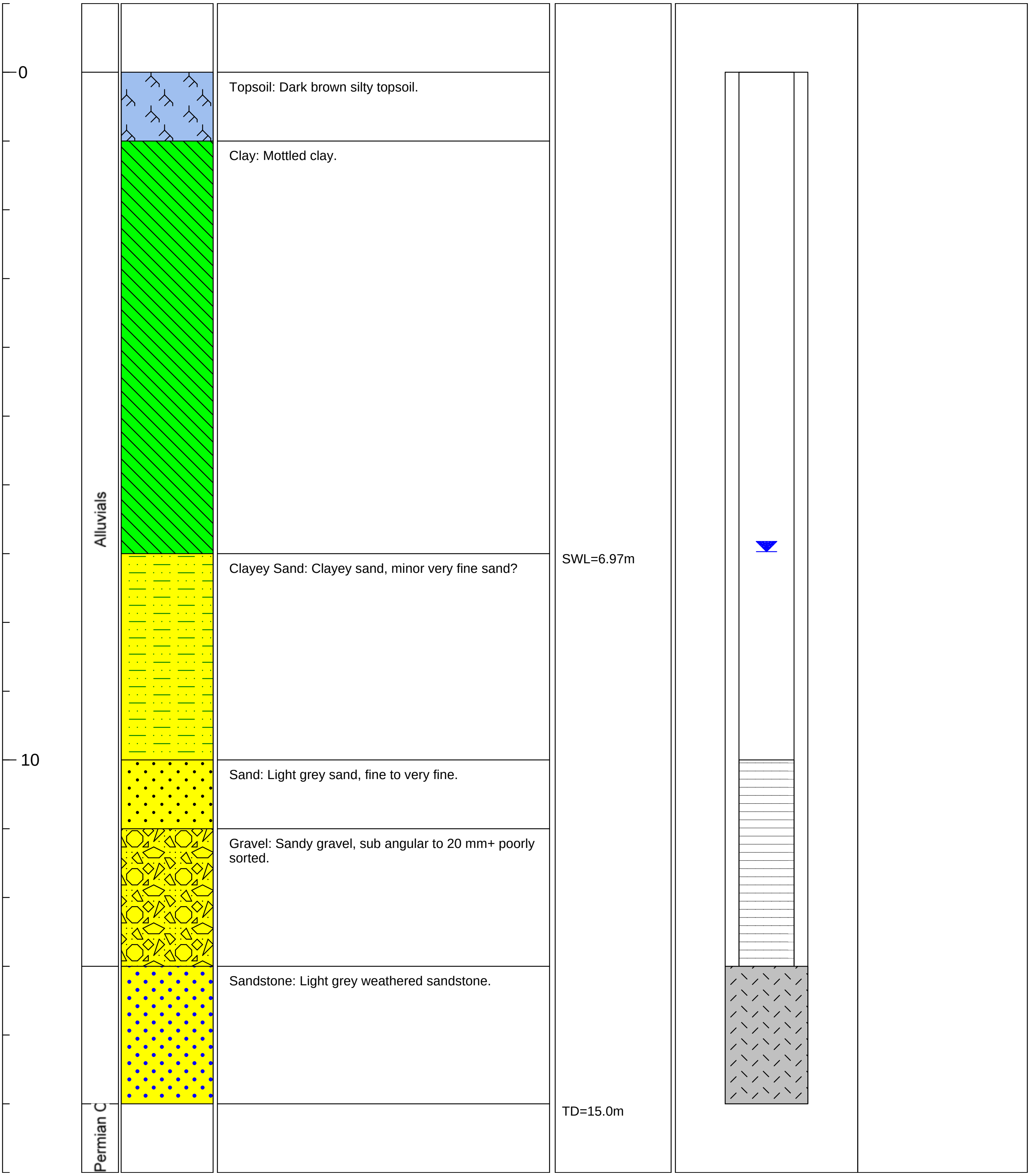
Commenced: 09/11/08
Completed: 09/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record: 6.4
160mm

Area:
East: 319643.281
North: 6403226.081
Collar (RL): 59.055

Static Water Level: 6.97mbgl
Date: 09/11/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion**	
					Diagram	**Notes**



Topsoil: Dark brown silty topsoil.

Clay: Mottled clay.

Clayey Sand: Clayey sand, minor very fine sand?

Sand: Light grey sand, fine to very fine.

Gravel: Sandy gravel, sub angular to 20 mm+ poorly sorted.

Sandstone: Light grey weathered sandstone.

SWL=6.97m

TD=15.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML244

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

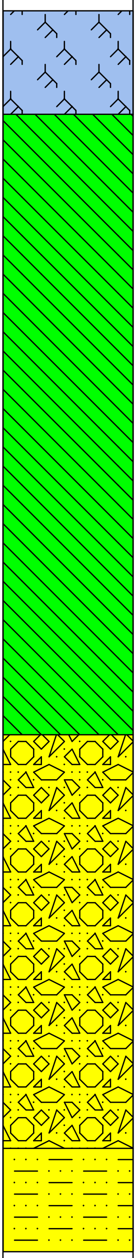
Commenced: 08/11/08
Completed: 08/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record:

Area:
East: 319568.795
North: 6403978.252
Collar (RL): 60.392

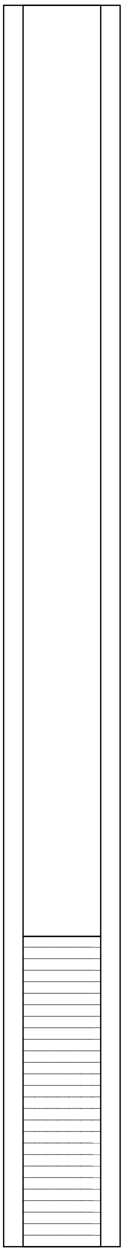
Static Water Level: DRY
Date:

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes
0	Alluvials		Topsoil: Dark brown silty topsoil.	
			Clay: Light red brown clay, minor sand at 5m.	
			Gravel: Sandy gravel, fine to coarse, minor clay horizons.	
10			Siltstone: Light grey weatehed siltstone.	
	Permian Coal Measures			TD=12.0m



Well Completion

Diagram | **Notes**



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Suite 9, 1051 Pacific Highway
Pympe
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML245

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

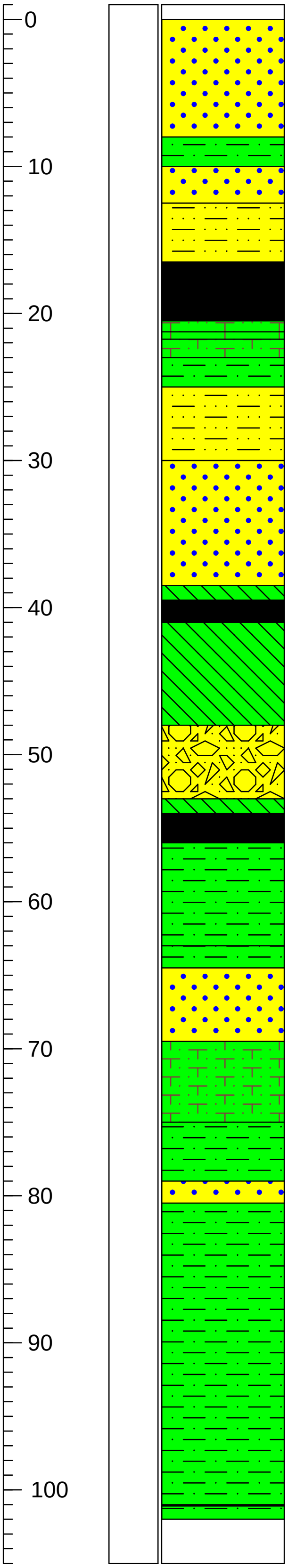
Commenced: 10/10/08
Completed: 13/10/08
Drilled: Intertech
Logged By: SRD/AF

Method: Tubex/Rotary Air
Fluid: Air
Bit Record: 6.6-4.8
165mm-120mm

Area:
East: 320035.092
North: 6404834.961
Collar (RL): 65.642

Static Water Level: DRY
Date:

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Sandstone: Light brown clayey sandstone.

Mudstone: Medium grey sandy mudstone, very fine grained.

Sandstone: Light brown yellow very fine grained sandstone, common clay indurated (hard).

Siltstone: Light grey sandy siltstone.

Coal: Dull banded coal.

Claystone: Alternating light grey claystone with coal bands from 1-10mm.

Claystone: Medium grey claystone.

Claystone: Light grey claystone.

Mudstone: Medium grey sandy mudstone, predominately fine coarse sand.

Siltstone: Light grey siltstone, minor fine to medium grained sand.

Sandstone: Grey green fine grained sandstone, indurated, minor clay.

Clay: Light grey clay, minor sand.

Coal: Coal

Clay: Medium grey clay, minor coal bands

Gravel: Medium grey clayey gravel, 2-10mm, sub rounded (hammer drilling, may be sandstone broken up by hammer), light grey clay matrix.

Clay: Medium grey clay.

Coal: Coal

Mudstone: Alternating mudstone sandstone, minor coal laminates.

Mudstone: Light grey mudstone.

Sandstone: Medium grey sandstone

Claystone: Alternating claystone sandstone with minor coal laminates. (72-73m more coal?)

Mudstone: Medium grey mudstone.

Sandstone: Medium grey sandstone.

Mudstone: Medium grey mudstone.

Coal: Bright coal. (Driller suggests 0.2-0.3m?)

Mudstone: Medium grey mudstone.

Completed with vibrating wires.

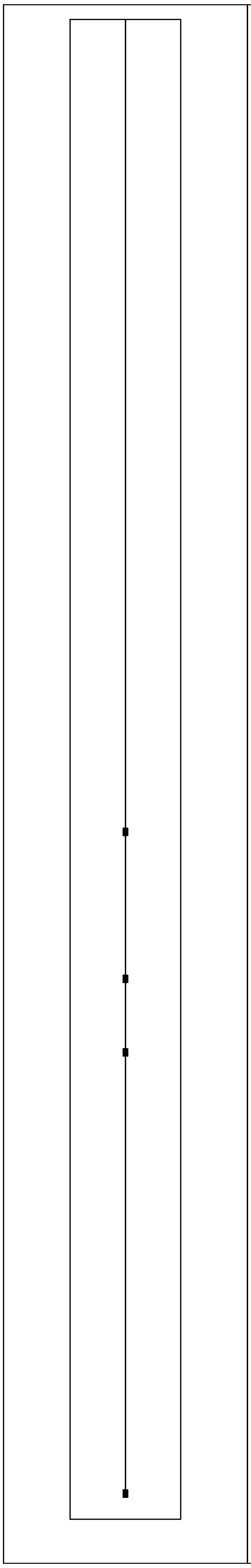
Bore dry.

Vibrating Wire Piezometer 55m

Vibrating Wire Piezometer 65m

Vibrating Wire Piezometer 70m

Vibrating Wire Piezometer 100m



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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML246

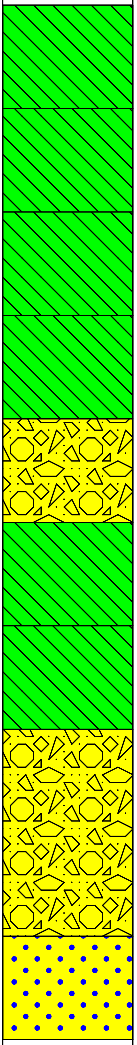
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

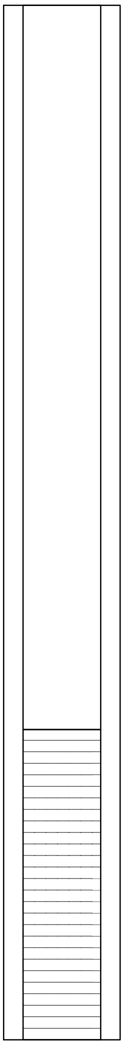
Commenced: 14/10/08
Completed: 14/10/08
Drilled: Intertech
Logged By: AF/SRD

Method: Tubex/Rotary Air
Fluid: Air
Bit Record: 6.4
160mm

Area:
East: 319892.735
North: 6404591.954
Collar (RL): 64.885

Static Water Level: DRY
Date: 14/10/08





Depth (mbgl)	**Geology**	**Lithological Description**	**Field Notes**	**Well Completion Notes**
0	Alluvials	Clay: Medium brown clay, minor fine sand.		
		Clay: Grey brown clay, red mottled.		
		Clay: Medium brown clay, minor fine sand.		
		Clay: Brown clay, minor fine sand.		
		Gravel: Light brown gravel, angular to sub rounded, 2-30mm (river rocks?).		
		Clay: Light brown clay, orange mottled.	Bore Dry	
		Clay: Light brown clay, orange grey mottled.		
		Gravel: Light brown (some grey) gravel, angular to sub rounded, some light grey clay.		
		Sandstone: Light grey brown, fine sandstone, some clay.		
10	Permian Coal Measures		TD=10.0m	

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

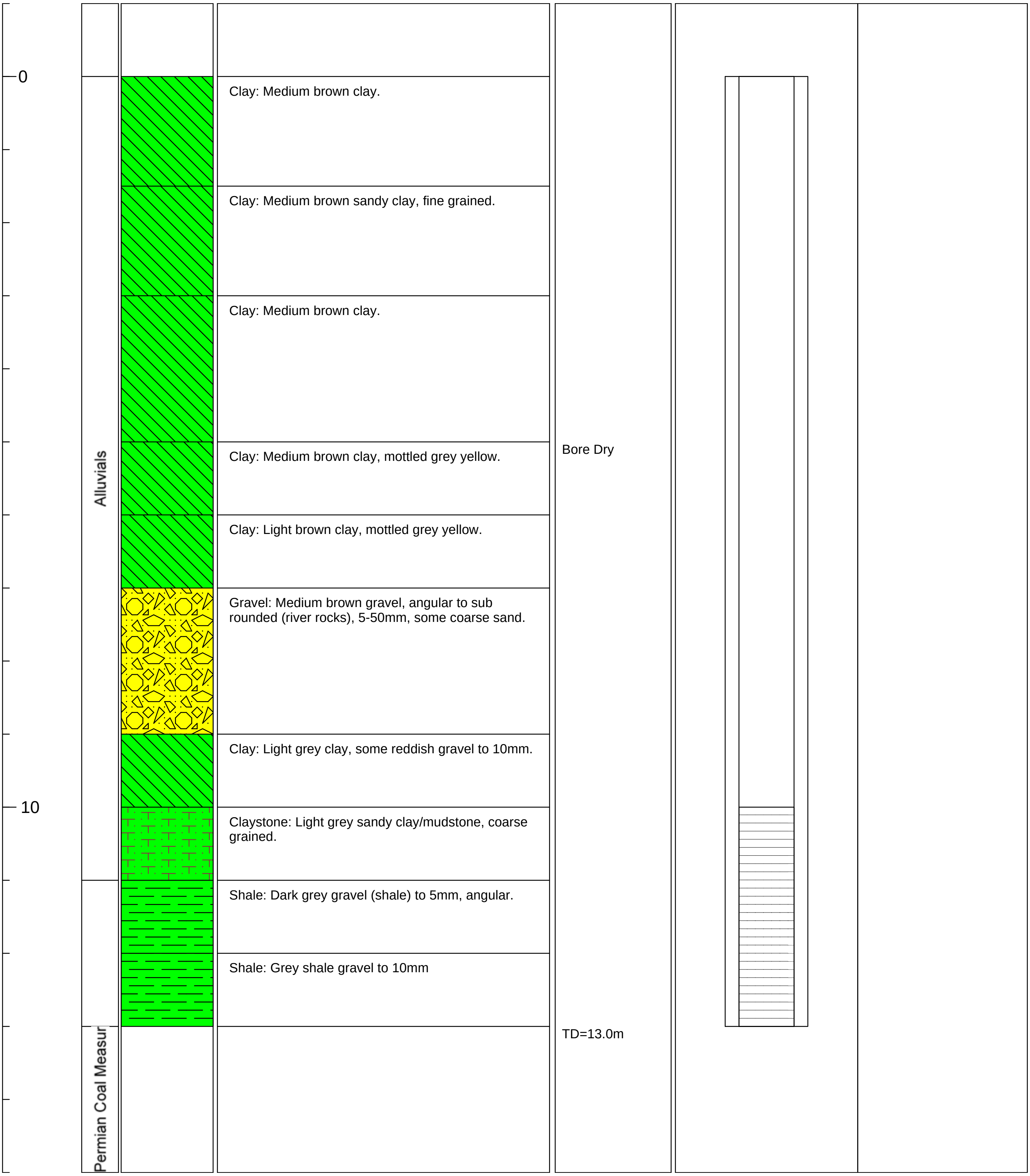
Well No: WML247

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced:	14/10/08	**Method:**	Tubex/Rotary Air	**Area:**	
Completed:	14/10/08	**Fluid:**	Air	**East:**	319734.393
Drilled:	Intertech	**Bit Record:**	6.4	**North:**	6404472.092
Logged By:	SRD		160mm	**Collar (RL):**	63.361

Static Water Level: DRY
Date: 14/10/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Clay: Medium brown clay.

Clay: Medium brown sandy clay, fine grained.

Clay: Medium brown clay.

Clay: Medium brown clay, mottled grey yellow.

Clay: Light brown clay, mottled grey yellow.

Gravel: Medium brown gravel, angular to sub rounded (river rocks), 5-50mm, some coarse sand.

Clay: Light grey clay, some reddish gravel to 10mm.

Claystone: Light grey sandy clay/mudstone, coarse grained.

Shale: Dark grey gravel (shale) to 5mm, angular.

Shale: Grey shale gravel to 10mm

Bore Dry

TD=13.0m

Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML248

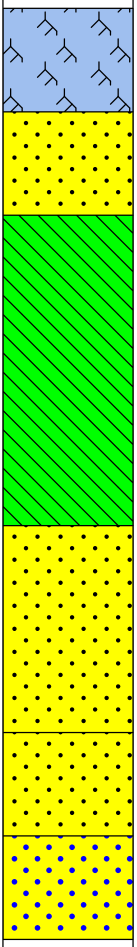
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

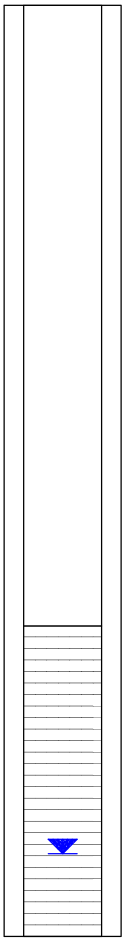
Commenced: 15/10/08
Completed: 15/10/08
Drilled: Intertech
Logged By: AF

Method: Tubex/Rotary Air
Fluid: Air
Bit Record: 6.4
160mm

Area:
East: 319706.093
North: 6403935.69
Collar (RL): 60.571

Static Water Level: 8.20mbgl
Date: 15/10/08





Depth (mbgl)	**Geology**	**Lithological Description**	**Field Notes**	**Well Completion Diagram**	**Notes**
0	Alluvials	Topsoil: Medium brown sandy topsoil.			
		Sand: Light brown gravelly silty sand.			
		Clay: Medium brown mottled dark brown clay, minor fine sand.			
		Sand: Predominatley medium to coarse sand and silt. Some gravels to 10mm. Sand and gravels angular to sub angular.			
		Sand: Predominatley fine to coarse sand . Some gravels to 15mm. Sand and gravels sub angular to angular.			
		Sandstone: Light yellow brown weathered sandstone, fine to medium grained.	SWL=8.20m		
10	Permian Coal Measures		TD=9.0m		

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Suite 9, 1051 Pacific Highway
Pymble
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Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML249

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

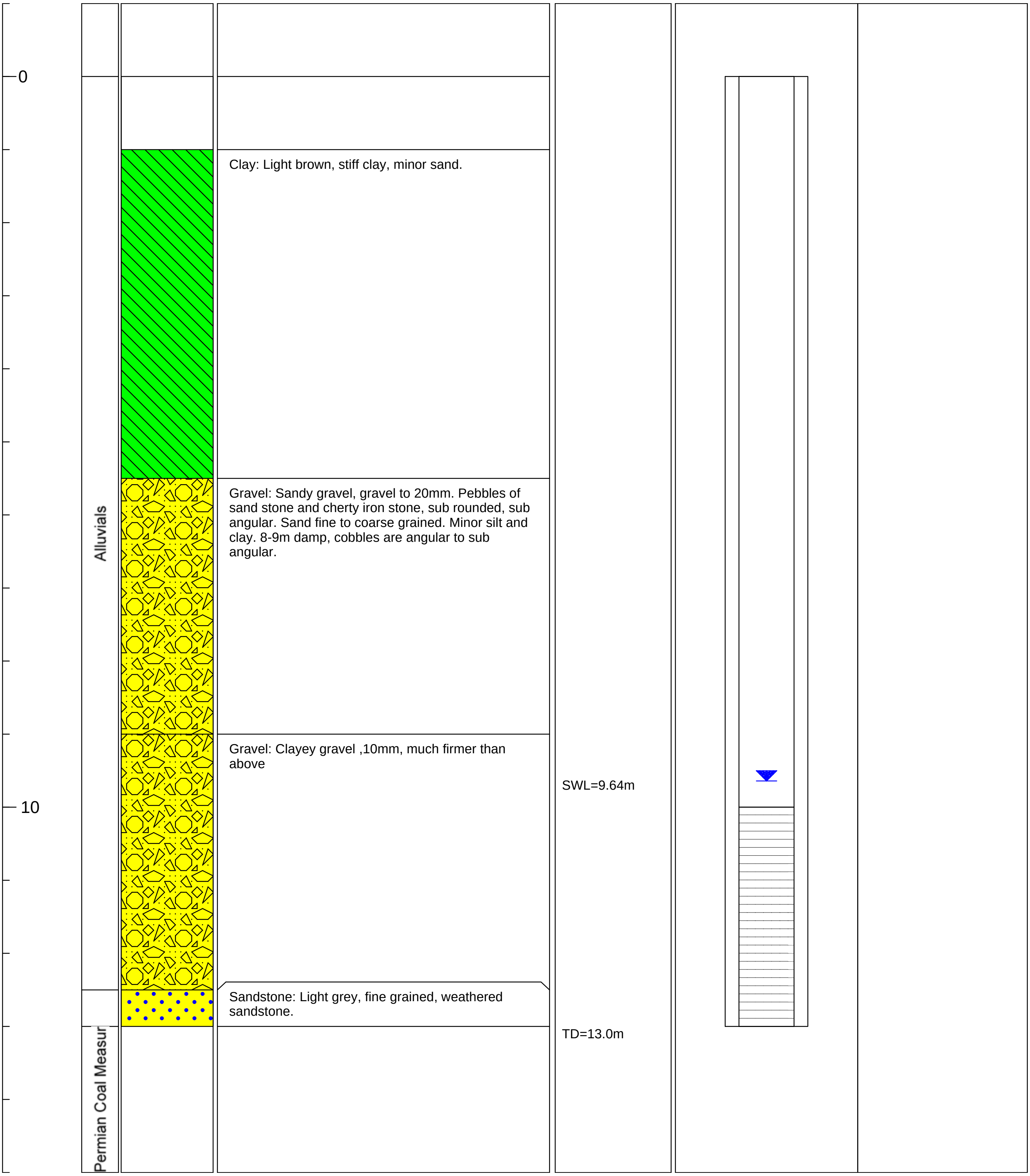
Commenced: 15/10/08
Completed: 15/10/08
Drilled: Intertech
Logged By: AF

Method: Tubex/Rotary Air
Fluid: Air
Bit Record: 6.4
160mm

Area:
East: 319577.37
North: 6404300.328
Collar (RL): 62.316

Static Water Level: 9.64mbgl
Date: 15/10/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay: Light brown, stiff clay, minor sand.

Gravel: Sandy gravel, gravel to 20mm. Pebbles of sand stone and cherty iron stone, sub rounded, sub angular. Sand fine to coarse grained. Minor silt and clay. 8-9m damp, cobbles are angular to sub angular.

Gravel: Clayey gravel ,10mm, much firmer than above

Sandstone: Light grey, fine grained, weathered sandstone.

SWL=9.64m

TD=13.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML250

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

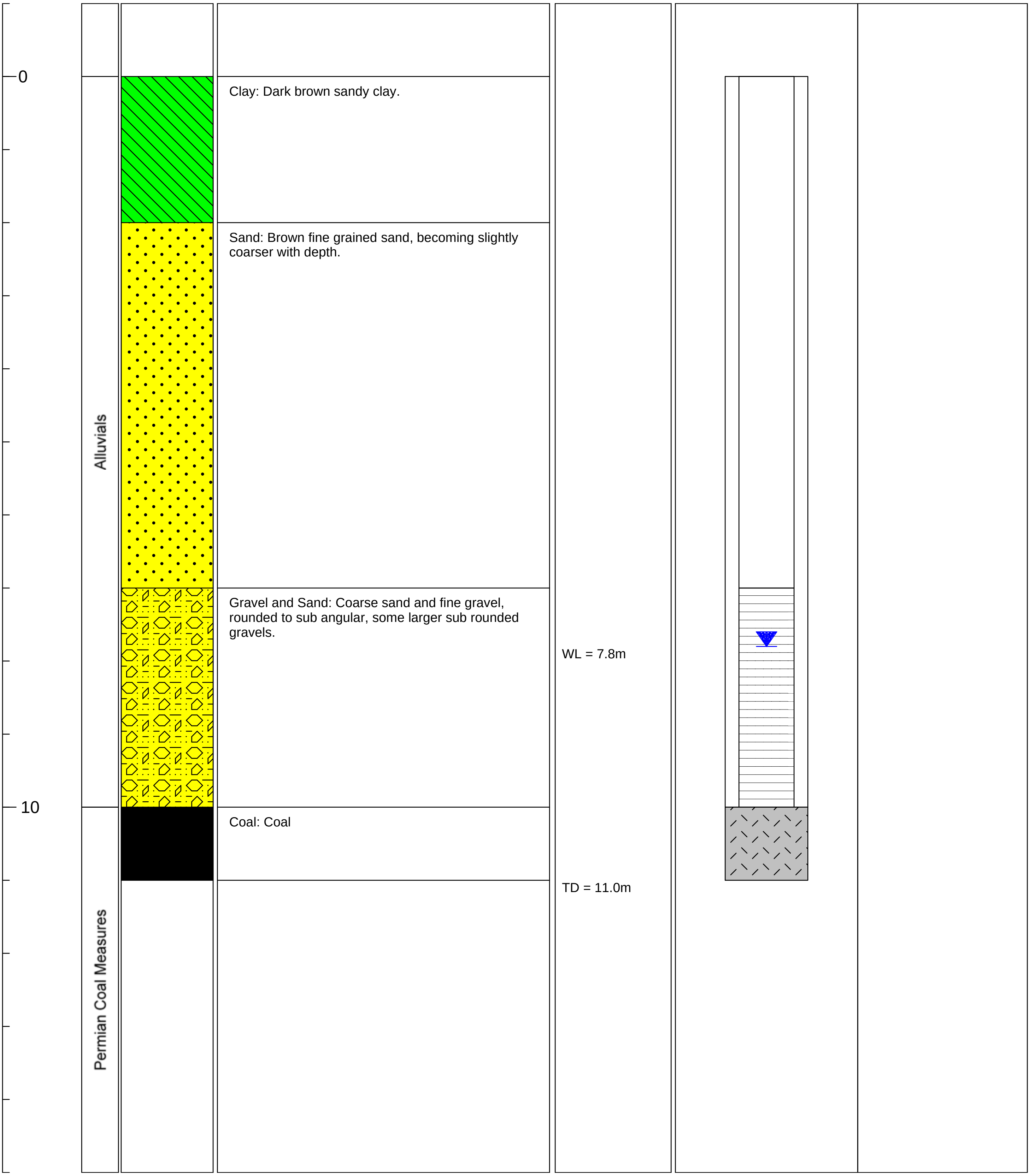
Commenced: 16/10/08
Completed: 16/10/08
Drilled: Intertech
Logged By: AF

Method: Tubex/Rotary Air
Fluid: Air
Bit Record: 160mm

Area:
East: 319454.633
North: 6404301.86
Collar (RL): 60.444

Static Water Level: 7.8m
Date: 16/10/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Clay: Dark brown sandy clay.

Sand: Brown fine grained sand, becoming slightly coarser with depth.

Gravel and Sand: Coarse sand and fine gravel, rounded to sub angular, some larger sub rounded gravels.

Coal: Coal

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Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML251

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

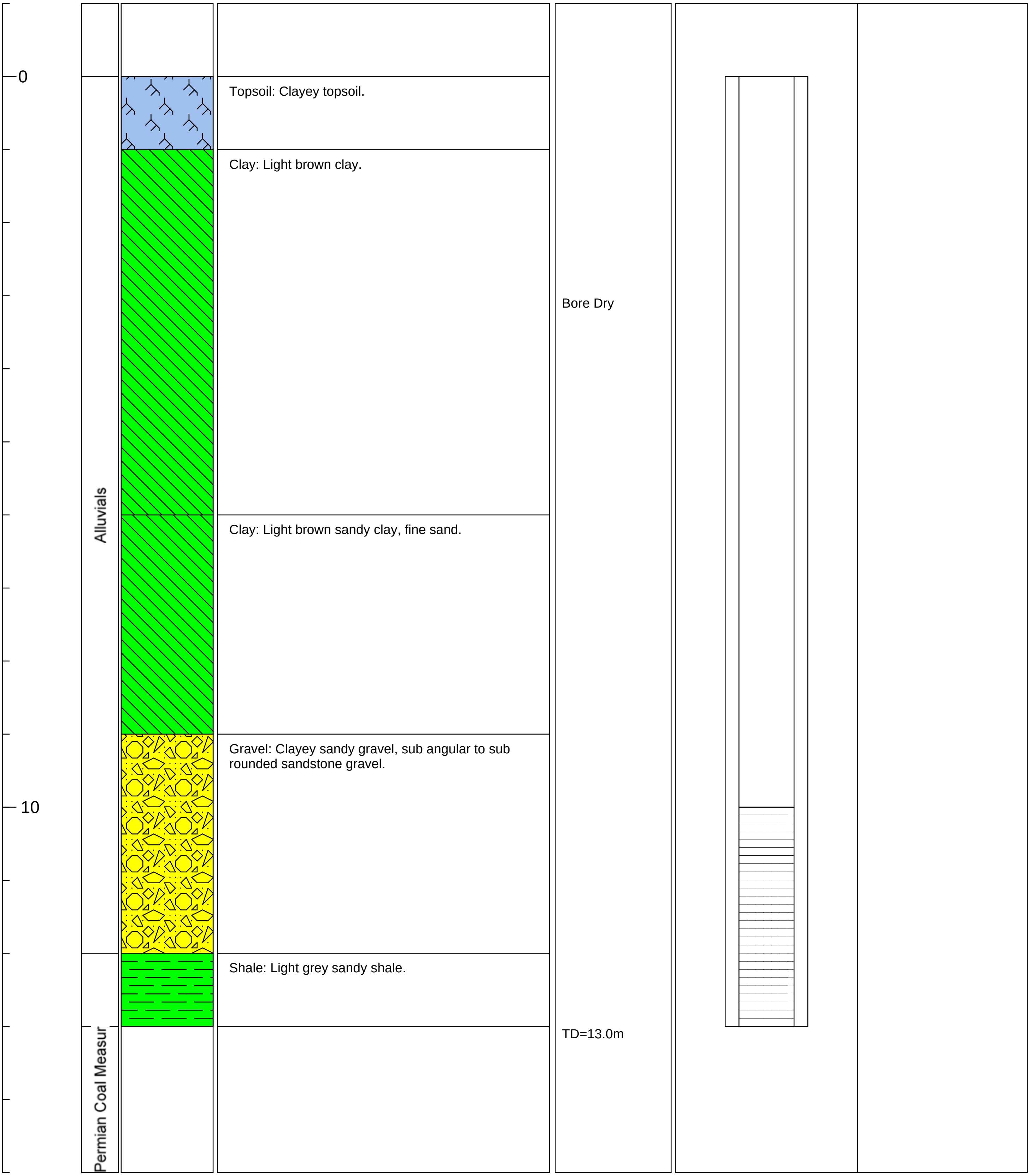
Commenced: 16/10/08
Completed: 16/10/08
Drilled: Intertech
Logged By: AF

Method: Tubex/Rotary Air
Fluid: Air
Bit Record:
160mm

Area:
East: 319644.531
North: 6404542.617
Collar (RL): 62.91

Static Water Level: Dry
Date: 16/10/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Topsoil: Clayey topsoil.

Clay: Light brown clay.

Clay: Light brown sandy clay, fine sand.

Gravel: Clayey sandy gravel, sub angular to sub rounded sandstone gravel.

Shale: Light grey sandy shale.

Bore Dry

TD=13.0m

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Pymble
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Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML251a

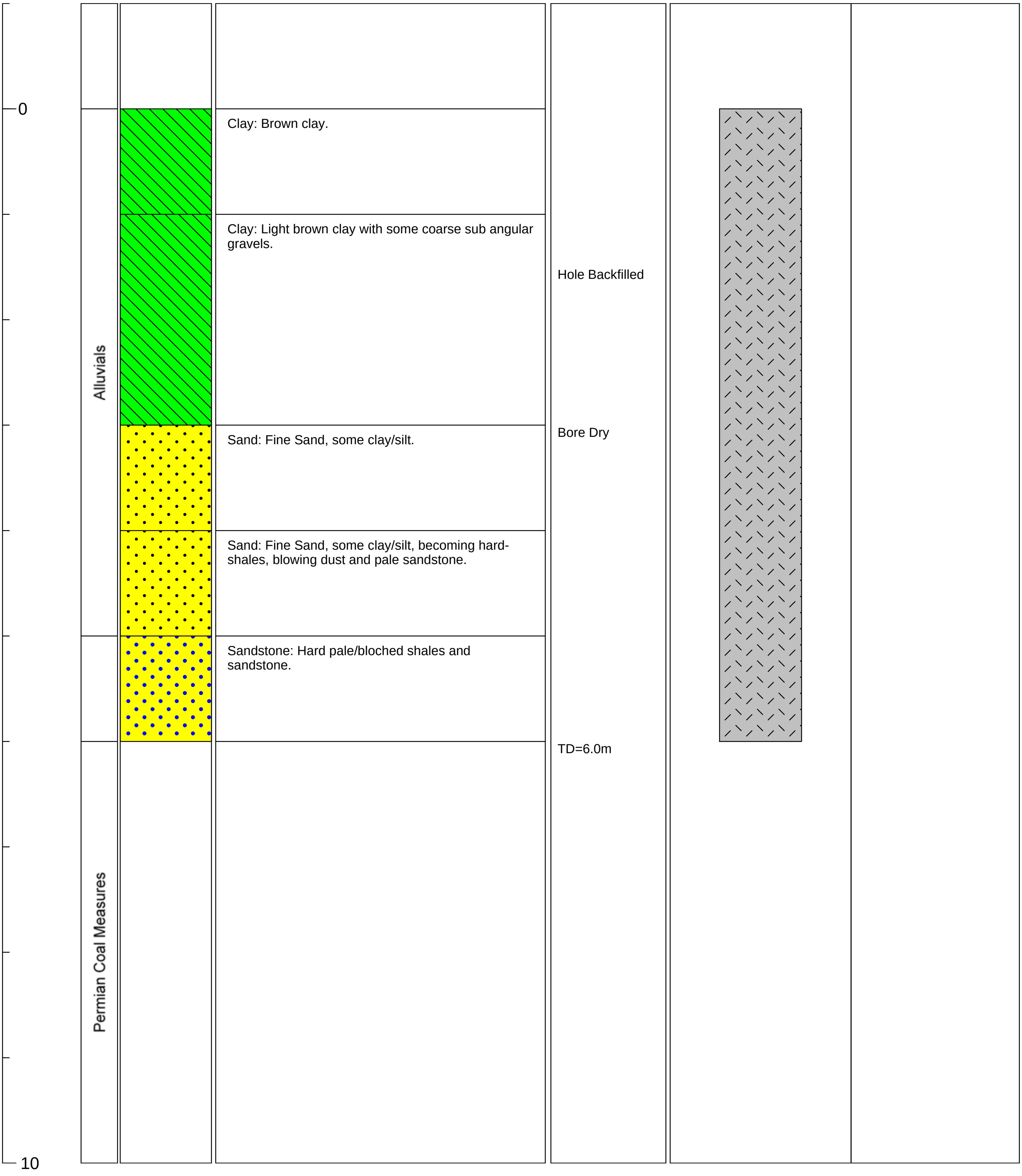
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced: 27/11/08
Completed: 27/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319846.004
North: 6404112.04
Collar (RL): 62.746

Static Water Level: DRY
Date: 27/11/08



Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes
0	Alluvials	🟩	Clay: Brown clay.			
		🟩	Clay: Light brown clay with some coarse sub angular gravels.	Hole Backfilled		
		🟨	Sand: Fine Sand, some clay/silt.	Bore Dry		
		🟨	Sand: Fine Sand, some clay/silt, becoming hard-shales, blowing dust and pale sandstone.			
		🟨	Sandstone: Hard pale/bloched shales and sandstone.			
	Permian Coal Measures			TD=6.0m		
10						

COMPOSITE WELL LOG

Well No: WML252

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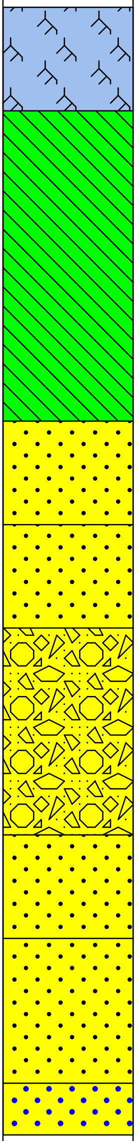
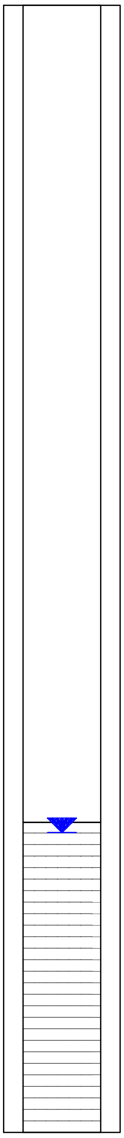
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced:	16/10/08	**Method:**	Tubex/Rotary Air	**Area:**	
Completed:	16/10/08	**Fluid:**	Air	**East:**	319621.445
Drilled:	Intertech	**Bit Record:**		**North:**	6403683.576
Logged By:	AF		160mm-135mm	**Collar (RL):**	60.242

Static Water Level: 8.0mbgl
Date: 16/10/08

Depth (mbgl)	**Geology**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes
0	Alluvials	Topsoil: Clayey sandy topsoil.			
		Clay: Medium red brown clay.			
		Sand: Red brown gravelly sand with common clay, gravel <15mm sub rounded to rounded.			
		Sand: Red brown gravelly sand with common clay, gravel <15mm angular to sub angular (Less coarse than above).			
		Gravel: Sandy gravel, poorly sorted, sub rounded, sub angular.			
		Sand: Gravelly sand, angular to sub angular, sub rounded.			
10		Sand: Gravelly sand, sub rounded.			
		Sandstone: Light grey weathered sandstone.			
	Permian Coal Measures				





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Suite 9, 1051 Pacific Highway
Pymble
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Australia
Tel: (+61) (02) 9440 2666
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COMPOSITE WELL LOG

Well No: WML253

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

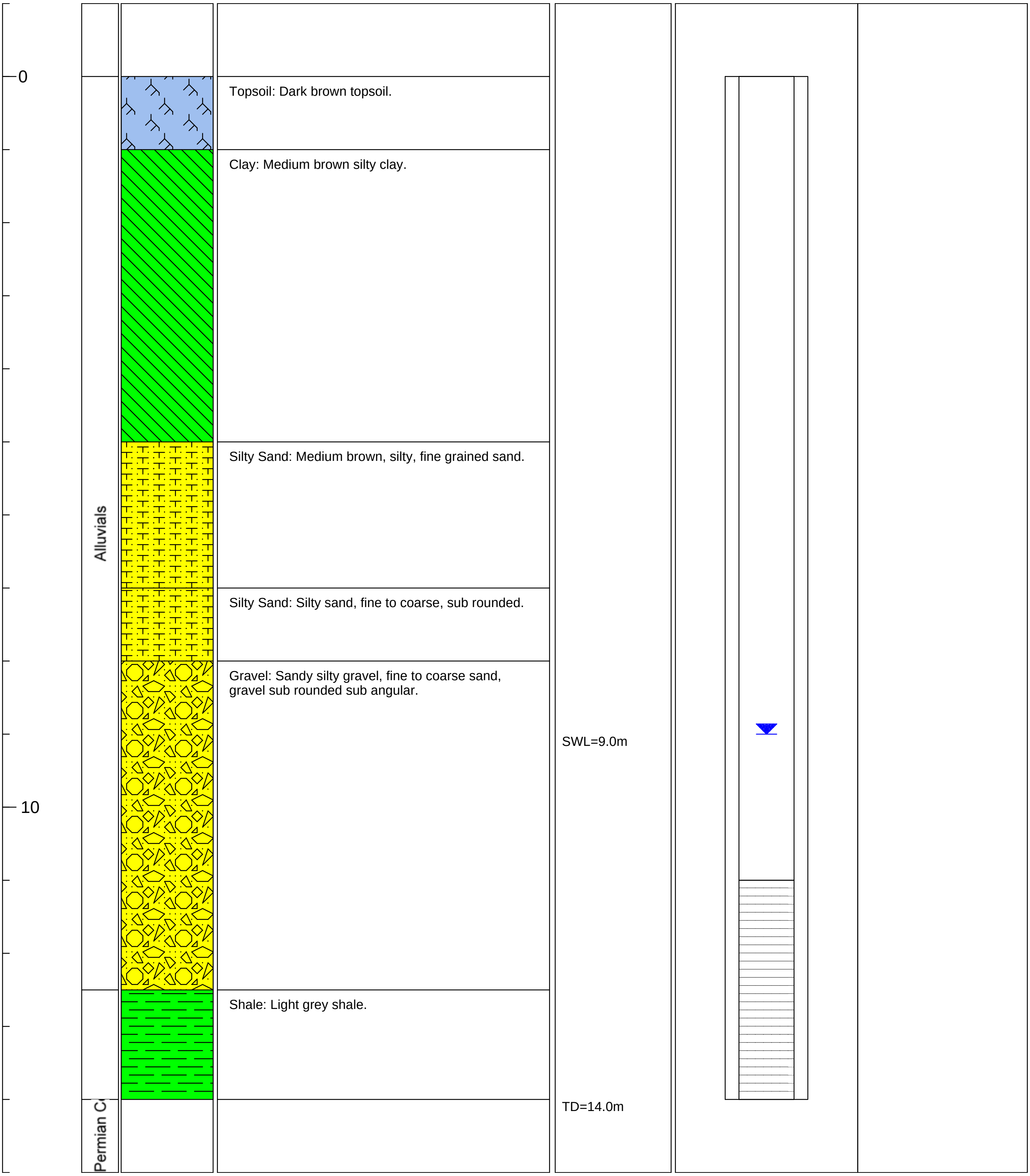
Commenced: 17/10/08
Completed: 17/10/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record:
160mm-135mm

Area:
East: 319555.437
North: 6403706.703
Collar (RL): 60.164

Static Water Level: 9.0mbgl
Date: 17/10/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion**	
					Diagram	**Notes**



Topsoil: Dark brown topsoil.

Clay: Medium brown silty clay.

Silty Sand: Medium brown, silty, fine grained sand.

Silty Sand: Silty sand, fine to coarse, sub rounded.

Gravel: Sandy silty gravel, fine to coarse sand, gravel sub rounded sub angular.

Shale: Light grey shale.

SWL=9.0m

TD=14.0m

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Suite 9, 1051 Pacific Highway
Pymble
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Australia
Tel: (+61) (02) 9440 2666
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COMPOSITE WELL LOG

Well No: WML254

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

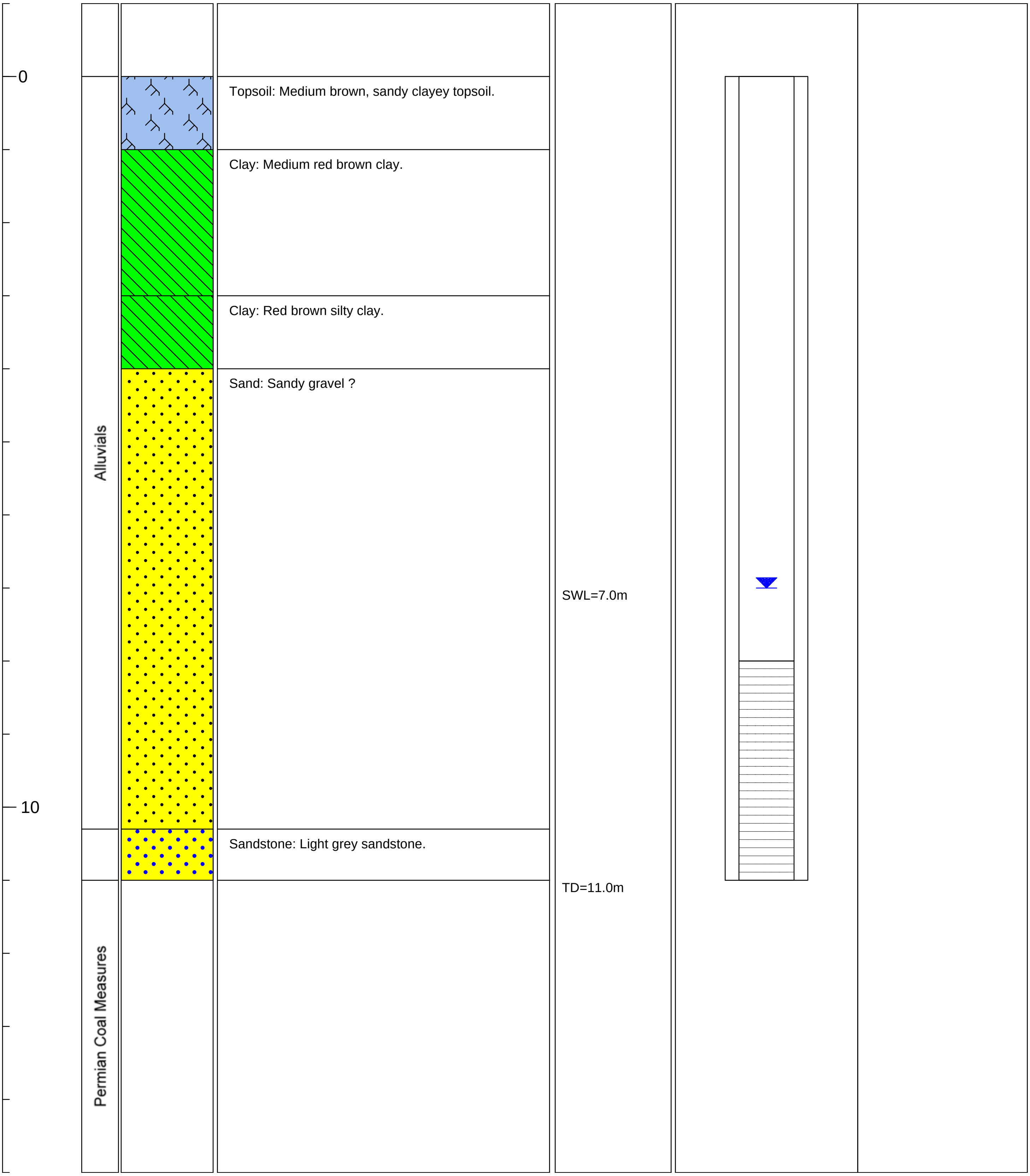
Commenced: 17/10/08
Completed: 17/10/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record:
160mm-135mm

Area:
East: 319709.104
North: 6403669.549
Collar (RL): 59.802

Static Water Level: 7.0mbgl
Date: 17/10/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Topsoil: Medium brown, sandy clayey topsoil.

Clay: Medium red brown clay.

Clay: Red brown silty clay.

Sand: Sandy gravel ?

Sandstone: Light grey sandstone.

