Subsidence Management Plan

# ANNEX D

## Groundwater Assessment

**Ashton Coal**
**Longwall Panels 1 - 4**

Subsidence Management Plan
Written Report

# ASHTON COAL OPERATIONS LIMITED

# ASHTON COAL MINE LONGWALL PANELS 1-4
# SUBSIDENCE MANAGEMENT PLAN
# GROUNDWATER ASSESSMENT

BY

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# EXECUTIVE SUMMARY


Ashton Coal Operations Ltd (ACOL) is proposing to develop a longwall mining project on its Ashton coal project near Camberwell. The initial stage will involve extraction of the Pikes Gully seam from Longwall Panels 1 to 4. A Subsidence Management Plan (SMP) is being prepared for Longwalls 1 to 4. This groundwater assessment report is prepared to support the SMP.

The SMP area is situated on moderately elevated terrain south of New England Highway between Glennies Creek and Bowmans Creek, and is also bounded to the south by the Hunter River. The underground mine is accessed from the Arties open cut which is north of the highway.

No major water courses, and no saturated alluvium, are present within the SMP area.

The Pikes Gully seam has a westerly dip of about 6º, and the overburden cover depth ranges from 35m at the north-eastern corner of the SMP area to about 150m near the south-western corner. The seam subcrops to the east of the SMP area, in part beneath the alluvium associated with Glennies Creek.

Groundwater is present within the Permian coal measures, with flow occurring mainly in the coal seams, including the Pikes Gully seam. Groundwater is also present in alluvium associated with Glennies Creek, Bowmans Creek and Hunter River in areas bordering the SMP area.

Groundwater investigations carried out for the EIS (HLA, 2001) have been supplemented by additional studies for the proposed underground mining. Three piezometers were installed to the east of Longwall 1, to allow testing and monitoring in the region between the proposed workings and Glennies Creek and its alluvium. Pumping tests were carried out to determine aquifer hydraulic properties.

A series of subsidence monitoring bores is also being installed over each proposed longwall panel, comprising multi-level piezometers set at approximately 30m intervals between the surface and the Pikes Gully seam. These will provide baseline data prior to commencement of longwall extraction, and will then be used to monitor any subsidence-related impacts of the underground mining on the groundwater system.

Groundwater in the coal measures is saline, with EC in the 6000 to 11000 µS/cm. Alluvial groundwater is less saline, with EC ranging from less than 500 to around 2000 µS/cm. Surface flow in Glennies Creek and Hunter River also has low salinity with EC below 1000 µS/cm, but the water quality of surface flow in Bowmans Creek is highly variable, ranging from less than 500 to more than 4000 µS/cm, presumably due to baseflow contributions from the catchment upstream of the Ashton area.

Groundwater inflows have been reported to the underground development headings along Longwall 1. Total inflow rate is currently about 8 L/s, and has an EC of 8500 µS/cm.

Hydraulic conductivity of the Pikes Gully seam away from outcrop areas is around 0.02-0.05 m/d, compared with around 1-10 m/d for the alluvium.

Although in physical proximity, there appears to be limited hydraulic interconnection between the alluvium and the coal measures, based on marked differences in observed water quality and groundwater levels. However, because the Pikes Gully seam subcrops beneath the Glennies Creek alluvium, an assessment has been made of the potential for mining impacts on this alluvium. It has been assessed that natural flow rates from the Glennies Creek alluvium to the Longwall 1 workings via undisturbed Pikes Gully seam would be in the order of 170 $m^3$/d (2 L/s).

If there were significant change to the hydraulic conductivity of the Pikes Gully seam, increased flow rates could occur. The region between the workings and the edge of the alluvium is not expected to undergo significant change, as it lies outside the subsidence impact zone. However, a change to flow conditions could possibly arise due to the development of a planar fracture due to lateral subsidence movements, which could lead to an increase in flow. It has been calculated that the increase in flow from the Glennies Creek alluvium to the workings as a result of either a change to the seam permeability or development of a planar fracture, could be in the range 38-290 $m^3$/d (0.4-3.4 L/s), although the upper end of this range is considered unlikely.

No such impact on the Bowmans Creek alluvium on the western side of the SMP area is considered possible, due to the presence of more than 100m of overburden coal measures between the workings and the Bowmans Creek alluvium. This overburden will remain undisturbed by subsidence impacts, as it is situated outside the subsidence impact zone.

It is predicted that maximum mine water inflows to the underground workings from all sources, ie drainage of the coal measures, interception of possible increased flow from Glennies Creek alluvium, and from additional rainfall recharge due to surface and sub-surface cracking, would be around 1450 $m^3$/d (17 L/s).

Groundwater level impacts within the coal measures are expected to be reasonably localised to the immediate Ashton area, based on limited impacts from the existing open cut operations. Groundwater level impacts in the Glennies Creek alluvium are predicted to be less than 0.5 m drawdown close to the Pikes Gully subcrop, but no measurable drawdown at the nearest water supply bores in Camberwell village. No water level impact is predicted for the Bowman Creek alluvium aquifer.

A comprehensive monitoring reporting and management program, including impact response strategy is outlined.

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## TABLES



## FIGURES

# 1 INTRODUCTION

Ashton Coal Operations Ltd (ACOL) is proposing to mine a series of coal seams at the Ashton Coal Mine near Camberwell in the Hunter Valley (**Figure 1**). An open cut mine has been developed on the northern side of New England Highway, and underground mining is proposed for an area to the south of the highway.

A Subsidence Management Plan (SMP) is being prepared for the first stage of underground mining, involving extraction of the Pikes Gully seam in Longwall Panels 1-4 (**Figure 2**). Peter Dundon and Associates Pty Ltd has been commissioned to undertake a groundwater assessment in support of this SMP.

The proposed longwalls are designed to mine final voids 215m wide separated by chain pillars of 25m rib to rib, with cut-throughs at 100m centres.

Access to the underground area is via a portal in the Arties Open Cut on the northern side of New England Highway, and coal access headings beneath the highway (**Figure 2**).

The overburden cover depth of the Pike Gully seam section to be mined ranges from 35m at the out-bye end of Longwall 1 to approximately 150m at the in-bye end of Longwall 4, principally as a result of the westerly seam dip. Over most of the SMP area, the surface topography refects the general dip of the overburden strata to the west, but on the eastern edge of the SMP area the ground surface dips steeply in places down to Glennies Creek.

The coal seam thickness in Longwalls 1 to 4 ranges from 2.7m at the out-bye end of Longwall 1 to 2.4m in Longwalls 3 and 4.

# 2 SITE DESCRIPTION

The Ashton lease area is located on the northern side of Hunter River, broadly between Glennies Creek and Bowmans Creek which are tributaries of the Hunter River. The lease straddles the New England Highway, with the existing Ashton open cut operations located north of the highway, and the proposed underground operations to the south (**Figure 1**).

The SMP area (**Figure 2**) comprises Longwall Panels 1 to 4, which are located on the eastern half of the Underground Mine area.

The surface topography generally dips to the west and is gently undulating over most of the SMP area. Surface elevation varies between about 100 mAHD along the eastern ridge to around 50 mAHD near the southern end of Longwall 4. In the east there are some steeper slopes dipping down to Glennies Creek and in the south down to the alluvial flats adjacent to the Hunter River. Along the western side of the SMP area, the topography flattens towards Bowmans Creek.

The SMP area does not include any major watercourses. Glennies Creek and Bowmans Creek are located outside the SMP area of Longwall Panels 1-4. Glennies Creek flows to the east of Longwall Panel 1, and Bowmans Creek passes just west of the westernmost panel (Panel 4). The setbacks from both Glennies Creek and Bowmans Creek comply with the required setbacks as defined in the DNR's guideline on management of stream/aquifer systems in relation to coal mining developments (DNR, 2005) which requires a buffer zone of 40m from the edge of the predicted angle of draw to the edge of saturated alluvium. The setback to the Hunter River and its alluvials is also in conformance with this guideline.

Although outside of the SMP boundary, the main natural features of the area are the creeks and their associated alluvial flats.

**Glennies Creek**
Glennies Creek is a permanent watercourse with a catchment area of several hundred square kilometres. Glennies Creek Dam is located upstream, so that the flow is partly regulated. Glennies Creek is located outside the SMP area, but approaches within approximately 150 m of the Longwall 1 goaf edge about halfway along the panel (**Figure 2**). The Pikes Gully seam is believed to outcrop or subcrop below the bed of Glennies Creek over the section closest to Longwall 1. The overburden cover depth at the goaf edge is approximately 70 m at the point closest to Glennies Creek.

**Hunter River**
The Hunter River is located to the south of and outside of the SMP area. The closest point of the longwall mining is the start corner of Longwall 3, which is approximately 175 m from the Hunter River, and 130 m from the edge of the Hunter River alluvium. The overburden depth at this point is approximately 115-120 m.

The southern end of Longwall 1 is situated approximately 340 m from Hunter River, and at least 90 m from the edge of Hunter River alluvium. The overburden depth at the southern end of Longwall 1 is approximately 65-75m.

**Bowmans Creek**
Bowmans Creek is located to the west of and outside of the Longwall panels 1 to 4. At its closest point, Longwall 4 comes within approximately 65 m of the top of the bank that defines the edge of Bowmans Creek. The overburden depth at this point is approximately 95 m. There is no saturated alluvium between Bowmans Creek and Longwall 4 in this area.

Bowmans Creek comprises a river channel that is incised some 2-5 m below the surrounding topography. The water channel comprises a series of ponds retained behind rock bars or pebble bars that are often vegetated. The elevated alluvial flats adjacent to Bowmans Creek extend close to Longwall 4 near its southern end, but drilling has revealed that the edge of saturated alluvium is located outside the required buffer zone along the western side of Longwall 4.

There is a minor ephemeral tributary of Bowmans Creek situated above the northern part of the SMP area, but it has no associated alluvium.

# 3 GROUNDWATER STUDIES

## 3.1 EIS STUDIES

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 open cut operations north of the New England Highway and the proposed underground operations south of the highway.

Relevant results of the groundwater investigations carried out for the EIS are summarised in **Annexures A** to **E**[1]. Locations of relevant investigation bores and sampling locations close to the SMP area are shown on **Figure 2**. The EIS investigations included:

- **Drilling (see Annexure A)**
    - Open hole investigation bores RA01 to RA03.
    - Bowmans Creek alluvium groundwater investigation/monitoring bores RM01 to RM10.
    - Test production bores PB1 and PB2 for determining hydraulic properties of Bowmans Creek alluvium.
    - 38 shallow hand auger soil investigation holes.
    - Piezometers WML19a, WML20, WML21 and WML22 were drilled in 2001, completed with screens at the Pikes Gully seam.
    - Regional monitoring bores G1 to G5 were drilled and completed as piezometers in 2003 to meet specific consent conditions in the development approval for the Ashton project.

- **Hydraulic Testing (see Annexure C)**
    - 3 hour pumping tests carried out on test bores PB1 and PB2.
    - Review of permeability test results for coal measures and alluvium from nearby projects.

- **Water Quality Sampling (see Annexures D and E)**
    - Water samples were collected from all the monitoring and test bores, as well as the existing bore RSGM1 and Ashton Well, and subjected to detailed laboratory analysis.
    - Surface water samples were also collected from Bowmans Creek and Glennies Creek for detailed lab analysis.

- **Groundwater Flow Modelling**
    - A three-dimensional groundwater flow model was set up, comprising 7 layers (only layers 1 to 3 are relevant to this SMP), and with a combination of natural boundary conditions (rivers and streams at Bowmans Creek, Glennies Creek and Hunter River), and mining induced boundaries at the nearby coal mines.
    - The model was calibrated against measured water levels in three bores, WML119a, WML120 and WML121.

[1] Note – Annexures A to E also include data gathered subsequent to EIS.

- o The model was used to simulate the proposed mining developments and to assess the potential mine water inflows, impacts on local and regional groundwater levels, drainage losses from the Bowmans Creek, Glennies Creek and Hunter River alluvium, and water quality impacts.
- o Sensitivity modelling was carried out to assess the potential impact of errors in the assumed hydraulic property values.

The results of the EIS studies are reported in detail in the EIS (HLA, 2001), and are drawn upon where relevant in this document.

## 3.2 BASELINE MONITORING

A baseline monitoring program that commenced during the EIS studies has continued through to the present time, and is ongoing. The groundwater component comprises discharge volumes (dewatering from open cut), groundwater levels in monitoring bores, and periodic sampling from monitoring bores for laboratory analysis of water quality.

The results of the ongoing monitoring are presented in the Annual Environmental Management Reports (ACOL, 2005 and 2006). All groundwater quality analysis results are presented in **Annexure D**, and plots of groundwater level fluctuation are presented as hydrographs in **Annexure F**.

The relevant outcomes from the baseline monitoring program relating to the SMP area are summarised in the following sections.

### 3.2.1 Groundwater Inflows / Discharges

Groundwater inflows to the underground workings were first observed in the Longwall 1 development headings, about 450m from the northern end on the eastern gateroad (**Figure 3**). Inflows are currently occurring to both the eastern and western gateroads along Longwall 1, and from the north-west headings (**Figure 3**). Water is pumped from the headings to a dam in the Arties Pit, north of the highway (**Figure 3**).

On 4 October 2006, the rate of groundwater discharge from the underground workings was estimated at 8-10 L/s (700-850 $m^3$/d). Most water is derived from the eastern gateroads (5-6 L/s), with smaller volumes from the western gateroads (2-3 L/s) and the north-west mains (1-2 L/s). It is possible that up to about 1 L/s of the total could be water introduced into the workings as water supply. Further, some of the water being pumped from the north-west mains is possibly derived via seepage through the Pikes Gully seam from the dam in Arties Pit. However, allowing for these increments, it is considered confidently that the total groundwater inflow rate to the underground workings would currently be at least 8 L/s.

The water discharged from the workings to the dam in Arties Pit is saline, with the following properties measured on 5 September 2006:

- pH 8.27
- Electrical conductivity (EC) 8530 µS/cm.

Salinities of specific inflows underground vary between about 3000 µS/cm to about 13000 µS/cm EC. The low salinity in this range applies to water discharging from a point on the eastern rib between cut-throughs 10 and 11, ie close to bores WML120A and WML120B. The highest salinity applies to water from a drill-hole which extends about 8m into the roof of the eastern gateroad, near 10 cut-through.

### 3.2.2 Groundwater Levels

Bore water levels have been monitored on a quarterly basis, in accordance with the Groundwater Management Plan (ACOL, 2006). Apart from the bores that were in place at the time of the EIS studies, several regional monitoring bores installed subsequently to comply with consent conditions have been added to the baseline monitoring network.

The groundwater level monitoring data are presented as hydrographs in **Figures F-1** and **F-2** (in **Annexure F**). They cover a six-year period, with intensive quarterly monitoring data available for the three-year period 2003-2006.

Groundwater levels in OC1 and OC2 (**Figure 1**) both showed sharp drawdown (**Figure F-1**) in response to dewatering associated with the Ashton Open Cut, prior to the loss of these two bores to mining activities. Bore G3B located in Camberwell Village south of the open cut (**Figure 1**) and screened in the Upper Barrett Seam, has also shown a steady decline in water level of over 5 m during the 3-year monitoring period (**Figure F-1**). Bores G1 (screened in the Upper Liddell seam and located north of the SMP area between the open cut and Bettys Creek) and G2 (screened in the Lower Barrett seam and located next to Bowmans Creek upstream of the SMP area), have both shown smaller drawdowns of 1-2 m over the 3-year period, that may have been related to the open cut dewatering.

The water level in G3A, screened in Glennies Creek alluvium, fell below the base of the bore between August 2004 and May 2005, probably due to the below average rainfall conditions during that period. The water level decline in G3A is believed to be unrelated to the open cut dewatering, as the water level has again risen above the bottom of the bore in May 2006 (**Figure F-1**).

RM02, screened in both Bowmans Creek alluvium and the top of the underlying Permian, and located just west of Longwall 4 (**Figure 2**), has shown the apparent response to a recharge event in January or February 2006 (**Figure F-2**).

No other monitoring bore has shown any significant change in water level.

### 3.2.3 Groundwater Quality

Water samples collected from selected monitoring bores are tested for pH, electrical conductivity (EC), total dissolved solids (TDS), suspended solids (TSS) and alkalinity as $CaCO_3$ on a quarterly basis. The baseline water quality data are presented in **Table D-1** (**Annexure D**).

The baseline water quality data relevant to the SMP area is summarised in **Table 3.1**.

**Table 3.1: Baseline Groundwater Quality Data Summary – 2000 to 2006**

| Aquifer Screened | Piezometers | pH | Electrical Conductivity (µS/cm) | |
|---|---|---|---|---|
| | | Range | Mean | Range |
| Bowmans Creek Alluvium | Ashton Well, RM04, RM08, RM09, RM10, PB1, PB2 | 6.53 - 8.18 | 1400 | 722 - 1570 |
| Glennies Creek Alluvium | WML120B | 7.05 | 1930 | 1930 |
| Pikes Gully Seam | WML20, WML21, WML119, WML120A, LW1 headings | 8.19 - 8.27 | 7640 | 6240 - 8530 |
| Other Permian Coal Measures | RSGM1, RM05, G1, G2, G3A, OC1, OC2 | 6.80 - 8.48 | 6670 | 4060 - 11000 |

### 3.2.4 Surface Water Quality

Surface water quality for Bowmans Creek and Glennies Creek has been monitored monthly for pH, EC and TSS. The results are presented in **Annexure E**, and summarised in **Table 3.2**.

**Table 3.2: Baseline Surface Water Quality Data Summary – 2000 to 2006**

| Water Source | Stations | pH | Electrical Conductivity (µS/cm) | |
|---|---|---|---|---|
| | | Range | Mean | Range |
| Bowmans Creek | SM3, SM4, SM5, SM6 | 7.26 – 8.46 | 1572 | 478 – 4510 |
| Glennies Creek | SM7, SM8, SM11 | 7.20 – 8.45 | 336 | 241 – 512 |
| Hunter River | SM9, SM10, SM12, SM13 | 7.62 – 8.52 | 636 | 350 - 950 |

## 3.3 SMP INVESTIGATIONS

Further investigations have been undertaken during 2006 to provide additional information in support of the proposed underground mining, and specifically in support of the SMP for Longwalls 1 to 4.

### 3.3.1 Piezometer Installation

The existing network of piezometers is currently being expanded to meet the monitoring requirements detailed in the consent conditions for the project. The additional piezometers required include the following:

- Expansion of the regional piezometer network to monitor potential impacts on the alluvium associated with Glennies Creek, Bowmans Creek and Hunter River.
- Subsidence monitoring bores WML106 to WML115 (**Figure 2**) – multi-level piezometers located above the proposed longwall panels.

- Replacement of some of the existing alluvium monitoring bores in the Bowmans Creek alluvium that were over-drilled, by pairs of adjacent piezometers completed separately into either the alluvium and the upper section of the underlying coal measures.

This program is currently in progress. Piezometers installed to date include:

- WML119 – located adjacent to Glennies Creek close to the eastern side of Longwall 1, screened in the Pikes Gully seam (investigation for Longwall 1-4 SMP).
- WML120A and WML120B – located adjacent to Glennies Creek close to the eastern side of Longwall 1, with the shallow bore screened in the alluvium and the deep bore screened in the Pikes Gully seam (investigation for Longwall 1-4 SMP).
- Subsidence monitoring bores WML107A, WML108A and B, WML109B, WML110B and C, WML111B, WML112B, WML113B and WML114B have been completed. At other sites, the bores have been drilled to the required depth, but casing and/or the installation of piezometers has not yet been completed (see **Section 3.3.2**).

The locations of the above bores are shown on **Figure 2**. Bore logs for the completed piezometers are presented in **Annexure B**.

Additional piezometers are proposed for the Hunter River alluvium at the southern end of the longwall panels and further alluvium bores on the eastern side of Glennies Creek (**Figure 2**) to comply with specific EIS commitments.

### 3.3.2 Subsidence Monitoring Bores

Subsidence monitoring bores are in progress at ten (10) locations (WML106 to WML115 on **Figure 2**). There is one bore at WML106, and a pair of shallow and deep bores at the other nine sites. All holes have been drilled, and installations of piezometers commenced during September 2006. As at 26 September 2006, four deep bores and nine shallow bores have been constructed. All monitoring bores proposed for Longwall Panels 1 to 4 have been installed and monitoring commenced.

Relevant construction details of the subsidence monitoring bores in progress listed in **Table 3.3**. Bore logs for the completed bores and those under construction are presented in **Annexure B**.

The shallow bore at each site has been or will be completed as a standpipe piezometer, screened in the shallowest aquifer encountered (alluvium at the sites close to Bowmans Creek and uppermost coal measures groundwater at the others). Annular bentonite and cement grout seals are to be installed to isolate the piezometers to the specific zone of interest in each case.

The deeper bore at each site has been or will be equipped with a series of vibrating wire piezometers – at approximately 30m intervals from the surface to about 50m above the top of the Pikes Gully seam – and fully-grouted in the hole.

The standpipe piezometers will be able to be used for sampling and hydraulic testing purposes as well as water level monitoring. The vibrating wire piezometers will be able to be used for groundwater level (pressure) monitoring.

**Table 3.3: Subsidence Monitoring Bores**

| Bore No | RL (mAHD) | Total Depth (m) | Base of Alluvium (m) | Base of Weathering (m) | Depth Water Intersected (m) | Piezometer Depths (m) | Water Level (Aug-Sep 2006) | | Date Completed |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | (m) | (mAHD) | |
| __WML106__ | __83.07__ | __88.0__ | __8.0__ | __11.0__ | __84__ | __38, 68, 84 *__ | __25.5__ | __57.6__ | __21 Sept 2006__ |
| __WML107A__ | __95.53__ | __120.45__ | __2.5__ | __14.0__ | __38__ | __38, 69, 98 *__ | __31.8__ | __63.7__ | __12 Sept 2006__ |
| __WML107B__ | __95.44__ | __48.0__ | __2.0__ | __14.0__ | __38__ | __22-25__ | __31.7__ | __63.7__ | __21 Sept 2006__ |
| __WML108A__ | __81.62__ | __80.0__ | __4.0__ | __-__ | __23__ | __53, 80 *__ | __20.7__ | __60.9__ | __13 Sept 2006__ |
| __WML108B__ | __81.38__ | __30.0__ | __2.0__ | __22.0__ | __23__ | __19-25__ | __20.9__ | __60.8__ | __3 Sept 2006__ |
| __WML109A__ | __72.58__ | __84.5__ | __4.0__ | __11.0__ | __-__ | __38, 65, 84.5 *__ | __5.9__ | __66.7__ | __23 Sept 2006__ |
| __WML109B__ | __72.63__ | __32.0__ | __1.0__ | __15.5__ | __-__ | __18-21, 28-31__ | __16.3__ | __56.6__ | __4 Sept 2006__ |
| _WML110A_ | _63.71_ | _110.0_ | _17.0_ | _-_ | _18.5_ | _? *_ | _13.4_ | _50.3_ | _04 May 2006_ |
| __WML110B__ | __63.74__ | __24.0__ | __17.0__ | __-__ | __18.5__ | __18-24__ | __13.5__ | __50.5__ | __5 Sept 2006__ |
| __WML110C__ | | __13.5__ | __15.0__ | __-__ | __?__ | __11-14__ | __13.5__ | __50.2__ | __5 Sept 2006__ |
| _WML111A_ | _58.20_ | _120.0_ | _8.5_ | _-_ | _14_ | _24, 54, 90, 118 *_ | _6.7_ | _51.5_ | _09 May 2006_ |
| __WML111B__ | __58.33__ | __18.0__ | __8.0__ | __-__ | __14__ | __12-18__ | __8.2__ | __50.6__ | __13 Sept 2006__ |
| _WML112A_ | _59.44_ | _285.5_ | _12.0_ | _12.0_ | _?_ | _50, 78, 107, 136 *_ | _Flowing_ | _59.4 +_ | _6 July 2006_ |
| __WML112B__ | __59.42__ | __36.0__ | __12.0__ | __12.0__ | __16__ | __16-19, 22-25__ | __9.7__ | __50.0__ | __13 Sept 2006__ |
| _WML112C_ | | _12.0_ | _12.0_ | _12.0_ | _?_ | _9-12_ | | | |
| _WML113A_ | _60.20_ | _140.0_ | _11.8_ | _-_ | _16, 25_ | _40, 65, 95, 124 *_ | _10.2_ | _50.0_ | _12 May 2006_ |
| __WML113B__ | __60.20__ | __20.0__ | __-__ | __-__ | __-__ | __15-18__ | __10.5__ | __50.0__ | __13 Sept 2006__ |
| _WML113C_ | | | | | | | | | |
| _WML114A_ | _71.53_ | _110.0_ | _3.0_ | _8.0_ | _-_ | _63, 88, 108 *_ | _10.5_ | _61.0_ | _16 May 2006_ |
| __WML114B__ | __71.47__ | __30.0__ | __2.5__ | __9.0__ | __-__ | __13-16, 27-30__ | __13.4__ | __58.3__ | __13 Sept 2006__ |
| _WML115A_ | _66.59_ | _178.4_ | _6.0_ | _?_ | _?_ | _40, 72, 93, 120, 144 *_ | _6.3_ | _60.3_ | |
| _WML115B_ | _66.35_ | _40.0_ | _6.0_ | _?_ | _?_ | _?_ | _6.0_ | _60.3_ | |

**Bold = installation completed.**
*Italics = bores drilled, but casing/piezometers not yet installed (water levels measured in open hole).*
* vibrating wire piezometers

## 3.3.3 Alluvium Delineation

### Glennies Creek

Groundwater bores WML119, WML120A and WML120B (**Figure 2**) have been installed adjacent to Glennies Creek, to assess and monitor for potential impacts on saturated alluvium along the creek alignment nearest to the longwall panel 1. Construction details are presented in **Annexure B**.

### Bowmans Creek

Bowmans Creek is located on the western side of the proposed underground mining area and will not be affected by Longwall Panels 1 to 4. An investigation drilling program was carried as part of the EIS studies, and established the edge of the alluvium as shown on **Figure 2**. Based on this line, it was considered possible that the alluvium may encroach across the proposed western edge of Longwall 4.

A further program has been initiated to better define the location of the edge of saturated alluvium in two areas – the first between 200 and 600 m from the southern end of Longwall 4, and the second around the oxbow where Bowmans Creek comes closest to Longwall 4, approximately 500-800 m from the northern end of the panel (**Figure 2**).

Bores RM1 and RM2 from the 2001 alluvium investigation program are located near the zone of possible encroachment by Longwall 4 beneath the alluvium. Bores WML110B and WML110C recently completed as shallow subsidence bores are also in this vicinity. The reported water levels in RM1 and RM2 show the alluvium in this area to be unsaturated, at least across to the line shown on **Figure 2**. The recent drilling of WML110A (not yet completed) and WML110B support this interpretation, as both holes encountered no water during drilling until 18.5 m, below the base of the alluvium.

A surface geological mapping and scout drilling program was initiated to verify the location of the edge of saturated alluvium close to the Bowmans Creek oxbow, near the central part of Longwall 4. One hole was drilled approximately 40 m east of the creek (shown as "Oxbow" on **Figure 2**), and encountered the top of coal measures sediments at a depth of 1 m, approximately 5 m above the creek bed level and above the water table in this area. Geological reconnaissance mapping revealed outcrops of coal measures sediments along the toe of the eastern bank of Bowmans Creek around the oxbow. This work confirmed that the edge of alluvium in this area is at least 70 m west of Longwall 4.

Further alluvium delineation scout drilling is proposed for the eastern side of Bowmans Creek north and south of the oxbow. This work will not have a bearing on Longwalls 1 to 4, but it is intended to assist with planning for future Longwalls 5 to 8.

#### ***Hunter River***

The edge of Hunter River alluvium as reported by HLA (2001) is indicated on **Figure 2**. This alignment was based on a combination of surface mapping and soil test pits.

On the basis of this assessment, all longwall panels are located at least 90 m from the edge of the Hunter River alluvium.

The alluvium is expected to be unsaturated for some distance from the edge of mapped alluvium. To improve delineation, a series of drillhole transects is proposed to be drilled along the southern ends of Longwalls 5 to 8 to more accurately delineate the edge of saturated Hunter River alluvium. This drilling will aim to determine the depth of alluvium and the elevation of the water table.

#### ***Soils Geotechnical Drilling***

A soils investigation drilling program is proposed, to establish geotechnical characteristics of the basal section of the Bowmans Creek alluvium at a number of locations. This program has no bearing on Longwalls 1 to 4, but is to be carried out to assist with planning for the proposed Longwall panels 5 to 8.

### 3.3.4 Hydraulic Testing

Pumping tests have been carried out on the new piezometers near Glennies Creek on the eastern side of Longwall 1 (WML119, WML120A and WML120B), and on existing Pikes Gully seam monitoring bores WML20 and WML21 (**Figure 2**).

The pumping test results are presented in **Annexure C** (**Figures C-1** to **C-5**). The hydraulic conductivity values determined from the tests are detailed in **Table 3.4**.

**Table 3.4: Hydraulic Testing Program – Coal Measures and Alluvium**

| Bore | Type of Test | Date | Test Rate | Test Interval | Hydraulic Conductivity | | Comments |
|---|---|---|---|---|---|---|---|
| | | | kL/d | m | m/d | m/s | |
| ***Pikes Gully Seam:*** | | | | | | | |
| WML20 | Pumping | 1 Sept 2006 | 6 | 114-118 | 0.04 | $4 \times 10^{-7}$ | |
| WML20 | Slug | 1 Sept 2006 | - | 114-118 | 0.015 | $2 \times 10^{-7}$ | |
| WML21 | Pumping | 1 Sept 2006 | 7.5 | 106-112 | 0.02 | $2 \times 10^{-7}$ | |
| WML119 | Pumping | 15 June 2006 | 8.3 | 18-21 | 0.1 | $1 \times 10^{-6}$ | |
| WML120B | Pumping | 15 June 2006 | 13.5 | 12-15 | 10 | $1 \times 10^{-4}$ | Weathered seam, close to outcrop |
| ***Glennies Creek Alluvium:*** | | | | | | | |
| WML120A | Pumping | 15 June 2006 | 7.7 | 5.5-8.5 | 5 | $6 \times 10^{-5}$ | |

## 3.3.5 Water Quality Sampling

Water samples collected from WML119, WML120B and WML120A were submitted to Australian Laboratory Services (ALS) for comprehensive analysis. The results are presented in **Table 3.5**.

**Table 3.5: Laboratory Analysis Results for WML119, WML120A and WML120B**

| Groundwater Bores | | | WML119 | WML120B | WML120A |
|---|---|---|---|---|---|
| Aquifer | | | Pikes Gully Seam | Pikes Gully Seam | Glennies Creek Alluvium |
| **Parameter** | **Units** | **LOR** | **14 June 2006** | **14 June 2006** | **14 June 2006** |
| pH Value (field) | | 0.01 | 8.19 | 6.86 | 7.05 |
| Conductivity @ 25°C | µS/cm | 1 | 6470 | 6350 | 1930 |
| Total Dissolved Solids (TDS) | mg/L | 1 | 4910 | 5620 | 1480 |
| Calcium | mg/L | 1 | 39 | 203 | 123 |
| Magnesium | mg/L | 1 | 122 | 354 | 83 |
| Sodium | mg/L | 1 | 1570 | 1260 | 221 |
| Potassium | mg/L | 1 | 9 | 13 | 2 |
| Carbonate as $CaCO_3$ | mg/L | 1 | <1 | <1 | <1 |
| Bicarbonate as $CaCO_3$ | mg/L | 1 | 1080 | 936 | 137 |
| Chloride | mg/L | 1 | 1830 | 2300 | 610 |
| Sulphate | mg/L | 1 | 167 | 462 | 111 |
| Total Anions (reported) | meq/L | 0.01 | 76.50 | 93.30 | 22.20 |
| Total Cations (reported) | meq/L | 0.01 | 80.70 | 94.40 | 22.60 |
| % Difference (reported) | % | 0.01 | 2.65% | 0.57% | 0.88% |

It can be seen that the groundwater derived from the Pikes Gully seam has a much higher salinity (EC around 6400 µS/cm) than the alluvium groundwater (EC 1900 µS/cm). In terms of relative ionic concentrations, the water chemistry is similar, with sodium and chloride being the dominant ions in both the alluvium and the coal measures groundwater. Both have a near neutral pH.

Water samples collected from WML20 and WML21, both screened in the Pikes Gully seam, during pumping tests on 1 September 2006, and a sample of mine inflow seepage from the

Longwall 1 development headings collected on 4 September 2006, had the following quality parameters:

**Table 3.6: Field Water Quality Parameters for Pikes Gully Seam**

| Groundwater Source | | | WML20 | WML21 | LW1 Development Headings |
|---|---|---|---|---|---|
| **Aquifer** | | | **Pikes Gully Seam** | **Pikes Gully Seam** | **Pikes Gully Seam** |
| **Parameter** | **Units** | **LOR** | **1 Sept 2006** | **1 Sept 2006** | **4 Sept 2006** |
| pH Value (field) | | 0.01 | 8.21 | 8.19 | 8.27 |
| Conductivity @ 25°C (field) | µS/cm | 1 | 6240 | 8140 | 8530 |

# 4 HYDROGEOLOGICAL CONDITIONS IN SMP AREA

## 4.1 GEOLOGY

The project area is located within the Hunter Coalfields of the Sydney Basin and includes coal resources and reserves that occur within the Foybrook Formation. These are unconformably overlain by younger (Quaternary to Recent) alluvial deposits associated with the main streams.

The coal measures within the SMP area dip towards the west-southwest at around 6°. No major faults or other significant structures or igneous intrusions (dykes or sills) are known to occur in the SMP area. However, based on experience at neighbouring mines, dykes and small scale structures such as rolls or folds in the seams may be encountered in the mine.

