VOLUME 2

TECHNICAL SPECIALISTS REPORTS

Strata Control Technology

R E P O R T T O :

ASHTON COAL OPERATIONS LTD

Subsidence Assessment for Extraction Plan for Longwalls 105-107 in the Upper Liddell Seam (Updated in November 2015 Based on Shortening of Longwall 105)

ASH4512

SCT Operations Pty Ltd PO Box 824 Wollongong NSW 2520 Australia
sctnsw@sct.gs

REPORT TO	Aaron McGuigan Technical Services Manager Ashton Underground Mine PO Box 699 SINGLETON NSW 2330
SUBJECT	Subsidence Assessment for Extraction Plan for Longwalls 105-107 in the Upper Liddell Seam (Updated in November 2015 Based on Shortening of Longwall 105)
REPORT NO	ASH4512
PREPARED BY	Ken Mills
DATE	18 November 2015

Ken Mills
Principal Geotechnical Engineer

SUMMARY

Ashton Coal Operations Ltd (ACOL) is proposing to mine Longwalls 105-107 in the Upper Liddell (ULD) Seam as part of their ongoing operations near Camberwell in the Hunter Valley. ACOL commissioned SCT Operations Pty Ltd (SCT) to undertake a subsidence assessment describing the impacts expected from this proposed mining in support of an Extraction Plan (EP) being prepared by SLR Consulting Australia Pty Ltd (SLR) for ACOL. This report presents our updated, based on shortening of Longwall 105, assessment of the subsidence impacts expected for the proposed mining of Longwalls 105-107 in the ULD within the area referred to as the EP Area.

Our assessment is based on the results of previous subsidence monitoring at Ashton Coal Mine where Longwalls 101 and 102 in the ULD Seam were mined below Longwalls 1-3 in the Pikes Gully (PG) Seam. This previous experience has been suitably modified to take account of the greater depths of Longwalls 105-107 based on the mechanics of multi-seam subsidence that these results imply.

The report has been updated from our earlier assessment report dated 28 May 2015 to reflect the revised layout whereby Longwall 105 has been shortened by approximately 370 m at the southern end due to underground geological constraints. The only substantive changes in terms of subsidence impacts as a result of the revised layout are a reduction in the area of ponding and several poles on the 132 kV power line that traverses the southern part of the longwall panels will no longer be directly mined under. Subsidence movements at the location of four poles, three of which are located at a change in direction, will be significantly reduced as a result of the change and these will no longer be susceptible to ponding.

This report has also been updated to included assessment of the relative changes from the stacked layout approved for the Bowmans Creek Diversion EA and the offset geometry proposed. Our assessment indicates that the offset layout proposed for Longwalls 105 to 107 is likely to produce subsidence effects that are of generally similar magnitude to the subsidence effects for the stacked layout approved in the Bowmans Creek EA. Lower subsidence effects than predicted for the stacked geometry are expected across most of the area. Slightly higher maximum subsidence is predicted in some areas because of a thicker seam section than was contemplated in the EA. Somewhat higher strains and tilts are expected at stacked edges based on the experience of monitoring a stacked edge above Longwall 102.

Subsidence from mining Longwalls 105-107 in the ULD Seam is expected to cause additional incremental subsidence of up to 2.7 m in the northern panels and up to 2.3 m in the southern panels. The total cumulative subsidence is expected to reach 3.8 m to 4.0 m in the central part of areas where there is overlap between longwall panels in both seams. The incremental subsidence estimates are based on 85% of the thickness of the ULD Seam and the cumulative subsidence estimates are based on 75% of the combined thickness of both seams. Both of these values are considered to be reasonably conservative.

Over most of the EP Area, incremental tilts and strains from mining in the ULD Seam are expected to be of similar to or lower magnitude than the tilts and strains observed during mining in the PG Seam despite the cumulative subsidence being almost double in magnitude. However, in areas where the goaf edges in the two seams are stacked above each other, or nearly so, mining in the ULD Seam is expected to remobilise goaf edge fractures that originally developed during mining in the PG Seam. In these areas maximum tilts are expected to double background values and maximum strains are expected to reach four times background values at the PG Seam goaf edge cracks. Areas where high tilts and strains are expected above stacked edges include the start of Longwalls 106A, and 106B, the finish of Longwalls 105, 106B, and 107B, the western side of Longwall 107A and the northern edges of Longwalls 6A and 7A in the PG Seam.

Tilts and strains at stacked goaf edges are expected to reach a maximum when the ULD Seam goaf edges are mined 20-30 m under the solid edge of a previously extracted panel in the PG Seam. In some cases these maxima will then reduce with further mining, but in other cases such as along the western edge of Longwall 7A in the PG Seam, the high tilts and strains are expected to be permanent.

The general landform above both the northern and southern longwall mining areas is expected to be lowered by a total cumulative subsidence of up to 3.8-4.0 m decreasing to about 1.5-1.7 m over the chain pillars.

Bowmans Creek and the two diversions are not expected to be subsided or otherwise impacted by the proposed mining so the general landform on either side of Bowmans Creek will be lower than the adjacent section of creek invert.

Perceptible cracks of up to about 200-300 mm wide are expected over the stacked goaf edges with local gradients in the surface of up to about 1 in 6 (160 mm/m) in these areas. It is anticipated that there may be potential for increased inflows to the mine at the completion of mining in the ULD Seam both because of the greater volumetric holding capacity of the subsidence bowls and the increased disturbance to the overburden strata associated with double subsidence from mining in two seams.

Perceptible cracks of up to about 200-300 mm wide are expected over the stacked goaf edges with local gradients in the surface of up to about 1 in 6 (160 mm/m) in these areas. It is anticipated that there may be potential for increased inflows to the mine at the completion of mining in the ULD Seam both because of the greater volumetric holding capacity of the subsidence bowls and the increased disturbance to the overburden strata associated with double subsidence from mining in two seams.

Approximately 54% of the total ponding area estimated as likely to be caused by mining Longwalls 105-107 in the ULD Seam is associated with expansion of existing farm dams, existing billabongs, and sections of existing or excised watercourses.

Most of these ponding areas were not free draining prior to the commencement of mining. However, mining subsidence will increase the area of ponding, in some cases significantly.

Ponds located above the southern longwall panels are located on grazing land that is owned by ACOL. These ponds represent approximately 62% of the total ponding area above Longwalls 105-107 in the ULD Seam and are the main ponding areas that are either new or extend well beyond existing ponds. Ponds located above the northern panels are predominantly within the excised sections of Bowmans Creek and the tributaries thereof. These ponds represent an area of approximately 21% of the total ponding area.

The options to improve the free draining characteristics of those sections of the landform that are required to be free draining include:

- Clearing existing drainage lines that have become blocked by vegetation or by construction works associated with the Bowmans Creek Diversion.

- Forming drainage lines that allow overflow into existing watercourses that feed into Bowmans Creek or direct into minor tributaries of the Hunter River.

It is understood that ACOL are planning to manage the impacts of ponding using all three of these approaches via an adaptive management strategy.

Impacts of ponding on surface infrastructure are expected to include periodic flooding of power poles on the 132 kV line across the southern panels and power poles on the 11 kV local electricity line, and periodic flooding of an AGLM access road and the alternative access route to Property 130. These impacts are expected to be manageable through building up the levels of low sections of the roads, cleaning out existing drains, and providing drainage of ponds that flood power lines.

The proposed layout in Longwalls 105-107 in the ULD Seam is consistent with keeping all secondary extraction at least 200 m from the Hunter River Alluvium (as defined in RPS 2009) and at least 40 m (in a horizontal direction) from the high bank of Bowmans Creek in its diverted function form as per the Statement of Commitments made for Longwalls 5 to 7 in the PG Seam in Schedule C of DA309-11-2001 Mod-6 Items 3.2 and 5.3.

Lemington Road and associated infrastructure including the culvert below the road, buried telecommunication lines alongside the road, the 33 kV power line also alongside the road, the Narama to Mount Owen fresh water line, the 11 kV local area electricity line, and the 132 kV electricity line crossing the southern panels are considered likely to be the infrastructure most significantly impacted by mining subsidence within the EP Area. All impacts are expected to be manageable albeit with some effort, particularly in respect of Lemington Road.

Subsidence movements are expected to be perceptible along Lemington Road from CH200 m to CH1200 m, where chainage is measured from the centre of the intersection with the New England Highway.

Mining induced subsidence is expected to occur incrementally with mining and so should be gradual and able to be managed with ongoing remediation works during the period of active mining. However, the magnitude of these works is expected to be significant, particularly near the finishing end of Longwall 106B.

During mining of Longwall 106B, subsidence impacts are expected from CH200 m to CH720 m with incremental subsidence increasing as the panel retreats to an estimated maximum of about 2.3 m in the interval CH300-360m near the corner of Longwall 106B. Significantly greater subsidence is expected on the southbound lane compared to the northbound lane because of tilt around the corner of the panel toward the existing goaf of Longwall 6B in the PG Seam.

Maximum tilts of up to about 130 mm/m (1 in 6) are expected in the interval CH310-CH350 m in a direction that is predominantly across the road (i.e. in a southeast direction) so that the southbound lane is expected to be up to about 600 mm lower than the northbound lane.

Elsewhere along the road, maximum tilt is expected to be less than 65 mm/m (1 in 15) with a significant component of this tilt still acting across the road causing differential subsidence between the lanes of up to about 300 mm.

Maximum strains of up to 70 mm/m, predominantly across the road, with potential for cracks up to about 100mm wide are considered possible around the corner of Longwall 106B. Horizontal strains elsewhere along the road are expected to be generally less than 10-15 mm/m with perceptible, but generally transient, tension cracks expected to be typically less than 50 mm wide at intervals of 5-10 m.

During mining of Longwall 107B, subsidence impacts are expected to be perceptible mainly from CH450 m to CH1120 m increasing as the panel retreats to estimated maximum incremental subsidence of 2.7 m over the centre of Longwall 107B in the interval between CH720 m and CH760 m.

Tilts are expected to be generally less than 40 mm/m but may reach up to about 70 mm/m at CH710 m dipping to the northwest and CH780m dipping to the southeast. Horizontal strains are expected to be generally less than 10-15 mm/m with tension cracks typically less than 50 mm wide. Some compression overrides are also considered possible.

Some stretching and compression of roadside barrier rails is considered possible and some allowance to loosen fixing bolts during the period of active mining is recommended to reduce damage to the rails and posts.

The culvert below Lemington Road is expected to be perceptibly impacted by mining subsidence with potential for cracks to develop within the structure or between elements of the structure so that there may be potential for fines migration and piping failure to cause sinkholes on the road surface.

There also appears to be potential for the capping slab above the central opening of the culvert to collapse if the outer culvert elements move apart. Monitoring and mitigation works are likely to be required to manage these hazards.

Impacts on buried telecommunication lines, buried pipelines that traverse the EP Area, and the 33 kV power line located alongside Lemington Road are expected to be significant in areas of stacked goaf edges. Mitigation works aimed at limiting the impacts are expected to be generally necessary for the infrastructure to remain serviceable. These measures include re-routing the infrastructure around stacked goaf edges, uncovering buried infrastructure in areas of stacked goaf edges so that horizontal strains are not able to build up, and developing management strategies for power lines that avoid over-tensioning of conductor fixings and stays.

No impacts to infrastructure alongside the New England Highway are expected. Impacts to the AGLM access road and various access roads within ACOL owned land are expected to be significant where these roads cross stacked goaf edges, but should be manageable through regrading and filling of cracks.

Impacts to the 11 kV, 33 kV, and 132 kV power transmission lines that cross the EP Area are expected to be generally similar to the impacts associated with the PG Seam mining, but may require special mitigation where they cross stacked goaf edges.

The 330 kV line located to the west of the EP Area is designed to tolerate more than the predicted subsidence, has been approved by the Mine Subsidence Board, and is not expected to be significantly impacted.

Bowmans Creek and the Bowmans Creek Diversion, Glennies Creek, and the Hunter River are not expected to be significantly impacted.

Groundwater impacts, impacts to the Bowmans Creek Alluvium and the Hunter River Alluvium, and to heritage features are not assessed in this report.

TABLE OF CONTENTS

PAGE NO

1. INTRODUCTION

Ashton Coal Operations Ltd (ACOL) is proposing to mine Longwalls 105-107 in the Upper Liddell (ULD) Seam as part of their ongoing operations near Camberwell in the Hunter Valley. ACOL commissioned SCT Operations Pty Ltd (SCT) to undertake a subsidence assessment describing the impacts expected from this proposed mining in support of an Extraction Plan (EP) being prepared by SLR Consulting Australia Pty Ltd (SLR) for ACOL. This report presents our updated, based on shortening of Longwall 105, assessment of the subsidence impacts expected for the proposed mining of Longwalls 105-107 in the ULD within the area referred to as the EP Area.

The Ashton Coal Project (ACP) was granted consent on 11 October 2002 by the Minister of Planning pursuant to the provisions of the *Environmental Planning and Assessment Act 1979* (DA 309-11-2001-i). The mine is approved to produce up to 5.45 million tonnes per annum of run of mine (ROM) coal and operate until 2023.

The consolidated consent has been modified on ten occasions, with the most recent on 12 December 2012. This specialist subsidence assessment has been prepared for the extraction of Longwalls 105-107 in the ULD Seam and covers the key requirements of Condition 3.12 and 3.13 in Schedule 2 of DA 309-11-2001-i.

A conceptual offset geometry was also approved for the Bowmans Creek Diversion Environmental Assessment (EA), but the subsidence effects were not estimated for this offset layout because the stacked geometry was expected to give higher values for all subsidence parameters. Experience of mining Longwalls 101 and 102 indicates that lower subsidence effects than predicted for the stacked geometry are expected across most of the area. Slightly higher maximum subsidence is predicted given the potential to extract a thicker seam section than was contemplated in the EA, with somewhat greater strains and tilts expected at stacked edges based on the experience of monitoring a stacked edge above Longwall 102.

The report is structured to provide:

1. A description of the general area including the proposed mining geometry, overburden depth, and other parameters of relevance to a subsidence assessment together with a general summary of surface features likely to be impacted by mining.

2. Subsidence estimates based on the previous multi-seam subsidence monitoring at the mine.

3. A more detailed description of individual infrastructure items and specific assessments of the likely subsidence impacts on each of the features identified.

4. Recommendations for subsidence monitoring.

2. SITE DESCRIPTION

This section presents a description of the general area including the proposed mining geometry, overburden depth, and other parameters of relevance to a subsidence assessment together with a general overview of surface features likely to be impacted by mining.

2.1 Proposed Mining Geometry

Figure 1 shows a plan of the proposed mining geometry for Longwalls 105 to 107 superimposed onto a 1:25,000 series topographic series plan of the area updated to reflect recent changes in surface infrastructure as well as previous mining in the Pikes Gully Seam at the Ashton Coal Project and in the Bayswater Seam at Ravensworth East Opencut Mine.

Table 1 presents a summary of the longwall panel dimensions.

Table 1: Proposed Longwall 105 to 107 Panel Dimensions

Panel	Nominal Gateroad Width (m)	TG Pillar Width Rib to Rib (m)	LW Void Width (m)	LW Length (m)
LW105	5.4	25	216	1021
LW106A	5.4	25	216	1354
LW106B	5.4	25	216	1063
LW107A	5.4	N/A	161	1351
LW107B	5.4	N/A	216	1145

Longwalls 105, 106A, and 107A in the ULD Seam are located in substantially the same area as Longwalls 5, 6A, and 7A in the PG Seam except that the proposed panels are offset 60m to the west and have different starting and finishing points, particularly Longwall 105 and Longwall 107A. Longwall 106B is located substantially below Longwall 6B in the PG Seam but offset 60m to the west, 30m north at the start line, and 60m north at the finish line. Longwall 107B is the same width (216 m) as most of the longwall panels at the mine and extends below Longwalls 7B and 8 in the PG Seam. There is no Longwall 108 proposed under this EP.

Figure 2 shows the isopachs of overburden depth to the ULD Seam. The overburden depth ranges from approximately 140 m in the north eastern corner of Longwall 6B to 220 m in the south western corner of Longwall 7A, mainly as a result of the general dip of the strata to the west-southwest. The previously mined longwall panels in the PG Seam are located approximately 35-40 m above the ULD Seam although there are areas where the seam separation reduces to 20 m in the vicinity of Longwalls 107B. The ULD seam thicknesses planned to be mined have been assumed to be 2.5 m for Longwalls 105, 106A, and 107A, and 2.8 m and 3.0 m respectively for Longwalls 106B and 107B. The height of longwall extraction in the PG Seam ranged within the EP Area from 2.3 m to 2.9 m with an average of about 2.5 m.

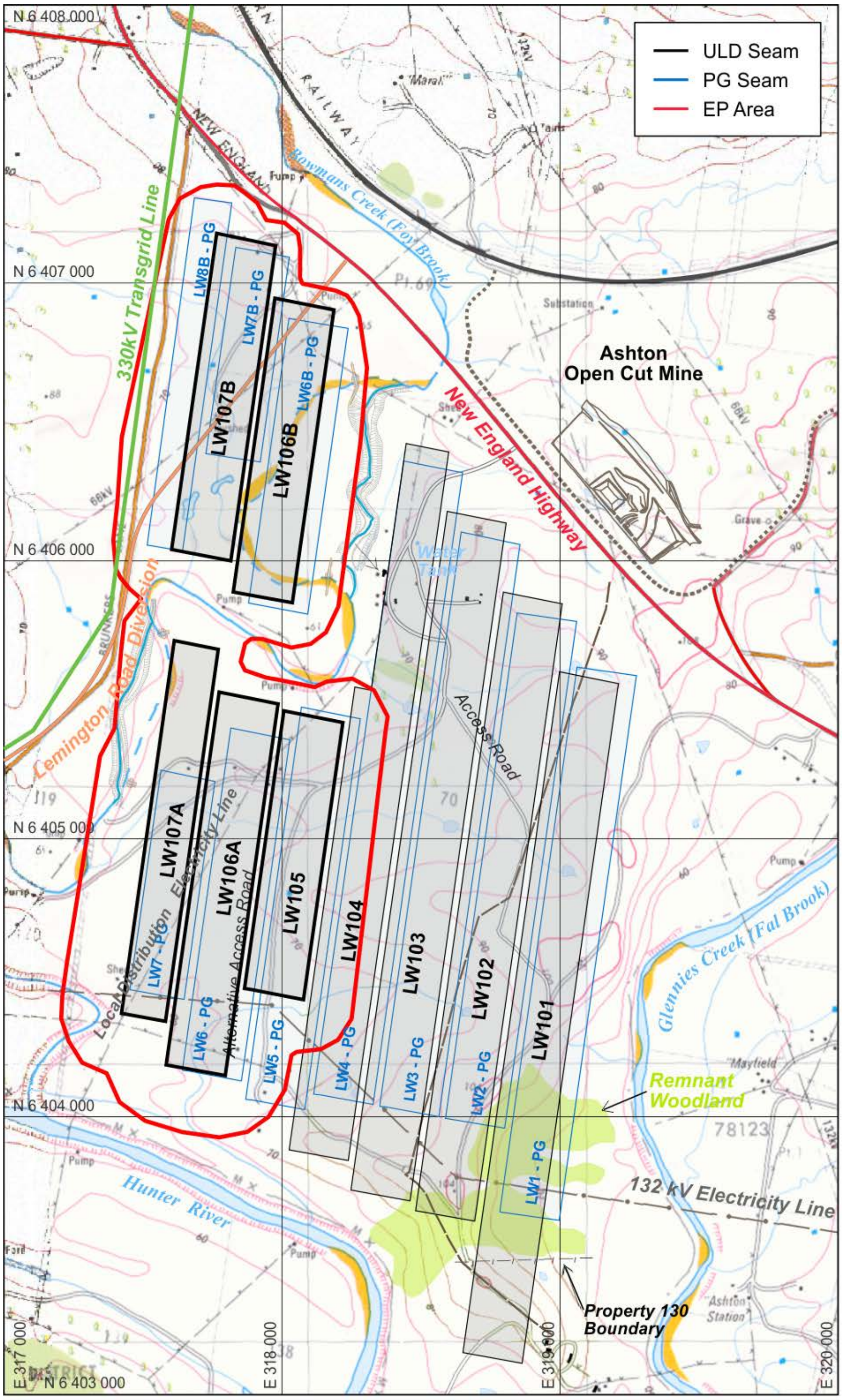


Figure 1: Site Plan showing proposed mining within the EP Area superimposed onto a 1:25,000 topographic series map of the area updated to reflect changes since the map was originally produced in 1982.

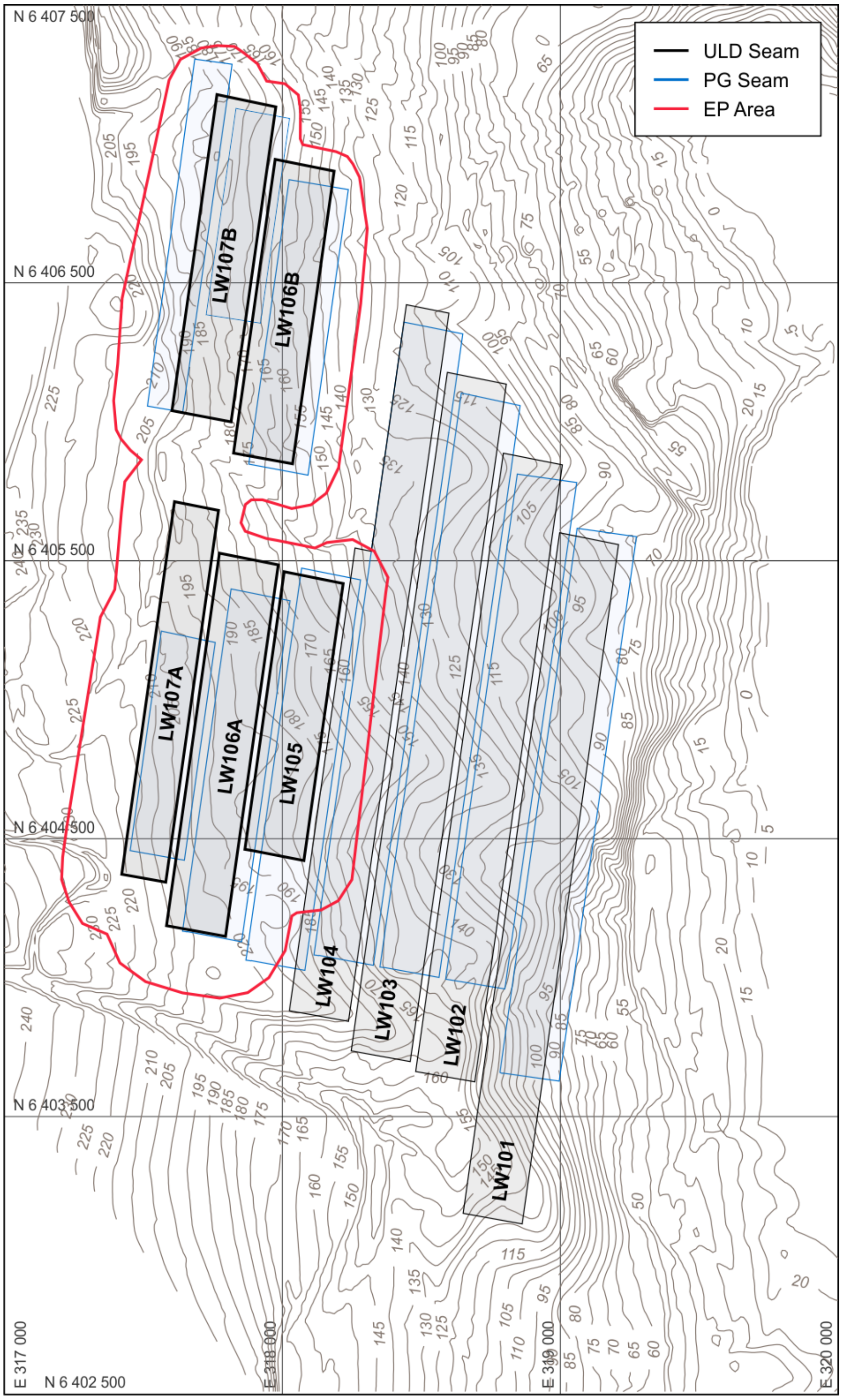


Figure 2: Overburden depth isopachs to the ULD Seam in the EP Area (PG Seam is located approximately 35-40m above ULD Seam).

2.2 Overview of Surface Features and Surface Infrastructure

Figure 3 shows the proposed mining layout superimposed onto a more detailed plan of the natural surface features and surface infrastructure.

The major natural features in the EP Area include Bowmans Creek which flows down a channel incised into a broad floodplain and adjacent slopes and the Hunter River located to the south of the area. ACOL has diverted Bowmans Creek to allow more efficient recovery of the coal resource. The Hunter River, as defined by the edge of the Hunter alluvium, is located further than 200 m to the south of the nearest goaf edge of the panels within the EP Area. Glennies Creek is located some 1 km to the east and remote from the EP Area.

The EP Area is predominantly cattle grazing land owned by ACOL. A triangle of land in the north western corner to the west of Lemington Road is owned by AGLM and is part of the now completed Ravensworth East Open Cut Mine, the remnant voids of which are being used for ash and tailings disposal.

Heritage items in the area comprise mainly archaeological scatter sites. The management of heritage features are outlined in ACOL's Aboriginal Cultural Heritage Management Plan.

There are two areas of River Red Gum located along the banks of Bowmans Creek to the south west of the EP Area beyond the area likely to be impacted by subsidence movements.

Impacts of mining on the landform and groundwater systems have been assessed in a separate specialist report by RPS (2015) and the discussion on landform and groundwater issues presented in this report is limited to an overview of the landform changes, nature of surface cracking, and a discussion of the offsets of panels from the Hunter River.

Table 2 provides a list of features (including ownership) located within or adjacent to the EP Area.

The major infrastructure located directly above the EP Area longwalls is associated with the recently constructed Lemington Road and a fibre optic cable alongside Lemington Road. Other major infrastructure in the general area includes the New England Highway to the north of the mining area together with a bridge over Bowmans Creek, a buried fibre optic cable alongside the New England Highway, four high voltage electricity lines, two alongside the New England Highway, one that traverses the southern end of the panels, and a newly constructed 330 kV line located on the western edge of the EP Area.

Other non-mining related infrastructure includes a local area electricity line, two buried Telstra copper wire telecommunication lines, a river gauging station on Bowmans Creek, and various farming related infrastructure such as fences, farm dams, and access roads.

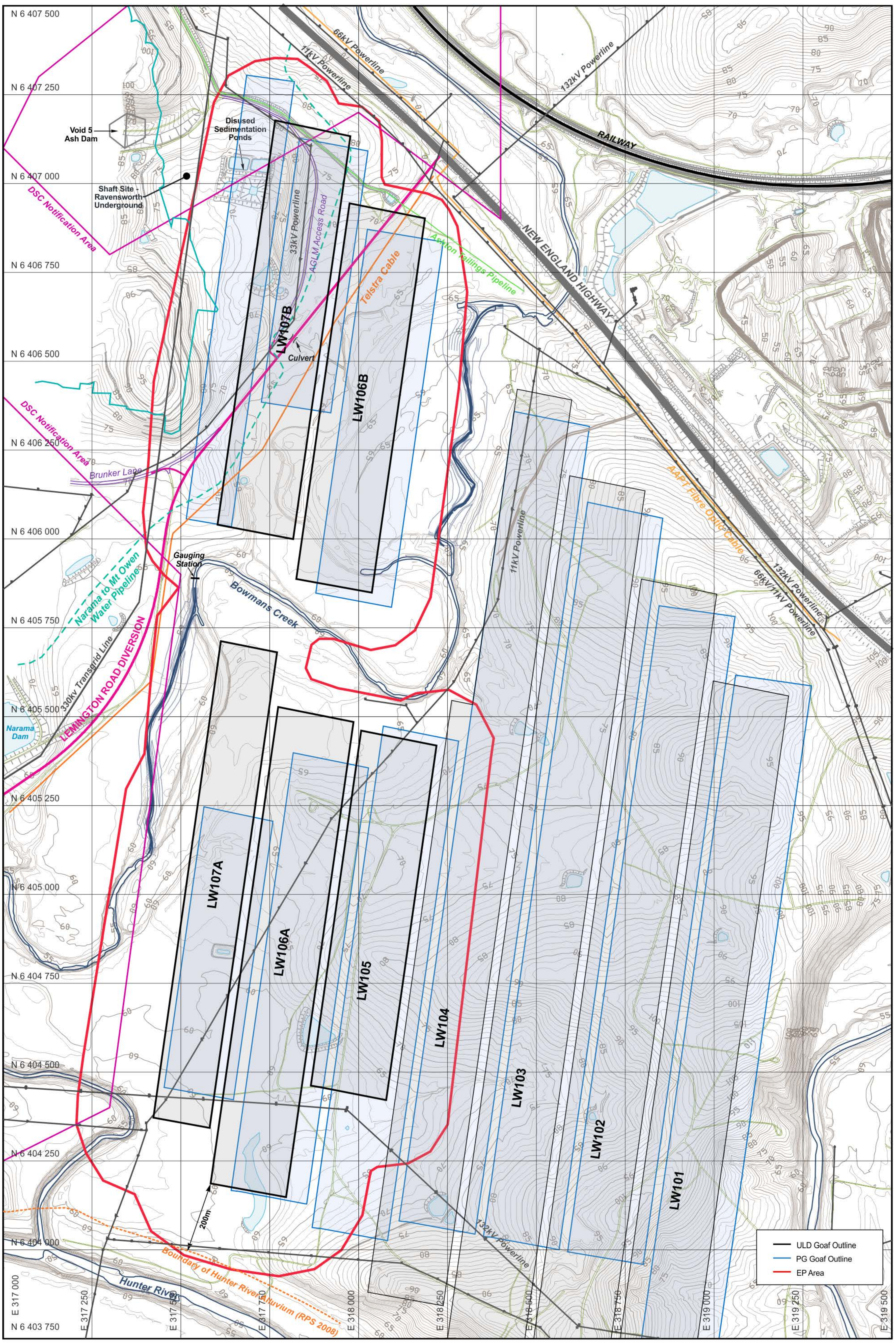


Figure 3: Natural Features and Surface infrastructure in the EP Area.

Mining related infrastructure that is not owned by ACOL includes a private road that provides secondary access to AGLM land and Ravensworth Underground Mine (RUM) infrastructure as well as access to former Ravensworth East Open Cut area (now managed by AGLM), clay lined sedimentation ponds located on the out of pit waste rock spoil dump for the opencut, a 33 kV power line servicing Ravensworth Open Cut Mine, No 5 Ventilation Shaft for RUM, and a polyline carrying fresh water from Narama Dam to Mt Owen Mine.

Table 2: Surface and Sub-surface Infrastructure in Vicinity of Longwalls 105 – 107

Infrastructure	Brief Description	Owner / Authority
Roads	Lemington Road	Singleton Shire Council
	New England Highway	Roads and Maritime Services
	Access roads	AGLM (and ACOL)
	Alternative Access Road to Property 130	ACOL
Power Transmission Lines	132 kV traversing the southern extent of the ACOL Mining Lease	AusGrid
	132 kV and Combined 66/11 kV lines parallel to New England Highway	AusGrid
	11 kV line traversing ACP	AusGrid
	330 kV line along western lease boundary	Transgrid
	33 kV transmission line on western side of Lemington Road	Glencore - Ravensworth Operations
Dams	Void 5 Ash Dam DSC Notification Area	AGLM
	Surface water dams	AGLM (and ACOL)
	Sedimentation dams	AGLM
Buried Pipelines	315 mm PN10 PE100 pipeline from Narama Dam to Mt Owen	Glencore - Ravensworth Operations
	Gas Pipeline Easement	AGLM
Buried Communication Lines	Telstra cables providing service to subdivided blocks on Ravensworth Operations	Glencore - Ravensworth Operations / Telstra
	Telstra cables providing service to NOW Stream Gauging Station on Bowman's Creek	NOW / Telstra
	Telstra cables providing service to Property No. 130 (Private Property)	Property 130 / Telstra
	Sydney to Brisbane fibre optic cable	AAPT
	Fibre Optic Cable to Ravensworth Operations (location unknown)	Glencore - Ravensworth Operations
Underground Mines	Ravensworth Underground Mine and No. 5 Shaft	Glencore – RUM
Other (Non ACOL)	Fences, gates, cattle grids	AGLM
	Stream Gauging Station 'Foy Brook' Station No. 210130, on Bowmans Creek	NOW

ACOL Owned Infrastructure	
Roads	Access road and tracks
Farm buildings	Rural residences (incl. various sheds)
	Farm sheds
Fences	Boundary fencing, internal fencing, gates and cattle grids
Pipelines	Hunter River pipeline (200 mm PE80 PN8)
	Underground borehole pump pipeline (355 mm PE100 PN8) yet to be constructed
	Clean water line (90OD PN12.5 PE100)
	Mine water line (250OD PN20 HDPE PE100)
	Two tailings lines (280OD PN20 HDPE PE100)
	Decant return (250OD PN20 HDPE PE100)
Surface water storages	Farm dams
Landform	Bowmans Creek diversion
Goaf Gas Drainage Boreholes	Goaf gas drainage boreholes (Existing and Additional Proposed)

The proposed longwall panels do not extend into the Dams Safety Notification Area for Narama Dam. An ash dam, known as Ravensworth Void 5 Ash Dam, has been constructed just beyond the north-western corner of the EP Area. This dam is located outside the EP Area but proposed mining extends into the DSC Notification Area for this dam.

RUM owned by Glencore has Development Consent for a multi-seam underground longwall operation that shares a boundary with the ACOL lease. The two mines are required by law to be separated by a 40 m wide barrier, 20m either side of the lease boundary. There is nevertheless some potential for future interaction between the two sites, particularly in relation to flow of mine water once underground mining at the ACP is complete. At the time of preparing this report, RUM is on care and maintenance.

AGLM has a gas pipeline easement that crosses the EP Area, but SCT understands that ACOL has received advice from AGLM that there are no plans to construct this pipeline during the period of mining in the EP Area.

ACOL owned infrastructure over the underground mine includes several farm buildings and houses (not occupied by residents), farm dams, farm roads, fences, a fresh water polyline from the Hunter River, the mine pump out polyline from the southern end of the panels, and four polylines that pass under the New England Highway below the bridge over Bowmans Creek.

3. PREVIOUS SUBSIDENCE MONITORING AND PREDICTED SUBSIDENCE BEHAVIOUR

In this section, previous subsidence monitoring results from Longwalls 101 and 102 are presented to illustrate the subsidence behaviour and seam interaction effects that can be expected over Longwalls 105-107. Subsidence estimates are then presented based on this previous experience at the Ashton Coal Project (ACP) and general experience of subsidence monitoring in New South Wales and elsewhere.

3.1 Summary of Previous Subsidence Monitoring

Subsidence monitoring has been undertaken at the ACP since the commencement of longwall operations in early 2007. The subsidence behaviour observed in the PG Seam has been consistent with supercritical width subsidence and with the subsidence behaviour expected.

Subsidence monitoring above Longwalls 101 and 102 has provided insight into the mechanics of multi-seam subsidence. The results of this monitoring are presented in detail in SCT Report ASH4302 "Longwall 102 End of Panel Subsidence Report". A summary of the key findings presented in this section is taken from that report. Figure 4 presents the subsidence monitoring results from XL5 Line, the main cross-panel subsidence line across all the southern panels. Figure 5 presents subsidence monitoring results from the northern end of Longwall 102 where this panel mind directly under an existing goaf edge in the PG Seam so that the goaf edges in the PG and ULD Seams were stacked directly above each other.

Table 3 presents a summary of the subsidence movements measured above Longwalls 101 and 102 and a comparison with the estimates for maximum incremental subsidence based on 85% of the second seam mining height and for maximum cumulative subsidence of 75% of the combined mining height for both seams.

Multi-seam subsidence presents a number of additional challenges for describing the subsidence behaviour. In a single seam mining environment, the subsidence behaviour is consistent with and largely controlled by the mining geometry in the seam that has been mined. In a multi-seam mining environment, the presence of previous mining in an overlying seam means that the starting point for subsidence estimation for the second seam is not necessarily zero and the subsidence behaviour is no longer simply a geometrical function of the seam being mined, but rather a complex interaction of the geometries in both seams.

The subsidence monitoring above Longwalls 101 and 102 indicated that for an offset mining geometry, the maximum subsidence can be estimated with reasonable confidence and the subsidence profile is also relatively predictable although the specific mechanics of the interaction of the two seams needs to be recognised.

Where panels in the two seams overlap in an offset geometry, maximum cumulative subsidence from mining both seams is in the order of 62-72% of the combined thickness of both seams (compared to 50-60% for the first seam mined) and incremental subsidence is in the order of 73-80% of the height of the second seam mined. For the purposes of prediction, values for maximum incremental subsidence of 85% of second seam mining height and maximum cumulative subsidence of 75% of combined seam height appear reasonably conservative.

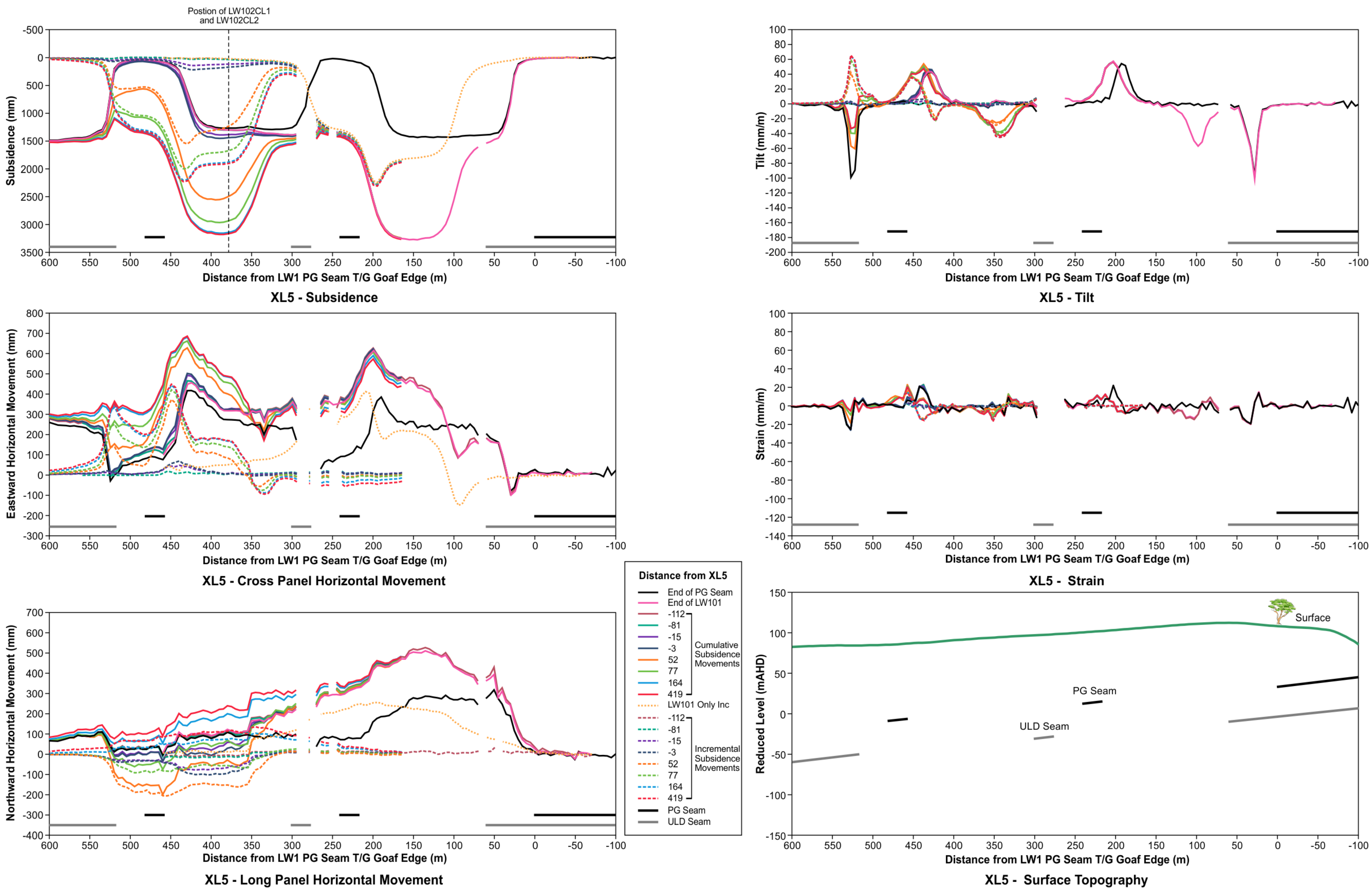


Figure 4: Subsidence monitoring on XL5 for mining in the PG and ULD Seams in an offset geometry.

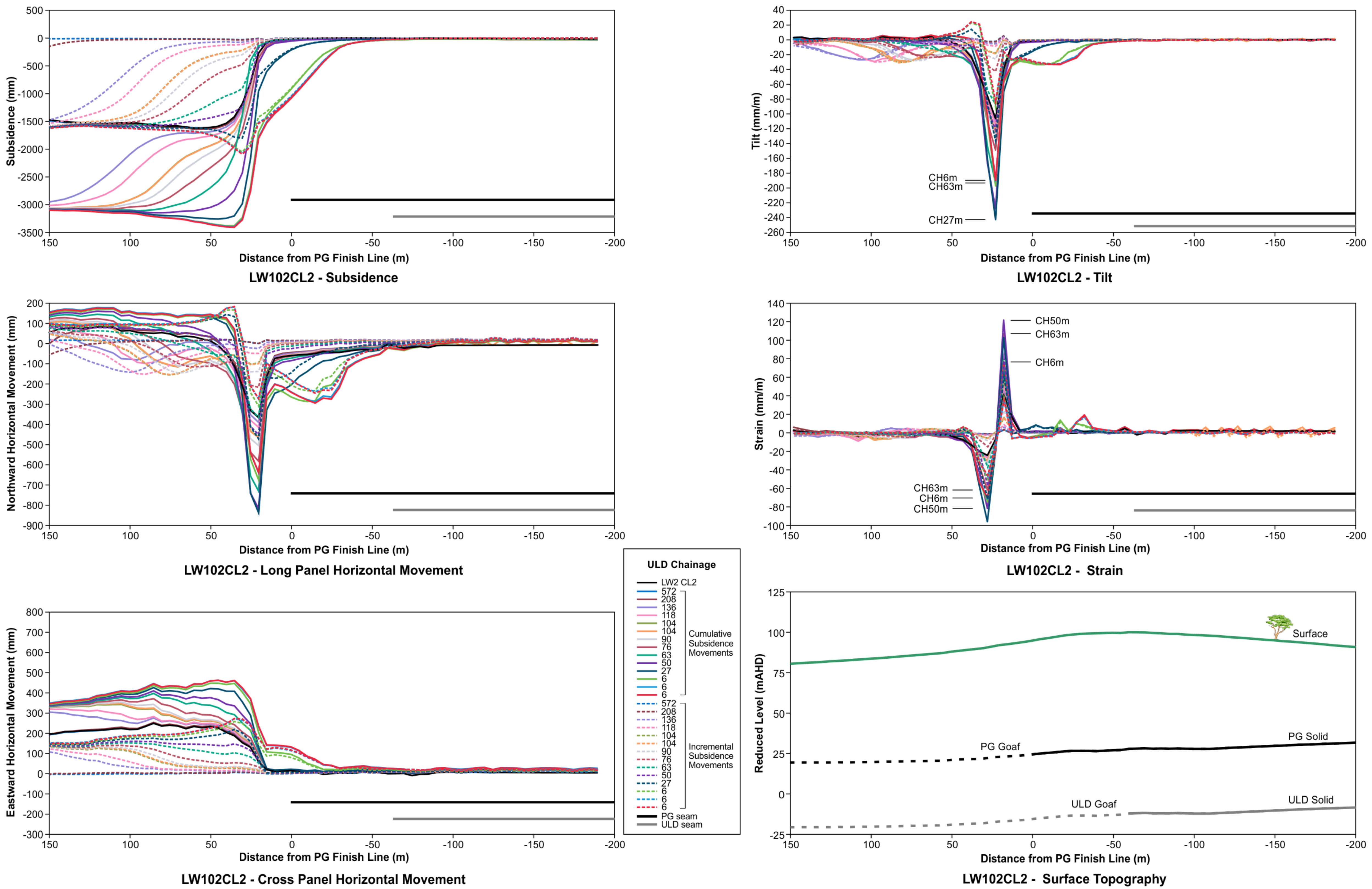


Figure 5: Subsidence monitoring results at the northern end of Longwall 102 where this longwall mined directly below an existing goaf edge in the PG Seam to create a stacked geometry.

Table 3: Measured Subsidence Above Longwalls 101 and 102

Location	Incremental Subsidence ULD Seam (m)	Max Incremental Tilt (mm/m)	Max Incremental Strain (mm/m)	Maximum Cumulative Subsidence (m)	Max Tilt (mm/m)	Max Strain (mm/m)
Measured During Mining in PG Seam	-	-	-	1.5	100	40
Predicted Based on Combined Seam Height of 5.2m (2.6m & 2.6m)	2.2 (85% T_2)	120	46	3.9 75% (T_1+T_2)	205	82
Measured on LW102CL1	2.1	33	14	3.2	38	12
Measured on XL5	2.3	66	18	3.2	54	24
Measured on LW102CL2 background	2.1	27	5	3.2	33	4
Measured on LW102CL2 stacked	2.1	87	65	3.4	193	107
Measured on LW102CL2 10-30m undercut	2.1	136	80	3.4	243	122
Measured at completion of LW102CL2	2.1	77	45	3.4	190	83

Locally, the incremental subsidence can be higher when subsidence that would otherwise have occurred during mining in the first seam except for the presence of a chain pillar is recovered during mining in the second seam when the chain pillar is destabilised.

Somewhat surprisingly, maximum values of subsidence parameters such as strain and tilt are typically of a similar or lower magnitude to the subsidence parameters measured in the first seam mined despite the greater subsidence. The maximum values of tilt and strain are typically less than 50% of the maximum calculated assuming single seam mining conditions but occasionally increase to the same magnitude as parameters measured during mining in the PG Seam.

However, a difference in behaviour is observed in areas where overlying goaf edges interact to form a stacked goaf edge.

Where the lower seam is mined from single seam to under an overlying goaf, the subsidence parameters are of similar magnitude to single seam mining, but the nature of the subsidence profile is significantly different with a large block above the start of the overlying panel subsiding en masse as the goaf edge is mined under.

Where the lower seam is mined out into solid from below an existing goaf in the upper seam a double goaf edge referred to as a stacked goaf edge is created. The maximum tilt in these areas is double the background levels and horizontal strains increase up to about four times background peaks elsewhere along the panel.

The presence of the transition from goaf to solid created within the overburden strata at the goaf edge by mining in the overlying seam appears to focus additional subsidence movements associated with mining the deeper seam into the same location. The strains and tilts reach a maximum when the lower seam has mined past the upper seam goaf edge by a distance of about equal to the separation between the two seams i.e. about 30 m for the ULD and PG Seams.

At the completion of Longwall 102, the total cross panel movements above the panel reached a magnitude of 0.69 m to the east (i.e. uphill) at a location near the western edge of the overlap between Longwalls 2 and Longwall 102. The magnitude, direction, and form of the total horizontal movement are consistent with the cross-panel horizontal movement observed during mining of the PG Seam.

Horizontal subsidence movements measured above Longwall 102 are typically in the range of 20-30% of the vertical subsidence. There is a strong similarity in the characteristics and distribution of horizontal subsidence movements between Longwalls 101 and 102 indicating a consistent mechanism driving the horizontal movements and a strong influence of strata dilation in this process.

Cross panel horizontal movements are observed to continue across most of the next PG Seam longwall panel at a magnitude that is less than, but only slightly less than, the vertical subsidence even though this panel was not directly mined under in the ULD Seam. This observation indicates that there is either some additional mechanism not related to incremental vertical subsidence or the ratio of horizontal movement to vertical movement associated with dilation increases to almost unity at the low levels of incremental subsidence observed over the adjacent PG Seam longwall panel.

The concept of an angle of draw determined purely as a function of overburden depth becomes somewhat less meaningful in a multi-seam mining environment because of the influence of previous mining and the interaction of overlying geometries. Following the completion of mining Longwall 102, the incremental vertical subsidence above the solid ULD Seam coal on the western side of the panel reduced to less than 20 mm at a distance of 120 m or approximately equal to the overburden depth of 135 m equivalent to an incremental angle of draw of 42°. However, previous mining in the PG Seam had caused some 1.5 m of subsidence at this location. At the finishing end of Longwall 102, the angle of draw was controlled by the presence of the PG goaf edge and reduced from approximately 45° when the longwall was at CH136 m to only 10° at CH90 m.

Beyond the solid goaf edge in the outermost seam, angles of draw appear to have a similar magnitude in a multi-seam environment as they do in a single seam mining environment, but where there is an existing goaf, the concept of an angle of draw becomes a little more difficult to define with confidence.

For the purposes of defining the area of influence of the subsidence and therefore the area of the EP Area, a distance equal to overburden depth is used except at the finishing end of each panel where it is reduced to half the overburden depth.

3.2 Subsidence Estimates

In this section, the subsidence estimates for mining in the ULD Seam (LW 105-107) are presented in the form of incremental subsidence contours i.e. the subsidence that is expected for mining in the ULD Seam, above that which has already occurred in the PG Seam. The changes in landform during the construction of Lemington Road add to the complexity of presenting contours of cumulative subsidence, although estimates are provided for the purposes of providing an indication of the magnitude of lowering of the surface around the BCD and the general landform. A more detailed assessment of cumulative landform changes is presented in Section 4.2.1.

Table 4 presents an estimate of incremental and cumulative subsidence parameters for each of the proposed longwall panels.

Table 4: Incremental and Cumulative Subsidence Parameters Predicted for the Revised Layout of ULD Seam Longwall Panels – LW 105 to 107 – Compared to Subsidence Parameters Predicted for the Approved Stacked Layout

ULD Seam Longwall Panels And Depth (m) and Depth Range (in brackets)	Revised Layout					Approved Layout		
	ULD Subs (m)	ULD Tilt (mm/m)		ULD Strain (mm/m)		Subs (m)	Tilt (mm/m)	Strain (mm/m)
	Normal and Stacked Edges	Normal	Stacked Edges[1]	Normal	Stacked Edges[1]			
Incremental Subsidence Parameters								
LW105 170 (155-195)	2.1	49	99	12	49	2.1	80	40
LW106A 175 (170-210)	2.1	48	96	12	48	2.1	80	40
LW106B 150 (140-180)	2.5	67	133	17	67	2.1	80	40
LW107A 190 (185-220)	2.1	44	88	11	44	2.1	80	40
LW107B 170 (165-200)	2.7	64	127	16	64	2.1	80	40
Cumulative Subsidence Parameters								
LW105 170 (155-200)	3.8	89	179	22	89	3.7	150	70
LW106A 175 (170-210)	3.8	87	174	22	87	3.7	150	70
LW106B 150 (140-180)	4	107	213	27	107	3.7	150	70
LW107A 190 (185-220)	3.8	80	160	20	80	3.7	150	70
LW107B 170 (165-200)	4	94	188	24	94	3.7	150	70

[1]The stacked edges occur where the ULD Seam is mined from under the PG Seam goaf into a solid abutment with peak values occurring when the PG Seam goaf edge is undermined by about 20-30m.

Maximum incremental subsidence has been estimated as 85% of the nominal combined extraction heights of the ULD Seam and cumulative subsidence has been estimated based on 75% of the combined thickness of both seams. The ULD seam thicknesses planned to be mined have been assumed to be 2.5 m for Longwalls 105, 106A, and 107A, and 2.8 m and 3.0 m respectively for Longwalls 106B and 107B. Variations in the cutting height that may occur for a range of reasons are expected to proportionally influence the maximum subsidence and other subsidence parameters.
Figure 6 shows the incremental subsidence contours predicted for proposed mining of Longwalls 105-107 in the ULD Seam within the EP Area. These incremental subsidence contours are based on profiles observed over Longwalls 101 and 102 with allowance for changes in geometry and overburden depth.

An important difference with predicting multi-seam subsidence parameters is recognition of the differences between background or normal multi-seam subsidence behaviour where the subsidence parameters are typically lower than for single seam mining at equivalent depth and a stacked geometry where the subsidence parameters are significantly higher.

Figure 7 shows a summary of the areas where stacked geometries and higher strains and tilts are likely to occur. The areas where greater impacts are expected are likely to be at stacked goaf edges such as the start of Longwalls 105, 106A, and 106B, the finish of Longwalls 105, 106B, and 107B, the western side of Longwall 107A and the northern edges of Longwalls 6A and 7A in the PG Seam.

Figure 8 shows a cross-section of the subsidence along the line of subsidence line XL13 over the central part of the northern longwall panels. Profiles of the incremental subsidence, cumulative subsidence, and previously approved subsidence are shown. There are some differences in detail, but the general characteristics of the subsidence predicted for this EA and the subsidence for the previously approved geometry.

3.3 Factors Influencing Reliability of Subsidence Estimates and Assumptions

In this section, the factors that influence the subsidence and the assumptions that have been made to arrive at the subsidence estimates are presented and discussed.

Subsidence estimates for the longwall panels in the PG Seam are considered to be reasonably reliable because of the previous experience of monitoring the PG Seam at ACP, and because the PG Seam is the first seam mined in undisturbed ground.

Subsidence estimates for the ULD Seam have a lower confidence because of the complex interactions between the previous mining and mining in the lower seam.

