Appendix 4 Subsidence Assessment

Strata Control Technology

REPORT TO:

ASHTON COAL MINE

Multi-Seam Subsidence Assessment for Ashton Coal Mine Longwalls 5 to 8

ASH3584

Mining Research and Consulting Group

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

REPORT TO Phil Fletcher
Technical Services Manager
Ashton Underground Mine
PO Box 699
SINGLETON NSW 2330

SUBJECT Multi-Seam Subsidence Assessment for Ashton Coal Mine Longwalls 5 to 8

REPORT NO ASH3584

PREPARED BY Ken Mills

DATE 23 October 2009

Ken Mills
Senior Geotechnical Engineer

Winton J. Gale
Managing Director

SUMMARY

Ashton Coal Operations Ltd (ACOL) is proposing to mine longwall panels in four seams as part of their ongoing operations near Camberwell in the Hunter Valley. ACOL is seeking to vary their development consent conditions for Longwalls 5 to 8 to allow diversion of Bowmans Creek. ACOL commissioned SCT Operations Pty Ltd (SCT) to undertake a subsidence assessment describing the impacts expected from the proposed mining as part of an Environmental Assessment being prepared on their behalf by Evans & Peck Pty Ltd. This report presents the results of our assessment of the subsidence impacts for the proposed mining of Longwalls 5 to 8 in each of the four seams.

Our assessment is based on the approach to estimating multi-seam subsidence described by Li et al (2007). Maximum subsidence over the centre of each longwall panel is expected to increase incrementally with each seam mined as shown below. The maximum tilt and strain values are also expected to increase incrementally as shown.

SEAM	MAXIMUM SUBSIDENCE (M)	MAXIMUM TILT (MM/M)	MAXIMUM STRAIN (MM/M)
PIKES GULLY	1.6	70	30
UPPER LIDDELL	3.7	150	70
UPPER LOWER LIDDELL	5.8	240	110
LOWER BARRETT	8.3	350	160

We understand that ACOL will review and modify mine plans in response to actual subsidence behaviour associated with mining in the deeper seams based on monitoring experience, expert interpretation, and other advice.

In the stacked arrangement of longwall panels proposed – where the longwall panels in each seam are directly below the panels in the seam above – subsidence over the chain pillars is sensitive to the stability of the chain pillars, but is expected to be generally less than 0.6m. Refinement of the pillar geometry to ensure stability will be based on numerical modelling and monitoring of Longwalls 1 to 4 pillars following mining in the lower seams.

If the longwall panels in the lower seams are offset, the subsidence profile is expected to be generally smoother and the total subsidence may be slightly less. A stacked arrangement has been used for subsidence assessment purposes. The stacked arrangement represents the worst case scenario because of the potential for higher subsidence, tilt and strain values allowing ACOL to carry out mining studies on alternate layouts in parallel with the EA application.

There is a possibility that strains and tilts may vary from predictions as a result from the interaction and reworking of the fractured overburden strata above each panel. Monitoring of subsidence over Longwalls 1 to 4 in the

lower seams as each seam is mined will allow more accurate predictions of subsidence parameters above Longwalls 5 to 8.

The maximum total subsidence below the alignment of the proposed diversion of Bowmans Creek is likely to be sensitive to the overburden bridging characteristics across the narrow panels directly below the creek alignment. If the overburden bridging characteristics expected for a single seam are replicated in the lower seams, maximum subsidence below Bowmans Creek is expected to be generally less than 0.4-0.5m when all the seams have been mined. We understand that ACOL will refine the multi-seam panel geometry below Bowmans Creek to ensure long term overburden bridging below the creek if ongoing monitoring and numerical modelling of multi-seam operations indicates that this is necessary.

Notwithstanding the low levels of subsidence expected at the diversion, nearby subsidence of up to 8-9m at the completion of mining the Lower Barrett Seam is expected to leave the creek diversion elevated above parts of the adjacent flood plain. Water falling as rain on the flood plain, water flowing as runoff from adjacent areas, and water that overtops Bowmans Creek during a flood event is expected to pool at the lowest point in the landform. The disturbance to the overburden strata caused by 8-9m of subsidence is expected to provide sufficient hydraulic connection between the surface and the mine for there to be a high potential for some of the water that pools in subsidence troughs to flow down into the mine. The potential for inflow is addressed by Aquaterra (2009) in their Bowmans Creek Diversion: Groundwater Impact Assessment Report.

We understand that ACOL proposes to maintain a free draining landscape by progressively constructing drainage works or filling subsidence areas on the floodplain, with the exception of the excised sections of the creek channel. This land filling and regrading work is intended to reduce the potential for water inflow into the mine and limit pooling of surface water.

The ground disturbance caused by the combined subsidence from four seams and potentially the filling operations is expected to significantly impact any surface infrastructure located directly over the panels. It is noted that the majority of the surface area affected by mining subsidence is owned by ACOL.

Power lines traversing the surface above the mining area are likely to lose ground clearance. Building structures are not expected to remain serviceable and will need to be relocated or demolished. Unsealed access roads are unlikely to remain serviceable during the period they are actively mined under by the second and subsequent seams, but once subsidence is complete, they can be re-established by regrading without undue difficulty. The sealed section of Brunkers Lane is likely to require significant remedial work to maintain it in a serviceable condition. Buried water pipes and Telstra Lines are not expected to remain serviceable.

Ravensworth Underground Mine owned by Xstrata is planning a multi-seam underground longwall operation that shares a lease boundary with the ACOL lease. There is unlikely to be any significant interaction between the two mines for mining operations in the Pikes Gully Seam. The effect of mining the deeper seams in either mine would be to reduce the confinement that is available to maintain the integrity and stability of the intervening barrier pillar. There is not considered likely to be any significant issue for the mining geometries that we understand are currently proposed, but consideration should be given to the actual mining geometries to ensure that there is no potential for a loss of confinement to the barrier pillar to cause instability or a loss of integrity

There is limited experience of how subsidence movements will develop outside the active mining area when multiple seams are extracted. For the stacked geometry proposed, it is anticipated that the goaf edge subsidence and angle of draw will increase with each seam mined. There has been a steady increase in angle of draw with depth in the four longwall panels mined to date. The angle of draw is expected to be generally of the order of 26.5° once mining in the Pikes Gully Seam is complete. There is potential for the cumulative angle of draw to the deeper seams to increase above 26.5° as a result of the higher levels of subsidence associated with multi-seam extraction. If the longwall panels in the lower seams are offset, the angle of draw for each additional seam will be controlled by the outermost panel in any of the previous seams and not necessarily by the panel currently being mined.

Infrastructure located outside the mining area is expected to experience subsidence movements greater than would be expected for single seam mining, but the actual magnitude of subsidence movement outside the area will need to be confirmed by monitoring in earlier panels. The protection barriers provided to the Narama Dam, the New England Highway and bridge over Bowmans Creek, buried fibre optic cable, and power transmission lines outside the mining area are expected to be sufficient, but ongoing review is recommended based on monitoring experience.

Insite Heritage Pty Ltd (2008) identified nine scatter sites in the immediate vicinity of Longwalls 5 to 8. These have been categorised as being of low significance. Most are likely to be impacted by subsidence movements and are likely to be buried by subsequent land filling and surface regrading operations. The waterhole site is remote from the proposed mining and is not expected to be affected by subsidence movements.

The proposed mining is located in an area currently below Bowmans Creek. ACOL are proposing to divert sections of Bowmans Creek to allow for more efficient resource recovery of Longwalls 5 to 8. The basis for the creek diversion and the studies that underpin it are reported elsewhere and have not been included in this report.

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1. INTRODUCTION

Ashton Coal Operations Ltd (ACOL) is proposing to mine longwall panels in four seams as part of their ongoing operations near Camberwell in the Hunter Valley. ACOL is seeking to vary their development consent conditions for Longwalls 5 to 8 to allow diversion of Bowmans Creek. ACOL commissioned SCT Operations Pty Ltd (SCT) to undertake a subsidence assessment describing the impacts expected as part of an Environmental Assessment being prepared on their behalf by Evans & Peck Pty Ltd. This report presents the results of our assessment of the subsidence impacts for the proposed mining of Longwalls 5 to 8 in each of the four seams.

ACOL currently has development consent for underground mining in this area, but ACOL is seeking to vary their development consent conditions for Longwalls 5 to 8 to include a diversion of Bowmans Creek and allow more efficient resource recovery.

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.

2. Subsidence estimates based on the previous subsidence monitoring at the mine and reported experience of multi-seam subsidence.

3. Identification of surface features likely to be impacted by subsidence and specific assessments of the likely subsidence impacts on each of the features identified.

4. Recommendations for subsidence monitoring programs and strategies to manage the subsidence impacts identified.

2. SITE DESCRIPTION

The Ashton Coal Mine is located approximately 14km northwest of Singleton in the Hunter Valley region of New South Wales. The project includes an open cut mine, an underground mine, a Coal Handling and Preparation Plant (CHPP) and associated rail siding and infrastructure. The mine has been developed in a staged manner, with the infrastructure and open cut mine developed concurrently. Development of the underground mine subsequently commenced in December 2005 and is accessed through the southern wall of the Arties Pit under the New England Highway.

The major natural features in the area include Bowmans Creek which lies directly over the proposed panels, the Hunter River to the south outside the proposed mining area, and Glennies Creek to the east of Longwalls 1 to 4, again outside the mining area considered in this report. ACOL propose to divert Bowmans Creek to allow more efficient recovery of the coal resource.

The major infrastructure within the general area includes the New England Highway in the north including a bridge over Bowmans Creek, a buried fibre optic cable alongside the highway, and three high voltage electricity lines, two alongside the highway and a third that traverses the southern end of the panels.

Other non-mining related infrastructure includes a local area electricity line, two buried Telstra copper wire lines, and a river gauging station on Bowmans Creek. Within the timeframe of the project, we understand that there is a proposal by Xstrata to upgrade Brunkers Lane to a public road as replacement for Lemington Road.

Mining related infrastructure that is not owned by Ashton includes a private road that provides secondary access to Macquarie Generation land and Ravensworth Underground as well as access to Ravensworth Open Cut, clay lined sedimentation ponds located on a waste rock spoil pile, an 11kV power line servicing Ravensworth Open Cut, and a large diameter polyline understood to carry fresh water from Narama Dam to Mt Owen Mine.

The Dams Safety Committee (DSC) Notification Area for Narama Dam (also known as Ravensworth Inpit Dam) overlaps the underground mine, although the dam itself is located outside the proposed mining area. A second water storage dam, known as Void 5 or Proposed Ravensworth Void 5 Ash Dam, is planned west of the north-western corner of the underground mine within the timeframe of mining. This dam will also be located outside the mining area, but the DSC Notification Area will overlap with the underground mine.

Ravensworth Underground Mine owned by Xstrata is planning a multi-seam underground longwall operation that shares a lease boundary with the ACOL lease. Although, the two mines are required by law to be separated by a 40m wide barrier, 20m either side of the lease boundary, there is nevertheless some potential for interaction, particularly when both are multi-seam operations.

Ashton owned infrastructure over the underground mine includes several farm buildings and houses, 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.

2.1 Existing Consents

ACOL was granted development consent on 11 October 2002 by the Minister of Planning pursuant to the provisions of the *Environmental Planning and Assessment Act 1979*. ACOL's consent for underground mining includes a series of longwall panels, oriented in a north-south direction. The operation is approved as a multi-seam operation and will extract coal from the following seams in descending order:

1. Pikes Gully Seam;
2. Upper Liddell Seam;

3. Upper Lower Liddell Seam; and
4. Lower Barrett Seam.

The original mine plan included up to seven longwall panels within each seam, subject to satisfying various conditions of consent. The bulk of these conditions relates to ongoing assessment and management of impacts to Bowmans Creek and associated alluvial aquifers which are potentially affected by Longwalls 5 to 8.