The major coal seams within the Ashton underground mining project area are, in descending stratigraphic order, the Lemington, Pikes Gully, Arties, Upper Liddell, Middle Liddell, Upper Lower Liddell, Lower Liddell, Upper Barrett and Lower Barrett seams. The Pikes Gully Seam is the shallowest seam proposed for underground mining at Ashton. This SMP includes mining only the Pikes Gully Seam in Longwalls 1 to 4 (**Figure 2**).

## 4.2 AQUIFERS

Two distinct aquifer systems occur within or near the SMP area:

- a fractured rock aquifer system in the coal measures, with groundwater flow mainly in the coal seams; and
- a shallow granular aquifer system in the unconsolidated sediments of the alluvium associated with Bowmans Creek, Glennies Creek and Hunter River.

The permeability of the coal measures is generally low and is usually one to two orders of magnitude lower than the unconsolidated alluvial aquifers. Within the coal measures, the most permeable horizons are the coal seams, which commonly have a hydraulic conductivity one to two orders of magnitude higher than the siltstones, shales and sandstone units. The coal seams are generally more brittle and therefore more densely fractured than the overburden and interburden strata and usually have a slightly higher hydraulic conductivity than surrounding rocks. The main coal seam of importance with respect to this SMP is the Pikes Gully Seam.

The groundwater in the coal measures aquifer system is saline.

The alluvium comprises mostly clay- and silt-bound sands and gravel, with occasional coarser horizons where the sands and gravels have become concentrated. There are alluvial aquifers associated with Glennies Creek to the east of Longwall 1, and with Bowmans Creek on the western side of Longwall 4. The Hunter River alluvium aquifer occurs to the south of the southern ends of Longwalls 1 to 4. However, there is no alluvium aquifer within the SMP area. The thin veneer of colluvium that blankets the higher elevations away from the above streams is unsaturated within the SMP area.

The salinity of the groundwater in the alluvium is somewhat variable, but is generally less saline than the coal measures groundwater. The moderately high salinity at some locations may be due to mixing with saline water leaking upwards from the coal measures sediments beneath.

### 4.2.1 Hydraulic Properties

The Pikes Gully coal seam which is to be mined in Longwalls 1-4 has been tested for hydraulic conductivity (permeability) in four piezometers close to the SMP area (WML20, WML21, WML119 and WML120B). The tests gave average hydraulic conductivity values ranging from 0.015 to 10 m/d (**Section 3.3.4**).

The value of 10 m/d (1 x $10^{-4}$ m/s) determined at WML120B is much higher than all other test results for the Pikes Gully seam, and is atypical for coal seams in the Hunter Valley. Bore WML120B is located close to outcrop, updip from the SMP area, and the result is believed to be more indicative of weathered Pikes Gully close to outcrop, rather than the coal seam at depth below the base of weathering.

The test results from WML20 and WML21 (around 0.02-0.04 m/d) are more indicative of the Pikes Gully Seam hydraulic conductivity away from outcrop, and are consistent with the reported lack of significant water inflows when drilling through the Pikes Gully seam in the subsidence monitoring bores WML106 to WML115 (**Figure 2**). WML106, which is located at the southern end of Longwall 1, was dry until the first water intersection at the Arties seam, some 15m below the Pikes Gully seam.

The WML20 and 21 hydraulic conductivities are more consistent with expectations for the coal seam aquifers in the Hunter coalfields, based on data from other nearby sites. HLA reported in the EIS (HLA, 2001) that packer tests on the Pikes Gully seam at Cumnock and Nardell gave average permeability values of 0.015 and 0.08 m/d respectively.

The test result from WML119 (0.1 m/d) suggest that this site is also probably within the weathered zone near outcrop.

It is considered appropriate to adopt a conservative hydraulic conductivity value of 0.1 m/d (1 x $10^{-6}$ m/s) for the unweathered Pikes Gully seam within the SMP area. A value of up to 10 m/d (1 x $10^{-4}$ m/s) may be appropriate for the weathered zone close to outcrop.

Similar hydraulic conductivity values would apply to the other coal seams in the sequence, which includes the following relevant seams in the SMP area:

- Lemington seam – about 15-20 m above the Pikes Gully seam;
- Arties seam – about 10 m below the Pikes Gully seam.

Based on observations during drilling of the subsidence monitoring bores WML106 to WML115, and testing results from a number of other sites in the Hunter coalfields, the hydraulic conductivity of the interburden sediments is expected to be one to two orders of magnitude lower than in the coal seams. A representative value of 0.001 m/d ($10^{-8}$ m/s) is considered appropriate for the interburden sediments in the SMP area.

A pumping test on the Glennies Creek alluvium in piezometer WML120B gave an average hydraulic conductivity value of 5 m/d for the alluvium. This value is also higher than values determined from testing on the Bowmans Creek alluvium (average about 0.6 m/d), but lower than typical values for the Hunter River alluvium (average about 40 m/d) (**Annexure C**).

### 4.2.2 Groundwater Quality

Based on the available water analysis results, the water quality of the groundwater within the SMP area is generally as indicated in the following table:

**Table 4.1: Representative Groundwater Quality for Aquifers in SMP Area**

| Aquifer System | | Pikes Gully Seam | Other Coal Measures | Glennies Creek Alluvium | Bowmans Creek Alluvium |
|---|---|---|---|---|---|
| **Parameter** | **Units** | | | | |
| pH | | 6.8 - 8.2 | 6.5 - 8.5 | 7 | 7 - 8 |
| Conductivity @ 25°C | µS/cm | 6200 - 8500 | 1000 - 11000 | 1900 | 1500 |
| Total Dissolved Solids (TDS) | mg/L | 4500 - 5500 | 700 - 7000 | 1500 | 1100 |
| Calcium | mg/L | 120 | 45 - 200 | 120 | 70 |
| Magnesium | mg/L | 240 | 45 - 250 | 85 | 30 |
| Sodium | mg/L | 1400 | 450 - 1800 | 220 | 180 |
| Potassium | mg/L | 10 | 1 - 11 | 2 | 10 |
| Carbonate as $CaCO_3$ | mg/L | 0 | 0 | 0 | 0 |
| Bicarbonate as $CaCO_3$ | mg/L | 1000 | 130 - 660 | 140 | 220 |
| Sulphate | mg/L | 320 | 100 - 600 | 110 | 95 |
| Chloride | mg/L | 2100 | 450 - 3100 | 610 | 240 |

Water quality in the coal measures is quite variable, but is generally saline. The variability in salinity is believed to be due to the highly variable permeability, with the poorest quality from horizons that are the least permeable. It is also possible that the salinity could be reduced in the coal measures close to subcrop areas, where there is potential for dilution of the salinity by direct recharge from rainfall, or downward leakage of lower salinity water from overlying alluvium.

The alluvium groundwater quality is compared with surface water quality in Bowmans Creek, Glennies Creek and Hunter River in the following table:

**Table 4.2: Comparison Between Alluvium Groundwater Quality and Surface Water Quality**

| Source | | Glennies Creek Alluvium (1 sample) | Glennies Ck Surface Water (SM7, SM8, SM11) | Bowmans Creek Alluvium (over 100 samples) | Bowmans Ck Surface Water (SM3-SM6) | Hunter R Surface Water (SM9, SM12-SM13) |
|---|---|---|---|---|---|---|
| **Parameter** | **Units** | | | | | |
| pH | | 7.0 | 7.2 - 8.5 | 6.9 - 8.2 | 7.3 - 8.5 | 7.6 - 8.5 |
| Conductivity @ 25°C | µS/cm | 1900 | 240 - 510 | 720 - 1250 | 480 - 4500 | 350 - 950 |

The surface water in Glennies Creek has consistently lower salinity than the alluvium groundwater sample from WML120A. It is possible that there are some pockets of more stagnant groundwater within the alluvium, or alternatively some mixing with higher salinity water from the underlying coal measures.

By contrast, the salinity of surface water in Bowmans Creek is variable, probably due to the influence of saline inflows or groundwater baseflow contributions from areas upstream of Ashton. Salinity is generally higher when stream flow is being sustained by baseflow from the upper catchment. The Bowmans Creek alluvium has reasonably low salinity, with possibly some upward leakage of saline water from the underlying coal measures at some sites. At times the surface flow is much more saline than the alluvium groundwater.

Hunter River salinity also displays a reasonably high variability. Note that no data on the Hunter River alluvium groundwater quality is available from the Ashton project area.

## 4.3 GROUNDWATER LEVELS AND FLOW PATTERN

The piezometric surface within the coal measures in the SMP area is defined approximately by levels from Pikes Gully seam piezometers WML20, WML21, WML119 and WML120B, and the open-hole water levels in the incomplete subsidence monitoring bores (**Figure 3**). This data shows that the water table is between about 15 and 40 m below ground surface, with the water table surface generally a muted reflection of the topography. There is a slight mound on the water table surface above Longwall 2, where the water table is around 65 mAHD, compared with around 55-60 mAHD at the southern end of Longwall 4 and around 50 mAHD further west beneath the Bowmans Creek alluvium. The groundwater levels in the Pikes Gully seam beneath the Glennies Creek alluvium are approximately 52 mAHD.

Groundwater levels may in some locations be a few metres lower in the Bowmans Creek alluvium than in the underlying coal measures, based on the water levels in WML110A (coal measures) and WML110B (alluvium) – see **Figure 3**. In areas where the alluvium groundwater level is lower than that in the coal measures, upward leakage may occur if the two are hydraulically connected.

## 4.4 RECHARGE AND DISCHARGE

The groundwater levels in the coal measures suggests a groundwater flow pattern that is controlled by recharge via rainfall infiltration predominantly in elevated areas, and flow downdip towards discharge points in low-lying areas. The role of regional groundwater sinks at nearby mines is not known, but the monitoring data at Ashton suggests that regional impacts from neighbouring mines may be minimal.

Recharge to the undisturbed groundwater system in the coal measures in the SMP area occurs by infiltration of rainfall in the outcrop/subcrop areas and higher ground, and downward percolation to the water table. Where coal seams are covered by overburden, recharge by downward percolation of rainfall through the overlying sediments would be very limited, and the groundwater is derived predominantly by down-dip flow form the subcrop and outcrop areas. Regional studies indicate that approximately 0.5-1.0 % of the annual rainfall recharges to the coal measures groundwater system (AGC, 1984). It is considered that this recharge rate is likely to apply to the undisturbed coal measures within the SMP area.

Where the coal seams subcrop beneath alluvium, in areas close to the SMP, there may be potential for downward leakage or upward leakage according to the relative groundwater levels in the alluvium and the coal measures, if the two are in hydraulic connection. If such connection does exist, it is possible that the direction of water flow between the alluvium and the coal measures could alternate on a seasonal basis or long-term according to climate variations.

Groundwater discharge from the system can occur through evaporation or by seepage and spring flow where the water table intersects the land surface, and through baseflow contributions to creeks and rivers, including discharge to alluvium where it occurs. Regionally, groundwater discharge can also occur to major groundwater sinks created by coal mine dewatering.

Discharge of saline groundwater from the coal measures aquifer system may occur by upward seepage in areas where the alluvium groundwater levels are lower than those in the coal measures. The saline water may mix with the alluvial groundwater and then be either transpired by trees and shrubs, or seep in to the creek bed during periods of low flow.

## 4.5 INTERACTION BETWEEN ALLUVIUM AND COAL MEASURES AQUIFERS

There is no saturated alluvium overlying the coal measures within the SMP area.

Longwall panel 1 approaches to approximately 140 m from the alluvium associated with Glennies Creek, and Longwall 4 approaches to approximately 70 m from a section of Bowmans Creek where there is no alluvium (the coal measures outcrop right at the waterline in the creek). The southern end of Longwall 1 is at least 90 m from the northern edge of saturated alluvium associated with Hunter River. In all three cases, the buffer zone between the edge of the saturated alluvium and the angle of draw from the nearest longwall panel is greater than the minimum specified in the DNR guideline for coal mining near streams in the Hunter region (DNR, 2005).

The Pikes Gully seam is believed to subcrop beneath the Glennies Creek alluvium, where the creek approaches closest to the eastern edge of Longwall 1, between bores WML119 and WML120A-B (**Figure 2**). Bore WML120B penetrated alluvium to about 8.5 m depth. The Pikes Gully seam was found at 12.5-14 m depth. WML119 revealed no alluvium, with the top of the coal measures occurring beneath just 30cm of topsoil, and the Pikes Gully seam at 20-22 m depth.

This proximity of the Glennies Creek alluvium to the Pikes Gully seam provides the potential for some degree of hydraulic interconnection between the alluvium and the underground workings. The assessment of this potential is discussed in **Section 5.4**.

There is not considered to be the same potential for interconnection between the underground workings and either Bowmans Creek or Hunter River alluvium, since the alluvium in those cases is both outside the zone of potential subsidence impacts, and is physically separated from the Pikes Gully seam by up to 100m or more of undisturbed coal measures sediments.

## 4.6 GROUNDWATER – SURFACE WATER INTERACTION

Discharge of saline groundwater from the coal measures aquifer system may be occurring in places by upward seepage into the alluvium in low-lying areas, such as Glennies Creek floodplains, if there is effective hydraulic connection between the coal measures and the alluvium. Coal measures groundwater may mix with the alluvial groundwater and then be either transpired by trees and shrubs, or seep into the creek bed during periods of low flow.

Variable quality of surface flow in Bowmans Creek (discussed in **Section 4.2.2**) suggests that saline groundwater baseflow is a significant component of total flow at times of low runoff. However, since the salinity of the Bowmans Creek alluvium is much less variable, it is believed that the source of high salinity in the surface flow is from higher up the catchment, upstream from Ashton. There is no evidence for discharge of saline groundwater to surface flow in Bowmans Creek within or near the SMP area.

There is no evidence of saline groundwater discharging to surface flow in Glennies Creek.

# 5 POTENTIAL SUBSIDENCE IMPACTS AND MITIGATION MEASURES

## 5.1 SUBSIDENCE IMPACTS

Strata Control Technology (2006) have predicted that maximum subsidence of 1.6-1.8 m will occur over the centres of Longwalls 1 to 4. Goaf edge subsidence is predicted to be 70-100mm.

The outer limit of subsidence beyond the goaf edge is accepted to be the 20mm subsidence line, and defines the angle of draw. SCT believe that the actual angle of draw is likely to be about 6 to 10º, however the predicted 20 mm subsidence line for Longwalls 1 to 4 has been defined conservatively using an angle of draw of 26.5º, and is shown on **Figure 2**.

Systematic horizontal movements of greater than 0.5 m are predicted by SCT for the shallow cover areas at the northern end of Longwall 1. Elsewhere, systematic horizontal movements of 0.3-0.5 m are expected. In areas of steeper surface topography, additional downslope movement of up to 0.2-0.5 m may occur. There is expected to be surface cracking associated with this downslope movement.

SCT (2006) indicate that horizontal subsidence movement of up to 100 mm may occur within the steep slope leading down to the Glennies Creek flats. This slope does not overlie any longwall panels. The predicted movement would be a movement of the slope as a whole, and no cracks are expected to develop in this area, and no decrease in slope stability is expected.

Lateral translation of up to 10 mm (outwards) is expected on the steep slope down to the Hunter River flats at the southern end of Longwall panels 1 to 4. As this slope is partly underlain by longwall panels, some greater localised downslope movements may occur.

## 5.2 SUB-SURFACE CRACKING IMPACTS

SCT (2006) reports that the 20-30 m zone immediately above the goaf will be highly disturbed as a result of subsidence, and that continuous cracking can be expected to extend above that to a height of at least 100 m above the goaf. Cracking may continue above 100 m height, but it is less certain whether above this height the cracking will be either continuous or discontinuous (SCT, pers comm).

The cover depths will range from about 35 to 90 m above Longwall 1, 45 to 120 m above Longwall 2, 70 to 130 m above Longwall 3, and 70 to 150 m above Longwall 4. Consequently, it is possible that subsidence induced subsurface cracking may result in hydraulic connection between the goaf and the surface over much of Longwalls 1, 2 and 3, and the northern half of Longwall 4.

Hydraulic connection to the surface is possible but not certain over the SMP area. A comprehensive monitoring program has been implemented to monitor the impacts of sub-surface cracking on the groundwater system. This consists of a series of multi-level piezometers within each longwall panel. These monitoring bores are described in more detail in **Section 3.3.2**.

Monitoring results from the first four panels (Longwalls 1 to 4) will be analysed to assess the heights of subsurface cracking and the resultant impacts on hydraulic connection through the Permian strata. The monitoring results will be used to design appropriate longwall mining approaches and management strategies for future longwall panels (Longwalls 5 to 8 in the Pikes Gully seam, and future longwalls in deeper coal seams) (see **Section 6.4**).

## 5.3 SURFACE CRACKING IMPACTS

SCT (2006) have stated that permanent surface tension cracks up to several hundred millimetres in width may develop in the vicinity of the longwall goaf edges. Based on experience at other sites, it is expected that surface cracking will extend to a maximum of depth of just a few metres. Because of the relatively shallow cover depths, it is possible that the surface cracking could connect directly with continuous subsurface fracturing up from the goaf over parts of Longwalls 1, 2 and 3, and the northern half of Longwall 4.

SCT also predict that significant surface cracking may develop on the steeper slopes leading down to Hunter River (southern ends of Longwalls 1 to 4. SCT state that no surface cracks are expected to occur on the steep parts of the slope leading down to Glennies Creek (eastern side of the central part of Longwall 1).

In areas where direct hydraulic connection between the ground surface and the goaf might develop following subsidence, there would be potential for direct recharge to the goaf by infiltration of rainfall and local runoff. Experience at other project sites suggests that the rate of recharge could increase from the present 0.5-1.0 % to around 20 % of incident rainfall within the subsidence affected areas (SCT, pers comm).

The maximum rate of additional recharge that might occur if direct hydraulic connection becomes established between the goaf and the surface, over say 80 percent of Longwalls 1, 2 and 3, and 50 percent of Longwall 4, would be approximately 370 $m^3$/d (4.3 L/s), calculated as follows:

| | |
|---|---|
| Area of probable direct hydraulic connection | $1.1 \times 10^6$ $m^2$ |
| Mean annual rainfall | 640 mm (0.64 m) |
| Present recharge rate | 0.5 to 1.0 % rainfall |
| Possible enhanced recharge rate | 20 % rainfall |

| | | |
|---|---|---|
| Present recharge | = | $1.1 \times 10^6 \times 0.64 \times (0.005 \text{ to } 0.01)$ |
| | = | 10 – 20 $m^3$/day (3500 – 7000 $m^3$/yr) |
| Possible enhanced recharge | = | $1.1 \times 10^6 \times 0.64 \times 0.20$ |
| | = | 385 $m^3$/day (140,000 $m^3$/yr) |
| Increase | = | 365 – 375 $m^3$/d |
| | = | 4.2 – 4.3 L/s |
| | = | 133,000 – 137,000 $m^3$/yr. |

The above is expected to be an upper limit, and may persist for a short time after subsidence occurs. The enhanced recharge rate is likely to reduce with time as the surface cracks are repaired, or naturally heal or become infilled with fines.

## 5.4 HYDRAULIC CONNECTION WITH GLENNIES CREEK ALLUVIUM

Longwall 1 will approach to within 150 m of Glennies Creek near the mid-point of Longwall 1 (**Figure 2**). The minimum distance from the edge of alluvium associated with the creek to the edge of the eastern gateroad will be 120 m, and to the eastern edge of the goaf will be 150 m.

The Pikes Gully seam in the gateroad at this location is expected to be at an elevation approximately 20 m below the bed level of Glennies Creek. The westerly-dipping seam subcrops beneath the Glennies Creek valley, and was drilled at 4 m below the base of the alluvium in WML120A (**Figure 2**). There was no alluvium encountered in WML119. The Pikes Gully subcrop line is expected to pass beneath Glennies Creek to the north of WML120 and to the south of WML119, and to lie on the eastern side of Glennies Creek for some of the area between these two bores (**Figure 2**).

Thus some degree of hydraulic connection between the alluvium and the Pikes Gully seam aquifer is likely, under existing conditions. The degree of interconnection has been assessed on the basis of the pumping tests carried out on bores WML120A and WML119, screened in the Pikes Gully seam, and WML120B screened in the alluvium. An assessment has then been made of the potential for flow between the Glennies Creek alluvium and the Pikes Gully seam at the projected closest point along the Longwall 1 gateroads, and the potential changes as a result of mining.

The hydraulic conductivities determined for Pikes Gully Seam from the pumping tests were as follows (**Section 3.3.4**):

- WML119 - 0.1 m/d
- WML120A - 10 m/d.

The value of 10 m/d probably represents the permeability of the Pikes Gully seam where it is highly weathered close to outcrop, whereas the hydraulic conductivity of the Pikes Gully seam at depth below the weathered zone is typically 0.02 m/d. The value of 0.1 m/d determined at WML119 is probably slightly enhanced by weathering and/or proximity to outcrop. The higher permeability close to outcrop could allow a ready flow of groundwater within the seam, and possibly to or from the alluvium, with the direction of flow determined by the relative heads in the two aquifers.

The groundwater levels are virtually identical in WML120A and WML120B, thus there is no driving hydraulic gradient under present conditions. Water salinity is markedly different between WML120A and WML120B, with the alluvium sample from WML120A reporting a TDS of 1480 mg/L, and the Pikes Gully seam samples from WML119 and WML120B reporting TDS of 4910 and 5620 mg/L respectively. The alluvium groundwater is more saline than the surface flow in Glennies Creek, based on the baseline monitoring which shows salinity at 3 sites ranging between 240 and 510 mg/L TDS over more than two years of monitoring (**Annexure E**).

The water quality and water level information suggests limited hydraulic connection, with a small groundwater flow rate, between the alluvium and the Permian coal measures. Saline groundwater leaking from the Permian into the basal part of the alluvium may have elevated the salinity of the alluvium groundwater slightly compared with the surface water flowing in Glennies Creek. The salinity of groundwater sampled from the Pikes Gully seam at WML119 and WML120A (EC 6470 and 6350 µS/cm) is similar to the salinity from WML20 on the western side of the SMP area, suggesting there has been negligible leakage of alluvium groundwater from the Glennies Creek alluvium to the Pikes Gully seam.

It is calculated that the current potential **natural rate of flow between the Glennies Creek alluvium and the Pikes Gully seam** at the nearest point along the eastern gateroad of Longwall 1, is around 170 $m^3/d$ (2.0 L/s), calculated as follows:

Hydraulic conductivity of Pikes Gully seam
= 10 m/d for first 30m, then 0.1 m/d – assume average of 1 m/d

Dip of strata = 6º

Thickness of Pikes Gully seam
= 2.5m

Elevation of Pikes Gully seam
-at subcrop = (say) 50 mAHD
-at gateroad = (say) 35 mAHD

Hydraulic gradient = 15m per 130m
= 0.115

Width of Pikes Gully seam outcrop beneath Glennies Creek alluvium
= (say) 600m

Darcy's Law: Q = K i A, where
Q = volume rate of flow ($m^3/d$)
K = hydraulic conductivity (m/d)
i = hydraulic gradient (m/m)
A = cross-sectional area of flow region ($m^2$)

Potential flow rate under present conditions
= 1 x 0.115 x 600 x 2.5
= 170 $m^3/d$ = 2.0 L/s = 62,000 $m^3/yr$.

This calculated flow rate is the rate of groundwater flow expected to occur from the Glennies Creek alluvium to the eastern gateroad of Longwall 1, via the Pikes Gully seam, once the development headings have reached the closest point to Glennies Creek, just west of WML120A and B, and assuming that the hydraulic conductivity of the Pikes Gully seam has not altered due to any mining influence. This is likely to be the case, as no subsidence effects are expected during the development heading advance.

The rate of flow will be limited by lower hydraulic conductivity beyond the weathered zone, which is expected to for only part of the distance between Glennies Creek and LW1. Even after longwall extraction, any enhancement of permeability is expected to be confined to the region west of the eastern gateroad, within the subsidence zone. Providing the bulk of the region between Glennies Creek and LW 1 remains unaffected by subsidence-induced cracking, the flow rate between the Glennies Creek alluvium and LW1 should remain unchanged.

However, in the low probability event that the permeability of the Pikes Gully seam does become enhanced in that region between the creek and LW1 as a result of the longwall extraction, a conservative calculation can be made of the potential increase in groundwater flow from the Glennies Creek alluvium to the workings, by assuming a 10-fold increase in hydraulic conductivity for the Pikes Gully seam in that zone. The potential flow rate would then be 10 times higher than under present conditions, calculated as follows:

$$
\begin{aligned}
Q &= K\ i\ A \\
&= 10 \times 0.115 \times 600 \times 2.5 \\
&= 1700\ m^3/d \ = \ 20\ L/s \ = \ 260\ ML/yr.
\end{aligned}
$$

It is extremely unlikely that the permeability of the full width of the contact zone between the Pikes Gully seam and the alluvium would increase by an order of magnitude. A more plausible impact might be an increase in permeability over a limited portion of the full width of the contact zone between the alluvium and the seam. If the hydraulic conductivity were to undergo a 10-fold increase over say a section 100 m wide, the flow rate through that section would be calculated as follows:

$$
\begin{aligned}
Q &= K\ i\ A \\
&= 10 \times 0.115 \times 100 \times 2.5 \\
&= 290\ m^3/d \ = \ 3.4\ L/s \ = \ 100\ ML/yr.
\end{aligned}
$$

An increase in bulk seam permeability as assumed above is unlikely to occur, as the bulk permeability of the coal seam would have to be increased by cracking or fracturing, which is not predicted to occur in the region between LW1 and the creek, as it is outside the subsidence impact zone. However, what may occur is a downslope horizontal subsidence movement which may cause lateral translation of the ridge east of LW1 towards Glennies Creek (SCT, 2006). There is a small possibility that this could be associated with the development of a bedding-plane fracture at the base of the Pikes Gully seam, which could provide a more permeable flow-path than currently exists between the alluvium and the workings. The rate of flow through an individual fracture is proportional to the cube of the fracture width, so the increase in flow rate would arise due to the widening of the bedding-plane accompanying lateral movement.

A planar flow-path which had a constant width of 2 mm would have a fracture permeability of about 0.003 m/s (270 m/d). The theoretical rate of groundwater flow along this fracture pathway would be calculated as follows:

$$Q_f = K_f\ i\ A,$$

where $Q_f$ = fracture flow rate ($m^3/d$)
$K_f$ = fracture hydraulic conductivity (m/d)
$i$ = hydraulic gradient (m/m)
$A$ = cross-sectional area of flow region ($m^2$), ie fracture aperture x width (0.002m x 600m).

The calculated fracture flow rate would be:

$$
\begin{aligned}
Q_f &= K_f\ i\ A \\
&= 275 \times 0.115 \times 0.002 \times 600 \\
&= 38\ m^3/d \ = \ 0.4\ L/s \ = \ 14{,}000\ m^3/yr.
\end{aligned}
$$

It is unlikely that a fracture plane would have an average aperture (fracture width) greater than 1-2 mm. However, even assuming the extreme and improbable case of a continuous 5 mm fracture plane over the full 600 m subcrop width and for the full distance between the creek and LW1, the hypothetical increase in groundwater flow would be only 600 $m^3/d$ (7 L/s).

In summary:

- The potential flow that could occur between the Glennies Creek alluvium and the development headings in the Pikes Gully seam through the 600 m wide section where the seam is believed likely to occur in subcrop beneath the alluvium, under the prevailing hydraulic conductivity of the seam, has been estimated at **170m$^3$/d (2.0 L/s)**.
- It is unlikely that bulk permeability of the seam will increase after longwall extraction, as this zone of interest is outside the predicted subsidence impact zone. However, in the low probability event that average bulk permeability of this zone were to increase by an order of magnitude, the calculated potential flow rate is **1700 m$^3$/d (20 L/s)**.
- If the permeability of a narrow 100m wide zone were to increase in permeability by two orders of magnitude, the flow through that 100 m zone could potentially be **290 m$^3$/d (3.4 L/s)**.
- Finally, in the event that a planar flow path were to develop as a result of lateral subsidence movement, with an aperture width of 2 mm, the potential flow rate through this planar fracture has been calculated as **38 m$^3$/d (0.4 L/s)**. In the extreme and improbable event that a planar fracture with a continuous aperture width of 5mm were to develop, the calculated flow rate between the alluvium and the workings would be only **600 m$^3$/d (7 L/s)**.
- These hypothetical flow rates compare with the current inflow rate to the eastern gateroads which are the closest to Glennies Creek of **430-520 m$^3$/d (5-6 L/s)**. This inflow comprises water from a number of sources, including storage within the coal of the Pikes Gully seam itself, and from roof and floor drainage, as well as the flow component from the Glennies Creek alluvium (**natural** discharge).

In the event that flow rates in excess of those described above occur as a result of mining subsidence impacts, the mitigation measures available to the company include possible grouting of the Pikes Gully seam in the barrier zone between the workings and Glennies Creek, by means of grout holes drilled either from underground or from the surface.

## 5.5 HYDRAULIC CONNECTION WITH BOWMANS CREEK ALLUVIUM

Longwall 4 will approach to approximately 70 m from Bowmans Creek, at its closest point. In this location, the Permian coal measures outcrop at the waters edge, and there is no saturated alluvium between the creek and LW4, as determined by drilling at the bore denoted "Oxbow" on **Figure 2**.

The Bowmans Creek alluvium does encroach slightly over the western edge of Longwall 4 near its southern end (**Figure 2**) however, the alluvium in this area is unsaturated. There are no occurrences of saturated alluvium within the SMP, nor within the minimum buffer zone specified in DNR's guideline for coal mining near streams and aquifer systems, ie 40m from the edge of the subsidence angle of draw (DNR, 2005).

Hence there will be no direct hydraulic connection created between the Bowmans Creek alluvium and the Longwalls as a result of the proposal. However, there would already be a natural flow, albeit extremely small, between the alluvium and the Pikes Gully seam in this area, the magnitude of which is dependent on the prevailing hydraulic conductivities of the intervening coal measures strata, and the head difference between groundwater in the alluvium and groundwater in the Pikes Gully seam at this location. There will theoretically be potential for a small increase in the natural rate of groundwater to flow from the alluvium to the goaf, due to an increased head difference following longwall extraction from LW4. This potential increase in flow has been calculated using Darcy's Law, as was done for Glennies Creek alluvium in the preceding section.

The hydraulic conductivity of the Pikes Gully seam at WML20 and WML21 near the southern and northern ends of LW4 respectively has been determined from test pumping to be around 0.02 m/d. The vertical permeability through the overburden coal measures would be at least 2 orders of magnitude lower than this, ie around 0.0001 m/d or less. This would be the prevailing permeability that will control the potential for flow from the Bowmans Creek alluvium to the LW1-4 workings.

The potential inflow rate from the Bowmans Creek alluvium to the LW4 goaf is calculated as 12-37 $m^3$/d (0.15-0.4 L/s), as follows:

Vertical hydraulic conductivity of coal measures (interburden)
= 0.0001 m/d

Alluvium groundwater level = 55 mAHD

Top of goaf above LW4 = -30 to -100 mAHD

Therefore, hydraulic gradient = 85m to 155m per (say) 150m
= 0.6 to 1.0

Length of LW4 = 2400 m

| | | | |
|---|---|---|---|
| Darcy's Law: | Q | = | K i A, where |
| | Q | = | flow rate ($m^3$/d) |
| | K | = | hydraulic conductivity (m/d) |
| | i | = | hydraulic gradient (m/m) |
| | A | = | cross-sectional area of flow region ($m^2$) |

Potential flow rate under present conditions
= 0.0001 x (0.6 to 1.0) x 2400 x (85 to 155)
= 12 to 37 $m^3$/d = 0.15 to 0.4 L/s = 4400 to 13500 $m^3$/yr.

The above potential flow rate assumes no change in the hydraulic conductivity of the coal measures strata between the alluvium and the goaf as a result of the longwall extraction. This is a reasonable assumption, as the flow path lies outside of the subsidence impact zone. The predicted volume of flow is negligible compared with the natural rate of inflow from the alluvium under recharge conditions.

## 5.6 PREDICTED MINE WATER INFLOWS

The modelling carried out for the EIS studies (HLA, 2001) has been reviewed to determine the likely groundwater inflows to Longwalls 1 to 4.

Groundwater inflows during the first 3 years of underground mining, which covers the Pikes Gully Seam extraction from Longwalls 1 to 4, were predicted to reach a maximum of 300 $m^3$/d (equivalent to 3.5 L/s) using the base case model (HLA, 2001). Inflows currently being experienced in the development headings for Longwall 1 already exceed this rate, and suggest that the model predictions may be under-estimating the potential inflow rates. However, HLA appear to have not considered the potential for inflows from Glennies Creek alluvium to the Pikes Gully seam. Their predicted inflow rates for years 1 to 3 are believed to represent groundwater derived only from the coal measures.

HLA did consider inflows from the alluvium later in the project, and predicted that inflow rates from the Glennies Creek alluvium would peak at just under 600 $m^3$/d (7 L/s) during underground mining of the Upper Lower Liddell seam, due to its subcrop beneath the alluvium. The Pikes Gully seam also subcrops beneath the alluvium, although over a more restricted area than the Upper Lower Liddell seam. It is considered appropriate to allow for additional inflows from the Glennies Creek alluvium in years 1 to 3, in addition to the inflows from the coal measures predicted by the model during the EIS studies.

HLA presented sensitivity model results only for later stages of the proposed mining operation, and did not include the period when Longwalls 1 to 4 were to be mined. However, the sensitivity results presented indicated a possible lower bound inflow rate of 75% of the base case, and an upper bound inflow rate of 290% of the base case. Applying these same factors to the base case inflow rates for Longwalls 1 to 4 suggests a possible range from 250 to 900 $m^3$/d (3 to 10 L/s). This represents the component of groundwater inflow that will be derived from the coal measures themselves.

