APPENDIX 11

Subsidence Assessment (MSEC)

Austar Coal Mine Pty Limited

REPORT

on

THE PREDICTION OF SUBSIDENCE PARAMETERS AND THE ASSESSMENT OF MINE SUBSIDENCE IMPACTS ON NATURAL FEATURES AND SURFACE INFRASTRUCTURE RESULTING FROM THE EXTRACTION OF PROPOSED AUSTAR LONGWALLS A6 TO A17 IN SUPPORT OF A PART 3A APPLICATION

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Report produced for:- Submission to The Department of Planning to Support the Part 3A Application

EXECUTIVE SUMMARY

Austar Coal Mine Pty Limited (Austar) proposes to continue underground coal mining operations at Austar Coal Mine, which is located in the Newcastle Coalfield of New South Wales, by extracting coal from the Greta Seam using Longwall Top Coal Caving (LTCC) mining techniques. The locations of the proposed Austar Longwalls A6 to A17 are shown in Drawing No. MSEC309-01, which together with all other drawings referred to in this report is included in Appendix J at the end of this report.

Mine Subsidence Engineering Consultants Pty Limited (MSEC) has been commissioned by Austar to study the mining proposals, identify all natural features and surface infrastructure above the proposed longwalls, and to prepare subsidence predictions and impact assessments in support of a Part 3A Application.

The proposed longwalls are located approximately 1 kilometre south of the township of Kitchener, at their closest point. A number of natural features and items of surface infrastructure have been identified in the vicinity of the proposed longwalls, including creeks, drainage lines, steep slopes, roads, electrical services, telecommunication services, dams, water bores, archaeological sites, survey control marks and building structures.

The predicted systematic subsidence parameters for the proposed longwalls have been obtained using the Incremental Profile Method. The subsidence model was calibrated to local data by comparing observed and back-predicted subsidence profiles along the monitoring lines above the previously extracted longwalls at the Colliery.

It was concluded from the back-analysis, that the values of maximum observed incremental subsidence for the previously extracted longwalls at the Colliery were all less than the values of maximum back-predicted incremental subsidence, based on the standard Newcastle Coalfield subsidence profiles. The shapes of the observed incremental subsidence profiles, however, were slightly wider, and the points of maximum observed incremental subsidence were located closer to the longwall tailgates, than for the back-predicted incremental subsidence profiles, based on the standard Newcastle Coalfield subsidence profiles.

The shapes of the back-predicted incremental subsidence profiles were adjusted to more closely match the observed incremental subsidence profiles by adopting the standard Newcastle Coalfield subsidence profiles based on a panel width-to-depth ratio of 0.3, rather than adopting the actual panel width-to-depth ratios, which varied between 0.38 and 0.65. No modifications were made to the magnitudes of the maximum back-predicted incremental subsidence for each longwall.

Austar Longwalls A6 to A17 are proposed to be extracted from the Greta Seam, which has an overall height varying between 4.0 metres and 7.0 metres at the proposed longwalls. The LTCC equipment will mine the bottom 3 metres of the seam, and recover only about 85 % of the top coal in the seam.

The predicted systematic subsidence parameters resulting from the extraction of the proposed longwalls were determined using a combination of two subsidence models both using the calibrated Incremental Profile Method. The first model predicted the systematic subsidence parameters resulting from the extraction of the bottom coal, and a second model predicted the systematic subsidence parameters resulting from the recovery of the top coal.

It has been recognised that the extraction heights for the proposed Austar Longwalls A6 to A17 are greater than those in the empirical database of the Incremental Profile Method, and greater than those at the previously extracted longwalls at the Colliery. A conservative upperbound case has also been assessed for the proposed longwalls, therefore, where the predictions and impact assessments have been undertaken assuming that the maximum possible total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls.

Chapter 1 of this report provides a general introduction to the study, which also includes a description of the mining geometry and geological details of the proposed mining area.

Chapter 2 identifies all the natural features and items of surface infrastructure above the proposed longwalls.

Chapter 3 includes a brief overview of longwall top coal caving, the development of mine subsidence, the back-calibration of the Incremental Profile Method to local data, and the subsidence models used to predict the systematic subsidence parameters for the proposed longwalls.

Chapter 4 provides the maximum predicted and maximum upperbound systematic subsidence parameters resulting from the extraction of the proposed longwalls.

Chapter 5 provides the predicted and upperbound subsidence parameters for each natural feature and item of surface infrastructure which was described in Chapter 2. The impact assessments for each of these features have been undertaken based on the predicted and the upperbound subsidence parameters.

Appendix C provides an introduction to longwall mining and subsidence.

Appendix D provides an introduction to methods of subsidence prediction.

Appendix E provides an background to the classification of damage to building structures.

The assessments provided in this report indicate that the levels of impact on the natural features and surface infrastructure can be managed by the preparation and implementation of subsidence management strategies. It is recommended, however, that a structural engineer inspect the building structures above the proposed longwalls, to assess their existing conditions, and to recommend any preventive measures, that might be required, prior to each structure being mined beneath.

It should be noted that more detailed assessments of the impacts of mine subsidence on some natural features and surface infrastructure have been undertaken by other consultants, and the findings in this report should be read in conjunction with the findings in all other relevant reports.

Monitoring of ground movements is recommended, as subsidence occurs, so as to compare the observed ground movements with those predicted, and to periodically review the predictions and impact assessments in the light of measured data.

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CHAPTER 1. BACKGROUND

1.1. Introduction

Austar Coal Mine Pty Limited (Austar) proposes to continue underground coal mining operations at Austar Mine, which is located in the Newcastle Coalfield of New South Wales, by extracting coal from the Greta Seam using Longwall Top Coal Caving (LTCC) mining techniques. The locations of the proposed Longwalls A6 to A17 are shown in Drawing No. MSEC309-01, which together with all other drawings referred to in this report is included in Appendix J at the end of this report.

Mine Subsidence Engineering Consultants Pty Limited (MSEC) has been commissioned by Austar to study the mining proposals, identify all natural features and surface infrastructure above the proposed longwalls, and to prepare subsidence predictions and impact assessments in support of the Part 3A Application.

The proposed longwalls are located approximately 1 kilometre south of the township of Kitchener, at their closest point. A number of natural features and items of surface infrastructure have been identified in the vicinity of the proposed longwalls, including creeks, drainage lines, steep slopes, roads, electrical services, telecommunication services, dams, water bores, archaeological sites, survey control marks and building structures.

Proposed Longwall A6 is a single panel, located at a minimum distance of 180 metres east of the future Longwalls A3 to A5, which are subject to a separate approval. Longwall A6 is also located at a minimum distance of 500 metres south-east of the previously extracted Longwalls SL2 to SL4 and more than 2 kilometres east of the previously extracted Longwalls 1 to 13A at the Colliery. Proposed Longwalls A7 to A17 are a series of panels, located at a minimum distance of 680 metres east of proposed Longwall A6.

Austar have approval to mine Longwalls A1 and A2, which are located north-west of the previously extracted Longwalls SL2 to SL4, and are currently being extracted using LTCC mining techniques. A separate SMP Application for the extraction of Longwalls A3 to A5 has been submitted to the Department of Primary Industries (DPI).

The proposed longwalls and the Study Area, as defined in Section 2.1, have been overlaid on an orthophoto of the area, which is shown in Fig. 1.1. The major natural features and surface infrastructure in the vicinity of the proposed longwalls can be seen in this figure.

This report provides information that will support a Part 3A Application to be submitted to the Department of Planning. In some cases, this report will refer to other sources of information on specific natural features and items of surface infrastructure, and these reports should be read in conjunction with this report.

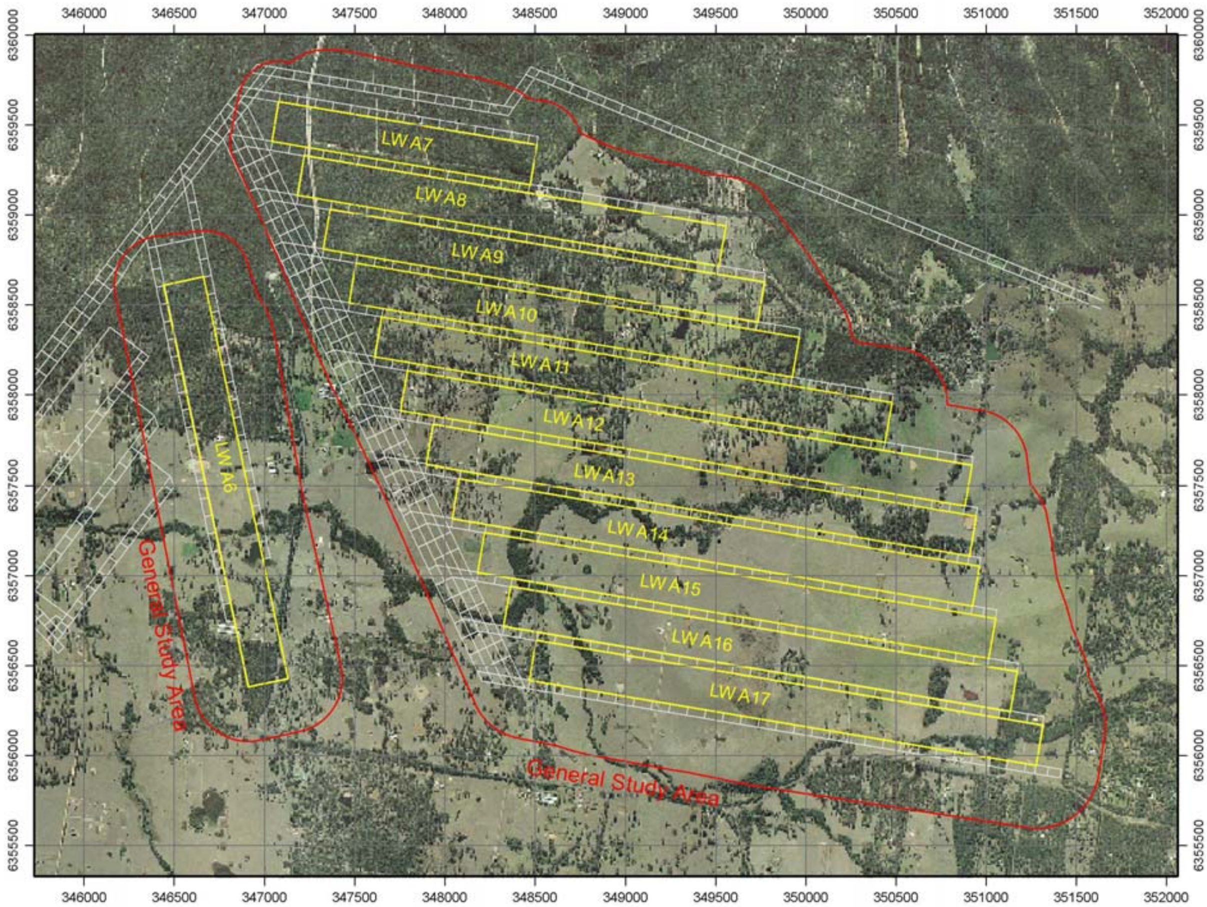

Fig. 1.1 Aerial Photograph Showing the Proposed Longwalls and the Study Area

1.2. Mining Geometry

The layout of the proposed Austar Longwalls A6 to A17 within the Greta Seam is shown in Drawing No. MSEC309-01. A summary of the dimensions of the proposed longwalls is provided in Table 1.1.

Table 1.1 Geometry of Proposed Longwalls

Longwall	Length (m)	Void Width (m)	Solid Chain Pillar Width (m)
LWA6	2280	227	-
LWA7	1455	227	-
LWA8	2370	227	45
LWA9	2445	227	45
LWA10	2495	227	45
LWA11	2870	227	45
LWA12	3175	227	45
LWA13	3055	227	45
LWA14	2930	227	45
LWA15	2875	227	45
LWA16	2850	227	45
LWA17	2850	227	45

The depth of cover to the Greta Seam above the proposed longwalls varies between a minimum of 445 metres, at the north-western corner of proposed Longwall A7, and a maximum of 750 metres, above the middle of proposed Longwall A17. The seam floor at the proposed longwalls generally dips from the north to the south.

The Greta Seam splits near the middle of proposed Longwalls A10 to A17, the location of which is shown in Drawing No. MSEC309-04. Drill hole SKD 14, which is located approximately 100 metres east of the split line in the middle of Longwall A8, indicates that the upper Greta Seam is 4.15 metres thick and the lower Greta Seam is 0.5 metres thick, having a sandstone interburden of 0.5 metres. Drill hole SKD12, which is located approximately 100 metres east of the commencing end of Longwall A7, indicates the upper Greta Seam is 4.00 metres thick and the lower Greta Seam is 1.4 metres thick, having a sandstone interburden of 10.5 metres. It appears from these exploration drill holes that the interburden between upper and lower Greta Seams increases rapidly towards the east.

The seam thickness at the proposed longwalls, west of the seam split, varies between a minimum of 5.3 metres, adjacent to the seam split, and a maximum of 7.0 metres, near the finishing (northern) end of proposed Longwall A6.

The surface level contours, seam floor contours, seam thickness contours, and depth of cover contours are shown in Drawings Nos. MSEC309-02 to MSEC309-05. The known geological structures at seam level are shown in Drawing No. MSEC309-06.

1.3. Geological Details

The proposed longwalls lie in the Newcastle Coalfield within the Northern Sydney Basin. The typical stratigraphic section of the Newcastle Coalfield (after Ives et al, 1999, Moelle and Dean-Jones, 1995, Lohe and Dean-Jones, 1995, Sloan and Allman, 1995) is shown in Table 1.2. The strata shown in this table were laid down between the Early Permian to Middle Triassic Periods.

The longwalls are proposed to be extracted from the Greta Seam, which is located within the Kitchener Formation of the Greta Coal Measures. The overlying strata comprise the Paxton Formation, which consist of interbedded sandstone and siltstone layers up to 20 metres thick. The uppermost layer in the Greta Coal Measures is the Pelton Seam, which is less than 0.5 metres thick. The underlying strata comprise the Kurri Kurri Conglomerate and the Neath Sandstone. Strong and thick strata consisting of conglomerate and sandstone are typically observed within these formations.

The main sequence overlying the Greta Coal Measures is the Branxton Formation, which is part of the Maitland Group sediments from the mid Permian period. The Maitland Group comprises, in order of deposition, the Branxton Formation, Muree Sandstone and Mulbring Siltstone. The Branxton Formation immediately overlies the Greta Coal Measures and is made up of a substantial thickness of sedimentary rocks and is up to 1300 metres in some locations. The lithology of the Branxton Formation generally consists of the coarser sandstone and conglomerate rocks at the base of the formation, grading to finer deposits of silty sandstone and siltstone at the top of the formation. The upper part of the formation contains a unit known as "Fenestella Shale" that contains numerous fossils of marine invertebrate fauna.

The Newcastle region is characterised by a complex geological setting, with a great variety of rock types occurring over short lateral and vertical distances (Moelle and Dean-Jones, 1995). Folds, normal faults and dykes dominate the region and generally trend north-west to north-north-west (Lohe and Dean-Jones, 1995).

The major geological features within the vicinity of the proposed longwalls are shown in Drawing No. MSEC309-06. There are no identified major faults or dykes at the locations of the proposed longwalls. The *Central Dyke* is located to the west of proposed Longwall A6. The *Quorrobolong Fault Zone* is located between proposed Longwall A6 and proposed Longwalls A7 to A17. The *Abernethy Fault Zone* is located to the north and to the east of proposed Longwalls A7 to A17.

Table 1.2 Stratigraphy of the Newcastle Coalfield
(after Ives et al, 1999, Moelle & Dean-Jones, 1995, Lohe & Dean-Jones, 1995, Sloan & Allan, 1995)

<table>
<tr><th colspan="3">STRATIGRAPHY</th><th rowspan="2">LITHOLOGY</th></tr>
<tr><th>Group</th><th>Formation</th><th>Coal Seams</th></tr>
<tr><td>Narrabeen Group</td><td>Clifton</td><td></td><td>Sandstone, siltstone, mudstone, claystone</td></tr>
<tr><td rowspan="9">Newcastle Coal Measures</td><td>Moon Island Beach</td><td>Vales Point
Wallarah
Great Northern</td><td>Sandstone, shale, conglomerate, claystone, coal</td></tr>
<tr><td colspan="2">Awaba Tuff</td><td>Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert</td></tr>
<tr><td>Boolaroo</td><td>Fassifern
Upper Pilot
Lower Pilot
Hartley Hill</td><td>Conglomerate, sandstone, shale, claystone, coal</td></tr>
<tr><td colspan="2">Warners Bay Tuff</td><td>Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert</td></tr>
<tr><td>Adamstown</td><td>Australasian
Montrose
Wave Hill
Fern Valley
Victoria Tunnel</td><td>Conglomerate, sandstone, shale, claystone, coal</td></tr>
<tr><td colspan="2">Nobbys Tuff</td><td>Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone chert</td></tr>
<tr><td>Lambton</td><td>Nobbys
Dudley
Yard
Borehole</td><td>Sandstone, shale, minor conglomerate, claystone, coal</td></tr>
<tr><td colspan="2">Waratah Sandstone</td><td>Sandstone</td></tr>
<tr><td rowspan="3">Tomago Coal Measures</td><td>Dempsey</td><td></td><td rowspan="3">Shale, siltstone, fine sandstone, coal, and minor tuffaceous claystone</td></tr>
<tr><td>Four Mile Creek</td><td></td></tr>
<tr><td>Wallis Creek</td><td></td></tr>
<tr><td rowspan="3">Maitland Group</td><td colspan="2">Mulbring Siltstone</td><td>Siltstone</td></tr>
<tr><td colspan="2">Muree Sandstone</td><td>Sandstone</td></tr>
<tr><td>Braxton</td><td></td><td>Sandstone, and siltstone</td></tr>
<tr><td rowspan="4">Greta Coal Measures</td><td>Paxton</td><td>Pelton</td><td rowspan="3">Sandstone, conglomerate, and coal</td></tr>
<tr><td>Kitchener</td><td>Greta</td></tr>
<tr><td>Kurri Kurri</td><td>Homeville</td></tr>
<tr><td colspan="2">Neath Sandstone</td><td>Sandstone</td></tr>
<tr><td rowspan="4">Dalwood Group</td><td>Farley</td><td></td><td rowspan="4">Shale, siltstone, lithic sandstone, conglomerate, minor marl and coal, and interbedded basalts, volcanic breccia, and tuffs</td></tr>
<tr><td>Rutherford</td><td></td></tr>
<tr><td>Allandale</td><td></td></tr>
<tr><td>Lochinvar</td><td></td></tr>
<tr><td colspan="4">Seaham Formation</td></tr>
</table>

CHAPTER 2. IDENTIFICATION OF SURFACE FEATURES

2.1. Definition of the Study Area

The "Study Area" is defined as the surface area that is likely to be affected by the proposed mining of Longwalls A6 to A17 in the Greta Seam at Austar Coal Mine. The extent of the Study Area has been calculated by combining the areas bounded by the following limits:-

- The 26½ degree angle of draw line,
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, and
- Features sensitive to far-field movements.

Given that the depth of cover above the proposed longwalls varies between 445 and 750 metres, the 26½ degree angle of draw line has been conservatively determined by drawing a line that is a horizontal distance varying between 225 and 375 metres around the limit of the proposed extraction area.

The predicted limit of vertical subsidence, taken as the predicted total 20 mm subsidence contour, has been determined using the Incremental Profile Method, which is described in further detail in Section 3.4 and Appendix D. The angle of draw to the predicted total 20 mm subsidence contour has been calibrated to 30 degrees adjacent to the longitudinal edges of the proposed longwalls, so as to match those observed over the previously extracted longwalls at the Colliery.

A line has therefore been drawn defining the general Study Area, based upon the 26½ degree angle of draw line and the predicted total 20 mm subsidence contour, and is shown in Drawing No. MSEC309-01.

There are areas that lie outside the general Study Area that are expected to experience either far-field horizontal movements, or valley related upsidence and closure movements. The surface features which are sensitive to such movements have been identified in this report and have been included as part of the Study Area. These features are listed below and details are provided in later sections of the report.

- Cony and Sandy Creeks, within the predicted limit of 20 mm total upsidence,
- Groundwater bores, and
- Survey control marks.

2.2. General Description of Surface Features and Infrastructure within the Study Area

The major natural features and items of surface infrastructure within the Study Area can be seen in the 1:25,000 Topographic Map of the area, published by the Central Mapping Authority (CMA), numbered QUORROBOLONG 91322-S.

The following sections in this Chapter identify and describe all major natural features and surface infrastructure that lie within the Study Area. A summary of these features is provided in Table 2.1 and are shown in Drawings Nos. MSEC309-07 to 21 in Appendix J.

Table 2.1 Natural Features and Surface Improvements

Item	Within Study Area	Environmentally Sensitive Area	Section Number Reference
NATURAL FEATURES			
Catchment Areas or Declared Special Areas			
Rivers or Creeks	✓		2.4.3
Aquifers or Known Groundwater Resources	✓		2.4.4
Springs			
Sea or Lake			
Shorelines			
Natural Dams			
Cliffs or Pagodas			
Steep Slopes	✓		2.4.10
Escarpments			
Land Prone to Flooding or Inundation	✓		2.4.12
Swamps, Wetlands or Water Related Ecosystems	✓		2.4.13
Threatened or Protected Species			
National Parks			
State Forests	✓		2.4.16
State Conservation Areas	✓		2.4.17
Natural Vegetation	✓		2.4.18
Areas of Significant Geological Interest			
Any Other Natural Features Considered Significant			
PUBLIC UTILITIES			
Railways			
Roads (All Types)	✓		2.5.2
Bridges	✓		2.5.3
Tunnels			
Culverts	✓		2.5.5
Water, Gas or Sewerage Infrastructure			
Liquid Fuel Pipelines			
Electricity Transmission Lines or Associated Plants	✓		2.5.10
Telecommunication Lines or Associated Plants	✓		2.5.11
Water Tanks, Water or Sewage Treatment Works			
Dams, Reservoirs or Associated Works			
Air Strips			
Any Other Public Utilities			
PUBLIC AMENITIES			
Hospitals			
Places of Worship			
Schools			
Shopping Centres			
Community Centres			
Office Buildings			
Swimming Pools			
Bowling Greens			
Ovals or Cricket Grounds			
Race Courses			
Golf Courses			
Tennis Courts			
Any Other Public Amenities			

Item	Within Study Area	Environmentally Sensitive Area	Section Number Reference
FARM LAND AND FACILITIES			
Agricultural Utilisation or Agricultural Suitability of Farm Land	✓		2.7.1
Farm Buildings or Sheds	✓		2.7.2
Tanks	✓		2.7.3
Gas or Fuel Storages	✓		2.7.4
Poultry Sheds			
Glass Houses			
Hydroponic Systems			
Irrigation Systems	✓		2.7.8
Fences	✓		2.7.9
Farm Dams	✓		2.7.10
Wells or Bores	✓		2.7.11
Any Other Farm Features			
INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS			
Factories			
Workshops			
Business or Commercial Establishments or Improvements			
Gas or Fuel Storages or Associated Plants			
Waste Storages or Associated Plants			
Buildings, Equipment or Operations that are Sensitive to Surface Movements			
Surface Mining (Open Cut) Voids or Rehabilitated Areas			
Mine Infrastructure Including Tailings Dams or Emplacement Areas	✓		2.8.8
Any Other Industrial, Commercial or Business Features			
AREAS OF ARCHAEOLOGICAL OR HERITAGE SIGNIFICANCE	✓		2.9.1
ITEMS OF ARCHITECTURAL SIGNIFICANCE			
PERMANENT SURVEY CONTROL MARKS	✓		2.11
RESIDENTIAL ESTABLISHMENTS			
Houses	✓		2.12.1
Flats or Units			
Caravan Parks			
Retirement or Aged Care Villages			
Associated Structures such as Workshops, Garages, On-Site Waste Water Systems, Water or Gas Tanks, Swimming Pools or Tennis Courts	✓		2.12.5
Any Other Residential Features	✓		2.12.5
ANY OTHER ITEM OF SIGNIFICANCE			
ANY KNOWN FUTURE DEVELOPMENTS			

2.3. Surface Topography

The surface level contours in the vicinity of the proposed longwalls are shown in Drawing No. MSEC309-02. The surface of the land within the central and southern parts of the Study Area is generally flat to undulating.

The major topological feature within the Study Area is the **Broken Back Range** which is located directly above Longwalls A6 to A10. There is also a hill located in the southern part of the Study Area above the middle of the proposed Longwall A17.

The surface levels within the Study Area vary from a low point of approximately 104 metres AHD, in the north-western corner of the Study Area, to a high point of approximately 236 metres AHD, at the top of the ridgeline located east of Longwall A10.

2.4. Natural Features

2.4.1. Catchment Areas and Declared Special Areas

There are no drinking water catchment areas, or declared special areas within the Study Area.

2.4.2. Rivers

There are no rivers within the Study Area.

2.4.3. Creeks

The locations of the major watercourses within the Study Area are shown in Drawing No. MSEC309-07. The major watercourses within the Study Area are briefly described below, with further details provided in the report by Umwelt (2008a).

Cony Creek commences to the east of the Study Area, and generally flows in a westerly direction, to where it drains into Quorrobolong Creek approximately 650 metres west of proposed Longwall A6. **Sandy Creek** commences to the south of the Study Area, and generally flows in a north-westerly direction, to where it drains into Cony Creek above the chain pillar between the proposed Longwalls A15 and A16. **Quorrobolong Creek** is located outside the Study Area, at a minimum distance of 625 metres west of Longwall A6, and drains into Ellalong Lagoon which is located at a distance of more than 6 kilometres west of the Study Area. Cony, Sandy and Quorrobolong Creeks are alluvial based ephemeral creeks, having average natural gradients of less than 1 mm/m within the Study Area.

There are numerous ephemeral drainage lines along the ridgeline and between the hills within the Study Area, which are also shown in Drawing No. MSEC309-07. The drainage lines in the southern and central parts of the Study Area flow into Cony and Sandy Creeks.

2.4.4. Aquifers and Known Groundwater Resources

The ground water resources within the Study Area occur in the shallow alluvial aquifers of Cony and Sandy Creeks and within the deeper Newcastle Coal Measures. Further descriptions of the aquifers within the Study Area are provided in the report by Umwelt (2008a).

2.4.5. Springs

There are no identified springs along Cony or Sandy Creeks within the Study Area. Details of any identified springs along the tributaries within the Study Area are provided in the report by Umwelt (2008a).

2.4.6. Sea or Lake

There are no seas, or lakes within the Study Area.

2.4.7. Shorelines

There are no shorelines within the Study Area.

2.4.8. Natural Dams

There are no natural dams within the Study Area. There are, however, a number of farm dams within the Study Area, which are described in Section 2.7.10.

2.4.9. Cliffs or Pagodas

There are no cliffs or pagodas within the Study Area. There are, however, some isolated rock outcrops within the Study Area, which are located at the upper reaches of the first order tributaries.

2.4.10. Steep Slopes

For the purposes of this report, a steep slope has been defined as an area of land having a natural gradient greater than 1 in 3 (ie: a grade of 33 %, or an angle to the horizontal of 18°). The reason for identifying steep slopes is to highlight areas in which existing ground slopes are considered to be marginally stable.

The minimum grade of 1 to 3 represents a slope that would generally be considered stable for slopes consisting of rocky soils or loose rock fragments. Clearly the stability of natural slopes varies depending on their soil or rock types, and in many cases, natural slopes are stable at much higher gradients than 1 to 3.

The steep slopes within the Study Area were identified from the 1 metre surface contours which were generated from an aerial laser scan of the area. There were two areas identified as having steep slopes which are shown in Drawing No. MSEC309-07.

The *Broken Back Range* crosses the northern part of the Study Area and is located directly above the proposed Longwalls A6 to A10. The natural surface gradients along the range, directly above the proposed longwalls, typically vary between 1 in 3 and 1 in 2 (ie: a grade of 50 %, or an angle to the horizontal of 27°), with isolated areas having natural surface gradients of up to 1 in 1.5 (ie: a grade of 67 %, or an angle to the horizontal of 34°).