The exact location of longwall panels is not fixed under the development consent but may vary within the approved footprint to meet mining engineering requirements or to minimise environmental impacts. The western extent of the approved underground mining area is currently subject to a separate application for development consent modification with respect to the Pikes Gully seam only, to extend the approved mining area closer to the western boundary of ACOL's existing mining lease.

2.2 Land Use and Ownership

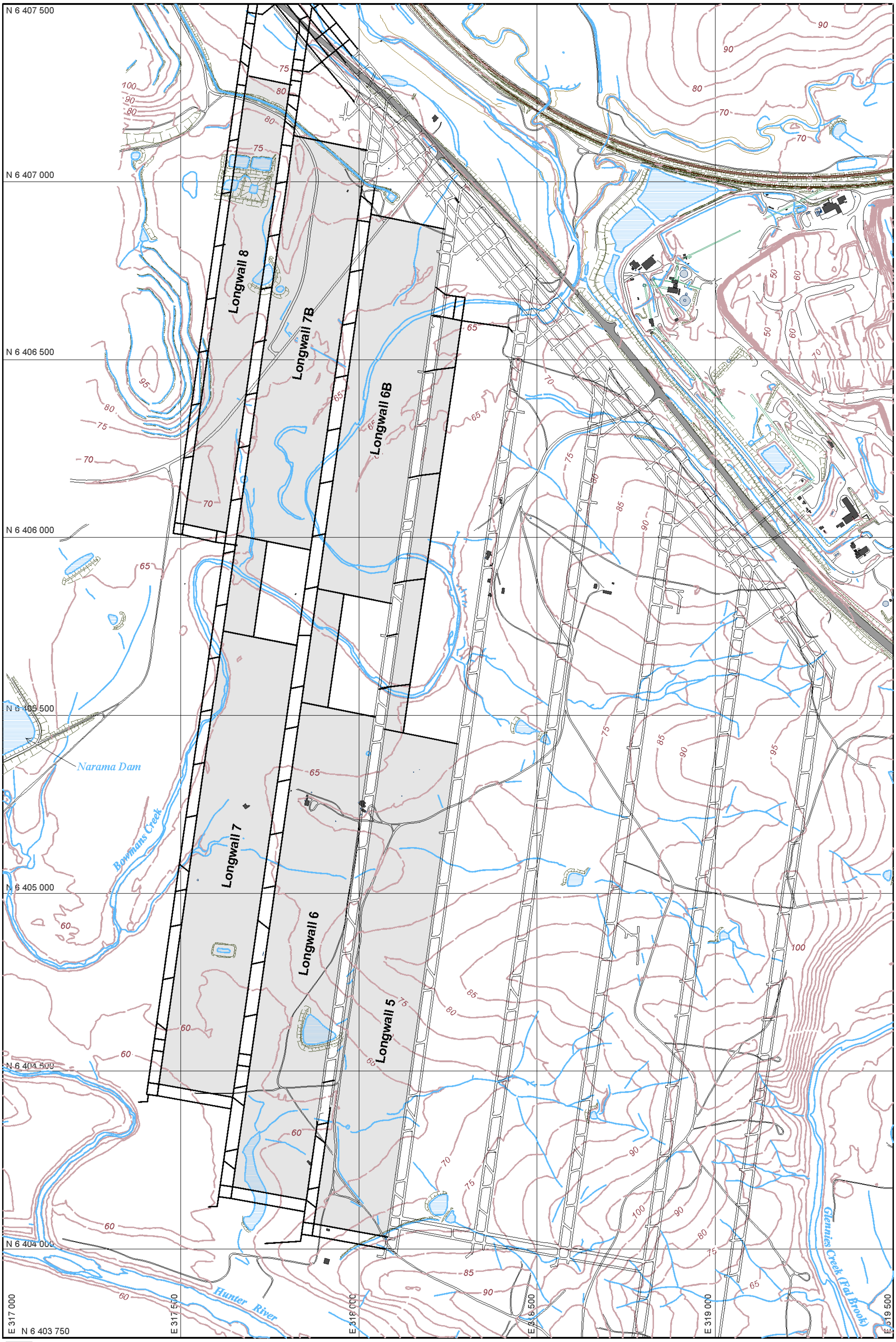
The proposed mining area is predominantly cattle grazing land on either side of Bowmans Creek. Longwalls 5 to 8 are located between the current mining area (Longwalls 1 to 4) to the east and the original alignment of Brunkers Lane to the west, the New England Highway to the north, and the Hunter River to the south.

Most of the surface area is owned by Ashton, but there is a triangle of land owned by Macquarie Generation in the north-western corner of the application that has been used as an out of pit spoil dump for the adjacent open cut mine. Land to the west is owned by Ravensworth Operations Pty Ltd.

2.3 Proposed Mining

Figure 1 shows a plan of the proposed mining area superimposed onto plan of the major surface features together with contours of surface RL. Figure 2 shows the proposed mining layout superimposed onto a plan of the natural surface features, surface infrastructure and proposed diversion of Bowman's Creek. Figure 3 shows the same plan superimposed onto contours of overburden depth to the Pikes Gully Seam. Table 1 summarises the panel dimensions.

In a stacked geometry, the proposed longwall panels are planned to be replicated in each of four seams, the Pikes Gully (PG) Seam, the Upper Liddell (ULD) Seam, the Upper Lower Liddell (ULLD) Seam, and the Lower Barrett (LB) Seam. There is some potential for the geometries in the lower seams to be varied to improve mining conditions and to reduce the subsidence impacts on the surface. The mining geometry shown has been used for the purposes of this assessment, recognising that a stacked geometry is likely to produce higher stains and tilts than an offset geometry. In an offset geometry, the subsidence profile is expected to be gentler with more subsidence over the chain pillars and less variation across each panel.



Proposed Mining Area

Figure 1: Site plan showing location of proposed mining area and contours of surface RL.

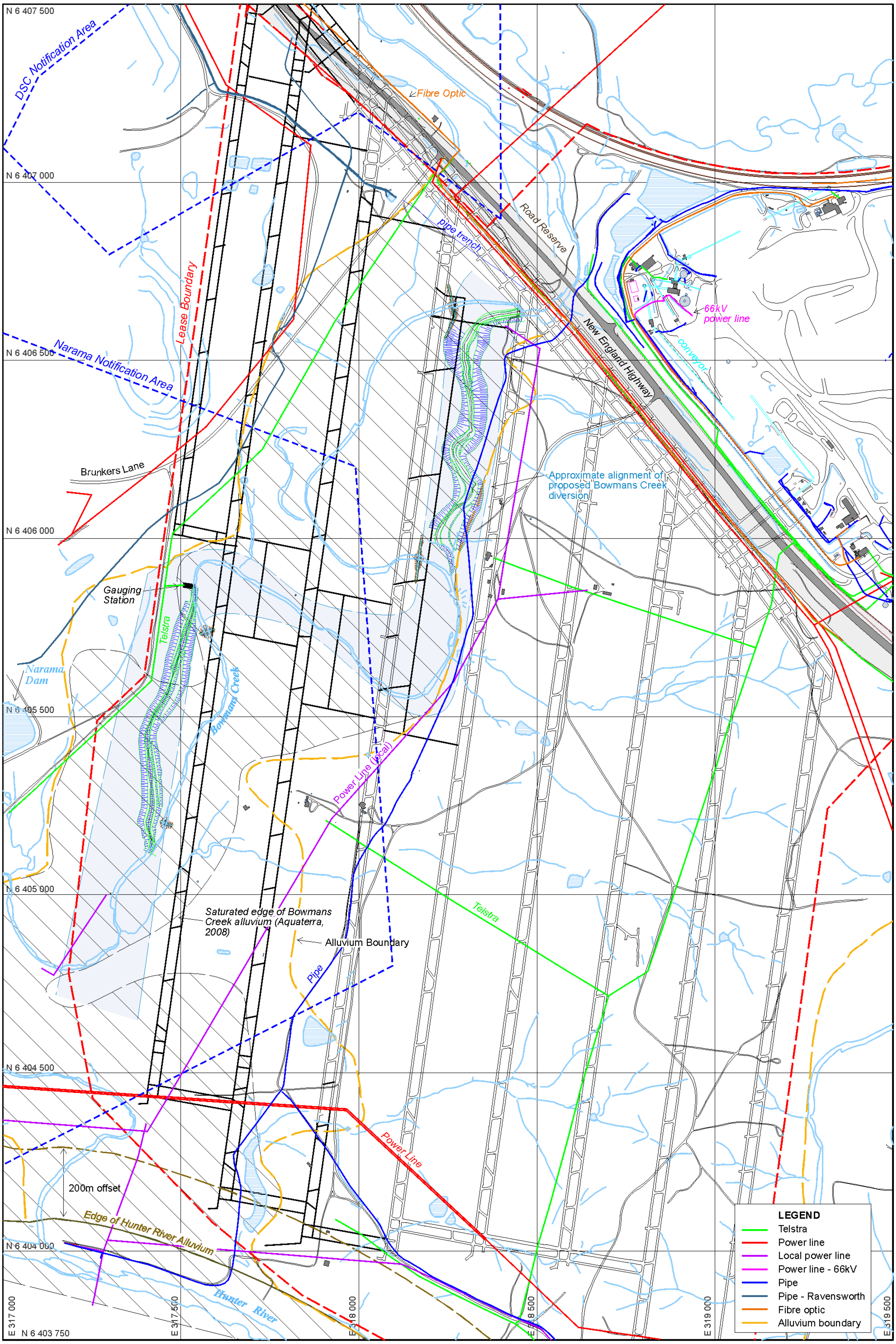


Figure 2: Site plan showing mine plan and location of surface infrastructure, natural features and proposed developments.