Accordingly, it is recommended that an allowance be made for an additional inflow from Glennies Creek alluvium of up to 290 $m^3$/d (3.4 L/s), based on the calculations presented in **Section 5.4** above.

Finally, allowance should be made for some of the increased rainfall recharge due to subsidence impacts to make its way into the workings. If 80 percent of the additional recharge were to flow to the workings, that would equate to an additional average inflow of around 260 $m^3$/d (3.0 L/s).

Accordingly, the maximum groundwater inflow rate that should be allowed for during the mining of Longwalls 1 to 4 is 1450 $m^3$/d (17 L/s), comprising the following components:

- Water derived from the coal measures (95 percentile) - 900 $m^3$/d (10 L/s)
- Additional inflow from Glennies Creek alluvium - 290 $m^3$/d (3.4 L/s)
- Additional rainfall recharge - 260 $m^3$/d (3.0 L/s).

The current inflow rate to the Longwall 1 development headings has been measured at approximately 8 L/s (700 $m^3$/d). Although at a very early stage of mining, this inflow rate is consistent with the above predictions.

Modifications have been made to the groundwater flow model, and further predictive modelling will be carried out as mining development proceeds.

## 5.7 GROUNDWATER LEVEL IMPACTS

The groundwater levels within the Pikes Gully seam aquifer will be drawn down effectively to the seam level within the SMP area. Groundwater levels will be similarly impacted in the subsidence affected overburden. The severely fractured zone, extending for approximately 30m immediately above the seam, will be dewatered, and groundwater levels will fall to the seam level. The overburden above this zone is predicted to be partly dewatered following coal extraction and goaf development.

Drawdown of the near-surface groundwater levels is expected to be greatest in the north-eastern part of the SMP area, where the overburden cover is limited. In the northern parts of Longwalls 1 and 2, total dewatering to the surface is expected to occur.

The network of subsidence monitoring bores (including some bores within the SMP area and others in future proposed mining areas) is intended to monitor the effects of subsidence on the overburden groundwater, and the monitoring results will be used to modify the groundwater flow model, so as to ensure reliable impact predictions during future proposed longwall extractions beneath areas of Bowmans Creek alluvium (not part of this SMP).

Regional groundwater level impacts in the coal measures are expected to be limited during the extraction of Longwalls 1 to 4. This is based on the monitoring results from the open cut, which have shown drawdowns in the range 1 to 5 m in regional monitoring bores G1, G2 and G3B, screened in the Upper Liddell, Lower Barrett and Upper Barrett seams respectively.

The mining of Longwalls 1 to 4 is expected to have no impact on groundwater levels in the Bowmans Creek alluvium. Minimal impact on groundwater levels in the Glennies Creek alluvium is also expected, although there may be a small localised lowering of groundwater levels in the immediate proximity to Longwall 1 where it comes closest to Glennies Creek. Based on test pumping of WML120B and WML119, drawdowns in the alluvium are expected to be less than 0.5 m.

No drawdown is expected in groundwater levels in the Hunter River alluvium.

No registered water bores occur in the coal measures within the areas where the predicted draw downs are significant. However, there is one well in the Glennies Creek alluvium in Camberwell, and one well in the Hunter alluvium south of the Ashton lease. Neither are expected to be impacted by the proposed coal extraction from Longwalls 1 to 4.

# 6 MONITORING, REPORTING AND MANAGEMENT

## 6.1 MONITORING

The groundwater monitoring program for Longwalls 1-4 is designed to monitor water levels and water quality in the following components of the groundwater system:

- Alluvial aquifers associated with Glennies Creek, Bowmans Creek and Hunter River
- Aquifers within the coal seams proposed to be mined in the underground mine
- Coal measures above the goaf of the underground mine
- Coal measures between the underground mine and Glennies Creek
- The regional coal measures aquifer system.

The groundwater monitoring program will also be coordinated with the surface water monitoring related to potential subsidence impacts on the alluvial aquifers.

The subsidence monitoring program for the underground mine operations will include the following groundwater monitoring:

| Monitoring Frequency | Groundwater Data Collection and Reporting |
|---|---|
| Weekly | Recording of total volume of water inflow to the underground workings, and where possible specific inflows to different parts of the workings |
| Quarterly | Measurements of groundwater level in the following monitoring bores:<br>- Pikes Gully seam bores – WML20, WML21, WML119, WML120B<br>- Subsidence monitoring bores – WML106, WML107A-B, WML108A-B, WML109A-B, WML110A-B, WML111A-B, WML112A-B, WML113A-B, WML114A-B, WML115A-B<br>- Bowmans Creek alluvium/coal measures bores – RM01, RM02, RM03, RM04, RM05, RM06, RM07, RM09, RM10, RSMG1, RA02, PB1<br>- Glennies Creek alluvium bores – WML120A, G5, G6<br>- Hunter River alluvium bores – G7, G8 |
| Quarterly | Detailed visual inspections of the underground workings, noting changes in roof and floor conditions and the location and flow rates of water inflows. |
| Quarterly | On-site screening of groundwater collected from piezometers and from the underground workings, for pH, EC, TDS and temperature |
| Bi-annually | Laboratory analysis of groundwater collected from selected piezometers for:<br>Physical parameters – pH, EC, TDS, turbidity, TSS<br>Major ions – Ca, Mg, Na, K, Cl, $SO_4$, $HCO_3$, $CO_3$<br>Dissolved metals – Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Zn<br>Nutrients/Other – Ammonia, nitrate, phosphorus, cyanide, fluoride |
| As required | On-site analysis of groundwater, at any time there is a significant change in flow rate or discoloration of the water |

Most elements of the above monitoring program have commenced and form part of the baseline monitoring system that has been ongoing since the issue of the EIS (HLA, 2001) and approval of the project. The baseline monitoring program will continue, and will progressively incorporate the new monitoring elements as they are installed or initiated. This monitoring program will continue through the full mining project, and on a reduced basis for at least 5 years post mining.

### Review of Monitoring

The monitoring data will be reviewed annually including a review of the groundwater modeling predictions, and if necessary a re-calibration of the groundwater model.
The accuracy of the groundwater model will be reviewed and if the predicted impacts using the recalibrated model differ significantly from the predictions outlined in this report, the assessment of potential groundwater impacts would be revised and if necessary additional or revised mitigation measures implemented. The trigger level for requiring a revision of the impact

assessment would be an assessed leakage rate from either the Bowmans Creek or Glennies Creek alluvium into the coal measures that is three times higher than the most likely predicted rates outlined in **Sections 5.4** and **5.5** of this report.

## 6.2 REPORTING

### *Annual Environmental Management Report (AEMR)*

The AEMR, which is required as a Consent Condition, will incorporate a Groundwater Management Report (GMR) prepared by an independent expert, which will contain the following:

- A basic statistical analysis (mean, range, variance, standard deviation) of the results for the parameters measured in individual bores / wells and as a subset of the aquifer;
- An interpretation of the water quality results and changes in time for water quality and water levels (supported with graphs and contour plots showing changes in aquifer pressure levels);
- Reporting on the differentiation between shallow and deep aquifers, with interpretation of results;
- An interpretation and review of the results in relation to cut-off criteria and predictions made in the EIS;
- An interpretation of the water balance, identifying the volume and make up of mine inflows as compared to the Part V licence (required under Part V of the Water Act 1912), and predictions made in the EIS or previous AEMRs; and
- provide an electronic copy of the data, forwarded to the relevant authorities.

### *Subsidence Monitoring and Impact Assessment Report (SMIAR)*

The SMIARs, which are required a s a Consent Condition, will incorporate a Groundwater Management Report (GMR) prepared by an independent expert, which will contain the following:

- The results of groundwater monitoring above and within the area of influence of the longwall panels, presented in graphical format to demonstrate trends in both water levels and water quality;
- Measurements of groundwater inflow to the underground workings;
- Assessments of any changes to aquifer hydraulic properties due to mine-induced fracturing;
- Assessment of any changes in groundwater quality due to mine-induced fracturing or cross aquifer interconnection;
- Results of the stream monitoring programs in Bowmans Creek and Glennies Creek;
- If necessary, a revised assessment of potential subsidence impacts on groundwater.

For SMIAR No 1, an independent audit of groundwater conditions in Longwall Panels 1, 2 and 3, and any current monitoring in Panel 4, will be carried out by an independent expert approved by the relevant authorities.

## 6.3 GROUNDWATER MANAGEMENT

Measures to be followed to minimise the groundwater impacts of the mining operation will include:

- Complete installation of the remaining elements of the monitoring network, as described in **Section 6.1** above.

- Close adherence to the monitoring program outlined in **Section 6.1**, so that unexpected changes to groundwater levels, groundwater quality, surface water quality or flow volumes, or groundwater hydraulic properties can be detected early enough to implement an adequate response to adverse impacts.

- Prompt response to any adverse impacts in excess of predictions.

### Management of Adverse Impact on Groundwater Users

In the event of any reported adverse impacts on the yield or quality of existing water supply wells or bores in excess of those predicted in this report, the cause will be investigated and if it is related to the Ashton operations, either the affected bore or well will be deepened or an alternative water source will be provided. It has been predicted that there may be drawdowns of up to 0.5 m in the Glennies Creek alluvium immediately east of the SMP area, but no detectable drawdown at the nearest existing bore in Camberwell village.

An inventory of all bores and wells to establish their status and condition will be compiled prior to commencement of longwall mining as a record for comparison purposes.

### Management of Adverse Longwall Mining Impacts

Adverse subsidence impacts on the groundwater resource or long-term salinity are not expected to occur from the mining of Longwalls 1 to 4. However, in the unlikely event that unexpected adverse impacts do occur, that are demonstrated to be greater than those predicted in the EIS or SMIARs, ACOL will implement a response that may include investigation of grouting or other sealing methods, alternative mine plans, amending mining methods or restricting longwall mining in certain areas.

The trigger criteria for investigation would be if groundwater inflows to the longwall panels exceeded the most likely inflow rates detailed in **Section 5.6** by 50 percent for at least three successive months, or alternatively that groundwater levels in any of the alluvial monitoring bores are observed to fall and remain for at least three successive months at levels 0.5m or more below historical lows from the pre-mining period. Based on the results of an investigation by an independent expert, an appropriate response program would be developed in consultation with DPI-Mineral Resources that may include further investigation and monitoring, or other actions.

## 6.4 PLANNING FOR FUTURE LONGWALL MINING

The comprehensive monitoring program outlined in Section 6.1 above is designed not only to allow assessments of impacts of Longwalls 1 to 4, but also to provide information that can assist with confirming mine plans and designs for future mining of Longwalls 5 to 8 in the Pikes Gully seam, and further longwalls in deeper seams beneath the Pikes Gully.

Consent condition 3.9 (Minister for Planning, 2002) states:

> *"The Applicant shall design underground mining operations to ensure that no direct hydraulic connection between the Bowmans Creek alluvium and the underground workings can occur through subsidence cracking. In order to achieve this criteria the Applicant shall assess levels of uncertainty in all subsidence predictions, and provide adequate contingency in underground mine design to ensure sufficient sound rock is*

> *maintained to provide an aquiclude between the Bowmans Creek alluvium and the underground mine goaf."*

Mining of Longwalls 1 to 4 will not lead to direct hydraulic connection between the Bowmans Creek alluvium, as there is no saturated alluvium within the subsidence impact zone of Longwalls 1 to 4. However, parts of Longwalls 5 to 8 will underlie saturated Bowmans Creek alluvium. It will be necessary to ensure that any mining from these longwall panels does not permit direct hydraulic connection between the alluvium and the workings, and that there is no significant loss of the alluvium groundwater resource.

The multi-level piezometers being installed above each of the proposed longwall panels are designed to identify, changes in groundwater levels (hydraulic pressures) within the overburden strata. It is also proposed to install a series of extensometers to monitor for vertical subsidence and ground strain (required under Consent Condition 3.19). In conjunction, these monitoring results will be used to assess the extent of continuous sub-surface cracking above the goaf, and any resultant changes in the hydraulic properties of the overburden that might lead to an increase in the potential for groundwater to flow from the surface to the underground workings.

At each multilevel piezometer location, a shallow standpipe piezometer has also been installed to allow monitoring of the water level and water quality of the shallowest groundwater at each site, in the upper part of the coal measures and separately in the alluvium where present (Longwalls 5 to 8). These piezometers will allow monitoring of water levels, sampling for water quality assessment, and repeat testing of hydraulic conductivity, to assess both pre-mining and post-mining conditions.

Additional monitoring of groundwater levels and quality in all major aquifer units (the Pikes Gully seam, other parts of the coal measures sequence, Bowmans Creek alluvium, Glennies Creek alluvium and Hunter River alluvium) will be carried out, together with surface water quality monitoring in Bowmans Creek, Glennies Creek and Hunter River, and inflow rates to the underground workings.

The monitoring and assessment results from Longwalls 1-4 will be used to predict potential impacts from future longwall panels, and if necessary to influence the design and layout of future panels.

# 7 CONCLUSIONS

ACOL is proposing to mine coal from the Pikes Gully seam by the longwall mining method from longwall panels 1 to 4 (the SMP area).

An assessment has been made of the existing groundwater conditions in the SMP area and nearby, and the potential impacts of the proposal either on the groundwater resource or on groundwater or surface water quality. The principal conclusions from this assessment are as follows:

- Surface topography comprises a ridge line above the easternmost panel LW1, with a fairly steep eastern slope down to Glennies Creek and its alluvial floodplain, and a gentle westerly slope down towards Bowmans Creek.

- The SMP area does not include any watercourses, apart from a minor ephemeral tributary of Bowmans Creek which drains a small catchment in the northern part of the SMP area. There is no saturated alluvium within the SMP area.

- Groundwater studies completed for the Ashton Coal Project EIS included drilling, hydraulic testing, water sampling and analysis, water level monitoring, and groundwater flow modelling. This work has been supplemented by further studies for the Longwall 1-4 SMP. The additional work included further drilling and test pumping, water sampling, and the design and installation of a network of subsidence monitoring bores. A baseline monitoring program has been maintained, including groundwater and surface water quality monitoring, and groundwater levels in key monitoring bores.

- Two aquifer systems are present in the area – fracture aquifers in the Permian coal measures, principally the coal seams; and alluvial aquifers associated with Hunter River, Bowmans Creek and Glennies Creek.

- Groundwater levels in the coal measures are between 10 and 30 m below ground surface within the SMP area. The potentiometric surface is a gentle reflection of the surface topography, with a high beneath the eastern ridge line and lows to the east and west towards Glennies Creek and Bowmans Creek respectively.

- Groundwater in the coal seams is saline, with electrical conductivities (EC) in the range 2000 to more than 10000 µS/cm, but usually between 5000 and 8000 µS/cm. Groundwater in the alluvium aquifer system is commonly low salinity, with EC below 1000 µS/cm, although there are some locations where salinity is higher, possibly due to mixing with saline groundwater from the underlying coal measures. Both alluvial and coal measures groundwaters have a near-neutral pH.

- The surface water in Glennies Creek is generally low salinity, with EC from the monthly monitoring program consistently less than 510 µS/cm. Likewise, Hunter River salinity is reasonably low, with EC reported up to 950 µS/cm. More variable salinity has been reported in Bowmans Creek, with EC ranging from 480 to 4500 µS/cm. There is no evidence of saline groundwater discharging to Bowmans Creek or Hunter River within or near the SMP area, and no evidence of any saline groundwater discharge to Glennies Creek.

- The hydraulic conductivity of the Pikes Gully seam, based on several pumping tests or permeability tests, is consistently around 0.02-0.05 m/d, except in the upper weathered zone near outcrop/subcrop, where a value of 10 m/d was determined in one test. Similar hydraulic conductivities would apply to other coal seams in the sequence.

- 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, and vertical conductivity in the order of 0.0001 m/d.

- The alluvium aquifer hydraulic conductivity is somewhat variable, but generally within the range 1 to 10 m/d.

- The eastern edge of Longwall 1 will be approximately 150 m from Glennies Creek and/or its alluvium at its nearest point. The western edge of Longwall 4 will be approximately 70 m from Bowmans Creek and/or its alluvium at its closest point. The southern end of Longwall 1 will be at least 90 m from the edge of Hunter River alluvium, and possibly further from the edge of saturated alluvium. In all cases, the buffer zones between the longwalls and the alluvium associated with these streams are greater than the minimum specified by the DNR (2005), viz 40 m from the edge of the subsidence zone defined by a 26.5º angle of draw.

- Groundwater was first encountered in the Longwall 1 development headings, about 450 m south from the northern end in the eastern gateroads. Inflows have also occurred to the western gateroads of Longwall 1, and to the north-west headings. Total groundwater inflow rate from these three locations combined is currently around 8 L/s. The salinity of the discharge water was measured at 8530 µS/cm (EC).

- Subsidence impacts reported by SCT (2006) indicate that continuous sub-surface cracking may extend upwards for at least 100 m from the goaf in Longwalls 1 to 4. It is therefore possible that the goaf will become hydraulically connected with the ground surface over much of Longwalls 1, 2 and 3, and the southern half of Longwall 4.

- Surface cracking is expected to occur within the subsidence zone, with permanent tension cracks up to several hundred millimetres in width at the goaf edges. They are expected to extend to only a few metres depth, but due to the relatively shallow cover depth, are likely to connect with sub-surface cracks over much of the SMP area. Significant surface cracking may also occur on the steeper slopes leading down to Glennies Creek to the east and Hunter River to the south.

- The direct connection between the surface and the goaf over some of the area, is expected to cause rainfall recharge to the coal measures aquifer system to increase from the present 0-5-1.0 % of rainfall to possibly 20 % of rainfall. This could lead to an additional 370 $m^3$/d, some of which may report to the Pikes Gully seam and the underground workings.

- Because of the proximity of Longwall 1 to Glennies Creek alluvium, and the believed subcrop of the seam beneath the alluvium, there is the potential for groundwater to flow from the alluvium to the workings via the seam. Based on the present permeability of the Pikes Gully seam, the potential for groundwater flow to the development headings when they reach the closest point to Glennies Creek, has been estimated at 170 $m^3$/d (2.0 L/s).

- Subsidence impacts are not expected to affect the bulk permeability of the Pikes Gully seam in the zone between Longwall 1 and Glennies Creek, as this area lies outside the subsidence impact zone, so the above leakage rate from the alluvium is expected to persist unchanged following mining. However, in the highly <u>unlikely</u> event that average permeability of the Pikes Gully seam were to increase 10-fold as a result of subsidence impacts, the groundwater flow rate from the Glennies Creek alluvium could increase to 1700 $m^3$/d (20 L/s). Alternatively, if the permeability of a narrow 100m wide zone were to increase 10-fold due to subsidence impacts, then the leakage rate from the alluvium could increase by 290 $m^3$/d (3.4 L/s) through this 100 m section. This outcome is considered improbable, but is a more plausible consequence to subsidence impact than a broad-scale 10-fold increase in hydraulic conductivity of the coal seam.

- Due to the steepness of the slope down to Glennies Creek, lateral subsidence movements are likely to occur between Longwall 1 and Glennies Creek, and could lead to the development of a planar bedding-plane fracture at the base of the Pikes Gully seam, which could create a more permeable pathway between the alluvium and the workings. Based on a conservative assumption that a 2mm wide planar fracture could form across the full breadth and length of the seam within the section that is believed likely to subcrop beneath the alluvium, a potential leakage rate from the alluvium to the workings of 38 $m^3$/d (0.4 L/s) could arise, ie about double the potential rate through the undisturbed seam. Even assuming an extreme and highly improbable case of a continuous 5 mm fracture plane over the same area, the hypothetical increase in groundwater flow would be only 600 $m^3$/d (7 L/s). This outcome is considered highly improbable, and is not expected to occur.

- Although Longwall 4 approaches to about 70 m from Bowmans Creek, the same potential for inflow from the alluvium to the workings is not expected to occur, as the Pikes Gully seam in that area is overlain by about 100 m of low permeability coal measures overburden, which will not be disturbed by the mining as it is outside the subsidence impact zone. The potential flow rate between the alluvium and the goaf through this overburden is estimated at between 12 and 37 $m^3$/d (between 0.15 and 0.4 L/s). This inflow rate would arise not because of any fracturing or subsidence impacts, but because of an increase in the head difference between the alluvium and the Pikes Gully seam following goaf development.

- There is no saturated Bowmans Creek alluvium occurring within the subsidence impact zone.

- Mine water inflows were predicted by the groundwater flow model to reach a maximum of about 300 $m^3$/d (3.5 L/s) during extraction of Longwalls 1 to 4 (HLA, 2001). Sensitivity modelling suggested that inflows could have a range from 250 to 900 $m^3$/d (3 to 10 L/s). Current inflows to the Longwall 1 development headings are already around 8 L/s (700 $m^3$/d), suggesting that the upper bound from the sensitivity modelling should be used for ongoing predictions.

- HLA also appear to have under-estimated groundwater inflows during the early years of mining, as they appear to have not considered the potential for inflows from the Glennies Creek alluvium to the Pikes Gully seam.

- Additional inflows from Glennies Creek alluvium of up to 290 $m^3$/d (3.4 L/s) would mean that the most likely maximum inflow rate to Longwalls 1 to 4 would be around 1450 $m^3$/d (17 L/s). This compares with the present inflow rate to the Longwall 1 development headings of 700 $m^3$/d (8 L/s).

- Groundwater level impacts in the coal measures are expected to be reasonably limited in areal extent. Groundwater levels will be drawn down effectively to the Pikes Gully seam level in the highly disturbed coal measures, but near surface groundwater levels will be less affected to the west and southwest of the SMP area.

- There is predicted to be drawdowns of less than 0.5 m in the Glennies Creek alluvium close where it comes closest to Longwall 1, but negligible regional impact. No drawdown is expected in the Bowmans Creek or Hunter River alluvium.

- A comprehensive monitoring and reporting program has been outlined in this report, consistent with the EIS commitments and consent conditions, which includes:

    - Volume rates of groundwater inflows
    - Groundwater levels
    - Groundwater quality
    - Subsidence-induced impacts
    - Surface water quality
    - Periodic review and revision of model predictions
    - AEMR reporting
    - SMIAR reporting

- Management strategies have been outlined, as well as mitigation measures in the event that unexpected adverse impacts on the groundwater resource or water quality arise from the project.

# 8 REFERENCES

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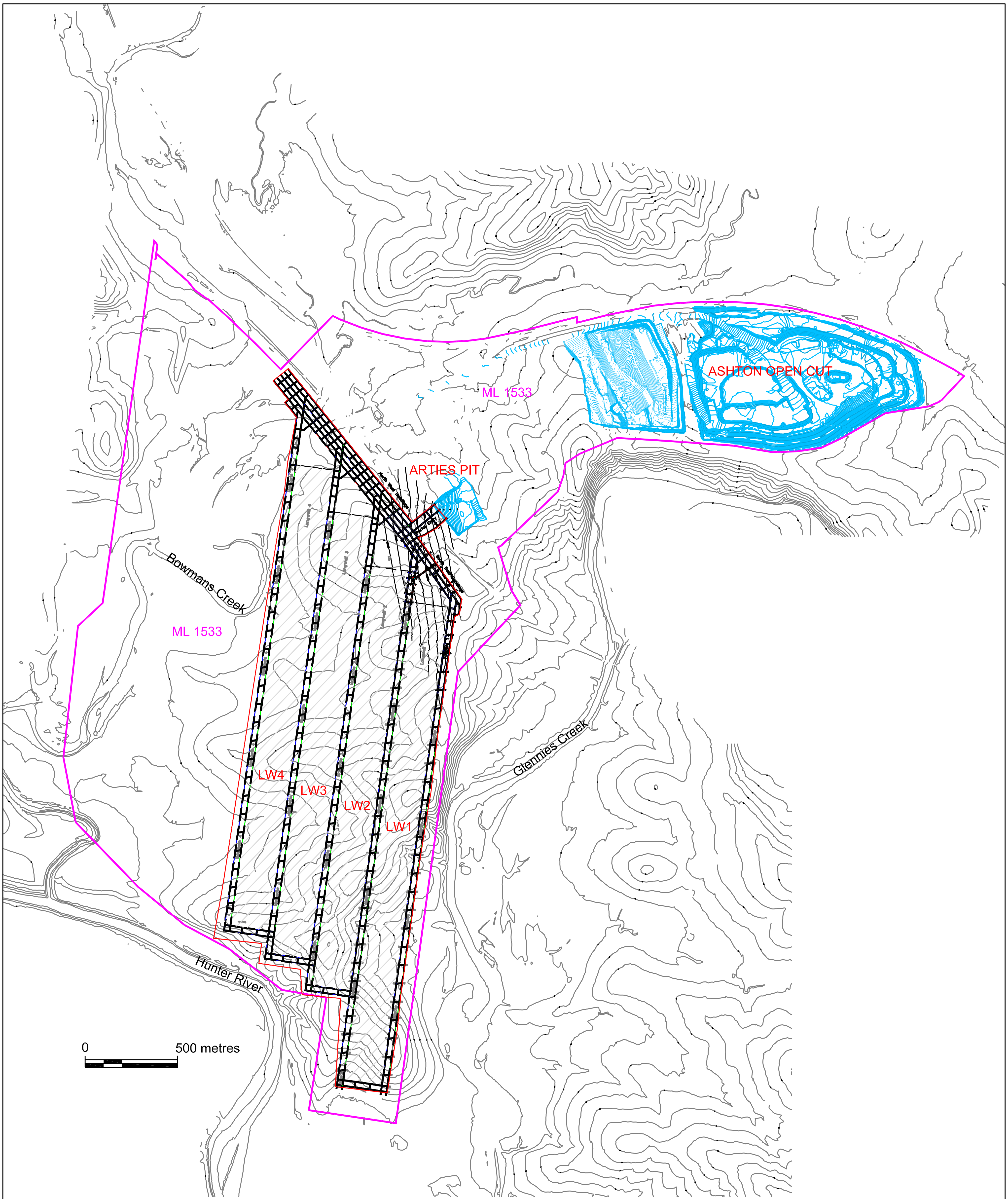
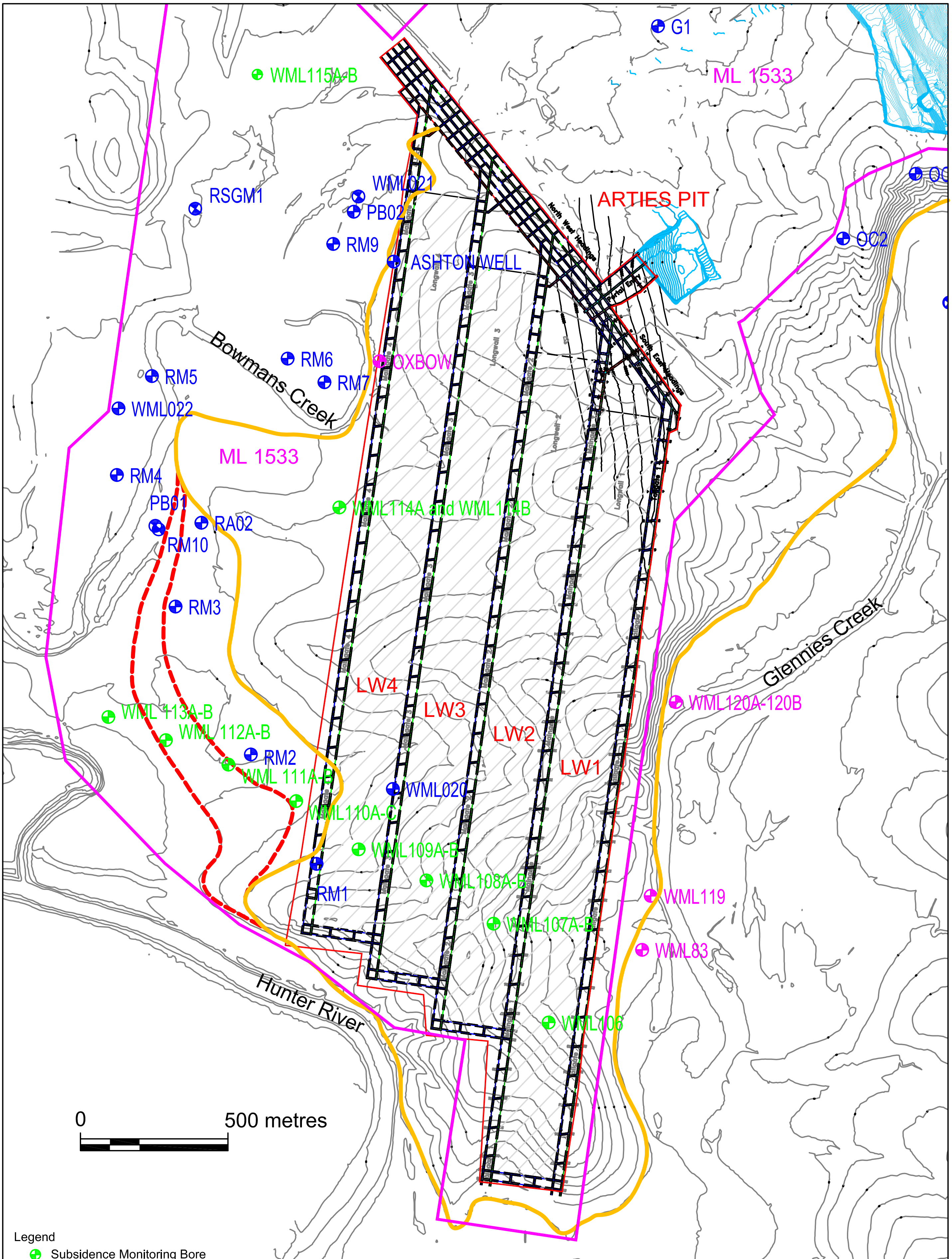


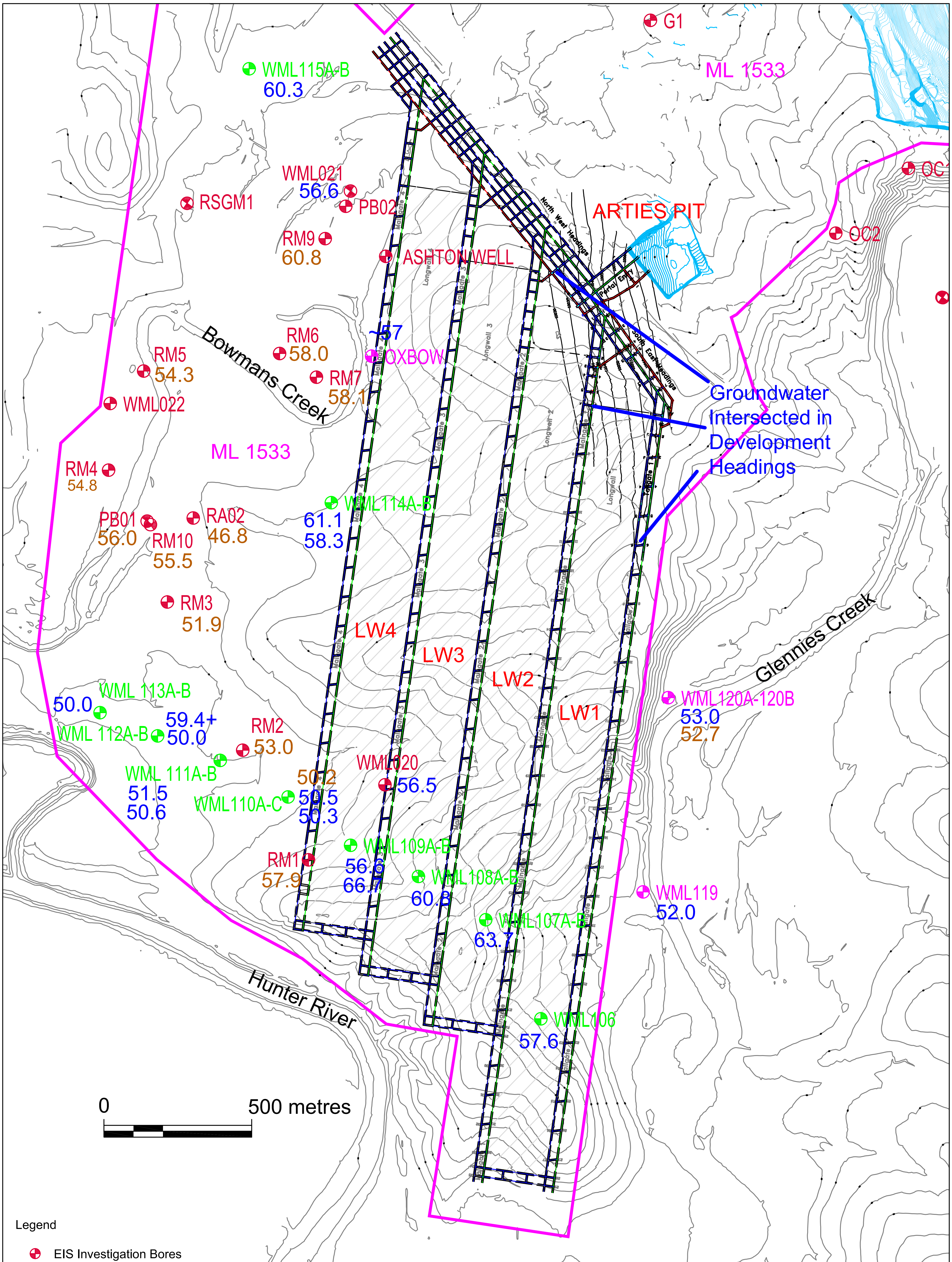

Legend

- ML1533 - Lease Boundary
- SMP Area - Longwalls 1-4
- SMP Longwalls 1-4 Development Headings

| | | | | |
|---|---|---|---|---|
| Date: | 18 September 2006 | Scale: | 1: 20,000 as A3 | **Ashton Coal Operations Ltd** |
| Initials: | PJD | Job No: | 05-0166 | **ASHTON COAL PROJECT**<br>**SMP - LONGWALLS 1 to 4**<br>**LOCATION PLAN** |
| Drawing No: | 05-0166-001a | Revision: | A | |
| **Peter Dundon and Associates Pty Limited** | | | | **Figure 1** |




| | | | | |
|---|---|---|---|---|
| Date: | 26 September 2006 | Scale: | 1: 12,000 as A3 | **Ashton Coal Operations Ltd** |
| Initials: | PJD | Job No: | 05-0166 | **SMP - LONGWALLS 1 to 4 PIEZOMETERS and SUBSIDENCE MONITORING BORES** |
| Drawing No: | 05-0166-002c | Revision: | C | |
| **Peter Dundon and Associates Pty Limited** | | | | **Figure 2** |




| | | | | |
|---|---|---|---|---|
| Date: | 18 September 2006 | Scale: | 1: 12,000 as A3 | **Ashton Coal Operations Ltd** |
| Initials: | PJD | Job No: | 05-0166 | **SMP - LONGWALLS 1 to 4 GROUNDWATER LEVELS** |
| Drawing No: | 05-0166-003b | Revision: | B | |
| **Peter Dundon and Associates Pty Limited** | | | | **Figure 3** |