There are also steep slopes located along the hill in the southern part of the Study Area, which is located directly above the proposed Longwall A17. The natural surface gradients along the southern side of the hill typically vary up to 1 in 1.5 and the natural surface gradients along the northern side of the hill typically vary up to 1 in 2.

2.4.11. Escarpments

There are no escarpments within the Study Area.

2.4.12. Land Prone to Flooding or Inundation

The natural gradients along the alignments of Cony and Sandy Creeks are very flat and are prone to flooding and inundation. A detailed flood study of the area has been undertaken and is described in the report by Umwelt (2008a).

2.4.13. Swamps, Wetlands and Water-Related Ecosystems

There are no swamps or wetlands within the Study Area. There are, however, a number of ponding areas along the alignments of Cony and Sandy Creeks within the Study Area, which are described in the report by Umwelt (2008a).

2.4.14. Threatened, Protected Species or Critical Habitats

There are no lands within the Study Area that have been declared as critical habitat under the *Threatened Species Conservation Act 1995*.

2.4.15. National Parks or Wilderness Areas

There are no National Parks, or any land identified as wilderness under the *Wilderness Act 1987* within the Study Area.

2.4.16. State Forests

The Study Area is partly located within the former **Aberdare State Forest**, which is located on the northern sides of Big Hill Road and Nash Lane. Part of the forest became a conservation area which is described in Section 2.4.17.

2.4.17. State Recreation Areas or State Conservation Areas

As part of the Lower Hunter Region Reservations Bill, 2,257 hectares of the Aberdare State Forest became part of the **Werakata State Conservation Area** on the 1st July 2007. The conservation area is located on the northern sides of Big Hill Road and Nash Lane.

2.4.18. Natural Vegetation

There is undisturbed native bushland within the Study Area on the northern sides of Coney Creek Road and Nash Lane, within the *Aberdare State Forest* and the *Werakata State Conservation Area*. The land within the Study Area, on the southern sides of Coney Creek Road and Nash Lane, has generally been cleared for agricultural utilisation, however, there are pockets of native bush, primarily along the alignments of Cony and Sandy Creeks.

2.4.19. Areas of Significant Geological Interest

There are no areas of significant geological interest within the Study Area.

2.4.20. Any Other Natural Feature Considered Significant

There are no other natural features considered significant within the Study Area.

2.5. Public Utilities

2.5.1. Railways

There are no railways within the Study Area.

2.5.2. Roads

The locations of the public roads within the vicinity of the proposed longwalls are shown in Drawing No. MSEC309-08. A brief description of the public roads is provided below.

Sandy Creek Road is located south of proposed Longwall A17, at a distance of 80 metres at its closest point, and provides access between the township of Ellalong, located west of the Study Area, with Freemans Drive and Lake Road, located east of the Study Area. Sandy Creek Road has a bitumen seal within the Study Area.

Quorrobolong Road crosses directly above the southern end of Longwall A6 and the western ends of Longwalls A7 and A8. The road provides access between the township of Kitchener, located north of the Study Area, and Sandy Creek Road in the southern part of the Study Area. Quorrobolong Road has a bitumen seal within the Study Area.

Coney Creek Road crosses directly above Longwalls A10 to A13 and **Nash Lane** crosses directly above the proposed Longwall A6. The roads provide access between the rural properties within the Study Area and Quorrobolong Road. Coney Creek Road and Nash Lane are unsealed within the Study Area.

Pelton Fire Trail crosses directly above Longwall A6 and **Big Hill Road** crosses directly above Longwalls A7 to A9. The roads are unsealed trails which are used for fire fighting purposes within the Aberdare State Forest.

2.5.3. Bridges

Two public road bridges have been identified within the Study Area, the locations of which are shown in Drawing No. MSEC309-08.

Bridge **BR-SR01** is situated where Sandy Creek Road crosses Sandy Creek, which is located 575 metres south of Longwall A17, at the southern extent of the Study Area. The bridge is a single span concrete structure having an overall span of approximately 12 metres. A photograph of Bridge BR-SR01 is provided in Fig. 2.1.

Fig. 2.1 Bridge BR-SR01 along Sandy Creek Road

Bridge **BR-QR01** is situated where Quorrobolong Road crosses Coney Creek, which is located 250 metres east of Longwall A6, at its closest point to the proposed longwalls. The bridge is a timber structure, with three intermediate timber supports, having an overall span of approximately 22 metres. A photograph of Bridge BR-QR01 is provided in Fig. 2.2. This bridge has historic significance which is described in the report by Umwelt (2008c).

Fig. 2.2 Bridge BR-QR01 along Quorrobolong Road

2.5.4. Tunnels

There are no tunnels within the Study Area.

2.5.5. Drainage Culverts

A number of road drainage culverts have been identified within the Study Area, the locations of which are shown in Drawing No. MSEC309-08. The sizes, types and GPS coordinates of the culverts, which were determined on site by MSEC, are provided in Table 2.2.

Table 2.2 Drainage Culverts within the Study Area

Road	Culvert	Approx. Easting	Approx. Northing	Type
Sandy Creek Road	DC-SR01	349940	6355860	2 x 3000W x 1200H
	DC-SR02	350015	6355905	1 x ϕ600
	DC-SR03	350160	6355965	1 x ϕ600
	DC-SR04	350285	6355975	1 x ϕ375
	DC-SR05	350510	6355985	2 x 1200W x 750H
	DC-SR06	350605	6355955	1 x ϕ450
	DC-SR07	350780	6355935	1 x ϕ300
	DC-SR08	351060	6355890	1 x ϕ300
	DC-SR09	351225	6355875	1 x ϕ450
	DC-SR10	351460	6355830	2 x ϕ900
Quorrobolong Road	DC-QR01	347175	6357290	3 x ϕ600
	DC-QR02	347125	6356950	1 x ϕ450
	DC-QR03	347100	6356785	3 x ϕ600
	DC-QR04	347090	6356720	2 x ϕ400
	DC-QR05	347065	6356620	1 x ϕ300
	DC-QR06	347255	6358730	Historic Culvert 1*
	DC-QR07	347270	6358770	Historic Culvert 2*
	DC-QR08	347280	6358875	Historic Culvert 3*
Coney Creek Road	DC-CR01	347540	6357700	1 x ϕ450
	DC-CR02	347910	6357645	1 x ϕ300
	DC-CR03	347935	6357640	1 x ϕ225
	DC-CR04	348150	6357610	1 x ϕ375
	DC-CR05	348290	6358245	1 x ϕ375
	DC-CR06	348330	6358225	2 x ϕ375
	DC-CR07	348430	6358215	1 x ϕ375
	DC-CR08	349010	6358095	3 x ϕ600
	DC-CR09	349655	6358315	1 x ϕ375
	DC-CR10	349700	6358325	1 x ϕ375
	DC-CR11	349765	6358350	1 x ϕ375
	DC-CR12	349850	6358390	1 x ϕ375

Note:- * denotes that details of historical Culverts 1, 2 and 3 are provided in the report by Umwelt (2008c).

There are also a number of drainage culverts on private land within the Study Area.

2.5.6. Water Services

There are no public water services within the Study Area. The rural properties within the Study Area have local water pipelines to the dams and private rainwater tanks.

2.5.7. Sewerage Pipelines and Sewerage Treatment Works

There are no sewerage pipelines, or sewage treatment works within the Study Area. The properties within the Study Area have local sewer connections to septic tanks, or package treatment plants.

2.5.8. Gas Pipelines

There are no gas pipelines within the Study Area.

2.5.9. Liquid Fuel Pipelines

There are no liquid fuel pipelines within the Study Area.

2.5.10. Electricity Transmission Lines and Associated Plants

The locations of the electrical services within the Study Area are shown in Drawing No. MSEC309-09. The electrical services, which are owned by Energy Australia, comprise above ground 11 kV powerlines supported by timber poles. The poles have unique identification numbers which have been shown in Drawing No. MSEC309-09. There are also low voltage powerlines which supply power to the rural properties within the Study Area.

2.5.11. Telecommunication Lines and Associated Plants

The locations of the telecommunications services within the Study Area are shown in Drawing No. MSEC309-10. The telecommunication services, which are owned by Telstra, comprise direct buried optical fibre cable and above ground and direct buried copper cables.

The **optical fibre cable** crosses directly above the proposed Longwalls A7 to A17. The cable runs between the Quorrobolong Telephone Exchange, which is located along Sandy Creek Road south of the proposed longwalls, and the township of Cessnock, which is located north of the Study Area.

The main and local **copper telecommunications cables** generally follow the alignments of Sandy Creek, Quorrobolong and Coney Creek Roads within the Study Area. The main cables are aerial cables supported by timber poles and the local cables are direct buried.

The **Quorrobolong Telephone Exchange** is located outside the general Study Area. The building is located on Sandy Creek Road, at a distance of 650 metres south of Longwall A17.

2.5.12. Water Tanks, Water and Sewerage Treatment Works

There are no public water or sewerage treatment works within the Study Area.

2.5.13. Dams, Reservoirs or Associated Works

There are no public dams, reservoirs, or associated works within the Study Area.

2.5.14. Air Strips

There are no air strips within the Study Area.

2.5.15. Any Other Public Utilities

There are no other public utilities within the Study Area.

2.6. Public Amenities

2.6.1. Hospitals

There are no hospitals within the Study Area.

2.6.2. Places of Worship

There are no places of worship within the Study Area.

2.6.3. Schools

There are no schools within the Study Area.

2.6.4. Shopping Centres

There are no shopping centres within the Study Area.

2.6.5. Community Centres

There are no community centres within the Study Area.

2.6.6. Office Buildings

There are no office buildings within the Study Area.

2.6.7. Swimming Pools

There are no public swimming pools within the Study Area.

2.6.8. Bowling Greens

There are no bowling greens within the Study Area.

2.6.9. Ovals or Cricket Grounds

There are no ovals or cricket grounds within the Study Area.

2.6.10. Race Courses

There are no race courses within the Study Area.

2.6.11. Golf Courses

There are no golf courses within the Study Area.

2.6.12. Tennis Courts

There are no public tennis courts within the Study Area.

2.6.13. Any Other Public Amenities

There are no other public amenities within the Study Area.

2.7. Farm Land and Facilities

2.7.1. Agriculture Utilisation and Agriculture Improvements

The land within the Study Area, south of Big Hill Road and Nash Lane, has predominately been cleared for agricultural utilisation. There are a number of vineyards and crops on the rural properties within the Study Area which are shown in Drawings Nos. MSEC309-11 to MSEC309-19.

2.7.2. Farm Buildings and Sheds

A total of 80 rural building structures (Structure Type R) have been identified within the Study Area, which include farm sheds, garages and other non-residential structures. The locations of the rural building structures are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and details are provided in Tables G.01 to G.05 in Appendix G. The locations, sizes, and details of the rural building structures were determined from an aerial photograph of the area and from site investigations.

2.7.3. Tanks

There are a number of larger tanks (Structure Type T) that have been identified within the Study Area, which include water and fuel storage tanks. The locations of these tanks are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and details are provided in Tables G.01 to G.05 in Appendix G. In addition to this, there are also a number of smaller rainwater and fuel storage tanks associated with the residences on each rural property, which are not shown in the drawings or the tables.

2.7.4. Gas and/or Fuel Storages

A number of the residences within the Study Area have gas or fuel storages. The locations of the larger tanks within the Study Area, including both rainwater and fuel storage tanks, are described in Section 2.7.3.

2.7.5. Poultry Sheds

There are no known poultry sheds within the Study Area.

2.7.6. Glass Houses

There are no known glass houses within the Study Area.

2.7.7. Hydroponic Systems

There are no known hydroponic systems within the Study Area.

2.7.8. Irrigation Systems

There are irrigation systems within the Study Area associated with the vineyards on the rural properties.

2.7.9. Fences

A number of fences have been identified within the Study Area. The majority of fences mark property boundaries and are constructed with timber or steel posts and with fencing wire or timber rails.

2.7.10. Farm Dams

A total of 134 farm dams (Structure Type D) have been identified within the Study Area. The locations of the farm dams within the Study Area are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and the details of the farm dams are provided in Table G.06 in Appendix G.

The maximum lengths of the farm dams vary between 7 metres and 270 metres and the surface areas of the farm dams vary between 40 and 9700 m^2. The dams are generally of earthen construction, and have been established by localised cut and fill operations within the natural drainage lines. The farm dams are generally shallow, with the dam wall heights generally being less than 3 metres.

2.7.11. Wells and Bores

There is one registered groundwater bore within the general Study Area, being Ref. GW038372, the location of which is shown in Drawing No. MSEC309-20. The details of this groundwater bore are provided in Table 2.3.

Table 2.3 Details of the Groundwater Bore within the General Study Area

ID	Easting (m)	Northing (m)	Diameter (m)	Depth (m)	Usage	Salinity
GW038372	347170	6357660	Not known	9.1	Not known	Not known

There are also three groundwater bores located in the vicinity of the general Study Area, being Refs. GW051324, GW078091 and GW054676, the locations of which are also shown in Drawing No. MSEC309-20.

The work summary sheet for the groundwater bore GW051324, which is located 730 metres south of Longwall A17, indicates that the bores is low yielding (approx. 0.3 L/sec) and high salinity (10001 ~ 14000 ppm).

The work summary sheet for the groundwater bore GW054676, which is located 1.4 kilometres west of Longwall A6, indicates that the bore is low yielding (approx. 1.0 L/sec) and salty. Discussions between Austar and the private owner of this bore also indicates that the water quality is poor (approx. 14,000 ~ 16,000 µS/cm) and is only left open for DNR baseline monitoring. The water is unsuitable for domestic or stock use.

The locations and details of the groundwater bores were provided by the Department of Natural Resources (DNR).

2.7.12. Any Other Farm Features

There are no other significant farm features within the Study Area.

2.8. Industrial, Commercial and Business Establishments

2.8.1. Factories

There are no factories within the Study Area.

2.8.2. Workshops

There are no workshops within the Study Area.

2.8.3. Business or Commercial Establishments or Improvements

There are no other known businesses or commercial establishments within the Study Area.

2.8.4. Gas or Fuel Storages and Associated Plant

There are no known gas or fuel storages, or associated plant within the Study Area.

2.8.5. Waste Storages and Associated Plant

There are no waste storages, or associated plant within the Study Area.

2.8.6. Buildings, Equipment or Operations that are Sensitive to Surface Movements

There are no known buildings, equipment or operations that are sensitive to surface movements within the Study Area.

2.8.7. Surface Mining (Open Cut) Voids and Rehabilitated Areas

There are no surface mining, or rehabilitation areas within the Study Area.

2.8.8. Mine Infrastructure Including Tailings Dams or Emplacement Areas

There are a number of exploration drill holes within the Study Area, the locations of which are shown in Drawing No. MSEC309-20. There is no other mine infrastructure within the Study Area.

2.8.9. Any Other Industrial, Commercial or Business Features

There are no other industrial, or commercial, or business features within the Study Area.

2.9. Areas of Archaeological or Heritage Significance

2.9.1. Items of Archaeological Significance

There are no lands within the Study Area declared as an Aboriginal Place under the *National Parks and Wildlife Act 1974*. There are, however, a number of archaeological sites which have been identified within the Study Area, including a number of artefact scatters, isolated finds and potential archaeological deposits, as well as one grinding groove site. The locations of the archaeological sites within the Study Area are shown in Drawing No. MSEC309-21 and details are provided in the report by Umwelt (2008b).

2.9.2. Items of Heritage Significance

There are 11 historical sites that have been identified within the Study Area, the locations of which are shown in Drawing No. MSEC309-21 and details are provided in Table 2.4.

Table 2.4 Historical Sites within the Study Area

Item	Site Type	Description
1	Bridge	Timber bridge BR-QR01 (Refer to Section 2.5.3)
4	Ford	Scattered materials utilised in the construction of the ford
5	Culvert 1	Single concrete culvert beneath Quorrobolong Road
6	Culvert 2	Single concrete culvert beneath Quorrobolong Road
7	Culvert 3	Single concrete culvert beneath Quorrobolong Road
8	Artefact Scatter	Machine-made brick, glass, concrete, salt glazed ceramic services pipe and metal fragments
9	Fencing 1	Single timber post
10	Fencing 2	Single timber post
14	Potential House Site	Potential former house site comprising brick rubble
16	Homestead Site 1	Structure Ref. A44a
17	Homestead Site 2	Structure Ref. A85a

A number of other historical sites have also been identified in the vicinity of the Study Area, including two quarry sites (Items 2 and 3), a cut tree (Item 11) and a tree stump (Item 12). The locations of these sites are also shown in Drawing No. MSEC309-21. Further descriptions of the historical sites within and adjacent to the Study Area are provided in the report by Umwelt (2008c).

2.9.3. Items on the Register of the National Estate

There are no items on the Register of National Estate within the Study Area.

2.10. Items of Architectural Significance

There are no items of architectural significance within the Study Area.

2.11. Permanent Survey Control Marks

There are eight survey control marks within the general Study Area, the locations of which are shown in Drawing No. MSEC309-20. Details of the survey control marks within the general Study Area are provided in Table 2.5.

Table 2.5 Survey Control Marks within the General Study Area

Survey Mark	Approx. MGA Easting (m)	Approx. MGA Northing (m)
SS 89024	348175	6357615
SS 89025	347605	6357700
PM 69715	351195	6355885
PM 70277	350345	6356010
PM 72586	350895	6355840
PM 72587	351375	6355855
PM 76248	346940	6356140
PM 109448	346895	6356175

There are also a number of other survey marks in the vicinity of the general Study Area which are also shown in this drawing. These marks could be subjected to far-field horizontal movements and have, therefore, been included as part of the Study Area.

2.12. Residential Establishments

2.12.1. Houses

There are 32 houses located within the Study Area, of which 29 are single-storey houses with lengths less than 30 metres (Type H1), and three are single-storey houses with lengths greater than 30 metres (Type H2). There are no double-storey houses (Types H3 and H4) within the Study Area.

The locations of the houses are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and the details of the houses are provided in Tables G.01 to G.05 in Appendix G. The locations and sizes of the houses were determined from an aerial photograph of the area and from field investigations. The distribution of the maximum plan dimension of the houses within the Study Area is provided in Fig. 2.3.

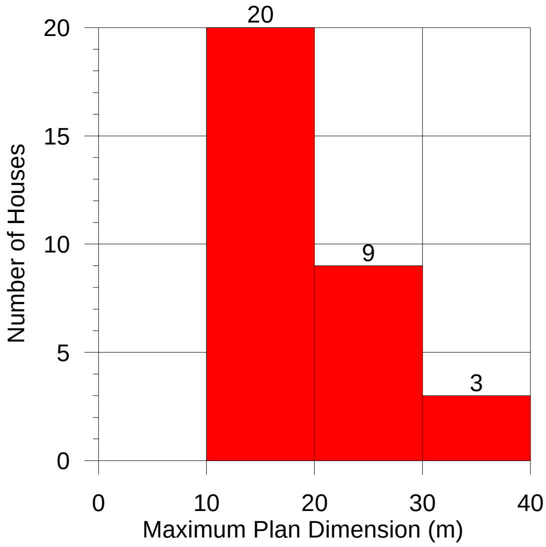

Fig. 2.3 Distribution of Maximum Plan Dimension of Houses within the Study Area

The distributions of the wall and roof constructions of the houses within the Study Area are provided in Fig. 2.4. The distribution of the footing types of the houses within the Study Area is provided in Fig. 2.5.

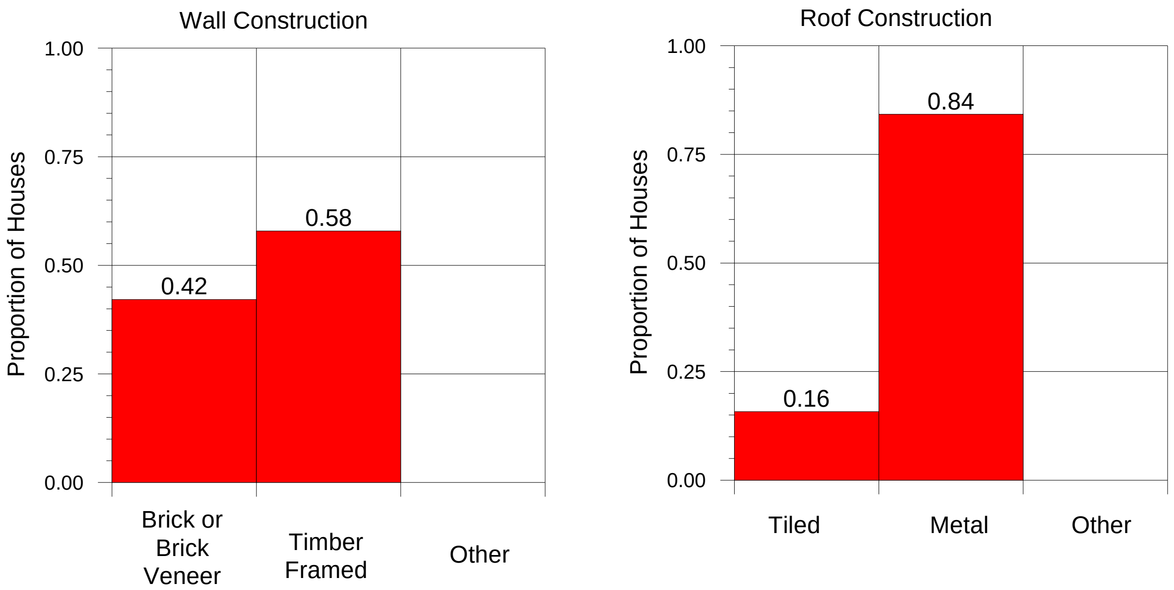

Fig. 2.4 Distribution of Wall and Roof Construction of Houses within the Study Area

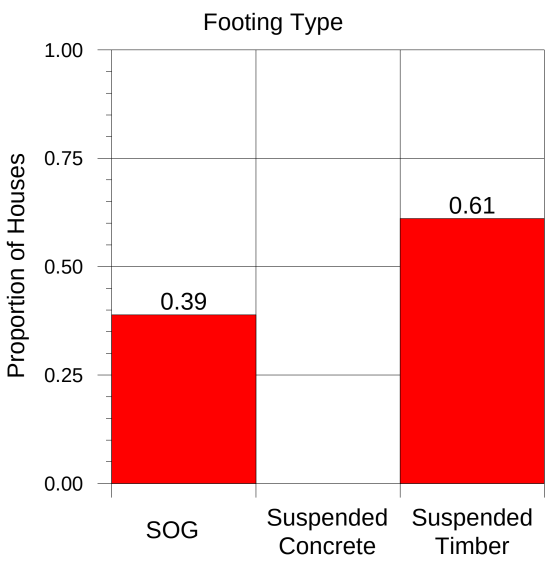

Fig. 2.5 Distribution of Footing Type of Houses within the Study Area

2.12.2. Flats or Units

There are no flats or units within the Study Area.

2.12.3. Caravan Parks

There are no caravan parks within the Study Area.

2.12.4. Retirement or Aged Care Villages

There are no retirement or aged care villages within the Study Area.

2.12.5. Any Other Associated Structures

The descriptions of rural building structures and tanks are provided in Sections 2.7.2 and 2.7.3, respectively. There are 11 privately owned swimming pools (Structure Type P) which have been identified within the Study Area, the locations of which are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and details are provided in Tables G.01 to G.05 in Appendix G.

The houses on each rural property within the Study Area have septic tanks. There are also private pipelines on the rural properties within the Study Area connecting with the farm dams and private water tanks.

2.12.6. Any Other Residential Feature

There are no other significant residential features within the Study Area.

2.13. Any Other Items

There are no other significant items within the Study Area.

2.14. Any Known Future Developments

There are no known future developments within the Study Area.

CHAPTER 3. OVERVIEW OF LONGWALL TOP COAL CAVING METHODS, THE DEVELOPMENT OF SUBSIDENCE, AND THE METHOD USED TO PREDICT THE MINE SUBSIDENCE PARAMETERS FOR THE PROPOSED LONGWALLS

3.1. Introduction

This chapter provides a brief overview of longwall top coal caving methods, the development of mine subsidence and the method that has been used to predict the subsidence movements for the proposed Longwalls A6 to A17 within this project. Detailed descriptions of longwall mining and the development of subsidence are provided in Appendix C of this report. Detailed descriptions of methods used to predict mine subsidence movements are provided in Appendix D of this report.

The maximum predicted and maximum upperbound systematic subsidence parameters within the Study Area resulting from the extraction of the proposed longwalls are provided in Chapter 4. The predicted and upperbound subsidence parameters and impact assessments for the natural features and items of surface infrastructure within the Study Area are provided in Chapter 5.

3.1.1. Overview of Longwall Top Coal Caving

Longwall Top Coal Caving (LTCC) has been developed in China over the past 20 years and is capable of extracting seam thicknesses between 4.5 and 12.5 metres. Austar has been given approval to use LTCC mining techniques to extract Longwalls A1 and A2 and is the first company in Australia to use such technology. Austar Longwalls A3 to A5 are proposed to be extracted using LTCC mining techniques.

Austar Longwalls A6 to A17 are also proposed to be extracted from the Greta Seam using LTCC techniques, where the seam thickness locally varies between 4.0 and 7.0 metres. A typical cross-section through one of the proposed Austar longwalls is shown in Fig. 3.1.

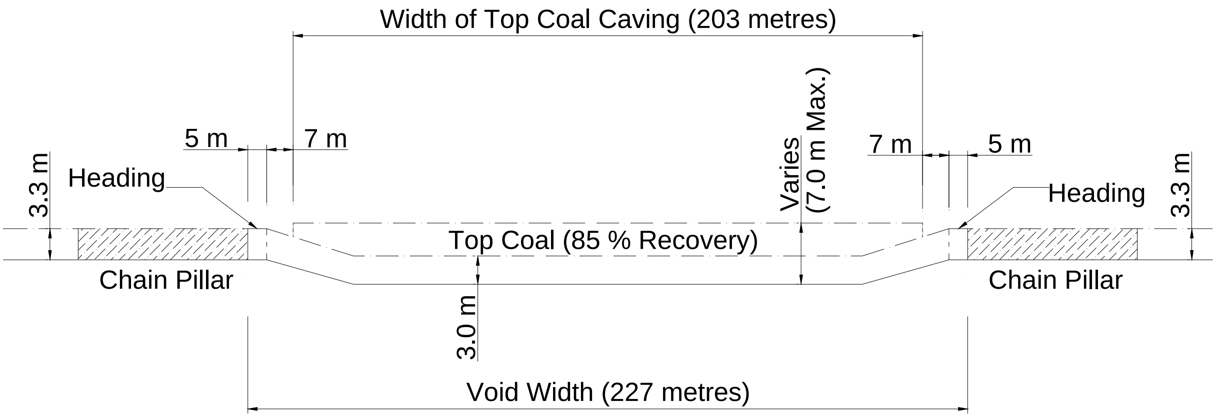

Fig. 3.1 Cross-Section through a Typical Proposed Austar Longwall A6 to A17

The development headings are initially extracted using continuous miners, and are 5 metres wide and 3.3 metres high. The headings are extracted above the seam floor, so that the floor of the longwall panel can be tapered down, as shown in the above figure, having a 1.3 metre drop over a horizontal distance of 23 metres from the headings.

The LTCC equipment uses a conventional longwall shearer to extract the bottom 3 metres of the coal seam, which is transported from the coal face by a face conveyor. The LTCC equipment uses specially designed shields with retractable flippers to allow the coal in the roof to cave behind the shields, which is transported by a second conveyor located behind the shields. A recovery of approximately 85 % of the top coal is generally achieved within the void width which is 12 metres clear of each chain pillar. Although it is proposed to extract a seam height of between 4.0 and 7.0 metres, the extracted seam height adjacent to the proposed chain pillars is only 3.3 metres.