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Pymble
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Australia
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COMPOSITE WELL LOG

Well No: WML255

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

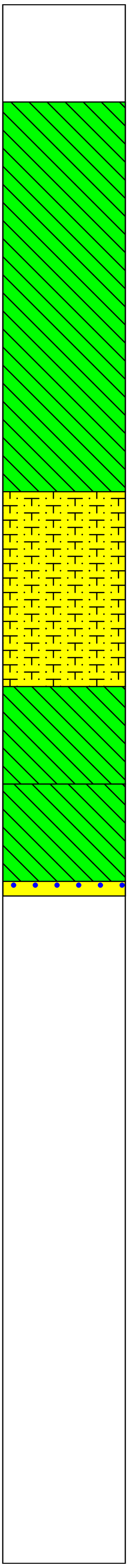
Commenced: 07/11/08
Completed: 07/11/08
Drilled: Intertech
Logged By: SRD

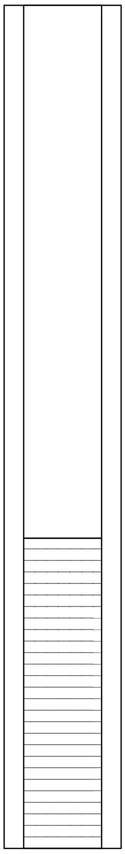
Method: Tubex / Rotary Air
Fluid: Air
Bit Record:

Area:
East: 319790.6273
North: 6403195.0880
Collar (RL): 62.5

Static Water Level: DRY
Date:

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Alluvials		Clay: Light brown silty clay, dry and stiff, minor fine sand.			
			Silty Sand: Light brown silty sand, fine to coarse grained, slightly damp 5-6m.	Bore Dry		
			Clay: Grey mottled red brown clay.			
			Clay: Light brown silty clay, minor fine to medium grained sand.			
			Sandstone: Light grey weathered sandstone.	TD=8.15m		
10	Permian Coal Measures					





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Australia
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Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML256

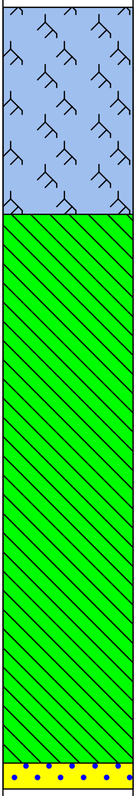
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

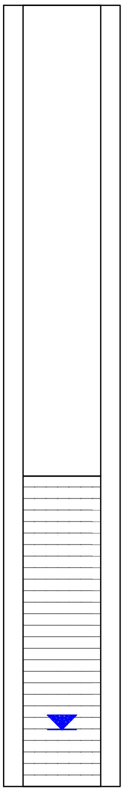
Commenced: 07/11/08
Completed: 07/11/08
Drilled: Intertech
Logged By: SRD

Method: Tubex / Rotary Air
Fluid: Air
Bit Record:

Area:
East: 319722.9456
North: 6402774.3918
Collar (RL): 56

Static Water Level: 7.0mbgl
Date: 07/11/08





Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Alluvials		Topsoil: Chocolate brown, silty topsoil.			
			Clay: Chocolate brown silty clay.			
			Sandstone: Light green grey, weathered sandstone, fine grained.	SWL=7.0m		
				TD=7.55m		
10	Permian Coal Measures					

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Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML257

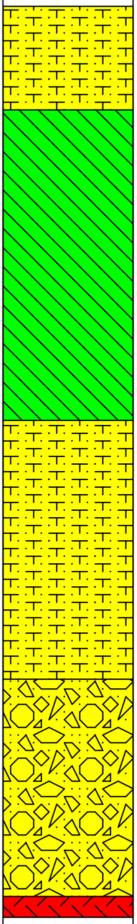
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

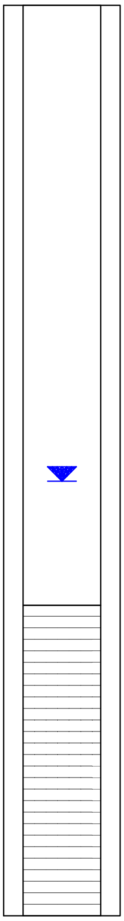
Commenced: 07/11/08
Completed: 07/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record:

Area:
East: 319806.9922
North: 6402980.4199
Collar (RL): 56

Static Water Level: 4.6mbgl
Date: 07/11/08





Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Alluvials		Silty Sand: Medium brown, silty, fine sand.			
			Clay: Dark chocolate brown silty clay.			
			Silty Sand: Medium orange brown silty sand.	SWL=4.6m		
			Gravel: Sandy gravel, gravel sub rounded.			
			Basement: Basement unidentified, hard surface.			
10	Permian Coal Measures			TD=8.8m		

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Australia
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COMPOSITE WELL LOG

Well No: WML258

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

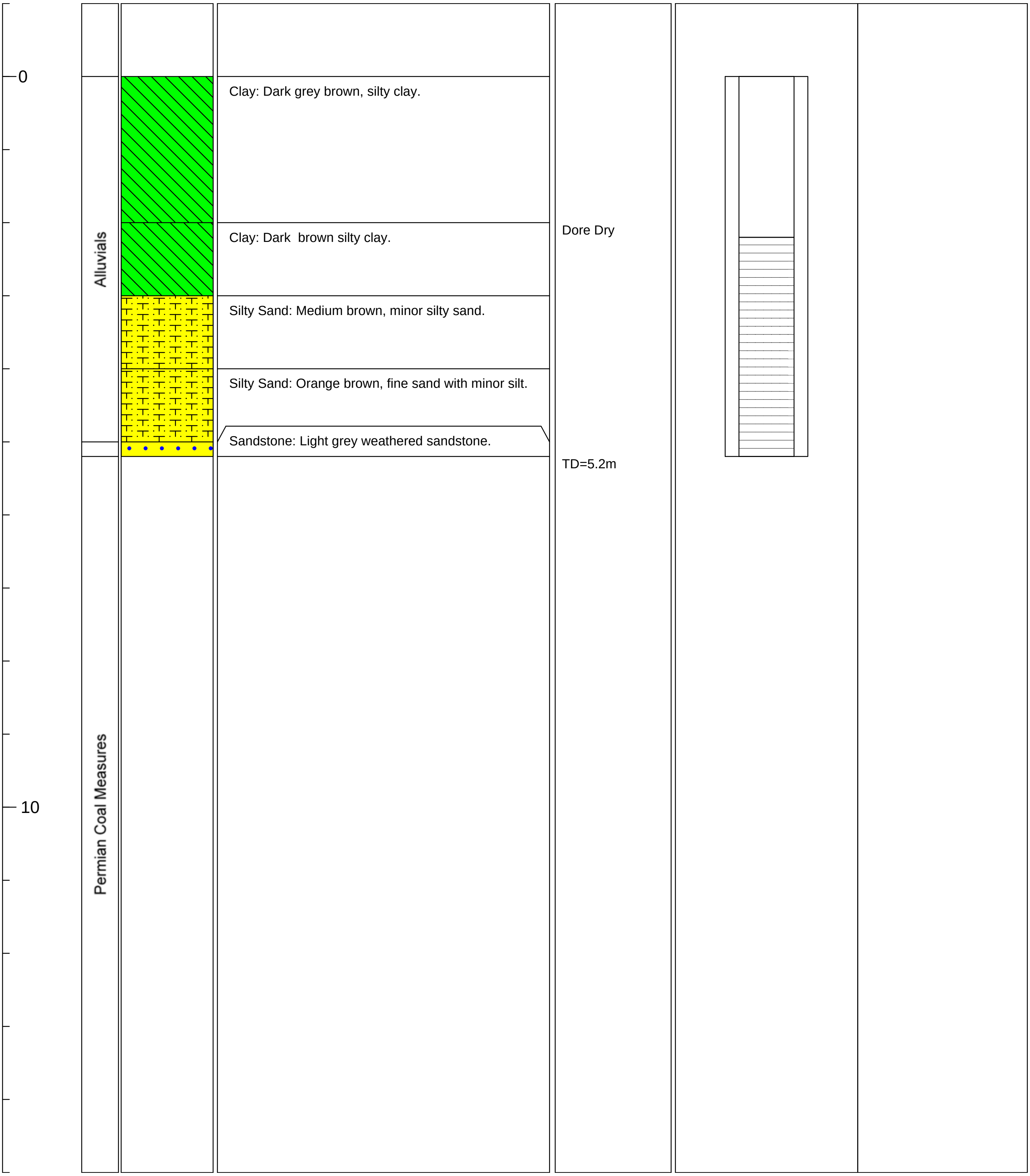
Commenced: 08/11/08
Completed: 08/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record:

Area:
East: 319679.1410
North: 6402981.4421
Collar (RL): 56.5

Static Water Level: DRY
Date: 08/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion: Diagram	Well Completion: Notes



Clay: Dark grey brown, silty clay.

Clay: Dark brown silty clay.

Silty Sand: Medium brown, minor silty sand.

Silty Sand: Orange brown, fine sand with minor silt.

Sandstone: Light grey weathered sandstone.

Dore Dry

TD=5.2m

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Australia
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Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML259

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

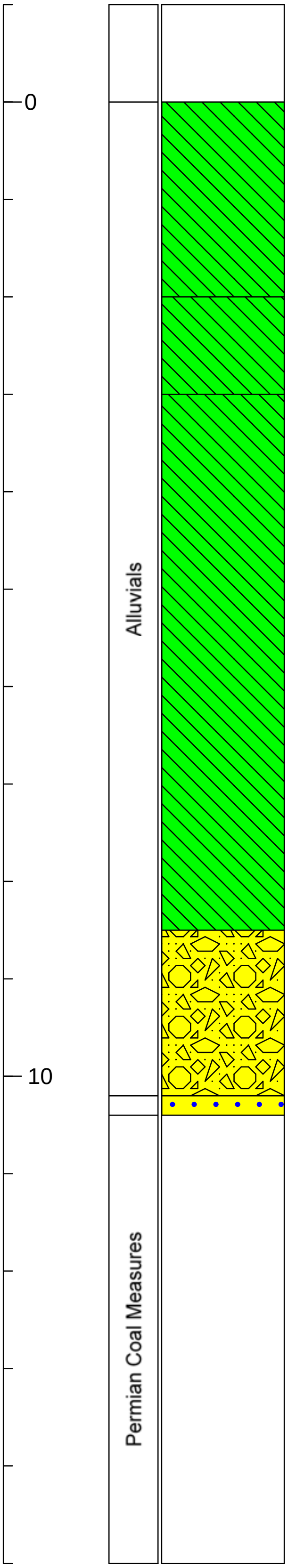
Commenced: 08/11/08
Completed: 08/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record:

Area:
East: 319929.2731
North: 6403869.9217
Collar (RL): 62.2

Static Water Level: 9.5mbgl
Date: 08/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Clay: Medium grey brown clay.

Clay: Orange grey silty clay, minor fine sand.

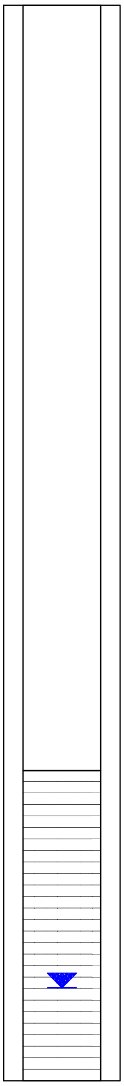
Clay: Medium brown silty clay, minor sand.

Gravel: Sandy gravel with minor clay, sub ang to sub rounded gravel. ?? gravel sub round to sub angular.??

Sandstone: Medium grey green weathered sandstone.

SWL=9.5m

TD=10.4m



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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML260

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

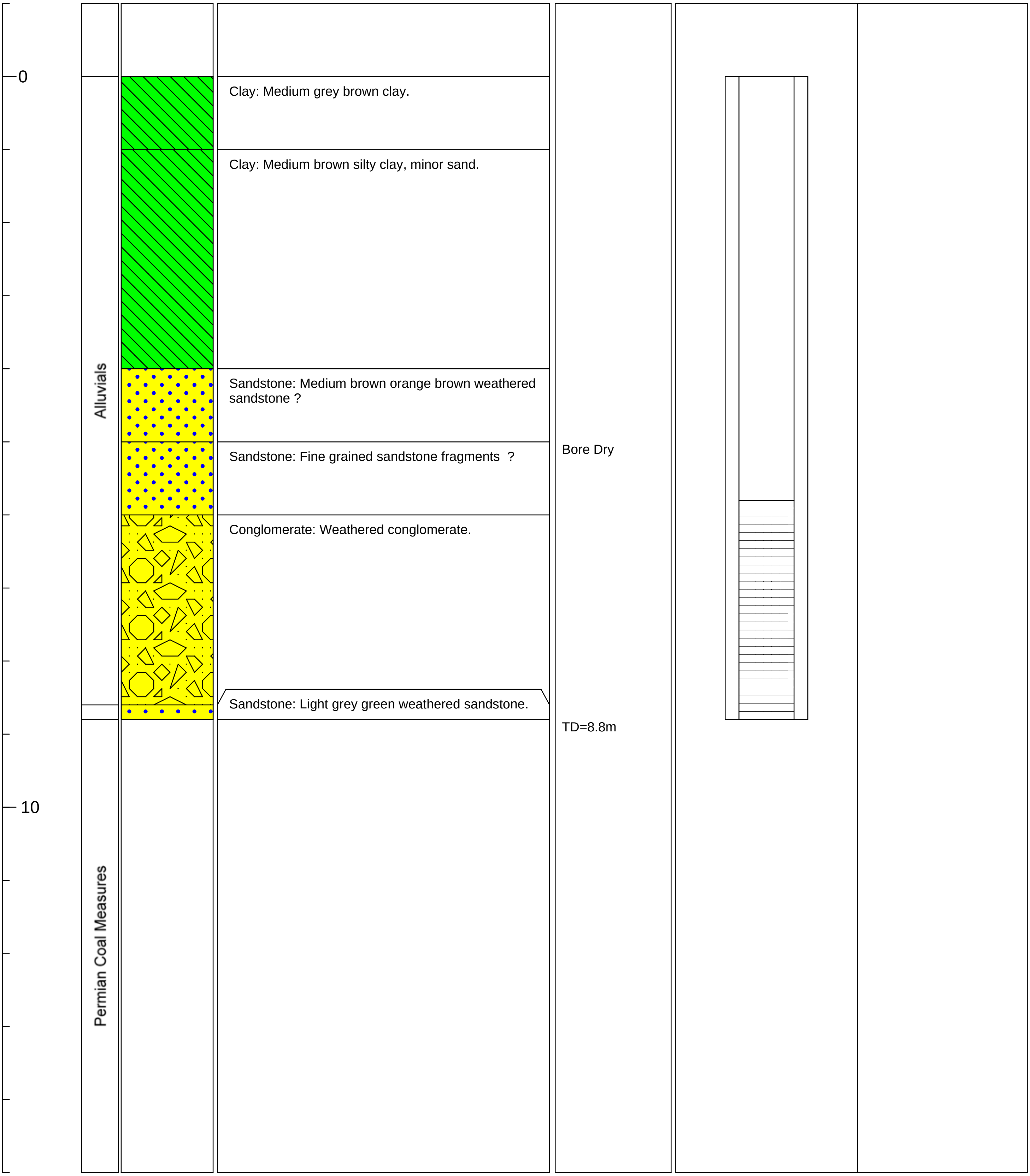
Commenced: 08/11/08
Completed: 08/11/08
Drilled: Intertech
Logged By: AF

Method: Tubex / Rotary Air
Fluid: Air
Bit Record:

Area:
East: 319899.6921
North: 6403635.4750
Collar (RL): 60.2

Static Water Level: DRY
Date: 08/11/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	Notes



Clay: Medium grey brown clay.

Clay: Medium brown silty clay, minor sand.

Sandstone: Medium brown orange brown weathered sandstone ?

Sandstone: Fine grained sandstone fragments ?

Conglomerate: Weathered conglomerate.

Sandstone: Light grey green weathered sandstone.

Bore Dry

TD=8.8m

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Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

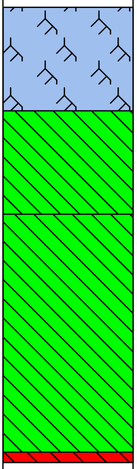
Well No: WML261

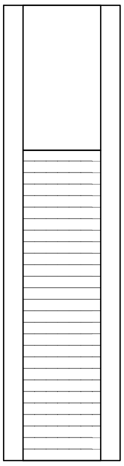
Client: Ashton Coal Operations Ltd **Project:** South East Open Cut

Commenced:	08/11/08	**Method:**	Tubex / Rotary Air	**Area:**	
Completed:	08/11/08	**Fluid:**	Air	**East:**	319976.6349
Drilled:	Intertech	**Bit Record:**		**North:**	6403623.4236
Logged By:	AF			**Collar (RL):**	62.4

Static Water Level: DRY **Date:** 08/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Alluvials		Topsoil: Clayey topsoil.			
			Clay: Light red brown clay, minor fine sand.			
			Clay: Light brown to yellow brown clay.	Bore Dry		
			Basement: Basement not identified. Hard surface, blowing dust	TD=4.4m		
10	Permian Coal Measures					





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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML262

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

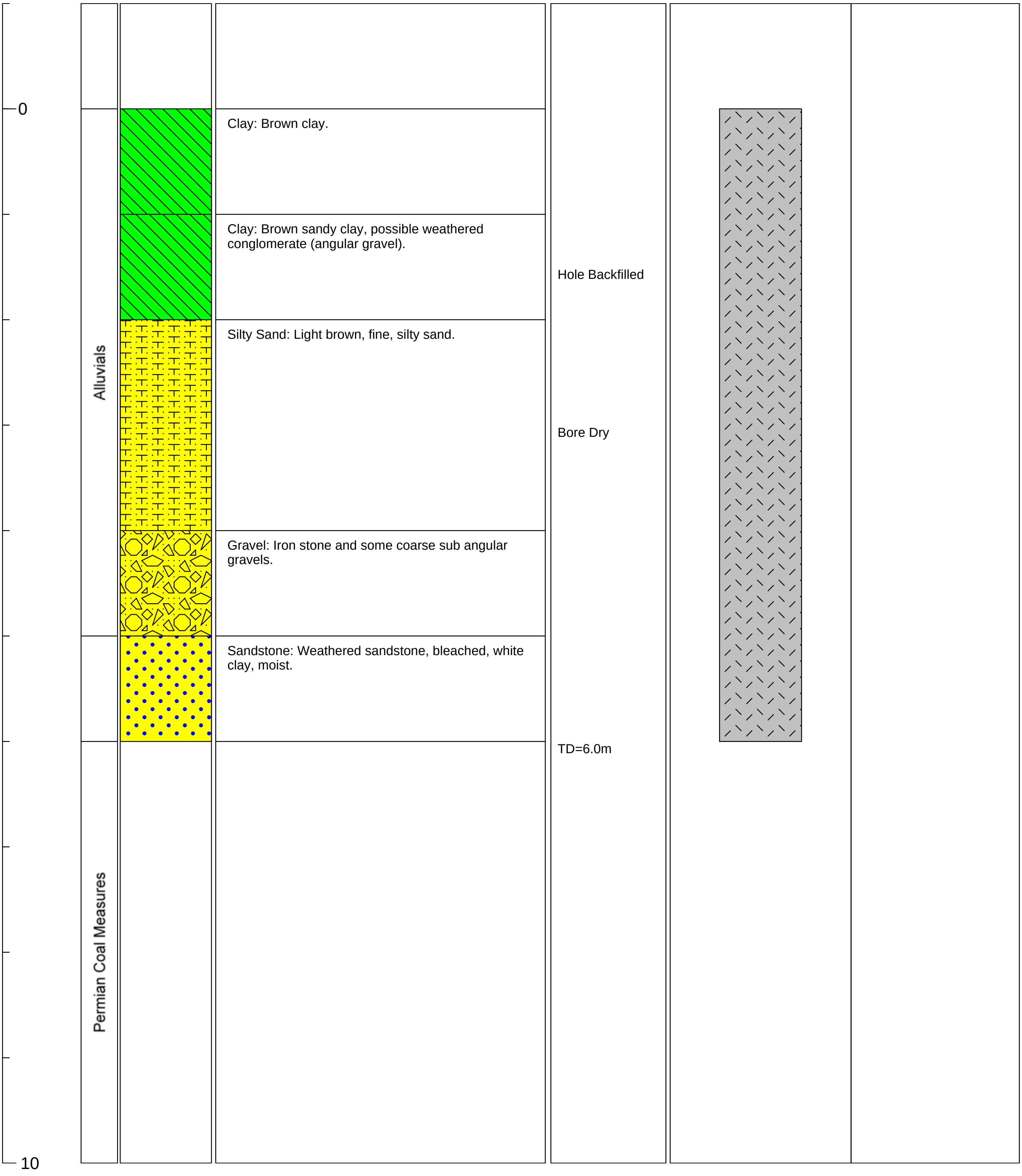
Commenced: 27/11/08
Completed: 27/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319811.043
North: 6404031.548
Collar (RL): 61.94

Static Water Level: DRY
Date: 27/11/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay: Brown clay.

Clay: Brown sandy clay, possible weathered conglomerate (angular gravel).

Silty Sand: Light brown, fine, silty sand.

Gravel: Iron stone and some coarse sub angular gravels.

Sandstone: Weathered sandstone, bleached, white clay, moist.

Hole Backfilled

Bore Dry

TD=6.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML263

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

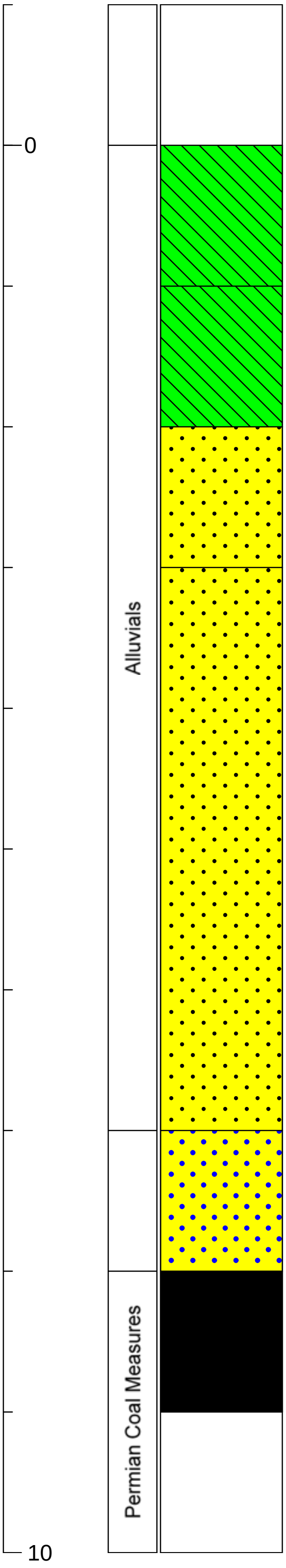
Commenced: 27/11/08
Completed: 27/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

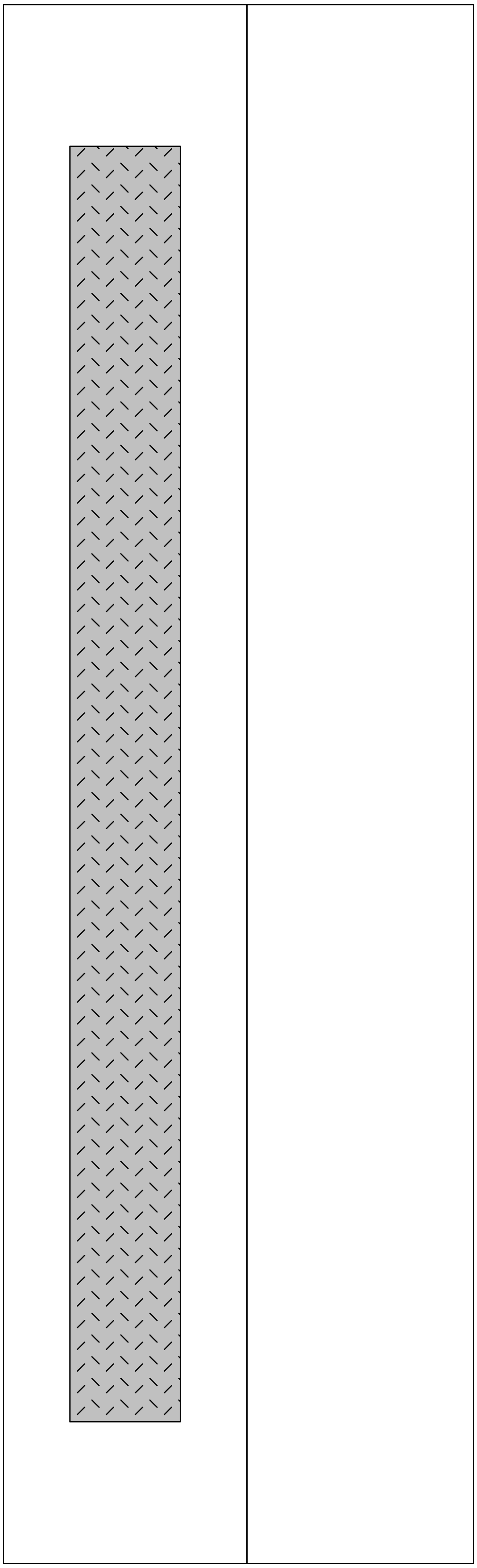
Area:
East: 319795
North: 6404000
Collar (RL): 61.5

Static Water Level: DRY
Date: 27/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Lithological Description	Field Notes
Clay: Brown clay.	
Clay: Light brown clay, possible weathered conglomerate.	Hole Backfilled
Sand: Light brown sand, some silty clay.	
Sand: Light brown, fine sand, coarser with depth, moist.	Bore Dry Collapsed to 6m
Sandstone: Weathered sandstone, probably bleached, white clay.	
Coal: Coal, light brown orange siltstone band.	
	TD=9.0m



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Australia
Tel: (+61) (02) 9440 2666
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COMPOSITE WELL LOG

Well No: WML264

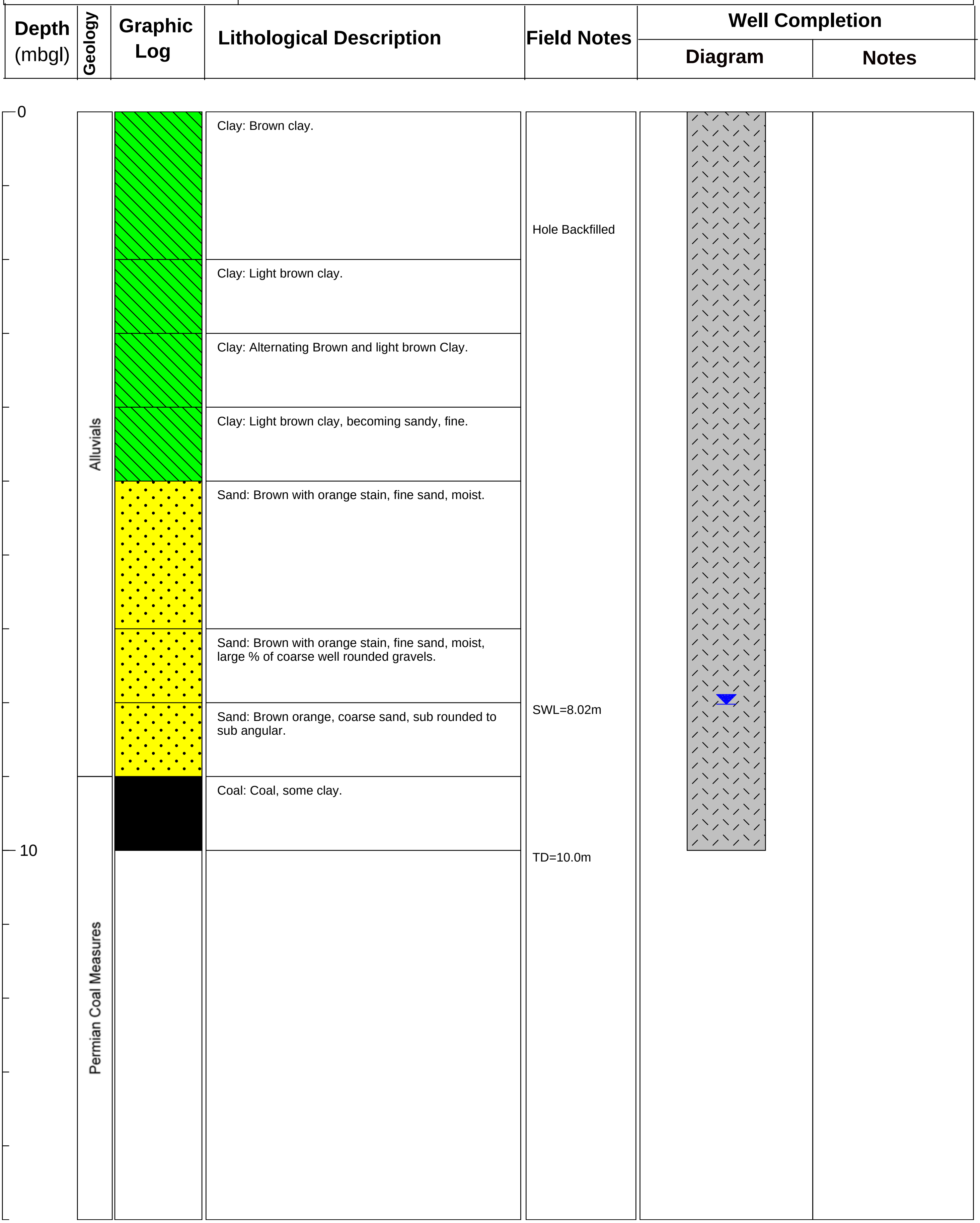
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319785.000
North: 6403950.000
Collar (RL): 61.000

Static Water Level: 8.02mbgl
Date: 28/11/08



Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Alluvials	🟩	Clay: Brown clay.	Hole Backfilled		
		🟩	Clay: Light brown clay.			
		🟩	Clay: Alternating Brown and light brown Clay.			
		🟩	Clay: Light brown clay, becoming sandy, fine.			
		🟨	Sand: Brown with orange stain, fine sand, moist.			
		🟨	Sand: Brown with orange stain, fine sand, moist, large % of coarse well rounded gravels.			
		🟨	Sand: Brown orange, coarse sand, sub rounded to sub angular.	SWL=8.02m		
	Permian Coal Measures	⬛	Coal: Coal, some clay.			
10				TD=10.0m		

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML265

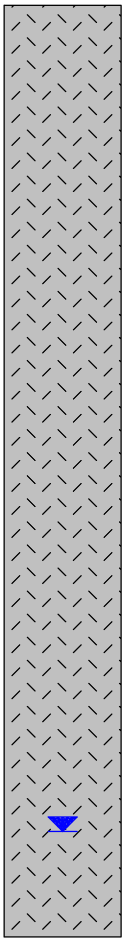
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319778.598
North: 6403911.054
Collar (RL): 60.688

Static Water Level: 7.98mbgl
Date: 28/11/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes
0	Alluvials	▨	Clay: Brown grey clay.	Hole Backfilled		
		▨	Clay: Brown clay.			
		▨	Clay: Brown clay, some fine sand.			
		▨	Clay: Brown sand, medium, some medium sub rounded gravel.			
		⠿	Sand: Coarse sand and gravel, rounded, to 3cm.			
		⠿	Sand: Orange brown, coarse, alluvial sand, sub rounded. Blowing dust (sandstone) at end of hole.	SWL=7.98m		
10	Permian Coal Measures			TD=9.0m		

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML266

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

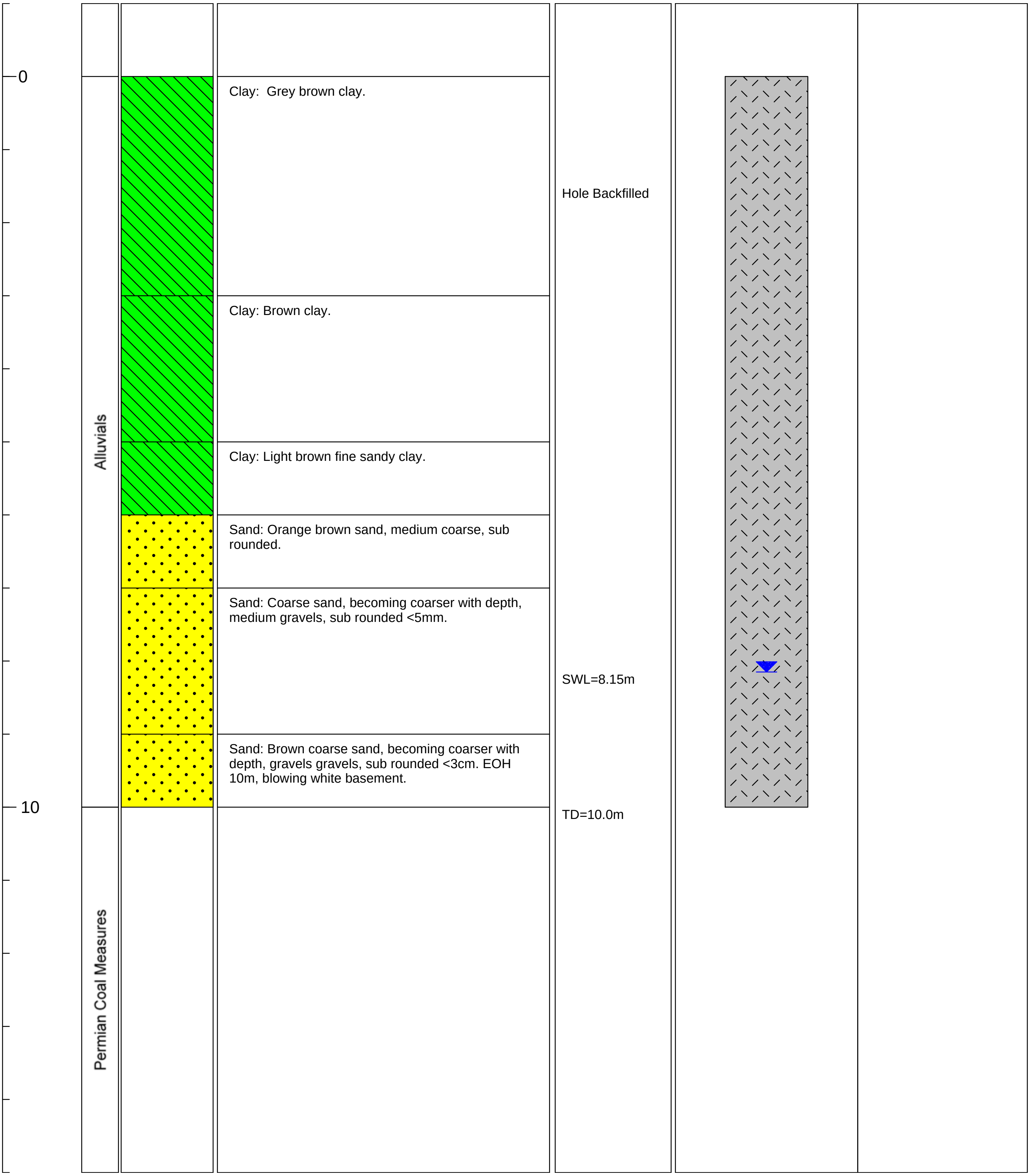
Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319780.145
North: 6403840.305
Collar (RL): 60.267

Static Water Level: 8.15mbgl
Date: 28/11/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion**	
					Diagram	**Notes**



Clay: Grey brown clay.

Clay: Brown clay.

Clay: Light brown fine sandy clay.

Sand: Orange brown sand, medium coarse, sub rounded.

Sand: Coarse sand, becoming coarser with depth, medium gravels, sub rounded <5mm.

Sand: Brown coarse sand, becoming coarser with depth, gravels gravels, sub rounded <3cm. EOH 10m, blowing white basement.

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

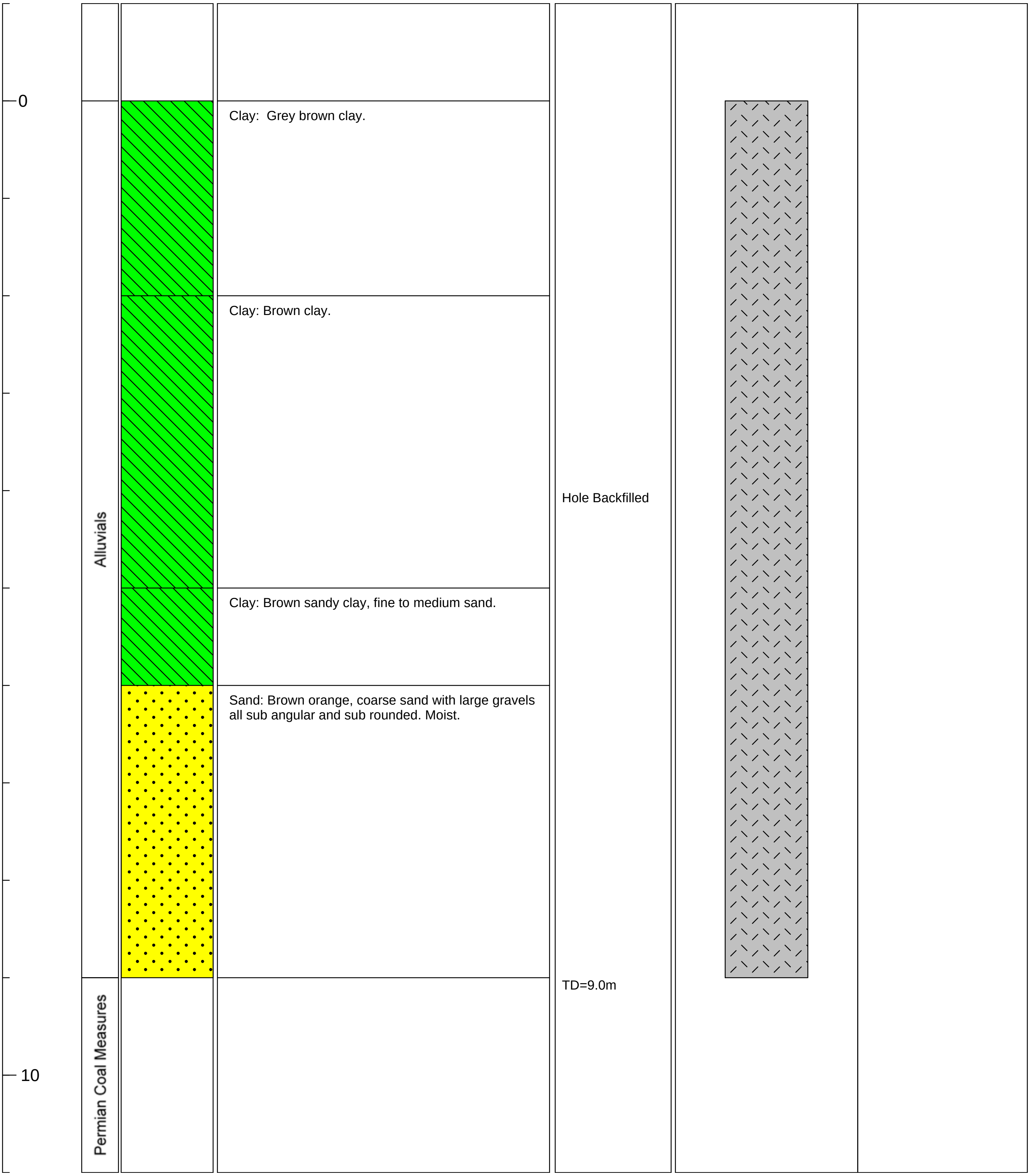
Well No: WML267

Client: Ashton Coal Operations Ltd **Project:** South East Open Cut

Commenced:	28/11/08	**Method:**	Blade	**Area:**	
Completed:	28/11/08	**Fluid:**	Air	**East:**	319775.146
Drilled:	Hunter Drilling	**Bit Record:**		**North:**	6403778.444
Logged By:	JV			**Collar (RL):**	59.634

Static Water Level: **Date:** 28/11/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay: Grey brown clay.

Clay: Brown clay.

Clay: Brown sandy clay, fine to medium sand.

Sand: Brown orange, coarse sand with large gravels all sub angular and sub rounded. Moist.

Hole Backfilled

TD=9.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML268

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

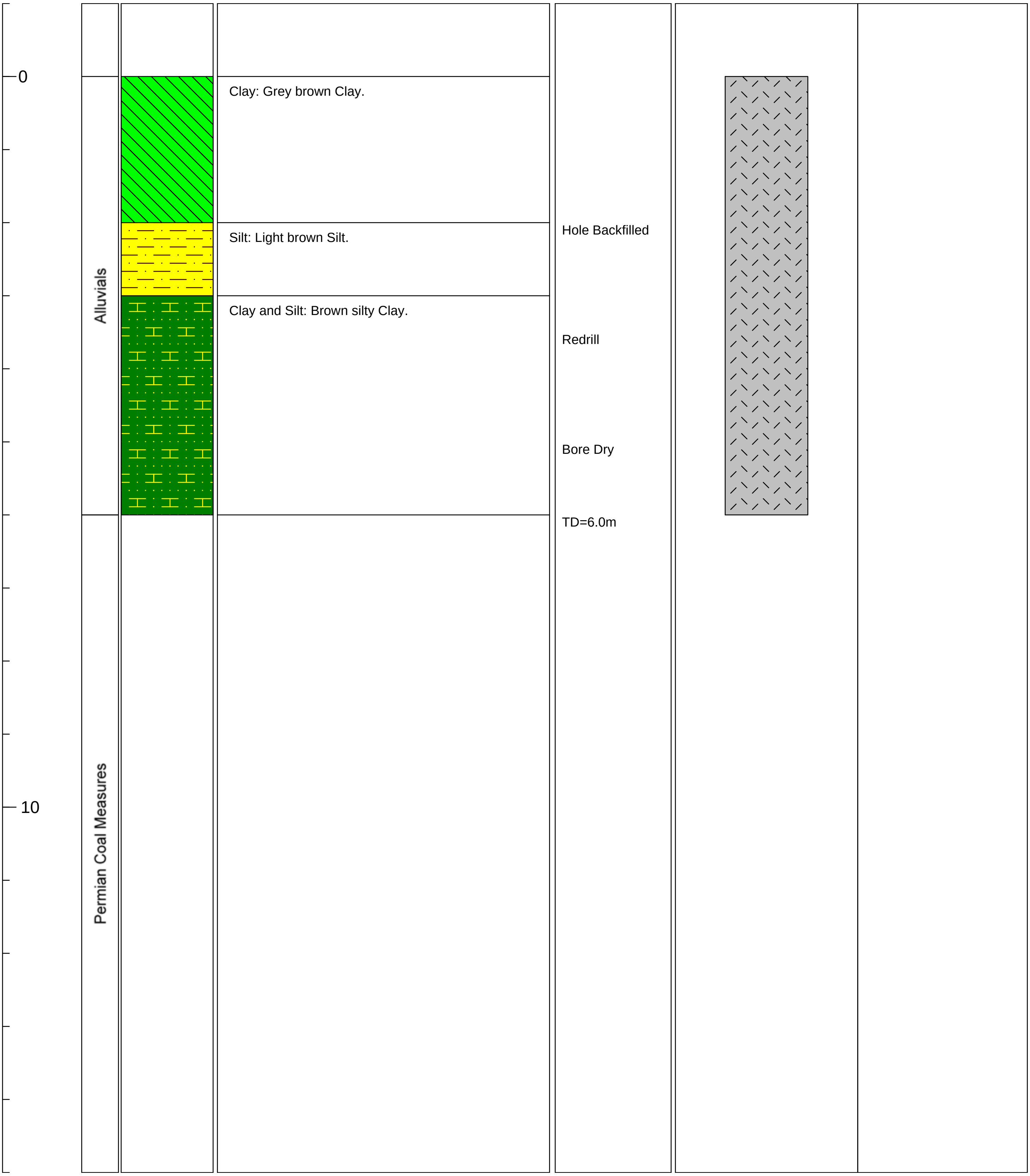
Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319649.211
North: 6404011.068
Collar (RL): 60.499

Static Water Level: DRY
Date: 28/11/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay: Grey brown Clay.

Silt: Light brown Silt.

Clay and Silt: Brown silty Clay.

Hole Backfilled

Redrill

Bore Dry

TD=6.0m

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Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML269

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

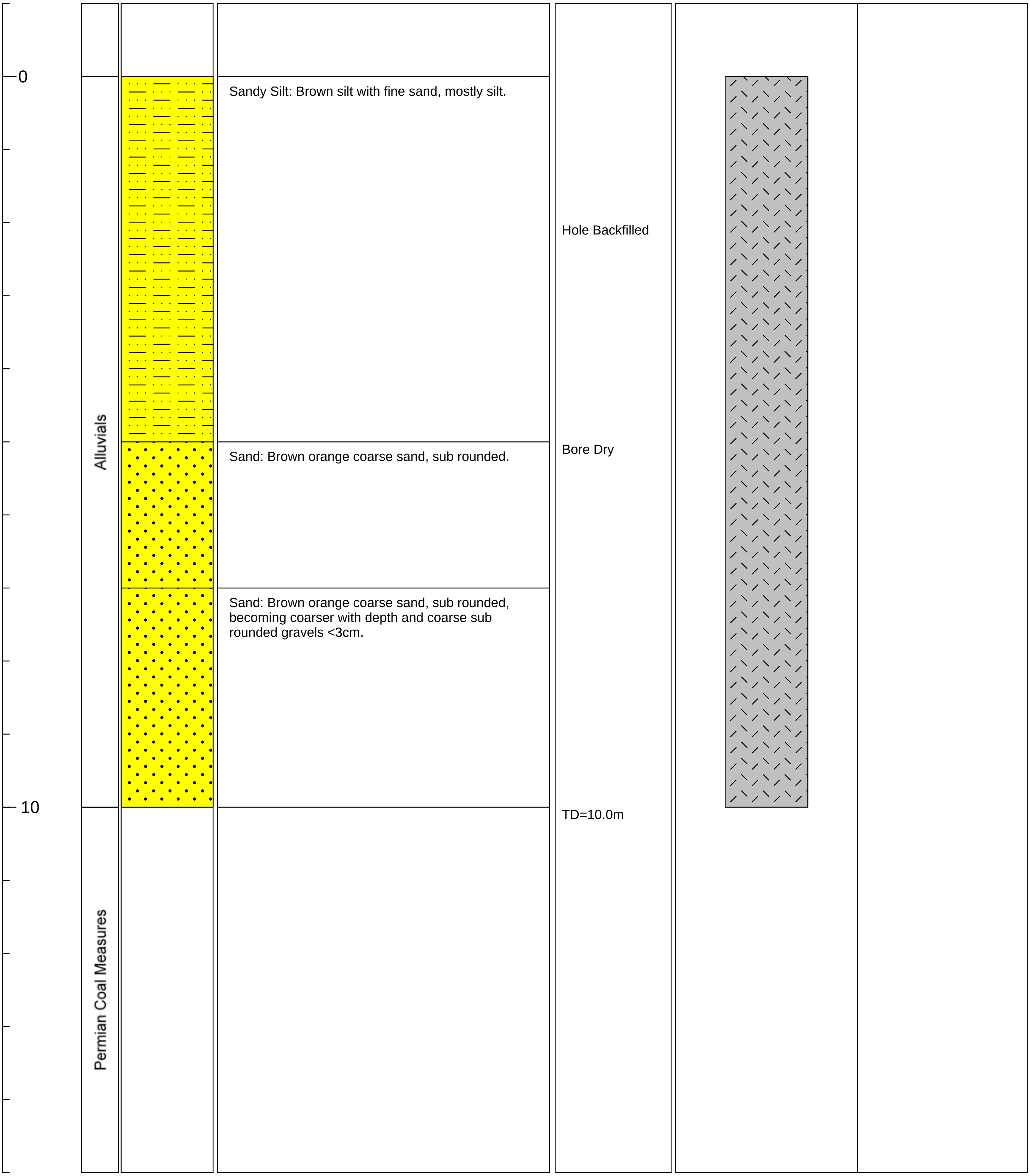
Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319648.894
North: 6403952.592
Collar (RL): 60.503

Static Water Level: DRY
Date: 28/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Sandy Silt: Brown silt with fine sand, mostly silt.

Sand: Brown orange coarse sand, sub rounded.

Sand: Brown orange coarse sand, sub rounded, becoming coarser with depth and coarse sub rounded gravels <3cm.

Hole Backfilled

Bore Dry

TD=10.0m

Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML270

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

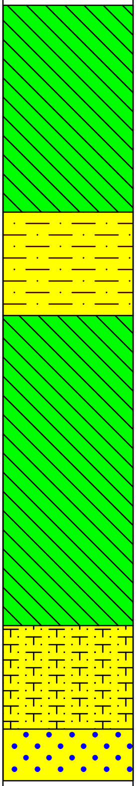
Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

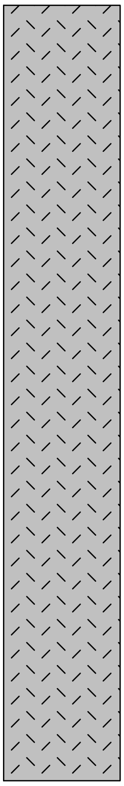
Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319659.786
North: 6404048.067
Collar (RL): 60.538

Static Water Level: DRY
Date: 28/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Alluvials		Clay: Grey brown clay.	Hole Backfilled		
			Silt: Light brown silt.			
			Clay: Brown silty clay.			
			Silty Sand: Brown orange silty sand, medium fine grained, moist.			
			Sandstone: Sandstone and iron stone, dust is light brown grey, moist.	TD=7.50m		
10	Permian Coal Measures					





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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML271

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

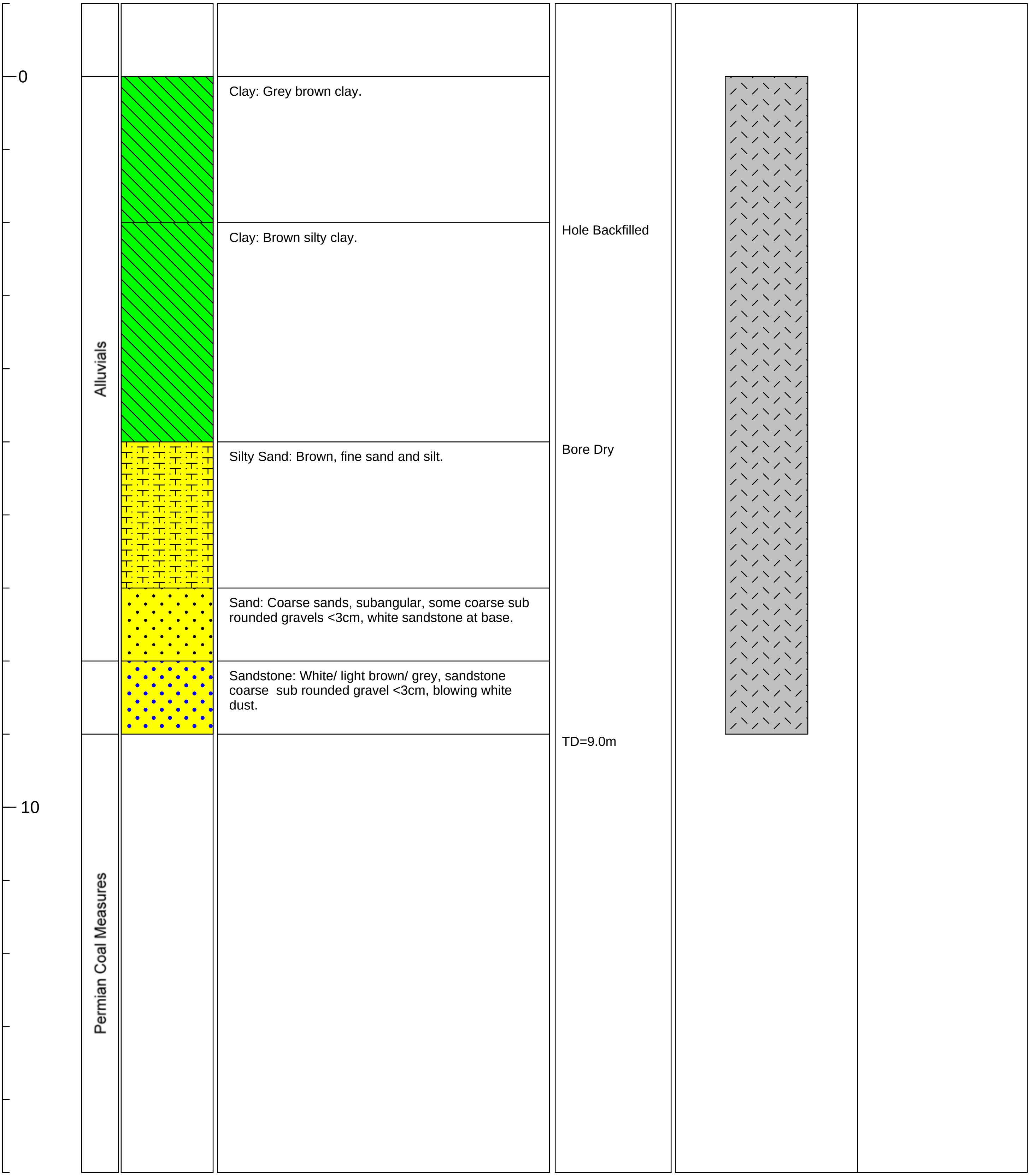
Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319657.280
North: 6404085.040
Collar (RL): 60.673

Static Water Level: Dry
Date: 28/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Clay: Grey brown clay.

Clay: Brown silty clay.

Silty Sand: Brown, fine sand and silt.

Sand: Coarse sands, subangular, some coarse sub rounded gravels <3cm, white sandstone at base.

Sandstone: White/ light brown/ grey, sandstone coarse sub rounded gravel <3cm, blowing white dust.