# ANNEXURE A

## EIS GROUNDWATER INVESTIGATION / MONITORING BORES

## Table A-1: Ashton Project Groundwater Monitoring Bores – EIS Studies

| Well No. | MGA Coordinates | | Ground Level | Top of Casing | Casing Depth (m) | Screened Interval (m) | Aquifer Screened | Static Water Level | | | Water Quality | | Present Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | North | (m AHD) | | | | | (mbgl) | (mAHD) | Date | EC (µS/cm) | pH | |
| Ashton Well | *318415* | *6406085* | | | | | Bowmans Creek alluvium | | | | *1053* | | ?Lost |
| RM01 | 318214 | 6403655 | 69.15 | 69.40 | 10.8 | 6.8-8.8 | Alluvium/Coal Measures | 11.45 | 57.95 | May 2006 | *3170* | *8.64* | Blocked |
| RM02 | 317993 | 6404037 | 60.60 | 61.05 | 12.4 | 9.4-11.4 | Permian Coal Measures | 9.49 | 51.56 | May 2006 | 4830 | 6.76 | Piezometer |
| RM03 | 317556 | 6404449 | 61.75 | 62.10 | 11.0 | 7.0-9.0 | Alluvium/Coal Measures | 10.11 | 51.99 | May 2006 | | | Piezometer |
| RM04 | 317156 | 6404997 | 61.95 | 62.25 | 9.6 | 6.6-8.6 | Alluvium/Coal Measures | 7.45 | 54.80 | May 2006 | 1560 | 7.14 | Piezometer |
| RM05 | 317439 | 6405385 | 65.90 | 66.25 | 13.5 | 10.0-12.0 | Permian Coal Measures | 11.82 | 54.43 | May 2006 | 2270 | 6.81 | Piezometer |
| RM06 | 317913 | 6405613 | 63.95 | 63.95 | 10.2 | 7.2-9.2 | Alluvium/Coal Measures | 6.09 | 57.86 | May 2006 | 1320 | 7.28 | Piezometer |
| RM07 | 318011 | 6405520 | 63.70 | 63.70 | 9.8 | 6.4-8.4 | Alluvium/Coal Measures | 5.73 | 57.97 | May 2006 | 1510 | 7.20 | Piezometer |
| RM08 | | | 65.50 | 65.50 | 8.2 | 6.2-8.2 | Alluvium/Coal Measures | *4.7* | *60.8* | *Nov 2000* | *1300* | *7.10* | Piezometer |
| RM09 | 318134 | 6405951 | 65.45 | 65.45 | 8.75 | 5.7-7.7 | Alluvium/Coal Measures | 5.45 | 60.00 | May 2006 | 1360 | 7.01 | Piezometer |
| RM10 | 317383 | 6404751 | 61.40 | 61.40 | 10.8 | 7.8-9.8 | Alluvium/Coal Measures | 5.86 | 55.54 | May 2006 | 1460 | 6.86 | Piezometer |
| RA01 | | | 68.35 | | 11.5 | | Permian Coal Measure | *9.2* | *59.1* | *July 2000* | | | ?Lost |
| RA02 | 317543 | 6404843 | 63.60 | | 11.25 | | Alluvium/Coal Measures | 8.34 | 55.26 | May 2006 | | | Dry at present |
| RA03 | | | 60.85 | | 6.0 | | Bowmans Creek alluvium | *3.6* | *57.3* | *July 2000* | | | ?Lost |
| RSGM1 | 317814 | 6405982 | | | | | Permian Coal Measures | 5.84 | | May 2006 | 8000 | 6.92 | Piezometer |
| PB1 | 317553 | 6405309 | 61.10 | | 7.8 | 5.4-7.8 | Alluvium/Coal Measures | 5.63 | 55.47 | May 2006 | 1540 | 7.12 | Piezometer |
| PB2 | | | 65.30 | | 9.5 | 4.8-7.0 | Alluvium/Coal Measures | *4.77* | *60.5* | *Aug 2004* | *1420* | *8.03* | Piezometer |
| GM1 | 319261 | 6404919 | 73.44 | | 33.7 | 25.0-31.0 | Upper Liddell Seam | 10.95 | 62.49 | May 2006 | 4920 | 7.78 | Piezometer |
| GM2 | 318434 | 6407198 | 67.33 | | 213 | 197-203 | Lower Barrett Seam | *7.85* | *59.48* | *May 2005* | 1460 | 6.76 | Lost |
| GM3A | 320247 | 6405968 | 64.31 | | 16 | 10.5-13.5 | Upper Barrett Seam | 13.75 | 50.56 | May 2006 | 6020 | 7.77 | Piezometer |
| GM3B | 320247 | 6405971 | 64.28 | | 7.5 | 4.5-6.0 | Glennies Ck Alluvium | 7.42 | 56.86 | May 2006 | | | Piezometer - dry |
| GM4 | | | | | | | | Dry | - | - | - | - | Blocked - debris |
| GM5 | | | | | | | | Dry | - | - | - | - | Dry |
| OC1 | | | | | | | | 57.15 | | May 2005 | 5740 | 7.02 | Lost |
| OC2 | | | | | | | | 57.82 | | May 2005 | 6080 | 7.95 | Lost |
| WML19a | 319950 | 6406544 | 110.96 | | 64.0 | 51-57 | Upper Barrett Seam | *49.0* | *62.0* | *22-6-2001* | | | ? Lost |
| WML20 | 318362 | 6404331 | 72.74 | | 124.0 | 114-118 | Pikes Gully Seam | 16.2 | 56.5 | 17-5-2006 | 6240 | 8.21 | Piezometer |
| WML21 | 318245 | 6406340 | 65.03 | | 117.0 | 106-112 | Pikes Gully Seam | 8.4 | 56.7 | 17-5-2006 | 8140 | 8.19 | Piezometer |
| WML22 | 317431 | 6405621 | 63.70 | | 193.0 | 183-189 | Pikes Gully Seam | - | - | - | - | - | Casing collapsed |

# ANNEXURE B

## SMP LONGWALLS 1-4 – INVESTIGATION / MONITORING BORES

### Table B-1: Ashton Underground Mine – SMP Longwalls 1 to 4 – Piezometers

| Well No. | MGA Coordinates | | Ground Level | Top of Casing | Casing Depth (m) | Screened Interval (m) | Aquifer Screened | Static Water Level | | | Water Quality | | Present Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | North | (m AHD) | | | | | (mbgl) | (mAHD) | Date | EC (µS/cm) | pH | |
| WML19a | 319950 | 6406544 | 110.96 | | 64.0 | 51-57 | Upper Barrett Seam | *49.0* | *62.0* | *22-6-2001* | *-* | *-* | ? Lost |
| WML20 | 318362 | 6404331 | 72.74 | | 124.0 | 114-118 | Pikes Gully Seam | 16.2 | 56.5 | 17-5-2006 | 6240 | 8.21 | Piezometer |
| WML21 | 318245 | 6406340 | 65.03 | | 117.0 | 106-112 | Pikes Gully Seam | 8.4 | 56.7 | 17-5-2006 | 8140 | 8.19 | Piezometer |
| WML22 | 317431 | 6405621 | 63.70 | | 193.0 | 183-189 | Pikes Gully Seam | - | - | - | - | - | Casing collapsed |
| WML119 | 319255 | 6403930 | 61.45 | 61.85 | 27.0 | 18-21 | Pikes Gully Seam | 9.45 | 52.00 | 14-6-2006 | 6470 | 8.19 | Piezometer |
| WML120A | 319292 | 6404580 | 60.35 | 60.74 | 8.5 | 5.5-8.5 | Glennies Creek Alluvium | 8.03 | 52.71 | 14-6-2006 | 1930 | 7.05 | Piezometer |
| WML120B | 319294 | 6404588 | 60.12 | 60.72 | 18 | 12-15 | Pikes Gully Seam | 7.7 | 53.02 | 14-6-2006 | 6350 | 6.86 | Piezometer |
| Bowmans Ck Oxbow | 318330 | 6405744 | 66.36 | - | 11.5 | Open hole | Coal Measures | 7.28 | ~ 57 | 14-6-2006 | - | - | Abandoned |

**Table B-2: Ashton Underground Mine – Subsidence Monitoring Bores**

| Well No. | MGA Coordinates | | Ground Level | Top of Casing | Casing Depth (m) | Screened Interval (m) | Aquifer Screened | Static Water Level | | | Water Quality | | Present Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | North | (m AHD) | | | | | (mbgl) | (mAHD) | Date | EC (µS/cm) | pH | |
| **WML106** | **318861** | **6403493** | **83.07** | | **-** | **38** | **? coal seam** | **25.5** | **57.6** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| | | | | | | **68** | **Pikes Gully seam** | **22.3** | **60.7** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| | | | | | | **84** | **Arties seam** | **21.5** | **61.5** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| **WML107A** | **318374** | **6403828** | **95.53** | | **-** | **38** | **? coal seam** | **39.2** | **56.5** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| | | | | | | **69** | **? coal seam** | **10.9** | **84.6** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| | | | | | | **98** | **Lemington seam** | **40.4** | **55.3** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| **WML107B** | **318679** | **6403818** | **95.44** | | | **15-18, 22-25** | **Coal measures** | **24.7** | **70.8** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| **WML108A** | **318447** | **6403975** | **81.62** | | **-** | **53** | **? coal seam** | **26.0** | **55.7** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| | | | | | | **80** | **? coal seam** | **21.7** | **60.0** | **22-9-2006** | | | **Vibrating wire piezo** |
| **WML108B** | **318447** | **6403979** | **81.38** | **81.78** | **30.0** | **19-25** | **? coal seam** | **20.8** | **60.8** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| **WML109A** | **318217** | **6404080** | **72.58** | | **-** | **38** | **? coal seam** | **15.7** | **56.9** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| | | | | | | **65** | **? coal seam** | **15.1** | **57.5** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| | | | | | | **84.5** | **? coal seam** | **21.5** | **51.1** | **22-9-2006** | **-** | **-** | **Vibrating wire piezo** |
| **WML109B** | **318211** | **6404081** | **72.63** | **72.98** | **32.0** | **18-21, 28-31** | **Coal measures** | **16.3** | **56.6** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| *WML110A* | *318005* | *6404244* | *63.71* | | | | *Open hole – coal measures* | *13.4* | *50.4* | *22-9-2006* | *-* | *-* | *Under construction* |
| **WML110B** | **318007** | **3404247** | **63.74** | **63.99** | **24.0** | **18-24** | **Coal Measures** | **13.6** | **50.4** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| **WML110C** | **?** | **?** | **?** | **?** | **14.0** | **11-14** | **Bowmans Ck Alluvium** | **13.6** | **~50.1** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| *WML111A* | *317776* | *6404367* | *58.2* | | | | *Open hole – coal measures + alluvium* | *5.9* | *52.3* | *22-9-2006* | *-* | *-* | *Under construction* |
| **WML111B** | **317775** | **6404363** | **58.33** | | **18.0** | **12-18** | **Coal measures** | **8.2** | **50.5** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| *WML112A* | *317564* | *6404450* | *59.44* | | | | *Open hole – coal measures + alluvium* | *0* | *59.4* | *22-9-2006* | *-* | *-* | *Under construction* |
| **WML112B** | **317567** | **6404450** | **59.42** | | **22.0** | **13-16, 19-22** | **Coal measures** | **9.7** | **50.0** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| *WML112C* | *?* | *?* | *?* | *?* | *12.0* | *9-12* | *Bowmans Ck Alluvium* | *-* | *-* | *-* | *-* | *-* | *Proposed* |

## Table B-2: Ashton Underground Mine – Subsidence Monitoring Bores

| Well No. | MGA Coordinates | | Ground Level | Top of Casing | Casing Depth (m) | Screened Interval (m) | Aquifer Screened | Static Water Level | | | Water Quality | | Present Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | North | (m AHD) | | | | | (mbgl) | (mAHD) | Date | EC (µS/cm) | pH | |
| *WML113A* | *317369* | *6404529* | *60.20* | | | | *Open hole – coal measures + alluvium* | *10.2* | *50.0* | *22-9-2006* | *-* | *-* | *Under construction* |
| **WML113B** | **317373** | **6404528** | **60.20** | | **20.0** | **15-18** | **Coal measures** | **10.5** | **50. 0** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| *WML113C* | *?* | *?* | *?* | *?* | *11.5* | *8.5-11.5* | *Bowmans Ck Alluvium* | *-* | *-* | *-* | *-* | *-* | *Proposed* |
| *WML114A* | *318152* | *6405239* | *71.53* | | | | *Open hole – coal measures* | *10.6* | *60.9* | *22-9-2006* | *-* | *-* | *Under construction* |
| **WML114B** | **318148** | **6405238** | **71.47** | | **30.0** | **13-16, 27-30** | **Coal measures** | **13.4** | **58.3** | **22-9-2006** | **-** | **-** | **Standpipe piezometer** |
| *WML115A* | *317874* | *6406707* | *66.59* | | | | *Open hole – coal measures* | *6.4* | *60.2* | *22-9-2006* | *-* | *-* | *Under construction* |
| *WML115B* | *317881* | *6406703* | *66.35* | | | | *Open hole – coal measures* | *6.0* | *60.3* | *22-9-2006* | *-* | *-* | *Under construction* |
| *WML115C* | *?* | *?* | *?* | *?* | *6.0* | *3-6* | *Bowmans Ck Alluvium* | *-* | *-* | *-* | *-* | *-* | *Proposed* |

**Bold = installed piezometer**
*Italics = installation not yet completed*

*Peter Dundon and Assoc.*

*Logging Sheet*

# BORES: WML106

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| Ashton Coal Operations Pty Ltd | WML106 | 83.07 mAHD | | | Hunter Drilling Services | 10-Apr-06 | |
| Locationt: | | | | | | | |
| Ashton Coal Project | | | | | | | |
| | | | Hole depths: | | | Supervised By: | |
| | | | As shown | | | R McCallum | |

| Description | Depth (metres) | Well Construction Details: |
|---|---|---|

**Yellow brown weathered clay**

**Grey siltstone with grey brown mudstone**

**Fine to medium grained sandstone**

**Grey siltstone and mudstone with coal traces**

**Coal**

**Dark grey mudstone with grey siltstone**

**Coal**

**Light grey medium and fine sized sandstone with dark grey siltstone**

**Mudstone with carbonaceous mudstone**

**Pikes gully seam**

**Grey sandstone with grey siltstone and dark grey mudstone**

**Arties Coal Seam**

**Grey sandstone with dark grey mudstone**

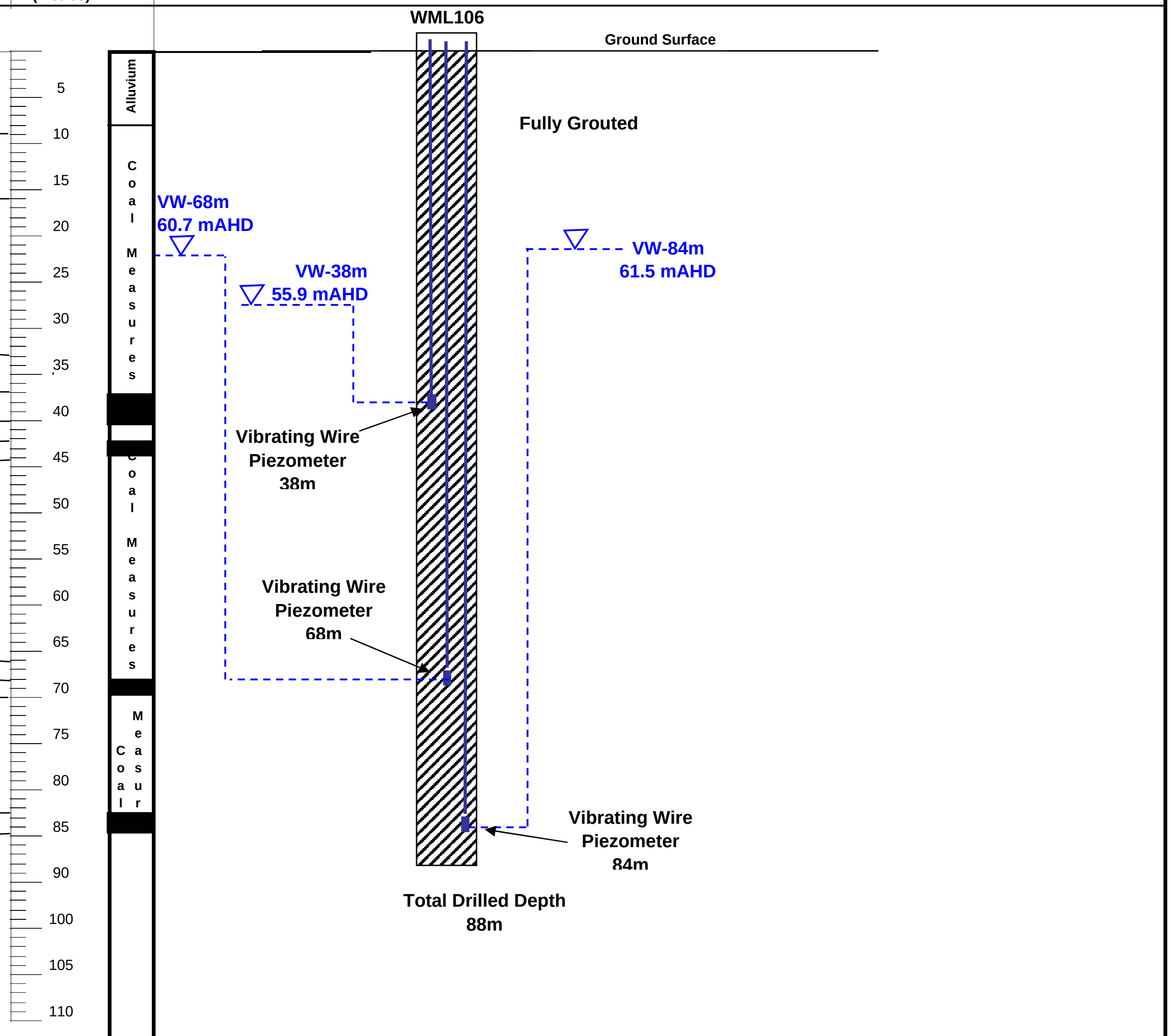



**Figure B-1: Log WML106**

*Peter Dundon and Assoc.*
*Logging Sheet*

# BORES: WML107A and WML107B

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| **Ashton Coal Operations Pty Ltd** | **WML107A** | **95.53 mAHD** | | | **Hunter Drilling Services** | **17-May-06** | |
| Locationt: | **WML107B** | **95.44 mAHD** | **95.70 mAHD** | **0.26m** | **Hunter Drilling Services** | **14-Sep-06** | |
| **Ashton Coal Project** | | | | | | | |
| | | | Hole depths: **As shown** | | | Supervised By: **R McCallum** | |

| Description | Depth (metres) | Well Construction Details: |
|---|---|---|
| Brown pebbly alluvium | | |
| Highly weathered mudstone | | |
| Coal | | |
| Grey fine grained sandstone with mudstone and siltstone | | |
| Coal | | |
| Light grey sandstone with grey mud- and siltstones | | |
| Matrix supported conglomerate | | |
| Light grey sandstone with grey mud- and siltstones | | |
| Coal | | |
| Light grey sandstone with grey mud- and siltstones | | |
| Light grey and matrix support conglomerates with sand-, silt- and mudstones | | |
| Bright and dull coal | | |
| Light grey sandstone with mud- and siltstones, and thin coal seams. | | |
| Pikes Gully seam | | |
| Grey siltstone with light grey sandstone | | |

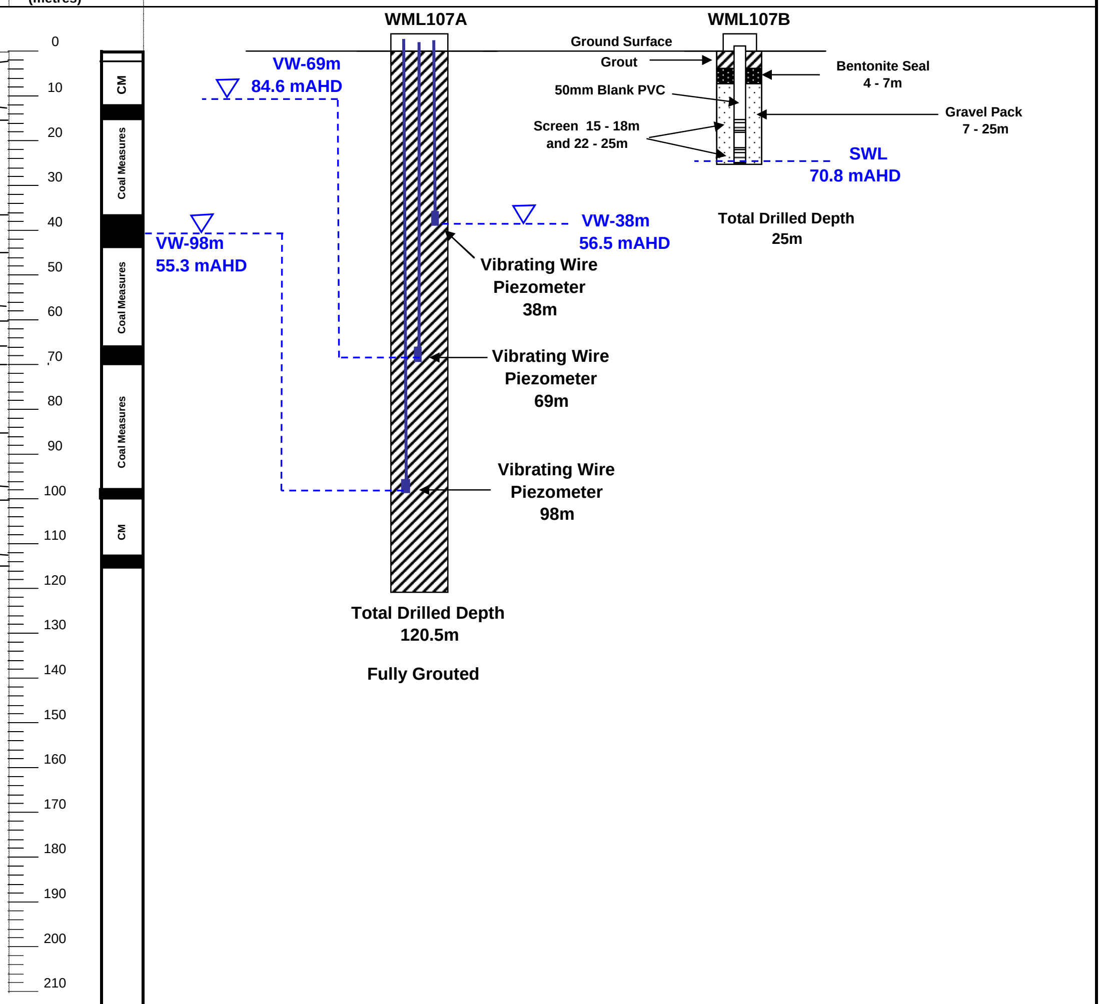



**Figure B-2: Log WML107A and WML107B**

*Peter Dundon and Assoc.*

*Logging Sheet*

## BORES: WML108A and WML108B

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| **Ashton Coal Operations Pty Ltd** | **WML108A** | **81.62 mAHD** | | | **Hunter Drilling Services** | **11-Apr-06** | |
| Locationt: | **WML108B** | **81.38 mAHD** | **81.12 mAHD** | **0.26 m** | **Hunter Drilling Services** | **12-Apr-06** | |
| **Ashton Coal Project** | | | | | | | |
| | | | Hole depths: **As shown** | | | Supervised By: **R McCallum** | |

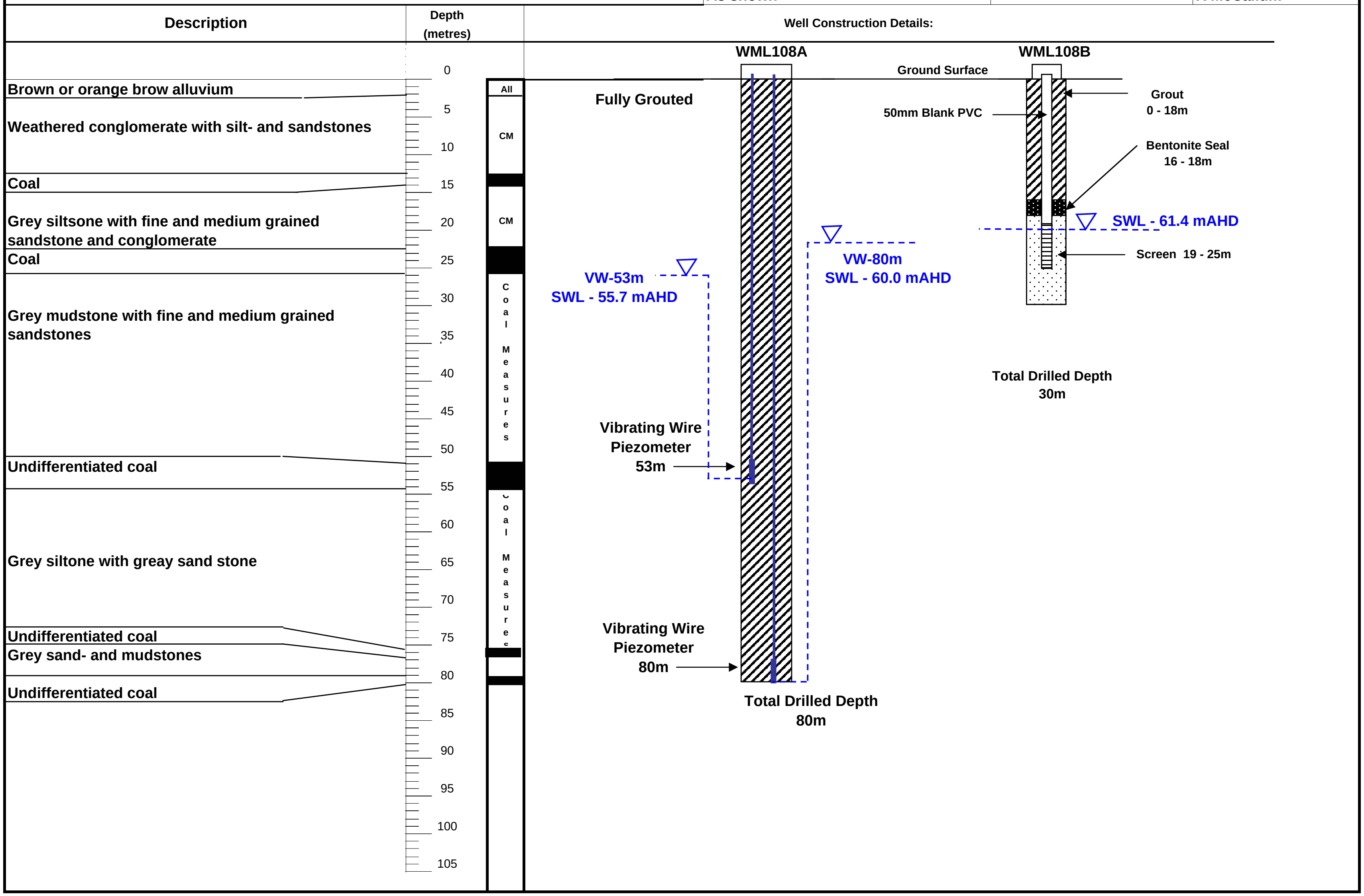



**Figure B-3: Logs WML108A and WML108B**

*Peter Dundon and Assoc.*
*Logging Sheet*

# BORES: WML109A and WML109B

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| **Ashton Coal OperationsPty Ltd** | **WML109A** | **72.58 mAHD** | | | **Hunter Drilling Services** | **12-Apr-06** | |
| Locationt: | **WML109B** | **72.63 mAHD** | **72.98 mAHD** | **0.35 m** | **Hunter Drilling Services** | **13-Apr-06** | |
| **Ashton Coal Project** | | | | | | | |
| | | | Hole depths: **As shown** | | | Supervised By: **R McCallum** | |

| Description | Depth (metres) | Well Construction Details: |
|---|---|---|

**Red brown alluvium**

**Brown multicolored sand- and siltstones**

**Conglomerate with sand and siltstones**

**Coal**

**Grey mudstone with grey sand- and siltstones**

**Coal**

**Grey sandstone with grey mudstone and siltstone**

**Undifferentiated coal**

**Grey sandstone with grey siltstone**

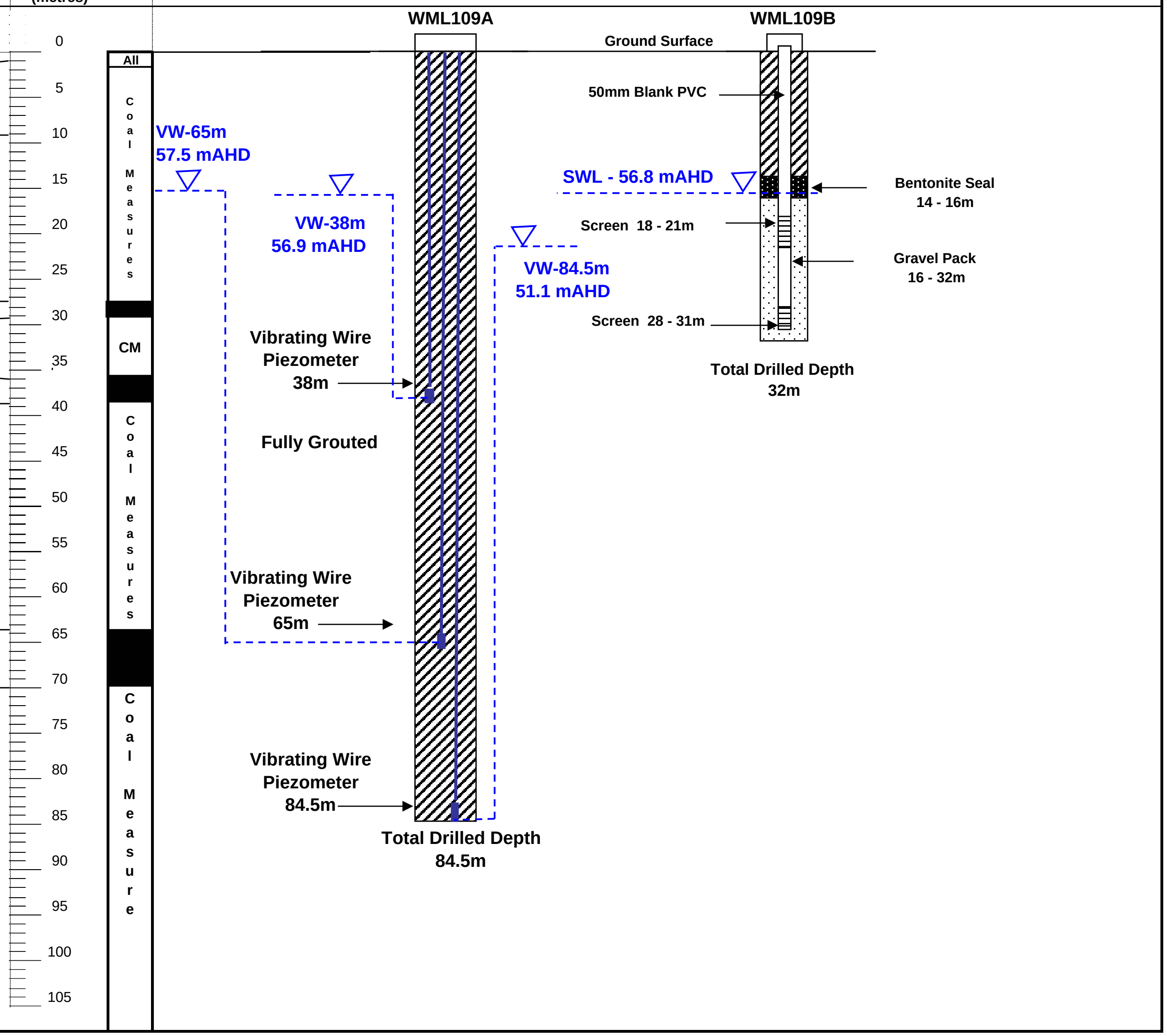



**Figure B-4: Logs WML109A and WML109B**

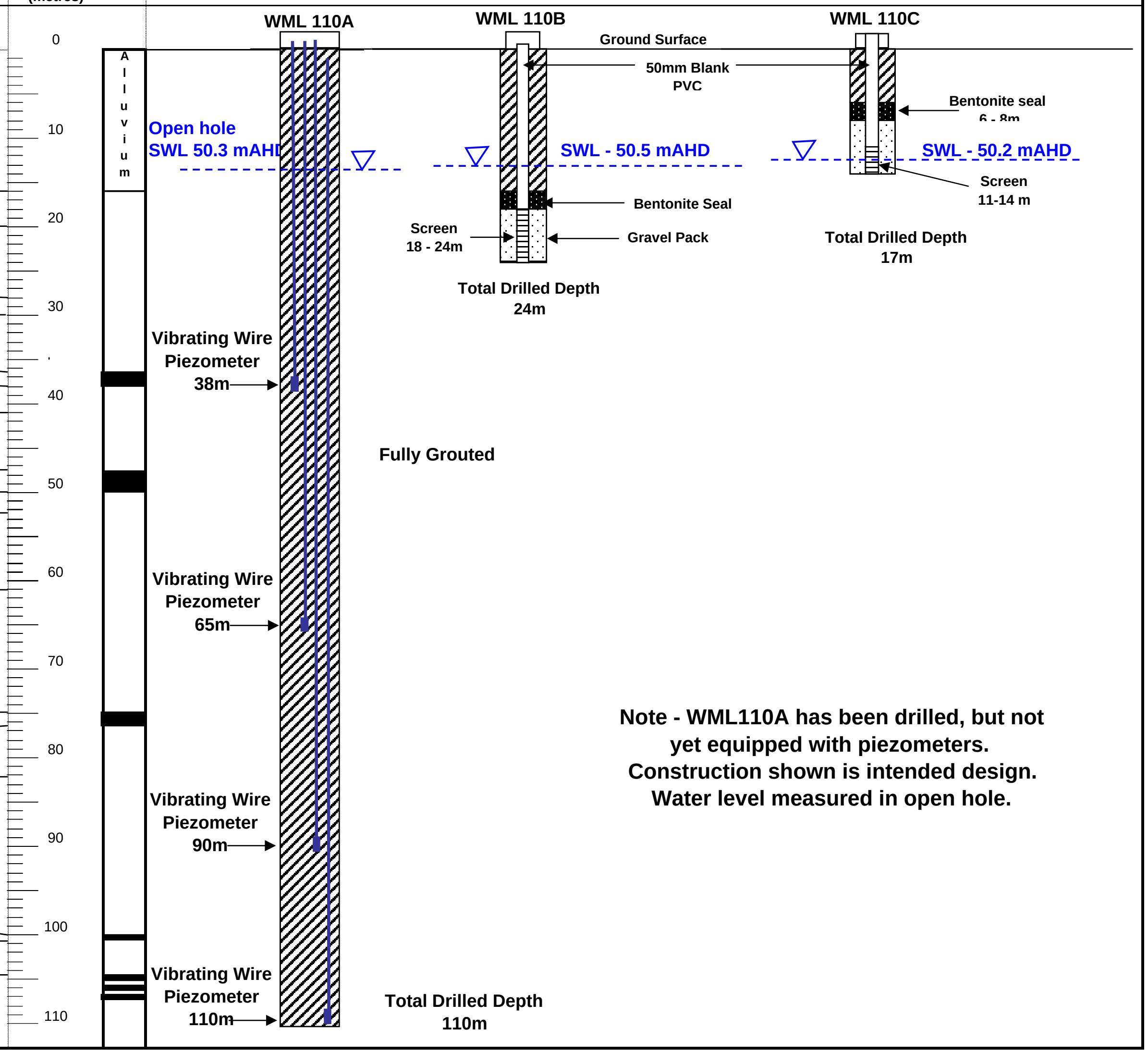
*Peter Dundon and Assoc.*
*Logging Sheet*

# BORES: WML110A, B and C

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| Ashton Coal Operations Pty Ltd | WML110A | 63.71 mAHD | | | Hunter Drilling Services | 03-May-06 | |
| Locationt: | WML110B | 63.74 mAHD | 63.99 mAHD | 0.25 m | Hunter Drilling Services | 05-May-06 | |
| Ashton Coal Project | WML110C | ? mAHD | | 0.00 m | Hunter Drilling Services | 04-May-06 | |
| | | | Hole depths: As shown | | | Supervised By: R McCallum | |

| Description | Depth (metres) |
|---|---|
| Brown alluvium | 0–15 |
| Brown grey sandstone | |
| Grey to multicolored conglomerate | |
| Sandstone | |
| Grey to multicolored conglomerate | |
| Coal | |
| Siltstone, sandstone | |
| Conglomerate, sandstone | |
| Coal | |
| Sandstone | |
| Siltstone | |
| Sandstone, minor siltstone | |
| Coal, carbonaceous mudstone | |
| Siltstone, mudstone, minor coal | |
| Sandstone, minor siltstone | |
| Coal | |
| Sandstone | |
| Siltstone, coal, mudstone | |

**Well Construction Details:**




Note - WML110A has been drilled, but not yet equipped with piezometers. Construction shown is intended design. Water level measured in open hole.