The strata behind the shields, immediately above the coal seam, is allowed to collapse into the void that is left as the coal face retreats. The collapsed zone comprises loose blocks and can contain large voids. Immediately above the collapsed zone, the strata remains relatively intact and bends into the void, resulting in new vertical factures, opening up of existing vertical fractures and bed separation. The amount of strata sagging, fracturing, and bed separation reduces towards the surface.

At the surface, the ground subsides vertically as well as moves horizontally towards the centre of the mined goaf area. The maximum subsidence at the surface varies, depends on a number of factors including longwall geometry, depth of cover, extracted seam thickness and geology. The maximum possible subsidence in the Newcastle Coalfield is typically between 55 % to 65 % of the extracted seam thickness.

3.2. Overview of Systematic Subsidence Parameters

The normal ground movements resulting from the extraction of pillars or longwalls are referred to as systematic subsidence movements. These movements are described by the following parameters:-

- **Subsidence** usually refers to vertical displacement of a point, but subsidence of the ground actually includes both vertical and horizontal displacements. These horizontal displacements in some cases, where the subsidence is small, can be greater than the vertical subsidence. Subsidence is usually expressed in units of *millimetres (mm)*.

- **Tilt** is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.

- **Curvature** is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (1/km)*, but the values of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.

- **Strain** is calculated as the change in horizontal distance between two points on the ground, divided by the original horizontal distance between them. Strain is typically expressed in units of *millimetres per metre (mm/m)*. **Tensile Strain** occurs where the distance between two points increases and **Compressive Strain** occurs when the distance between two points decreases. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20.

A cross-section through a typical single longwall panel showing typical profiles of subsidence, tilt, curvature and strain is provided in Fig. 3.2.

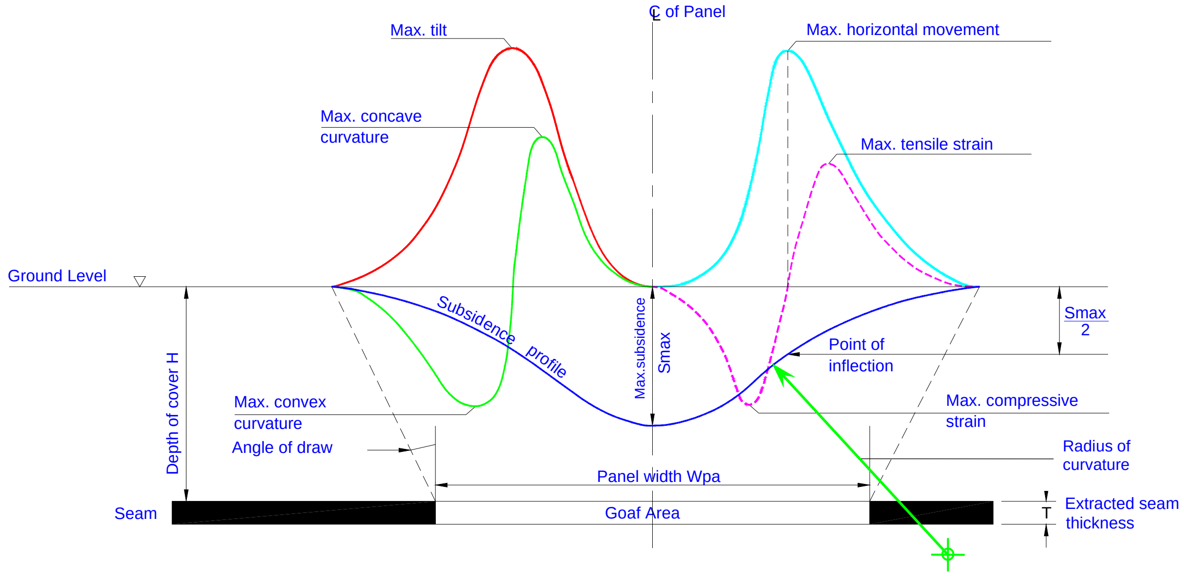

Fig. 3.2 Typical Profiles of Systematic Subsidence Parameters for a Single Longwall Panel

The predicted **incremental** subsidence, tilts, curvatures and strains are the additional parameters which result from the extraction of each longwall. The predicted **cumulative** subsidence, tilts, curvatures and strains are the accumulated parameters which result from the extraction of a series of longwalls.

3.3. Overview of Non-Systematic Subsidence Movements

Non-systematic subsidence movements include far-field horizontal movements, irregular subsidence movements and valley related movements. These movements are briefly described below, with more detailed descriptions provided in Appendix D.

3.3.1. Far-Field Horizontal Movements

In addition to the systematic horizontal movements which occur above and adjacent to extracted longwalls, far-field horizontal movements have been observed at considerable distances from extracted longwalls. Such movements are predictable and occur whenever significant excavations occur at the surface or underground.

Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain. These movements generally do not result in impact, except where they occur at large structures which are very sensitive to differential horizontal movements.

Detailed descriptions of far-field horizontal movements and the method used to predict such movements are provided in Section 5.22.2 and Appendix D.5.9.

3.3.2. Irregular Subsidence Movements

Irregular subsidence movements can result from near surface geological structures, including faults, dykes and abrupt changes in geology. The presence of these features near the surface can result in a bump in the subsidence profile, which is accompanied by locally higher tilts and strains.

Irregular subsidence movements can also occur at shallow depths of cover, where the collapsed zone above the extracted longwalls extends near to the surface. In this situation, the resulting subsidence profiles becomes very erratic, which are accompanied by higher tilts and strains. This type of irregular subsidence movement is generally only seen where the depth of cover is less than 100 metres and is unlikely to occur above the proposed longwalls, as the depth of cover generally exceeds 500 metres.

The non-systematic tilts and strains resulting from irregular subsidence movements can be much greater than those resulting from the normal systematic subsidence movements. Irregular subsidence movements, and the impacts resulting from such movements, are described in Section 5.22.7 and Appendices D.5.8 and D.6.

3.3.3. Valley Related Movements

The creeks and tributaries within the Study Area may also be subjected to valley related movements, which are commonly observed along river and creek alignments in the Southern Coalfield, but less commonly observed in the Newcastle Coalfield. The reason why valley related movements are less commonly observed in the Newcastle Coalfield could be that the systematic subsidence movements are typically much larger than those observed in the Southern Coalfield and tend to mask any smaller valley related movements which may occur.

Valley related movements are a natural phenomenon, resulting from the formation and ongoing development of the valley, as illustrated in Fig. 3.3. The potential for these natural movements are influenced by the geomorphology of the valley.

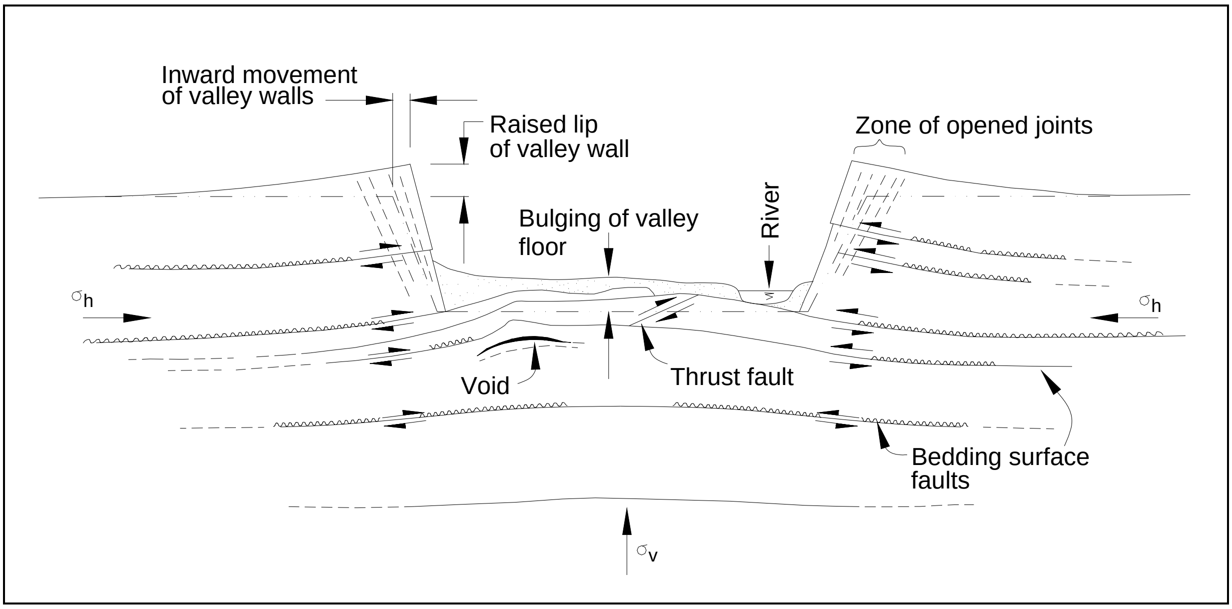

Fig. 3.3 Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)

Valley related movements can be accelerated by mine subsidence, and are described by the following parameters:-

- **Upsidence** is the reduced subsidence, or the net uplift within the base of a valley and is typically expressed in units of *millimetres* (*mm*). Upsidence results from the dilation or buckling of near surface strata in the base of the valley which results from the redistribution of the horizontal in situ stresses around the extracted voids and collapsed zones above extracted longwalls.

- **Closure** is the reduction in the horizontal distance between the valley sides and is expressed in units of *millimetres* (*mm*). Closure also results from the redistribution of horizontal in situ stresses around the extracted voids and collapsed zones above extracted longwalls.

- **Compressive Strains** occur within the bases of valleys as the result of valley closure movements and are calculated as the decrease in horizontal distance over a standard bay length, divided by the original bay length. **Tensile Strains** also occur adjacent to the valleys as the result of valley closure movements and are calculated as the increase in horizontal distance over a standard bay length, divided by the original bay length. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20. Compressive and tensile strains due to valley closure movements are typically expressed in units of *millimetres per metre (mm/m)*.

The predicted valley related movements resulting from the extraction of the proposed longwalls in this project were made using the empirical method outlined in ACARP Research Project No. C9067 (Waddington and Kay, 2002). A detailed description of valley related movements, and the method used to predict such movements, are provided in Appendices D.5.3 to D.5.7. There are other methods available to predict valley related movement, however, the ACARP method was adopted for this project as it is the most thoroughly used and tested method.

3.4. The Incremental Profile Method

The predicted systematic subsidence parameters for the proposed Austar Longwalls A6 to A17 were obtained using the Incremental Profile Method. The Incremental Profile Method is an empirical model which was developed by MSEC, when previously trading as Waddington Kay and Associates. The standard Incremental Profile Method is briefly described below, with further details provided in Appendix D.

The standard Incremental Profile Method is based on a large database of observed monitoring data from previously extracted longwalls within the Southern, Newcastle, Hunter and Western Coalfields of New South Wales. The database consists of detailed subsidence monitoring data from Collieries including: Angus Place, Appin, Baal Bone, Bellambi, Beltana, Bulli, Chain Valley, Clarence, Coalcliff, Cooranbong, Cordeaux, Corrimal, Cumnock, Dartbrook, Delta, Dendrobium, Eastern Main, Ellalong (now Austar), Fernbrook, Glennies Creek, Gretley, Invincible, John Darling, Kemira, Lambton, Liddell, Metropolitan, Mt. Kembla, Munmorah, Nardell, Newpac, Newstan, Newvale, Newvale 2, South Bulga, South Bulli, Stockton Borehole, Teralba, Tahmoor, Tower, Wambo, Wallarah, Western Main, Ulan, West Cliff, West Wallsend and Wyee.

The empirical database includes observed subsidence profiles based on extraction heights varying from less than 2 metres up to 5 metres. Of these observed subsidence profiles, 7 % are for cases having seam extraction heights of less than 2 metres, 74 % are for cases having seam extraction heights between 2 and 3 metres, 15 % are for cases having seam extraction heights between 3 and 4 metres, and 4 % are for cases having seam extraction heights between 4 and 5 metres.

Using the observed monitoring data, MSEC has developed a large database of observed incremental subsidence profiles, which are the additional observed subsidence profiles which resulted from the extraction of each longwall within a series of longwalls. It can be seen from the normalised incremental subsidence profiles within the database, that the observed shapes and magnitudes are reasonably consistent where the mining geometry and local geology are similar.

Subsidence predictions made using the Incremental Profile Method use the database of observed incremental subsidence profiles, the proposed longwall geometries, local surface and seam information, and geology. The method has a tendency to over-predict the systematic subsidence parameters, ie: is slightly conservative, where the proposed mining geometry and geology are within the range of the empirical database. The predictions are often tailored to local conditions where observed monitoring data is available close to the proposed mining area.

There is detailed survey monitoring data over the previously extracted longwalls at the Colliery and, hence, the Incremental Profile Method was calibrated to the local monitoring data, which is described in the following section.

3.4.1. Calibration of the Incremental Profile Method

Austar and Strata Control Technology (SCT) provided local monitoring data over the previously extracted longwalls at the Colliery, prior to Longwalls A1 and A2, which includes Longwalls SL1 to SL4 and Longwalls 1 to 13A. The locations of the previously extracted longwalls at the Colliery and the subsidence monitoring lines are shown in Drawing No. MSEC309-01.

The previously extracted longwalls at the Colliery have void widths varying between 155 and 225 metres, depths of cover varying between 350 and 510 metres and extracted seam thicknesses varying between 3.1 and 3.5 metres at the monitoring line locations.

Two meetings between Austar, MSEC, and SCT occurred on the 1st August and 26th September 2006. At the meetings and in subsequent discussions, SCT provided additional background information on the project, and were involved in the discussions on potential subsidence mechanisms, methods of prediction for top coal caving, shapes of predicted subsidence profiles, and experience of subsidence modelling for Austar Longwalls A1 and A2 and for thick seam extractions on other projects.

Initially, the magnitudes and shapes of the observed incremental subsidence profiles along each monitoring line were compared with the back-predicted subsidence profiles obtained using the standard Incremental Profile Method, which is based on the typical Newcastle Coalfield subsidence profiles.

The back-predictions made using the standard Incremental Profile Method used the longwall void widths and solid chain pillar widths, and used the local depths of cover and extracted seam thicknesses at the locations of the monitoring lines. The standard Incremental Profile Method was not modified for the presence of any thick massive strata units, which can reduce the sag subsidence directly above the extracted longwalls. The model was also not modified for the presence of geological structures, as there were no significant geological structures identified at seam level within the extracted goaf areas of the proposed longwalls.

It is possible to further refine the predictions made using the Incremental Profile Method based on the performance of the chain pillars, where the pillars behave differently from those within the empirical database and where advice is provided by the relevant experts in pillar design. The predictions made using the standard Incremental Profile Method were not modified for varying strengths of coal in the chain pillars, or for varying strengths of the seam floor and seam roof. These refinements were not made in the model, as the refined predictions would not exceed those obtained for the upperbound case, as described in Section 3.6, which were used in the impact assessments for the natural features and surface infrastructure above the proposed longwalls.

It was found that the values of maximum observed incremental subsidence for the previously extracted longwalls along each monitoring line were less than the values of maximum back-predicted incremental subsidence obtained using the standard Incremental Profile Method, as shown in Fig. F.09 in Appendix F. That is, the back-predictions made for the longwalls along each monitoring line using the standard Incremental Profile Method were greater than those observed. Also, as described in Section 4.5, the maximum observed subsidence resulting from the extraction of Austar Longwalls A1 and A2, were less than those predicted using the Incremental Profile Method.

It was also found that the observed incremental subsidence profiles along the monitoring lines were slightly wider, and that the points of maximum observed subsidence were located closer to the longwall tailgates, than for the back-predicted incremental subsidence profiles obtained using the standard Incremental Profile Method. Similar changes in the widths of the predicted subsidence profiles, and similar shifts in the positions of maximum predicted subsidence occur when comparing the shapes of predicted incremental subsidence profiles for varying panel width-to-depth ratios, which is illustrated in Fig. 3.4.

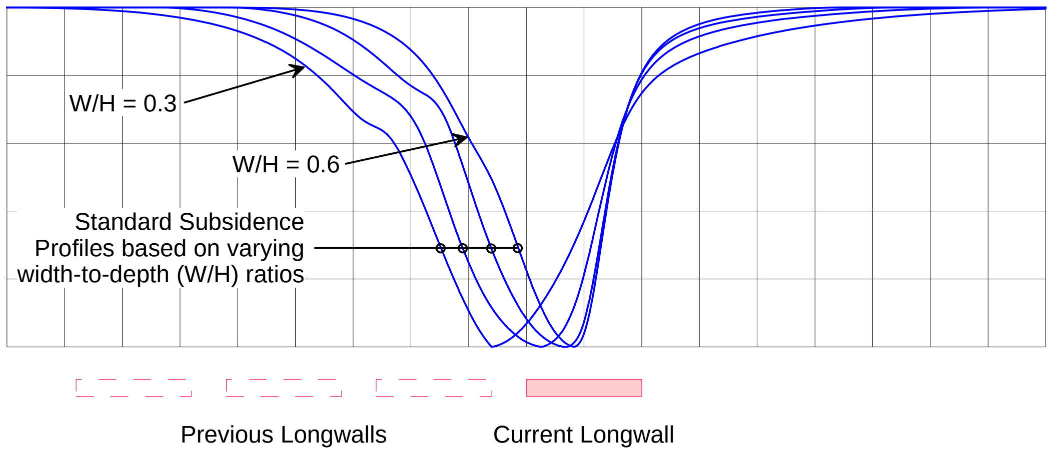

Fig. 3.4 Standard Normalised Profiles based on Varying Width-to-Depth Ratios

It was found, therefore, that the shapes of the back-predicted incremental subsidence profiles along each monitoring line could be adjusted to more closely match those observed, by adopting the standard Newcastle Coalfield subsidence profiles based on smaller panel width-to-depth ratios. The observed incremental subsidence profiles along each monitoring line were then compared with a range of back-predicted incremental subsidence profiles using the standard Newcastle Coalfield profiles for varying panel width-to-depth ratios. No modifications were made to the magnitudes of the maximum back-predicted incremental subsidence for each longwall.

It was found that the shapes of the back-predicted incremental subsidence profiles closely matched the observed incremental subsidence profiles by adopting the standard Newcastle Coalfield subsidence profiles based on a panel width-to-depth ratio of 0.3, rather than adopting the actual panel width-to-depth ratios, which varied between 0.38 and 0.65.

The angle of draw to the predicted total 20 mm subsidence contour, obtained using the Incremental Profile Method, was also calibrated to 30 degrees adjacent to the longitudinal edges of the longwalls, so as to match those observed over the previously extracted longwalls at the Colliery.

The comparisons between the observed subsidence profiles along each monitoring line, and the back-predicted subsidence profiles obtained using the standard Newcastle Coalfield profiles based on a width-to-depth ratio of 0.3, are shown in Figs. F.01 to F.08 in Appendix F. It can be seen from these figures, that the shapes of the back-predicted profiles reasonably match those observed along each monitoring line.

It can also be seen from these figures that the maximum back-predicted incremental subsidence for each longwall is greater than the maximum observed incremental subsidence. A comparison between maximum back-predicted and maximum observed incremental subsidence for each longwall is provided in Fig. F.09 in Appendix F.

The maximum observed incremental subsidence is generally between 45 % and 100 % of the maximum back-predicted incremental subsidence. In no case did the maximum observed incremental subsidence, or maximum observed total subsidence exceed the maximum back-predicted incremental subsidence, or the maximum back-predicted total subsidence, respectively. The variations in the ratios of maximum observed to maximum predicted subsidence, as shown in Fig. F.09, are due to the varying longwall geometries, depths of cover, extracted seam heights, and geologies at the locations of each monitoring line

3.5. Systematic Subsidence Predictions for the Proposed Longwalls A6 to A17

The predicted systematic subsidence parameters for the proposed Austar Longwalls A6 to A17 were obtained using the calibrated Incremental Profile Method, which adopts the standard Newcastle Coalfield subsidence profiles based on a panel width-to-depth ratio of 0.3. No subsidence reduction factors were applied to the predictions due to the presence of any thick or massive strata units.

Predictions were made at points on a regular grid orientated north-south and east-west across the Study Area. A grid spacing of 10 metres in each direction was adopted, which provides sufficient resolution for the generation of systematic subsidence, tilt and strain contours.

Two separate subsidence models were combined to predict the systematic subsidence parameters for the proposed longwalls. The first model predicted the systematic subsidence parameters resulting from the extraction of the bottom coal and a second model predicted the systematic subsidence parameters resulting from the recovery of the top coal.

The subsidence models use the mining geometry, surface level contours, seam floor contours and seam thickness contours to make predictions across the Study Area. The surface level, seam floor and seam thickness contours were provided by Austar and are shown in Drawings Nos. MSEC309-02, MSEC309-03 and MSEC309-04, respectively.

The bottom coal subsidence model adopted longwall void widths of 227 metres, chain pillar widths of 45 metres and an extraction height of 3 metres. The top coal subsidence model adopted longwall void widths of 203 metres, effective chain pillar widths of 45 metres and an extraction height varying between 1.0 and 4.0 metres, of which only 85 % of the top coal is recovered.

Although the overall extraction height varies up to 7.0 metres, the height of the chain pillars are 3.3 metres, giving a slenderness (height-to-width) ratio of 1 in 14, which is within the range of the empirical database. If the strata is capable of spanning the extracted goafs with minimal sag subsidence then, based on a pillar height of 3.3 metres, the maximum achievable subsidence due to pillar squashing alone would be in the order of 50 % of the extracted seam thickness (ie: 3.3 metre pillar / 7.0 metre extraction height).

The maximum equivalent extraction height of 6.4 metres (ie: 3 metres of bottom coal plus 85 % of 4.0 metres of top coal) is greater than the extraction heights for the cases within the empirical database, which includes extraction heights up to 5 metres. As the maximum proposed equivalent extraction height is slightly greater than those within the empirical database, the relationship between chain pillar squashing and goafing may be different to the cases within the empirical database.

An additional subsidence factor has, therefore, been applied to the top coal subsidence model which increases the maximum predicted incremental subsidence to that which is achieved for the extraction of the full void width of 227 metres. A summary of the subsidence factors for the top coal subsidence model are provided in Table 3.1.

Table 3.1 Additional Subsidence Factors for the Top Coal Subsidence Model

Subsidence Model	Longwall	Additional Subsidence Factor
Top Coal Caving	LWA6	1.6
	LWA7	1.5
	LWA8 to LW17	1.2

The predicted systematic subsidence parameters for the proposed longwalls are the addition of the parameters obtained from the bottom coal subsidence model and the top coal subsidence model.

It has been recognised that the maximum equivalent extraction height for the proposed longwalls is greater than those in the empirical database and greater than those for the previously extracted longwalls at the Colliery. A conservative upperbound case has also been assessed in this report for risk management purposes and is described in the following section.

3.6. Predicted Upperbound Case for the Proposed Longwalls

The thickness of the Greta Seam at the proposed longwalls varies between a minimum of 4.0 metres, at the commencing (eastern) ends of the proposed Longwalls A11 to A17 and a maximum of 7.0 metres, near the commencing (northern) end of the proposed Longwall A6. It should be noted, that it is intended that the LTCC equipment will mine the bottom 3 metres of the seam and recover only about 85 % of the top coal in the seam.

The maximum predicted total subsidence occurs adjacent to the maingate of Longwall A14, after the completion of Longwall A17. The seam thickness at the location of maximum predicted total subsidence is 6.0 metres, of which, only 85 % of the top coal is recovered. The equivalent extracted seam thickness at the location of maximum predicted total subsidence is, therefore, 5.55 metres (ie: 3 metres of bottom coal plus 85 % of 3 metres of top coal).

The empirical database for the Incremental Profile Method has 13 cases where the extracted seam height is greater than 4 metres, which includes one case where the extracted seam height was 4.8 metres, which occurred at West Wallsend Colliery, and another case where the extracted seam height was 5.0 metres, which occurred at Mandalong Colliery. It should also be noted that the extracted seam heights for the previously extracted longwalls at the Colliery, which were used to calibrate the Incremental Profile Method, varied between 3.1 metres and 3.5 metres.

It has been recognised, therefore, that the maximum equivalent extraction heights for the proposed Austar Longwalls A6 to A17 are greater than those in the empirical database and greater than those at the previously extracted longwalls at the Colliery. For this reason, a second and more conservative prediction case has also been assessed for the proposed longwalls.

The conservative prediction case, referred to as the *Upperbound Case* in the remainder of this report, has been undertaken assuming that the maximum possible total subsidence is achieved above the proposed longwalls. The maximum possible total subsidence at the surface resulting from longwall mining is less than the extracted seam thickness, due to the formation of voids within the collapsed zone, dilation between spanning strata within the fractured zone, and the presence of the chain pillars.

The maximum observed subsidence at various Collieries within the New South Wales Coalfields are shown as the points in Fig. 3.5. All the points above 65 % seam thickness are for multi-seam extraction cases, where the re-activation of overlying goafs result in subsidence of up to 78 % of seam thickness. The multi-seam extraction cases are not relevant to the proposed Austar Longwalls A6 to A17, which are single-seam extractions. All the points below 65 % seam thickness are for single-seam extractions, which are relevant to the proposed Austar Longwalls A6 to A17.

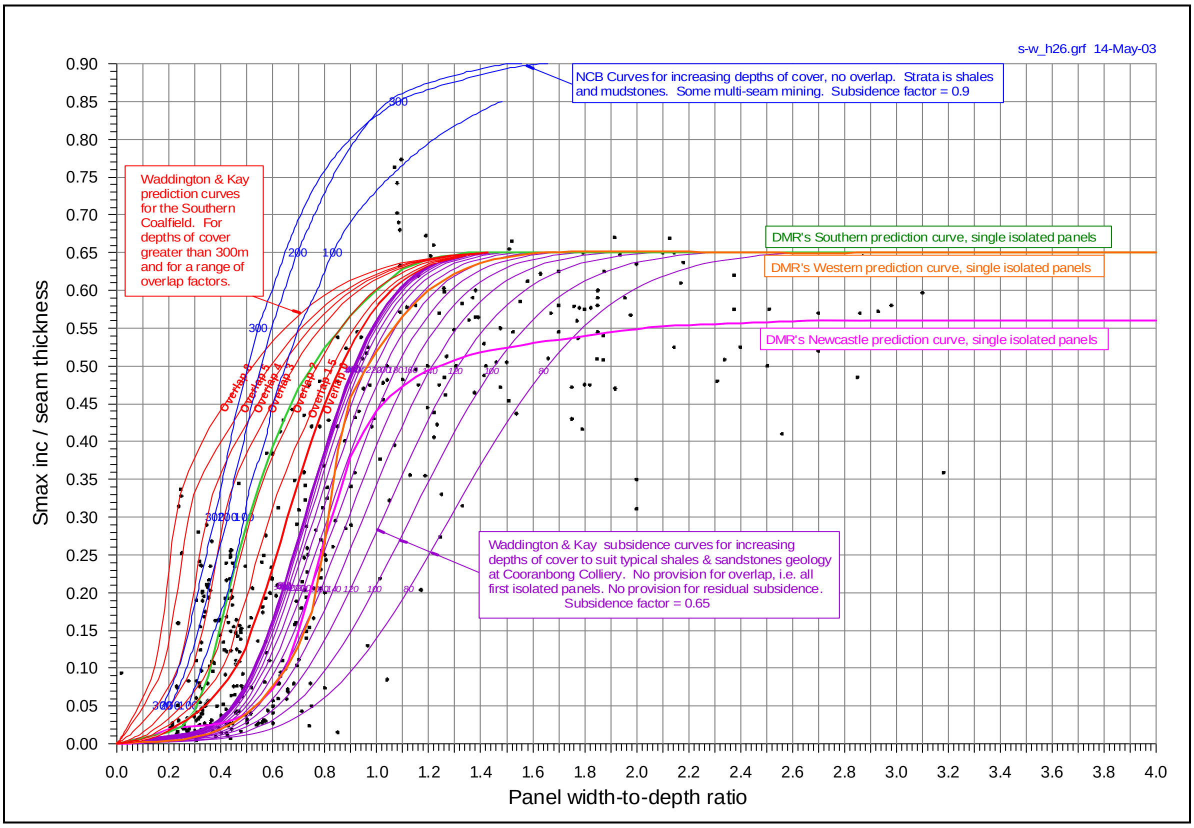

Fig. 3.5 Maximum Observed Subsidence in the New South Wales Coalfields

The blue lines in the above figure are the National Coal Board prediction curves including multi-seam extraction cases and, therefore, are not relevant to the proposed Austar Longwalls A6 to A17, which are single-seam extractions.