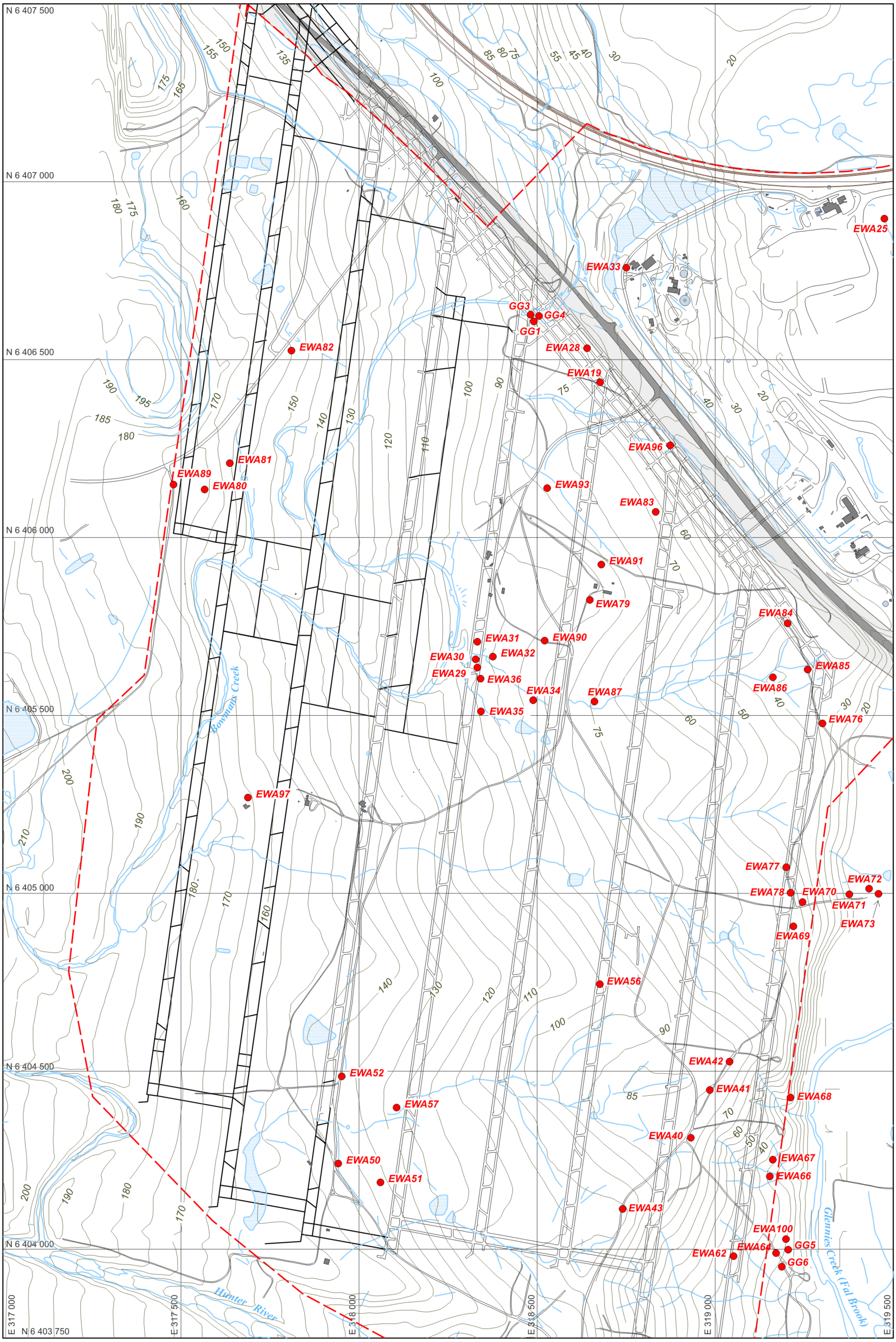


Figure 3: Plan showing overburden depth to Pikes Gully Seam and location of archeological sites *(Ref. Figure 2, Ashton Coal Drawing No. A-000, Revision B)*.

Table 1: Proposed Longwall 5 to 8 Panel Dimensions

Panel	Gateroads Nominal	Pillars c-c	LW Width c-c	LW Length c-c
LW5	5.4	30	210.5	1401
LW6	5.4	35	210.5	1376
LW6B	5.4	30	210.5	1063
LW7	5.4	30	210.5	1285
LW7B	5.4	30	210.5	1135
LW8	5.4	25	122.5	1245

Table 2 summarises the mining section, depth, and separation between seams based on the borehole log from WMLC235 located in the middle of the proposed mining area at E317667, N6405619. The overburden depth to each seam has been determined from multiple borehole intersections across the proposed mining area.

Table 2: Summary of Proposed Mining Horizons from WMLC235

Seam	Mining Section (m)	Depth at WMLC235 (m)	Separation to Seam Below (m)
Pikes Gully	2.4	167	27
Upper Liddell	2.4	196	31
Upper Lower Liddell	2.4	231	32
Lower Barrett	2.8	266	-

3. PREDICTED SUBSIDENCE BEHAVIOUR

The stacked mine layout shown in Figure 1 has been adopted as the mine layout for lower seams for the purpose of preparing cumulative subsidence estimates for all four seams. There is limited experience in Australia of subsidence monitoring where multiple seams have been mined. The experience generally of a stacked mining geometry is even more limited because of the practical difficulties of physically mining this type of geometry.

The subsidence estimates presented have been prepared for concept mine planning and environmental assessment purposes. It is recognised that the final mine layouts for lower seams may vary to meet engineering, safety and environmental requirements as more information on multiple seam subsidence interaction becomes available from Longwalls 1 to 4 at Ashton and from other sites. The subsidence estimates provided should be viewed in this context.

Li et al (2007) have summarised the experience of subsidence monitoring above multi-seam mining operations and provided a basis to estimate subsidence behaviour. This experience indicates that the second and subsequent seams cause maximum subsidence of approximately 80% of the total accumulated seam section mined. Li et al show data that suggests that, for the second seam mined, the strains and tilts are sensitive to the particular layout geometries, are greatest for stacked geometries, and are more than would be expected based on cumulative seam thickness alone. It is recognised within the subsidence community that more work is required to refine knowledge of multi-seam mining and further validate these findings. The prediction of subsidence estimates for ACOL is based on the work presented by Li et al.

3.1 Subsidence Estimates

In this section, the subsidence estimates are presented in the form of subsidence contours, and in terms of maximum subsidence estimated for each seam. Indicative maximum strain and tilt estimates are also provided.

Figures 4 to 7 show the subsidence contours that are expected at the completion of mining in each seam. Point measurements of the maximum and minimum subsidence in the centre of each panel and over the chain pillars are also shown. The contour intervals are variable between plots for clarity, simplicity of presentation, and to avoid any implication that the subsidence can be estimated across the full range of subsidence movements expected with the level of resolution that is possible for single seam workings alone.

Table 3 summarises the average maximum subsidence that is expected at the completion of mining in each seam. These values are expected over the central part of the full width panels. In general, the tilts and strains are likely to be greater in Longwall 5 where the overburden depth is less and decrease in magnitude as the overburden depth increases toward Longwall 8. However, the unconsolidated material on the surface in the land owned by Macquarie Generation is expected to cause locally higher levels of subsidence, strain and tilt.

Table 3: Summary of Expected Subsidence Movements

SEAM	MAXIMUM SUBSIDENCE (M)	MAXIMUM TILT (MM/M)	MAXIMUM STRAIN (MM/M)
PIKES GULLY	1.6	70	30
UPPER LIDDELL	3.7	150	70
UPPER LOWER LIDDELL	5.8	240	110
LOWER BARRETT	8.3	350	160

Note: values shown are cumulative.

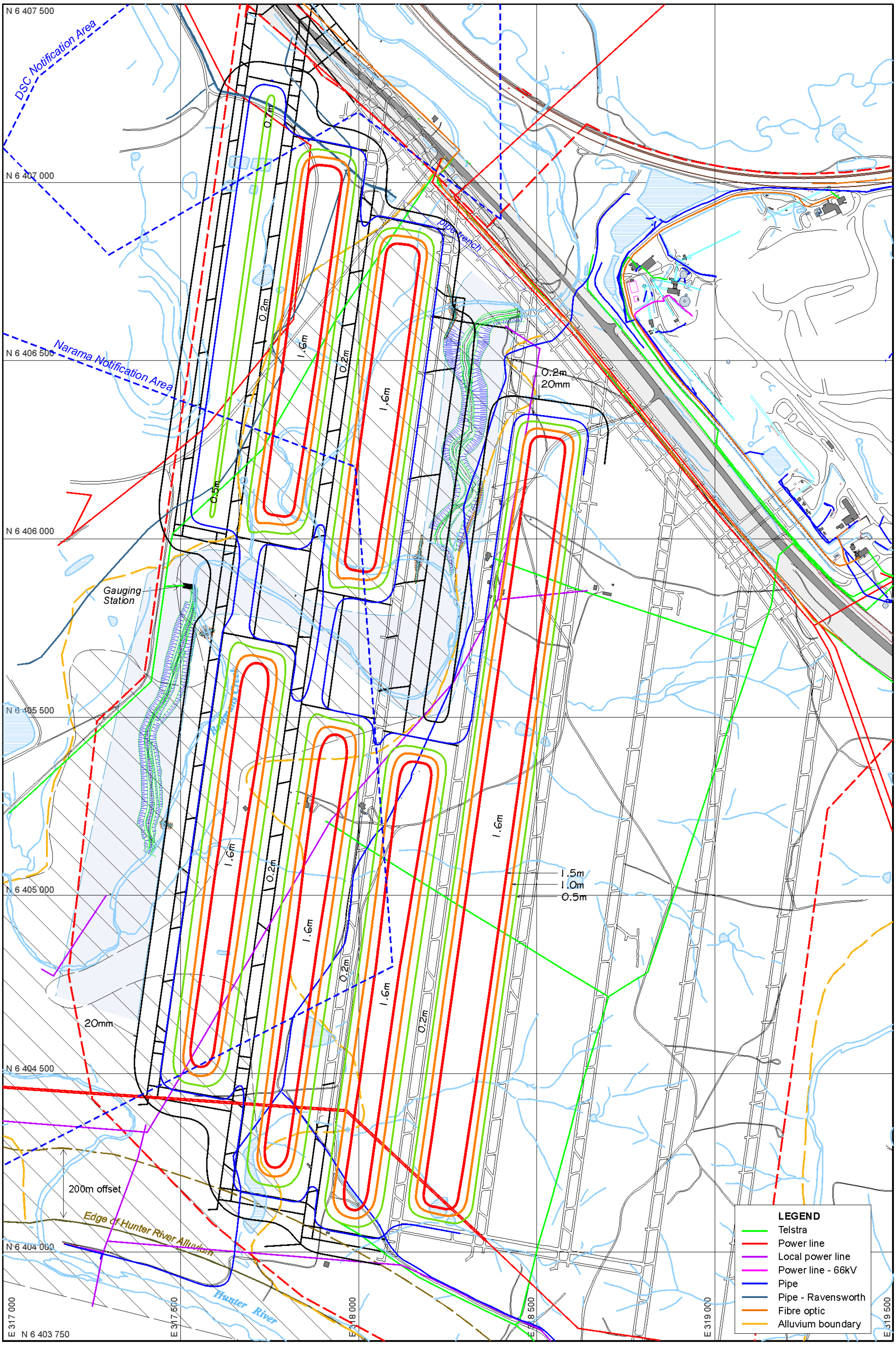


Figure 4: Subsidence contours at completion of mining in Pikes Gully Seam.