**Figure B-5: Logs WML110A, WML110B and WML110C**

*Peter Dundon and Assoc.*

*Logging Sheet*

# BORES: WML111A and WML111B

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| **Ashton Coal Operations Pty Ltd** | **WML111A** | **58.20 mAHD** | | | **Hunter Drilling Services** | **05-May-06** | |
| Locationt: | **WML111B** | **58.33 mAHD** | **58.77 mAHD** | **0.44 m** | **Hunter Drilling Services** | **10-May-06** | |
| **Ashton Coal Project** | | | | | | | |
| | | | Hole depths: **As shown** | | | Supervised By: **R McCallum** | |

| Description | Depth (metres) | Well Construction Details: |
|---|---|---|
| Brown alluvium | | |
| Pebble sized conglomerate with sandstone | | |
| Coal | | |
| Grey mudstone with grey sandstone | | |
| Coal | | |
| Grey mudstone with grey sand- and siltstone | | |
| Pebble sized conglomerate | | |
| Grey siltstone with grey sandstone and very thin | | |
| Pebble sized conglomerate | | |
| Coal | | |
| Grey siltstone with grey sandstone | | |
| Coal | | |
| Light grey sandstone | | |
| Grey siltstone | | |
| Undifferentiated coal | | |
| Grey sandstone and siltstone | | |
| Coal | | |
| Grey sand- and siltstone | | |
| Coal | | |
| Grey mud-, sand- and siltstone | | |

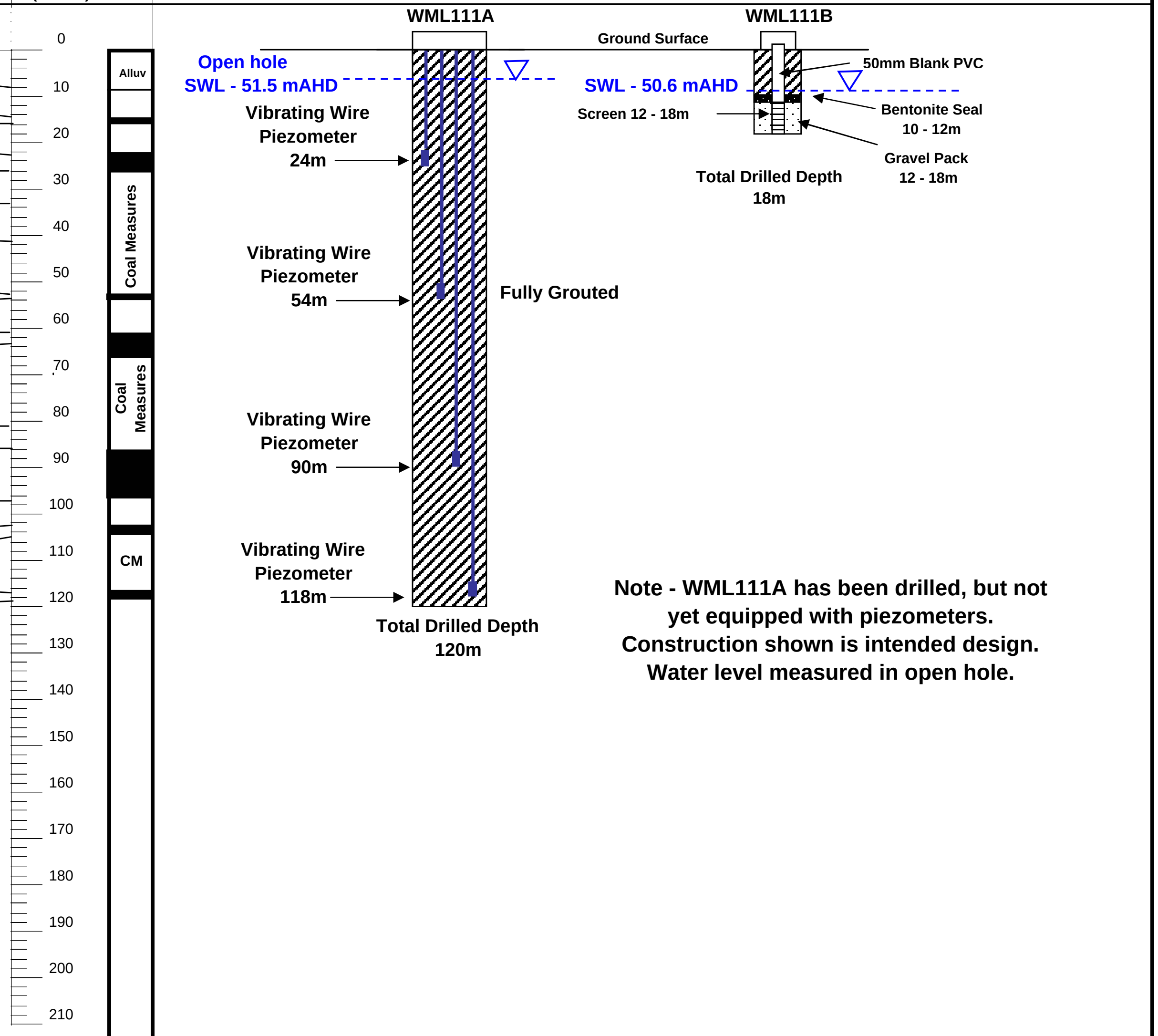



**Figure B-6: Logs WML111A and WML111B**

*Peter Dundon and Assoc.*
*Logging Sheet*

# BORES: WML112A, WML112B and WML112C

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| **Ashton Coal Operations Pty Ltd** | **WML112A** | **59.44 mAHD** | | | **Hunter Drilling Services** | **?** | |
| Locationt: | **WML112B** | **59.42 mAHD** | **59.74 mAHD** | **0.32 m** | **Hunter Drilling Services** | **06-Jul-06** | |
| **Ashton Coal Project** | **WML112C** | **? mAHD** | **? m** | **? m** | **Hunter Drilling Services** | **?** | |
| | | | Hole depths: **As shown** | | | Supervised By: **R McCallum** | |

| Description | Depth (metres) | Well Construction Details: |
|---|---|---|
| | | |

**Weathered and low strength alluvium**
**Coal**
**Grey pebbly conglomerate**
**Coal**
**Conglomerate**
**Light grey sandstone with grey siltstone, coal bands**
**Coal**
**Sandstone, siltstone**
**Conglomerate, minor sandstone**
**Coal and sandstone**
**Sandstone**
**Coal**
**Siltstone, sandstone**
**Sandstone, minor siltstone**
**Interbedded siltstone, sandstone, mudstone, coal**
**Coal**
**Siltstone, sandstone**
**Coal**
**Sandstone, minor siltstone, carb mudstone**
**Mudstone**
**Coal - Lemington seam**
**Sandstone, interbedded mudstone, siltstone**
**Coal**
**Sandstone, minor siltstone, mudstone**
**Coal - Pikes Gully seam**
**Sandstone**
**Coal - Arties seam**
**Sandstone**
**Conglomerate, minor sandstone**
**Sandstone**
**Coal**

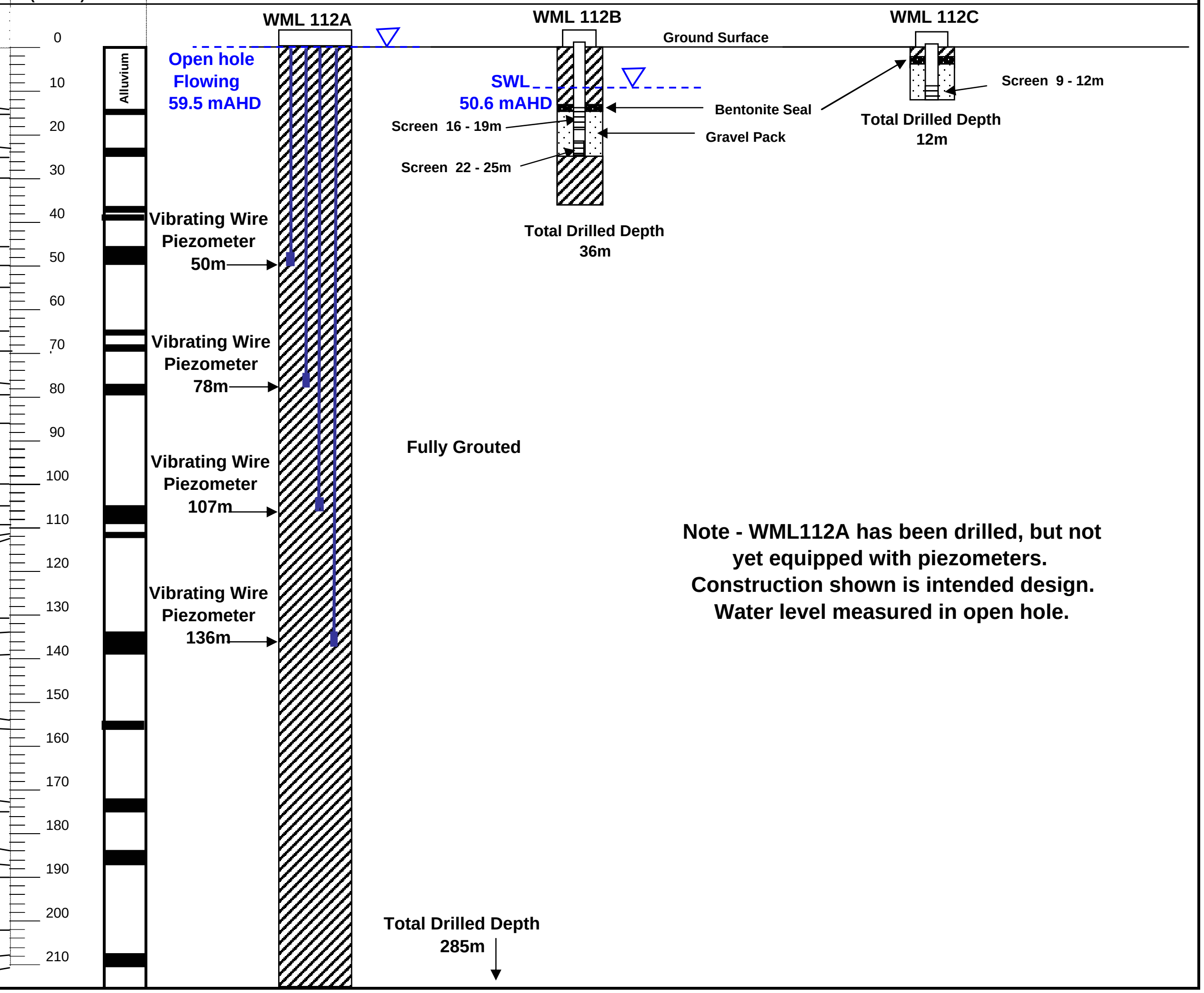



**Figure B-7: Logs WML112A, WML112B and WML112C**

*Peter Dundon and Assoc.*
*Logging Sheet*

# BORES: WML113A, WML113B and WML113C

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| **Ashton Coal Operations Pty Ltd** | **WML113A** | **60.20 mAHD** | | | **Hunter Drilling Services** | **10-May-06** | |
| Locationt: | **WML113B** | **60.20 mAHD** | **60.48 mAHD** | **0.28 m** | **Hunter Drilling Services** | **11-May-06** | |
| **Ashton Coal Project** | **WML113C** | **? mAHD** | **? m** | **? m** | **Hunter Drilling Services** | **?** | |
| | | | Hole depths: **As shown** | | | Supervised By: **R McCallum** | |

| Description | Depth (metres) | Well Construction Details: |
|---|---|---|

**Brown and dark brown alluvium**
**Grey sand- and siltstone with dark grey mudstone**
**Coal**
**Grey sand- and siltstone with mudstone**
**Multicolored conglomerate**
**Coal**
**Grey sand- and siltstone with pebbly conglomerate**
**Coal**
**Grey silt- and sandstone**
**Coal**
**Grey siltstone with grey sandstone**
**Pebbly conglomerate with little sand- and siltstone**
**Coal**
**Grey siltstone with grey sandstone**
**Coal**
**Grey siltstone and sandstone, with mudstone**
**Multicolored pebbly conglomerate**
**Coal**
**Grey sand and siltstone**

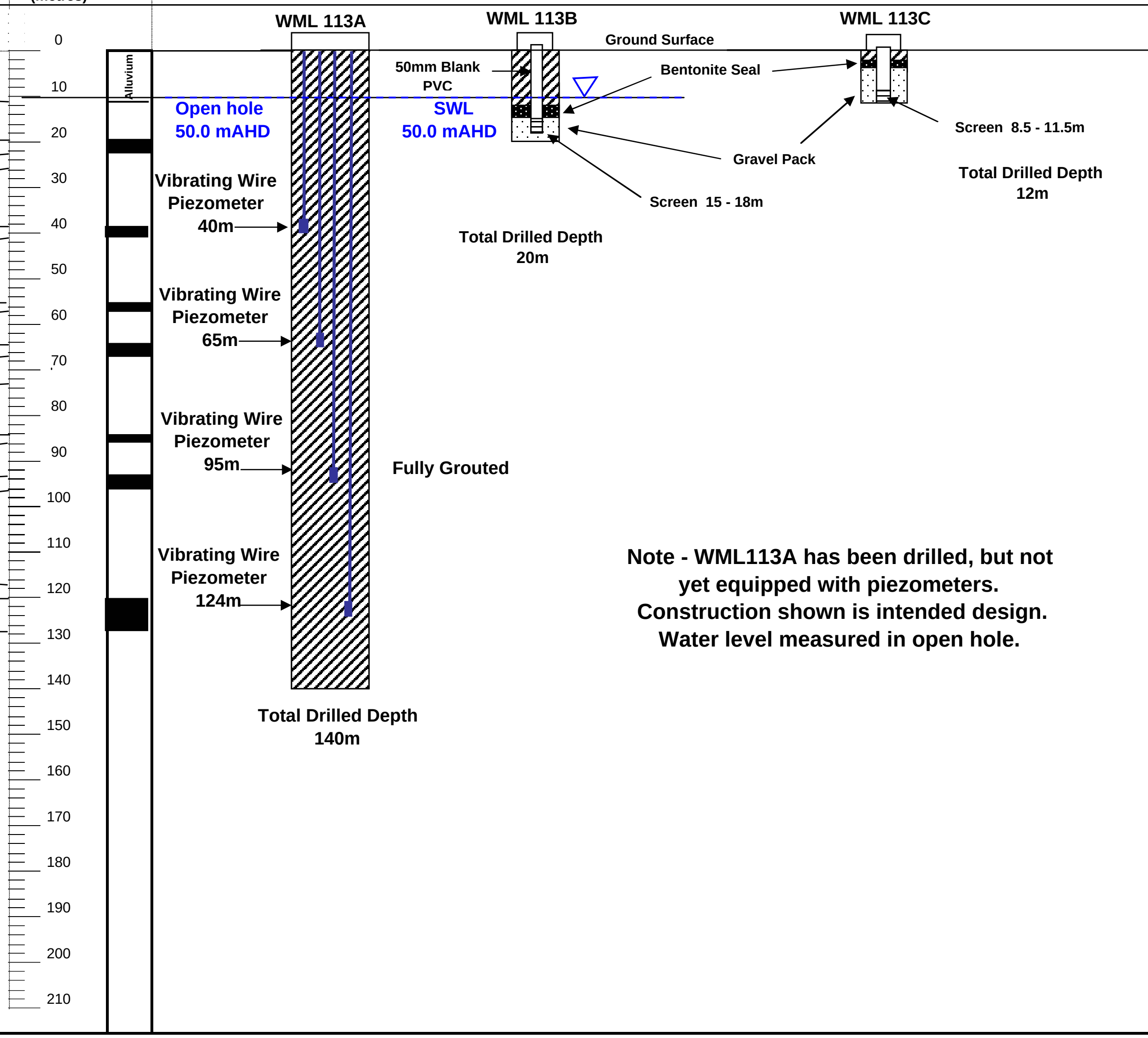



**Figure B-8: Logs WML113A, WML113B and WML113C**

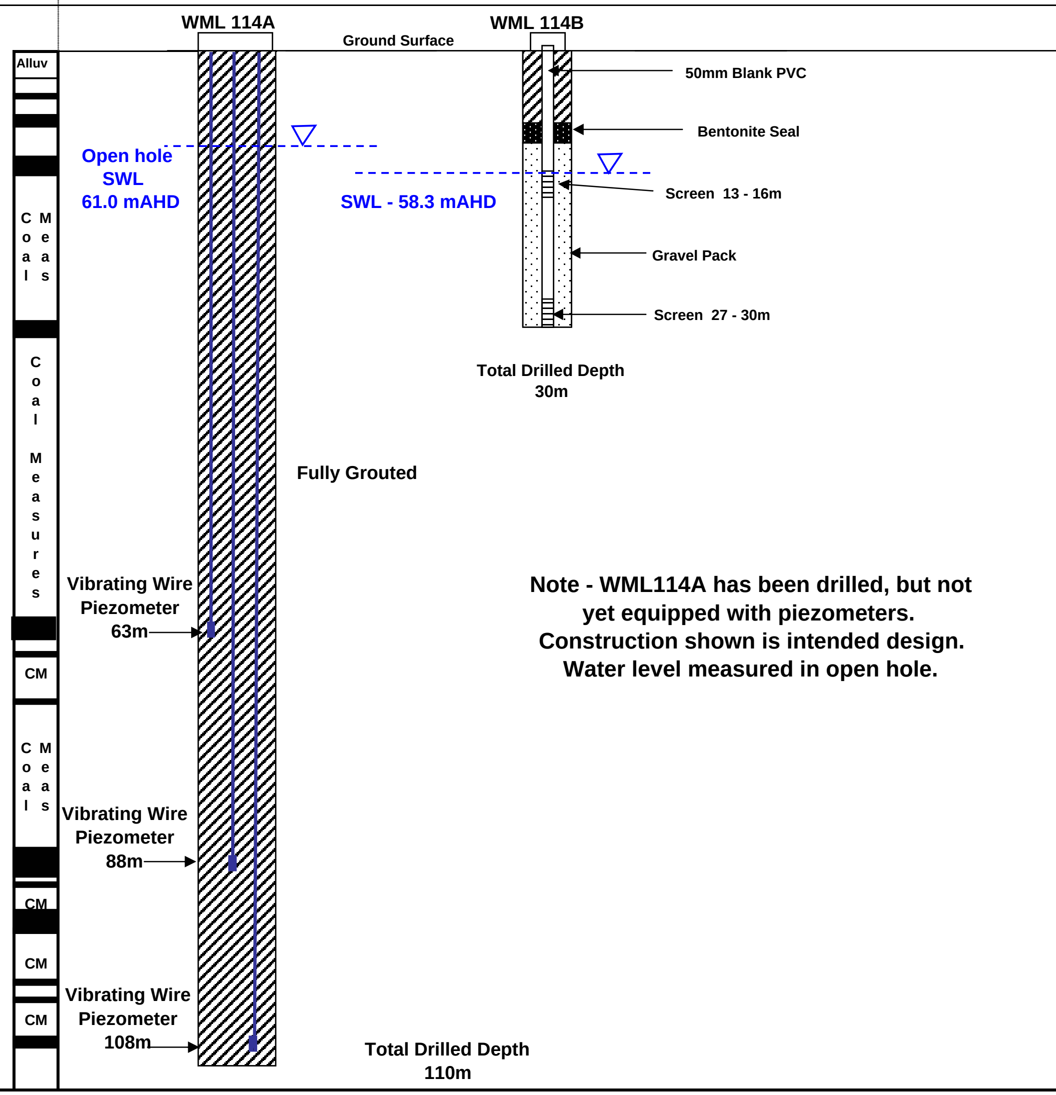
*Peter Dundon and Assoc.*
*Logging Sheet*

# BORES: WML114A and WML114B

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| Ashton Coal Operations Pty Ltd | WML114A | 71.53 mAHD | | | Hunter Drilling Services | 15-May-06 | |
| Locationt: | WML114B | 71.47 mAHD | 71.71 mAHD | 0.24 m | Hunter Drilling Services | 17-May-06 | |
| Ashton Coal Project | | | | | | | |
| | | | Hole depths: As shown | | | Supervised By: R McCallum | |

| Description | Depth (metres) |
|---|---|
| Brown clayey alluvium | |
| Highly weathered silt-, sand- and mudstone | |
| Coal | |
| Grey mudstone and siltstone | 10 |
| Coal | |
| Sandstone, minor siltstone | 20 |
| Siltstone | |
| Sandstone | |
| Coal | 30 |
| Siltstone, sandstone | 40 |
| Sandstone, minorsiderite, siltstone | |
| Conglomerate, minor siltstone | 50 |
| Coal | 60 |
| Sandstone, siltstone, mudstone, coal interbeds | |
| Siltstone | 70 |
| Sandstone, minor siltstone | 80 |
| Coal | 90 |
| Siltstone, sandstone | |
| Coal | |
| Siltstone, sandstone | 100 |
| Sandstone, siltstone, coal bands | |
| Coal | |
| Sandstone | 110 |

**Well Construction Details:**




**Note - WML114A has been drilled, but not yet equipped with piezometers. Construction shown is intended design. Water level measured in open hole.**

**Figure B-9: LOgs WML114A and WML114B**

*Peter Dundon and Assoc.*
*Logging Sheet*

# BORES: WML115A, WML115B and WML115C

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Project No: | 05-0166 |
| Client: | Bore: | Elevation (GL): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
| Ashton Coal Operations Pty Ltd | WML115A | 66.59 mAHD | | | Hunter Drilling Services | ? | |
| Locationt: | WML115B | 66.35 mAHD | ? mAHD | ? m | Hunter Drilling Services | ? | |
| Ashton Coal Project | WML115C | ? mAHD | ? m | ? m | Hunter Drilling Services | ? | |
| | | | Hole depths: As shown | | | Supervised By: R McCallum | |

| Description | Depth (metres) |
|---|---|
| Alluvium | |
| Sandstone | 10 |
| Coal | |
| Sandstone | 20 |
| Coal, siltstone | |
| Sandstone | 30 |
| Siltstone | |
| Interbedded sandstone, siltstone, siderite, coal | 40 |
| Coal | |
| Sandstone, minor siltstone | 50–60 |
| Conglomerate | |
| Sandstone | 70 |
| Coal | |
| Siltstone, minor coal, sandstone | 80 |
| Coal | |
| Sandstone | 90 |
| Coal | |
| Sandstone, some siltstone at base | 100 |
| Sandstone, minor coal bands | 110 |
| Siltstone, coal | 120 |
| Siltstone, sandstone | |
| Sandstone | 130 |
| Conglomerate, sandstone | |
| Sandstone | 140 |
| Coal | |
| Sandstone, siltstone bands | 150 |
| Coal | 160 |
| Sandstone, siltstone | 170 |
| Coal | |
| Sandstone | 180 |

Well Construction Details:

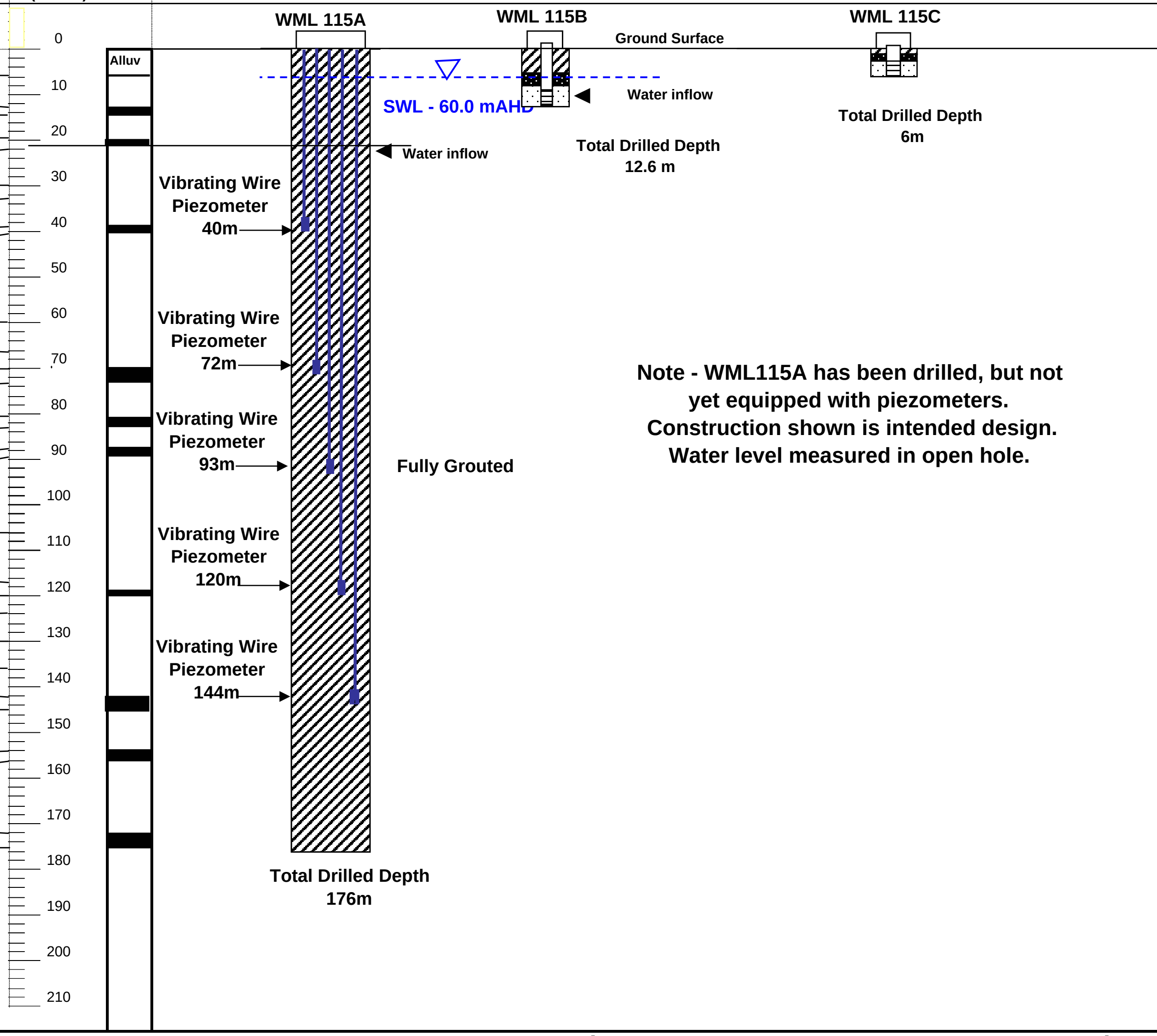



Figure B-10: Logs WML115A, WML115B and WML115C

*Peter Dundon and Assoc.*

*Logging Sheet*

# BORE: WML119

| | | | |
|---|---|---|---|
| | | Project No: | |
| Client: **Ashton Coal Operations Ltd** | Elevation (Concr): | **61.45 mAHD** | |
| | Elevation (TOC): | **61.85 mAHD** | |
| Location: **Ashton Coal** | Stickup: | **0.4 m** | |
| | Hole Depth: | **27.0 m** | |
| Drilling Contractor: **Hunter Drilling Services** | Date Started: | **08-Jun-06** | Supervised By: |
| | Date Completed: | **08-Jun-06** | **Steve Collett** |

| Description | Depth (metres) | Well Construction Details: |
|---|---|---|

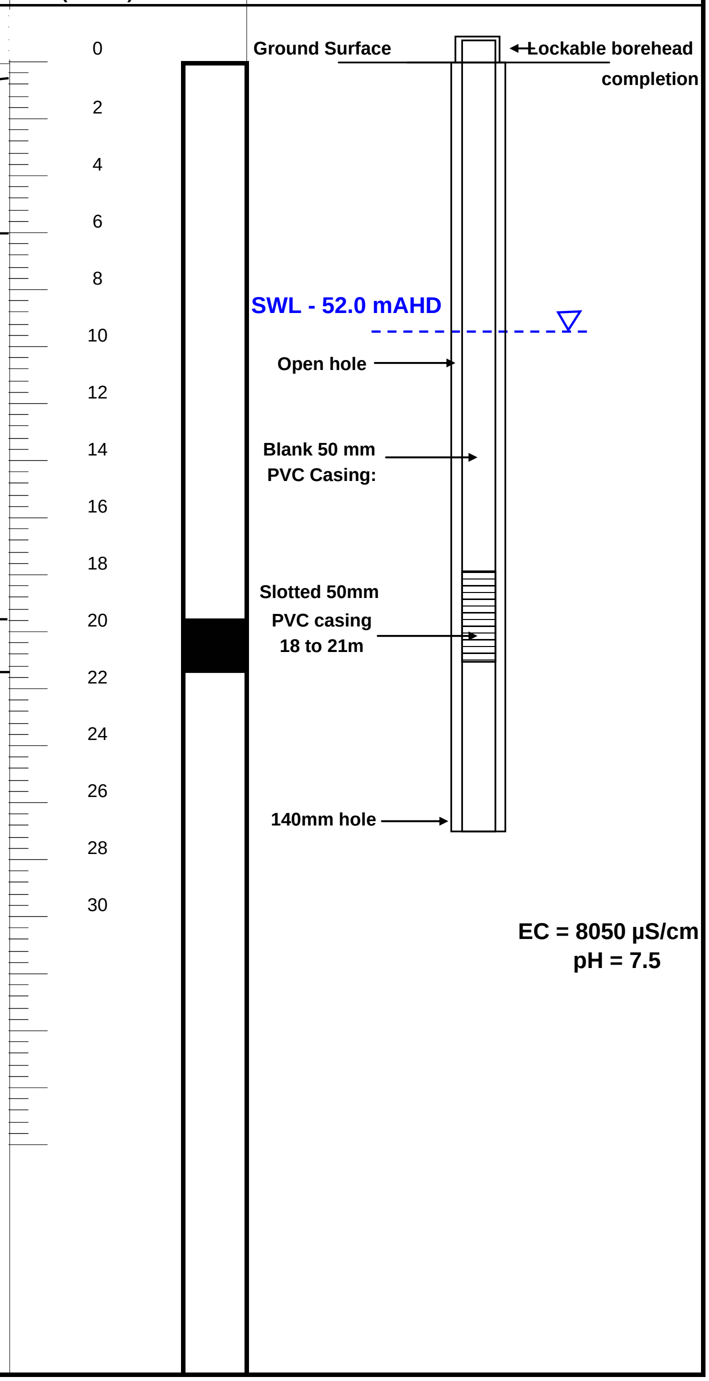
**Topsoil**

**Sandstone - yellow oxidized fine grain**

**Sandstone/siltstone/conglomerate - light grey sequence of fine grain sandstone /siltstone and conglomerate**

**Pikes Gully Coal - black , distinctive water**

**Sandstone - grey fine grained arkose**




**EC = 8050 µS/cm**
**pH = 7.5**

**Figure B-11: Log WML119**

*Peter Dundon and Associates Pty Ltd*

*Logging Sheet*

# BORES: WML120A and WML120B

| | |
|---|---|
| Project No: | 05-0166 |

| Client: | Bore: | Elevation (Concrete): | Elevation (TOC): | Stickup: | Drilling Contractor: | Date Started: | Date Finished: |
|---|---|---|---|---|---|---|---|
| Ashton Coal | WML120A | 60.35 mAHD | 60.95 mAHD | 0.595 m | Hunter Drilling Services | 8-Jun-06 | 14-Jun-06 |
| Location: | WML120B | 60.12 mAHD | 60.51 mAHD | 0.389 m | Hunter Drilling Services | 8-Jun-06 | 14-Jun-06 |
| Ashton Coal | | NB elevation from handheld GPS | | | | | |
| | | | Hole depths: As shown | | | Supervised By: Steve Collett | |

| Description | Depth (metres) |
|---|---|
| Alluvium, dark brown silty clay | 0 – 3 |
| Alluvium, brown silty clay | 3 – 7 |
| Alluvium, light brown sands. Sands poorly sorted. In sample but likely moderately sorted thin beds of medium the gravelly sands. Yields water from this section | 7 – 8.5 |
| Sandstone, yellow weathered Permian Sandstone | 8.5 – 9 |
| Sandstone, grey very fine grained sandstone, hard cemented. Laminated structure with some coal fragments | 9 – 12.5 |
| Pikes Gully Coal, black, vitreous hard coal. Prone to fretting so perhaps slightly oxidised | 12.5 – 14 |
| Sandstone, grey fine grained sandstone of arkosic composition | 14 – |