The thick green and red lines are the Department's prediction curves for the Southern and Western Coalfields, which have a maximum subsidence of 65 % of seam thickness for supercritical conditions. The thick magenta line is the Department's prediction curve for the Newcastle Coalfield, which has a maximum subsidence of 58 % of seam thickness for supercritical conditions. The thin red and purple lines are the prediction curves used by the Incremental Profile Method for the Southern and Newcastle Coalfields, which have a maximum subsidence of 65 % of seam thickness for supercritical conditions.

The Department's methods for the Southern and Western Coalfields and the Incremental Profile Method prediction curves all have a maximum subsidence of 65 % of seam thickness for supercritical conditions. The Upperbound Case has, therefore, been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of the effective extracted seam thickness is achieved above the proposed longwalls.

It is noted, that this provides some additional conservatism, as the maximum observed subsidence in the Newcastle Coalfield is typically 55 to 60 % of the extracted seam thickness. Also, as described previously, if the strata is capable of spanning the goaf with minimal sag subsidence, the maximum achievable subsidence due to pillar squashing alone would be in the order of 50 % of the extracted seam thickness (ie: 3.3 m pillars / 7.0 m extraction height).

The effective extracted seam thickness is taken as the overall void area (ie: volume of the extracted coal), divided by the overall width of extraction. A cross-section through three of the proposed longwalls is shown in Fig. 3.6.

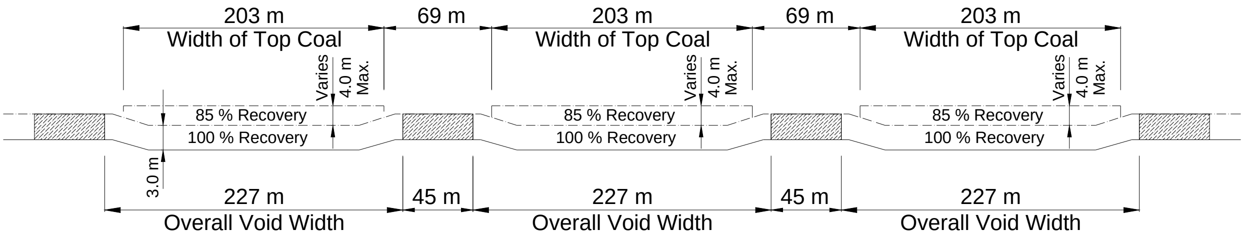

Fig. 3.6 Part Cross-section through Proposed Longwalls A7 to A17

The effective extracted seam thickness is, therefore, calculated as follows:-

$$T_{eff} = \frac{100\% \times T_{BC} \times 227m + 85\% \times T_{TC} \times 203m}{227m + 45m}$$

where T_{BC} = 3.0 metres (Thickness of bottom coal)
T_{TC} = 1.0 ~ 4.0 metres (Thickness of top coal)

Using the above equation, the effective extracted seam thickness above the proposed longwalls varies between a minimum of 3.2 metres, at the commencing (eastern) ends of proposed Longwalls A11 to A17, and a maximum of 5.0 metres, near the finishing (northern) end of proposed Longwall A6. The Upperbound Case has been determined by scaling up the predicted systematic subsidence parameters, such that a maximum subsidence of 65 % of effective extracted seam thickness is achieved above the proposed longwalls.

Predictions and impact assessments for the natural features and items of infrastructure have been made in this report for both the Predicted and the Upperbound Cases. Based on all the observed monitoring data within the New South Wales Coalfields, it is unlikely that the maximum total upperbound subsidence of 65 % of effective extracted seam thickness would be exceeded for the proposed longwalls.

The potential for impacts on natural features and items of infrastructure are dependent on the magnitudes of the subsidence parameters, which are typically defined by the parameters of subsidence, tilt, curvature and strain, and do not depend on whether these result from LTCC or conventional longwall mining. The impact assessments have, therefore, been undertaken using the same methods that are used for conventional longwall mining in the Coalfields of New South Wales.

CHAPTER 4. MAXIMUM PREDICTED AND UPPERBOUND SYSTEMATIC SUBSIDENCE PARAMETERS FOR THE PROPOSED LONGWALLS

4.1. Introduction

The following sections provide the maximum predicted and maximum upperbound systematic subsidence parameters resulting from the extraction of the proposed Austar Longwalls A6 to A17. The predicted and upperbound subsidence parameters and the impact assessments for the natural features and items of surface infrastructure are provided in Chapter 5.

The maximum predicted and maximum upperbound subsidence parameters, and the predicted and upperbound subsidence contours provided in this report show the systematic movements, and do not include the valley related upsidence and closure movements, or the effects of faults and other geological structures. Such effects have been addressed separately in the impact assessments for each feature provided in Sections 5.2 to 5.21 and in Section 5.22.

4.2. Maximum Predicted Systematic Subsidence Parameters for the Proposed Longwalls

The maximum predicted systematic subsidence parameters resulting from the extraction of the proposed longwalls were determined using the calibrated Incremental Profile Method, as described in Sections 3.4 and 3.5. The predicted cumulative and total systematic subsidence contours, after the extraction of the proposed longwalls, are shown in Drawings Nos. MSEC309-23 and MSEC309-24 in Appendix J.

A summary of the maximum predicted incremental systematic subsidence parameters, due to the extraction of each of the proposed longwalls, is provided in Table 4.1. A summary of the maximum predicted cumulative systematic subsidence parameters, after the extraction of each of the proposed longwalls, is provided in Table 4.2. A summary of the maximum predicted travelling tilts and strains, during the extraction of each of the proposed longwalls, is provided in Table 4.3.

Table 4.1 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Predicted Incremental Subsidence (mm)	Maximum Predicted Incremental Tilt (mm/m)	Maximum Predicted Incremental Tensile Strain (mm/m)	Maximum Predicted Incremental Compressive Strain (mm/m)
LWA6	250	1.1	0.1	0.4
LWA7	465	2.4	0.4	0.7
LWA8	1090	5.6	0.8	1.7
LWA9	1085	5.1	0.8	1.6
LWA10	1060	5.0	0.7	1.4
LWA11	1045	4.8	0.6	1.3
LWA12	1040	4.8	0.6	1.1
LWA13	1040	4.8	0.6	1.1
LWA14	1070	4.9	0.6	1.2
LWA15	1105	5.1	0.6	1.2
LWA16	1135	5.2	0.6	1.3
LWA17	1140	5.3	0.6	1.3

Table 4.2 Maximum Predicted Cumulative Systematic Subsidence Parameters after the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LWA6	260	1.1	0.1	0.4
After LWA7	465	2.4	0.4	0.7
After LWA8	1370	5.8	0.7	1.7
After LWA9	1655	6.2	0.7	1.8
After LWA10	1775	6.6	0.8	1.8
After LWA11	1870	6.7	0.8	1.8
After LWA12	1915	6.7	0.8	1.8
After LWA13	1920	6.7	0.8	1.8
After LWA14	1920	6.7	0.8	1.8
After LWA15	1920	6.7	0.8	1.8
After LWA16	1920	6.7	0.8	1.8
After LWA17	1925	6.7	0.8	1.8

Table 4.3 Maximum Predicted Travelling Subsidence Parameters during the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
During LWA6	0.8	0.1	0.1
During LWA7	1.7	0.3	0.2
During LWA8	3.8	0.6	0.4
During LWA9	3.3	0.4	0.3
During LWA10	3.2	0.4	0.3
During LWA11	3.1	0.4	0.3
During LWA12	3.0	0.4	0.3
During LWA13	3.0	0.4	0.3
During LWA14	2.9	0.3	0.3
During LWA15	3.0	0.3	0.3
During LWA16	3.1	0.4	0.3
During LWA17	3.1	0.4	0.3

The maximum predicted incremental systematic tilt of 5.6 mm/m (ie: 0.6 %) represents a change in grade of 1 in 180. The maximum predicted cumulative systematic tilt of 6.7 mm/m (ie: 0.7 %) represents a change in grade of 1 in 150. The maximum predicted travelling tilt of 3.8 mm/m (ie: 0.4 %) represents a change in grade of 1 in 265.

The minimum radii of curvature associated with the maximum predicted incremental systematic tensile and compressive strains of 0.8 mm/m and 1.7 mm/m are 19 kilometres and 8.8 kilometres, respectively. The minimum radii of curvature associated with the maximum predicted cumulative systematic tensile and compressive strains of 0.8 mm/m and 1.8 mm/m are 19 kilometres and 8.3 kilometres, respectively. The minimum radii of curvature associated with the maximum predicted travelling tensile and compressive strains of 0.6 mm/m and 0.4 mm/m are 25 kilometres and 38 kilometres, respectively.

4.3. Maximum Upperbound Systematic Subsidence Parameters for the Proposed Longwalls

The upperbound systematic subsidence parameters resulting from the extraction of the proposed longwalls were determined by scaling up the predicted systematic subsidence parameters, such that a maximum subsidence of 65 % of effective extracted seam thickness was achieved above the proposed longwalls, as described in Section 3.6. The upperbound cumulative and total systematic subsidence contours, after the extraction of the proposed longwall, are shown in Drawings Nos. MSEC309-25 and MSEC309-26 in Appendix J.

A summary of the maximum upperbound incremental systematic subsidence parameters, due to the extraction of each of the proposed longwalls, is provided in Table 4.4. A summary of the maximum upperbound cumulative systematic subsidence parameters, after the extraction of each of the proposed longwalls, is provided in Table 4.5. A summary of the maximum upperbound travelling tilts and strains, during the extraction of each of the proposed longwalls, is provided in Table 4.6.

Table 4.4 Maximum Upperbound Incremental Systematic Subsidence Parameters due to the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Upperbound Incremental Subsidence (mm)	Maximum Upperbound Incremental Tilt (mm/m)	Maximum Upperbound Incremental Tensile Strain (mm/m)	Maximum Upperbound Incremental Compressive Strain (mm/m)
LWA6	405	1.8	0.2	0.5
LWA7	760	3.9	0.6	0.9
LWA8	1685	8.4	1.2	2.7
LWA9	1635	7.5	1.4	2.5
LWA10	1575	7.2	1.2	2.2
LWA11	1535	6.9	1.1	2.0
LWA12	1505	6.8	1.0	1.9
LWA13	1485	6.7	0.9	1.9
LWA14	1505	6.8	0.9	1.9
LWA15	1535	7.0	0.9	2.0
LWA16	1560	7.1	0.9	2.0
LWA17	1560	7.2	0.9	2.1

Table 4.5 Maximum Upperbound Cumulative Systematic Subsidence Parameters after the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Upperbound Cumulative Subsidence (mm)	Maximum Upperbound Cumulative Tilt (mm/m)	Maximum Upperbound Cumulative Tensile Strain (mm/m)	Maximum Upperbound Cumulative Compressive Strain (mm/m)
After LWA6	425	1.9	0.2	0.5
After LWA7	760	3.9	0.6	0.9
After LWA8	2190	9.2	1.1	2.7
After LWA9	2640	9.5	1.1	3.1
After LWA10	2825	10	1.1	3.0
After LWA11	2960	10	1.2	3.0
After LWA12	3025	10	1.2	3.0
After LWA13	3040	10	1.2	3.0
After LWA14	3040	10	1.2	3.0
After LWA15	3040	10	1.2	3.0
After LWA16	3040	10	1.2	3.0
After LWA17	3040	10	1.2	3.0

Table 4.6 Maximum Upperbound Travelling Subsidence Parameters during the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Upperbound Travelling Tilt (mm/m)	Maximum Upperbound Travelling Tensile Strain (mm/m)	Maximum Upperbound Travelling Compressive Strain (mm/m)
During LWA6	1.2	0.2	0.1
During LWA7	2.8	0.4	0.3
During LWA8	5.8	0.9	0.6
During LWA9	5.0	0.7	0.5
During LWA10	4.7	0.6	0.4
During LWA11	4.5	0.6	0.4
During LWA12	4.4	0.5	0.4
During LWA13	4.2	0.5	0.4
During LWA14	4.1	0.5	0.4
During LWA15	4.2	0.5	0.4
During LWA16	4.3	0.5	0.4
During LWA17	4.3	0.5	0.4

The maximum upperbound incremental systematic tilt of 8.4 mm/m (ie: 0.8 %) represents a change in grade of 1 in 120. The maximum upperbound cumulative systematic tilt of 10 mm/m (ie: 1.0 %) represents a change in grade of 1 in 100. The maximum upperbound travelling tilt of 5.8 mm/m (ie: 0.6 %) represents a change in grade of 1 in 170.

The minimum radii of curvature associated with the maximum upperbound incremental systematic tensile and compressive strains of 1.4 mm/m and 2.7 mm/m are 11 kilometres and 5.6 kilometres, respectively. The minimum radii of curvature associated with the maximum upperbound cumulative systematic tensile and compressive strains of 1.2 mm/m and 3.1 mm/m are 13 kilometres and 4.8 kilometres, respectively. The minimum radii of curvature associated with the maximum upperbound travelling tensile and compressive strains of 0.9 mm/m and 0.6 mm/m, are 17 kilometres and 25 kilometres, respectively.

4.4. Predicted and Upperbound Systematic Subsidence Parameters along the Prediction Lines

The predicted and upperbound systematic subsidence parameters were determined along two prediction lines. Prediction Line A crosses transversely through proposed Longwall A6 and Prediction Line B crosses transversely through proposed Longwalls A8 to A17. The locations of the prediction lines are shown in Drawing No. MSEC309-22.

The profiles of predicted incremental and cumulative systematic subsidence, tilt and strain along Prediction Lines A and B, at the completion of each of the proposed longwalls, are shown in Figs. H.01 and H.02, respectively, in Appendix H. A summary of the maximum predicted incremental and total systematic subsidence parameters along Prediction Line A, due to the extraction of Longwall A6, is provided in Table 4.7. A summary of the maximum predicted cumulative systematic subsidence parameters along Prediction Line B, after the extraction of each of the proposed longwalls, is provided in Table 4.8

Table 4.7 Maximum Predicted Incremental and Total Systematic Subsidence Parameters along Prediction Line A due to the Extraction of Longwall A6

Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Tensile Strain (mm/m)	Maximum Predicted Compressive Strain (mm/m)
Incremental Systematic Subsidence Parameters due to Longwall A6	240	0.8	< 0.1	0.3
Total Systematic Subsidence Parameters after Longwall A6 including Stage 2 Longwalls	1015	3.8	0.4	0.3

The total values provided in the above table are the maximum predicted parameters along the prediction line within the Study Area, including the predicted movements resulting from the extraction of the Stage 2 Longwalls A3 to A5.

Table 4.8 Maximum Predicted Cumulative Systematic Subsidence Parameters along Prediction Line B after the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LWA7	< 20	< 0.1	< 0.1	< 0.1
After LWA8	220	0.7	0.1	0.3
After LWA9	1085	4.3	0.5	1.4
After LWA10	1380	5.3	0.6	1.5
After LWA11	1575	5.6	0.6	1.5
After LWA12	1675	5.7	0.6	1.5
After LWA13	1740	5.7	0.6	1.5
After LWA14	1755	5.7	0.6	1.5
After LWA15	1785	5.7	0.6	1.5
After LWA16	1860	5.7	0.6	1.5
After LWA17	1925	6.0	0.7	1.5

The profiles of upperbound incremental and cumulative systematic subsidence, tilt and strain along Prediction Lines A and B, at the completion of each of the proposed longwalls, are shown in Figs. I.01 and I.02, respectively, in Appendix I. A summary of the maximum upperbound incremental and total systematic subsidence parameters along Prediction Line A, due to the extraction of Longwall A6, is provided in Table 4.9. A summary of the maximum upperbound cumulative systematic subsidence parameters along Prediction Line B, after the extraction of each of the proposed longwalls, is provided in Table 4.10.

Table 4.9 Maximum Upperbound Incremental and Total Systematic Subsidence Parameters along Prediction Line A due to the Extraction of Longwall A6

Longwall	Maximum Upperbound Subsidence (mm)	Maximum Upperbound Tilt (mm/m)	Maximum Upperbound Tensile Strain (mm/m)	Maximum Upperbound Compressive Strain (mm/m)
Incremental Systematic Subsidence Parameters due to Longwall A6	390	1.2	0.1	0.5
Total Systematic Subsidence Parameters after Longwall A6 including Stage 2 Longwalls	2130	7.8	0.9	0.5

Table 4.10 Maximum Upperbound Cumulative Systematic Subsidence Parameters along Prediction Line B after the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Upperbound Cumulative Subsidence (mm)	Maximum Upperbound Cumulative Tilt (mm/m)	Maximum Upperbound Cumulative Tensile Strain (mm/m)	Maximum Upperbound Cumulative Compressive Strain (mm/m)
After LWA7	< 20	< 0.1	< 0.1	< 0.1
After LWA8	350	1.1	0.1	0.4
After LWA9	1670	6.4	0.7	2.2
After LWA10	2140	8.0	0.8	2.6
After LWA11	2460	8.5	0.8	2.5
After LWA12	2605	8.6	0.9	2.5
After LWA13	2705	8.6	0.9	2.5
After LWA14	2735	8.6	0.9	2.5
After LWA15	2745	8.6	0.9	2.5
After LWA16	2775	8.6	0.9	2.5
After LWA17	2835	8.6	0.9	2.5

4.5. Comparison between Predicted and Observed Subsidence Profiles for Austar Longwalls A1 and A2

The subsidence movements resulting from the extraction of Austar Longwalls A1 and A2 were monitored along a number of survey lines, including Line 1A, Line 1B and Line 2. The locations of Longwalls A1 and A2 and the monitoring lines are shown in Drawing No. MSEC309-01 in Appendix J.

The predicted subsidence contours resulting from the extraction of Austar Longwalls A1 and A2 were determined using the calibrated Incremental Profile Method, which was described in Section 3.4. Comparisons between the predicted and observed subsidence movements along the monitoring lines are provided below.

4.5.1. Line 1A

The predicted and observed profiles of subsidence, tilt and strain along Line 1A are shown in Fig. F.10 in Appendix F. It is noted that, at the time of the latest survey on the 28th July 2008, the extraction face of Longwall A2 had only just passed beyond Line 1A and, therefore, the maximum subsidence resulting from the extraction of Longwall A2 had not fully developed at this monitoring line.

The maximum observed subsidence after the extraction of Longwall A1 of 96 mm is similar to but slightly less than the maximum predicted subsidence of 110 mm. The maximum observed subsidence during the extraction of Longwall A2, measured in the latest survey on the 28th July 2008, of 272 mm is less than the maximum predicted subsidence of 1285 mm at the completion of mining. It is noted, as described above, that the maximum subsidence resulting from the extraction of Longwall A2 had not fully developed at Line 1A in the latest survey.

It is difficult making comparisons between the shapes of the observed and predicted subsidence profiles, as the maximum observed subsidence after Longwall A1 is less than 100 mm and the maximum observed subsidence during the extraction of Longwall A2, during the latest survey, had not fully developed.

There is a scatter in the observed strain profile in the order of ±0.3 to ±0.5 mm/m. It is difficult making comparisons between the observed and predicted strains profiles along Line 1A, as the observed strains are typically in the order of the scatter in the strain profile directly above Longwalls A1 and A2.

4.5.2. Line 1B

The predicted and observed profiles of subsidence, tilt and strain along Line 1B are shown in Fig. F.11 in Appendix F. It is noted that, at the time of the latest survey on the 24th July 2008, the extraction face of Longwall A2 had passed beyond Line 1B by a minimum distance of 480 metres and, therefore, it is expected that at approximately 90 % of the final subsidence resulting from the extraction of Longwall A2 had developed at Line 1B.

The maximum observed subsidence after the extraction of Longwall A1 of 101 mm is similar to but less than the maximum predicted subsidence of 145 mm. The maximum observed subsidence during the extraction of Longwall A2, measured on the 24th July 2008, of 744 mm is less than the maximum predicted of 1370 mm. It is noted, that that some residual subsidence is expected to occur along Line 1B, in the order of 10 % of the maximum subsidence in the latest survey.

It can be seen from Fig. F.11, that the shape of the observed subsidence profile, after the extraction of Longwall A2, reasonably matches that predicted, taking into account the differences between the maximum observed and maximum predicted subsidence.

The maximum observed compressive strain in the latest survey of 1.7 mm/m is similar to but slightly less than the maximum predicted compressive strain of 1.8 mm/m. The maximum observed tensile strain of 2.8 mm/m is greater than the maximum predicted tensile strain of 1.3 mm/m. It is noted, however, that the maximum observed tensile strain occurs between Marks 166 and 117, which are located at the top of the ridgeline and, therefore, the horizontal movements measured in this bay could include some downslope movements.

4.5.3. Line 2

The predicted and observed profiles of subsidence, tilt and strain along Line 2 are shown in Fig. F.12 in Appendix F. It is noted that, at the time of the latest survey on the 24th July 2008, the extraction face of Longwall A2 had passed beyond the end of Line 2 (ie: Mark 201) by a distance of 220 metres and, therefore, the final subsidence had not fully developed at this end of the survey line.

The maximum observed subsidence after the extraction of Longwall A1 of 75 mm is similar to but slightly greater than the maximum predicted subsidence of 60 mm. The maximum observed subsidence during the extraction of Longwall A2, measured on the 24th July 2008, of 741 mm is less than the maximum predicted of 1255 mm. It is noted, that that some residual subsidence is expected to occur along Line 2, in the order of 10 % of the maximum subsidence in the latest survey.

It can be seen from Fig. F.12, that the slope of the observed subsidence profile, after the extraction of Longwall A2, reasonably matches the predicted slope near the commencing end of this longwall. There is, however, a lateral shift of approximately 100 metres between the observed and predicted subsidence profiles. It is possible that the lateral shift is the result of the changes in surface topography, or a result of massive strata units spanning between the chain pillar and the commencing ends of the extracted longwalls.

The maximum observed compressive strain in the latest survey of 1.3 mm/m is greater than the maximum predicted compressive strain of 1.0 mm/m. It is noted, that the maximum observed compressive strain occurs between Marks 237 and 238, which are located 175 metres outside the extracted goaf area and could, therefore, be the result of a bumped survey mark or an irregular subsidence movement. The maximum observed tensile strain of 1.1 mm/m is similar to but less than the maximum predicted tensile strain of 1.3 mm/m.

4.6. Comparison of Predicted Subsidence Parameters Obtained using the Holla Series and Department's Handbook Methods

For comparison, the maximum predicted systematic subsidence parameters along Prediction Line B were also determined using the Holla Series Method (Holla 1988) and the Department's Handbook Method (DMR 1987). These methods only allow for the prediction of the maximum values of systematic subsidence, tilt, curvature and strain, and do not precisely indicate where these maxima will occur.

It should be noted that the proposed extraction heights for the proposed longwalls are greater than those on which the Holla Series and Department's Handbook Methods were based. It should also be noted that the Holla Series Method was based on observed subsidence monitoring data from the Southern Coalfield only. Dr. Holla advised verbally, however, that this method could be applied to the Newcastle Coalfield, and that the method would over predict subsidence in the Newcastle Coalfield. The predicted systematic subsidence parameters obtained using these methods, therefore, can only be used as a general comparison.

The overall void widths of the proposed Longwalls A8 to A17 are 227 metres and the chain pillar widths are 45 metres. Along Prediction Line B, the depth of cover varies between 520 metres and 670 metres, with an average depth of cover of approximately 590 metres. Along Prediction Line B, the overall seam thickness varies between 5.75 metres and 6.15 metres, with an average overall seam thickness of approximately 5.8 metres. The effective extracted seam thickness, based on 85 % recovery of the top coal, is 5.4 metres (ie: 3 metres of bottom coal plus 85 % of 2.8 metres of top coal).

The maximum predicted subsidence using the Holla Series Method (Holla 1988) is determined from Fig. 4 of a published paper which has been reproduced in Fig. 4.1. This figure provides the maximum predicted subsidence, as a ratio of the extracted seam thickness, for varying panel width-to-depth ratios and varying pillar width-to-depth ratios, based on critical extraction conditions.

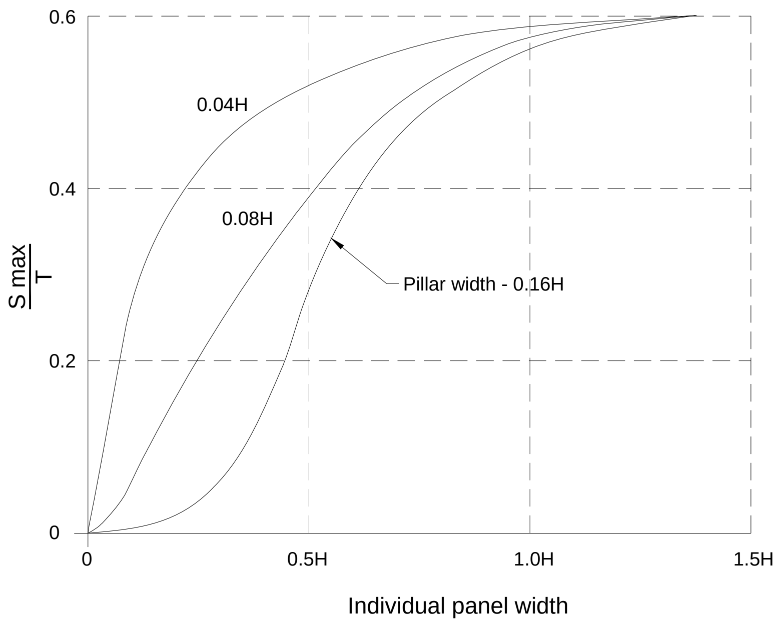

Fig. 4.1 Graph for the Prediction of Maximum Subsidence over a Series of Panels for Critical Extraction Conditions (after Holla, 1988)

Based on an individual panel width-to-depth ratio of 0.38 (ie: 227 metres / 590 metres) and a chain pillar width-to-depth ratio of 0.076 (ie: 45 metres / 590 metres), the maximum predicted total subsidence obtained using Fig. 4.1 is 0.34 times the effective extracted seam thickness, giving a maximum total subsidence of 1800 mm.

The systematic tilts and strains can be predicted using the Department's Handbook Method (DMR 1987) and are obtained by multiplying various factors by the maximum subsidence in millimetres and dividing the result by the depth of cover in metres. The factors for tensile strain, compressive strain and tilt are given in Figs. 10, 11 and 13 of the handbook. The curvatures are determined from the strains using the graph in Fig. 14 of the handbook.

For equivalent panel width-to-depth ratios above 1.4, i.e. for critical extraction conditions, the factors are 0.4 for tensile strain, 0.6 for compressive strain and 1.8 for tilt. In the original handbook, these factors were only applicable to single panels, but Dr. Holla verbally advised that the Department's Method can be used to determine the tilts and strains over a series of longwall panels, using the overall width of the series in calculating the width-to-depth ratio.

The tilts and strains have been determined for critical extraction conditions, ie: adopting an overall panel width-to-depth ratio of greater than 1.4, using the Department's Handbook Method. The maximum predicted systematic tilt, tensile strain, and compressive strain are 5.5 mm/m, 1.2 mm/m, and 1.8 mm/m, respectively.

A comparison between the predicted total systematic subsidence parameters obtained using the Holla Series and Department's Handbook Methods and the Incremental Profile Method is provided in Table 4.11.