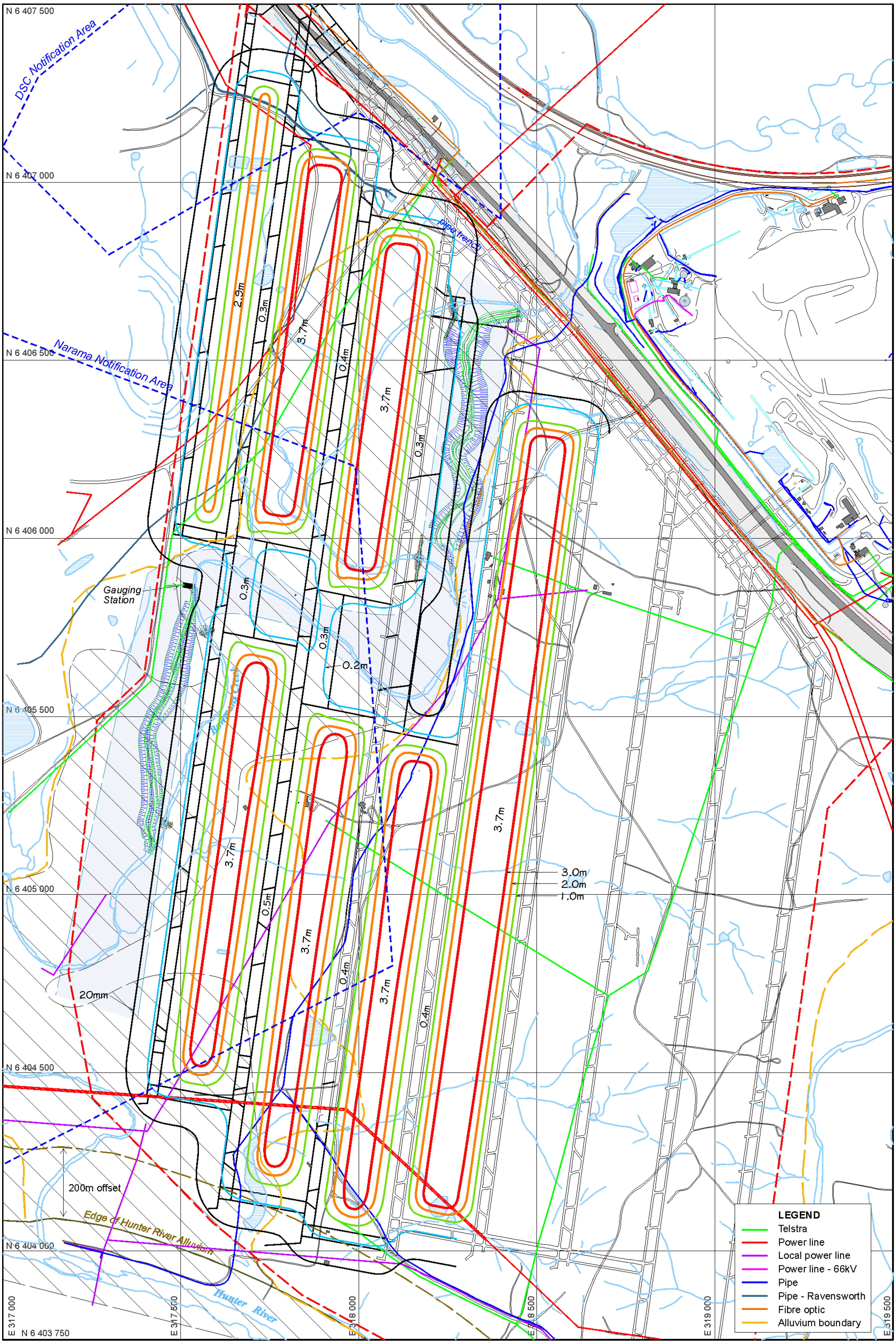


Figure 5: Subsidence contours at completion of mining in Upper Liddell Seam.

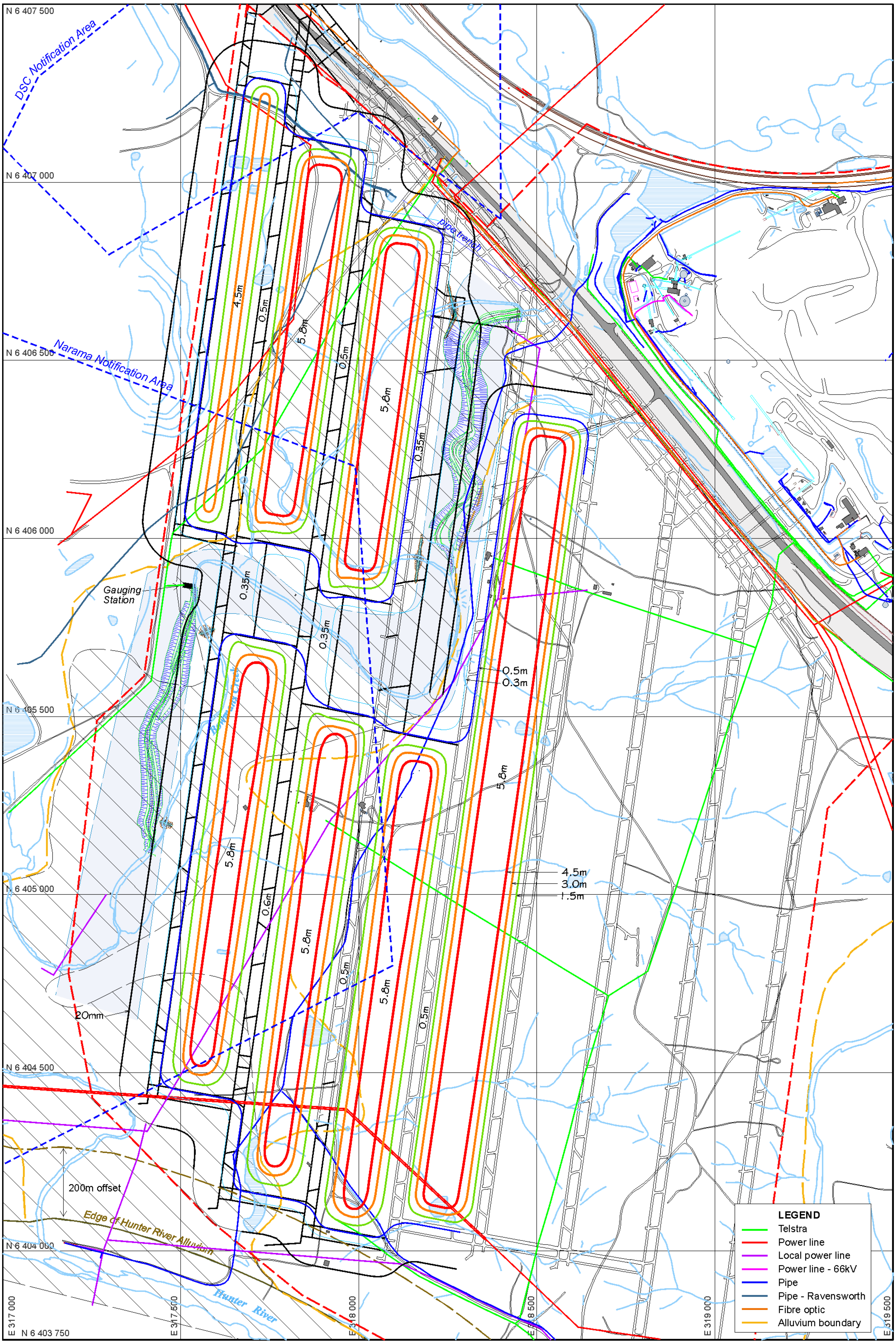


Figure 6: Subsidence contours at completion of mining in Upper Lower Liddell Seam.

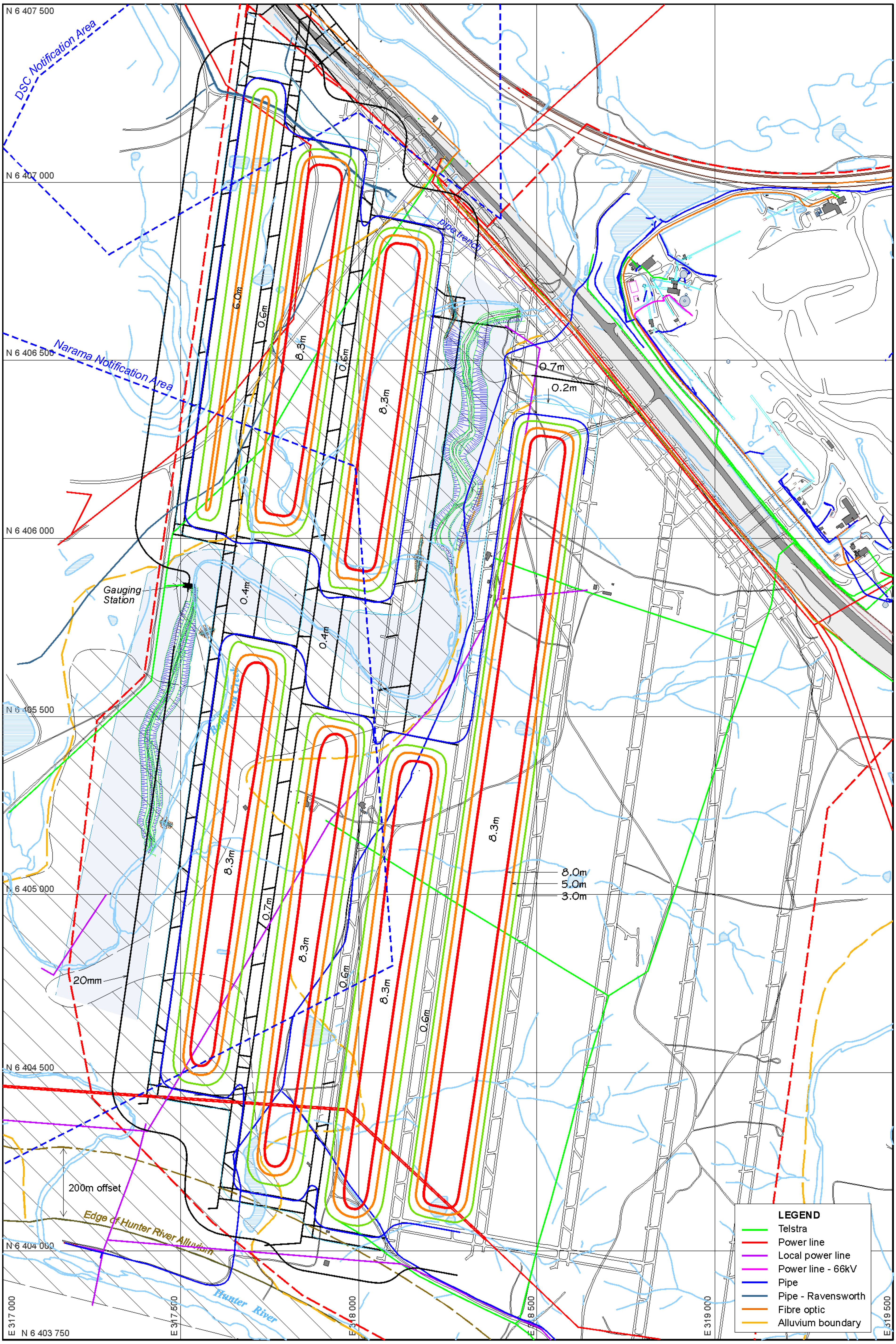


Figure 7: Subsidence contours at completion of mining in Lower Barrettl Seam.

The values shown in Figures 4 to 7 for the 122.5m wide panel (Longwall 8) should be regarded as only indicative due to the current lack of data with respect to subsidence behaviour of subcritical width panels over multi-seam extraction. As understanding of multi-seam subsidence improves, it is anticipated that these subsidence estimates will be able to be improved.

Surface cracks associated with mining in the Pikes Gully Seam are expected to be generally less than 100mm wide, but may increase locally up to 200mm wide at the top of unconsolidated slopes such as those associated with overburden spoil dumps. As subsequent seams are mined, the magnitude of surface cracking along solid goaf edges and chain pillar edges is expected to increase at least in proportion to maximum subsidence and possibly at a higher rate as the overburden strata softens.

With 8m of subsidence and maximum tilts of the order of 350mm/m, the ground surface is expected to become significantly distorted. Flat ground is likely to rotate so that it is difficult to walk up. The width of individual cracks will depend on the nature of the ground surface, but one or more cracks with an accumulated width of 1m wide and vertical steps of several metres are considered likely to develop. In practice, incremental remediation activities are likely to limit the width of cracks that are visible at any given time.

Although surface infrastructure is unlikely to remain serviceable at these strains and tilt levels, relocation or temporary mitigation measures are possible for some infrastructure. Natural features such as trees, creek channels, and flat areas are likely to be significantly disturbed.