Hole Backfilled

Bore Dry

TD=9.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML272

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

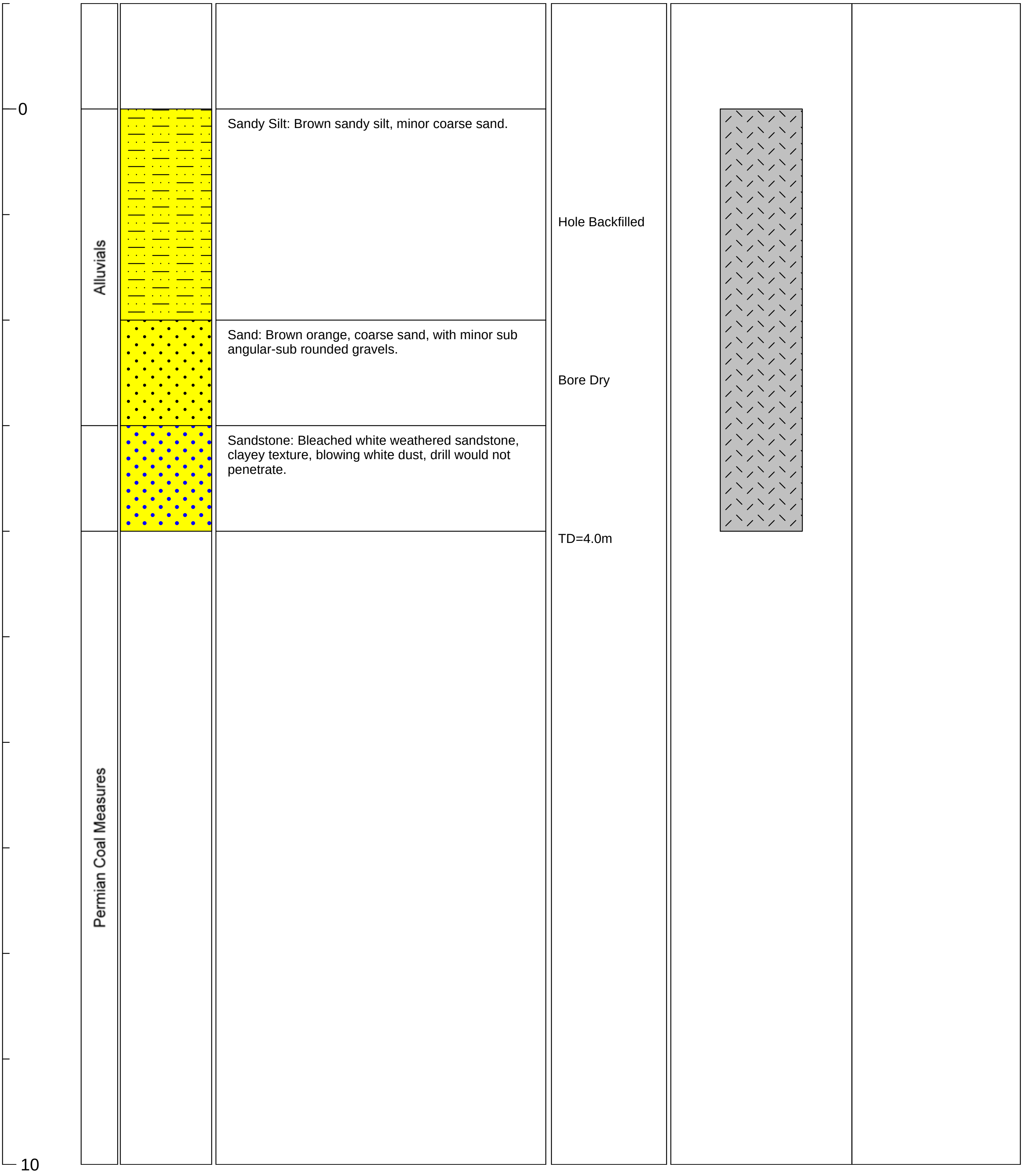
Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319683.307
North: 6404139.373
Collar (RL): 60.863

Static Water Level: Dry
Date: 28/11/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Sandy Silt: Brown sandy silt, minor coarse sand.

Sand: Brown orange, coarse sand, with minor sub angular-sub rounded gravels.

Sandstone: Bleached white weathered sandstone, clayey texture, blowing white dust, drill would not penetrate.

Hole Backfilled

Bore Dry

TD=4.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML273

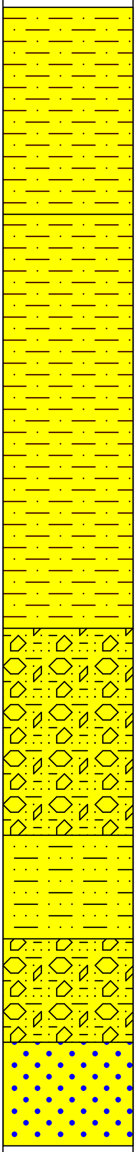
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

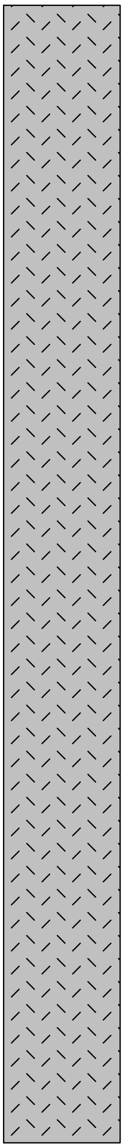
Commenced: 28/11/08
Completed: 28/11/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319599.640
North: 6404092.834
Collar (RL): 60.509

Static Water Level: 7.1mbgl
Date: 28/11/08





Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Alluvials		Silt: Brown grey Silt.	Hole Backfilled		
			Silt: Light brown silt, with large gravels sub angular to sub rounded <3cm at 5-6m.	Bore Dry		
			Gravel and Sand: Brown orange coarse sand, sub angular to sub rounded with coarse gravels <1cm, sub angular to sub rounded, moist at 8m.			
			Siltstone: Light grey Siltstone/Sandstone, large gravel sub rounded with some ironstone fragments.			
			Gravel and Sand: Orange brown coarse Sand with large Gravels <3cm, sub angular sub rounded.			
10			Sandstone: Orange Sandstone.			
	Permian Coal Measures			TD=11.0m		

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Suite 9, 1051 Pacific Highway
Pymble
NSW   2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML274

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

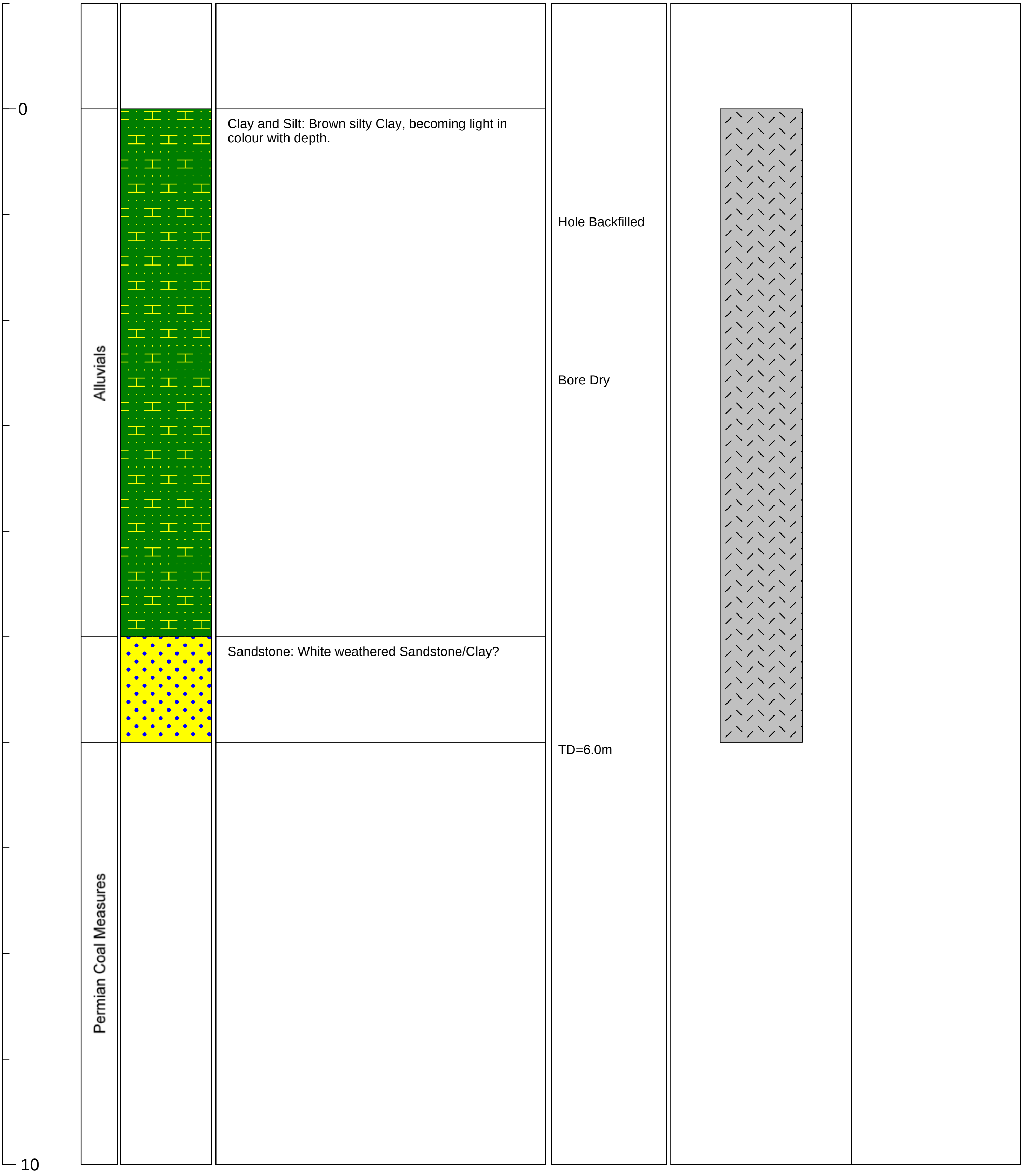
Commenced: 01/12/08
Completed: 01/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319686.909
North: 6404170.147
Collar (RL): 60.814

Static Water Level: DRY
Date: 01/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay and Silt: Brown silty Clay, becoming light in colour with depth.

Sandstone: White weathered Sandstone/Clay?

Hole Backfilled

Bore Dry

TD=6.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML275

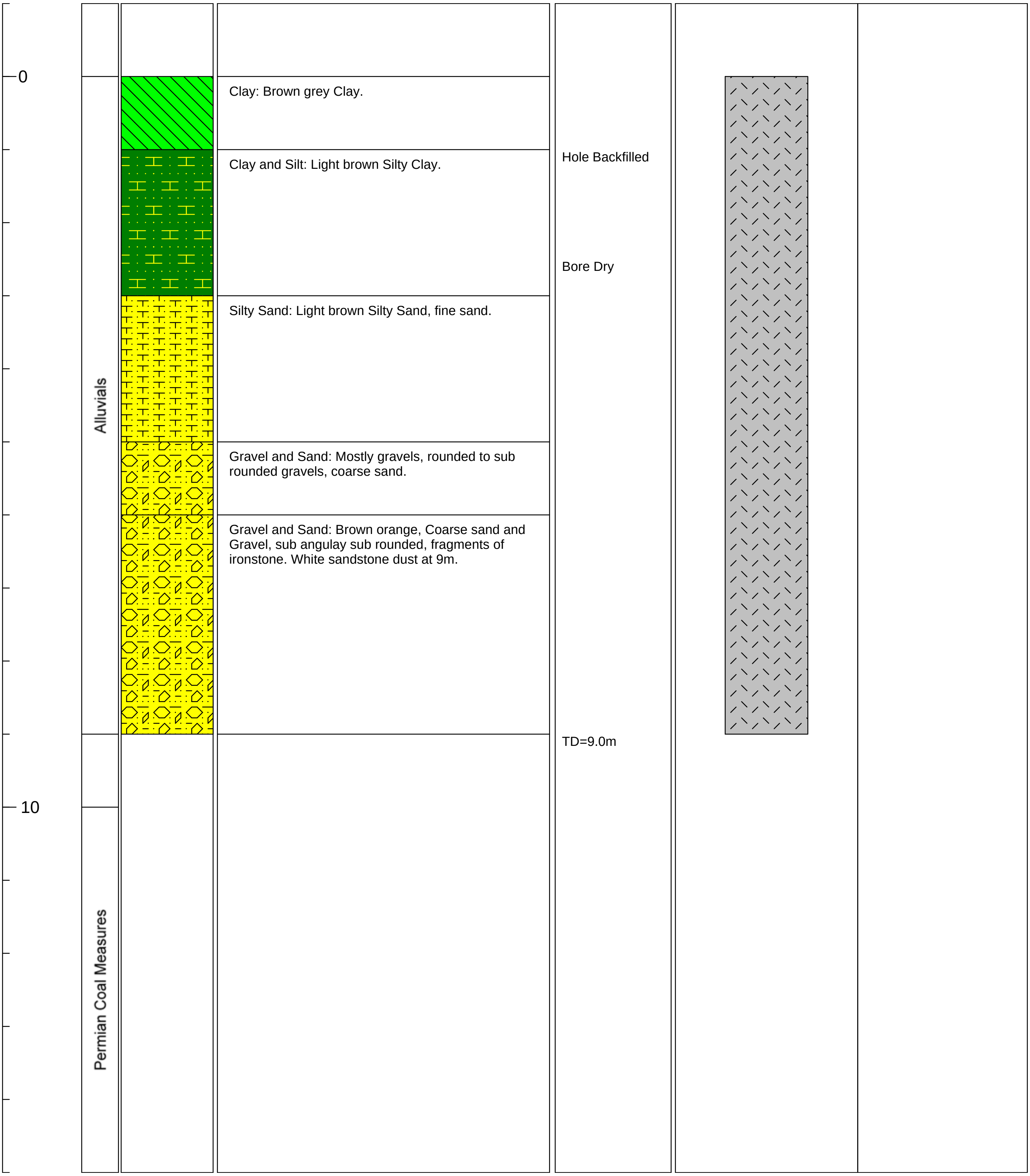
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced: 01/12/08
Completed: 01/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319700
North: 6404230
Collar (RL): 61

Static Water Level: DRY
Date: 01/12/08



Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Alluvials		Clay: Brown grey Clay.			
			Clay and Silt: Light brown Silty Clay.	Hole Backfilled Bore Dry		
			Silty Sand: Light brown Silty Sand, fine sand.			
			Gravel and Sand: Mostly gravels, rounded to sub rounded gravels, coarse sand.			
			Gravel and Sand: Brown orange, Coarse sand and Gravel, sub angulay sub rounded, fragments of ironstone. White sandstone dust at 9m.			
				TD=9.0m		
10	Permian Coal Measures					

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML276

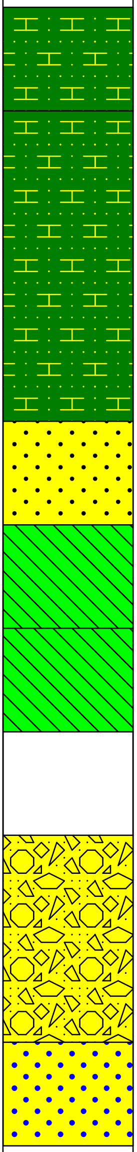
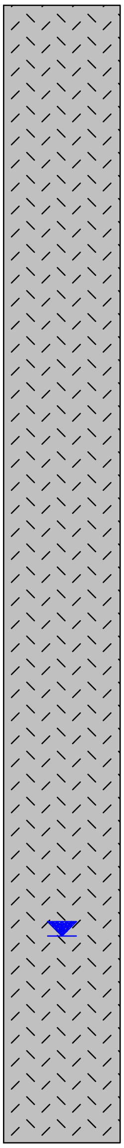
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced: 01/12/08
Completed: 01/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319734.924
North: 6404302.315
Collar (RL): 61.798

Static Water Level: 9.0 mbgl
Date: 01/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes
0	Alluvials		Clay and Silt: Dark brown Clay/Silt, mostly Clay.			
			Clay and Silt: Dark brown Clay/Silt, mostly clay, colour becoming lighter brown with depth.	Hole Backfilled		
			Sand: Light brown fine Sand.			
			Clay: Light brown Clay.			
			Clay: Light brown Clay, with very coarse gravel, sub angular up to 5cm.			
			Sandy Clay: Orange brown clay with coarse sand. Some fine sub angular Gravel.			
			Gravel: Coarse gravel (iron stones), 3-5cm, sub rounded - sub angular.	SWL = 9.0mbgl		
10			Sandstone: White Sandstone and blue shale.			
	Permian Coal Measures			TD=11.0m		

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML277

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

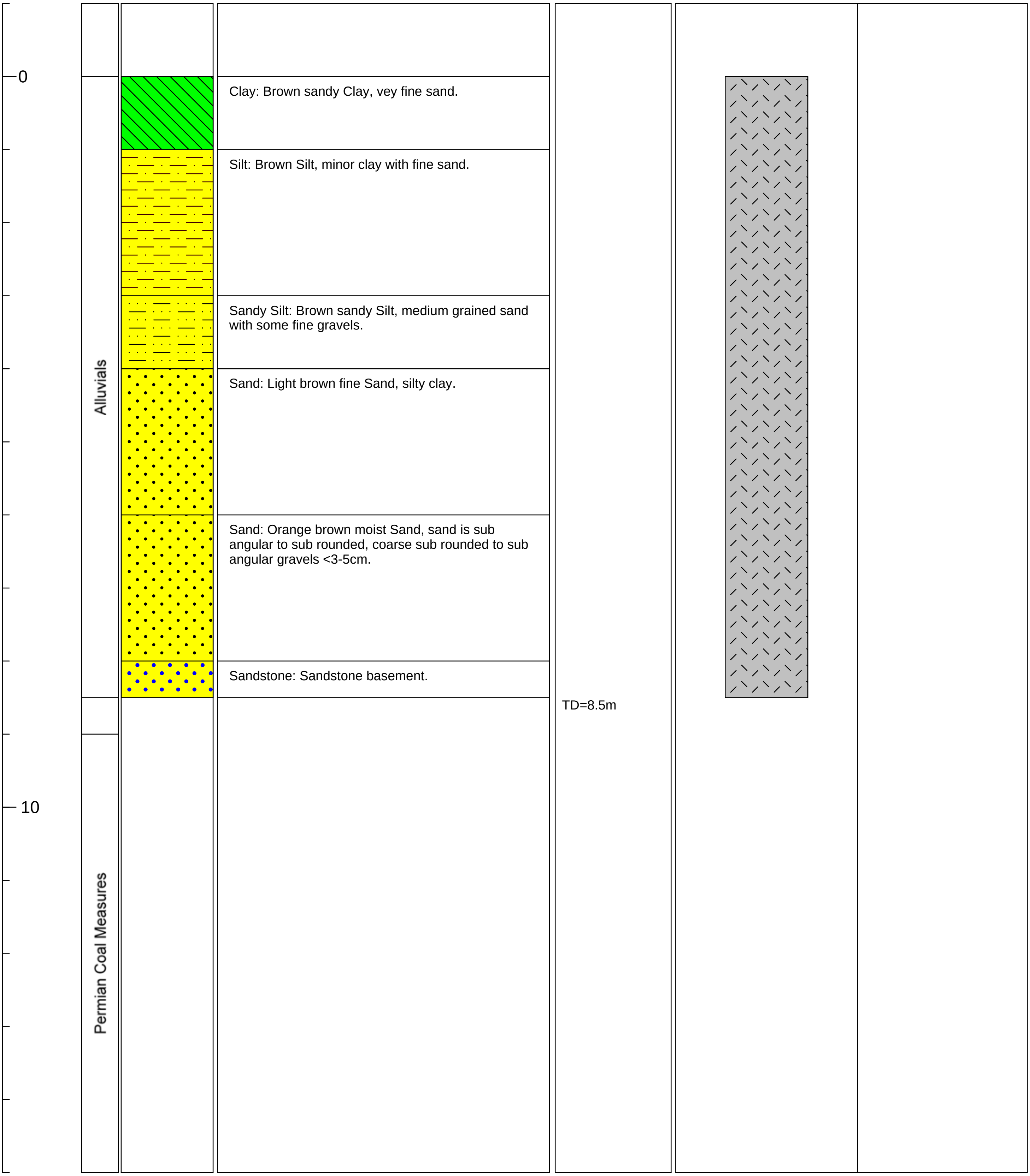
Commenced: 01/12/08
Completed: 01/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319624.176
North: 6404172.597
Collar (RL): 58.971

Static Water Level:
Date: 01/12/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Clay: Brown sandy Clay, vey fine sand.

Silt: Brown Silt, minor clay with fine sand.

Sandy Silt: Brown sandy Silt, medium grained sand with some fine gravels.

Sand: Light brown fine Sand, silty clay.

Sand: Orange brown moist Sand, sand is sub angular to sub rounded, coarse sub rounded to sub angular gravels <3-5cm.

Sandstone: Sandstone basement.

TD=8.5m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML278

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

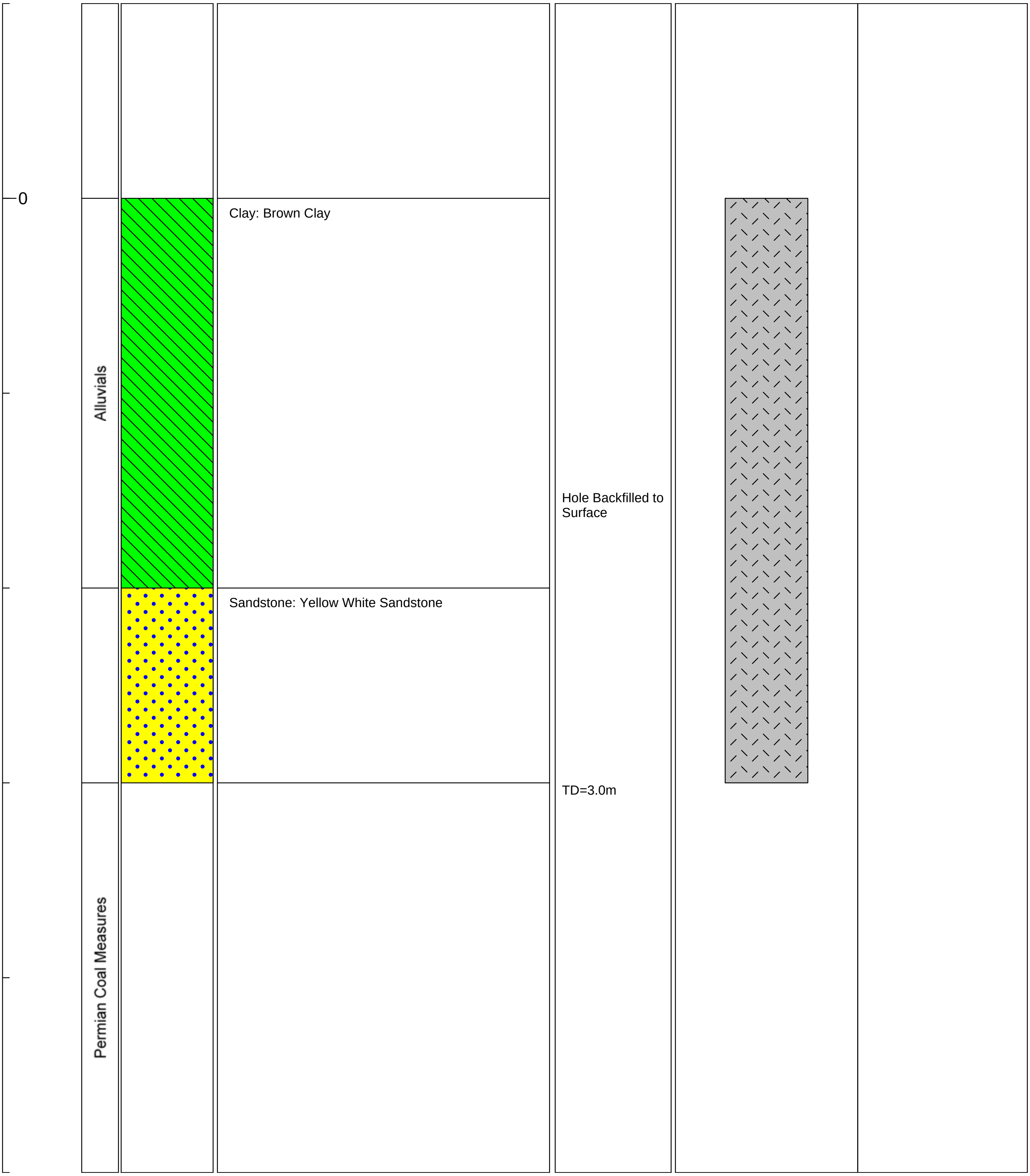
Commenced: 01/12/08
Completed: 01/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319755.097
North: 6404172.458
Collar (RL): 62.335

Static Water Level:
Date: 01/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay: Brown Clay

Sandstone: Yellow White Sandstone

Hole Backfilled to Surface

TD=3.0m

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Pymble
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Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML279

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

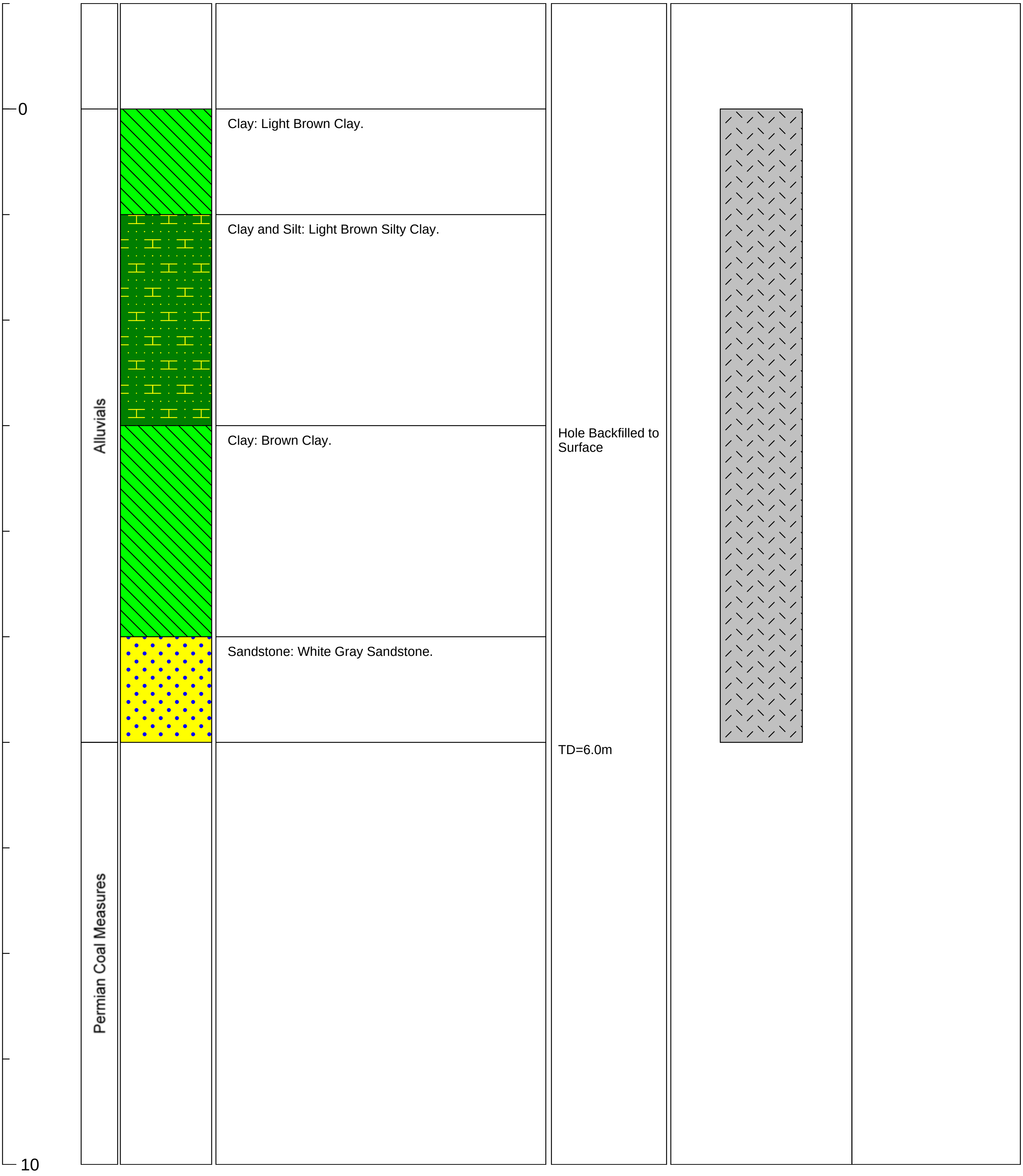
Commenced: 01/12/08
Completed: 01/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319624.176
North: 6404172.597
Collar (RL): 58.971

Static Water Level:
Date: 01/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion**	
					Diagram	**Notes**



Clay: Light Brown Clay.

Clay and Silt: Light Brown Silty Clay.

Clay: Brown Clay.

Sandstone: White Gray Sandstone.

Hole Backfilled to Surface

TD=6.0m

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Pymble
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Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML280

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

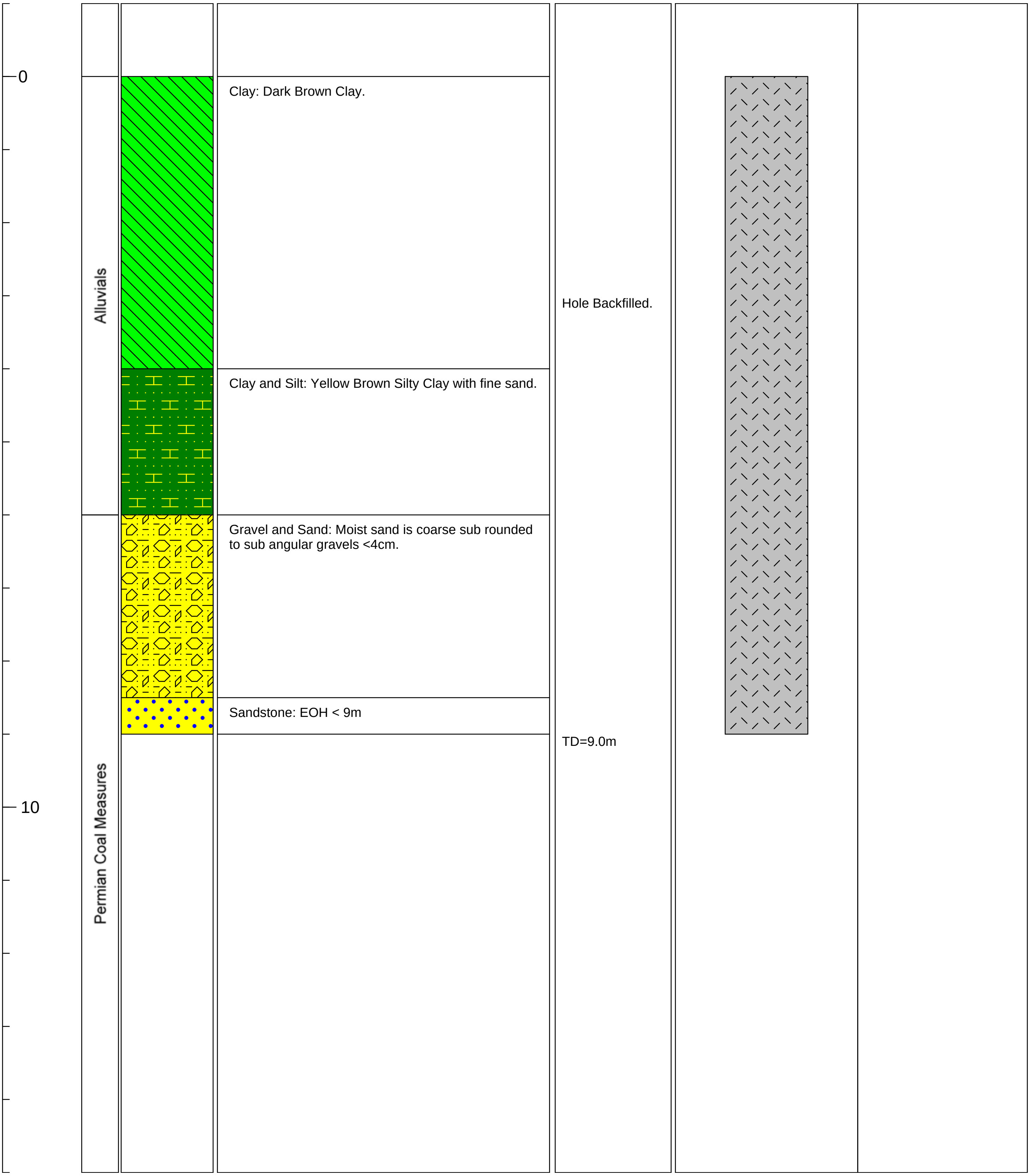
Commenced: 01/12/08
Completed: 01/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319712.669
North: 6404368.524
Collar (RL): 62.457

Static Water Level:
Date: 01/12/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Clay: Dark Brown Clay.

Clay and Silt: Yellow Brown Silty Clay with fine sand.

Gravel and Sand: Moist sand is coarse sub rounded to sub angular gravels <4cm.

Sandstone: EOH < 9m

Hole Backfilled.

TD=9.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML281

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

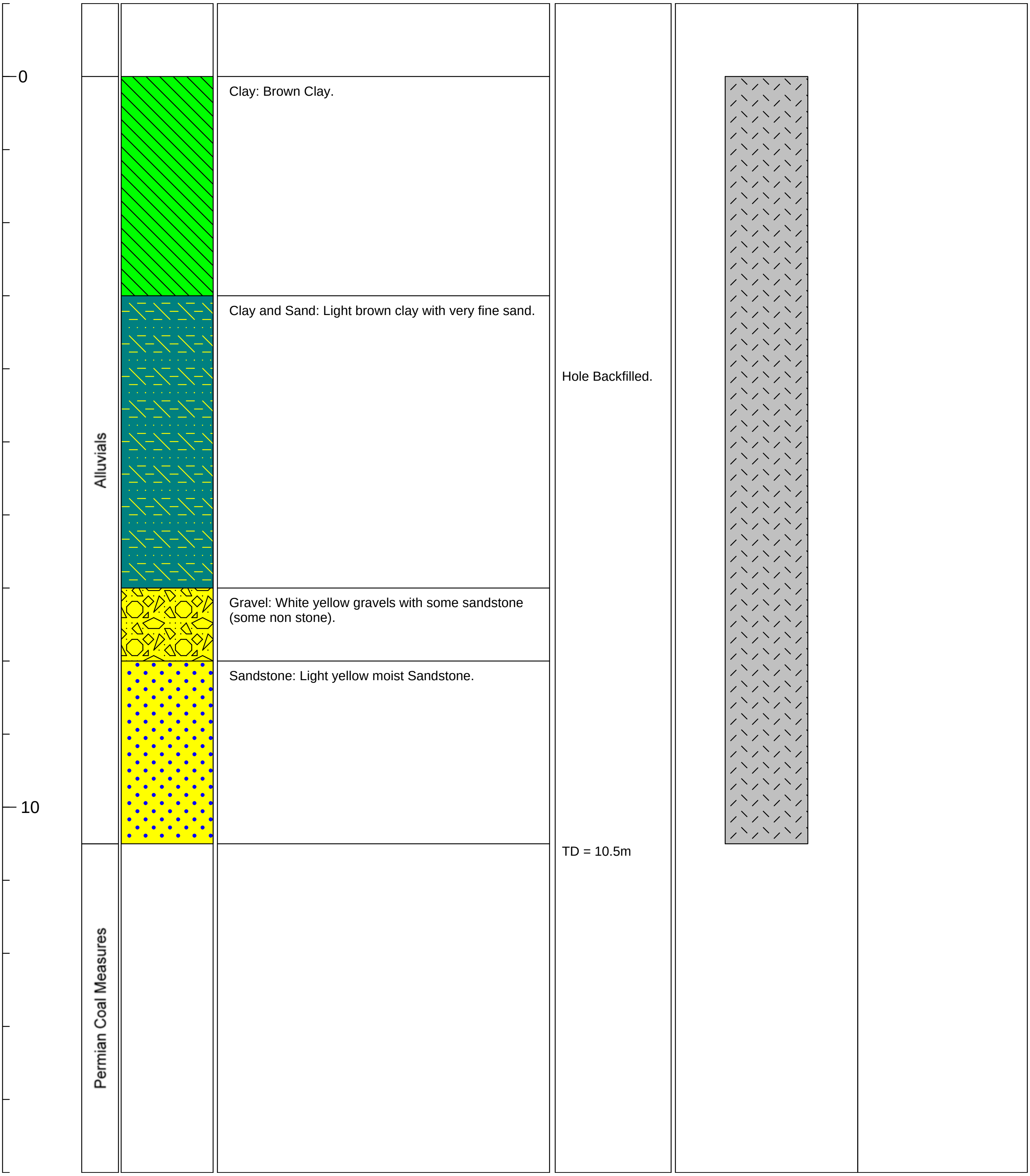
Commenced: 01/12/08
Completed: 01/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319714.261
North: 6404429.267
Collar (RL): 62.599

Static Water Level:
Date: 01/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay: Brown Clay.

Clay and Sand: Light brown clay with very fine sand.

Gravel: White yellow gravels with some sandstone (some non stone).

Sandstone: Light yellow moist Sandstone.

Hole Backfilled.

TD = 10.5m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML282

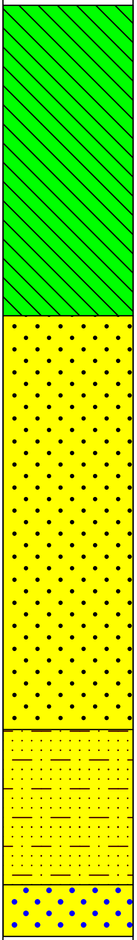
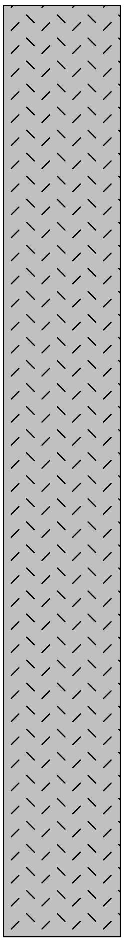
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced: 02/12/08
Completed: 02/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319779.933
North: 6404560.667
Collar (RL): 63.322

Static Water Level:
Date: 02/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes
0	Alluvials		Clay: Brown gray clay.			
			Sand: Yellow brown fine silty sand.	Hole Backfilled.		
			Sand and Silt: Yellow brown fine silty sand. Sand is sub rounded.			
			Sandstone: Yellow hard drilling sandstone.	TD = 9.0m		
10	Permian Coal Measures					

Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML283

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

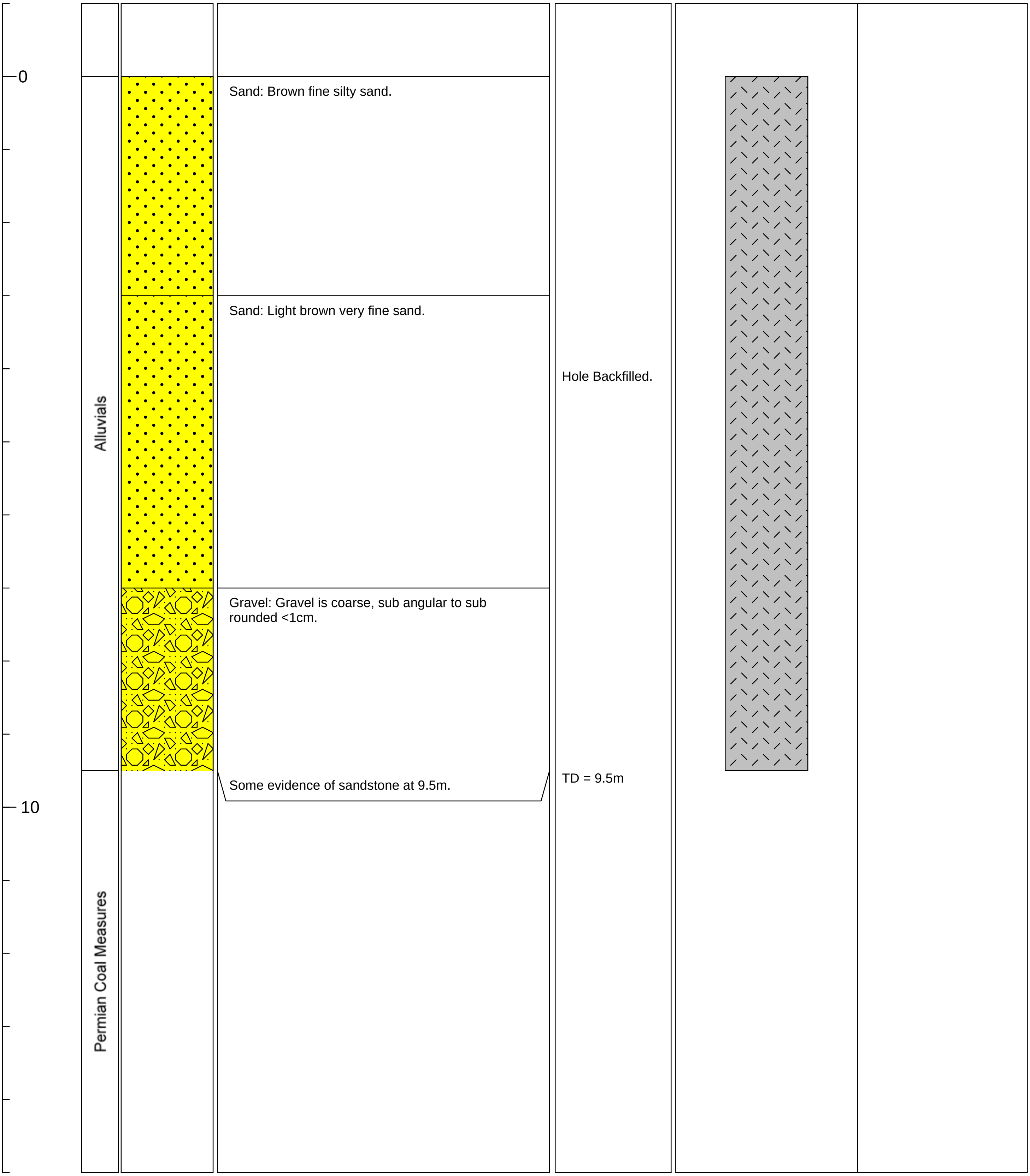
Commenced: 02/12/08
Completed: 02/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319534.443
North: 6404525.303
Collar (RL): 60.714

Static Water Level:
Date: 02/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Sand: Brown fine silty sand.

Sand: Light brown very fine sand.

Gravel: Gravel is coarse, sub angular to sub rounded <1cm.

Some evidence of sandstone at 9.5m.

Hole Backfilled.

TD = 9.5m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML284

Client: Ashton Coal Operations Ltd **Project:** South East Open Cut

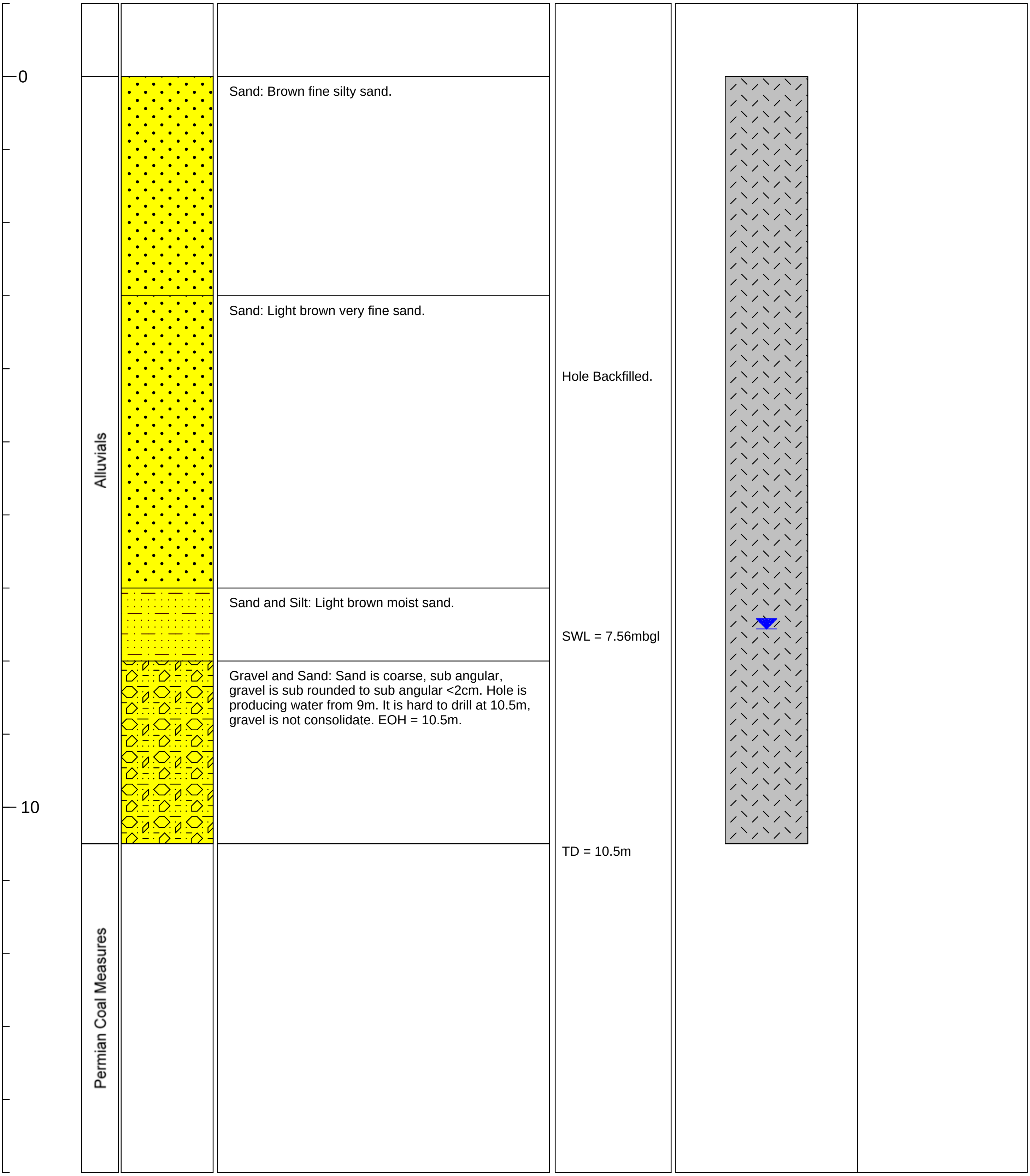
Commenced: 02/12/08
Completed: 02/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319490
North: 6404400
Collar (RL): 60.3

Static Water Level: 7.65mbgl **Date:** 02/12/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Sand: Brown fine silty sand.

Sand: Light brown very fine sand.

Sand and Silt: Light brown moist sand.

Gravel and Sand: Sand is coarse, sub angular, gravel is sub rounded to sub angular <2cm. Hole is producing water from 9m. It is hard to drill at 10.5m, gravel is not consolidate. EOH = 10.5m.

Hole Backfilled.

SWL = 7.56mbgl

TD = 10.5m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML285

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

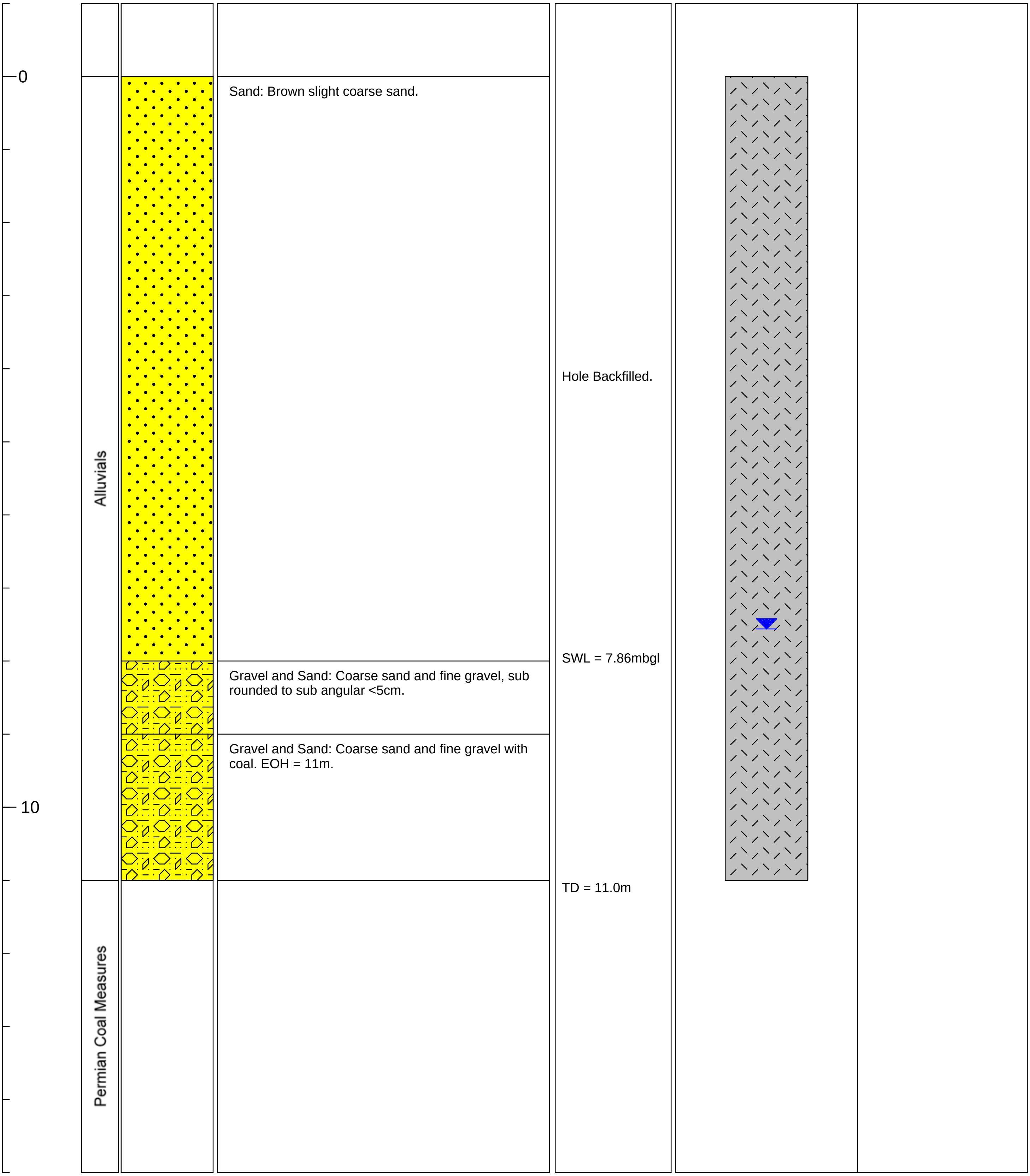
Commenced: 02/12/08
Completed: 02/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319459.174
North: 6404352.598
Collar (RL): 60.044

Static Water Level: 7.86mbgl
Date: 02/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Sand: Brown slight coarse sand.

Gravel and Sand: Coarse sand and fine gravel, sub rounded to sub angular <5cm.

Gravel and Sand: Coarse sand and fine gravel with coal. EOH = 11m.

Hole Backfilled.