Table 4.11 Comparison of Maximum Predicted Parameters Obtained using Alternative Methods

Predicted Parameter	Holla Series and Department's Handbook Methods	Incremental Profile Method (Predicted)	Incremental Profile Method (Upperbound)
Subsidence (mm)	1800	1925	2835
Tilt (mm/m)	5.5	6.0	8.6
Hogging Curvature (1/km)	0.10	0.05	0.06
Sagging Curvature (1/km)	0.14	0.10	0.17
Tensile Strain (mm/m)	1.2	0.7	0.9
Compressive Strain (mm/m)	1.8	1.5	2.5

It can be seen from the above table that the maximum predicted subsidence and tilt obtained using the Holla Series and Department's Handbook Methods are less than those obtained using the Incremental Profile Method, for both the predicted and upperbound cases.

The maximum predicted tensile strain obtained using the Holla Series and Department's Handbook Methods is greater than that obtained using the Incremental Profile Method, for both the predicted and upperbound cases. The maximum predicted compressive strain obtained using the Holla Series and Department's Handbook Methods is greater than that obtained using the Incremental Profile Method, for the predicted case, and is less than that obtained by the Incremental Profile Method, for the upperbound case.

4.7. Estimation of the Reliability of the Systematic Subsidence Predictions

As described in Section 3.4.1, the Incremental Profile Method has been calibrated to local conditions using the monitoring data above the previously extracted longwalls at the Colliery, prior to Austar Longwalls A1 and A2. It was found that the shapes of the back-predicted incremental subsidence profiles could be made to more closely match the shapes of the observed incremental subsidence profiles by adopting the standard Newcastle Coalfield subsidence profiles based on a panel width-to-depth ratio of 0.3, rather than adopting the actual panel width-to-depth ratios, which varied between 0.38 and 0.65.

No modifications were made to the magnitudes of the maximum back-predicted incremental subsidence in the comparisons for the previously extracted longwall at the Colliery. It was found that the maximum observed incremental subsidence was generally between 45 % and 100 % of the maximum back-predicted incremental subsidence. In no case did the maximum observed incremental subsidence or maximum observed total subsidence exceed the maximum back-predicted incremental subsidence or the maximum back-predicted total subsidence, respectively.

As described in Section 4.5, the maximum observed subsidence resulting from the extraction of Austar Longwalls A1 and A2 were less than those predicted using the Incremental Profile Method. It is noted, that the extraction face of Longwall A2 had only pass beneath monitoring Lines 1A and 2 and, therefore, some additional residual subsidence is expected to occur along these lines.

Also, as described in Section 4.6, the maximum predicted subsidence for the proposed Longwalls A7 to A17, obtained using the Departments Method, is less than that predicted using the Incremental Profile Method. It is noted, that although the maximum predicted strain obtained using the Departments Method is greater than that predicted using the Incremental Profile Method, it is less than the maximum predicted strain obtained using the Incremental Profile Method for the Upperbound Case.

The calibrated Incremental Profile Method should, therefore, provide realistic, if not conservative predictions where the longwall and mining geometries are within the range of the empirical database. It has been recognised, however, that the extraction heights for the proposed longwalls are greater than those in the empirical database, and greater than those at the previously extracted longwalls at the Colliery.

Predictions and impact assessments for a conservative upperbound case have, therefore, been undertaken which assumed that a maximum total subsidence of 65 % of effective extracted seam thickness is achieved above the proposed longwalls, as described in Section 3.6. Based on all the monitoring data throughout the Coalfields of New South Wales, it is unlikely that the maximum upperbound systematic subsidence would be exceeded.

Empirical methods of subsidence prediction are generally accepted as providing predictions of maximum subsidence to an accuracy of ±10 % to ±15 %, where the longwall and mining geometries are within the ranges of the empirical databases. It was indicated by Dr Lax Holla, in his paper entitled, “Reliability of Subsidence Prediction Methods for use in Mining Decisions in New South Wales” (Holla 1991c), that the accuracy of predictions of maximum subsidence, made using the Department’s Empirical Method, generally ranged from +8 % to -11 %. Of the 14 examples, referred to in the paper, from longwalls at seven different collieries in the Southern and Newcastle Coalfields, the predicted maximum subsidence was less than the measured maximum subsidence in only four cases. Where empirical models have been calibrated to local data, even greater accuracies have been found to be possible in predicting the maximum values of the subsidence parameters.

The prediction of systematic subsidence parameters at a specific point is more difficult, however, based upon a large number of comparative analyses, it is concluded that the vertical subsidence predictions at any point, using the Incremental Profile Method, should generally be accurate to within ±15 %, where the longwall and mining geometries are within the range of the empirical database, and where the model has been calibrated to local data. Where vertical subsidence is predicted at points beyond the goaf edge, which are likely to experience very low values of subsidence, the vertical subsidence predictions should generally be accurate to within 50 mm of subsidence.

The systematic tilts can be predicted to a similar level of accuracy as the systematic subsidence. It has been found, however, that variations between predicted and observed tilts at a point can occur where there is a lateral shift between the predicted and observed subsidence profiles, which can result from seam dip or variations in topography. In these situations, the lateral shift can result in the observed tilts being greater than those predicted in some locations and less than those predicted in other locations.

It is highlighted, however, that measured strains have been found to vary considerably from those predicted at a point, not only in magnitude, but also in sign, that is measured tensile strains occur where compression is predicted, and visa versa. This variation is seen as a reflection not only of the variations in local surface geology and the difficulties in measuring small changes in distances accurately, but also the fact that strains result from both mining induced curvatures and differential horizontal movements.

Accordingly the confidence levels that we assign to subsidence and tilt predictions cannot be assigned to strain predictions. The following reasons contribute to why strain predictions cannot be made with the same degree of confidence as subsidence and tilt predictions:-

- Variations in local geology can affect the way in which the near surface rocks are displaced as subsidence occurs. In the compression zone, the surface strata can buckle upwards or can fail by shearing and sliding over their neighbours. If localised cross bedding exists within the top strata layer, then shearing can occur at relatively low values of stress. This can result in fluctuations in the local strains, which can range from tensile to compressive. In the tensile zones around mined voids, existing joints can be opened up at relatively low strain values and new fractures can be formed at random, leading to localised concentrations of tensile strain.

- Where a thick surface layer of soil, clay or rock exists, the underlying movements in the bedrock are often transferred to the surface at reduced levels and the measured strains are, therefore, more evenly distributed and hence more systematic in nature than they would be if they were measured at rockhead.
- Strain measurements can sometimes give a false impression of the state of stress in the ground. For example:-
    - buckling of the near-surface strata can result in localised cracking and apparent tensile strain in areas where overall, the ground is in fact being compressed, because the actual values of the measured strains are dependent on the locations of the survey pegs.
    - where joints open up or cracks develop in the tensile phase, it may be difficult for these joints to close up during the compressive phase, if the joints fill with soil or if shearing occurs during the movements. In these cases, the ground can appear to be in tension when, in reality, it is actually in compression.
- Sometimes, survey errors can also affect the measured strain values and these can result from movement in the benchmarks, inaccurate instrument readings, or disturbed survey pegs. In these circumstances it is not surprising that the predicted systematic strain at a point does not match the measured strain. For example, it is difficult to measure variations in baylengths more accurately than ±5 mm, especially where tripods have to be set over sunken survey marks. Over a typical baylength of 20 metres, surveying error variations of ±0.25 mm/m are commonly seen in the observed strain data.
- In sandstone dominated environments, much of the earlier ground movements can be concentrated at existing natural joints. These concentrations of strain at these pre-existing joints results in high strain values being observed at the natural joints accompanied by lower values between the joints.

It is also recognised that the ground movements above a longwall panel can be affected by the gradient of the coal seam, the direction of mining and the presence of faults and dykes above the panel, which can result in a lateral shift in the subsidence profile.

The Incremental Profile Method approach allows a more realistic assessment of the subsidence impacts than applying the maximum predicted strains at every point, which would be overly conservative and would yield an excessively overstated assessment of the potential subsidence impacts. However, because of the variability in observed strain values, the prediction of strain at a point obtained using the Incremental Profile Method should be considered within an appropriate confidence interval.

Predictions of strain at isolated features have been provided in this report for comparison purposes, so that the potentials for impact can be compared from place to place. As described above, it is possible that the actual strain at each feature could be greater or less than that predicted, or could be tensile where compression was predicted, or visa versa. It is expected, however, that the observed strains at the features will generally be within the range of the maximums predicted within the Study Area, which were provided in Sections 4.2 and 4.3.

The range of actual strains resulting from the extraction of the proposed longwalls at Austar is expected to be similar to that at Appin Colliery, where the depth of cover was approximately 500 metres and the range of predicted strains was similar to the range predicted for the proposed longwalls at Austar. The distribution of measured strains at Appin Colliery is shown in Fig. D.7 in Appendix D, which is reproduced in Fig. 4.2 below.

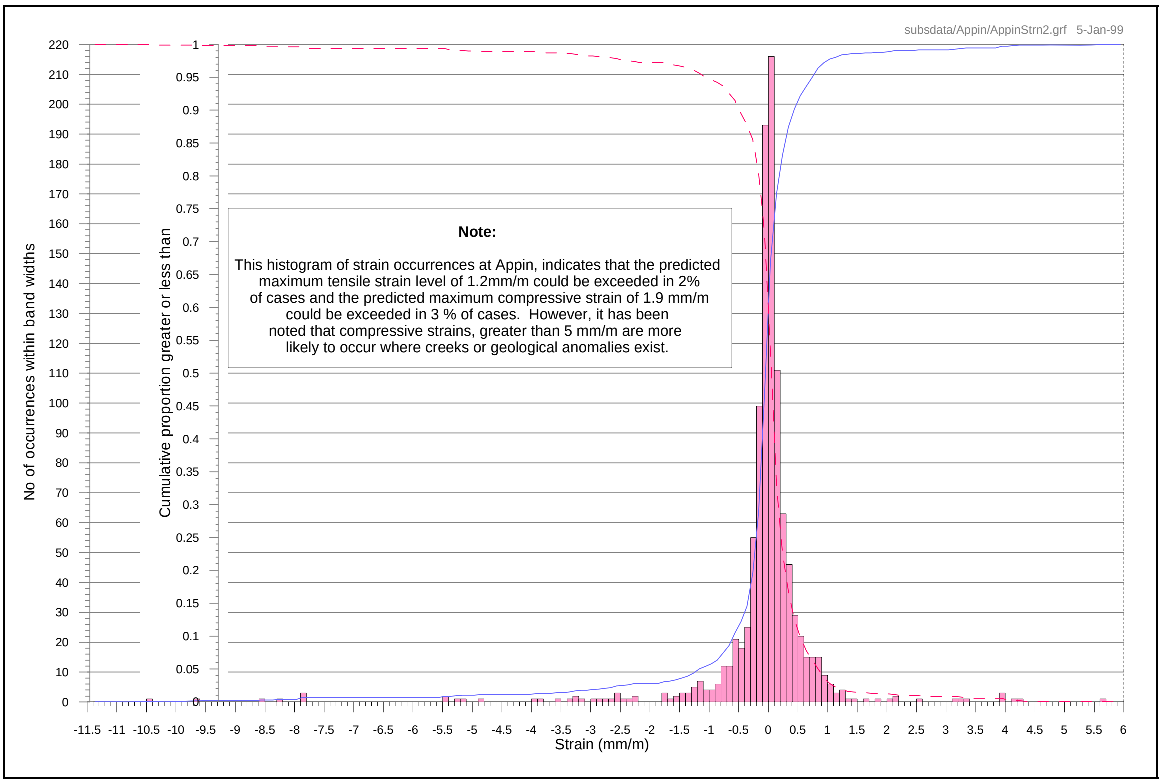

Fig. 4.2 Distribution of Measured Strains at Appin Colliery

It can be seen from this figure that the majority of the measured strains at Appin Colliery were between 1.5 mm/m tensile and 2.0 mm/m compressive, which is similar to the range of predicted systematic strains and, to a lesser extent, the upperbound systematic strains for the proposed longwalls at Austar. It can also be seen from this figure, that approximately 2 % to 3 % of the measured strains were in the range 2.0 mm/m to 5.5 mm/m, as well as a few measured strains which exceeded 5.5 mm/m, which were generally associated with creek alignments.

The distribution of measured strains at Appin Colliery is based on monitoring data across the mining areas. Outside the goaf areas, the ranges of measured strains are expected to be smaller than that shown in Fig. 4.2. Outside the limit of systematic subsidence, the measured strains are expected to be typically within survey tolerance.

The range of actual strains resulting from the extraction of the proposed longwalls at Austar, outside the goaf areas but within the limit of systematic subsidence, is expected to be similar to that observed for Tahmoor Longwall 24B, where the depth of cover was approximately 400 metres and the range of predicted strains was also similar to the range predicted for the proposed longwalls at Austar. The distribution of measured strains adjacent to Tahmoor Longwall 24B is shown in Fig. 4.3.

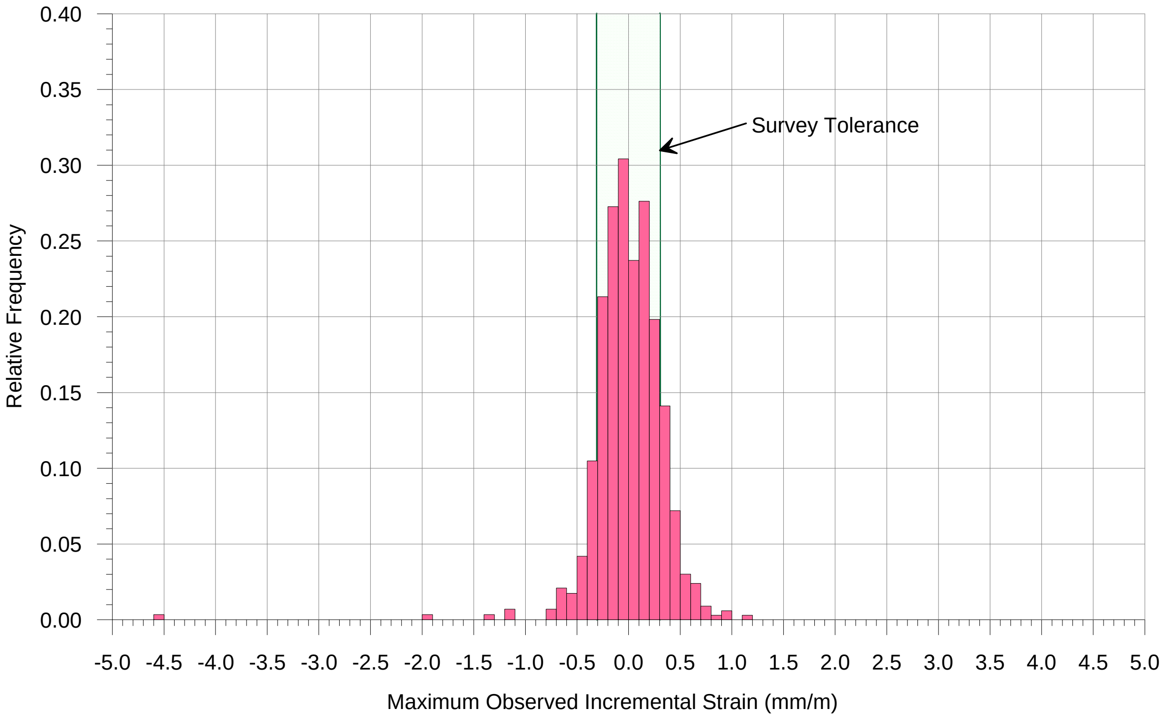

Fig. 4.3 Distribution of Measured Strains Adjacent to Tahmoor Longwall 24B

4.8. Estimation of the Reliability of Upsidence and Closure Predictions

It should be noted that the development of the predictive methods for upsidence and closure are the result of recent research and the methods do not, at this stage, have the same confidence level as systematic subsidence prediction techniques. As further case histories are studied, the method is being improved, but it can be used in the meantime, so long as suitable factors of safety are applied. This is particularly important where the predicted levels of movement are small, and the potential errors, expressed as percentages, can be higher.

Whilst the major factors that determine the levels of movement have been identified, there are some factors that are difficult to isolate. One factor that is thought to influence the upsidence and closure movements is the level of in situ horizontal stress that exists within the strata. In situ stresses are difficult to obtain and not regularly measured, and the limited availability of data makes it difficult to be definitive about the influence of the in situ stress on the upsidence and closure movements. The methods are, however, based predominantly upon the measured data from Tower Colliery, where the in situ stresses are high. The methods will, therefore, tend to over-predict the movements in areas of lower stress.

It should be noted, that the method used to predict upsidence and closure was not adjusted for any local changes in the geology within the creek and river beds. The database for upsidence and closure is mainly based on creeks and rivers which predominantly have sandstone beds. It has been observed, where creeks or rivers are founded on thinly bedded shales, that the observed closure is higher and the observed upsidence is smaller than what would be predicted using the upsidence and closure models.

CHAPTER 5. PREDICTED AND UPPERBOUND SUBSIDENCE PARAMETERS AND IMPACT ASSESSMENTS FOR THE NATURAL FEATURES AND ITEMS OF SURFACE INFRASTRUCTURE

5.1. Introduction

The following sections provide the predicted and upperbound subsidence parameters, resulting from the extraction of the proposed longwalls, for the natural features and items of surface infrastructure within the Study Area. The impact assessments have been made for each natural feature and item of surface infrastructure, based on the predicted and on the upperbound subsidence parameters. Significant natural features and items of surface infrastructure located outside the general Study Area, which may be subjected to far-field horizontal or valley related movements and may be sensitive to these movements, have also been included as part of these assessments.

In the case of isolated natural features or items of surface infrastructure, it is possible that the actual subsidence parameters may be greater or less than those predicted, depending on their position within the subsidence trough. For the purposes of this report, however, the predictions provide the best available indication of the overall subsidence parameters that are likely to be experienced by each feature.

In determining specific predictions for isolated features, an additional factor of safety has been applied by taking the maximum predicted and upperbound values of subsidence, tilt, curvature and strain within 20 metres of the perimeter of each isolated feature.

5.2. Cony and Sandy Creeks

The locations of the watercourses within the Study Area are shown in Drawing No. MSEC309-07. The predicted and upperbound subsidence parameters and the impact assessments for Cony and Sandy Creeks are provided in the following sections. The predicted and upperbound subsidence parameters and the impact assessments for the other drainage lines within the Study Area are provided in Section 5.3.

5.2.1. Predicted Systematic Subsidence and Valley Related Movements

The predicted profiles of incremental and cumulative subsidence, upsidence and closure along Cony and Sandy Creeks, after the extraction of each of the proposed longwalls, are shown in Figs. H.03 and H.04, respectively, in Appendix H. A summary of the maximum predicted values of cumulative subsidence, upsidence and closure along the creeks, after the extraction of each of the proposed longwalls, is provided in Table 5.1.

Table 5.1 Maximum Predicted Cumulative Subsidence, Upsidence and Closure along Cony and Sandy Creeks within the Study Area after the Extraction of Each of the Proposed Longwalls

Creek	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Upsidence (mm)	Maximum Predicted Cumulative Closure (mm)
Cony Creek	After LWA6	200	20	20
	After LWA12	200	45	65
	After LWA13	910	150	125
	After LWA14	1490	255	190
	After LWA15	1780	290	220
	After LWA16	1840	310	240
	After LWA17	1865	320	250
Sandy Creek	After LWA13	< 20	< 20	< 20
	After LWA14	35	< 20	< 20
	After LWA15	300	< 20	< 20
	After LWA16	1190	40	25
	After LWA17	1410	65	25

The values provided in the above table are the maximum predicted parameters along the creeks within the Study Area, including the predicted systematic and valley related movements resulting from the extraction of the Stage 2 Longwalls A3 to A5.

The profiles of equivalent valley height used to determine the predicted valley related upsidence and closure movements along the creeks are shown in Figs. H.03 and H.04. The equivalent valley height is calculated by multiplying the measured overall valley depth by a factor which reflects the shape of the valley. The overall valley height is measured after examining the terrain across the valley within a radius of half the depth of cover. The factor varies from 1.0, for steeply sided valleys in flat terrain, to less than 0.5, for valleys of flatter profile in undulating terrain. An equivalent valley height factor of 0.7 has been adopted for Cony and Sandy Creeks. This factor is consistent with the observed valley related movements along monitoring lines at a number of Collieries in the Newcastle and Hunter Coalfields.

The predicted changes in surface level along the alignments of the creeks are illustrated by the predicted net vertical movement profiles shown in Figs. H.03 and H.04, which have been determined by the addition of the subsidence and upsidence movements. A summary of the maximum predicted cumulative net vertical movements and the subsequent changes in grade along the alignments of the creeks, after the extraction of each of the proposed longwalls, is provided in Table 5.2.

Table 5.2 Maximum Predicted Cumulative Net Vertical Movements and Changes in Grade along the Alignments of Cony and Sandy Creeks after the Extraction of Each Proposed Longwall

Creek	Longwall	Maximum Predicted Cumulative Net Subsidence (mm)	Maximum Predicted Cumulative Net Uplift (mm)	Maximum Predicted Cumulative Increase in Creek Gradient (mm/m)	Maximum Predicted Cumulative Decrease in Creek Gradient (mm/m)
Cony Creek	After LWA6	+180	< -20	+0.5	-0.5
	After LWA11	+180	< -20	+0.5	-0.5
	After LWA12	+180	-25	+1.0	-0.5
	After LWA13	+780	-25	+3.0	-3.0
	After LWA14	+1445	< -20	+4.0	-5.0
	After LWA15	+1725	< -20	+5.0	-4.0
	After LWA16	+1785	< -20	+6.0	-4.5
	After LWA17	+1815	-20	+6.0	-4.5
Sandy Creek	After LWA13	< +20	< -20	< +0.1	< -0.1
	After LWA14	+30	< -20	+0.5	-0.1
	After LWA15	+280	< -20	+1.5	-1.0
	After LWA16	+1150	< -20	+5.0	-5.0
	After LWA17	+1350	< -20	+5.0	-5.0

The values provided in the above table are the maximum predicted parameters along the creeks within the Study Area, including the predicted systematic and valley related movements resulting from the extraction of the Stage 2 Longwalls A3 to A5.

A summary of the maximum predicted systematic tilt, systematic tensile strain and systematic compressive strain along Cony and Sandy Creeks, at anytime during or after the extraction of each of the proposed longwalls, is provided in Table 5.3.

Table 5.3 Maximum Predicted Systematic Tilt, Tensile Strain and Compressive Strain along Cony and Sandy Creeks during or after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Predicted Systematic Tilt (mm/m)	Maximum Predicted Systematic Tensile Strain (mm/m)	Maximum Predicted Systematic Compressive Strain (mm/m)
Cony Creek	During or After LWA6	0.5	< 0.1	0.3
	During or After LWA12	1.0	0.1	0.3
	During or After LWA13	4.0	0.5	0.3
	During or After LWA14	5.5	0.5	0.7
	During or After LWA15	4.5	0.4	0.6
	During or After LWA16	4.5	0.4	0.6
Sandy Creek	During or After LWA16	5.0	0.6	0.4
	During or After LWA17	5.5	0.6	0.4

The values provided in the above table are the maximum predicted parameters along the creeks within the Study Area, including the predicted systematic movements resulting from the extraction of the Stage 2 Longwalls A3 to A5.

5.2.2. Upperbound Systematic Subsidence and Valley Related Movements

The upperbound systematic subsidence parameters at the creeks have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as described in Section 3.6. The upperbound valley related movements at the creeks have been determined using the maximum upperbound incremental subsidence resulting from the extraction of each of the proposed longwalls.

The upperbound profiles of incremental and cumulative subsidence, upsidence and closure along Cony and Sandy Creeks, after the extraction of each of the proposed longwalls, are shown in Figs. I.03 and I.04, respectively, in Appendix I. A summary of the maximum upperbound values of cumulative subsidence, upsidence and closure along the creeks, after the extraction of each of the proposed longwalls, is provided in Table 5.4.

Table 5.4 Maximum Upperbound Cumulative Subsidence, Upsidence and Closure along Cony and Sandy Creeks within the Study Area after the Extraction of Each of the Proposed Longwalls

Creek	Longwall	Maximum Upperbound Cumulative Subsidence (mm)	Maximum Upperbound Cumulative Upsidence (mm)	Maximum Upperbound Cumulative Closure (mm)
Cony Creek	After LWA6	320	30	25
	After LWA12	320	45	65
	After LWA13	1330	155	125
	After LWA14	2140	260	195
	After LWA15	2590	295	225
	After LWA16	2680	315	245
	After LWA17	2785	325	250
Sandy Creek	After LWA13	< 20	< 20	< 20
	After LWA14	60	< 20	< 20
	After LWA15	440	< 20	< 20
	After LWA16	1675	40	25
	After LWA17	2040	65	25

The values provided in the above table are the maximum upperbound parameters along the creeks within the Study Area, including the upperbound systematic and valley related movements resulting from the extraction of the Stage 2 Longwalls A3 to A5.

The upperbound changes in surface level along the alignments of the creeks are illustrated by the upperbound net vertical movement profiles shown in Figs. I.03 and I.04, which have been determined by the addition of the subsidence and upsidence movements. A summary of the maximum upperbound cumulative net vertical movements and the subsequent changes in grade along the alignments of the creeks, after the extraction of each of the proposed longwalls, is provided in Table 5.5.

Table 5.5 Maximum Upperbound Cumulative Net Vertical Movements and Changes in Grade along the Alignments of Cony and Sandy Creeks after the Extraction of Each Proposed Longwall

Creek	Longwall	Maximum Upperbnd. Cumulative Net Subsidence (mm)	Maximum Upperbnd. Cumulative Net Uplift (mm)	Maximum Upperbnd. Cumulative Increase in Creek Gradient (mm/m)	Maximum Upperbnd. Cumulative Decrease in Creek Gradient (mm/m)
Cony Creek	After LWA6	+295	< -20	+1.0	-1.0
	After LWA12	+295	-25	+1.0	-1.0
	After LWA13	+1200	< -20	+4.0	-4.5
	After LWA14	+2095	< -20	+5.5	-7.0
	After LWA15	+2535	< -20	+7.0	-6.0
	After LWA16	+2625	< -20	+7.5	-6.5
	After LWA17	+2695	< -20	+8.0	-6.5
Sandy Creek	After LWA13	< +20	< -20	< +0.1	< -0.1
	After LWA14	+55	< -20	+0.5	-0.5
	After LWA15	+425	< -20	+2.0	-1.5
	After LWA16	+1635	< -20	+6.5	-7.0
	After LWA17	+1980	< -20	+7.0	-7.5

The values provided in the above table are the maximum upperbound parameters along the creeks within the Study Area, including the upperbound systematic and valley related movements resulting from the extraction of the Stage 2 Longwalls A3 to A5.

A summary of the maximum upperbound systematic tilt, systematic tensile strain and systematic compressive strain along Cony and Sandy Creeks, at anytime during or after the extraction of each of the proposed longwalls, is provided in Table 5.6.

Table 5.6 Maximum Upperbound Systematic Tilt, Tensile Strain and Compressive Strain along Cony and Sandy Creeks during or after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Upperbound Systematic Tilt (mm/m)	Maximum Upperbound Systematic Tensile Strain (mm/m)	Maximum Upperbound Systematic Compressive Strain (mm/m)
Cony Creek	During or After LWA6	1.0	0.1	0.4
	During or After LWA12	1.5	0.1	0.4
	During or After LWA13	5.5	0.7	0.4
	During or After LWA14	7.0	0.6	1.1
	During or After LWA15	6.5	0.6	1.1
	During or After LWA16	6.5	0.7	1.1
Sandy Creek	During or After LWA16	7.0	0.8	0.5
	During or After LWA17	7.5	0.7	0.8

The values provided in the above table are the maximum upperbound parameters along the creeks within the Study Area, including the upperbound systematic movements resulting from the extraction of the Stage 2 Longwalls A3 to A5.

5.2.3. Impact Assessments for the Cony and Sandy Creeks

The impact assessments for Cony and Sandy Creeks, based on the predicted and the upperbound subsidence parameters, are provided in the following sections. The findings in this report should be read in conjunction with the findings from the flood model which are provided in the report by Umwelt (2008a).