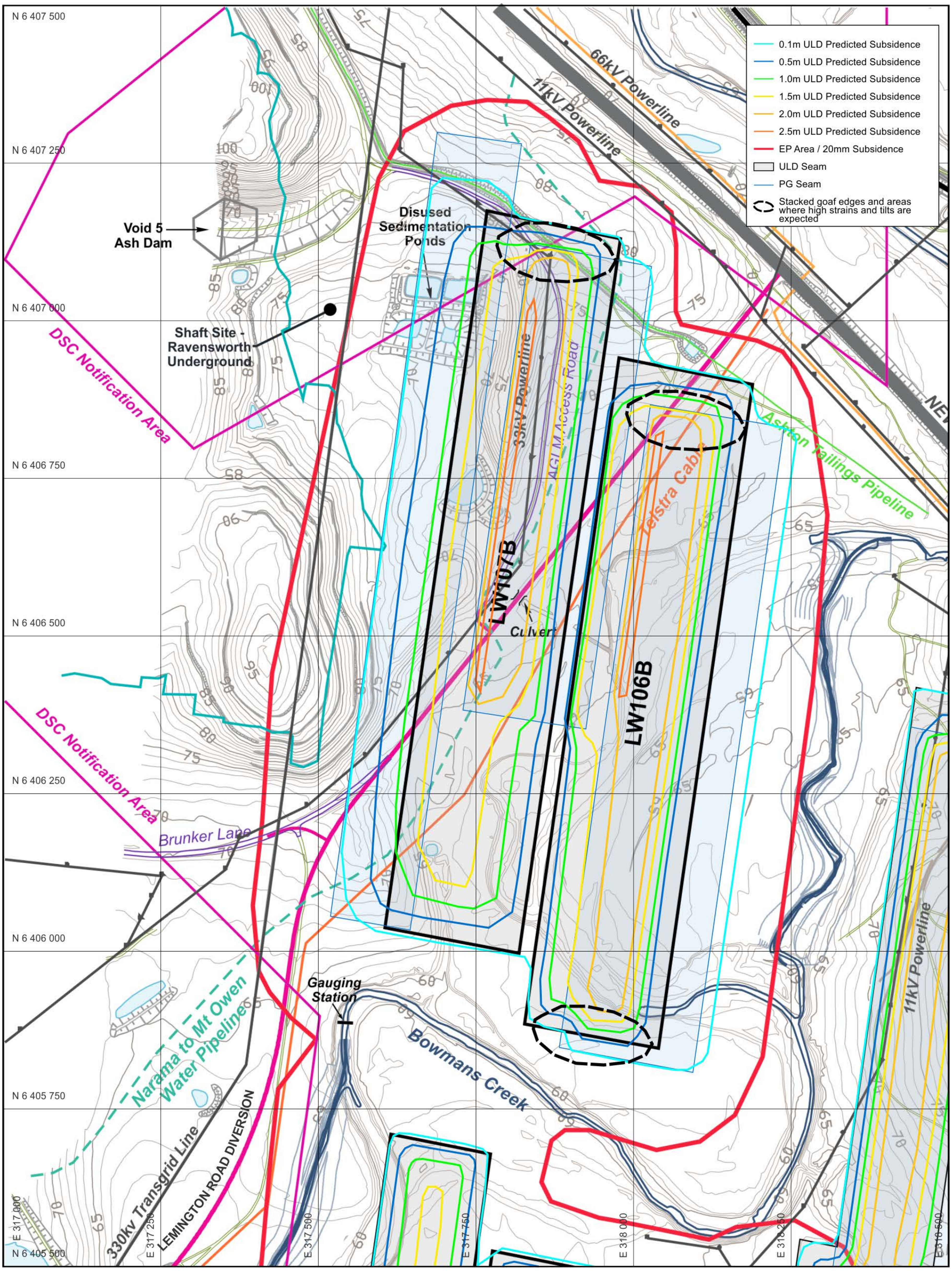


Figure 6: Summary of incremental subsidence contours for northern panels superimposed onto the surface features plan showing areas of stacked goaf edges likely to produce high strains and tilts.

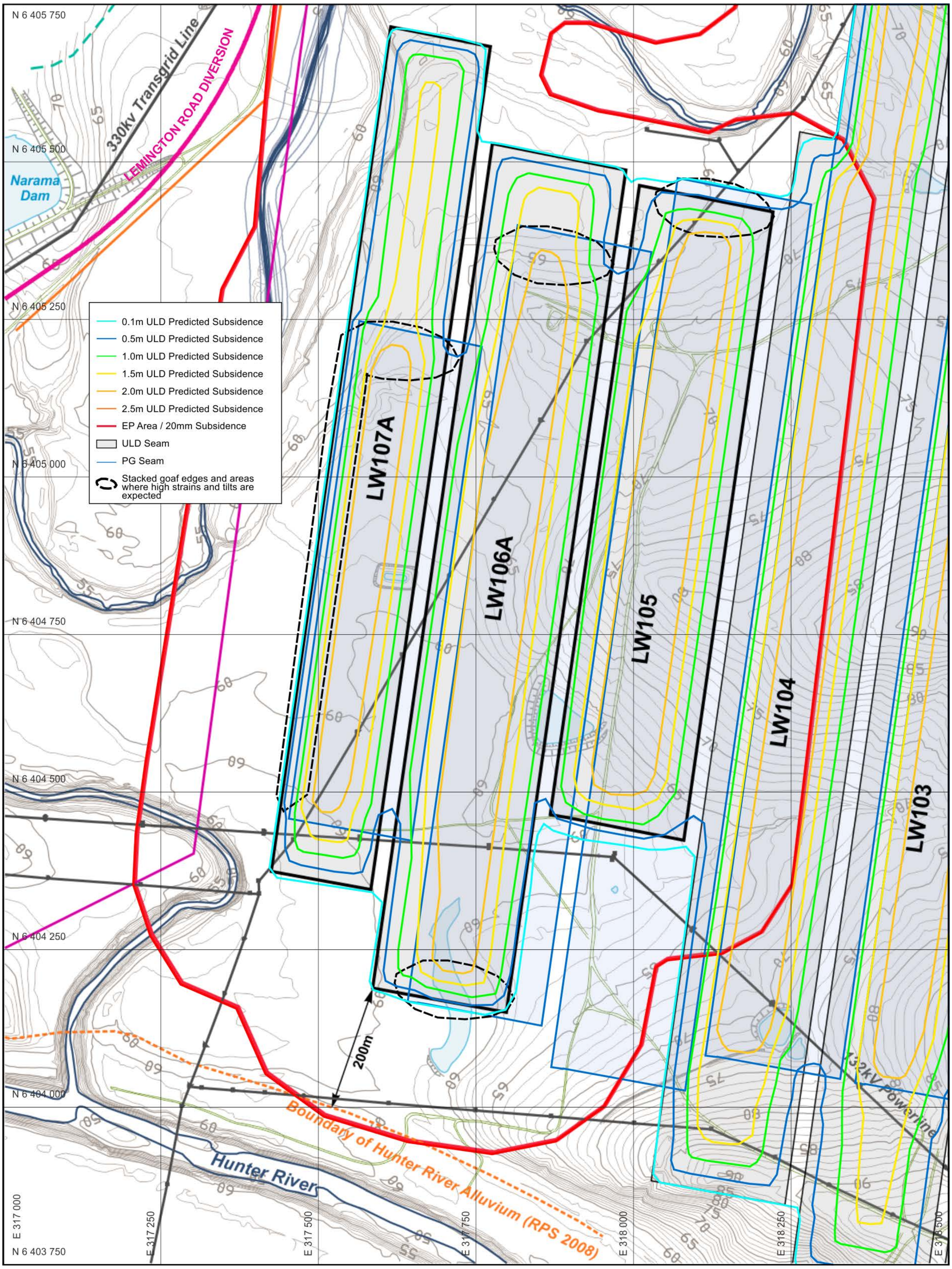


Figure 7: Summary of incremental subsidence contours for southern panels superimposed onto the surface features plan showing areas of stacked goaf edges likely to produce high strains and tilts.

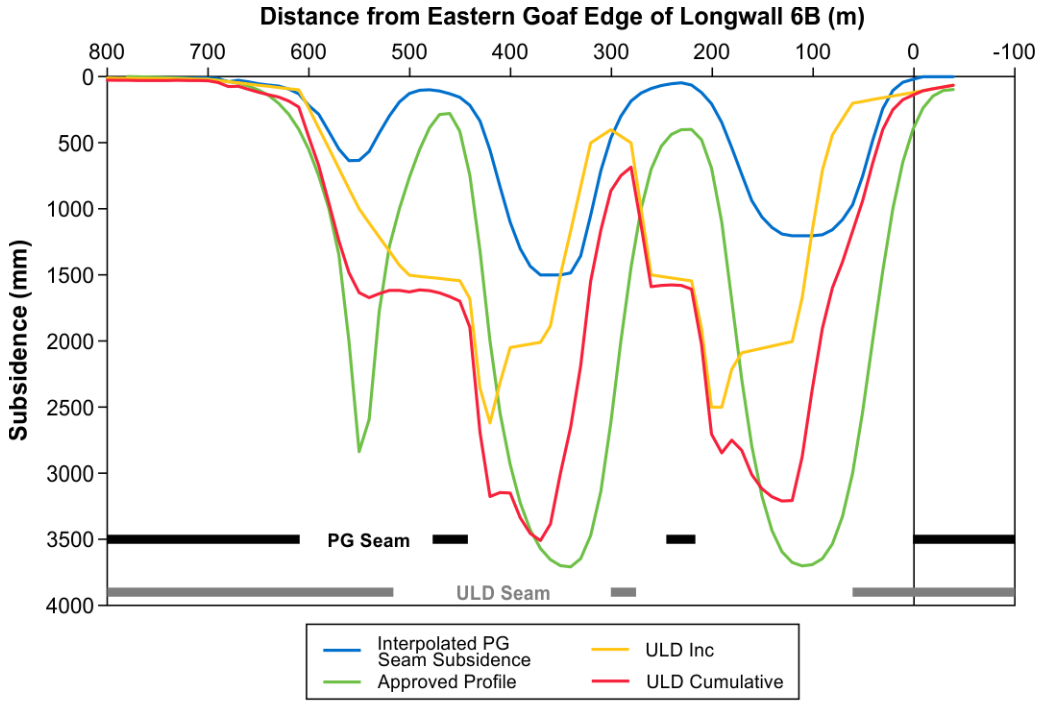


Figure 8: Subsidence profiles predicted across Longwalls 106B and 107B and a comparison with the subsidence profiles predicted for the panel geometry approved in the BCD Modification.

The absence of previous analogues for mining below the supporting chain pillars in subcritical width panels (Longwall 8 in the PG Seam) also reduces the confidence in the subsidence predictions that can be made.

Nevertheless, the mechanics indicated by the monitoring above Longwalls 101 and 102 are consistent with expectations and have been used to scale the subsidence parameters from those measured to the somewhat greater depths above Longwalls 105-107B. On this basis, the estimated subsidence is considered to be a reasonable best estimate, but some greater allowance for variation from predicted would be appropriate.

It should be recognised that some of the geometries in the Bowmans Creek area, particularly above the northern panels have no analogue above Longwalls 101 and 102 so the estimated subsidence are more indicative in these areas compared to the more robust estimates that are possible elsewhere in areas where analogues exist. Longwall 8 in the PG Seam is subcritical in width (i.e. the panel width is less than the overburden depth) so full subsidence did not develop during the period that Longwall 8 was mined. When Longwall 107B mines under the chain pillar between Longwalls 7B and 8 and destabilises it, additional subsidence is expected above Longwall 8 when the surface above the chain pillar moves down on one side of the panel causing the bridging beam of the overburden strata to also be lowered on that side.

It is difficult to estimate whether this additional subsidence will be linear across the panel purely in response to additional subsidence over the PG Seam chain pillar and lowering of one end of the bridging overburden strata or whether the overburden strata above Longwall 8 will also be destabilised so that subsidence that did not occur during mining in the PG Seam because of the subcritical nature of the panel at that time is recovered during mining in the ULD Seam. The magnitude of the subsidence above Longwall 107B (and Longwall 8 in the PG Seam) is therefore difficult to predict with confidence, however the resulting impacts are expected to be manageable.

Additional subsidence in the vicinity of Longwall 8 in the PG Seam of up to about double the estimated subsidence is considered possible as Longwall 7B is mined. Any additional subsidence that may occur is expected to occur during the period of active mining so that it can be managed in much the same way that the subsidence that is expected is managed. Additional subsidence is expected to occur gradually and incrementally with mining, rather than suddenly, and so should be manageable through the management plans that are in place for the expected subsidence.

3.4 Comparison with Subsidence Predictions for Approved Layout

Table 4 summarises the subsidence effects for the proposed layout for Longwalls 105 to 107B and comparative values for the approved layout. The increases in the maximum subsidence in the proposed layout compared to those for the approved layout are mainly a result of the increased seam thickness planned to be mined in the revised layout, but also on a slightly more conservative approach to estimating maximum subsidence for the revised layout.

Increases in the tilts and strains are expected at the stacked edges based on the experience above the stacked edge in Longwall 102. The tilts and strains for other areas are less than was predicted for the stacked geometry.

Subsidence from mining Longwalls 105-107 in the ULD Seam is expected to cause additional incremental subsidence of up to 2.7 m in the northern panels and up to 2.3 m in the southern panels. The total cumulative subsidence is expected to reach up to 3.8 m to 4.0 m in the central part of areas where there is overlap between longwall panels in both seams, most likely in the northern part of Longwall 106B where the overburden depth is lowest. The incremental subsidence estimates are based on 85% of the thickness of the ULD Seam and the cumulative subsidence estimates are based on 75% of the combined thickness of both seams. Both of these values are considered to be reasonably conservative and actual subsidence is expected to be less than indicated in Table 4.

Over most of the area of Longwalls 105-107, incremental tilts and strains from mining in the ULD Seam are expected to be of similar to or lower magnitude than the tilts and strains predicted for, and observed during, mining in the PG Seam despite the cumulative subsidence for the ULD being almost double in magnitude.

However, in areas where the goaf edges in the two seams are stacked above each other, or nearly so, mining in the ULD Seam is expected to remobilise goaf edge fractures that originally developed during mining in the PG Seam. The experience in Longwall 102 of forming a stacked edge indicates that in these areas maximum tilts are likely to double background values and maximum strains are likely to reach four times background values at the PG Seam goaf edge cracks.

Areas where high tilts and strains are expected above stacked edges include the start of Longwalls 106A, and 106B, the finish of Longwalls 105, 106B, and 107B, the western side of Longwall 107A and the northern edges of Longwalls 6A and 7A in the PG Seam.

Tilts and strains at stacked goaf edges are expected to reach a maximum when the ULD Seam goaf edges are mined 20-30 m under the solid edge of a previously extracted panel in the PG Seam. In some cases these maxima will then reduce with further mining, but in other cases such as along the western edge of Longwall 107A, the high tilts and strains are expected to be permanent.

The impacts to landform are expected to be generally similar for the revised geometry to those predicted for the stacked geometry. The general landform above both the northern and southern longwall mining areas is expected to be lowered by up to 3.8-4.0 m with perceptible cracks of up to about 200-300 mm wide expected over the stacked goaf edges.

Ponding within the subsidence bowls and increased inflows through into the overburden strata are expected with steep dips at the stacked goaf edges. Bowmans Creek and the two diversions are not expected to be subsided or otherwise impacted by the proposed mining so the general landform on either side of Bowmans Creek will be much lower than the adjacent section of creek invert. The resulting landform is therefore not expected to be free draining without some additional earthworks or pumping infrastructure.

The proposed layout in Longwalls 105-107 in the ULD Seam is consistent with keeping all secondary extraction at least 200 m from the Hunter River Alluvium (as defined in RPS 2009) and at least 40 m (in a horizontal direction) from the high bank of Bowmans Creek in its diverted form as per the Statement of Commitments made for Longwalls 5 to 7 in the PG Seam in Schedule C of DA309-11-2001 Mod-6 Items 3.2 and 5.3.

The impacts to surface infrastructure are expected to be similar to or less than the impacts anticipated for the stacked geometry. The infrastructure likely to be most significantly impacted by mining subsidence includes Lemington Road and associated infrastructure including the culvert below the road, buried telecommunication lines alongside the road, the 33 kV power line also alongside the road, the Narama to Mount Owen fresh water line, the 11 kV local area electricity line, and the 132 kV electricity line crossing the southern panels. All impacts are expected to be manageable albeit with some effort, particularly in respect of Lemington Road.

4. ASSESSMENT OF SUBSIDENCE IMPACTS

The natural features and surface improvements in the proposed mining area have been identified on the basis of multiple site visits, information provided by ACOL, and the work of other specialists.

In this section, the impacts of the expected subsidence movements on the natural features and surface improvements are assessed and described. A full list of the surface infrastructure is presented in Table 1 and together with the expected subsidence impacts in Table 5.

4.1 Natural Features

Natural features in the EP Area include the incised channel of Bowmans Creek and two sections that have been diverted, the Bowmans Creek floodplain and associated alluvium, the Hunter River and associated alluvium, and two sections of Red River Gum alongside the lower reaches of Bowmans Creek. Glennies Creek, the other major watercourse in the general area, is located some 1 km to the east and remote from the EP Area.

The EP Area is predominantly cattle grazing land owned by ACOL. A triangle of land in the north western corner is owned by AGLM and is part of the now completed Ravensworth East Open Cut Mine.

4.1.1 Bowmans Creek

The main channel of Bowmans Creek that includes the two diversions is largely protected from subsidence effects by solid coal barriers in both the PG and ULD Seam. These barriers extend to generally greater than about 90-100 m from the top of the bank.

The proposed layout in Longwalls 105-107 in the ULD Seam is consistent with keeping all secondary extraction at least 40 m (in a horizontal direction) from the high bank of Bowmans Creek in its diverted function form as per the Statement of Commitments made for Longwalls 5 to 7 in the PG Seam in Schedule C of DA309-11-2001 Mod-6 Item 5.3.

The barrier is narrowest and approximately 40m to the high bank and 60 m to the low bank of Bowmans Creek at the southwest corner of Longwall 106B (and Longwall 6B in the PG Seam), but the bridging effects around the corners of both panels are also expected to limit subsidence in this area to low levels. The barrier to the high bank of the incised channel of Bowmans Creek is approximately 40 m at the southwest corner of Longwall 107A and to the eastern edge of Longwall 6B in the PG Seam.

The barriers are expected to be sufficient to protect the channel of Bowmans Creek from any significant subsidence related impacts. The floor of channel is not expected to experience perceptible valley closure effects because of the alluvial nature of the river channel and adjacent banks.

Table 5: Summary of Impacts to Surface Features

Feature	Section	Impact
Natural Features		
Bowmans Creek	4.1.1	No perceptible impacts, protected by offsets consistent with DA309-11-2001 Mod-6 Item 5.3
Flood Plain Landform	4.1.2	General lowering of the landform by a total of up to about 4m in some areas expected to cause ponding, particularly in areas that are lower than Bowmans Creek (which will not have subsided). Steep grades and tensile cracking are expected at stacked goaf edges
Bowmans Creek Alluvium	4.1.3	Assessed in specialist report (RPS 2015).
Hunter River Alluvium	4.1.4	Assessed in specialist report (RPS 2015). Protected by 200m offset consistent with DA309-11-2001 Mod-6 Item 3.2
Groundwater	4.1.5	Assessed in specialist report (RPS 2015).
Red River Gum	4.1.6	No perceptible subsidence impacts
Infrastructure		
Lemington Road	4.2.1	Incremental subsidence to 2.7m with high strains and tilts (1 in 6) across the road expected at the stacked goaf edge of LW106B. Significant monitoring and incremental repair to the road is likely to be required
Lemington Road Culvert	4.2.2	Potential for capping plate to become dislodged causing sudden collapse or cracking that leads to piping failure
New England Highway	4.2.3	No impact
Access Roads	4.2.4	Incremental subsidence to 2.7m with high strains and tilts expected at the northern edge of LW107B. Similar impact to alternative access to Property 130, but primary access not affected.
330 kV Power Transmission Line	4.3.1	Minor movements possible but much less than pylons are designed to accommodate
132 kV Line traversing the southern part of the ACOL Mining Lease	4.3.2	Impacts similar to those observed over LW101 and LW102 with specific assessment and upgrading of poles to be undertaken prior to mining
132 kV and Combined 66/11 kV lines parallel to New England Highway	4.3.3	No Impact
11 kV line traversing ACP	4.3.4	Impacts generally similar to those previously experienced for the PG Seam. Some additional works such as sheaving conductors likely to be required at stack goaf edges and changes of direction
33 kV transmission line on western side of Lemington Road	4.3.5	Impacts generally similar to those experienced previously but greater tilts are expected to affect several poles and temporary support and sheaving or re-routing likely to be necessary.
Narama Dam	4.4.1	No impact to dam
Void 5 Ash Dam	4.4.2	No impact to dam
Disused Sedimentation Dams	4.4.3	Some minor subsidence movements likely but not expected to cause significant changes in function
NOW Gauging Station	4.4.4	Small subsidence movements unlikely to affect functionality
AAPT Sydney to Brisbane fibre optic cable	4.5.1	No impact

Feature	Section	Impact
Ravensworth Fibre Optic	4.5.2	Potential to damage cable in areas of stacked goaf edge and high strains
Telstra Cable Servicing Ravensworth and NOW Gauging Station	4.5.3	Potential to damage cable in areas of stacked goaf edge and high strains that may need to be uncovered or re-routed
Telstra Cable Servicing Property 130	4.5.4	No impact
Buried Pipeline from Narama Dam to Mt Owen	4.6.1	Some impact expected where this line crosses stacked edges. Uncovering of pipeline in high strain zones at stacked edges likely to be required.
AGLM Gas Pipeline Easement	4.6.2	No impact
ACOL Owned Pipelines	4.6.3	Potential impact in stacked goaf edge areas of high strain
Ravensworth Underground Mine and No. 5 Shaft	4.7	Minor shear movements possible at the shaft location but not expected to be perceptible or affect integrity of shaft
Fences and Farm Infrastructure	4.8	Minor impacts requiring visual inspection and regular maintenance
Unoccupied ACOL Owned Residences	4.9	Impacts expected by structures are not occupied

4.1.2 Flood Plain Landform

The flood plain around Bowmans Creek is expected to be subsided in the southern panels by a total of up to about 3.8 m cumulative subsidence (some 2.1 m of incremental subsidence) and in the northern panels by up to 4.0 m (some 2.7 m of incremental subsidence). Along the stacked goaf edges on the western side of Longwall 107A, at the start of Longwall 106A, and at the start of Longwall 106B, the subsidence step is likely to be relatively steep with final landform gradients of up to about 160 mm/m or 1 in 6. These steps in the landform are expected to present a barrier to natural drainage and some ponding is expected as a result. The barriers may lead to ponding that is up to several metres deep depending on the gradients in the original landform and any landform drainage works that may have been undertaken since the completion of mining in the PG Seam.

Figure 9 shows the outline of all areas where ponding is considered possible after the completion of mining Longwalls 105 to 107 in the ULD Seam.

These areas have been determined based on consideration of the subsided surface developed by subtracting the subsidence predicted due to mining in the ULD Seam from the surface topography measured by LiDAR at the completion of mining Longwall 8 in the PG Seam. Subsidence associated with mining Longwall 6B in the PG Seam occurred after the LiDAR survey was undertaken. The estimated subsidence associated with mining Longwall 6B was also subtracted from the LiDAR surface to give a final landform at the completion of mining in both the PG and ULD Seams.

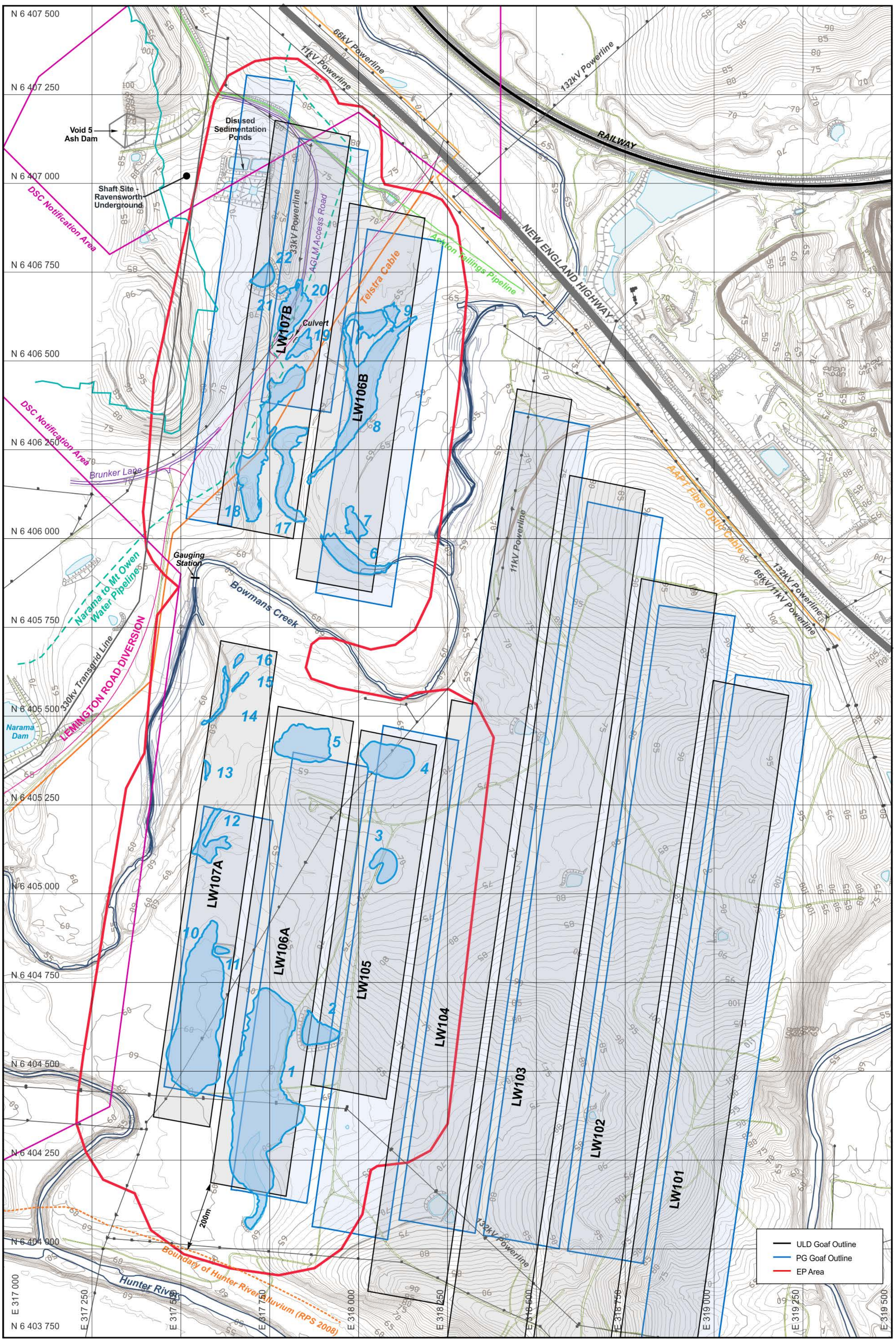


Figure 9: Areas where ponding is expected to develop in the landform above Longwalls 105-107 at the completion of mining in the ULD Seam including existing dams.

All the areas of potential ponding are numbered in Figure 9 for ease of reference. The ponding areas listed represent all the areas where ponding potential has been identified at the resolution of the technique used to determine the final landform.

Table 6 summarises the estimated depth, area, and approximate volumes of each of the ponding areas identified in Figure 9.

Table 6 : Summary of Ponding Areas and Volumes Including Existing Storages

Pond	Longwall	Comments	Area (m^2)	Maximum Estimated Depth (m)	Approx Volume (m^3)
1	LW106A	Existing Dam/Billabong	77,030	1.5	38,515
2	LW105	Existing Dam	5,760	1.5	2,880
3	LW105		4,688	0.5	781
4	LW105		11,558	1.0	3,853
5	LW106A		12,814	1.0	4,271
6	LW106B	Existing Billabong	7,497	2.5	6,247
7	LW106B		3,097	0.5	516
8	LW106B	Existing Billabong	30,673	2.5	25,118
9	LW106B	Existing Watercourse	1,328	0.5	221
10	LW107A		50,085	2.25	37,563
11	LW107A	Existing Dam	638	1.25	266
12	LW107A		5,351	1.25	2,230
13	LW107A	Marginal	475	0.5	79
14	LW107A	Existing Watercourse	1,811	2.0	1,208
15	LW107A	Marginal	533	0.5	89
16	LW107A	Marginal	471	0.5	79
17	LW107B	Existing Billabong	11,156	2.0	7,437
18	LW107b		19,951	0.5-2.0	9,250
19	LW107b		2,490	1.0	830
20	LW107b		8,038	1.25	3,349
21	LW107b	Existing Dam	376	0.5	63
22	LW107b	Existing Dam	2,716	1.0	905
		Total	**258,536**		**145,751**

Some 54% or just over half of the total ponding areas estimated as likely to be caused by mining Longwalls 105-107 in the ULD Seam (Ponds 1, 2, 6, 8, 9, 11, 12, 14, 17, 18, 21, and 22) are associated with existing farm dams, existing billabongs, sections of existing watercourses, and excised sections of Bowmans Creek. Most of these ponding areas were not free draining prior to the commencement of mining. However, it is recognised that the impact of mining subsidence will increase the area of ponding, in some cases significantly.

There are several small ponds (13, 15, and 16) representing 0.5% of the total ponding area that may or may not form depending on the interaction of actual subsidence and the local landform. The depth of these ponds is close to the resolution and effective accuracy of the landform generated from the LiDAR data and superposition of estimated subsidence. These ponds are of small volume, are relatively insignificant, and have only been included for completeness.

Ponds 1-5 and 10-12 are all located above the southern longwall panels on grazing land that is owned by ACOL. These ponds are the main ponding areas that are either new or extend well beyond existing ponds. Their total area represents approximately 62% of the total ponding area above Longwalls 105-107 in the ULD Seam. Ponds 6, 7, 8, 9, and 17 are all located within the excised sections of Bowmans Creek. These ponds represent an area of approximately 21% of the total ponding area.

Potential options to improve the free draining characteristics of those sections of the landform that are required to be free draining include:

- clearing existing drainage lines that have become blocked by vegetation (Pond 19) or by construction works associated with the Bowmans Creek Diversion (Pond 18)

- forming drainage lines that allow overflow into existing watercourses that feed into Bowmans Creek (Ponds 4, 5, and 12) or the Hunter River (Ponds 1 and 10)

It is understood that ACOL are planning to manage the impacts of ponding using a combination of these approaches via an adaptive management strategy.

In the northern panels, the subsidence bowls created above Longwalls 106B and 107B have potential to create ponds in the excised section of Bowmans Creek that are up to about 4 m deep as a result of cumulative subsidence from the PG and ULD Seams. These ponds are not expected to be able to completely free drain into the current alignment of Bowmans Creek because the general landform around the excised section of creek is lower as a result of subsidence than the level of the diverted channel. It is anticipated that there may be potential for increased inflows to the mine at the completion of mining in the ULD Seam both because of the greater volumetric holding capacity of the subsidence bowls and the increased disturbance to the overburden strata associated with double subsidence from mining in two seams.

A similar series of subsidence bowls is expected to develop above Longwalls 105, 106A, and 107A. Natural surface flow from the Bowmans Creek floodplain into Bowmans Creek to the west and direct into the Hunter River to the south is likely to be constrained within a subsidence bowl developed from combined subsidence in the PG and ULD Seams. This subsidence bowl may be up to 3.8 m below the original ground surface but current ponding from the PG Seam is understood to be generally less than 1 m.

With incremental subsidence from the ULD Seam of 2.1 m in the southern panels, the maximum depth of ponding is expected to be generally less than 3.1 m in this area.

The stacked edges also represent an area of high strain (up to about 100 mm/m cumulative strain) with cracks of up to about 200-300 mm wide similar to those observed above the northern end of Longwall 102 likely to be observed along the goaf edges shown in Figure 7. These high strain areas have the potential to provide an enhanced pathway for ingress of ponded water into the overburden strata if ponding occurs and they are not remediated.

A program of landform reshaping is expected to be necessary to reduce the potential for ingress of water into the overburden strata through mining induced tension cracks, particularly along stacked goaf edges, and above subsided panels. ACOL routinely undertakes ripping of subsidence cracks and it is anticipated that this work would need to be continued along goaf edges in the EP Area.

Areas where ponding may impact on surface infrastructure include:

- Pond 1 causing local flooding around power poles on the 132 kV power line specifically (Set 10, CN90483 and CN90484).
- Pond 3 causing local flooding of the alternative right of way to Property 130. The primary right of way is not expected to be impacted by subsidence or ponding resulting from the extraction of Longwalls 105-107.

- Ponds 4 and 10 causing flooding of the area around poles on the local 11 kV power line.

- Pond 18 flooding the area traversed by the buried Telstra cable and Narama to Mount Owen water pipeline.

- Pond 20 flooding a section of the AGLM access road, Narama Water Pipeline, and one pole on the 33 kV power line.

The reduction in the length of Longwall 105 by approximately 370 m has reduced the size of Pond 1 and flooding around the 132 kV power poles at the change of direction and in the vicinity of the alternative access to Property 130.

Areas of local ponding that have potential to impact the AGLM access road and the alternate right of way to Property 130 can be managed through local rock filling to lift the road surfaces above the ponding level. It is possible that rock fill may be required along a 50 m length of AGLM access road to an estimated maximum depth of about 1 m in order to lift the road surface above the ponding level, but cleaning of the drain to the excised section of Bowmans Creek is also expected to be effective until that area fills up.

Ponding around power poles, buried cables, and buried pipes does not necessarily directly affect the operation of the infrastructure, but it does potentially reduce access for maintenance work and for increase the rate of deterioration of wooden poles and possibly the effectiveness of their foundation in the soil. A program of drainage channels would be expected to be effective to manage the potential for long term impacts to surface infrastructure.

4.1.3 Bowmans Creek Alluvium

The impacts on the Bowmans Creek Alluvium of mining Longwalls 105 to 107 in the ULD Seam are discussed in detail in RPS (2015).

It is anticipated that the vertical inflows from this alluvium into the deeper strata are likely to be influenced by water levels within the alluvium, rainfall recharge, the vertical hydraulic conductivity of clay layers within the alluvium, and the presence of any through going mining induced fractures that may develop. Cracks that develop during the period of mining are expected to become gradually less hydraulically conductive over time as sediments washed into them by rainfall recharge tend to fill the flow paths that are developed during active subsidence.

4.1.4 Hunter River Alluvium

The alluvium associated with the Hunter River is continuous with the Bowmans Creek Alluvium, but for a range of administrative purposes, the boundary of the Hunter River Alluvium is defined as shown in Figure 9.

The proposed layout in Longwalls 105-107A in the ULD Seam is consistent with keeping all secondary extraction at least 200 m from the Hunter River Alluvium (as defined in RPS 2009) and shown in Figure 9 as per the Statement of Commitments made for Longwalls 5 to 7 in the PG Seam in Schedule C of DA309-11-2001 Mod-6 Items 3.2.

The Hunter River Alluvium is remote from the longwall panels and no significant changes to the hydraulic conductivity of the Hunter River Alluvium are expected from the proposed mining in the ULD Seam.

4.1.5 Groundwater

The impacts of groundwater from proposed mining within the EP Area are assessed by RPS (2015) in a separate specialist report.

4.1.6 River Red Gum

There are two areas of River Red Gum located along the banks of Bowmans Creek to the south west of the EP Area. These areas are beyond the area likely to be significantly impacted by subsidence movements. The groundwater impacts are assessed separately in RPS (2015).

4.2 Road Infrastructure

The main items of public infrastructure above and within close proximity of the EP Area are listed in Table 2. In this section the impacts of proposed mining on each of these separate items of infrastructure are discussed in further detail.

4.2.1 Lemington Road

Lemington Road is a two lane, tarsealed road that crosses Longwalls 106B and 107B in the ULD Seam and Longwalls 6B (corner), 7B, and 8 in the PG Seam. The road is a local road administered by Singleton Shire Council. The road was constructed during and following mining of Longwalls 7B and 8 in the PG Seam as part of the Ravensworth North Opencut Mine Project. The mining of Longwall 6B in the PG Seam occurred after the road was constructed. This mining caused low level subsidence above the corner of the panel and minor cracking along the edge of the road.

A deed of agreement called the Lemington Road Deed has been developed between Singleton Council, Ravensworth Operations, and ACOL. This deed sets out the roles and responsibilities for monitoring, management, and the distribution of costs likely to be incurred during subsidence and remediation activities associated with Lemington Road.

Figure 10 shows a photograph of the road looking to the north across the area above Longwalls 106B and 107B from a position near CH1000 m. Road

Figure 10: Lemington Road looking north from about CH1000m with AGLM Access Road evident in the middle distance and the culvert midway along the barriers. Traffic on the New England Highway is evident in the distance.

chainages used in this report to locate infrastructure along Lemington Road are measured as metres from the intersection with the New England Highway (centre of the highway).

Mining Longwalls 106B and 107B is expected to cause perceptible subsidence movements over the interval from CH200m to CH1200m. Mining induced subsidence is expected to occur incrementally with mining and so should be gradual and able to be managed with regular remediation works. The magnitude of the works is expected to be significant, particularly near the finishing end of Longwall 106B.

During mining of Longwall 106B, subsidence impacts are expected from CH200 m to CH720 m with incremental subsidence increasing as the panel retreats to an estimated maximum of about 2.3 m in the interval CH300 m to CH360 m near the corner of Longwall 106B. Significantly greater subsidence is expected on the southbound lane compared to the northbound lane because of tilt around the corner of the panel toward the existing goaf of Longwall 6B in the PG Seam.

Maximum tilts of up to about 130 mm/m (1 in 6) are expected in the interval CH310-CH350m in a direction that is predominantly across the road (i.e. in a southeast direction) so that the southbound lane is expected to be up to about 600 mm lower than the northbound lane

Elsewhere along the road, maximum tilt is expected to be less than 65 mm/m (1 in 15) with a significant component of this tilt still acting across the road causing differential subsidence between the lanes of up to about 300 mm.

Maximum strains of up to 70 mm/m, predominantly across the road, with potential for cracks up to about 100 mm wide are considered possible around the corner of Longwall 106B. Horizontal strains elsewhere along the road are expected to be generally less than 10-15 mm/m with perceptible, but generally transient, tension cracks expected to be typically less than 50 mm wide at intervals of 5-10 m.

During mining of Longwall 107B, subsidence impacts are expected to be perceptible mainly from CH450 m to CH1120 m increasing as the panel retreats to an estimated maximum incremental subsidence of 2.7 m over the centre of Longwall 107B in the interval between CH720 m and CH760 m. Tilts are expected to be generally less than 40 mm/m but may reach up to about 70 mm/m at CH710 m dipping to the northwest and CH780 m dipping to the southeast. Horizontal strains are expected to be generally less than 10-15 mm/m with tension cracks typically less than 50 mm wide. Some compression overrides are also considered possible.

Figure 11 shows a profile of the road during various stages of mining Longwalls 106B and 107B and estimates of the maximum subsidence parameters as an indication of where the various impacts are considered most likely to be observed.

Some stretching and compression of roadside barrier rails is considered possible and some allowance to loosen fixing bolts during the period of active mining is recommended to reduce damage to the rails and posts.

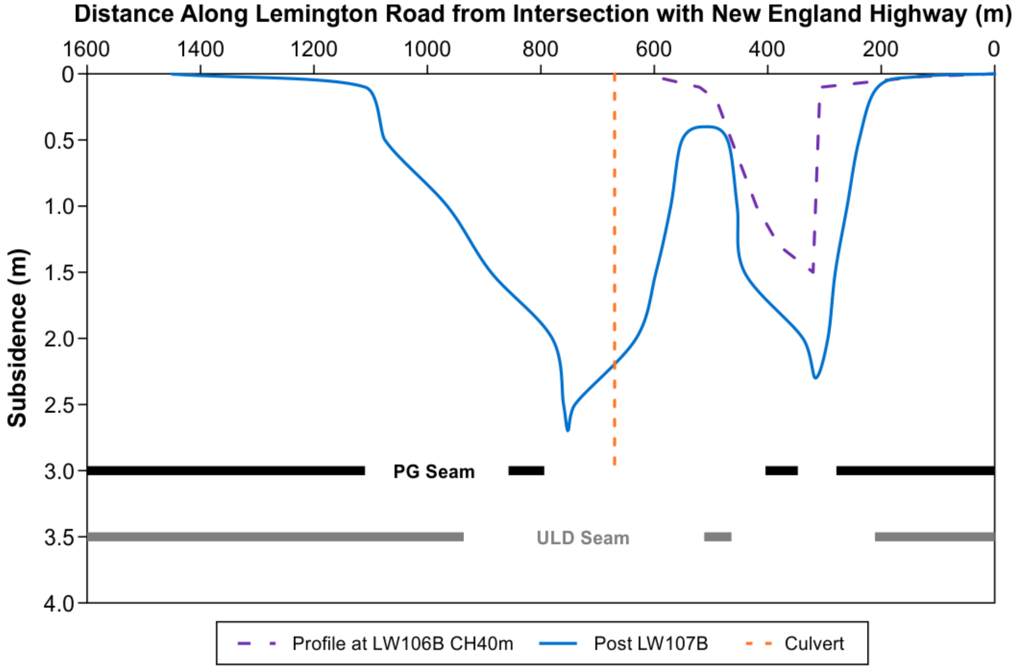


Figure 11: Predicted subsidence profile along the centreline of Lemington Road.

4.2.2 Lemington Road Culvert

Figure 12 shows a photograph of the concrete culvert constructed as part of the diversion of Lemington Road. This structure is located at CH670 m in an area where there is expected to be incremental subsidence of up to about 2.0 m, maximum tilts of up to 65 mm/m, maximum strains of up to 16 mm/m. The tilts and strains are expected to be mainly transient and in a north south direction across the axis of the culvert.

SCT are not aware of the construction details of the culvert, but it appears to have been constructed as a concrete base, two rectangular, pre-cast, C-section concrete elements arranged in two rows and completed with a separate concrete capping piece spanning between them. There are concrete nib walls at either end. The culvert is some 10-15 m long and about 4-5 m wide.

Subsidence movements are expected to cause differential horizontal movements across the structure initially in tension and then compression of the order of 100 mm. Much of this movement is expected to be taken up by perceptible cracking in the continuous concrete elements such as the base of the culvert and relative movements between the individual box section elements and the capping piece. The nib walls are also expected to be cracked and may become disconnected from the culvert structure.

The culvert appears to be constructed from a number of separate pre-cast concrete elements so that differential movements are likely to be able to be accommodated by relative movement of these various elements.

Figure 12: Lemington Road Culvert.

The integrity of the culvert is primarily important in the context of supporting the overlying road formation with the surface of the road located only a few metres above the top of the culvert. If the culvert cracks, it is possible for particle migration and piping of the subgrade leading to potholes on the surface. If the capping piece falls between the two pre-cast units that support it, there is potential for a trench to form on the road surface that may be up to about 1m deep and only a few metres wide.

Regular monitoring of the differential displacement between the two rows of pre-cast concrete elements is recommended during the active phase of subsidence below the culvert structure. This monitoring will be especially important directly below the carriageway. Temporary support for the capping slab above the central opening using timber cribs or similar is recommended as a contingency if the overlap of the central slab is not sufficient to accommodate the measured horizontal movements.

The subsidence expected at the culvert will mean that the top of the subsided section of road will be lowered to about the current level of the base of the culvert together with the general surface along the central section of Longwalls 106B and 107B.

The potential for the road surface to become inundated during flooding is expected to be increased, but SCT understands that the road has been designed to remain above 1 in 100 year flood levels.

4.2.3 New England Highway

The New England Highway is located approximately 150 m from the corner of Longwall 106B and 130m from the corner of Longwall 107B. Subsidence monitoring experience above previous longwall panels in the PG Seam and Longwalls 101 and 102 in the ULD Seam indicates that subsidence movements above the finishing end of the panel are largely restricted to within the footprint of the longwall panels. No perceptible impacts are expected at the New England Highway as a result of mining in the EP Area.

4.2.4 Access Roads

There are several access roads that cross the EP Area. These are mainly unsealed. Maximum tilts and strains are expected at locations where these roads cross stacked goaf edges.

Figure 13 shows a photograph of the AGLM access road. At the northern end of Longwall 107B maximum incremental subsidence of 2.7 m is expected with maximum cumulative subsidence of up to about 4.0 m.

Maximum cumulative tilts of up to 190 mm/m (1 in 5) are expected where the road crosses the northern end of Longwall 107B. Elsewhere maximum cumulative tilts are expected to be generally less than 110 mm/m (1 in 9).

Figure 13: AGLM Access Road.

Maximum strains of up to 95 mm/m are expected at the northern end of Longwall 107B leading to cracks of generally less than 200-300 mm wide with maximum strains elsewhere of generally less than 30mm/m and regular cracks of generally less than 100 mm wide and compression humps of less than about 200 mm high.

The nature of the road and the limited access means that impacts to the AGLM access road are likely to be able to be accommodated with occasional regrading. There may also be a need to raise the level of the road by up to about 1.5 m over a length of about 200m to avoid ponding that is expected to occur in this area.

Most of the other access roads are located on ACOL owned property and impacts will be able to be managed by occasional regrading. Some areas may require the road surface to be raised to avoid periodic flooding depending on what other drainage works are undertaken.

The primary access to Property 130 will not be affected by proposed mining so access to Property 130 will be maintained throughout the period of mining. The alternative access will be mined under and some regrading of this alternative access is likely to be necessary at the completion of Longwall 105.

4.3 Power Transmission Lines

There are multiple power transmission lines located in the vicinity of the EP Area. The impacts of mining subsidence on each of these lines are discussed in this section. The impacts of mining subsidence are not expected to cause power interruptions but some mitigatory work is likely to be required on several of the lines and drainage works may be required to prevent periodic flooding around poles located in areas where ponding occurs.

4.3.1 330kV Power Line West of Longwall 107B

Figure 14 shows a photograph of the 330 kV power transmission line owned by Transgrid that traverses the western boundary of the EP Area. This line is supported on steel truss pylons and was relocated into the corridor along the lease boundary between ACP and RUM as part of the Ravensworth North Opencut expansion to minimise impacts from future mining.

The pylon foundations are designed to accommodate the combined subsidence movements associated with the mining of all four seams proposed to be mined at both the ACP and at RUM.

The line is remote, approximately 180 m, from the edge of Longwall 107B in the ULD Seam and approximately 100 m from the nearest goaf edge of Longwall 8 in the PG Seam. Although subsidence of up to about 50mm is expected at each of Towers 36-40, no impacts to the integrity of the towers from the proposed mining in the EP Area are expected because of the special foundation designs for these pylons.

A program of monitoring the total three dimensional subsidence movements in the general vicinity of Towers 36-40 at the end of each longwall panel is recommended to confirm that the subsidence movements are of the order expected.

Figure 14: 330kV Transgrid Power Transmission Line.

4.3.2 132kV Line Traversing Southern Blocks

Figure 15 shows a photograph of a 132 kV power transmission line owned by AusGrid crosses the southern ends of all the southern blocks at ACP. The line is supported on two pole structures along straight sections and three pole structures at changes of direction. These structures have been upgraded in stages following monitoring of subsidence movements observed during mining in the PG Seam and the first few panels in the ULD Seam and specific assessment of each structure and the associated ground clearances.

The reduction in length of Longwall 105 due to geological constraints underground means that the three pole structure shown in Figure 15, specifically poles CN80451, CN80452, CN80453, and the next pole further in the distance, CN80017, will not be directly mined under. The impacts of the revised layout have been assessed separately in SCT Report ASH4392.

SCT understands that structures across Longwalls 105, 106A, and 107A will be upgraded prior to mining these panels.

There is potential for some poles in areas where surface ponding is expected to become periodically submerged. Surface drainage works are expected to be effective in managing the potential for ponding.

The program of upgrading has allowed the subsidence movements to be successfully managed to date and it is anticipated that the remaining upgrades will allow successful management of the subsidence movements expected within the EP Area.

4.3.3 132kV and Combined 66/11kV Lines along New England Highway

The power transmission lines located alongside the New England Highway are owned by AusGrid. These lines are remote from the ends of the longwall panels proposed to be mined in the EP Area. No subsidence movements are expected at the location of these structures as a result of mining Longwalls 105-107 and even if there were minor movements, the single pole structures supporting these lines are tolerant of subsidence movements. No monitoring of subsidence movements on these lines is considered necessary.

Figure 15: 132kV AusGrid Power Transmission Line.

4.3.4 11kV Local Area Power Transmission Lines

Figure 16 shows a photograph of one of the local area 11 kV line owned by AusGrid that traverses the EP Area. The single pole structures on these lines have to date been found to be generally tolerant of subsidence movements experienced and the poles are closely enough spaced that ground clearances are not compromised if poles tilt together.

Figure 16: 11kV Local Power Transmission Line.

The reduction in length of Longwall 105 due to geological constraints underground means that the three pole structure shown in Figure 15, specifically poles CN80451, CN80452, CN80453, and the next pole further in the distance, CN80017, will not be directly mined under. The impacts of the revised layout have been assessed separately in SCT Report ASH4392.

In general, the subsidence impacts on this line of mining in the EP Area are expected to be similar to the impacts from mining in the PG Seam. However, the line crosses a stacked goaf edge at the northern end of Longwall 105 and higher levels of strain and tilt are expected in this area.

Sheaving of the conductors on poles located in areas of high tilt such as stacked goaf edge at the northern end of Longwall 105 and at changes in direction is recommended to ensure that insulators and supporting cross members do not become overloaded by changes in conductor tension.
There is potential for some poles in areas where surface ponding is expected to become periodically submerged. Surface drainage works are expected to be effective in managing the potential for ponding.

4.3.5 33kV Line on Western Side of Lemington Road

Figure 17 shows a photograph of one of the single pole structures on the 33kV power transmission line owned by Glencore Ravensworth Operations. This line traverses the surface immediately to the west of Lemington Road. The pole in the photograph is located approximately in the centre of Longwall 107B in an area where the subsidence if expected to reach 2.7 m as a result of mining in the ULD Seam with total cumulative subsidence of the general landform, including the pole shown in Figure 17, of up to 4.0 m. Maximum incremental tilts of up to about 70 mm/m are expected with maximum cumulative tilt of up to 100 mm/m possible.

Figure 17: 33kV Local Power Transmission Line.

There is potential for one of the poles on this line located near the Lemington Road culvert to become periodically submerged. Surface drainage works are expected to be effective in managing the potential for ponding.

The next pole along this line to the north of the one shown in Figure 17 is located directly above the stacked edge of Longwall 7B in the PG Seam and Longwall 107B in the ULD Seam. Large tilts of up to about 200 mm/m are expected at ground level in the vicinity of this pole with potential for up to about 2-3 m of lateral translation at conductor level, mainly to the southeast.

Given the stayed nature of these poles, a specific assessment and management strategy for each of these poles is recommended. Management of the tension in the stay and conductor tensions and clearances on this line is likely to be required to keep the line operational during the period of active mining. Other options that may be more practical given the expectation of further mining in this area would be relocation of the line further to the west into an area of lower subsidence prior to mining Longwall 107B or temporary decommissioning of the line with removal of the conductors during the period of active mining.

Survey monitoring of the poles on this line is recommended during the period of active mining if the poles are not relocated. Sheaving of the conductors and some form of tension limiting mechanism on the stays is also recommended.

4.4 Dams

There are a variety of dams and a flow gauging weir on Bowmans Creek located within or in close vicinity to the EP Area. The dams in the EP Area include two DSC prescribed dams and numerous smaller farm dams and dams relating to mining activity. The impacts of mining on these various structures are discussed in this section.

4.4.1 Narama Dam

Narama Dam owned by Glencore Ravensworth Operations is located to the west of Longwall 107A. The proposed longwall panels do not extend into the Dams Safety Notification Area for Narama Dam. Recent changes to the DSC Notification Area for Narama Dam were gazetted on 3 May 2013. The edge of the EP Area extends into the Notification Area but no mining is planned within the Notification Area for this dam.

The goaf edge of Longwall 107A is approximately 400 m from the wall of Narama Dam in an area where the PG Seam was not mined and so the mining subsidence movements will be a result of mining in one seam only. At an overburden depth of approximately 200 m in this area, the horizontal and vertical subsidence movements expected at the dam wall are expected to be imperceptible for all practical purposes.

Subsidence monitoring on XL5 subsidence line is expected to be sufficient to confirm the low levels of subsidence movement expected at the location of the dam wall.

4.4.2 Void 5 Ash Dam

The Void 5 Ash Dam is located approximately 350m to the west of the north-western corner of Longwall 107B at the eastern end of Void 5. Longwall 107B mines approximately 100 m into the DSC Notification Area for this dam. Subsidence movements at the dam wall are expected to be imperceptible for all practical purposes. The dam wall is understood to be constructed from material that is likely to be tolerant to small movements.

Monitoring of a small number of survey marks on this dam wall is recommended to confirm that mining of Longwall 107B does not cause any significant movements. Before and after monitoring is considered sufficient given the low levels of ground movements expected.

4.4.3 Disused Sedimentation Ponds

Figure 18 shows a photograph of one of the four disused sedimentation ponds owned by AGLM. These ponds are located over the northern part of Longwall 8 in the PG Seam and immediately to the west of Longwall 107B in the ULD Seam. SCT understands that AGLM do not intend to use these ponds again for sedimentation purposes and instead intend them to be used as a wildlife habitat.

Subsidence movements at the location of these ponds are difficult to estimate with confidence because Longwall 8 in the PG Seam was subcritical in width. Full subsidence did not develop during mining in the PG Seam because the overburden strata was partly supported on the chain pillars. Mining Longwall 107B in the ULD Seam is expected to destabilise one of these supporting chain pillars so that some of the subsidence associated with mining in the PG Seam will be recovered during mining in the ULD Seam. The uncertainty arises from whether mining in the ULD Seam will also cause the subcritical width overburden strata to become destabilised thereby further increasing the subsidence observed over Longwall 8 beyond the limits of Longwall 107B.

Subsidence across the sedimentation ponds is expected to range from about 0.1m on the western side of the four ponds to about 1.5 m on the eastern side. Some minor cracking is expected, but apart from the overflow points between adjacent ponds being altered, the dams are expected to remain serviceable and suitable as a wildlife habitat as intended by AGLM.

No specific monitoring of these structures apart from visual observation is considered to be required.

Figure 18: Disused Sedimentation Ponds

4.4.4 Other Farm Dams

There are numerous small dams located across the EP Area owned by AGLM and ACOL. Experience of mining below these dams indicates that some cracking may cause minor water loss in a small proportion of dams that are mined under. These losses do not pose an operational risk to mining underground and with a small amount of crack filling remediation work, the dams can be restored to their original condition.

4.4.5 NOW Stream Gauging Station

The New South Wales Office of Water (NOW) maintain a flow gauging station, Foy Brook Station No 210130, on Bowmans Creek located at the northern end of the western diversion of Bowmans Creek. The concrete gauging weir shown in Figure 19 is located approximately 170 m northwest of the north-western corner of Longwall 107A near the edge of the EP Area in an area where there has been no mining in the PG Seam. The overburden depth to the ULD Seam is approximately 195 m so the gauging station is protected by an angle of draw of greater than 35°. Maximum subsidence is expected to be less than about 30 mm in this area and imperceptible for most practical purposes. Given that there is unlikely to be significant differential subsidence across the weir, the effectiveness of the structure as a gauging station is unlikely to be significantly compromised as a result of the proposed mining.

Figure 19: Bowmans Creek Flow Gauging Station.

4.6 Buried Communications Lines

There are two buried fibre optic cables and several buried copper lines located within and in close proximity to the EP Area. An assessment of the impacts on mining subsidence on these lines is presented in this section.

