ASHTON COAL LONGWALL 8
END OF PANEL GROUNDWATER REPORT

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EXECUTIVE SUMMARY

Ashton Coal Pty Ltd completed the extraction of longwall panel 8 (LW8) at their underground longwall mine operation over the period 27 February 2012 to 5 June 2012. LW8 accesses coal from the Pikes Gully coal seam and is located to the North-West of the approved underground mine plan (Figure 1).

This report forms an end of panel groundwater review following the commencement of LW8. It has been prepared after consideration of all available groundwater and surface water monitoring data. Particular attention has been devoted to the assessment of potential impacts to Bowmans Creek and the associated alluvial floodplain which is located adjacent to the southern half of LW8 (Figure 2).

An alluvial aquifer associated with the Bowmans Creek flood plain (Bowmans Creek alluvium) is located, at its closest point, east of southern half of LW8 (Figure 2). Extensive, high frequency monitoring at key piezometers within the Bowmans Creek alluvium was conducted throughout coal extraction at LW8 to identify any impacts associated with LW8 extraction.

To further facilitate the identification of impacts associated with coal extraction, groundwater levels and quality are routinely monitored from all the unconfined alluvial aquifers surrounding the underground mine. Within the confined formations such as the various coal seams, the Permian interburden and overburden pressure heads are monitored. Pressure heads are converted to potentiometric surfaces allowing for a comparison with groundwater levels and analysis of hydraulic gradients.

This review has considered subsidence impacts associated with coal extraction at LW7B and LW8 and observations and measurements of water inflows to the underground workings (volumes, flow rate and quality).

- Subsidence monitoring during coal extraction at LW8 has resulted in a lowering of the base of the Bowmans Creek alluvial aquifer by approximately 1m. The groundwater level within the aquifer is also shown to reduce following subsidence. The net result does not equate to a reduction in the saturated thickness across the Bowmans Creek alluvium, in some areas the saturated thickness is observed to increase.
- Underground inflows are reported as a total volume across the entire underground workings and as a separate volume of inflows to the Pikes Gully longwall panel 1 (LW1) adjacent to Glennies Creek (Figure 1).

Groundwater level in the Hunter River alluvium and the Glennies Creek alluvium floodplains do not show impacts attributable to coal extraction at LW8. This is to be expected given the distance separating LW8 and the Hunter River and Glennies Creek alluviums.

Fluctuations observed in groundwater levels and potentiometric surfaces over the LW8 extraction period are demonstrated to be within baseline data ranges and directly attributable to seasonal effects.

The impacts associated with coal extraction at LW8 are within the approved predictions documented in the Environmental Impact Statement (2001 EIS) completed by HLA Envirosciences, the Bowmans Creek Diversion Environmental Impact Assessment (2009 EA) completed by Evans and Peck and the Subsidence Management Plan Approval (2010 SMP) for Longwalls 5-6 and Miniwalls 7-8 completed by RPS' Water Management business unit.

A summary comparison of observed impacts with the 2001 EIS, the 2009 EA and 2010 SMP predictions is presented in Table E1.1.

Table E1.1: Comparison of observed impacts against the 2001 EIS, 2009 EA and 2010 SMP predictions

Impact Description	Impact observed to date (end of LW8)	Predicted Groundwater Related Impacts to LW8		
		2001 EIS (LW1 to 6)	**2009 EA (LW1 to 8)**	**2010 SMP (LW6 to 8)**
Groundwater drawdown to the Glennies Creek alluvium (east of LW1)	Up to 0.4m during LW1, followed by full recovery	2.2m	0.2m	No additional impact predicted
Groundwater drawdown to the Bowmans Creek alluvium (above LW6A, LW7A, LW7B)	0m	0.5 to 1.3m (in Ashton well)	0.5 to 2m	0.5 to 2m
Groundwater drawdown to the Hunter River alluvium (South of LW6 to LW8)	0m	<0.5m	0.01m	0.01m
Baseflow impacts to Glennies Creek	0.045ML/d (0.5L/s)	0.27ML/d (3.16L/s)	No additional Impact, 0.23ML/d (2.6L/s)	No additional Impact, 0.23ML/d (2.6L/s)
Baseflow reduction to Bowmans Creek	0L/s	0.38ML/d (4.5L/s)	0.03ML/d (0.34L/s)	0.03ML/d (0.34L/s)
Baseflow reduction to the Hunter River	0L/s	0.25ML/d (2.9L/s)	0.006ML/d (0.07L/s)	0.01ML/d (0.12L/s)
Total Underground Inflows	1ML/d (11.3L/s)	1.5ML/d (17.8L/s)	1.2ML/d (14L/s)	1.2ML/d (14L/s)

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1. INTRODUCTION

1.1 Background

Ashton Coal Operations Pty Limited (ACOL) operates the Ashton Coal Project (ACP) located approximately 14km west of Singleton in the Hunter Valley, NSW. ACOL is a wholly owned subsidiary of Yancoal Australia Limited, which is the majority (90%) joint venture owner of the mine.

The ACP comprises an open cut mine, an underground mine, a coal handling and preparation plant, rail loading facilities, run-of-mine and product coals stockpiles, and various surface support infrastructure and facilities. The development consent (DA 309-11-2001) for the ACP was granted by the Minister for Planning in October 2002 with the ACP approved to produce up to 5.45Mtpa of ROM coal until February 2024.

The underground mine is located south of the New England Highway and is situated between Bowmans Creek, Glennies Creek and the Hunter River. It is accessed from the highwall of the open cut pit, on the north side of the highway (Figure 1).

The underground mine is a longwall operation and approved to extract coal from the Pikes Gully (PG), Upper Liddell (ULD), Upper Lower Liddell (ULLD) and Lower Barrett (LB) coal seams via a longwall mining operation. The approval includes the diversion of the Bowmans Creek via two diversion channels, which re-route the creek to areas not undermined by longwall panels (Figure 1).

Development headings for the underground mine commenced in 2005 with longwall coal extraction in the PG seam commencing in 2007. The mine plan comprises eight longwall panels in the PG Seam (Figure 1). With the exception of LW6B coal extraction in the PG seam has now been completed. Figures 1 and 2 present the extraction that has occurred to-date in the PG seam.

Eight end of panel groundwater reports assessing the impacts from each longwall have been issued to ACOL prior to this report (Table 1.1).

Table 1.1: ACP Underground Mine Progression – Pikes Gully Coal Seam

Panel	Start date	End date	Report reference
LW1	12/03/2007	15/10/2007	Aquaterra, 2008
LW2	10/11/2007	21/7/2008	Aquaterra, 2009a
LW3	20/8/2008	3/03/2009	Aquaterra, 2009b
LW4	2/04/2009	15/10/2009	Aquaterra, 2010a
LW5	4/01/2010	7/06/2010	Aquaterra, 2011
LW6A	9/07/2010	22/11/2010	RPS Aquaterra, 2011
LW6B	Not yet commenced	-	-
LW7A	23/3/2011	5/08/2011	RPS Aquaterra, 2012a (as part of the 2011 Annual Environmental Monitoring Report)
LW7B	3/10/2011	17/1/2012	RPS Aquaterra, 2012b
LW8	27/2/2012	05/06/2012	This report

The mine plan and schedule has been altered in response to the construction of the Bowmans Creek diversion channels. In particular, the extent of extraction at LW7A and LW7B was reduced and LW6B has been delayed. Extraction at LW6B will now follow the completion of longwall panel 1 in the ULD seam (LW101). Following LW6B extraction mining will resume in the ULD seam followed by the underlying ULLD and LB seams.

A groundwater monitoring network was first installed in the project area in July 2000 to assess the hydrogeological conditions of the site as part of an impact analysis study for the ACP. Baseline groundwater investigations for the ACP are reported in Appendix H of the 2001 EIS (HLA Envirosciences, 2001).

A baseline monitoring program including monthly monitoring of groundwater level monitoring, quarterly groundwater quality sampling and quarterly surface water flow and quality monitoring in the Hunter River, Glennies Creek and Bowmans Creek has ensued since installation.

Subsequent investigations undertaken for the ACP have resulted in a significant expansion of the groundwater monitoring network. Additional piezometer installations (both standpipe and vibrating wire piezometers), hydraulic testing, underground inflow monitoring and groundwater quality monitoring have been incorporated into the baseline and operational monitoring networks providing an extensive understanding of the site hydrogeological conditions (Figure 1 and Appendix A).

1.2 Scope of this Report

Mining of LW8 in the PG seam commenced on 27 February 2012 and was completed on 5 June 2012. This report provides a review of the site hydrogeological conditions following the commencement of coal extraction at LW8.

Groundwater level monitoring frequencies were increased to fortnightly in selected key piezometers prior to the commencement of extraction at LW8 (Section 4.2). Monitoring of the entire ACP groundwater network has continued over the LW8 extraction period according to frequencies detailed in the Ashton Coal Water Management Plan (RPS Aquaterra 2012e).

Monitoring results from the LW8 extraction period are compared to the baseline data trends to allow the identification of impacts associated with LW8 extraction.

This end of panel report has been prepared following consideration of all available monitoring data, including:

- Groundwater level monitoring records.
- Groundwater inflow rate and volume to the underground mine.
- Water quality data from underground inflows, surface water samples and selected groundwater water samples.
- Subsidence survey data from transects across the LW6B to LW8 goafs (XL13), the LW8 goaf (XL14), and the in-bye (CL1) and out-bye ends of LW8 (CL2).

A comparison is provided of the actual impacts and the impacts predicted in the groundwater assessment reports for the 2001 EIS (HLA Envirosciences, 2001), the 2009 EA (Evans & Peck, 2009 and Aquaterra, 2009f), and the Subsidence Management Plan for LW6 to 8 (Aquaterra, 2010b).

Table 1.2: Figure Summary

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2. SITE DESCRIPTION

2.1 Longwall 8

Coal extraction of LW8 was completed over the period 27 February 2012 to 5 June 2012. Extraction began at chainage 1250m and was advanced northwards to chainage 0m.

The thickness of the PG seam ranged from 2.25m to 3.01m along the LW8 panel and the overburden thickness above LW8 ranged from 140m at the north-east corner to around 180m between cut-through 13 and 14 along main gate 9 (MG9 13- 14 C/T).

Deposits of saturated alluvium of the Bowmans Creek floodplain are located adjacent to the southern half of the panel, on its eastern side (Figure 2).

2.2 Rainfall

Table 2.1 presents the monthly rainfall data collected at Ashton and provides a comparison with the long-term average (LTA) in the Singleton area (data from the NSW Bureau of Meteorology, station number 061397). Monthly rainfall and long-term (median) average monthly rainfall are plotted on the hydrographs to assist with interpretations of observed groundwater responses (Figures 11 to 27).

During the months of LW8 extraction (February 2012 to June 2012) the area received 55.8mm of rainfall, which was 12mm greater than the LTA of 43.8mm for the same time period.

Table 2.1: Ashton Coal Monthly Rainfall

	Jun 11	Jul 11	Aug 11	Sep 11	Oct 11	Nov 11	Dec 11	Jan 12	Feb 12	Mar 12	Apr 12	May 12	Jun 12
Rainfall (mm)	*132.4*	17.4	*43.8*	*55.6*	*101.6*	*155.2*	43.4	45.8	*142.6*	*76.6*	28.8	12.2	*55.8*
LTA (mm)	43.8	40.8	31.5	50.4	34.5	64.6	83.4	83.4	94.7	68.5	41.3	43.6	43.8

- Italics denotes months of above average rainfall and shading denotes period of LW8 extraction

- LTA: long-term average, data from the NSW bureau of meteorology station number 061397

2.3 Hydrogeology

Two main groundwater systems occur within the ACP underground mine area as follows:

- Groundwater within the Permian hard-rock and coal measures. The predominant groundwater flow occurs along cleat fractures within the coal seams which are therefore considered as aquifers relative to the less permeable confining interburden units.
- Moderate to low permeability aquifers comprised of unconsolidated alluvial sediments. These alluvial aquifers systems are associated with Bowmans Creek, Glennies Creek and the Hunter River.

Groundwater flow in the Permian is dominated by fracture flow, particularly within the coal seams. The hydraulic conductivity of the coal seams is low, generally two or more orders of magnitude lower than the alluvial sediments. Higher permeabilities are found within the coal seams in areas with less overburden (and therefore reduced lithostatic pressure) close to the seam outcrop. The hydraulic conductivity of the coal seams has been shown to decline with increasing depth of cover. As groundwater flow and storage are dominated by relatively tight, sparse fracturing, the storage capacity within the Permian rocks is limited.

Hydraulic testing has indicated hydraulic conductivities in the order of 1 to 10m/d may apply to parts of the PG Seam within the weathered zone very close to outcrop, whereas typical values for the seam in the unweathered zone are in the order of 0.001 to 0.05m/d. The results of hydraulic testing of standpipe piezometers in the zone between Glennies Creek and LW1 have confirmed that the higher permeabilities of the outcrop zone are limited to a depth of less than 100m from outcrop (Aquaterra, 2008a).

The unconsolidated alluvial sediments comprise clay and silt-bound sands and gravel, with occasional coarser lenses or horizons where sands and gravel have been concentrated. The alluvial aquifer associated with Glennies Creek has generally been found to be moderately or poorly permeable, with hydraulic conductivity values less than 1m/d, but with occasional coarser horizons with conductivity up to greater than 10m/d. The alluvial aquifer associated with Bowmans Creek is generally characterised by high silt and clay content, and is less permeable than Glennies Creek, with a mean hydraulic conductivity of around 0.5m/d.

2.4 Groundwater quality

The groundwater in the coal measures aquifer system is brackish to slightly saline. Typical salinities range up to more than 6,000mg/L total dissolved solids (TDS), corresponding to an electrical conductivity (EC) of 8,000µS/cm or more. EC is not a direct salinity measurement, but it is considered an effective indicator of groundwater salinity.

Salinity within the Glennies Creek alluvium is generally moderate to low, particularly in the more permeable alluvium that contains a higher rate of through flow from surface recharge. In these areas, the EC is generally below 2,000µS/cm. There are other areas with increased salinity. Groundwater in these areas, generally away from the creek, is more stagnant in the poorly connected alluvial materials that mix with colluvium and fine sediments.

EC within the Bowmans Creek alluvium ranges from 772 to 9,920µS/cm, with an average of 2,280µS/cm. Groundwater in the colluvium that exists adjacent to parts of LW8 is more saline (4,500 to 13,800µS/cm), indicating that there is not a strong hydraulic connection with the less saline groundwater typically identified from Bowmans Creek alluvium.

Groundwater in both the Permian formations and the alluvium typically has higher salinity levels than surface flows in Glennies Creek and Bowmans Creek.

2.5 Groundwater levels

Groundwater levels in the Permian coal measures may have been influenced by historical mining in the area. It is considered likely that the groundwater levels in the Permian were higher than in both the alluvium and in the creeks/streams prior to commencement of mining at Ashton. Higher potentiometric surfaces in the Permian suggest that under natural conditions, groundwater is discharged from the Permian to the alluvium and to the surface streams. This is reflected in relatively higher salinities in areas in the alluvium and in the constant stream flow during periods of low rainfall and runoff.

At multi-level piezometer sites, potentiometric surfaces are commonly higher in the deeper piezometers in the Permian than in the shallow alluvium and the near-surface parts of the Permian sequence, unless affected by mining activity. Historically in some locations, potentiometric surfaces in the Permian sequences have been observed to be above the ground level elevation (artesian - positive pressure). Typically across the ACP, there is an upward hydraulic gradient with depth below surface under natural conditions.

In areas where mining impacts have lowered the potentiometric surface elevation in the Permian, the hydraulic gradients may have been reversed. In this case so the potential for water to flow from the alluvium directly into the underlying Permian exists. However, groundwater studies utilizing data collected from the ongoing monitoring program have indicated that there is generally very poor hydraulic connection between the alluvium and the underlying Permian coal measures. Permian Vertical flow between the formations is therefore limited under the low pressure gradients.

3. SUBSIDENCE MONITORING

3.1 Survey cross sections

As underground mining progressed closer to Bowmans Creek, subsidence survey monitoring was undertaken directly above the longwall goaf.

Four subsidence survey lines (Figure 2) have been established as follows:

- XL13 starts at Bowmans Creek and spans from the western edge of Bowmans Creek 140m west of LW8 (western extension to XL13 used for LW7B survey).
- XL14 starts above the middle of LW8 to cover 170 m west of LW8.
- CL1 spans across the Bowmans Creek alluvium at the in-bye end of LW8.
- CL2 spans across regolith at the out-bye end of LW8.

The plots of movement versus time are shown on Figures 3 to 6.

Vertical ground movement ranged from 96 to 108mm on the westward edge of the LW8 goaf (Figure 3 and Figure 4), 44mm on the southern goaf edge (Figure 5) and 12mm on the northern goaf edge (Figure 6). An additional 54mm of vertical movement was measured at the eastern edge of LW8 goaf due to a combination of LW7B and LW8 mining, for a total movement of 90mm (Figure 3).

On the westward edge of LW7B an additional 49mm of vertical subsidence due to LW8 mining gave a total subsidence at the completion of LW8 of 135mm.

Maximum ground movement inside the LW8 goaf footprint was 869mm. The effect of subsidence has also caused the lowering of the Bowmans Creek alluvium by an additional 19mm. The void width of LW8 is considerably less than that of LW7B (134m versus 198m) and consequently the degree of subsidence above LW8 is much smaller as is apparent on Figure 3.

Subsidence surveys were also undertaken along a 132KV power (that crosses LW8) at power pole locations PP31 and PP37 (Figure 2). Measurements at these locations indicate that subsidence (measured from the Top RL) at PP31 was 212mm (from and at PP37 a total of 386mm. A summary of the subsidence testing at PP31 and PP37 is provided in Tables 3.1 and 3.2.

Table 3.1: Subsidence Recorded at PP31

Test	Date	RL Base (m)	RL Top (m)
Original	22/09/2011	83.354	97.510
Test-01	22/12/2011	83.342	97.498
Test-02	03/01/2012	83.345	97.502
Test-03	24/01/2012	83.346	97.501
Test-04	15/05/2012	83.345	97.499
Test-05	17/05/2012	83.342	97.496
Test-06	21/05/2012	83.331	97.484
Test-07	25/05/2012	83.128	97.280
Test-08	16/06/2012	82.976	97.124
Total Subsidence		0.378	0.386

Table 3.2: Subsidence Recorded at PP37

Test	Date	RL Base (m)	RL Top (m)
Original	27/02/2012	71.215	87.207
Test-01	13/03/2012	71.212	87.206
Test-02	15/03/2012	71.211	87.203
Test-03	20/03/2012	71.211	87.199
Test-04	22/03/2012	71.178	87.168
Test-05	26/03/2012	71.109	87.098
Test-06	28/03/2012	71.006	86.995
Total Subsidence		0.209	0.212

Data extracted from ACOL files

A specific subsidence survey had been conducted along a 132KV power line at locations PP31 and PP37 since it crosses LW8 at both ends (Figure 2).

The Macquarie Generation sedimentation dams located above LW8 were surveyed before and after mining (Figure 2). The subsidence at the Macquarie Generation sedimentation dams surveying has indicated that up to 467mm was measured at 467mm (Table 3.2).

Table 3.3: Subsidence at Macquarie Generation Sedimentation Dams

Location			Original	Test - 01	Test -02
			25/06/2008 (12:00 P.M)	**07/08/2008 (12:00 P.M)**	**16/06/2012 (12:00 P.M)**
STN	Easting	Northing	R.L.	R.L.	R.L.
D1	317649.213	6407084.319	75.346	75.314	75.245
D2	317701.690	6407077.872	75.042	75.040	74.575
D3	317761.513	6407067.396	75.041	75.044	74.975
D4	317633.589	6407038.559	75.015	74.990	74.939
D5	317687.731	6407035.841	74.726	74.725	74.361
D6	317751.426	6407025.113	74.713	74.711	74.615
D7	317600.427	6406969.120	72.887	72.875	72.827
D8	317662.433	6406955.348	72.603	72.605	72.242
D9	317727.899	6406941.977	72.659	72.662	72.386

4. GROUNDWATER LEVELS

4.1 Groundwater monitoring network

An extensive network of piezometers monitoring groundwater levels (unconfined formations) and potentiometric surfaces (confined formations) has been installed across the ACP underground area (Figures 1 and 2). The network is designed to monitor the hydrogeological conditions at the site so that impacts resulting from mining operations can be identified and assessed.

The monitoring network targets the identified geological units in the area. These units include saturated alluviums, Triassic sandstone, Permian mudstone, sandstone and coal measures. Targeted monitoring of individual units is achieved through the use of sealed standpipe piezometers screened across target intervals and completely sealed (grouted) multi-level vibrating wire piezometers (VWPs).

The monitoring network is distributed across the underground mining area to provide comprehensive coverage (Figure 1). Monitoring coverage intensity is increased in the saturated alluvial sediments associated with Glennies Creek, Bowmans Creek and the Hunter River.

The underground monitoring complete piezometer network is listed with monitored units in Tables 1 to 5 of Appendix A.

4.2 Monitoring frequency

Routine monitoring of the ACP groundwater piezometer network began prior to the commencement of underground mining. Groundwater levels are monitored on a monthly basis and groundwater quality is monitored on quarterly and bi-annual basis.

During LW8 extraction the monitoring frequency at key monitoring piezometers close to LW8 was increased to fortnightly. These piezometers were:

- WML115A, WML115B and WML115C.
- WML308, WML311, WML325, WML323 and WML324.
- T5, T6.
- RA30 and RSGM1.
- Ashton well.

In addition a number of standpipe piezometers were equipped with data loggers set to record pressure heads on 6-hourly intervals. Recorded pressures are converted to a piezometric pressure head allowing the comparison to groundwater levels. During the extraction of LW8 piezometers equipped with automated loggers installed were:

- WML308.
- Paired site WML311 and WML325.
- Paired site WML323 and WML324.
- Ashton well.

Groundwater quality is monitored in selected standpipe piezometers by sampling for field analysis (ph and electrical conductivity) and for laboratory analysis (major anions and cations, metals and dissolved solids) in accordance with the monitoring frequencies specified in the WMP.

Water level hydrographs relevant to the PG seam extraction are shown on Figures 7 and 8 (PG seam), Figures 11 to 13 (overburden and shallow seams), Figures 15 to 19 (saturated alluvium), and Figures 18 to 19 (paired sites - alluvium and coal measures overburden).

Hydrostatic head profiles for selected VWPs are presented in Figures 9 and 14. These profiles demonstrate the vertical difference in depressurisation across the various formations.

4.3 Observed Effects

4.3.1 Bowmans Creek Alluvium

Piezometers monitoring the Bowmans Creek alluvium show no response attributable to LW8 extraction (Figure 15). Observed water level fluctuations are within the long-term trends and show variation consistent with rainfall recharge.

The prior extraction of LW7B caused subsidence impacts to the overlying Bowmans Creek alluvium. The subsided section of the alluvium is situated above the southern half of LW7B (Figure 2).

The section of cross-section XL13, west of Brunkers Lane, was surveyed for subsidence resulting from LW8 mining. Figure 3 indicates that the subsidence at CH-XL13370 increased by 19mm. Subsidence of this magnitude is considered negligible compared to the 1400mm subsidence observed during LW7B mining.

4.3.2 Hunter River Alluvium

Piezometers which monitor the Hunter River alluvium have shown no response to the extraction at LW8 (Figure 16). Instead the water table reflects the rainfall controlled natural recharge and discharge patterns with an overall increasing trend since 2010.

All piezometers have shown a recent regression following above average rainfall earlier in the year. The decline of the groundwater levels observed is attributed to a reduction in rainfall recharge over the period, rather than as a result of underground mining activity, and there has been no discernible response to mining to date.

4.3.3 Glennies Creek Alluvium

Piezometers which monitor the Glennies Creek alluvium have shown no response to the extraction at LW8 (Figure 17). The hydrographs display fluctuations due to climatic conditions but show no significant response to mining operations. Prior to high rainfall occurring in 2011, the piezometers appear to show a very minor long-term reduction in water levels (of the order of 2-3cm/year) which is subsequently masked by a recharge event. However this apparent water level decline may also be the result of long-term climatic variations.

Water table responses in Glennies Creek alluvium to the east of Glennies Creek are consistent with the rainfall controlled natural recharge and discharge responses also observed in the Hunter River and Bowmans Creek alluvium.

4.3.4 Pikes Gully Seam

Hydrographs showing piezometers in PG seam are presented in Figures 7 and 8. They include the following piezometers:

- Standpipe piezometers to the east of LW1 (near Glennies Creek) – WML119, WML181, WML182, WML183, WML184, WML185 and WML186.
- Multi-level vibrating wire piezometers – WML106-84m, WML189-93m, WML191-100m, WML213-205m and WMLC335-67m.
- Standpipe piezometers (now destroyed) located within the underground mining area – WML20 and WML21.

Groundwater Level Responses in the Underground LW1 to 8 Area

No responses were observed in the piezometers monitoring the PG seam in the longwall chain pillars during the extraction of LW8 (Figure 8). These piezometers have previously shown responses to the LW1 development headings and show a continuation of established trends.

Dewatering responses in the PG Seam prior to mining LW8 are seen in decommissioned PG piezometers WML20 and WML21 (Figure 8). Dewatering responses in this area were predicted in the EIS.

Piezometers located inside the LW1 to LW8 area are depressurised (WML191-100m and WML189-93m). Piezometers located outside the LW1 to 8 area (WML213-205.5m and WML106-84m) show gradual and partial depressurisation effects.