5.2.3.1. The Increased Likelihoods of Ponding and Flooding

A detailed flood model of the creeks has been developed by Umwelt using the predicted and the upperbound subsidence movements resulting from the extraction of the proposed longwalls, which were provided by MSEC. The increased likelihoods of ponding and flooding along the creeks have been assessed in the flood model and are provided in the report by Umwelt (2008a).

5.2.3.2. The Likelihood of Cracking in the Creek Beds

The maximum predicted systematic tensile strains along Cony and Sandy Creeks, at any time during or after the extraction of the proposed longwalls, are 0.5 mm/m and 0.6 mm/m, respectively, and the associated minimum radii of curvature are 30 kilometres and 25 kilometres, respectively.

The maximum upperbound systematic tensile strains along Cony and Sandy Creeks, at any time during or after the extraction of the proposed longwalls, are 0.7 mm/m and 0.8 mm/m, respectively, and the associated minimum radii of curvature are 21 kilometres and 19 kilometres, respectively.

Fracturing of the uppermost bedrock has been observed in the past where the systematic tensile strains have been greater than 0.5 mm/m. It is likely, therefore, that some fracturing will occur in the uppermost bedrock beneath the alluvial creek beds, based on both the predicted and the upperbound systematic tensile strains, above Longwalls A13 to A17. Hence, it is possible that some minor surface cracking could occur in the creek beds where the depths of cover to bedrock are relatively shallow.

The maximum predicted systematic compressive strains along Cony and Sandy Creeks, at any time during or after the extraction of the proposed longwalls, are 0.7 mm/m and 0.4 mm/m, respectively, and the associated minimum radii of curvature are 21 kilometres and 38 kilometres, respectively.

The maximum upperbound systematic compressive strains along Cony and Sandy Creeks, at any time during or after the extraction of the proposed longwalls, are 1.1 mm/m and 0.8 mm/m, respectively, and the associated minimum radii of curvature are 14 kilometres and 19 kilometres, respectively.

Buckling and dilation of the uppermost bedrock has been observed in the past where the compressive strains have been greater than 2 mm/m. The predicted and upperbound systematic compressive strains along Cony and Sandy Creeks are all less than 2 mm/m and are unlikely, therefore, to result in the buckling and dilation of the uppermost bedrock beneath the alluvial creek beds.

Surface cracking in soils as the result of systematic subsidence movements is not commonly seen at depths of cover greater than 500 metres, such as at Austar, and any cracking that has been observed has generally been isolated and of a minor nature. It has also been observed in the past, that surface cracking as the result of systematic subsidence movements occurs only within the top few metres of the surface soils and tends to be filled with alluvial materials during subsequent flow events.

Surface cracking as the result of valley related movements have been observed in the past along creek and drainage lines at depths of cover greater than 500 metres. The maximum predicted closure movements at Cony and Sandy Creeks, resulting from the extraction of the proposed longwalls, are 250 mm and 25 mm, respectively. The maximum upperbound closure movements at Cony and Sandy Creeks, resulting from the extraction of the proposed longwalls, are also 250 mm and 25 mm, respectively.

The compressive strains resulting from valley related movements are more difficult to predict than systematic strains. It has been observed in the past, however, that compressive strains greater than 2 mm/m have occurred at the predicted and upperbound levels closure along Cony Creek and where the creeks have been directly mined beneath, as can be seen in Fig. D.22 in Appendix D. Compressive strains due to valley closure movements greater than 2 mm/m are generally not observed more than 250 metres outside extracted longwall goaf areas, as can be seen in Fig. D.23 and Fig. D.24.

It is possible, therefore, that some compressive buckling and dilation of the uppermost bedrock could occur beneath the alluvial bed of Cony Creek above and within 250 metres of the Longwalls A13 to A17. It has been observed in the past, that the depth of buckling and dilation of the uppermost bedrock, resulting from valley related movements, is generally less than 10 to 15 metres.

Surface cracking can potentially occur in the locations where the uppermost bedrock buckles and where the depths of cover to bedrock are shallow. Any surface cracking that occurs as a result of the extraction of the proposed longwalls is likely to be filled with alluvial materials during subsequent flow events.

In times of heavy rainfall, any dilated bedrock beneath the creek beds would become water charged, and the surface water would flow over any surface cracks. Surface water that is diverted into the dilated bedrock beneath the creeks, during times of rainfall, is unlikely to significantly affect the overall quality or quantity of the surface water flow, as the cross-sectional area of dilated bedrock is very small when compared to the cross-sectional area of the creek channels.

Any surface cracking would tend to be naturally filled with alluvial materials during subsequent flow events, especially during times of heavy rainfall. If any surface cracks were found not to heal naturally, some remediation measures may be required at the completion of mining. Where necessary, any significant surface cracks in the creek beds could be easily remediated by infilling with alluvials or other suitable materials, or by locally regrading and recompacting the surface.

As described in Section 5.22.8, the likely height of the fractured zone is 225 metres to 265 metres above the proposed longwalls. The depths of cover along the alignments of these creeks are greater than 550 metres and, therefore, the estimated depth of the constrained zone, which is located above the fractured zone, is greater than 285 metres to 325 metres.

The constrained zone, also known as the continuous deformation zone, is illustrated in Fig. 5.18 and Fig. 5.19. The constrained zone contains confined rock strata above the fractured zone which has sagged slightly but, because they are constrained, have absorbed most of the strain energy without suffering significant fracturing or alteration to the original physical properties. Some bed separation or slippage can be present as well as discontinuous vertical cracks, usually on the underside of thick strong beds. Weak or soft beds in this zone may suffer plastic deformation.

The Cessnock Sandstone forms the upper section of the constrained zone, which is relatively homogeneous and contains relatively thick beds. Vertical fracturing within the constrained zone is generally discontinuous and is unlikely, therefore, to result in increased hydraulic conductivity. It is unlikely, therefore, that there would be any net loss of water from the creeks resulting from the extraction of the proposed longwalls.

Where Quorrobolong Creek was previously mined beneath by Longwalls 1 to 6 and Longwall SL1 at the Colliery, where the depths of cover vary between 310 and 370 metres, there was no reported loss of water from the creek and no reported surface cracking in the creek bed.

Further discussion on the potential impacts of surface cracking and changes in surface water flows are provided in the report by Umwelt (2008a).

5.2.3.3. Impact Assessments for the Creeks Based on Increased Predictions

If the predicted systematic subsidence parameters along the creeks were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would be similar to or less than the upperbound parameters at the creeks. It is unlikely that the upperbound systematic subsidence parameters at the creeks would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

The maximum upperbound systematic tensile strains at Cony and Sandy Creeks of 0.7 mm/m and 0.8 mm/m, respectively, are only slightly less than the maximum upperbound systematic tensile strain anywhere above Longwalls A13 to A16 of 0.9 mm/m and are unlikely, therefore, to be exceeded. If the maximum upperbound systematic tensile strain anywhere above the proposed longwalls of 1.2 mm/m were to occur at Cony or Sandy Creeks, the likelihood and extent of surface cracking in the creek beds would only slightly increase.

If the maximum upperbound systematic compressive strain anywhere above the proposed longwalls of 3.0 mm/m were to occur at Cony or Sandy Creeks, the likelihood and extent of buckling and dilation of the uppermost bedrock would increase accordingly. Any surface tensile cracking could still be remediated by infilling with alluvial or other suitable materials, or by locally regrading and recompacting the surface.

5.2.4. Recommendations for the Creeks

The assessed impacts on Cony and Sandy Creeks resulting from the predicted and upperbound systematic subsidence and valley related movements can be managed with the implementation of suitable management strategies.

It is recommended that the creek beds are visually monitored during the extraction of the proposed longwalls, and that any significant surface tensile cracking is remediated by infilling with alluvials or other suitable materials, or by locally regrading and recompacting the surface. With these management strategies in place, it is unlikely that there would be any significant impact on the creeks resulting from the extraction of the proposed longwalls.

5.3. Drainage Lines

There are a number of drainage lines around and between the hills within the Study Area which are shown in Drawing No. MSEC309-07. The drainage lines are located across the Study Area and are likely, therefore, to be subjected to the full range of predicted systematic subsidence movements. A summary of the maximum predicted and maximum upperbound total systematic subsidence parameters at the drainage lines, resulting from the extraction of the proposed longwalls, is provided in Table 5.7.

Table 5.7 Maximum Predicted and Upperbound Total Systematic Subsidence Parameters at the Drainage Line Resulting from the Extraction of Longwalls A6 to A17

Case	Maximum Cumulative Subsidence (mm)	Maximum Cumulative Tilt (mm/m)	Maximum Cumulative Tensile Strain (mm/m)	Maximum Cumulative Compressive Strain (mm/m)
Predicted	1925	6.7	0.8	1.8
Upperbound	3040	10	1.2	3.0

The drainage lines have been included in the flood modelling which has been undertaken by Umwelt using the predicted and upperbound subsidence movements resulting from the extraction of the proposed longwalls, which were provided by MSEC. An assessment of the changes in surface level at the drainage lines are provided in the report by Umwelt (2008a).

Tensile strains greater than 0.5 mm/m or compressive strains greater than 2 mm/m may be of sufficient magnitude to result in the fracturing or buckling of the uppermost bedrock. The maximum predicted and maximum upperbound systematic strains at the drainage lines are likely, therefore, to be of sufficient magnitude to result in fracturing of the uppermost bedrock, which could result in surface cracking where the depths of cover to bedrock are shallow.

Surface cracking in soils as the result of systematic subsidence movements is not commonly seen at depths of cover greater than 500 metres, such as at Austar, and any cracking that has been observed has generally been isolated and of a minor nature. It would be expected, therefore, that any surface cracking that occurs along the drainage lines, as a result of the systematic subsidence movements, would be of a minor nature due to the relatively small magnitudes of the predicted and upperbound systematic strains and due to the relatively high depths of cover.

Surface tensile cracking as the result of systematic subsidence movements occurs only within the top few metres of the surface soils and would be expected to be filled with the alluvial materials during subsequent flow events. If any surface cracks were found not to heal naturally, some remediation measures may be required at the completion of mining.

Surface cracking as the result of valley related movements has been observed in the past along drainage lines at depths of cover greater than 500 metres. The valley heights of the drainage lines within the Study Area are relatively small and it is expected, therefore, that the predicted compressive strains due to the valley closure movements would be less than the maximum predicted systematic strains along the drainage lines.

It is recommended that the drainage lines are visually monitored during the extraction of the proposed longwalls, and that any significant surface tensile cracks are remediated by infilling with alluvials or other suitable materials, or by locally regrading and recompacting the surface.

5.4. Steep Slopes

The locations of steep slopes within the Study Area are shown in Drawing No. MSEC309-07. For the purposes of this report, steep slopes have been defined as areas of land having a natural gradient greater than 1 in 3 (ie: a grade of 33 %, or an angle to the horizontal greater than 18°). The predicted and upperbound subsidence parameters and the impact assessments for the steep slopes are provided in the following sections.

5.4.1. Predicted Subsidence Parameters for the Steep Slopes

A summary of the maximum predicted systematic subsidence parameters at the steep slopes, during or after the extraction of each of the proposed longwalls, which ever is the greater, is provided in Table 5.8.

Table 5.8 Maximum Predicted Cumulative Systematic Subsidence Parameters at the Steep Slopes after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Tensile Strain (mm/m)	Maximum Predicted Compressive Strain (mm/m)
Broken Back Range	During or After LWA6	185	1.2	0.1	0.3
	During or After LWA7	325	1.4	0.2	0.4
	During or After LWA8	1290	5.2	0.6	2.0
	During or After LWA9	1615	6.2	0.6	2.1
	During or After LWA10	1760	6.5	0.7	2.0
	During or After LWA11	1800	6.6	0.7	2.0
	During or After LWA17	1805	6.7	0.8	2.0
Hill above Longwall A17	During or After LWA16	270	2.1	0.3	< 0.1
	During or After LWA17	1345	5.0	0.6	0.4

The values provided in the above table are the maximum predicted systematic subsidence parameters which occur at the steep slopes at any time during or after the extraction of each of the proposed longwalls.

5.4.2. Upperbound Subsidence Parameters for the Steep Slopes

The upperbound systematic subsidence parameters for the steep slopes have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

A summary of the maximum upperbound systematic subsidence parameters at the steep slopes, during or after the extraction of each of the proposed longwalls, whichever is the greater, is provided in Table 5.9.

Table 5.9 Maximum Upperbound Cumulative Systematic Subsidence Parameters at the Steep Slopes after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Upperbound Subsidence (mm)	Maximum Upperbound Tilt (mm/m)	Maximum Upperbound Tensile Strain (mm/m)	Maximum Upperbound Compressive Strain (mm/m)
Broken Back Range	During or After LWA6	305	1.9	0.2	0.4
	During or After LWA7	525	2.2	0.3	0.6
	During or After LWA8	2020	7.5	0.8	2.7
	During or After LWA9	2540	9.1	0.8	3.1
	During or After LWA10	2825	9.6	0.9	3.0
	During or After LWA11	2910	9.8	1.0	3.0
	During or After LWA17	2920	9.8	1.0	3.0
Hill above Longwall A17	During or After LWA16	390	2.9	0.5	< 0.1
	During or After LWA17	1865	6.7	0.8	0.5

The values provided in the above table are the maximum upperbound systematic subsidence parameters which occur at the steep slopes at any time during or after the extraction of each proposed longwall.

5.4.3. Impact Assessments for the Steep Slopes

The maximum upperbound systematic tilt at the steep slopes along the Broken Back Range, at any time during or after the extraction of the proposed longwalls, is 9.8 mm/m (ie: 1.0 %), or a change in grade of 1 in 100. The maximum upperbound systematic tilt at the steep slopes along the hill above Longwall A17, at any time during or after the extraction of the proposed longwalls, is 6.7 mm/m (ie: 0.7 %), or a change in grade of 1 in 150.

The steep slopes are more likely to be impacted by ground strains, rather than tilt, as the maximum upperbound tilts at the steep slopes are small when compared to the existing natural gradients, which typically vary between 1 in 3 (ie: 33 %) to 1 in 2 (ie: 50 %), with isolated areas having existing natural gradients up to 1 in 1.5 (ie: 67 %).

The maximum upperbound systematic tensile and compressive strains at the steep slopes along the Broken Back Range, at any time during or after the extraction of the proposed longwalls, are 1.0 mm/m and 3.0 mm/m, respectively, and the associated minimum radii of curvature are 15 kilometres and 5.0 kilometres, respectively. The maximum upperbound systematic tensile and compressive strains at the steep slopes along the hill above Longwall A17, at any time during or after the extraction of the proposed longwalls, are 0.8 mm/m and 0.5 mm/m, respectively, and the associated minimum radii of curvature are 19 kilometres and 30 kilometres, respectively.

Tensile strains greater than 0.5 mm/m or compressive strains greater than 2 mm/m may be of sufficient magnitude to result in the fracturing or buckling of the uppermost bedrock. The maximum predicted and maximum upperbound systematic strains at the steep slopes are likely, therefore, to be of sufficient magnitude to result in fracturing of the uppermost bedrock, which could result in surface cracking where the depths of cover to bedrock are shallow.

Surface cracking in soils as the result of systematic subsidence movements is not commonly seen at depths of cover greater than 500 metres, such as at Austar, and any cracking that has been observed has generally been isolated and of a minor nature. It would be expected, therefore, that any surface cracking that occurs along the steep slopes, as a result of the extraction of the proposed longwalls, would be of a minor nature due to the relatively small magnitudes of predicted and upperbound systematic strains and due to the relatively high depths of cover. Surface tensile cracking is generally limited to the top few metres of the surface soils.

The maximum width of potential surface cracking at the steep slopes can be predicted from Fig. D.8 in Appendix D, which shows the relationship between maximum observed crack width and depth of cover, based upon measured data in the NSW Coalfields and observations over mines in the United Kingdom. The depth of cover at the steep slopes is greater than 500 metres and, therefore, the maximum predicted crack width resulting from the extraction of the proposed longwalls is 25 mm. It is more likely, however, that a number of narrower cracks, rather than a single larger crack, would develop at the steep slopes as the result of the systematic tensile strains.

Minor surface cracking tends to heal naturally, especially during rain events. If any significant cracking were to be left untreated, however, erosion channels could develop along the steep slopes. In this case, it is recommended that appropriate mitigation measures be undertaken, including infilling of surface cracks with soil or other suitable materials, or by locally regrading and recompacting the surface.

The steep slopes within the Study Area have natural gradients typically less than 1 in 2, and the depths of cover at the steep slopes are greater than 500 metres. It is unlikely, therefore, that the predicted and upperbound systematic strains would be of sufficient magnitudes to result in the slippage of soils down the steep slopes.

If movement of the surface soils were to occur during the extraction of the proposed longwalls, minor tension cracks at the tops of slopes and minor compression ridges at the bottoms of slopes may form. In this case, minor mitigation measures might be required, including infilling of surface cracks with soil or other suitable materials, and local regrading and recompacting of compression bumps.

5.4.4. Impact Assessments for the Steep Slopes Based on Increased Predictions

If the predicted systematic subsidence parameters at the steep slopes were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the steep slopes. It is unlikely that the upperbound systematic subsidence parameters at the steep slopes would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound systematic tilt anywhere above the proposed longwalls of 10 mm/m were to occur at the steep slopes, it would still be unlikely to result in any significant impact, as the change in surface gradient of only 1.0 %, or 1 in 100, is still very small when compared to the natural gradients of the steep slopes.

If the maximum upperbound systematic tensile and compressive strains anywhere above the proposed longwalls of 1.2 mm/m and 3.0 mm/m, respectively, were to occur at the steep slopes, the likelihood and extent of surface cracking would increase accordingly. Any surface cracking would still be expected to be of a minor nature and could be remediated by infilling the cracks with soil or other suitable materials, or by locally regrading and recompacting the surface.

5.4.5. Recommendations for the Steep Slopes

The assessed impacts on the steep slopes resulting from the predicted and upperbound systematic subsidence parameters can be managed with the implementation of suitable management strategies. With the necessary remediation measures implemented, it is unlikely that any significant impact on the steep slopes would occur as a result of the extraction of the proposed longwalls.

It is recommended that the surface is visually monitored during the extraction of the proposed longwalls. Appropriate management strategies should be developed, in liaison with the property owners, so that any surface tensile cracking can be remediated, as required, throughout the mining period.

5.5. Roads

The locations of roads within the Study Area are shown in Drawing No. MSEC309-08. The roads are located across the Study Area and, therefore, will be subjected to the full range of predicted systematic subsidence movements. The predicted and upperbound subsidence parameters and impact assessments for the major roads within the Study Area are provided in the following sections.

5.5.1. Predicted Subsidence Parameters for the Roads

The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignments of Sandy Creek Road, Quorrobolong Road, Coney Creek Road and Pelton Fire Trail, resulting from the extraction of the proposed longwalls, are shown in Figs. H.05, H.06, H.07 and H.08, respectively, in Appendix H. The predicted profiles along the alignments of Nash Lane and Big Hill Road are also shown in Figs. H.07 and H.08, respectively.

A summary of the maximum predicted cumulative systematic subsidence parameters along the alignments of the roads, after the extraction of each of the proposed longwalls, is provided in Table 5.10.

Table 5.10 Maximum Predicted Cumulative Systematic Subsidence Parameters along the Alignments of the Roads after the Extraction of Each of the Proposed Longwalls

Road	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
Sandy Creek Road	After LWA16	< 20	< 0.1	< 0.1	< 0.1
	After LWA17	140	0.4	< 0.1	< 0.1
Quorrobolong Road	After LWA6	105	0.5	0.1	< 0.1
	After LWA7	400	1.5	0.1	0.5
	After LWA8	530	2.0	0.3	0.5
	After LWA17	545	2.1	0.3	0.5
Coney Creek Road and Nash Lane	After LWA6	250	2.2	0.3	0.3
	After LWA10	815	3.5	0.3	0.3
	After LWA11	1340	5.3	0.6	0.5
	After LWA12	1570	5.3	0.6	0.6
	After LWA13	1755	5.3	0.5	0.5
	After LWA17	1790	5.3	0.4	0.5
Pelton Fire Trail and Big Hill Road	After LWA6	205	1.0	0.1	0.3
	After LWA7	340	1.3	0.2	0.3
	After LWA8	1330	5.0	0.6	1.6
	After LWA9	1645	5.1	0.7	1.7
	After LWA10	1775	5.4	0.7	1.7
	After LWA17	1840	5.5	0.7	1.7

The values provided in the above table for Nash Lane are the maximum predicted parameters along the road within the Study Area, including the predicted movements resulting from the Stage 2 Longwalls A3 to A5.

The roads will also be subjected to travelling tilts and strains where the extraction faces of the proposed longwalls pass beneath them. A summary of the maximum predicted travelling tilts and strains at the roads, during the extraction of each of the proposed longwalls, is provided in Table 5.11.

Table 5.11 Maximum Predicted Travelling Tilts and Strains at the Roads during the Extraction of Each of the Proposed Longwalls

Road	Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
Sandy Creek Road	During LWA17	0.3	< 0.1	< 0.1
Quorrobolong Road	During LWA6	0.3	< 0.1	< 0.1
	During LWA7	1.4	0.2	0.2
	During LWA8	1.0	0.1	0.1
Coney Creek Road and Nash Lane	During LWA6	0.7	0.1	0.1
	During LWA10	2.2	0.3	0.2
	During LWA11	2.8	0.3	0.3
	During LWA12	3.0	0.4	0.3
	During LWA13	2.7	0.3	0.2
Pelton Fire Trail and Big Hill Road	During LWA6	0.6	0.1	0.1
	During LWA7	1.2	0.2	0.1
	During LWA8	3.5	0.5	0.4
	During LWA9	3.3	0.4	0.3
	During LWA10	3.0	0.4	0.3

5.5.2. Upperbound Subsidence Parameters for the Roads

The upperbound systematic subsidence parameters for the roads have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The upperbound profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignments of Sandy Creek Road, Quorrobolong Road, Coney Creek Road and Pelton Fire Trail, resulting from the extraction of the proposed longwalls, are shown in Fig. I.05, I.06, I.07 and I.08, respectively, in Appendix I. The upperbound profiles along the alignments of Nash Lane and Big Hill Road are also shown in Figs. I.07 and I.08, respectively.

A summary of the maximum upperbound cumulative systematic subsidence parameters along the alignments of the roads, after the extraction of each of the proposed longwalls, is provided in Table 5.12.

Table 5.12 Maximum Upperbound Cumulative Systematic Subsidence Parameters along the Alignments of the Roads after the Extraction of Each of the Proposed Longwalls

Road	Longwall	Maximum Upperbound Cumulative Subsidence (mm)	Maximum Upperbound Cumulative Tilt (mm/m)	Maximum Upperbound Cumulative Tensile Strain (mm/m)	Maximum Upperbound Cumulative Compressive Strain (mm/m)
Sandy Creek Road	After LWA16	< 20	0.1	< 0.1	< 0.1
	After LWA17	205	0.6	0.1	< 0.1
Quorrobolong Road	After LWA6	175	0.8	0.1	0.1
	After LWA7	660	2.3	0.1	0.8
	After LWA8	900	3.3	0.5	0.8
	After LWA17	925	3.4	0.4	0.8
Coney Creek Road and Nash Lane	After LWA6	560	4.9	0.7	0.4
	After LWA10	1230	5.2	0.7	0.4
	After LWA11	2085	7.5	0.8	0.7
	After LWA12	2440	7.8	0.8	1.2
	After LWA13	2700	8.0	0.7	1.2
	After LWA17	2755	8.1	0.7	1.2
Pelton Fire Trail and Big Hill Road	After LWA6	340	1.7	0.2	0.4
	After LWA7	560	2.0	0.3	0.4
	After LWA8	2105	7.4	0.8	2.6
	After LWA9	2615	7.2	1.0	2.8
	After LWA10	2825	7.4	1.1	2.7
	After LWA17	2930	7.5	1.1	2.7

The values provided in the above table for Nash Lane are the maximum upperbound parameters along the road within the Study Area, including the predicted movements resulting from the Stage 2 Longwalls A3 to A5.

A summary of the maximum upperbound travelling tilts and strains at the roads, during the extraction of each of the proposed longwalls, is provided in Table 5.13.

Table 5.13 Maximum Upperbound Travelling Tilts and Strains at the Roads during the Extraction of Each of the Proposed Longwalls

Road	Longwall	Maximum Upperbound Travelling Tilt (mm/m)	Maximum Upperbound Travelling Tensile Strain (mm/m)	Maximum Upperbound Travelling Compressive Strain (mm/m)
Sandy Creek Road	During LWA17	0.5	0.1	< 0.1
Quorrobolong Road	During LWA6	0.5	0.1	< 0.1
	During LWA7	2.4	0.4	0.3
	During LWA8	1.7	0.3	0.2
Coney Creek Road and Nash Lane	During LWA6	1.1	0.1	0.1
	During LWA10	3.3	0.4	0.3
	During LWA11	4.1	0.5	0.4
	During LWA12	4.4	0.5	0.4
	During LWA13	3.9	0.5	0.4
Pelton Fire Trail and Big Hill Road	During LWA6	1.0	0.1	0.1
	During LWA7	2.0	0.3	0.2
	During LWA8	5.4	0.7	0.6
	During LWA9	4.9	0.6	0.5
	During LWA10	4.5	0.6	0.4

5.5.3. Impact Assessments for the Roads

The maximum upperbound systematic tilt at the roads, at any time during or after the extraction of the proposed longwalls, is 8.1 mm/m (ie: 0.8 %), or a change in grade of 1 in 125. The maximum upperbound tilt is less than 1 % and is unlikely, therefore, to result in any significant impacts on the serviceability or the drainage of water at the roads.

The maximum predicted systematic tensile and compressive strains at the roads, at any time during or after the extraction of the proposed longwalls, are 0.7 mm/m and 1.7 mm/m, respectively. The minimum radii of curvature associated with the maximum upperbound systematic tensile and compressive strains are 21 kilometres and 8.8 kilometres, respectively.

The maximum upperbound systematic tensile and compressive strains at the roads, at any time during or after the extraction of the proposed longwalls, are 1.1 mm/m and 2.7 mm/m, respectively. The minimum radii of curvature associated with the maximum upperbound systematic tensile and compressive strains are 14 kilometres and 5.6 kilometres, respectively.

Tensile strains greater than 0.5 mm/m or compressive strains greater than 2 mm/m may be of sufficient magnitude to result in the fracturing or buckling of the uppermost bedrock. The maximum predicted systematic strains at Coney Creek Road and Big Hill Road, and the maximum upperbound systematic strains at Quorrobolong, Coney Creek and Big Hill Roads are likely, therefore, to be of sufficient magnitude to result in fracturing of the uppermost bedrock, which could result in surface tensile cracking where the depths of cover to bedrock are shallow.

It would be expected, however, that any surface cracking that occurred at these roads, as a result of the extraction of the proposed longwalls, would be of a minor nature due to the relatively small magnitudes of the predicted and upperbound systematic strains and due to the relatively high depths of cover. Quorrobolong Road has a bitumen seal within the Study Area and Coney Creek and Big Hill Roads are unsealed roads.

The maximum width of potential surface tensile cracking along the roads can be predicted from Fig. D.8 in Appendix D, which shows the relationship between maximum observed crack width and depth of cover, based upon measured data in the NSW Coalfields and observations over mines in the United Kingdom.

The depth of cover along the roads varies between 450 metres and 600 metres directly above the proposed longwalls. Based on Fig. D.8, therefore, the maximum predicted crack width along the roads resulting from the extraction of the proposed longwalls is 25 mm. It is more likely, however, that a number of narrower cracks, rather than a single larger crack, would develop at the roads as the result of the systematic tensile strains.

Any tensile cracking or compressive rippling of the road surfaces, resulting from the extraction of the proposed longwalls, could be remediated using normal road maintenance techniques. With the implementation of suitable remediation measures, the roads can be maintained in a safe and serviceable condition throughout the mining period.