4.6.1 AAPT Sydney to Brisbane Fibre Optic Cable

A fibre optic cable linking Sydney and Brisbane is located alongside the New England Highway immediately to the north of the EP Area. This fibre optic cable is located beyond the area where perceptible subsidence movements are expected to occur. The distance between the northern goaf edge of the panels and the fibre optic cable is greater than half the overburden depth. No impacts are expected at the location of the AAPT fibre optic cable from the proposed mining within the EP Area.

4.6.2 Ravensworth Fibre Optic Cable

SCT understands that Glencore Ravensworth Operations owns a fibre optic cable that services the Ravensworth Operations. The exact location of this line is not known but it is understood to run generally alongside Lemington Road. The line is understood to have been constructed after ACOL's approval to mine was granted.

Proposed mining within the EP Area is expected to cause horizontal strains sufficient to compromise the serviceability of a fibre optic line. The high horizontal strains are most likely to occur in areas where there is a stacked goaf edge causing strains generated by mining in the ULD Seam to be concentrated at the location of cracks initially formed during mining in the PG Seam.

The stacked goaf edge located at the northern end of Longwall 106B is one such area where high strains are expected. Locating this fibre optic cable and ensuring it does not pass through one of the high strain zones is likely to be necessary to ensure its ongoing serviceability.

If the line is required to remain operational, an alternative routing away from high subsidence impact areas or exposing the line so that it can accommodate the predicted strains without becoming overloaded would both be effective strategies.

4.6.3 Telstra Cable to East of Lemington Road

A Telstra owned buried copper wire telephone line is located on the eastern side of Lemington Road. This line is understood to service subdivided blocks associated with Ravensworth Operations and the NOW Stream Gauging Station located on Bowmans Creek.

This line passes through the area of the stacked geometry at the northern end of Longwall 106B. The maximum cumulative horizontal strains in this area are expected to reach 110 mm/m at their peak and are therefore expected to exceed the nominal 20 mm/m horizontal strain generally regarded as the upper limit for serviceability of buried copper wire telecommunications lines.

The options to manage this cable if it is required to remain serviceable include:

- Finding an alternative route that is protected from subsidence impacts and relaying the cable along this route. A route alongside the 330 kV power transmission line is likely to be the most secure against all future subsidence impacts.

- Uncovering the cable through the area of expected maximum horizontal strain near the end of Longwall 106B while there is active mining in this area so that tensile and compressive strains can be equalised.

4.6.4 Telstra Cable Servicing Property 130

The Telstra cable that services Property 130 and other ACOL owned properties is located outside the EP Area to the east, except where it services some of the ACOL owned properties. The service to Property 130 is not expected to be impacted by proposed mining in the EP Area.

4.6.5 Telstra Cable Servicing NOW Stream Gauging Station

The Telstra cable that services the NOW Stream Gauging Station on Bowmans Creek is a branch off the line discussed in Section 4.5.3.

4.7 Buried Pipelines

There are several buried pipelines that traverse the EP Area, most of them owned by ACOL. The potential for subsidence to impact the serviceability of these lines is discussed in this section.

4.7.1 Narama Dam to Mt Owen Water Line

A 315 mm diameter PN10 PE100 pipeline extends from Narama Dam to Mt Owen Mine. This pipeline follows the eastern side of Lemington Road, crosses Lemington Road in the vicinity of the Lemington Road culvert, and then follows the access road from Lemington Road to Ravensworth Operations in the north. Prior to the Lemington Road upgrade, this pipeline crossed the road through the culvert, but with the diversion and upgrade of Lemington Road the pipeline appears to have been relocated.

The pipeline crosses the end of Longwall 107B in an area that is immediately adjacent to a stacked goaf edge. Uncovering this pipeline through the area of the stacked geometry at the northern end of Longwall 107B is recommended to ensure that the line remains serviceable. Cumulative horizontal strains of up to 100 mm/m (10%) are expected in this area and at these strain levels, there is potential for the pipeline to be damaged if all the strain is localised at a single point.

SCT is not aware of the detail of the crossing point under Lemington Road. However, the strains generated from mining in the PG Seam are likely to have been relieved as a result of the realignment and the strains associated with mining in the ULD Seam are expected to be of generally similar magnitude to the strains generated during mining in the PG Seam except at stacked edges where they are much larger.

Elsewhere along the line, the cumulative strains are expected to be generally less than about 25 mm/m and are therefore likely to be of similar magnitude to the 15-18 mm/m strains experienced in this area during mining in the PG Seam.

4.7.2 AGLM Gas Pipeline Easement

AGLM has a gas pipeline easement that crosses the central part of Longwalls 106B and 107B. SCT understands that AGLM do not intend to construct a gas pipeline along this easement during the period of proposed mining in the ULD Seam. The proposed mining does not have any practical implication for the easement.

4.7.3 ACOL Owned Pipelines

There are several pipelines associated with ACOL operations located within the EP Area. In general, mine owned infrastructure does not require to be assessed for an EP, but these lines are assessed because of the potential for consequential impacts from fractured pipelines.
The Hunter River pipeline is a 200 mm diameter PE80 PN8 polyline that provides clean water from an intake near the Hunter River to the ACP Coal Preparation Plant. Figure 20 shows a photograph of this line where it is exposed near the pump. There is some potential for mining induced ground movements to exceed the nominal strain limits of this pipe, particularly in zones of high compression strain where overrides may develop and at stacked goaf edges. Compression zones are most likely to develop within the subsidence bowls created by mining. Any leakage as a result of a fracture is likely to be substantially contained within the subsidence bowl and would be more of an operational issue than an environmental issue. The line crosses two stacked goaf edges, one near the start of Longwall 106B and the other at the finish of Longwall 105.

A dirty water pipeline delivering water pumped from the mine back to the ACP Coal Preparation Plant follows a similar route to the Hunter River pipeline but with several branches to each side. A rupture of this pipeline may present more of an environmental issue but outflows are still likely to be substantially contained within the subsidence bowl created by mining. The areas where this line crosses stacked goaf edges include the finish of Longwall 105 and the western side of Longwall 107A.

Uncovering the pipes is expected to significantly reduce potential for mining induced subsidence impacts because the strains developed in the ground are not able to be transmitted to the pipeline. A system for monitoring pressure or similar that can detect a leak and shut down the pump may provide an alternative to uncovering the pipe.

A number of polylines delivering tailings from the ACP Coal Preparation Plant to the ACOL Tailings Dam and decant return cross the northern end of Longwalls 107B and the corner of Longwall 106B. Figure 21 shows how these pipes are laid in an open trench where they cross Longwall 107B. Although high strains are expected in the vicinity of the stacked edge at the northern end of Longwall 107B, the exposure of the pipes in an open trench is expected to prevent large strains from developing. Some regular inspection and visual monitoring during the period of active subsidence is recommended to confirm that there is sufficient slack in the lines to accommodate the ground movements expected to result from mining Longwall 107B.

Minor pipelines and stock water delivery networks may be affected by mining subsidence movements particularly where they cross stacked edges or compression overrides but in general it is expected these would be repaired on an as required basis without the need for any mitigatory work.

4.8 RUM Infrastructure

Ravensworth Underground Mine (RUM) has constructed No. 5 Ventilation Shaft approximately 120 m west of the goaf edge of Longwall 8 in the PG Seam and 217 m west of the goaf edge of Longwall 107B in the ULD Seam.

Figure 20: ACOL Freshwater Line.

Figure 21: ACOL tailings disposal lines in open trench.

The shaft was constructed after Longwall 8 in the PG Seam was mined and after ACOL was granted approval to mine in the ULD Seam. The shaft is outside the EP Area and not connected to the underground workings, but is assessed because of its closer proximity to the EP Area.

Proposed mining in the ULD Seam may cause horizontal shear movements within the overburden strata that extend horizontally as far as the RUM shaft. However, the magnitude of these movements is likely to be so small as to be of no practical significance for the operational integrity of the shaft. Future mining at RUM is expected to have a similar level of potential for low level shear movements.

At the time of preparing this report RUM is on care and maintenance and the underground developments are remote from the EP Area. The main impact of proposed mining in the EP Area on underground operations at RUM is likely to occur at the completion of underground mining at the ACP when the mine is allowed to flood. At this point, there will be potential for horizontal flow from the ACP into the RUM workings that will need to be managed by RUM.

4.9 Fences and Other Farm Infrastructure

Most of the fences in the EP Area are owned by ACOL with the balance owned by AGLM. Across most of the EP Area, the horizontal strains and tilts expected from proposed mining in the ULD Seam are not expected to cause significantly more impact to fences and other farm infrastructure than occurred during mining in the PG Seam. The areas where greater impacts are expected are likely to be at stacked goaf edges such as the start of Longwalls 106A, and 106B, the finish of Longwalls 105, 106B, and 107B, the western side of Longwall 107A and the northern edges of Longwalls 6A and 7A in the PG Seam.

In areas of high strain, fences are likely to become tight so that wires snap or loose so that they become ineffective for stock control. Farm buildings constructed with brick and masonry walls or large floor slabs are likely to be perceptibly impacted in areas where horizontal strains are greater than about 7-10mm/m. Other infrastructure such as water reticulation systems, gates, cattle grids, and stockyards may also be affected depending on their specific location. In general, these impacts can most easily be managed as and when they occur.

A program of regular visual inspection and appropriate remediation as required is considered a satisfactory way to manage most of the impacts.

4.10 ACOL Owned Residential Structures

There are several residential structures located within the EP Area including the one shown in Figure 22. These are owned by ACOL and are understood to be unoccupied. Mining subsidence within the EP Area is expected to cause perceptible impacts to these structures particularly where there are brick walls, masonry structures such as fireplaces, and large concrete slabs. As a precautionary measure, it is recommended that these structures are not occupied during the period of active mining.

5. RECOMMENDATIONS FOR SUBSIDENCE MONITORING AND MANAGEMENT

The program of subsidence monitoring program used at ACP has been suitable to date to assess the nature of subsidence related ground movements in a multi-seam environment and to manage the associated impacts. It is recommended that this program continues in the EP Area. The program includes:

- Three dimensional monitoring of a cross line, XL5, that crosses all the southern panels at the mine.
- Three dimensional monitoring of a cross line, XL13, that crosses the panels located in the northwest of the mining area.
- Three dimensional monitoring of longitudinal lines located on the ULD panel centreline at the start and end of each panel.

Figure 22: Unoccupied ACOL Owned Residential Structures.

Additional monitoring recommended for the EP Area includes:

- Three dimensional monitoring on a subsidence line that follows Lemington Road from CH50m to CH1200m.
- Three dimensional monitoring on a 100m long subsidence line perpendicular to and centred about Lemington Road at CH305m.
- Monitoring of the culvert under Lemington Road in three dimensions using an array of fixed prisms located within the culvert below each lane of the carriageway and at the ends of the culvert.
- Monitoring of power poles associated with the 33kV Glencore owned line during the period of active subsidence and installation of a stay tension limiting device that can be adjusted to avoid the pole become overloaded.
- Monitoring of the three dimensional movement of Towers 36-40 on the 330kV line and if appropriate the relative positions of each of the legs relative to each other at the completion of each adjacent longwall panel.
- Monitoring the position of the RUM No 5 Ventilation Shaft at the completion of each adjacent longwall panel.

- Regular visual inspection of Lemington Road, the culvert under Lemington Road, power poles on the 11kV, 33kV, and 132kV lines, the surface above buried pipelines, and fences during the periods of active mining in each area.

The main focus of managing subsidence impacts associated with mining in the EP Area will need to be on Lemington Road, the culvert below Lemington Road, and the various power transmission lines in the area. A specific management plan for Lemington Road and the culvert is beyond the scope of this report, but will need to be established in consultation with the various government authorities and with Ravensworth Operations.

6. CONCLUSIONS

Our assessment indicates that the offset layout proposed for Longwalls 105 to 107 is likely to produce subsidence effects that are of generally similar magnitude to the subsidence effects for the stacked layout approved in the Bowmans Creek EA. Lower subsidence effects than predicted for the stacked geometry are expected across most of the area. Slightly higher maximum subsidence is predicted in some areas because of a thicker seam section than was contemplated in the EA. Somewhat higher strains and tilts are expected at stacked edges based on the experience of monitoring a stacked edge above Longwall 102.

The report has been updated from our earlier assessment report ASH4378 dated 28 May 2015 to reflect the revised layout whereby Longwall 105 has been shortened by approximately 370 m at the southern end due to underground geological constraints. The only substantive changes in terms of subsidence impacts as a result of the revised layout are that the area of ponding has been reduced slightly and several of the poles on the 132 kV power lines that traverse the southern part of the longwall panels will no longer be directly mined under. Subsidence movements at the location of four poles on this line, three of which are located at a change in direction, will be significantly reduced as a result of the reduction in the length of Longwall 105.

Subsidence from mining Longwalls 105-107 in the ULD Seam is expected to cause additional incremental subsidence of up to 2.7 m. The total cumulative subsidence is expected to reach 3.8 m to 4.0 m in the central part of areas where there is overlap between longwall panels in both seams.

The incremental subsidence estimates are based on 85% of the thickness of the ULD Seam and the cumulative subsidence estimates are based on 75% of the combined thickness of both seams. Both of these values are considered to be reasonably conservative.

Over most of the EP Area, incremental tilts and strains from mining in the ULD Seam are expected to be of similar or lower magnitude than the tilts and strains observed during mining in the PG Seam despite the cumulative subsidence being almost double in magnitude.

An exception occurs in areas where the goaf edges in the two seams are stacked above each other, or nearly so, so that mining in the ULD Seam remobilises goaf edge fractures that originally developed during mining in the PG Seam. In these areas maximum tilts are double background values and maximum strains are four times background values.

Specific areas where high tilts and strains are expected above stacked edges include the start of Longwalls 106A, and 106B, the finish of Longwalls 105, 106B, and 107B, the western side of Longwall 107A and the northern edges of Longwalls 6A and 7A in the PG Seam.

Tilts and strains at stacked goaf edges are expected to reach a maximum when the ULD Seam goaf edges are mined 20-30 m under the solid edge of a previously extracted panel in the PG Seam. In some cases these maxima will then reduce with further mining, but in other cases such as along the western edge of Longwall 7A, the high tilts and strains are expected to be permanent.

The general landform above both the northern and southern longwall mining areas is expected to be lowered by a total cumulative subsidence of up to 3.8-4.0 m with perceptible cracks of up to about 200-300 mm wide expected over the stacked goaf edges. Ponding within the subsidence bowls and increased inflows through into the overburden strata are expected with steep dips of up to about 1 in 6 (160 mm/m) at the stacked goaf edges.

Bowmans Creek and the two diversions are not expected to be subsided or otherwise impacted by the proposed mining so the general landform on either side of Bowmans Creek will be much lower than the adjacent section of creek invert. Steps in the subsided landform are expected to present a barrier to natural drainage and some ponding is expected as a result, possibly up to several metres deep depending on the gradients in the original landform and any landform drainage works that may have been undertaken since the completion of mining in the PG Seam.

Approximately 54% of the total ponding area estimated as likely to be caused by mining Longwalls 105-107 in the ULD Seam is associated with expansion of existing farm dams, existing billabongs, and sections of existing or excised watercourses. Most of these ponding areas were not free draining prior to the commencement of mining. However, mining subsidence will increase the area of ponding, in some cases significantly. The ponding volumes for the billabong at the southern end of Longwall 105 and 106 (Pond 1) has been recalculated and although the ponded area has reduced, the volume for Pond 1 has increased significantly as a result of the revised calculation.

Ponds located above the southern longwall panels are located on grazing land that is owned by ACOL. These ponds represent approximately 62% (approximately two thirds) of the total ponding area above Longwalls 105-107 in the ULD Seam and are the main ponding areas that are either new or extend well beyond existing ponds.

Ponds located above the northern panels are predominantly within the excised sections of Bowmans Creek and tributaries thereof. These ponds represent an area of approximately 21% of the total ponding area.

The options to improve the free draining characteristics of those sections of the landform that are required to be free draining include:

- Clearing existing drainage lines that have become blocked by vegetation or by construction works associated with the Bowmans Creek Diversion.
- Forming drainage lines that allow overflow into existing watercourses that feed into Bowmans Creek or direct into minor tributaries of the Hunter River.

It is understood that ACOL are planning to manage the impacts of ponding using all three of these approaches via an adaptive management strategy.

Impacts of ponding on surface infrastructure are expected to include periodic flooding of power poles on the 132 kV line across the southern panels and power poles on the 11 kV local electricity line, and periodic flooding of an AGLM access road and the alternative access route to Property 130. These impacts are expected to be manageable through building up the levels of low sections of the roads and providing drainage of ponds that flood power lines. The shortening of Longwall 105 has reduced the number of poles on the 132 kV line likely to become susceptible to flooding from five to one.

The proposed layout in Longwalls 105-107 in the ULD Seam is consistent with keeping all secondary extraction at least 200 m from the Hunter River Alluvium (as defined in RPS 2009) and at least 40 m (in a horizontal direction) from the high bank of Bowmans Creek in its diverted function form as per the Statement of Commitments made for Longwalls 5 to 7 in the PG Seam in Schedule C of DA309-11-2001 Mod-6 Items 3.2 and 5.3.

Lemington Road and associated infrastructure including the culvert below the road, buried telecommunication lines alongside the road, and the 33 kV power line also alongside the road are considered likely to be the infrastructure most significantly impacted by mining subsidence within the EP Area, but all impacts are expected to be manageable albeit with some effort.

Subsidence movements are expected to be perceptible along Lemington Road from CH200 m to CH1200 m, where chainage is measured from the centre of the intersection with the New England Highway. Mining induced subsidence is expected to occur incrementally with mining and so should be gradual and able to be managed with ongoing remediation works during the period of active mining. However, the magnitude of these works is expected to be significant, particularly near the finishing end of Longwall 106B.

During mining of Longwall 106B, subsidence impacts are expected from CH200 m to CH720 m with subsidence increasing as the panel retreats to an estimated maximum of about 2.3m in the interval CH300 m to CH360 m near the corner of Longwall 106B. Significantly greater subsidence is expected on the southbound lane compared to the northbound lane because of tilt around the corner of the panel toward the existing goaf of Longwall 6B in the PG Seam.

Maximum tilts of up to about 130 mm/m (1 in 6) are expected in the interval CH310 m to CH350 m in a direction that is predominantly across the road (i.e. in a southeast direction) so that the southbound lane is expected to be up to about 600mm lower than the northbound lane. Elsewhere along the road, maximum tilt is expected to be less than 65 mm/m (1 in 15) with a significant component of this tilt still acting across the road causing differential subsidence between the lanes of up to about 300 mm.

Maximum strains of up to 70 mm/m, predominantly across the road, with potential for cracks up to about 100 mm wide are considered possible around the corner of Longwall 106B. Horizontal strains elsewhere along the road are expected to be generally less than 10-15 mm/m with perceptible, but generally transient, tension cracks expected to be typically less than 50 mm wide at intervals of 5-10 m.

During mining of Longwall 107B, subsidence impacts are expected to be perceptible mainly from CH450 m to CH1120 m increasing as the panel retreats to an estimated maximum of 2.7 m over the centre of Longwall 107B in the interval between CH720 m and CH760 m. Tilts are expected to be generally less than 40 mm/m but may reach up to about 70 mm/m at CH710 m dipping to the northwest and CH780 m dipping to the southeast.

Horizontal strains are expected to be generally less than 10-15 mm/m with tension cracks typically less than 50 mm wide. Some compression overrides are also considered possible.

Some stretching and compression of roadside barrier rails is considered possible and some allowance to loosen fixing bolts during the period of active mining is recommended to reduce damage to the rails and posts.

The culvert below Lemington Road is expected to be perceptibly impacted by mining subsidence with potential for cracks to develop within the structure or between elements of the structure so that there may be potential for fines migration and piping failure to cause sinkholes on the road surface.

There also appears to be potential for the capping slab above the central opening of the culvert to collapse if the outer culvert elements move apart. Monitoring and mitigation works are likely to be required to manage these hazards.

Impacts on buried telecommunication lines, buried pipelines that traverse the EP Area, and the 33 kV power line located alongside Lemington Road are expected to be significant in areas of stacked goaf edges.

Mitigation works aimed at limiting the impacts are expected to be generally necessary for the infrastructure to remain serviceable.

These measures include re-routing the infrastructure around stacked goaf edges, uncovering buried infrastructure in areas of stacked goaf edges so that horizontal strains are not able to build up, and developing management strategies for power lines that avoid over-tensioning of conductor fixings and stays.

Shortening of Longwall 105 by approximately 370 m at the southern end of the panel due to underground geological constraints means that several poles on the 132 kV power lines that traverse the southern part of the longwall panels will no longer be directly mined under. Subsidence movements at the location of four poles, three of which are located at a change in direction, will be significantly reduced as a result of the change.

RPS

SURFACE WATER AND GROUNDWATER ASSESSMENT
UPPER LIDDELL SEAM EXTRACTION PLAN
LONGWALLS 105 TO 107
ASHTON COAL PROJECT

SURFACE WATER AND GROUNDWATER ASSESSMENT UPPER LIDDELL SEAM EXTRACTION PLAN LONGWALLS 105 TO 107

ASHTON COAL PROJECT

Prepared by:

RPS
Level 9, 17 York Street, Sydney NSW 2007
GPO Box 4401 Sydney NSW 2001
T: 61 2 8270 8388
F: 61 2 8270 8399
E: water@rpsgroup.com.au
W: rpsgroup.com.au

Our ref: S55P/600/012d
Date: 26 November 2015

Prepared for:

Ashton Coal Operations Pty Limited
Glennies Creek Road
Camberwell NSW 2330
T: 61 2 6576 1111
F: 61 2 6576 1122
E: James.Barben@yancoal.com.au
W: ashtoncoal.com.au

Document Status

	Issue Date	Purpose of Document
Revision A	16 January 2015	Draft report for client review
Revision B	18 February 2015	Incorporation of review comments
Revision C	23 October 2015	Corrected width of LW107B
Revision D	26 November 2015	Updated for shortened LW105

	Name	Position	Signature	Date
Author	Greg Sheppard	Principal Hydrogeologist		26/11/2015
Reviewer	Brad Woods	Principal Engineer		26/11/2015

Disclaimer

This document is and shall remain the property of RPS Group. The document may only be used for the purposes for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised copying or use of this document in any form whatsoever is prohibited.

EXECUTIVE SUMMARY

Ashton Coal Operations Pty Ltd are currently undertaking longwall coal mining in the Upper Liddell seam at the Ashton Coal Project. The Upper Liddell seam is the second coal seam to be extracted in the multi-seam mining operation. A mining extraction and subsidence management plan has been approved for longwalls LW101 to LW104 in the Upper Liddell seam and mining is currently taking place at longwall LW104.

In accordance the Development Consent (DA 309-11-2001 MOD-6) monitoring of the first four longwalls in each successive seam is required to be assessed to allow a more accurate prediction of subsidence parameters above the remaining longwalls in that seam.

The following report undertakes a review of subsidence impact monitoring with regard to groundwater completed for the extraction of LW101 and LW102 in the Upper Liddell seam and the cumulative effect of multi-seam subsidence with overlying PG LW1 and LW2. The predicted versus observed subsidence impacts are used to validate predicted surface and groundwater impacts as presented in the 2012 ULD Extraction Plan Groundwater Impact Assessment, for inclusion in the ULD LW104 to 107 subsidence management and extraction plan.

Since the approval of the Development Consent, a modified mine plan has been adopted. The mine plan has been revised and comprises seven longwall panels (LW101 to LW107), with LW107B being widened in place of extracting the originally assessed LW108. The original design width of LW107B was approximately 160m, in the new mine plan the width of LW107B has been increased to 216m. In addition to the widened LW107B, LW105 has been shortened due to geological constraints identified during the PG extraction and confirmed in the ULD during development drives for LW105.

Monitoring Results

Monitoring has shown that maximum subsidence for LW101 and LW102 has generally been of the order of 20 to 25% less than predicted, and validates the original LW105 to LW108 subsidence predictions as presented in the ULD extraction plan as being conservative and worst case.

No detrimental impacts to surface water flows or quality have been identified resulting from longwall extraction at Ashton Coal Operations to date.

Groundwater level response to multi seam extraction has generally been less than predicted in the Glennies Creek and Hunter River Alluvial aquifers. Some localised drawdown has resulted within the Bowmans Creek alluvium that is generally consistent with model predictions. On the whole water level decline within the alluvial aquifers has generally been substantially less than that predicted in the 2009 Groundwater Impact Assessment.

Water levels within the Permian lithologies, including the Pikes Gully seam and the coal measures overburden are observed to respond as predicted.

No detrimental water quality impacts have occurred within the alluvial aquifers in response to longwall extraction, in fact depressurisation of the underlying Permian strata has resulted in a reduced contribution of saline water to the alluvial aquifers and a corresponding reduction in electrical conductivity.

On the whole groundwater monitoring has shown impacts to be generally in line with, or less than, those previously predicted.

Groundwater inflows to the underground mine have also been generally less than predicted, including to the multi seam extraction of LW101 and LW102. The last longwall to be mined in the Pikes Gully seam, LW6B, located beneath the excised channel of the Bowmans Creek eastern diversion resulted in mine inflow rates greater than predicted, these inflows have subsequently subsided with total mine inflows being less than predicted.

Groundwater Model

During 2014, the existing groundwater model was updated and recalibrated to latest monitoring data. The update was undertaken as part of an investigation in the LW6B inflow event.

The updated model matches the observed drawdown and short-term recovery in response to large episodic rainfall of groundwater levels in the shallow alluvium in the vicinity of LW6B and a conclusion is that inflow from alluvium to the mine is not sufficient to account for the magnitude of the observed inflow event.

From the available monitoring data to date, it is apparent that significant depressurisation has occurred in the shallow Lemington seams following the LW6B inflows (Lemington 15A & B, Figure 27). These seams are a potential source of the inflows and may receive recharge where they subcrop beneath saturated BCA.

Surface Water Impacts

The assessment has found that no additional impacts on fluvial geomorphology, surface water flows or surface water quality are anticipated as a result of the extraction of LW105 to LW107 over and above those predicted in the 2012 Upper Liddell Seam Extraction Plan.

Furthermore as the magnitude and extent of subsidence of the revised mine plan is likely to be less than, or equal to that of the approved mine plan, no additional impacts on flooding are anticipated.

Groundwater Impacts

Predicted groundwater level impacts resulting from the revised groundwater modelling are consistent with or less than previous and approved predicted impacts. Maximum predicted water level declines resulting from the extraction of the remaining longwalls in the Upper Liddell Seam are of the order of 3.5m in the Bowmans Creek alluvial aquifer, and less than 0.5m in the alluvium of Glennies Creek and the Hunter River.

No detrimental impacts on groundwater quality are anticipated as a result of the extraction of LW105 to LW107B in the Upper Liddell seam.

Predicted baseflow impacts are of the order of 1.5L/s (0.13 ML/day) in Bowmans Creek and 1L/s or less (<0.08 ML/day) in the Hunter River and Glennies Creek. It is noted that only in Bowmans Creek does the predicted impact represent an actual loss of water from the creek. For Glennies Creek and the Hunter River, the predicted impacts represent a net reduction in the baseflow contribution to the surface water feature, with both cases remaining as “gaining” water courses in the vicinity of the ACP.

Licensing

Ashton currently hold sufficient groundwater and surface water access licences to meet its anticipated requirements associated with mine inflows and dewatering, including sufficient contingency should additional short term inflows occur from either the Hard-Rock or alluvial sources.

TABLE OF CONTENTS

TABLES

FIGURES (compiled at end of report)

APPENDICES

1. INTRODUCTION

1.1 The Ashton Coal Project

Ashton Coal Operations Pty Limited (ACOL) operates the Ashton Coal Project (ACP) approximately 14km west of Singleton in the Hunter Valley, NSW. ACOL is a wholly owned subsidiary of Yancoal Australia Limited (Yancoal).

The ACP comprises an open cut mine, an underground mine (Figure 1), a coal handling and preparation plant (CHPP), rail loading facilities, run-of-mine (ROM) and product coals stockpiles, and various surface support infrastructure and facilities. Development consent (DA 309-11-2001) for the ACP was granted by the Minister for Planning in October 2002. The ACP is approved to produce up to 5.45Mtpa of ROM coal up to February 2024.

Construction of the open cut mine (the North East Open Cut – NEOC) commenced in 2002, and ceased coal production in September 2011. The mine void will be used for rejects and tailings emplacement for the remaining life of the underground mine.

The underground mine is a longwall operation which is approved to mine coal from the Pikes Gully (PG), Upper Liddell (ULD), Upper Lower Liddell (ULLD) and Lower Barrett (LB) coal seams (in descending order). The underground mine is located south of the New England Highway and is situated between the highway and the Hunter River. It is accessed from the highwall of the open cut pit, on the northern side of the New England Highway.

Development of the underground mine commenced in the PG seam in 2005 with longwall coal extraction commencing in 2007. The general longwall layout comprises eight longwall panels in the PG seam (LW1, LW2, LW3, LW4, LW5, LW6A & 6B, LW7A &7B and LW8) and seven longwall panels in the ULD seam (LW101, LW102, LW103, LW104, LW105, LW106A and 106B, and LW107A. The original mine plan included an eighth longwall in the ULD seam (LW108), however this has been omitted in favour of a plan for a longer width of extraction in LW107A.

The first longwall of the ULD seam (LW101) commenced extraction in August 2012. Following the completion of LW101 and the commissioning of the Bowmans Creek diversions, the longwall was shifted back to mine the last remaining PG seam (LW6B), which was completed in October 2013. At the time of writing, longwall extraction is being undertaken on LW103 of the ULD seam.

Impact assessments were presented for the ULD Extraction Plan for longwalls LW101 to LW108 in 2012 (ACOL, 2012). While the extraction plan covered all eight proposed ULD longwalls, only extraction of LW101 to LW104 was approved, with approval for the extraction of LW105 to LW108 pending assessment and validation of predictions following the multi-seam extraction of LW101 and LW102 in the ULD.

This report quantifies the observed response of multi-seam mining at the ACP, covering; subsidence, surface water, and groundwater, in comparison with predicted impacts. The observed responses are then used as a basis for the validation of impact predictions for the proposed extraction of the remainder of the ULD seam. Cumulative impacts from the ACP and adjacent mining operations are also addressed.

1.2 Relevant Regulation and Legislation

A number of regulations, policies, guidelines, plans and statutory provisions relating to surface water and groundwater management are referred to in this report and are outlined in the following sections.

This report has been prepared with consideration of the following policies and guidelines:

- Stream/Aquifer Guidelines – Management of stream/aquifer systems in coal mining developments, Hunter Region (DIPNR, 2005).NSW Groundwater Policy Framework Document – General (DLWC, 1997).
- NSW Groundwater Quality Protection Policy (DLWC, 1998).
- NSW Groundwater Dependent Ecosystem Policy (DLWC, 2002).

- National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000).
- National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000).
- NSW Water Sharing Plan for the Hunter Regulated River Water (WSP), 2003.
- NSW Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (WSP), 2009.

1.2.1 Consent Conditions

Development Consent (DA No. 309-11-2001-i) Condition 3.9 states that:

> "The Applicant shall ensure that underground mining does not cause any exceedances of the performance measures in Table 1, to the satisfaction of the Director-General".

Table 1.1: Subsidence Impact Performance Measures

Watercourses	
Bowmans Creek	No greater subsidence impact or environmental consequences than predicted in the documents referred to in condition 1.2ac). • Ashton Coal Bowmans Creek Diversion Environmental Assessment (Evans & Peck, 2009). • Ashton Coal Bowmans Creek Diversion Response to Submissions, (Wells Environmental Services, 2010). • Ashton Coal Bowmans Creek Diversion Statement of Commitments, (ACOL, 2010)
Bowmans Creek – Eastern and Western Diversions	Hydraulically and geomorphologically stable
Bowmans Creek alluvium	No greater subsidence impact or environmental consequences than predicted in the documents referred to in condition 1.2 ac)

The revised subsidence predictions of SCT (2011) predict greater subsidence than indicated in the documents referred to in condition 1.2ac. However, this subsidence will not impact the permanent alignment of Bowmans Creek (i.e. the creek with the diversions in place), because the creek itself is not impacted by subsidence (because there is no mining underneath the creek). The diversions were designed to have the same relative stability as the sections of Bowmans Creek that they replace. The revised subsidence predictions of SCT (2011) have no implications for the stability of the diversions because there is no mining underneath the diversions.

Development Consent (DA No. 309-11-2001-MOD6) Condition 1.18 states that:

> "The Applicant shall design underground workings to ensure that longwall voids do not result closer than 40 metres from any point vertically beneath the high bank of Bowmans Creek (except those sections of channel made redundant by the diversion)."

The intention of the definition of "high bank" in the *Water Management Act 2000* is to mark the edge of the stream zone which is clearly aquatic (i.e. wet most of the time, and frequently subject to fluvial processes). The methodology used by the surveyor delineated the "high bank" according to the edge of the terrace, which is infrequently inundated. Thus, it was considered a conservative approach to delineation of the high bank.

1.3 Water Licensing

Water licensing at the ACP is administered under the *Water Management Act 2000* and *Water Act 1912*. Access to, and share in, entitlements for surface water and alluvial groundwater sources at the ACP is governed by the rules of the *Water Sharing Plan for the Hunter Regulated River Water Source 2003* and *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009.* Non-alluvial groundwater licences are governed by the Water Act 1912.

A summary of ACOL's current water access entitlements and licences is provided in Table 1.2.

Table 1.2: ACOL Groundwater / Surface Water Licences

Licence	Licence type	Annual Volume ML
Groundwater		
20BL172482, 20BL171364, 20BL169937	WA - Hardrock	230.0
20BL169508	WA - Hardrock NEOC	100.0
WAL29566	WMA – Bowmans Creek Alluvium	358.0
Surface Water		
WAL29565 + WAL23912	WMA – Bowmans Creek	280.0
WAL15583 (General Security) + WAL8404 (High Security)	WMA – Glennies Creek	434.0
WAL1121 (General Security) + WAL19510 (High Security)	WMA – Hunter River	465.0

1.4 Scope of this Report

In accordance with Item 3.3 of the Statement of Commitments, Schedule C of the Ashton Coal Operations Pty Limited Bowmans Creek Diversion Development Consent Modification DA 309-11-2001 MOD-6:

"Subsidence will be monitored and managed in accordance with approved Extraction Plans (or equivalent), the development of which will be informed by:

- Subsidence monitoring over LW1-4 in the lower seams, as each seam is mined, to allow more accurate predictions of subsidence parameters above LW5-8."

The following report undertakes a review of subsidence monitoring completed for the extraction of LW101 and LW102 in the ULD and the cumulative effect of multi-seam subsidence with overlying PG LW1 and LW2. The predicted versus observed subsidence impacts are used to validate predicted surface and groundwater impacts as presented in the 2012 ULD Extraction Plan Groundwater Impact Assessment , for inclusion in the ULD LW104 to 107 subsidence management and extraction plan.

1.5 Mine Plan Revisions

The original ULD mine plan, as presented in the 2012 Upper Liddell Seam Extraction Plan (ACOL, 2012), comprised eight longwall panels (LW1 to LW8). The ULD mine plan for this assessment has been revised and comprises seven longwall panels (LW101 to LW107), with LW107B being widened in place of extracting LW108. The original design width of LW107B was approximately 160m, in the new mine plan the width of LW107B has been increased to 216m. The resulting changes to the subsidence predictions arising from the revised layout are discussed in Section 3.1.

In addition to the removal of LW108, ACOL have also opted to reduce the length of extraction of LW105. For the current mine plan, the southern end of LW105 has been shortened by approximately 370 meters to avoid the impacts of localised faulting. This faulting was observed in the development gate roads and in the overlying Pikes Gully Seam.

The revised longwall dimensions are provided on Table 1.3.

Changes Required for Shortening of LW105

No significant changes are required to the impact assessment arising from the shortening of LW105 and rerunning of the groundwater model was not deemed necessary. The shortening of LW105 will ultimately have a beneficial effect in terms of reducing overall subsidence and groundwater inflows. A discussion regarding the implications of the reduced length of LW105 has been added to the sections on potential impacts relating to subsidence, surface water impacts and groundwater impacts (Section 6).

Table 1.3: ACOL Longwall Dimensions

Panel	Nominal Gateroad Width (m)	TG Pillar Width Rib to Rib (m)	LW Void Width (m)	LW Length (m)
LW105	5.4	25	216	1021
LW106A	5.4	25	216	1354
LW106B	5.4	25	216	1063
LW107A	5.4	N/A	161	1351
LW107B	5.4	N/A	216	1145

1.6 Risk Assessment Workshop

An initial risk assessment for the extraction of LW101 to 108 in the ULD seam was conducted in August 2011 and is included in the ULD Seam Extraction Plan (ACOL, 2012). Following the experience gained from the extraction of LW101 and LW102 in the ULD seam, and the observed inflow event associated with LW6B extraction, a further risk assessment workshop was held for the extraction of LW104 to 108.

Risk assessment participants are summarised on Table 1.4.

Table 1.4: ULD LW105 to 108 Risk Assessment Workshop Attendance

Name	Role	Company	Years Experience
Andrew Hutton	RA Facilitator/Scribe	SLR Consulting	20
Chris Jones	RA Facilitator	SLR Consulting	7
James Barben	RA Attendance	ACOL	7
Aaron McGuigan	RA Attendance	ACOL	11
Jeff Peck	RA Attendance	ACOL	30+
Alan Tight	RA Attendance	ACOL	6
Ken Mills	RA Attendance - Technical subsidence expert	SCT	30+
Brad Woods	RA Attendance - Technical hydrology expert	RPS	30+
Greg Sheppard	RA Attendance - Technical hydrology expert	RPS	18

1.6.1 Key Areas of Risk

Key areas of risk that are relevant to surface water and groundwater are provided Appendix A and summarised below:

- Potential impacts to Bowmans Creek and the Hunter River due to mine subsidence. Potential impacts to channel stability and possible resulting environmental impacts.
- Potential for losses from surface water, including Bowmans Creek and excised channel areas.
- Alluvial aquifers – potential groundwater level and quality changes due to greater than predicted mine subsidence.
- Hard rock aquifers – potential groundwater levels and quality changes due to greater than predicted mine subsidence – particularly in relation to unknown structures and what the contributions could be (i.e. would LW6B inflows be repeated).

A number of existing and proposed risk reduction strategies are in place to manage these potential impacts at ACOL. These key risk areas are addressed in detail in the impact assessment section (Section 5).

2. EXISTING ENVIRONMENT

2.1 Climate

The Singleton area experiences a humid subtropical climate, characterised by hot wet summers and cool drier winters. Key climate statistics for Singleton, as recorded at the Jerry's Plains Post Office, are summarised on Table 2.1. The average annual rainfall for the Singleton area is 645.9mm.

Table 2.1: Singleton Area Temperature and Rainfall

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (1907 to 2014)													
Mean maximum temperature (°C)	31.8	30.9	28.9	25.3	21.3	18	17.4	19.4	22.9	26.3	29.1	31.2	25.2
Mean minimum temperature (°C)	17.2	17.1	15	11	7.4	5.3	3.8	4.4	7	10.3	13.2	15.7	10.6
Rainfall (1884 to 2014)													
Mean rainfall (mm)	77.1	73.1	59.7	44	40.7	48.1	43.4	36.1	41.7	51.9	61.9	67.5	645.9
Median rainfall (mm)	64.3	51.4	47.1	32.3	29.9	31.2	35.1	30.5	34.3	49.2	50.1	57	644.2

Note: Red denotes maximum values, blue denotes minimum values.

2.2 Geology

The ACP is located within the Hunter Valley Coalfield of the Sydney Basin. The Permian aged coal reserves within the ACP mining lease are mostly within the Foybrook Formation of the Vane Sub-Group (Hebden to Lemington seams), with limited occurrence of the Bayswater Seam which is the basal unit of the Jerry's Plains Sub-Group. Both sub-groups are part of the Whittingham Coal Measures, the basal coal-bearing sequence of the Singleton Supergroup.

The major mineable coal seams considered suitable for longwall mining are (in descending stratigraphic order) the Pikes Gully (PG), Upper Liddell (ULD), Upper Lower Liddell (ULLD), and Lower Barrett Seams.

The Bayswater Seam has only a limited presence in the south-western corner of the ACP underground mine area. The Lemington Seams (seams 1 to 19), consisting of minor seams of varying thickness, are located stratigraphically between the PG Seam and the base of the Bayswater Seam, and are present in the overburden across the mining area. Some of the Lemington Seams are mined in the ACP North East Open Cut (NEOC) located north of the New England Highway.

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

The main regional geological structures in the area are the:

- Bayswater Syncline, the axis of which is located west of the ACP in the Ravensworth South and Narama mines.
- Camberwell Anticline, which passes to the east, through Camberwell village and the Camberwell Mine open cut.
- Glennies Creek Syncline further to the east.

The axes of these structures run from north to south and north-north-west to south-south-east. The coal seams to be mined at the ACP are outcropping in the study area on the western and north-eastern limbs of the Camberwell anticline. These subcrops for the PG and ULD seams are shown in Figure 3.

The Pikes Gully coal seam thickness in the mine area varies between 1.8m and 3m, though it is generally in the range of 2.3 to 2.8m.

The ULD Seam ranges up to 3.2m in thickness, with an average of 2.2m. The ULD Seam outcrops/subcrops to the east of the ACP (Figure 3) and has a depth to approximately 240m (-180mAHD) in the south-west corner of the underground mine area. The interburden sequences between the seams vary in thickness between 7m and 63m. A summary of the mean seam/interburden/overburden depths and thicknesses is listed in Table 2.2.

Table 2.2: Thicknesses of Coal Seam and Interburden Layers in the ACP Area (m)

Geological Units	Mean	Range
Pikes Gully overburden (Pikes Gully to base of alluvium)	Variable from 0 to 200m, due to dip on strata	0 to 200
Pikes Gully Seam	2.2	1.8 to 3.0
Interburden (Upper Liddell to Pikes Gully)	36	13 to 63
Upper Liddell Seam	2.2	up to 3.2
Interburden (Upper Lower Liddell to Upper Liddell)	28	7 to 47
Upper Lower Liddell Seam	2.1	up to 6.1
Interburden (Lower Barrett to Upper Lower Liddell)	40	24 to 62
Lower Barrett Seam	2.2	Up to 5.9

Within the ACP area, alluvium occurs in association with the Hunter River and its tributaries Bowmans Creek and Glennies Creek.

In the Bowmans Creek alluvium (BCA) up to 15m of sandy silts, silts and silty clays are identified, with occasional horizons of silty sands and gravels. The maximum recorded saturated thickness is 4.5m.

Extensive investigation of the Glennies Creek alluvium (GCA) has been undertaken as part of the SEOC investigation and Aquifer verification assessment (RPS, 2014). The upper GCA comprises a 2 to 8m thick clayey alluvium layer which blankets the Glennies Creek flood plain and extends east and west of Glennies Creek. This is underlain by a clayey sand / sandy clay layer of between 2m and 6m thick. The maximum recorded saturated thickness is 6m.

The Hunter River alluvium (HRA) comprises mainly clay and silty clay, with gravel horizons. A basal gravel horizon 8.5m thick was drilled in RA27. The saturated thickness in this bore was 6m, but greater saturated thicknesses may occur.

2.3 Landform

The ACP is located in an area of rolling hills typical of that part of the Hunter Valley region. Elevations on site range from around 60mAHD in the Bowmans Creek and Glennies Creek gullies near the confluence with the Hunter River to approximately 100mAHD on the ridgeline that runs generally north-south adjacent to Glennies Creek. Relatively flat alluvial flood plains exist in the vicinity of the creeks. This ridgeline adjacent to Glennies Creek acts as a drainage divide where to the west / north-west of the ridge, the land falls gently to the west towards Bowmans Creek at a grade of approximately 0.024 (i.e. 2.4m per 100m). The drainage across the majority of longwall panels is to the west towards Bowmans Creek.

2.3.1 Post PG Extraction

Following the full extraction of the PG seam, the natural westward drainage across the site has been interrupted by a series of subsidence troughs. The troughs are generally linear features above the centerlines of the longwall panels. Maximum subsidence along the center of the troughs is generally of the order of 1.3 to 1.5m.

Survey data from Subsidence Cross-Line 5 (XL5) is presented on Figure 4 as reduced levels (mAHD). The location of XL5 is shown on Figure 2. The section highlights the degree of subsidence resulting from single seam extraction of longwalls LW1 to LW7A in the PG seam, as well as LW101, LW102 and part of LW103 in the ULD Seam. In terms of disrupting natural surface drainage, it is apparent that the subsidence troughs have the greatest influence in the areas of more subdued topography.

More detailed subsidence survey over the area of multi-seam extraction along XL5 is shown on Figure 5, where the subsidence is presented as total subsidence from baseline survey.

2.4 Surface Water

The ACP is bounded by three main surface water features including; Bowmans Creek to the west, Glennies Creek to the east, and the Hunter River to the south (Figure 2).

2.4.1 Bowmans Creek

Bowmans Creek is a predominantly perennial creek, although during extended dry periods it is noted to go dry in sections and is expressed as a series of disconnected pools. The creek generally flows in a southerly direction from its origins in the Mount Royal Range, approximately 30km north-east of the ACP. Upstream of the New England Highway and the ACP, Bowmans Creek has a catchment area of approximately 254km^2. From the New England Highway to the Hunter River, the creek flows south-westwards across the western parts of the mining area. It comprises a river channel that is incised some 2-5m below the surrounding topography. The channel comprises a series of ponds retained behind cobble bars that are often vegetated. Some rock bars do occur within the channel, but not in the sections of the proposed creek diversions. Connectivity with the alluvium is thought to be relatively low due to the presence of the low permeability silt and clay matrix in the alluvial material. There is a significant thickness of Permian interburden between Bowmans Creek and the uppermost target coal seam – the Pikes Gully seam.

The approved mine plan for the ACP includes two diversions of the natural course of Bowmans Creek. These diversions, known as the eastern and western diversions (Figure 2) were completed and commissioned in early 2013. The diversion channels were designed to have similar grade and levels of stability as the sections of creek being diverted. The excised sections of Bowmans Creek are separated from the main channel and diversion channels by block banks. The block bank is designed to overtop in events larger than the 5 year ARI flood to reduce the flow volume through the diversions.

2.4.2 Glennies Creek

Glennies Creek is approximately 45km long and flows from its headwaters at Mount Royal to the Hunter River. Glennies Creek has a catchment of approximately 49km^2 of which 23km^2 is impounded within the Glennies Creek Dam (Lake St Clair), approximately 20km north-east of the ACP. Flow in Glennies Creek is perennial and is partly regulated by the dam releases. Glennies Creek is located outside the mining area, but approaches to within approximately 150m of the LW1 goaf edge about halfway along the panel (Figure 2). The Pikes Gully seam is believed to outcrop or subcrop below the bed of Glennies Creek over part of the section closest to LW1. The overburden cover depth at the Pikes Gully LW1 goaf edge is approximately 70m at the point closest to Glennies Creek.

The Upper Liddell and Upper Lower Liddell seams are also thought to subcrop beneath the Glennies Creek floodplain (Figure 2), but these subcrops are several hundred metres further to the east of the Pikes Gully sub-crop, and also have a much shorter intersection with the creek compared with the Pikes Gully seam.

2.4.3 Hunter River

The Hunter River is located to the south of and outside of the proposed mining area. The closest point of the longwall mining is the start corner of LW5, which is approximately 310m from the Hunter River, and 200m from the edge of the Hunter River alluvium. The Pikes Gully overburden depth at this point is approximately 150 to 155m.

The southern end of LW1 is situated approximately 515m from Hunter River, and at least 480m from the edge of Hunter River alluvium. The overburden depth at the southern end of LW1 is approximately 50 to 80m.

2.5 Groundwater

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

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

Some “perched” groundwater and layering of groundwater systems may also occur within the upper weathered mantle of the Permian coal measures.

2.5.1 Permian Coal Measures

The permeability of the coal measures is generally low, with rock mass permeabilities more than two orders of magnitude lower than the unconsolidated alluvial aquifers. Within the coal measures, the most permeable horizons are the coal seams, which commonly have hydraulic conductivities one to two orders of magnitude higher than the siltstones, shales and sandstone units. The coal seams are generally more brittle and therefore more densely fractured compared to the overburden and interburden strata (which creates this higher permeability).

Within the coal seams, the groundwater flows predominantly through cleat fractures, with very little evidence of structure-related fracturing. Due to the laminar nature of the coal measures, groundwater flow generally occurs within, or along the boundaries between, stratigraphic layers. This means that effective rock mass vertical permeability is significantly lower than horizontal (typically three or more orders of magnitude).

2.5.2 Alluvial Aquifers

Bowmans Creek

The Bowmans Creek alluvium is characterised by fine silts and clays, sometimes containing large cobbles, and silty sands. The presence of fine silts and clays as a matrix around the cobbles and sands has a strong moderating influence on the alluvium hydraulic conductivity.

The lateral extent of saturated Bowmans Creek alluvium has been determined from a combination of remote sensing, ground mapping, exploration drilling, and monitoring of groundwater levels over a range of above and below average climatic conditions (Aquaterra, 2009). The limits of saturated alluvium for Bowmans Creek are shown on Figure 2. It is noted that this extent of saturation will vary seasonally with changing water levels.

Drilling and remote sensing investigations (HLA, 2001; Aquaterra, 2008) have shown that there is a sharp demarcation between the Bowmans Creek alluvium and the Hunter River alluvium. This sharp line of demarcation extends across the confluence, with no evidence for an embayment of Hunter River alluvium into the Bowmans Creek valley.

The saturated thickness of the alluvium reaches a maximum of around 4.5m.

Glennies Creek

The Glennies Creek alluvium generally occurs in association with the deposition of paleo-sediments by the creek. These deposits occur within two main terraces, a lower terrace adjacent to the creek, and an upper terrace that merges with colluvium and finally regolith associated with the slopes of the rising Permian subcrop. The terraces are tiered, with an elevation change between terraces in the order of 1 to 3m.

The meander of Glennies Creek that runs closest to the underground mine (LW1) incises to the edge of the alluvium and some Permian bedrock is visible in the stream banks. This is close to the subcrop of the Pikes Gully seam, as shown in Figure 3.

Investigations for the SEOC project (Aquaterra, 2009, 2014) showed that the alluvium associated with Glennies Creek has a highly variable hydraulic conductivity, which appears to have been caused by the meandering nature of the creek during the deposition of the alluvium. The extent of saturation within the Glennies Creek alluvium is provided on Figure 2.

Hunter River

The investigations into the Hunter River alluvium across the southern end of the site indicate that it is deeper and generally more transmissive than either the Bowmans Creek or Glennies Creek alluvium. Floodplain alluvium of the Hunter River was extensively tested at the neighbouring Hunter Valley No.1 mine in 1992. Those results indicated that "typical" basal sands and gravels are present within the alluvium, resulting in alluvium permeability two to four times that of the current day river bed sediments.

2.5.3 Groundwater Dependent Ecosystems

The ecological investigation conducted by ERM, 2009 showed that there are no Groundwater Dependent Ecosystems (GDEs) within the area of alluvial aquifers that were predicted to be impacted during mining activities within the ULD. The assessment was undertaken as part of the South East Open Cut EA, but included cumulative assessment with ACP underground mining.

Two stands of River Red Gum have been surveyed alongside the southern reaches of Bowmans Creek near the confluence with the Hunter River, and a small isolated and narrow stand of River Red Gums have been recorded along the eastern side of the Glennies Creek, and one individual River Red Gum was recorded along the northern portion of Glennies Creek (Figure 2). These are expected to be largely dependent on surface water flows and seasonal wetting of the alluvium, with seasonally recharge to an extent on groundwater baseflows through extending their roots into the water table. There are no impacts predicted on alluvial groundwater levels in these areas.

3. PREVIOUS IMPACT ASSESSMENTS

3.1 Subsidence Predictions

Subsidence predictions undertaken for the ULD LW1-8 Extraction Plan (SCT, 2011) were prepared to incorporate:

- The then current mine design, allowing for the offset longwall panel arrangement and removal of miniwalls (as presented in the EIS).
- Relevant site-specific information regarding subsidence behaviour and overburden characteristics obtained during secondary extraction in the PG Seam.
- More recent data and methods for the estimation of subsidence in multi-seam mining environments (which differ considerably to those used for the EIS) as described by Li et al. (2010).

SCT estimated maximum subsidence using an approach based on empirical data reported by Li et al. (2010). This approach indicated that maximum subsidence would not exceed 85% of the combined thickness of the two seams being mined (in this case PG and ULD). The corresponding maximum tilts and strains were then estimated on the basis of the anticipated maximum subsidence and an empirical approach used for single seam mining.

In addition to the empirical approach, numerical modelling was also conducted, which incorporated the geomechanical properties of the overburden strata and the interaction between the offset chain pillars (SCT, 2010). Modelling results predicted maximum subsidence of the order of 55 to 60% of the combined seam thickness.

The predicted subsidence values obtained using the empirical approach were adopted as they were considered to be more conservative and accounted for the variability associated with multi-seam operations. The empirical approach provided what was considered to be the "potential worst case" for subsidence predictions at the ACP.

Revised subsidence predictions provided by SCT (2011) indicate cumulative maximum subsidence ranging from 3.9 to 4.5m across ULD LW101-108 as summarised on Table 3.1.

Table 3.1: Summary of revised subsidence predictions (SCT, 2011)

Seam	Cumulative Maximum Subsidence (85% of Combined Seam Thickness) (m)	Max Tilt (mm/m)	Max Strain (mm/m)	Incremental Subsidence From Mining ULD Seam (m)	Incremental Max Tilt (mm/m)	Incremental Max Strain (mm/m)
LW1	4.4	235	94	2.9	183	73
LW2	4.0	189	76	2.5	139	55
LW3	4.0	162	65	2.5	119	48
LW4A	3.9	128	51	2.4	93	37
LW4B	3.9	151	60	2.4	110	44
LW5	4.0	103	41	2.5	76	30
LW6A	4.0	100	40	2.5	73	29
LW6B	4.3	132	53	2.8	101	41
LW7A	4.0	89	36	2.2	66	26
LW7B	4.5	116	47	3.0	91	36
LW8	4.4	107	43	3.4	98	39

The revised subsidence predicted by SCT (2011) had no implications for fluvial geomorphological processes in Bowmans Creek or Glennies Creek. Subsidence affects the land adjacent to the creeks, but the creeks themselves are protected by the 40m buffer from the high bank as well as the diversions in Bowmans Creek.

3.2 Surface Water Assessment

The most recent surface water assessments that have been undertaken at ACP that are relevant to the current assessment are:

- Bowmans Creek Diversion, Flood Study (Hyder, 2009).
- Bowmans Creek Diversion, Flood Hydrology and Geomorphology (Fluvial Systems, 2009).
- Fluvial Geomorphology Technical Report: Upper Liddell Seam, Longwalls 1-8 Extraction Plan (Fluvial Systems, 2011).