The groundwater responses observed to date for each piezometer is summarised as follows:

- WML106-84m and WML20 responded to LW1 development headings, with WML20 responding further to LW2 headings. WML20 became dry during the nearby mining of LW3 maingate headings (Figure 8).
- VWP WML191-100m located in the chain pillar between LW2 and LW3 showed dramatic depressurisation in response to the mining of LW3, but showed no response to the earlier passage of the LW2 development headings. WML189-93m, which is also located in the chain pillar to the north of WML191, showed marked drawdown as the LW2 development heading passed and no further responses during the extraction of LW3 (Figure 8).
- WML21, located in the northern part of LW5, responded strongly to the advance of the North West Mains and LW4 development headings past this point. The water level had fallen more than 100m below surface and could no longer be monitored before LW8 started. The PG Seam is 105m below surface at WML21, and is believed to be dewatered at this location (Figure 8).
- WML213-205m is remote from LW1 to LW6A and from the North West Mains. The steady drawdown observed in WML213 during LW3 to LW8 is believed to be due to the cumulative effect of Ashton's underground operations and mining activities on neighbouring mine sites. The measured potentiometric surface in the PG Seam at the end of LW8 extraction was around 49mAHD. The seam is at around 140mAHD at the WML213 site (Figure 9).
- WMLC335-67m was installed to the south of ULD LW101, following LW7B extraction. The measured potentiometric surface in the PG Seam following LW7B was around 48mAHD and the seam is around 21.5mAHD. This piezometer along with WML213 (Figure 8) show the PG Seam has remained saturated and only partially depressurised outside the mined area.

The hydrostatic head profiles displayed in Figure 9 were developed for the VWPs: WMLP115A (located above LW7B – now decommissioned), WML213 (located outside the area of longwall extraction, where Bowmans Creek merges into the Hunter River), WML189 and WML191 (which are located above chain pillars between LW2 and LW3) and WMLC334 (south of LW2, near the Hunter River). VWP monitor pressure heads in multiple formations at a single location providing the ability to compare potentiometric surfaces of the strata and therefore analyse hydraulic gradients. Each VWP contributes high value to the monitoring network and the understanding of the hydrogeological system.

The hydrostatic head profiles represent a snapshot of potentiometric surfaces in relation to the elevation for each piezometer prior to LW1 development (baseline levels), and following each of the LW1 to LW8 extractions. Generally, under pre-mining conditions, in the ACOL area, pressures plot close to the 45° hydrostatic line, although there is a slight shift from the line due to the upward head gradient.

Marked deviations from the hydrostatic line were first noted at WML189 and WML191 due to the depressurisation effects of LW2 development headings and LW3 extractions. Note that a significant depressurisation effect in both WML189 and WML191 is observed to have occurred at the Lemington 15 Seam level, approximately 45m above the PG Seam, during the mining from LW3.

Steady deviations from the hydrostatic line had mostly occurred in the PG Seam at WML115A prior to LW7b extraction. However during extraction of LW7b, for the first time, depressurisation effects were also observed to propagate into the overlying Lemington Seams. The Lemington 19 Seam is now fully dewatered whilst the shallower Lemington 7 to 15 Seams show only partial depressurisation or stress induced effects. During the remainder of LW7b extraction WML115A sensors were lost due to subsidence and the severing of the communications and no further data is able to be recovered.

Steady deviations from the hydrostatic line have continued in WML213. However, unlike the piezometers inside the area of mining (WML115A, WML189 and WML191), only limited depressurisation or stress induced effects have been noted in the Lemington 15 and 19 Seams, while no significant effects have occurred in the overlying Lemington Seams.

WMLC335 and 334 (recently installed) are included on Figures 8 and 9 and currently show no significant effect from activity associated with LW8.

Potentiometric surface contours for the PG Seam have been produced from groundwater levels measured following the completion of LW8 extraction (Figure 10). The potentiometric contouring shows a tight cone of depression which emanates from LW1 to LW8. The groundwater contours show that the effects are localised, with steep gradients around the mining perimeter, indicating low hydraulic connectivity with strata outside the mined area. The potentiometric contouring has not changed significantly since the mining of LW7B.

Depressurisation of the PG Seam around LW8 mostly occurred during the development of the NW Mains and development headings for LW6A to B and LW7A to LW7B. In addition, the water level in the PG Seam responded to the mining of the development headings with only limited additional drawdown occurring in response to subsequent longwall extraction.

It is noted that the overall extent of coverage provided by the existing monitoring program has been diminished with the loss of WML115A (during LW7B advancement).

Groundwater level responses east of LW1

Piezometers east of LW1 (between LW1 and Glennies Creek) do not respond to coal extraction at LW8 (Figure 7). With the exception of WML119, the PG water level in the area exhibits a stable trend over the LW8 extraction period.

The water level WML119 exhibits a sharp rise towards the end of LW8 extraction (Figure 7). This is likely a response to the developments for ULD LW101 and not related to extraction at LW8.

A steady drawdown water levels at WML184 and WML185 was observed during mining at LW1 (Figure 7). Since June 2008 throughout the mining of LW3 to LW8 the water levels in these piezometers has exhibited a long-term recovery trend.

The groundwater level at WML186 shows a recovery trend from June 2010 (Figure 7). This recovery trend observed suggests a steady reduction in the hydraulic conductivity of the PG Seam within the barrier. This is possibly a delayed response to the in-seam grouting carried out in 2007 and/or the progressive infilling of fractures with fines (from the floodplain alluvium).

The gradual recovery in water levels in the PG is accompanied by a corresponding reduction in the rate of underground inflows observed in TG1A, further discussed in Section 6.

4.3.5 Permian Units

Varying pressure responses have been observed in piezometers that monitor the overlying shallow coal measures overburden, Bayswater seams and Lemington seams. Hydrographs for these are presented in Figures 11 to 13.

Observed drawdown effects are apparent on the hydrostatic head profiles (Figure 14).

Coal Measures Overburden

Figure 11 features hydrographs from selected piezometers along Bowmans Creek. WML115B is located in the northern portion of the creek above the LW7B goaf, while the hydrograph of RM6 represents the response of an unmined sector of central Bowmans Creek, and the RM2 hydrograph represents the southern section of Bowmans Creek above LW6A and 7A goaf.

During the extraction of LW8, the water level responses to mining were most notable at the WML115B site, located in close proximity to the LW8 goaf. The response added to that already identified from the mining of LW7B. The hydrograph (Figure 11) indicates an additional drawdown of 1m in response to LW8 extraction, for a total of 7m following all longwall mining.

WMLP324 and WMLP325 both show the continuation of a gradual declining trend that commenced coinciding with the extraction of LW7b. It is noted that the declining trend continues post LW8 extraction.

No response from LW8 mining is measured elsewhere. The response within the coal measures is restricted to the area immediately surrounding LW8. Similar pressure responses have also been observed previously in nearby piezometer T1-P (before it was lost) as well as piezometers further to the south, T2-P, T3-P and T4-P during the extractions of earlier longwalls. The timing and magnitude of each response was related to the position of the piezometers in relation to the longwall face at the time of monitoring. These responses have been repeated a number of times and shown to be related to changes in storage as a result of bed separation effects.

Bayswater seams

Piezometers which monitor the Bayswater Seam are located to the south and south east of LW6A to LW7A and are located outside the influence of LW8 extraction. As such, no response was observed during LW8 mining (Figure 12). Historically WML113 and WML213 exhibited a gradual decline which is believed to be a response to mining at the adjacent Narama mine and not the Ashton operation. The hydrograph profiles have indicated a consistent downward prior to the completion of LW6A extraction, after which both have shown strong recovery.

Aside from some transient pressure responses observed during LW7A, the long-term drawdown responses cannot be related to any specific activities on the ACOL site.

Lemington seams

All piezometers which monitor the Lemington seams have responded to mining of LW1 to LW8 (Figure 13). Generally, depressurisation occurs over a relatively broad area in the PG seam in response to the development headings, whereas in the overburden, responses are only seen once longwall extraction occurs and then only within the area of subsided strata or in the immediately adjacent area. Hence, the magnitude of response in each overburden piezometer has varied according to the proximity of the piezometer to the nearest active or extracted longwall.

Most piezometers had previously responded during mining of LW1 to LW7B, no additional pressure responses were detected during the mining of LW8.

VWP responses in WML115A, which monitors the Lemington 4 to 15 Seams above LW7B, indicate that there was significant disturbance of the strata around the period of 10 November 2011 (Figure 13). As a result of this disturbance, all WML115A vibrating wire piezometers were lost, presumably due to ground movements severing the communication cables. Although, all piezometers were still pressurised at the time they ceased recording. The final sets of readings are shown on Figure 9.

Hydraulic head profiles presented in Figure 9 show that before WML115A was lost, the groundwater responses indicated dewatering in the deeper coal measures (PG, Lemington 15 & 19 seams), with propagation of this depressurisation into the uppermost section of the coal measures (Lemington 2-9 seams and coal measures overburden). This suggests that connective cracking from the underground workings may have propagated as high as the coal measures overburden in this locality.

No significant responses to LW8 extraction were measured in the southern part of the mine. WML108 (south of LW3) indicated minor depressurisation effects in Lemington seams. These seams however were mostly dewatered during LW5 extraction (Figure 14).

The groundwater responses in the Lemington seams above LW8 were not measured due to the loss of WML115 VWPs during LW7B mining.

Groundwater level responses in the Lemington seams are summarised as follows:

- The uppermost section of the coal measure overburden shows a pressure response to mining. Following LW7B extraction the saturated thickness levels at WML115B stabilised at 2.3 to 2.5m of water above the base of the screened interval (Figure 11). During LW8 extraction water levels have continued to declined further and at the end of LW8 extraction the saturated thickness in this piezometer has reduced by a further meter.

- Piezometers monitoring Lemington seams do not show responses to LW8 extraction (Figure 13). Responses observed in the Lemington seams to date have been interpreted to be associated with an increase of storage within the seams, caused by bed separation (dilation of fractures and cleats) and not dewatering.
- The lower Lemington 15 seam (WML115-93m) exhibited a sudden depressurisation response following the commencement of LW7B extraction (Figure 13). This is possibly associated with connective cracking, creating preferential flow paths to the underground workings. In contrast to the responses noted in the coal measures overburden and the shallower Lemington 7 seam, the Lemington 15 and 19 seams have revealed a gradual head decline since LW2 extraction (Figure 13). This suggests that slow dewatering has occurred at these levels for some time. WML269-142m in Lemington 15 seam continues to show a marked decline in the potentiometric surface of the coal seam.
- WML106-68m shows a small but sudden depressurisation response at the conclusion of LW8 extraction (Figure 13).

4.3.6 Hydraulic Connectivity of the Permian Overburden and Saturated Alluvium

Connectivity between the Permian overburden and the overlying alluvium is evaluated using paired standpipes piezometers as summarised in Table 4.1. Each pair includes a piezometer monitoring the Permian overburden and another monitoring the overlying saturated alluvium. Piezometer locations are shown on Figure 1 and more specifically to LW8 in Figure 2.

Table 4.1: Paired Standpipe Piezometer Summary

Water course	Alluvium piezometer	Permian piezometer
Bowmans Creek	T1-A (decommissioned)	T1-P (decommissioned)
	T2-A (decommissioned)	T2-P (decommissioned)
	T3-A (decommissioned)	T3-P (decommissioned)
	T4-A (decommissioned)	T4-P (decommissioned)
	WMLP115C	WMLP115B
	WMLP323	WMLP324
Hunter River	N/A	
Glennies Creek	WMLP120B	WMLP120A

Bowmans Creek Alluvium

Hydrographs of selected paired piezometers, for the Bowmans Creek alluvium, are displayed on Figures 18 and 19. In general the paired sites tend to exhibit similar water level response profiles between the alluvium and Permian aquifers where the Permian aquifer have not been affected by longwall extraction. These profiles represent climate driven variability, instead of responses to mining activity. The similarity in the profiles indicates a degree of hydraulic continuity between the alluvium and the overburden, particularly at T3 where water levels in the overburden have recovered to those in the alluvium following the extraction of LW7A.

WML115B, located in the Permian overburden is in close proximity to the LW8 goaf and shows additional drawdown in response to LW8 extraction in addition to the observed decline due to LW7B extraction. An apparent rise in water levels at WML115C during LW7B extraction (which monitors the overlying Bowmans Creek alluvium at the same location) is attributed to subsidence and re-equilibration of water levels in the alluvium, rather than an actual water level rise.

Both paired piezometers at WML323/324 and WML311/325 appear to show the beginnings of a declining water level trend following LW7B extraction that continues through LW8 extraction. Continued monitoring of these piezometers as well as WML115B/C will identify any connectivity with alluvial aquifers should this occur.

Glennies Creek Alluvium

The Hydrographs for WML120A and 120B are shown on Figure 19. The Permian water level (WML120A) shows a steady recovery following the passing of LW1 up to 2011 after which it closely mirrors the alluvium water levels. The alluvium water level (WML120B) has remained relatively constant with no impacts post LW1 from the time series profile.

5. GROUNDWATER AND SURFACE WATER QUALITY

5.1 Monitoring Program

Monitoring of groundwater quality in the Glennies Creek alluvium, Bowmans Creek alluvium, coal measures overburden and PG Seam was undertaken prior to the commencement of mining to establish baseline conditions.

A primary aim of the monitoring program is to assess if alluvium groundwater or surface water is lost to the underground. In addition the program is setup to identify any potential adverse impacts the underground extraction may have on the quality of the alluvium or surface water.

EC is used as the key screening parameter as it provides an easily measurable representation of salinity. The different water bodies (surface, alluvium, or the Permian) have characteristic salinity signatures or allowing identification by EC levels.

Surface water EC is measured at a number of stations, the locations of which are displayed on Figure 20. A summary of EC measurements from these locations is provided in Table 5.1.

The key standpipe piezometers used to monitor groundwater EC are listed in Table 5.2. Mine inflows are monitored through sampling associated with the mine water management scheme.

5.2 Baseline Data

Data from the underground water quality monitoring program has been collected throughout the mining of the PG seam LW1 to LW8 and previously reported by Aquaterra (2008). Inflow quality comprises the total of all seepage into the underground, not just seepage through the eastern rib.

Initially, while access to the LW1 development headings was available, samples were collected from several locations along the eastern rib of LW1. Access to LW1 was progressively lost due to the longwall advance, water inflows to TG1A however are contained and conveyed along TG1A to a collection point at 18CT. At 18CT the water is piped through the goaf to the LW1 Backroad, which continues to be accessible (Figure 1). EC monitoring of the LW1 Backroad Pipe discharge from TG1A has continued through the extraction of LW8.

On the basis of the water quality monitoring data, the typical pre-mining EC of the water sources was as follows:

- PG Seam:
  - 6,000 to 6,500µS/cm (north of LW1 CT13).
  - 8,000 to 9,000µS/cm (south of LW1 CT14).
- Glennies Creek alluvium - 500 to 2,200µS/cm.
- Bowmans Creek alluvium - 1,000 to 2,000+ µS/cm.
- Colluvium - 4,000 to 13,500µS/cm.
- Uppermost water zone in coal measures overburden above LW5 to LW6A - 320 to 2,000µS/cm.
- Glennies Creek surface water - 250 to 350µS/cm (increases to 800 to 900µS/cm during high runoff).
- Bowmans Creek surface water - 600 to 1,000µS/cm (increases to 2,000+ µS/cm during low flow).

5.3 Monitoring Results

5.3.1 Surface water

Surface water EC data has been plotted on Figure 21 for each water course. All graph legends are ordered with stations from upstream (top station in the legend) to downstream (bottom station in the legend). In addition, recent data is included as Table 5.1.

Glennies Creek

Glennies Creek EC (SM7, 8 and 11) does not show any significant trends across the monitoring period. The most consistent data set is derived from SM8 during 2006, a period of very little rainfall. This relatively flat profile (during 2006) represents the relatively steady influence of alluvial groundwater flow to the creek during periods of low rainfall with later, more erratic data influenced by surface water runoff following significant rainfall events. Since the large rainfall events of late 2011 and early 2012 a relative decline in salinity at SM7 and SM11 is observed.

Glennies Creek shows the lowest overall EC of the three monitored water courses with no significant impacts related to LW8 extraction.

Bowmans Creek

With the exception of SM4, water quality in Bowmans Creek (SM3, SM5 AND SM6) has remained relatively stable.

SM4 shows a number of significant increases in salinity across the monitoring period (Figure 21). These increases are attributed to periods of significantly reduced rainfall and low stream flow (MPR, 2009). Such increasing salinity trends are typical of ephemeral streams and represent the influence of evaporative salt concentration in standing surface water that occurs during prolonged dry periods.

In addition, SM4 is located on a rock bar of subcropping Permian sandstone and as a result is likely to receive very little groundwater contribution from the alluvium during low flow periods.

Other than the noted trends in SM4, water quality in Bowmans Creek shows small scale variability, with an overall consistent trend of slightly reducing salinity across the LW8 monitoring period. No impacts are apparent from the extraction of LW8.

Hunter River

The available data for the Hunter River monitoring sites (SM9, 10, 12, 13 and 14) is limited to post LW7A extraction (Figure 21). The data shows relatively high variability between sampling points, ranging from around 360 up to 1000µS/cm. From the available data no impacts attributable to longwall extraction are apparent.

5.3.2 Groundwater

A summary of all available groundwater EC measurements is presented in Table 5.2. The data sets are plotted on Figures 22, 23, 24, 25 and 26, grouped by aquifer, and discussed in the following sections.

Bowmans Creek Alluvium

The piezometers that monitor the Bowmans Creek alluvium generally show that the groundwater EC readings have remained steady across the LW8 extraction period (Figure 22). The piezometers in the vicinity of LW8 (T5, T6, WMLP311 and WMLP323) have freshened slightly over the extraction period in response to high rainfall events that occurred during the early stages of extraction. The overall long-term decrease in EC has (in part) been attributed to the elimination of upward leakage of saline groundwater from the underlying Permian coal measures.

Water quality at T7 displays an elevated and variable EC level. The elevated EC level indicates that this piezometer may be connected to groundwater from the Permian coal measures and is not considered to be representative of Bowmans Creek alluvium.

Glennies Creek Alluvium

A long-term trend of reducing EC levels is observed within the Glennies Creek alluvium throughout longwall mining. This is attributed (in part) to the reduced effects of upward leakage from the Permian coal measures.

The EC trends have shown a gradual increase at WML120B and WML129 starting in early 2011 (Figure 23). This is considered to be a delayed response from high surface runoff events that occurred during mid to late 2011, during this period the Glennies Creek flow at SM8 displayed elevated EC levels (Figure 21) similar to those currently being recorded at WML120B.

The maximum EC level recorded at WML120B of 830µS/cm is still significantly lower that the baseline EC value recorded at this location prior to underground (Figure 23). High baseline EC levels indicate that in this area the alluvium maybe have been connected to the nearby outcropping PG seam.

The EC trend observed in piezometer WML129 has remained relatively stable (365 to 580µS/cm) across the monitoring period to date (Figure 23). The observed small increase is within baseline trends and not a response to LW8 extraction.

Coal Measures and Overburden

Piezometers WML120A and WML119 continue to follow the established water quality trends with EC levels of 655 and 178µS/cm with no response to LW8 extraction (Figure 24). The influence of induced water flow from Glennies Creek (Aquaterra, 2012b) is the dominant driver behind the low EC values.

The groundwater EC levels in the shallow coal measures (WML115B) have shown a significant increase since spring 2011 (Figure 24). This increase in salinity coincides with the decline in water levels in the WML115B, and with the increased inflows noticed while mining LW7B.

Mine inflows

The LW1 Backroad Pipe (total of TG1A inflows) EC levels remained consistent during LW8 and have not deviated significantly from the 1900µS/cm observed since completion of LW6A (Figure 25).

The EC of underground inflows (collected at MG01, MG03 to MG05, LW7B 11CT) is high and extremely erratic (5,000 to 9,000µS/cm). The elevated salinity suggests that the majority of inflow is coming from (or through) the PG seam and overburden. MG01 and MG03 had initially display a consistent trend of declining EC, however, following a period of relative stabilisation both sites commence to display erratic EC levels consistent with the majority of the underground monitoring points.

Table 5.1: Surface Water EC Monthly Results (µS/cm)

Date	SM1	SM2	SM3	SM4	SM4A	SM5	SM6	SM7	SM8	SM9	SM10	SM11	SM12	SM13	SM14
16/09/2011	-	-	852	864	863	889	888	814	829	789	779	428	432	424	446
14/10/2011	510	366	630	604	614	613	610	453	433	667	665	439	612	592	660
10/11/2011	-	-	847	845	833	839	853	562	540	1000	968	562	947	981	981
16/12/2011	-	-	511	510	507	507	-	378	338	-	-	345	-	605	604
18/01/2012	-	-	951	982	949	939	1010	403	416	840	845	441	783	846	847
21/02/2012	140	139	365	329	304	362	391	312	315	-	391	322	378	421	448
23/03/2012	2950	3020	915	915	928	893	913	306	310	541	586	320	-	572	580
26/04/2012	-	-	990	995	988	982	992	452	458	893	902	482	784	897	881
25/05/2012	-	-	940	987	977	923	1020	414	413	978	977	432	848	973	977
22/09/2012	-	-	847	861	866	858	861	293	297	691	705	298	556	701	701
19/07/2012	472	509	632	631	634	629	891	278	282	576	691	279	444	614	616

Table 5.2 Groundwater EC Summary (µS/cm)

Aquifer/Seam	Piezometer ID	Pre-Longwall Extraction	LW1: 12/03/2007 to 15/10/2007	LW2: 10/11/2007 to 21/07/2008	LW3: 20/08/2008 to 03/03/2009	LW4: 02/04/2009 to 15/02/2009	LW5: 04/01/2010 to 07/06/2010	LW6A: 09/07/2010 to 22/11/2010	LW7A: 23/03/2011 to 05/08/2011	LW7B: 03/10/2011 to 17/01/2012	LW8: 27/02/2012 to 05/06/2012
Bowmans Creek Alluvium	RA30	-	-	-	1600	1530-1610	1310-1320	1430	-	1136	1344
	RM06	1220-1340	-	772-1170	878-1240	824-980	1020-1120	-	-	704	-
	RM07	956-1690	-	1230-1320	813-874	845-897	1030	-	-	909	-
	RM08	1300	-	-	-	939	1270	-	-	-	-
	RM09	969-1360	-	1190-1350	930-997	921-930	997-1000	1090	-	-	-
	T1-A	-	-	-	1120	1080	1670	1680	-	-	-
	T5	-	-	-	1400	1310	1220	1200	-	1087	955
	T6	-	-	-	1400	1400-1420	1360	1170	-	1043	952

Aquifer/Seam	Piezometer ID	Pre-Longwall Extraction	LW1: 12/03/2007 to 15/10/2007	LW2: 10/11/2007 to 21/07/2008	LW3: 20/08/2008 to 03/03/2009	LW4: 02/04/2009 to 15/02/2009	LW5: 04/01/2010 to 07/06/2010	LW6A: 09/07/2010 to 22/11/2010	LW7A: 23/03/2011 to 05/08/2011	LW7B: 03/10/2011 to 17/01/2012	LW8: 27/02/2012 to 05/06/2012
	T7	-	-	-	5350	5380-5770	5260	5960	-	5390	5770
	WML115C	-	-	-	5030	-	-	-	-	-	-
	WMLP299	-	-	-	-	-	-	-	-	-	-
	WMLP311	-	-	-	-	-	-	-	-	1000	790
	WMLP312	-	-	-	-	-	-	-	-	3110	-
	WMLP323	-	-	-	-	-	-	-	-	964	871
Glennies Creek Alluvium	WML120B	1231-1930	1020-1188	1240	915-987	839-903	639-718	637	-	737	830
	WML129	380-571	378-522	-	458-578	490-571	433-436	471	-	365	465
Coal Measures Overburden	RM06	1220-1340	-	772-1170	878-1240	824-980	1020-1120	-	-	704	-
	RM07	956-1690	-	1230-1320	813-874	845-897	1030	-	-	909	-
	RM08	1300	-	-	-	939	1270	-	-	-	-
	T1-P	-	-	-	8000	1210-8510	1070-1980	1840	-	1670	-
	WML115B	-	-	3790-3970	3770	3720-3940	4180-4270	-	-	4550	5410
	WMLP324	-	-	-	-	-	-	-	-	383	598
	WMLP325	-	-	-	-	-	-	-	-	809	1307
Pikes Gully	WML119	6470	3090-3870	2320	86-1820	87-126	139	87-155	-	106	178
	WML21	8140	8530-8700	6460-8280	7690-7990	7500-7550	7180	-	-	-	-
	WML120A	6350	742-950	828	810-1140	919-935	1050	600-1020	-	596	655
	WML181	-	4920	-	2460-2680	2600-2640	2670	2600	-	3170	3850
	WML182	-	4220	8680	6510-6950	6390-6760	7900	6760-8400	-	5090	4220
	WML183	-	8570	8180	5310-5950	5310-5950	5570	5310-5440	-	4760	4780
	WML184	-	-	4560	4400-5140	4940-5270	5440	1790-5210	-	974	1073
	WML185	-	-	4430	2900-2940	2310-2710	2650	2710	-	1182	1168
	WML186	-	-	463	-	933-1300	1550	1140-1640	-	-	-

Aquifer/Seam	Piezometer ID	Pre-Longwall Extraction	LW1: 12/03/2007 to 15/10/2007	LW2: 10/11/2007 to 21/07/2008	LW3: 20/08/2008 to 03/03/2009	LW4: 02/04/2009 to 15/02/2009	LW5: 04/01/2010 to 07/06/2010	LW6A: 09/07/2010 to 22/11/2010	LW7A: 23/03/2011 to 05/08/2011	LW7B: 03/10/2011 to 17/01/2012	LW8: 27/02/2012 to 05/06/2012
Upper Liddell	WML261	-	-	-	-	1420-2510	1430	1220	-	1260	-
	WML262	-	-	-	-	6270-7170	6970	-	-	7370	7280

6. GROUNDWATER INFLOWS

Water exported from the mine is monitored by flow meters on the discharge pipelines, as is the water pumped into the mine to meet operational needs of the longwall operation. Total groundwater inflow rate is determined by a water balance approach, using flow volumes recorded at water meters on the discharge pipelines and the imported water pipeline.