An angle of draw of 26.5° or half depth provides a reasonable indication of the limit of subsidence impacts for most practical purposes in a single seam mining environment. The angle of draw is expected to be of the order of 26.5° once mining in the Pikes Gully Seam is complete. For the stacked, multi-seam geometry proposed, it is anticipated that the goaf edge subsidence and angle of draw will increase with each seam mined. If the longwall panels in the lower seams are offset, the angle of draw for each additional seam is likely to be controlled by the outermost panel in any of the previous seams and not necessarily by the panel currently being mined.

Monitoring of the goaf edge subsidence and angle of draw for multi-seam operations including Longwalls 1 to 4 in the deeper seams at Ashton is expected to have provided a basis to design appropriate barriers for infrastructure protection by the time that ACOL is mining Longwalls 5 to 8 in the lower seams.

3.2 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 Pikes Gully Seam are considered to be the most reliable because the Pikes Gully Seam is the first seam mined. The results of previous subsidence monitoring at Ashton and elsewhere for single-seam extraction operations are thus directly applicable. Subsidence estimates for the second, third and fourth seams mined become progressively less reliable because of the limited experience of subsidence monitoring about multiple seams.

The cumulative extraction height of the proposed mining is well outside the empirical database on which the estimates of strain and tilt are based. For example, Li et al (2007) report that the strains and tilts observed over multi-seam mining operations are increased significantly when the second seam was mined. At Newstan, they report an increase in strain from 15mm/m to 107mm/m and an increase in tilt from 67mm/m to 280mm/m as a result of a second seam being mined in a stacked geometry at 60m overburden depth to the upper seam. At Sigma Colliery, Schumann (1987) reports an increase in tilt as a result of mining the second seam from 20mm/m to 127mm/m at 133m overburden depth to the upper seam also in a stacked geometry. These levels of strain and tilt are not normally experienced in single seam operations.

Experience reported from other sites indicates that the strains and tilts may vary significantly depending on the particular geometries involved. Stacked geometries appear to cause higher strains and tilts compared to offset geometries.

The 210m wide longwall panels are of supercritical width for mining in the Pikes Gully Seam. In supercritical width panels, the central part of the surface above each panel is resting fully on the goaf, so the magnitude of maximum subsidence is a function of the seam thickness mined and the bulking characteristics of the overburden strata. Maximum subsidence is typically in the range 55-65% of seam thickness mined. For a 2.4m mining section, maximum subsidence is therefore estimated to be 1.6m. The maximum subsidence measured to date at Ashton has been 1.53m over Longwall 1 so the single seam subsidence estimates are considered reasonable and slightly conservative.

Longwall 8 is 122.5m wide because of lease boundary constraints. The width to depth ratio of this panel varies along the panel but is approximately 0.83 at the northern end. At this width to depth ratio, the panel is of subcritical width, but the overburden stratum is no longer able to substantially bridge across the panel. Full subsidence is not reached in the centre of this panel for mining in the Pikes Gully Seam. Estimates of maximum subsidence in subcritical width panels tend to be sensitive to the nature of the overburden strata and in situ stress conditions, and so are difficult to predict with a high level of certainty.

In single seam longwall panels, the subsidence over the centre of a chain pillar is controlled by the elastic compression of the strata above and below the chain pillar as well as a small amount of compression of the coal in the chain pillar itself. At 150m deep, the elastic compression usually causes less than 200mm of surface subsidence in total when both adjacent panels have been mined. The chain pillars are typically large enough to prevent pillar instability that might cause additional subsidence and the 25m wide pillars (measured rib to rib) proposed at Ashton are expected to remain stable.

The subsidence behaviour of the second seam mined is controlled by the ratio of panel width to the vertical separation between seams. For the proposed mining, the separation between adjacent seams is only about 30m, so the interburden to all the lower seams in all the panels, including the narrow panel, are expected to behave as though they were of supercritical width with caving from the lower seams extending through the interburden to interact with the previously formed goaf in the upper seams.

When the second seam is mined below previously extracted supercritical width panels, the additional subsidence is expected to approach 90% of the mining section in the second seam, giving a maximum subsidence of approximately 80% of the accumulated mining height for both seams (Li et al 2007). The overburden stratum has already been disturbed so that the shear stiffness of bedding planes is much lower than it was prior to mining the first seam. The goaf edge subsidence profile is therefore much steeper and the tilts and strains are much higher because the overburden strata is less stiff and more flexible.

For Longwall 8, mining in the lower seams is expected to cause additional subsidence, but the rate at which this additional subsidence will occur is difficult to predict with confidence. A high degree of uncertainty is associated with the incremental subsidence estimates in these panels. The estimates are intended to err on the side of greater subsidence until such times as monitoring data from earlier multi-seam panels becomes available.

There is also some uncertainty about the potential for pillar instability when the chain pillars are stacked. The effective width to height of the pillars decreases as more seams are mined because there is reduced capacity to develop confinement within the core of pillars that are surrounded above and below and on both sides by goaf. With lower confinement, the pillar strength is reduced and additional subsidence above the chain pillars may occur as a result of pillar instability.

For the 25m chain pillars proposed, pillar instability in the previously extracted seams is expected to cause additional subsidence, but when in the extraction sequence this instability might occur is not able to be determined with confidence. For the purposes of surface subsidence estimation, the chain pillars are assumed to remain stable on the basis that, in practice, the chain pillars would need to be increased to control roadway stress conditions and the surface tilts and strain are likely to be greater if the chain pillars do remain stable.

There is limited experience of how subsidence movements will develop outside the active mining area when multiple seams are extracted. In a directly stacked geometry such as that proposed at Ashton, an angle of draw of 26.5° from the deepest seam mined is considered reasonable to use until such times as monitoring data becomes available from multi-seam mining operations to allow this estimate to be refined. Any subsidence movements at half depth from the goaf edge are still expected to be of low magnitude.

If the mining geometry in the deeper seams is offset, the extent of subsidence outside the mining area is likely to be controlled by the distance from the goaf edge of the outermost longwall panel.

4. ASSESSMENT OF SUBSIDENCE IMPACTS

The natural features and surface improvements in the proposed mining area have been identified on the basis of several site visits to walk over the surface, discussion with colliery personnel, and discussion with other specialist groups working for the colliery. In this section, these features and improvements are described and the impacts of the expected subsidence movements are assessed and described.

4.1 Natural Features

The main natural features of interest in and adjacent to the proposed mining area are Bowmans Creek and its associated alluvial flats, and the Hunter River.

4.1.1 Bowmans Creek

Bowmans Creek meanders from north to south across the proposed mining area. In the north, the stream channel is cut into the surrounding countryside to a depth of several metres. In the south, near the confluence with the Hunter River, the channel is deeply incised to a depth of 10-15m below the surrounding alluvial floodplain.

The stream channel comprises a series of pools retained behind gravel bars. There are conglomerate rock exposures in the banks at several locations, typically near sharp changes in direction, but along most of its length, the channel is cut into the alluvium and the banks comprise sand, silt, and clay material. There are two ponded sections of a previous stream channel that we understand have been artificially disconnected from the main channel and several tributaries draining off the surrounding countryside.

Figure 8 shows a selection of photographs of Bowmans Creek illustrating the nature of various sections of the stream channel. The photographs were taken shortly after a period of heavy rain when the flow in the river was still several hundred megalitres per day. In extended dry periods, the stream channel is reduced to a series of ponds with surface flow reduced to only a few megalitres per day.

ACOL propose to divert Bowmans Creek so that it runs along the northern, unmined section of Longwall 5, crosses to the west within its natural channel, across an area where the panels are of narrow width to reduce surface subsidence, and then down the unmined section of Longwall 8. The location of this diversion is shown in Figure 2.

Figure 8: Photographs of Bowmans Creek.

The proposed mining geometry is expected to maintain subsidence at less than 0.4-0.5m below the alignment of the proposed diversion of Bowmans Creek. However, nearby subsidence from each of the four seams of 1.6m, 3.7m, 5.8m and 8.3m respectively, is expected to leave the creek diversion increasingly elevated above the adjacent floodplain.

Unless the subsided channel and floodplain are remediated, for example by incrementally backfilling with suitably compacted material, there is potential during flood periods for the creek to realign itself across the subsided trough. Any water, from surface runoff or overtopping of the diversion channel, that flows into the subsided section of the original channel will be unable to flow back into the diverted creek alignment and is likely to pool in the subsidence trough and is likely to flow into the mine through the fractured overburden strata. The rate and volume of any inflow is likely to increase with each seam mined and the associated additional subsidence and overburden fracturing that this causes. The potential for inflow is also discussed further in Section 4.1.3.

4.1.2 Hunter River

The Hunter River is located to the south of, and outside of, the proposed mining area. Figure 9 shows a photograph of the Hunter River.

Figure 9: Photograph of the Hunter River south of the proposed mining area.

The closest point of longwall mining to the edge of the Hunter River channel is at the start corner of Longwalls 5 and 6. The horizontal distances between the goaf edge and the Hunter River channel are approximately 325m and 300m respectively. The overburden depths to the Lower Barrett Seam are 260m and 275m respectively, so the nominal barrier to the edge of the channel for the deepest seam proposed to be mined is 26.5° plus 160m.

We understand that the longwall start positions are based on an offset of 200m from the edge of Hunter River alluvium where the edge of the alluvium has been determined by Aquaterra (2008). A distance of 200m is equivalent to 26.5° plus 120m offset to this point for the Pikes Gully Seam and 26.5° plus 60m offset to the Hunter River alluvium for the Lower Barrett Seam. The offset distance is therefore greater than the 26.5° + 40m typically used for determining offsets from creeks and rivers and their associated alluvium.

There are not expected to be any subsidence impacts on the Hunter River channel. We understand that hydrogeological impacts associated with flow from the Hunter River channel and the associated alluvium have been assessed by Aquaterra (2008).

4.1.3 Pooling in Subsidence Troughs and Mine Inflows

Water falling as rain on the flood plain, water flowing as runoff from adjacent areas, and water that overtops Bowmans Creek during a flood event is expected to flow to the lowest point in the land form and pool there. The disturbance to the overburden strata caused by increased subsidence from each seam is expected to incrementally increase the hydraulic connection between the surface and the mine.

The volume available in subsidence troughs in which surface water can pool is expected to increase with each coal seam mined. The hydraulic conductivity of the overburden strata is also expected to increase with each additional coal seam mined. At the completion of mining in the Pikes Gully Seam, some proportion of the water that pools in subsidence troughs and water stored in the Bowmans Creek alluvium above the longwall panels is expected to drain downward into the mine. At the completion of mining in the Lower Barrett Seam, the storage volume available in subsidence troughs and the hydraulic conductivity of the subsided overburden strata are likely to be such that a significant volume of surface water is expected to flow downward into the mine following high intensity rainfall events.

Incrementally filling subsidence troughs with suitably compacted material of low hydraulic conductivity after each panel is mined is expected to reduce both the storage volume available on the surface in topographic low points and access of runoff water to the fracture network in the overburden strata. Such a filling operation is likely to involve large volumes of material and cause significant disturbance to the land surface and surface infrastructure. The impacts associated with such an operation are beyond the scope of this report. Nevertheless, the approach is recommended as means to control rainfall and surface run-off from pooling on the surface and eventually entering the mine. SCT understands that Evans and Peck (2009) discuss this further in the overview EA report.

4.1.4 General Surface Cracking

The surface cracking that is expected to develop over the goaf edges of the proposed longwall panels is likely to require remediation to reduce ingress of surface water, injury to livestock, and entrapment of small animals.