Well Construction Details:

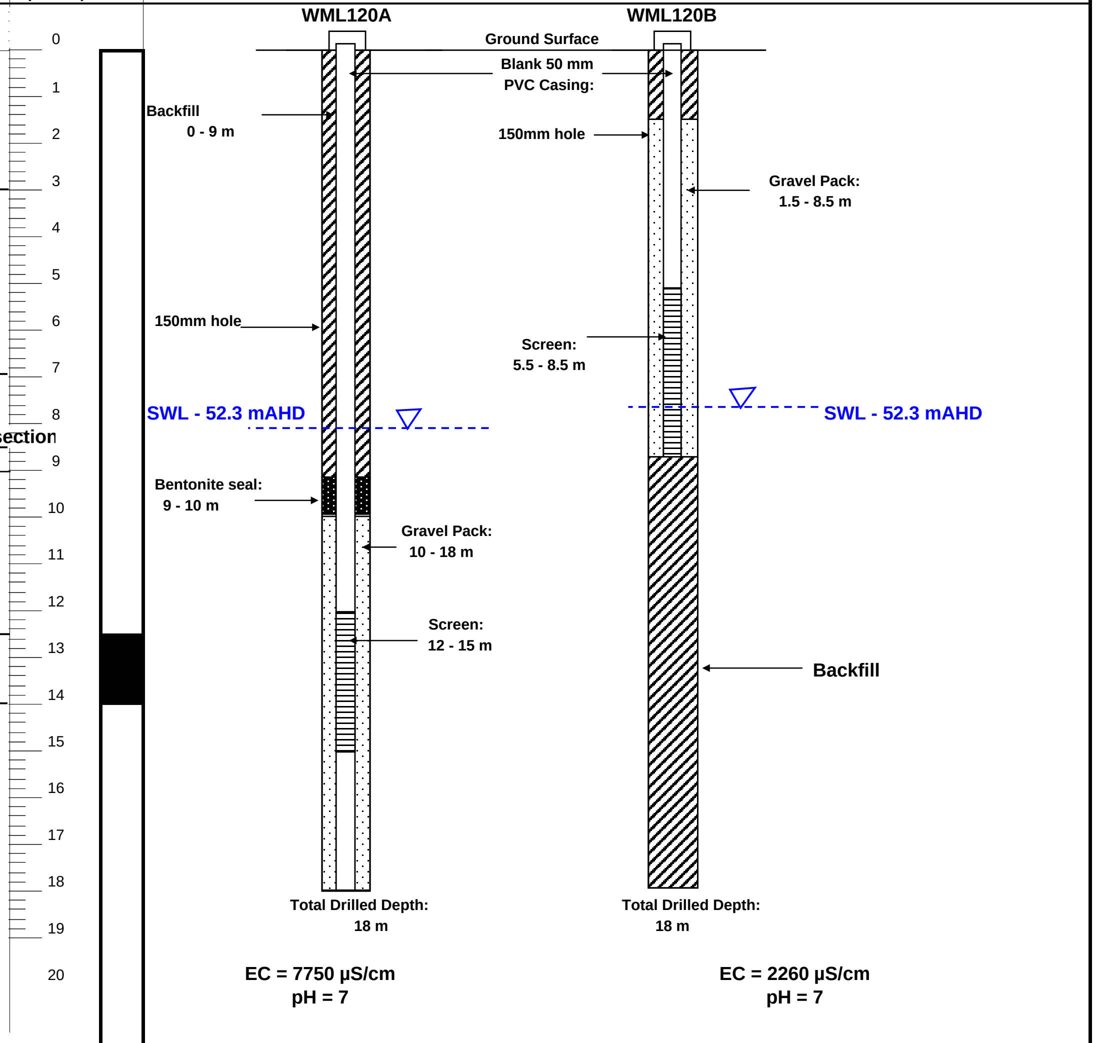



**Figure B-12: Logs WML120A and WML120B**

*Peter Dundon and Assoc.*

*Logging Sheet*

## BORE: Bowman Creek "Oxbow"

| | | | | |
|---|---|---|---|---|
| | | | Project No: | 05-0156 |
| Client: Ashton Coal | Elevation (Concr): | 64 mAHD | | |
| | Elevation (TOC): | | | |
| Location: Ashton Coal | Stickup: | | | |
| | Hole Depth: | 11.5 m | | |
| Drilling Contractor: Hunter Drilling Services | Date Started: | 08-Jun-06 | Supervised By: | |
| | Date Completed: | 08-Jun-06 | | Steve Collett |

| Description | Depth (metres) |
|---|---|
| | 0 |
| Topsoil | 2 |
| Sandstone - yellow oxidized fine grain, slighty clayey Moist sample from 5m | 4 |
| | 6 |
| Sandstone, very hard | 8 |
| Carbonaceous shale, oxidised and damp | 10 |
| Sandstone, grey thinly bedded sandstone and soft siltstone | 12 |
| | 14 |
| | 16 |
| | 18 |
| | 20 |
| | 22 |
| | 24 |
| | 26 |
| | 28 |
| | 30 |

Well Construction Details:

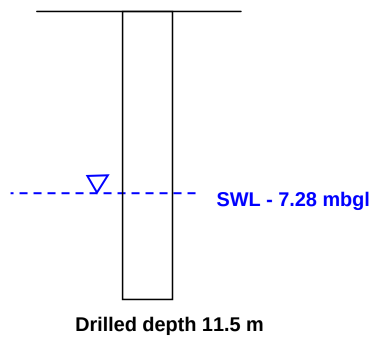



**Figure B-13: Log "Oxbow"**

# ANNEXURE C

## HYDRAULIC TESTING RESULTS

## Hydraulic Testing Relevant to SMP Area

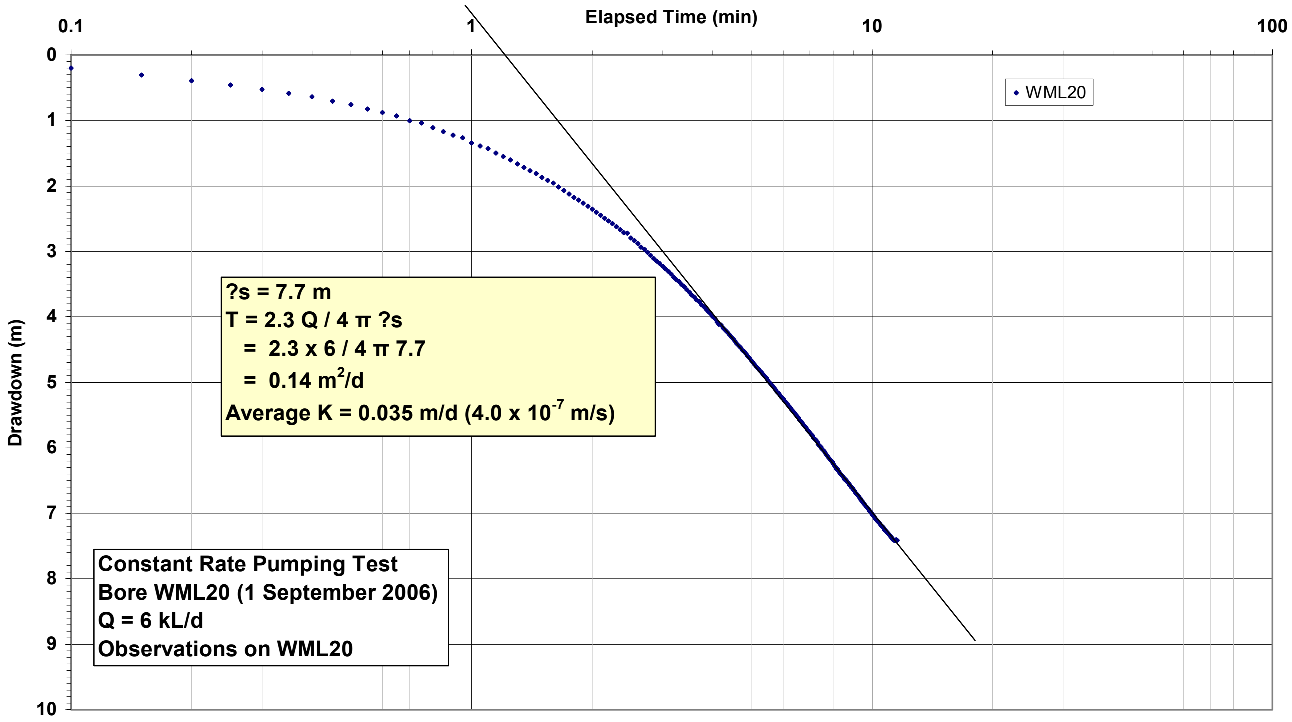
The results of hydraulic testing of the Pikes Gully seam aquifer and Bowmans Creek alluvium are summarised below:

**Table C-1: Hydraulic Testing Program – SMP Longwalls 1 to 4**

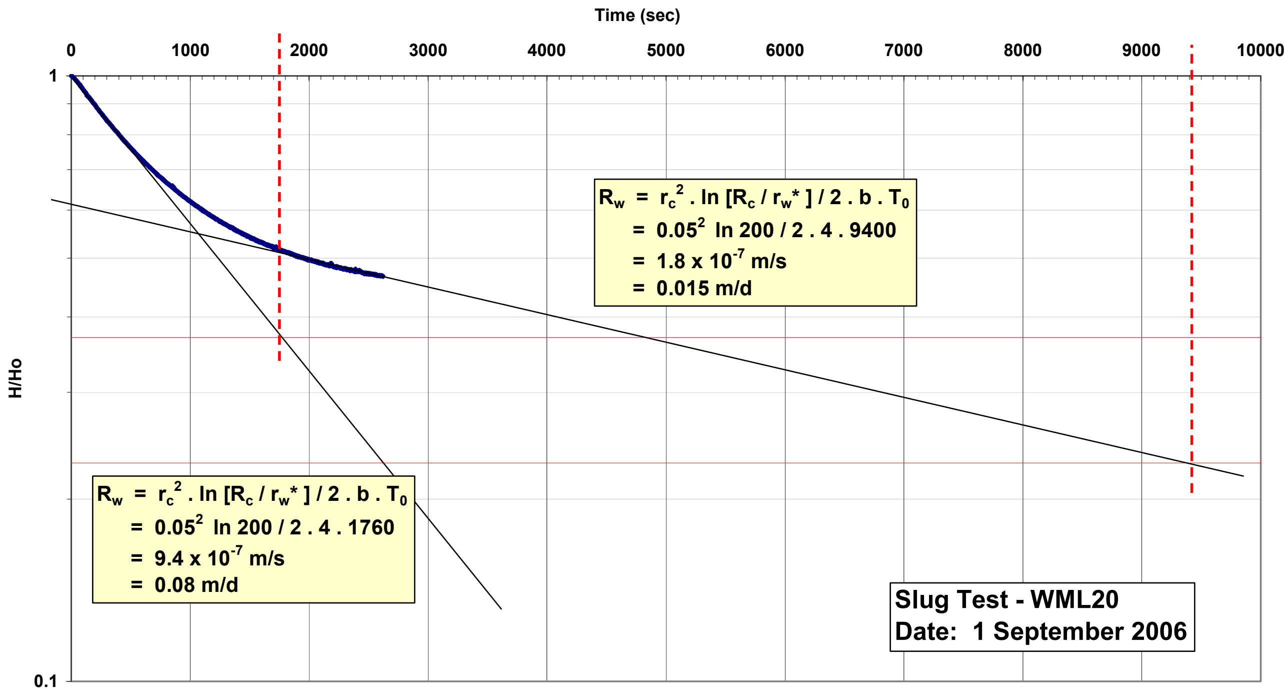
| Bore | Location (see Figure 2) | Date | Test Interval | Hydraulic Conductivity | |
|---|---|---|---|---|---|
| | | | m | m/d | m/s |
| *Pikes Gully Seam* | | | | | |
| WML20 | S end LW4 | 1 Sept 2006 | 114-118 | 0.04 | $4 \times 10^{-7}$ |
| WML21 | N end LW5 | 1 Sept 2006 | 106-112 | 0.02 | $2 \times 10^{-7}$ |
| WML119 | E of LW1 (S end) | 15 June 2006 | 18-21 | 0.1 | $1 \times 10^{-6}$ |
| WML120B | E of LW1 (N end) | 15 June 2006 | 12-15 | 10 | $1 \times 10^{-4}$ |
| *Bowmans Creek Alluvium* | | | | | |
| PB1 | Centre of LW8 | 2001 | 5.4-7.6 | 0.94 | $1 \times 10^{-5}$ |
| PB2 | N end LW5 | 2001 | 4.8-7.0 | 0.48 | $6 \times 10^{-6}$ |
| *Glennies Creek Alluvium* | | | | | |
| WML120A | E of LW1 (N end) | 15 June 2006 | 5.5-8.5 | 5 | $6 \times 10^{-5}$ |

Plots of the pumping test results for the 2006 testing program are presented as **Figures C-1 to C-5**. Pumping test plots for PB1 and PB2 are presented in the EIS (HLA, 2001).

## CONSTANT RATE TEST - WML20

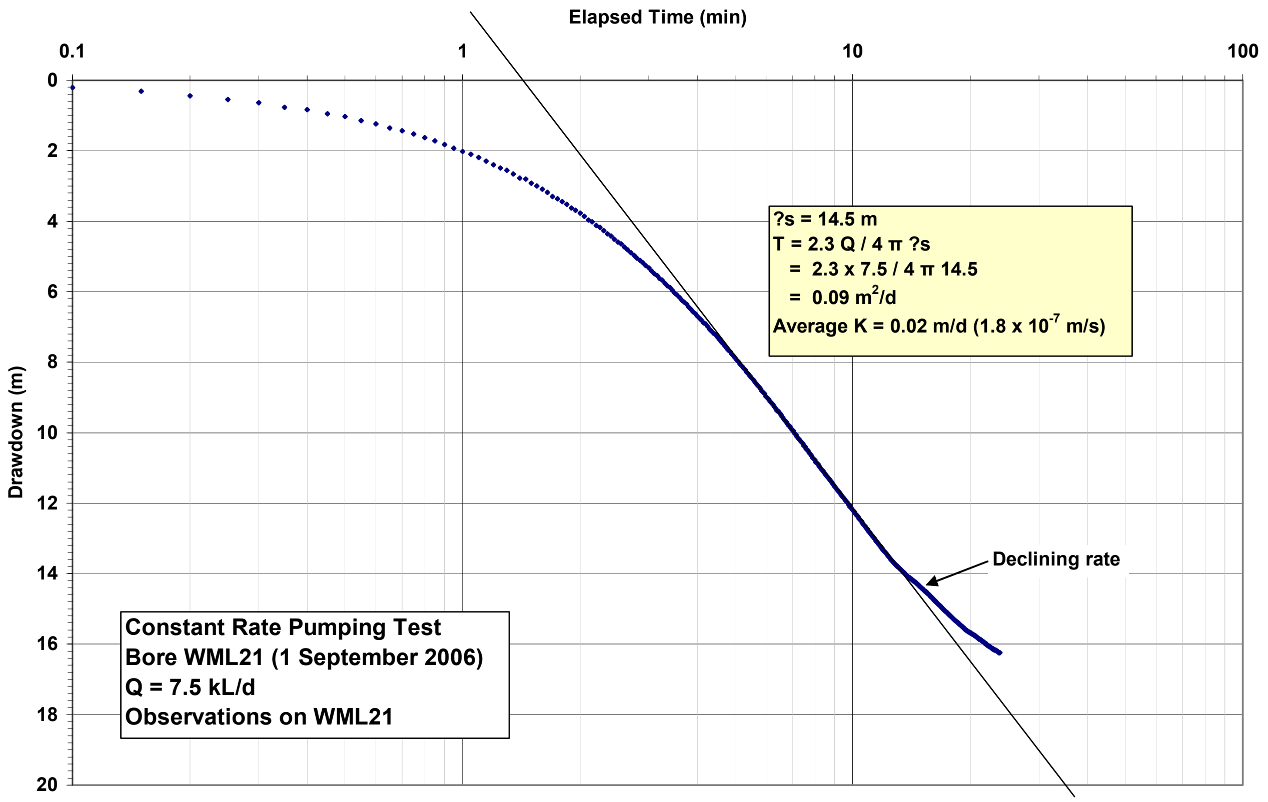



## SLUG TEST - WML20

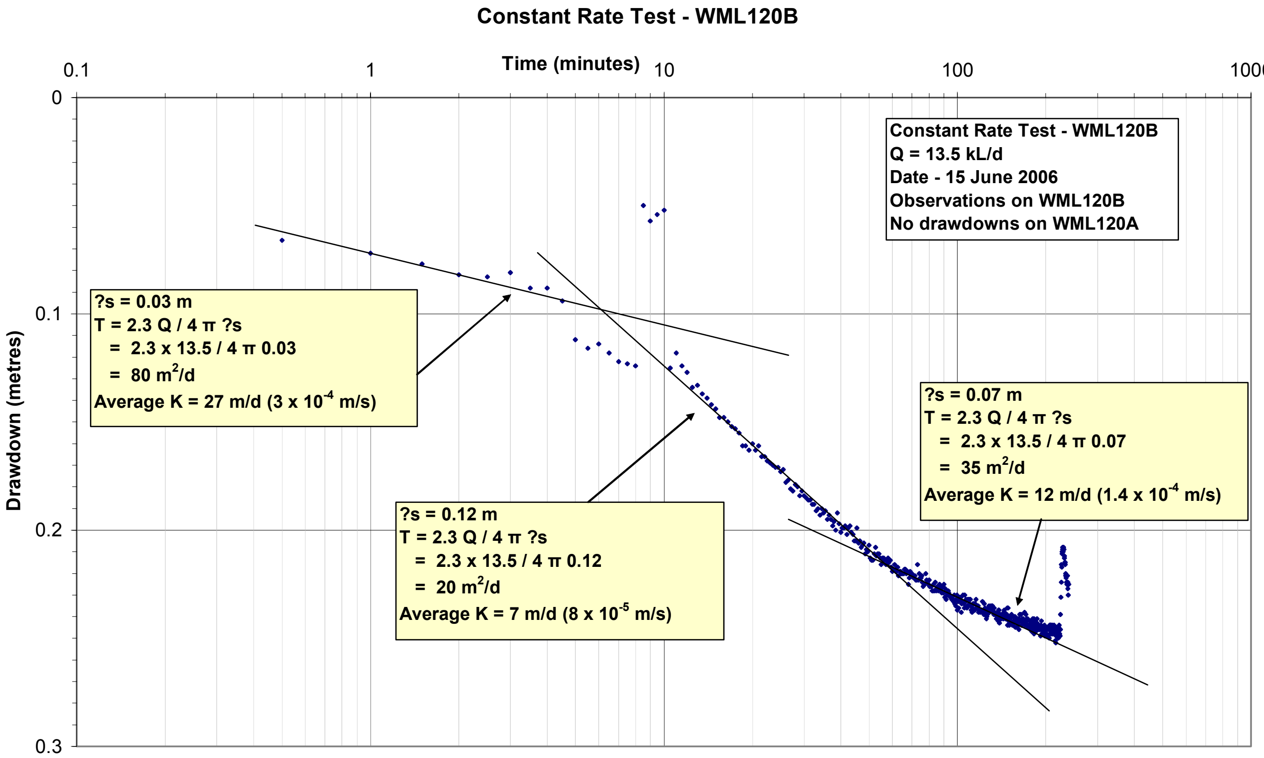


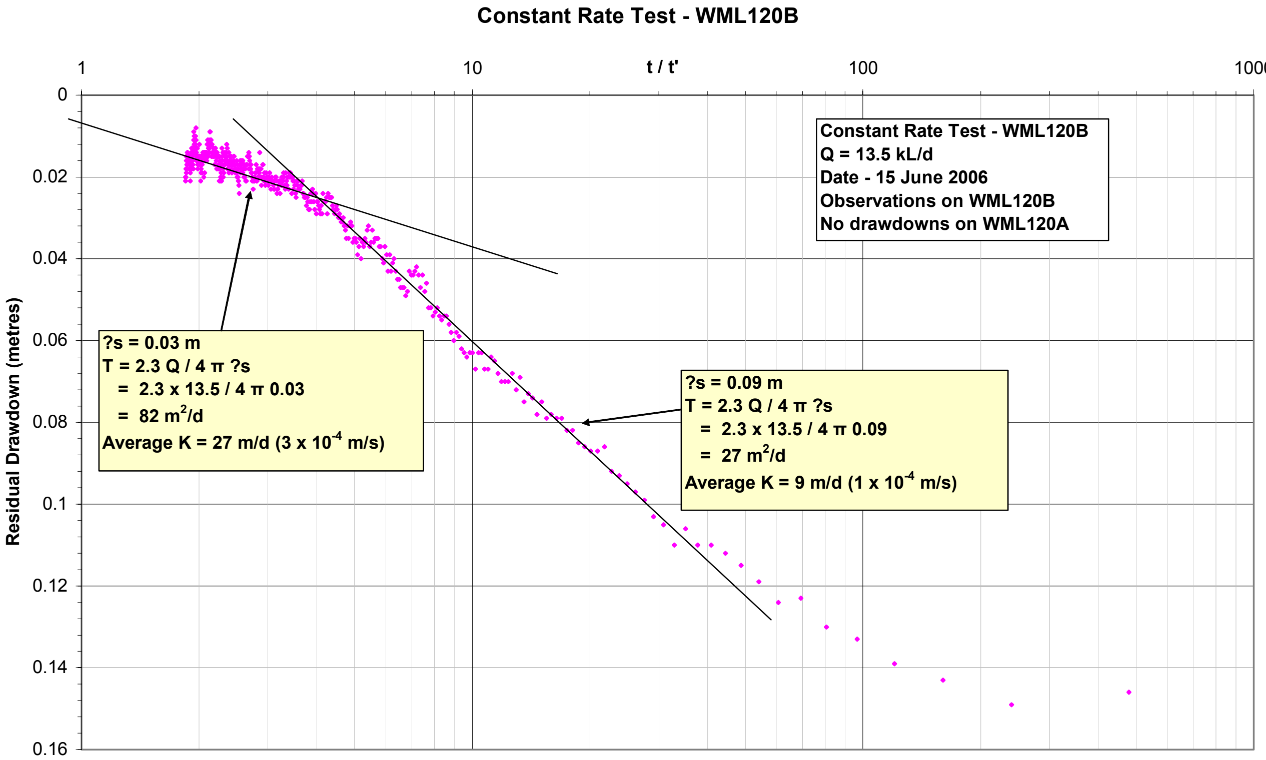

| | | | | |
|---|---|---|---|---|
| Date: | 15 September 2006 | Scale: | as indicated | **Ashton Coal Operations Ltd** |
| Initials: | PJD | Job No: | 05-0166 | **SMP - LONGWALLS 1 to 4** |
| Drawing No: | 05-0166-104B | Rev: | B | **HYDRAULIC ANALYSIS** |
| **Peter Dundon and Associates Pty Limited** | | | | **WML20 (Pikes Gully Seam)** — **Figure C-1** |

CONSTANT RATE TEST - WML21

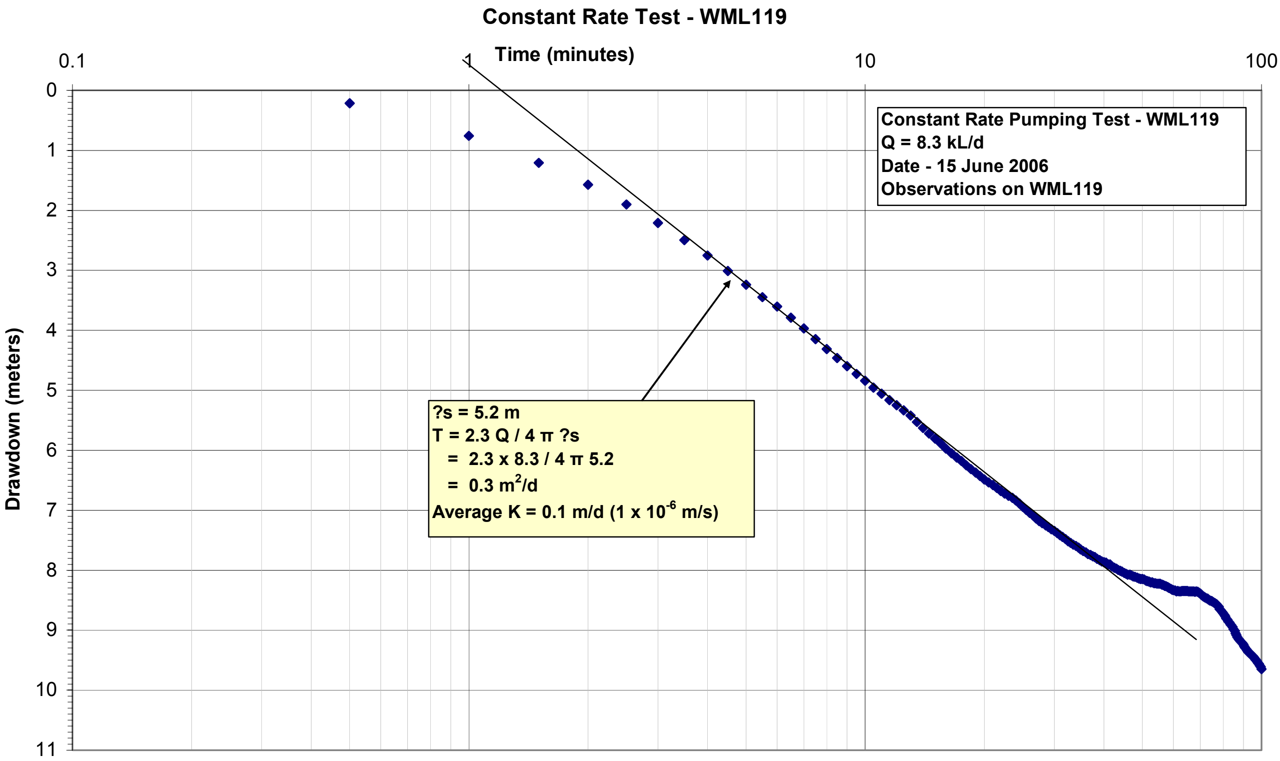


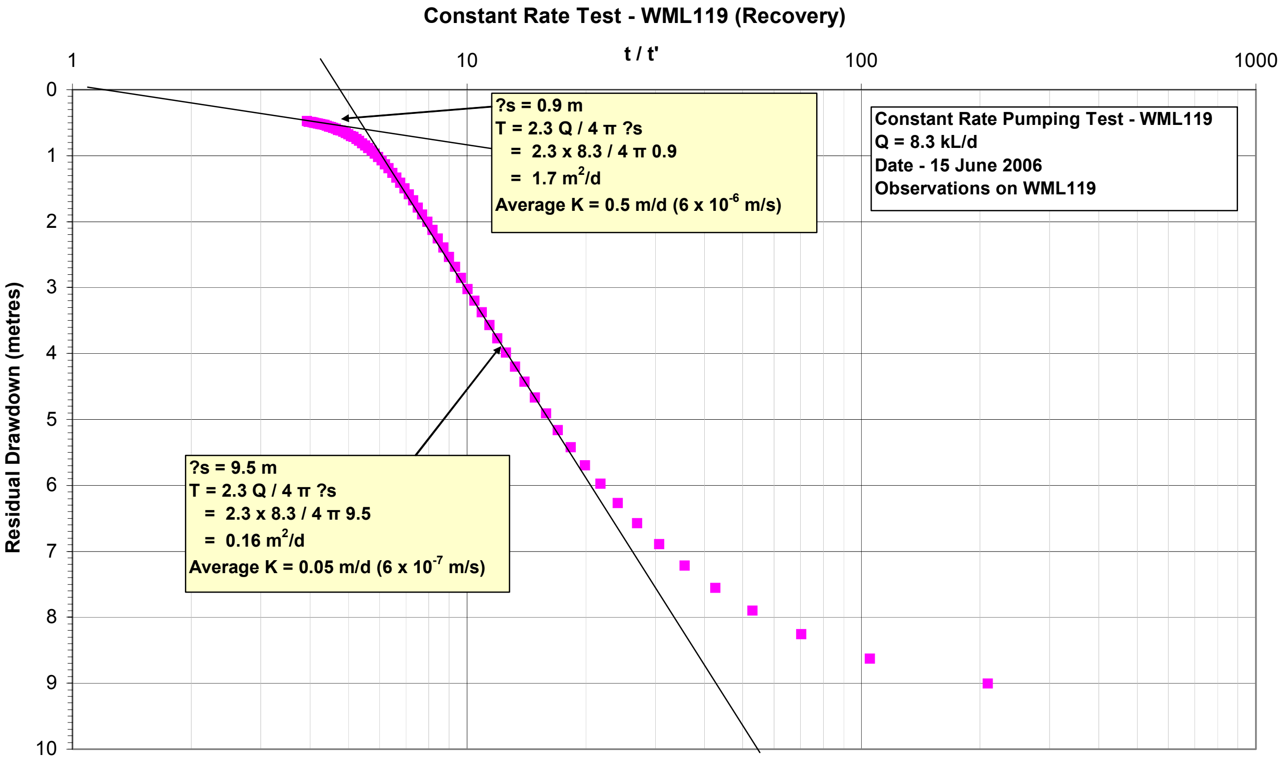

| | | | | |
|---|---|---|---|---|
| Date: | 15 September 2006 | Scale: | as indicated | **Ashton Coal Operations Ltd** |
| Initials: | PJD | Job No: | 05-0166 | **SMP - LONGWALLS 1 to 4**<br>**PUMPING TEST ANALYSIS**<br>**WML21 (Pikes Gully Seam)** |
| Drawing No: | 05-0166-105B | Rev: | B | |
| **Peter Dundon and Associates Pty Limited** | | | | **Figure C-2** |