Within the mine water is often diverted to holding areas for operational reasons, this will impact on the resulting water balance as the volume of water being diverted and impounded is not accounted for until it is discharged. During times when water is diverted and stored underground the calculated mine inflows will underestimate the groundwater inflows, conversely when diverted water is discharged water balance calculations will over estimate the groundwater inflow component. The best representation of actual inflows is therefore to average the calculated inflows each month. These monthly averages are presented on Figure 26.

Water is exported from the mine via a borehole pump direct to the mine water supply circuit and via pipelines along the gate-roads to the sump in Arties Pit near the mine portal. Prior to May 2010 a sump borehole situated at the south west corner of LW1 was used. Post May 2010 a new sump borehole (Sump Bore No 2) located to the south of LW6A has been used (Figure 1).

The total inflow rate includes all the groundwater seepages into TG1A, all goaf inflows from LW1 to LW8, seepages into main gate headings of LW8, all inflows to the North West Mains, and other miscellaneous seepages. Calculated inflows are conservative in that they include a component of recycled water derived from seepage losses back into the North West Mains from the storage dam in Arties Pit beside the mine portal.

Figure 26 compares calculated average monthly groundwater inflows with the current 2012 groundwater model prediction and the previous 2001 EIS prediction.

The following observations are noted:

- The average monthly inflow rate ranged from 7.8L/s (0.67ML/d) up to 18.5L/s (1.6ML/d) over the LW8 extraction period. The average inflow rate for the period was approximately 12 L/sec which is below the approved 2012 model predictions of 16.8 L/sec in September 2012.
- Historically groundwater inflows have remained well below the groundwater model predictions. From the middle of LW7B extraction, inflow rates increase. This increase in inflows correlates with the dewatering of the lower Lemington Seams and propagation of depressurisation into the Permian overburden as discussed in Section 4.3.2. The elevated inflows show short term peaks that matched EIS predictions in January 2012.
- Inflows increase again during the later part of LW8 extraction in a similar manner to that observed towards the end of LW7B. The increase in inflows again correlates with a potentiometric surface decline observed in the overlying Permian overburden, particularly at WML115B. In this instance the peak inflows recorded marginally exceed the EIS predictions at the completion of LW8 in June 2012.

The rate of inflows into TG1A (easternmost heading of LW1) is monitored separately from other inflows, to allow determination of groundwater contributions from Glennies Creek alluvium. Following completion of LW1, the EC of the separated inflows gradually declined to around 1500µS/cm and based on comparison of EC between the PG Seam and Glennies Creek alluvium, it has been derived that initially approximately 70% of the total TG1A inflows were derived from the Glennies Creek alluvial floodplain, to the east of LW1 (Peter Dundon and Associates, 2007).

The TG1A inflow rate as measured from the LW1 Backroad Pipe peaked at around 2.25L/s during the extraction of LW1 in 2007 and has since declined to a rate of 0.5L/s at the conclusion of LW8 extraction (Figure 27). Following the completion of LW6A the EC of discharge from the Backroad Pipe has increased to around 1900µS/cm (Figure 24).

The gradual reduction in TG1A inflow rate combined with the increase in EC suggest that the inflow contribution from Glennies Creek alluvium has also decreased as a percentage of the total inflow rate with the inflow contribution from the Glennies Creek alluvium now estimated to be approximately 60% of the TG1A inflows.

7. COMPARISONS WITH APPROVED PREDICTIONS

7.1 Overview of 2001 EIS, 2009 EA and 2010 SMP Groundwater Assessments

The performance of the groundwater system in response to mining operations was compared with the predicted impacts that were made in the groundwater impact assessment reports for the 2001 EIS, 2012 EA and 2010 SMP.

The main parameters of predicted impacts for each assessment were:

- Environmental Impact Statement (HLA Envirosciences, 2001).
  - Total rates of groundwater inflow to the underground mine – Section 5.2 (page 17) and Figure 11 of the EIS Appendix H.
  - Total rates of inflow losses from the Glennies Creek, Bowmans Creek and Hunter River alluvial aquifer systems – Section 5.3 (pages 17-18) and Figure 13 of the EIS Appendix H.
  - Groundwater level drawdowns – Section 5.4 (page 18) and Figures 14-16 of the EIS Appendix H.
- Bowmans Creek Diversion Environmental Impact Assessment (Aquaterra, 2009f).
  - Total rates of groundwater inflow into the underground mine – Section 6.8 (page 130) and Figure 6.7 and 6.8.
  - Total rates of inflow losses from Glennies Creek, Bowmans Creek and Hunter River alluvium aquifer systems – Section 6.1 (Page 149) and Figure 6.15.
  - Groundwater level drawdown (Page 130) – Section 6.9 and Figure 6.9.
- Subsidence Management Plan LW6 to 8 (Aquaterra, 2010b).
  - Total rates of groundwater inflow to the underground mine – Section 4.6.3 (Page 69) and Figure 4.7.
  - Total rates of inflow losses from Glennies Creek, Bowmans Creek and Hunter River alluvium aquifer systems – Section 4.6.2 (Page 68) and Figure 4.6.
  - Groundwater level drawdown – Section 4.6.2 (Page 68 - 69) and Figure 4.6.

Each parameter is summarised in Table 7.1 and addressed in the following sections.

It is important to note that the mine plans and mine schedules that were modelled in the above groundwater assessments were different to the actual extraction. The following are significant changes:

- The mine plan assessed for the 2001 EIS comprised of 6 longwalls (LW1 to LW6), while the mine plan that was used in the 2012 EA and 2010 SMP groundwater assessments comprised of 8 longwalls (LW1 to 8).
- Extraction of LW7A was concluded earlier than intended and extraction at LW7B was commenced further north than initially intended (Figure 1). The result of this is the total extraction at both longwalls was less than what was modeled.
- Extraction of LW6B was delayed and will now take place following extraction of LW101 in the ULD seam.
- Due to the postponement of LW6B and reduced abstraction at LW7, the commencement of mining of longwalls LW8 and LW101 has occurred earlier than in the modeling predictions.

For comparison purposes, it has been determined that the extraction of LW8 occurred during Mining Year 8 (end of LW6) as modelled in the 2001 EIS, and during the year 2011 as modelled in the 2009 EA and 2010 SMP.

Table 7.1: Comparison of Actual Groundwater Impacts to EIS, EA and SMP Predictions

Impact Description	Impact observed to date (end of LW8)	Predicted Groundwater Related Impacts to LW8		
		EIS, 2001 (LW1 to 6)	EA, 2009 (LW1 to 8)	SMP, 2010 (LW6 to 8)
Groundwater drawdown to the Glennies Creek alluvium (east of LW1)	up to 0.4m during LW1, followed by full recovery	2.2m	0.2m	No additional impact predicted
Groundwater drawdown to the Bowmans Creek alluvium (above LW6A, LW7A, LW7B)	0m	0.5 to 1.3m (in Ashton well)	0.5 to 2m	0.5 to 2m
Groundwater drawdown to the Hunter River Alluvium (South of LW6 to 8)	0m	<0.5m	0.01m	0.01m
Baseflow impacts to Glennies Creek	0.045ML/d (0.5L/s)	0.27ML/d (3.16L/s)	No additional Impact, 0.23ML/d (2.6L/s)	No additional Impact, 0.23ML/d (2.6L/s)
Baseflow reduction to Bowmans Creek	0 L/s	0.38ML/d (4.5L/s)	0.03ML/d (0.34L/s)	0.03ML/d (0.34L/s)
Baseflow reduction to the Hunter River	0 L/s	0.25ML/d (2.9L/s)	0.006ML/d (0.07L/s)	0.01ML/d (0.12L/s)
Total Underground Inflows	1ML/d (11.3L/s)	1.45ML/d (16.8L/s)	1.2ML/d (14L/s)	1.2ML/d (14L/s)

7.2 Groundwater Level Drawdown

7.2.1 Bowmans Creek Alluvium

The 2001 EIS, 2009 EA and 2010 SMP predicted groundwater a drawdown of 0.5 to 2.0m for the stage of mining associated with the extraction of LW8.

There are no hydrographs showing predicted drawdown presented in the 2001 EIS, but it is stated that drawdown will be less than 0.5m except for the Ashton Well which is predicted to show a drawdown of 1.3m. It is predicted in the 2009 EA and 2010 SMP that the alluvium will dewater in areas overlying the panels and that mining associated drawdown impacts of 0.5 to 2m within the saturated alluvium may be observed.

However, as discussed under Section 4.2.3 no reduction in the Bowmans Creek alluvium storage occurred during LW8 extraction (or earlier longwall panels) and hence there was no seepage loss from the Bowmans Creek alluvium. Figures 15 and 18 demonstrate no depressurisations during the LW8 extraction period. The impacts from underground mining to the Bowmans Creek alluvium is therefore considered to be undetected and within the 2001 EIS, 2009 EA and 2010 SMP predictions.

The groundwater monitoring results demonstrate that LW8 extraction has been completed in full compliance with Development Consent Condition 3.9.

7.2.2 Glennies Creek Alluvium

Hydrographs of predicted drawdown in the Glennies Creek alluvium were presented in the 2001 EIS (HLA Envirosciences, 2001). The hydrographs shown are of the “North Piezometer” (registered piezometer GW064515 in Camberwell village) and “South Piezometer” at a location described to be within the alluvium overlying the sub-crop of the ULD seam adjacent to the underground mine. Locations of the North Piezometer and South Piezometer are shown on Figure 1.

ACOL has a network of monitoring piezometers located in the general vicinity of these two notional sites:

- G3B adjacent to the North Piezometer.
- WML120B and WML129 (alluvium piezometers on western side of Glennies Creek) and WML247 (on the eastern side of Glennies Creek) near "South Piezometer". The location of HLA's "South Piezometer" shown on their Figure E1 (HLA Envirosciences, 2001) it is situated very close to piezometers WML120B and WML249 (see Figure 1).

Piezometer G3B has been dry through the underground mining period, impact identification from the underground mine is therefore not possible.

Monitoring of piezometer WML120B commenced prior to the first observations of inflows to the underground mine (Figure 19). An initial drawdown of approximately 0.6m was observed which is shown to recover over time. Following the completion of LW8 extraction, the groundwater level at WML120B had recovered slightly to be only 0.4m below the pre-LW1 level. The EIS had predicted a 1.3m drawdown in Year 3, increasing to 2.2 m drawdown by Year 7, coinciding with the present state of underground mining. Hence actual drawdown is very much less than predicted in the EIS as we can add that water levels in the piezometer have subsequently fully recovered.

Groundwater level drawdown in the Glennies Creek alluvium has been significantly less than predicted in the EIS. The groundwater level in piezometer WML120B indicated an initial drawdown (during LW1 activity) of about 0.4m (Figure 19), but has since recovered to pre mining levels - well below the EIS prediction of 2.2m for this locality by this stage of mining.

The groundwater monitoring results are also consistent with the SMP predictions, which state that no impacts on Glennies Creek alluvium is predicted to occur beyond which has had already occurred as a result of mining LW1.

The hydrographs of piezometers on the eastern side of Glennies Creek indicate no suggestion that any mine-related drawdown has occurred at all in the alluvium east of Glennies Creek.

7.2.3 Hunter River Alluvium

There has been no groundwater level impact to the Hunter River alluvium, which is consistent with the EA and SMP predictions, and is lower than the EIS prediction of <0.5m for this stage of mining. This is discussed in more detail in Section 7.3.3.

7.2.4 Permian Coal Measures

Predicted drawdown impacts on the Permian coal measures were only presented in the EIS for the completion of mining, not for intermediate stages of mine life. Therefore it is not possible to compare actual impacts with the predicted impacts for the present stage of mining.

7.3 Seepages Losses from Alluvium

7.3.1 Seepage Losses from Glennies Creek

The total inflows to the eastern gateroad of LW1 (TG1A) have been closely monitored since the first appearance of seepage as the LW1 development headings passed below the water table. Monitoring has continued to the present time through the installation of the collection system and LW1 Backroad Pipeline described in Section 1. In addition to flow rates, the EC and pH are monitored.

The inflows into TG1A include groundwater from storage within the PG seam, water seeping through the barrier from the Glennies Creek alluvium and possibly small flows from the roof and floor rock. Through an assessment of the water quality of TG1A inflows in comparison to the in-situ groundwater quality of the PG seam and the Glennies Creek alluvium respectively, it was calculated that approximately 70% of the total TG1A inflows is derived from Glennies Creek alluvium. The balance comes from storage in the PG seam and other Permian strata.

The calculated seepage from Glennies Creek alluvium into the underground workings is plotted on Figure 27 together with the alluvium seepage inflow rates predicted in the EIS and EA.

The extractions of LW8 did not impact further to the baseflow losses from Glennies Creek and there were no increases in inflows observed at TG1A during the period. Actual Glennies Creek inflow rates during LW8 varied between 0.33 and 0.52L/s (0.03-0.05ML/d) at the conclusion of LW8. The seepage was evaluated to 0.34L/s (0.03ML/d) in July 2012. All values are well below the EIS prediction of 3.16L/s (0.27ML/d) and EA prediction of 2.6L/s (0.23ML/d) for this stage of the mining operation (Figure 27). The actual seepage rates have also continued to be less than the maximum rates contained in the SMP LW6 to 8 predictions (2.6L/s / 0.23ML/d).

The seepage rate has stabilised prior to the end of LW1 and no incremental increases in measured seepage rate or influence of mining LW2 to LW8 has been observed. Rather, the plot of seepage inflows is indicating a downward trend followed by a relative stabilisation since conclusion of LW7A, consistent with the recovery in water levels at WML120A and other nearby piezometers described in Section 4.2.1 (shown on Figures 7, 8 and 9). This suggests a likely reduction in the permeability of the PG seam within the barrier, possibly due to clogging by suspended fines, or a delayed benefit from the TG1A rib grout injection program implemented during 2007.

7.3.2 Seepage Losses from Bowmans Creek

Although it was reported in the EIS and EA that seepage from the Bowmans Creek alluvium was predicted to occur during this stage of mining and LW7B has caused part of the alluvium aquifer to subside (i.e. the southern half of LW7B, see Figure 2), there has been no observed mining-induced reduction in alluvium saturated thickness, and hence no seepage loss from the alluvium, as a result of LW8 extraction or earlier longwalls to date.

Despite the likely presence of subsidence induced fracturing in the Permian beneath the alluvium, there has been no loss of groundwater storage in the alluvium in that area. The multi-level vibrating wire piezometer piezometer WML115A, which is located mid-panel just inside the area of saturated alluvium, was affected by the subsidence, and the cables to all piezometers in that piezometer were severed shortly after subsidence occurred. However, the shallow standpipe piezometer WML115B, which is screened at 9.6 to 12.6m depth in Permian coal measures, including one of the thin upper Lemington seams, has continued to report a water level above the screen, indicating that this part of the sequence remains saturated, and therefore any fracturing at that site is not providing a direct hydraulic connection between the goaf and the base of the alluvium.

Accordingly, the impact on Bowmans Creek is less than predicted in the EIS (4.5L/s/0.38ML/d), SMP and EA studies (0.34L/s/0.03ML/d).

7.3.3 Seepage Losses from the Hunter River

Mining of LW8 did not occur in close proximity the Hunter River alluvium (Figure 2), and therefore there were no groundwater related impacts that could potentially occur to the alluvium as a result of LW8 extraction.

The southern ends of LW6A and LW7B are about 250 and 360m from the edge of the Hunter River and associated alluvium. It was reported in the 2011 AEMR (RPS Aquaterra, 2012) that the mining of the extractions of LW6A and LW7B resulted in no reduction in alluvium storage and consequently, no seepage losses from the Hunter River alluvium is likely to have occurred. The situation has not altered during the extraction of LW8 and the water table in the Hunter River alluvium has continued to rise from above average rainfall.

Accordingly, the impact on the Hunter River is less than predicted in the EIS (2.9L/s/0.25ML/d), EA (0.07L/s/0.006ML/d) and SMP (0.12L/s/0.01ML/d) studies for this stage of mining.

7.4 Groundwater Inflows into the Underground Mine

The total inflow rate includes all the groundwater inflows to TG1A, all goaf inflows from LW1 to LW8, inflows into maingate headings of LW8, all inflows to the North West Mains, and miscellaneous seepages. The figures are conservative, as they may also include some recycled water, derived from seepage losses back into the North West Mains from the sump in Arties Pit beside the mine portal.

The measured/calculated total groundwater inflow rates to the underground mine since the commencement of monitoring are plotted on Figure 27, for comparison with the inflow rates predicted in the EIS and EA assessments for the equivalent stage of the mining operation.

The 2001 EIS and 2009 EA predicted a progressively increasing total inflow rate, from 0L/s in 2005, increasing to 5L/s (during LW1 extraction in 2006), progressively increasing to values of 17L/s (2001 EIS) and 14L/s (2009 EA and 2010 SMP) during LW8 extraction.

Calculated inflows are shown to remain within approved predictions. The net groundwater inflows to the underground mine have been determined from the mine water balance to range from 3 to 16L/s (0.28 to 1.2ML/d), and averaged 11.3L/s (1ML/d) during the extraction previous to LW8 (Figure 23).

Monitoring of Bowmans Creek, and Hunter River alluvium has demonstrated that there is no significant seepage to the underground mine. Minor inflows from the Glennies Creek alluvium is within the predictions and shown to be decreasing. This is confirmed by the fact that the mine water EC levels have decrease where a decrease would have been likely if water was coming from less saline alluvium groundwater.

8. CONCLUSION

Coal extraction at LW8 in the PG seam occurred adjacent to the Bowmans Creek alluvium flood plain. Extensive monitoring of the groundwater level within the alluvium and overlying Permian overburden was conducted to allow for the identification of impacts. Analysis of the monitoring results demonstrates that no adverse impacts to the Bowmans Creek alluvium occurred as a result of LW8 extraction.

Subsidence effects are expected to have substantially dewatered the Permian strata above each panel area within the zone of subsidence at least across the LW1 to LW8 footprint. Monitoring results have shown that the overlying Permian strata remains saturated with partial depressurisation outside the LW1 to LW8 goaf area.

The continuing saturation of the uppermost part of the Lemington sequence, as shown at standpipe piezometer WML115B, indicates that the Permian sequence has not been completely depressurised above the southern part of LW7B.

Monitoring of the Bowmans Creek and Hunter River alluvium has demonstrated no observed impacts attributable to mining in terms of a reduction of aquifer thickness or depressurisation.

Mining related impacts to the Glennies Creek alluvium had stabilized prior to the completion of LW1 extraction. No significant incremental impacts or influence from mining of LW2 to LW8 have been observed with groundwater inflows from the Glennies Creek shown to decline over time.

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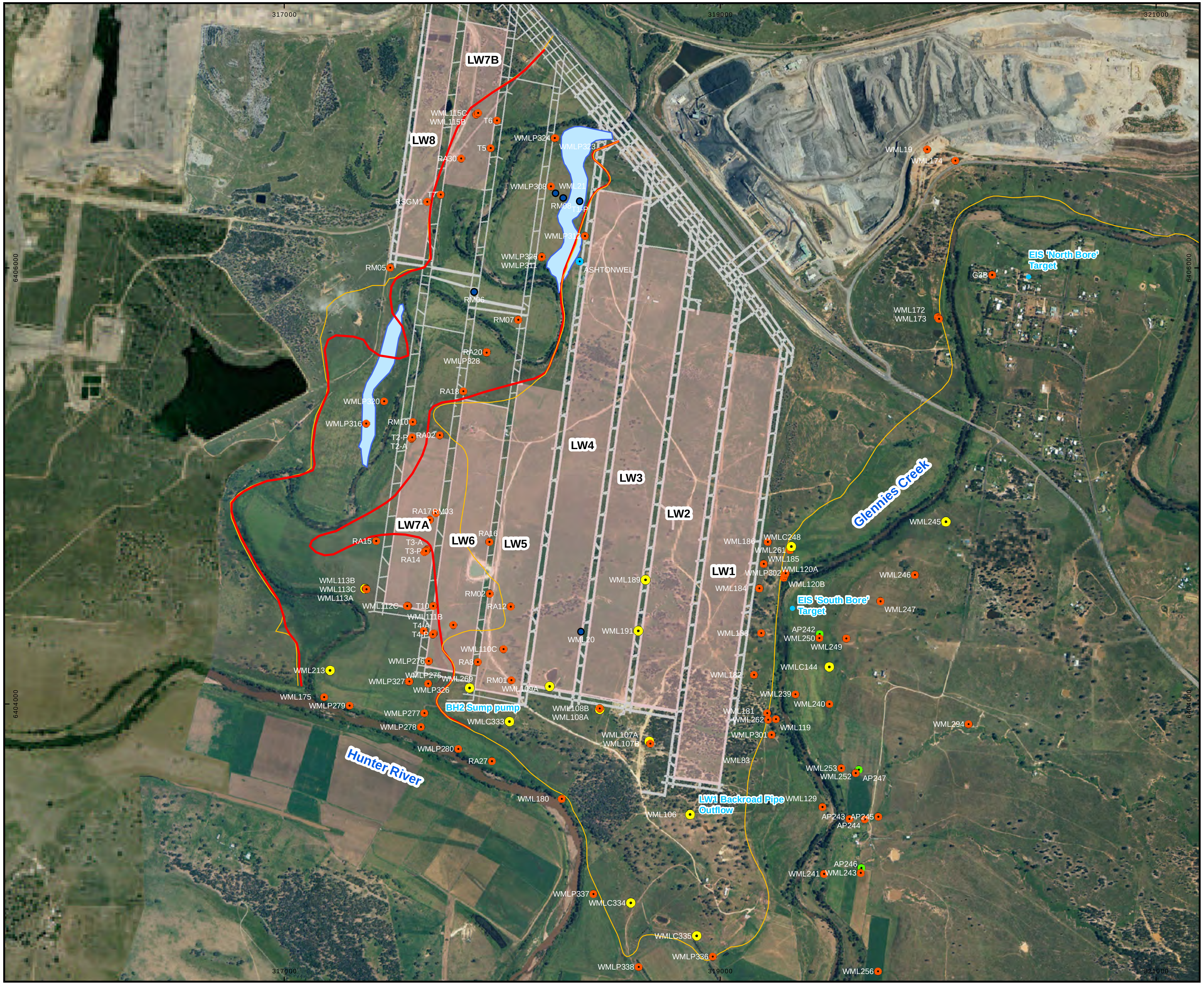
FIGURES



LEGEND

Monitoring Bores

Type

- Stand pipe
- Test bore
- Vibrating wire
- Well
- Decommissioned
- Alluvium boundary
- Saturated alluvium boundary
- Bowmans Creek Diversion
- Pikes Gully Seam Extraction
- Mine Plan (Pikes Gully)

N

200 0 200 400

Metres

APPROX SCALE 1:17,000 @ A3

GDA 1994 MGA Zone 56

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

RPS Aquaterra

FIGURE 1

Ashton Coal

Groundwater Monitoring Network

S56_047b Rev: A Produced: HZ Reviewed: SC Date: 23/10/2012

LEGEND

Monitoring Bores

Type

- Stand pipe
- Test bore
- Vibrating wire
- Well
- Monitoring Point
- Power Pole
- Brunkers Lane
- Subsidence Cross Section Line
- Alluvium boundary
- Saturated alluvium boundary
- Bowmans Creek Diversion
- Maquarie Generation Sedimentation Dams
- Pikes Gully Seam Extraction
- Mine Plan (Pikes Gully)

N

100 0 100 200

Metres

APPROX SCALE 1:10,000 @ A3

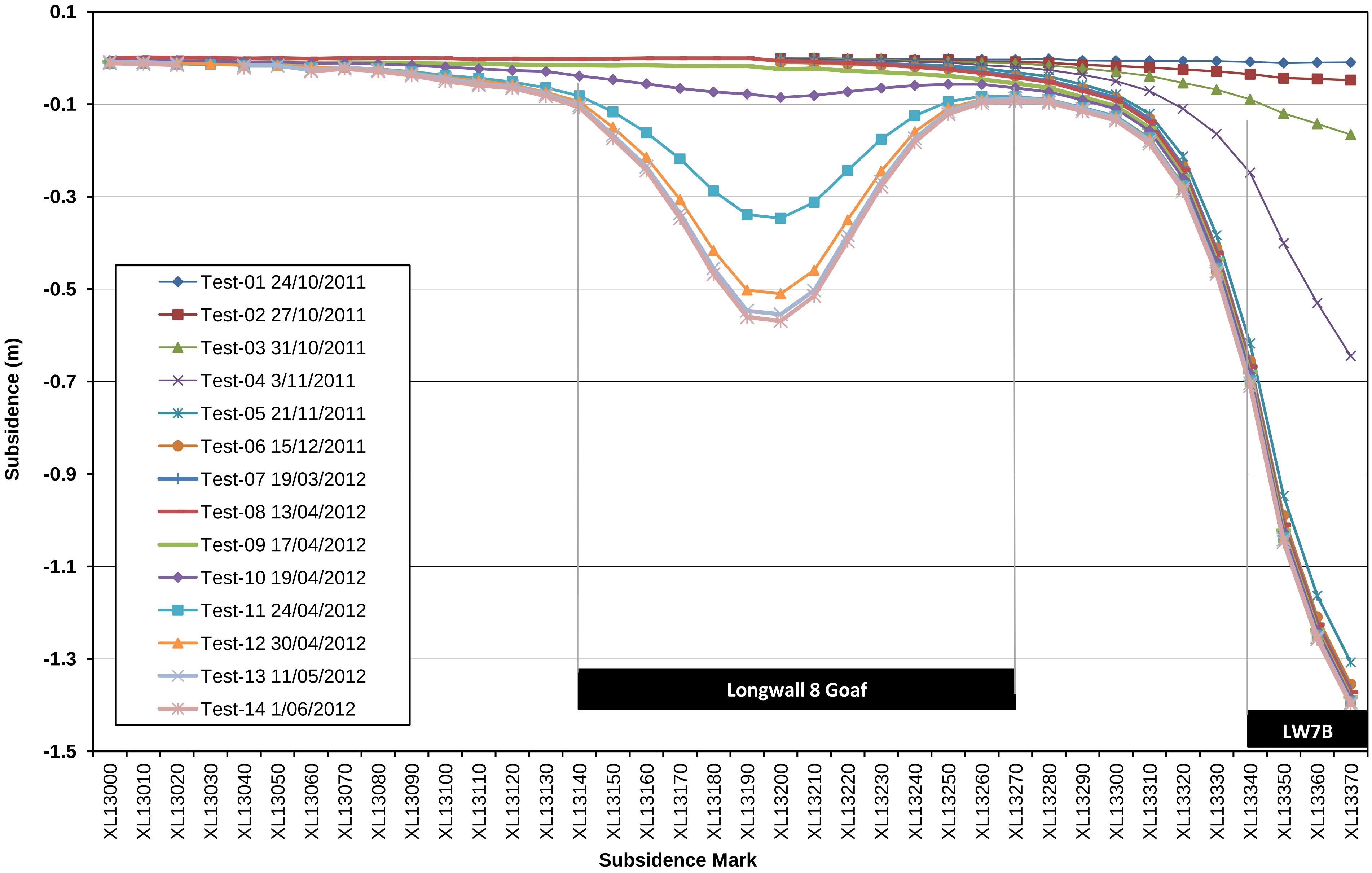
GDA 1994 MGA Zone 56

RPS Aquaterra

FIGURE 2

Ashton Coal Groundwater Monitoring Network (LW8)