3.2.1 Flood Hydrology

The 2009 flood study was largely focussed on how the Bowmans Creek Diversion would respond to and impact on, flood events. Of relevance to the current assessment, the study concluded that subsidence resulting from longwall extraction would significantly increase floodplain storage and would introduce pondage areas that would capture flows from local tributaries in small frequent events, and significantly attenuate peak flows entering the Hunter River in larger events such as the 20 year and 100 year ARI.

The predicted 100 year ARI flood contours for Bowmans Creek on subsided topography are shown on Figure 6. The contours show the inundation of subsidence troughs above longwalls LW6B, LW7A, LW7B, and the southern portions of LW5 and LW6A.

The predicted 1 year ARI flood contours for Bowmans Creek compounded with a 100 year ARI flood event in the Hunter River are shown of Figure 7. The Hunter River flood results in significantly more extensive inundation and greater depths, particularly above the southern subsidence troughs.

3.2.2 Fluvial Geomorphology

The fluvial geomorphological technical report (Fluvial Systems, 2011), concluded that the revised subsidence predictions for ULD LW101 to 108 (refer Section 3.1) has no implications for fluvial geomorphological processes in Bowmans Creek or Glennies Creek. Subsidence affects the land surrounding Bowmans Creek, not the Creek itself (including a buffer of 40m from the high bank). It was noted that the diversions are designed to spill into the former channel for events greater than a 1 in 5 year ARI. The higher subsidence will simply mean deeper water in the former channels in the event of high flows spilling into them. Velocities would be relatively low in the former channels – they would tend to be depositional zones rather than zones of sediment scour.

The chance of avulsion (scouring of a new river channel) is considered to be low because high flood flows will spill in a controlled way over block banks, not over the banks of the diversion channels. Additionally, the bed and banks of the diversion channels are designed to be stable.

Subsidence poses little risk to Glennies Creek, with the nearest point being 120m east of LW101. At this location, Glennies Creek is noted to abut the valley wall and has no alluvium on the western side. A small risk of slope failure or mass movement of the valley wall was noted.

3.3 Groundwater Assessment

Groundwater impacts as a result of ULD extraction have previously been assessed in:

- 2001 EIS.
- 2009 Bowmans Creek Diversion Groundwater Impact Assessment.
- 2012 Upper Liddell Seam Extraction Plan – Groundwater Impact Assessment.

A groundwater assessment for the extraction of ULD LW105 to 108 was undertaken as part of the Upper Liddell Seam Extraction Plan – Groundwater Impact Assessment (RPS Aquaterra, 2012). This assessment also predicted impacts for LW101 to 104.

The layout of the ULD LW101 to 104 was configured to minimise potential baseflow losses and surface water impacts by avoiding alluvial aquifers, creeks, and the Hunter River. At its closest point, ULD TG1 was offset about 185m to the west of Glennies Creek, and ULD LW104B was offset by at least 40m from the high bank of Bowmans Creek. ULD LW105 to 108 mining will be offset by at least 200m from the Hunter River Alluvium, but mining will occur below the Bowmans Creek alluvium.

This assessment focused on impacts to four key areas where mining occurred closest to the alluvium including:

- Glennies Creek Alluvium to the east of ULD LW101.
- Glennies Creek and Hunter River Alluvium to the south of ULD LW101.
- Hunter River Alluvium directly south of ULD LW105 to 108.
- Bowmans Creek Alluvium in the vicinity of the Oxbow, west of ULD LW104.

Revised baseflow impacts were also summarised for Bowmans Creek, Glennies Creek, and the Hunter River. Drawdown and baseflow impacts were presented at key times, which aligned with the completion of ULD LW104 and ULD LW108.

A summary of the key outcomes of the assessment is as follows.

3.3.1 ULD LW101 to LW104

The revised predicted impacts resulting from ULD LW 101 to 104 mining were consistent with, or below the predictions made in the groundwater impact assessment reports of the EIS (HLA, 2001) and the Bowmans Creek Diversion EA (Aquaterra, 2009e) for the same stage of mining. The revised impacts indicate the following:

- Drawdown to Glennies Creek alluvium was predicted to increase to a maximum of 0.11m south-east of ULD LW101 at the end of ULD LW104 mining (2014). This represents an additional impact of 0.06m post-PG extraction.
- There is very little alluvium on the western side of Glennies Creek in the area closest to the underground mine. Here, the drawdown is predicted to increase to 0.18m at the end of ULD LW4 mining (2014) and represents an additional impact of 0.04m post PG extraction. The revised prediction was consistent with the 2009 EA prediction, but was much less than that presented in the 2001 EIS of 2.5m.
- No impact (drawdown) to the Hunter River alluvium to the south-west of ULD LW101 and south of ULD LW105 to 107, which is consistent with both the 2001 EIS and 2009 EA predictions.
- Drawdown in the Bowmans Creek alluvium at the oxbow, are mostly residual effects from the mining of the PG Seam. Drawdown was predicted to increase to 0.45m at the end of ULD LW104 mining (2014) and represents an additional impact of 0.13m post-PG extraction. The revised prediction was consistent with the 2009 EA prediction for this stage of mining.
- Baseflow impacts to Glennies Creek were predicted to increase to 2.9L/s (0.25ML/d), by the end of ULD LW104 mining. This represents an additional baseflow impact of 0.3L/s (0.026ML/d) post-PG extraction. The revised prediction was consistent with the 2009 EA predictions and lower than the 2001 EIS prediction of 3.3L/s (0.28ML/d).
- In the vicinity of LW101, Bowmans Creek baseflow was predicted to change from a slightly gaining creek, at 0.011L/s (prior to underground mining) to a creek that loses about 0.15L/s (0.012ML/d) at the cessation of ULD LW104 mining. This represents an additional baseflow impact of 0.12L/s (0.011ML/d) post-PG mining. The revised impact is lower than the impacts predicted in the 2009 EA (0.5L/s / 0.04ML/d) and 2001 EIS (4.3L/s / 0.37ML/d) for this stage of mining.
- A small reduction in baseflow contribution to the Hunter River of 0.13L/s (0.011ML/d) was predicted at the end of ULD LW104 mining. This represents an additional baseflow impact of only 0.06L/s (0.004ML/d) post-PG mining. The revised impact is less than the impacts predicted in the 2009 EA (0.3L/s / 0.026ML/d) and 2001 EIS (2.9L/s / 0.25ML/d) for this stage of mining.
- No Groundwater Dependent Ecosystems (GDE's) or existing users were identified in areas where groundwater impacts may occur. There are small stands of River Red Gums on the eastern side of Glennies Creek, which were not predicted to be impacted by the extraction of ULD LW101 to 104.

- At the end of ULD LW101 to 104, the PG seam is predicted to be completely depressurised in the area of PG extraction. The 10m drawdown contour in the PG seam extends approximately 300m south of LW101 (equivalent to approximately 25mAHD) and 800m south-west of LW104. The drawdown is heavily influenced by dewatering operations at the Ravensworth Underground Mine.

3.3.2 ULD LW105 to LW108

The predicted impacts resulting from ULD LW 5 to 8 mining were generally consistent with, or below the predictions made in the groundwater impact assessment reports of the EIS (HLA, 2001) and the Bowmans Creek Diversion EA (Aquaterra, 2009e) for the equivalent stage of mining. The revised impacts indicate the following:

- Drawdown to Glennies Creek alluvium is predicted to increase slightly from 0.11m (post-LW101 to 104) to 0.16m to the south-east of ULD LW1, and from 0.18 to 0.2m, to the east of ULD LW1 at the end of ULD LW108 extraction. The revised drawdown to the east of ULD LW1 is consistent with the 2009 EA prediction, but is much lower than 2001 EA prediction of 2.5m for the same stage of mining.
- No impact to the Hunter River alluvium was predicted to the south-west of ULD LW101 and south of ULD LW105 to 107. This was consistent with both the 2001 EIS and 2009 EA predictions.
- Bowmans Creek alluvium was predicted to be largely desaturated following ULD extraction, with some areas of residual saturation predicted to remain, such as in the Bowmans Creek oxbow.
- Drawdown to Bowmans Creek alluvium was found to be mostly residual effects from the mining of the PG Seam. Drawdown to Bowmans Creek alluvium at the oxbow was predicted to increase to 0.73m at the end of ULD LW108 mining, and represents an additional impact of 0.41m post-PG mining cessation. The revised impact is lower than the 2009 EA prediction of 1.7m for this stage of mining.
- Baseflow impacts to Glennies Creek were predicted to increase to 3.0L/s (0.26ML/d) at the cessation of ULD LW8 mining. This represents an additional baseflow impact of 0.4L/s (0.034ML/d) post-PG mining cessation and 0.1L/s (0.0086ML/d) post-LW104 extraction. The revised impacts were consistent with 2009 EA predictions, and lower than 2001 EIS predictions of 5.5L/s (0.47ML/d) for the same stage of mining.
- Baseflow impacts to Bowmans Creek were predicted to increase to 0.86L/s (0.074ML/d) at the cessation of ULD LW108 mining. This represents an additional baseflow loss of 0.41L/s (0.035ML/d) post-PG mining cessation and 0.27L/s (0.023ML/d) post- the completion of ULD LW4. The revised prediction was lower than the impacts predicted in the 2009 EA (1.2L/s / 0.1ML/d) and 2001 EIS (4.62L/s / 0.4ML/d) for this stage of mining.
- A small reduction in the baseflow contribution to the Hunter River of 0.23L/s (0.02ML/d) was predicted at the cessation of ULD LW108 mining. This represents an additional baseflow reduction of 0.16L/s (0.014ML/d) post-PG mining, and 0.1L/s (0.008ML/d) post- the completion of ULD LW104. The revised impact is lower than the impacts predicted in the 2009 EA (0.5L/s / 0.04ML/d) and 2001 EIS (3.47L/s / 0.3ML/d) for this stage of mining.
- No GDEs or existing users were identified in areas where groundwater impacts may occur. There are small stands of River Red Gums near the Hunter River, but these are located outside the zone of predicted drawdown, and therefore are not predicted to be impacted by the extraction of ULD LW105 to 108.

3.3.3 Predicted Mine Inflows

Predicted Mine Inflows from the 2012 ULD Extraction Plan and the 2009 EA up to the end of ULD extraction are presented on Figure 8.

For the period of LW101 to 104 extraction, predicted inflows ranged from 14.4 to 16.8 L/s (approx. 1.25 to 1.45 ML/day), and for LW105 to 108, ranged from 15.2 to 16.44 L/s (1.31 to 1.42 ML/day).

The potential for surface water inflow entering the underground mine as a result of mining beneath the Bowmans Creek floodplain during ULD LWs 106 to 108 was also assessed. If the subsided floodplain was to become inundated during flooding, the presence of large subsidence troughs has potential to result in the ponding of large volumes of water, with the potential to then seep into the mine workings via connective cracking. In order to prevent this, the project included a commitment to reshape the subsidence troughs in order to create a “free draining” landform to promote surface water flows to the downstream creek channel or floodplain.

Potential inflows to the underground from inundation of the troughs were not substantial, and were assessed to be in the range of 0.3 to 4.3L/s (0.03 to 0.37ML/d).

4. MONITORING

Observed versus predicted impacts for the extraction of LW101 to LW103 are summarised in the following sections. At the time of assessment the first 1000m of LW103 had been mined (extraction commenced 21 August 2014).

4.1 Subsidence Monitoring

Subsidence cross sections are presented in Figures 5 to 7. Subsidence monitoring for LW101 and LW102 is presented on Figure 5 for subsidence cross line 5 (XL5). Predicted versus observed subsidence is summarised on Table 4.1.

Table 4.1: Predicted Versus Observed Multi-seam subsidence

Seam	Predicted Maximum Subsidence (85% of Combined Seam Thickness) (m)	Predicted Incremental Subsidence From Mining ULD Seam (m)	Observed Maximum Subsidence (XL5) (m)	Observed Incremental Subsidence From Mining ULD Seam (m)	Cumulative subsidence as %age of combined seam thickness
LW1	4.4	2.9	3.27	1.85	63.2%
LW2	4.0	2.5	3.18	1.88	67.6%

As can be seen from Table 4.1, actual observed subsidence is considerably less than that predicted by the empirical subsidence method (Section 3.1). The observed cumulative subsidence as a percentage of combined seam thickness was approximately 63.2% for PG LW1 and ULD LW101, and 67.6% for PG LW2 and ULD LW102. This is considerably less than the 85% suggested by the empirical observations (Li et al., 2010), but is similar to the numerical modelling assessment of 55 to 60% of the combined seam thickness.

The predicted subsidence is shown to be conservative with only approximately 65% of the predicted maximum subsidence being realised.

The monitoring data validates the LW105 to 108 subsidence predictions as presented in the ULD extraction plan as being conservative and worst case.

4.2 Surface Water Monitoring

4.2.1 Flow Monitoring

Surface water flow monitoring is undertaken at monitoring points on Bowmans Creek, J1 to J3, as shown on Figure 9. Gauging station J1 is located upstream of the eastern diversion of Bowmans Creek, J2 is located downstream of the western diversion, and J3 is located midway in the oxbow area between the two diversions. A NSW Office of Water gauging station (Site 210130) also exists on Bowmans Creek just downstream of the New England Highway (Figure 9).

Gauging data is available from October 1993 until February 2014 at the NSW Office of Water site, and from June 2013 to October 2014 at the three ACOL gauging sites.

Figure 10a shows the daily flow from NOW Site 210130 since 1994. For ease of display of the full range of flow data the vertical (flow) axis is plotted on a logarithmic scale. A number of data gaps are apparent; these are generally inferred to be due to loss of data rather than indicating no flow. A no flow situation would be preceded by a regression in flow volumes as can be observed following large flow events. A prolonged regression is apparent from January 2006 until mid-2007, however, throughout this time at least some minimal flow is recorded. The average daily flow over the duration of data collection is 47.5ML/day. This value is skewed by a number of very large flow events and in comparison, the median daily flow for the same period is around 2.3ML/day.

Figure 10b presents the cumulative deviation from the average daily flow (of 49.2ML/day). The cumulative deviation plot is useful in identifying periods of generally low, or below average flow (as indicated by a downwards trending plot) and periods of high or above average flow (as indicated by an upwards trending plot). Figure 10b shows flows in Bowmans Creek to be dominated by long periods of below average rainfall, offset by generally short, very high intensity flow events. Since the commencement of longwall extraction at the ACP, including the mining of LW6B, the flow in Bowmans Creek has generally been average or below average but has been offset by a number of very large flow events, namely during June and July 2007 and November 2011 to January 2012; as well as smaller but still significant events in December 2008 and March 2013.

Data from the ACOL flow gauging sites is presented on Figure 11. Figure 11 is truncated at a flow volume of 50ML/day to highlight the more frequent low flow events; data is also presented from the NOW gauging site for the same period for comparison. It should be noted that while the stations all show very similar trends at low flows, the peak flow estimated at the NOW station over the period was approximately 2170ML/day compared with the maximum of 491ML/day estimated from the ACOL stations for the same event. The margin of error for the individual station flow estimates precludes the direct comparison of flows between stations.

The flow gauging hydrographs indicate that no discernable impact has occurred resulting from underground mining operations at ACP.

4.2.2 Surface Water Quality

Surface water quality is monitored at a number of locations as shown on Figure 9. Key monitoring locations are summarised on Table 4.2.

Table 4.2: Key Surface Water Monitoring Locations

Monitoring Point	Purpose
Bowmans Creek	
SM3	Bowmans Creek Upstream
SM5	Bowmans Creek Mid
SM6	Bowmans Creek Downstream
Glennies Creek	
SM7	Glennies Creek Upstream
SM8	Glennies Creek Mid
SM11	Glennies Creek Downstream
Hunter River	
SM9	Hunter River Upstream
SM10	Hunter River Mid
SM13	Hunter River Downstream

Monitoring data is available for the period September 2003 to October 2014 and is presented on Figures 12 to 14. Monitoring data are presented for electrical conductivity (EC) and pH as these are the key indicators of water quality and will enable the identification of potential impacts from mining operations.

Electrical Conductivity

EC data for key surface water monitoring locations are provided in Figures 12 to 14.

Data for Bowmans Creek is presented on Figure 12. Prior to any underground mining taking place surface water salinity in Bowmans Creek, as indicated by EC, is observed to be increasing. Coinciding with the commencement of PG extraction at LW1 there is a substantial drop in EC, this drop is due to an extreme rainfall event in June 2007 of 286mm. This rainfall resulted from a storm that caused extensive flooding throughout the Hunter and Central Coast Region. Following the extreme event, salinities are noted to stay relatively low for the next six years, before starting to increase again in 2013. All three monitoring locations show very similar long term trends, but are overprinted with varying short term fluctuations, this is most apparent at the downstream (SM6) monitoring location.

It is noted that during periods of low flow the surface water salinity in Bowmans Creek (and Glennies Creek) tends to increase. This is attributed to two separate processes, these being evaporative concentration within the pooled and slow moving water bodies, and the relative dominance of vertical leakage of more saline groundwater from the Permian lithologies.

Salinity in Glennies Creek (Figure 13) is substantially lower and more consistent than that in Bowmans Creek, possibly due to the regulated discharge from the Glennies Creek Dam. Prior to 2006, the upstream monitoring point (SM7) was recording salinities more than double that of the mid and downstream monitoring locations. From 2006 onwards, all three monitoring locations show very uniform trends. The reason for the early (pre- 2006) discrepancy between the monitoring locations is unclear. The large rainfall event and flooding that resulted in a freshening of the Bowmans Creek flow, has the opposite effect at Glennies Creek, resulting in a slight increase in EC. Long term salinity has remained generally stable, fluctuating around a mean salinity of approximately 400 µS/cm.

Salinity of the Hunter River water (Figure 14) is generally between that of Bowmans Creek and Glennies Creek. All three monitoring points generally show a close correlation, with the main discrepancy observed at SM9 during 2005/2006. The response observed at SM9 over this period is similar to that observed at SM6 in Bowmans Creek over the same period.

Over the period of monitoring EC, the Hunter River displays a general trend of increasing salinity.

pH

pH data for the surface water monitoring points are presented on Figures 12 to 14. pH values at all monitoring points are generally fairly stable with no long term trends apparent. In Glennies Creek and the Hunter River (Figures 13 and 14), pH values at the upstream, mid, and downstream monitoring points are generally fairly uniform. In the Hunter River, pH values across all three monitoring points are generally in the range 8.0 to 8.4, with an average of around 8.2 pH units. In Glennies Creek, pH typically ranges from 7.5 to 8.1, with an average of around 7.8.

pH values in Bowmans Creek (Figure 12) differ in that there is a consistent change in pH from the upstream to the downstream monitoring location. SM7, located upstream, is typically in the range 7.4 to 7.8, with an average of 7.6, while SM6 located downstream ranges from 7.8 to 8.2, with an average value of 8.0. This trend has not changed following the commencement of mining at ACP.

No evidence of mining influences is observed in any of the water quality data.

4.3 Groundwater Levels

The ACP groundwater monitoring network includes piezometers targeting the key hydrogeological units (alluvium, Coal Measures Overburden, Lemington seams, PG seam, ULD seam and underlying coal seams). The network is geographically distributed across the underground mining area (Figure 1) with particular focus on areas of saturated alluvium and those areas predicted to be impacted by mining.

Targeted monitoring of individual hydrogeological units is achieved through the use of sealed standpipe piezometers and fully grouted multi-level vibrating wire piezometers (VWPs).

The monitoring network has grown over the life of mining. New piezometers have been installed and a number have also been lost due to subsidence.

Impacts of Multi-seam Extraction

Multi-seam extraction at ACP has been completed at longwalls LW101 and LW102, and has commenced (21 August 2014) at LW103. The groundwater response to multi-seam extraction and increased subsidence has been monitored at a number of piezometers. Key monitoring locations in the vicinity of LW101 to LW103 are shown on Figure 2.

Although not likely to be influenced by LW101 to LW103, key Bowmans Creek Monitoring locations are also included, as this is where the greatest influence from underground mining on alluvial aquifers has been observed to date.

The locations of the piezometers relative to LW101 to LW103 are presented in Figure 2.

4.3.1 Glennies Creek Alluvium

Figures 15 and 16 present hydrographs of the key standpipe piezometers monitoring water levels within the GCA. Figure 15 presents the water level trends since ULD extraction began, and is presented with monthly rainfall, while Figure 16 presents the longer term water level trends with the long-term cumulative rainfall deviation (CRD).

The CRD plot represent the cumulative deviation of actual monthly rainfall from the long term average monthly rainfall, and provides an indication of longer term climatic trends. A downward trending plot indicates sustained, below average rainfall and conversely, a sustained upward trend indicates sustained above average rainfall.

Water levels in the GCA piezometers are shown to respond relatively rapidly to extreme rainfall events with this response most pronounced in the piezometers closer to the creek (such as WML129 and WML241). The GCA piezometers show a strong recharge response during LW101 extraction, and again following the commencement of LW102. The recharge events are generally followed by a period of regression and then stabilisation.

In general, groundwater levels within the GCA appear to be responding to long term climatic conditions, over-printed by shorter term responses to high intensity rainfall events. During the period of extraction of the ULD seam there is a general correlation with the CRD.

No evidence of impacts due to longwall extraction is observed.

4.3.2 Hunter River Alluvium

Figures 17 and 18 present hydrographs of the key piezometers monitoring water levels within the Hunter River Alluvium (HRA). Figure 17 presents the water level trends since ULD extraction began, and is presented with monthly rainfall, while Figure 18 presents the longer term water level trends with the long-term cumulative rainfall deviation.

In general, all of the HRA piezometers continuing a declining trend that commenced in early 2012 follow a period of groundwater recharge and rising water levels (Figure 17). The decline coincides with the commencement of the LW101 development headings, however, as the decline is observed in all HRA piezometers, including those well away from LW101, this timing is noted to be a coincidence and unrelated. It is also noted that during the period of HRA water level decline there was also a decline in mine inflows and dewatering requirement (Section 4.3.3), thus supporting the conclusion that the HRA water level decline is not related with mining at ACP.

During the period of LW101 extraction, there is a large recharge event in early 2013 that is observed in all HRA piezometers. Following the recharge event, water levels continue the declining trend.

Over the period of LW102 extraction the general water level decline has continued, and is over-printed by two small recharge events. The decline stabilises towards the end of LW102 extraction at WMLP278, WMLP279, WMLP280 and WMLP337, which are all located in close proximity to the Hunter River and may indicate equilibration of the HRA groundwater levels and the Hunter River level in this vicinity. WMLP336 and WMLP338 are located further from the Hunter River and continue to decline.

Figure 18 shows a close correlation between long term water levels and the cumulative rainfall deviation. The continued water level decline during ULD extraction is attributed to longer term climatic and recharge conditions rather than a mining related response.

4.3.3 Bowmans Creek Alluvium

Bowmans Creek alluvium hydrographs are presented on Figures 19 to 22. Although not influenced by ULD extraction to date, a number of the piezometers show a strong response to LW6B extraction in the Pikes Gully.

The response is observed most notably in the northern piezometers (Figure 19 and 20).

Figure 19 presents BCA piezometers located to the east of LW6B, with those to the west are plotted on Figure 20. A strong decline in water level is observed following the commencement of LW6B. The decline is most pronounced at T5 and T6, located above the LW6B/7B chain pillar, and at RA30, located above LW7B. The initial decline ranged in magnitude from 0.8 to 3.3 m prior to being fully recharged by a large rainfall event in November 2013. Following the recharge event, water levels resumed the declining trend until a couple of smaller recharge events occurred in March and April of 2014. The most recent monitoring data from Figure 19 (eastern piezometers) indicates the water level decline to have diminished with a partial water level recovery. The western piezometers, as shown on Figure 20 however, show only a minor water level recovery at RA30 and T5.

The water level decline that commenced following the start of LW6B also coincided with elevated mine inflows as discussed further in Section 4.5.

Further south in the BCA, the response is not as strongly apparent (Figures 21 and 22). A small increase in the rate of decline is observed at WMLC328 and RA18 (Figure 21) that may be attributable to LW6B, however, the majority of water level decline presented is attributed to a long term climatic response.

4.3.4 Permian

The Permian lithologies overlying the immediate mining area are expected to become substantially, to completely, dewatered over the period of PG and ULD longwall extraction. A number of VWP installations within the mining area have been selected to demonstrate the depressurisation as well as VWPs outside of the active mining area to the south and east to assess drawdown propagation and depressurisation within the Permian lithologies. Selected VWP hydrographs are presented on Figures 23 to 27.

WML213

WML213 has been monitoring water levels in the Permian lithologies since August 2008, which coincides with the end of LW2 and start of LW3 in the PG seam. WML213 is approximately 440m west of LW6A and 390m south-west of LW7A at their nearest points. As such, it provides a good representation of pre-mining conditions (or close to) in the south-west of the ACP. The WML213 hydrograph is presented on Figure 23.

The VWP sensor installed in the PG Seam shows almost 100m decline in piezometric head over the duration of monitoring, which is consistent with predictions

The sensors in the underlying ULD and Upper Lower Liddell (ULLD) Seam also show a significant depressurisation response of up to 36m. The ULLD appears to show a greater depressurisation than the ULD despite being further from the PG seam. At the commencement of LW103 extraction there is a depressurisation response in the ULLD sensor but not the ULD sensor that is as yet unexplained. The reasons for this may become more apparent as ULD mining progresses.

The deeper Lower Barret (LB) Seam remains unaffected and retains a piezometric head above all the overlying sensors.

Of interest is the gradual decline in the Lemington 15 seam, while seams above (Lemington 8-9 and Bayswater), and the seam below (Lemington 19), appear to show no significant response. The Lemington 15 sensor also shows an increase in depressurisation that coincides with the LW7A extraction and development headings (not plotted). This may indicate that a greater hydraulic connection (higher hydraulic conductivity) with the longwall goaf exists in this seam.

WMLC335

WMLC335 is located to the south of LW101 and has been operational since May 2012. The WMLC335 hydrograph is shown on Figure 24. A strong depressurisation response is observed in most sensors with the commencement of extraction in LW101. This is particularly apparent in the overlying Arties Seam and underlying ULLD and Upper and Lower Barrett Seams. A greater depressurisation response is observed in the Arties Seam than in the ULD_B Seam, possibly indicating a greater hydraulic connection (and higher permeability) with the goafed formations. A 9m decline is observed in the ULD_B seam compared with a 13m decline in the Arties Seam.

WML189

WML189 is located in the chain pillar between PG LW2 and LW3. The hydrograph for WMLP189 is presented on Figure 25, and include sensors in the Lemington 15, PG, and Arties seams. Data is presented for the period August 2007 to January 2014.

The PG sensor shows an initial depressurisation response in association with the extraction of PG LW1, there is then an increase in pressure from December 2007 to June 2008 that coincides with the extraction of LW2. Given the position of the VWP in the chain pillar, this increase in pressure is attributed remnant saturation within the seam and increased abutment pressure due to subsidence. This pressure then dissipates and diminishes over the remainder of the PG extraction period.

The underlying Arties Seam also displays an increase in pressure with the advance of LW2 followed by a regression as the pressure dissipates. There is then a marked depressurisation event associated with the passing of LW3. This depressurisation with LW3 is also observed in the shallower Lemington 15 seam, which becomes completely depressurised by the end of PG mining.

All communication with the VWPs was lost due to subsidence associated with LW102 extraction, prior to this a rapid depressurisation is observed in the Arties seam.

With the Lemington 15 seam only 49m below ground level at this location, it is apparent that the entire sequence above the ULD has been substantially, if not completely, depressurised and/or desaturated.

WML191

WML191 is also located in the chain pillar of PG LW2 and LW3. The hydrograph for WMLP361 is presented on Figure 26, and include sensors in the Lemington 15, PG, ULD, ULLD and LB seams. Data is presented for the period October 2007 to July 2014.

Following the extraction of PG LW3 in August 2008, there is a complete depressurisation of the Lemington 15 and PG seams. Some residual saturation is observed in the PG chain pillar until the extraction of LW102, when complete depressurisation occurred prior to losing communication with the sensors.

The ULD and ULLD seams show a gradual depressurisation response to PG extraction, which accelerates rapidly in the ULD upon commencement of LW101. Following the passing of LW102, communication was lost to all sensors with the exception of the shallow and desaturated Lemington Seam.

Complete depressurisation/desaturation of the formations above the mined seams is indicated.

Following the passing of LW102, communication was lost with WML191.

WMLC361

WMLC361, while not directly undermined, is situated between the start points of PG LW6B and LW8. The hydrograph for WMLC361 is presented on Figure 27, and include sensors in the Lemington 5-6, 8, and 15 seams, as well as the Arties and ULD seams. Data is presented for the period September 2013 to November 2014.

The VWP was installed following the extraction of LW7 and LW8 and substantial depressurisation of the Arties Seam is indicated. Further depressurisation occurs as a result of the extraction of LW6B with almost 50m decline in piezometric head observed in the Lemington 15 seam. Only a relatively small response, and complete recovery with recharge, is observed in the shallower Lemington seams. The pressure decline observed in Lemington 15 is inferred to be in response to the LW6B inflows.

The ULD Seam shows a gradual decline, but remains elevated above the Arties Seam.

4.4 Groundwater Quality

A summary of electrical conductivity (EC) as monitored in key piezometers in the vicinity of LW101 to LW103 is provided below.

Plots of the EC data, grouped by aquifer, are presented on Figures 28 to 31 to provide an understanding of the long term trends.

EC is used as a key groundwater quality screening parameter as it provides an easily measurable representation of water quality. Each water body (surface, alluvium or the Permian) typically has a distinct salinity and EC range.

Results from the monitoring of groundwater quality over the LW6B extraction period have generally aligned with the baseline trend of low salinity within the GCA and low to moderate salinity within the Permian lithologies.

Glennies Creek Alluvium

EC levels observed in GCA piezometers are presented on Figure 28.

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. This response is most apparent at WML120B and WML239, with EC levels more than halving over the PG extraction period at WML120B.

Over the period of ULD extraction there has been no further decline in EC and EC levels have been relatively stable, albeit with short term fluctuations. Both WML129 and WML120B show a small increase in EC over the LW102 extraction period, however, the increase is well within historical limits.

Aside from the distinct freshening (reduction of EC) that occurred following the commencement of PG extraction at LW1, no other mining related impacts are apparent.

Hunter River Alluvium

EC levels observed in HRA piezometers are presented on Figure 29.

Prior to ULD extraction the available data indicate a general trend of declining EC. WMLP279 is the most up-stream piezometer and has been relatively stable over the period of ULD extraction. Since the commencement of mining in the ULD, WMLP280, WMLP278, and WMLP337 have started to increase in EC.

The increase in EC observed at WMLP280, WMLP278, and WMLP337 is not considered to be related to longwall extraction. In fact, the opposite impact of lowering EC would be expected to be seen. The trend of increasing EC is therefore attributed to natural fluctuation. No impacts associated with ULD extraction are indicated.

Bowmans Creek Alluvium

EC level for Bowmans Creek Piezometers are presented on Figure 30.

Figure 30 shows the majority of piezometers to have EC values in the range of 800 to 2,000 µS/cm, with a number of piezometers (RSGM1, T7 and WML115C) initially measuring elevated EC in the range, 3,500 to 9,000 µS/cm. T7 and WML115C have subsequently reduced and are more consistent with the majority of data. RSGM1 has also reduced in EC but remains elevated above the other piezometers at around 2,500 to 4,000 µS/cm.

More recently, the range of EC in the majority of piezometers has narrowed to around 1000 to 1400 µS/cm, showing a general reduction in EC over time. The reduction in EC at RSGM1 and T7 occurred following the completion of PG LW8 in 2012.

Current ULD extraction is considered to be currently too far from the BCA (over 400m at the closest point) for any further changes or impacts to yet be realised.

Permian Coal Measures Overburden

Water quality within the shallow Permian formations (or coal measure overburden) is presented on Figure 31.

Figure 31 shows two distinct ranges of water quality within the shallow Permian lithologies. Piezometers WML119, WML120A, WML261, and WMLP302 show EC levels generally below 2,000 µS/cm with a trend of reducing EC over time. At these locations, the shallow CMOB subcrops beneath the GCA and reflect the change in hydrostatic condition from an upward hydraulic gradient to a downward hydraulic gradient and leakage from GCA and Glennies Creek surface flow to CMOB. The low EC values are therefore indicative of leakage and recharge from the GCA. WML119 shows a significant reduction in EC with the commencement of PG mining at LW1.

WML262 and WMLP301 are more indicative of Permian lithologies that are not hydraulically connected with alluvial bodies or that are not directly influenced by recharge. EC levels are generally in the range 6,000 to 8,000 µS/cm, with a recent spike to 8,900 µS/cm.

Other than the freshening (reduction in EC) in the shallower Permian lithologies, no mining related impacts are observed.

4.5 Mine Inflows

Net groundwater inflows into the underground mine are determined using a water balance approach, which balances total water extracted from the mine with the volume of water pumped into the mine as used for operational purposes.

The net dewatering volumes are determined by recording cumulative flows at water meters on the discharge pipelines and the imported water pipeline.

Within the underground workings, water accumulates in low points of the mine and is pumped out once it reaches one of the dewatering sumps. Dewatering pumps may sometimes be out of service due to maintenance and repairs. This may affect the water balance as water that accumulates underground is not accounted for until it is pumped out.

The net dewatering rate is provided on Figure 32. Over the LW101 extraction period the net mine dewatering ranged from approximately 16L/s down to a period when more water was being imported into the mine than being pumped out. This net gain in water resulted from diverting inflows in the PG seam at the time to storage and was prior to BH03 in the ULD being brought online.

Over the LW102 extraction period the net mine inflows had increased ranging from approximately 16 to 31L/s with an average of around 22.5L/s.

The elevated inflows observed at the start of LW102 extraction are the result of an inflow event that occurred during LW6B extraction. These inflows caused an exceedance of the inflow trigger value that was sustained for a period of three months and was reported in accordance with the WMP (RPS, 2014).

The component of inflows attributable to LW102 extraction, as abstracted from BH3, was generally of the order of 2 to 3L/s over the LW102 extraction period.

For the later part of LW102 extraction, net dewatering declined towards the predicted inflow levels, with another slight increase in inflows, again associated with the LW6B inflow event and a recharge to the overlying alluvial and shallow CMOB lithologies. Following the completion of LW102 net dewatering rates again declined to meet the 2012 predicted dewatering rates.

Another increase in inflows is apparent in September/October 2014, this increase is associated with the drilling and installation of dewatering bore BH4A located above LW7A. By late December, inflows rates have again declined to below the level of the 2012 predicted inflows.

4.6 Summary of Predicted versus Observed Impacts

A summary of predicted impacts from the 2009 EA and 2012 ULD Extraction Plan, and observed impacts for multi-seam extraction to date is presented on Table 4.3. It is noted that in general the predicted impacts are for the end of LW104 while mining is currently being undertaken in LW103.

Table 4.3: Summary of Predicted versus Observed Impacts

Type of Impact	Magnitude of predicted impact - 2009	Magnitude of predicted impact - 2012	Stage of Mining for prediction	Observed Impact
Subsidence				
Maximum Subsidence	3.7 m	Up to 4.4m	LW101/LW102	Up to 3.7m
Surface Water				
Surface Water Quality	Reduction in EC from pre-mining conditions	Reduction in EC from pre-mining conditions	Life of Mine	Nil
Groundwater Level Drawdown				
GCA	Maximum 0.4 m although generally less than 0.1 m (end of ULD)	0.11 to 0.18 m	End of LW104	Nil observed above climatic variation
HRA	0.1 m (end of ULD)	0.01m	End of LW104	Nil observed above climatic variation
BCA - North	Largely dewatered (end of ULD)	Up to 1.5 m	End of LW104	Up to 5m but generally less (0.5 to 3m)
BCA - South	Largely dewatered (end of ULD)	Up to 2 m	End of LW104	Nil observed above climatic variation
PG at WML213	Approx. 100 m (end of ULD)	Approx. 100 m	End of LW104	Approx. 100m
PG at WMLC335	Approx. 30 m (end of ULD)	Approx. 30 m	End of LW104	Approx. 16m
Groundwater Quality				
GCA	Reduction in EC from pre-mining conditions	Reduction in EC	Life of Mine	General reduction in EC
HRA	Reduction in EC from pre-mining conditions	Nil	Life of Mine	Nil observed above climatic variation
BCA	Reduction in EC from pre-mining conditions	Reduction in EC	Life of Mine	General reduction in EC
Baseflow				
Glennies Creek	2.7 L/s	2.9 L/s	End of LW104	Assumed less than 2.9 L/s
Hunter River	0.69 L/s	0.69 L/s	End of LW104	Assumed less than 0.69 L/s
Bowmans Creek	1.5 L/s	0.13 L/s	End of LW104	Assumed greater than 0.13 L/s
Mine Inflows				
Average inflow LW101/102	15.9 L/s	16.3L/s	LW101/102	20.5 L/s*

* - Includes period of LW6B extraction

In general, with the exception of predicted drawdown in the BCA, observations are generally consistent with, or less than, predicted impacts.

In the northern BCA observed impacts resulting from the LW6B inflows are greater than predicted in the 2012 GIA but are significantly less than those predicted in the 2009 EA. In the southern BCA, observed groundwater drawdown is significantly less than predicted in both the 2009 and 2012 assessments.

Despite the elevated inflows associated with the LW6B inflow event, average inflows for the period of LW101 to LW102 extraction are only around 25% greater than predicted.

The magnitude of drawdown and propagation of depressurisation within the PG seam is equal to or less than predicted (as observed at WML213 and WML335).

5. GROUNDWATER MODEL UPDATE

Following the LW6B inflow event, the groundwater model for the ACP was refined and recalibrated to facilitate the investigation into the inflows and to forward predict any implications for previous impact assessments and groundwater licensing requirements (RPS, 2014b).

The update and recalibration comprised a general increase in the level of detail represented in the model. The refined model was recalibrated and used for prediction simulations.

Refinement of the model comprised:

- Update of the mining sequence of PG and initial ULD to as implemented from expected.
- Refinement of the mining sequence to monthly increments from two or three monthly to yearly (both calibration and prediction simulations).
- Refinement of timing of construction of the BCD to as implemented from expected.
- Application of historical monthly rainfall and evaporation rather than long-term average.
- Addition of mining operations at Glendell.
- Refinement of mine progress at Ravensworth Underground.
- Recalibration of model representation of subsidence-induced change to hydraulic properties
- No change to model geometry.
- Minor changes to hydraulic properties in the; Bowmans Creek Alluvium, Glennies Creek Alluvium, Hunter River Alluvium and distribution of interburden at outcrop at Glennies Creek.

The results of modelling indicate that the inflow event between October 2013 and February 2014 is a potentially separate hydrogeological process to that encountered during normal mine operation.

A conclusion of the report, which was noted to require confirmation through field investigation, was that the inflow event at LW06B was associated with the same hydrogeological process that was responsible for the minor increase in inflow rates experienced in LW07B (January 2012) and, potentially also, the minor increase in inflow rates experienced in LW07A (June 2011).

The updated model matches the observed drawdown and short-term recovery in response to large episodic rainfall of groundwater levels in the shallow alluvium in the vicinity of LW06B and a conclusion is that inflow from alluvium to the mine is not sufficient to account for the magnitude of the observed inflow event.

From the available monitoring data to date, it is apparent that significant depressurisation has occurred in the shallow Lemington seams following the LW6B inflows (Lemington 15A & B, Figure 27). These seams are a potential source of the inflows and may receive recharge where they subcrop beneath saturated BCA.

Model predictions of mine inflows for ULD extraction were prepared and partitioning between various groundwater and surface water sources for the purpose of water licensing was undertaken.

In general, refinements to the groundwater model indicate desaturation of BCA may not be as extensive as previously considered. Predicted mine inflow rates were generally consistent with that predicted in the 2009 BCD EA (Aquaterra, 2009) and 2012 ULD Extraction Plan.

Review of modelled licensing requirements, calibrated to historical mine operation, against current licences held by ACP indicate that there are sufficient licences available to meet modelled requirement. Further detail on licensing is presented in Section 4.0.

5.1 Mine Inflows

The total mine inflows predicted with the updated groundwater model peak at around 12.4 L/s during mining of the ULD LW105 to 108 (Figure 32). The predicted peak inflow rate of 12.4 L/s is slightly lower than the rates predicted for the same stage of mining in the 2009 and 2012 groundwater assessments.

5.2 Impact to Groundwater Levels

The modelled impact to groundwater levels was determined by calculating the difference in groundwater pressure or level between the calibration and prediction simulation and null cases at equivalent times.

The modelled change in groundwater level in the BCA indicated a maximum 3.5m decline following mining of the ULD Seam and is, in general, less than that predicted in the 2009 and 2012 groundwater assessments. In previous assessments, the BCA was predicted to be extensively dewatered by the end of mining of the PG extraction, which has not been observed. It is noted that the tabulated values of drawdown presented in the 2009 EA were with respect to areas within the BCA that were not fully dewatered. The drawdown within desaturated areas was not tabulated.

The modelled change in groundwater levels in the GCA and HRA following mining of the ULD seam were less than 0.5m.

5.3 Impact to Baseflows

The modelled impact to surface water flows in Bowmans Creek, Glennies Creek and the Hunter River was determined by calculating the difference in flux, into and out of the defined river boundary conditions (using the Modflow River package) between calibration and prediction simulations and null cases at equivalent times.

Bowmans Creek is a “gaining” water course and transitions to a “losing” water course under both scenarios, i.e. With Mining and Null Case. As explained in the 2009 BCD EA, this is due to the impact on Bowmans Creek by the Ravensworth Underground Mine regardless of the presence of ACP Underground. The predicted impact of ACP Underground on BC is a “take” of up to 132m^3/d. In comparison, the predicted impact to Bowmans Creek in the 2009 BCD EA was a “take” of up to 71m^3/d. It is noted that the BCD EA presents a “gaining” water course as a positive flux, i.e. there is positive baseflow (groundwater contribution to surface water feature). In the model upgrade report, due to the need to partition the “take” from various water courses, a “gaining” surface water feature represents a loss of groundwater to surface water, therefore is a negative flux.

Glennies Creek is a “gaining” water course and remains so under both With Mining and Null Case scenarios. The predicted impact of ACP Underground is a small reduction in groundwater contribution to Glennies Creek. The predicted “take” is up to 76m^3/d. The predicted impact to Glennies Creek in the 2009 BCD EA was higher, being up to 230m^3/d. The difference in predicted “take” from Glennies Creek is due to a change in the configuration of the model at that location during the calibration process. The updated approach is more consistent with observed inflow volumes and observed impacts within the Glennies Creek Alluvium.

The Hunter River is a “gaining” water course and remains so under both With Mining and Null Case. The predicted impact of ACP Underground is a small reduction in groundwater contribution to the Hunter River. The predicted “take” is up to 87m^3/d. In the BCD EA, the predicted impact was up to 63m^3/d and accordingly the refined model prediction is consistent with previous findings.

The partitioning of “take” from the various water sources is presented in Section 7.

6. POTENTIAL IMPACTS FOR LW105 TO LW107B EXTRACTION

6.1 Subsidence

6.1.1 Original Mine Plan

Predicted subsidence from the extraction of ULD LW105 to LW108 is presented on Figure 33 and is summarised on Table 3.1.

The maximum predicted subsidence following ULD extraction is 4.0m for LW105, LW106A and LW107A, 4.3 to 4.5m for LW106B and LW107B, respectively, and 4.4m for LW108.

6.1.2 Revised Mine Plan

An amended mine plan is proposed for the LW104 to LW107B extraction plan. Key changes involve the removal of LW108 in favour of an increased extraction width of LW107B, and the shortening of LW105 due to geological constraints.

SCT (2014) undertook an assessment of the implications that the removal of LW108 and widening of LW107B would have on subsidence above the extracted panels. SCT concluded that for the revised mine plan, subsidence parameters (maximum subsidence, tilt, and strain) would generally be equal to, or less than, those for the previously assessed mine plan. The removal of LW108 from the mine plan would also result in a reduced area to be affected by subsidence.

Similarly the reduced length of LW105 will also result in a reduction of the overall magnitude of subsidence above the areas of LW105 that will not be extracted.

Given that there will not be any increase in the area to be affected by multi-seam subsidence, or any increase in maximum, subsidence, tilt or strain, and also given the fact that monitoring to date shows the magnitude of observed maximum subsidence to be of the order of 20 to 25% less than predicted, the subsidence assessment presented in the 2012 ULD Extraction Plan for LW105 to LW108 and the subsequent groundwater modelling and impact assessment, is considered to be conservative and still valid for the current mine plan.

6.2 Surface Water Impacts

6.2.1 Fluvial Geomorphology

An assessment of impact from subsidence on the fluvial geomorphology of Bowmans and Glennies creeks was undertaken by Fluvial Systems for the 2009 Bowmans Creek EA. The assessment concluded that there were no implications for fluvial geomorphology in Bowmans Creek, however, whilst no direct effects on the fluvial geomorphology in Glennies Creek were anticipated, the assessment identified a small potential risk for slumping on the steeper banks of Glennies Creek. It is noted that following the extraction of LW101 and LW102 in the ULD, there have been no observed mass movement or slumping of the banks of Glennies Creek.

No further risks are posed to Glennies Creek or the Hunter River arising from the extraction of ULD LW105 to LW107B, as the mine plan is located such that there would be no subsidence cracking beneath the water courses or their associated alluvium. The reduced length of LW105 and increased start position away from the Hunter River will also further reduce the potential for impacts on the Hunter River.

No impacts to the fluvial geomorphology of Bowmans Creek are anticipated as a result of the extraction of ULD LW105 to LW107B.

6.2.2 Impact on Geomorphology and Flooding

Free draining landform

Subsidence above longwall panels is predicted to cause localised changes in surface topography and may impede the natural drainage between subsidence troughs. To date subsidence monitoring has shown the subsidence predictions to be conservative, however, some disruption of local drainage above the longwalls can still be expected and either the excavation of drainage channels between subsidence troughs, or infilling of locally affected areas may be required. Indicative remedial works following full subsidence in the ULD seam are indicated on Figure 34. Without full subsidence at the southern end of LW105, some modification to the indicative remedial works may be required.

Flooding

The 100 year ARI flood extent for Bowmans Creek is presented on Figures 6 and 7.

Hyder (2009) indicated that subsidence resulting from longwall extraction would significantly increase floodplain storage leading to areas of ponding and attenuation of peak flows entering the Hunter River in larger events such as the 20 year and 100 year ARI.

However, as the magnitude and extent of subsidence is predicted to be equal to, or less than, that of the approved mine plan, no additional impacts on flooding are anticipated. The revised mine plan would result in a slightly wider area of inundation above LW107B and a reduced depth and area of inundation above LW105.

The potential for surface water inflow to the underground mine as a result of mining beneath the Bowmans Creek floodplain during ULD LW106 to LW108 was assessed as part of the 2012 GIA. The presence of large subsidence troughs within the Bowmans Creek floodplain has the potential to cause large volumes of water to “pond” in the subsidence troughs and drain into the mine workings via connective cracking if flooding occurs within the floodplain. In order to prevent this, the project includes proposals to first rehabilitate surface cracking, and where practical, to reshape subsidence troughs to create a “free draining” landscape to promote surface water flows to the downstream creek channel or floodplain.

Potential inflow to the underground from inundation of the troughs was assessed to be in the range of up to 4.3L/s (0.37ML/d). For the current mine plan this is considered to be reasonable.

As well as inundation of subsidence troughs, it is noted that a large flood event would also replenish any depleted alluvial aquifers as was observed in the BCA aquifer following the completion of LW6B extraction.

6.2.3 Impact on Water Quality and Salinity

Consistent with previous assessments, the extraction of ULD LW105 to LW107B is not anticipated to have any detrimental impacts on surface water quality.

6.3 Groundwater Impacts

6.3.1 Mine Inflows

Predicted dewatering volumes are provided on Figure 32. During the recalibration of the groundwater model (RPS, 2014b); it was found that it was not possible to calibrate the model to both water level and inflows observed following LW6B extraction within the constraints of the currently available data.

It is considered likely that the inflows observed following LW6B extraction, may be associated with elevated permeabilities within the shallow Lemington seams. With this in mind it is possible that a similar inflow event may be expected during the extraction of LW106B. Monitoring data in the vicinity of LW6B, notably WMLC361, indicate that significant depressurisation of the intermediate Lemington seams has already occurred, substantially reducing the head and storage that would be available to drive further inflows.

It is therefore considered reasonable to expect that short to medium term inflows of up to six month duration, as observed following LW6B, may be expected to occur associated with undermining LW6B, and that peak inflows of the order of 50% in excess of predicted values may be expected to occur.

The revised mine plans are not anticipated to result in any significant change to the overall predicted inflows.

6.3.2 Groundwater Level Impacts

Predicted maximum drawdowns within the BCA, GCA, and HRA at the end of mining in ULD, for the 2009 EA, 2012 GIA, and 2014 model update are tabulated on Table 6.1.

Table 6.1: Predicted Maximum Drawdowns (End ULD)

	2009 EA	2012 GIA	2014 Model Update
Bowmans Creek Alluvium	Largely Desaturated (>4.00 m)	4.00 m	3.50 m
Glennies Creek Alluvium	1.00 m	1.00 m	<0.50 m
Hunter River Alluvium	0.50 m	0.50 m	<0.50 m

Modelling results from the 2012 GIA and the 2014 model update in terms of groundwater drawdowns in alluvial aquifers are generally very consistent and are within the approved impacts of the 2009 EA. The 2012 assessment is the more conservative of the two and is considered the most appropriate assessment for comparison of future mining related drawdown within the alluvial aquifers. Predicted groundwater drawdown in the alluvium and regolith layer (Layer 1) at the end of ULD mining from the 2012 GIA is presented on Figure 35.

With the revised mine plan, no significant changes to the predicted alluvial drawdown is anticipated above LW107B, while the reduced LW105 is likely to result in slightly less drawdown in the HRA at the southern end of LW105 and adjacent LW106A.

6.3.3 Baseflow Impacts

Predicted baseflow impacts to Bowmans Creek, Glennies Creek and the Hunter River at the end of mining in ULD, for the 2009 EA, 2012 GIA, and 2014 model update are tabulated on Table 6.2.

Table 6.2: Predicted Baseflow Impacts (End ULD)

	2009 EA	2012 GIA	2014 Model Update
Bowmans Creek	1.2 L/s	0.86 L/s	1.53 L/s
Glennies Creek	Nil	3.00 L/s	0.88 L/s
Hunter River	0.5 L/s	0.23 L/s	1.01 L/s

Based on observed water level responses within the respective alluvial aquifers, the predicted baseflow impacts from the most recent model update are considered to be the best representation of what is likely to occur. Baseflow impacts of the order of 1.5L/s reduction in Bowmans Creek and 1L/s or lower reductions in the Hunter River and Glennies Creek are anticipated. It is noted that only in Bowmans Creek does the predicted impact represent an actual loss of water from the creek. For Glennies Creek and the Hunter River, the predicted impacts represent a net reduction in the baseflow contribution to the surface water feature, with both cases remaining as “gaining” water courses in the vicinity of the ACP.

The revised mine plan is not anticipated to result in any significant changes to the predicted baseflow impacts as the revised longwall layouts are not in the vicinity of the river channels and will not result in any significant changes to alluvial drawdowns. It is noted, however, that any changes that do occur would be beneficial and would act to reduce the overall baseflow impacts.

6.3.4 Groundwater Quality

No detrimental impacts on groundwater quality are anticipated as a result of the extraction of ULD LW105 to LW107B. As has been observed following the extraction of the PG seam, the depressurisation of the Permian strata has resulted in a reduction of saline water input to the shallow groundwater system. This same result will continue with the extraction of the ULD seam.

6.3.5 Groundwater Dependent Ecosystems

Figure 35 shows the predicted drawdown in the vicinity of the River Red Gum stands on Bowmans Creek and Glennies Creek to be less than 0.1m following the extraction of the ULD seam. No detrimental impacts on these GDEs are anticipated resulting from mining of the ULD seam.

6.3.6 Other Groundwater Users

No detrimental impacts are predicted from the mining operation on surrounding registered groundwater licence holders.

6.3.7 Implications of Revised Mine Plans

It is anticipated that the revised mine plans, such as the removal of LW108 in favour of an increased width of LW107B, and the shortening of LW105, will act to reduce the overall impacts from mining.

7. LICENSING

7.1 Water Sharing Plans

Water licensing is administered under the *Water Management Act* 2000 and *Water Act* 1912.

Access to surface water and alluvial licences at ACP is governed by the *Water Sharing Plan for the Hunter Regulated River Water Source* 2003 (HRRWS 2003) and the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources* 2009 (HUAWS 2009).

Access to hard-rock licences at ACP is governed by the *Water Act* 1912 as the draft *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources* is yet to commence.

7.1.1 HRRWS 2003

There are three management zones within the HRRWS 2003. Each of these management zones is of relevance to the ACP.

- Management Zone 1 – all of the HRRWS upstream of the junction of the Hunter River and Glennies Creek.
- Management Zone 2 – all of the HRRWS downstream of the junction of the Hunter River and Glennies Creek.
- Management Zone 3 – all of the HRRWS within the catchment of Glennies Creek.

Flow Classes and Environmental Water Provisions (Cease to Pump)

Not applicable to the HRRWS 2003 since surface water licences are governed by "security class" of respective licences.

Licence Dealings

The constraints to dealings within this Plan are specified in HRRWS 2003, ss. 52-58.

<u>Trading</u>

Of relevance to ACP is the constraint to trading between management zones within the water source. The relevant sections, s. 53 (5) and (6) are presented below.

> "53 Rules relating to constraints within this water source.
>
> (5) Assignment of water allocations from a water allocation account of an access licence nominating water supply works in management zone 2 or management zone 3 to a water allocation account of an access licence nominating water supply works in Management Zone 1 shall be prohibited if, in the opinion of the Minister:
>
> (a) this would place the supply of water allocations already in the water allocation accounts of access licences nominating water supply works in Management Zone 1 at any risk, or
>
> (b) it would place the future reliability of supply to access licences nominating water supply works in Management Zone 1 at a significant risk.
>
> (6) Assignment of water allocations from a water allocation account of an access licence nominating water supply works in Management Zone 1 or Management Zone 2 to a water allocation account of an access licence nominating water supply works in Management Zone 3 shall be prohibited if, in the opinion of the Minister:
>
> (a) this would place the supply of water allocations already in the water allocation accounts of access licences nominating water supply works in Management Zone 3 at any risk, or
>
> (b) it would place the future reliability of supply to access licences nominating water supply works in Management Zone 3 at a significant risk."

There is also a general restriction to trading into or out of the water source. The relevant sections are s. 57 (2) and (3) and are presented below.

"57 Rules for water allocation assignment between water sources.

(2) Water allocations from the water allocation account of an access licence in this water source may not be assigned to the water allocation account of an access licence in any other water source.

(3) Water allocations from the water allocation account of an access licence in any other water source may not be assigned to the water allocation account of an access licence in this water source."