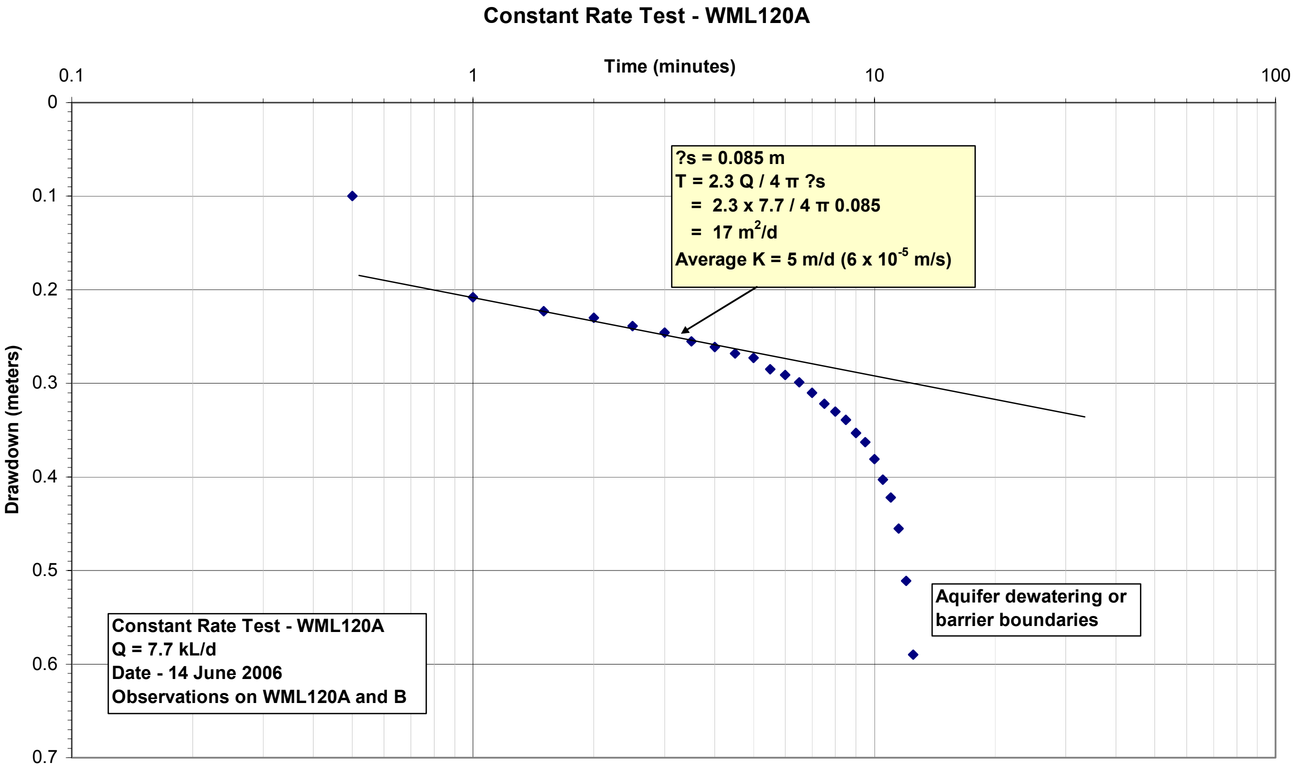



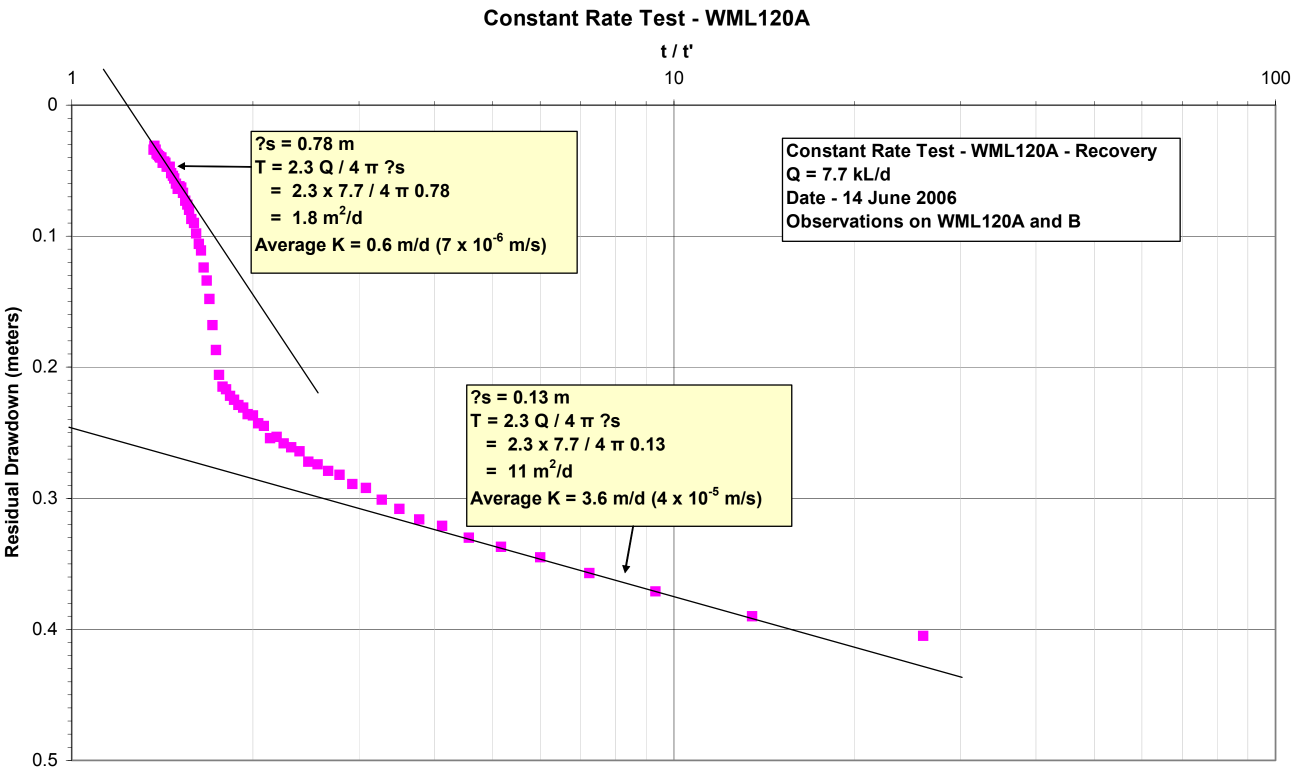

| | | |
|---|---|---|
| Date: 15 September 2006 | Scale: as indicated | **Ashton Coal Operations Ltd** |
| Initials: PJD | Job No: 05-0166 | **SMP - LONGWALLS 1 to 4 PUMPING TEST ANALYSIS WML120B (Pikes Gully Seam)** |
| Drawing No: 05-0166-102C | Rev: C | |
| **Peter Dundon and Associates Pty Limited** | | **Figure C-3** |




| | | | |
|---|---|---|---|
| Date: 15 September 2006 | Scale: as indicated | **Ashton Coal Operations Ltd** | |
| Initials: PJD | Job No: 05-0166 | **SMP - LONGWALLS 1 to 4<br>PUMPING TEST ANALYSIS<br>WML119 (Pikes Gully Seam)** | |
| Drawing No: 05-0166-103C | Rev: C | | |
| **Peter Dundon & Associates Pty Limited** | | | **Figure C-4** |




| | | |
|---|---|---|
| Date: 15 September 2006 | Scale: as indicated | **Ashton Coal Operations Ltd** |
| Initials: PJD | Job No: 05-0166 | **SMP - LONGWALLS 1 to 4** **PUMPING TEST ANALYSIS** **WML120A (Glennies Ck Alluvium)** |
| Drawing No: 05-0166-101C | Rev: C | |
| **Peter Dundon and Associates Pty Limited** | | **Figure C-5** |

# ANNEXURE D

## GROUNDWATER QUALITY MONITORING DATA

All relevant groundwater quality data obtained either from investigation programs or from the baseline monitoring program are detailed in **Table D-1**.

**Table D-1: Groundwater Sample Analysis Results**
**(page 1 of 7)**

| Bore / Well / Spring / Soak | | | | Ashton Well | RSMG1 | | | | | | | | | | | | | | | | | | | | | | | | | | RM01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer | | | | Bowmans Creek Alluvium | Coal Measures (Ravensworth Seam) | | | | | | | | | | | | | | | | | | | | | | | | | | B C Alluvium + Permian |
| Parameter | Units | LOR | ANZECC (2000) Guideline Value for Freshwater Ecosystem Protection | 22-Nov-00 | 22-Nov-00 | 20-Jun-01 | 18-Jul-01 | 01-Sep-02 | 16-Oct-02 | 01-Nov-02 | 01-Dec-02 | 01-Jan-03 | 01-Feb-03 | 01-Mar-03 | 01-Apr-03 | 01-May-03 | 19-Jun-03 | 19-Jul-03 | 01-Aug-03 | 01-Nov-03 | 01-Feb-04 | 01-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-May-05 | 01-Aug-05 | 01-Nov-05 | 01-Mar-06 | 01-May-06 | 29-Nov-00 |
| pH Value (field) | | 0.01 | | | | 7.25 | 7.21 | 6.83 | 6.84 | 6.8 | 6.98 | 7.35 | 6.93 | 8 | 7.49 | 8.13 | 7.00 | 7.11 | 6.88 | | | | | 6.87 | 7.17 | 7.82 | 8.14 | 7.01 | 6.98 | 6.92 | 8.64 |
| Conductivity (field) | µS/cm | 0 | | 1053 | 9520 | 5720 | 8670 | 9890 | 10200 | 9870 | 5830 | 9630 | 10800 | 9930 | 10100 | 9880 | 10300 | 10200 | 10400 | 10200 | 9960 | 10000 | 10300 | 10900 | 9050 | 5480 | 8720 | 11000 | 8900 | 8000 | 3170 |
| Lab Conductivity @ 25°C | µS/cm | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids (TDS) | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | 5460 | 6340 | 3140 | 6120 | 6620 | 7040 | 6880 | 1780 |
| Calcium | mg/L | 1 | | | | 139 | 172 | 187 | 182 | 194 | 97 | 174 | 181 | 184 | 182 | 174 | 190 | 187 | 174 | | | | | | | | | | | | 53 |
| Magnesium | mg/L | 1 | | | | 157 | 226 | 252 | 239 | 237 | 115 | 211 | 232 | 233 | 228 | 228 | 224 | 233 | 224 | | | | | | | | | | | | 33 |
| Sodium | mg/L | 1 | | | | 1470 | 1630 | 1670 | 1640 | 1840 | 958 | 1640 | 1670 | 1590 | 1680 | 1590 | 1840 | 1760 | 1730 | | | | | | | | | | | | 589 |
| Potassium | mg/L | 1 | | | | 11 | 5 | 4 | 3 | 4 | 2 | 1 | 2 | 2 | 2 | 1 | 3 | 4 | 4 | | | | | | | | | | | | 8 |
| Carbonate as CaCO3 | mg/L | 1 | | | | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | | | | | | | | | | | | 50 |
| Bicarbonate as CaCO3 | mg/L | 1 | | | | 581 | 365 | 631 | 626 | 618 | 360 | 629 | 618 | 611 | 643 | 623 | 584 | 640 | 656 | | | | | | | | | | | | 104 |
| Sulphate | mg/L | 1 | | | | 514 | 557 | 567 | 558 | 548 | 290 | 495 | 549 | 551 | 523 | 552 | 561 | 502 | 535 | | | | | | | | | | | | 70 |
| Chloride | mg/L | 1 | | | | 2120 | 2680 | 2880 | 3080 | 3000 | 1490 | 2610 | 2760 | 2790 | 2720 | 3100 | 3120 | 3080 | 2850 | | | | | | | | | | | | |
| Silica | | | | | | 72.3 | 76.2 | 75.8 | 75.1 | 35.3 | 53.5 | 66.7 | 78.1 | 72.6 | 81.1 | 77 | 82.2 | 76.9 | 77.2 | | | | | | | | | | | | 44.1 |
| Arsenic - Filtered | mg/L | 0.001 | 0.013 | | | <0.01 | <0.01 | 0.001 | 0.002 | 0.003 | <0.01 | 0.003 | 0.003 | 0.002 | 0.003 | <0.001 | 0.002 | 0.004 | <0.001 | | | | | | | | | | | | |
| Cadmium - Filtered | mg/L | 5E-05 | 0.0002 | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.005 | <0.001 | <0.001 | 0.0002 | 0.0004 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | | |
| Chromium - Filtered | mg/L | 0.002 | ID | | | 0.015 | <0.005 | <0.005 | <0.001 | 0.141 | 0.02 | <0.005 | 0.003 | 0.004 | <0.001 | <0.005 | <0.005 | <0.005 | <0.001 | | | | | | | | | | | | |
| Copper - Filtered | mg/L | 0.0005 | 0.0014 | | | 0.014 | 0.007 | 0.003 | 0.003 | 0.005 | 0.03 | 0.004 | 0.007 | 0.004 | 0.002 | 0.003 | 0.003 | 0.003 | 0.005 | | | | | | | | | | | | |
| Nickel - Filtered | mg/L | 0.001 | 0.011 | | | 0.011 | 0.004 | 0.002 | 0.002 | 0.003 | <0.01 | <0.001 | 0.004 | 0.003 | 0.003 | 0.005 | 0.004 | 0.004 | 0.002 | | | | | | | | | | | | |
| Lead - Filtered | mg/L | 5E-05 | 0.0034 | | | 0.013 | 0.008 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 | 0.007 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | | |
| Zinc - Filtered | mg/L | 0.005 | 0.008 | | | 0.044 | 0.024 | 0.009 | 0.03 | 0.023 | 0.04 | 0.008 | 0.031 | 0.014 | 0.01 | 0.014 | 0.009 | 0.012 | 0.017 | | | | | | | | | | | | |
| Mercury - Filtered | mg/L | 0.0001 | 0.00006 | | | <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 | | | | | | | | | | | | |
| Nitrate as N | mg/L | 0.01 | 0.7 | | | 2.76 | 3.03 | 2.57 | 2.45 | 2.46 | 6 | 3.04 | 2.99 | 2.18 | 2.08 | 2.00 | 1.06 | 2.00 | 1.92 | | | | | | | | | | | | <0.01 |

| Bore / Well / Spring / Soak | | | | RM02 | | | | | RM04 | | | | | | | | | | | | | | | | | | RM05 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer | | | | B C Alluvium + Permian | | | | | Bowmans Creek Alluvium | | | | | | | | | | | | | | | | | | Permian | | | | | | |
| Parameter | Units | LOR | ANZECC (2000) Guideline Value for Freshwater Ecosystem Protection | 29-Nov-01 | 01-Nov-04 | 01-Feb-05 | 01-Aug-05 | 01-Mar-06 | 28-Nov-00 | 26-Jul-01 | 18-Sep-02 | 16-Oct-02 | 01-Nov-02 | 01-Dec-02 | 01-Jan-03 | 01-Feb-03 | 01-Mar-03 | 01-Apr-03 | 01-May-03 | 19-Jun-03 | 19-Jul-03 | 01-Aug-03 | 01-Nov-04 | 01-Feb-05 | 01-May-05 | 01-Mar-06 | 29-Nov-00 | 22-Nov-03 | 29-Nov-03 | 01-Nov-04 | 02-Feb-05 | 06-May-05 | 01-Mar-06 |
| pH Value (field) | | 0.01 | | 7.31 | 6.71 | 6.88 | 7.87 | 6.76 | 7.34 | 6.96 | 7.1 | 7.06 | 7.1 | 7.23 | 7.5 | 7.11 | 8.06 | 7.55 | 8.18 | 7.30 | 7.38 | 7.12 | 7.04 | 7.22 | 8.17 | 7.14 | 7.04 | | | 6.53 | 6.83 | 8 | 6.81 |
| Conductivity (field) | µS/cm | 0 | | 7340 | 8400 | 7130 | 6060 | 4830 | 1040 | 961 | 1040 | 1050 | 1070 | 1080 | 1070 | 1110 | 1120 | 1150 | 1160 | 1180 | 1190 | 1240 | 1600 | 1580 | 722 | 1560 | 2460 | 2245 | 2172 | 2460 | 2550 | 1070 | 2270 |
| Lab Conductivity @ 25°C | µS/cm | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids (TDS) | mg/L | 1 | | 5930 | | | | | 648 | | | | | | | | | | | | | | | | | | 1670 | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Calcium | mg/L | 1 | | 170 | | | | | 51 | 38 | 43 | 37 | 37 | 39 | 39 | 39 | 44 | 44 | 43 | 47 | 46 | 45 | | | | | 46 | | | | | | |
| Magnesium | mg/L | 1 | | 236 | | | | | 21 | 17 | 18 | 18 | 17 | 19 | 18 | 19 | 23 | 19 | 21 | 23 | 24 | 22 | | | | | 44 | | | | | | |
| Sodium | mg/L | 1 | | 1130 | | | | | 139 | 154 | 144 | 133 | 188 | 161 | 146 | 141 | 129 | 140 | 132 | 200 | 172 | 173 | | | | | 452 | | | | | | |
| Potassium | mg/L | 1 | | 9 | | | | | 4 | 4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | | | | | 6 | | | | | | |
| Carbonate as CaCO3 | mg/L | 1 | | <1 | | | | | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 4 | | | | | <1 | | | | | | |
| Bicarbonate as CaCO3 | mg/L | 1 | | 135 | | | | | 210 | 231 | 216 | 196 | 221 | 206 | 205 | 202 | 183 | 202 | 202 | 202 | 220 | 204 | | | | | 371 | | | | | | |
| Sulphate | mg/L | 1 | | 602 | | | | | 18 | 67 | 75 | 73 | 77 | 77 | 73 | 79 | 78 | 77 | 78 | 80 | 76 | 76 | | | | | 107 | | | | | | |
| Chloride | mg/L | 1 | | 1820 | | | | | 164 | 148 | 160 | 170 | 180 | 163 | 163 | 160 | 174 | 152 | 205 | 234 | 229 | 234 | | | | | 468 | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Silica | | | | 34.4 | | | | | 24.7 | 20 | 21.6 | 20.9 | 9.9 | 20.8 | 20.3 | 24 | 20.6 | 24.9 | 21.4 | 23.1 | 22.0 | 22.9 | | | | | 38.3 | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic - Filtered | mg/L | 0.001 | 0.013 | | | | | | | <0.01 | 0.002 | <0.001 | 0.002 | <0.01 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | | | | | | | | | | | |
| Cadmium - Filtered | mg/L | 5E-05 | 0.0002 | | | | | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.005 | <0.001 | <0.001 | <0.0001 | <0.0001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Chromium - Filtered | mg/L | 0.002 | ID | | | | | | | <0.001 | <0.001 | <0.001 | 0.003 | <0.01 | <0.005 | 0.003 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Copper - Filtered | mg/L | 0.0005 | 0.0014 | | | | | | | 0.004 | <0.001 | 0.003 | <0.001 | 0.05 | 0.004 | 0.14 | 0.003 | 0.005 | 0.003 | 0.011 | 0.003 | 0.008 | | | | | | | | | | | |
| Nickel - Filtered | mg/L | 0.001 | 0.011 | | | | | | | 0.008 | 0.006 | 0.009 | 0.003 | 0.01 | 0.004 | 0.015 | 0.008 | 0.007 | 0.008 | 0.009 | 0.007 | 0.009 | | | | | | | | | | | |
| Lead - Filtered | mg/L | 5E-05 | 0.0034 | | | | | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 | 0.015 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Zinc - Filtered | mg/L | 0.005 | 0.008 | | | | | | | 0.01 | 0.005 | 0.031 | <0.005 | 0.04 | 0.009 | 0.101 | 0.309 | 0.016 | 0.016 | 0.014 | 0.012 | 0.034 | | | | | | | | | | | |
| Mercury - Filtered | mg/L | 0.0001 | 0.00006 | | | | | | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.0002 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nitrate as N | mg/L | 0.01 | 0.7 | 0.2 | | | | | <0.01 | 0.22 | 0.26 | 0.26 | 0.1 | 0.24 | 0.2 | 0.35 | 0.26 | 0.15 | 0.18 | 0.25 | 0.15 | 0.15 | | | | | <0.01 | | | | | | |

**Table D-1: Groundwater Sample Analysis Results**
**(page 3 of 7)**

| Bore / Well / Spring / Soak | | | | RM06 | | | | | | | RM07 | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer | | | | B C Alluvium + Permian | | | | | | | B C Alluvium + Permian | | | | | | | | | | | | | | | | | | | | | | | | | |
| Parameter | Units | LOR | ANZECC (2000) Guideline Value for Freshwater Ecosystem Protection | 29-Nov-00 | 22-Nov-04 | 29-Nov-04 | 01-Nov-04 | 01-Feb-05 | 01-Aug-05 | 01-Mar-06 | 29-Nov-00 | 29-Jun-01 | 18-Jul-01 | 01-Sep-02 | 16-Oct-02 | 01-Nov-02 | 01-Dec-02 | 01-Jan-03 | 01-Feb-03 | 01-Mar-03 | 01-Apr-03 | 01-May-03 | 19-Jun-03 | 19-Jul-03 | 01-Aug-03 | 01-Nov-03 | 01-Feb-04 | 05-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-May-05 | 01-Aug-05 | 01-Nov-05 | 01-Mar-06 | 01-May-06 |
| pH Value (field) | | 0.01 | | 7.24 | | | 7.15 | 7.36 | 8.18 | 7.28 | 7.29 | 7.1 | 7.27 | 7.04 | 7.01 | 7.1 | | 7.42 | 7.11 | 8.01 | 7.57 | 8.12 | 7.10 | 7.36 | 7.04 | | | | | 7.13 | 7.21 | 7.81 | 8.17 | 7.23 | 7.21 | 7.2 |
| Conductivity (field) | µS/cm | 0 | | 1340 | | | 1260 | 1220 | 1220 | 1320 | 986 | 956 | 974 | 1210 | 1280 | 1310 | | 1380 | 1410 | 1390 | 1480 | 9920 | 1590 | 1620 | 1690 | 1600 | 1370 | 1320 | 1310 | 1620 | 1660 | 6120 | 1290 | 1550 | 1520 | 1510 |
| Lab Conductivity @ 25°C | µS/cm | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids (TDS) | mg/L | 1 | | 926 | | | | | | | 614 | | | | | | | | | | | | | | | | | | | 947 | 988 | 3610 | 834 | 844 | 980 | 952 |
| Calcium | mg/L | 1 | | 65 | | | | | | | 35 | 45 | 45 | 53 | 48 | 47 | | 49 | 53 | 52 | 60 | 168 | 67 | 66 | 66 | | | | | | | | | | | |
| Magnesium | mg/L | 1 | | 35 | | | | | | | 18 | 25 | 23 | 28 | 29 | 29 | | 29 | 35 | 31 | 32 | 218 | 41 | 42 | 39 | | | | | | | | | | | |
| Sodium | mg/L | 1 | | 172 | | | | | | | 149 | 132 | 147 | 151 | 148 | 207 | | 170 | 164 | 149 | 174 | 1540 | 251 | 213 | 216 | | | | | | | | | | | |
| Potassium | mg/L | 1 | | 4 | | | | | | | 2 | 5 | 5 | 3 | 3 | 3 | | 3 | 3 | 3 | 3 | 1 | 3 | 4 | 4 | | | | | | | | | | | |
| Carbonate as CaCO3 | mg/L | 1 | | <1 | | | | | | | <1 | <1 | <1 | <1 | <1 | <1 | | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | | | | | | | | | | | |
| Bicarbonate as CaCO3 | mg/L | 1 | | 217 | | | | | | | 197 | 239 | 241 | 201 | 195 | 203 | | 199 | 205 | 187 | 203 | 623 | 184 | 212 | 205 | | | | | | | | | | | |
| Sulphate | mg/L | 1 | | 104 | | | | | | | 58 | 84 | 74 | 87 | 89 | 90 | | 87 | 108 | 108 | 110 | 536 | 125 | 118 | 128 | | | | | | | | | | | |
| Chloride | mg/L | 1 | | 204 | | | | | | | 155 | 142 | 165 | 218 | 242 | 264 | | 247 | 235 | 214 | 263 | 3120 | 347 | 355 | 355 | | | | | | | | | | | |
| Silica | | | | 23.5 | | | | | | | 21.2 | 22.9 | 25 | 22.4 | 20.4 | 9.5 | | 18.2 | 23.6 | 18.6 | 24.1 | 74.7 | 23.2 | 20.5 | 22.4 | | | | | | | | | | | |
| Arsenic - Filtered | mg/L | 0.001 | 0.013 | | | | | | | | | 0.04 | <0.01 | <0.001 | <0.001 | <0.001 | | <0.001 | 0.004 | <0.001 | 0.001 | 0.003 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Cadmium - Filtered | mg/L | 5E-05 | 0.0002 | | | | | | | | | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | | <0.001 | <0.001 | <0.0001 | <0.0001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Chromium - Filtered | mg/L | 0.002 | ID | | | | | | | | | 0.099 | 0.062 | <0.001 | <0.001 | 0.191 | | <0.005 | 0.01 | <0.001 | <0.001 | <0.005 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Copper - Filtered | mg/L | 0.0005 | 0.0014 | | | | | | | | | 0.217 | 0.005 | <0.001 | 0.001 | 0.003 | | <0.001 | 0.008 | <0.001 | <0.001 | 0.003 | 0.001 | <0.001 | 0.003 | | | | | | | | | | | |
| Nickel - Filtered | mg/L | 0.001 | 0.011 | | | | | | | | | 0.182 | 0.071 | 0.001 | 0.001 | 0.002 | | <0.001 | 0.006 | 0.001 | 0.004 | 0.005 | 0.003 | 0.002 | 0.001 | | | | | | | | | | | |
| Lead - Filtered | mg/L | 5E-05 | 0.0034 | | | | | | | | | 0.145 | 0.036 | <0.001 | <0.001 | <0.001 | | <0.001 | 0.014 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Zinc - Filtered | mg/L | 0.005 | 0.008 | | | | | | | | | 0.911 | 0.208 | 0.002 | 0.009 | 0.014 | | <0.005 | 0.04 | 0.001 | 0.001 | 0.015 | <0.005 | 0.005 | 0.009 | | | | | | | | | | | |
| Mercury - Filtered | mg/L | 0.0001 | 0.00006 | | | | | | | | | 2E-04 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | | | | | | | | | | | |
| Nitrate as N | mg/L | 0.01 | 0.7 | <0.01 | | | | | | | <0.01 | 0.17 | 0.02 | 0.06 | 0.07 | 0.2 | | 0.07 | 0.56 | 0.06 | 0.05 | 2.02 | 0.15 | 0.09 | 0.11 | | | | | | | | | | | |

**Table D-1: Groundwater Sample Analysis Results**
**(page 4 of 7)**

| Bore / Well / Spring / Soak | | | | RM08 | RM09 | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer | | | | Bowmans Creek Alluvium | Bowmans Creek Alluvium | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Parameter | Units | LOR | ANZECC (2000) Guideline Value for Freshwater Ecosystem Protection | 29-Nov-00 | 00-Jan-00 | 20-Jun-01 | ? | 01-Sep-02 | 16-Oct-02 | 01-Nov-02 | 01-Dec-02 | 01-Jan-03 | 01-Feb-03 | 01-Mar-03 | 01-Apr-03 | 01-May-03 | 19-Jun-03 | 19-Jul-03 | 01-Aug-03 | 01-Nov-03 | 01-Feb-04 | 01-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-May-05 | 01-Aug-05 | 01-Nov-05 | 01-Feb-06 | 01-May-06 |
| pH Value (field) | | 0.01 | | 7.1 | 7.47 | 7.38 | | 6.99 | 6.96 | 7 | 7.09 | 7.46 | 7.06 | 8.07 | 7.62 | 8.18 | 7.13 | 7.34 | 7.04 | | | | | 6.97 | 7.11 | 6.89 | 8.15 | 7.2 | 7.08 | 7.01 |
| Conductivity (field) | µS/cm | 0 | | 1300 | 1000 | 969 | 943 | 1080 | 1110 | 1080 | 1120 | 1090 | 1150 | 1160 | 1220 | 1160 | 1160 | 1160 | 1190 | 1190 | 1180 | 1160 | 1250 | 1260 | 1260 | 5810 | 1160 | 1360 | 1310 | 1360 |
| Lab Conductivity @ 25°C | µS/cm | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids (TDS) | mg/L | 1 | | 736 | 596 | | | | | | | | | | | | | | | | | | | 750 | 756 | 3640 | 722 | 740 | 872 | 832 |
| Calcium | mg/L | 1 | | 53 | 38 | 39 | 40 | 47 | 41 | 40 | 42 | 39 | 41 | 46 | 45 | 44 | 47 | 46 | 42 | | | | | | | | | | | |
| Magnesium | mg/L | 1 | | 34 | 17 | 19 | 19 | 22 | 21 | 21 | 21 | 21 | 22 | 25 | 23 | 23 | 25 | 26 | 22 | | | | | | | | | | | |
| Sodium | mg/L | 1 | | 182 | 162 | 132 | 158 | 141 | 135 | 180 | 160 | 145 | 137 | 130 | 143 | 129 | 191 | 168 | 164 | | | | | | | | | | | |
| Potassium | mg/L | 1 | | 3 | 2 | 7 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | | | | | | | | | | | |
| Carbonate as CaCO3 | mg/L | 1 | | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | | | | | | | | | | | |
| Bicarbonate as CaCO3 | mg/L | 1 | | 197 | 201 | 275 | 260 | 201 | 199 | 206 | 195 | 191 | 193 | 175 | 200 | 210 | 193 | 203 | 197 | | | | | | | | | | | |
| Sulphate | mg/L | 1 | | 90 | 61 | 114 | 54 | 79 | 82 | 77 | 81 | 77 | 86 | 86 | 89 | 88 | 86 | 85 | 84 | | | | | | | | | | | |
| Chloride | mg/L | 1 | | 213 | 138 | 124 | 154 | 180 | 188 | 197 | 178 | 176 | 171 | 186 | 160 | 216 | 224 | 230 | 211 | | | | | | | | | | | |
| Silica | | | | 19.3 | 21.9 | 25.3 | 26.5 | 24.7 | 23 | 11.5 | 23.8 | 22.8 | 27.7 | 22.6 | 26.9 | 23.5 | 25.9 | 22.5 | 23.3 | | | | | | | | | | | |
| Arsenic - Filtered | mg/L | 0.001 | 0.013 | | | <0.01 | <0.01 | 0.001 | <0.001 | 0.001 | <0.01 | <0.001 | 0.006 | 0.002 | <0.001 | 0.001 | <0.001 | 0.001 | <0.001 | | | | | | | | | | | |
| Cadmium - Filtered | mg/L | 5E-05 | 0.0002 | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.005 | <0.001 | 0.006 | <0.0001 | 0.0001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Chromium - Filtered | mg/L | 0.002 | ID | | | 0.01 | 0.008 | <0.001 | <0.001 | 0.28 | <0.01 | <0.005 | 0.005 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Copper - Filtered | mg/L | 0.0005 | 0.0014 | | | 0.012 | 0.007 | <0.001 | <0.001 | 0.002 | <0.01 | <0.001 | 0.007 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.004 | | | | | | | | | | | |
| Nickel - Filtered | mg/L | 0.001 | 0.011 | | | 0.012 | 0.012 | 0.002 | 0.002 | 0.002 | <0.01 | <0.001 | 0.007 | 0.002 | 0.002 | 0.002 | 0.004 | 0.004 | 0.002 | | | | | | | | | | | |
| Lead - Filtered | mg/L | 5E-05 | 0.0034 | | | 0.007 | 0.008 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 | 0.007 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | | | | | | | | | | | |
| Zinc - Filtered | mg/L | 0.005 | 0.008 | | | 0.056 | 0.046 | 0.005 | 0.015 | 0.008 | 0.01 | <0.005 | 0.033 | 0.007 | 0.003 | <0.005 | <0.005 | 0.011 | 0.01 | | | | | | | | | | | |
| Mercury - Filtered | mg/L | 0.0001 | 0.00006 | | | <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 | | | | | | | | | | | |
| Nitrate as N | mg/L | 0.01 | 0.7 | 0.12 | 0.02 | 0.14 | 0.04 | 0.08 | 0.03 | 0.06 | 0.09 | 0.12 | 0.39 | 0.16 | 0.11 | 0.12 | 0.14 | 0.12 | 0.12 | | | | | | | | | | | |

| Bore / Well / Spring / Soak | | | | RM10 | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer | | | | Bowmans Creek Alluvium | | | | | | | | | | | | | | | | | | | | | | | | | |
| Parameter | Units | LOR | ANZECC (2000) Guideline Value for Freshwater Ecosystem Protection | 00-Jan-00 | 20-Jun-01 | 18-Jul-01 | 01-Sep-01 | 16-Oct-02 | 01-Nov-02 | 01-Dec-02 | 01-Jan-03 | 01-Feb-03 | 01-Mar-03 | 01-Apr-03 | 01-May-03 | 19-Jun-03 | 19-Jul-03 | 01-Aug-03 | 01-Nov-03 | 01-Feb-04 | 01-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-May-05 | 01-Aug-05 | 01-Nov-05 | 01-Feb-06 | 01-May-06 |
| pH Value (field) | | 0.01 | | 7.42 | 7.57 | 7.59 | 7.13 | 7.04 | 7.1 | 7.21 | 7.56 | 7.19 | 8.12 | 7.62 | 8.15 | 7.16 | 7.31 | 7.02 | | | | | 6.85 | 6.95 | 7.09 | 8.1 | 7.1 | 6.96 | 6.86 |
| Conductivity (field) | µS/cm | 0 | | 1010 | 1160 | 1160 | 1050 | 1080 | 1070 | 1110 | 1100 | 1160 | 1150 | 1260 | 1210 | 1250 | 1260 | 1320 | 1340 | 1390 | 1450 | 1470 | 1490 | 1460 | 3700 | 1330 | 1570 | 1410 | 1460 |
| Lab Conductivity @ 25°C | µS/cm | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids (TDS) | mg/L | 1 | | 654 | | | | | | | | | | | | | | | | | | | 862 | 870 | 2240 | 858 | 912 | 936 | 882 |
| Calcium | mg/L | 1 | | 34 | 45 | 48 | 42 | 39 | 37 | 41 | 41 | 39 | 44 | 48 | 45 | 48 | 46 | 48 | | | | | | | | | | | |
| Magnesium | mg/L | 1 | | 15 | 20 | 20 | 19 | 17 | 17 | 18 | 19 | 18 | 23 | 20 | 21 | 22 | 21 | 22 | | | | | | | | | | | |
| Sodium | mg/L | 1 | | 177 | 171 | 190 | 147 | 140 | 188 | 169 | 151 | 148 | 140 | 150 | 137 | 256 | 178 | 185 | | | | | | | | | | | |
| Potassium | mg/L | 1 | | 3 | 8 | 6 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | | | | | | | | | | | |
| Carbonate as CaCO3 | mg/L | 1 | | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | | | | | | | | | | | |
| Bicarbonate as CaCO3 | mg/L | 1 | | 217 | 242 | 238 | 224 | 214 | 216 | 202 | 204 | 200 | 179 | 192 | 187 | 424 | 198 | 185 | | | | | | | | | | | |
| Sulphate | mg/L | 1 | | 66 | 104 | 88 | 72 | 74 | 73 | 77 | 73 | 80 | 78 | 82 | 85 | 87 | 84 | 87 | | | | | | | | | | | |
| Chloride | mg/L | 1 | | 141 | 189 | 227 | 160 | 173 | 187 | 173 | 179 | 176 | 194 | 191 | 237 | 208 | 234 | 259 | | | | | | | | | | | |
| Silica | | | | 20.2 | 25.7 | 27.6 | 25.4 | 24.6 | 11.2 | 0.05 | 23.6 | 25.9 | 23.1 | 27.9 | 24.4 | 25.3 | 23.4 | 24.2 | | | | | | | | | | | |
| Arsenic - Filtered | mg/L | 0.001 | 0.013 | | <0.01 | <0.01 | 0.001 | 0.002 | <0.001 | <0.01 | <0.001 | 0.002 | <0.001 | 0.001 | 0.001 | <0.001 | 0.001 | <0.001 | | | | | | | | | | | |
| Cadmium - Filtered | mg/L | 5E-05 | 0.0002 | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.005 | <0.001 | <0.001 | <0.0001 | 0.0001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Chromium - Filtered | mg/L | 0.002 | ID | | <0.001 | 0.001 | <0.001 | <0.001 | 0.155 | 0.02 | <0.005 | 0.004 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Copper - Filtered | mg/L | 0.0005 | 0.0014 | | 0.005 | 0.003 | 0.001 | 0.001 | 0.003 | 0.01 | 0.001 | 0.003 | <0.001 | 0.002 | 0.001 | 0.001 | 0.001 | 0.004 | | | | | | | | | | | |
| Nickel - Filtered | mg/L | 0.001 | 0.011 | | 0.002 | 0.002 | 0.001 | <0.001 | 0.002 | <0.01 | <0.001 | 0.002 | 0.001 | 0.002 | 0.002 | 0.003 | 0.002 | 0.001 | | | | | | | | | | | |
| Lead - Filtered | mg/L | 5E-05 | 0.0034 | | 0.001 | 0.003 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | | | | |
| Zinc - Filtered | mg/L | 0.005 | 0.008 | | 0.012 | 0.024 | 0.005 | 0.017 | 0.023 | 0.03 | 0.006 | 0.019 | 0.003 | 0.017 | 0.007 | 0.010 | 0.006 | 0.012 | | | | | | | | | | | |
| Mercury - Filtered | mg/L | 0.0001 | 0.00006 | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.0002 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | | | | | | | | | | | |
| Nitrate as N | mg/L | 0.01 | 0.7 | 0.07 | 0.02 | 0.01 | 0.03 | <0.01 | 0.04 | 0.05 | 0.04 | 0.25 | 0.01 | 0.06 | 0.04 | 0.06 | 0.04 | 0.04 | | | | | | | | | | | |