It is difficult to estimate the magnitude of surface cracks from multi-seam stacked longwall operations because there is limited previous experience. Surface cracks of generally less than 100mm wide and possibly up to 200mm wide are expected in isolated locations along goaf edges at the completion of mining in the Pikes Gully Seam. Cumulative crack widths and steps of 500mm or more are expected along goaf edges at the completion of mining in the Lower Barrett Seam, but it is expected that surface cracking and stepping would be remediated at the completion of each panel in each seam to reduce the potential for water ingress, so the cumulative crack widths are unlikely to ever become apparent.

4.2 Surface Improvements

The various items of surface infrastructure located within the proposed mining area are described in detail in this section, along with potential subsidence impacts, starting with major and minor non-mining infrastructure, mining infrastructure associated with operations other than Ashton, and finishing with Ashton owned infrastructure.

4.2.1 New England Highway

Figure 10 shows a photograph looking east along the edge of the New England Highway road reserve in an area where a buried fibre optic cable and two high voltage electricity lines are located.

The southern edge of the New England Highway road reserve is located some 80m to 100m from the northern ends of Longwalls 5 to 8. The main headings pass directly under the highway. The depth of overburden in this area ranges from 90-130m to the Pikes Gully Seam, 135-175m to the Upper Liddell Seam, 170-210m to the Upper Lower Liddell Seam, and 205-250m to the Lower Barrett Seam.

The road reserve lies outside 26.5° angle of draw for the proposed mining in the Pikes Gully Seam and Upper Liddell Seam, but would fall within the 26.5° angle of draw for the Upper Lower Liddell Seam and Lower Barrett Seam.

Any increase in angle of draw that may occur as a result of multi-seam mining operations will need to be taken into account in designing the finish lines for the longwall panels in the deeper seams, but even so, the proposed mining is not expected to have any perceptible impact on the road surface itself.

A continuation of the current end of panel subsidence monitoring program is recommended for the lower seams to confirm the low levels of subsidence movements anticipated and the extent of these movements.

Figure 10: Photograph looking east along New England Highway road reserve.

4.2.2 Buried Fibre Optic Cable

The Powertel fibre optic cable follows the alignment of the 132kV power lines on the southern side of the New England Highway as shown in Figure 11 up to the intersection with the realigned Brunkers Lane where it crosses under the highway and is located on the northern side of the highway from there on.

Available plans indicate that the fibre optic cable comes within 90m of the end of Longwall 6 before it passes under the highway and follows the northern side of the highway further west. The overburden depth at this location is approximately 120m to the Pikes Gully Seam and 205m to the Lower Barrett Seam. Subsidence movements at the location of the fibre optic cable associated with mining in the Pikes Gully Seam are expected to be small in magnitude and of a general body nature that is not expected to impact on the fibre optic cable.

Some low level subsidence movements may be possible at the location of the fibre optic cable from mining in the deeper seams but the serviceability of the fibre optic cable is unlikely to be affected by the low levels of movement anticipated. However, the take-off positions of the longwall panels in the lower seams can easily be adjusted if required on the basis of monitoring experience in earlier panels.

Figure 11: Photograph of Powertel cable and high voltage power lines in New England Highway road reserve.

4.2.3 132kV & 66kV Electricity Lines

Two electricity lines (one 132kV and one 66kV) supported on single poles are located along the southern side of the New England Highway as shown in Figures 10 and 11. Both cross the highway near the intersection with Brunkers Lane. The poles are supported with multiple stays in this area.

An 11kV line also supported on the poles of the southern 66kV line continues along the southern side of the highway.

The corner poles are located approximately 100m from the end of Longwall 6. The overburden depth at this location is approximately 120m to the Pikes Gully Seam and 205m to the Lower Barrett Seam.

Single pole structures are relatively tolerant to subsidence movements, but these structures are not expected to experience significant subsidence movements because of their location beyond the ends of the panel where the tilts and strains are expected to be very small. Monitoring of the tension in the stay wires at the change in direction is recommended as the longwalls in this area reach their finish line.

A second 132kV electricity line crosses the southern end of all the longwall panels. This line is supported on a two pole structure for the straight sections as shown in Figure 12a and three stayed poles at changes in direction as shown in Figure 12b.

Power lines traversing the surface above the proposed mining area are likely to experience subsidence movements of a magnitude that depends on their location relative to the individual longwall panels and the stacking arrangements for each seam. Although the individual pole structures are relatively tolerant of subsidence movements, reductions in ground clearance are expected to make it necessary to relocate the line as the lower seams are mined, particularly if the longwall panels in the lower seams are mined in a stacked arrangement.

The line is expected to be able to remain serviceable during mining in the Pikes Gully Seam based on the experience of mining Longwall 1. Some mitigation works may be necessary particularly at changes in direction and where the conductors are fixed to the poles for tensioning purposes. We understand that ACOL and Energy Australia are currently in consultation to replace the 3 pole structure at the change of direction point before Longwall 5 subsidence impacts the structure.

As the deeper seams are mined, the ground clearance to conductors will become progressively less. A detailed assessment to determine when insufficient ground clearance is likely to become an issue for ongoing serviceability of the line and will need to be undertaken once the mine layout in the lower seams has been finalised. Relocation of the line to an area outside the mining area or relocation of individual pole structures to directly over chain pillars is likely to be necessary before the Lower Barrett Seam is mined.

4.2.4 Local Area Electricity Lines

Several local area electricity lines cross the proposed mining area. These are supported on single pole structures, some with the conductor suspended from insulators and others fixed directly to cross-arms. The 11kV line supported on the 66kV poles at the northern end of the panels has already been noted (Figure 10).

There is a line located on the Macquarie Generation land that skirts the edge of the spoil dump. The single pole structures on this line are shown in Figures 13a and 13b. They are stayed at changes in direction.

Figure 12: Photographs of 132kV line at the southern end of the proposed mining area.

Figure 13: Photographs of single pole structures on 66kV power lines.

There is a line that extends north to south across the Application Area that services the Ashton owned properties and continues south across the Hunter River after passing under the 132kV line. The line also branches at the southern edge of the Application Area, servicing Ashton's submersible pump and crossing Bowmans Creek. Figure 14 shows a selection of photographs of this line. The line is supported on single pole structures.

Power lines traversing the surface above the proposed mining area are likely to increasingly lose ground clearance with each seam mined. Incremental mitigation and remediation work is likely to be required as each seam is mined to maintain the lines in an operational condition. The tilts and strains expected during mining of the Upper Lower Liddell Seam and Lower Barrett Seam are not expected to allow the lines to remain serviceable during the period of active mining unless the poles are located at high points in the subsidence profile such as above the chain pillars in a stacked geometry. The options to relocate the line either temporarily or permanently will depend on where individual poles are located relative to the final mining layout adopted.

4.2.5 Buried Telstra Lines

Three buried, copper wire, Telstra lines cross the proposed mining area. The western line crosses Longwalls 6 to 8. This line previously serviced the gauging station and provides future connection for subdivided blocks that form part of the southern extent of the Ravensworth lease.

The other two lines are branches off the line located over Longwalls 1-3 that service the house located over Longwall 6 and another Ashton owned building located over Longwall 5. These lines are understood to be currently active.

Typically buried copper lines in good repair are likely to remain serviceable where ground strains are less than about 20mm/m. The Telstra lines are not expected to remain serviceable once they are impacted by subsidence from mining in the Upper Liddell Seam where maximum ground strains of 70mm/m are expected. Cumulative ground strains are predicted to reach a maximum of 160mm/m at the completion of mining in the Lower Barrett Seam.

Alternative communication provisions for the residents on site and adjoining private property tenants are recommended and we understand that these are addressed in accordance with ACOL's existing Subsidence Management Plans.

4.2.6 Bowmans Creek Flow Gauging Station

A flow gauging station is located on Bowmans Creek outside the proposed mining area to the west of Longwall 7. Figure 15 shows photographs of this installation. We understand that the station was previously used for the Hunter Salinity Trading Scheme. The sections of Bowmans Creek that are planned to be diverted are located either side of the gauging station so the

Figure 14: Photographs of single pole structures on local electricity lines.

Figure 15: Flow gauging station on Bowmans Creek.

gauging station will be able to continue to operate, although it may need to be recalibrated given changes to the flood plain landform.

If the gauging station were to be left in its current location, it would be approximately 140m to the nearest longwall goaf. The overburden depth to the Pikes Gully Seam is approximately 180m in this area so it is unlikely that significant changes would be observed at the flow gauging station for the currently proposed longwall geometry.

The radio communication link and underground cabling between the weir and the communication structure is not expected to be impacted by mining subsidence. The power supply infrastructure and any buried telecommunications that the station uses may be impacted by subsidence. This infrastructure is discussed in other sections of this report.

4.2.7 Brunkers Lane (Private Road)

Brunkers Lane is the name given to a tarsealed section of road that was realigned from its location on the western edge of ACOL's lease to its current location during open cut mining operations on the site owned by Macquarie Generation. Figure 16 shows a photograph of the section of road located over Longwalls 6 to 8.

Figure 16: Sealed section of Brunkers Lane.

Although the road is accessible to the public along the section that is within the proposed mining area, we understand that the road is not actually a public road. Macquarie Generation maintains this roadway as a private roadway as far as the Void 5 access gate as an alternate access for heavy vehicle traffic to the mine when access via the normal route becomes restricted. The road is also planned to be used for heavy vehicle movements associated with construction of the Void 5 dam. The road has recently been upgraded including the highway intersection.

Ravensworth Open Cut uses this road as a rear access to their site through a locked gate although we understand this is not a legal right of way.

We also understand that there are proposed plans to upgrade this section of the road and possibly transfer it to public ownership to:

1. replace Lemington Road should the open cut operations expand through the area where Lemington Road is currently located,

2. provide access to a number of subdivided blocks that form part of the southern extent of the Ravensworth lease.

The timing of any implementation of these plans is currently unknown, but it is anticipated that if they do occur they could occur within the projected life of the Ashton Coal Project.

The sealed section of Brunkers Lane and any proposed upgrades are likely to require significant remedial work to maintain them in a serviceable condition during mining of Longwalls 7 and 8 in each of the seams. If the road becomes a public road, temporary diversions and/or continuous manning of the site is likely to be necessary during the period of active mining. Filling, regrading, and resealing of the road surface is likely to be required at the completion of Longwalls 6, 7 and 8 in each seam. The road crosses a minor tributary of Bowman's Creek. The tributary passes under the road through circular steel pipes. Replacement and re-levelling of this structure and the surrounding landform is likely to be required at the completion of each longwall panel.

4.2.8 Macquarie Generation Access Road

The alternative access to Macquarie Generation land continues from Brunkers Lane on a gravel road as shown in Figure 17. This road is located over the northern end of Longwall 7. The overburden depth in this area is approximately 145m to the Pikes Gully Seam.

Unsealed access roads are unlikely to remain serviceable during the period of active mining in the second and subsequent seams, but once subsidence is complete, it is anticipated that they could be re-established by regrading without any particular practical difficulty.

Figure 17: Unsealed access road on Macquarie Generation lease.

4.2.9 Macquarie Generation Sedimentation Ponds

Figure 18 shows a panorama of the surface above the out of pit spoil pile in the northwest corner of the proposed mining area. The surface has been substantially rehabilitated and revegetated having been previously open cut mined. There are four clay lined sedimentation ponds and a fifth downstream dam that are still used. All five dams are located over Longwall 8 and the overburden depth is approximately 150m to the Pikes Gully Seam.