Conversion of Licences

Of potential interest to ACP are the rules governing conversion of licence category. The relevant sections are s. 55 (5) and (6), and are presented below.

"55 Rules for conversion of access licence category.

(5) On application of the access licence holder, the Minister may cancel a regulated river (general security) access licence or a regulated river (high security) access licence, and issue a major utility access licence subject to:

(a) the application of a conversion factor established by the Minister and published in an Order made under section 71Z of the Act that protects the environmental water, domestic and stock rights, native title rights and the reliability of supply to all other access licences in this water source, and

(b) the volume of water in the regulated river (general security) access licence or regulated river (high security) access licence water allocation account being equal to or greater than its share component volume.

Note. The volume of water in the regulated river (general security) access licence or regulated river (high security) access licence water allocation account which is in excess of the share component volume of the new regulated river (major utility) access licence will not be credited to the new regulated river (major utility) access licence water allocation account.

(6) On application of the access licence holder, the Minister may cancel a regulated river (general security) access licence, and issue a regulated river (high security) access licence, subject to:

(a) the application of a conversion factor established by the Minister and published in an Order made under section 71Z of the Act that protects the environmental water, domestic and stock rights, native title rights and the reliability of supply to all other access licences in this water source, and

Note. Assessments indicate that a conversion factor of 1/3 should be used, which would result in 1 Megalitre of regulated river (high security) access licence share component resulting from conversion of 3 Megalitres of regulated river (general security) access licence share component.

(b) the volume of water in the regulated river (general security) access licence water allocation account being equal to or greater than its share component volume.

Note. The volume of water in the regulated river (general security) access licence water allocation account which is in excess of the share component volume of the new regulated river (high security) access licence will not be credited to the new regulated river (high security) access licence water allocation account."

7.1.2 HUAWS 2009

There are three water sources within the HUAWS 2009 that are of relevance to the ACP. Some water sources in the HUAWS 2009 are divided into management zones, HUAWS 2009, s. 5 (1) (g) and (h). The management zone of each source is also indicated below.

- Hunter Regulated River Alluvial Water Source.
  - Management Zone 1 - Upstream Glennies Creek Management Zone.
  - Management Zone 2 - Downstream Glennies Creek Management Zone (*not relevant to ACP*).
  - Management Zone 3 - Glennies Creek Management Zone.
- Glennies Water Source.
- Jerrys Water Source.
  - Jerrys Management Zone.
  - Appletree Flat Management Zone (*not relevant to ACP*).

Flow Classes and Environmental Water Provisions (Cease to Pump)

The declaration of flow classes for all surface water licences is presented in HUAWS 2009, s. 17 (1).

> "17 Flow classes for these water sources.
>
> (1) This Plan establishes the following flow classes as the basis for sharing of daily flows from these water sources:
>
> Note. The following flow classes apply to all access licences extracting from surface water specified for each water source from the commencement date of this Plan, excluding those access licences to which clause 19 (3) (i) applies and access licences that nominate a work that is a runoff harvesting dam."

Flow classes also apply to existing aquifer access licence holders in the Jerrys Management Zone of the Jerry Water Source and the Glennies Water Source and is presented in HUAWS 2009, s. 17(1).

> "… Note. They will also apply to all existing aquifer access licence holders in the Isis River Water Source,…, the Jerrys Management Zone of the Jerrys Water Source, the Glennies Water Source,.. and the Dora Creek Water Source extracting from alluvial aquifers within 40 metres of the top of the high bank of the river from year six of this Plan…"
>
> Flow classes to do apply to aquifer access licences outside of 40m from the top of the high bank, with exception where there has been conversion from unregulated river to an aquifer licence. The relevant section is HUAWS 2009, s. 17(1).
>
> "… Note. …For those aquifer access licences extracting outside the 40 metres from the top of the high bank in the Isis River Water Source,…, the Jerrys Water Source, the Glennies Water Source,…and the Dora Creek Water Source, the flow classes in clause 17 (1) will not apply, except where provided for under clause 68 (3) of this Plan."

The relevant clause governing translation from unregulated river to aquifer access licence is presented in HUAWS 2009, s. 68(3).

> "68 Access licences which nominate a water supply work which may be used to take water from the alluvial sediments in these water sources
>
> (3) Any aquifer access licence arising from a dealing involving the conversion of an unregulated river access licence to an aquifer access licence, under Part 12 of this Plan, shall be subject to the same access rules as unregulated river access licences for the corresponding water source or management zone specified in clause 19 of this Plan."

The flow classes of water sources of relevance to ACP are provided below, HUAWS 2009, s. 17 (1) (y), (aa) and (tt).

> " (y) for the Jerrys Management Zone of the Jerrys Water Source, no flow classes are established by this Plan,
>
> Note. From year six of this Plan, in the Jerrys Management Zone the taking of water from pools will only be permitted when there is a visible inflow and outflow, as required under clause 19 (3) (d) of this Plan. Where higher or more stringent flow conditions currently exist on licences, these conditions will continue.
>
> …
>
> (aa) for the Glennies Water Source, as measured at the causeway on Goorangoola Creek (230 metres downstream of the boundary between DP 752462, Lot 23 and Lot 24):
>
> (i) the Very Low Flow Class is when there is no visible flow, and
>
> (ii) A Class is when there is a visible flow,
>
> …
>
> (tt) for the Hunter Regulated River Alluvial Water Source, no flow classes are established by this Plan,
>
> Note. The augmentation of the local water utility in this water source may trigger review of the flow access rules specified within this Plan in accordance with clause 17 (2) (l)."

Planned environmental water is maintained through use of cease to pump/take where water must not be taken when flows are in the relevant Very Flow Class and is presented in HUAWS 2009, s. 19 (3) (a).

> "19 Planned environmental water
>
> (3) Subject to subclause (8), the planned environmental water established in subclause (1) (b) is maintained as follows:
>
> (a) subject to paragraph (i), water must not be taken under an access licence with a share component that specifies a water source or an extraction component that specifies a management zone with a Very Low Flow Class that has commenced, when flows are in the relevant Very Low Flow Class."

Of relevance to ACP is an exception to the application of planned environmental water provisions where aquifer access licences are used only to account for the take of water in association with aquifer interference activity, HUAWS 2009, s. 19 (8).

> "(8) Subclause (3) does not apply to the taking of water under an access licence that is used only to account for the taking of water in association with an aquifer interference activity."

Licence Dealings

The constraints to dealings within the Plan are specified in HUAWS 2009, ss. 69-74.

Trading

Of relevance to ACP is restriction of trade within water sources from outside of 40m from the top of the high bank of a river to within 40m from the top of the high bank of a river with respect to Jerrys Water Source and Glennies Water Source, as presented in HUAWS 2009, s. 70 (2) (c) & (k).

> "70 Rules relating to constraints within these water sources
>
> (2) The dealings specified in subclause (1) are prohibited if:
>
> (c) the dealing involves an assignment of access rights under section 71Q of the Act, or an allocation assignment under section 71T of the Act from an aquifer access

licence that nominates a water supply works which may be used to take water from the alluvial sediments in these water sources, which is located more than 40 metres from the top of the bank of a river to an aquifer access licence that nominates a water supply work which may be used to take water from the alluvial sediments in these water sources, which is located within 40 metres from the top of the bank of a river, in the Isis River Water Source,…, the Jerrys Water Source, the Glennies Water Source,…or the Dora Creek Water Source,

…

(k) the dealing involves an access licence that nominate a water supply works which may be used to take water from the alluvial sediments in these water sources, which is located more than 40 metres from the top of the bank of a river being amended under section 71W of the Act to nominate a water supply work which may be used to take water from the alluvial sediment in these water sources which is located within 40 metres from the top of the bank of a river, in the Isis River Water Source,…, the Jerrys Water Source, the Glennies Water Source,…and the Dora Creek Water Source,"

There is a similar restriction on trade within the Hunter River Regulated Alluvial Water Source from outside of 200m from the top of high bank to within 200m from the top of high bank and vice versa, and is presented in HUAWS 2009, s. 70 (2) (d) & (e) and (l) & (m).

There is restriction on assignment and allocation between management zones of the Hunter Regulated River Alluvial Water Source and is presented in HUAWS 2009, s. 70 (2) (g), (h) & (i) and (3) (j) (xii) & (xiii). These are not listed here because, as will be shown, there is no net "take" from the Hunter Regulated River Alluvial Water Source and there are also no licences currently held in this water source. As such, the above restrictions are not directly relevant to ACP.

There are restrictions on dealings involving redistribution of access licences from a currently nominated water supply works within a water source, and is presented in HUAWS 2009, s. 70 (2) (j) (vii) & (xi).

""70 Rules relating to constraints within these water sources

(2) The dealings specified in subclause (1) are prohibited if:

(j) the dealing involves an access licence that currently nominates a water supply works in:

(vii) the Muswellbrook Water Source, the Jerrys Water Source,…, the Newcastle Water Source, being amended under section 71W of the Act to nominate a water supply work in a different tributary within the water source,

…

(xi) the Murmurra River,…, Hunter Regulated River Alluvial Water Source,,…and the Lower Goulburn River Water Sources, being amended under section 71W of the Act to nominate a water supply work in an area which is subject to an order under section 324 of the Act,"

There are general restrictions on trade between water sources and is presented in HUAWS 2009, s. 71 (2), (3), (4) & (6). Of potential interest to ACP may be an exception on dealings to change a water source where both access licences involved in the dealing nominates the same water supply work or the nominated work supply works exist on adjoining areas of land owned by the same person.

"71 Rules for change of water source

(2) Dealings under section 71R and 71W of the Act to change the water source to which an access licence applies are prohibited in these water sources if:

(a) the dealing involves a change of water source from one extraction management unit to another extraction management unit, and

(b) the dealing is from any water source within the Goulburn, Lake Macquarie or Hunter Extraction Management Units, except for:

(i) dealings from the Upper Wollombi Brook to the Lower Wollombi Brook Water Sources, and

(ii) dealings into the Krui River,…, the Jerrys,…and the North Lake Macquarie Water Sources, provided that the dealing does not cause the sum of all access licence share components in the respective water sources to exceed the sum of all access licence share components for the water source at the commencement of this Plan.

Note. Dealings between regulated river access licences and aquifer access licences may be allowed in future Water Sharing Plans. The Water Sharing Plan for the Hunter Regulated River Water Source 2003 does not currently allow for dealings between alluvial and regulated river access licences. These rules should be reviewed at the term of this Plan.

(3) Dealings under section 71R and 71W of the Act to change the water source to which an access licence applies are prohibited in these water sources if the dealing involves an unregulated river (high flow) access licence.

(4) Dealings under section 71R and 71W of the Act to change the water source to which an access licence applies are prohibited in these water sources if the dealing would result in the total extraction pursuant to access licences which nominate a water supply works which may be used to take water from the alluvial sediments in these water sources, plus basic landholder rights extraction would require a temporary water restriction order to be made under section 324 (2) of the Act.

…

(6) Dealings under section 71R and 71W of the Act to change the water source to which an access licence applies are prohibited except where both access licences involved in the dealing:

(a) nominate the same water supply work, or

(b) the nominated water supply work exists on the same area of land owned by the same person, or

(c) the nominated water supply work exists on adjoining areas of land owned by the same person.

Note. This is to allow for dealings to occur on a property, where the given property extends over two or more water sources, to allow for the reasonable movement of water around the property."

<u>Conversion of Licences</u>

Of potential interest to ACP are the rules governing conversion of licence category. The relevant section is HUAWS 2009, s. 72 (2), (3) & (4). In general unregulated river licences can be converted to aquifer access licences on an equal share basis, but conversion from aquifer access to unregulated river is only permitted for the Jerrys Water Source and the Hunter Regulated River Alluvial Water Source.

"72 Rules for conversion of access licence category

(2) Conversion of an access licence of one category to an access licence of another category is permitted only if the conversion is from:

(a) an unregulated river access licence to an aquifer access licence in these water sources,

(b) an aquifer access licence to an unregulated river access licence in the Martindale Creek,…, the Jerrys, the Hunter Regulated River Alluvial,…or the Lower Goulburn River Water Sources,

(c) an unregulated river access licence to an major utility access licence, or

…

(3) For any conversion of an access licence under subclause (2), the access licence being converted shall be cancelled and a new licence issued.

(4) The share component on an access licence issued under subclause (2) (a), (b), and (c) is to be equal to the cancelled access licence share component."

7.1.3 *Water Act 1912*

Conditions in regard to hard-rock licences are specified on individual licence certificates. In general, access licences specify the volumetric limit of take, usually informed by analysis, to demonstrate the requested yield which can be sustainably achieved, and the details as to the specific parcel of land to which the access licence is tied.

7.2 Current Licences

Table 7.1 provides a summary of the water licences currently held by ACP (Ashton, 2013).

Table 7.1: Current Water Licences

Water Sharing Plan / Water Source	Licence No.	Water Access Limit (ML/y)
Hunter Regulated River Water Source 2003:		
Glennies Creek		
High Security	WAL8404 (Zone 3A)	80
	WAL997 (Zone 3A)	11
	Total	91
General Security	WAL15583 (Zone 3A)	354
	WAL872 (Zone 3A)	12
	WAL984 (Zone 3A)	9
	Total	375
Supplementary	WAL1358 (Zone 3A)	4
	Total	4
Hunter River		
High Security	WAL1120 (Whole Water Source)	3
	WAL19510 (Zone 1B)	130
	Total	133
General Security	WAL1121 (Zone 1B)	335
	Total	335
Supplementary	WAL6346 (Whole Water Source)	15.5
	Total	15.5
Hunter Unregulated and Alluvial Water Sources 2009:		
Hunter Regulated River Alluvial Water Source		
Unregulated River	NIL	0
Aquifer Access	NIL	0
	Total	0
Glennies Water Source		
Unregulated River	NIL	0
Aquifer Access	NIL	0
	Total	0
Jerrys Water Source		

Water Sharing Plan / Water Source	Licence No.	Water Access Limit (ML/y)
Unregulated River	WAL23912	14
	WAL29565	266
	Total	280
Aquifer Access	WAL29566	358
	Total	358
Water Act 1912:		
Hard-Rock	20BL169508 (Mine Dewatering –Portal)	100
	20BL171364 (Mine Dewatering - BH01)	511
	20BL172482 (Mine Dewatering - BH02)	
	20BL173302 (Mine Dewatering - BH03)	
	20BL173418 (Mine Dewatering - BH04)	
	Total	611

7.3 Partitioning

As outlined in the NSW Aquifer Interference Policy (NSW Office of Water, 2012), where an aquifer interference activity causes "take" from an adjacent water source, a licence is required to be held in the adjacent water source to account for that take. In the case of the ACP, the nominated water supply work is mine dewatering from the hard-rock.

There are three water sources in the HUAWS 2009, one water source (two management zones – Hunter River upstream of junction with Glennies Creek and Glennies Creek) within the HRRWS 2003 as well as Hard-Rock under the *Water Act* 1912.

Table 7.2 presents the adopted nomenclature for what is referred to on-site as Hunter River, Hunter River Alluvium, Bowmans Creek, Bowmans Creek Alluvium, Glennies Creek, Glennies Creek Alluvium and Hard-Rock in terms of relevant water sources from a licensing point of view.

Table 7.2: Adopted Nomenclature for Various Water Sources

Water Sharing Plan / Source	Licence Class	Local Reference	Adopted Abbreviation
HRRWS 2003:			
Glennies Creek	High Security, General Security and Supplementary	Glennies Creek	GC_
Hunter River	High Security, General Security and Supplementary	Hunter River	HR_
HUAWS 2009:			
Hunter Regulated River Alluvial Water Source	Unregulated River	Not used[a]	-
	Aquifer Access	Hunter River Alluvium	HRA
Glennies Water Source	Unregulated River	Not used[a]	-
	Aquifer Access	Glennies Creek Alluvium	GCA
Jerrys Water Source	Unregulated River	Bowmans Creek	BC_
	Aquifer Access	Bowmans Creek Alluvium	BCA
Water Act 1912:			
Hard-Rock	Hard-Rock	Hard-Rock	H-R

a. It has been assumed in the groundwater model that all take from the Hunter River and Glennies Creek pertains to the HRRWS 2003.

Mine dewatering at ACP in the hard-rock leads to increased exchange from alluvial groundwater to the hard-rock. In turn, the "take" from the alluvial groundwater source is replenished from surface water sources. As will be presented, in the case of GCA, there is no net "take" from the alluvium since increased exchange from alluvium to hard-rock is fully replenished from the GC surface water source. For BCA, the increased exchange from alluvium to the hard-rock is only partially replenished from the BC surface water source.

Partitioning of dewatering activity at ACP was undertaken using the results from groundwater modelling. Figure 36 presents the demarcation of various groundwater sources, defined via the MODFLOW Hydrostratigraphic Unit (HSU) module. The United States Geological Survey zone budget program, ZonBud V3.01, was used to process the MODFLOW output files.

Table 7.3 presents a summary of partitioned take from various water sources in the period March 2014 – December 2026. Detailed model output with respect to partitioning of prediction simulation is presented in RPS 2014b. As mining progresses to the ULLD and LBR Seams, the relative % contribution from hard-rock, presented in Table 7.4, becomes more consistent and less variable with respect to proximity to BCA and GC. This is due to mining activity moving deeper and further away from the BCA and GC water sources.

From Table 7.3, the predicted take from hard-rock during completion of mining at ACP reaches a peak of 417 Megalitres per Water Year (ML/wy). The calculated take from BC and BCA is 20ML and 10ML/wy respectively. The calculated take from GC is 27ML/wy and is 0ML/wy from GCA. The calculated take from HR is 31ML/wy and is 0M L/wy from the HRA. The predicted take from the various water sources is essentially consistent with the findings from the 2009 BCD EA.

Table 7.3: Prediction Model – Predicted Water Take by Water Year (ML)

Water Year	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27[b]
BC_	-8	-20	-15	-15	-14	-14	-15	-15	-15	-14	-14	-14	-14	-7
BCA	-4	-10	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-4
GC	-7	-20	-21	-21	-22	-23	-24	-25	-25	-26	-27	-27	-27	-14
GCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HR	-10	-29	-28	-27	-28	-28	-29	-29	-30	-31	-31	-31	-31	-16
HRA	1	2	2	2	2	2	2	2	2	2	2	2	2	1
Hard-Rock	-72	-235	-297	-306	-297	-310	-328	-372	-379	-360	-372	-400	-417	-206
Total	**-100**	**-313**	**-368**	**-377**	**-368**	**-383**	**-403**	**-448**	**-456**	**-438**	**-451**	**-479**	**-496**	**-246**
Mine Activity:	ULD_102	ULD_103	ULD_104	ULD_106A	ULD_107A	ULLD_201	ULLD_203	ULLD_204	ULLD206B	ULLD_208	LBR_302	LBR_303	LBR_306A	LBR_307B
		ULD_104	ULD_105	ULD_106B	ULD_107B	ULLD_202	ULLD_204	ULLD_205	ULLD207A	LBR_301	LBR_303	LBR_304	LBR_306B	LBR_308
			ULD_106A	ULD_107A	ULD_108			ULLD206A	ULLD207B			LBR_305	LBR_307A	
					ULLD_201				ULLD_208					

Table 7.4: Prediction Model - Predicted Water Take by Water Year (%)

Water Year	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27[b]
BC_	8.0%	6.4%	4.2%	3.9%	3.9%	3.8%	3.6%	3.3%	3.2%	3.3%	3.2%	3.0%	2.9%	3.0%
BCA	4.0%	3.2%	2.5%	2.5%	2.5%	2.4%	2.2%	2.0%	1.9%	2.0%	1.9%	1.8%	1.8%	1.7%
GC	6.6%	6.5%	5.7%	5.6%	5.9%	6.0%	5.9%	5.5%	5.6%	6.0%	5.9%	5.6%	5.5%	5.6%
GCA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
HR	9.7%	9.2%	7.5%	7.3%	7.5%	7.4%	7.1%	6.5%	6.6%	7.0%	6.9%	6.5%	6.3%	6.5%
HRA	-0.7%	-0.6%	-0.5%	-0.5%	-0.5%	-0.5%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
Hard-Rock	72.4%	75.3%	80.5%	81.2%	80.7%	80.9%	81.6%	83.1%	83.1%	82.1%	82.5%	83.5%	84.0%	83.7%

7.4 Licensing Requirement

Comparison of predicted take from various water sources presented in Table 7.3 and Table 7.4, with current licences available at ACP, presented in Table 7.1 is summarised in Table 7.5 below.

Table 7.5: Comparison of Modelled Licence Requirement and Current Water Licences

Water Sharing Plan / Source	Abbrev.	Licence Class	Current Licence Holding (ML)	Predicted Requirement (ML)
HRRWS 2003:				
Glennies Creek	GC_	High Security	91	27
		General Security	375	
Hunter River	HR_	High Security	133	31
		General Security	335	
HUAWS 2009:				
Hunter River Regulated Alluvial Water Source	N/A[a]	Unregulated	0	-
	HRA	Aquifer Access	0	0
Glennies Water Source	N/A[a]	Unregulated	0	-
	GCA	Aquifer Access	0	0
Jerrys Water Source	BC_	Unregulated	280	31
	BCA	Aquifer Access	358	17
Water Act 1912:				
Hard-Rock	H-R	Mine Dewatering	611	417

a. It has been assumed in the groundwater model that all take from the Hunter River and Glennies Creek, defined in the model as per the HRRWS 2003, pertains to the HRRWS 2003.

From Table 7.5, ACP has sufficient licences to meet its modelled requirements associated with mine inflows and dewatering, including sufficient contingency should additional short term inflows occur from either the Hard-Rock or BCA sources.

In practice, the water balance at ACP comprises more components than just groundwater / surface water interaction. The water balance includes internal transfers and storages, input requirements for mining machinery and dust suppression. Table 7.5 presents the modelled licence requirements due to mine dewatering activity (based on the model as currently configured).

7.4.1 Accumulated Goaf Water

It is noted that a significant volume of water (estimated at 390 ML) is currently accumulated in the LW6, LW7 and LW8 goaf areas that are located down gradient and not accessible to dewatering bore BH02, located to the south of the LW5 Maingate. This water will be extracted by the newly installed dewatering bore BH04A prior to the mining of LW105 to LW107 in the ULD seam.

As the water has accumulated in the workings since the seam extraction, it is proposed that this volume of water will be back accounted and applied to the last two water years, namely 2012/2013 and 2013/2014.

8. WATER MANAGEMENT

Water management at the ACP is detailed and managed under the Ashton Coal Water Management Plan (WMP) (Ashton, 2015). The WMP specifies groundwater and surface water impact assessment criteria and provides Trigger Action Response Plans for key groundwater and surface water monitoring parameters are also provided.

Groundwater and surface water monitoring programmes are also detailed in the WMP, as are the reporting and review requirements. The WMP has been recently updated to reflect changes to the groundwater monitoring network.

9. REFERENCES

Aquaterra, 2009. Bowmans Creek Diversion: Groundwater Impact Assessment Report. Report reference S55G/011G, 21 October 2009.

Ashton Coal Pty Ltd, 2015. *Water Management Plan*. Reference No. MP 3.4.1.8, Version 5, dated 14 May 2014.

Evans and Peck, 2009, *Bowmans Creek Diversion, Environmental Assessment*. Ashton Coal Operations Pty Ltd, Evans & Peck, Sydney, December

ERM, 2009. *Ashton Coal South East Open Cut – Flora and Fauna Assessment* (Appendix 10 of SEOC Project EA & Modification to the Existing Consent).

Gippel, C.J., 2009, *Flood Hydrology and Geomorphology*. Appendix 7 in Bowmans Creek Diversion, Environmental Assessment. Ashton Coal Operations Pty Ltd, Fluvial Systems Pty Ltd, October

HLA-Envirosciences, 2001, *Environmental Impact Statement Ashton Coal Project,* Prepared for White Mining Limited, Singleton

Li, G., Steuart, P., Pâquet, R. and Ramage, R. 2010. A case study on mine subsidence due to multi-seam longwall extraction. In Hagan, P. and Saydam, S. (eds) Proceedings, Second Australasian Ground Control in Mining Conference 2010, 23-24 November, The University of NSW, Sydney. The Australasian Institute of Mining and Metallurgy, Publication Series No 9/2010, Carlton, pp. 191-200.

RPS, 2014. *Ashton Coal Underground Mine Longwall 102 End of Panel Groundwater Review*. Report reference S55Q/003b, 8 December 2014.

RPS, 2014b. Ashton Coal Groundwater Model Update. Report reference S55N/022b, 9 May 2014.

RPS, 2014c. Revisions to the Groundwater Monitoring Program. Report reference S56H/004a, 2 September 2014.

RPS Aquaterra, 2012. *Upper Liddell Seam Extraction Plan, Groundwater Impact Assessment*. Report reference S55J/037f, 2 February 2012.

SCT, 2009, *Multi-seam subsidence assessment for Ashton Coal Longwalls 5 to 8*. Appendix 4 in Bowmans Creek Diversion, Environmental Assessment. Ashton Coal Operations Pty Ltd, SCT Operations Pty Ltd, October

SCT, 2011, *Subsidence assessment for Upper Liddell Seam, Longwalls 1-8 Extraction Plan*. Ashton Coal Operations Pty Ltd, SCT Operations Pty Ltd, September

SCT, 2011, *Subsidence Assessment for Ashton Coal Mine Longwalls 6B to 8 in the Pikes Gully Seam based on the Bowman's Creek Diversion Mine Plan (ASH3657)*, prepared for Ashton Coal Mine, Strata Control Technology Operations Pty Ltd, Wollongong, NSW, Australia.

Water Act 1912 No. 44 (NSW). Current version 1 January 2014. Accessed 8 May 2014.

Water Management Act 2000 No. 92 (NSW). Current version 1 January 2014, accessed 8 May 2014.

Water Sharing Plan for the Hunter Regulated River Water Source 2003 (NSW). Current version 1 January 2014, accessed 8 May 2014.

Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 (NSW). Current version 1 January 2014, accessed 8 May 2014.

FIGURES

LEGEND

- ULD Underground Mine Plan
- Pikes Gully Seam Extraction
- ULD Seam Extraction

N

250 0 250 500 750
Metres

APPROX SCALE 1:20,000 @ 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

FIGURE 1

Ashton Project Area

012a_DD01_Ashton_Coal_Project.mxd Produced: JC Reviewed: GS Date: 22/12/2014

LEGEND

- Groundwater Monitoring Site
- ULD Underground Mine Plan
- ULD Extraction
- Pikes Gully Seam Extraction
- Alluvium boundary
- Bowmans Creek Diversion
- Red River Gum
- Subsidence Survey Line

N

0 150 300 450 600
Metres

APPROX SCALE 1:17,000 @ A3

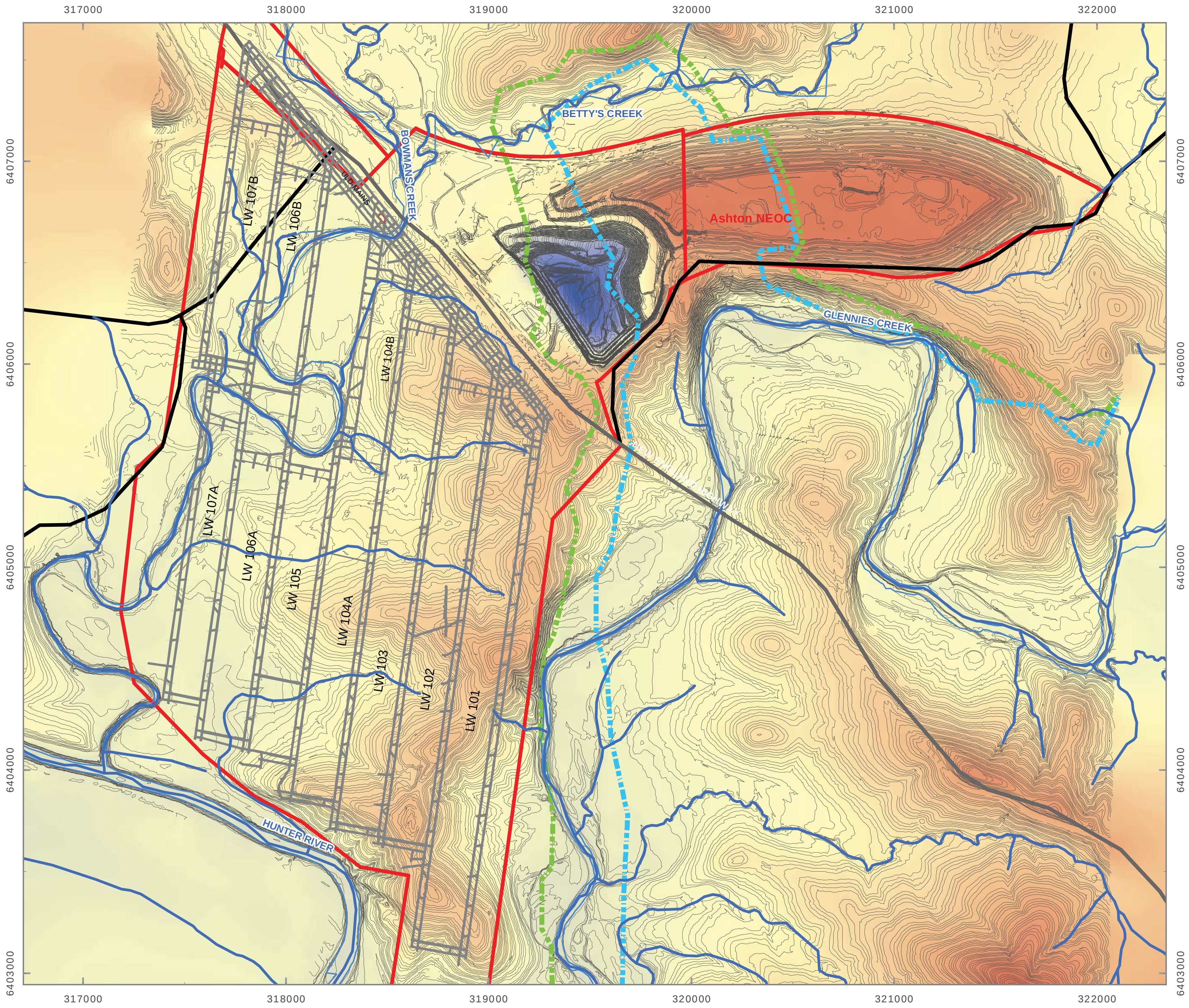
GDA 1994 MGA Zone 56

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.

FIGURE 2

Groundwater Monitoring Network

S55X_001a_DD01_Ashton_Coal_Groundwater_Monitoring_Network.mxd Produced: JC Reviewed: GS Date: 24/11/2015



LEGEND

Roads

Layer

ULD Mine Plan

Creeks

ULD Extraction

Ashton Mine Lease

topo_raster6

Surface Elevation

High : 160

Low : -30

PG Seam Outcrop

ULD Seam Outcrop

N

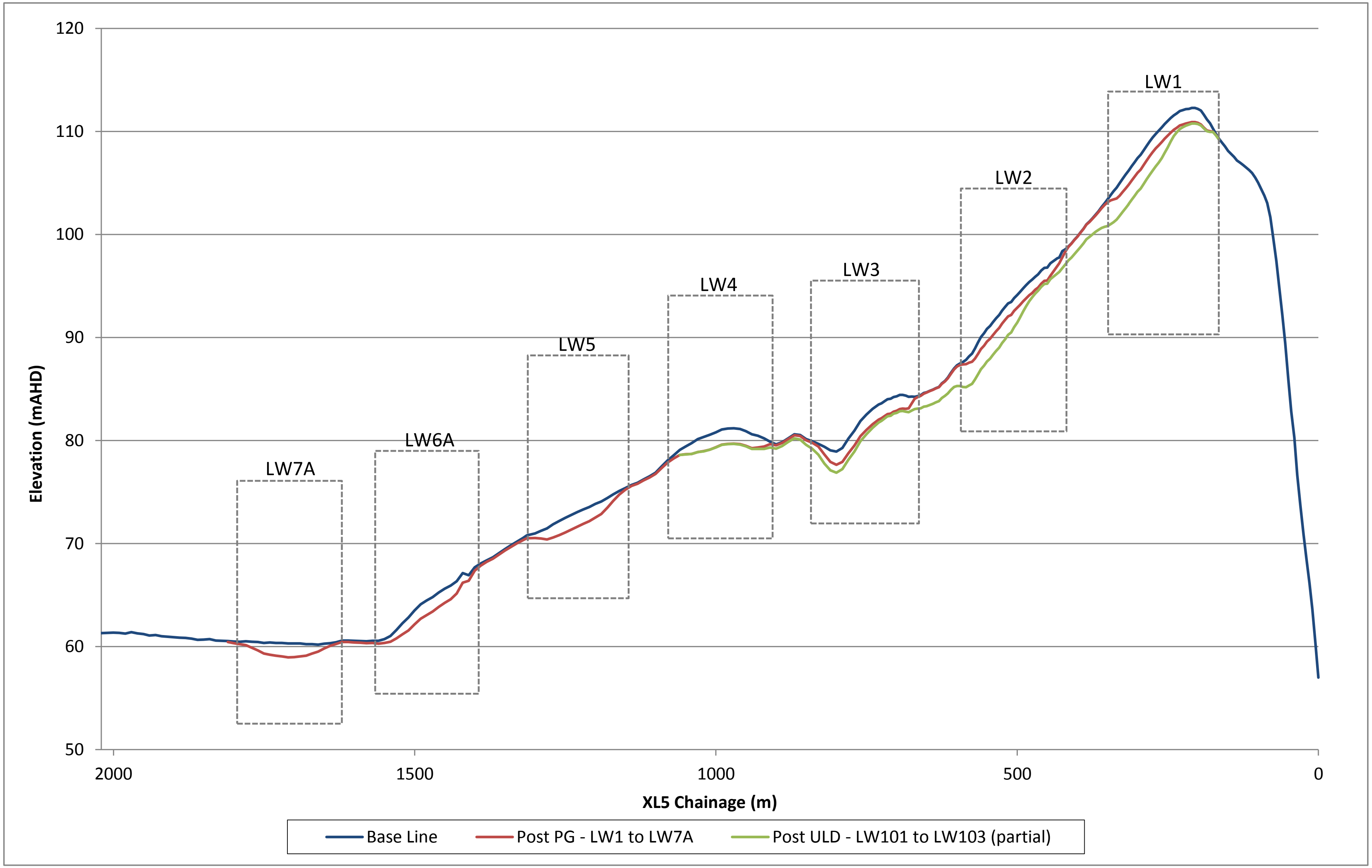
0 0.175 0.35 0.7 Kilometres

FIGURE 3

Topography and Seam Outcrop

Floodlines Compiled from Hyer 2009 and Worley Parsons 2009

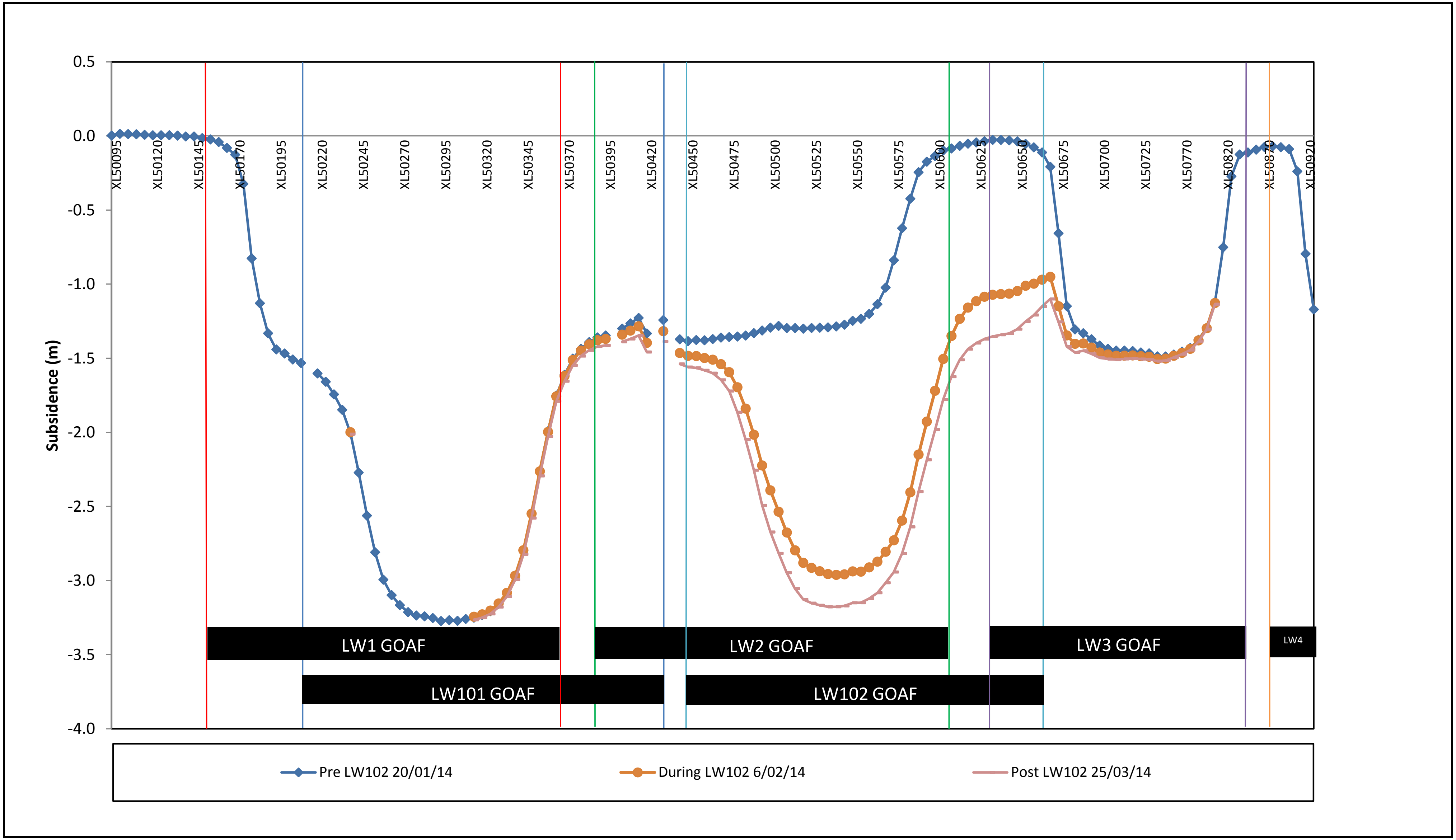
AUTHOR	JC	PROJECT NO	S55X/001a
CHECKED BY	GS	REVISION	A
DATE	24/11/2015	DRAWING NO	003



RPS

XL5 Section FIGURE 4

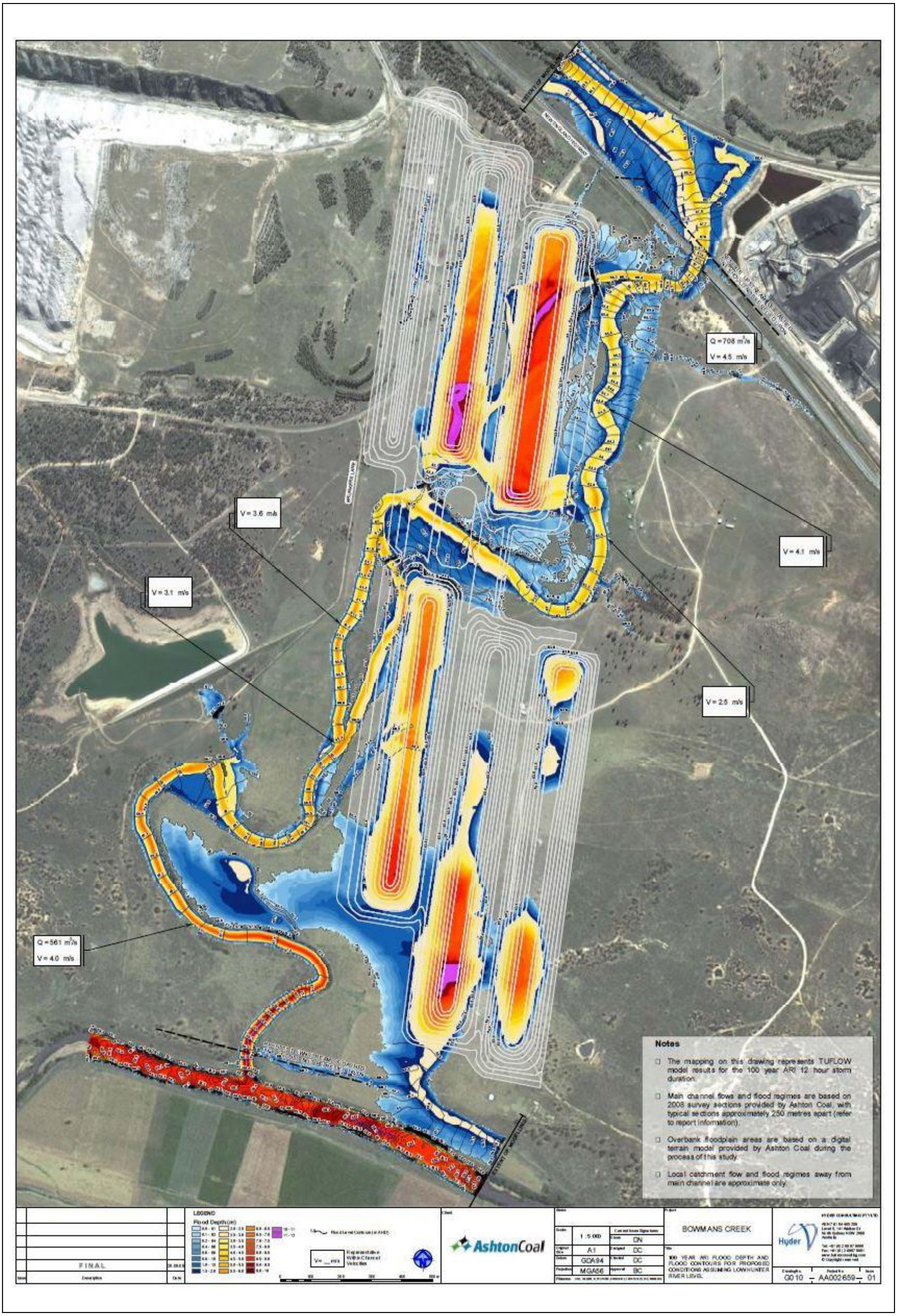
F:\Jobs\S55P\300\Subsidence\[XL5 edm tests.xlsx]Figure 4 S55P



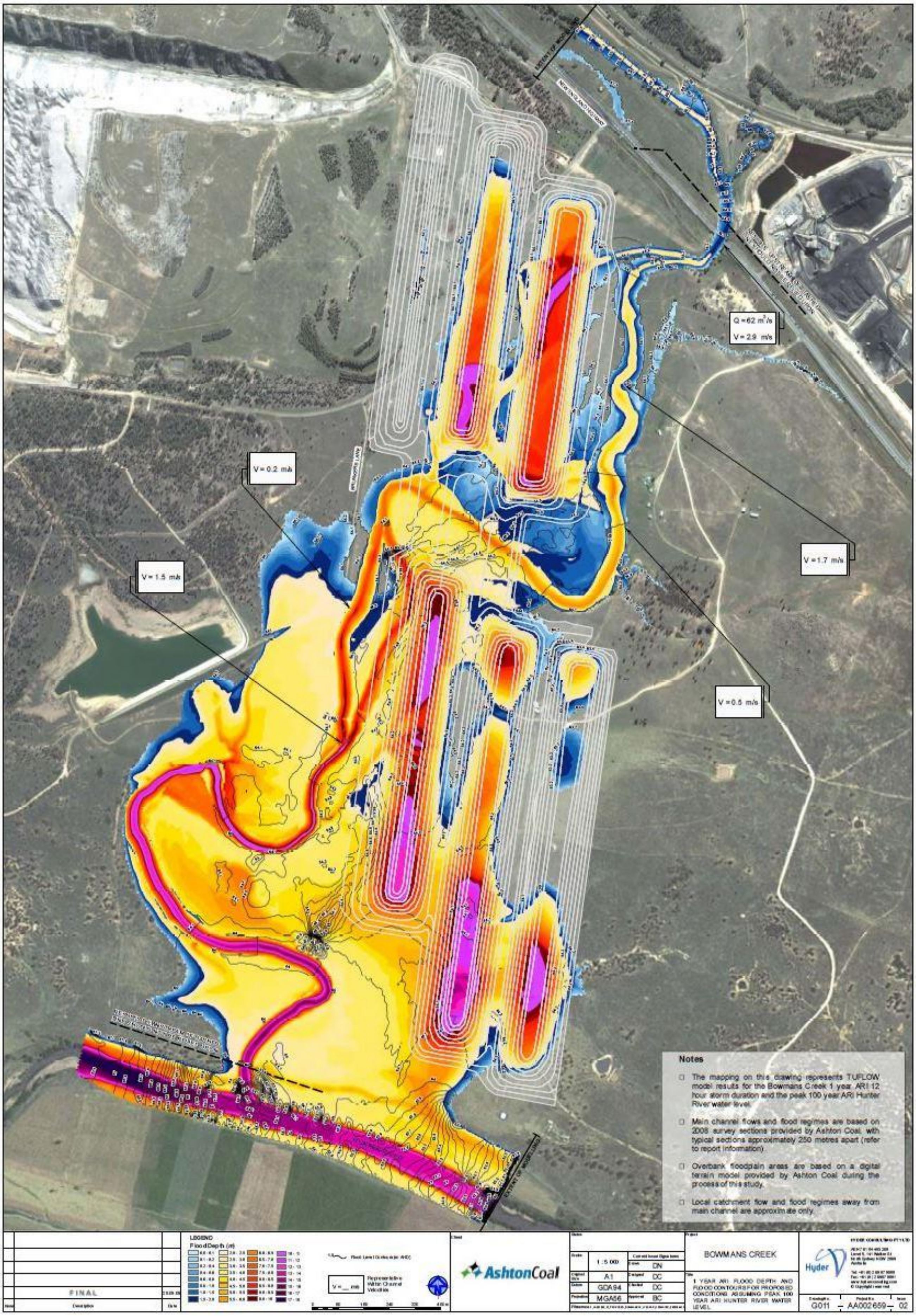
RPS

SUBSIDENCE LINE LW102 X5 FIGURE 5

F:\Jobs\S55Q\300\Excel\003a\Projects\[003a_Subsidence.xlsx]Figure 5

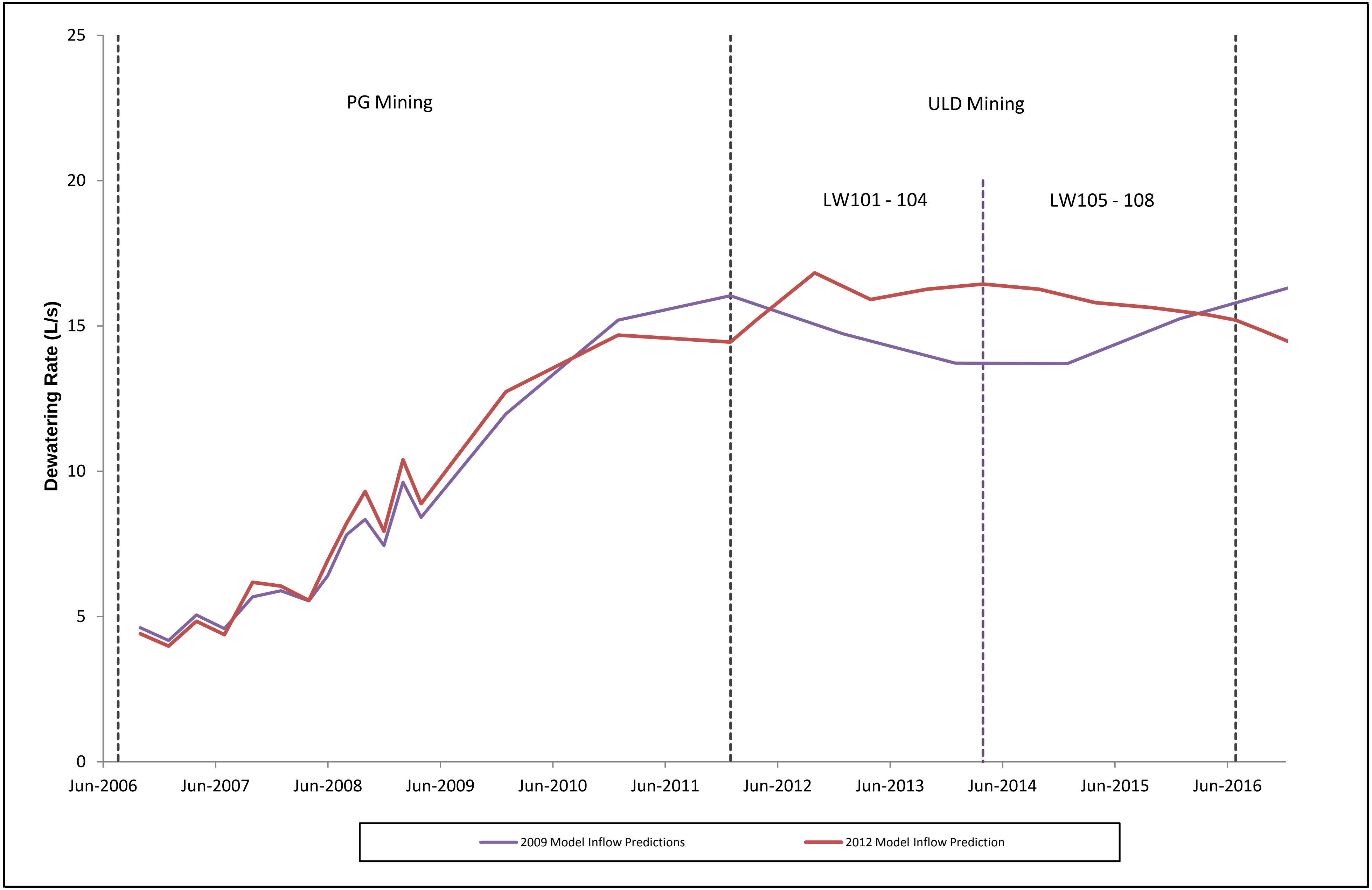


BOWMANS CREEK 100 YEAR ARI FLOOD CONTOURS FIGURE 6



RPS

HUNTER RIVER 100 YEAR ARI FLOOD CONTOURS FIGURE 7



RPS

PREDICTED INFLOWS FIGURE 8

F:\Jobs\S55P\300\Excel\Projects\012a\[predicted inflows.xls]Figure 8 S55P

LEGEND

- Surface Water Monitoring Station
- Bowmans Creek Diversion
- ULD Underground Mine Plan
- ULD Extraction
- Flow Gauging Site

N

0 250 500 750 1,000 Metres

APPROX SCALE 1:25,737 @ A3

GDA 1994 MGA Zone 56

Data Source: GIS files provided by Ashton Coal

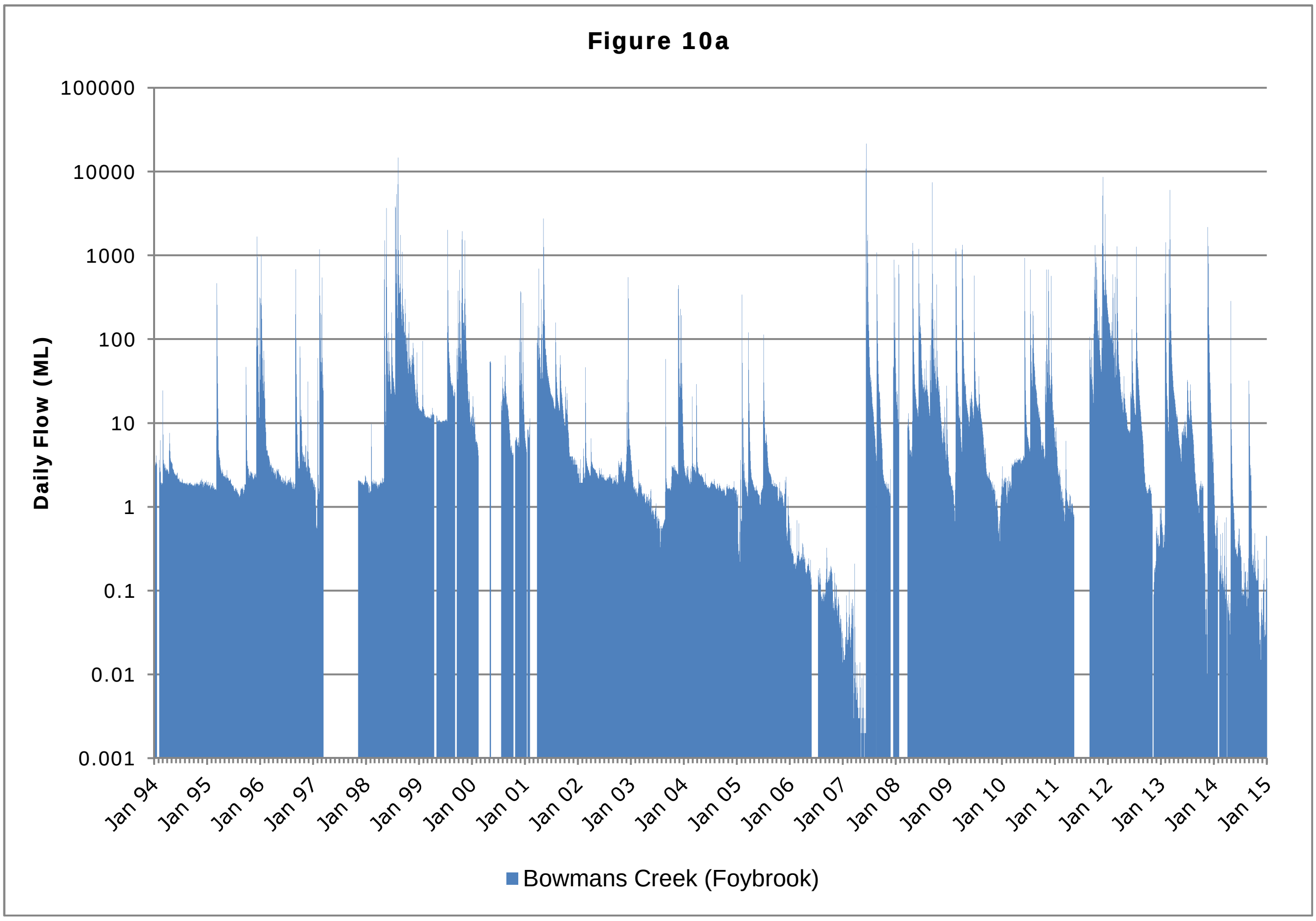
Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