5.5.4. Impact Assessments for the Roads Based on Increased Predictions

If the predicted systematic subsidence parameters at the roads were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the roads. It is unlikely that the upperbound systematic subsidence parameters at the roads would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound systematic tilt anywhere above the proposed longwalls of 10 mm/m were to occur at the roads, the maximum change in grade would only be 1 % and unlikely, therefore, to result in any significant impacts on the serviceability or the drainage of water from the roads.

If the maximum upperbound systematic tensile and compressive strains anywhere above the proposed longwalls of 1.2 mm/m and 3.1 mm/m, respectively, were to occur at the roads, the likelihood and extent of surface cracking would increase accordingly. Any surface cracking, however, would still be expected to be of a minor nature and easily remediated using normal road maintenance techniques.

With the necessary remediation measures implemented, it is likely that the roads can be maintained in a safe and serviceable condition throughout the mining period.

5.5.5. Recommendations for the Roads

The assessed impacts on the roads within the Study Area, resulting from the predicted and upperbound systematic subsidence parameters, can be managed with the implementation of suitable management strategies.

It is recommended that the roads should be visually monitored as each of the proposed longwalls are mined beneath them, such that any impacts can be identified and remediated accordingly. It is also recommended that management strategies are developed, in consultation with Cessnock City Council, so that the roads can be maintained in a safe and serviceable condition throughout the mining period.

5.6. Bridges

The locations of the bridges within the Study Area are shown in Drawing No. MSEC309-09. The predicted and upperbound subsidence parameters and impact assessments for the bridges are provided in the following sections.

5.6.1. Predicted Subsidence Parameters for the Bridges

Bridges BR-SR01 and BR-QR01 will not be directly mined beneath and are located at minimum distances of 575 metres and 250 metres from the proposed longwalls. A summary of the maximum predicted total systematic subsidence, tilts and strains at the bridges, after the completion of the proposed longwalls, is provided in Table 5.14.

Table 5.14 Maximum Predicted Total Systematic Subsidence, Tilt and Strain at the Bridges after the Completion of the Proposed Longwalls

Bridge	Location	Maximum Predicted Systematic Subsidence (mm)	Maximum Predicted Systematic Tilt (mm/m)	Maximum Predicted Systematic Strain (mm/m)
BR-SC01	Sandy Creek Road and Sandy Creek	< 20	0.3	< 0.1
BR-QR01	Quorrobolong Road and Coney Creek	35	0.3	< 0.1

The values provided in the above table are the maximum predicted systematic subsidence parameters within 20 metres of each bridge.

The bridges could be subjected to valley related movements. A summary of the maximum predicted valley related upsidence and closure movements at the bridges, after the completion of the proposed longwalls, is provided in Table 5.15.

Table 5.15 Maximum Predicted Total Upsidence and Closure at the Bridges after the Completion of the Proposed Longwalls

Bridge	Location	Maximum Predicted Upsidence (mm)	Maximum Predicted Closure (mm)
BR-SC01	Sandy Creek Road and Sandy Creek	20	25
BR-QR01	Quorrobolong Road and Coney Creek	< 20	< 20

5.6.2. Upperbound Subsidence Parameters for the Bridges

The upperbound systematic subsidence parameters for the powerlines have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

A summary of the maximum upperbound total systematic subsidence, tilts and strains at the bridges, after the completion of the proposed longwalls, is provided in Table 5.14.

Table 5.16 Maximum Upperbound Total Systematic Subsidence, Tilt and Strain at the Bridges after the Completion of the Proposed Longwalls

Bridge	Location	Maximum Upperbound Systematic Subsidence (mm)	Maximum Upperbound Systematic Tilt (mm/m)	Maximum Upperbound Systematic Strain (mm/m)
BR-SC01	Sandy Creek Road and Sandy Creek	30	0.4	< 0.1
BR-QR01	Quorrobolong Road and Coney Creek	60	0.5	< 0.1

The values provided in the above table are the maximum upperbound systematic subsidence parameters within 20 metres of each bridge.

A summary of the maximum upperbound valley related upsidence and closure movements at the bridges, after the completion of the proposed longwalls, is provided in Table 5.15.

Table 5.17 Maximum Upperbound Total Upsidence and Closure at the Bridges after the Completion of the Proposed Longwalls

Bridge	Location	Maximum Upperbound Upsidence (mm)	Maximum Upperbound Closure (mm)
BR-SC01	Sandy Creek Road and Sandy Creek	20	25
BR-QR01	Quorrobolong Road and Coney Creek	< 20	< 20

5.6.3. Impact Assessments for the Bridges

The maximum upperbound systematic tilt at the bridges, at any time during or after the extraction of the proposed longwalls, is 0.5 mm/m (ie: < 0.1 %), or a change in grade of 1 in 2000. The maximum upperbound tilt is less than 1 % and is unlikely, therefore, to result in any significant impacts on the serviceability of the bridges.

The maximum upperbound systematic strains at the bridges, at any time during or after the extraction of the proposed longwalls, are less than 0.1 mm/m and the associated minimum radii of curvature are greater than 150 kilometres. The systematic strains and curvatures at the bridges are very small and are unlikely to result in any significant impacts on the structural integrity of the bridges.

The maximum upperbound upsidence and closure movements at the bridges are 20 mm and 25 mm, respectively. The upperbound valley related movements at the bridges are very small and are unlikely to result in any significant impacts on the structural integrity of the bridges.

5.6.4. Impact Assessments for the Bridges Based on Increased Predictions

If the predicted systematic subsidence parameters at the bridges were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the bridges.

If the predicted systematic subsidence parameters at the bridges were to be increased by a factor of 2 times, the maximum predicted tilt at the bridges would still be less than 1 % and the maximum predicted systematic strains at the bridges would be in the order of 0.1 mm/m and, therefore, would still be unlikely to result in any significant impacts on the serviceability or structural integrity of the bridges.

5.6.5. Recommendations for the Bridges

It is recommended that the Bridges BR-SC01 and BR-QC01 are visually monitored during the extraction of the proposed longwalls.

5.7. Drainage Culverts

The locations of the drainage culverts within the Study Area are shown in Drawing No. MSEC309-08. The predictions and impact assessments for the historical culverts DC-QR06, DC-QR07 and DC-QR08 are provided in Section 5.19. The predictions and impact assessments for the remaining drainage culverts within the Study Area are provided below.

The drainage culverts are located across the mining area and are expected, therefore, to be subjected to the full range of predicted systematic subsidence movements. The maximum upperbound systematic tilt, tensile strain and compressive strain within the Study Area, resulting from the extraction of the proposed longwalls, are 10 mm/m, 1.2 mm/m and 3.1 mm/m, respectively.

The maximum upperbound systematic tilt is equivalent to a change in grade of 1 % and is unlikely, therefore, to impact upon the serviceability of the drainage culverts. In addition to this, a number of the drainage culverts are orientated parallel or obliquely to the proposed longwalls and, therefore, the components of tilt along the main axes of the culverts are expected to be less than the maximum predicted within the Study Area.

The drainage culverts are relatively short, typically less than 4 metres in length and it is unlikely, therefore, that the ground strains would be fully transferred into the drainage culverts, especially at the magnitudes of the predicted strains. It is unlikely, therefore, that the predicted systematic strains would result in any significant impacts on the drainage culverts.

The minimum radii of curvature associated with the maximum upperbound systematic tensile and compressive strains are 13 kilometres and 4.8 kilometres, respectively. The maximum upperbound differential movements at the mid-lengths of the culverts, relative to the ends of the culverts, are less than 1 mm based on the minimum upperbound radii of curvature and are unlikely, therefore, to result in any significant impacts.

The drainage culverts are located along drainage lines and could, therefore, experience some valley related upsidence and closure movements. The drainage culverts are orientated along the drainage lines and since the upsidence and closure movements will be orientated perpendicular to the main axes of the culverts, they are unlikely to result in any significant impacts.

The ground movements associated with upsidence and closure are generally spread over a relatively short distance. These sudden changes in ground movement could induce greater strains or changes in grade at the drainage culverts. It is expected, however, that some of the ground movements and ground strains will be taken up by the road base, which will tend to reduce the impacts on the drainage culverts and the road pavements.

It is also possible, that the drainage culverts could experience localised strain concentrations above natural joints at rockhead, where the depths of the overlying soils are shallow. Any impacts on the drainage culverts due to these localised strain concentrations would be expected to be of a relatively minor nature, which could be easily repaired or, if necessary, replaced. With any necessary remediation measures implemented, it is expected that the drainage culverts can be maintained in a serviceable condition throughout the mining period.

5.8. Electrical Services

The locations of the electrical services within the Study Area are shown in Drawing No. MSEC309-09. The electrical services comprise a number of branches of an 11 kV powerline which are located across the Study Area and, therefore, will be subjected to the full range of predicted systematic subsidence movements. The predicted and upperbound subsidence parameters and impact assessments for electrical services are provided in the following sections.

5.8.1. Predicted Subsidence Parameters for the 11 kV Powerlines

The predicted profiles of incremental and cumulative systematic subsidence and tilts along and across the alignments of Branches 1, 2, 3 and 4 of the 11 kV powerline, resulting from the extraction of the proposed longwalls, are shown in Figs. H.09, H.10, H.11 and H.12, respectively, in Appendix H. The locations of the branches are indicated in Drawing No. MSEC309-09.

A summary of the maximum predicted cumulative systematic subsidence and tilts along and across the alignments of the 11 kV powerline branches, after the extraction of each of the proposed longwalls, is provided in Table 5.18.

Table 5.18 Maximum Predicted Cumulative Systematic Subsidence and Tilts Along and Across the Alignments of 11 kV Powerline Branches after the Extraction of Each Proposed Longwall

Location	Longwall	Maximum Predicted Cumulative Systematic Subsidence (mm)	Maximum Predicted Cumulative Systematic Tilt Along Alignment (mm/m)	Maximum Predicted Cumulative Systematic Tilt Across Alignment (mm/m)
Branch 1	After LWA14	45	0.3	< 0.1
	After LWA15	305	2.4	0.1
	After LWA16	1075	3.9	0.6
	After LWA17	1340	2.9	2.9
Branch 2	After LWA9	105	0.6	0.6
	After LWA10	900	3.9	4.0
	After LWA11	1615	3.4	5.0
	After LWA12	1800	2.4	4.0
	After LWA17	1825	1.5	2.1
Branch 3	After LWA6	235	0.8	0.2
	After LWA11	965	5.2	1.3
	After LWA12	1525	5.2	1.3
	After LWA13	1755	4.9	4.6
	After LWA17	1820	4.5	3.4
Branch 4	After LWA6	85	0.4	0.5
	After LWA7	385	1.4	1.2
	After LWA8	505	2.0	3.7
	After LWA17	520	2.0	4.1

The powerlines will also be subjected to travelling tilts where the extraction faces of the proposed longwalls pass beneath them. A summary of the maximum predicted travelling tilts at the powerline branches, during the extraction of each of the proposed longwalls, is provided in Table 5.11.

Table 5.19 Maximum Predicted Travelling Tilts at the 11 kV Powerline Branches during the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Predicted Travelling Tilt (mm/m)
Branch 1	During LWA15	0.7
	During LWA16	2.1
	During LWA17	2.2
Branch 2	During LWA10	2.3
	During LWA11	3.1
	During LWA12	2.8
Branch 3	During LWA6	0.7
	During LWA11	2.5
	During LWA12	3.0
	During LWA13	2.8
Branch 4	During LWA6	0.2
	During LWA7	1.4
	During LWA8	0.9

5.8.2. Upperbound Subsidence Parameters for the Powerlines

The upperbound systematic subsidence parameters for the powerlines have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The upperbound profiles of incremental and cumulative systematic subsidence and tilts along and across the alignments of Branches 1, 2, 3 and 4 of the 11 kV powerline, resulting from the extraction of the proposed longwalls, are shown in Figs. I.09, I.10, I.11 and I.12, respectively, in Appendix I.

A summary of the maximum upperbound cumulative systematic subsidence and tilts along and across the alignments of the 11 kV powerline branches, after the extraction of each of the proposed longwalls, is provided in Table 5.20.

Table 5.20 Upperbound Cumulative Systematic Subsidence and Tilts Along and Across the Alignments of 11 kV Powerline Branches after the Extraction of Each Proposed Longwall

Location	Longwall	Maximum Upperbound Cumulative Systematic Subsidence (mm)	Maximum Upperbound Cumulative Systematic Tilt Along Alignment (mm/m)	Maximum Upperbound Cumulative Systematic Tilt Across Alignment (mm/m)
Branch 1	After LWA14	65	0.5	< 0.1
	After LWA15	445	3.4	0.2
	After LWA16	1530	5.5	0.9
	After LWA17	1915	3.9	4.0
Branch 2	After LWA9	175	0.9	0.9
	After LWA10	1345	5.5	5.7
	After LWA11	2505	4.9	7.0
	After LWA12	2795	3.8	5.6
	After LWA17	2830	2.3	3.9
Branch 3	After LWA6	375	1.2	0.3
	After LWA11	1420	7.3	1.9
	After LWA12	2340	7.2	1.7
	After LWA13	2700	6.8	6.4
	After LWA17	2805	6.9	5.0
Branch 4	After LWA6	140	0.6	0.7
	After LWA7	645	2.2	1.8
	After LWA8	860	3.2	6.3
	After LWA17	885	3.3	6.8

A summary of the maximum upperbound travelling tilts at the powerline branches, during the extraction of each of the proposed longwalls, is provided in Table 5.21.

Table 5.21 Maximum Upperbound Travelling Tilts at the 11 kV Powerline Branches during the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Upperbound Travelling Tilt (mm/m)
Branch 1	During LWA15	1.0
	During LWA16	3.0
	During LWA17	3.1
Branch 2	During LWA10	3.5
	During LWA11	4.5
	During LWA12	4.1
Branch 3	During LWA6	1.1
	During LWA11	3.6
	During LWA12	4.3
	During LWA13	4.1
Branch 4	During LWA6	0.4
	During LWA7	2.4
	During LWA8	1.5

5.8.3. Impact Assessments for the Powerlines

The cables along the 11 kV powerline branches are not affected by ground strains, as they are supported by the poles above ground level. The cables can, however, be affected by the changes in bay lengths, ie: the distances between the poles at the levels of the cables, which result from mining induced differential subsidence, horizontal ground movements and lateral movements at the tops of the poles due to tilting of the poles. The stabilities of the poles can also be affected by mining induced tilts and by changes in the catenary profiles of the cables.

The maximum upperbound systematic tilt along the alignments of the powerline branches, at any time during or after the extraction of the proposed longwalls, is 7.3 mm/m (ie: 0.7 %), or a change in grade of 1 in 135. The maximum upperbound systematic tilt across the alignments of the powerline branches, at any time during or after the extraction of the proposed longwalls, is 7.0 mm/m (ie: 0.7 %), or a change in grade of 1 in 145.

High tilts at the locations of poles could adversely impact the cable catenaries or could result in stability problems for the poles, especially the tension poles that are supported by guy ropes. Overhead powerlines can typically tolerate tilts of up to 20 mm/m at the locations of the poles without any significant impacts on the cables or poles. It is unlikely, therefore, that the maximum predicted or the maximum upperbound systematic tilts would result in any significant impacts on the powerlines.

The maximum upperbound systematic horizontal movement associated with the maximum upperbound systematic tilt at the powerline branches is 110 mm. If the maximum upperbound systematic tilt and maximum upperbound systematic horizontal movement were to occur at the location of a pole, the maximum upperbound horizontal movement at the top of the pole would be 200 mm. Based on a minimum bay length of 50 metres, the maximum upperbound horizontal movement at the tops of the poles would result in a change in bay length of less than 0.5 %. It is unlikely, therefore, that the maximum upperbound change in bay lengths would result in any significant impacts on the powerlines.

5.8.4. Impact Assessments for the Powerlines Based on Increased Predictions

If the predicted systematic subsidence parameters at the powerlines were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the powerlines. It is unlikely that the upperbound systematic subsidence parameters at the powerlines would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound systematic tilt and maximum upperbound systematic horizontal movement anywhere above the proposed longwalls of 10 mm/m and 150 mm, respectively, were to occur at the location of a pole, the changes in bay lengths would still be less than 1 % of the original bay lengths and unlikely, therefore, to result in any significant impacts on the powerlines.

5.8.5. Recommendations for the Powerlines

The assessed impacts on the 11 kV powerlines resulting from the predicted and upperbound systematic subsidence parameters can be managed with the implementation of suitable management strategies.

It is recommended that the 11 kV powerlines should be inspected by a suitably qualified person prior to being mined beneath, to assess the existing conditions of the powerlines and to determine whether any preventive measures are required. The powerlines should be visually monitored as each longwall mines beneath them, so that any impacts can be identified and rectified immediately. It is also recommended that management strategies are developed, in consultation with Energy Australia, so that the powerlines can be maintained in a safe and serviceable condition throughout the mining period.

5.9. Optical Fibre Cable

The location of the optical fibre cable is shown in Drawing No. MSEC309-10. The predicted and upperbound subsidence parameters and impact assessments for the optical fibre cable are provided in the following sections.

5.9.1. Predicted Subsidence Parameters for the Optical Fibre Cable

The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignment of the optical fibre cable, resulting from the extraction of the proposed longwalls, are shown in Fig. H.13 in Appendix H. A summary of the maximum predicted cumulative systematic subsidence and strains along the alignment of the optical fibre cable, after the extraction of each of the proposed longwalls, is provided in Table 5.22.

Table 5.22 Maximum Predicted Cumulative Systematic Subsidence and Strains along the Alignment of the Optical Fibre Cable after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
Optical Fibre Cable	After LWA7	65	0.1	< 0.1
	After LWA8	580	0.2	0.7
	After LWA9	1375	0.7	1.4
	After LWA10	1695	0.6	1.5
	After LWA11	1810	0.6	1.4
	After LWA12	1885	0.6	1.4
	After LWA13	1900	0.6	1.4
	After LWA14	1905	0.6	1.4
	After LWA15	1905	0.6	1.4
	After LWA16	1905	0.6	1.4
	After LWA17	1905	0.6	1.4

The optical fibre cable will also be subjected to travelling strains where the extraction faces of the proposed longwalls pass beneath it. A summary of the maximum predicted travelling strains at the optical fibre cable, during the extraction of each of the proposed longwalls, is provided in Table 5.23.

Table 5.23 Maximum Predicted Travelling Strains at the Optical Fibre Cable during the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
Optical Fibre Cable	During LWA8	0.2	0.2
	During LWA9	0.4	0.3
	During LWA10	0.4	0.3
	During LWA11	0.4	0.3
	During LWA12	0.4	0.3
	During LWA13	0.3	0.3
	During LWA14	0.2	0.2
	During LWA17	0.3	0.2

5.9.2. Upperbound Subsidence Parameters for the Optical Fibre Cable

The upperbound systematic subsidence parameters for the optical fibre cable have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The upperbound profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignment of the optical fibre cable, resulting from the extraction of the proposed longwalls, are shown in Fig. I.13 in Appendix I. A summary of the maximum upperbound cumulative systematic subsidence and strains along the alignment of the optical fibre cable, after the extraction of each of the proposed longwalls, is provided in Table 5.24.

Table 5.24 Maximum Upperbound Cumulative Systematic Subsidence and Strains along the Alignment of the Optical Fibre Cable after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Upperbound Cumulative Subsidence (mm)	Maximum Upperbound Cumulative Tensile Strain (mm/m)	Maximum Upperbound Cumulative Compressive Strain (mm/m)
Optical Fibre Cable	After LWA7	115	0.1	< 0.1
	After LWA8	825	0.3	0.9
	After LWA9	2085	0.9	2.2
	After LWA10	2600	0.8	2.5
	After LWA11	2865	0.9	2.4
	After LWA12	2985	1.0	2.4
	After LWA13	3015	1.0	2.4
	After LWA14	3020	1.0	2.4
	After LWA15	3020	1.0	2.4
	After LWA16	3020	1.0	2.4
	After LWA17	3020	1.0	2.4

A summary of the maximum upperbound travelling strains at the optical fibre cable, during the extraction of each of the proposed longwalls, is provided in Table 5.25.

Table 5.25 Maximum Upperbound Travelling Strains at the Optical Fibre Cable during the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Upperbound Travelling Tensile Strain (mm/m)	Maximum Upperbound Travelling Compressive Strain (mm/m)
Optical Fibre Cable	During LWA8	0.3	0.2
	During LWA9	0.6	0.5
	During LWA10	0.6	0.4
	During LWA11	0.6	0.4
	During LWA12	0.5	0.4
	During LWA13	0.5	0.4
	During LWA14	0.3	0.2
	During LWA17	0.4	0.3

5.9.3. Impact Assessments for the Optical Fibre Cable

The optical fibre cable within the Study Area is direct buried and, therefore, will not be affected by the tilts resulting from the extraction of the proposed longwalls. The cable, however, is likely to experience the ground strains resulting from the extraction of the proposed longwalls.

The maximum upperbound systematic tensile and compressive strains at the optical fibre cable, at any time during or after the extraction of the proposed longwalls, are 1.0 mm/m and 2.5 mm/m, respectively. The minimum radii of curvature associated with the maximum upperbound systematic tensile and compressive strains are 15 kilometres and 6.0 kilometres, respectively.

Elevated compressive strains are also likely to occur where the optical fibre cable crosses the creeks and drainage lines within the Study Area. The maximum upperbound closure at the creek and drainage line crossings is 30 mm, which occurs where the optical fibre cable crosses Sandy Creek above Longwall A17. It is expected, therefore, that the maximum compressive strain due to the upperbound closure movement would be less than the maximum upperbound systematic compressive strain.

Based on previous experience of mining beneath optical fibre cables in the past, it has been found that optical fibre cables can typically tolerate tensile strains of up to 4 mm/m without significant impact. It is expected, therefore, that the optical fibre cable could tolerate the predicted and upperbound systematic tensile strains resulting from the extraction of the proposed longwalls.

The tensile strains in the optical fibre cable, however, can be higher where the cable connects to the support structures, which may act as anchor points, preventing any differential movements that may have been allowed to occur with the ground. Tree roots have also been known to anchor cables to the ground. The extent to which the anchor points affect the ability of the cable to tolerate the mine subsidence movements depends on the cable size, type, age, installation method and ground conditions.

In addition to this, optical fibre cables contain additional fibre lengths over the sheath length, where the individual fibres are loosely contained within tubes. Compression of the sheath can transfer to the loose tubes and fibres and result in "micro-bending" of the fibres constrained within the tubes, leading to higher attenuation of the transmitted signal. If the maximum predicted or maximum upperbound systematic compressive strains were to be fully transferred into the optical fibre cable, the strains may be of sufficient magnitude to result in the reduction in the capacity of the cable or transmission loss.

It is recommended that the optical fibre cable is monitored during the extraction of the proposed longwalls using optical fibre sensing techniques, such as Optical Time Domain Reflector (OTDR) monitoring. Preventive measures can be undertaken, such as excavating and exposing the cable, if a strain concentration is detected during mining. With the required preventive measures in place, it is expected that the optical fibre cable can be maintained in a serviceable condition throughout the mining period.

5.9.4. Impact Assessments for the Optical Fibre Cable Based on Increased Predictions

If the predicted systematic subsidence parameters at the optical fibre cable were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the cable. It is unlikely that the upperbound systematic subsidence parameters at the cable would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound systematic tensile and compressive strains anywhere above the proposed longwalls of 1.2 mm/m and 3.0 mm/m, respectively, were to occur at the optical fibre cable, it would still be unlikely that any significant impact would occur on the cable. It would be possible, however, that strain concentrations could occur at any anchor points along the cable during the extraction of the proposed longwalls. It is expected, however, that the cable could be maintained in a serviceable condition by monitoring and the implementation of suitable preventive measures if a strain concentration is detected.

5.9.5. Recommendations for the Optical Fibre Cable

It is recommended that the optical fibre cable is monitored during the extraction of the proposed longwalls using optical fibre sensing techniques, such as Optical Time Domain Reflector (OTDR) monitoring. It is also recommended that Austar establish management strategies, in consultation with Telstra, for the protection of the optical fibre cable as the longwalls are mined. With these strategies in place, it is expected that the optical fibre cable can be maintained in a serviceable condition throughout the mining period.

5.10. Aerial Copper Telecommunications Cables

The locations of the aerial copper telecommunications cables within the Study Area are shown in Drawing No. MSEC309-10. The aerial cables within the Study Area follow the alignment of Sandy Creek Road. The predicted and upperbound subsidence parameters and impact assessments for the aerial copper telecommunications cables within the Study Area are provided in the following sections.

5.10.1. Predicted Subsidence Parameters for the Aerial Copper Cables

The predicted profiles of incremental and cumulative systematic subsidence and tilt along the alignment of the main aerial copper telecommunications cables are similar to those for Sandy Creek Road, which are shown in Fig.H.05 in Appendix H. A summary of the maximum predicted cumulative systematic subsidence and tilts along and across the alignment of the main aerial copper telecommunications cables, after the extraction of each of the proposed longwalls, is provided in Table 5.26.

Table 5.26 Maximum Predicted Cumulative Systematic Subsidence Parameters at the Main Aerial Copper Telecommunications Cables after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt along Alignment (mm/m)	Maximum Predicted Cumulative Tilt across Alignment (mm/m)
Main Aerial Copper Cables	After LWA16	< 20	< 0.1	0.2
	After LWA17	140	0.4	1.0

5.10.2. Upperbound Subsidence Parameters for the Aerial Copper Cables

The upperbound systematic subsidence parameters for the aerial main copper telecommunications cables have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The upperbound profiles of incremental and cumulative systematic subsidence and tilt along the alignment of the aerial main copper telecommunications cables are similar to those for Sandy Creek Road, which are shown in Fig. I.05 in Appendix I. A summary of the maximum upperbound cumulative systematic subsidence and tilts along and across the alignment of the main aerial copper telecommunications cables, after the extraction of each of the proposed longwalls, is provided in Table 5.27.

Table 5.27 Maximum Upperbound Cumulative Systematic Subsidence Parameters at the Main Aerial Copper Telecommunication Cables after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Upperbound Cumulative Subsidence (mm)	Maximum Upperbound Cumulative Tilt along Alignment (mm/m)	Maximum Upperbound Cumulative Tilt across Alignment (mm/m)
Aerial Main Copper Cables	After LWA16	< 20	0.1	0.3
	After LWA17	205	0.6	1.3

5.10.3. Impact Assessments for the Aerial Copper Cables

The aerial copper telecommunication cables are not affected by ground strains, as they are supported by the poles above ground level. The cables can, however, be affected by the tilting of the poles, which affects the catenary profiles of the cables.

The maximum upperbound systematic tilt at the aerial main copper telecommunication cables, at any time during or after the extraction of the proposed longwalls, is 1.3 mm/m (ie: 0.1 %), or a change in grade of 1 in 770. The maximum upperbound tilt is less than 1 % and is unlikely, therefore, to result in any significant impacts on the aerial main copper telecommunication cables along Sandy Creek Road.

5.10.4. Impact Assessments for the Aerial Copper Cables Based on Increased Predictions

If the predicted systematic subsidence parameters at the aerial main copper telecommunication cables were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the cables. It is unlikely that the upperbound systematic subsidence parameters at the cables would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

Even if the upperbound tilt at the cables were increased by a factor of 2 times, the change in grade would still be less than 1 % and unlikely, therefore, to result in any significant impacts on the aerial main copper telecommunication cables along Sandy Creek Road.

5.10.5. Recommendations for the Aerial Copper Cables

The assessed impacts on the aerial main copper telecommunication cables resulting from the predicted and upperbound systematic subsidence parameters are not significant. It is recommended, however, that the cables are visually monitored during the extraction of Longwall A17.

It is also recommended that management strategies are developed, in consultation with Telstra, so that the serviceability of the aerial copper telecommunication cables can be maintained throughout the mining period.