SWL = 7.86mbgl

TD = 11.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML286

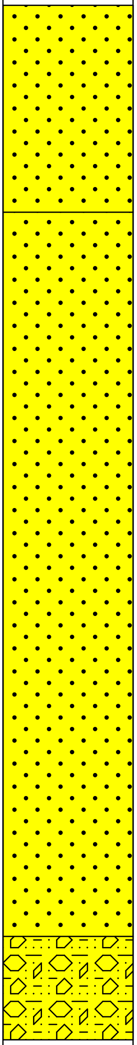
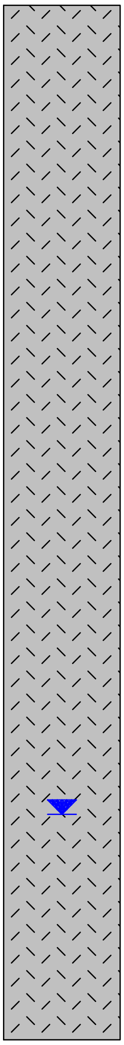
Client: Ashton Coal Operations Ltd **Project:** South East Open Cut

Commenced: 02/12/08
Completed: 02/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319447.9
North: 6404238.029
Collar (RL): 59.962

Static Water Level: 7.82mbgl **Date:** 02/12/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Notes
0	Alluvials		Sand: Brown fine sand.			
			Sand: Brown fine sand. It is slightly coarse and moist at 9m.	Hole Backfilled. SWL = 7.82mbgl		
			Gravel and Sand: Brown fine sand and fine gravel. Sand is slightly coarse and moist at 9m.	TD = 10.0m		
10	Permian Coal Measures					

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML287

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

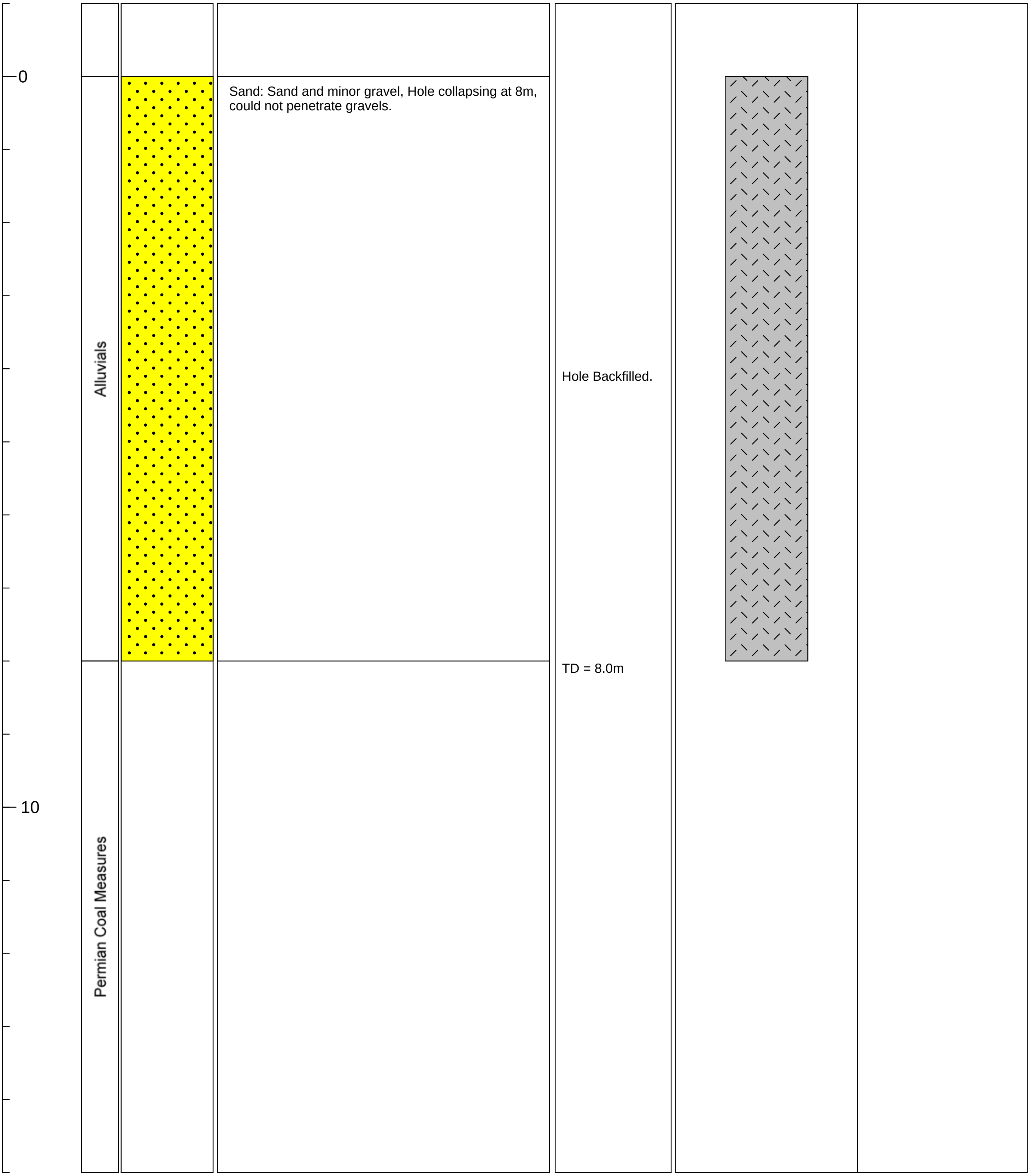
Commenced: 03/12/08
Completed: 03/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319390.46
North: 6404132.849
Collar (RL): 60.085

Static Water Level:
Date: 03/12/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Sand: Sand and minor gravel, Hole collapsing at 8m, could not penetrate gravels.

Hole Backfilled.

TD = 8.0m

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Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML288

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

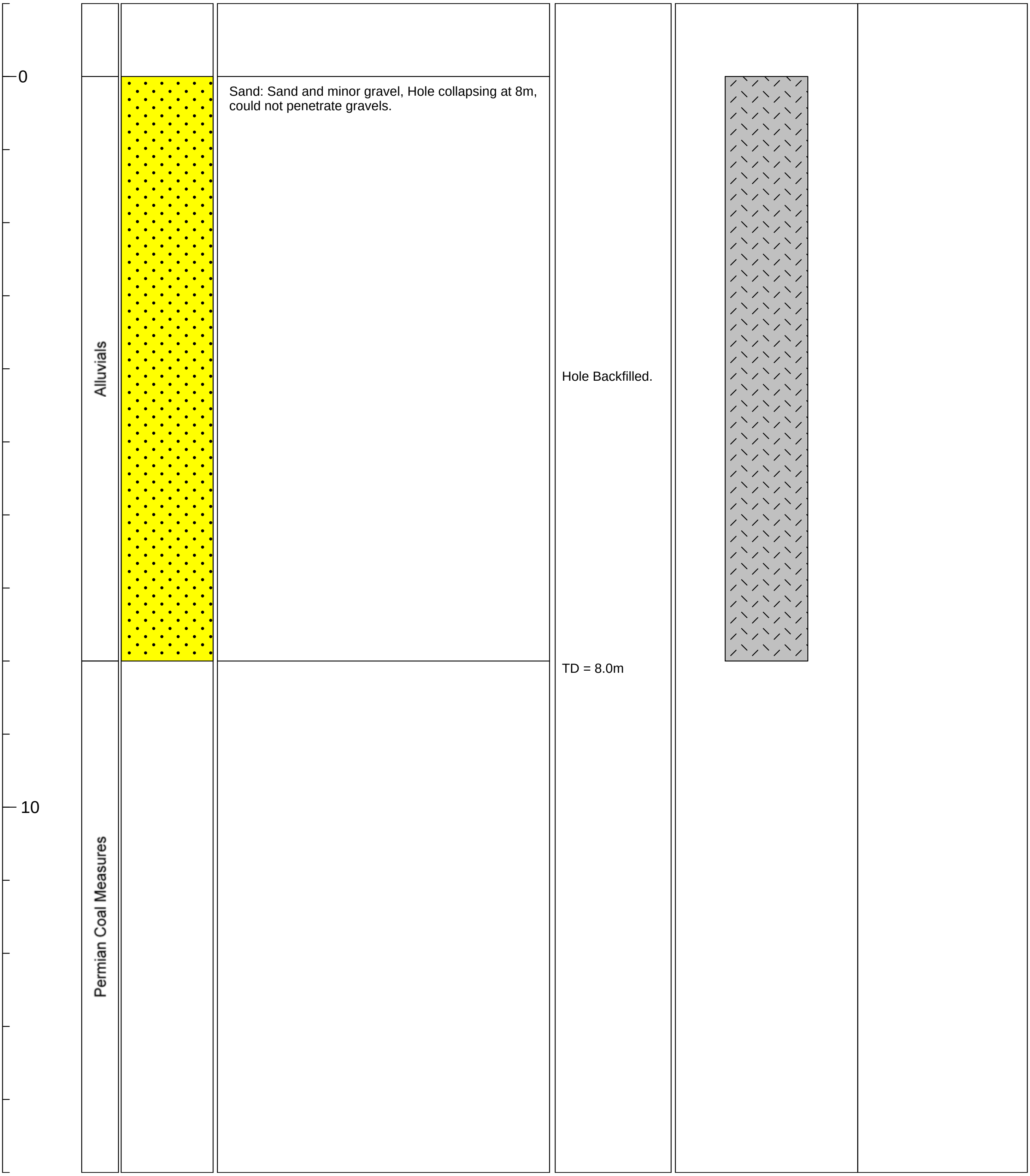
Commenced: 03/12/08
Completed: 03/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319385.31
North: 6404023.013
Collar (RL): 59.737

Static Water Level:
Date: 03/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Sand: Sand and minor gravel, Hole collapsing at 8m, could not penetrate gravels.

Hole Backfilled.

TD = 8.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML289

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

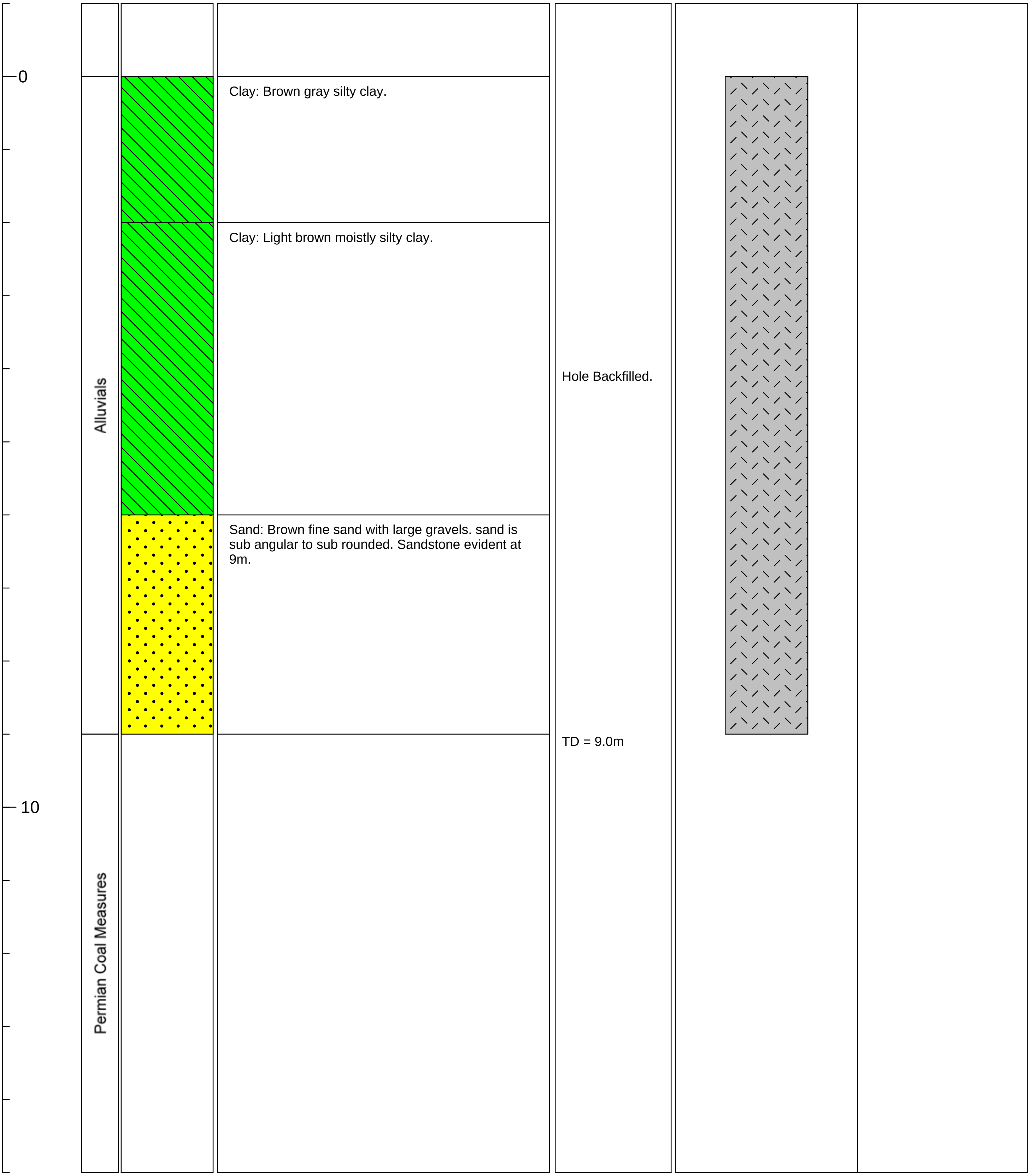
Commenced: 03/12/08
Completed: 03/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319617.209
North: 6403885.58
Collar (RL): 60.044

Static Water Level:
Date: 03/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes



Clay: Brown gray silty clay.

Clay: Light brown moistly silty clay.

Sand: Brown fine sand with large gravels. sand is sub angular to sub rounded. Sandstone evident at 9m.

Hole Backfilled.

TD = 9.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML290

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

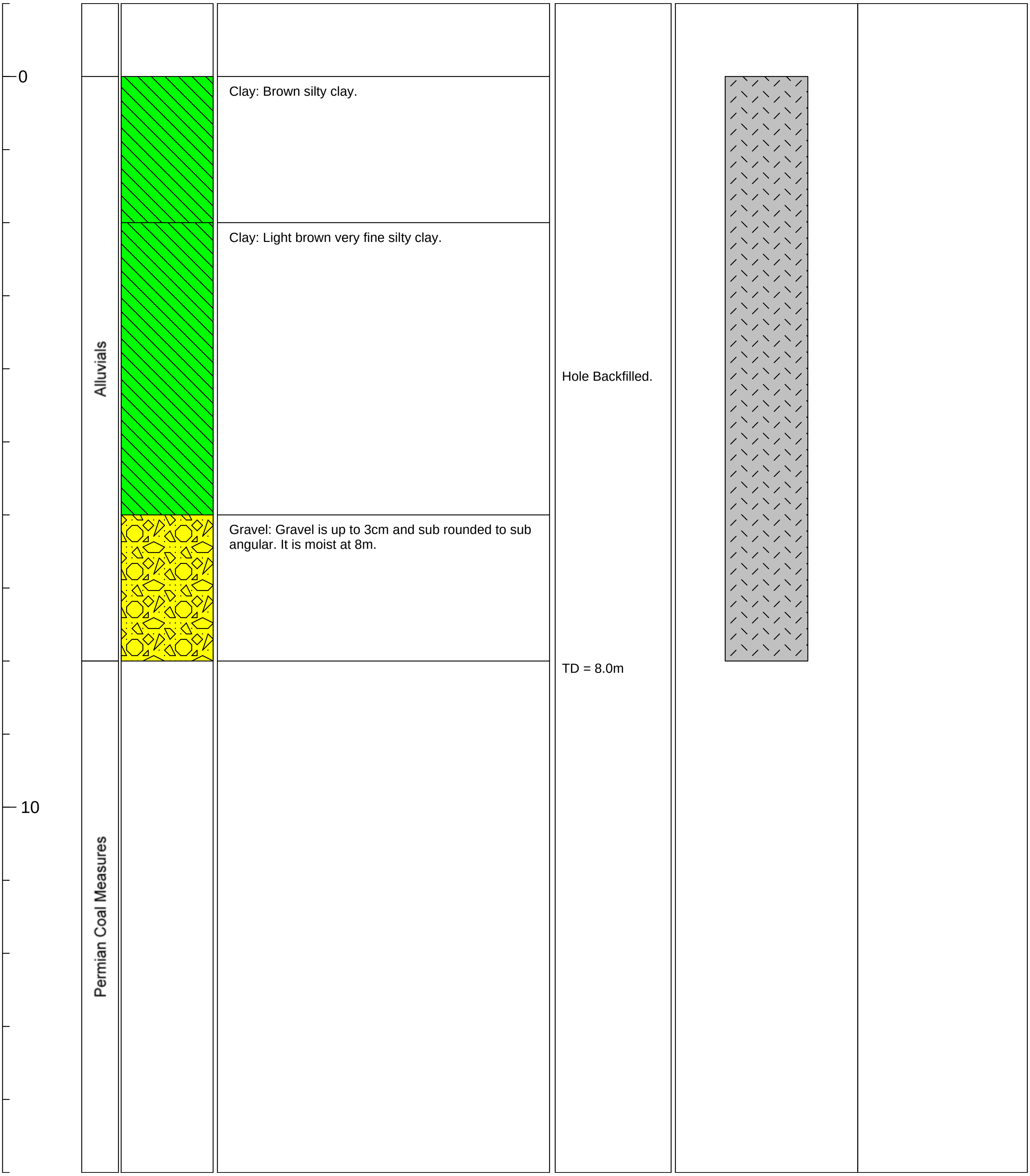
Commenced: 03/12/08
Completed: 03/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319601.893
North: 6403790.554
Collar (RL): 60.026

Static Water Level:
Date: 03/12/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Clay: Brown silty clay.

Clay: Light brown very fine silty clay.

Gravel: Gravel is up to 3cm and sub rounded to sub angular. It is moist at 8m.

Hole Backfilled.

TD = 8.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML291

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

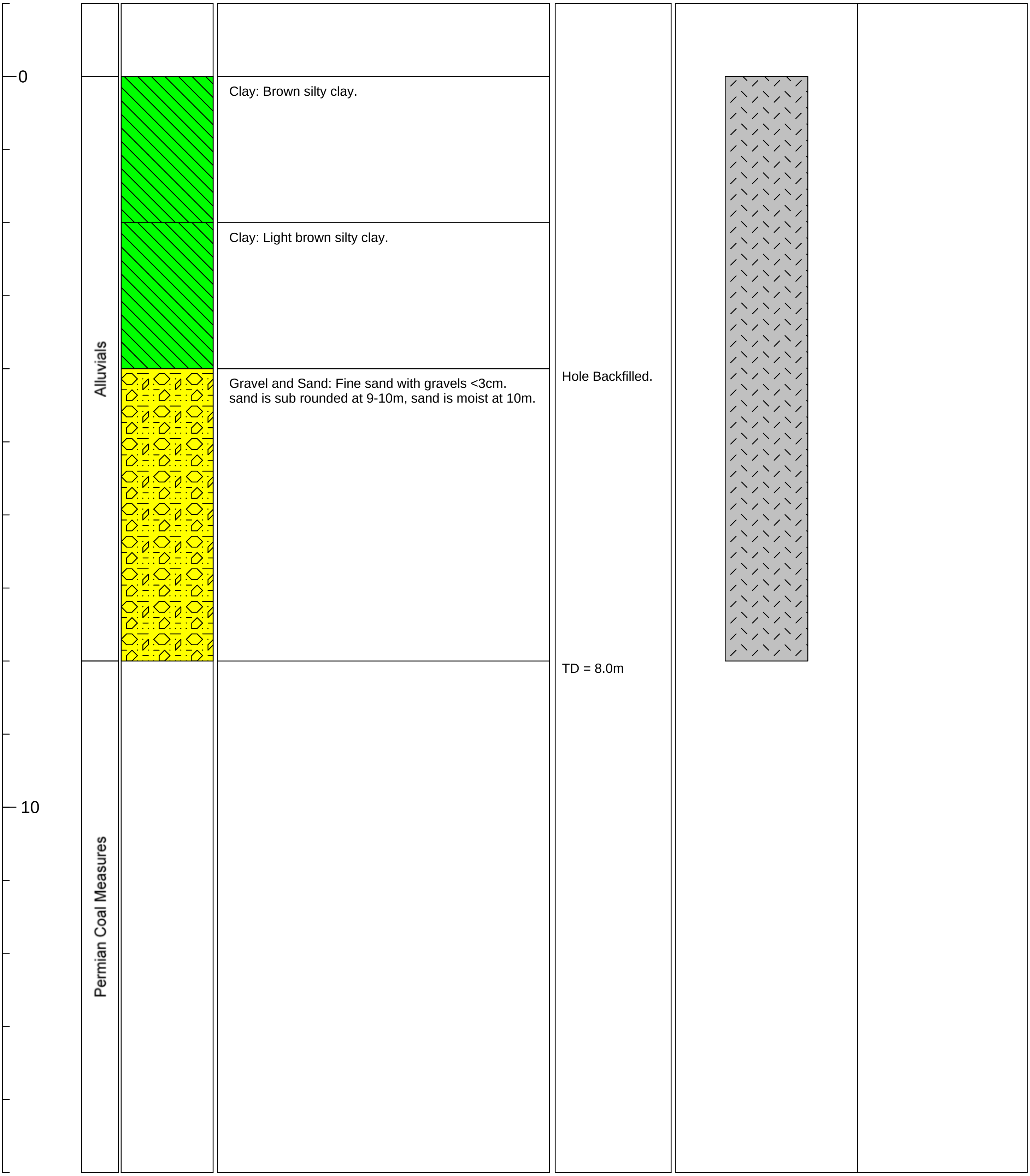
Commenced: 04/12/08
Completed: 04/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319568.795
North: 6403885.58
Collar (RL): 59.65

Static Water Level:
Date: 04/12/08

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Clay: Brown silty clay.

Clay: Light brown silty clay.

Gravel and Sand: Fine sand with gravels <3cm. sand is sub rounded at 9-10m, sand is moist at 10m.

Hole Backfilled.

TD = 8.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML292

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

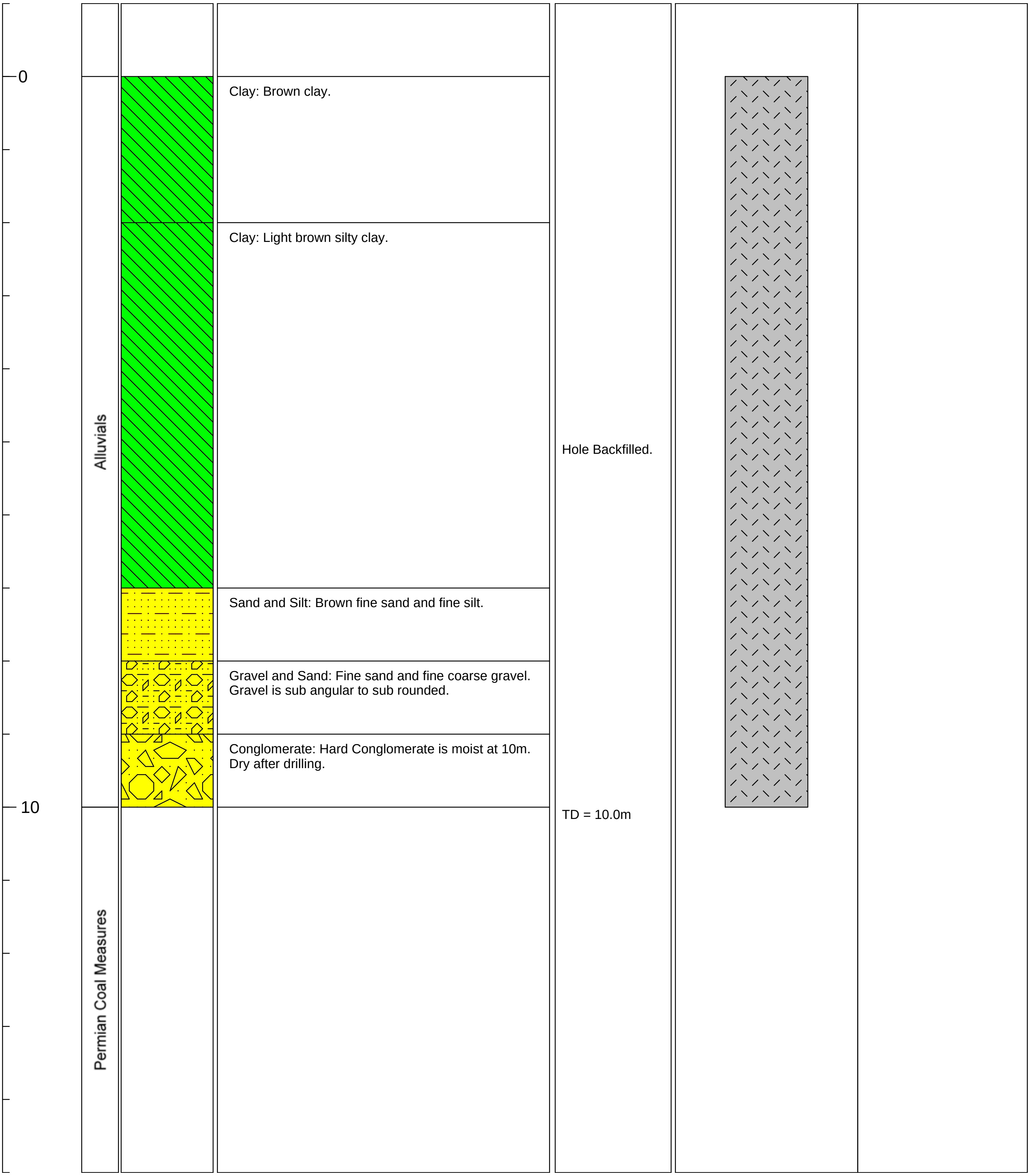
Commenced: 04/12/08
Completed: 04/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 319573
North: 6404257
Collar (RL):

Static Water Level:
Date: 04/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	Notes



Clay: Brown clay.

Clay: Light brown silty clay.

Sand and Silt: Brown fine sand and fine silt.

Gravel and Sand: Fine sand and fine coarse gravel. Gravel is sub angular to sub rounded.

Conglomerate: Hard Conglomerate is moist at 10m. Dry after drilling.

Hole Backfilled.

TD = 10.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML293

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

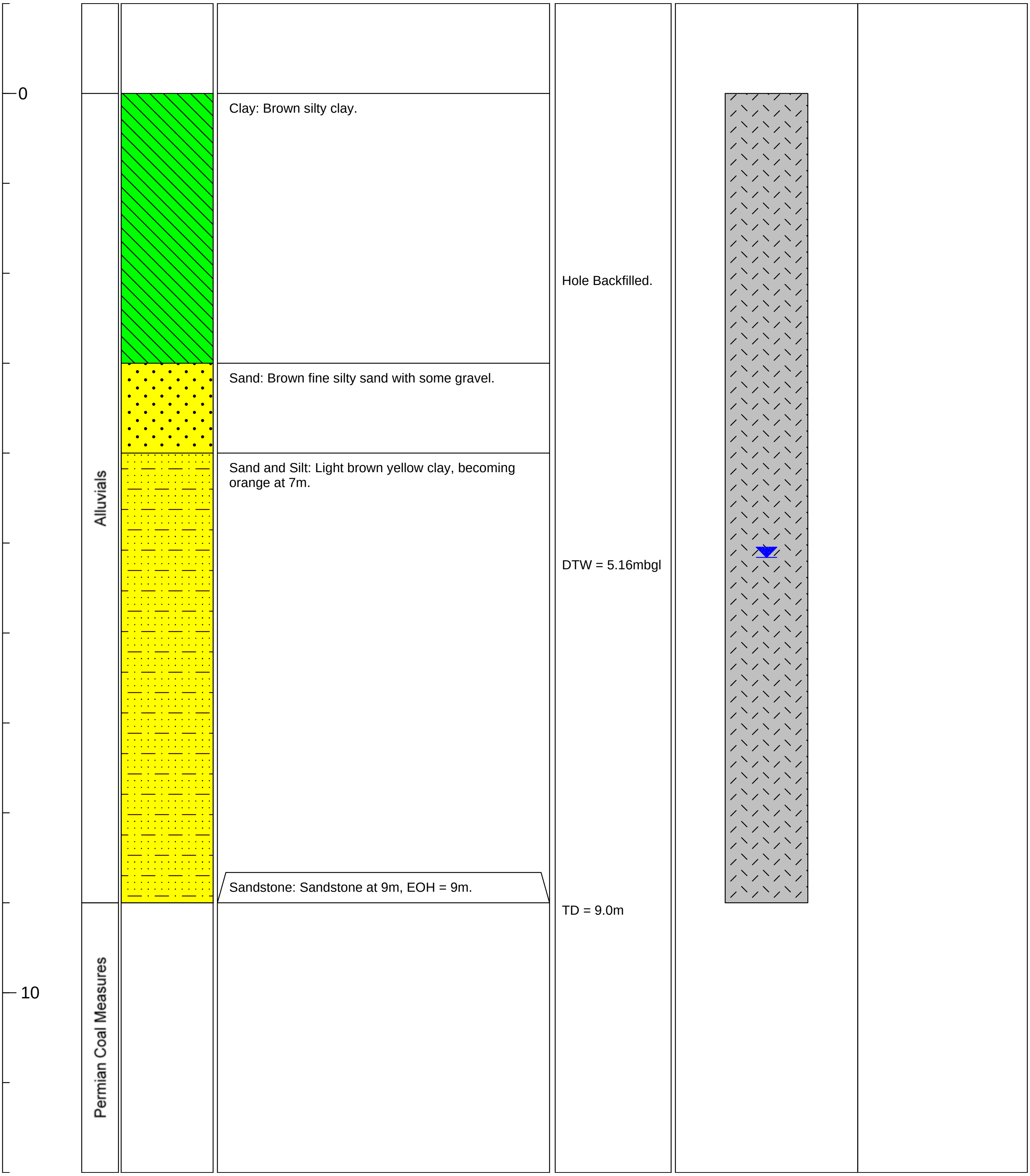
Commenced: 04/12/08
Completed: 04/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 320075
North: 6404061
Collar (RL):

Static Water Level: 5.16mbgl
Date: 04/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion**	
					Diagram	**Notes**



Clay: Brown silty clay.

Sand: Brown fine silty sand with some gravel.

Sand and Silt: Light brown yellow clay, becoming orange at 7m.

Sandstone: Sandstone at 9m, EOH = 9m.

Hole Backfilled.

DTW = 5.16mbgl

TD = 9.0m

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WML294

Client: Ashton Coal Operations Ltd
Project: South East Open Cut

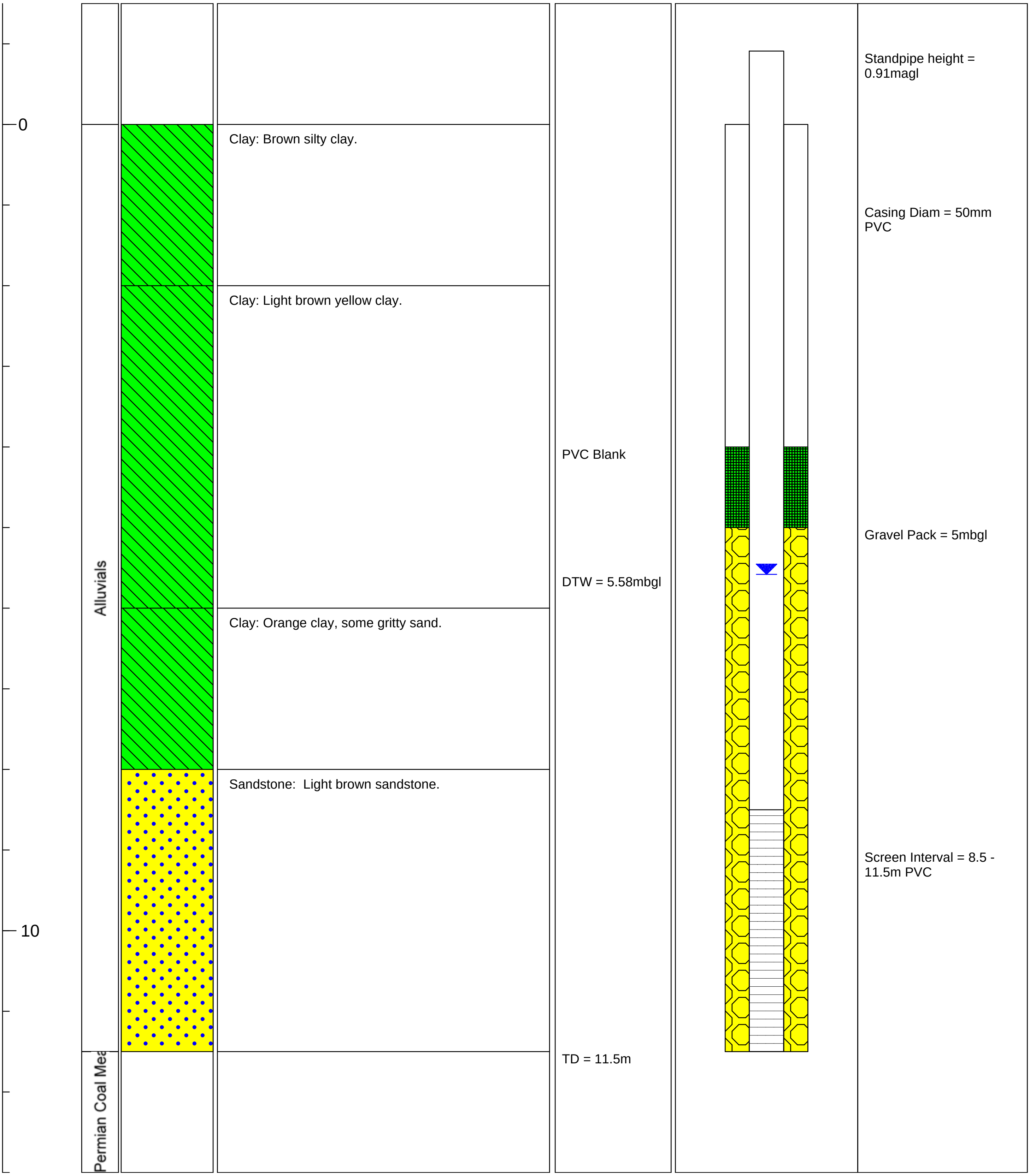
Commenced: 04/12/08
Completed: 04/12/08
Drilled: Hunter Drilling
Logged By: JV

Method: Blade
Fluid: Air
Bit Record:

Area:
East: 320139
North: 6403908
Collar (RL):

Static Water Level: 5.58mbgl
Date: 04/12/08

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion**	
					Diagram	**Notes**



Clay: Brown silty clay.

Clay: Light brown yellow clay.

Clay: Orange clay, some gritty sand.

Sandstone: Light brown sandstone.

PVC Blank

DTW = 5.58mbgl

TD = 11.5m

Standpipe height = 0.91magl

Casing Diam = 50mm PVC

Gravel Pack = 5mbgl

Screen Interval = 8.5 - 11.5m PVC

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Suite 9, 1051 Pacific Highway
Pymble
NSW 2073
Australia
Tel: (+61) (02) 9440 2666
Fax: (+61) (02) 9449 3193

COMPOSITE WELL LOG

Well No: WMLP244

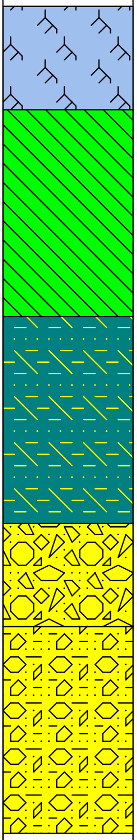
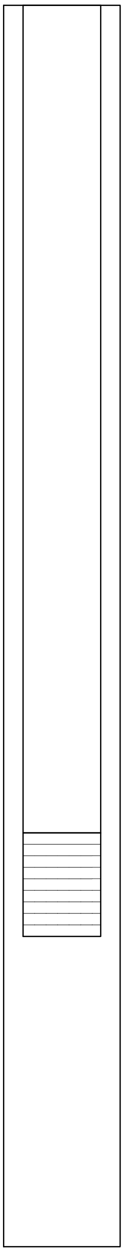
Client: Ashton Coal Operations Ltd
Project: South East Open Cut

Commenced: 08/11/08
Completed: 08/11/08
Drilled: Intertech
Logged By: AF

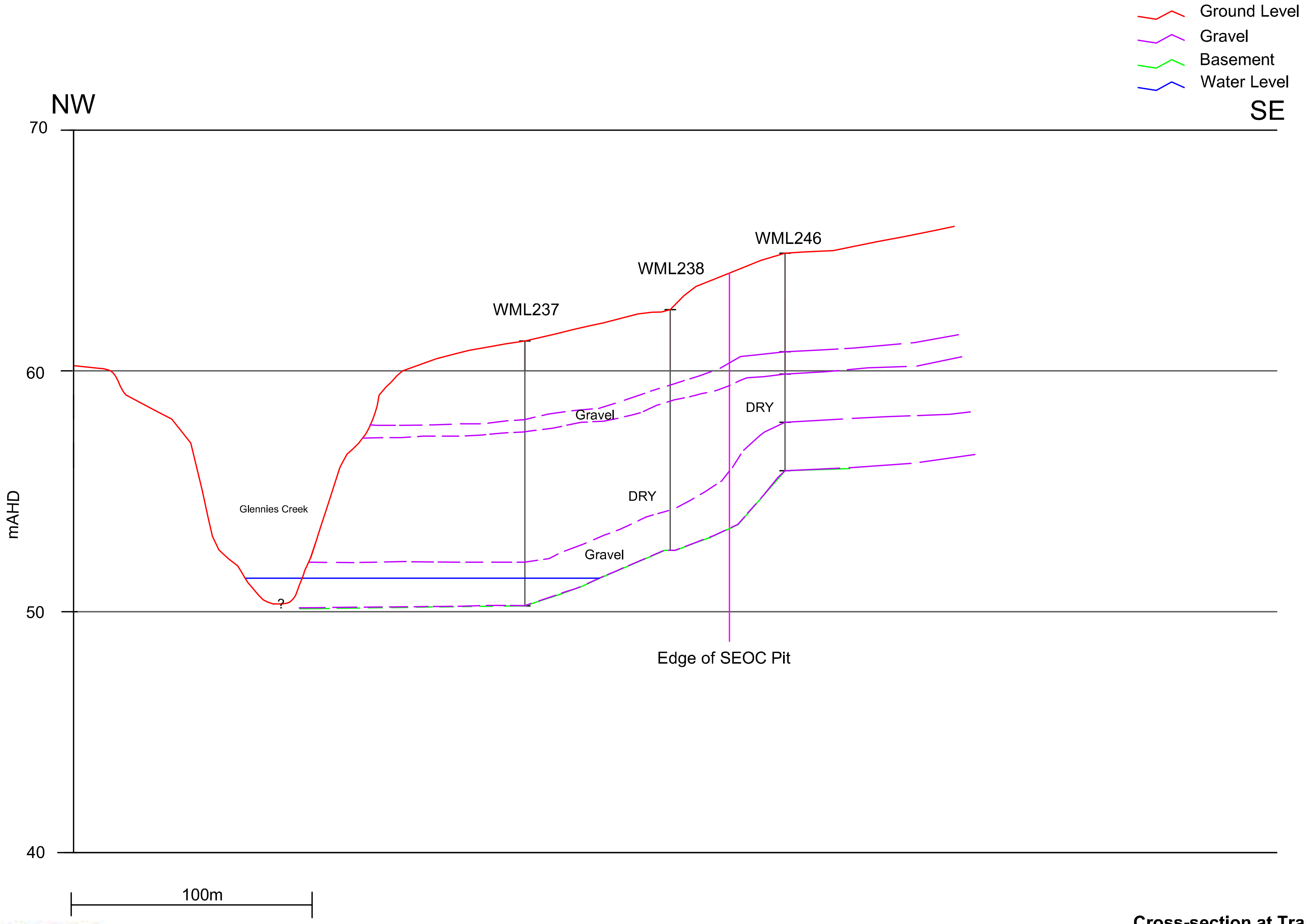
Method: Tubex / Rotary Air
Fluid: Air
Bit Record:

Area:
East:
North:
Collar (RL):

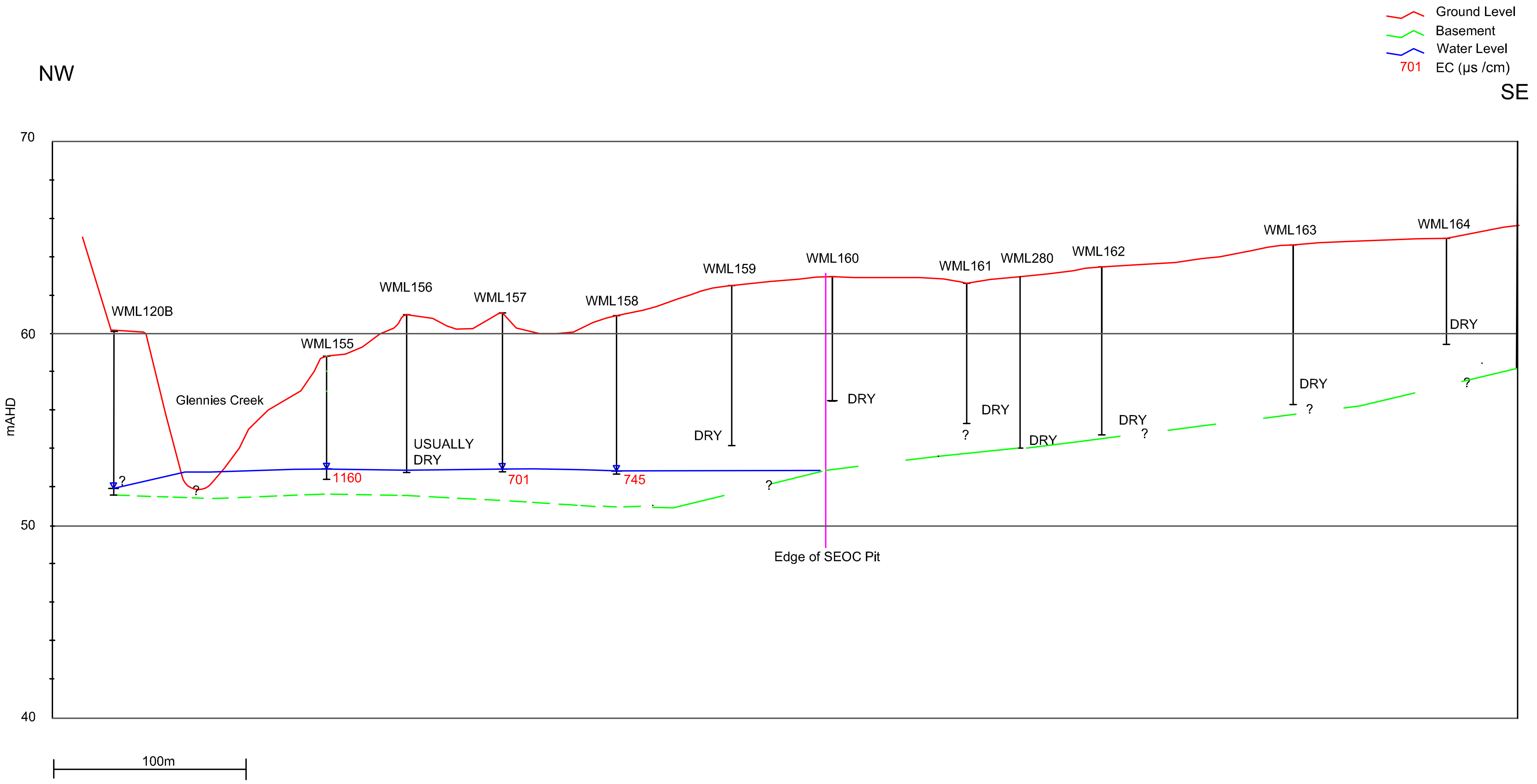
Static Water Level: ??mbgl
Date:

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes
0	Alluvials & colluvials		Topsoil: Dark brown silty topsoil.			
			Clay: Black clay			
			Clay and Sand: lighter brown clay with some sand			
			gravel: gravel with clay and sand in matrix			
			Gravel and Sand: sandy gravel with significant clay content			
	Permian C		Permian: Permian mudstone basement			
10				TD=12.0m		