**Table D-1: Groundwater Sample Analysis Results**
**(page 6 of 7)**

| Bore / Well / Spring / Soak | | | | PB1 | | | | | | PB2 | GM1 | | | | | | | | | | | GM2 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer | | | | Bowmans Creek Alluvium | | | | | | Bowmans Creek | Upper Liddell Seam | | | | | | | | | | | Lower Barrett Seam | | | | | | | |
| Parameter | Units | LOR | ANZECC (2000) Guideline Value for Freshwater Ecosystem Protection | 29-Nov-00 | 27-Nov-00 | 01-Nov-04 | 01-Feb-05 | 08-Aug-05 | 01-Mar-06 | 28-Nov-00 | 01-Nov-03 | 01-Feb-04 | 01-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-May-05 | 01-Aug-05 | 01-Nov-05 | 01-Feb-06 | 01-May-06 | 01-Nov-03 | 01-Feb-04 | 01-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-May-05 | 01-Aug-05 |
| pH Value (field) | | 0.01 | | | 7.65 | 7.08 | 7.18 | 8.22 | 7.12 | 8.03 | | | | | 7.69 | 7.55 | 6.81 | 8.38 | 7.87 | 7.74 | 7.78 | | | | | 7.01 | 7.18 | 6.76 | |
| Conductivity (field) | µS/cm | 0 | | 1352 | 1020 | 1600 | 1560 | 1070 | 1540 | 1420 | 5240 | 5390 | 5520 | 5620 | 5780 | 5500 | 9370 | 5600 | 5230 | 4980 | 4920 | 8600 | 7520 | 6200 | 6010 | 4680 | 4060 | 1460 | |
| Lab Conductivity @ 25°C | µS/cm | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids (TDS) | mg/L | 1 | | | 614 | | | | | 852 | | | | | 3190 | 3220 | 5920 | 3180 | 3290 | 3450 | 3440 | | | | | 2620 | 2360 | 822 | |
| Calcium | mg/L | 1 | | | 614 | | | | | 852 | | | | | | | | | | | | | | | | | | | |
| Magnesium | mg/L | 1 | | | 31 | | | | | 34 | | | | | | | | | | | | | | | | | | | |
| Sodium | mg/L | 1 | | | 14 | | | | | 24 | | | | | | | | | | | | | | | | | | | |
| Potassium | mg/L | 1 | | | 189 | | | | | 265 | | | | | | | | | | | | | | | | | | | |
| Carbonate as CaCO3 | mg/L | 1 | | | 3 | | | | | 3 | | | | | | | | | | | | | | | | | | | |
| Bicarbonate as CaCO3 | mg/L | 1 | | | <1 | | | | | <1 | | | | | | | | | | | | | | | | | | | |
| Sulphate | mg/L | 1 | | | 219 | | | | | 207 | | | | | | | | | | | | | | | | | | | |
| Chloride | mg/L | 1 | | | 69 | | | | | 86 | | | | | | | | | | | | | | | | | | | |
| Silica | | | | | 146 | | | | | 216 | | | | | | | | | | | | | | | | | | | |
| Arsenic - Filtered | mg/L | 0.001 | 0.013 | | 20 | | | | | 17.5 | | | | | | | | | | | | | | | | | | | |
| Cadmium - Filtered | mg/L | 5E-05 | 0.0002 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Chromium - Filtered | mg/L | 0.002 | ID | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Copper - Filtered | mg/L | 0.0005 | 0.0014 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nickel - Filtered | mg/L | 0.001 | 0.011 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lead - Filtered | mg/L | 5E-05 | 0.0034 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zinc - Filtered | mg/L | 0.005 | 0.008 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mercury - Filtered | mg/L | 0.0001 | 0.00006 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nitrate as N | mg/L | 0.01 | 0.7 | | <0.01 | | | | | <0.01 | | | | | | | | | | | | | | | | | | | |

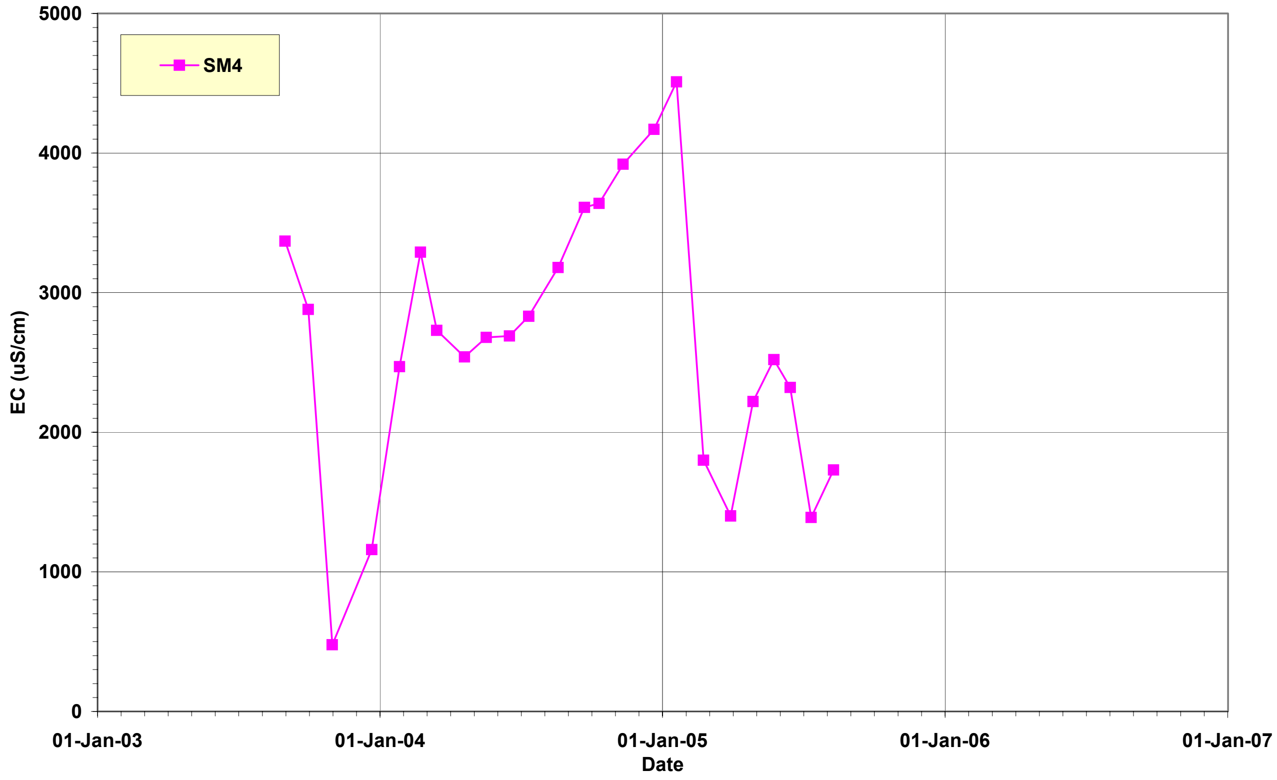
**Table D-1: Groundwater Sample Analysis Results**
**(page 7 of 7)**

| Bore / Well / Spring / Soak | | | | GM3A | | | | | | | | OC1 | | | | | | | OC2 | | | | | | | WML20 | WML21 | WML119 | WML120 A | WML120 B | LW1 Headings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer | | | | Upper Barrett Seam | | | | | | | | Coal Measures | | | | | | | Coal Measures | | | | | | | Pikes Gully Seam | Pikes Gully Seam | Pikes Gully Seam | Glennies Creek Alluvium | Pikes Gully Seam | Pikes Gully Seam |
| Parameter | Units | LOR | ANZECC (2000) Guideline Value for Freshwater Ecosystem Protection | 01-Nov-03 | 01-Feb-04 | 01-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-Aug-05 | 01-Mar-06 | 01-Nov-03 | 01-Feb-04 | 01-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-Aug-05 | 01-Nov-03 | 01-Feb-04 | 01-May-04 | 01-Aug-04 | 01-Nov-04 | 01-Feb-05 | 01-May-05 | 01-Sep-06 | 01-Sep-06 | 14-Jun-06 | 14-Jun-06 | 14-Jun-06 | 04-Sep-06 |
| pH Value (field) | | 0.01 | | | | | | 7.64 | 7.63 | 8.48 | 7.77 | | | | | 6.87 | 7.02 | 6.99 | | | | | 8.01 | 7.95 | 7.05 | 8.21 | 8.19 | 8.19 | 7.05 | 6.86 | 8.27 |
| Conductivity (field) | µS/cm | 0 | | 8380 | 8620 | 8660 | | 7540 | 6460 | 5720 | 6020 | 6250 | 6270 | 6330 | 6380 | 6490 | 5740 | 1260 | 6570 | 6580 | 6670 | 6570 | 6700 | 6080 | 1400 | 6240 | 8140 | | | | 8530 |
| Lab Conductivity @ 25°C | µS/cm | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 6470 | 1930 | 6350 | |
| Total Dissolved Solids (TDS) | mg/L | 1 | | | | | | 4300 | 3670 | 3200 | 4160 | | | | | 3670 | 3400 | 688 | | | | | 3830 | 3660 | 772 | | | 4910 | 1480 | 5620 | |
| Calcium | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 39 | 123 | 203 | |
| Magnesium | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 122 | 83 | 354 | |
| Sodium | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1570 | 221 | 1260 | |
| Potassium | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 9 | 2 | 13 | |
| Carbonate as CaCO3 | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | <1 | <1 | <1 | |
| Bicarbonate as CaCO3 | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1080 | 137 | 936 | |
| Sulphate | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 167 | 111 | 462 | |
| Chloride | mg/L | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1830 | 610 | 2300 | |
| Silica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic - Filtered | mg/L | 0.001 | 0.013 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cadmium - Filtered | mg/L | 5E-05 | 0.0002 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Chromium - Filtered | mg/L | 0.002 | ID | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Copper - Filtered | mg/L | 0.0005 | 0.0014 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nickel - Filtered | mg/L | 0.001 | 0.011 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lead - Filtered | mg/L | 5E-05 | 0.0034 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zinc - Filtered | mg/L | 0.005 | 0.008 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mercury - Filtered | mg/L | 0.0001 | 0.00006 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nitrate as N | mg/L | 0.01 | 0.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

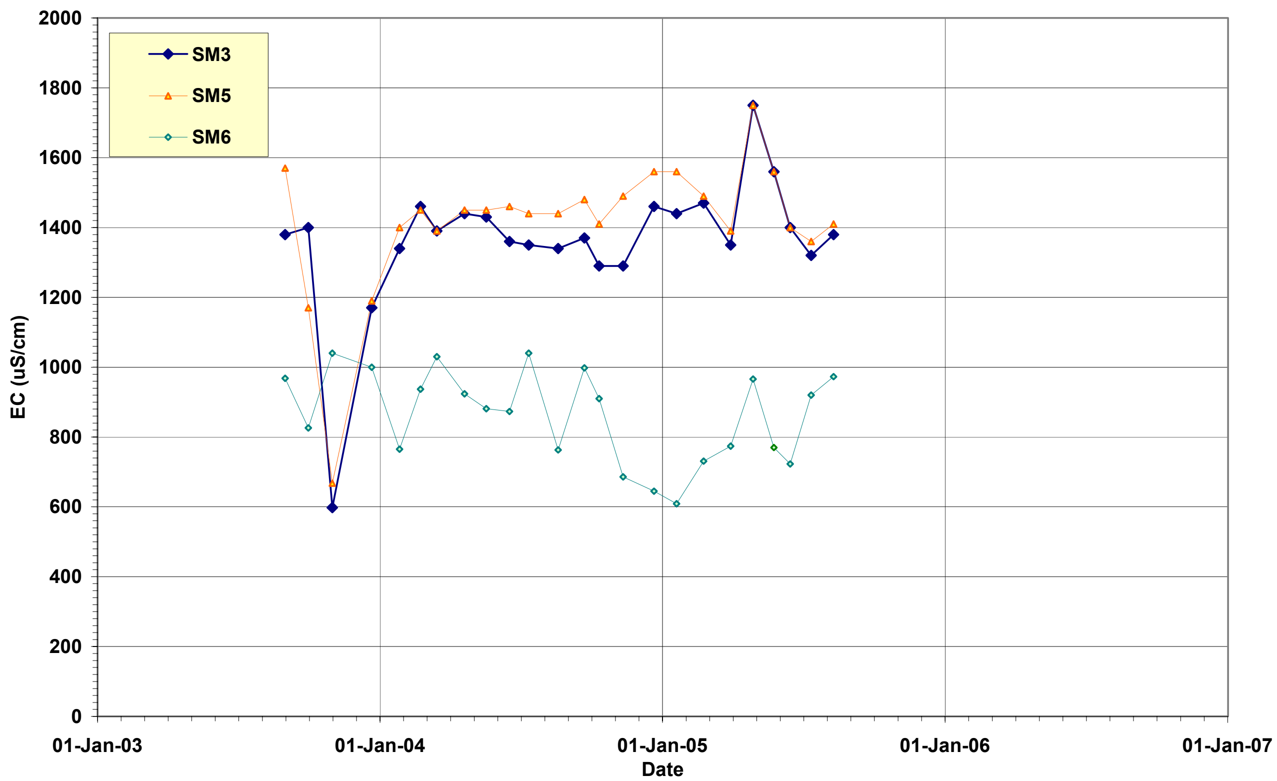
# ANNEXURE E

## SURFACE WATER QUALITY MONITORING DATA

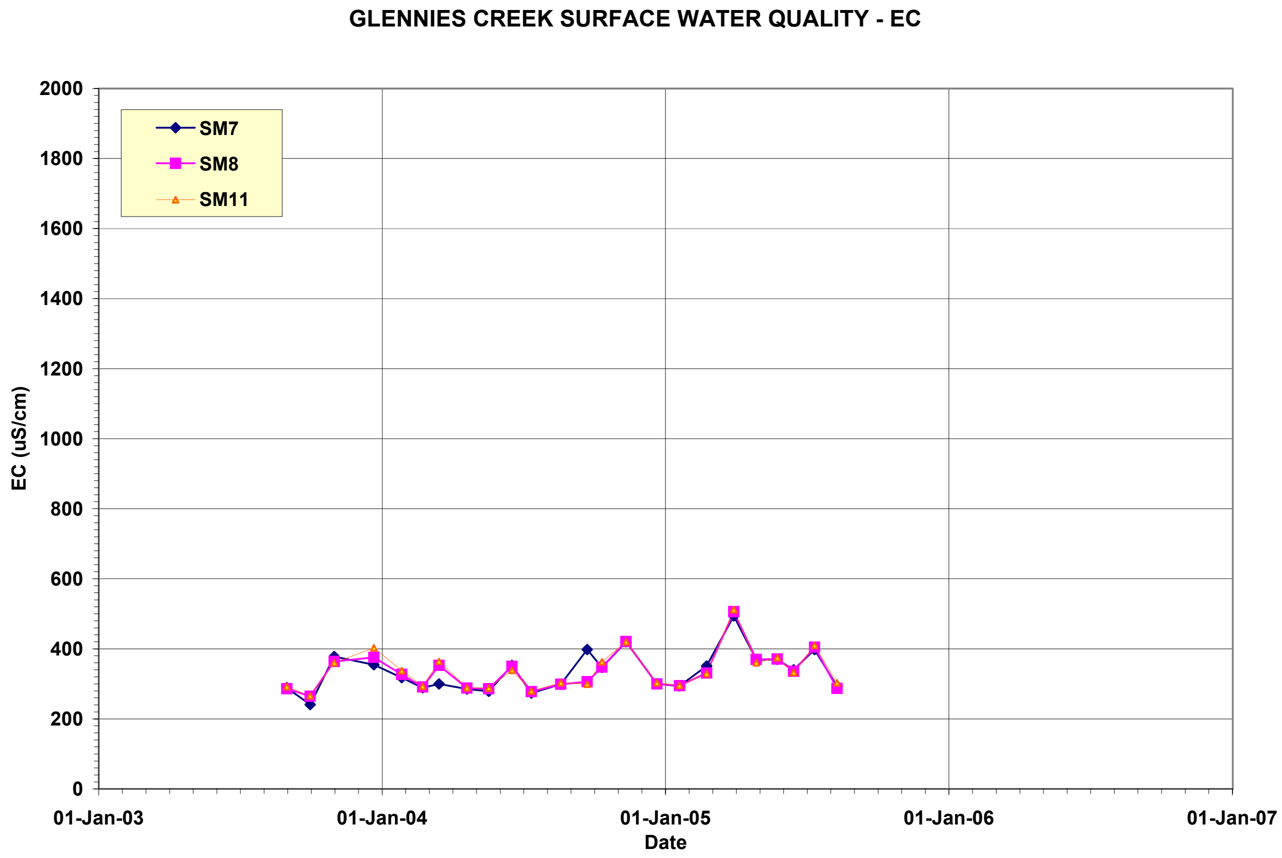
## BOWMANS CREEK SURFACE WATER QUALITY - EC

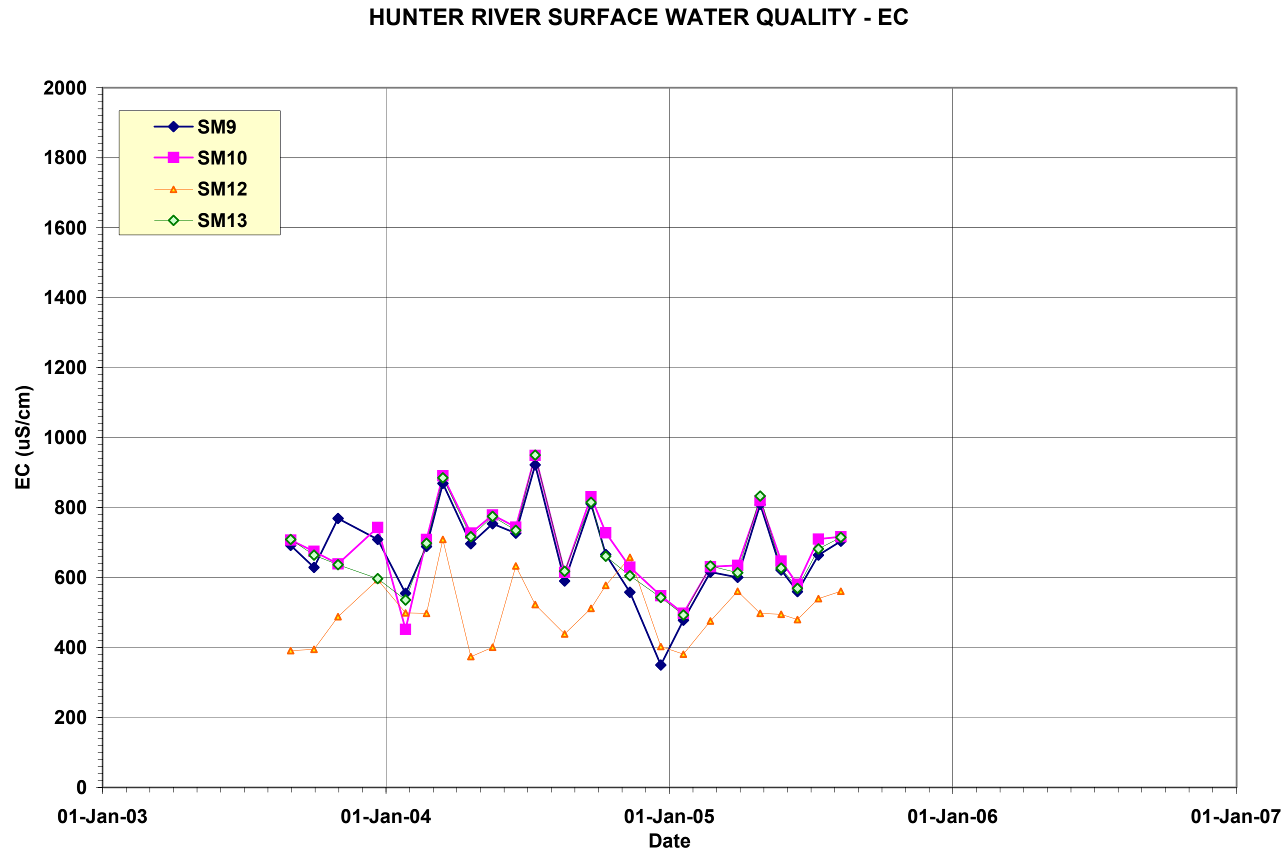



## BOWMANS CREEK SURFACE WATER QUALITY - EC




| | | |
|---|---|---|
| Date: 15 September 2006 | Scale: as indicated | **Ashton Coal Operations Ltd** |
| Initials: PJD | Job No: 05-0166 | **SMP - LONGWALLS 1 to 4 BOWMANS CREEK SURFACE WATER QUALITY EC** |
| Drawing No: 05-0166-108 | Rev: 0 | |
| **Peter Dundon and Associates Pty Limited** | | **Figure E-1** |



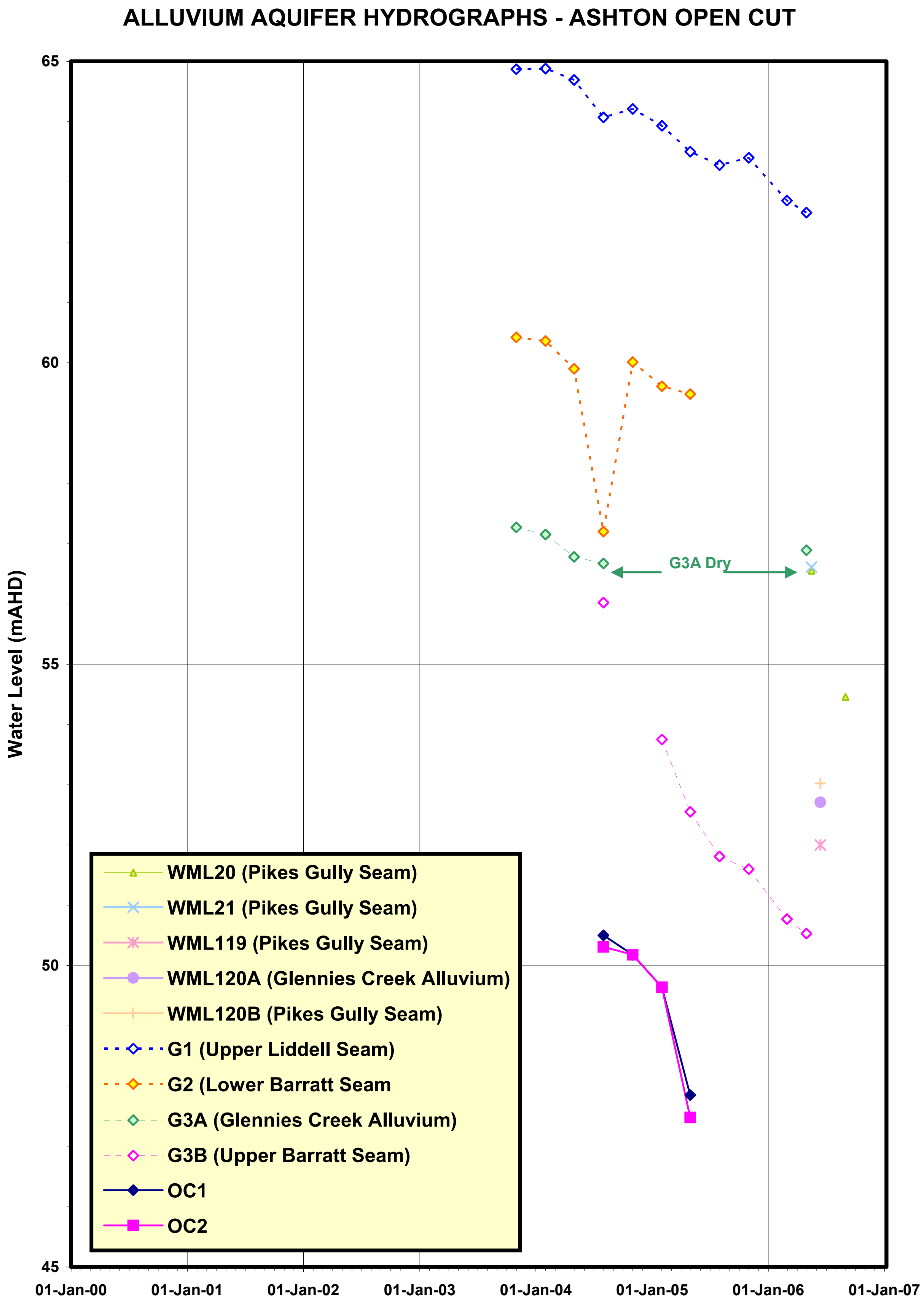




| | | |
|---|---|---|
| Date: 10 October 2006 | Scale: as indicated | **Ashton Coal Operations Ltd** |
| Initials: PJD | Job No: 05-0166 | **SMP - LONGWALLS 1 to 4 GLENNIES CREEK and HUNTER RIVER SURFACE WATER QUALITY EC** |
| Drawing No: 05-0166-109a | Rev: A | |
| **Peter Dundon and Associates Pty Limited** | | **Figure E-2** |

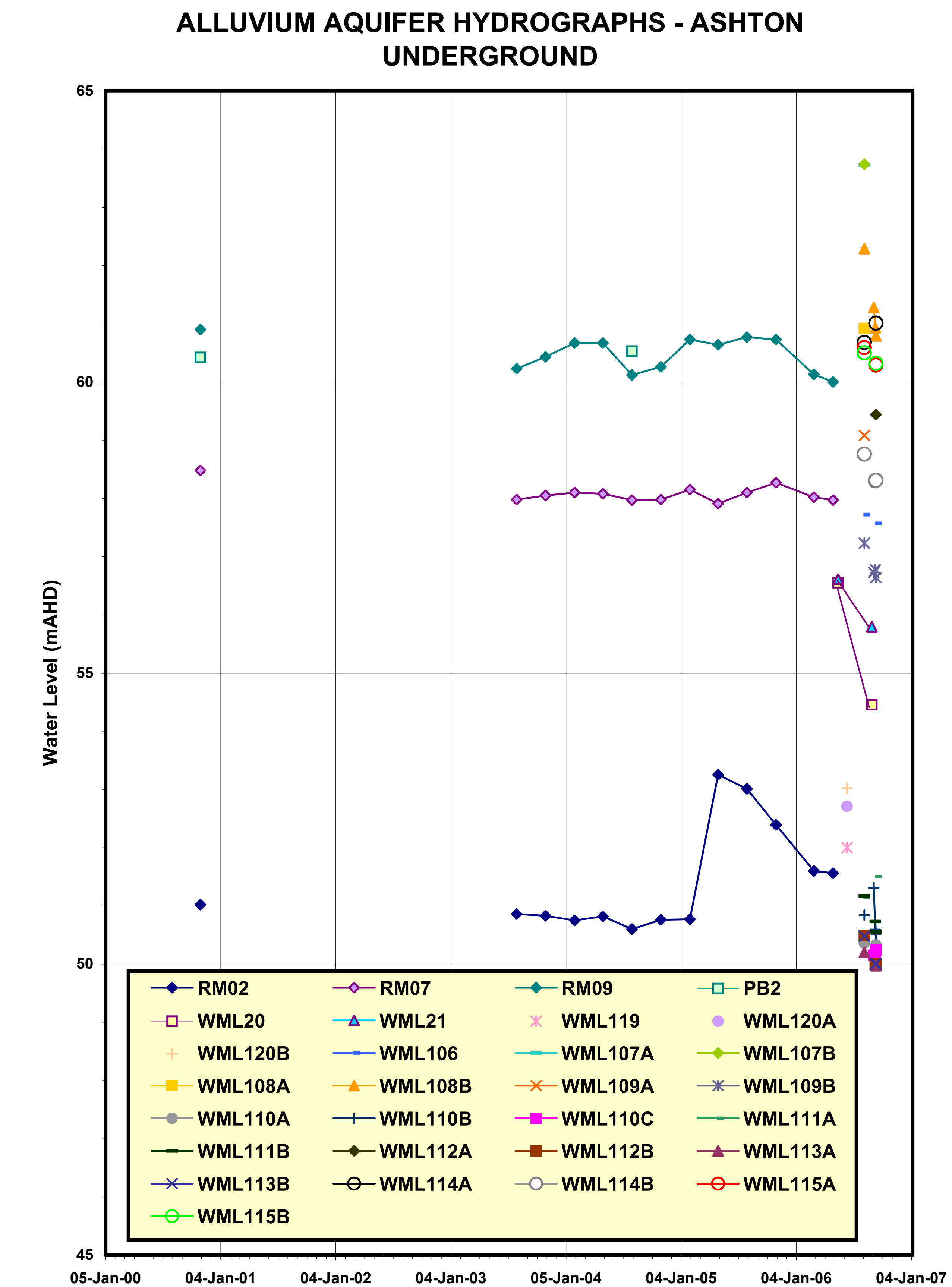
# ANNEXURE F

## BASELINE GROUNDWATER LEVEL MONITORING RESULTS

Groundwater levels monitored as part of the baseline monitoring program are presented as hydrographs in **Figures F-1** and **F-2**.




| | | | | |
|---|---|---|---|---|
| Date: | 15 September 2006 | Scale: | as indicated | **Ashton Coal Operations Ltd** |
| Initials: | PJD | Job No: | 05-0166 | **SMP - LONGWALLS 1 to 4**<br>**GROUNDWATER LEVEL HYDROGRAPHS**<br>**ASHTON OPEN CUT AREA** |
| Drawing No: | 05-0166-107 | Rev: | 0 | |
| **Peter Dundon and Associates Pty Limited** | | | | **Figure F-1** |




| | | | |
|---|---|---|---|
| Date: 15 September 2006 | Scale: as indicated | **Ashton Coal Operations Ltd** | |
| Initials: PJD | Job No: 05-0166 | **SMP - LONGWALLS 1 to 4 GROUNDWATER LEVEL HYDROGRAPHS ASHTON UNDERGROUND AREA** | |
| Drawing No: 05-0166-106 | Rev: 0 | | |
| **Peter Dundon and Associates Pty Limited** | | | **Figure F-2** |