S56_046b Rev: B Produced: HZ Reviewed: AL Date: 12/10/2012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Test-02 27/10/2011
Test-03 31/10/2011
Test-04 3/11/2011
Test-05 21/11/2011
Test-06 15/12/2011
Test-07 19/03/2012
Test-08 13/04/2012
Test-09 17/04/2012
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Longwall 8 Goaf
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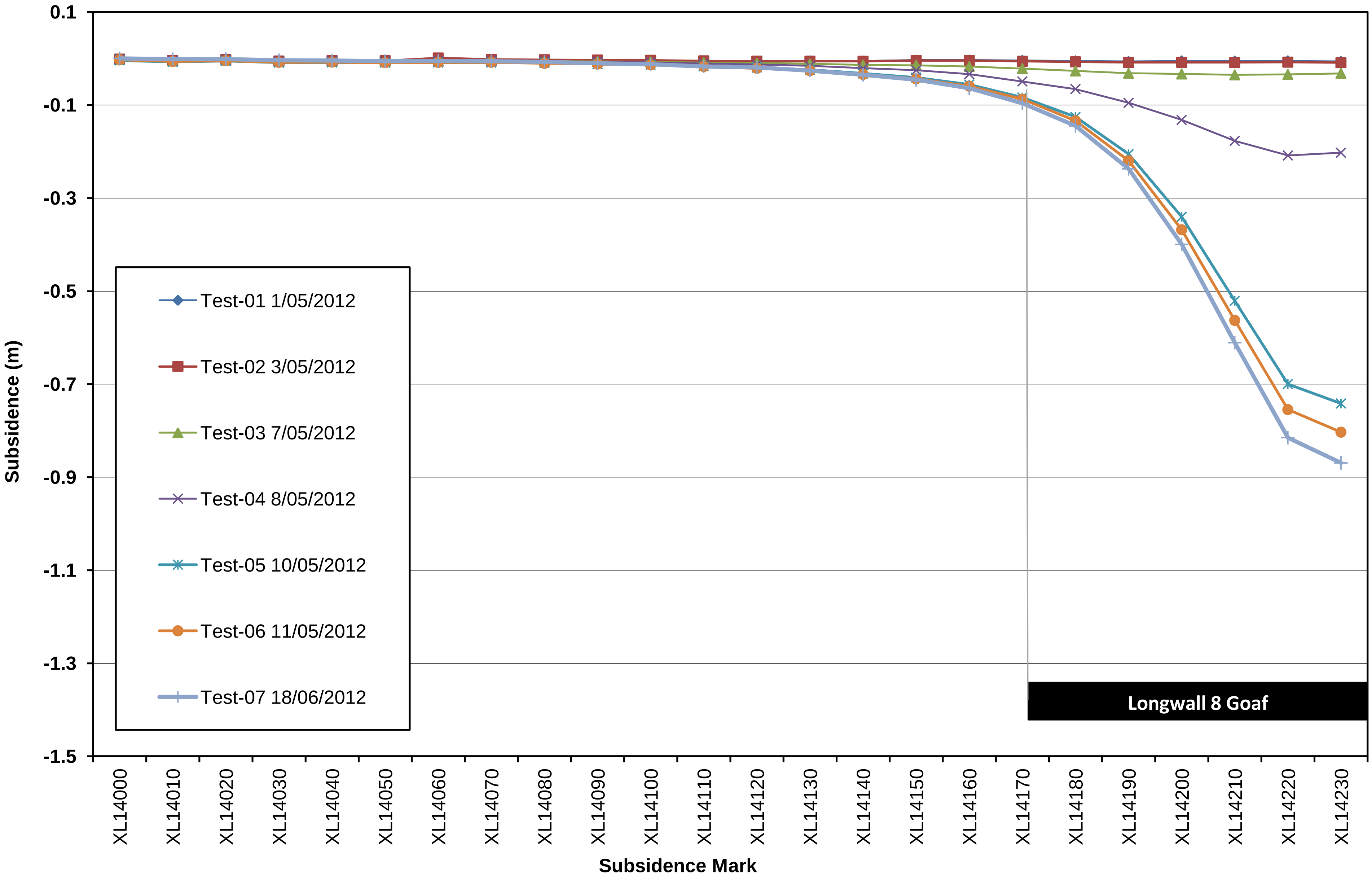

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Test-03 7/05/2012
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Test-05 10/05/2012
Test-06 11/05/2012
Test-07 18/06/2012
Longwall 8 Goaf
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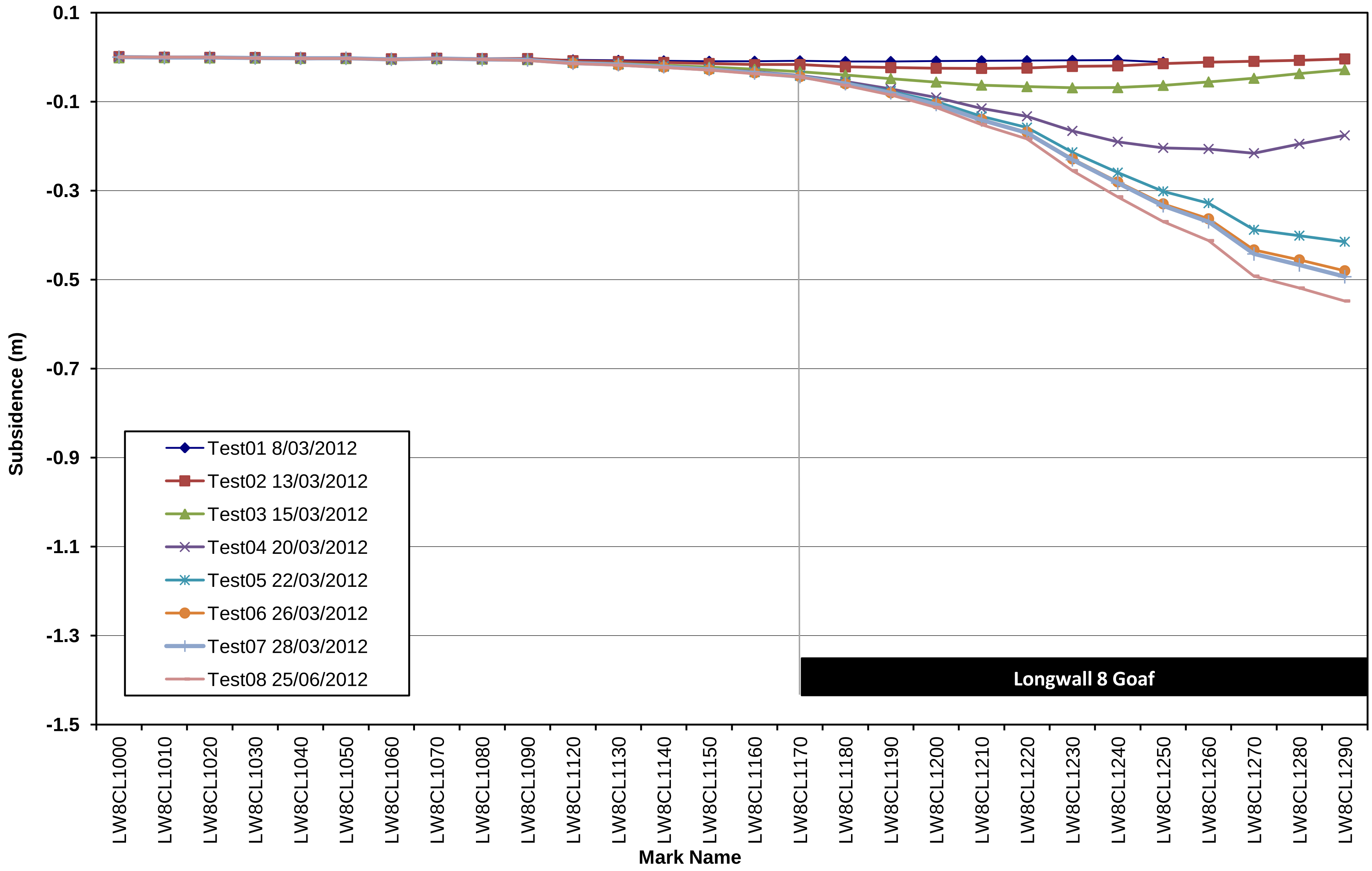
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Test02 13/03/2012
Test03 15/03/2012
Test04 20/03/2012
Test05 22/03/2012
Test06 26/03/2012
Test07 28/03/2012
Test08 25/06/2012
Longwall 8 Goaf
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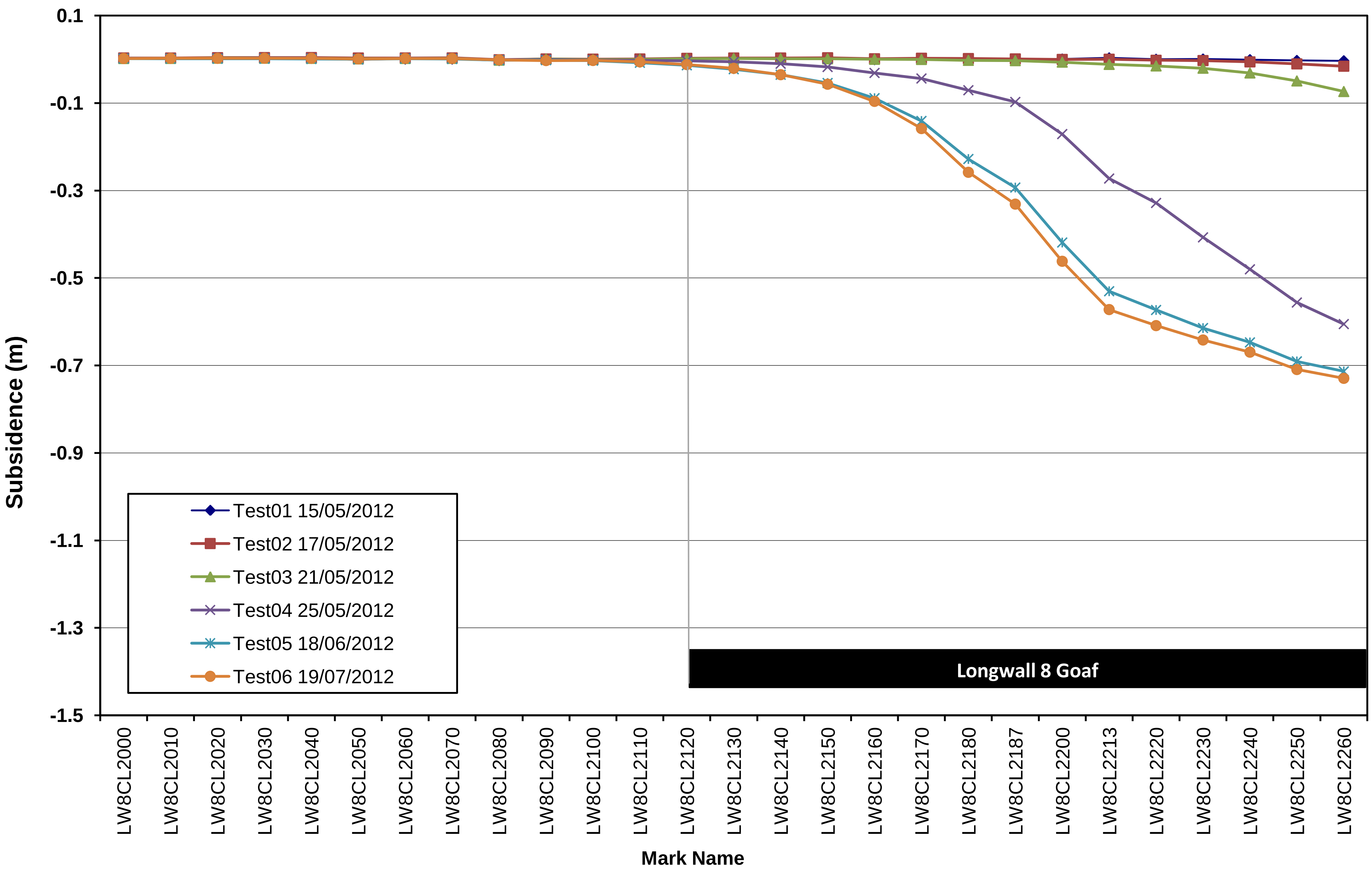
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-0.9
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-1.3
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Test02 17/05/2012
Test03 21/05/2012
Test04 25/05/2012
Test05 18/06/2012
Test06 19/07/2012
Longwall 8 Goaf
LW8CL2000
LW8CL2010
LW8CL2020
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LW8CL2040
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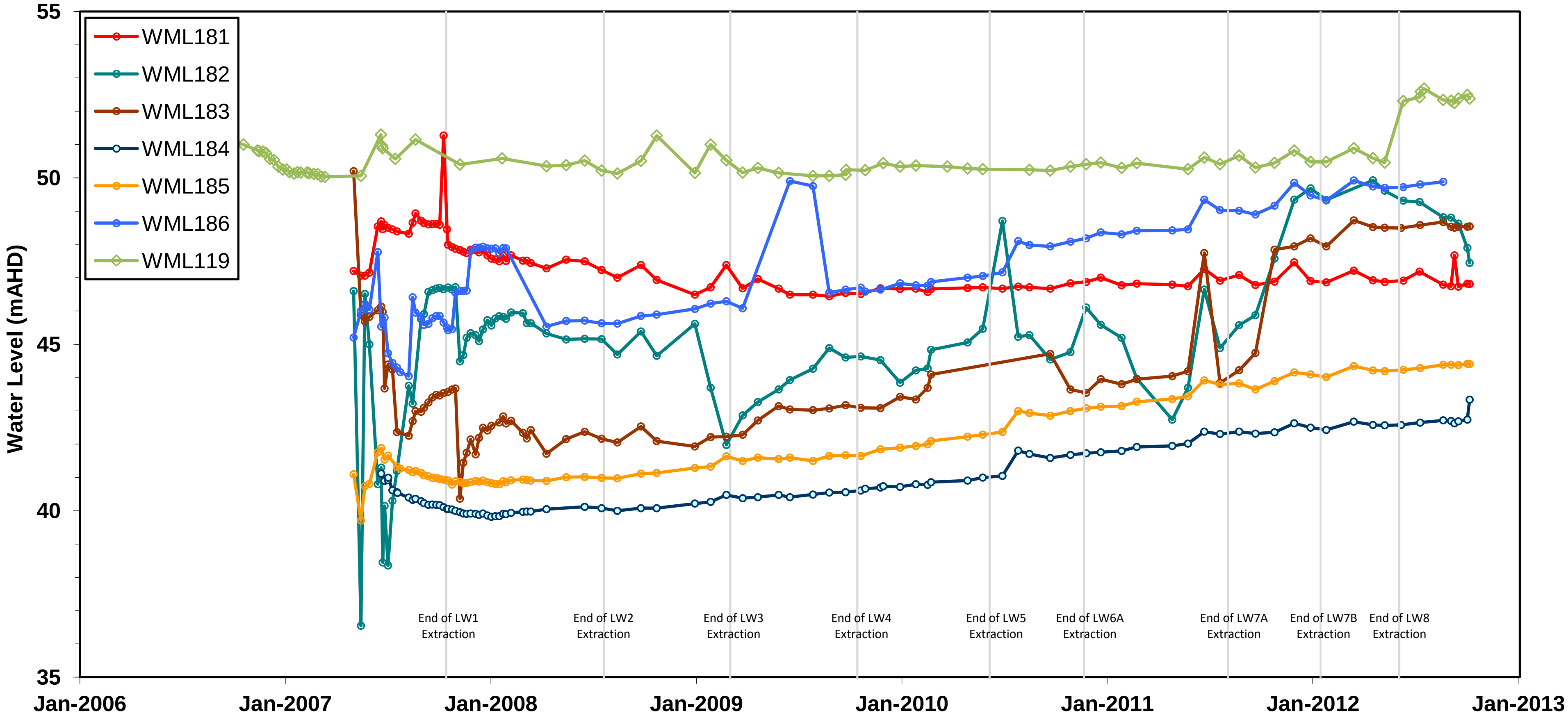
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45
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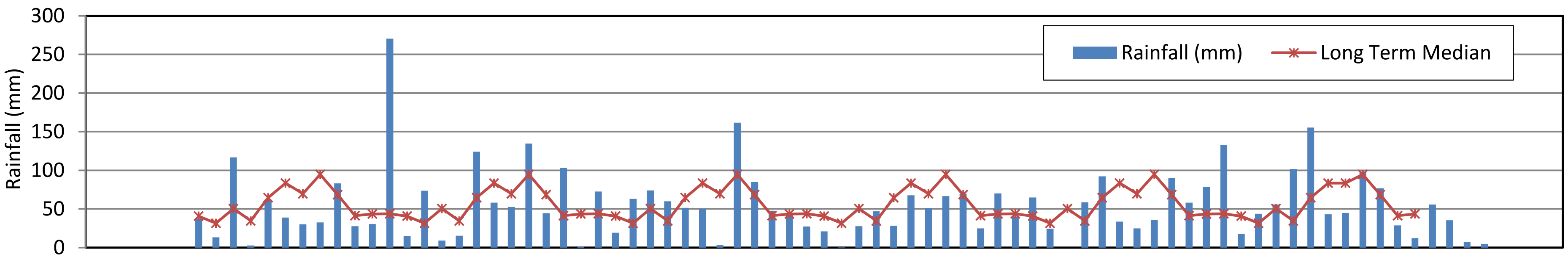
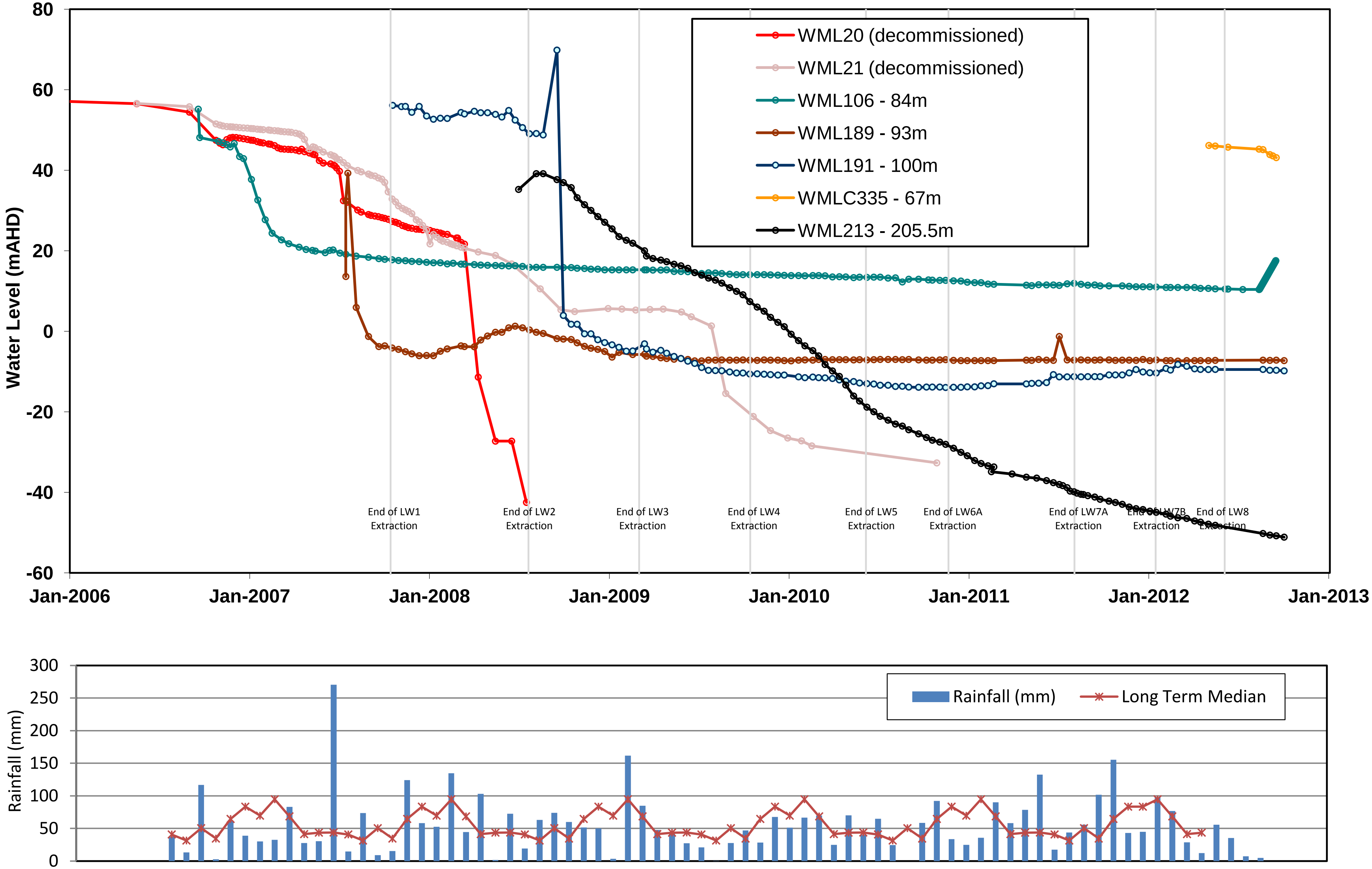
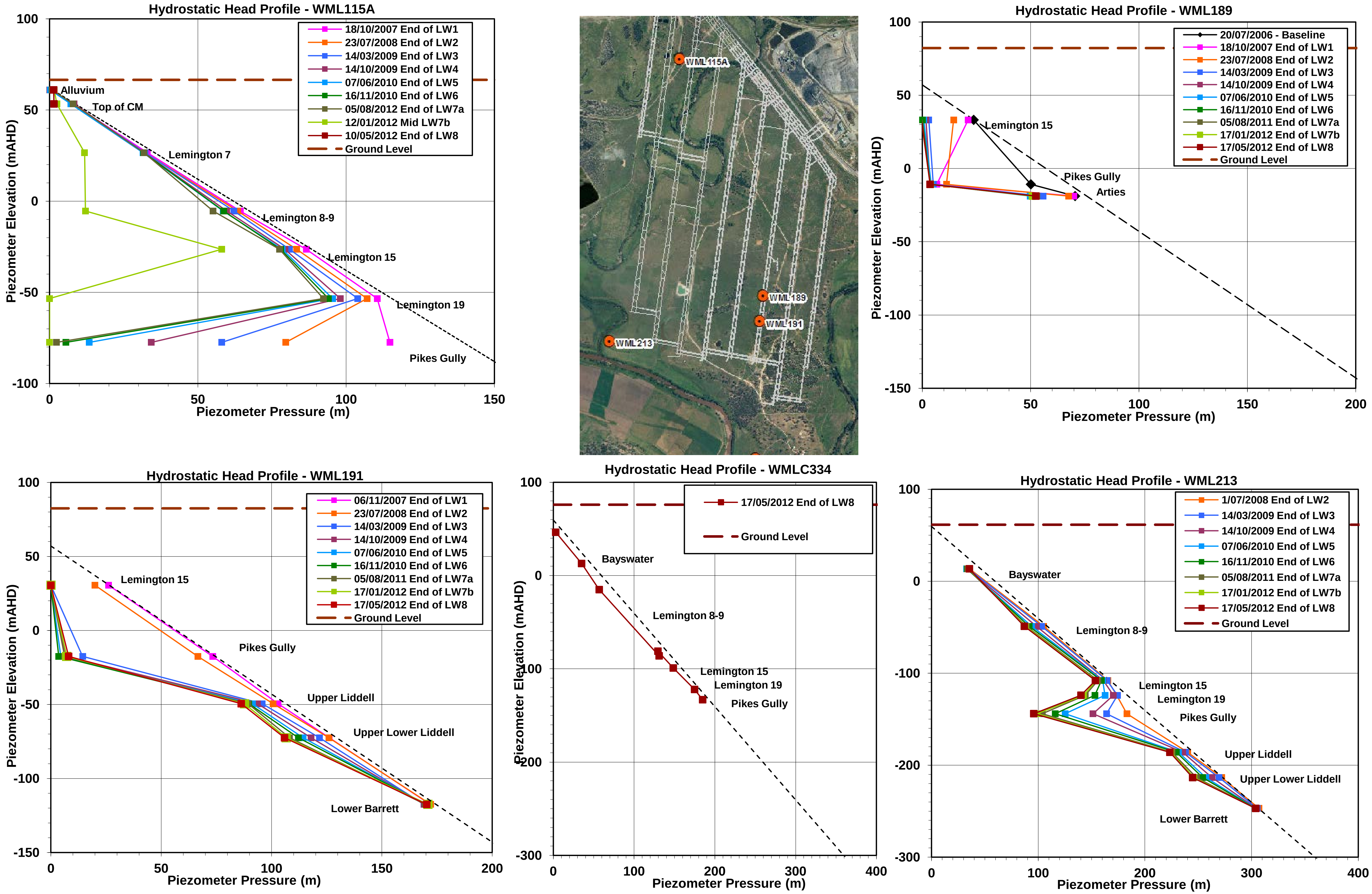
WML183
WML184
WML185
WML186
WML119
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013