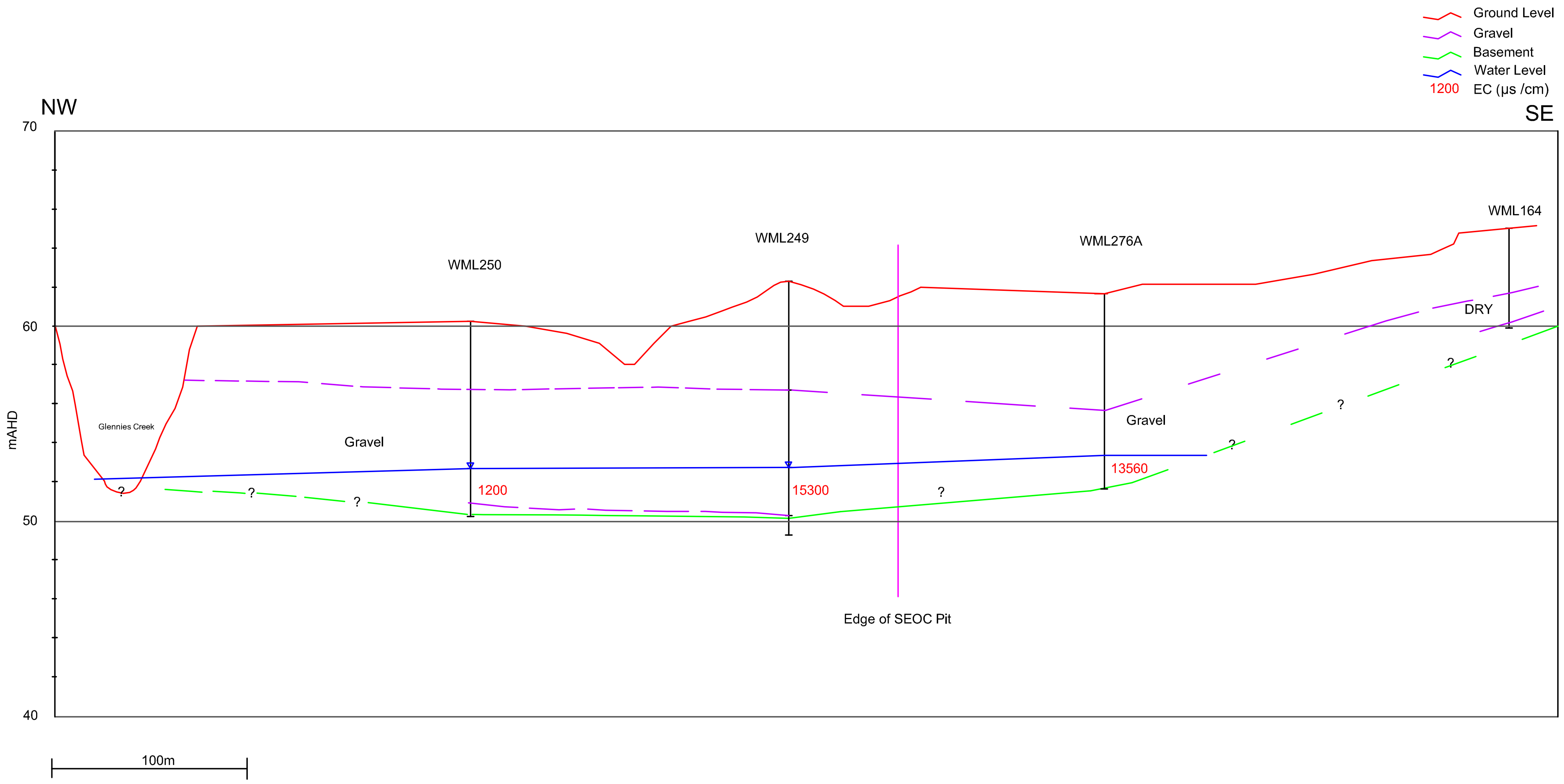
APPENDIX B ALLUVIUM CROSS SECTIONS



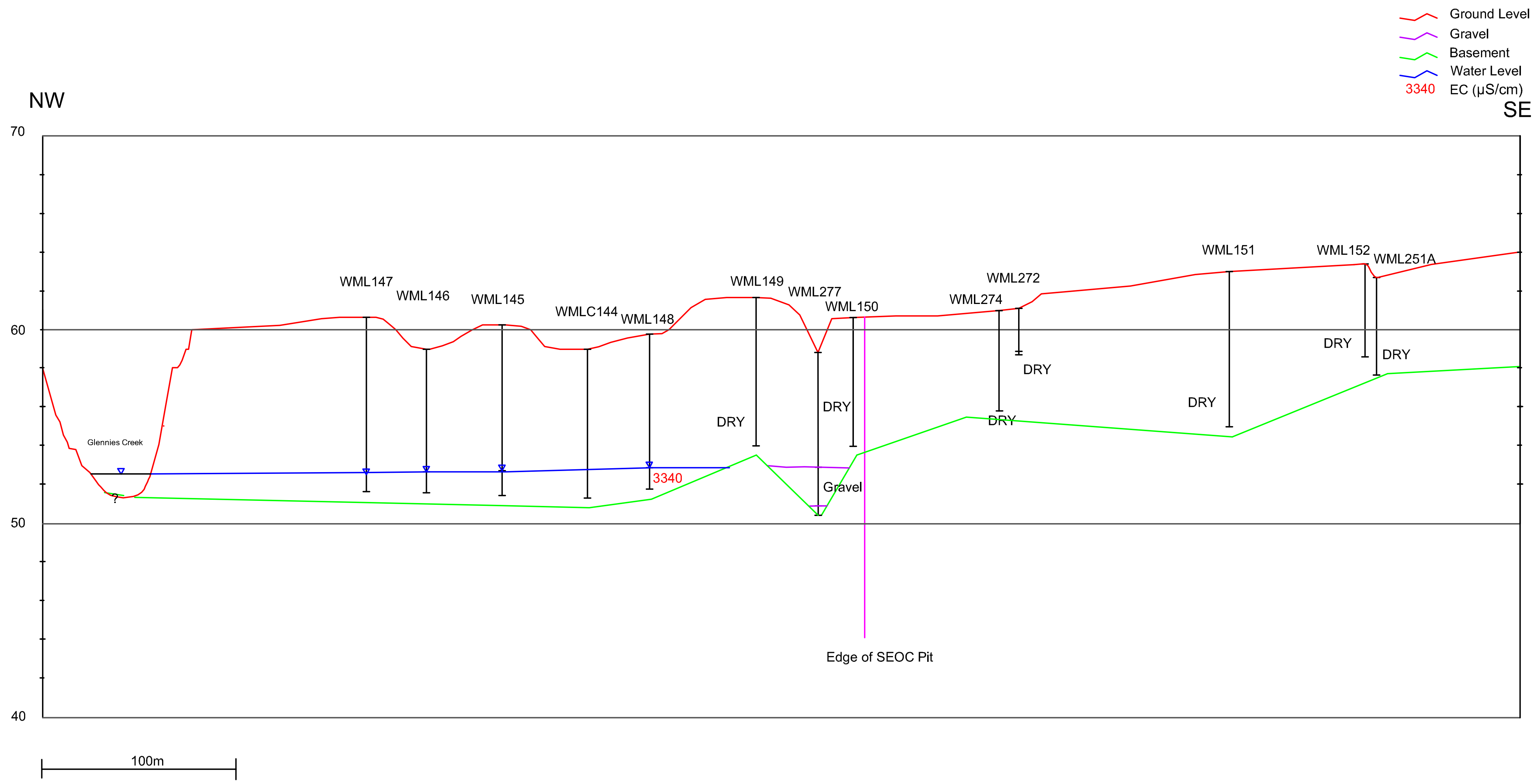
Cross-section at Transect 1



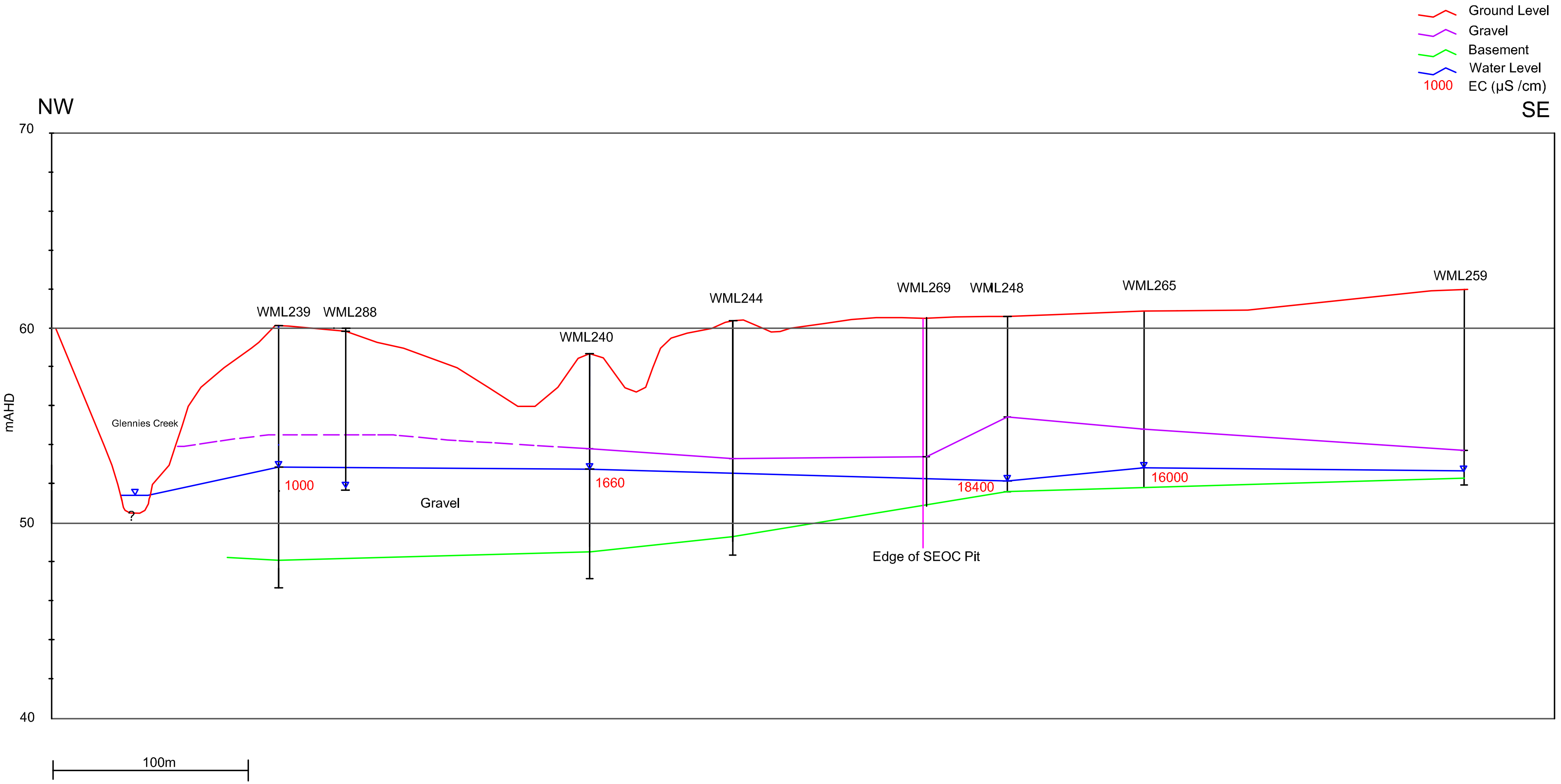
Cross-section at Transect 2



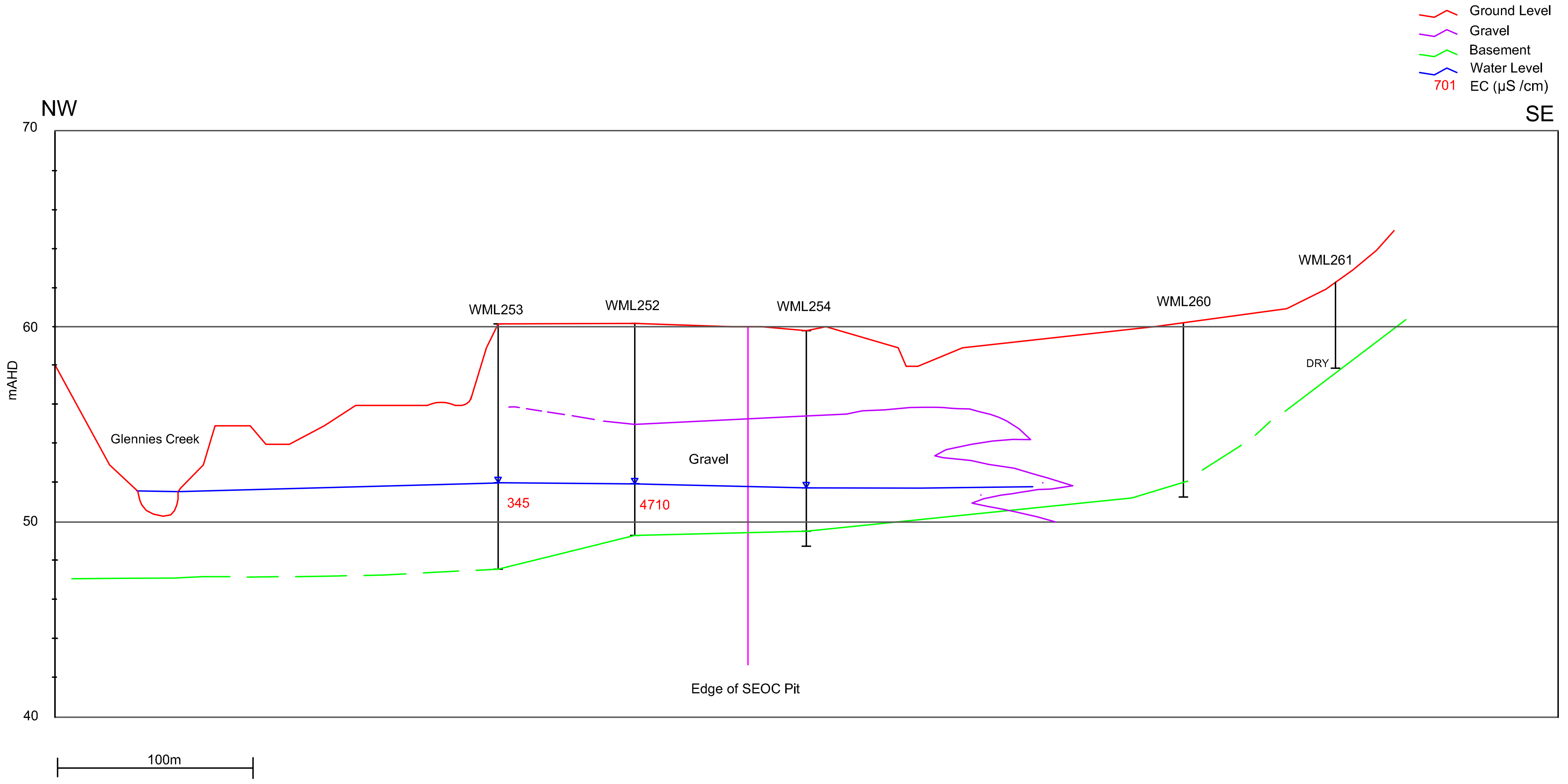
Cross-section at Transect 3



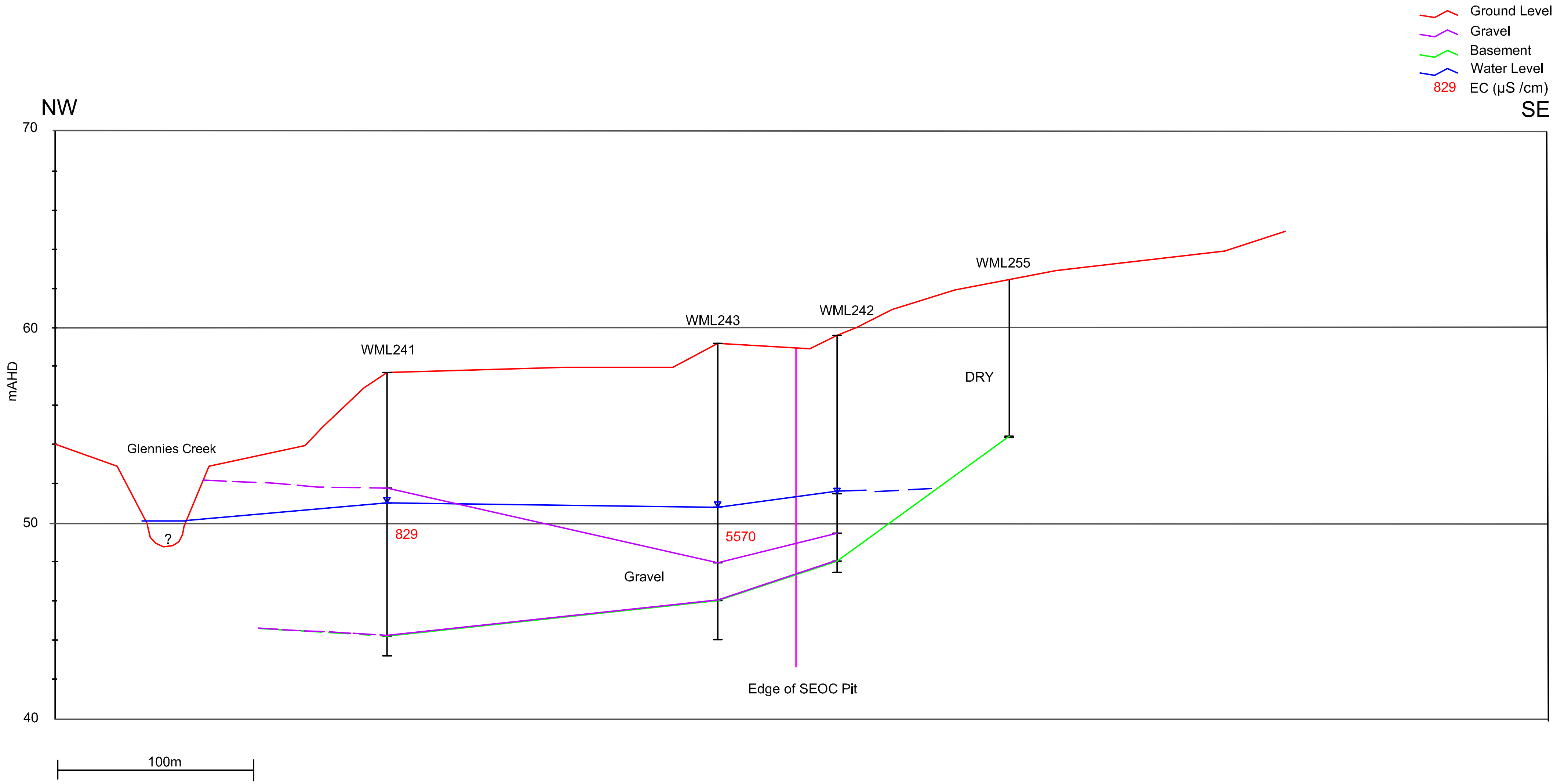
Cross-section at Transect 4



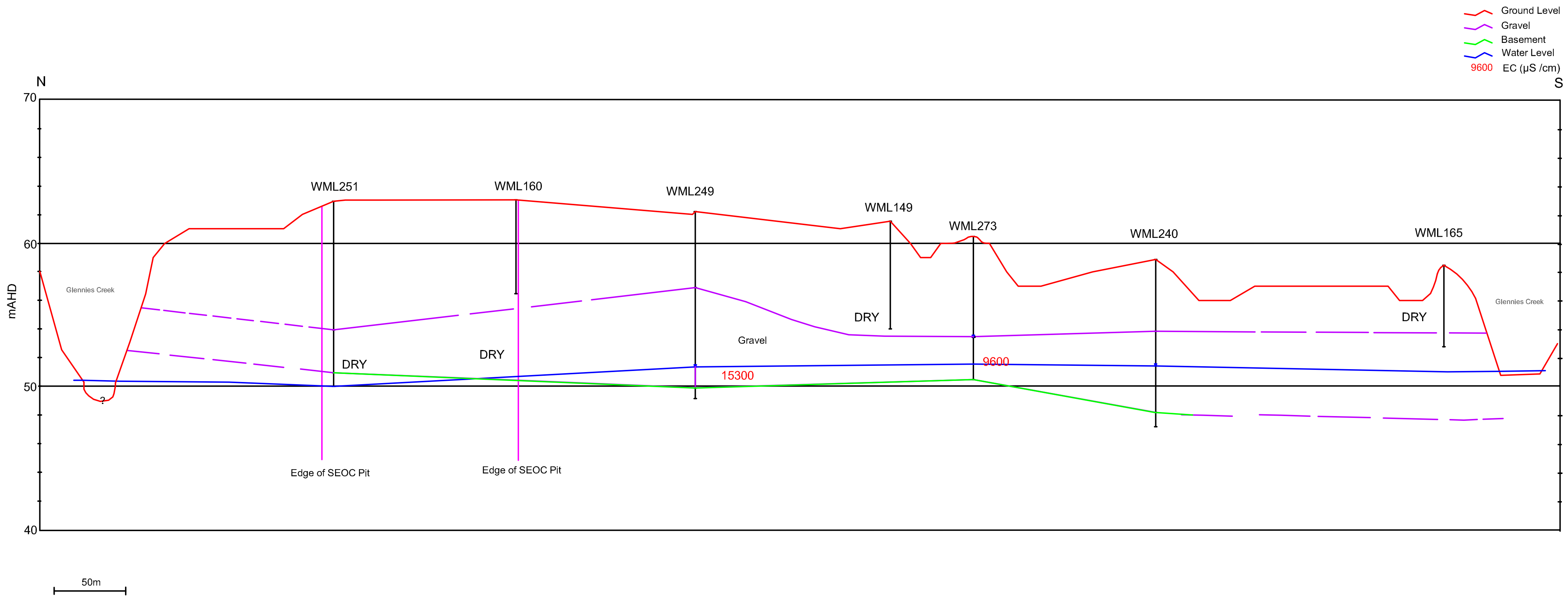
Cross-section at Transect 5



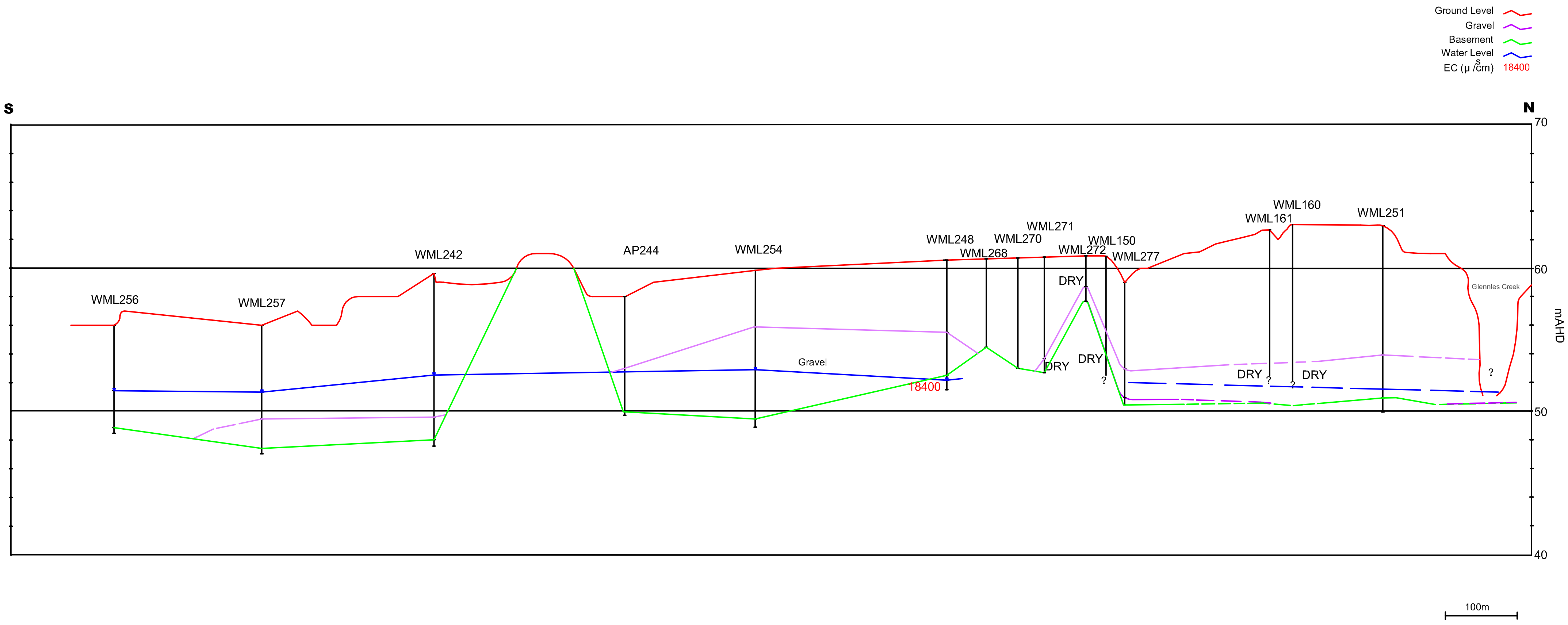
Cross-section at Transect 6



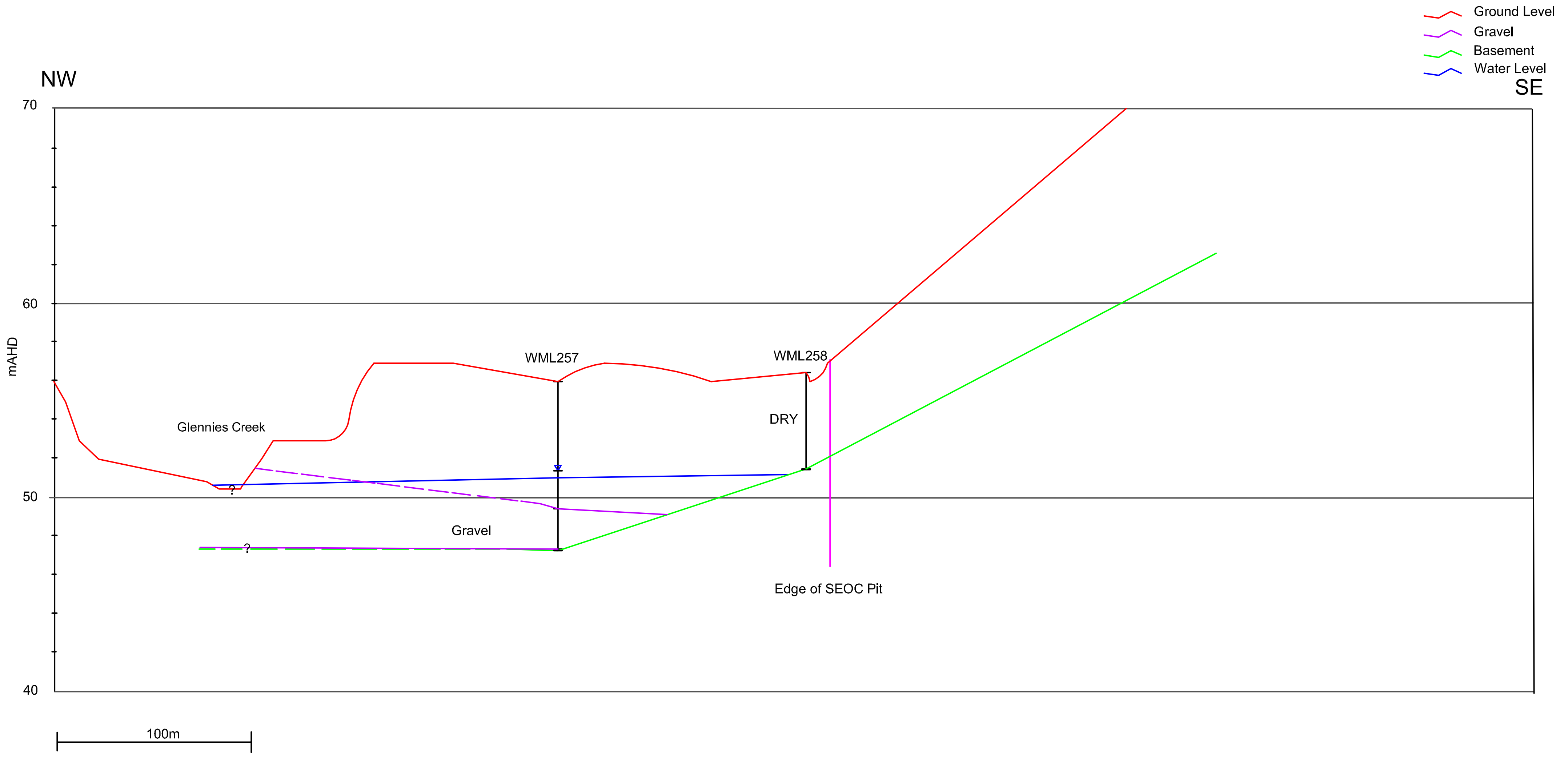
Cross-section at Transect 7



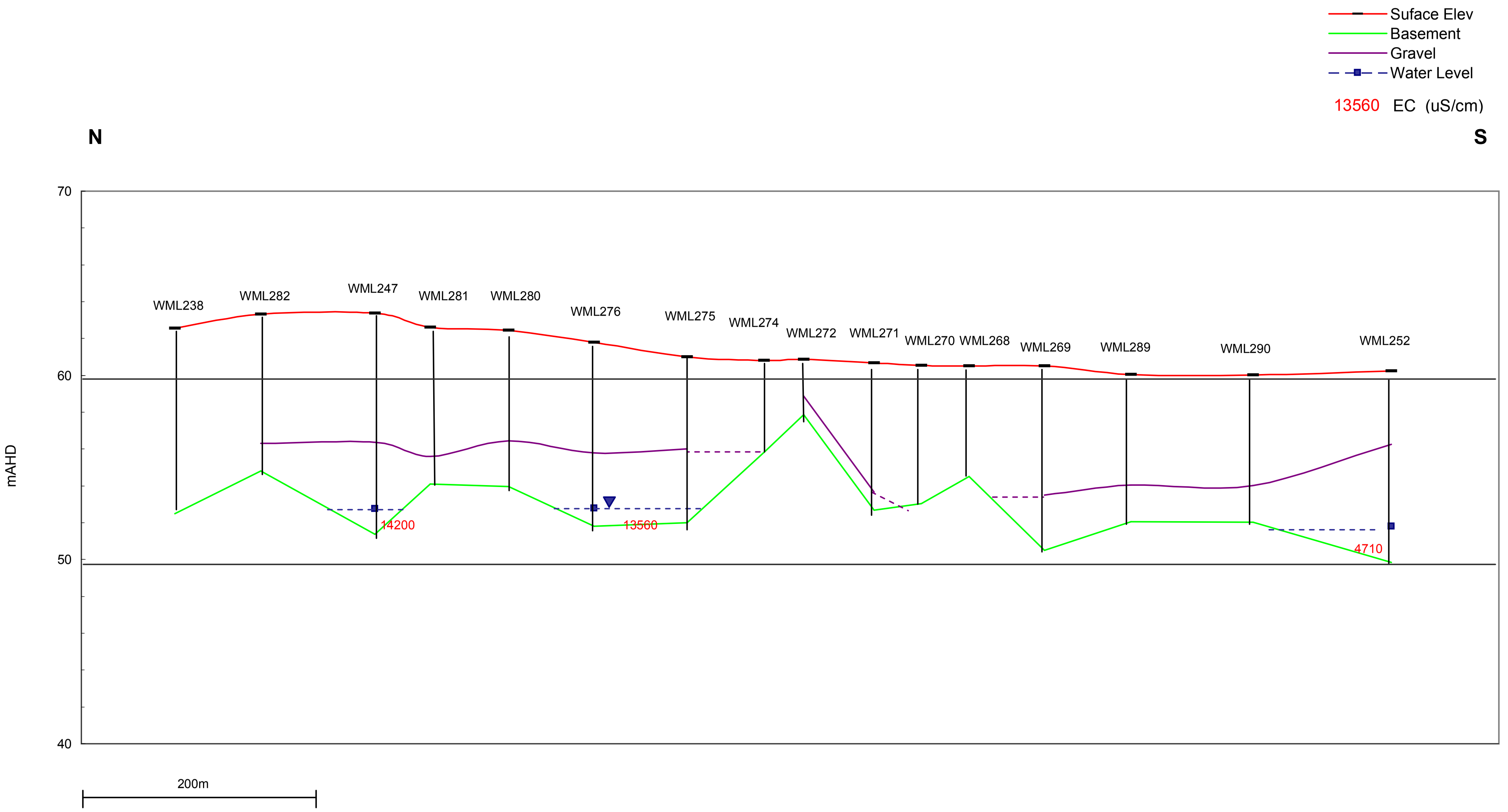
Cross-section at Transect 8



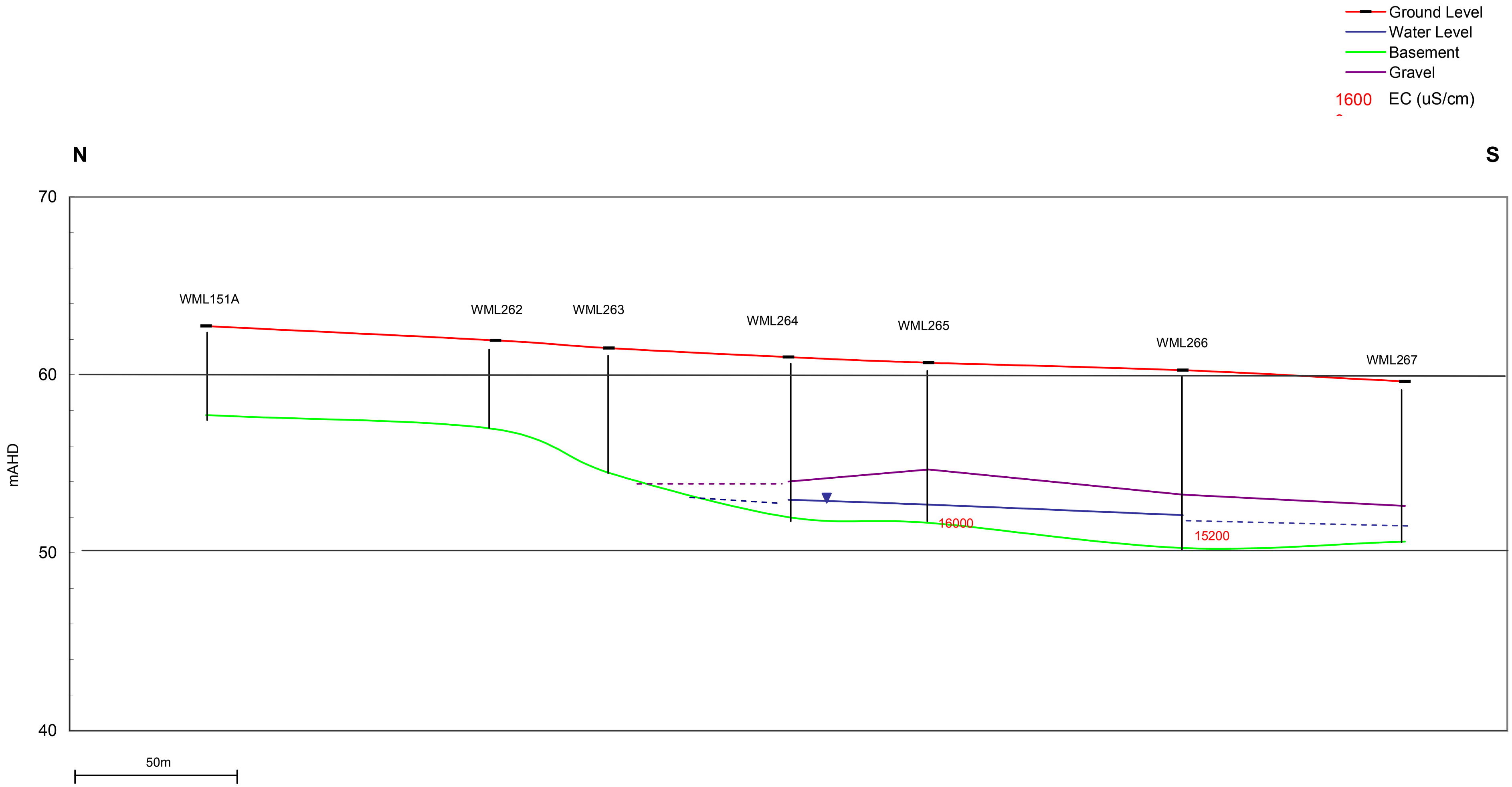
Cross-section at Transect 9



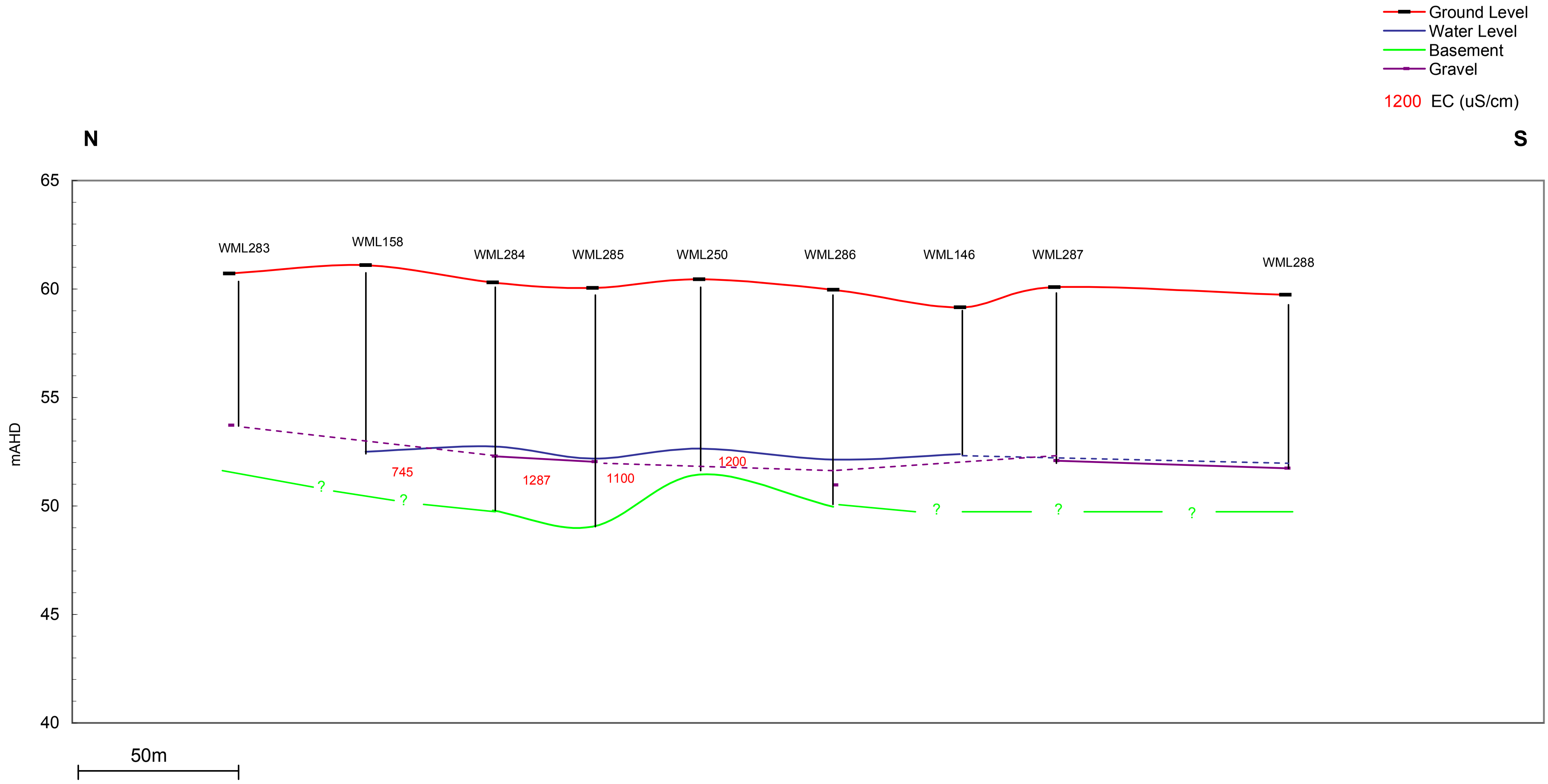
Cross-section at Transect 10



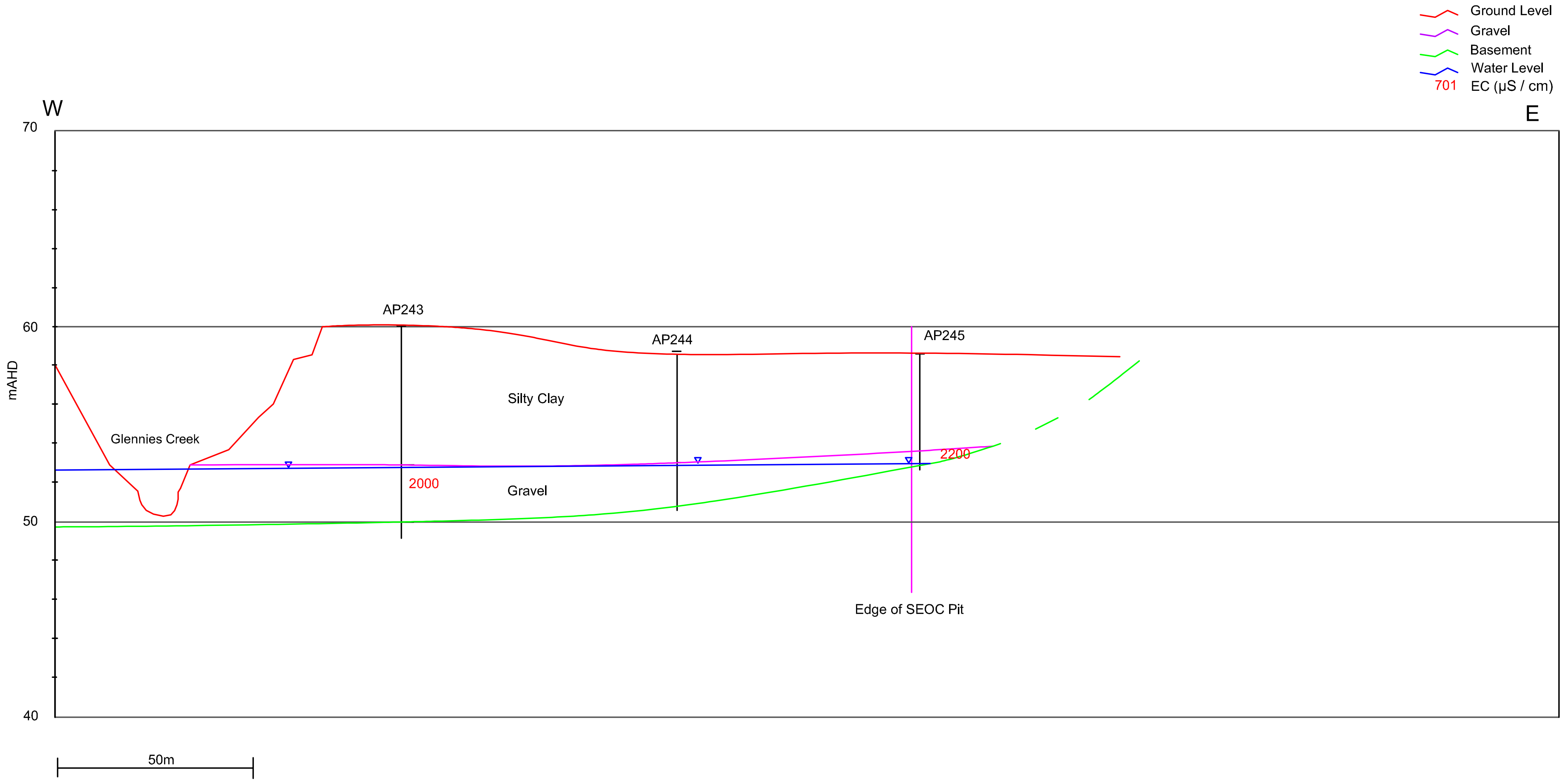
Cross section at Transect 11



Cross section at Transect 12



Cross section at Transect 13



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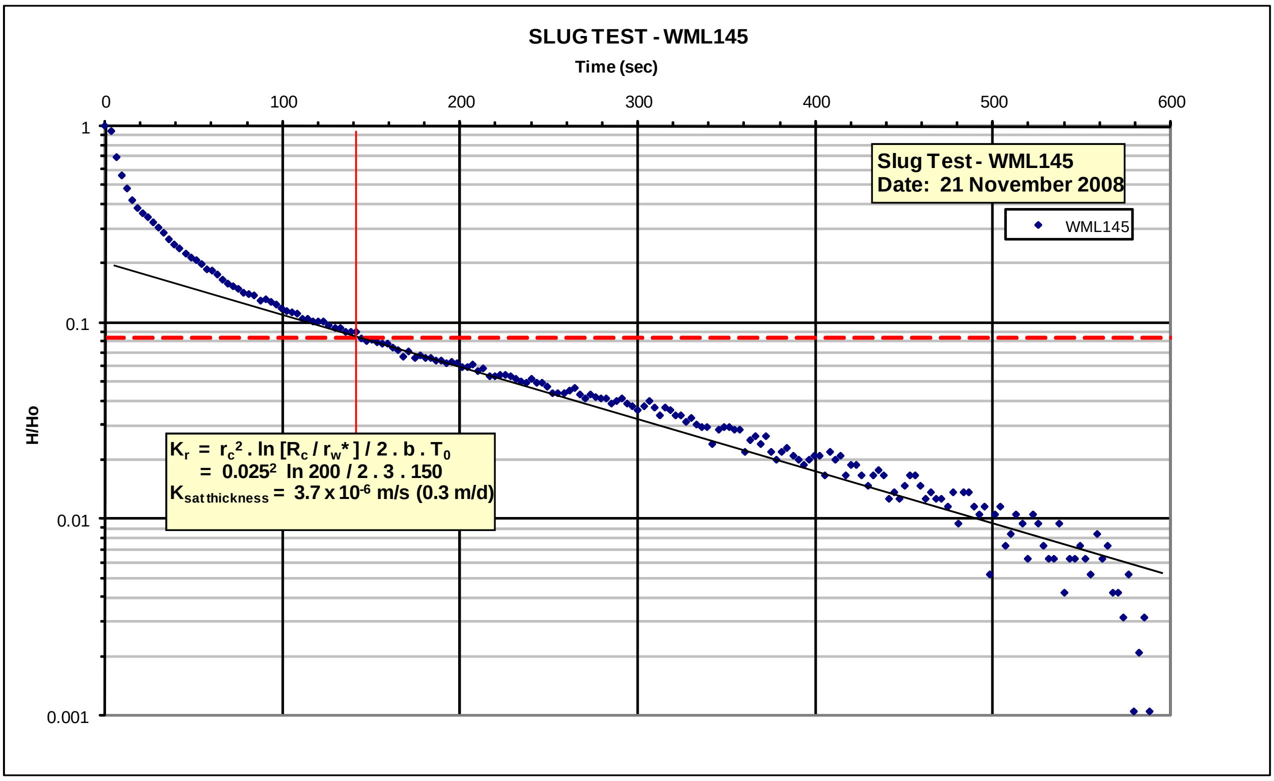
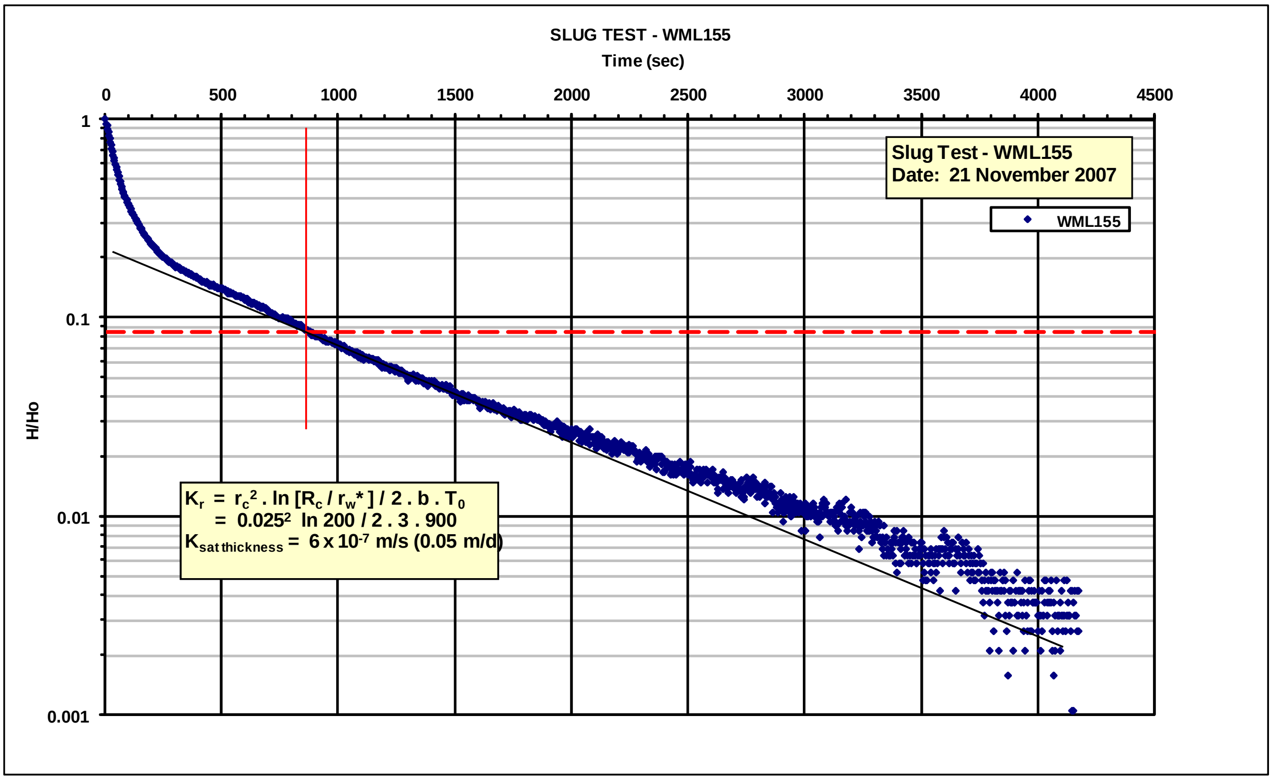
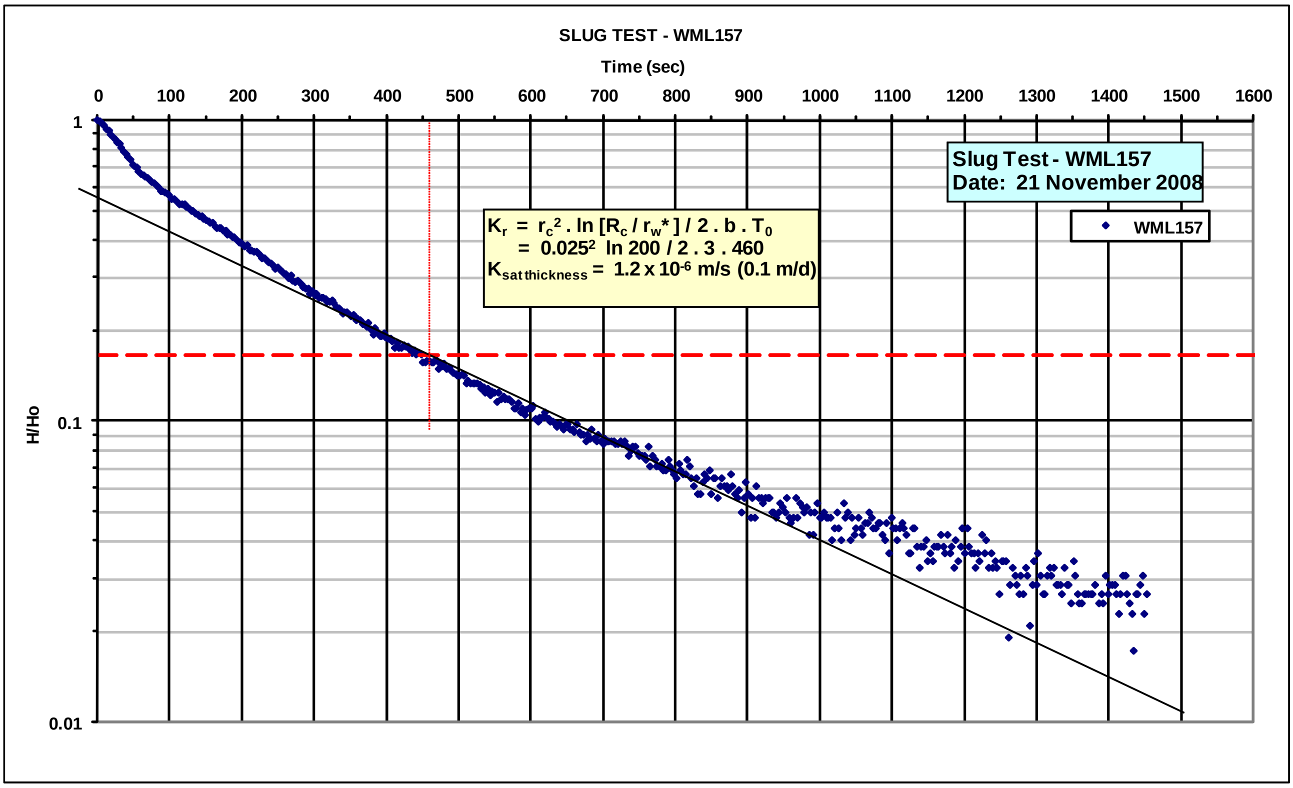
Cross-section at Transect 14

APPENDIX C1 SLUG TEST RESULTS

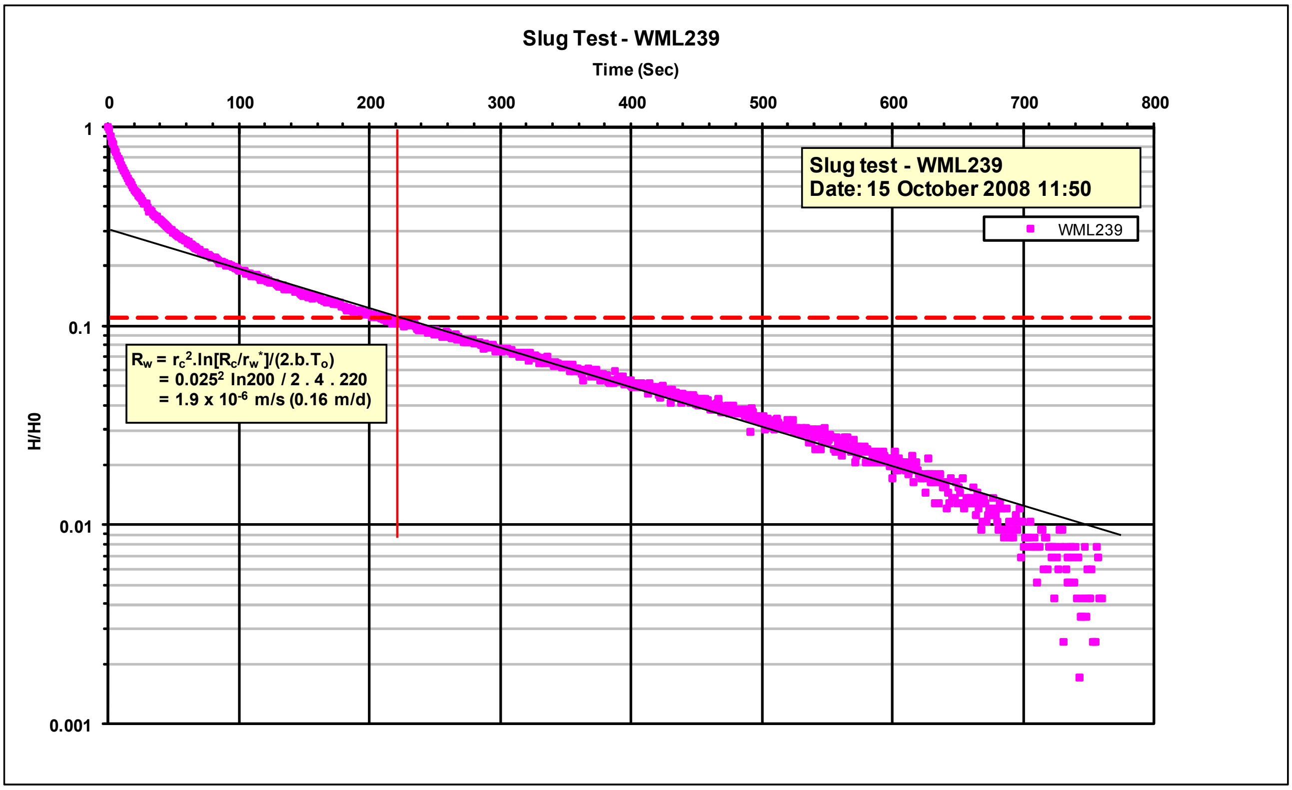




Date:	2 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT** **SEOC HYDRAULIC TESTING** **(SLUG TEST WML145 AND WML155)**
Drawing No:	S36-20-145_155	Rev:	0	
aquaterra				**Appendix C1**

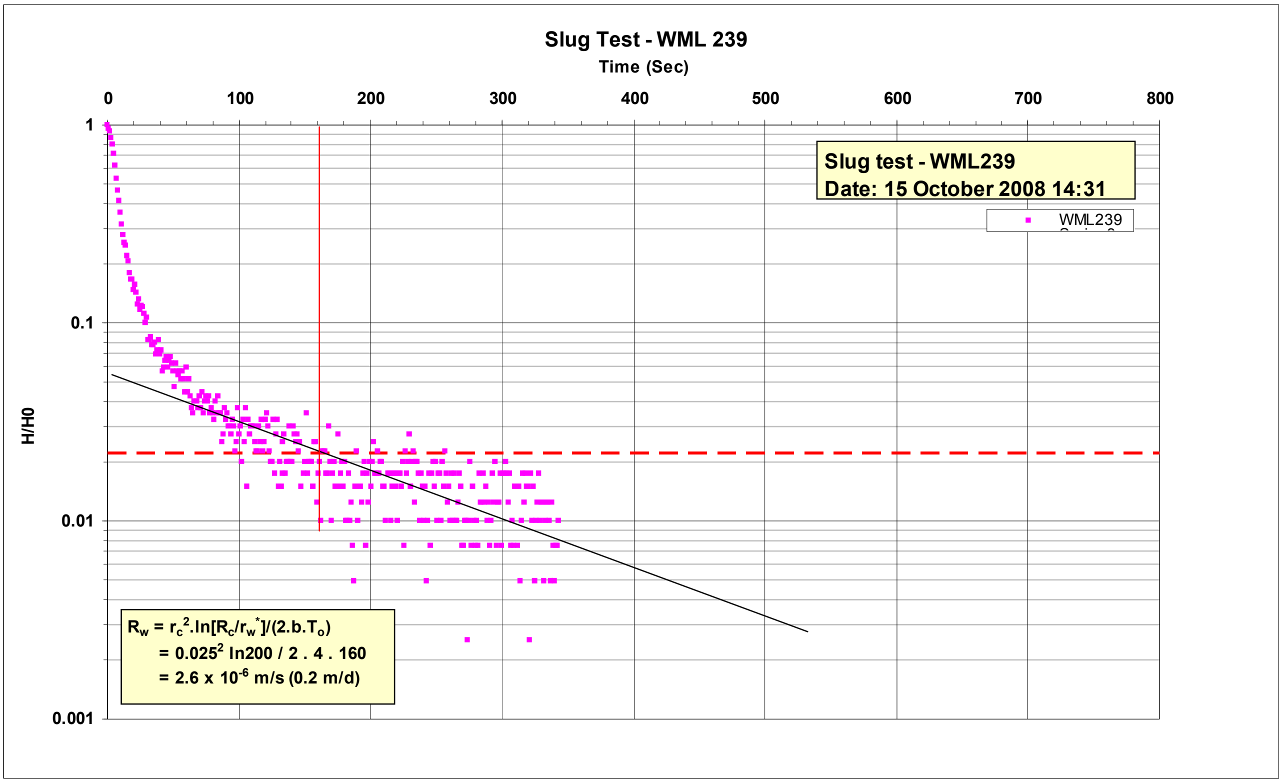


Date:	2 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT SEOC HYDRAULIC TESTING (SLUG TEST WML157)**
Drawing No:	S36-20-157a	Rev:	0	**Appendix C1**