The four clay lined sedimentation ponds and a fifth downstream dam are expected to experience the subsidence movements of up to 6m of vertical subsidence, 240mm/m of tilt and 110mm/m of horizontal strain.

Figure 18: Panorama of surface above out of pit spoil pile.

Mining subsidence movements are expected to cause temporary and permanent tensile cracking in the ponds with differential settlement across the two western ponds and the downstream dam. Remedial work will be required to restore the dam volumes and overflow levels to their pre-mining condition. Resealing of cracks is also likely to be necessary to ensure the integrity of the dams. We would recommend that the dams are pumped down during the few weeks of mining under them as a precaution against cracks that may allow uncontrolled discharge and possible erosion of the dam wall.

4.2.10 Polyethylene Pipes

A polyethylene water supply pipeline from Narama to Mt Owen crosses Longwalls 7 and 8. The pipeline is buried for most of its length, but is exposed where it passes through a culvert below Brunkers Lane (Figure 19) above Longwall 7.

A separate group of pipes associated with ACOL tailings transfer and water reclamation from Void 4 are laid in an open trench across Macquarie Generation's lease (Figure 19b). Further to the east in an area to the north of Longwalls 6 and 7, these pipes are buried in a shallow. They pass under Brunker's Lane, alongside Bowmans Creek and under the New England Highway at the Bowmans Creek Bridge (Figure 19c).

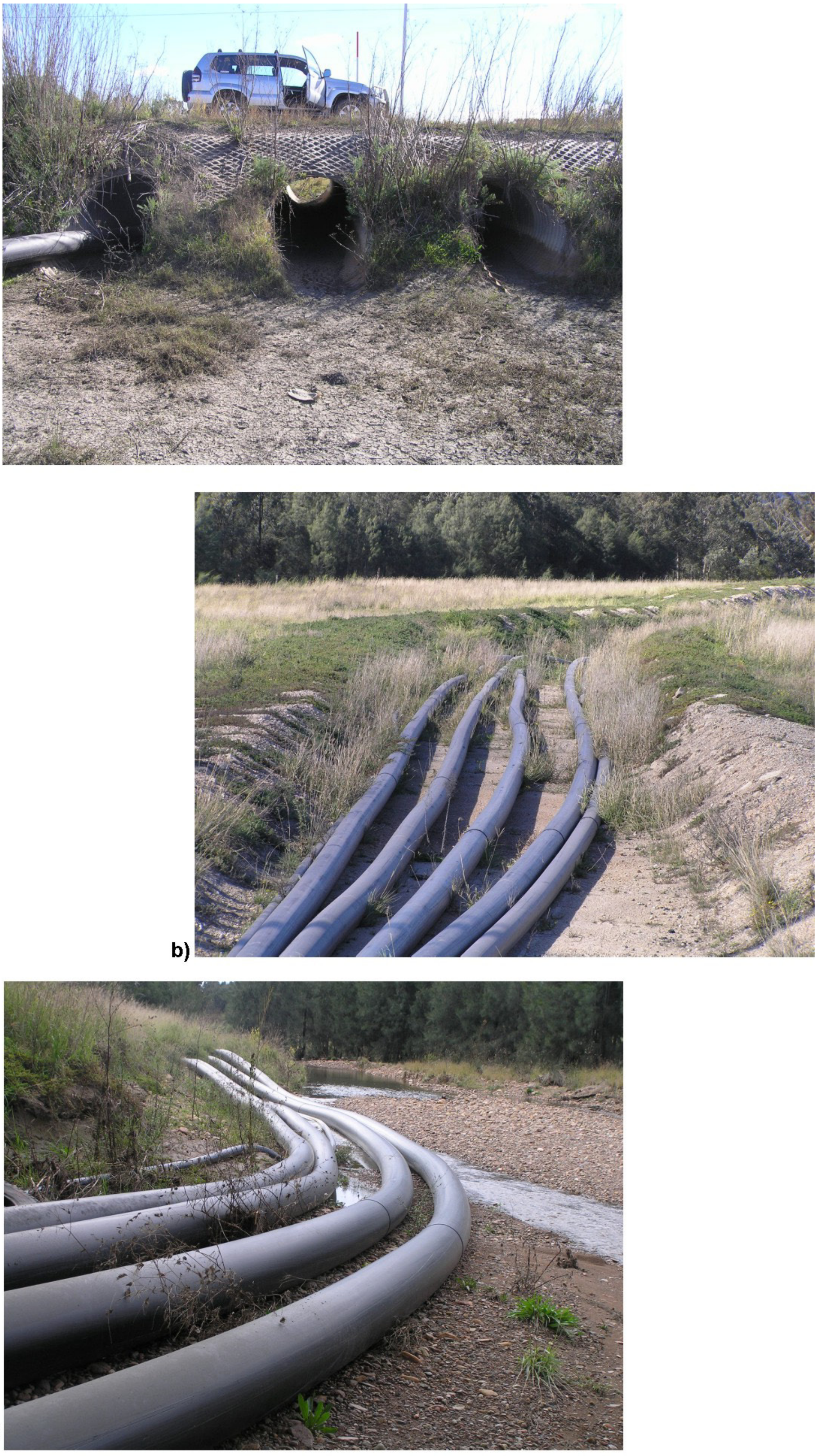
The diameters of the pipes range from 110mm to 315mm. All the lines except the fresh water line from the Hunter River carry mine water.

The polyethylene pipes located in open trenches or laying on the surface are not expected to be impacted by mining subsidence except in terms of grade changes that may affect sediment accumulation in the pipes.

The buried polyethylene pipes located over longwall panels are expected to experience the full range of subsidence movements. The predicted strains are expected to exceed the 5-10mm/m working strains of polyethylene if they are concentrated at a point and there is tight contact between the fill material and the pipe. However, the contact between the ground and the pipe is not expected to be sufficiently tight for all the ground strains to be transferred to the pipe.

Mining of panels in the Pikes Gully Seam is not expected to cause the buried polyethylene pipes to become overstressed, but there is potential for damage if there is good contact between the backfill and the pipe and the subsidence movements become concentrated at large cracks or compression humps. Mining in the lower seams is expected to cause strains sufficient to rupture the pipes if a stacked mining geometry is used.

A failsafe strategy would involve exposing the buried pipeline so that shear could not be generated between the soil and the pipe or bypassing sections across the surface with a temporary pipe and reconnecting back to the buried pipe once it is confirmed that the buried section remains serviceable.



a)

b)

c)

Figure 19: Polyethylene pipelines

4.2.11 Narama Dam

Narama Dam, also known as Ravensworth Inpit Dam, is a 1,000Ml capacity earth dam located outside the proposed mining area to the west of Longwall 8. Figure 20a shows the dam wall and downstream structures. Figure 20b shows the dam wall looking from the nearest point to the proposed mining.

We understand that Narama Dam provides water for Mt Owen Mine and other Xstrata mining operations. Although the toe of the dam is outside the Ashton Coal Mining Lease, the DSC Notification Area for Narama Dam falls within the proposed mining area.

Narama Dam is an earth dam. The toe of the dam is approximately 430m from the nearest goaf edge of Longwall 8. The overburden depth at this location ranges 190-200m, so there is not expected to be any impact from mining on this infrastructure.

A concrete structure downstream of the dam on the original watercourse and associated steel pipes are located approximately 550m from the nearest goaf edge of Longwall 8. There is not expected to be any impact from mining on this infrastructure.

Subsidence movement at Narama Dam are expected to be imperceptible for all practical purposes, but we recommend that the existing network of survey pegs around Narama Dam is monitored at the completion of Longwalls 7 and 8 in each of the seams to confirm the low levels of movement expected.

4.2.12 Ravensworth Void 5 Ash Dam

A second water storage dam knows as the Ravensworth Void 5 Ash Dam is planned west of the north-western corner of the proposed mining area within the timeframe of mining Longwalls 5 to 8 in the Pikes Gully Seam. This dam will also be located outside the mining area, but the DSC Notification Area will overlap with the proposed mining area.

The details of this dam remain uncertain, but we understand that the toe of the dam will be approximately 260m from the goaf edge of Longwall 8. The overburden depth to the Pikes Gully Seam in this area is approximately 155m, so mining in the Pikes Gully Seam is not expected to have any perceptible impact on the dam.

We understand that the dam is designed to accommodate the potential for low level subsidence movements that may occur as a result of subsidence from Longwall 8 in the lower seams. A program of subsidence monitoring based on an array of pegs located around the dam wall is recommended. We recommend that surveys be conducted at the completion of Longwalls 7 and 8 in each seam and more frequently if significant movements are observed or expected based on other subsidence monitoring.


a)


b)

Figure 20: Namara Dam.

4.2.13 Ravensworth Underground Mine

Ravensworth Underground Mine owned by Xstrata is planning a multi-seam underground longwall operation that shares a lease boundary with the ACOL lease. Although, the two mines are required by law to be separated by a 40m wide barrier, 20m either side of the lease boundary, there is nevertheless some potential for interaction, particularly when both operations are multi-seam operations.

The proposed mining in the Pikes Gully Seam is not expected to have a significant impact on any proposed main heading developments in Ravensworth Underground Mine in the vicinity of the lease boundary. If longwall panels are proposed in Ravensworth Underground alongside the lease boundary with Ashton, some consideration should be given to the potential for cumulative stress effects.

The effect of mining the deeper seams in either mine would be to reduce the confinement that is available to maintain the integrity and stability of the intervening barrier pillar. There is not considered likely to be any significant issue for the mining geometries that we understand are currently proposed, but consideration should be given to the actual mining geometries to ensure that there is no potential for a loss of confinement to the barrier pillar to cause instability or a loss of integrity.

The ACOL lease is up dip of the Ravensworth Underground Mine so there is potential for mine water that may collect against the barrier in Ashton Underground Mine to flow down into Ravensworth Underground Mine through the coal seam.

4.2.14 ACOL Owned Infrastructure

ACOL owned infrastructure located within the proposed mining area includes several farm buildings and houses, three farm dams, farm roads, fences, a fresh water polyethylene pipe from the Hunter River, and the mine pump out polyethylene pipe from the southern end of the panels. These pipes traverse the surface above Longwalls 5 and 6 in shallow trenches.

Figure 21 shows panoramas that include most of the surface infrastructure within the proposed mining area that is owned by ACOL.

Building structures, including all farm buildings and houses are not expected to remain serviceable following mining in the Pikes Gully Seam and are likely to require relocation or demolition.

Unsealed access roads are unlikely to remain serviceable during the period of active mining, particularly mining in the second and subsequent seams, but once subsidence is complete, they should be able to be re-established by regrading. Sections of road affected by surface pooling or possible filling operations may need to be re-established on a new alignment.

Figure 21: Panoramas looking northwest and southwest across proposed mining area.

The buried pipelines are unlikely to remain serviceable for the subsidence expected after mining in the second and subsequent seams. Uncovering the pipelines so that they lay in shallow trenches is expected to be sufficient to prevent them being damaged by subsidence movements.

4.2.15 Disused and Dilapidated Infrastructure

There are two disused pump stations located along Bowmans Creek within the proposed mining area. Figure 22 shows a photograph of the northern one of these. All that remains is a small tin shed which is in an advanced state of disrepair. The power supply and pump out line have been disconnected and all the machinery has been removed.

Figure 22: Disused pump shed adjacent to Bowmans Creek.

Figure 23 shows a photograph of a shed that Macquarie Generation has advised is not occupied and is in an advanced state of disrepair.

The two disused pump stations located along Bowmans Creek are likely to be destroyed by the diversion of Bowmans Creek. The dilapidated shed located on the Macquarie Generation land beyond the northern end of Longwall 8 is currently in an advanced state of disrepair. Any mining subsidence movements are not likely to significantly change this status.