300
250
200
150
100
50
0
Rainfall (mm)
Rainfall (mm)
Long Term Median



Water Level (mAHD)
80
60
40
20
0
-20
-40
-60
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
WML20 (decommissioned)
WML21 (decommissioned)
WML106 - 84m
WML189 - 93m
WML191 - 100m
WMLC335 - 67m
WML213 - 205.5m
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Rainfall (mm)
300
250
200
150
100
50
0
Rainfall (mm)
Long Term Median


Hydrostatic Head Profile - WML115A
18/10/2007 End of LW1
23/07/2008 End of LW2
14/03/2009 End of LW3
14/10/2009 End of LW4
07/06/2010 End of LW5
16/11/2010 End of LW6
05/08/2012 End of LW7a
12/01/2012 Mid LW7b
10/05/2012 End of LW8
Ground Level
Alluvium
Top of CM
Lemington 7
Lemington 8-9
Lemington 15
Lemington 19
Pikes Gully
Piezometer Elevation (mAHD)
Piezometer Pressure (m)
WML115A
WML189
WML191
WML213
Hydrostatic Head Profile - WML189
20/07/2006 - Baseline
18/10/2007 End of LW1
23/07/2008 End of LW2
14/03/2009 End of LW3
14/10/2009 End of LW4
07/06/2010 End of LW5
16/11/2010 End of LW6
05/08/2011 End of LW7a
17/01/2012 End of LW7b
17/05/2012 End of LW8
Ground Level
Lemington 15
Pikes Gully
Arties
Piezometer Elevation (mAHD)
Piezometer Pressure (m)
Hydrostatic Head Profile - WML191
06/11/2007 End of LW1
23/07/2008 End of LW2
14/03/2009 End of LW3
14/10/2009 End of LW4
07/06/2010 End of LW5
16/11/2010 End of LW6
05/08/2011 End of LW7a
17/01/2012 End of LW7b
17/05/2012 End of LW8
Ground Level
Lemington 15
Pikes Gully
Upper Liddell
Upper Lower Liddell
Lower Barrett
Piezometer Elevation (mAHD)
Piezometer Pressure (m)
Hydrostatic Head Profile - WMLC334
17/05/2012 End of LW8
Ground Level
Bayswater
Lemington 8-9
Lemington 15
Lemington 19
Pikes Gully
Piezometer Elevation (mAHD)
Piezometer Pressure (m)
Hydrostatic Head Profile - WML213
1/07/2008 End of LW2
14/03/2009 End of LW3
14/10/2009 End of LW4
07/06/2010 End of LW5
16/11/2010 End of LW6
05/08/2011 End of LW7a
17/01/2012 End of LW7b
17/05/2012 End of LW8
Ground Level
Bayswater
Lemington 8-9
Lemington 15
Lemington 19
Pikes Gully
Upper Liddell
Upper Lower Liddell
Lower Barrett
Piezometer Elevation (mAHD)
Piezometer Pressure (m)

LEGEND

- Pikes Gully Seam Monitoring Piezometers
- Pikes Gully Potentiometric surface (mAHD)
- Pikes Gully Seam Extraction
- Mine Plan (Pikes Gully)

N

200 0 200 400

Metres

APPROX SCALE 1:18,000 @ A3

GDA 1994 MGA Zone 56

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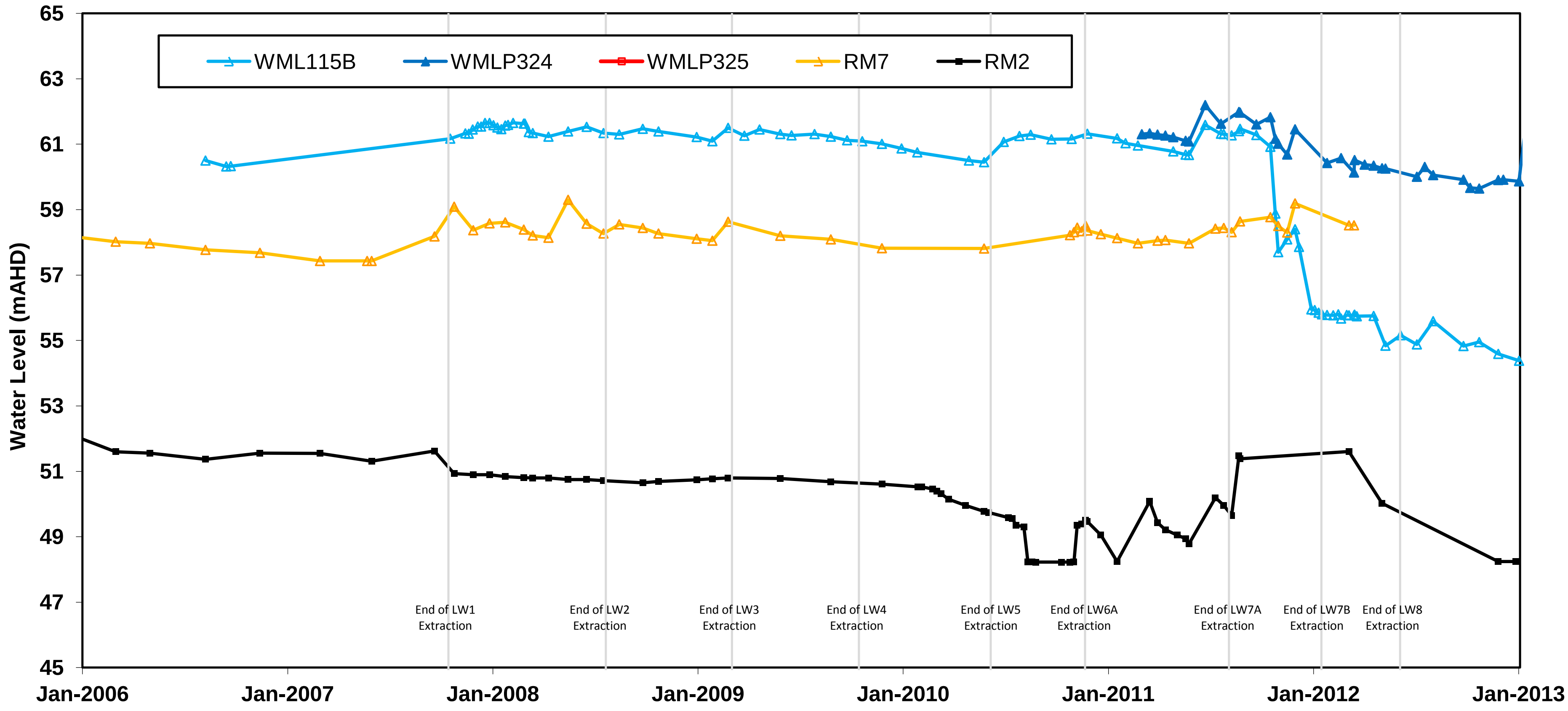
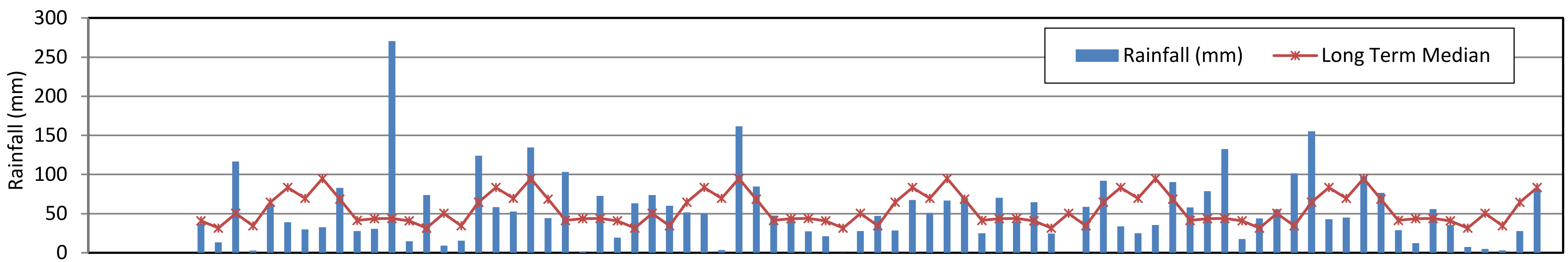
FIGURE 10

Potentiometric Surface Contours Pikes Gully Seam - End of LW8

S56_043a Rev: A Produced: HZ Reviewed: AL Date: 15/10/2012





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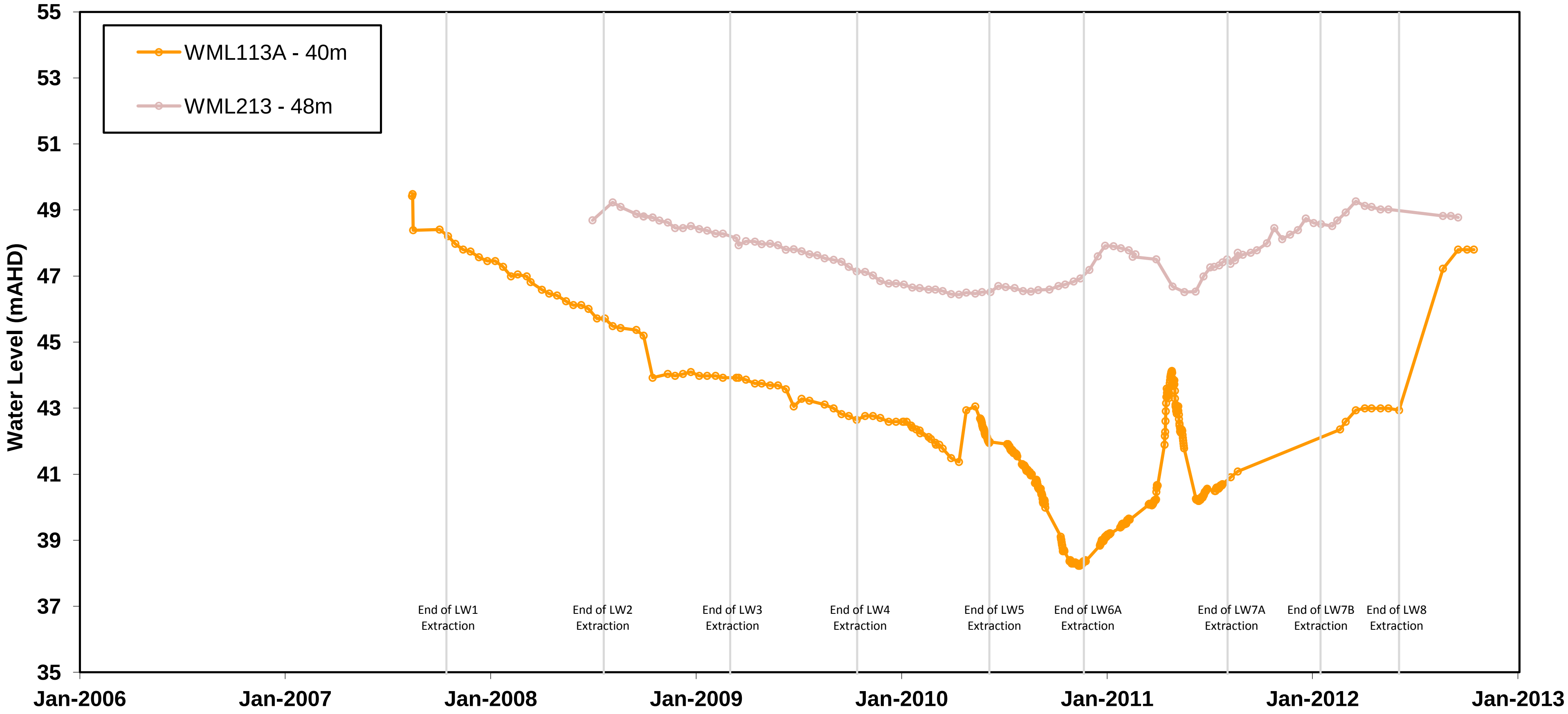
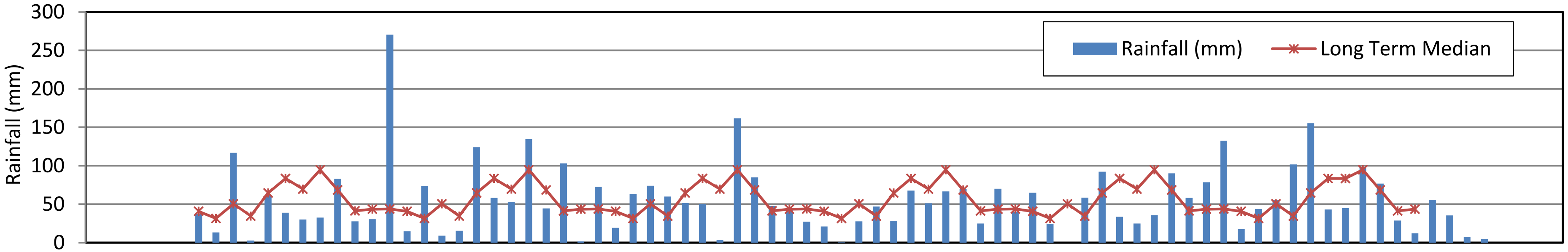
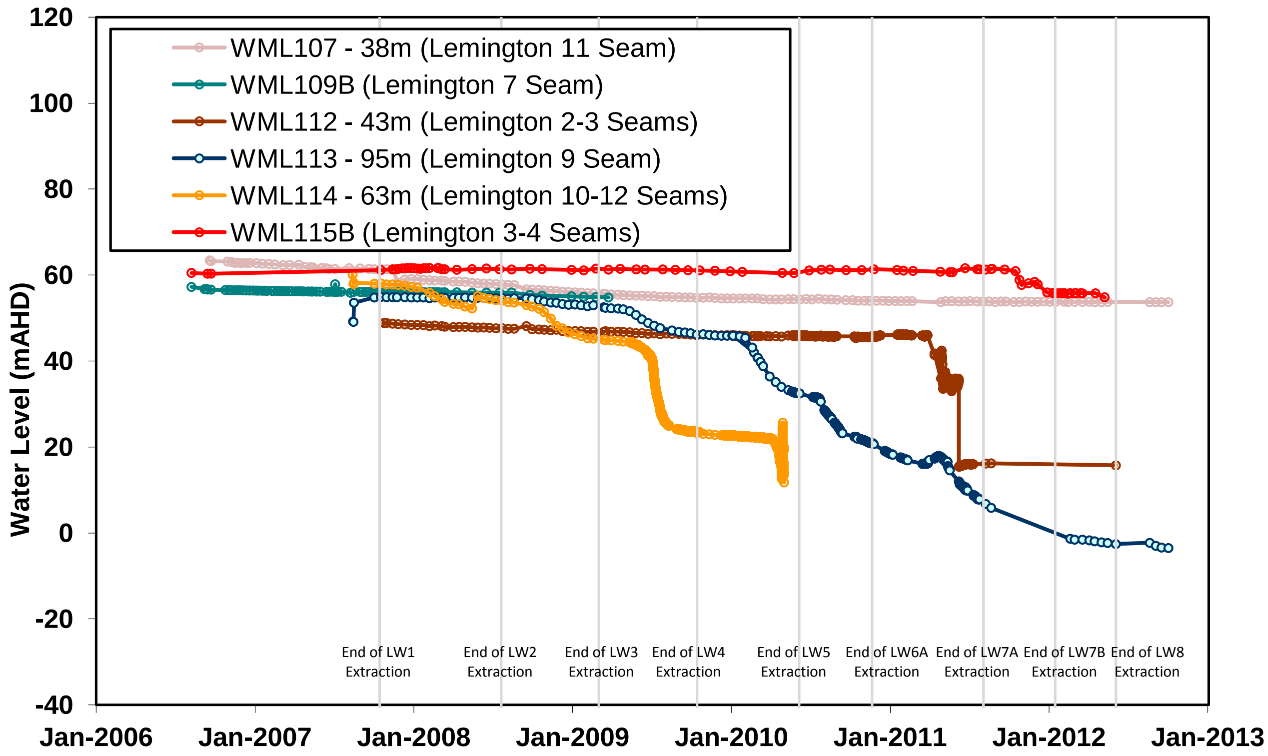
GROUNDWATER LEVEL HYDROGRAPHS - COAL MEASURES OVERBURDEN ALONG BOWMANS CREEK Figure 11

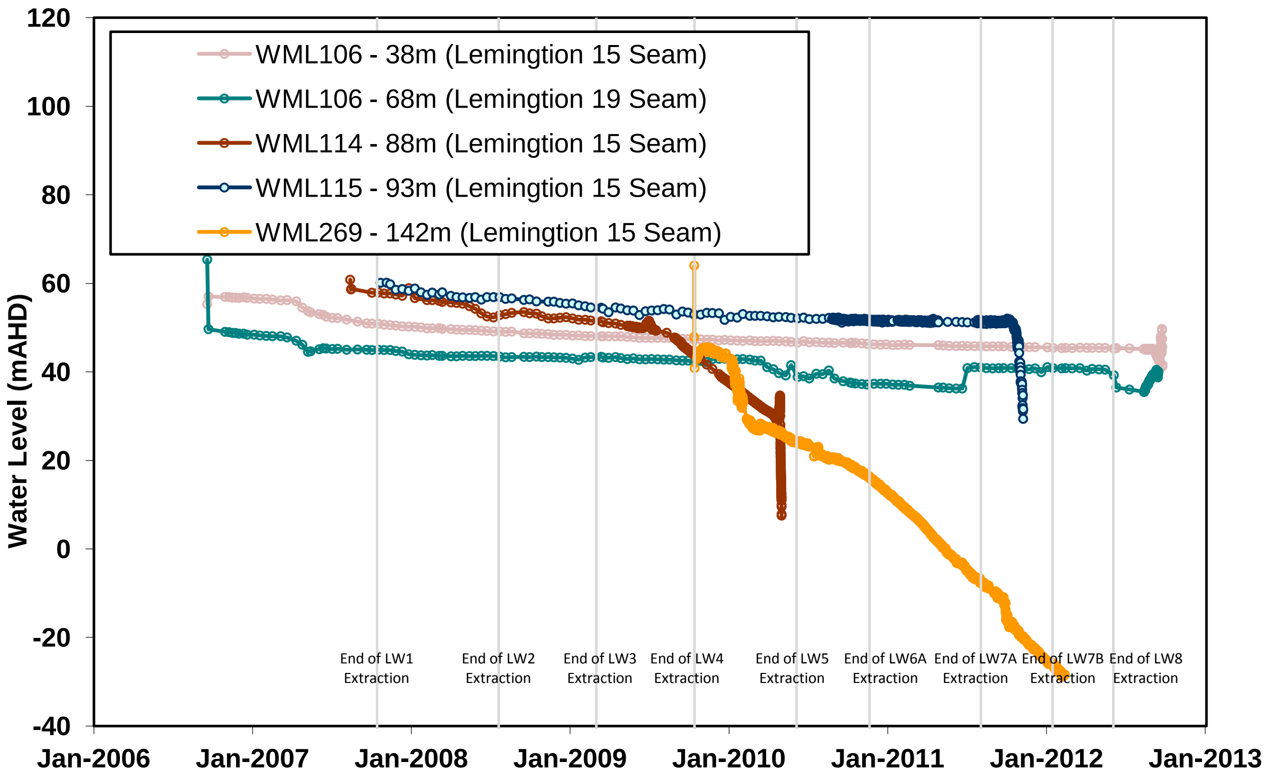


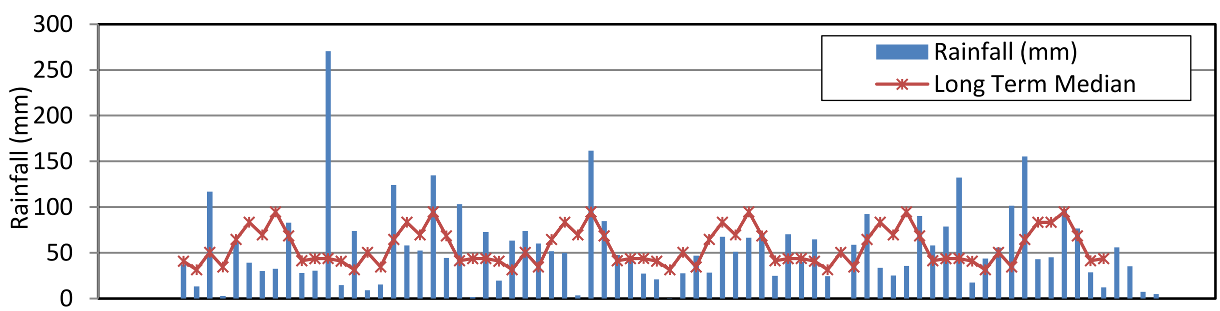
WML113A - 40m
WML213 - 48m
Water Level (mAHD)
55
53
51
49
47
45
43
41
39
37
35
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013

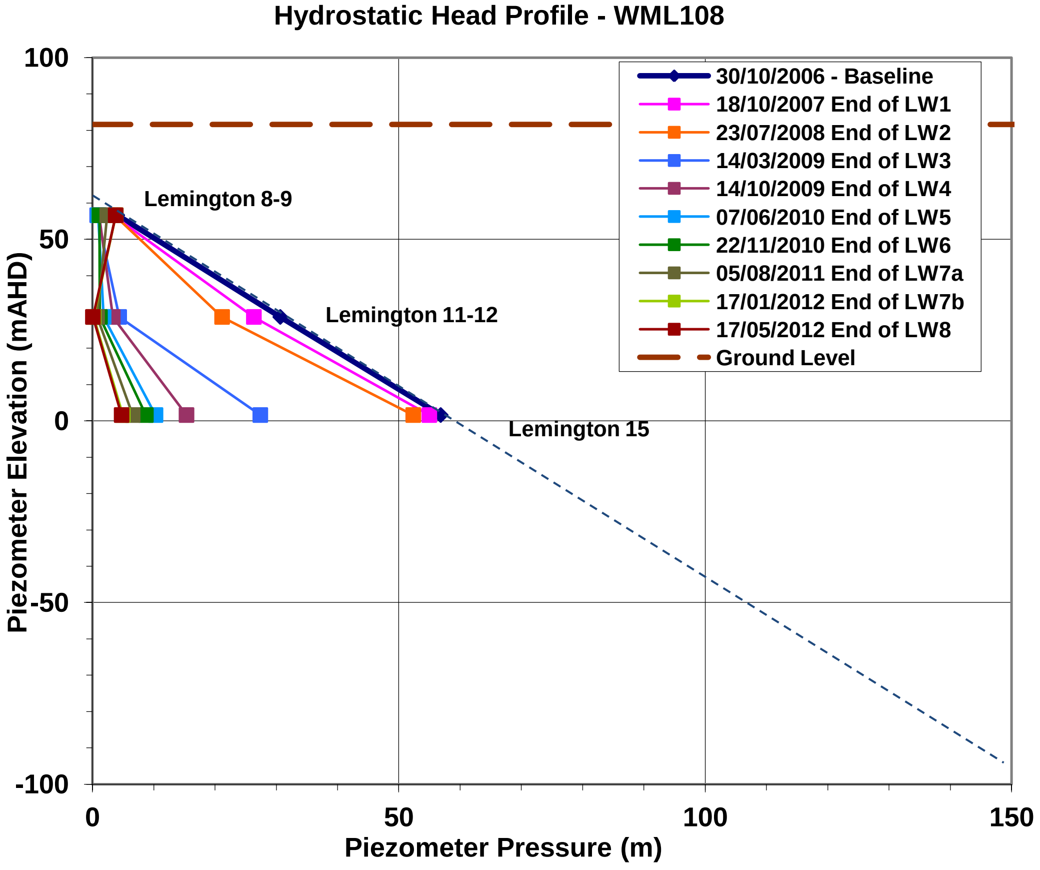


Rainfall (mm)
300
250
200
150
100
50
0
Rainfall (mm)
Long Term Median

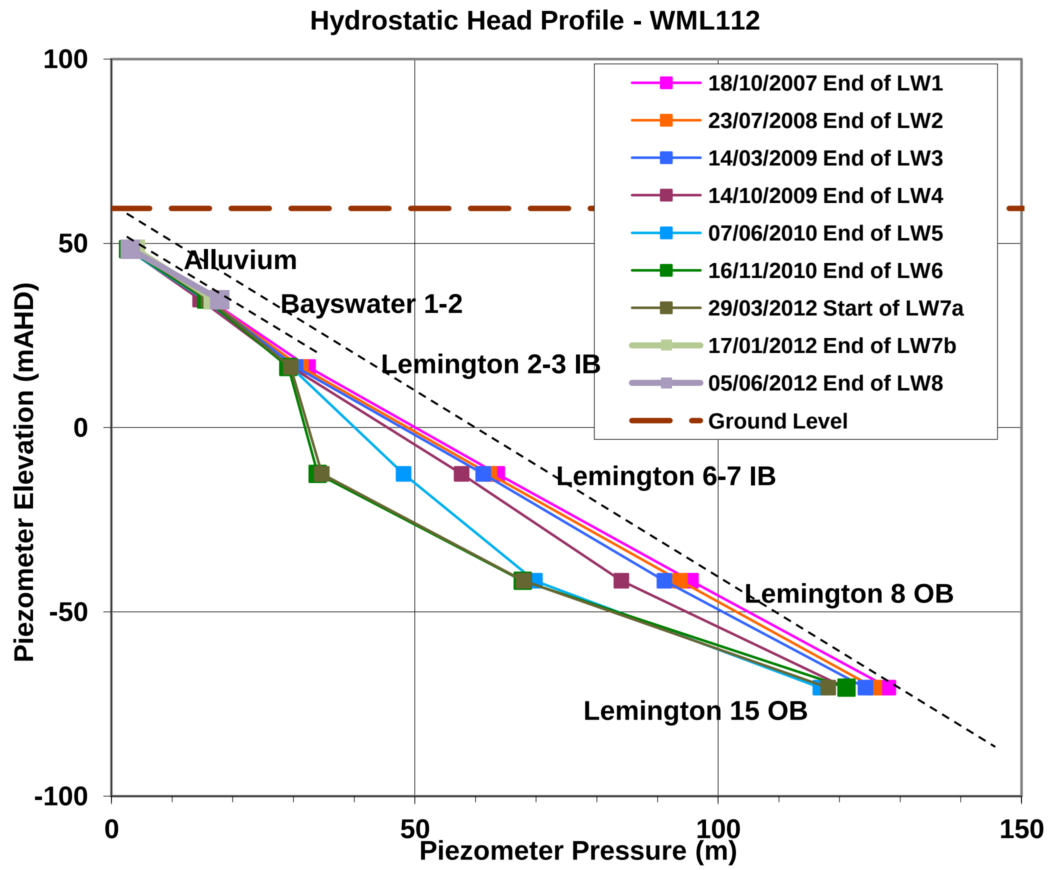

WML107 - 38m (Lemington 11 Seam)
WML109B (Lemington 7 Seam)
WML112 - 43m (Lemington 2-3 Seams)
WML113 - 95m (Lemington 9 Seam)
WML114 - 63m (Lemington 10-12 Seams)
WML115B (Lemington 3-4 Seams)
Water Level (mAHD)
120
100
80
60
40
20
0
-20
-40
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013