Slug test - WML239
Date: 15 October 2008 11:50

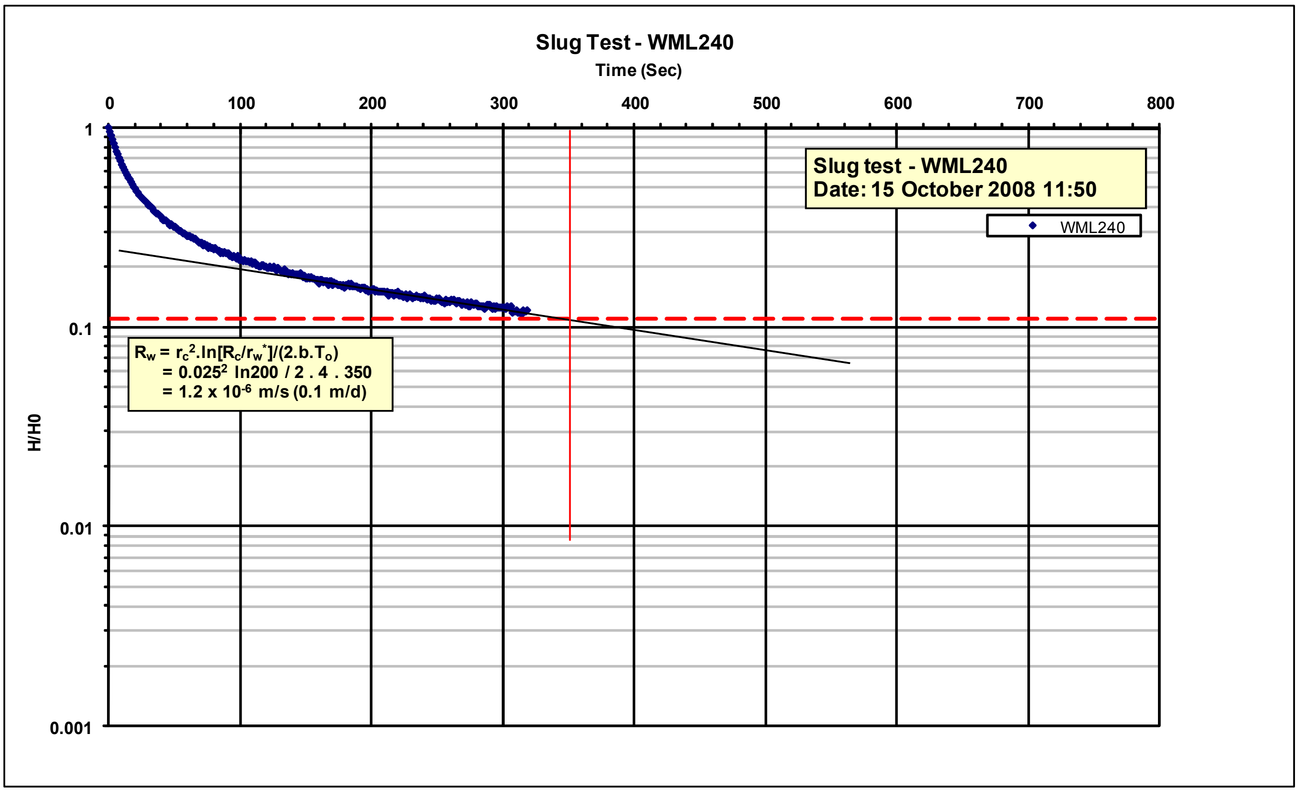
$R_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2 \ln 200 \ / \ 2 \ . \ 4 \ . \ 220$
$= 1.9 \times 10^{-6}$ m/s (0.16 m/d)



Slug test - WML239
Date: 15 October 2008 14:31

$R_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2 \ln 200 \ / \ 2 \ . \ 4 \ . \ 160$
$= 2.6 \times 10^{-6}$ m/s (0.2 m/d)

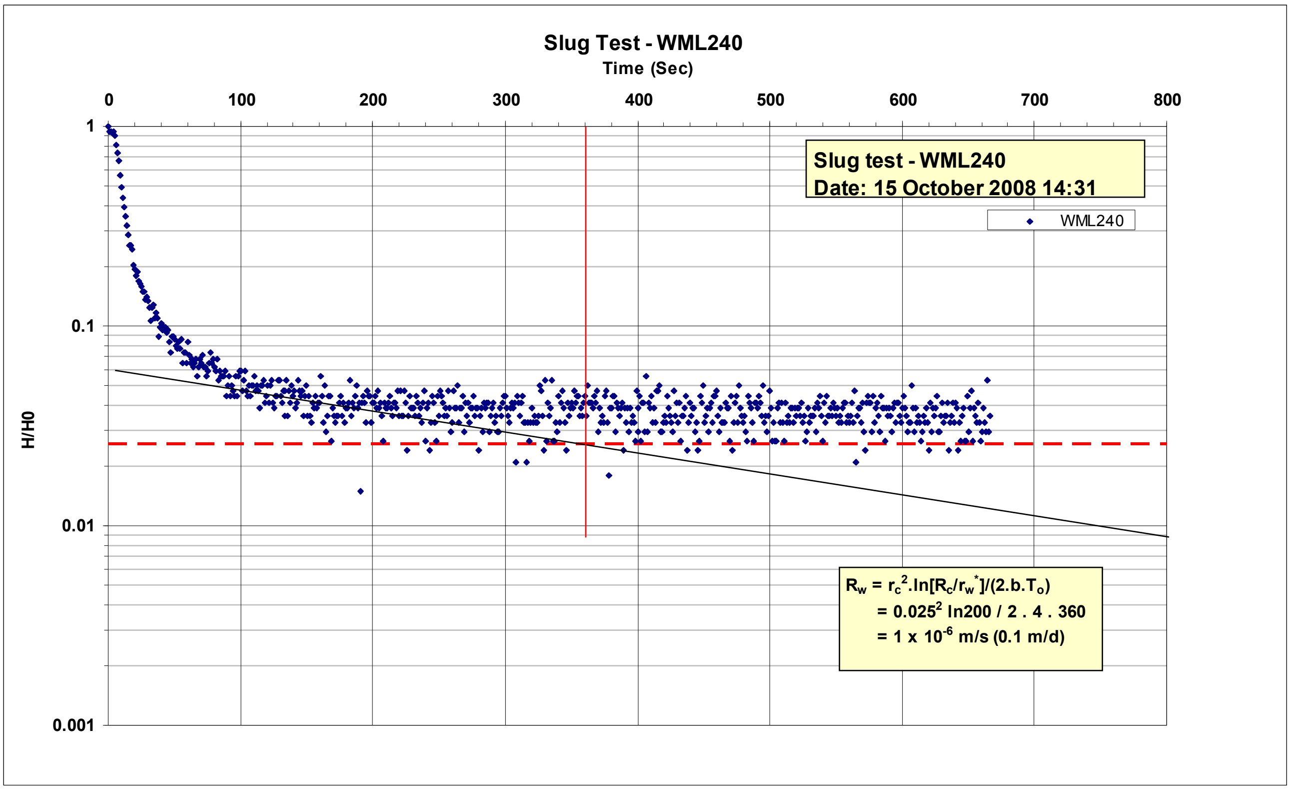
Date:	2 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT SEOC HYDRAULIC TESTING (SLUG TEST WML239)**
Drawing No:	S36-20-239	Rev:	0	
aquaterra				**Appendix C1**



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

$= 0.025^2 \ \ln200 \ / \ 2 \ . \ 4 \ . \ 350$

$= 1.2 \times 10^{-6}$ m/s (0.1 m/d)



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

$= 0.025^2 \ \ln200 \ / \ 2 \ . \ 4 \ . \ 360$

$= 1 \times 10^{-6}$ m/s (0.1 m/d)

Date: 2 April 2009

Scale: As Shown

Initials: PZ

Job No: S36

Drawing No: S36-20-240

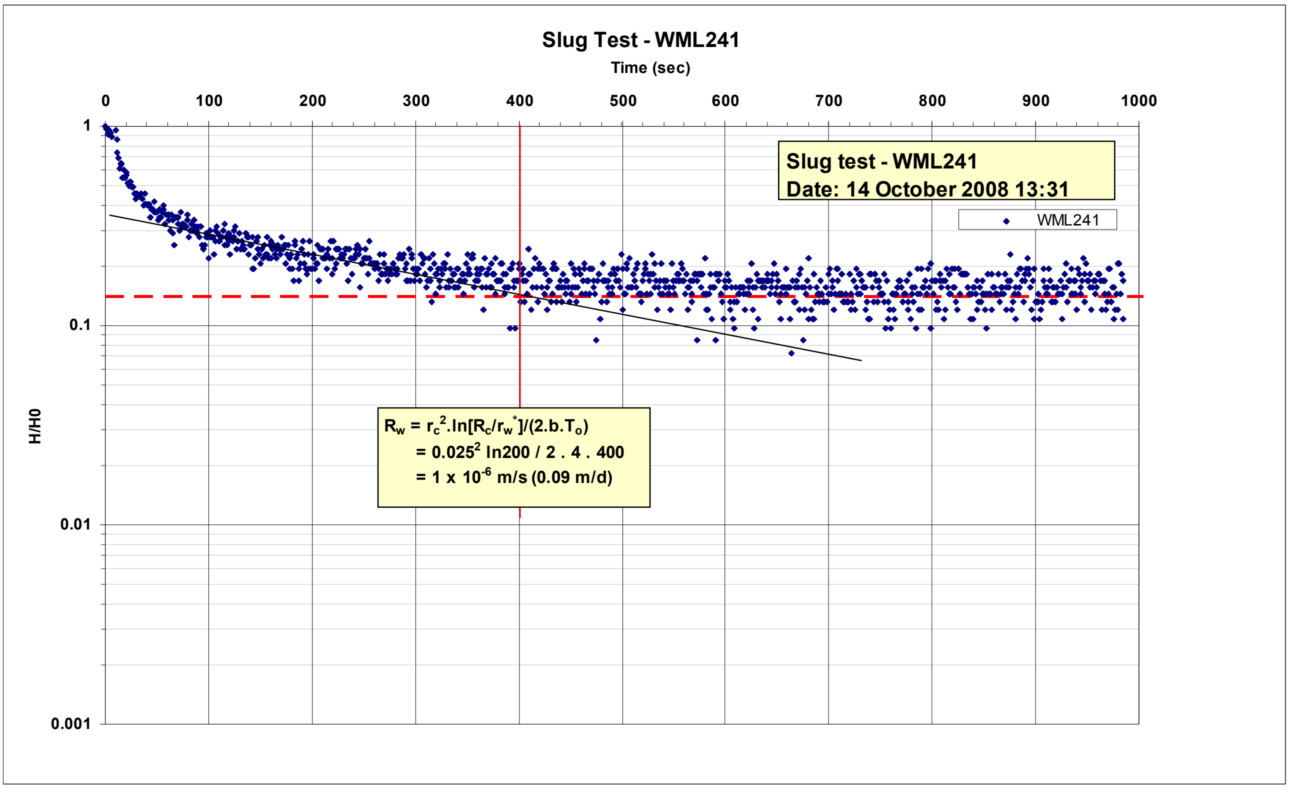
Rev: 0

aquaterra

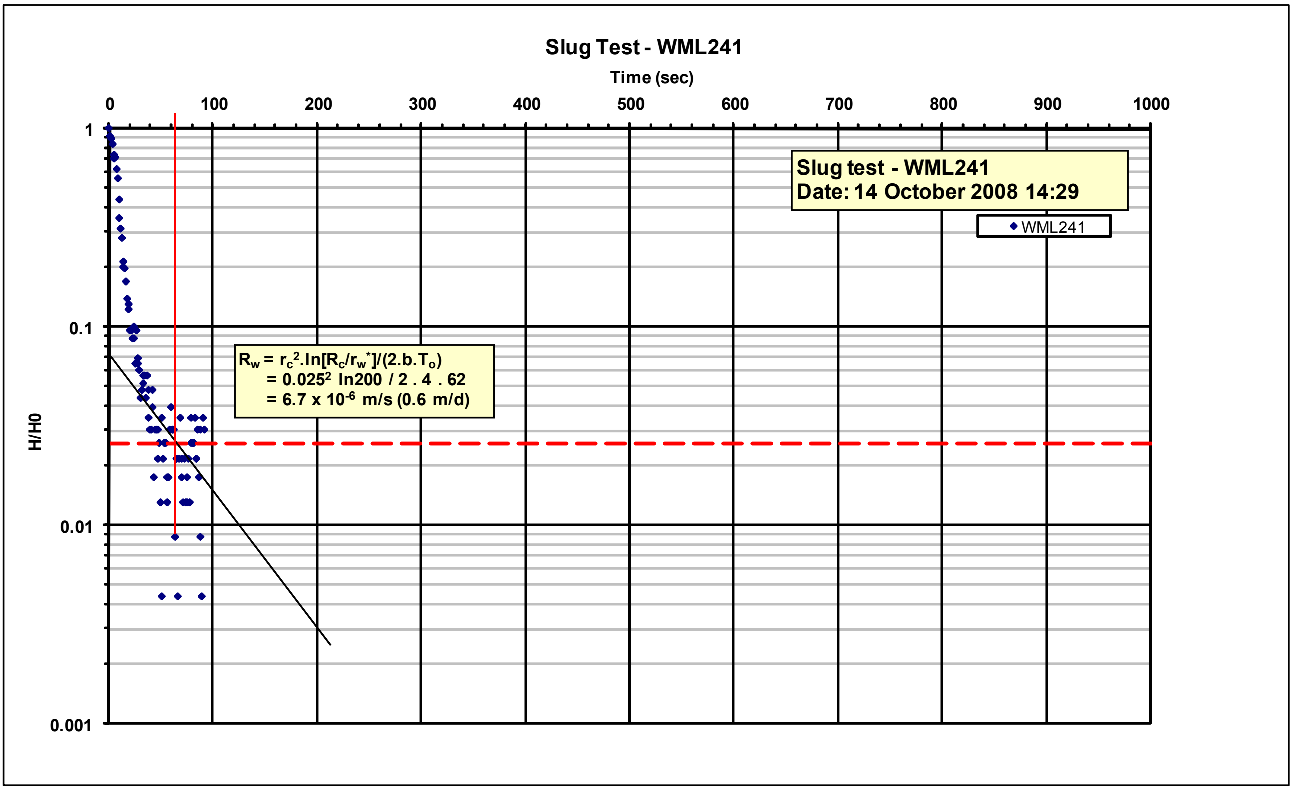
Ashton Coal Operations Ltd

ASHTON COAL PROJECT
SEOC HYDRAULIC TESTING
(SLUG TEST WML240)

Appendix C1

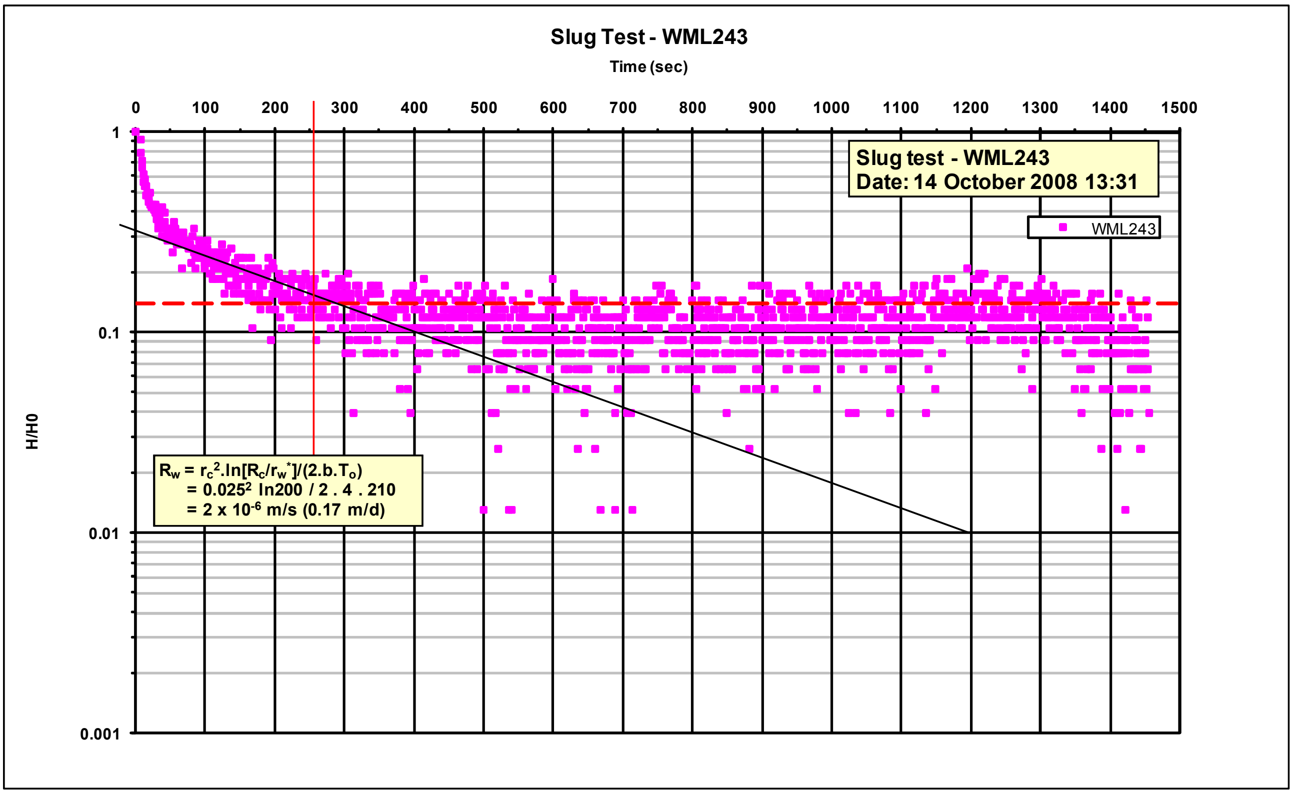


$R_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2 \ln200 / 2 . 4 . 400$
$= 1 \times 10^{-6}$ m/s (0.09 m/d)



$R_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2 \ln200 / 2 . 4 . 62$
$= 6.7 \times 10^{-6}$ m/s (0.6 m/d)

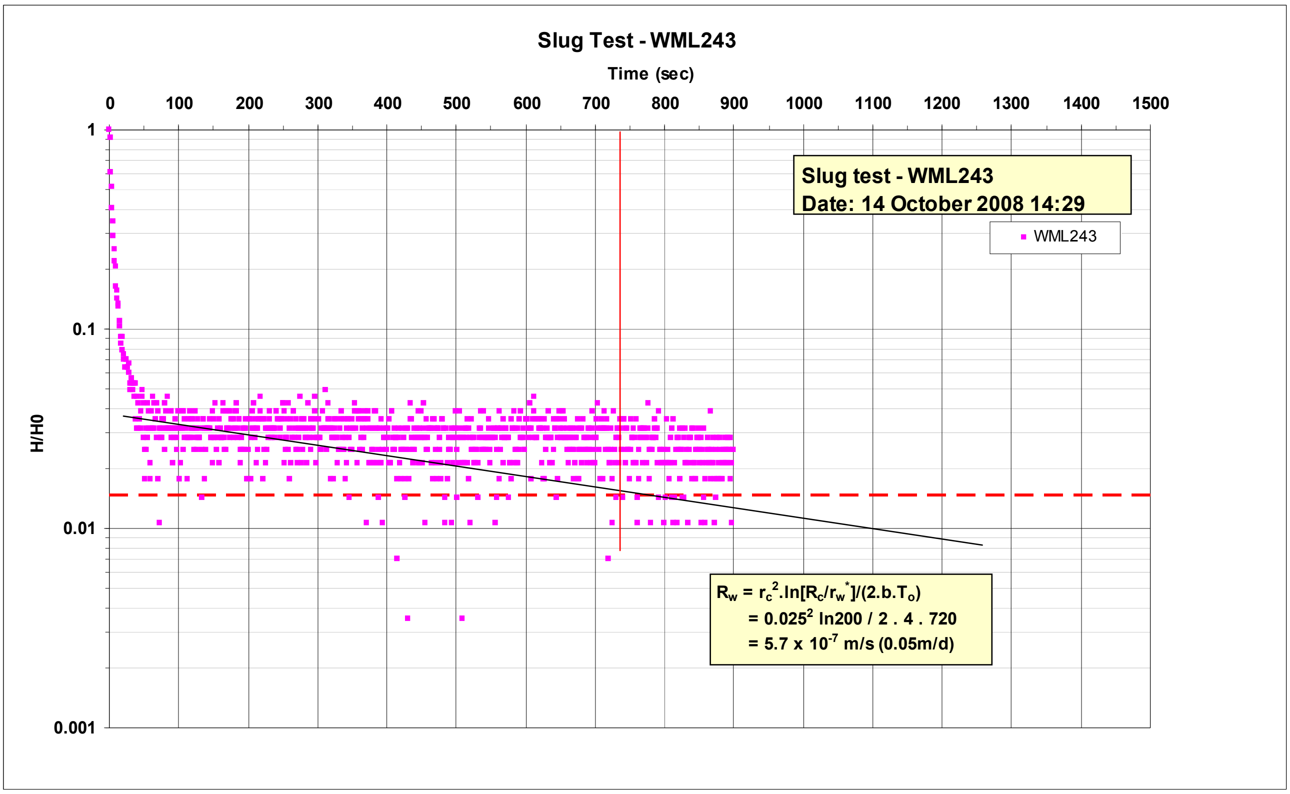
Date:	2 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT SEOC HYDRAULIC TESTING (SLUG TEST WML241)**
Drawing No:	S36-20-241	Rev:	0	
aquaterra				**Appendix C1**



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

$= 0.025^2 \ln 200 \ / \ 2 \ . \ 4 \ . \ 210$

$= 2 \times 10^{-6}$ m/s (0.17 m/d)

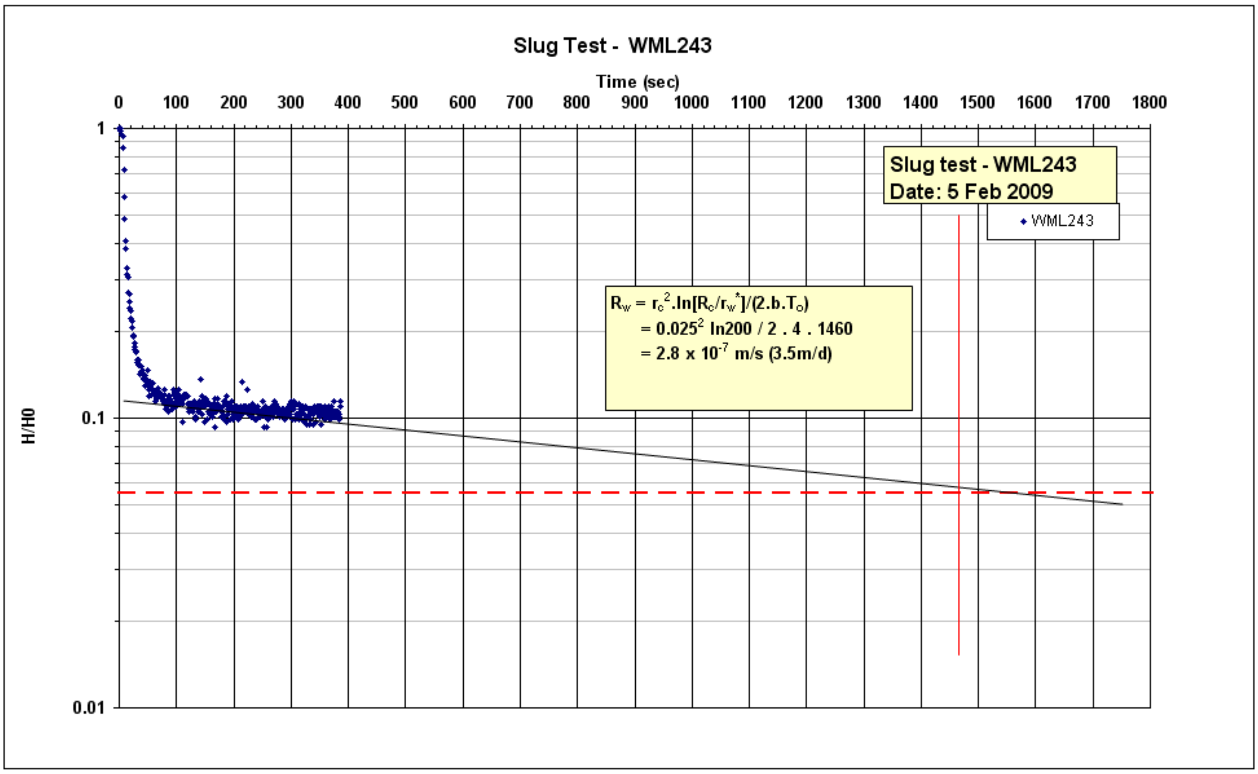


$R_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$

$= 0.025^2 \ln 200 \ / \ 2 \ . \ 4 \ . \ 720$

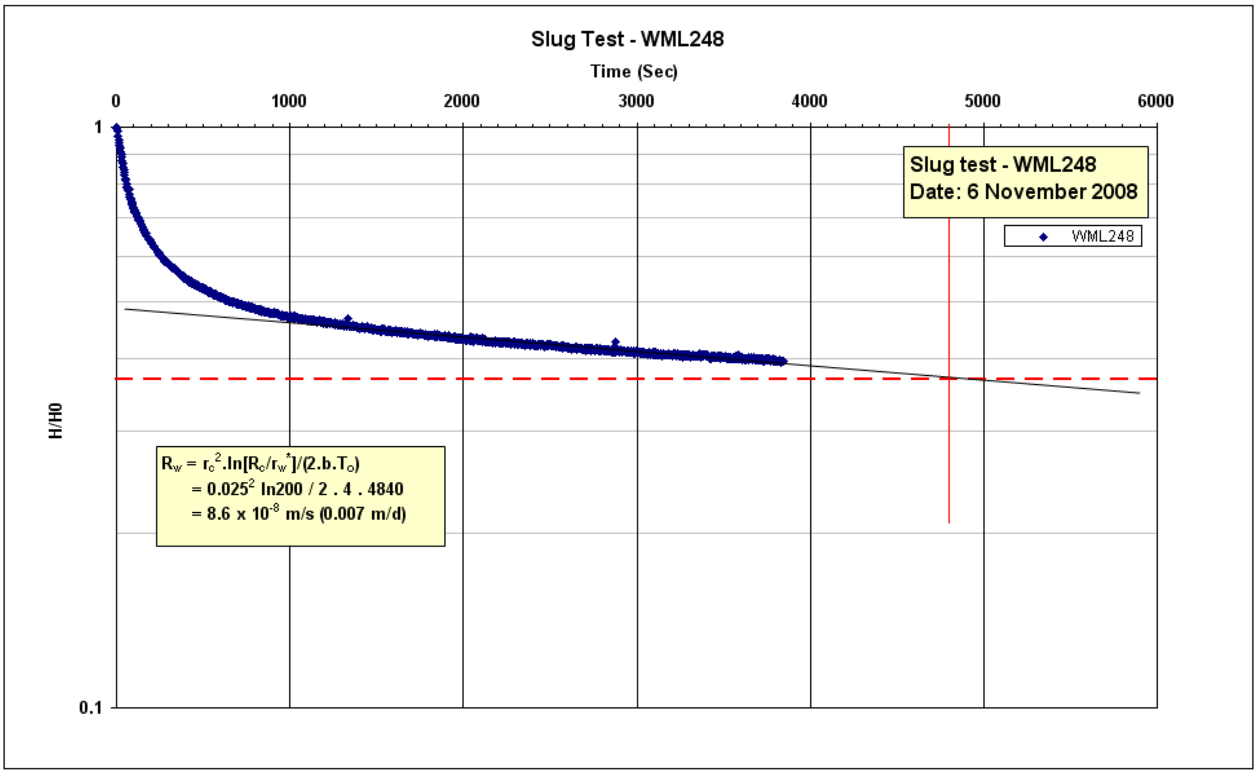
$= 5.7 \times 10^{-7}$ m/s (0.05m/d)

Date:	2 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT** **SEOC HYDRAULIC TESTING** **(SLUG TEST WML243)**
Drawing No:	S36-20-243	Rev:	0	
aquaterra				**Appendix C1**



Slug test - WML243
Date: 5 Feb 2009

$R_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2 \ln 200 / 2 . 4 . 1460$
$= 2.8 \times 10^{-7}$ m/s (3.5m/d)



Slug test - WML248
Date: 6 November 2008

$R_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2 \ln 200 / 2 . 4 . 4840$
$= 8.6 \times 10^{-8}$ m/s (0.007 m/d)

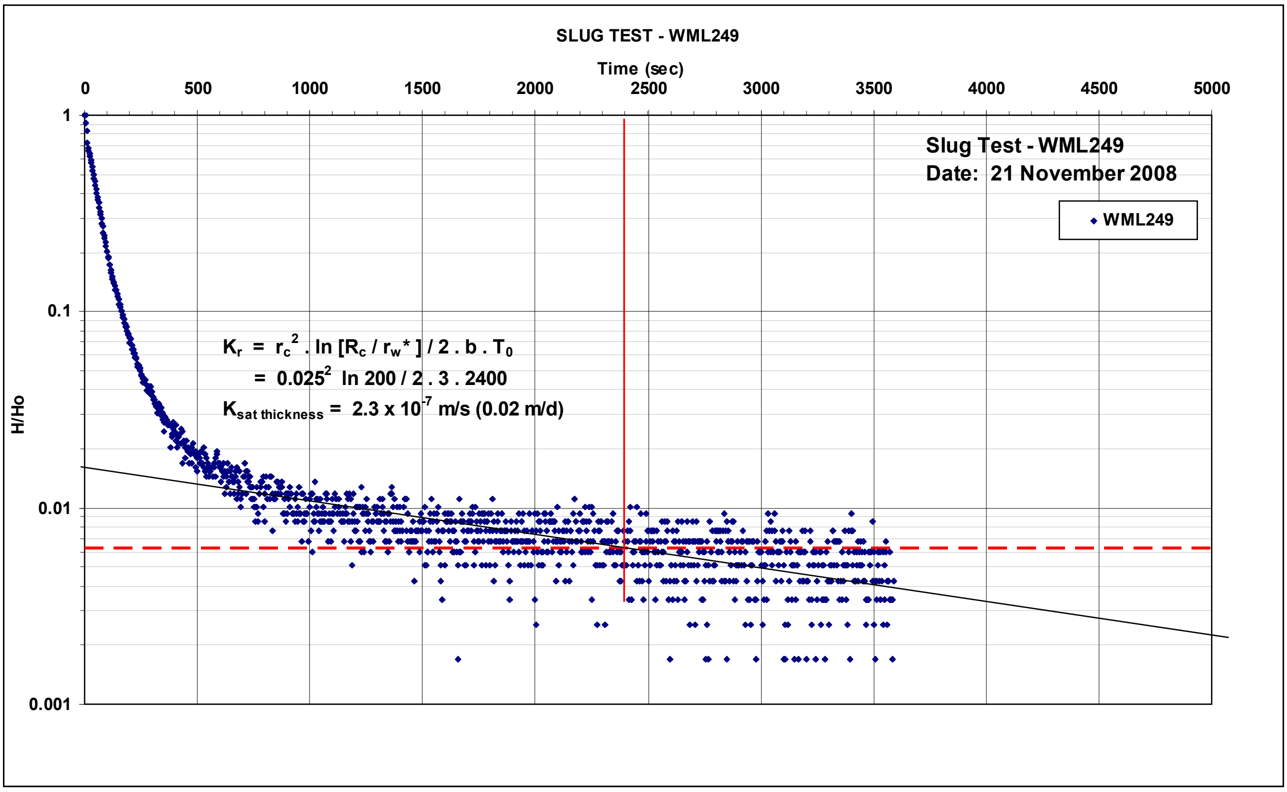
Date:	23 Feb 2009	Scale:	As Shown
Initials:	JvdA	Job No:	S36
Drawing No:	S36-20_243_248	Rev:	A

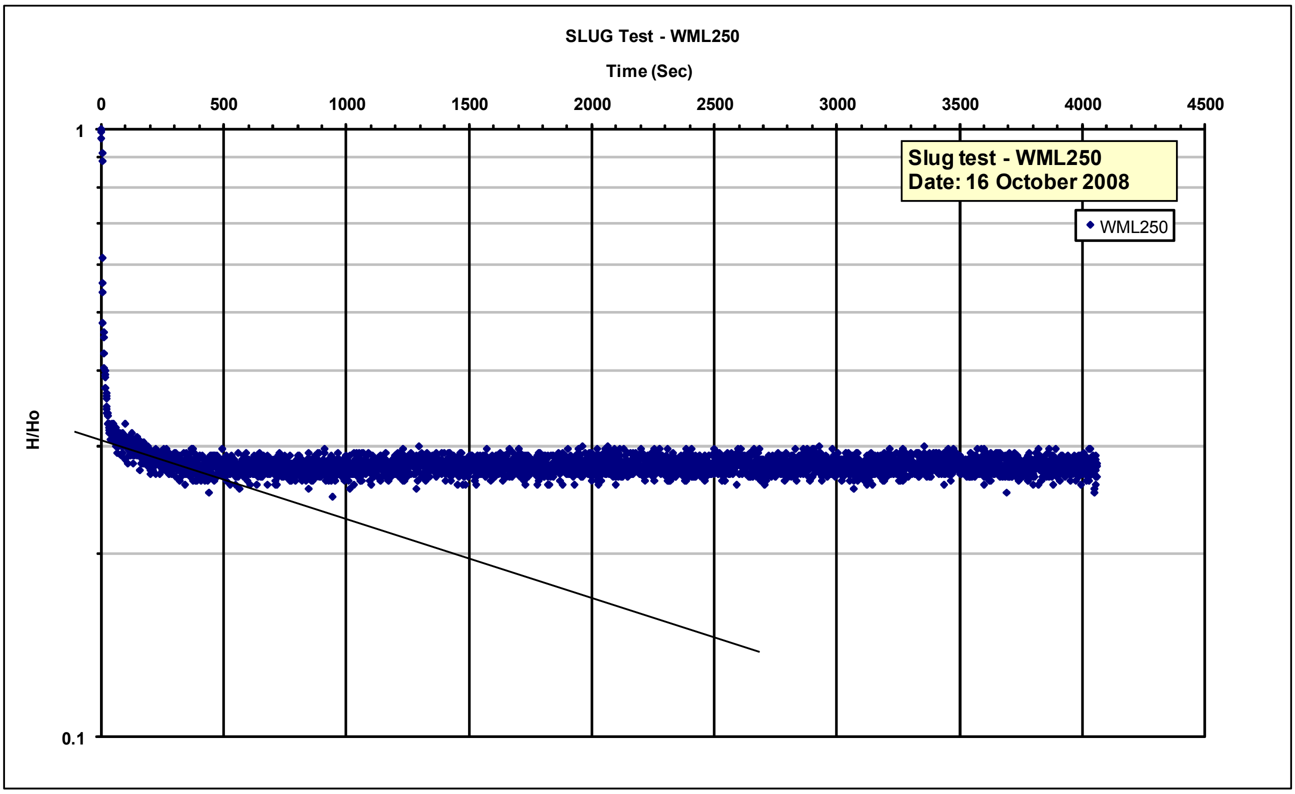
aquaterra

Ashton Coal Operations Pty Ltd

ASHTON COAL PROJECT
SEOC HYDRAULIC TESTING
(SLUG TEST WML243 and WML248)

Appendix C.1





Date: 3 April 2009

Scale: As Shown

Initials: PZ

Job No: S36

Drawing No: S36-20-249_250a

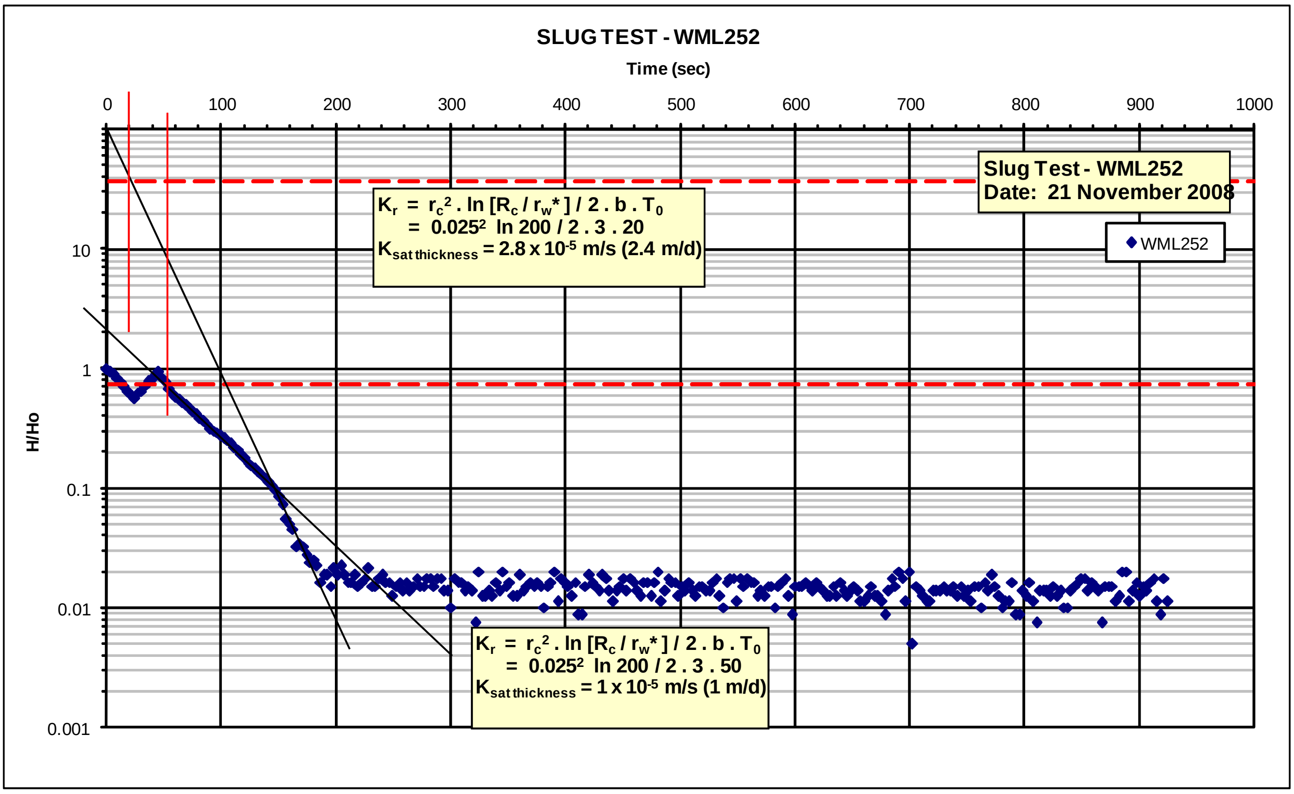
Rev: 0

aquaterra

Ashton Coal Operations Ltd

ASHTON COAL PROJECT
SEOC HYDRAULIC TESTING
(SLUG TEST WML249 AND WML250)

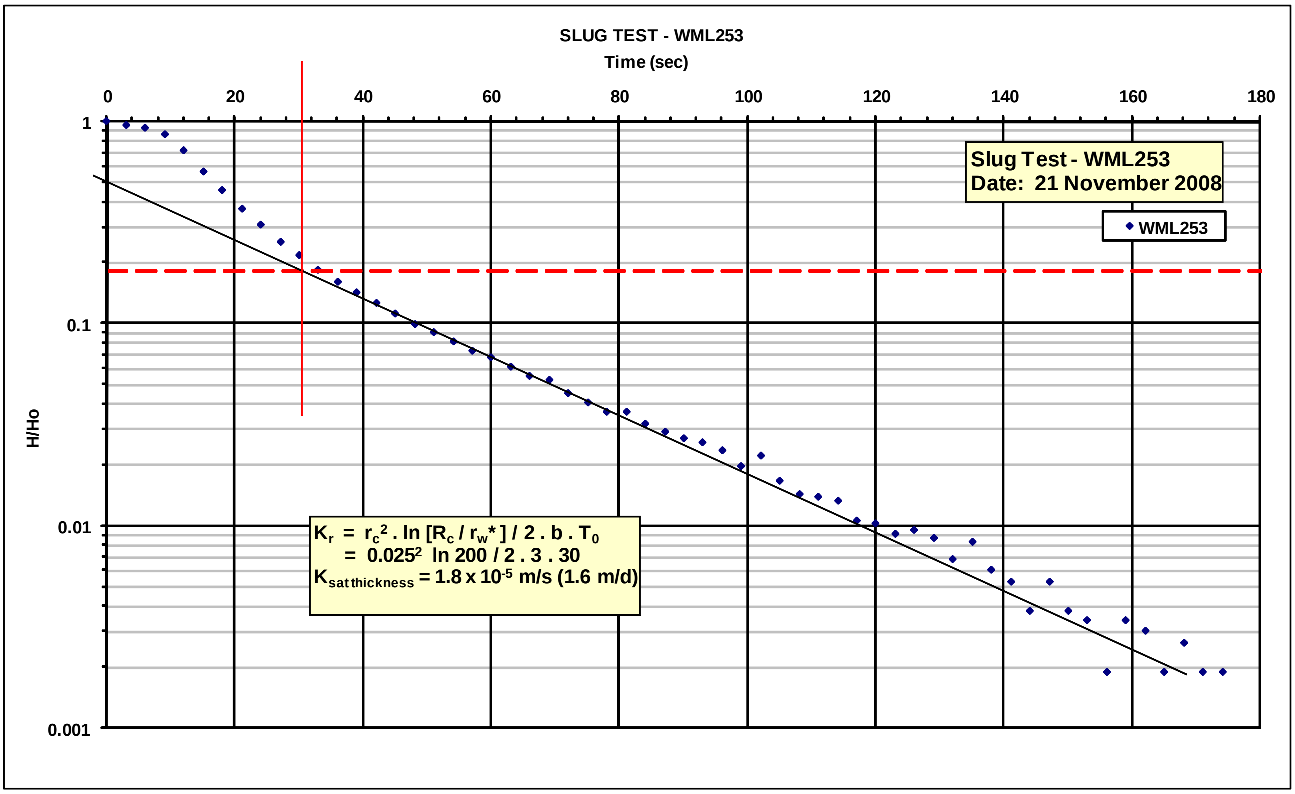
Appendix C1



Slug Test - WML252
Date: 21 November 2008

$K_r = r_c^2 . \ln [R_c / r_w^*] / 2 . b . T_0$
$= 0.025^2 \ \ln 200 / 2 . 3 . 20$
$K_{sat\,thickness} = 2.8 \times 10^{-5}$ m/s (2.4 m/d)

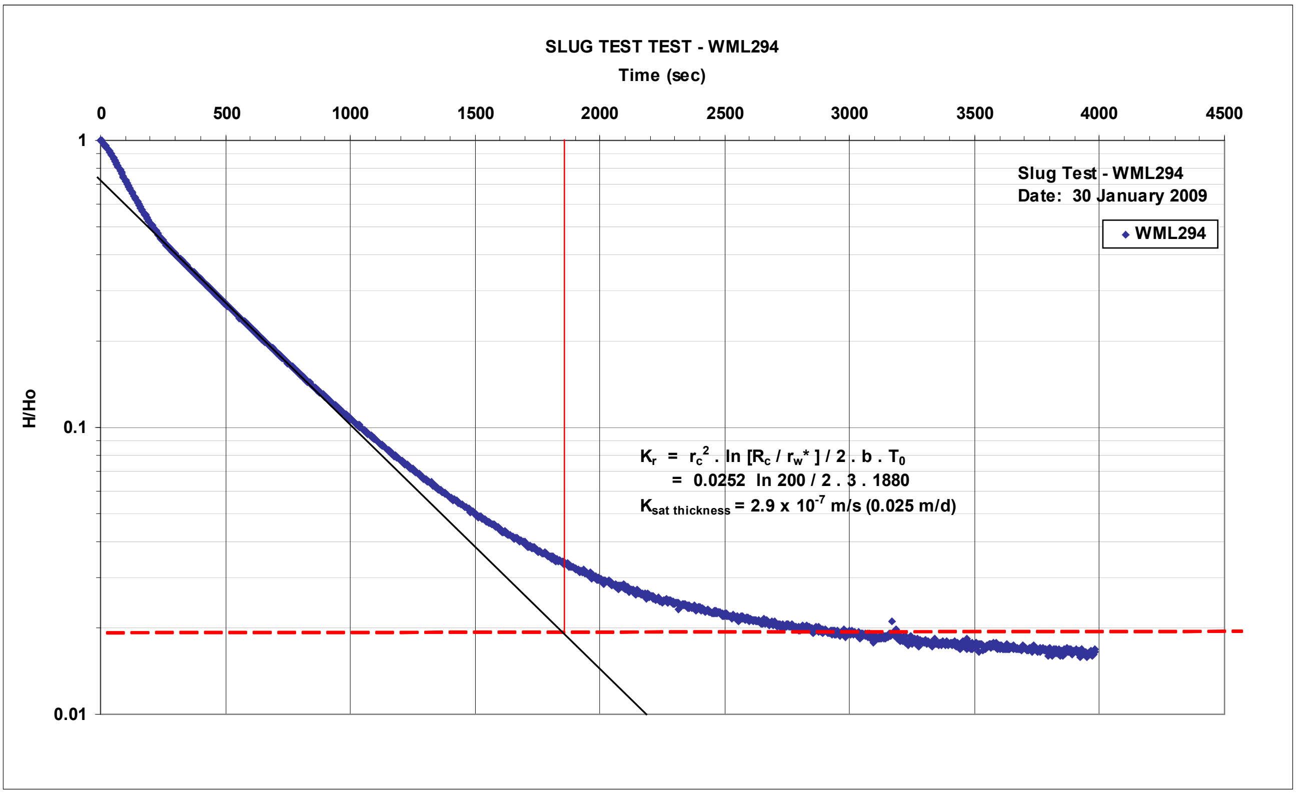
$K_r = r_c^2 . \ln [R_c / r_w^*] / 2 . b . T_0$
$= 0.025^2 \ \ln 200 / 2 . 3 . 50$
$K_{sat\,thickness} = 1 \times 10^{-5}$ m/s (1 m/d)

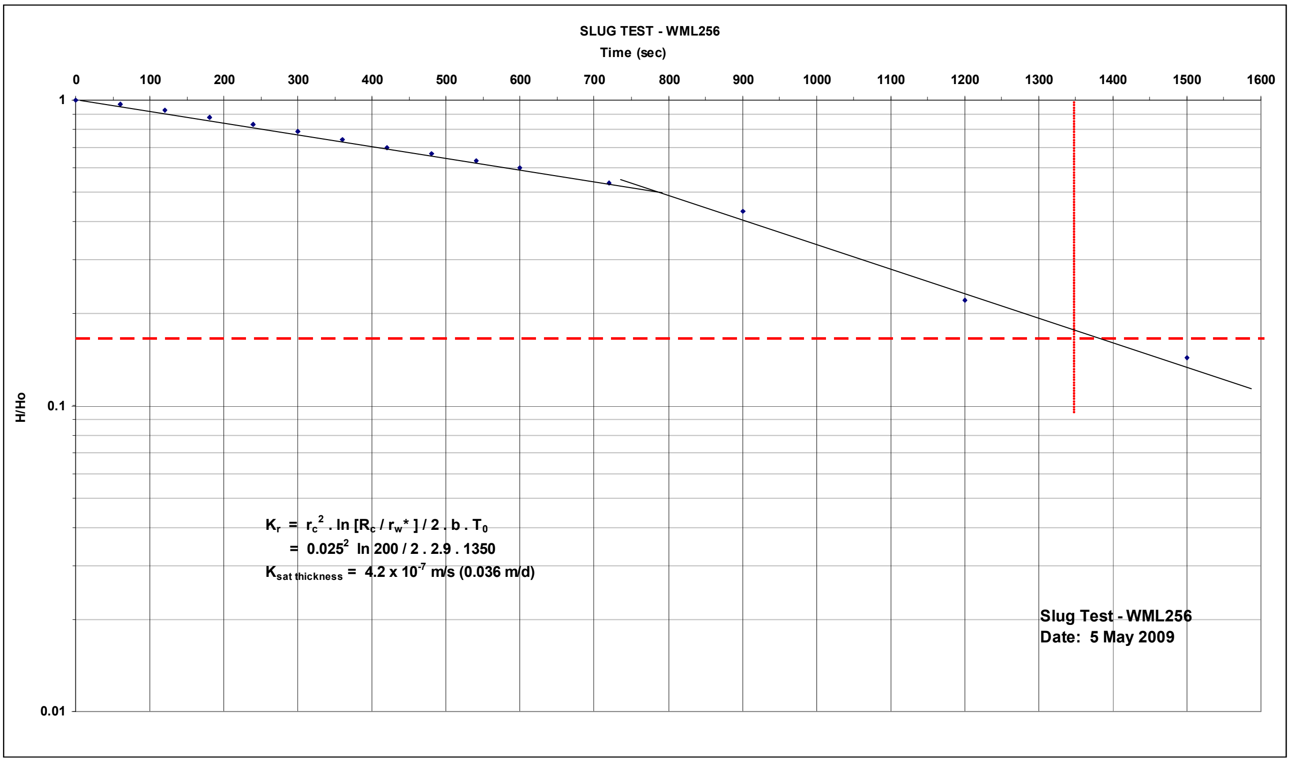


Slug Test - WML253
Date: 21 November 2008

$K_r = r_c^2 . \ln [R_c / r_w^*] / 2 . b . T_0$
$= 0.025^2 \ \ln 200 / 2 . 3 . 30$
$K_{sat\,thickness} = 1.8 \times 10^{-5}$ m/s (1.6 m/d)