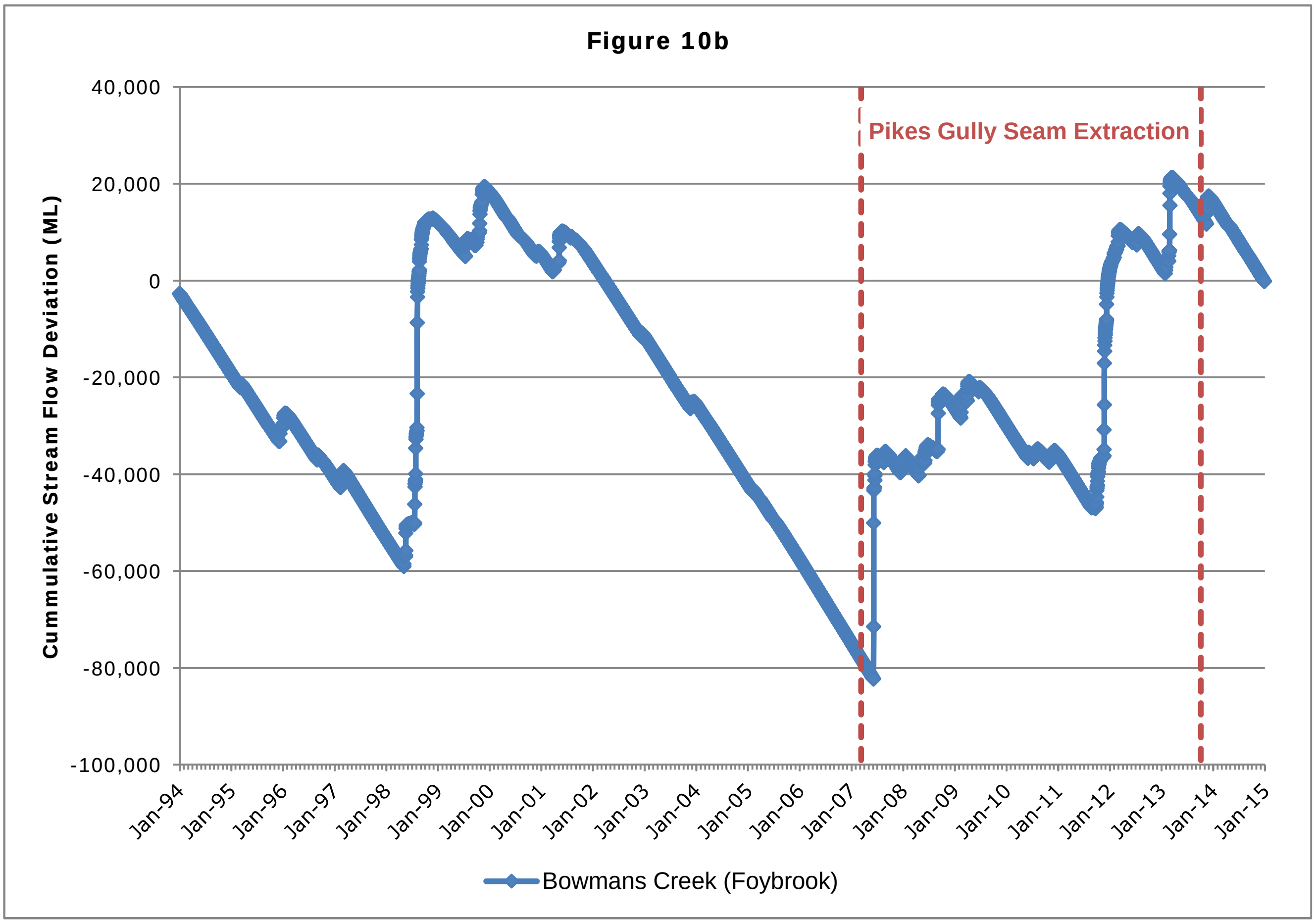
RPS

FIGURE 9

Surface Water Monitoring Network

S55X_001a_DD04_Ashton_Coal_Surface_Water_Monitoring_Network.mxd Produced: JC Reviewed: GS Date: 24/11/2015

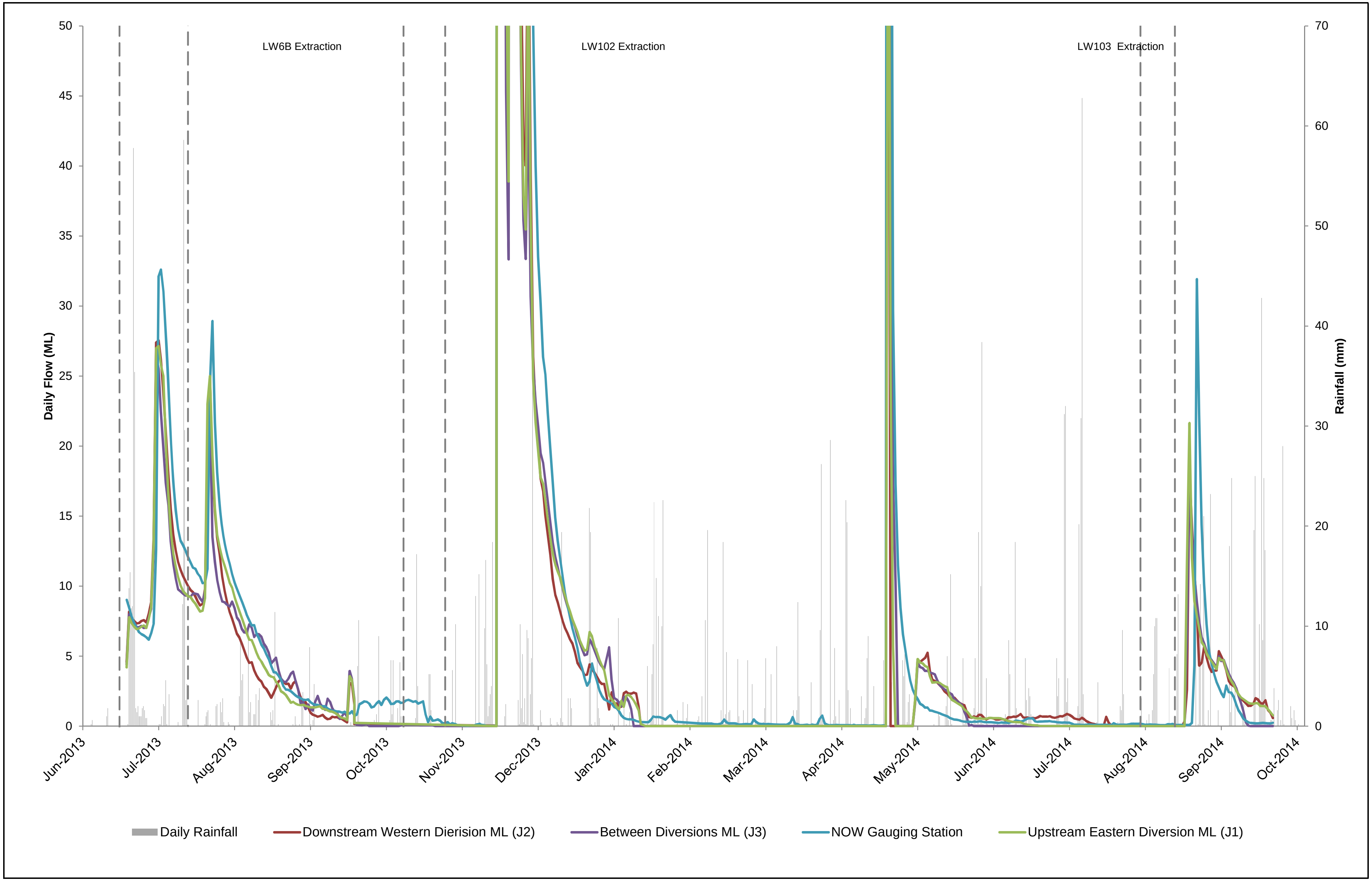




RPS

NOW Surface Water Flows FIGURE 10

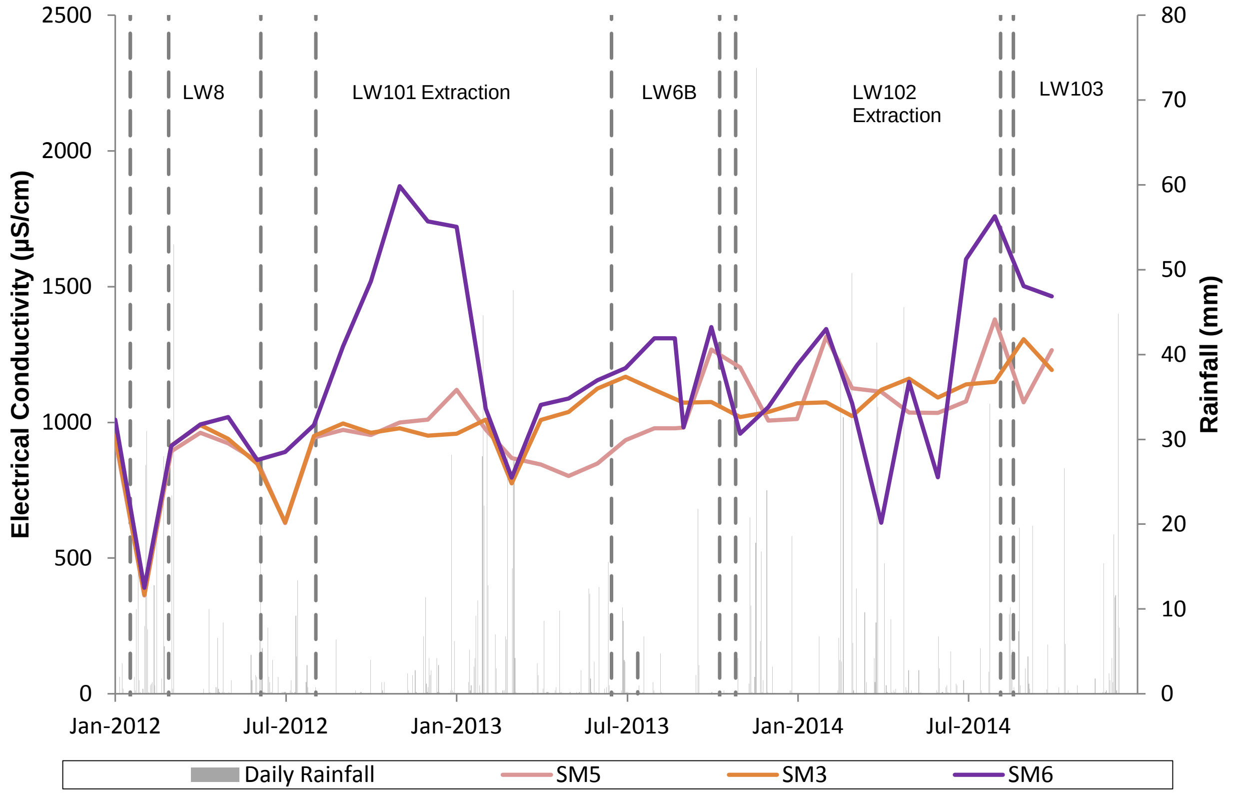
F:\Jobs\S55P\300\Data\Streamflow\[Ashton NOW Stream Gauges.xlsx]Figure 10

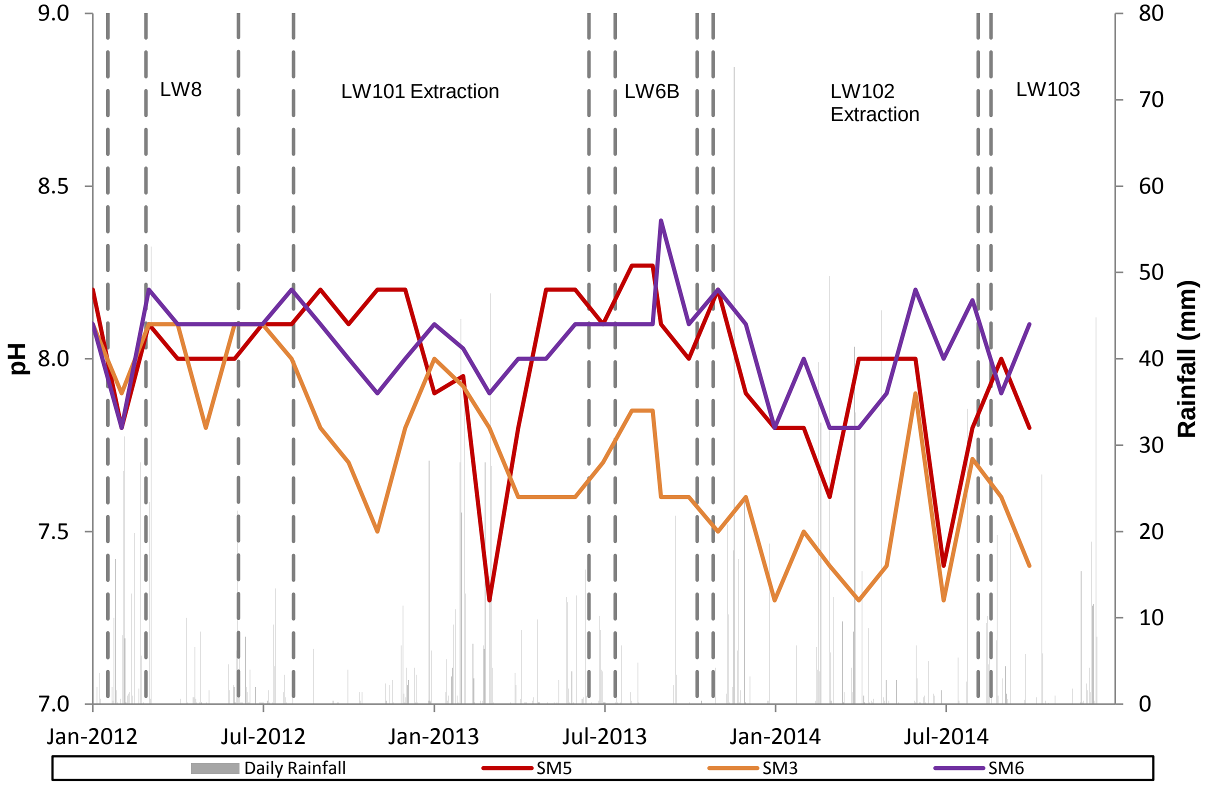


RPS

SURFACE WATER FLOW FIGURE 11

F:\Jobs\S55P\300\Data\Streamflow\[016a.xlsx]Figure 11 S55P

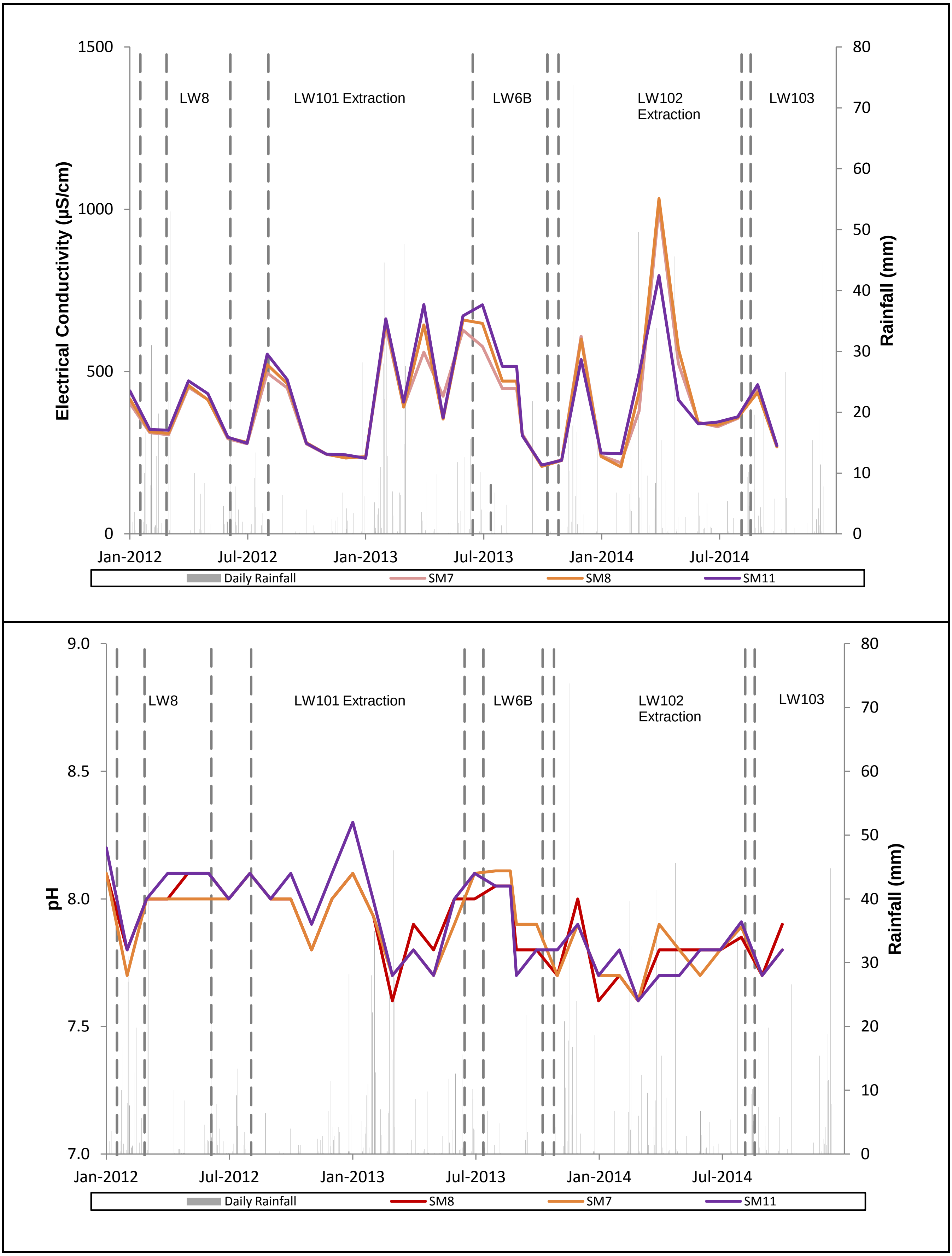




RPS

SURFACE WATER SALINITY and pH - BOWMANS CREEK FIGURE 12

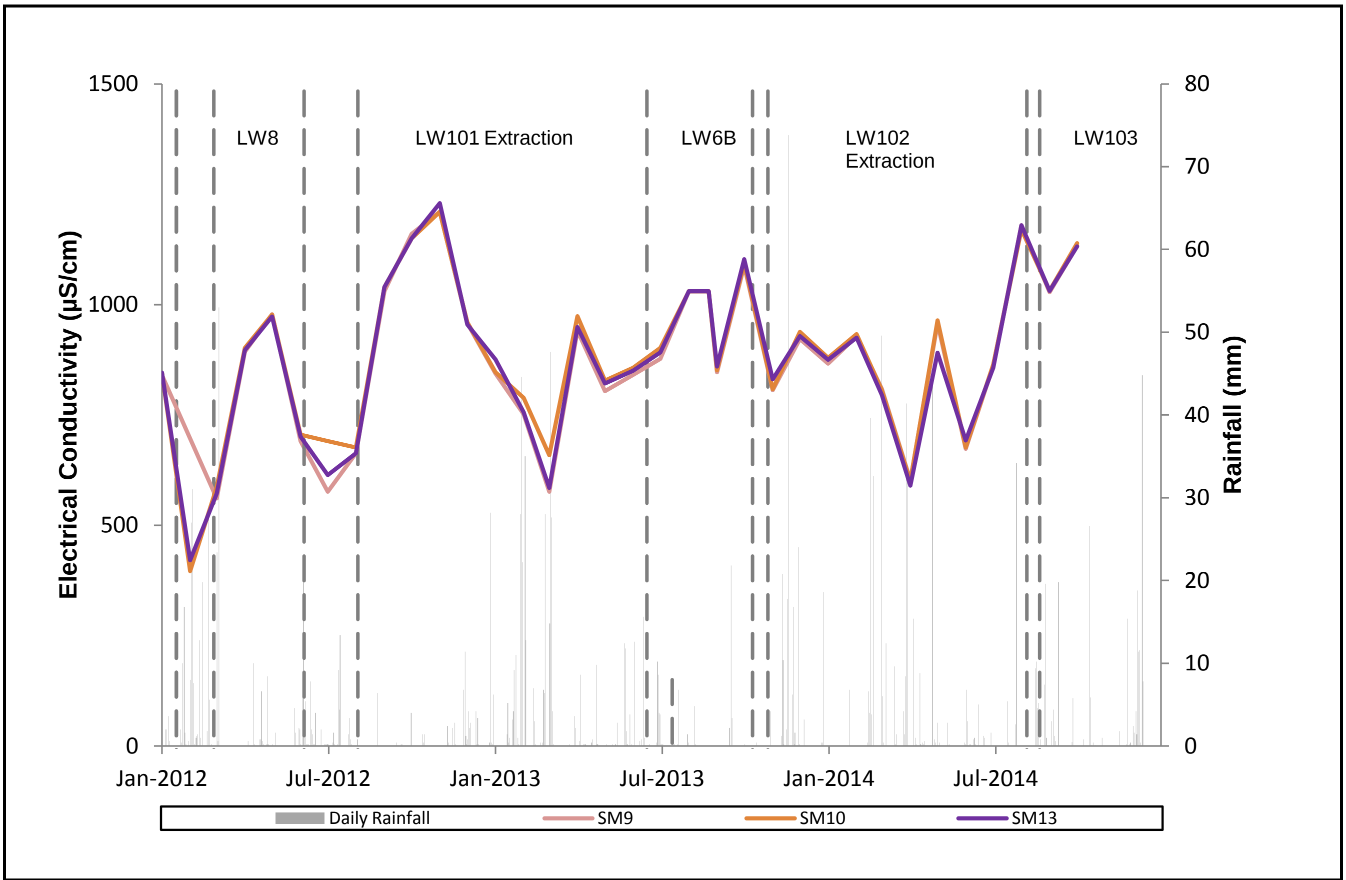
F:\Jobs\S55P\300\Surface Water\[Surface Water Quality.xlsx]Figure 12 WQ S55P

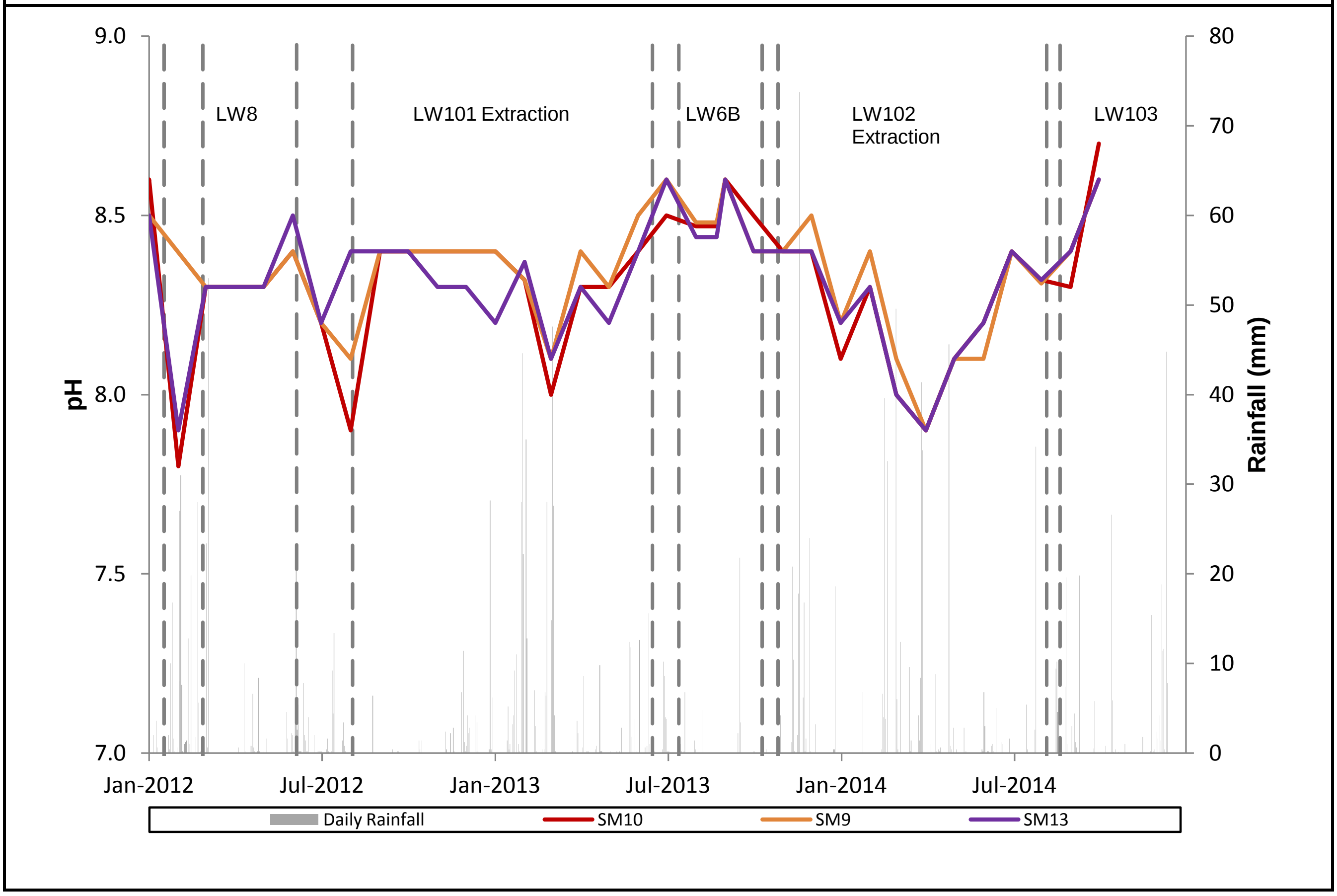


RPS

SURFACE WATER SALINITY and pH - GLENNIES CREEK FIGURE 13

F:\Jobs\S55P\300\Surface Water\[Surface Water Quality.xlsx]Figure 13 WQ S55P

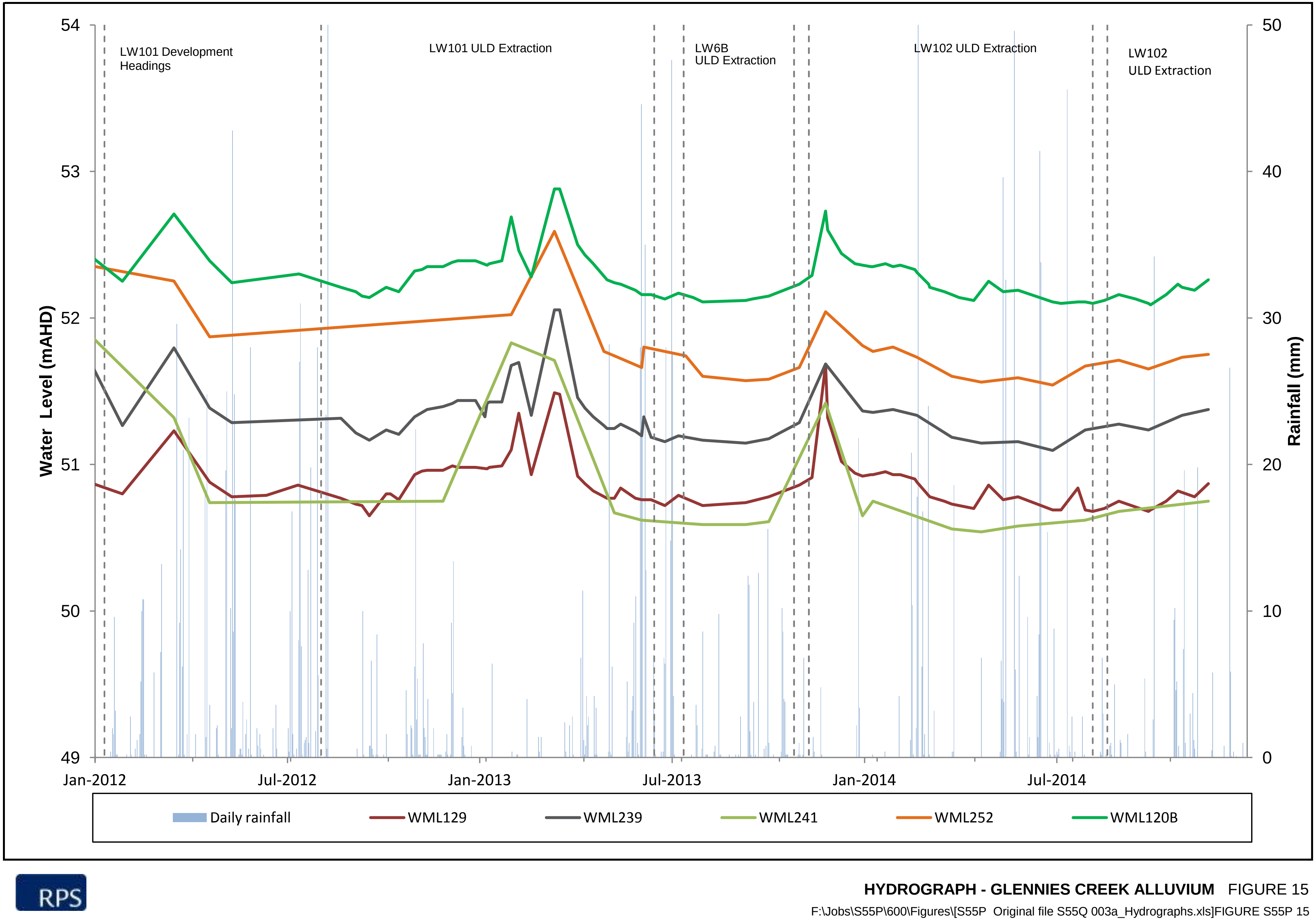




RPS

SURFACE WATER SALINITY and pH - HUNTER RIVER FIGURE 14

F:\Jobs\S55P\300\Surface Water\[Surface Water Quality.xlsx]Figure 14 WQ S55P



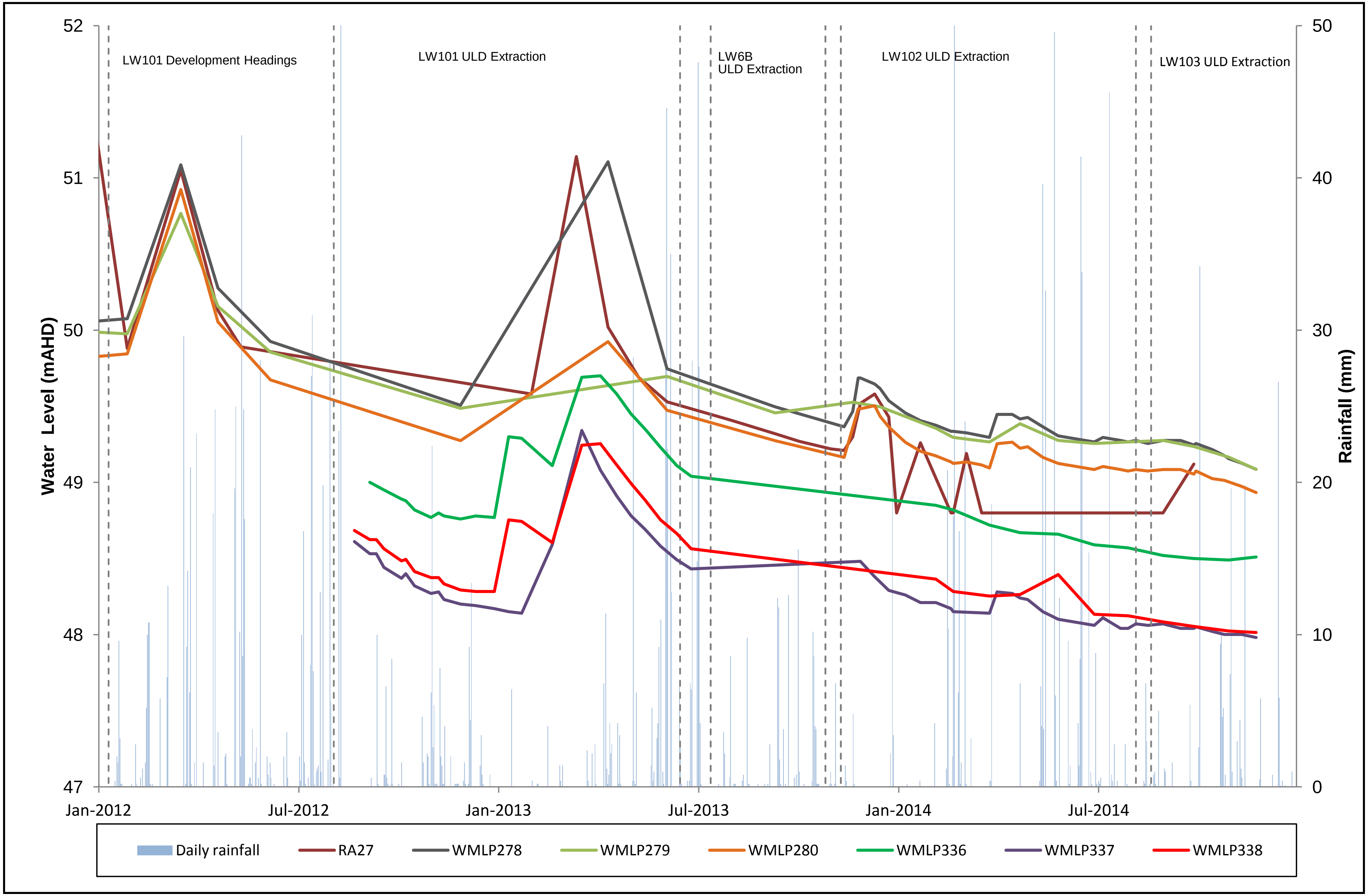
HYDROGRAPH - GLENNIES CREEK ALLUVIUM FIGURE 15

F:\Jobs\S55P\600\Figures\[S55P Original file S55Q 003a_Hydrographs.xls]FIGURE S55P 15

RPS

HYDROGRAPH - GLENNIES CREEK ALLUVIUM WITH CRD FIGURE 16

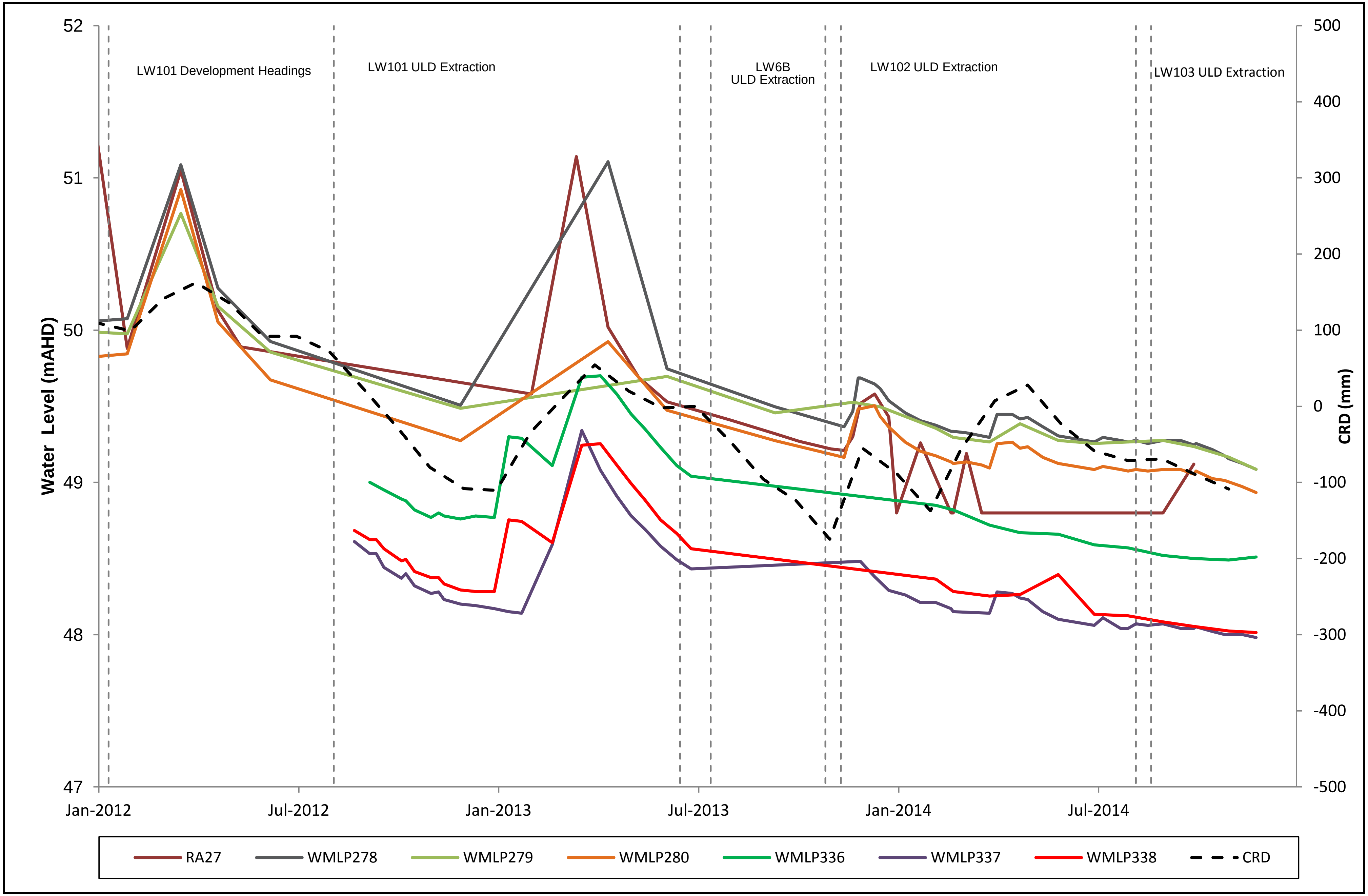
F:\Jobs\S55P\600\Figures\[S55P Original file S55Q 003a_Hydrographs.xls]FIGURE S55P 16



RPS

HYDROGRAPH - HUNTER RIVER ALLUVIUM FIGURE 17

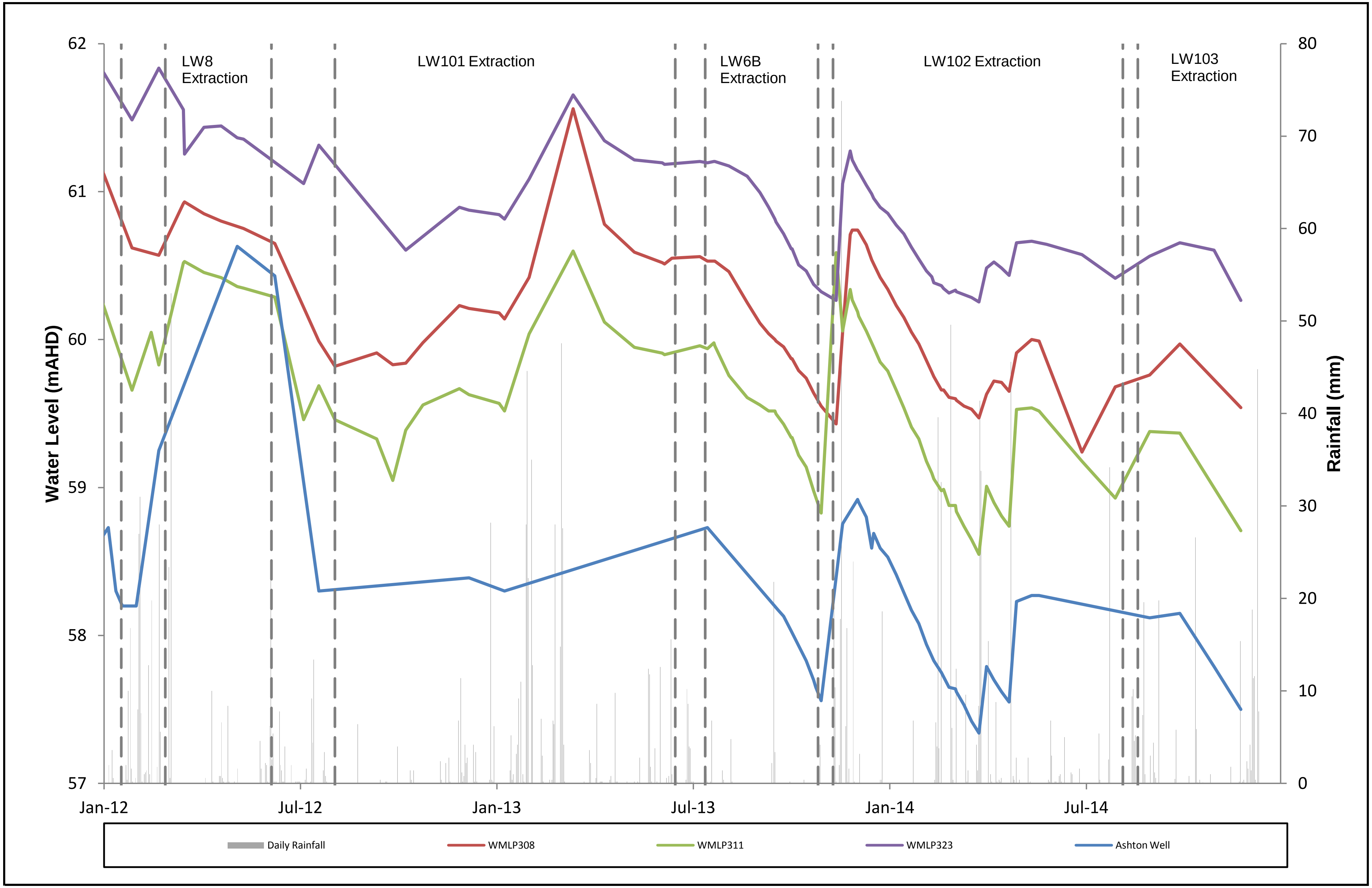
F:\Jobs\S55P\600\Figures\[S55P Original file S55Q 003a_Hydrographs.xls]FIGURE S55P 17



RPS

HYDROGRAPH - HUNTER RIVER ALLUVIUM WITH CRD FIGURE 18

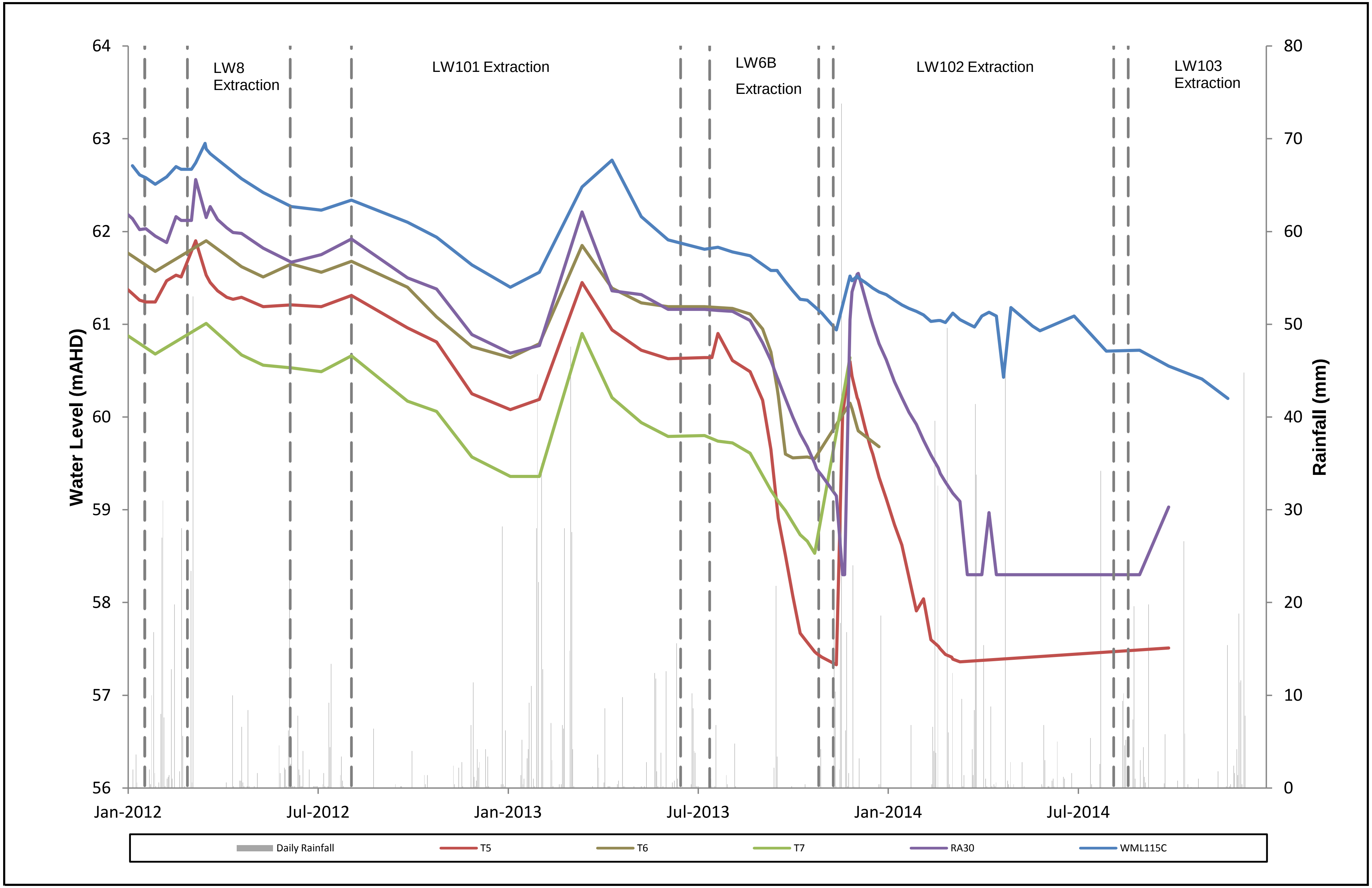
F:\Jobs\S55P\600\Figures\[S55P Original file S55Q 003a_Hydrographs.xls]FIGURE S55P 18



RPS

HYDROGRAPH - BOWMANS CREEK ALLUVIUM (NORTH EAST) FIGURE 19

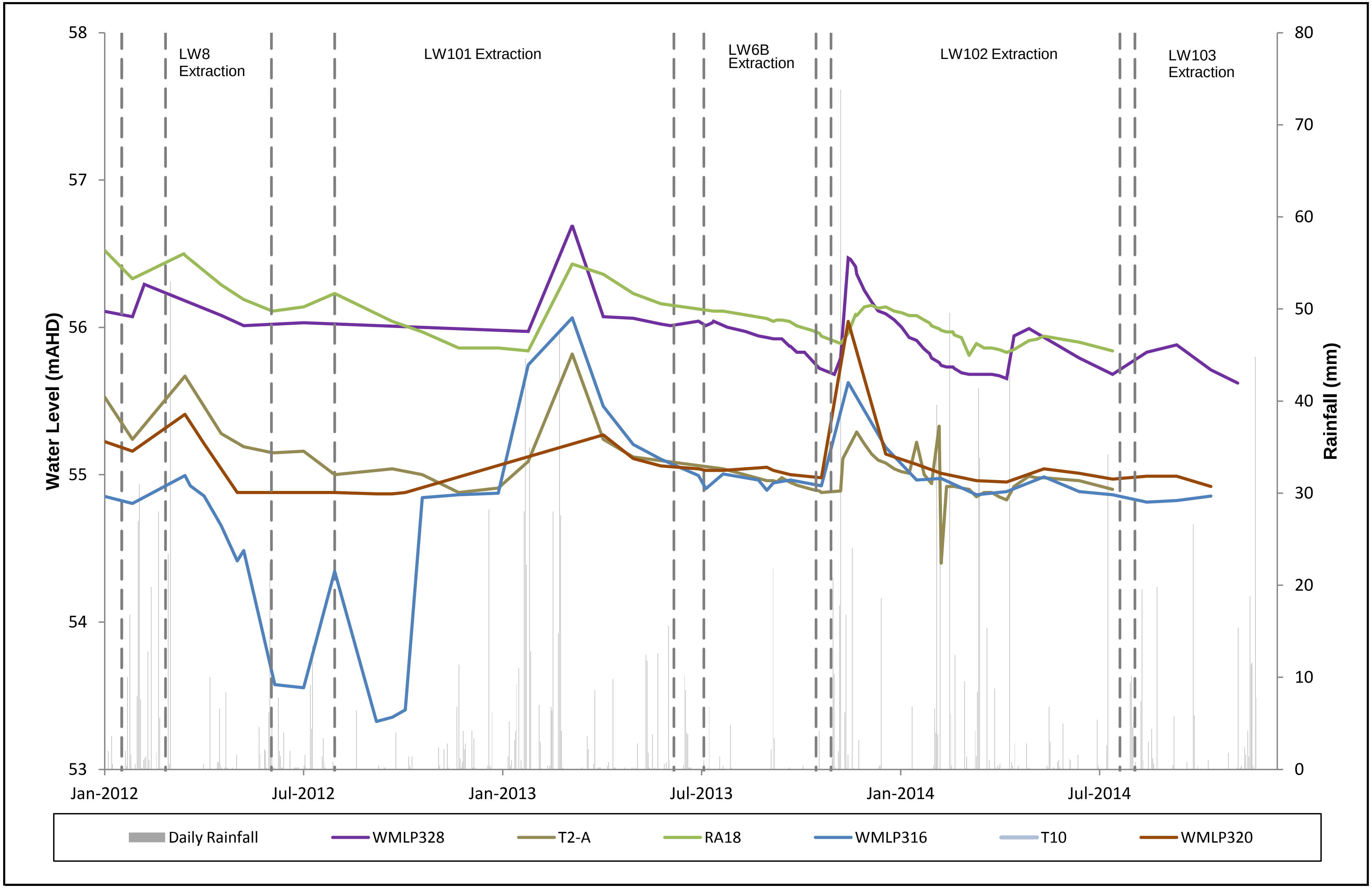
F:\Jobs\S55P\600\Figures\[S55P (2) ULD Extraction Original file S56C 013a_Hydrographs.xls]Figure S55P 19



RPS

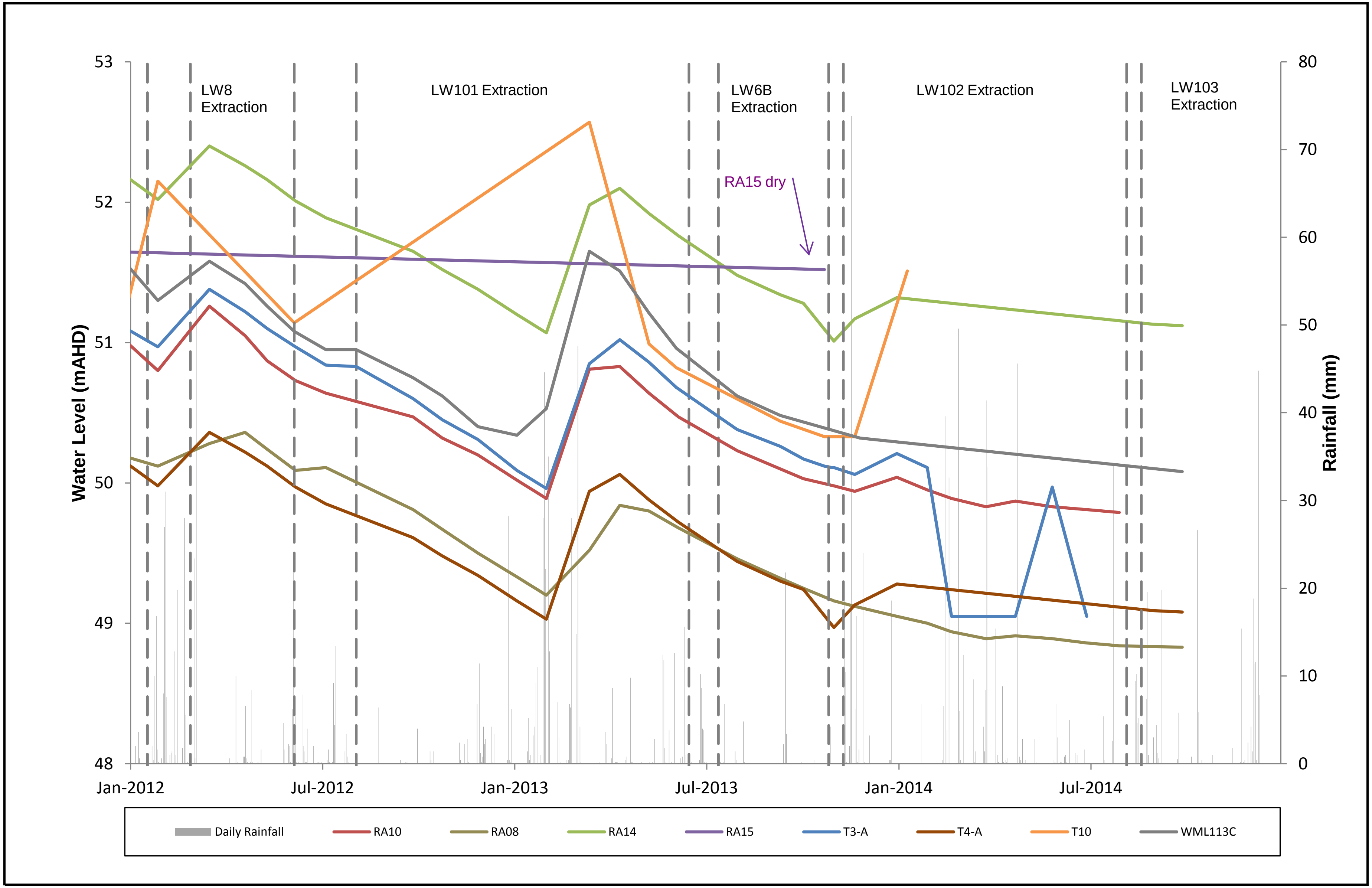
HYDROGRAPH - BOWMANS CREEK ALLUVIUM (NORTH-WEST) FIGURE 20

F:\Jobs\S55P\600\Figures\[S55P (2) ULD Extraction Original file S56C 013a_Hydrographs.xls]Figure S55P 20