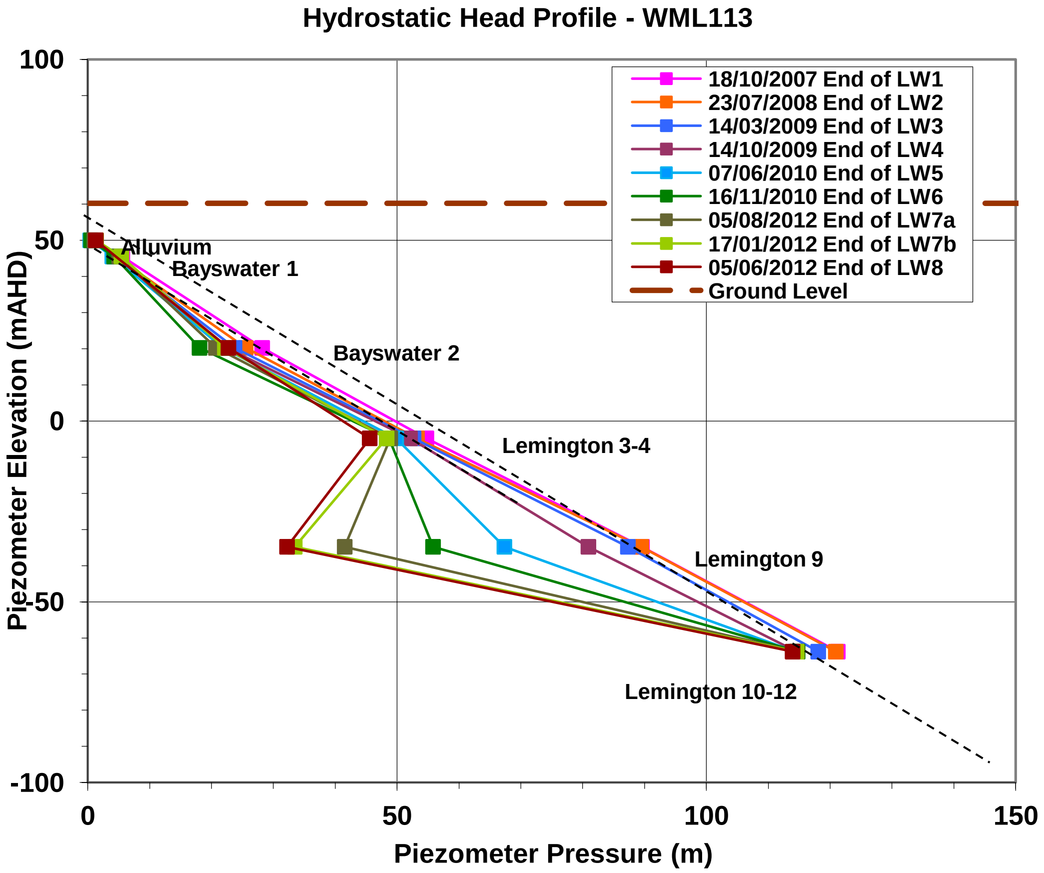

WML106 - 38m (Lemington 15 Seam)
WML106 - 68m (Lemington 19 Seam)
WML114 - 88m (Lemington 15 Seam)
WML115 - 93m (Lemington 15 Seam)
WML269 - 142m (Lemington 15 Seam)
Water Level (mAHD)
120
100
80
60
40
20
0
-20
-40
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013

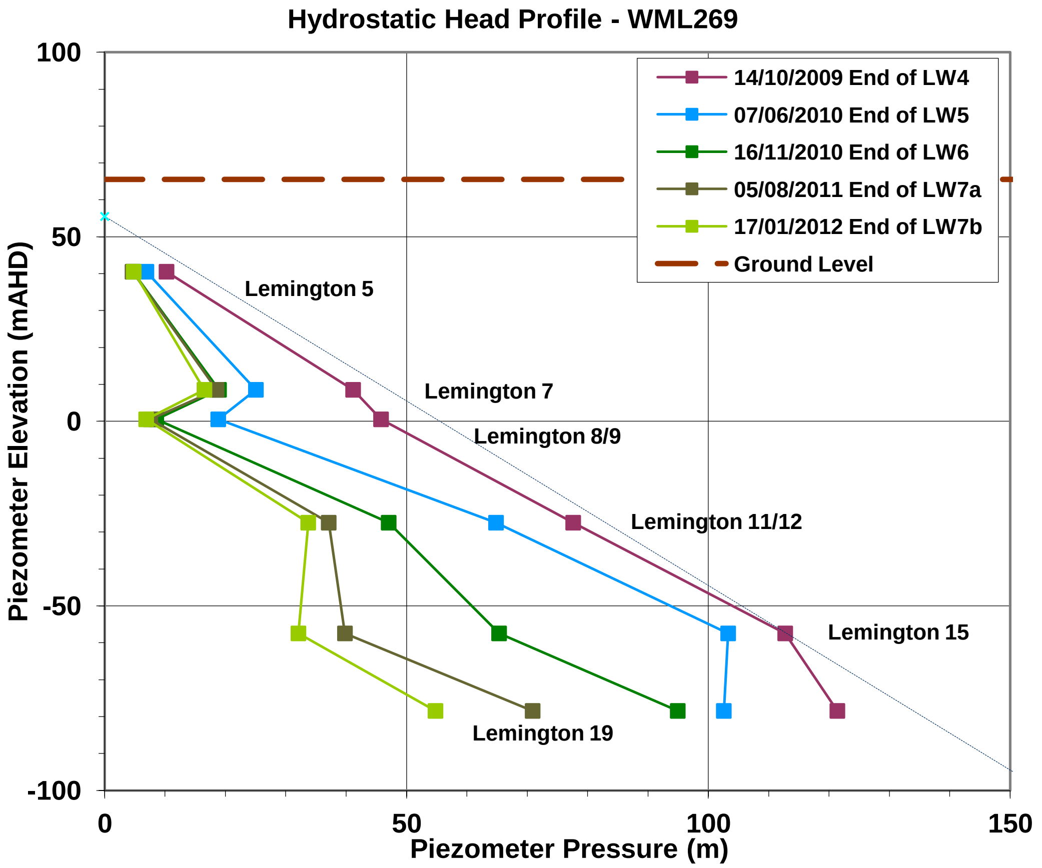

Rainfall (mm)
Long Term Median
Rainfall (mm)
300
250
200
150
100
50
0

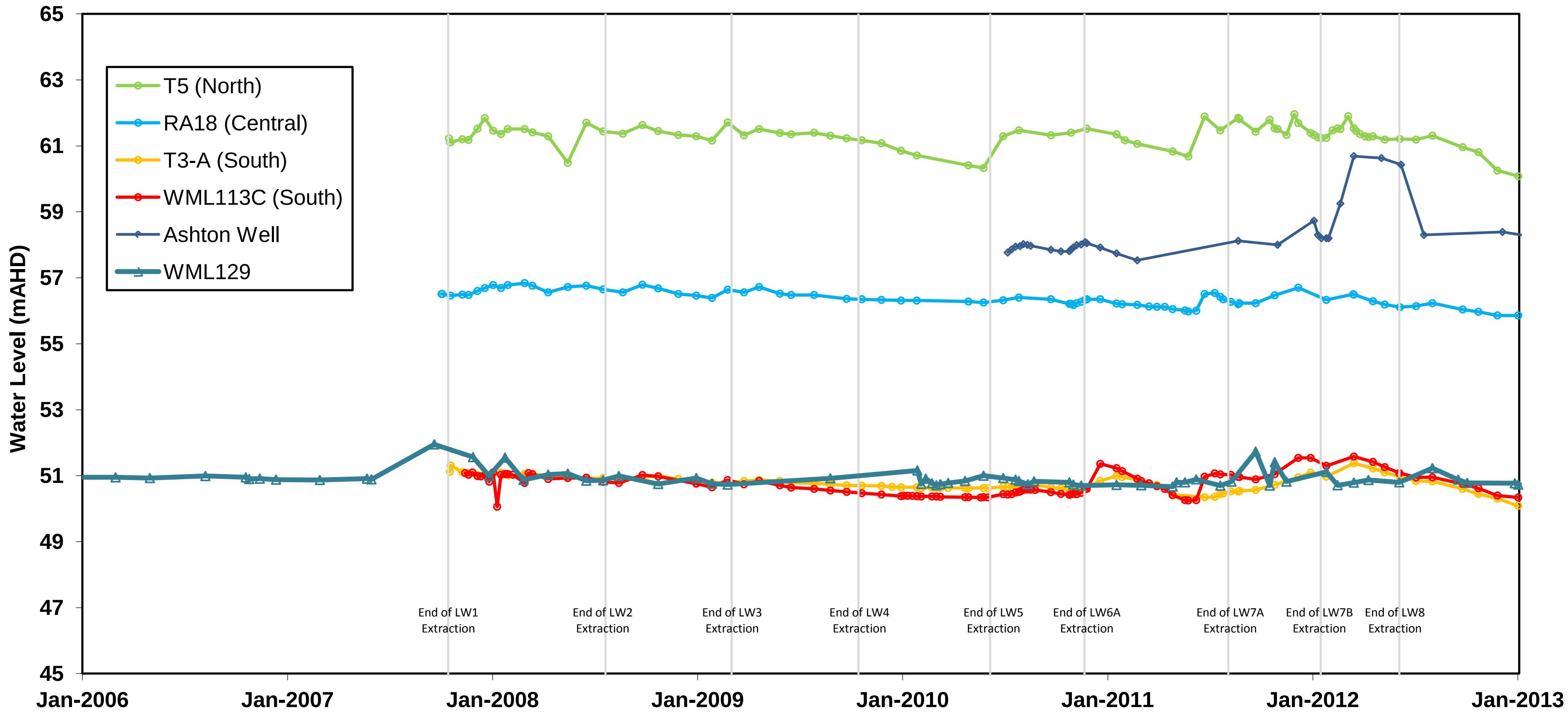

Hydrostatic Head Profile - WML108
30/10/2006 - Baseline
18/10/2007 End of LW1
23/07/2008 End of LW2
14/03/2009 End of LW3
14/10/2009 End of LW4
07/06/2010 End of LW5
22/11/2010 End of LW6
05/08/2011 End of LW7a
17/01/2012 End of LW7b
17/05/2012 End of LW8
Ground Level
Lemington 8-9
Lemington 11-12
Lemington 15
Piezometer Elevation (mAHD)
Piezometer Pressure (m)

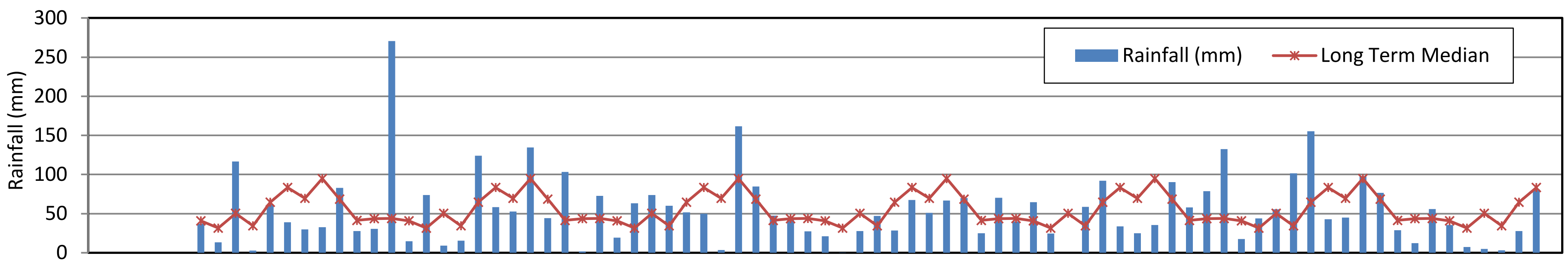

WML113A
WML112A
WML269
WML108A

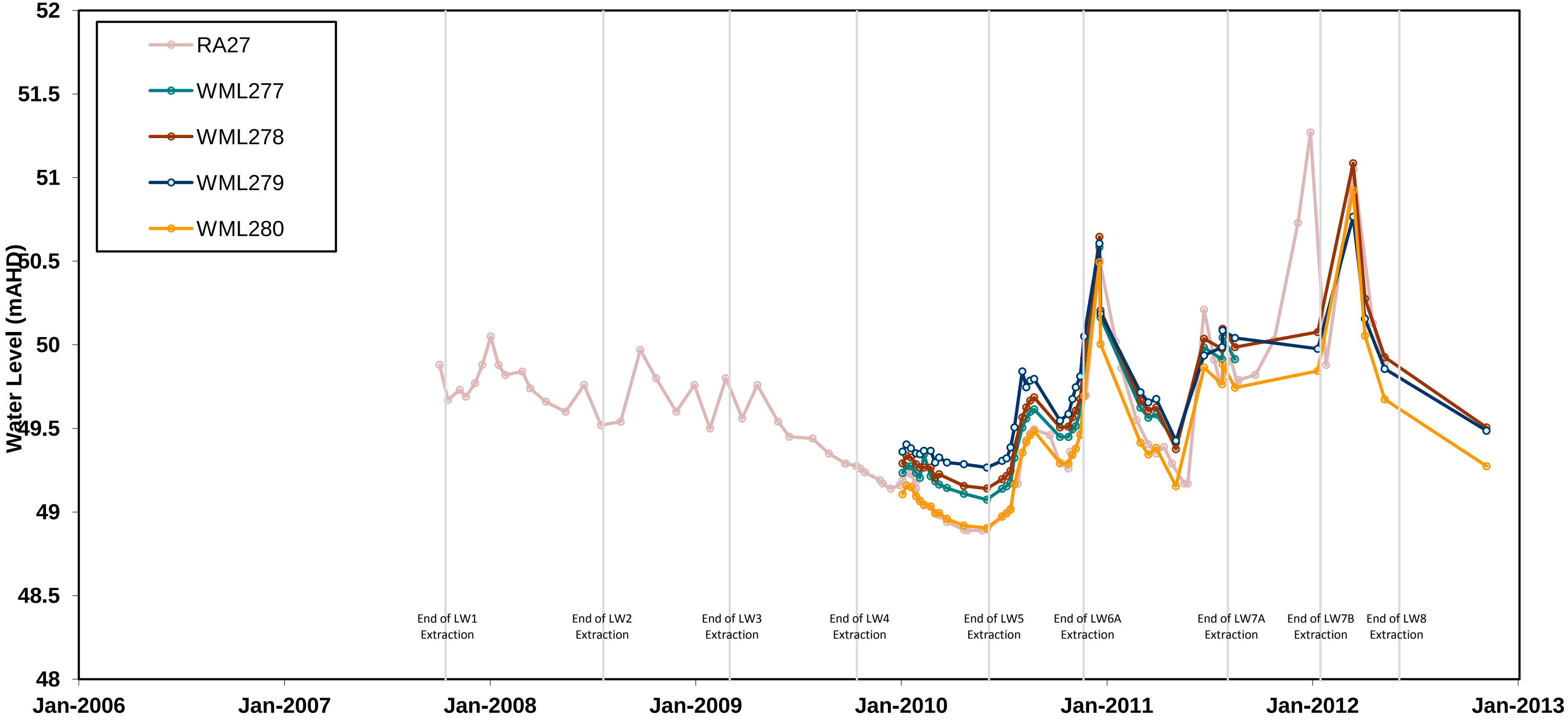

Hydrostatic Head Profile - WML112
18/10/2007 End of LW1
23/07/2008 End of LW2
14/03/2009 End of LW3
14/10/2009 End of LW4
07/06/2010 End of LW5
16/11/2010 End of LW6
29/03/2012 Start of LW7a
17/01/2012 End of LW7b
05/06/2012 End of LW8
Ground Level
Alluvium
Bayswater 1-2
Lemington 2-3 IB
Lemington 6-7 IB
Lemington 8 OB
Lemington 15 OB
Piezometer Elevation (mAHD)
Piezometer Pressure (m)

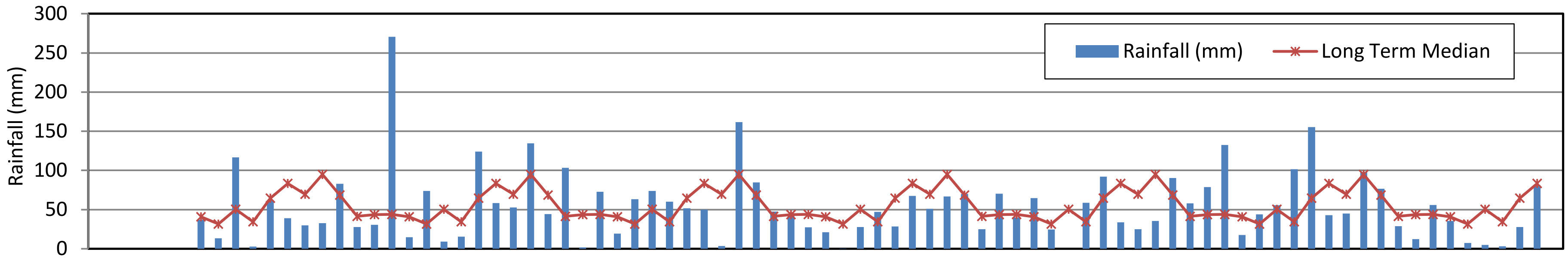

Hydrostatic Head Profile - WML113
18/10/2007 End of LW1
23/07/2008 End of LW2
14/03/2009 End of LW3
14/10/2009 End of LW4
07/06/2010 End of LW5
16/11/2010 End of LW6
05/08/2012 End of LW7a
17/01/2012 End of LW7b
05/06/2012 End of LW8
Ground Level
Alluvium
Bayswater 1
Bayswater 2
Lemington 3-4
Lemington 9
Lemington 10-12
Piezometer Elevation (mAHD)
Piezometer Pressure (m)

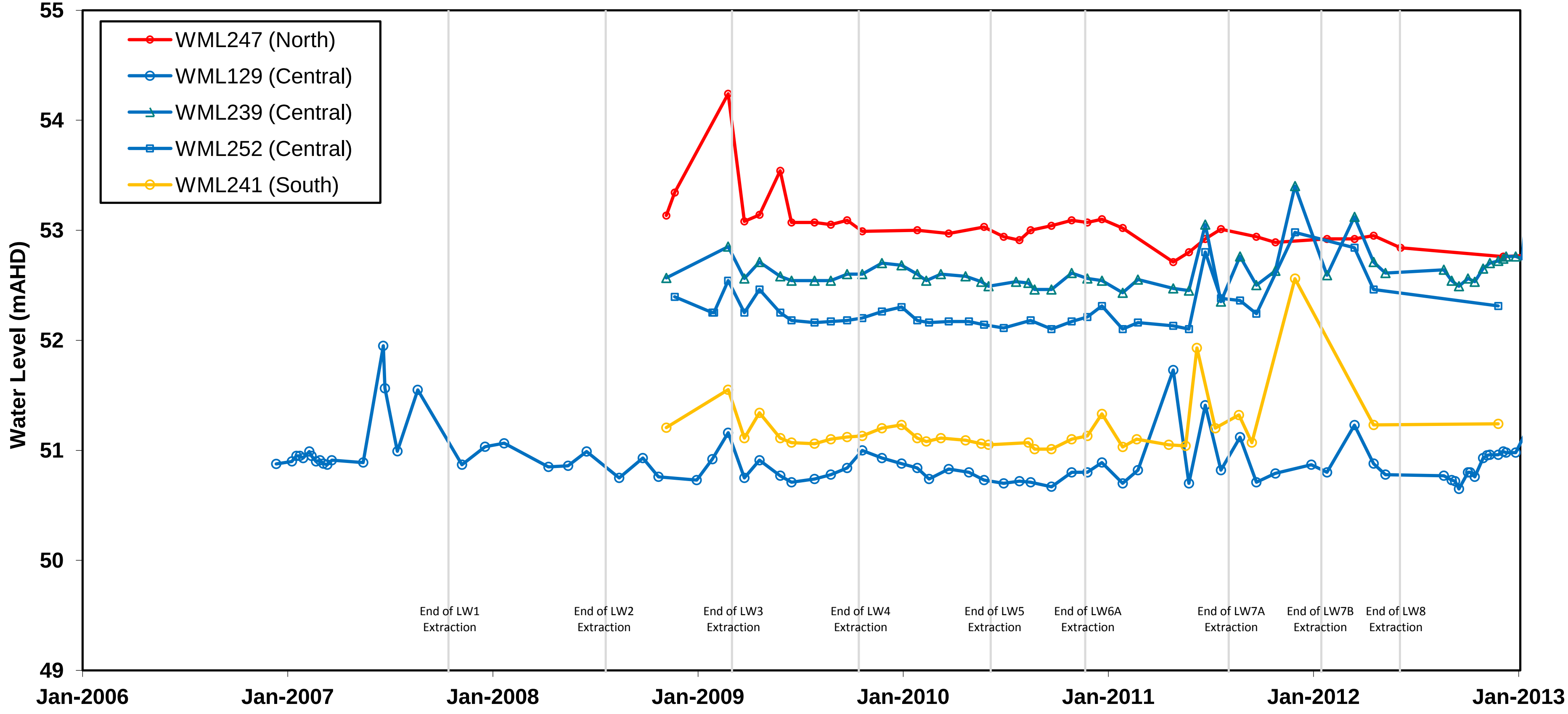

Hydrostatic Head Profile - WML269
14/10/2009 End of LW4
07/06/2010 End of LW5
16/11/2010 End of LW6
05/08/2011 End of LW7a
17/01/2012 End of LW7b
Ground Level
Lemington 5
Lemington 7
Lemington 8/9
Lemington 11/12
Lemington 15
Lemington 19
Piezometer Elevation (mAHD)
Piezometer Pressure (m)


Water Level (mAHD)
65
63
61
59
57
55
53
51
49
47
45
T5 (North)
RA18 (Central)
T3-A (South)
WML113C (South)
Ashton Well
WML129
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013

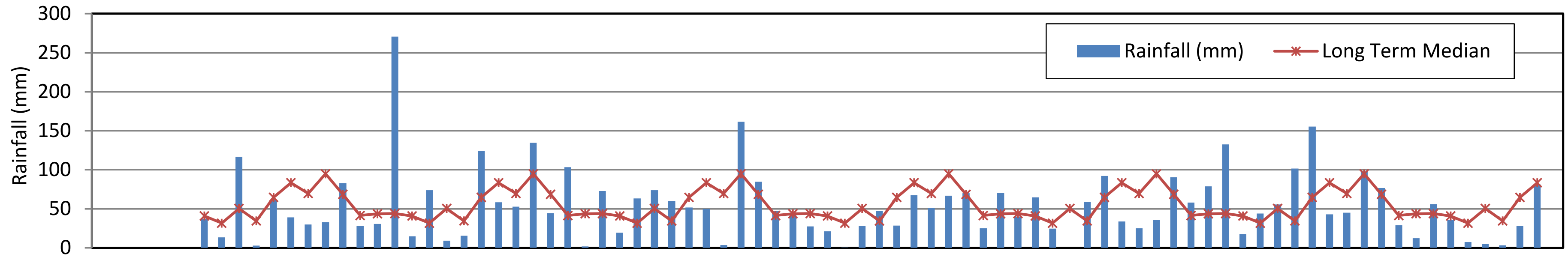

Rainfall (mm)
300
250
200
150
100
50
0
Rainfall (mm)
Long Term Median


RA27
WML277
WML278
WML279
WML280
Water Level (mAHD)
52
51.5
51
50.5
50
49.5
49
48.5
48
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction