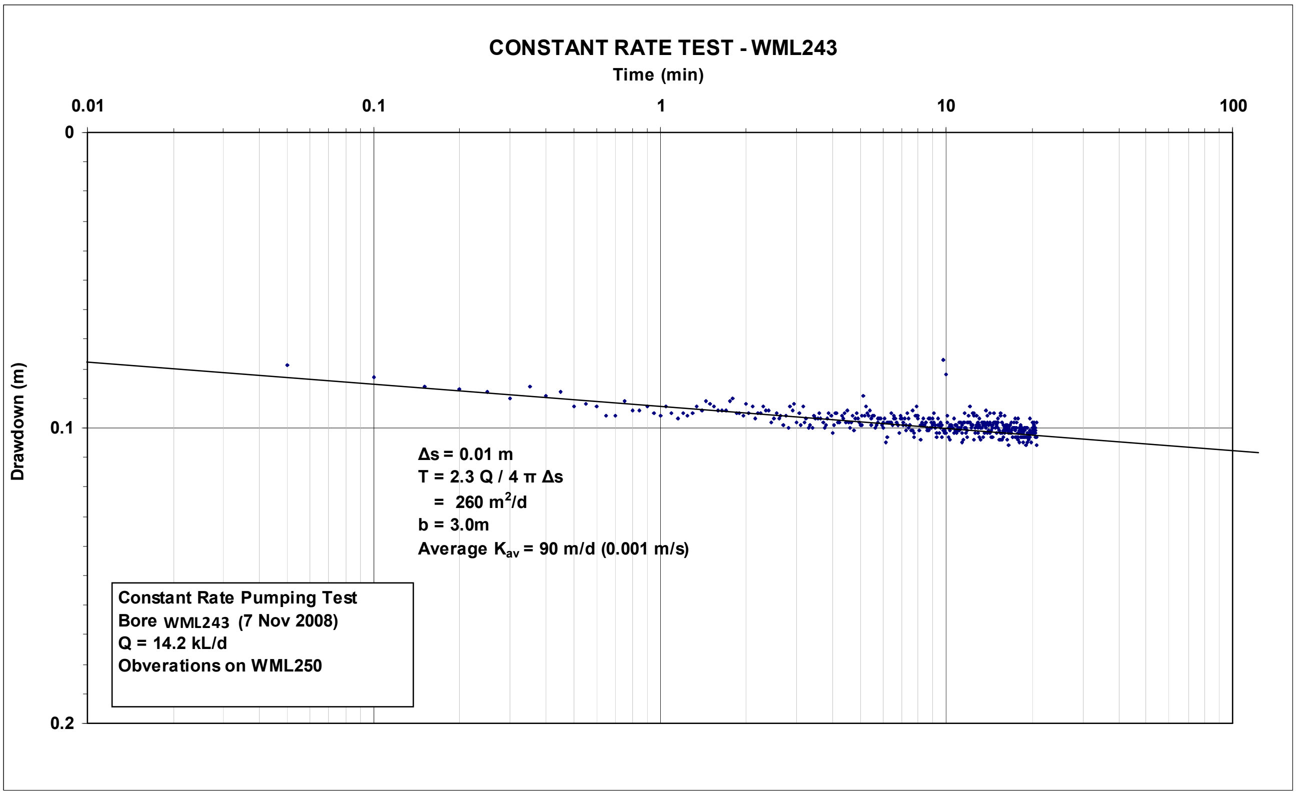
Date:	3 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT SEOC HYDRAULIC TESTING (SLUG TEST WML252 AND WML253)**
Drawing No:	S36-20-252-253a	Rev:	0	
aquaterra				**Appendix C1**



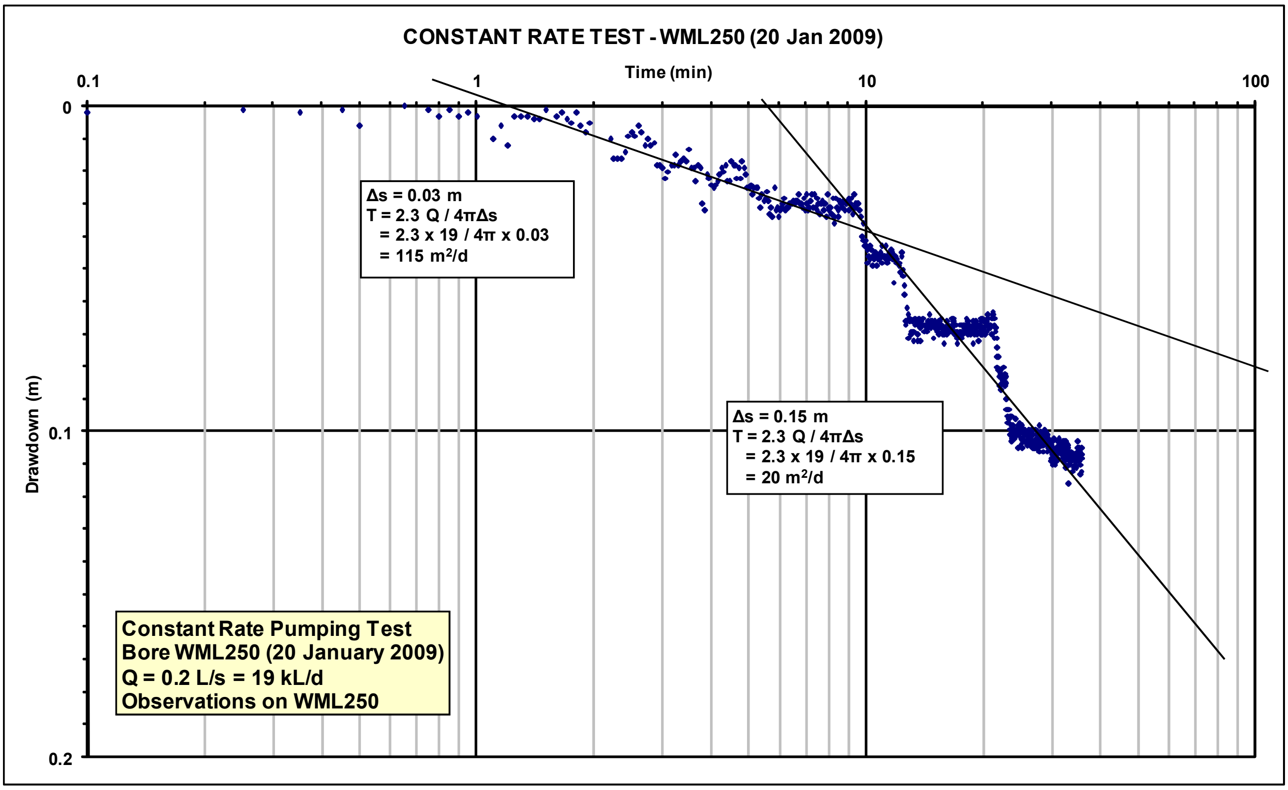


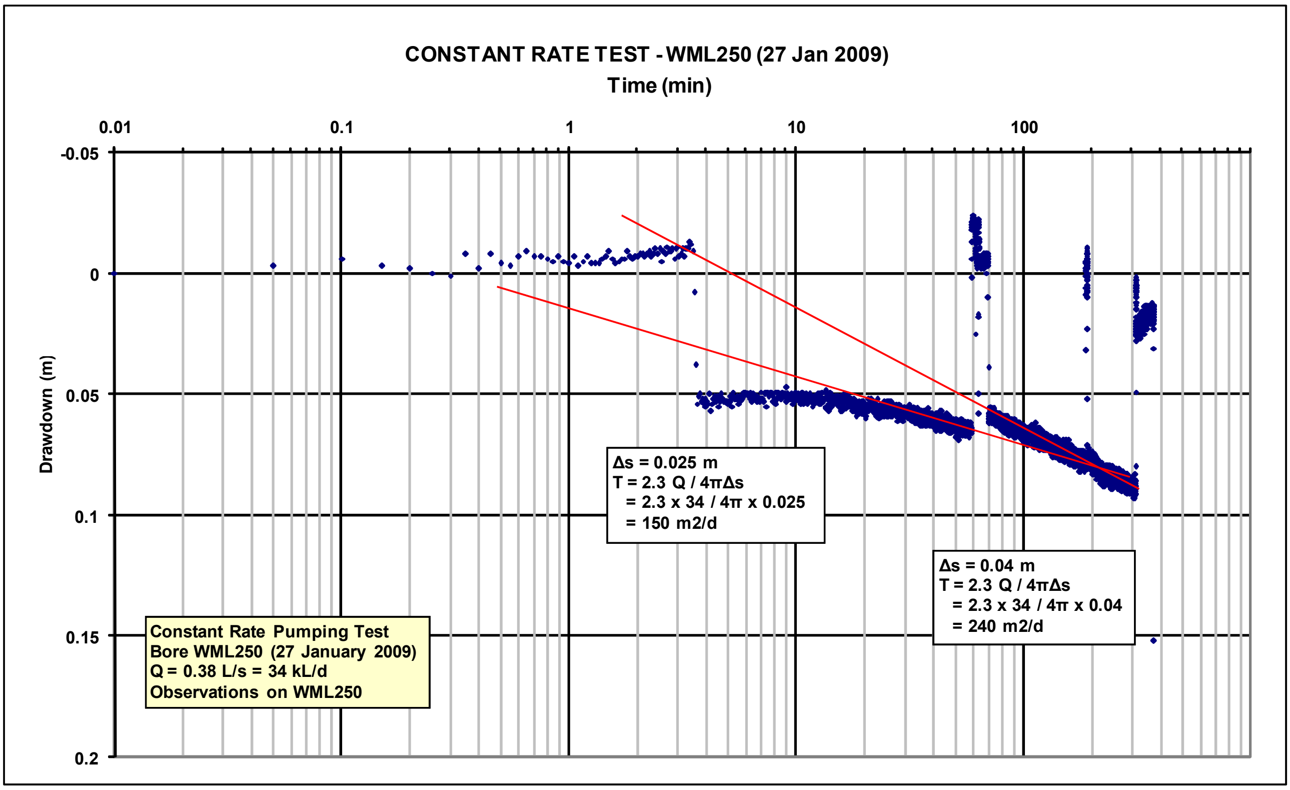
Date:	2 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT** **SEOC HYDRAULIC TESTING** **(SLUG TEST WML294 and WML256)**
Drawing No:	S36-20-299_256	Rev:	0	
aquaterra				**Appendix C1**

APPENDIX C2 CONSTANT RATE TEST RESULTS

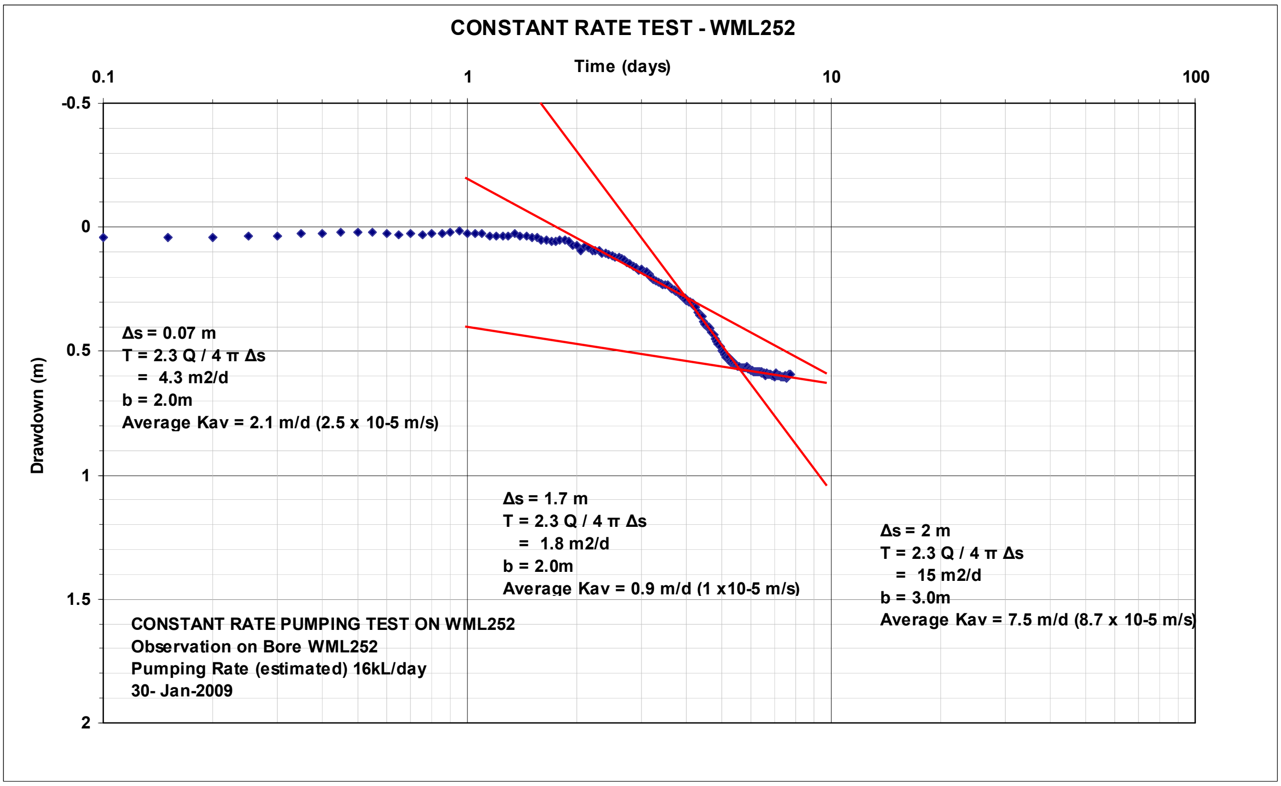


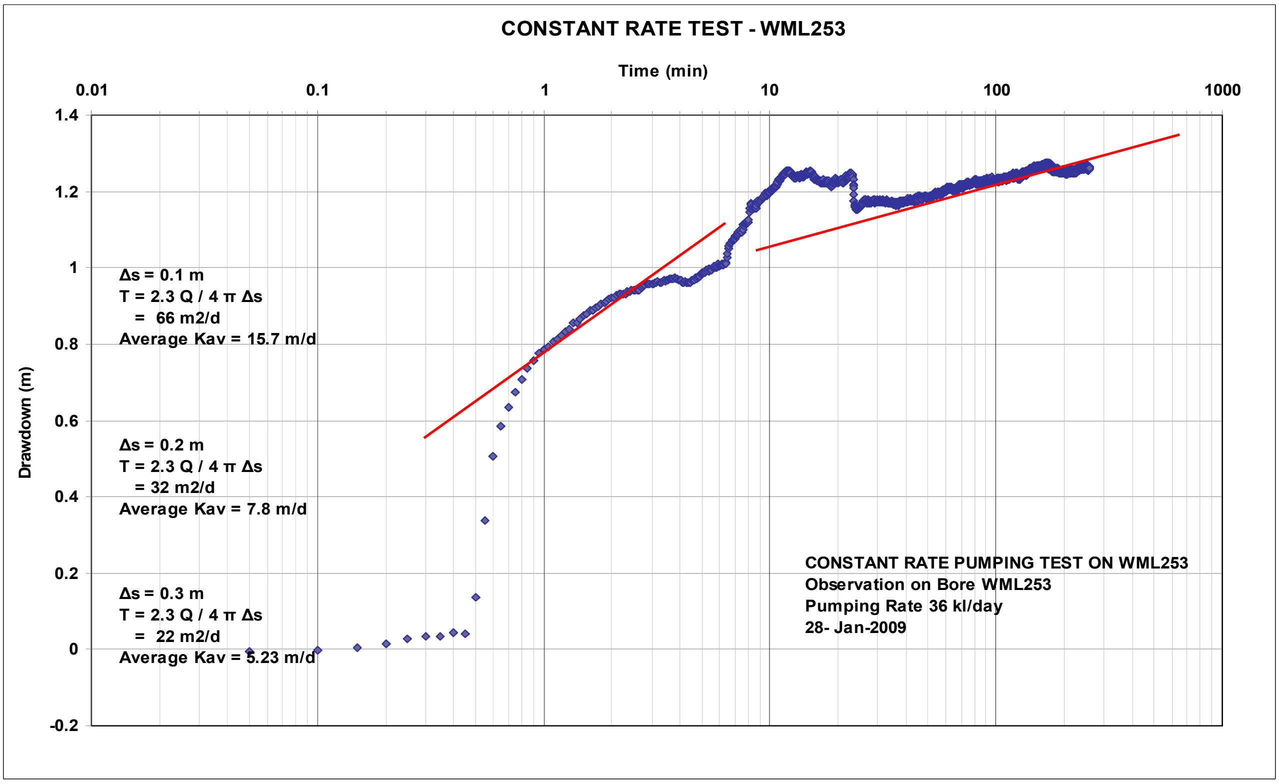
Date:	3 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT** **SEOC HYDRAULIC TESTING** **(CONSTANT RATE TEST WML243)**
Drawing No:	S36-20-243a	Rev:	0	
aquaterra				**Appendix C1**





Date:	6 April 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**ASHTON COAL PROJECT SEOC HYDRAULIC TESTING (CONSTANT RATE TEST WML250)**
Drawing No:	S36-20-250a	Rev:	0	
aquaterra				**Appendix C1**





Date:	3 April 2009	Scale:	As Shown
Initials:	PZ	Job No:	S36
Drawing No:	S36-20-252-253a	Rev:	0

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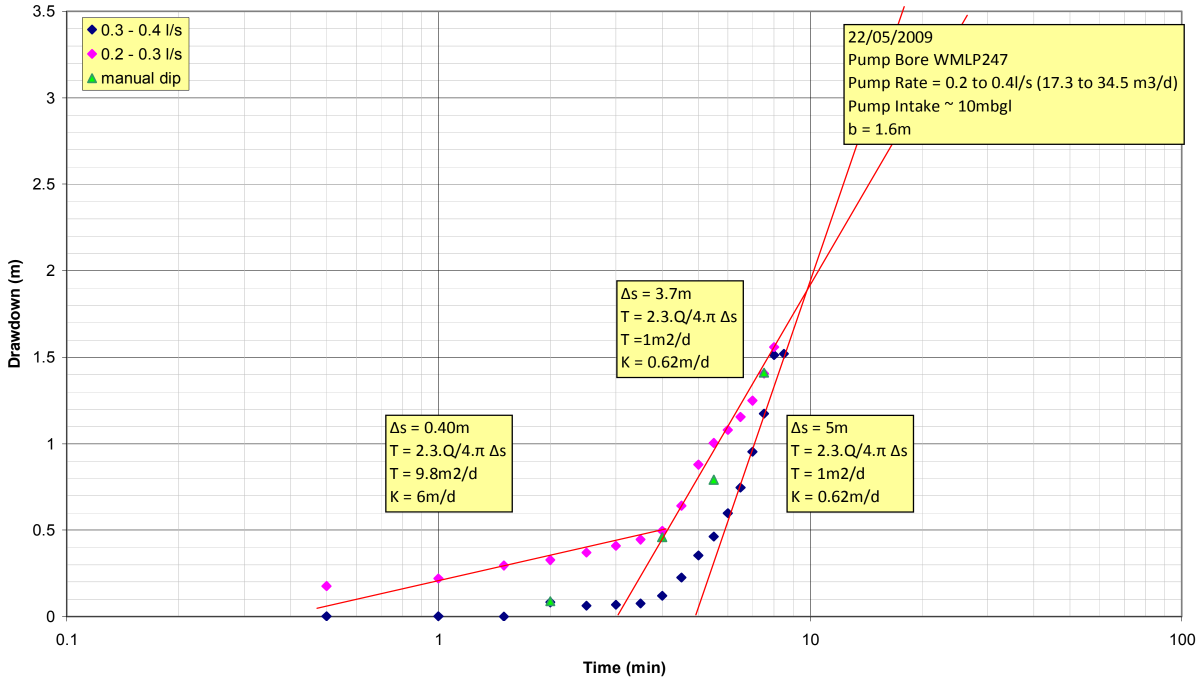
Ashton Coal Operations Ltd

ASHTON COAL PROJECT
SEOC HYDRAULIC TESTING
(CONSTANT RATE TEST WML252 AND WML253)

Appendix C1

CONSTANT RATE TEST - WMLP247



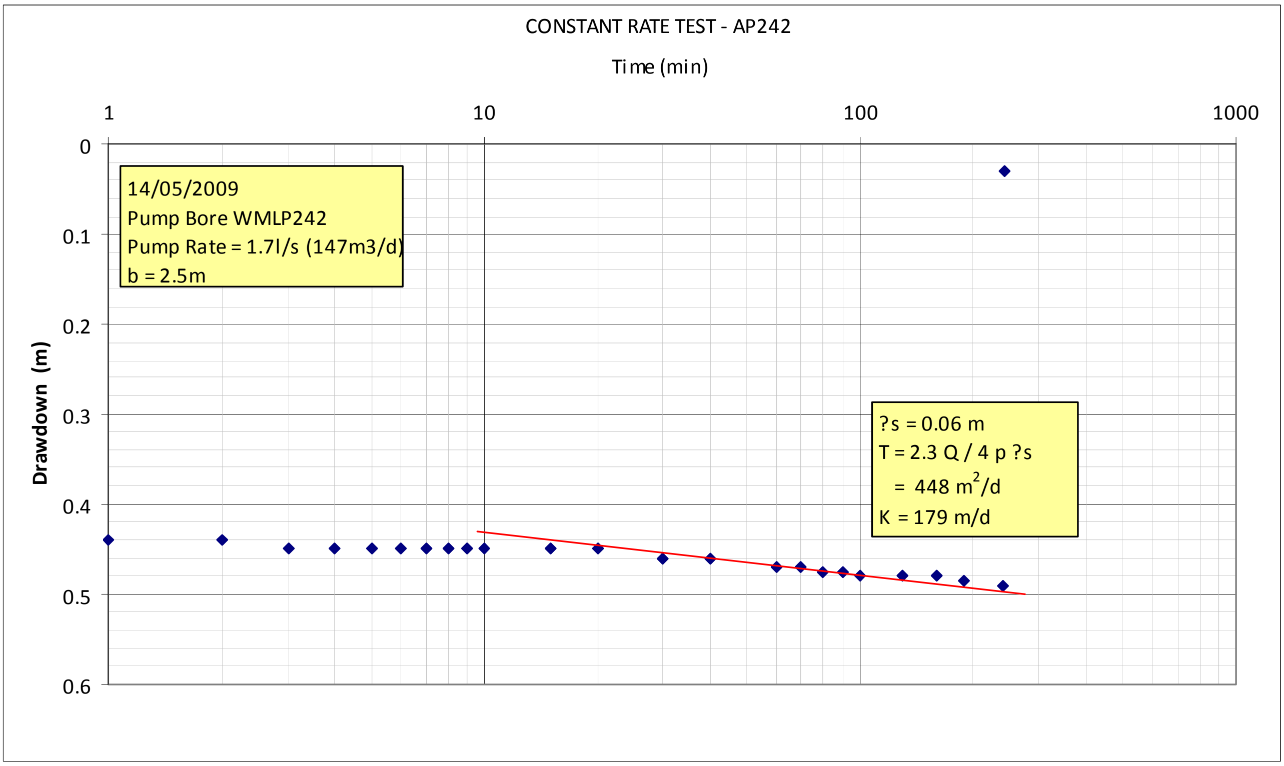
22/05/2009
Pump Bore WMLP247
Pump Rate = 0.2 to 0.4l/s (17.3 to 34.5 m3/d)
Pump Intake ~ 10mbgl
b = 1.6m

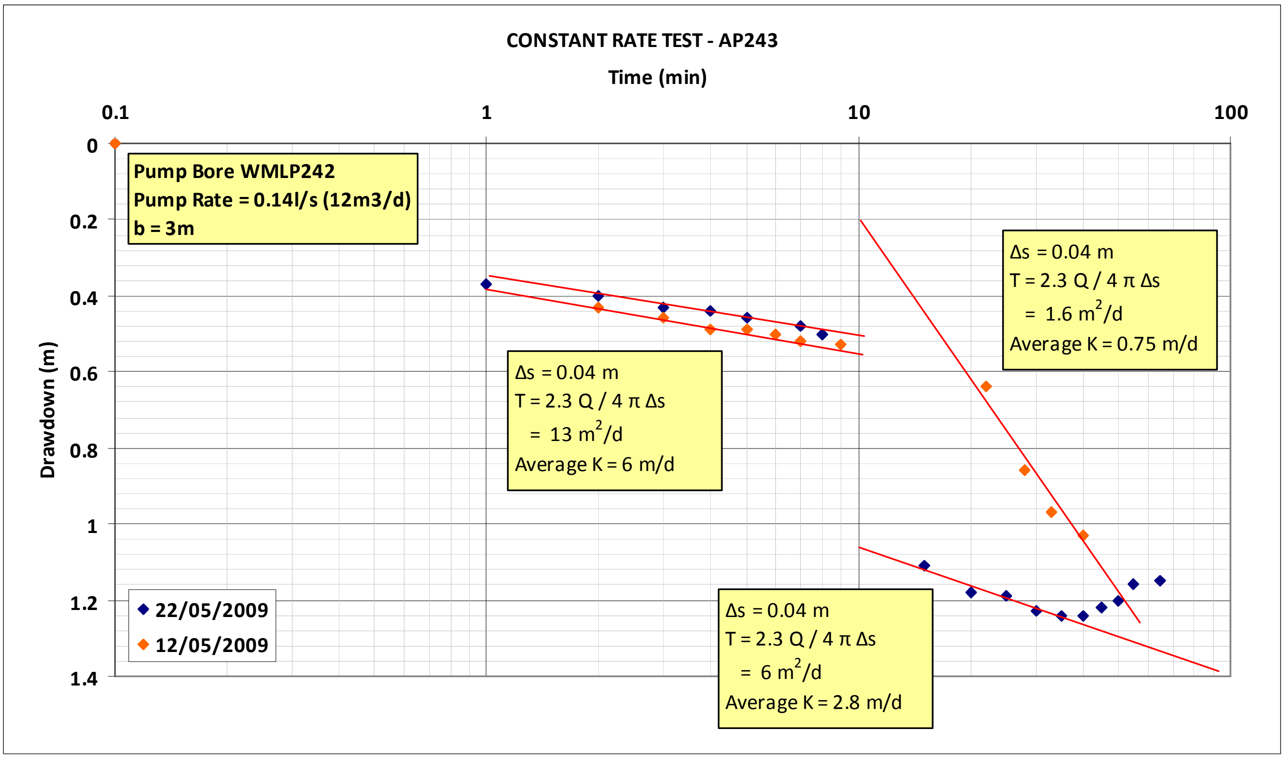
Δs = 3.7m
T = 2.3.Q/4.π Δs
T =1m2/d
K = 0.62m/d

Δs = 0.40m
T = 2.3.Q/4.π Δs
T = 9.8m2/d
K = 6m/d

Δs = 5m
T = 2.3.Q/4.π Δs
T = 1m2/d
K = 0.62m/d

Date:	7 July 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	JVDA	Job No:	S36	**ASHTON COAL PROJECT SEOC HYDRAULIC TESTING (CONSTANT RATE TEST AP247)**
Drawing No:	S36-20-AP247	Rev:	0	
aquaterra				**Appendix C1**





Date: 7 July 2009
Scale: As Shown
Initials: JVDA
Job No: S36
Drawing No: S36-20-WMLP242_243
Rev: 0

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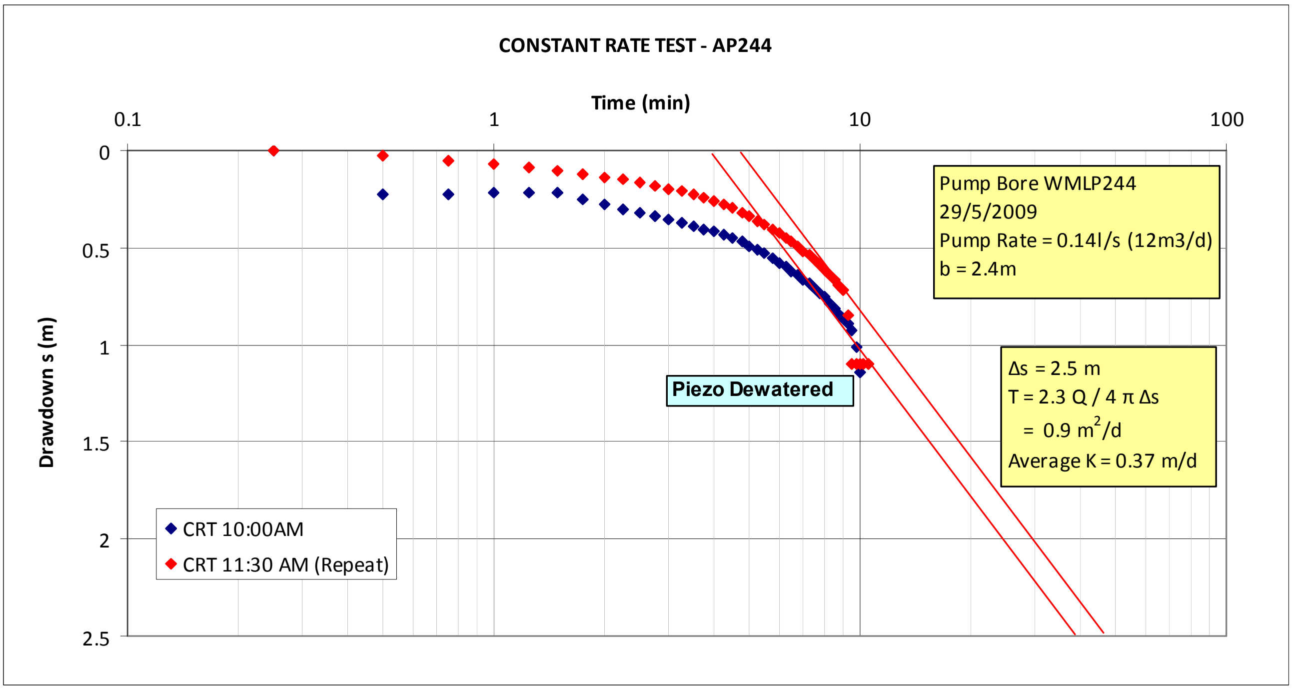
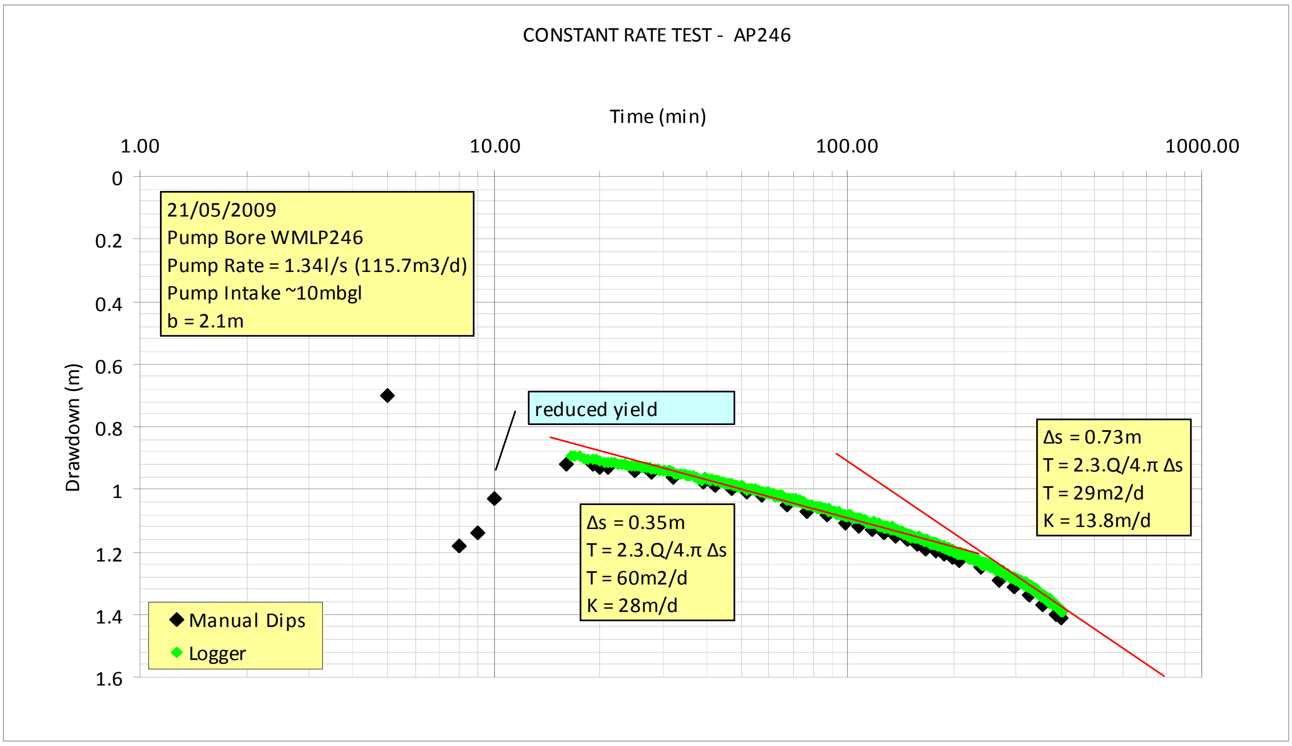
Ashton Coal Operations Ltd

ASHTON COAL PROJECT
SEOC HYDRAULIC TESTING
CONSTANT RATE TEST ON
AP242 AND AP243

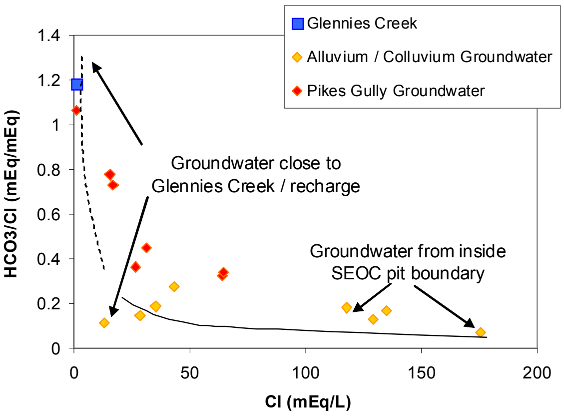
Appendix C1

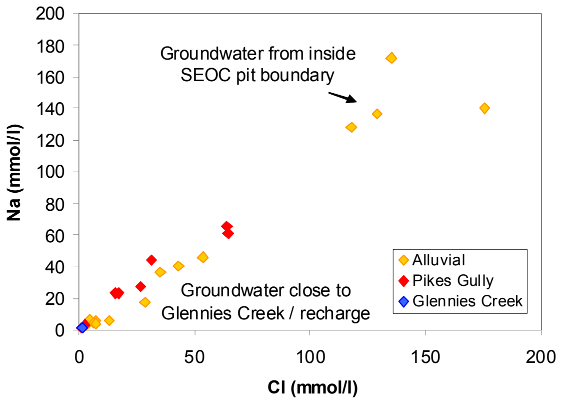


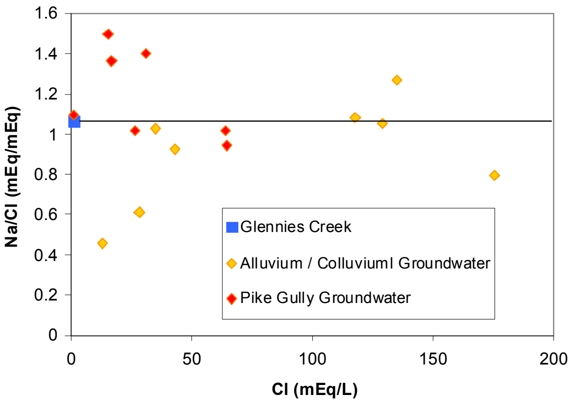


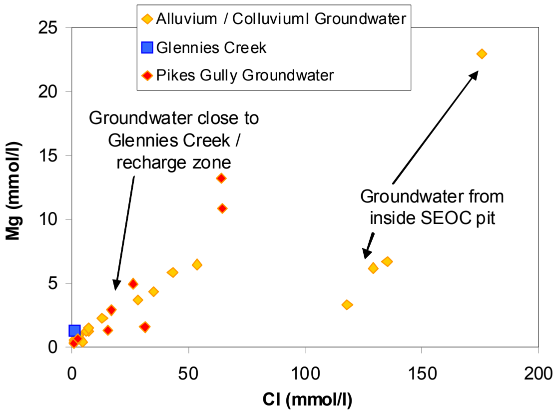
Date:	1 June 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	JVDA	Job No:	S36	**ASHTON COAL PROJECT SEOC HYDRAULIC TESTING (CONSTANT RATE TEST AP244 AND AP246**
Drawing No:	S36-20-AP244 AND AP246	Rev:	0	**Appendix C1**
aquaterra				

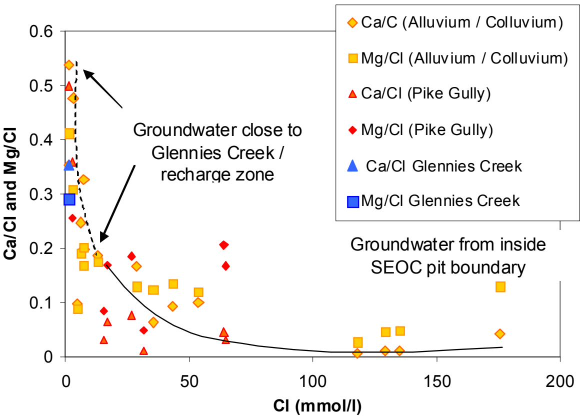
APPENDIX D IONIC RATIO PLOTS OF GROUNDWATER











Groundwater Mixing Line

- - - - - - - - Fresh (recharge)

——— Saline (remote from recharge source)

Date:	23 March 2009	Scale:	As Shown
Initials:	PZ	Job No:	S36
Drawing No:	S36-014a	Rev:	A

aquaterra

Ashton Coal Operations Ltd

ASHTON COAL PROJECT
SEOC
IONIC RATIOS OF GROUND WATER

Appendix D

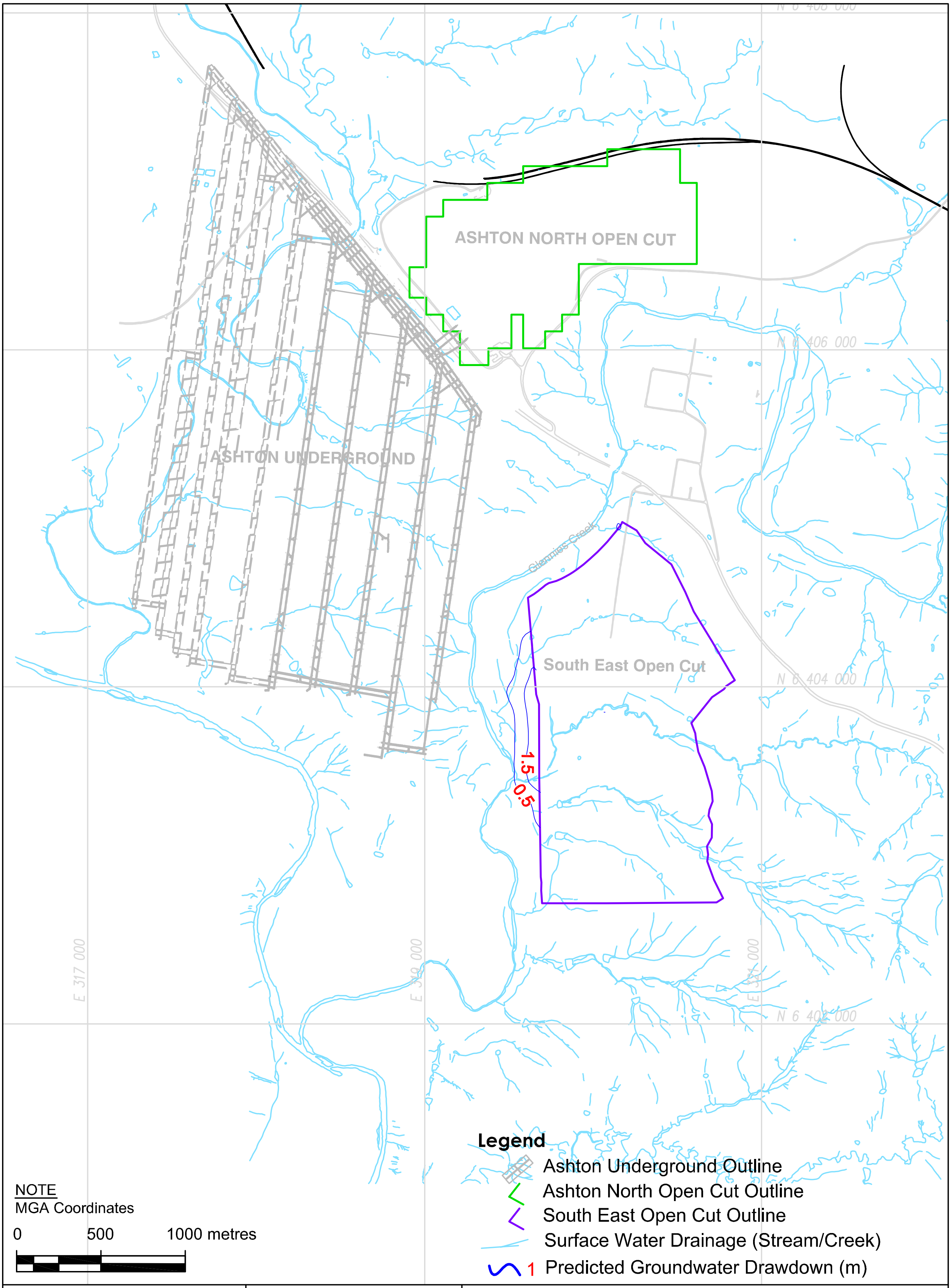
APPENDIX E WATER QUALITY – SUMMARY OF LABORATORY RESULTS

Summary of Laboratory Results

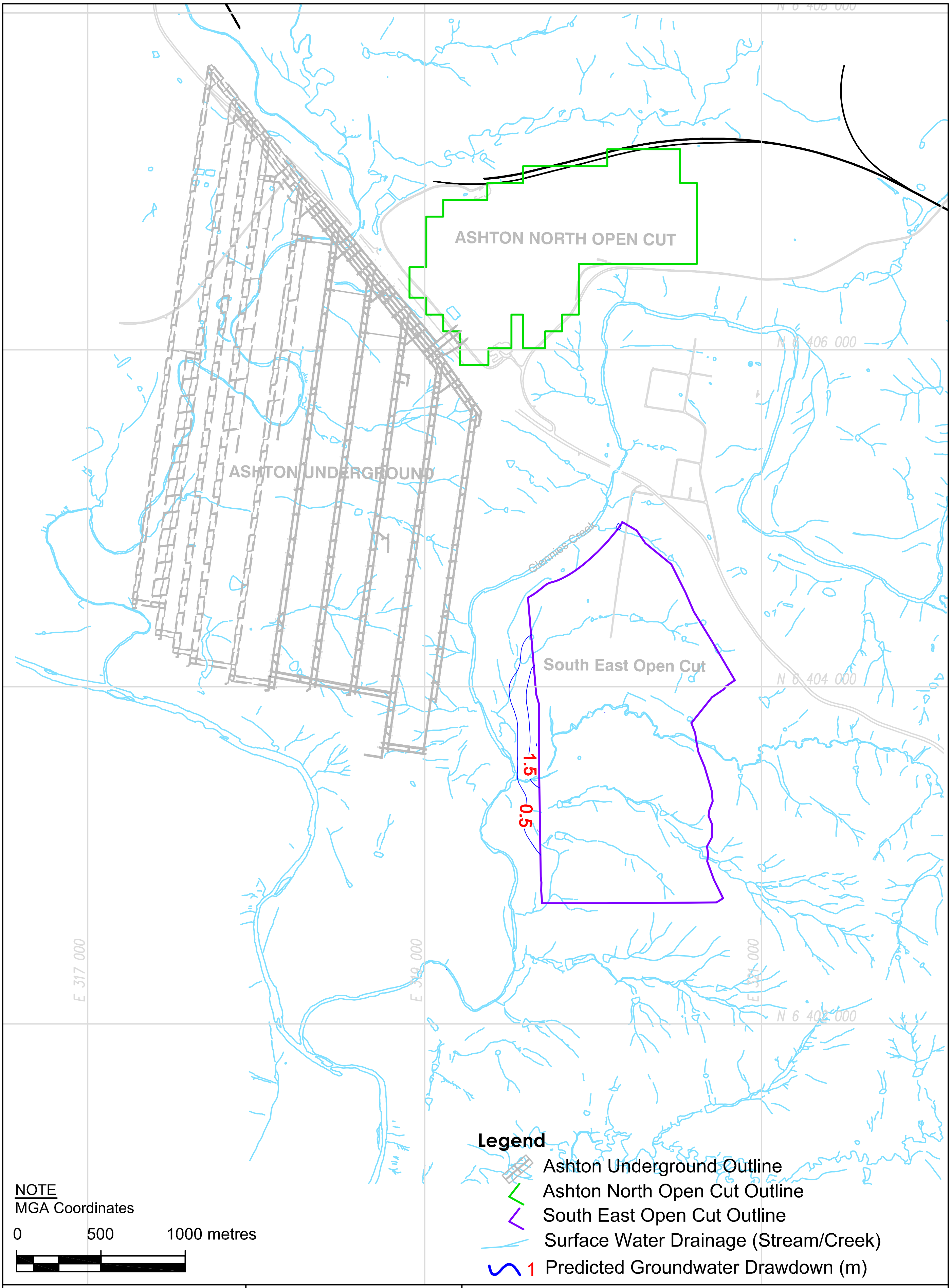
Piezometer	ANZECC (2000) Guideline^		GLENNIES CREEK	WML148	WML155	WML157	WML239	WML240	WML241	WML243	WML247	WML248	WML249	WML249	WML250	WML252	WML253	SEOC_A
Sample date:			21/11/2008	21/11/2008	21/11/2008	21/11/2008	07/11/2008	06/11/2008	07/11/2008	07/11/2008	06/11/2008	06/11/2008	21/11/2008	06/11/2008	06/11/2008	21/11/2008	21/11/2008	21/11/2008
Analyte grouping/Analyte		Units																
pH Value		pH Unit	6.98	6.85	7.25	7.2	7.01	6.72	7.34	6.97	7.92	7.53	7.95	8	7.1	6.73	7.87	8.14
Electrical Conductivity @ 25°C		µS/cm	310	3340	1160	701	1000	1660	829	5570	14200	18400	16100	15300	1200	4710	345	6470
Total Dissolved Solids @180°C		mg/L	176	2800	967	500	690	1400	539	3310	8320	12000	9490	9480	754	2640	236	3780
Alkalinity by PC Titrator																		
Hydroxide Alkalinity as CaCO3		mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3		mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	172	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3		mg/L	75	210	128	201	152	91	190	598	1320	781	967	1050	170	331	118	372
Total Alkalinity as CaCO3		mg/L	75	210	128	201	152	91	190	598	1320	781	1140	1050	170	331	118	372
Sulfate as SO4 - Turbidimetric		mg/L	14	34	114	24	19	31	6	195	38	1080	856	747	20	259	6	200
Chloride		mg/L	45	1010	260	104	221	466	163	1530	4180	6230	4790	4580	258	1250	46	1900
Dissolved Major Cations																		
Calcium		mg/L	18	191	96	56	62	98	18	162	30	293	64	61	58	90	28	215
Magnesium		mg/L	9	90	36	22	29	56	10	143	80	556	163	150	30	106	13	157
Sodium		mg/L	31	401	90	59	93	138	156	917	2940	3210	3940	3130	141	832	27	1050
Potassium		mg/L	2	<1	1	<1	2	2	1	2	21	18	11	10	<1	2	<1	3
Dissolved Metals																		
Aluminium	**-**	mg/L	0.08	<0.01	0.02	<0.01	<0.01	<0.01	0.03	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	**0.013**	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.001	<0.001	0.01	<0.001	0.004	0.004	<0.001	<0.001	<0.001	<0.001
Cadmium	**0.0002**	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	**0.0002**	<0.0001	0.0001	<0.0001	**0.0031**	<0.0001	<0.0001
Chromium	**-**	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001
Copper	**0.0014**	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Lead	**0.0034**	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	**-**	mg/L	0.016	0.022	0.014	<0.001	0.007	0.261	0.151	0.204	0.111	0.271	0.008	0.017	0.006	0.086	0.076	0.301
Nickel	**0.011**	mg/L	<0.001	0.003	<0.001	<0.001	<0.001	0.003	<0.001	0.004	0.004	0.017	0.001	0.002	<0.001	<0.001	<0.001	0.003
Selenium	**-**	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.012	0.016	0.017	<0.010	<0.010	<0.010	<0.010
Silver	**-**	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.010	<0.010	<0.010	<0.010	<0.001	<0.001	<0.001	<0.001
Zinc	**0.008**	mg/L	0.01	0.015	0.01	0.005	0.006	**0.008**	0.006	**0.008**	0.007	**0.039**	**0.012**	**0.011**	**0.015**	0.007	<0.005	**0.009**
Boron	**-**	mg/L	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	0.09	0.07	0.07	0.06	0.05	<0.05	0.07	<0.05	<0.05
Iron	**-**	mg/L	0.11	<0.05	<0.05	<0.05	<0.05	0.94	0.85	0.15	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	**0.00006**	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nitrite as N		mg/L	<0.01	0.02	0.02	0.02	<0.01	<0.01	<0.01	0.32	<0.01	0.11	0.02	<0.01	<0.01	0.02	0.02	0.03
Nitrate as N		mg/L	0.04	1.68	0.76	0.13	1.79	1.39	0.02	28.4	0.01	1.94	1.6	1.44	5.42	5.05	0.02	45.4
Nitrite + Nitrate as N		mg/L	0.04	1.69	0.77	0.14	1.79	1.39	0.02	28.7	0.01	2.05	1.62	1.44	5.42	5.08	0.04	45.5
Ionic Balance																		
Total Anions		meq/L	3.05	33.4	12.3	7.47	9.67	15.6	8.53	59.1	145	214	176	166	11.1	47.2	3.77	65.3
Total Cations		meq/L	3.05	34.4	11.7	7.17	9.52	15.6	8.52	59.8	137	201	188	152	11.5	49.5	3.64	69.6
Ionic Balance		%	0.07	1.48	2.48	2.04	0.81	0.09	0.12	0.57	3.03	3.21	3.42	4.44	1.85	2.32	1.71	3.18

*** ANZECC (2000) guideline values for Freshwater Ecosystem Protection**
-Indicates where data are not available
Value equals ANZECC guideline value for freshwater ecosystems
Value exceeds ANZECC guideline value for freshwater ecosystems