HYDROGRAPH - BOWMANS CREEK ALLUVIUM (CENTRAL) FIGURE 21

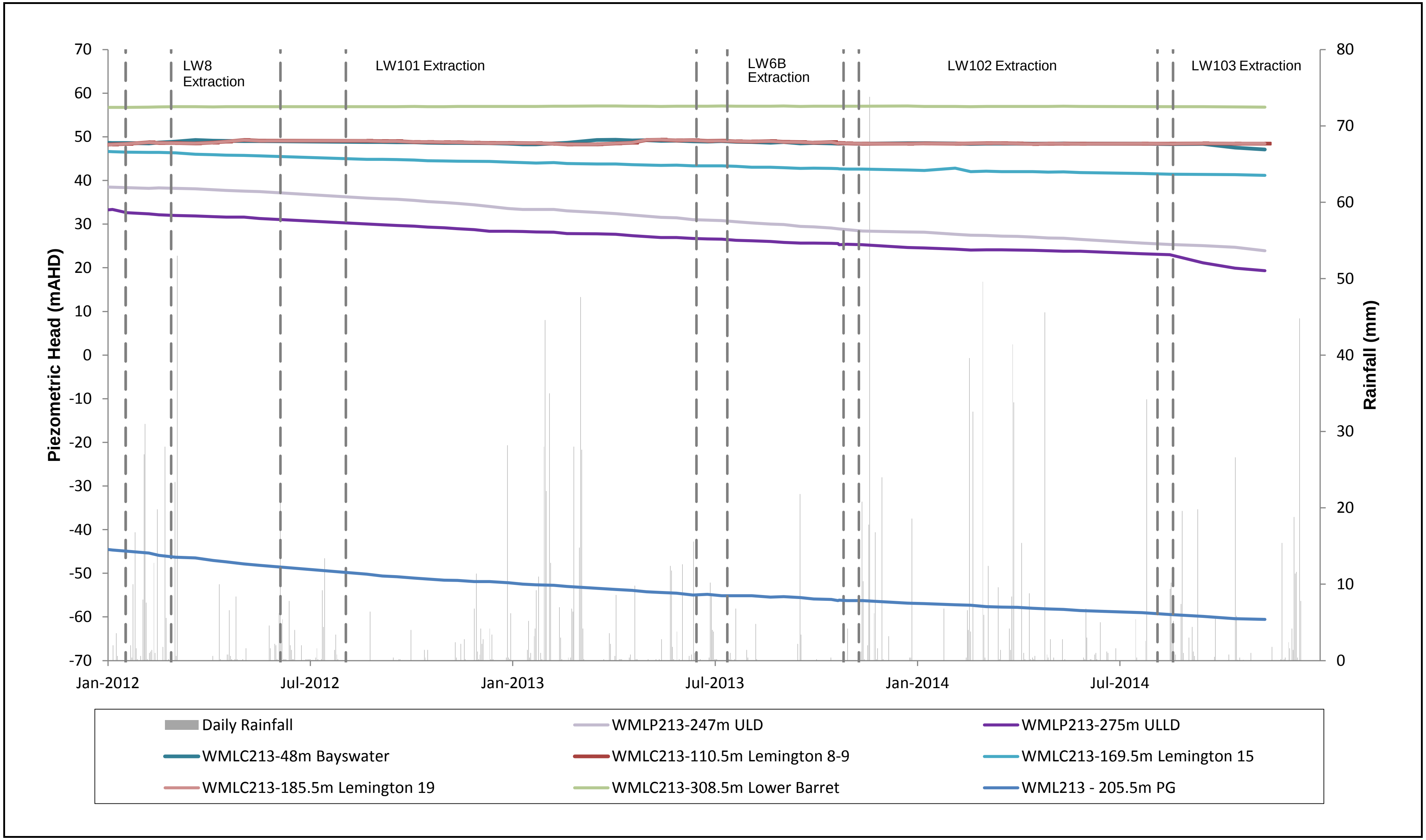
F:\Jobs\S55P\600\Figures\[S55P (2) ULD Extraction Original file S56C 013a_Hydrographs.xls]Figure S55P 21



HYDROGRAPH - BOWMANS CREEK ALLUVIUM (SOUTH) FIGURE 22

F:\Jobs\S55P\600\Figures\[S55P (2) ULD Extraction Original file S56C 013a_Hydrographs.xls]Figure S55P 22

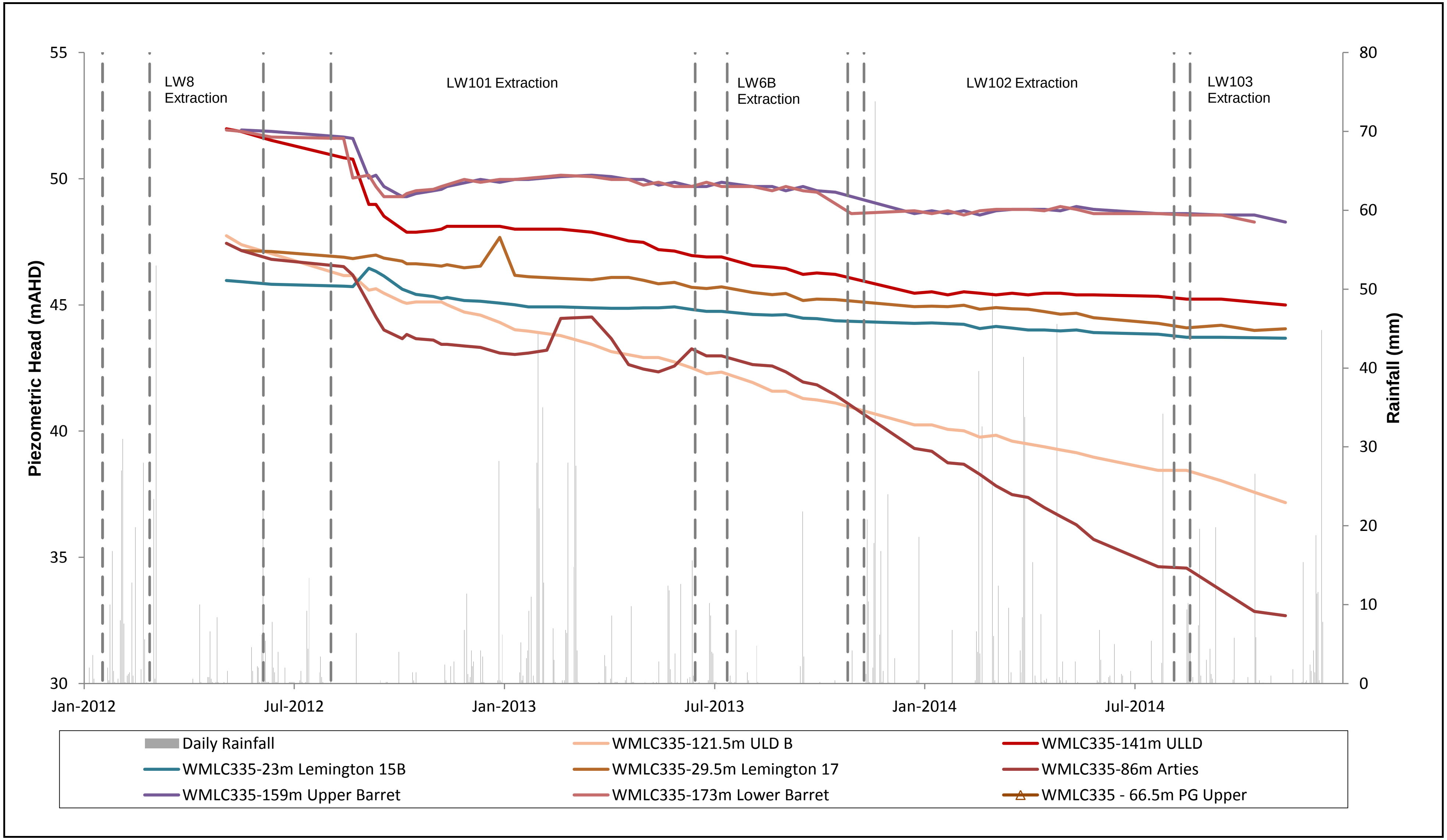
RPS



RPS

HYDROGRAPH WML 213 PIEZOMETERS FIGURE 23

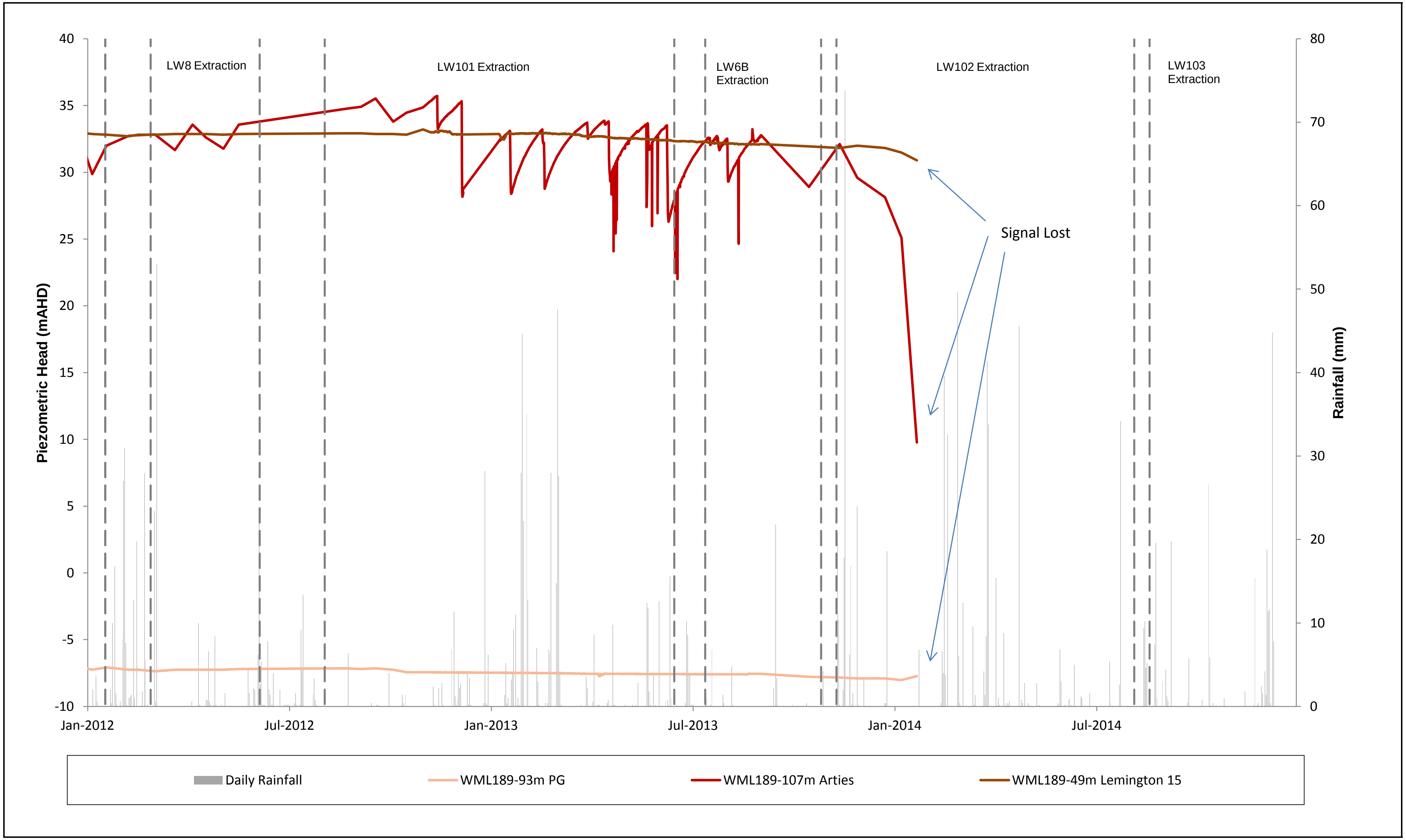
F:\Jobs\S55P\600\[Copy of 012a_Hydrographs.xlsx]Figure 23 WML 213



RPS

HYDROGRAPH WMLC335 PIEZOMETERS FIGURE 24

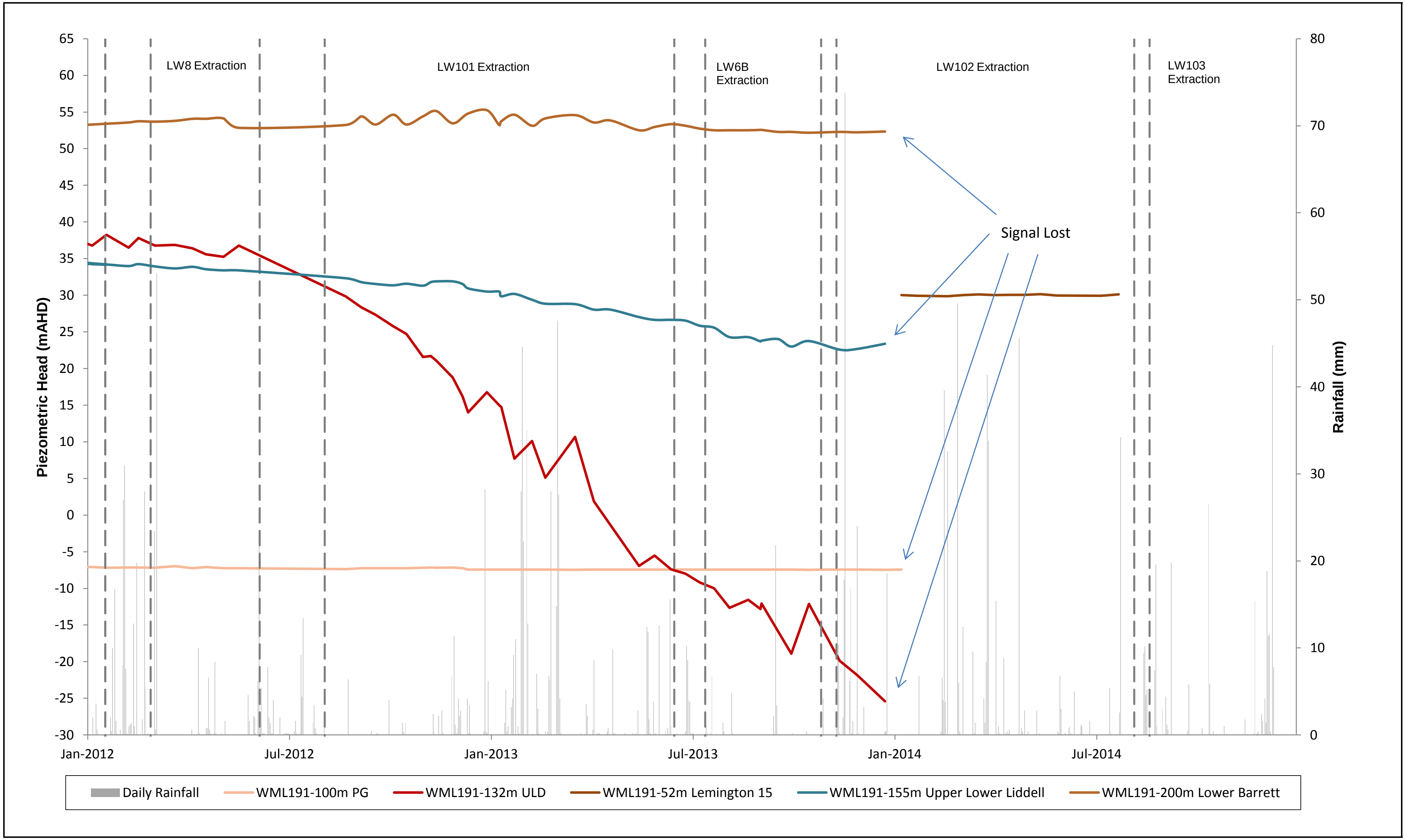
F:\Jobs\S55P\600\[Copy of 012a_Hydrographs.xlsx]Figure 24 WMLC335



RPS

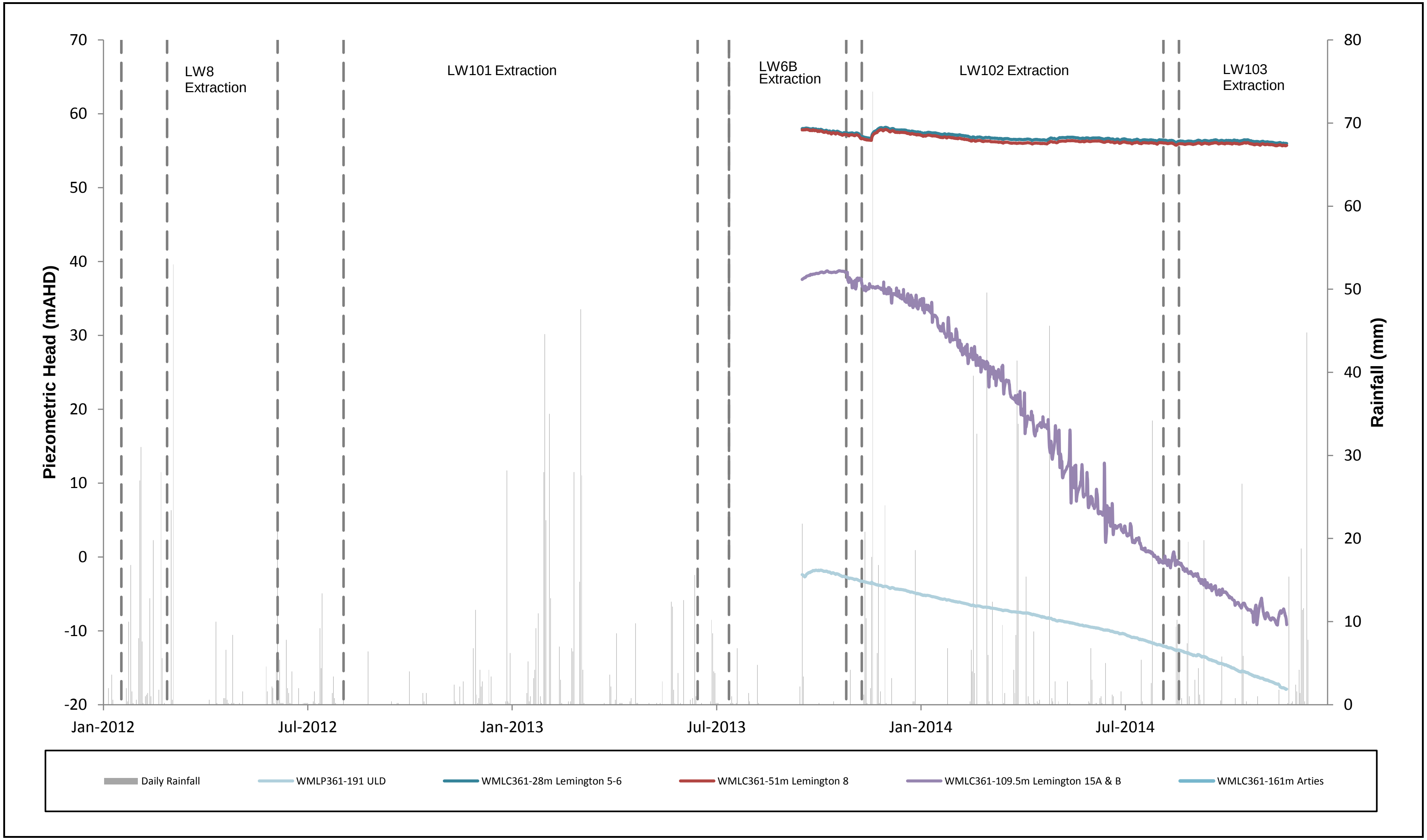
HYDROGRAPH WML189 PIEZOMETERS FIGURE 25

F:\Jobs\S55P\600\[Copy of 012a_Hydrographs.xlsx]Figure 25 WML189



HYDROGRAPH WML191 PIEZOMETERS FIGURE 26

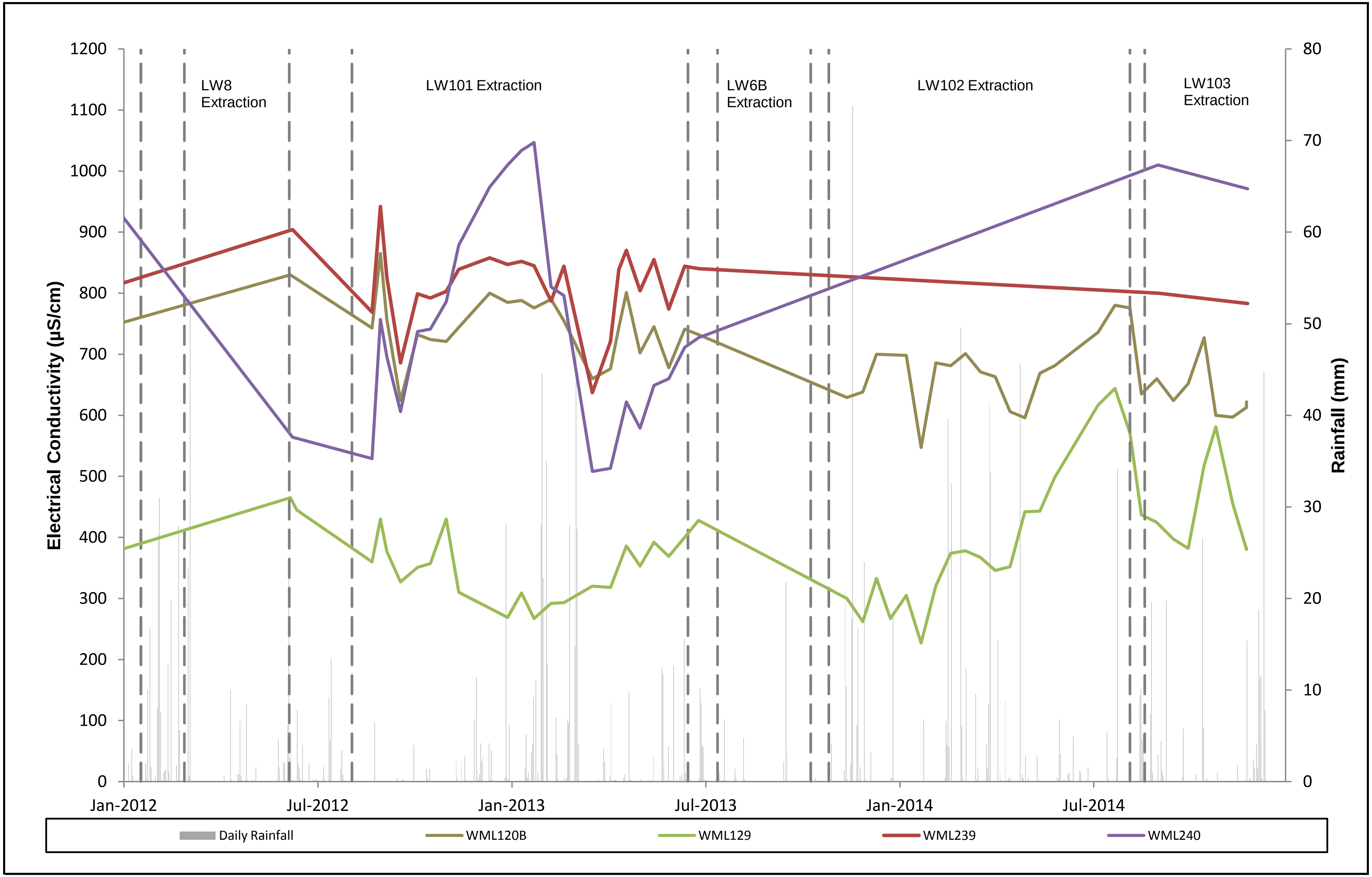
F:\Jobs\S55P\600\[Copy of 012a_Hydrographs.xlsx]Figure 26 WML191



RPS

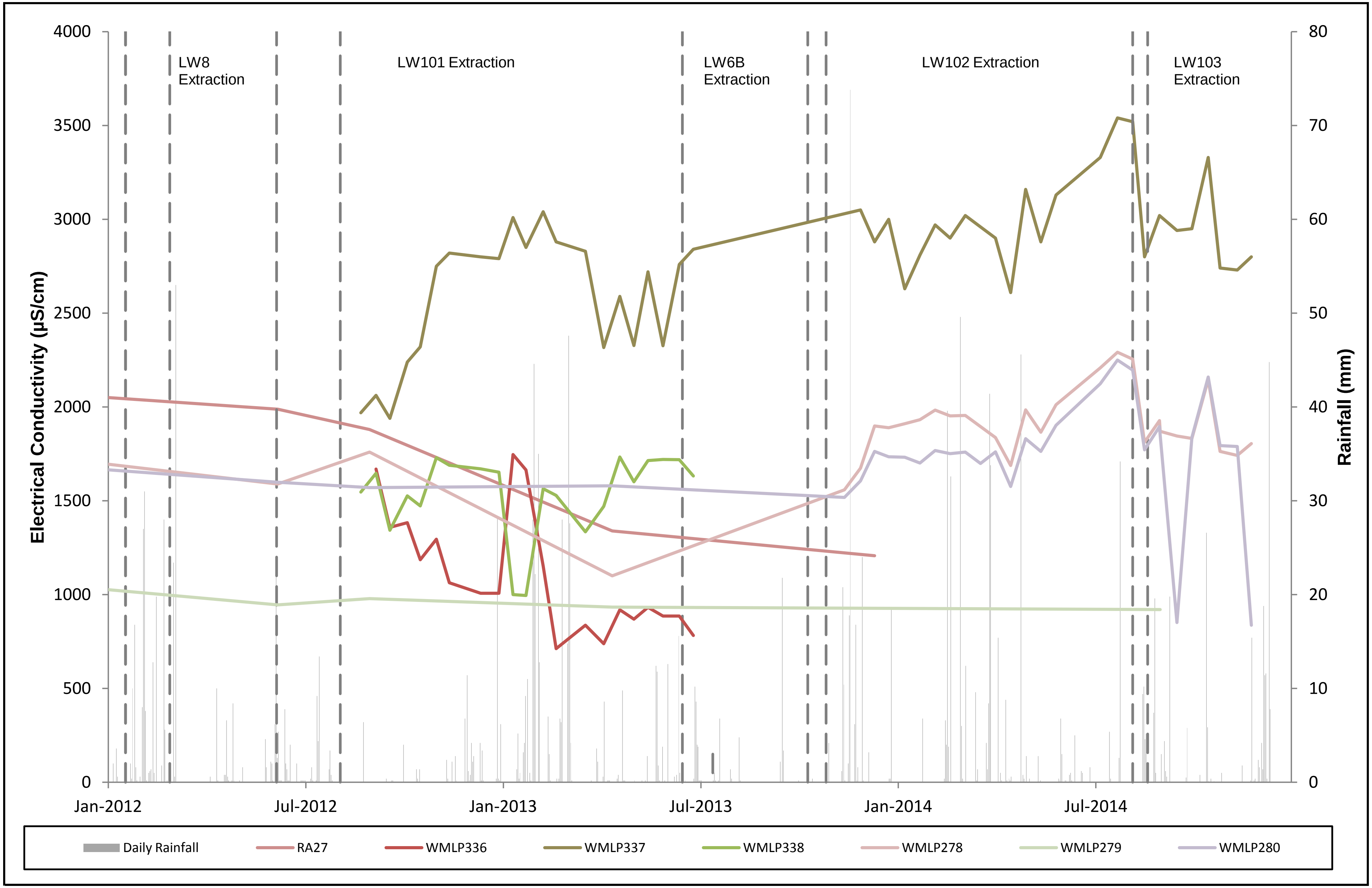
HYDROGRAPH WMLC361 PIEZOMETERS FIGURE 27

F:\Jobs\S55P\600\[Copy of 012a_Hydrographs.xlsx]Figure 27 WMLC361



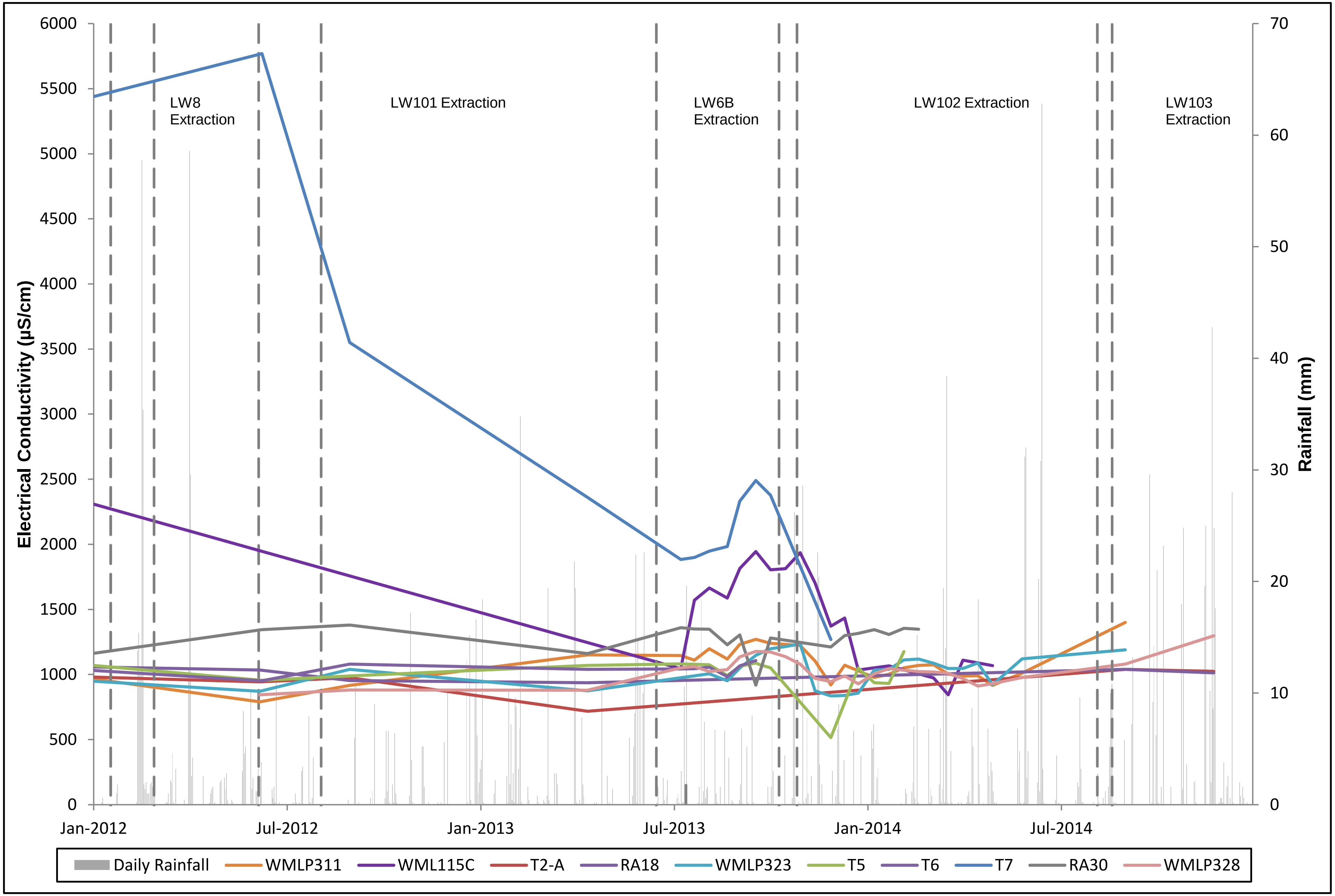
GROUNDWATER SALINITY - GLENNIES CREEK ALLUVIUM FIGURE 28

F:\Jobs\S55P\600\Figures\[S55P Original file S56C 008e 2014 GWR.xls]Figure S55P 28



GROUNDWATER SALINITY - HUNTER RIVER ALLUVIUM FIGURE 29

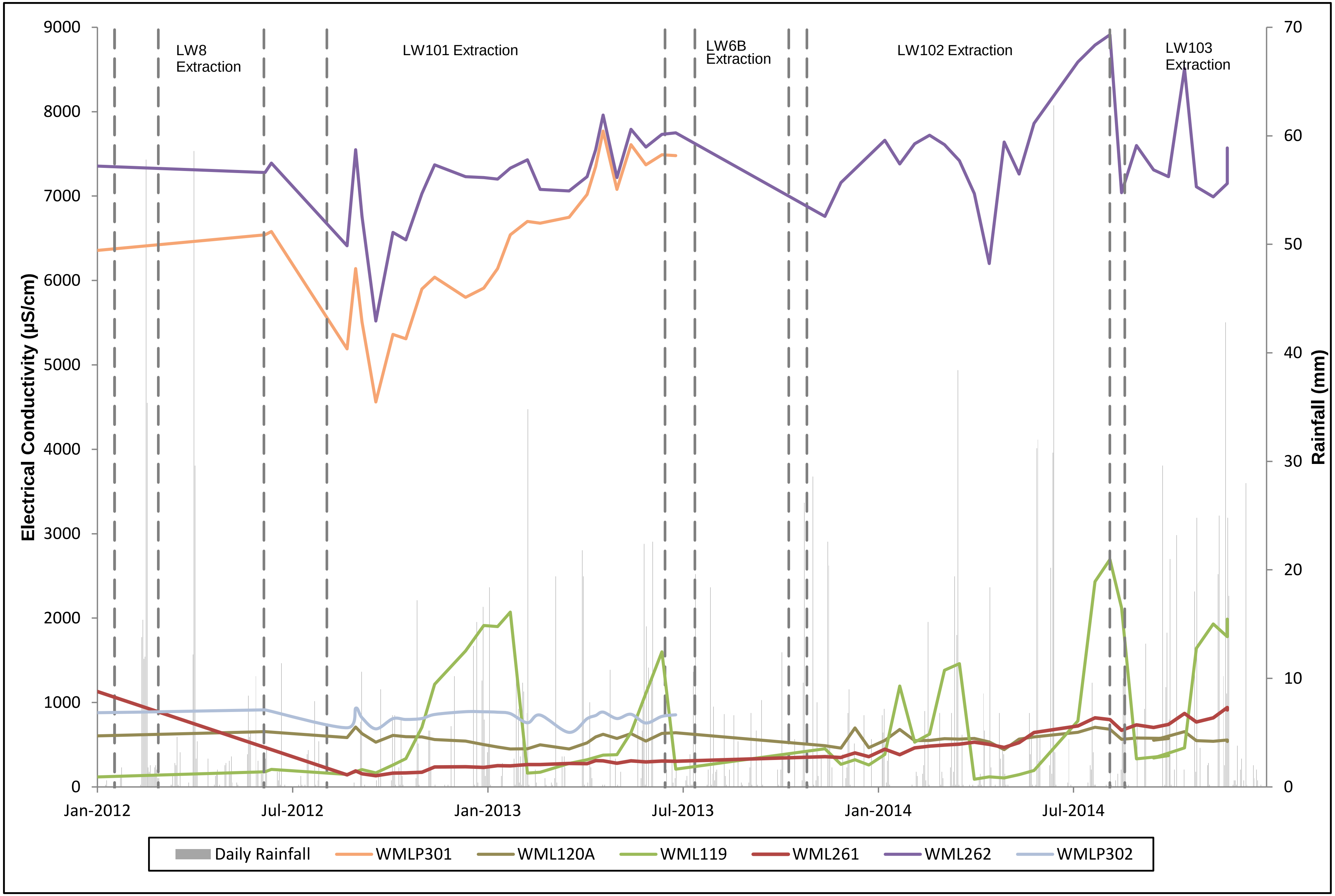
F:\Jobs\S55P\600\Figures\[S55P Original file S56C 008e 2014 GWR.xls]Figure S55P 29



RPS

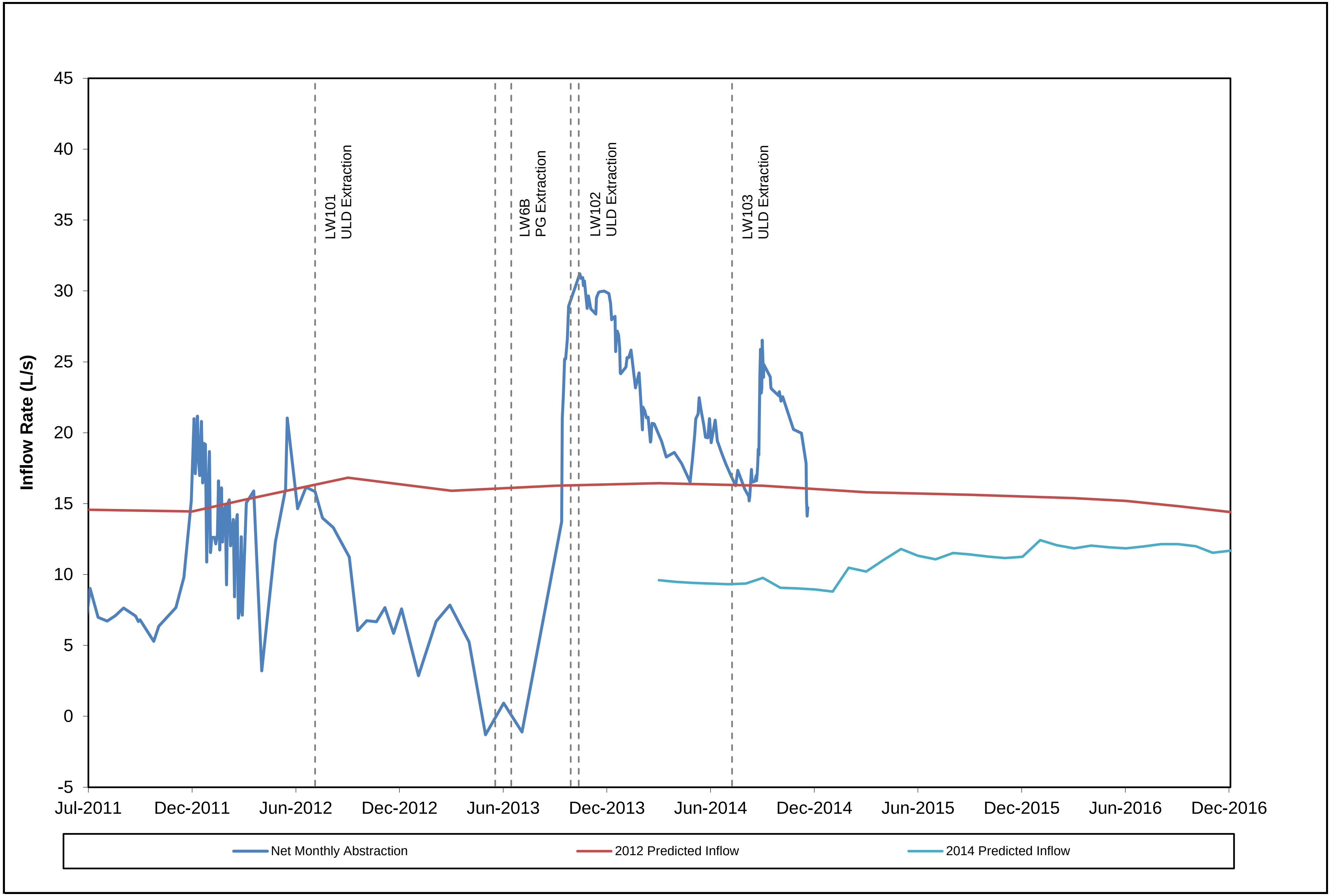
GROUNDWATER SALINITY - BOWMANS CREEK ALLUVIUM FIGURE 30

F:\Jobs\S55P\600\[S55P Original file S56C 008e 2014 GWR.xls]Figure S55P 30



GROUNDWATER SALINITY - PERMIAN FIGURE 31

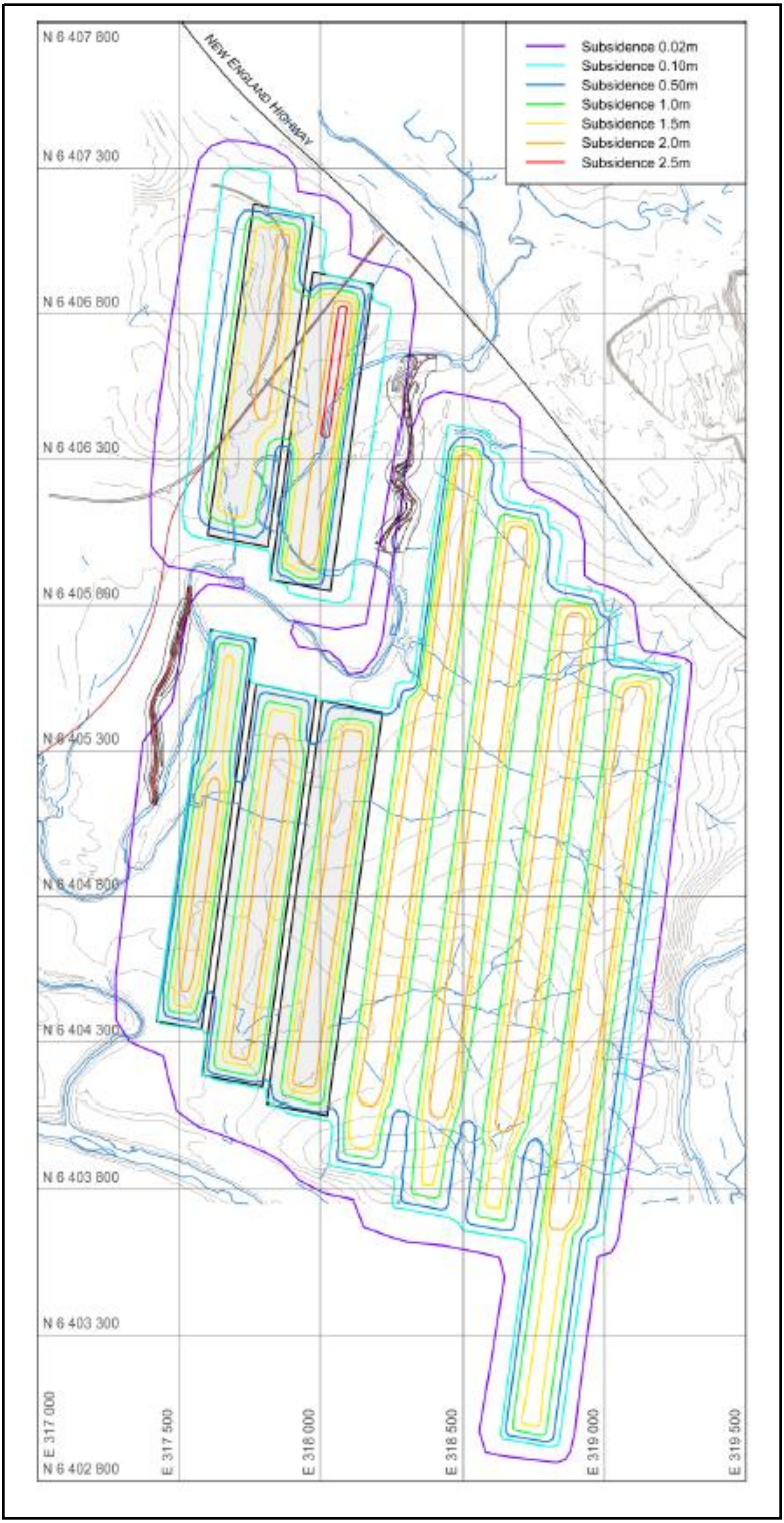
F:\Jobs\S55P\600\[S55P Original file S56C 008e 2014 GWR.xls]Figure S55P 31



RPS

PREDICTED AND OBSERVED DEWATERING FIGURE 32

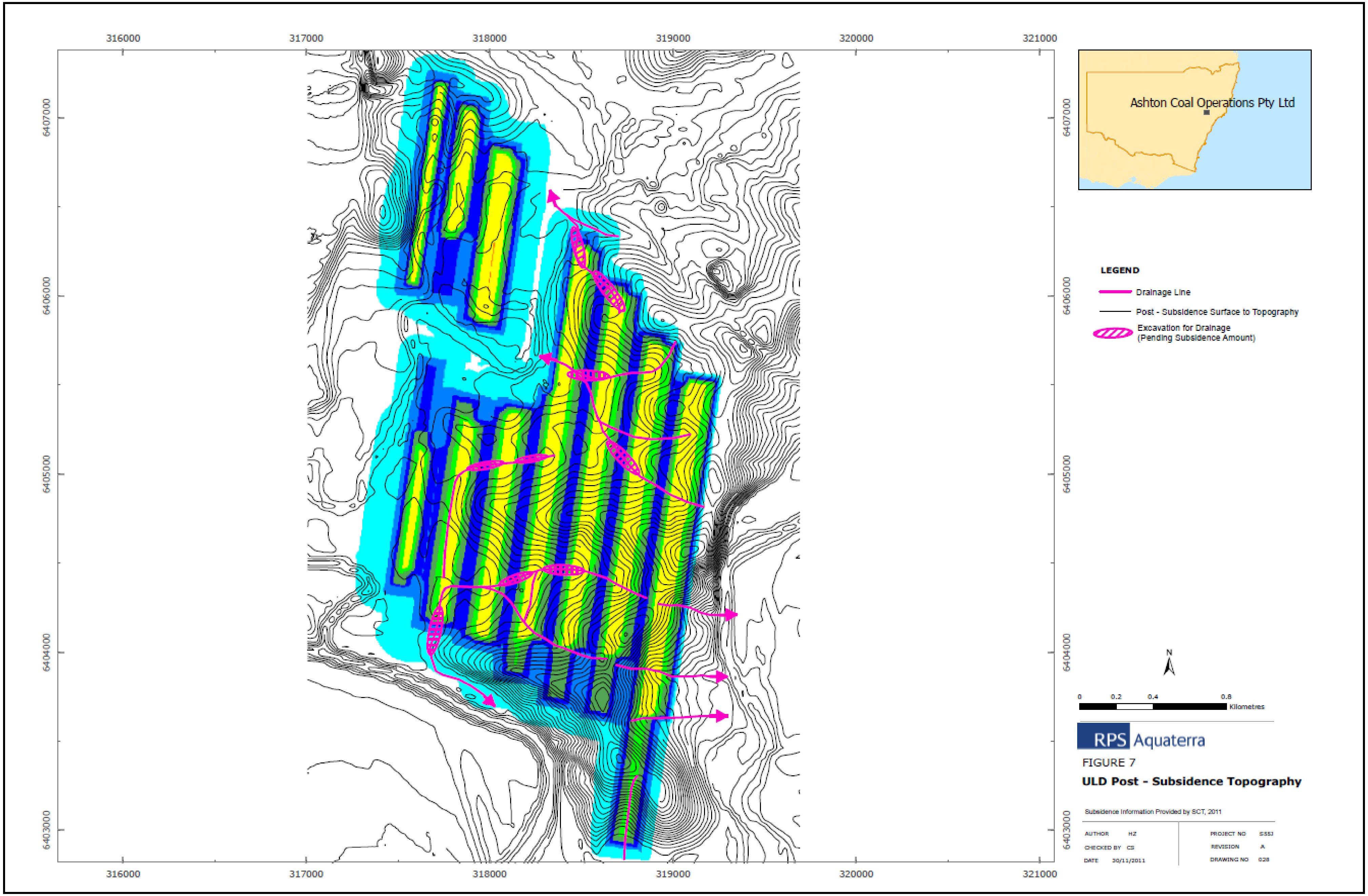
F:\Jobs\S55P\300\Excel\Projects\012a\[012a_Inflows.xls]FIGURE 32



RPS

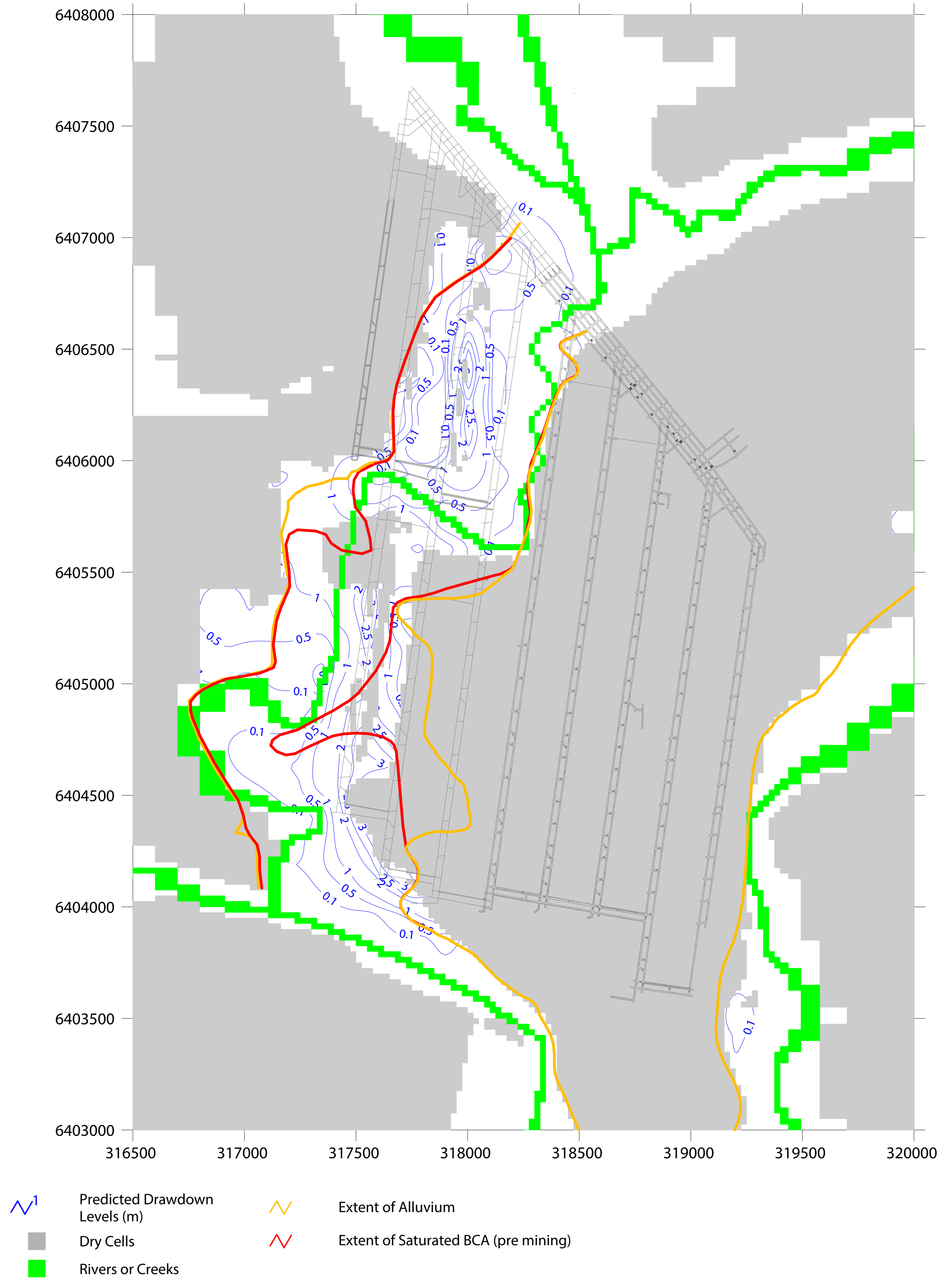
PREDICTED SUBSIDENCE FIGURE 33

F:\Jobs\S55P\600\[S55P Original file S55P 300 Excel Projects Inflows.xls]FIGURE 33 S55P



RPS

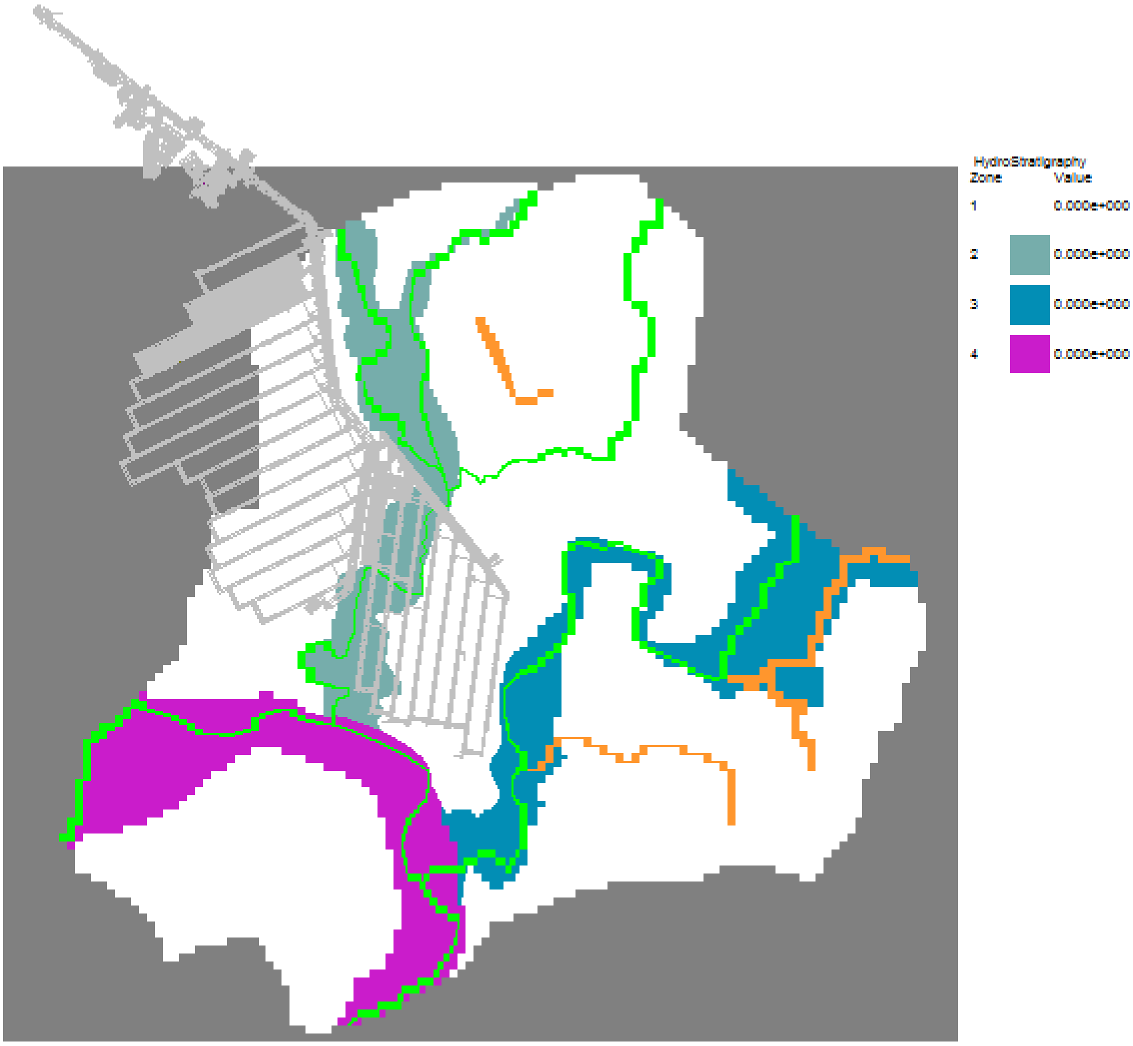
ULD Post - Subsidence Topography FIGURE 34



Date	16 February 2015	Scale	As Shown	Ashton Coal Operations Ltd
Initials	GS	Project	S55P	Predicted Groundwater Drawdown Levels at the End of ULD LW8 (Original Mine Plan) in the Alluvium and Regolith (Layer1)

RPS

Figure 35



ADOPTED PARTITIONING OF GROUNDWATER SOURCES FIGURE 36

APPENDIX A:
ULD LW104 TO 108 RISK ASSESSMENT

Table A.9.1: ULD LW105 to 108 Risk Assessment Workshop Outcomes.