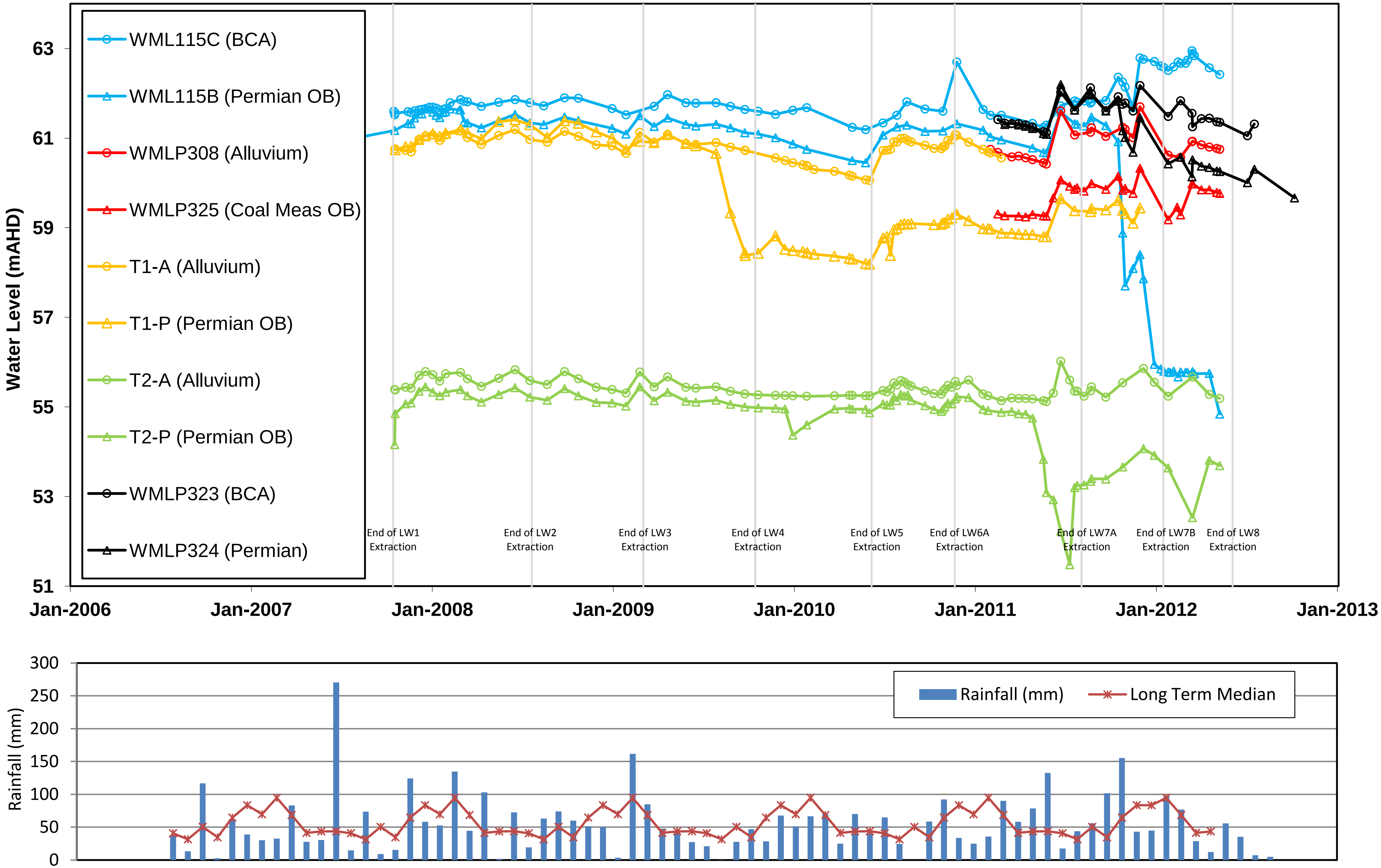

Rainfall (mm)
300
250
200
150
100
50
0
Rainfall (mm)
Long Term Median



55
54
53
52
51
50
49
Water Level (mAHD)
WML247 (North)
WML129 (Central)
WML239 (Central)
WML252 (Central)
WML241 (South)
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013



300
250
200
150
100
50
0
Rainfall (mm)
Rainfall (mm)
Long Term Median



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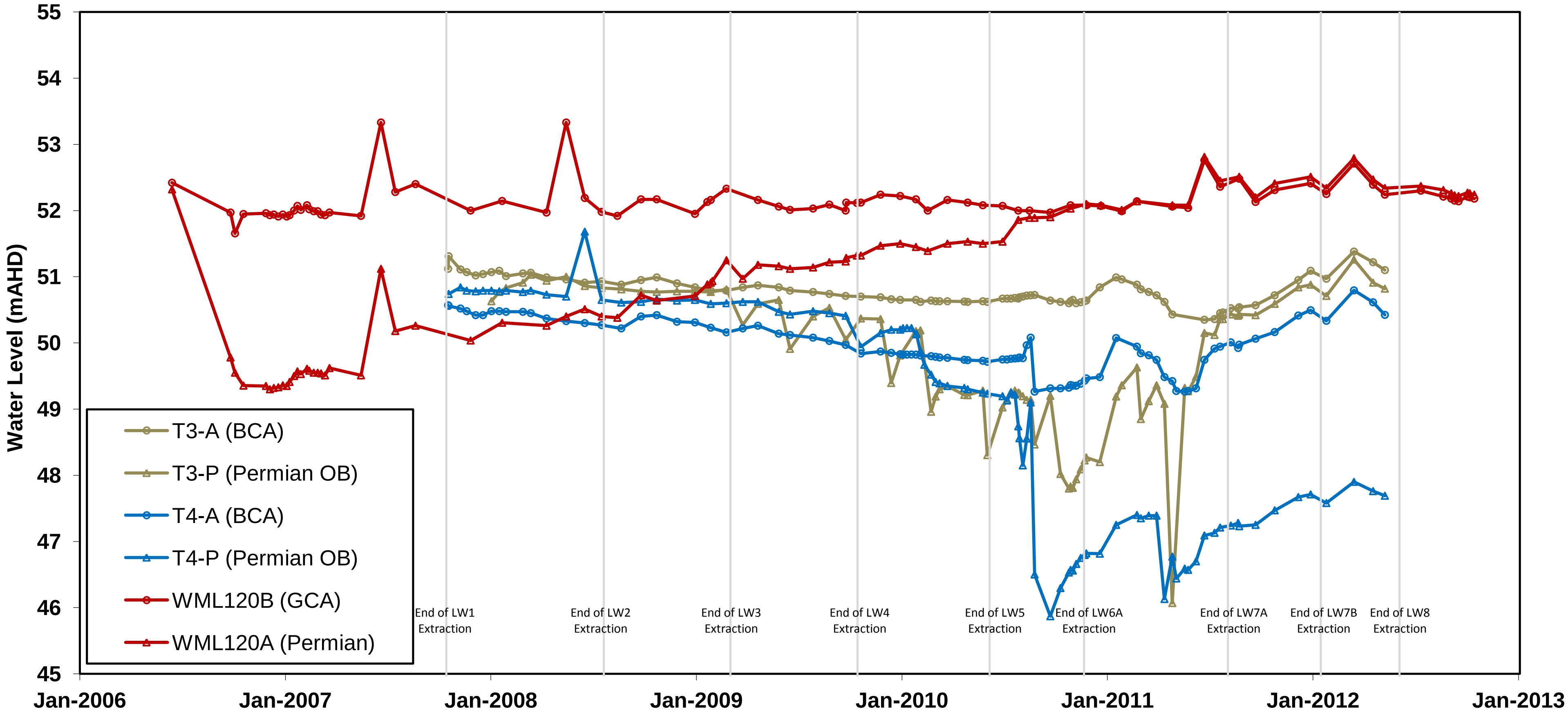
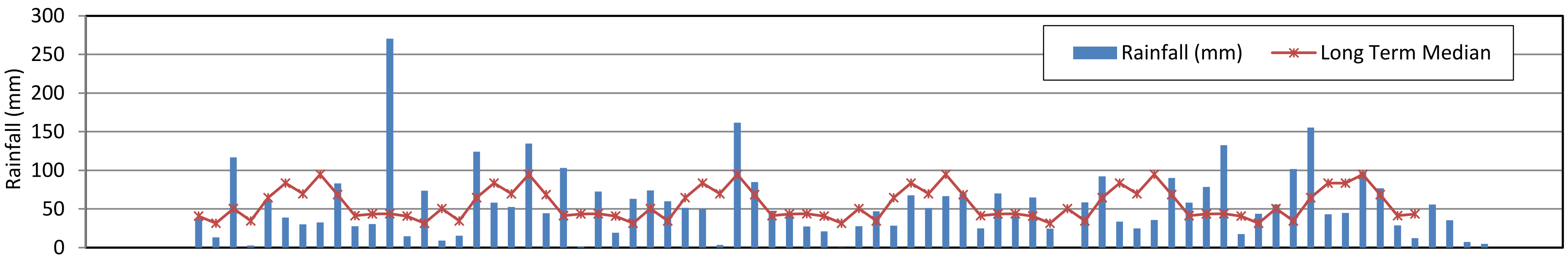
HYDROGRAPHS - PAIRED PIEZOMETERS Figure 18





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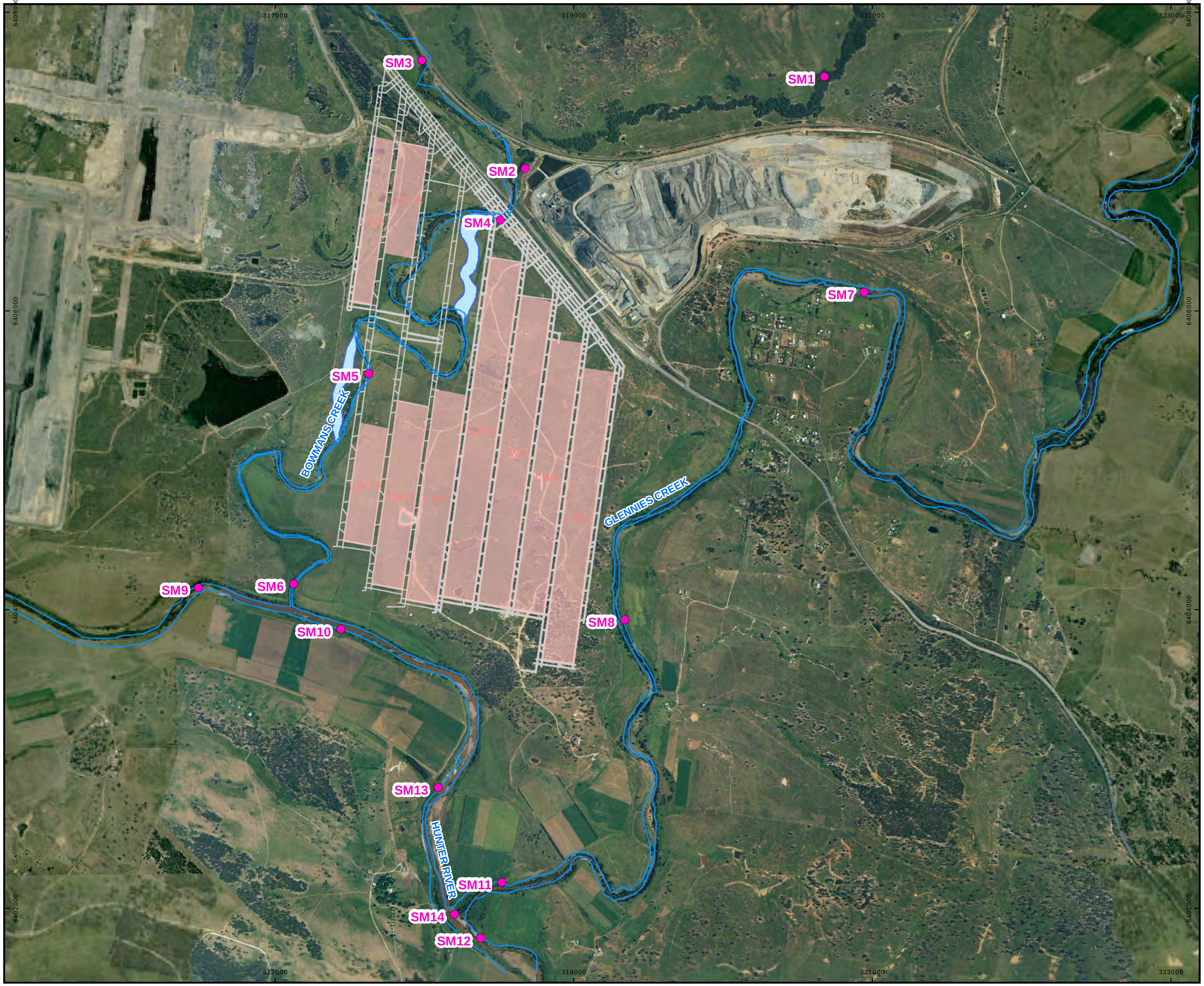
HYDROGRAPHS - PAIRED PIEZOMETERS Figure 19



LEGEND

- Surface Water Monitoring Location
- Pikes Gully Seam Extraction
- Bowmans Creek Diversion
- Creeks or River
- Mine Plan (Pikes Gully)

N

200 0 200 400

Metres

APPROX SCALE 1:24,826 @ A3

GDA 1994 MGA Zone 56

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

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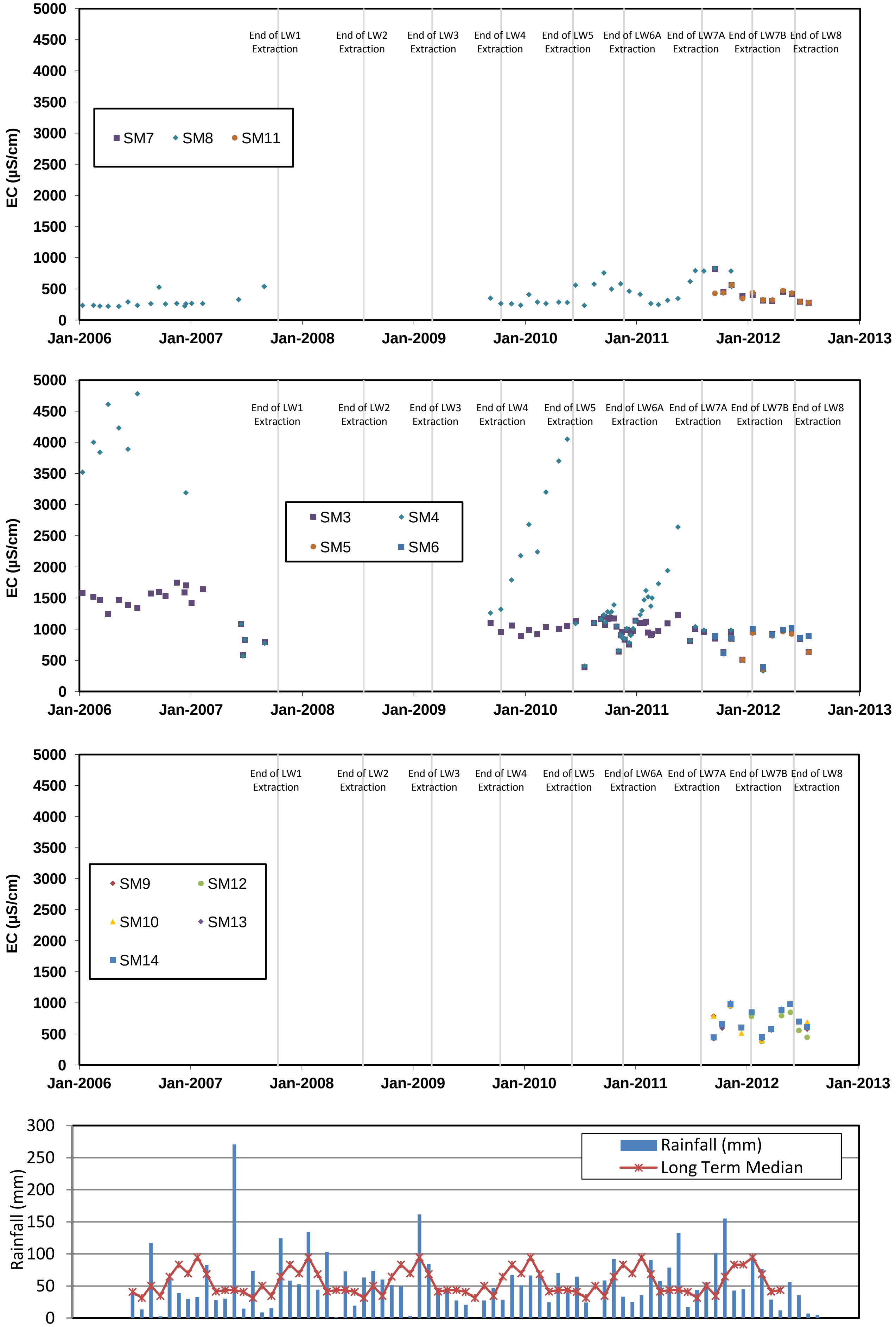
FIGURE 20

Ashton Coal
Surface Water Monitoring Network

S56_062 Rev: A Produced: HZ Reviewed: AL Date: 08/10/2012



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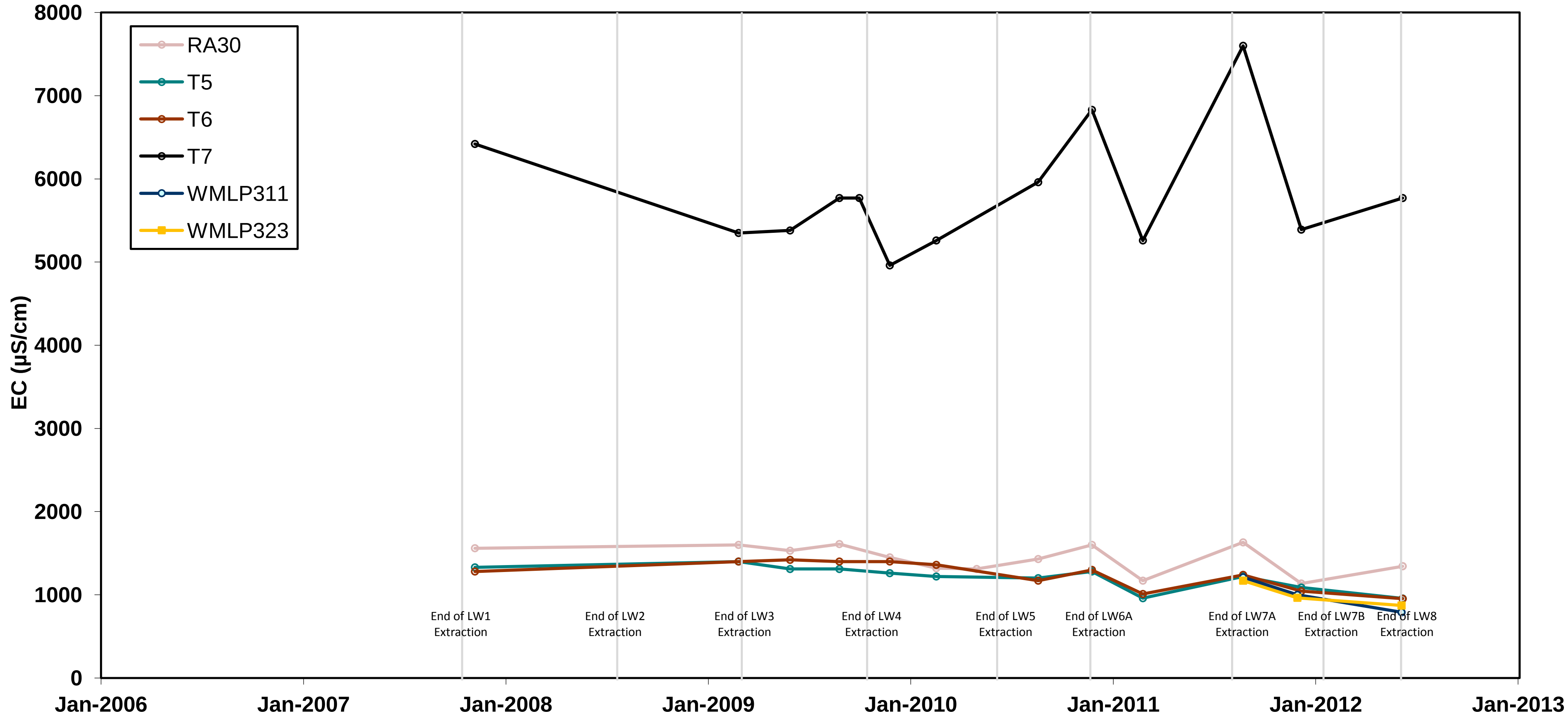
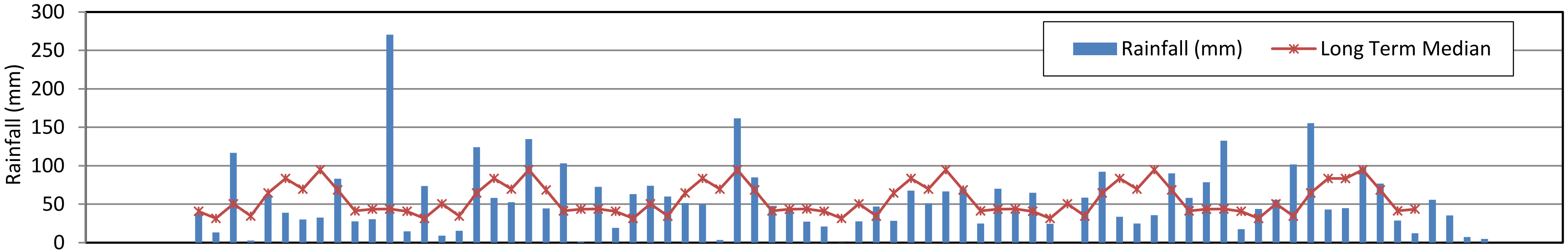
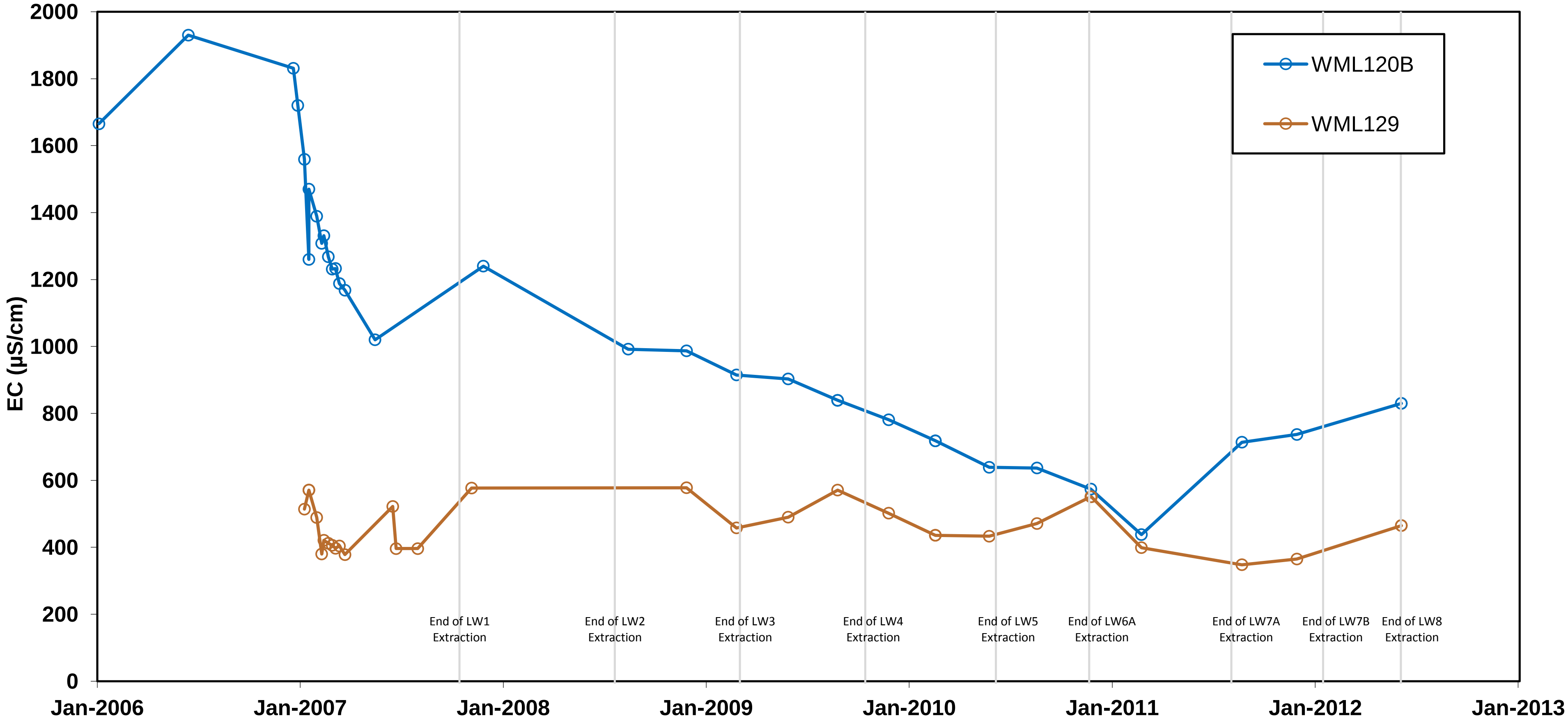
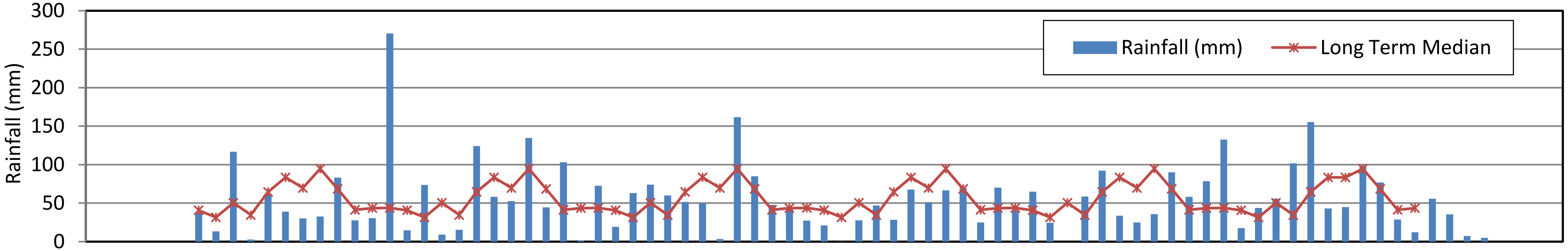
SURFACE WATER EC - GLENNIES CREEK, BOWMANS CREEK, HUNTER RIVER Figure 21