Figure 23: Disused shed beyond the northern end of Longwall 8.

4.3 Natural Heritage Features

The Aboriginal archaeological sites located within general area around Ashton Mine have been described by Insite Heritage Pty Ltd (IHPL) and the setting for these sites is described in detail in IHPL (2008). Their locations are shown in Figure 3. The descriptions of the sites and assessments of significance presented in this section are taken directly from IHPL (2008).

Within the immediate vicinity of Longwalls 5 to 8, there are nine sites that have been identified and these are all considered to be of lesser significance. The sites include Brunkers Lane Site (EWA82) which is considered an indicator of the potential for subsurface deposits on the creek flats, although these are likely to have lost some contextual integrity due to the history of ploughing. The remaining sites are isolated finds.

The nature of the sites located within the immediate vicinity of Longwalls 5 to 8 is summarised in Table 4 based on the descriptions presented in IHPL (2008).

IHPL have identified four categories of subsidence impact based on the level of subsidence that was expected for mining the Pikes Gully Seam with limited panel widths to control subsidence. Another category has been added to these four categories to reflect the potential for disturbance and burial associated with land filling and regrading operations that are expected in areas of high subsidence. The potential impacts on each of the sites are reassessed in Table 4 based on mining four seams in a stacked geometry.

- High – definite potential for cracking to occur that will require repair
- Medium – subsidence will be experienced but only a moderate chance of cracking that requires repair
- Low – subsidence may be experienced at the site, but there is a low chance that repair work will be required.
- No Impact – no impact anticipated from mining subsidence
- Buried – site likely to be buried or highly disturbed by regrading and land filling operations

Table 4 : Summary of Aboriginal Archaeological Sites Located in Immediate Vicinity of Longwalls 5-8.

SITE NAME	SITE TYPE	SITE DIMENSIONS	LANDFORM	POTENTIAL IMPACT
EWA50	Two Artefacts	1m x 2m	Tributary Flat	Buried
EWA51	Isolated Find	1m x 2m	Tributary Flat	Buried
EWA52	Isolated Find	1m x 2m	Tributary Flat	Buried
EWA57	Two Artefacts	50m x 5m	Tributary Bottom	Buried
EWA80	Isolated Find	50m x 2m	Flat spur	Buried
EWA81	Isolated Find	50m x 2m	Terrace	High
EWA82	Open Camp Site	20m x 2m	Terrace	Buried
EWA89	Isolated Find	50m x 5m	Terrace	Medium
EWA97	Three Artefacts	20m x 20m	Terrace Edge	Buried

The waterhole site comprising GG1, GG3 and GG4 is considered to be a site of significance. This site is located approximately 200m from the nearest mining extraction at an overburden depth of approximately 80-85m to the Pikes Gully Seam. This site has been independently assessed in SCT Letter Report ASH3571 dated 28 July 2009 for mining Longwall 4 in the Pikes Gully Seam. The site is sufficiently remote from the longwall panels that no impact is expected at this site from the proposed mining subsidence.

5. RECOMMENDATIONS FOR SUBSIDENCE MONITORING AND MANAGEMENT

A program of subsidence monitoring is recommended to confirm that the subsidence behaviour is developing as expected.

A cross-line with pegs spaced at 1/20th depth (6m to 9m) centres and measured in three dimensions is recommended across the middle of all the southern panels and a second line across the middle of all the northern panels. Peg to peg strain measurement is not required given the high strain levels anticipated. It is recommended to survey this line for each panel once the longwall has mined at least 150m past. Additional surveys as the longwall face approaches and passes would provide useful information on the development of vertical and horizontal subsidence movements over longwall panels at Ashton and provide measurement of time related subsidence movements.

A longitudinal subsidence line at the start of each longwall panel is recommended to continue to provide early confirmation of the overburden strata bridging behaviour at Ashton.

Additional survey lines are recommended to measure subsidence movements in the multi-seam operations where different arrangements of panels occur. The understanding of subsidence behaviour in multi-seam operations is still relatively limited, so every opportunity to measure interaction effects should be taken.

Monitoring of individual items of infrastructure is recommended on an as required basis.

6. CONCLUSIONS

Our assessment is based on the approach to estimating multi-seam subsidence described by Li et al (2007). Maximum subsidence over the centre of each longwall panel is expected to increase incrementally with each seam mined as shown below. The maximum tilt and strain values are also expected to increase incrementally as shown.

SEAM	MAXIMUM SUBSIDENCE (M)	MAXIMUM TILT (MM/M)	MAXIMUM STRAIN (MM/M)
PIKES GULLY	1.6	70	30
UPPER LIDDELL	3.7	150	70
UPPER LOWER LIDDELL	5.8	240	110
LOWER BARRETT	8.3	350	160

We understand that ACOL will review and modify mine plans in response to actual subsidence behaviour associated with mining in the deeper seams based on monitoring experience, expert interpretation, and other advice.

In the stacked arrangement of longwall panels proposed – where the longwall panels in each seam are directly below the panels in the seam above – subsidence over the chain pillars is sensitive to the stability of the chain pillars, but is expected to be generally less than 0.6m. Refinement of the pillar geometry to ensure stability will be based on numerical modelling and monitoring of Longwalls 1 to 4 pillars following mining in the lower seams.

If the longwall panels in the lower seams are offset, the subsidence profile is expected to be generally smoother and the total subsidence may be slightly less. A stacked arrangement has been used for subsidence assessment purposes. The stacked arrangement represents the worst case scenario because of the potential for higher subsidence, tilt and strain values allowing ACOL to carry out mining studies on alternate layouts in parallel with the EA application.

There is a possibility that strains and tilts may vary from predictions as a result from the interaction and reworking of the fractured overburden strata above each panel. Monitoring of subsidence over Longwalls 1 to 4 in the lower seams as each seam is mined will allow more accurate predictions of subsidence parameters above Longwalls 5 to 8.

The maximum total subsidence below the alignment of the proposed diversion of Bowmans Creek is likely to be sensitive to the overburden bridging characteristics across the narrow panels directly below the creek alignment. If the overburden bridging characteristics expected for a single seam are replicated in the lower seams, maximum subsidence below Bowmans Creek is expected to be generally less than 0.4-0.5m when all the seams have been mined. We understand that ACOL will refine the multi-seam panel geometry below Bowmans Creek to ensure long term overburden bridging below the creek if ongoing monitoring and numerical modelling of multi-seam operations indicates that this is necessary.

Notwithstanding the low levels of subsidence expected at the diversion, nearby subsidence of up to 8-9m at the completion of mining the Lower Barrett Seam is expected to leave the creek diversion elevated above parts of the adjacent flood plain. Water falling as rain on the flood plain, water flowing as runoff from adjacent areas, and water that overtops Bowmans Creek during a flood event is expected to pool at the lowest point in the landform. The disturbance to the overburden strata caused by 8-9m of subsidence is expected to provide sufficient hydraulic connection between the surface and the mine for there to be a high potential for some of the water that pools in subsidence troughs to flow down into the mine. The potential for inflow is addressed by Aquaterra (2009) in their Bowmans Creek Diversion: Groundwater Impact Assessment Report.

We understand that ACOL proposes to maintain a free draining landscape by progressively constructing drainage works or filling subsidence areas on the floodplain, with the exception of the excised sections of the creek channel. This land filling and regrading work is intended to reduce the potential for water inflow into the mine and limit pooling of surface water.

The ground disturbance caused by the combined subsidence from four seams and potentially the filling operations is expected to significantly impact any surface infrastructure located directly over the panels. It is noted that the majority of the surface area affected by mining subsidence is owned by ACOL.

Power lines traversing the surface above the mining area are likely to lose ground clearance. Building structures are not expected to remain serviceable and will need to be relocated or demolished. Unsealed access roads are unlikely to remain serviceable during the period they are actively mined under by the second and subsequent seams, but once subsidence is complete, they can be re-established by regrading without undue difficulty. The sealed section of Brunkers Lane is likely to require significant remedial work to maintain it in a serviceable condition. Buried water pipes and Telstra Lines are not expected to remain serviceable.

Ravensworth Underground Mine owned by Xstrata is planning a multi-seam underground longwall operation that shares a lease boundary with the ACOL lease. There is unlikely to be any significant interaction between the two mines for mining operations in the Pikes Gully Seam. The effect of mining the deeper seams in either mine would be to reduce the confinement that is available to maintain the integrity and stability of the intervening barrier pillar. There is not considered likely to be any significant issue for the mining geometries that we understand are currently proposed, but consideration should be given to the actual mining geometries to ensure that there is no potential for a loss of confinement to the barrier pillar to cause instability or a loss of integrity

There is limited experience of how subsidence movements will develop outside the active mining area when multiple seams are extracted. For the stacked geometry proposed, it is anticipated that the goaf edge subsidence and angle of draw will increase with each seam mined. There has been a steady increase in angle of draw with depth in the four longwall panels mined to date. The angle of draw is expected to be generally of the order of 26.5° once mining in the Pikes Gully Seam is complete. There is potential for the cumulative angle of draw to the deeper seams to increase above 26.5° as a result of the higher levels of subsidence associated with multi-seam extraction. If the longwall panels in the lower seams are offset, the angle of draw for each additional seam will be controlled by the outermost panel in any of the previous seams and not necessarily by the panel currently being mined.

Infrastructure located outside the mining area is expected to experience subsidence movements greater than would be expected for single seam mining, but the actual magnitude of subsidence movement outside the area will need to be confirmed by monitoring in earlier panels. The protection barriers provided to the Narama Dam, the New England Highway and bridge over Bowmans Creek, buried fibre optic cable, and power transmission lines outside the mining area are expected to be sufficient, but ongoing review is recommended based on monitoring experience.

Insite Heritage Pty Ltd (2008) identified nine scatter sites in the immediate vicinity of Longwalls 5 to 8. These have been categorised as being of low significance. Most are likely to be impacted by subsidence movements and are likely to be buried by subsequent land filling and surface regrading operations. The waterhole site is remote from the proposed mining and is not expected to be affected by subsidence movements.

The proposed mining is located in an area currently below Bowmans Creek. ACOL are proposing to divert sections of Bowmans Creek to allow for more efficient resource recovery of Longwalls 5 to 8. The basis for the creek diversion and the studies that underpin it are reported elsewhere and have not been included in this report.

7. REFERENCES

Aquaterra 2008 "Ashton Underground Mine - Bowmans Creek Alluvium Investigations" Report for ACOL dated October 2008

Aquaterra 2009 "Bowmans Creek Diversion: Groundwater Impact Assessment Report" Report prepared for Ashton Coal Operations Ltd, dated 21 September 2009 S55G/600/011D

Evans and Peck 2009 "Bowmans Creek Diversion - Environmental Assessment" Report prepared for ACOL.

GHA 2001 "Ashton Coal Project - Assessment of the Impact of Subsidence from Longwall Mining" Report prepared by G E Holt & Associates for White Mining Ltd, dated 23 October 2001.

Insite Heritage Pty Ltd 2008 "SMP Archaeological Impact Assessment, Longwalls 5 to 9" Report prepared for Ashton Coal Operations, dated October 2008.

Li G., Steuart P. and Paquet, R. 2007 "A Case Study on Multi-Seam Subsidence with Specific Reference to Longwall Mining Under Existing

SCT Letter Report ASH3571 2009 "Assessment of Subsidence Impacts on Grinding Groove Site North of Longwall 4" dated 28 July 2009.