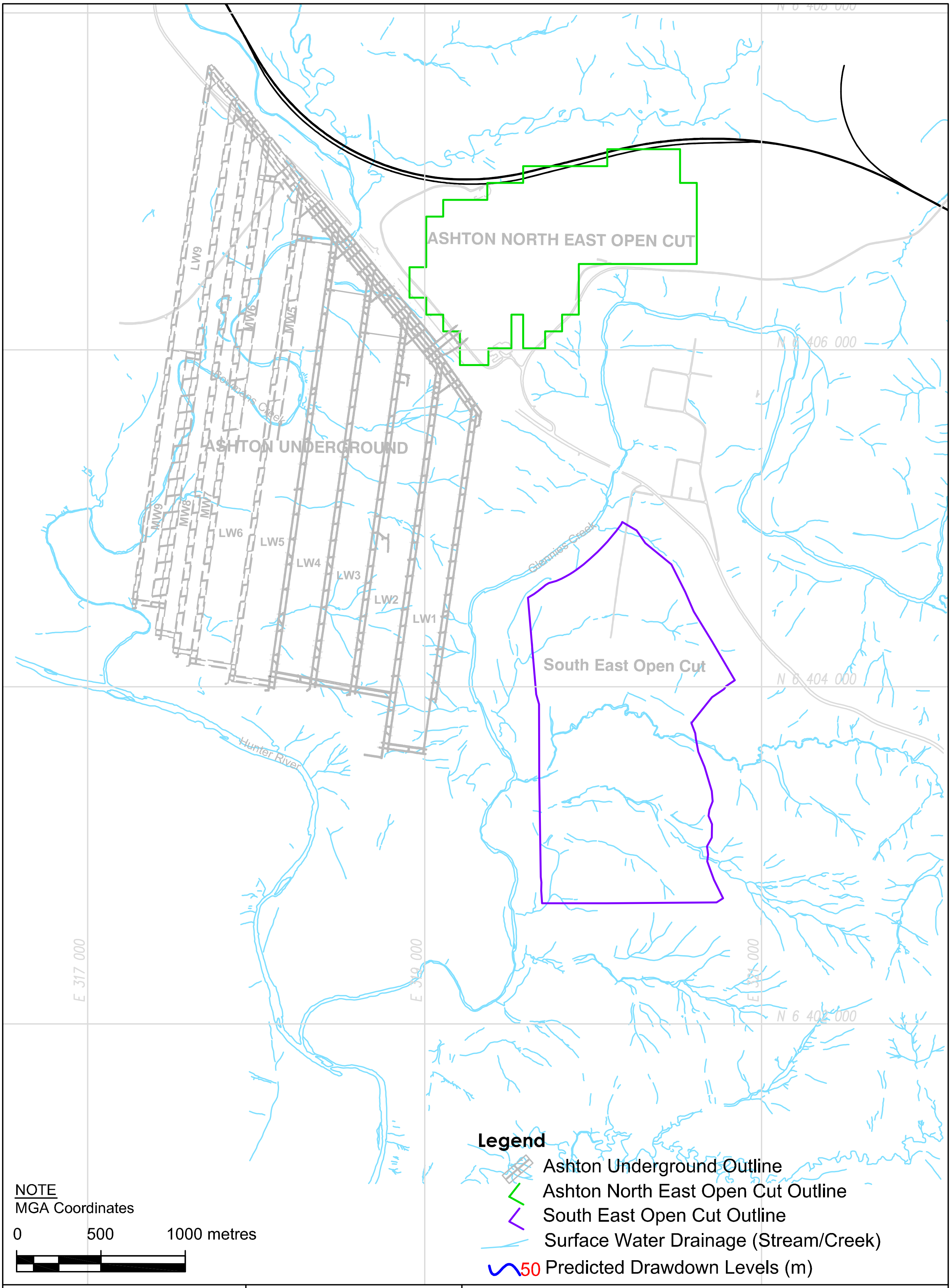
APPENDIX F GROUNDWATER MODEL PREDICTIONS



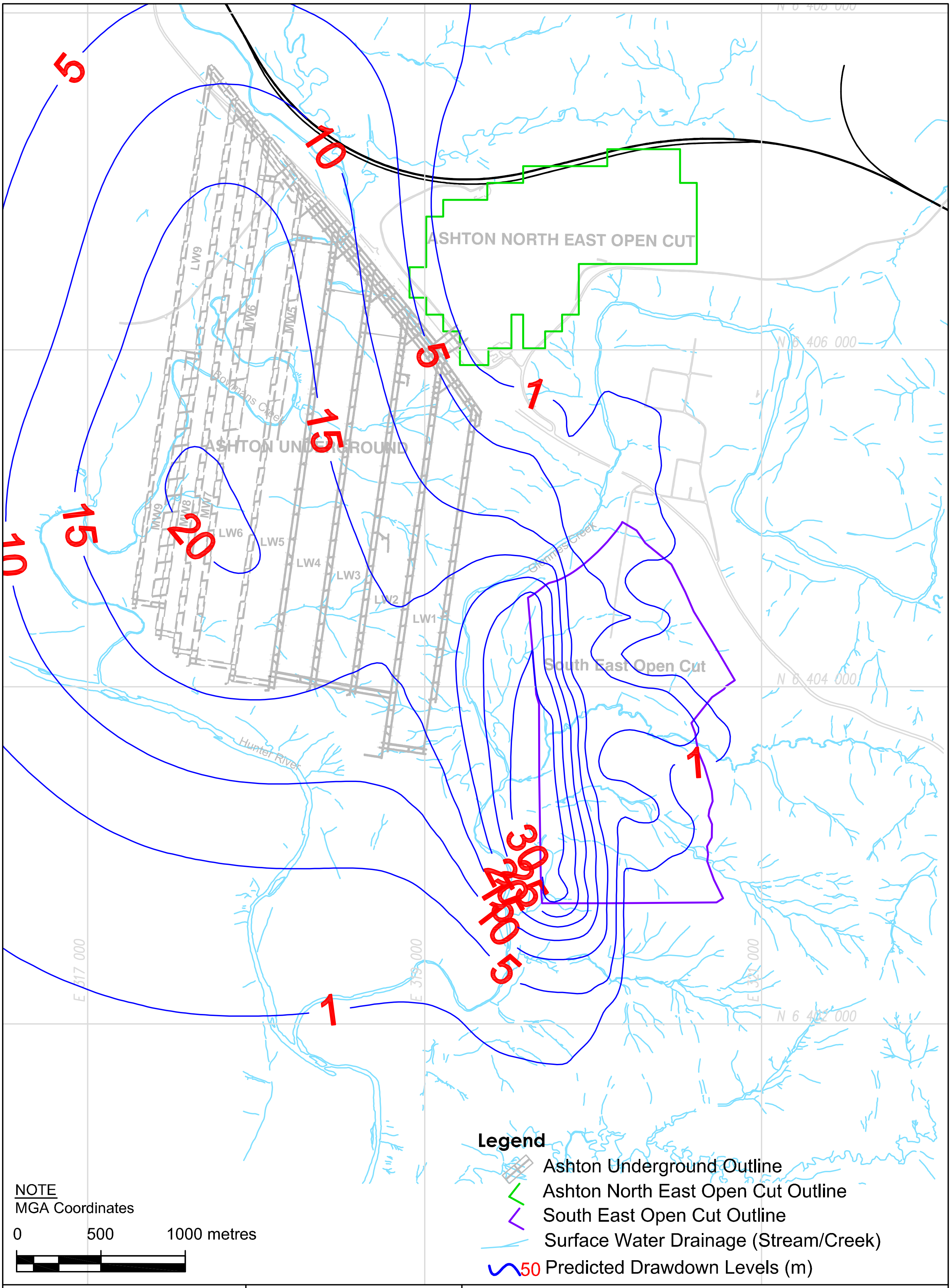
Date: 08 July 2009	Scale: As Show	**Ashton Coal Operations Pty Ltd**
Initials: JVDA	Job No: S36	**Predicted Drawdown Levels in Alluvium After 5 Years Mining**
Drawing No: S36-051a	Rev: B	
aquaterra		**Appendix F**



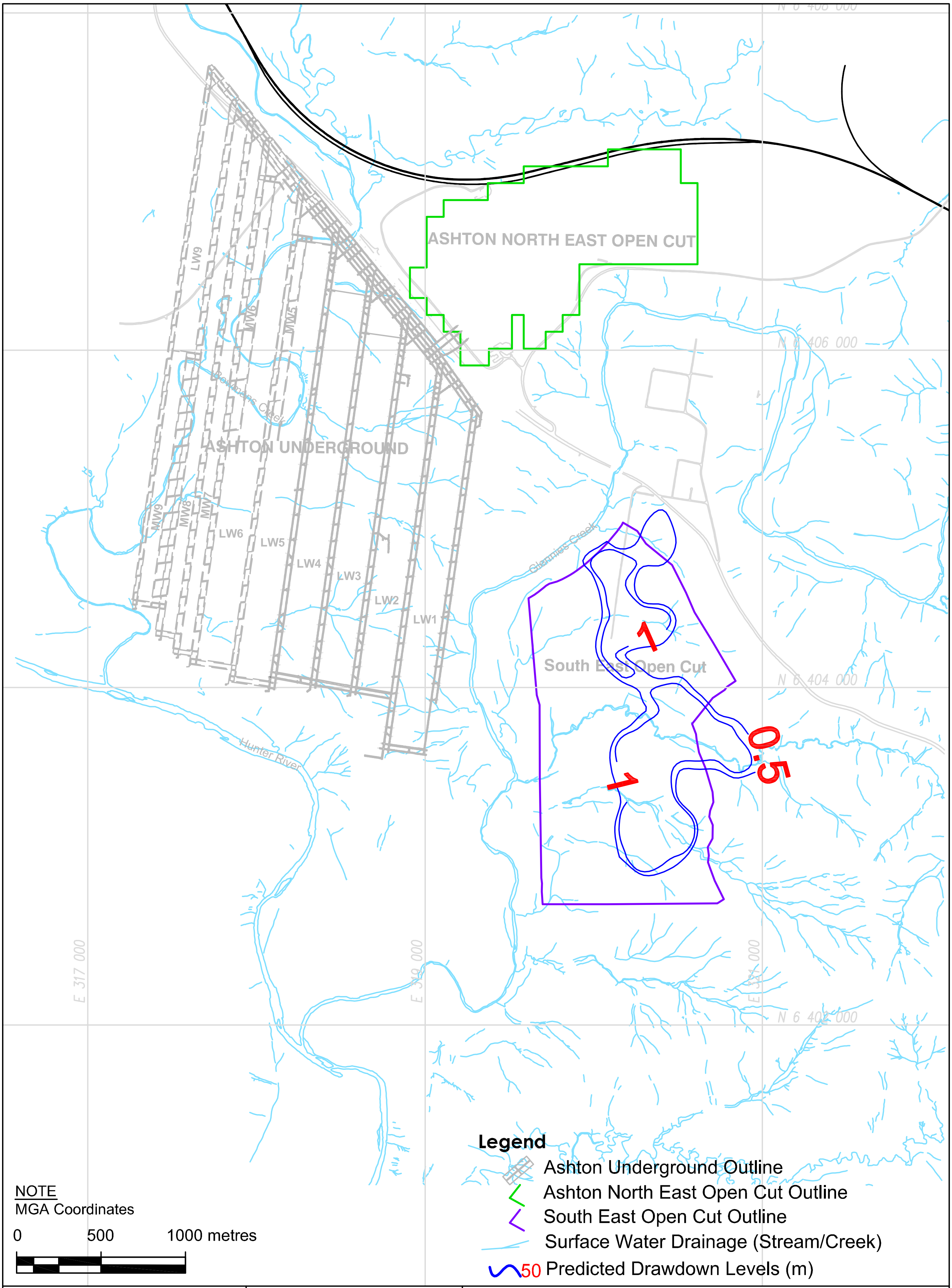
Date: 08 July 2009	Scale: As Show	**Ashton Coal Operations Pty Ltd**
Initials: JVDA	Job No: S36	**Predicted Drawdown Levels in Alluvium After 7 Years Mining**
Drawing No: S36-051	Rev: B	
aquaterra		**Appendix F**



Date:	26 June 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**Predicted Drawdown Levels in Alluvium after 107 Years**
Drawing No:	S36-080a	Rev:	A	
aquaterra				**Appendix F**



Date:	26 June 2009	Scale:	As Shown	**Ashton Coal Operations Ltd**
Initials:	PZ	Job No:	S36	**Predicted Drawdown Levels in Upper Lower Liddell Seam after 7 Years Mining**
Drawing No:	S36-077b	Rev:	B	
aquaterra				**Appendix F**



Date: 26 June 2009

Scale: As Shown

Initials: PZ

Job No: S36

Drawing No: S36-078a

Rev: A

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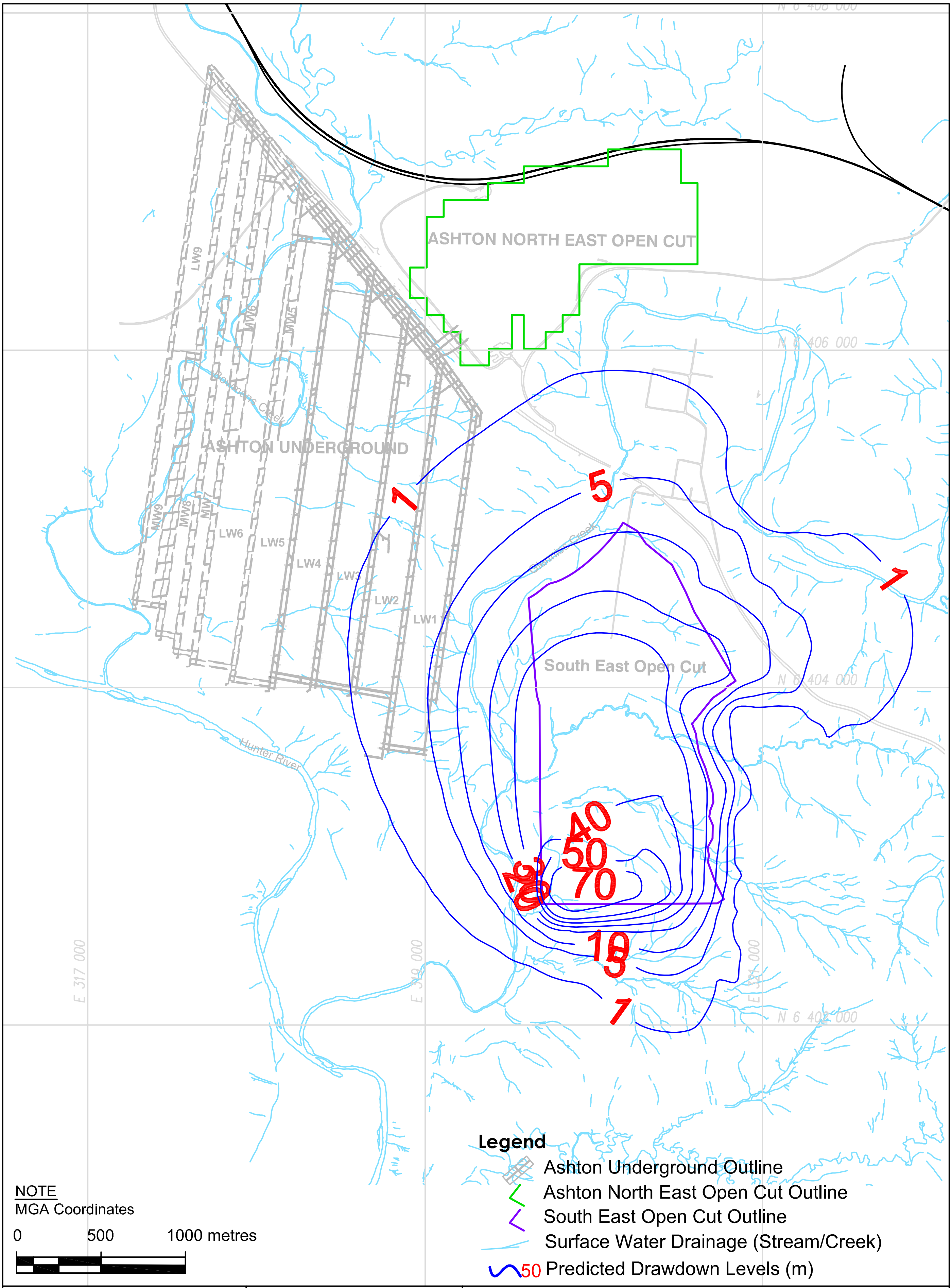
Ashton Coal Operations Ltd

Predicted Drawdown Levels in Upper Lower Liddell Seam after 107 Years

Appendix F



Date: 26 June 2009

Scale: As Shown

Initials: PZ

Job No: S36

Drawing No: S36-079b

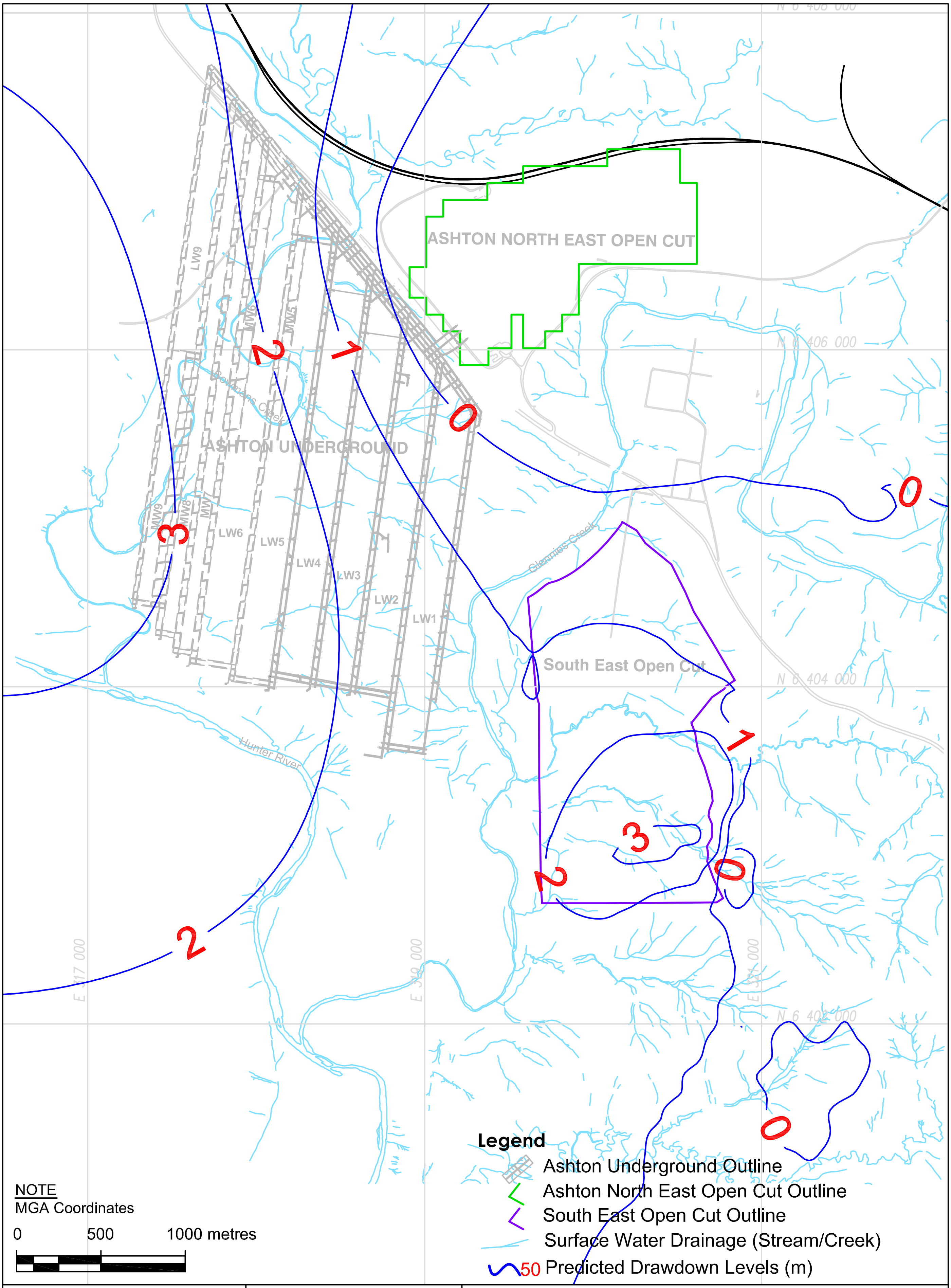
Rev: B

aquaterra

Ashton Coal Operations Ltd

Predicted Drawdown Levels in Upper Hebdon to Lower Hebdon Seam after 7 Years Mining

Appendix F



Date:	28 May 2009	Scale:	As Shown
Initials:	PZ	Job No:	S36
Drawing No:	S36-081	Rev:	0

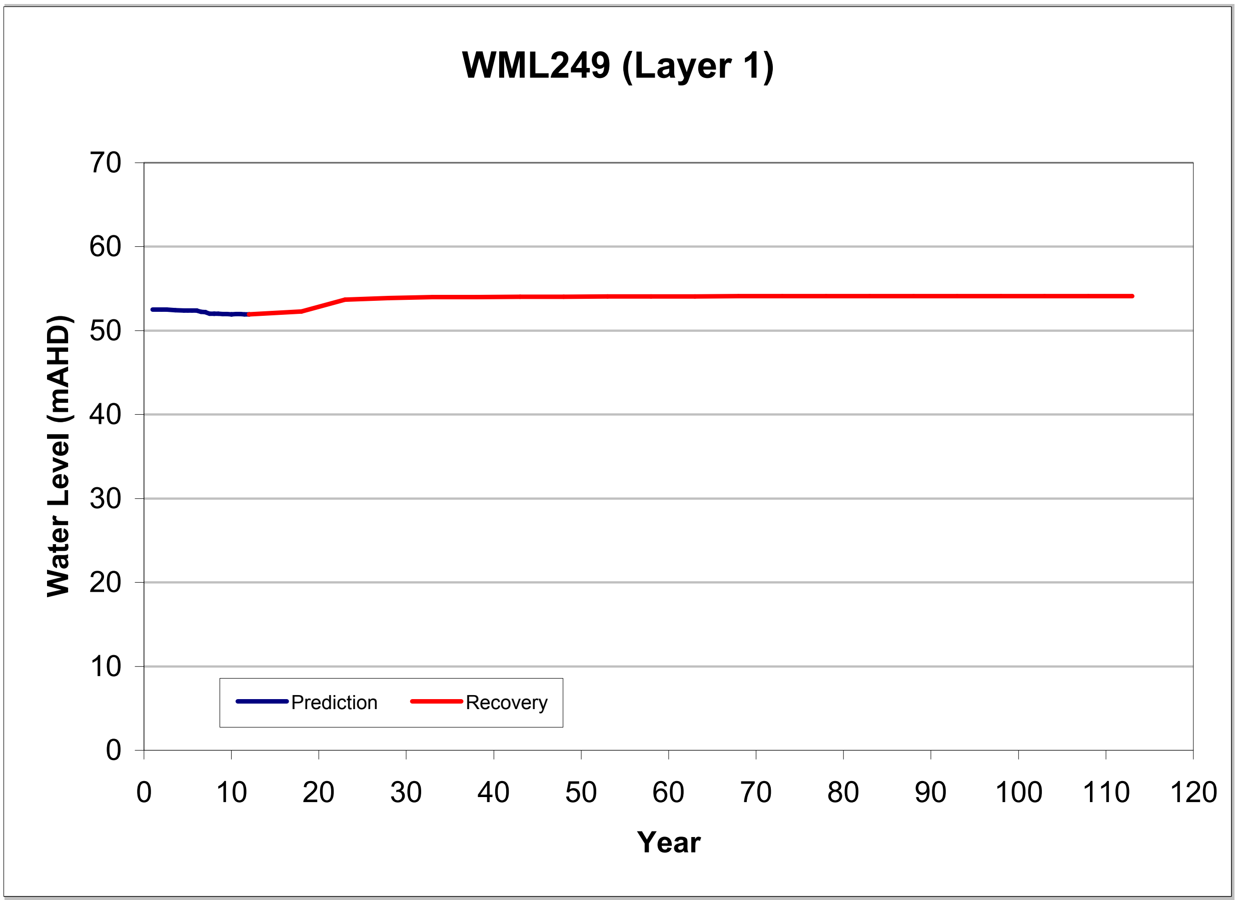
aquaterra

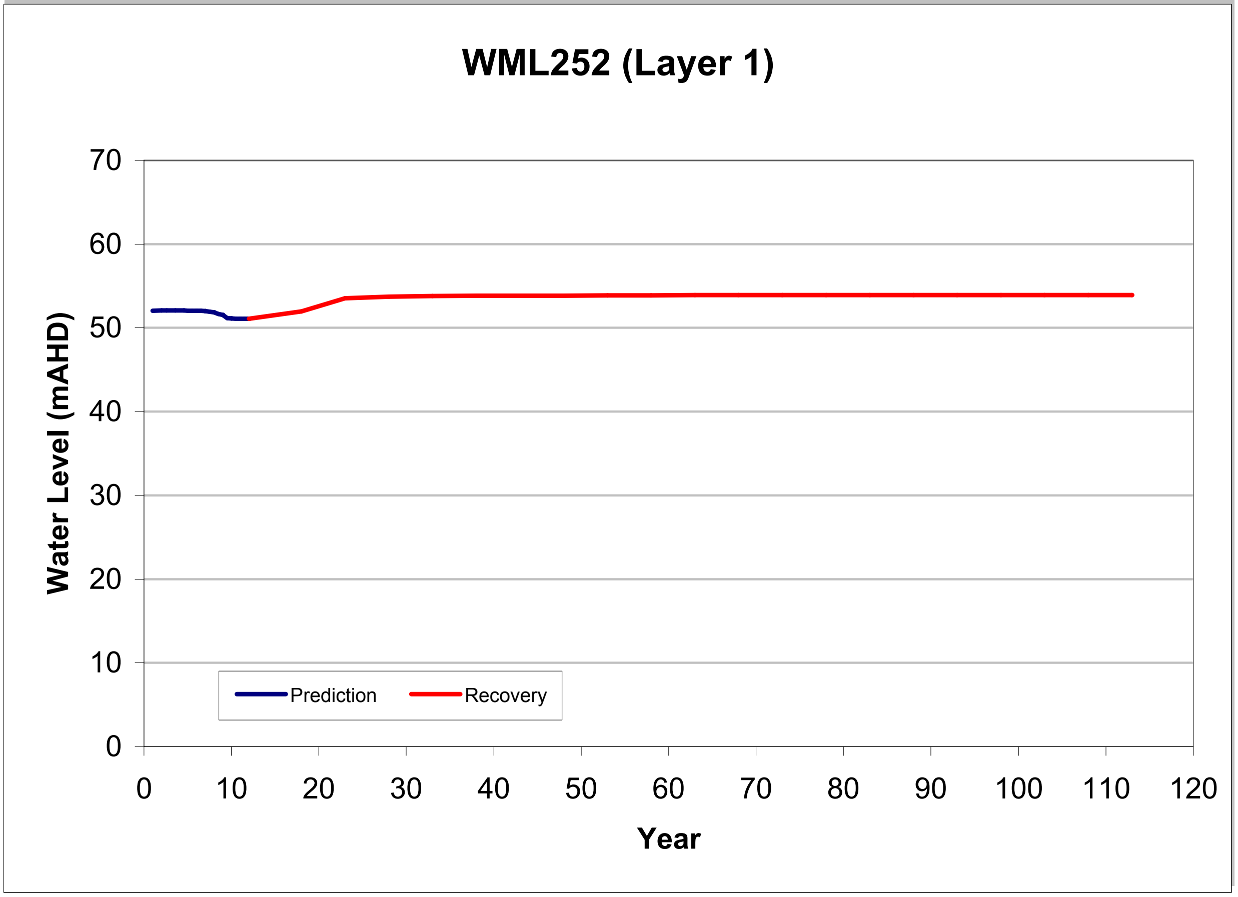
Ashton Coal Operations Ltd

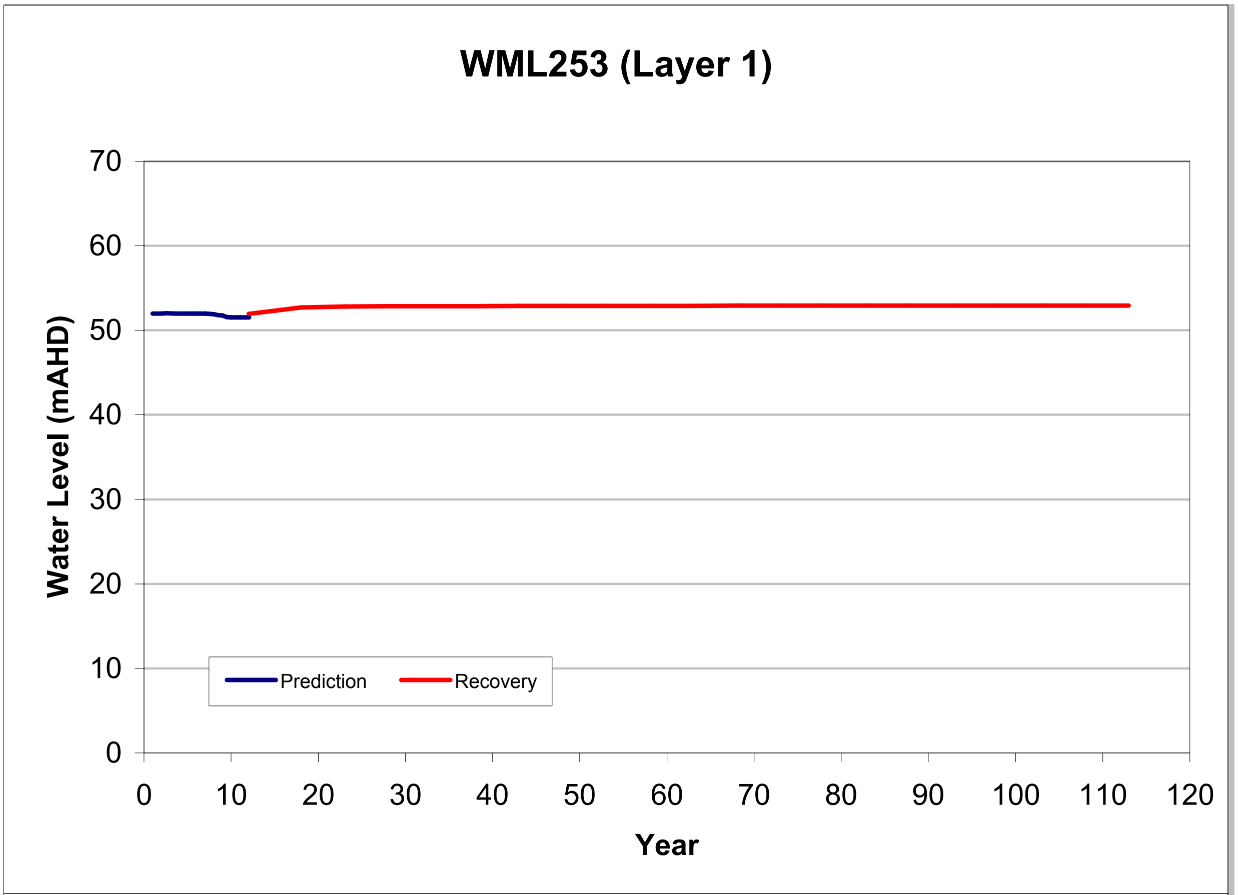
Predicted Drawdown Levels
in Upper Hebdon to Lower Hebdon Seam
after 107 Years

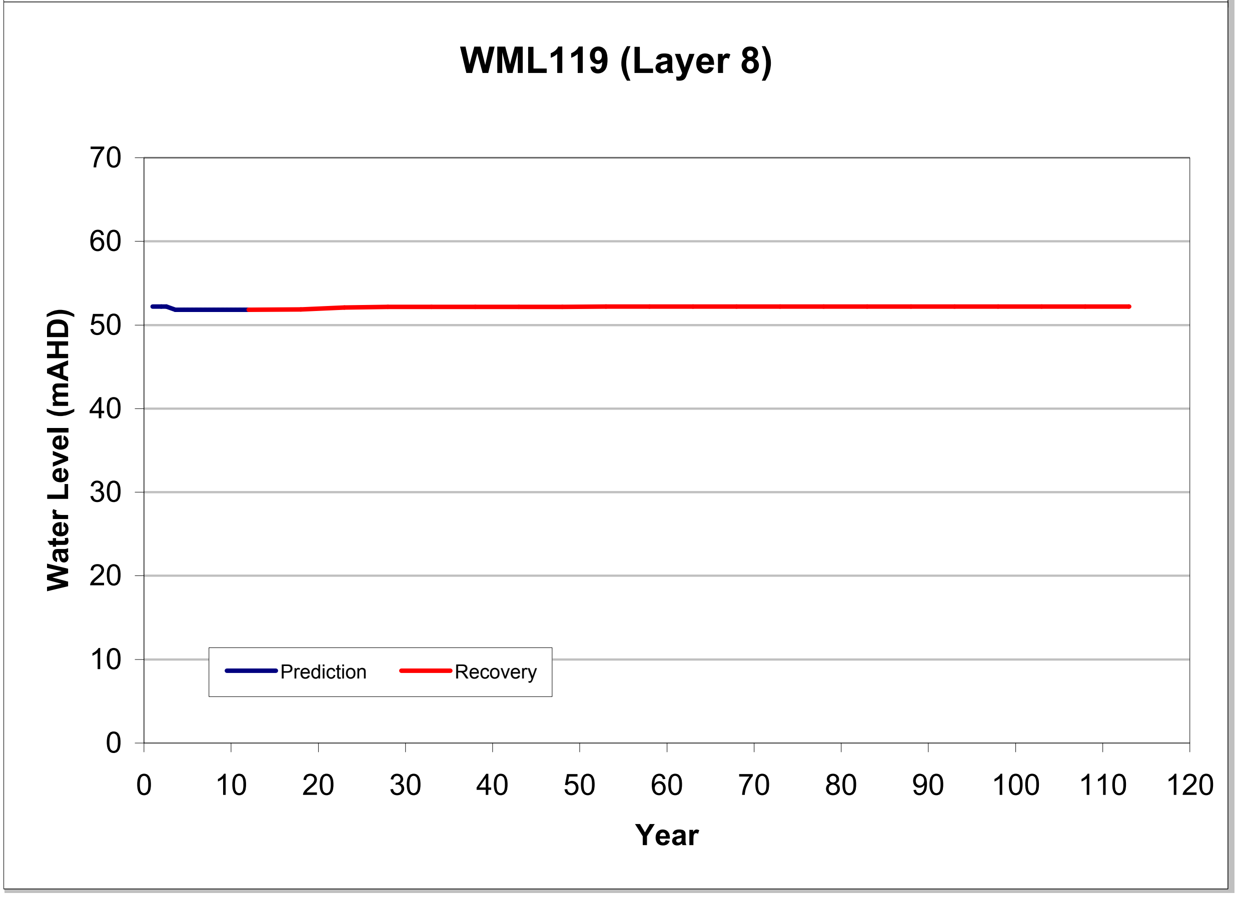
Appendix F

APPENDIX G SEOC MODEL RECOVERY RUN RESULTS


WML249 (Layer 1)
Water Level (mAHD)
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
Year
Prediction
Recovery


WML252 (Layer 1)
Water Level (mAHD)
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
Year
Prediction
Recovery


WML253 (Layer 1)
Water Level (mAHD)
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
Year
Prediction
Recovery


WML119 (Layer 8)
Water Level (mAHD)
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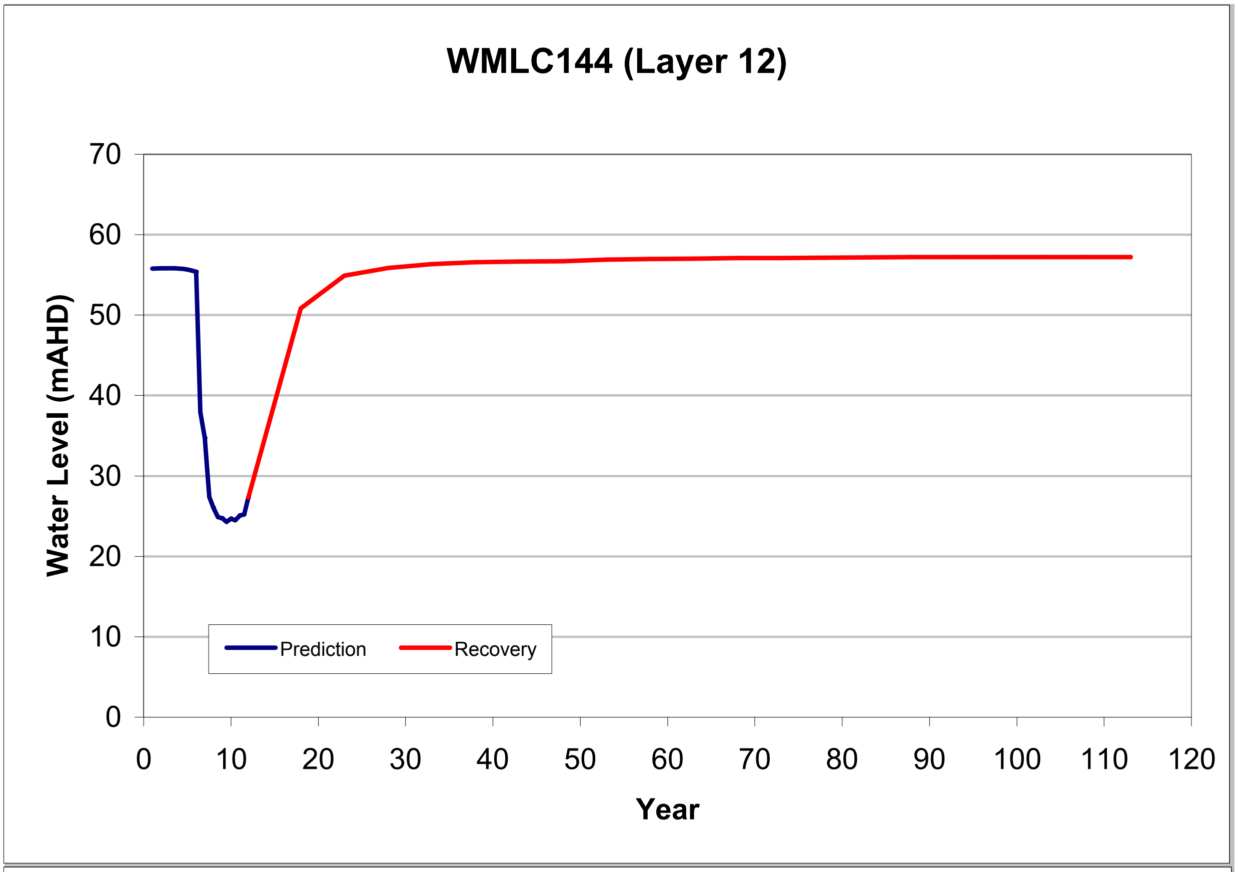
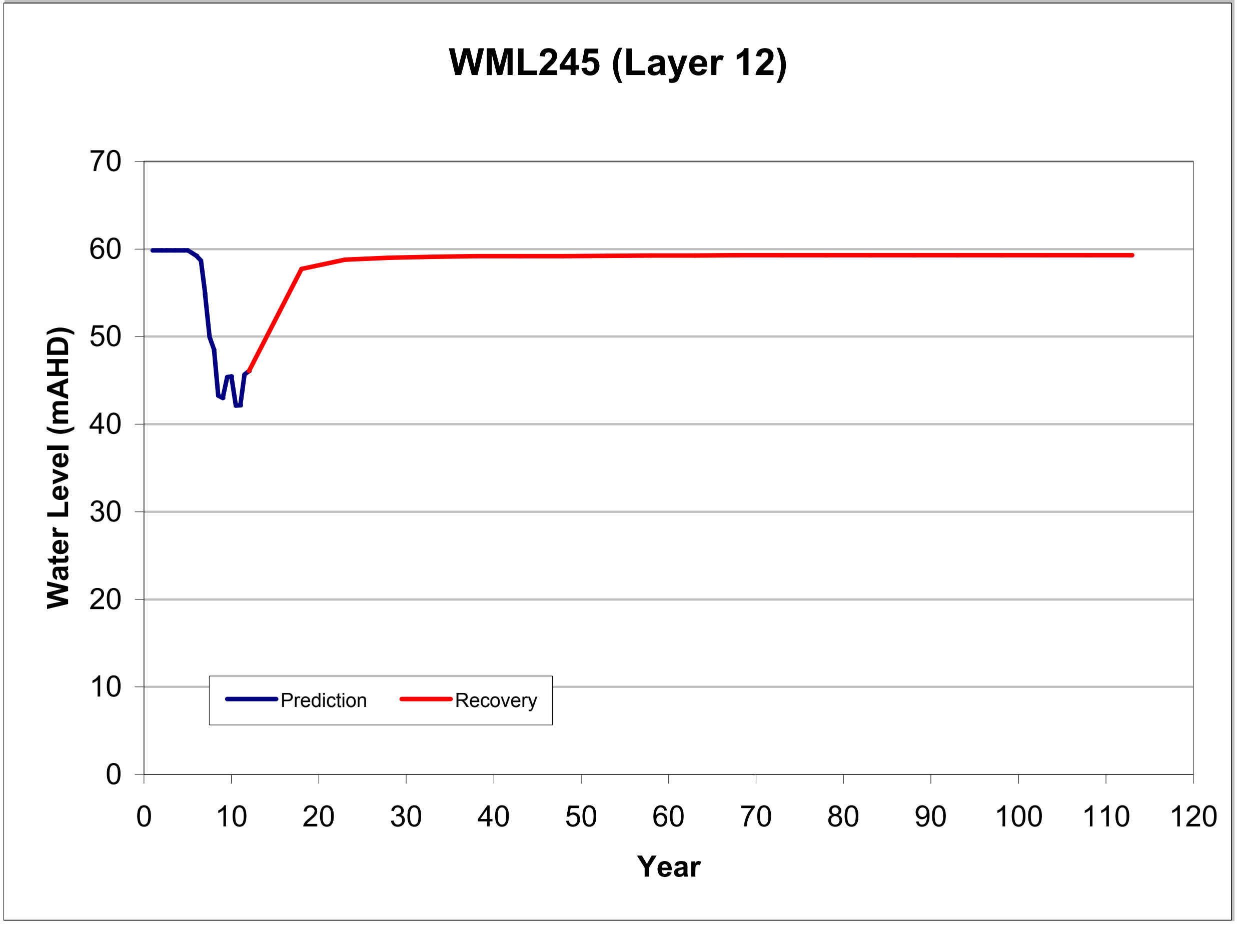
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
Year
Prediction
Recovery


WMLC144 (Layer 12)
Water Level (mAHD)
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
Year
Prediction
Recovery


WML245 (Layer 12)
Water Level (mAHD)
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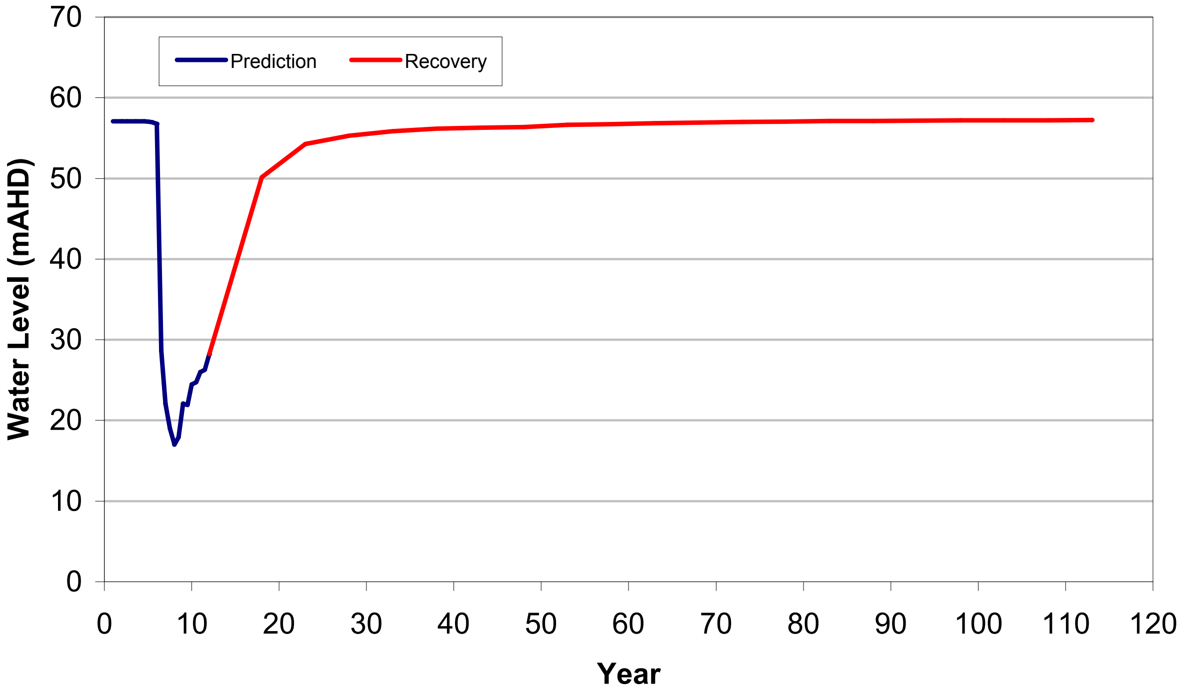
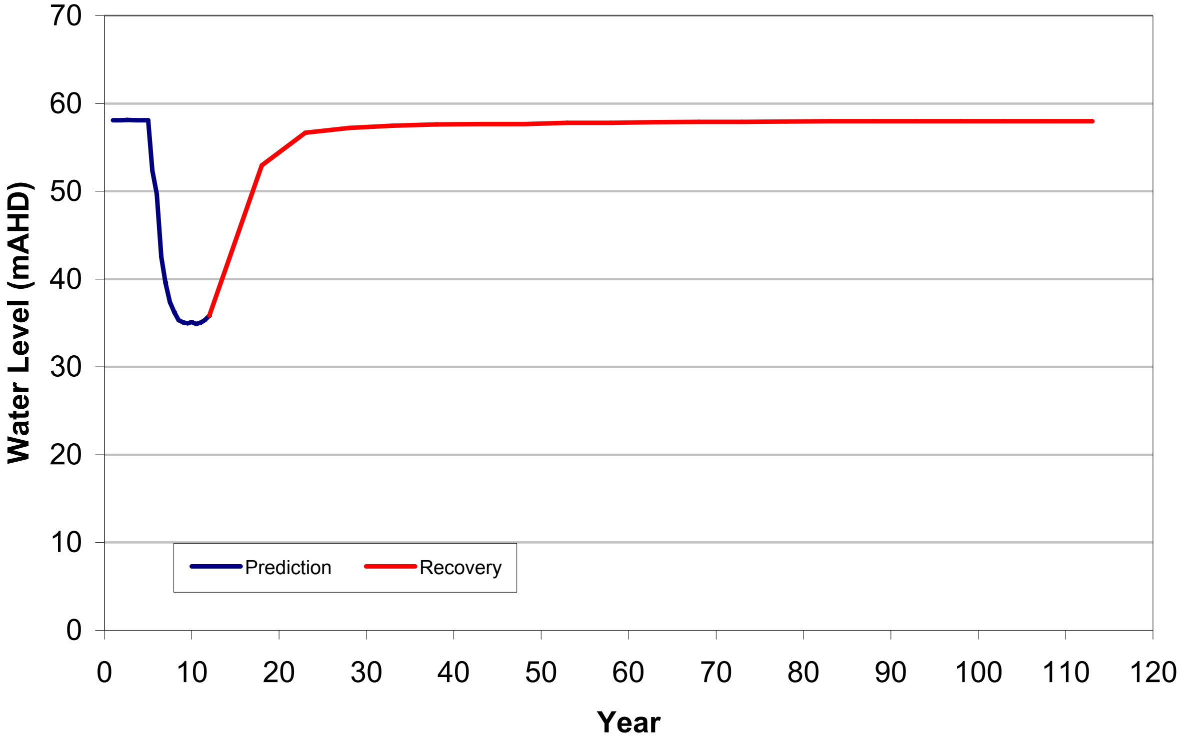
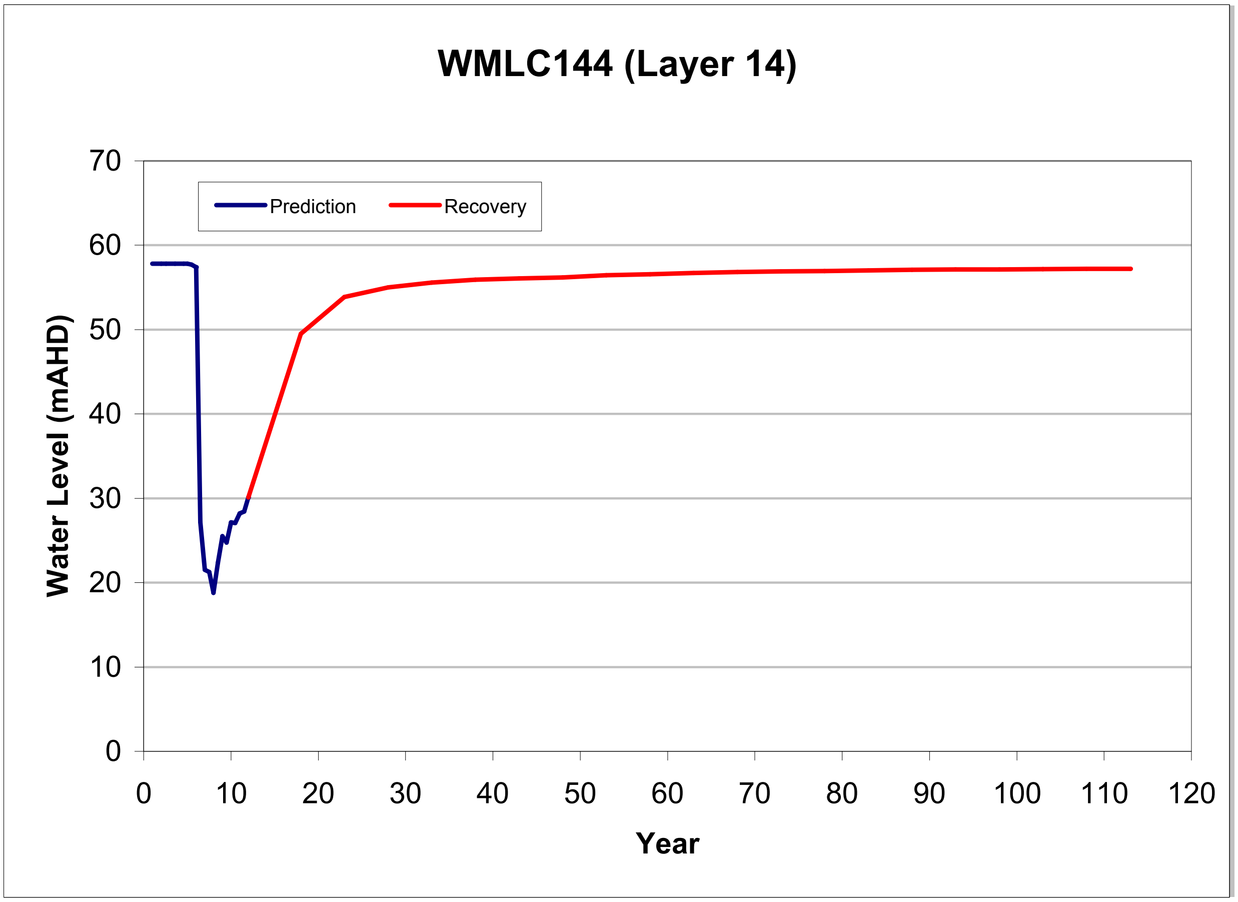
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
Year
Prediction
Recovery

WMLC144 (Layer 13)



WML245 (Layer 13)




WMLC144 (Layer 14)
Prediction
Recovery
Water Level (mAHD)
0
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70
80
90
100
110
120
Year

In Australia

Perth
Suite 4
125 Melville Parade
Como WA 6152
Australia
Tel +61 8 9368 4044
Fax +61 8 9368 4055
perth@aquaterra.com.au

Adelaide
Ground Floor
15 Bentham Street
Adelaide SA 5000
Australia
Tel +61 8 8410 4000
Fax +61 8 8410 6321
adelaide@aquaterra.com.au

Sydney
Suite 9
1051 Pacific Highway
Pymble NSW 2073
Australia
Tel +61 2 9440 2666
Fax +61 2 9449 3193
sydney@aquaterra.com.au

In the UK

Lewes
Cobbe Barns
Beddingham, Lewes
East Sussex BN8 6JU
United Kingdom
Tel +44 1273 858 223
Fax +44 1273 858 229
lewes@aquaterra.uk.com

In Mongolia

Ulaanbaatar
701 San Business Center
7th khoroo
Sukhbaatar district
Ulaanbaatar
Mongolia
Tel +976 95854921
mongolia@aquaterra.mn

aquaterra
Water and Environment