Process /Sub-Process	Potential Event /Consequences	Existing Risk Treatment	Consequence	Likelihood	Risk Rank	Risk Reduction Strategy	Person Responsible
1 - NATURAL FEATURES							
1.02 Rivers or Creeks (Bowmans Creek, Hunter River and Glennies Creek)	Water quality changes to Bowmans Creek and Hunter River due to mine subsidence. Changes to channel stability. Flow on environmental impacts result.	Approved creek diversion and mine designed to minimise effects on the creeks and rivers. Mine design includes a 40 metre offset from high bank - Bowmans Creek. Specialist Surface Water and Groundwater Studies previously completed. Existing Surface Water, Groundwater and Land Management Plans.	2	D	5	Consider detrimental impacts to surface and ground water in the impact assessments. Implement and recommendations from that work.	ACOL RPS
1.02 Rivers or Creeks (Bowmans Creek, Hunter River and Glennies Creek)	Water losses from the surface (including Bowmans creek and excised area).	Approved creek diversion and mine designed to minimise effects on the creeks and rivers. Mine design includes a 40 metre offset from high bank - Bowmans Creek. Existing Surface Water, Groundwater and Land Management Plans. Existing license allocation. Upstream and downstream stations to measure water volumes (flow monitor). Block banks on the excised sections with plans to raise from 1 in 1 to 1 in 5 year levels.	2	B	12	Include this aspect in the surface water and ground water assessments. Consider plans to reduce possible water inflow into workings.	ACOL RPS
1.03 Aquifers or Known Groundwater Resources	Alluvial ground water level and quality changes due to mine subsidence greater than predicted.	Specialist Surface Water and Groundwater studies previously completed. Existing Groundwater Management Plan, including monitoring programs. End of panel reports, reviewing predicted against actual impacts to groundwater. Recently calibrated groundwater model. Groundwater licenses.	3	D	9	Groundwater Assessment for EP/SMP Area is planned.	ACOL RPS

Process /Sub-Process	Potential Event /Consequences	Existing Risk Treatment	Consequence	Likelihood	Risk Rank	Risk Reduction Strategy	Person Responsible
	Hard Rock ground water level and quality changes due to mine subsidence greater than predicted (including the combined effect) -some unknowns in the structures and what the contributions could be.	Specialist Surface Water and Groundwater. Existing Groundwater Management Plan, including monitoring programs. End of panel reports, reviewing predicted against actual impacts to groundwater. Recently calibrated groundwater model. Groundwater licenses.	3	C	13	Groundwater Assessment for EP/SMP Area is planned. Review the monitoring requirements - review whether additional monitoring wells are required.	ACOL RPS
1.11 Land Prone to Flooding or Inundation	Land Prone to Flooding or Inundation changes due to mine subsidence.	EA includes commitments to maintain a free draining landform (this may not be achievable). Existing Surface Water and Land Management Plans.	2	D	5	Review the risk of flooding and inundation considering the predicted final landform. Existing land use is agricultural and owned by the company. No risk of inundation for buildings or infrastructure. Consider potential ponding in groundwater assessment.	ACOL RPS SCT (flood modelling)
1.12 Swamps, Wetlands or Water Related Ecosystems	Swamps, wetlands or water related ecosystems changes due to mine subsidence. (Hunter River, Bowmans Creek and Glennies Creek) Surface water quality/quantity changes.	Existing Surface Water and Land Management Plans. Biodiversity Management Plan. Monitoring program.					

Table A.9.2: Yancoal Risk Matrix.

	Effect / Consequence				
Loss Type	**1 Insignificant**	**2 Minor**	**3 Moderate**	**4 Major**	**5 Catastrophic**
(P) Harm to People	**Slight injury or health effects** – first aid / minor or no medical treatment level	**Minor injury or health effects** – restricted work or minor lost time injury	**Serious bodily injury or health effects** – major lost time injury / permanent disability	**Single fatality, permanent total disabilities**	**Multiple fatalities**
(E) Environmental Impact	**Environmental nuisance –** trivial or negligible, short term impact to area of low significance, minimal or no physical remediation required No regulation. Cost < $1,000	**Minor environmental harm –** short term impact to area of limited local significance, limited physical remediation Reportable Breach /Minor Non Compliance, potential warning notice, other notices (infringement / prosecution) unlikely. Costs $1,000 - $5,000	**Serious environmental harm –** medium term impact to area of local conservation value, medium term physical remediation, actual community health impacts or significance or pollution or contamination Infringement Notice but Prosecution unlikely Costs $5k - $50k	**Major environmental harm –** long term reversible impacts to area of regional conservation significance, health statistics in community alter as a result of this incident or pollution or contamination Prosecution Costs $50k - $500k	**Extreme environmental harm –** irreversible impacts on environmental values of extreme & widespread areas, or those of national conservation significance, community fatalities or pollution or contamination Prosecution, License revoked Costs > $500k
(O) Asset Damage and Other Consequential Losses	**Slight damage** < $0.1M or < 1 shift disruption to operation	**Minor damage** $0.1M - $1.0M. or 1 Shift – 1 day disruption to operation	**Local damage** $1.0M - $5.0M or 1 day - 1 week disruption to operation	**Major damage** $5.0M -$25.0M or 1 week – 1 month Partial loss of operation	**Extreme damage** > $25.0M.or > 1 month Substantial or total loss of operation
(R) Impact on Reputation	**Slight impact –** Public awareness may exist but no public concern Isolated compliance failure – no brand damage	**Limited impact –** Some local public concern Intervention of regulating authority – minimal brand damage	**Considerable impact -** Regional public concern Major compliance failure involving fines – medium brand damage	**National impact –** National public concern Temporary withdrawal of license to operate – significant brand damage	**International impact -** International public attention Loss of shareholder confidence – irreparable brand damage

Likelihood	**Likelihood Examples (Guide)**	**1 Insignificant**	**2 Minor**	**3 Moderate**	**4 Major**	**5 Catastrophic**
A (Almost Certain)	Likely that the unwanted event could occur several times per year at this location	**11** (M)	**16** (H)	**20** (H)	**23** (E)	**25** (E)
B (Likely)	Likely that the unwanted event could occur several times per year in the Australian mining industry; or could happen annually	**7** (M)	**12** (M)	**17** (H)	**21** (E)	**24** (E)

YANCOAL
兖煤澳大利亚有限公司

AshtonCoal
PART OF THE YANCOAL AUSTRALIA GROUP

EMAIL: info@yancoal.com.au
WEBSITE: www.ashtoncoal.com.au
ABN 22 078 556 500

26 October 2015

Howard Reed
Department of Planning and the Environment
GPO Box 39
Sydney NSW 2001

Dear Howard

ACOL Extraction Plan LW 105 to 107B

Ashton Coal Operations Limited (ACOL) submitted an Extraction Plan (EP) to the Department of Planning and Environment's (DP&E), dated 4 August 2015 with the EP covering Longwall (LW) 105 to 107 in the Upper Liddell (ULD) Seam. This letter responds to the DP&E comments from the letter dated 4 September 2015 regarding the EP.

If you would like any additional information about the EP or this response letter, please do not hesitate to contact myself on (02) 6570 9102 or Chris Jones from SLR Consulting (Lead Consultant) on (02) 4037 3219.

Yours sincerely,

James Barben
Environment and Community Coordinator
Ashton Coal Operations Pty Limited

Office: (02) 6570 9102 and Mobile: 0409 526 374

Attachment 1 – SCT Letter Report

Attachment 2 – RPS Letter Report

Table 1 – Response to DP&E Queries

DP&E Comment	SLR/ACOL Comment
Subsidence Impact Performance Measures The Department notes the requirement for Ashton Coal to comply with the subsidence performance criteria in the development consent (DA 309-11-2001-i) which, amongst other things, require no greater subsidence impacts or environmental consequences on Bowmans Creek and its alluvium than predicted in the Bowmans Creek Diversion Environmental Assessment (EA). The information provided in the draft Extraction Plan does not allow the Department to readily determine if: 1. Impacts associated with mining operations in LWs 101 to 104 complied with the subsidence impact performance measures for Bowmans Creek and its alluvium; or 2. Predicted impacts associated with mining operations in LWs 105 to 107 would comply with the subsidence impact performance measures for Bowmans Creek and its alluvium; or 3. Further adaptive management is required as part of the LWs 105-107 mine plan to ensure compliance. It is therefore requested that Ashton Coal provide a table which clearly includes the subsidence impacts and environmental consequences on Bowmans Greek and its alluvium predicted in the documents titled: • Ashton Coal Bowmans Creek Diversion Environmental Assessment, Evans & Peck, December 2009; • Ashton Coal Bowmans Creek Diversion Response to Submissions, Wells Environmental Services, May 2010; and • Ashton Coal Bowmans Creek Diversion Statement of Commitments, December 2010. This table should also include a comparison against the subsidence impacts and environmental consequences predicted in the documents titled: • Subsidence Assessment for Extraction Plan for Longwalls 105-107 in the Upper Liddell Seam, SCT Operations Pty Ltd (SCT), May 2015; and • Ashton Coal Groundwater Model Update, RPS Aquaterra Pty Ltd, 2014.	Based on discussions between James Barben (ACOL) and Sarah Wilson (DP&E) following the submission of the EP, ACOL understands that the DP&E wish to establish consistency between the predicted impacts in the 2009 Ashton Coal Bowmans Creek Diversion Environmental Assessment (EA) and the predicted impacts in the EP specifically relating to Bowmans Creek and its alluvium. Additional details responding to these comments have been provided by the subsidence specialist – Attachment 1 (Strata Control Technology - SCT) and ACOL groundwater specialist - Attachment 2 (RPS).
It is noted that the Surface Water and Groundwater Assessment (SWGA) (RPS, February	**From the SGWA - Section 6.1.2 Revised Mine Plan (RPS**

DP&E Comment	SLR/ACOL Comment
2015) in Volume 2 of the draft Extraction Plan provides comparisons based on the Subsidence Assessment undertaken by SCT in 2011 and the Groundwater Impact Assessment undertaken by RPS Aquaterra in 2012. However, there is limited discussion on the revised subsidence predictions presented in SCT's 2015 assessment.	**2015)** *Given that there will not be any increase in the area to be affected by multi-seam subsidence, or any increase in maximum, subsidence, tilt or strain, and also given the fact that monitoring to date shows the magnitude of observed maximum subsidence to be of the order of 20 to 25% less than predicted, the subsidence assessment presented in the 2012 ULD EP for LW105 to LW108 and the subsequent groundwater modelling and impact assessment, is considered to be conservative and still valid for the current mine plan.* SCT (2015) have undertaken an assessment of the implications that the amended mine plan will have on subsidence above the extracted panels. SCT concluded that for the revised mine plan, subsidence parameters (maximum subsidence, tilt, and strain) would generally be equal to, or less than, those for the previously assessed mine plan. The removal of LW108 from the mine plan would also result in a reduced area to be affected by subsidence.
It appears from the discussion provided in Section 6 of the SWGA that both mine inflows and baseflow impacts in Bowmans Creek are now predicted to increase significantly over the original predictions.	Mine inflows (Section 6.3.1) and Baseflow Impacts (Section 6.3.3) are outlined in the 2015 RPS SWGA. RPS prepared a letter response providing further comparison of Bowmans Creek mine inflows and baseflow impacts between the 2009 EA and the 2014 Groundwater Model (see **Attachment 2**). A summary of key findings is outlined below: **Mine Inflows** It is noted at total water take (mine inflows) at end of ULD mining in the 2014 model is approximately 1ML/d compared to 1.5ML/d for the same stage of mining in the 2009 model. Given the reduced mine inflows predicted by the 2014 model, combined with a reduced drawdown in the alluvium (predicted and observed) it reasonable to conclude that the corresponding alluvial water take would therefore also be less than that of the 2009 EA. **Baseflow Impacts** With respect to predicted baseflow impacts on Bowmans Creek at the end of ULD extraction, the 2014 Model Update, and therefore the 2015 Impact assessment, is well within the

DP&E Comment	SLR/ACOL Comment
	approved impacts of the 2009 EA.
As indicated in Note 1 of Condition 3.9, the Extraction Plan is required to define more detailed performance indicators for each of the subsidence impact performance measures. It is recognized that more detailed performance indicators have been included in the relevant management plans for biodiversity, heritage and built features. However, no performance indicators are defined in the site's Water Management Plan (WMP) for Bowmans Creek or its alluvium. It is expected that the comparison table described above would assist in Ashton Coal developing this information, which will then need to be reflected in the WMP.	Performance indicators and triggers are shown in Section 6.2 (Groundwater Criteria) and Section 7 (Surface water and groundwater triggers) of the ACOL Water Management Plan (WMP). Additionally the Bowmans Creek Diversion Management Plan (Section 3 of the WMP) contains Performance and Completion Criteria for the Bowmans Creek Diversion.
It is recognized that Ashton Coal has undertaken initial consultation with the majority of the relevant government agencies and stakeholders during the preparation of the different sub-plans within the Extraction Plan. Several agencies and stakeholders provided feedback and raised issues that Ashton Coal indicates have been addressed in subsequent versions of the plans. However, with the exception of the RMS, none of these agencies or stakeholders has provided confirmation that they are satisfied with the final draft plans. Therefore, the Department requests written confirmation that: • DRE is satisfied with the Coal Resource Recovery Plan, Subsidence Monitoring Program, Built Features Management Plans, Public Safety Management Plan and the Rehabilitation Management Plan; and • Key stakeholders are satisfied with the relevant components of the draft Extraction Plan, particularly the Built Features Management Plans for the assets owned by Ausgrid, Transgrid, Glencore, AGL Macquarie, Telstra and Singleton Shire Council. If this confirmation is not included in the updated draft Extraction Plan submitted to the Department, then a conditional approval requiring such confirmation prior to the commencement of secondary extraction will be required from DRE, and prior to mining in the vicinity of the assets listed above from the assets' owners	ACOL received an email from Paul Langley at the Division of Resources and Energy (DRE) on 21 September 2015. The email stated that DRE are still assessing the EP documentation, but consider the Coal Resource Recovery Plan (Condition 3.12 g of the Development Consent) to be adequate. DRE are requesting that the current Mining Operations Plan (MOP) is updated to include: a. All aspects of the Land Management Plan. b. Address all aspects of rehabilitation of subsidence impacts, including rehabilitation objectives, completion criteria and rehabilitation monitoring. DRE stated that their formal comments would be provided directly to DP&E. ACOL will update the MOP prior to mining LW 105, which will then cover the rehabilitation requirements of the DRE. Following discussions with DP&E, ACOL accepts that conditional approval may be required for some asset management plans.
In addition, the Department requires clarification: • Of the status of negotiations with the NSW Dams Safety Committee (DSC) to obtain approval to mine within the Notification Areas of the Void 5 Ash Dam and the Narama Dam;	ACOL has a legal obligation to obtain DSC approval prior to mining within a DSC Notification Area. ACOL will be liaising with the DSC closer to the mining of LW 107B as the Void 5 DSC area lies in the northern section of LW 107B. Currently ACOL holds first workings approval for extraction within the DSC area (in the Upper Liddell Seam), but ACOL requires secondary extraction approval prior to mining within the DSC Notification Area. The ACOL workings lie outside the notification area for the Narama Dam, therefore no notification is required (see Figure 2 of main EP report).

DP&E Comment	SLR/ACOL Comment
• Of the status of the Transport Management Plan (TMP) for Lemington Road, which was agreed to be prepared by Ashton Coal and presented to Singleton Shire Council's Road Committee on 30 July 2015; and • That Glencore will accept responsibility to undertake any repairs as a result of subsidence impacts from the proposed mining on the fibre optic cable along Lemington Road.	ACOL agreed to present the Asset Management Plan to Singleton Shire Council (SSC) Road Committee rather than a Transport Management Plan. A Transport Management Plan will be developed and implemented prior to subsidence impacts on Lemington Road in consultation with SSC. The SSC Asset Management Plan was presented to the SSC Roads Committee as part of internal SSC consultation in July 2015. Glencore have been consulted as part of the EP process and informed of the potential impacts to their infrastructure. Lemington Road and associated infrastructure is managed in accordance with a Deed between Glencore, ACOL and SSC. It is not the responsibility of ACOL to undertake any repairs as a result of subsidence impacts on the fibre optic line as this was built as part of the Ravensworth North Project over an approved operation. ACOL will however inform Glencore of any subsidence impacts on the cable if they are observed.
Longwall Dimensions The dimensions of several of the longwalls in the main Extraction Plan document differ from those assessed as part of the Subsidence Assessment (SA) (SCT, 2015) and the SWGA. In particular, in the main Extraction Plan the length of LW107A is 6.4 metres longer than that assessed in the SA and the width of LW107B is 6 metres wider that that assessed in the SWGA. The Department requires clarification of the proposed dimensions of the longwalls. If they differ from those assessed in the SA or the SWGA, then the assessments will need to be updated to reflect the revised dimensions and associated impacts. This is all the more necessary since LWs 107A and 107B are located adjacent to Bowmans Creek.	Table 1 of the SCT Report contained minor dimensional errors. The SCT report has been updated to be consistent with the correct dimensions. The SCT report addressed the full proposed EP Area of LW 105-107. The SWGA assessment referenced LW 107B as 210 metres wide (Executive Summary and Section 1.4.1) in the text, with the actual width being 216m. This report has subsequently been updated to be correct. The 2014 Groundwater Model included LW 108 and change to the mine plan (widening of LW 107 and removal of LW 108) should reduce impacts to groundwater.
The site's Water Management Plan (WMP) was prepared earlier this year and approved by the Department on 27 April 2015. It has not been updated to reflect the revised mine plan, or include any of the recommendations made in the SA or SWGA. In particular, the SA predicts that mining associated with LWs 105 - 107 will result in a significant increase in the areas of ponding, and recommends options to improve the free drainage characteristics of the landform to manage the impacts of ponding. These recommendations are extensive (including clearing existing drainage lines, forming new drainage lines and landform reshaping) and need to be incorporated into the WMP.	The Water Management Plan will be updated prior to the mining of LW 105 to 107 to include additional details regarding ponding management. This detail will also be included in the updated MOP.

APPENDIX 1

SCT SUBSIDENCE LETTER

SCT Operations Pty Ltd
ABN 23 078 328 853
www.sct.gs

HEAD OFFICE
Cnr Kembla & Beach Streets Wollongong NSW 2500 Australia
PO Box 824 Wollongong NSW 2520 Australia
Telephone +61 2 4222 2777 Fax: +61 2 4226 4884
Email: sctnsw@sct.gs

MACKAY OFFICE
Telephone/Fax: +61 7 4952 5717
Email: p.cartwright@sct.gs

BENDIGO OFFICE
Telephone: +61 3 5443 5941
Email: s.macgregor@sct.gs

BRISBANE OFFICE
Telephone: +61 429 881 771
Email: y.heritage@sct.gs

18 September 2015

James Barben
Environment and Community Coordinator
Ashton Coal Operations Pty Ltd
PO Box 699
Singleton NSW 2330

Dear James

SUBSIDENCE COMPARISON FOR REVISED LONGWALL 105-107 VERSUS BOWMANS CREEK DIVERSION ENVIRONMENTAL ASSESSMENT, DECEMBER 2009

Further to the letter from Department of Planning and Environment (DRE) to Dr Digby Short dated 4 September 2015, please find herein a comparison of the predicted subsidence behaviour for the revised Longwalls 105-107 at the Ashton Coal Project (ACP), referred to as the revised layout, and the subsidence predicted for the Bowmans Creek Diversion Environmental Assessment (SCT Report ASH3584) that was based on a stacked geometry in both seams, referred to as the approved or stacked layout. A conceptual offset geometry was also approved for the Bowmans Creek Diversion Environmental Assessment (EA), but the subsidence effects were not estimated for this offset layout because the stacked geometry was expected to give higher values for all subsidence parameters.

Our assessment indicates that the revised offset layout is likely to produce subsidence effects that are of generally similar magnitude to the subsidence effects for the approved stacked layout. For the revised offset layout and based on the experience of mining Longwalls 101 and 102, lower subsidence effects than predicted for the stacked geometry are expected across most of the area. Slightly higher maximum subsidence is predicted given the potential to extract a thicker seam section than was contemplated in the EA, with somewhat greater strains and tilts expected at stacked edges based on the experience of monitoring a stacked edge above Longwall 102.

The area affected by subsidence impacts is overall slightly less for the revised layout compared to the approved layout. However, the footprint changes associated with this revised layout mean there is subsidence in some areas where there was no subsidence in the approved layout and vice versa.

1. INTRODUCTION

ACOL received approval from the then Department of Planning for the Bowmans Creek Diversion Environmental Assessment (EA) and subsequent modification to the existing development consent (DA309-11-2001-MOD6) on the 24th December 2011. SCT prepared a subsidence assessment for this application in SCT Report ASH3584 "Multi-Seam Subsidence Assessment for Ashton Coal Mine Longwalls 5 to 8" dated 23 October 2009.

SCT's subsidence assessment was based on a stacked layout in each of the four seams. This layout was assessed in anticipation that the subsidence effects would be generally greater in a stacked geometry than in the preferred, but at that time yet to be finalised, offset geometry. A conceptual offset geometry was also approved for the EA, but the subsidence effects were not estimated for this offset layout because there was limited data available at that time to make predictions for an offset geometry and the stacked geometry was expected to give higher values for all subsidence parameters.

ACOL has subsequently revised the layout in the Upper Liddell (ULD) Seam in the vicinity of Bowmans Creek as a largely offset geometry. The subsidence assessment for this revised layout is presented in SCT Report ASH4378 "Subsidence Assessment for Extraction Plan for Longwalls 105-107 in the Upper Liddell Seam" dated 14 April 2015.

DRE requested a comparison of the subsidence predicted for the revised layout against the subsidence predicted for the approved layout. SCT Operations Pty Ltd (SCT) was commissioned by ACOL to provide this comparison. This report presents the results of a comparison of the predicted subsidence effects predicted for these two layouts.

2. SITE OVERVIEW

Figure 1 shows a plan of the area of interest in the vicinity of the Bowmans Creek Diversion. The revised layout in the ULD Seam is shown overprinted on the approved layout and the extent of the longwall panels in the Pikes Gully (PG) Seam that were actually mined.

The southern ends of Longwalls 105, 106A, 106B, and 107A and the northern end of Longwalls106B and 107B extend outside the approved area by up to 90m (at the southern end of Longwall 107A). These changes improve resource recovery within the constraints of providing a 200m buffer to the Hunter River. An effect of extending Longwall 107A by 90m is to reduce the buffer between the corner of the panel and an incised section of Bowmans Creek from 104m under the approved plan to 51m with the extension. The overburden depth to the ULD Seam is approximately 210m in this area so impacts from this mining are expected to be perceptible at Bowmans Creek but slight and of no practical significance.

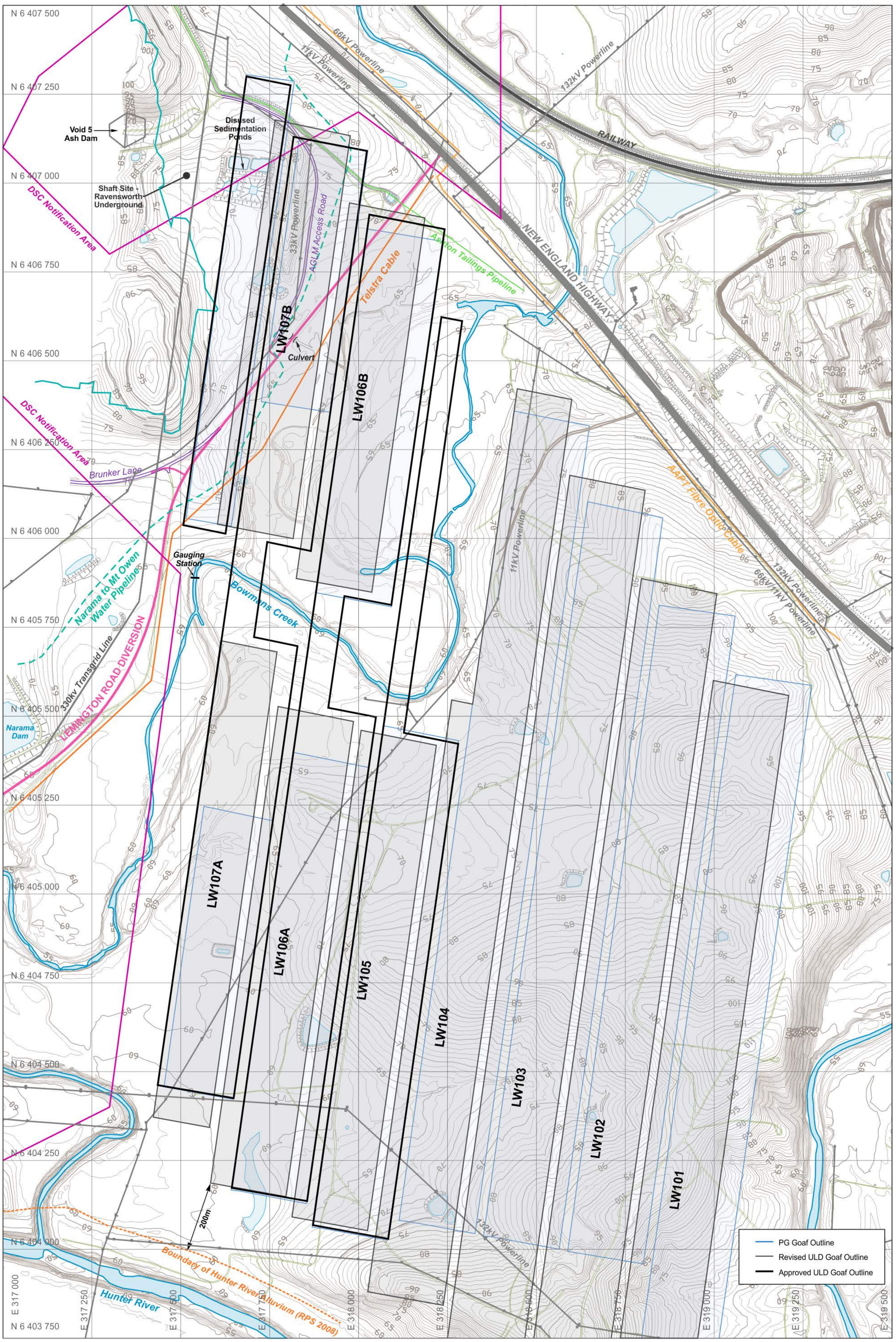


Figure 1: Site plan showing location of revised layout and the approved layout.

3. SUBSIDENCE EFFECTS COMPARISON

Table 1 summarises the subsidence effects for revised layout and comparative values for the approved layout. The subsidence effects for the revised layout are based on improved estimates of the seam thickness that became available since the original assessment and the recent experience of mining ULD Seam longwall panels below Longwalls 1, 2, and 3 in the PG Seam, particularly the experience gained above the stacked goaf edge at the finishing end of Longwall 102.

The increases in the maximum subsidence estimates are mainly a result of the increased seam thickness planned to be mined in the revised layout, but also on a slightly more conservative approach to estimating maximum subsidence for the revised layout. Increases in the tilts and strains are expected at the stacked edges based on the experience above the stacked edge in Longwall 102. The tilts and strains for other areas are less than was predicted for the stacked geometry.

Table 1: Incremental and Cumulative Subsidence Parameters Predicted for the Revised Layout of ULD Seam Longwall Panels – LW 105 to 107 – Compared to Subsidence Parameters Predicted for the Approved Stacked Layout

ULD Seam Longwall Panels And Depth (m) and Depth Range (in brackets)	Revised Layout					Approved Layout		
	ULD Subs (m)	ULD Tilt (mm/m)		ULD Strain (mm/m)		Subs (m)	Tilt (mm/m)	Strain (mm/m)
	Normal and Stacked Edges	Normal	Stacked Edges[1]	Normal	Stacked Edges[1]			
Incremental Subsidence Parameters								
LW105 170 (155-200)	2.1	49	99	12	49	2.1	80	40
LW106A 175 (170-210)	2.1	48	96	12	48	2.1	80	40
LW106B 150 (140-180)	2.5	67	133	17	67	2.1	80	40
LW107A 190 (185-220)	2.1	44	88	11	44	2.1	80	40
LW107B 170 (165-200)	2.7	64	127	16	64	2.1	80	40
Cumulative Subsidence Parameters								
LW105 170 (155-200)	3.8	89	179	22	89	3.7	150	70
LW106A 175 (170-210)	3.8	87	174	22	87	3.7	150	70
LW106B 150 (140-180)	4	107	213	27	107	3.7	150	70
LW107A 190 (185-220)	3.8	80	160	20	80	3.7	150	70
LW107B 170 (165-200)	4	94	188	24	94	3.7	150	70

[1]The stacked edges occur where the ULD Seam is mined from under the PG Seam goaf into a solid abutment with peak values occurring when the PG Seam goaf edge is undermined by about 20-30m.

Subsidence from mining Longwalls 105-107 in the ULD Seam is expected to cause additional incremental subsidence of up to 2.7m in the northern panels and up to 2.3m in the southern panels. The total cumulative subsidence is expected to reach up to 3.8m to 4.0m in the central part of areas where there is overlap between longwall panels in both seams, most likely in the northern part of Longwall 106B where the overburden depth is lowest. The incremental subsidence estimates are based on 85% of the thickness of the ULD Seam and the cumulative subsidence estimates are based on 75% of the combined thickness of both seams. Both of these values are considered to be reasonably conservative and actual subsidence is expected to be less than indicated in Table 1.

The section shown in Figure 2 (reproduced from Figure 8 in SCT Report ASH4378) shows a section through the central part of the northern panels where the subsidence line is located, but the maximum subsidence at the northern end of these panels is expected to be slightly greater and approach the maxima shown in Table 1.

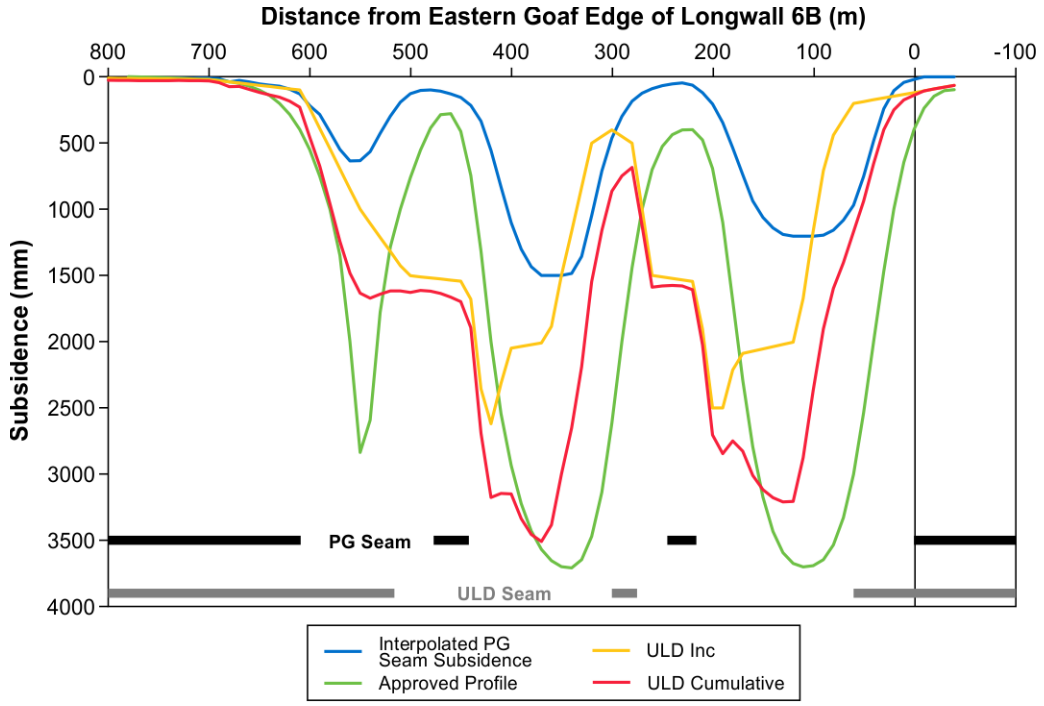


Figure 2: Subsidence profiles predicted across Longwalls 106B and 107B and a comparison with the subsidence profiles predicted for the panel geometry approved in the BCD Modification.

Over most of the area of Longwalls 105-107, incremental tilts and strains from mining in the ULD Seam are expected to be of similar to or lower magnitude than the tilts and strains predicted for, and observed during, mining in the PG Seam despite the cumulative subsidence for the ULD being almost double in magnitude.

However, in areas where the goaf edges in the two seams are stacked above each other, or nearly so, mining in the ULD Seam is expected to remobilise goaf edge fractures that originally developed during mining in the PG Seam. The experience in Longwall 102 of forming a stacked edge indicates that in these areas maximum tilts are likely to double background values and maximum strains are likely to reach four times background values at the PG Seam goaf edge cracks.

Areas where high tilts and strains are expected above stacked edges include the start of Longwalls 105, 106A, and 106B, the finish of Longwalls 105, 106B, and 107B, the western side of Longwall 107A and the northern edges of Longwalls 6A and 7A in the PG Seam.

Tilts and strains at stacked goaf edges are expected to reach a maximum when the ULD Seam goaf edges are mined 20-30m under the solid edge of a previously extracted panel in the PG Seam. In some cases these maxima will then reduce with further mining, but in other cases such as along the western edge of Longwall 107A, the high tilts and strains are expected to be permanent.

The impacts to landform are expected to be generally similar for the revised geometry to those predicted for the stacked geometry. The general landform above both the northern and southern longwall mining areas is expected to be lowered by up to 3.8-4.0m with perceptible cracks of up to about 200-300mm wide expected over the stacked goaf edges. Ponding within the subsidence bowls and increased inflows through into the overburden strata are expected with steep dips at the stacked goaf edges. Bowmans Creek and the two diversions are not expected to be subsided or otherwise impacted by the proposed mining so the general landform on either side of Bowmans Creek will be much lower than the adjacent section of creek invert. The resulting landform is therefore not expected to be free draining without some additional earthworks or pumping infrastructure.

The proposed layout in Longwalls 105-107 in the ULD Seam is consistent with keeping all secondary extraction at least 200m from the Hunter River Alluvium (as defined in RPS 2009) and at least 40m (in a horizontal direction) from the high bank of Bowmans Creek in its diverted form as per the Statement of Commitments made for Longwalls 5 to 7 in the PG Seam in Schedule C of DA309-11-2001 Mod-6 Items 3.2 and 5.3.

The impacts to surface infrastructure are expected to be similar to or less than the impacts anticipated for the stacked geometry. The infrastructure likely to be most significantly impacted by mining subsidence includes

Lemington Road and associated infrastructure including the culvert below the road, buried telecommunication lines alongside the road, the 33kV power line also alongside the road, the Narama to Mount Owen fresh water line, the 11kV local area electricity line, and the 132kV electricity line crossing the southern panels. All impacts are expected to be manageable albeit with some effort, particularly in respect of Lemington Road.

If you have any queries or require further clarification of any of these issues, please don't hesitate to contact me directly.

Regards

Ken Mills
Principal Geotechnical Engineer

APPENDIX 2

RPS SURFACE AND GROUNDWATER RESPONSE LETTER

Level 9, 17 York Street, Sydney NSW 2000, GPO Box 4401, Sydney NSW Australia 2001
T +61 2 8270 8388 F +61 2 8270 8399 E water@rpsgroup.com.au W rpsgroup.com.au

MEMORANDUM

COMPANY:	Ashton Coal		
ATTENTION:	James Barben		
FROM:	RPS Water		
DATE:	20 October 2015	JOB NO: S55P	DOC NO: 026b
SUBJECT:	Comparison of Predicted Impacts on Bowmans Creek between the 2009 Bowmans Creek Diversion EA and the 2015 LW105 to 107 Surface Water and Groundwater Impact Assessment		

James,

Please find below our comparison of the differences in predicted impacts on Bowmans Creek between the 2009 Bowmans Creek Diversion Environmental Assessment (EA) and the 2015 Longwall (LW) 105 to 107 Surface Water and Groundwater Impact Assessment.

The key objective of this assessment is to ascertain whether the predicted impacts from the 2015 LW105 to 107 Surface Water and Groundwater Impact Assessment are consistent with the approved impacts of the 2009 Bowmans Creek Diversion EA.

A focus of the assessment has been on comparison of predicted impacts on:

- Drawdown in the Alluvial Aquifer;
- Predicted baseflow impacts; and
- Alluvial water take.

In undertaking this review it has become apparent that a comparison is not as simple as directly comparing the numbers presented within the reports, as these numbers have generally been derived using different methodology and are not directly comparable. There have also been changes to the model for the later assessments. The 2015 Impact Assessment was based on the results of the 2014 Model Update, and so it is the 2014 modelling that will be compared to the 2009 EA. While both the 2009 and 2014 modelling utilised Modflow Surfact, the 2014 Model Update adopted the use of fully variable saturated flow (for which calculations are based on saturated porosity, as opposed to specific yield). Seasonal variability has also been built into the later models with monthly stresses for recharge and evapotranspiration, whereas the 2009 model was based on uniform annual stress for these components.

It should be noted that the current (2014) model is considered to be more representative of actual conditions, is more refined in its approach and may therefore be considered to be a more “accurate” model.

For the purposes of this comparison and the assessment of whether the predicted impacts of the 2015 LW105 to 107 Impact Assessment are consistent with the approved impacts of the 2009 EA, attention is focused on the comparison of the equivalent stage of mining, that being the end of ULD extraction.

1. Aquifer Drawdown

The Bowmans Creek alluvial aquifer is represented in Layer 1 of both the 2009 and 2014 models and therefore allows for relatively straight forward comparison.

Predicted water levels in Layer 1 at end of ULD extraction for both models are provided on Figure 1 and Figure 2.

In the 2009 EA the BCA is predicted to be substantially dewatered (unsaturated) at the end of ULD mining. It is noted that quoted drawdowns for the BCA from the 2009 modelling are for the remnant areas of saturation, much more significant drawdowns occur where the BCA has become completely desaturated.

In the 2014 Model Update, although some BCA cells are predicted to become unsaturated, particularly above LW6B in the north and LW107A in the south, the degree of drawdown and desaturation is considerably less, and continuity of saturated alluvium throughout the BCA is predicted to be maintained.

With respect to drawdown within the BCA, the 2014 Model Update, and therefore the 2015 Impact assessment, is well within the approved impacts of the 2009 EA.

2. Baseflow Impacts

Predicted baseflow impacts in the 2009 model are reported as the total baseflow impact at end of mining (130m^3/d), and at end of ULD (100m^3/day) compared with predicted pre-mining baseflows. This scenario is shown on Figure 3 and includes the cumulative impacts of the neighbouring Ravensworth Underground Mine.

In the 2014 Model Update the reported base flow impacts are the difference between the "null case" (without ACP) and the "with mining case" (with ACP). The reported take of up to 132m^3/d is the maximum predicted difference between the null case and the with mining case and occurs in 2013 and is therefore not directly comparable with the values reported in the 2009 EA This maximum predicted baseflow take is also of short duration. This scenario is also shown on Figure 3.

To enable a direct comparison, the predicted baseflows with ACP have been subtracted from the predicted baseflows without ACP at the end of ULD extraction for both the 2009 and 2014 models. These scenarios are also shown on Figure 3 and provide the following baseflow impacts:

- 2009 EA – 71m^3/d
- 2014 Model Update – 44m^3/d

With respect to predicted baseflow impacts on Bowmans Creek at the end of ULD extraction, the 2014 Model Update, and therefore the 2015 Impact assessment, is well within the approved impacts of the 2009 EA.

3. Alluvial Water Take

It is not possible to directly assess alluvial water take between the two models without undertaking additional modelling analyses as predicted mine inflows in the 2009 EA were not partitioned between water sources. However it is noted at total water take (mine inflows) at end of ULD mining in the 2014 model is approximately 1ML/d compared to 1.5ML/d for the same stage of mining in the 2009 model.

It was also not possible to directly compare calibrated hydraulic properties of the BCA between models as the full calibration data set for the 2009 model is not reported. It is noted however that horizontal hydraulic conductivities for the BCA in both models are consistent at 0.5m/d. Vertical hydraulic conductivity in the 2014 model, however, is much greater (5x10^{-3}m/d compared to 5x10^{-6}m/d) indicating a more conservative modelling approach, despite the reduction of predicted impacts to the BCA.

Given the reduced mine inflows predicted by the 2014 model, combined with a reduced drawdown in the alluvium (predicted and observed) it reasonable to conclude that the corresponding alluvial water take would therefore also be less than that of the 2009 EA.

4. Summary

From the assessment detailed above it is apparent that with respect to predicted impacts on the Bowmans Creek Alluvial aquifer and baseflows to Bowmans Creek, the predicted impacts of the

2015 Surface water and Groundwater Assessment are consistent with (i.e. are less than) the approved impacts of the 2009 Bowmans Creek Diversion EA.

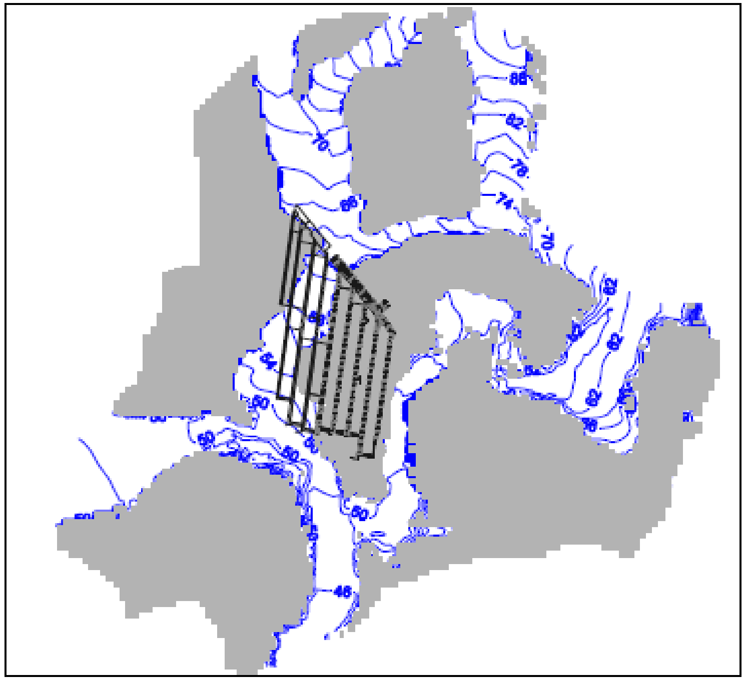
We trust the assessment provided above is sufficient for your current requirements. Please don't hesitate to contact us should you require any further information.

Yours sincerely,
RPS Water

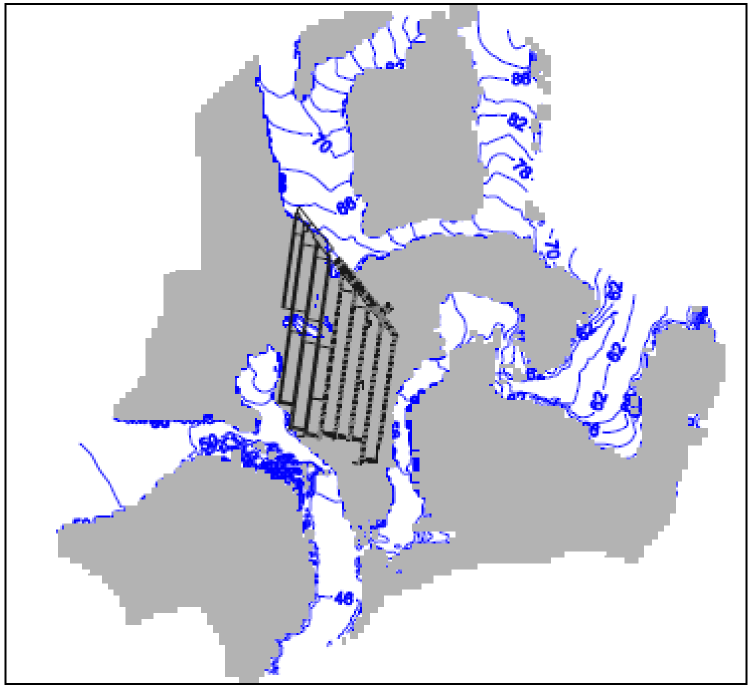
Greg Sheppard
Principal Hydrogeologist

FIGURES

2009 EA – WITHOUT ACP



2009 EA- WITH ACP

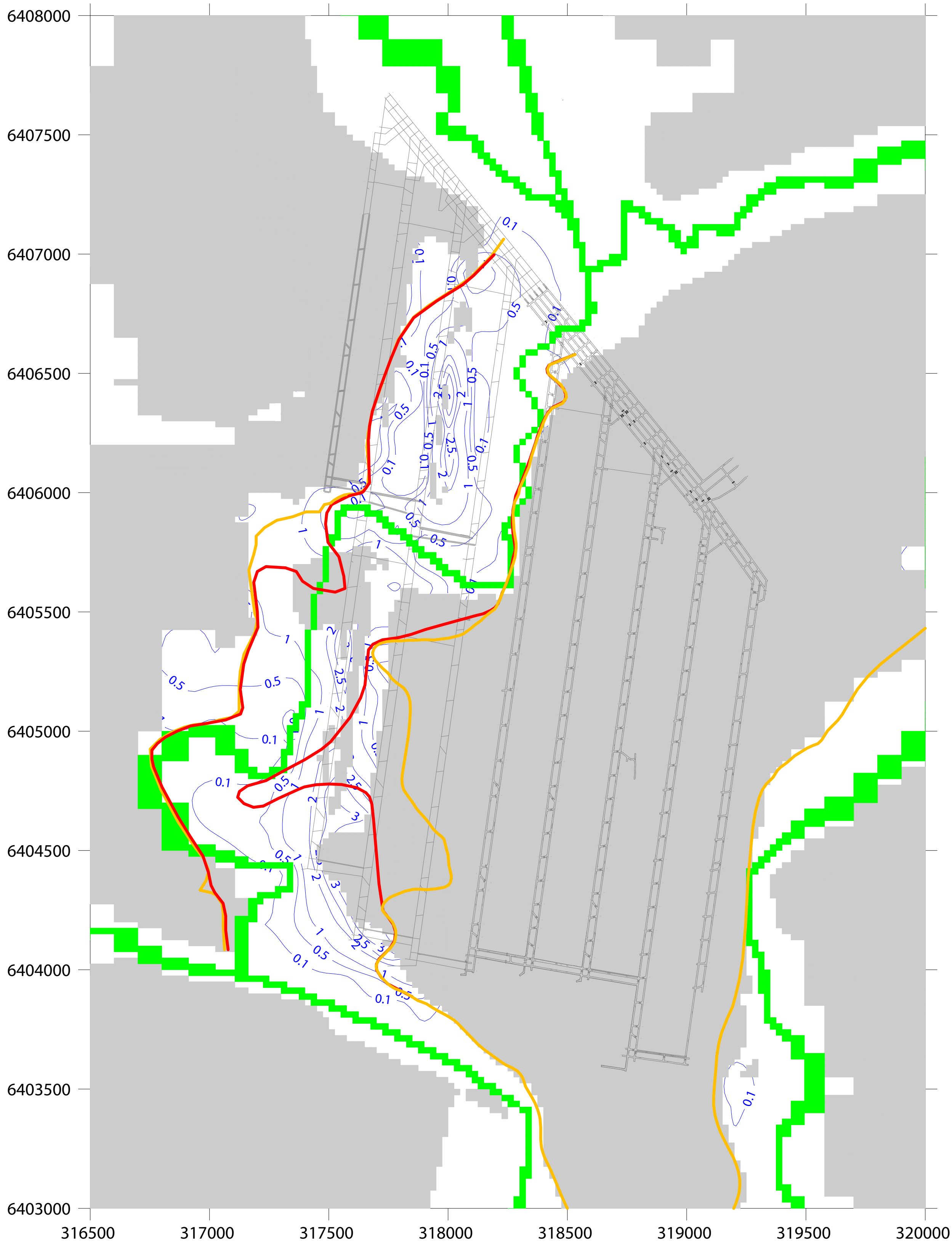


SOURCE: 2009 BCD EA – FIGURE 6.9

Grey shading denotes dry cells within Layer 1 of the model. In the without ACP image the full saturation or baseline condition is shown. In the with ACP image the BCA above the longwall panels is shown to be almost complete desaturated.

2009 PREDICTED WATER LEVELS FIGURE 1

f:\jobs\s55p\100\client\026a\026a figure 1.docx



Predicted Drawdown Levels (m)

Dry Cells

Rivers or Creeks

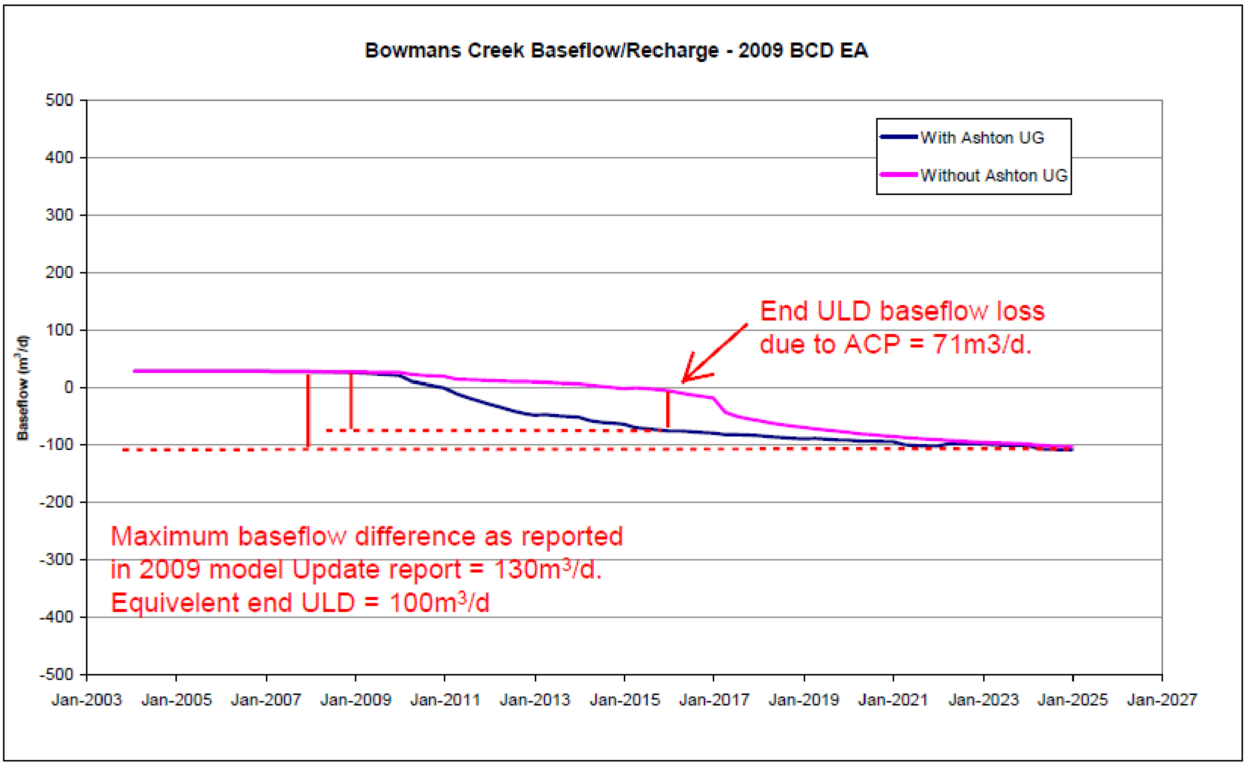
Extent of Alluvium

Extent of Saturated BCA (pre mining)

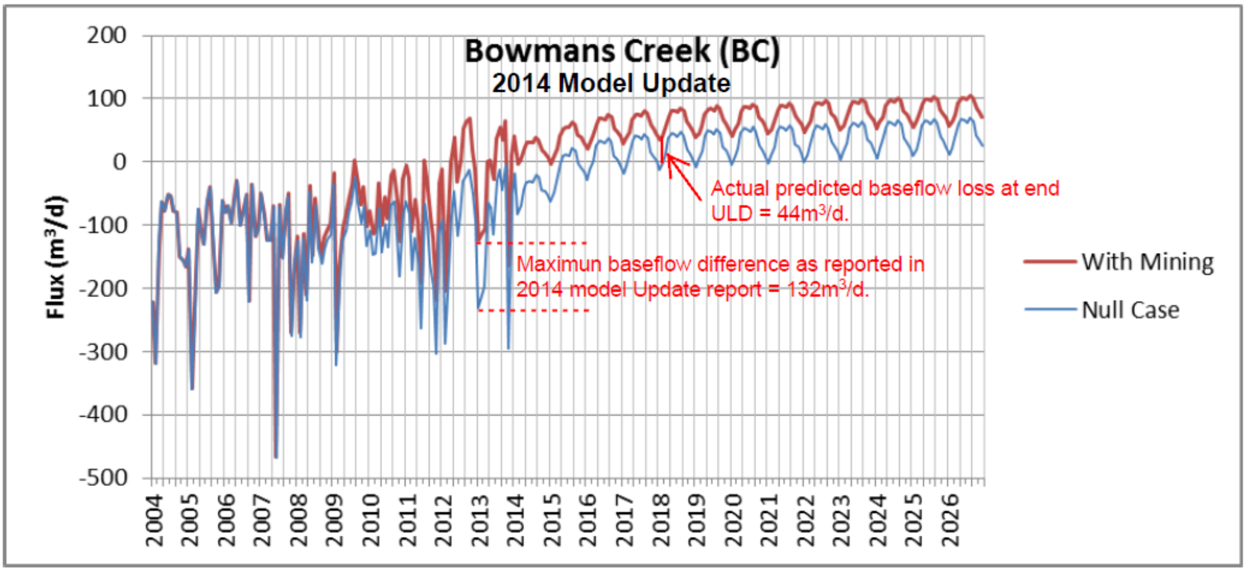
Date 16 February 2015	Scale As Shown	Ashton Coal Operations Ltd
Initials GS	Project S55P	Predicted Groundwater Drawdown Levels at the End of ULD LW8 in the Alluvium and Regolith (Layer1) 2014 Model Update

RPS

Figure 2



2009 BCD EA – FIGURE 6.15 (ANOTATED)



2014 MODEL UPDATE – FIGURE 22 (ANOTATED)

Likelihood	Likelihood Examples (Guide)	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
C (Possible)	The unwanted event could well have occurred in the Australian mining industry at some time in the past 10 years	**4** (L)	**8** (M)	**13** (H)	**18** (H)	**22** (E)
D (Unlikely)	The unwanted event has happened in the Australian mining industry at some time; or could happen in 50 years	**2** (L)	**5** (L)	**9** (M)	**14** (H)	**19** (H)
E (Rare)	The unwanted event has never been known to occur in the Australian mining industry; or is highly unlikely that it could ever occur	**1** (L)	**3** (L)	**6** (M)	**10** (M)	**15** (H)