8000
7000
6000
5000
4000
3000
2000
1000
0
EC (µS/cm)
RA30
T5
T6
T7
WMLP311
WMLP323
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013


300
250
200
150
100
50
0
Rainfall (mm)
Rainfall (mm)
Long Term Median





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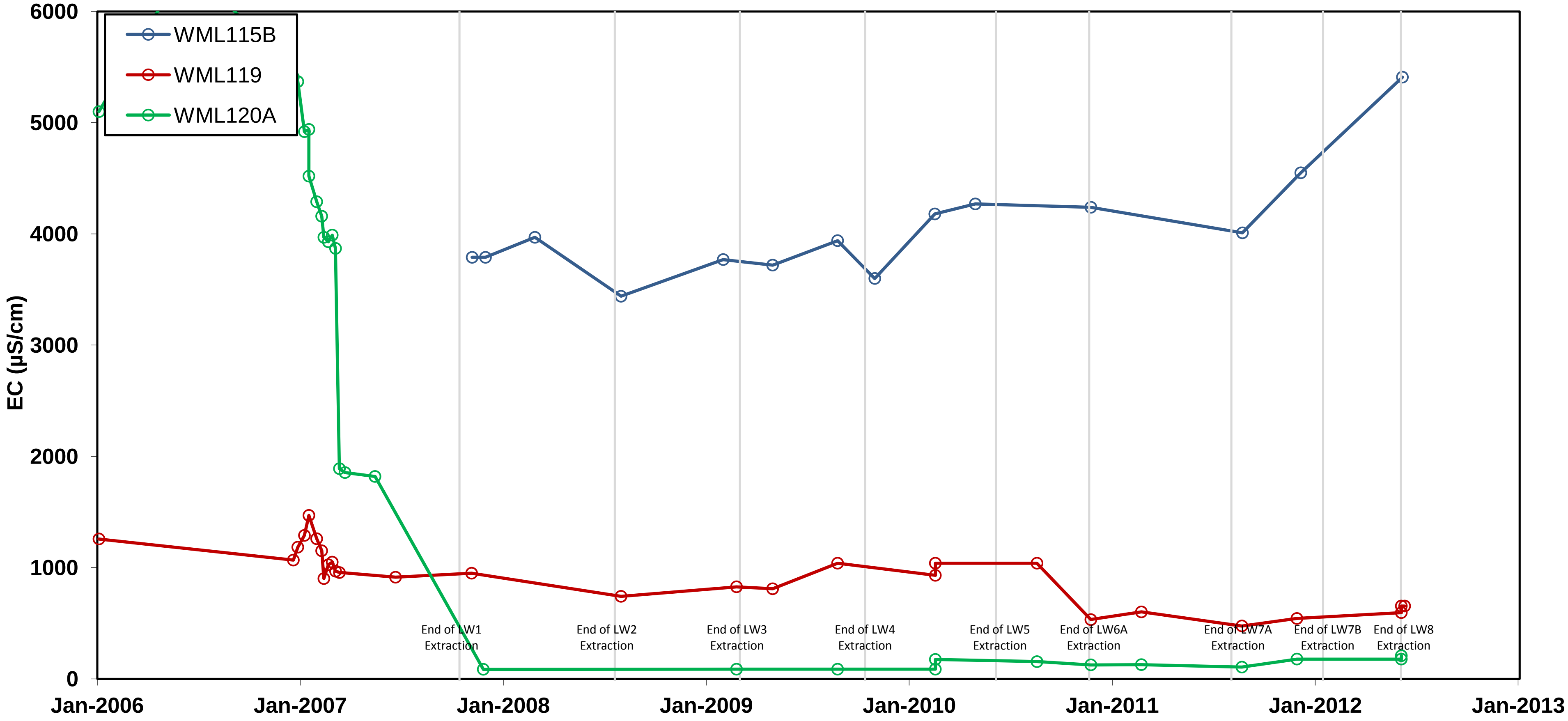
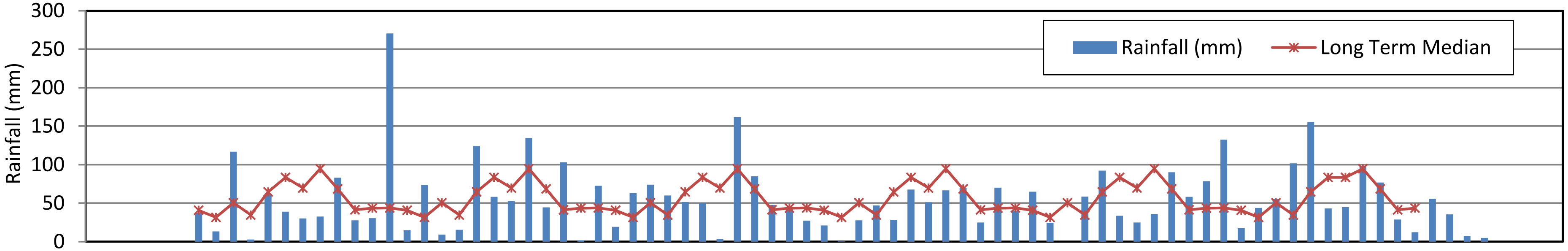
GROUNDWATER EC - GLENNIES CREEK ALLUVIUM Figure 23





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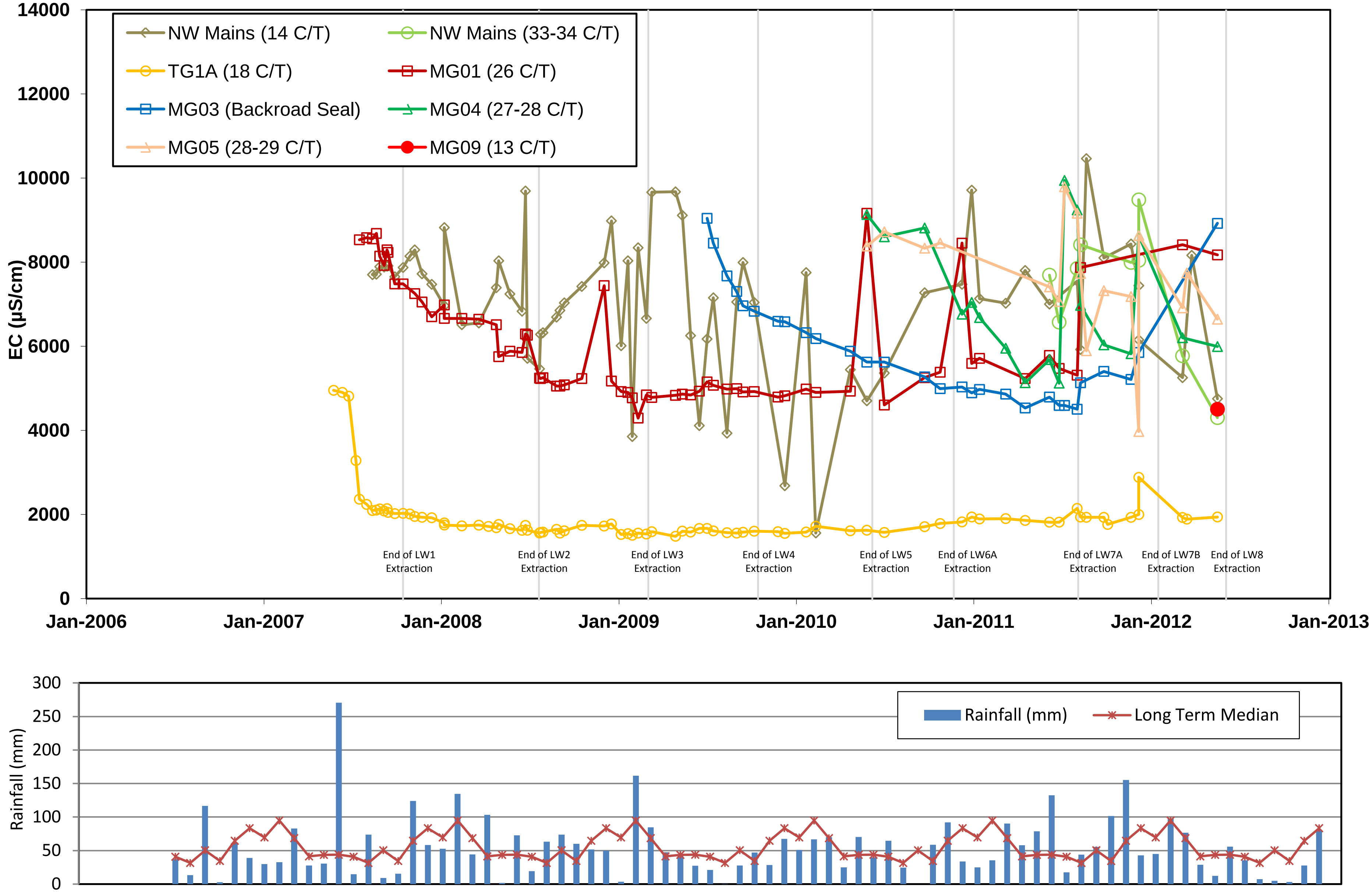
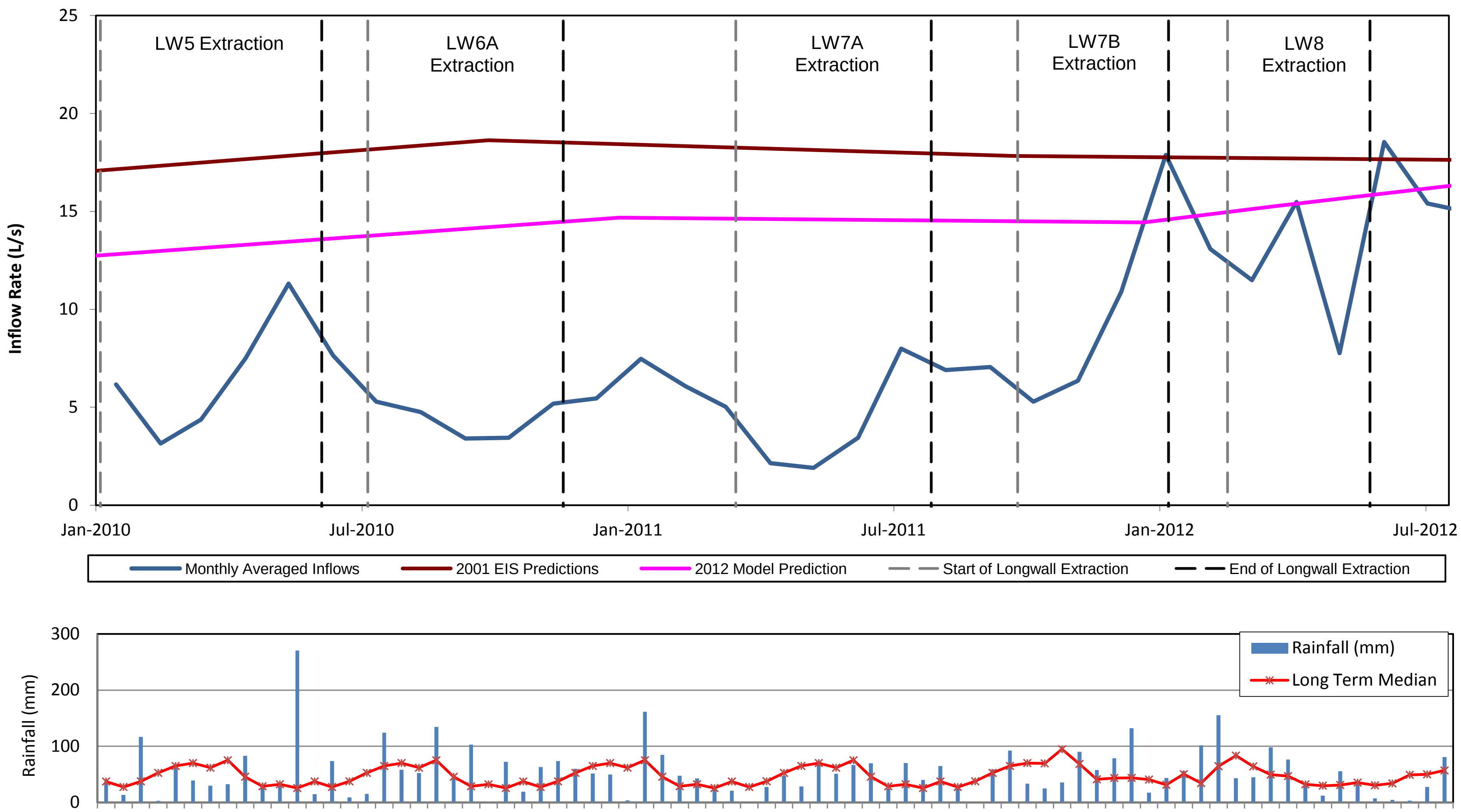
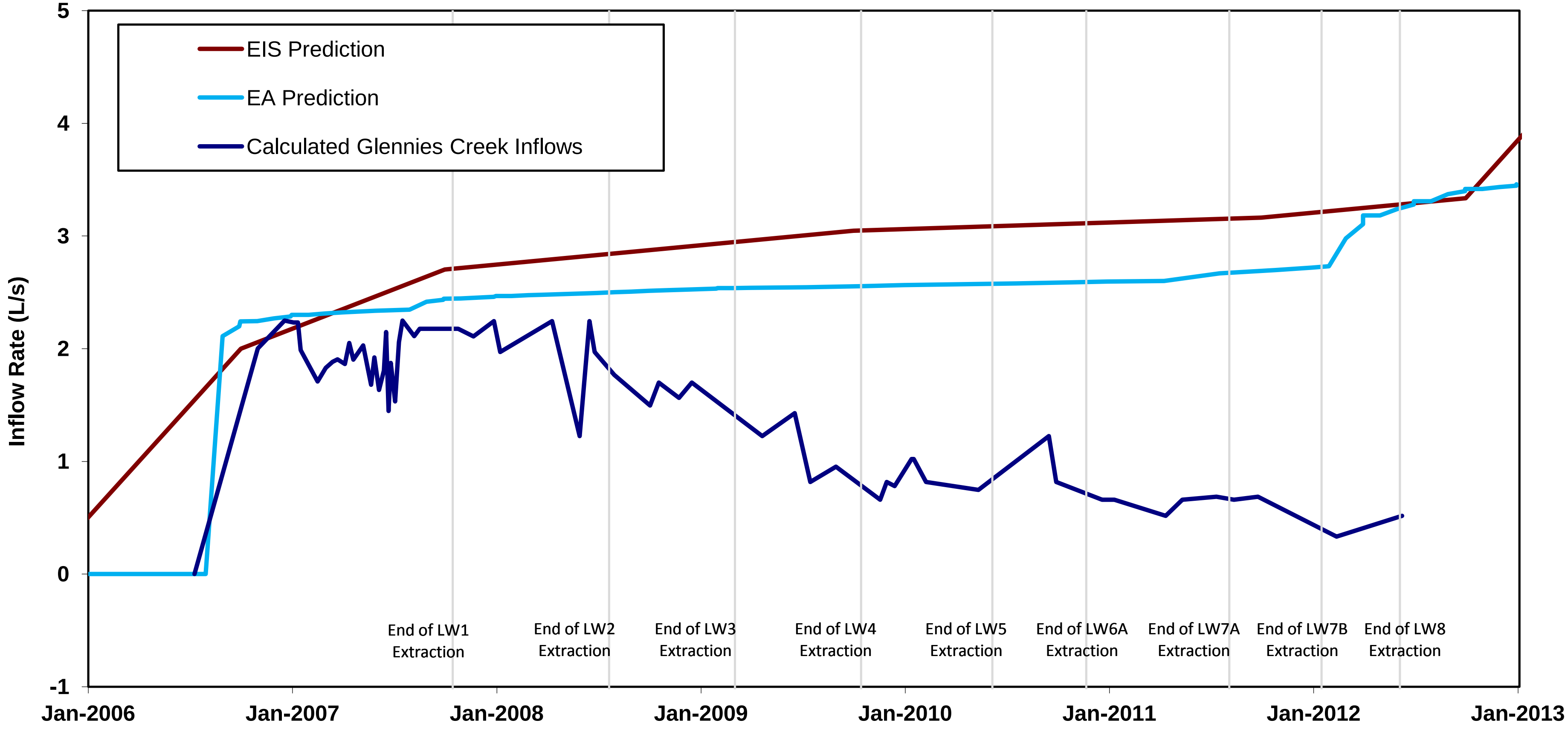
Ashton Coal Operations Pty Ltd

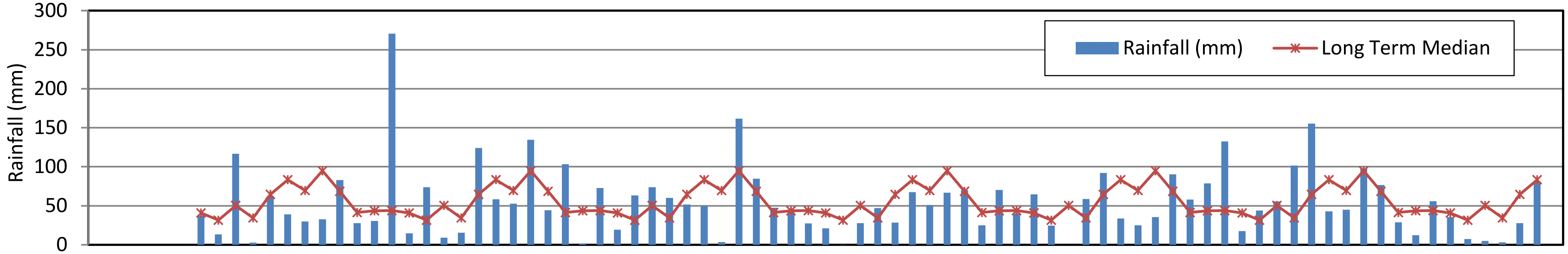
GROUNDWATER EC - PIKES GULLY COAL MEASURES Figure 24


NW Mains (14 C/T)
NW Mains (33-34 C/T)
TG1A (18 C/T)
MG01 (26 C/T)
MG03 (Backroad Seal)
MG04 (27-28 C/T)
MG05 (28-29 C/T)
MG09 (13 C/T)
EC (µS/cm)
14000
12000
10000
8000
6000
4000
2000
0
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013
Rainfall (mm)
300
250
200
150
100
50
0
Rainfall (mm)
Long Term Median



Total Underground Inflows FIGURE 26


EIS Prediction
EA Prediction
Calculated Glennies Creek Inflows
Inflow Rate (L/s)
5
4
3
2
1
0
-1
End of LW1 Extraction
End of LW2 Extraction
End of LW3 Extraction
End of LW4 Extraction
End of LW5 Extraction
End of LW6A Extraction
End of LW7A Extraction
End of LW7B Extraction
End of LW8 Extraction
Jan-2006
Jan-2007
Jan-2008
Jan-2009
Jan-2010
Jan-2011
Jan-2012
Jan-2013


Rainfall (mm)
300
250
200
150
100
50
0
Rainfall (mm)
Long Term Median

APPENDIX A:
ASHTON COAL UNDERGROUND MONITORING NETWORK

Ashton Coal – Current Groundwater Monitoring Network

Table 1: 2001 Environmental Impact Statement Piezometers

Piezometer	Location	Aquifer
RM02	Located within maingate chain pillars of LW5	Colluvium/CM
RM05	Located south-west corner LW8	CM Overburden
RM07	Located in oxbow between LW6A and LW6B	BC Alluvium/CM
RSGM1	Located within LW8	Bayswater Seam

Table 2: 2008 Test Piezometers

Piezometer	Location	Screened Aquifer
T2-A	Located within LW7A, close to the northern end of extraction	BC Alluvium
T2-P		CM Overburden
T3-A	Located within southern part of LW7A, 65m from LW6A goaf edge	BC Alluvium
T3-P		CM Overburden
T4-A	Located within the southern part of LW6A, about 155m from the start line	BC Alluvium
T4-P		CM Overburden
T5	Located within tailgate chain pillars of LW7B	BC Alluvium
T6		
T7	Located within maingate chain pillars of LW8	BC Alluvium
T10	Located within chain pillar between LW6A and LW7A	BC Alluvium

Table 3: 2008 Bowmans Creek Alluvium Investigation Piezometers

Piezometer	Location	Screened Aquifer
RA10	Located above maingate chain pillar of LW7A	BC Alluvium
RA12	Located mid-panel within LW5	Colluvium
RA14	Located inside LW7A	BC Alluvium
RA15	Located west of LW7A	BC Alluvium
RA16	Located within maingate chain pillars of LW5	Colluvium
RA18	Located just outside northern end of LW6A	BC Alluvium
RA27	Located to the south of LW5-LW7A, along the bank of Hunter River.	HR Alluvium
RA30	Located within LW7B	BC Alluvium

Table 4: General Underground Monitoring Network

Piezometer	Location	Screened Aquifer	Installation date
WML107B	Located outside southern end of LW2	Lem8-9	Sep-06
WML108B			
WML110C	Located inside southern end above LW6A	BC Colluvium	
WML111B	Located inside southern end of LW6A	CM Overburden	May-06
WML112C	Located near LW7A maingate	BC Alluvium	Jul-06
WML112B		Bayswater 1-2	
WML113C	Located just west of southern end of LW7A	BC Alluvium	May-06
WML113B		Bayswater 1	
WML115B	Located in eastern chan pillars of LW7B	CMOB & Lem3-4	-
WML115C		BC Alluvium	
WMLP316	Located adjacent to the west diversion	BC Alluvium	Feb-11
WMLP320			
WMLP308	Located adjacent to the eastern creek diversion	BC Alluvium	Feb-11
WMLP311			
WMLP323			
WMLP324		CM Overburden	
WMLP325			
WMLP326	Located southwest of LW6A	BC Alluvium	Feb-11
WMLP327		CM Overburden	
WML275	Located within/close to southern end of LW6A	BC Alluvium	-
WML276			
WML277	Located to the south of LW5-LW7A, along the bank of Hunter River.	HR Alluvium	-
WML278			
WML279			
WML280			
WML119	Located to the east of LW1 and west of Glennies Creek	Pikes Gully	Jun-06
WML120A			
WML120B		GC Alluvium	Jun-06
WML129			-
WML181		Pikes Gully	Mar-07
WML182			
WML183			
WML184			
WML185			
WML186			
WML187			
WMLP301		Arties	Jul-10
WMLP302			
WML261		Upper Liddell	Oct-09

Piezometer	Location	Screened Aquifer	Installation date
WML262		Upper Liddell	Oct-09
WMLP336	Located south of LW1	HR Alluvium	Jul-12
WMLP337	Located south of LW3		
WMLP338	Located south of LW2		

Table 5: Multi-level Vibrating Wire Piezometers

Piezometer	Location	Aquifer	Installation Date
WML106-32*	Located outside southern end of LW1	Lem15	Jul-06
WML106-68*		Lem19	
WML106-84*		PG	
WML107A -38	Located outside southern end of LW2	Lem11	May-06
WML107A -69		Lem15	
WML107A -69		Lem15	
WML107A -98		Lem19	
WML108A-53	Located outside southern end of LW3	Lem11-12	Apr-06
WML108A-80		Lem15	
WML113A-40	Located just west of southern end of LW7A	Bayswater 2	May-06
WML113A-65		Lem9	
WML113A-95		Lem10-12	
WML113A-124		Lem15	
WML189-49	Located in chain pillars between LW1 and LW2	Lem15	-
WML189-93		Arties	
WML189-101		Pikes Gully	
WML191-52	Located in chain pillars between LW1 and LW2	Lem15	-
WML191-100		Pikes Gully	
WML191-132		Upper Liddell	
WML191-155		Upper Lower Liddell	
WML191-200		Lower Barrett	
WML213-48	Located southwest of LW7A	Bayswater	-
WML213-110.5		Lem8-9	
WML213-169.5		Lem15	
WML213-185.5		Lem19	
WML213-205		Pikes Gully	
WML213-247		Upper Liddell	
WML213-276		Upper Lower Liddell	
WML213-300		Lower Barrett	
WML269-24	Located in maingate chain pillars close to LW5 start line	Lem5	-
WML269-56		Lem7	
WML269-64		Lem8-9	

Piezometer	Location	Aquifer	Installation Date
WML269-92		Lem11-12	
WML269-122		Lem15	
WML269-142		Lem19	
WMLC333-124m	Located to the south of LW4	Lem15B	Feb-12
WMLC333-144m		Lem17A	
WMLC333-178m		Arties	
WMLC333-212m		Upper Liddell	
WMLC333-232m		Upper Lower Liddell	
WMLC333-251m		Upper Barrett	
WMLC333-264m		Lower Barrett	
WMLC334-29.5m	Located to the south of LW1 and LW2	Lem10	Apr-12
WMLC334-63m		Lem15	
WMLC334-91m		Lem19	
WMLC334-126m		Arties	
WMLC334-157m		Upper Liddell	
WMLC334-175m		Upper Lower Liddell	
WMLC334-209m		Lower Barrett	
WMLC334-198m		Upper Barrett	
WMLC335-23m	Located to the south of LW1 and LW2	Lem15A	Apr-12
WMLC335-29.5m		Lem17	
WMLC335-67m		PG-U	
WMLC335-86m		Arties	
WMLC335-121.5m		Upper Liddell	
WMLC335-141.5m		Upper Lower Liddell	
WMLC335-159m		Upper Barrett	
WMLC335-173m		Lower Barrett	

* Piezometer destroyed by longwall extraction in September 2012