5.11. Direct Buried Copper Telecommunications Cables

The locations of the direct buried copper telecommunications cables within the Study Area are shown in Drawing No. MSEC309-10. The direct buried local copper cables within the Study Area generally follow the alignments of Sandy Creek Road, Quorrobolong Road, Coney Creek Road and Nash Lane. The direct buried consumer copper cables connect the local copper cables to the rural properties. The predicted and upperbound subsidence parameters and impact assessments for the direct buried copper telecommunications cables within the Study Area are provided in the following sections.

5.11.1. Predicted Subsidence Parameters for the Copper Cables

The predicted profiles of systematic subsidence and strain along the alignments of the direct buried copper telecommunication cables are similar to those along the alignments of Sandy Creek Road, Quorrobolong Road and Coney Creek Road / Nash Lane, which are shown in Figs. H.05, H.06 and H.07, respectively, in Appendix H. A summary of the maximum predicted cumulative systematic subsidence and strains along the alignments of the direct buried copper telecommunication cables, after the extraction of each of the proposed longwalls, is provided in Table 5.28.

Table 5.28 Maximum Predicted Cumulative Systematic Subsidence and Strains along the Direct Buried Copper Cables Resulting from the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
Direct Buried Copper Cables near Sandy Creek Road	After LWA15	650	0.4	0.4
	After LWA16	1200	0.5	0.5
	After LWA17	1395	0.5	0.6
Direct Buried Copper Cables near Quorrobolong Road and Nash Lane	After LWA6	250	0.3	0.3
Direct Buried Copper Cables near Coney Creek Road	After LWA8	420	0.1	0.2
	After LWA9	1325	0.6	1.0
	After LWA10	1645	0.5	1.1
	After LWA11	1740	0.6	1.1
	After LWA12	1815	0.6	1.1
	After LWA13	1885	0.6	1.1
	After LWA17	1900	0.6	1.1

The direct buried copper telecommunication cables will also be subjected to travelling strains where the extraction faces of the proposed longwalls pass beneath them. A summary of the maximum predicted travelling strains at the cables, during the extraction of each of the proposed longwalls, is provided in Table 5.29.

Table 5.29 Maximum Predicted Travelling Strains at the Direct Buried Copper Cables during the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
Direct Buried Copper Cables near Sandy Creek Road	During LWA15	0.2	0.1
	During LWA16	0.2	0.2
	During LWA17	0.3	0.2
Direct Buried Copper Cables near Quorrobolong Road and Nash Lane	During LWA6	0.1	0.1
Direct Buried Copper Cables near Coney Creek Road	During LWA9	0.4	0.3
	During LWA10	0.4	0.3
	During LWA11	0.4	0.3
	During LWA12	0.4	0.3
	During LWA13	0.3	0.2

5.11.2. Upperbound Subsidence Parameters for the Copper Cables

The upperbound systematic subsidence parameters at the direct buried copper telecommunication cables have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The upperbound profiles of systematic subsidence and strain along the alignments of the direct buried copper telecommunication cables are similar to those along the alignments of Sandy Creek Road, Quorrobolong Road and Coney Creek Road / Nash Lane, which are shown in Figs. I.05, I.06 and I.07, respectively, in Appendix I. A summary of the maximum upperbound cumulative systematic subsidence and strains along the direct buried copper telecommunication cables, after the extraction of each of the proposed longwalls, is provided in Table 5.30.

Table 5.30 Maximum Upperbound Cumulative Systematic Subsidence and Strains along the Direct Buried Copper Cables after the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Upperbound Cumulative Subsidence (mm)	Maximum Upperbound Cumulative Tensile Strain (mm/m)	Maximum Upperbound Cumulative Compressive Strain (mm/m)
Direct Buried Copper Cables near Sandy Creek Road	After LWA15	925	0.6	0.5
	After LWA16	1735	0.6	0.8
	After LWA17	2020	0.6	0.9
Direct Buried Copper Cables near Quorrobolong Road and Nash Lane	After LWA6	560	0.7	0.4
Direct Buried Copper Cables near Coney Creek Road	After LWA8	605	0.1	0.3
	After LWA9	2005	0.9	1.7
	After LWA10	2515	0.6	2.0
	After LWA11	2715	0.8	1.9
	After LWA12	2845	0.8	1.9
	After LWA13	2935	0.8	1.9
	After LWA17	2965	0.8	1.9

A summary of the maximum upperbound travelling strains at the direct buried copper telecommunication cables, during the extraction of each of the proposed longwalls, is provided in Table 5.31.

Table 5.31 Maximum Upperbound Travelling Strains at the Direct Buried Copper Cables during the Extraction of Each of the Proposed Longwalls

Location	Longwall	Maximum Upperbound Travelling Tensile Strain (mm/m)	Maximum Upperbound Travelling Compressive Strain (mm/m)
Direct Buried Copper Cables near Sandy Creek Road	During LWA15	0.2	0.2
	During LWA16	0.3	0.3
	During LWA17	0.3	0.3
Direct Buried Copper Cables near Quorrobolong Road and Nash Lane	During LWA6	0.1	0.1
Direct Buried Copper Cables near Coney Creek Road	During LWA9	0.6	0.4
	During LWA10	0.6	0.4
	During LWA11	0.6	0.4
	During LWA12	0.5	0.4
	During LWA13	0.5	0.4

5.11.3. Impact Assessments for the Direct Buried Copper Telecommunication Cables

The local and consumer copper telecommunication cables are direct buried and are unlikely, therefore, to be impacted by tilt. The cables, however, are likely to experience the ground strains resulting from the extraction of the proposed longwalls.

The maximum upperbound systematic tensile and compressive strains at the direct buried copper telecommunication cables, at any time during or after the extraction of the proposed longwalls, are 0.9 mm/m and 2.0 mm/m, respectively. The minimum radii of curvature associated with the maximum upperbound systematic tensile and compressive strains are 17 kilometres and 7.5 kilometres, respectively. Modern copper cables can, in some cases, tolerate tensile strains of up to 20 mm/m, without impact.

It is unlikely, therefore, that the direct buried copper telecommunication cables would be impacted as a result of the extraction of the proposed longwalls, based on the predicted and on the upperbound systematic strains. It is possible, however, that the cables could experience locally elevated tensile strains where they are anchored to the ground by associated infrastructure, or by tree roots. It is unlikely at the magnitudes of the predicted and upperbound systematic strains, however, that there would be any significant impact on the copper cables at any anchor points.

5.11.4. Impact Assessments for the Direct Buried Copper Cables Based on Increased Predictions

If the predicted systematic subsidence parameters at the direct buried copper telecommunication cables were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the cables. It is unlikely that the upperbound systematic subsidence parameters at the cables would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound systematic tensile and compressive strains anywhere above the proposed longwalls of 1.2 mm/m and 3.0 mm/m, respectively, were to occur at the copper telecommunication cables, it would still be unlikely to result in any impact on the cables, as the strains would still be much less than 20 mm/m.

5.11.5. Recommendations for the Copper Cables

The assessed impacts on the copper telecommunication cables resulting from the predicted and upperbound systematic subsidence parameters are not significant.

It is recommended that management strategies are developed, in consultation with Telstra, so that the serviceability of the direct buried copper telecommunication cables can be maintained throughout the mining period.

5.12. Predictions and Impact Assessments for the Quorrobolong Telephone Exchange

The location of the Quorrobolong Telephone Exchange is shown in Drawing No. MSEC309-10. The building is located outside the Study Area and is unlikely, therefore, to be subjected to any significant systematic subsidence movements resulting from the extraction of the proposed longwalls.

The building could be subjected to small far-field horizontal movements resulting from the extraction of the proposed longwalls. Far-field horizontal movements have, in the past, been observed more than 1 kilometre from longwall extractions, however, these movements tend to be bodily movements which are not associated with any significant strains. It is unlikely, therefore, that the Quorrobolong Telephone Exchange would be impacted by far-field horizontal movements resulting from the extraction of the proposed longwalls.

5.13. Rural Building Structures

A total of 80 rural building structures (Structure Type R) have been identified within the Study Area, which include farm sheds, garages and other non-residential structures. The locations of the rural building structures are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and details are provided in Tables G.01 to G.05 in Appendix G. The predicted and upperbound subsidence parameters and impact assessments for the rural building structures within the Study Area are provided in the following sections.

5.13.1. Predicted Subsidence Parameters for the Rural Building Structures

Predictions of systematic subsidence, tilt, curvature and strain have been made at the centroid and at the vertices of each rural building structure, as well as eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

At these points, the maximum predicted values of systematic subsidence, tilt, curvature and strain have been determined, during and after the extraction of each of the proposed longwalls, for each rural building structure. An additional strain of 0.2 mm/m has been added to the magnitude of the predicted strains, where the predicted subsidence is greater than 20 mm, to account for the scatter which is generally observed in strain profiles.

The maximum predicted systematic subsidence parameters for each rural building structure within the Study Area are provided in Tables G.01 and G.02. A summary of the number of rural building structures within various ranges of predicted systematic subsidence and tilts, after the extraction of each of the proposed longwalls, is provided in Table 5.32. A summary of the number of rural building structures within various ranges of predicted systematic curvatures and strains, after the extraction of each of the proposed longwalls, is provided in Table 5.33.

Table 5.32 Summary of the Maximum Predicted Systematic Subsidence and Tilts for the Rural Building Structures within the Study Area after the Extraction of Each Proposed Longwall

Longwall	Predicted Subsidence (mm)						Predicted Tilt (mm/m)			
	< 500	≥ 500 & < 1000	≥ 1000 & < 1500	≥ 1500 & < 2000	≥ 2000 & < 2500	≥ 2500	< 5	≥ 5 & < 7	≥ 7 & < 10	≥ 10
After LWA6	80	0	0	0	0	0	80	0	0	0
After LWA7	80	0	0	0	0	0	80	0	0	0
After LWA8	80	0	0	0	0	0	80	0	0	0
After LWA9	80	0	0	0	0	0	80	0	0	0
After LWA10	75	4	1	0	0	0	79	1	0	0
After LWA11	73	2	0	5	0	0	78	2	0	0
After LWA12	69	2	3	6	0	0	80	0	0	0
After LWA13	68	2	3	7	0	0	80	0	0	0
After LWA14	68	1	3	8	0	0	79	1	0	0
After LWA15	68	1	3	8	0	0	79	1	0	0
After LWA16	63	1	8	8	0	0	79	1	0	0
After LWA17	63	1	7	9	0	0	79	1	0	0

Table 5.33 Summary of the Maximum Predicted Systematic Curvatures and Strains for the Rural Building Structures within the Study Area after the Extraction of Each Proposed Longwall

Longwall	Predicted Curvature (1/km)				Predicted Systematic Strain (mm/m)					
	< 0.05	≥ 0.05 & < 0.10	≥ 0.10 & < 0.15	≥ 0.15	< 0.25	≥ 0.25 & < 0.5	≥ 0.5 & < 1.0	≥ 1.0 & < 1.5	≥ 1.5 & < 2.0	≥ 2.0
After LWA6	80	0	0	0	67	13	0	0	0	0
After LWA7	80	0	0	0	67	13	0	0	0	0
After LWA8	80	0	0	0	66	14	0	0	0	0
After LWA9	80	0	0	0	60	20	0	0	0	0
After LWA10	78	2	0	0	58	17	5	0	0	0
After LWA11	77	3	0	0	52	21	5	2	0	0
After LWA12	77	3	0	0	51	16	11	2	0	0
After LWA13	77	3	0	0	51	15	12	2	0	0
After LWA14	77	3	0	0	51	15	12	2	0	0
After LWA15	77	3	0	0	45	17	16	2	0	0
After LWA16	77	3	0	0	40	21	17	2	0	0
After LWA17	77	3	0	0	27	25	26	2	0	0

It can be seen from Table 5.32, that no rural building structures are assessed to experience a predicted tilt greater than 7 mm/m. It can be seen from Table 5.33, that no rural building structures are assessed to experience a predicted systematic strain greater than 1.5 mm/m. It is possible, however, that some rural building structures could experience strains greater than 1.5 mm/m, due to anomalous non-systematic movements, which is discussed further in the impact assessments for the rural building structures.

5.13.2. Upperbound Subsidence Parameters for the Rural Building Structures

The upperbound systematic subsidence parameters at the rural building structures have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The maximum upperbound systematic subsidence parameters for each rural building structure within the Study Area are provided in Tables G.03 and G.04. A summary of the number of rural building structures within various ranges of upperbound subsidence and tilts, after the extraction of each of the proposed longwalls, is provided in Table 5.34. A summary of the number of rural building structures within various ranges of upperbound systematic curvatures and strains, after the extraction of each of the proposed longwalls, is provided in Table 5.35.

Table 5.34 Summary of the Maximum Upperbound Systematic Subsidence and Tilts for the Rural Building Structures within the Study Area after the Extraction of Each Proposed Longwall

Longwall	Upperbound Subsidence (mm)						Upperbound Tilt (mm/m)			
	< 500	≥ 500 & < 1000	≥ 1000 & < 1500	≥ 1500 & < 2000	≥ 2000 & < 2500	≥ 2500	< 5	≥ 5 & < 7	≥ 7 & < 10	≥ 10
After LWA6	80	0	0	0	0	0	80	0	0	0
After LWA7	80	0	0	0	0	0	80	0	0	0
After LWA8	80	0	0	0	0	0	80	0	0	0
After LWA9	80	0	0	0	0	0	80	0	0	0
After LWA10	75	0	4	1	0	0	75	4	1	0
After LWA11	73	0	2	0	5	0	78	0	2	0
After LWA12	67	2	2	2	2	5	74	6	0	0
After LWA13	66	3	1	2	1	7	74	6	0	0
After LWA14	66	2	1	2	2	7	74	5	1	0
After LWA15	62	6	1	2	2	7	73	6	1	0
After LWA16	60	3	1	7	1	8	74	5	1	0
After LWA17	60	3	1	5	3	8	74	5	1	0

Table 5.35 Summary of the Maximum Upperbound Systematic Curvatures and Strains for the Rural Building Structures within the Study Area after the Extraction of Each Proposed Longwall

Longwall	Upperbound Curvature (1/km)				Upperbound Systematic Strain (mm/m)					
	< 0.05	≥ 0.05 & < 0.10	≥ 0.10 & < 0.15	≥ 0.15	< 0.25	≥ 0.25 & < 0.5	≥ 0.5 & < 1.0	≥ 1.0 & < 1.5	≥ 1.5 & < 2.0	≥ 2.0
After LWA6	80	0	0	0	64	14	2	0	0	0
After LWA7	80	0	0	0	64	14	2	0	0	0
After LWA8	80	0	0	0	62	16	2	0	0	0
After LWA9	80	0	0	0	57	21	2	0	0	0
After LWA10	78	2	0	0	55	18	5	2	0	0
After LWA11	74	3	3	0	49	20	5	2	3	1
After LWA12	73	4	3	0	48	17	8	3	3	1
After LWA13	72	5	3	0	44	20	7	5	3	1
After LWA14	72	5	3	0	40	24	7	5	3	1
After LWA15	72	5	3	0	36	23	12	5	3	1
After LWA16	69	8	3	0	35	23	13	5	3	1
After LWA17	69	8	3	0	18	29	23	6	3	1

It can be seen from Table 5.34, that one rural building structure is assessed to experience an upperbound tilt greater than 7 mm/m, at the completion of the proposed longwalls, and that no rural building structures are assessed to experience an upperbound tilt greater than 10 mm/m at any time.

It can be seen from Table 5.35, that one rural building structure is assessed to experience an upperbound systematic strain greater than 2 mm/m. It is also possible, however, that some rural building structures could experience strains greater than 2 mm/m, due to anomalous non-systematic movements, which is discussed further in the impact assessments for the rural building structures.

5.13.3. Impact Assessments for the Rural Building Structures

The majority of the rural building structures within the Study Area are of lightweight construction. It has been found from past longwall mining experience, that tilts less than 10 mm/m (ie: Category A to Category C) generally do not result in any significant impacts on rural building structures.

It is unlikely, therefore, that the maximum predicted or the maximum upperbound tilts at the rural building structures within the Study Area would be of sufficient magnitude to result in any significant impacts on the stability of these structures. It is possible, however, that the larger upperbound tilts could result in some minor serviceability impacts, including door swings and issues with roof gutter and pavement drainage. It is expected, however, that any impacts on the rural building structures as the result of tilts of these magnitudes could remediated using normal building maintenance techniques.

The maximum predicted systematic strains at the rural building structures within the Study Area, at any time during or after the extraction of the proposed longwalls, vary between 0.9 mm/m tension and 1.3 mm/m compression. The maximum upperbound systematic strains at the rural building structures within the Study Area, at any time during or after the extraction of the proposed longwalls, vary between 1.1 mm/m tension and 2.2 mm/m compression.

The distribution of the maximum predicted systematic strains at the rural building structures, resulting from the extraction of the proposed longwalls, is provided Fig. 5.1. The distribution of the maximum upperbound systematic strains at the rural building structures, resulting from the extraction of the proposed longwalls, is provided Fig. 5.2.

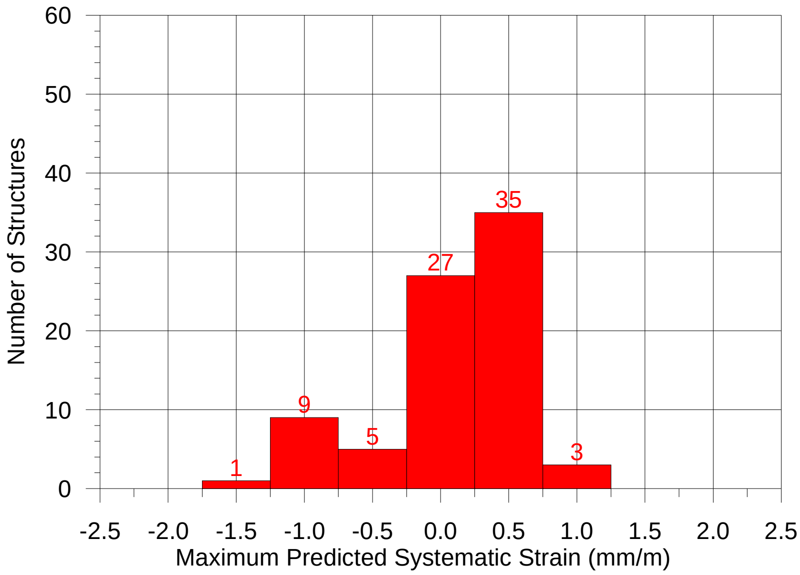

Fig. 5.1 Distribution of the Maximum Predicted Systematic Strains at the Rural Building Structures within the Study Area Resulting from the Extraction of the Proposed Longwalls

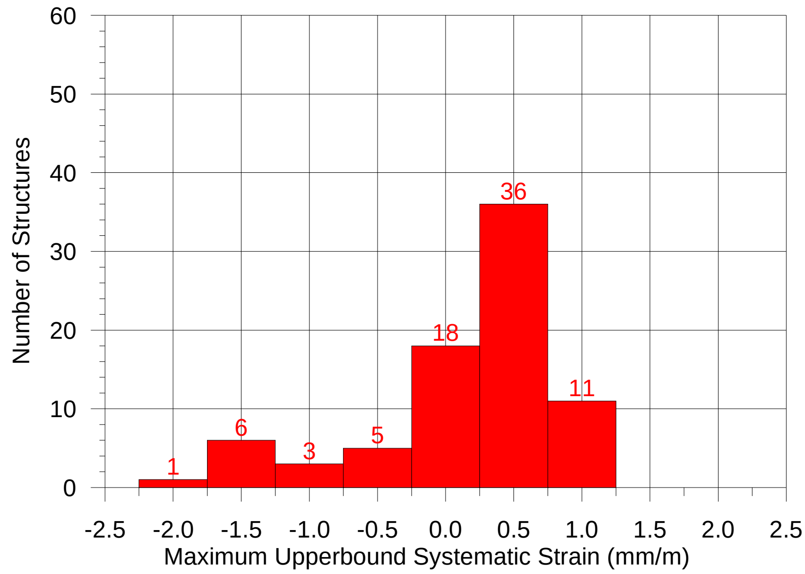

Fig. 5.2 Distribution of the Maximum Upperbound Systematic Strains at the Rural Building Structures within the Study Area Resulting from the Extraction of the Proposed Longwalls

As highlighted in Section 4.7, the confidence levels assigned to the prediction of strain at a point are less than those assigned to the prediction of subsidence and tilt at a point. It is likely, therefore, that the actual strains for some rural building structures will be greater than those predicted and that the actual strains for other rural building structures will be less than those predicted. It is also likely, that some rural building structures would experience tension, where compression was predicted, and visa versa. It is expected, however, that the overall range of actual systematic strains at the rural building structures within the Study Area would be similar to that predicted.

The assessed strain impacts on the rural building structures have been determined using the method outline in Appendix E. The distribution of the assessed strain impacts for the rural building structures within the Study Area, based on the predicted systematic subsidence parameters, is provided Fig. 5.3. The distribution of the assessed strain impacts for the rural building structures within the Study Area, based on the upperbound systematic subsidence parameters, is provided Fig. 5.4.

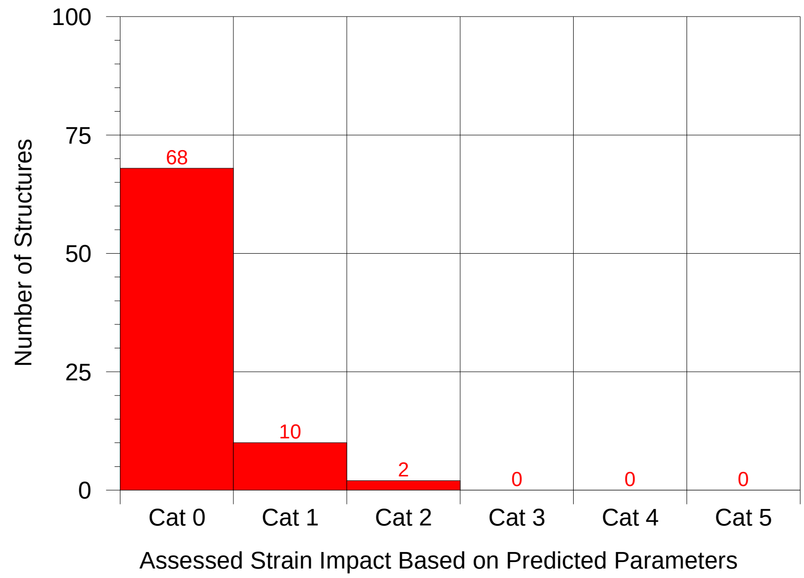

Fig. 5.3 Distribution of the Assessed Strain Impacts for the Rural Building Structures within the Study Area Based on the Predicted Systematic Subsidence Parameters

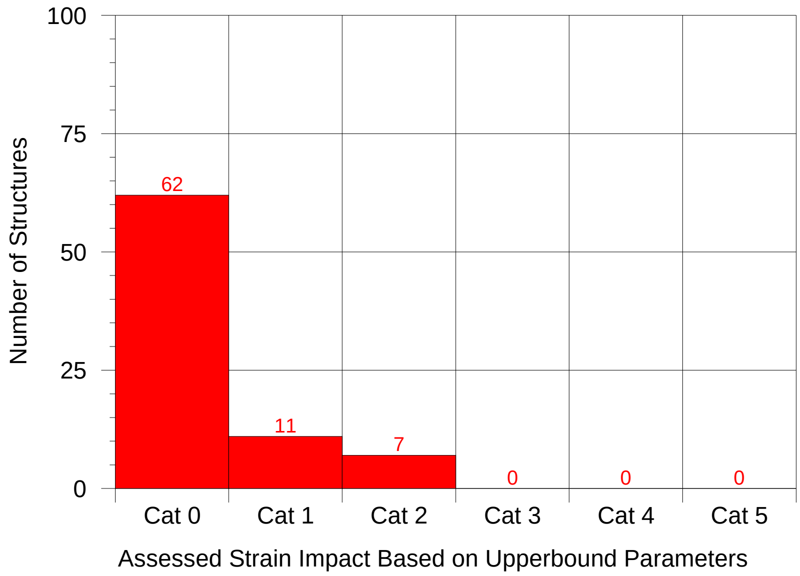

Fig. 5.4 Distribution of the Assessed Strain Impacts for the Rural Building Structures within the Study Area Based on the Upperbound Systematic Subsidence Parameters

Based on the predicted systematic subsidence parameters, it has been assessed that ten rural building structures within the Study Area (ie: 13 % of the total) could experience very slight impacts (ie: Category 1) and two rural building structures (ie: 3 % of total) could experience slight impacts (ie: Category 2) as a result of the extraction of the proposed longwalls.

Based on the upperbound systematic subsidence parameters, it has been assessed that 11 rural building structures within the Study Area (ie: 14 % of the total) could experience very slight impacts (ie: Category 1) and seven rural building structures (ie: 9 % of total) could experience slight impacts (ie: Category 2) as a result of the extraction of the proposed longwalls.

It is expected, however, that any impacts on the rural building structures as the result of systematic strains of these magnitudes could be remediated using normal building maintenance techniques.

It is also possible, that some rural building structures within the Study Area could experience strains greater than those predicted as the result of non-systematic anomalous movements, due to near surface geological features, the locations of which cannot be predicted prior to mining. The likelihood of impacts resulting from non-systematic movements can only be assessed by considering past longwall mining experience.

The maximum predicted systematic tensile and compressive strains resulting from the extraction of the proposed Longwalls A6 to A17 are similar to the maximum predicted systematic tensile and compressive strains resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B, which were 0.7 mm/m and 1.7 mm/m, respectively.

At the time of writing this report, the longwalls at Tahmoor Colliery had mined directly beneath or adjacent to approximately 800 houses, rural building structures and public amenities. To date, there have been no reported impacts on the rural building structures resulting from the extraction of the longwalls at Tahmoor Colliery. Less than 1 % of all building structures (including the houses and public amenities) at Tahmoor Colliery had reported impacts that were assessed as moderate or greater (ie: Category 3 or greater), which were considered to have occurred as the result of non-systematic anomalous movements. In two of these cases (ie: 0.3 % of all building structures), the impacts were substantial and the costs to repair these structures were deemed to be greater than the costs to rebuild these structures.

The maximum upperbound systematic tensile and compressive strains resulting from the extraction of the proposed Longwalls A6 to A17 are, however, greater than the maximum predicted systematic tensile and compressive strains resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B. If the upperbound strains were fully realised, the likelihood of impacts resulting from systematic subsidence movements would increase accordingly, as illustrated by Fig. 5.3 and Fig. 5.4, however, the likelihood of impacts resulting from non-systematic anomalous movements would not significantly increase. The reason for this is that impacts resulting from non-systematic anomalous movements are governed by the coincidence of near surface geological features with the rural building structures, rather than by relatively small increases in the systematic subsidence parameters.

The observations at Tahmoor Colliery provide a valuable empirical guide to the level of impact that could occur as the result of the extraction of the proposed Austar Longwalls A6 to A17. While specific subsidence predictions have been provided for each structure within the Study Area, these should only be used as guide to the overall level of impact on the structures. The predictions for individual structures do not include, for example, the impacts resulting from non-systematic anomalous movement. Based on the observations at Tahmoor Colliery, the expected incidence of anomalous movements being coincident with structures is less than 1 % of the total number of structures directly mined beneath.

It is noted that further research is currently being conducted by MSEC on the impacts of longwall mining on building structures as part of an ACARP research project. It is hoped that the findings of this research will be available by the time a SMP Application is lodged for the proposed Austar Longwalls A6 to A17.

It is expected that any impacts on the rural building structures that occur as the result of the extraction of the proposed longwalls could be remediated using well established building techniques. With these remediation measures in place, it is unlikely that there would be any significant impacts on rural building structures resulting from the extraction of the proposed longwalls.

5.13.4. Impact Assessments for the Rural Building Structures Based on Increased Predictions

If the predicted systematic subsidence parameters at the rural building structures were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the rural building structures. It is unlikely that the upperbound systematic subsidence parameters at the rural building structures would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound systematic tilt anywhere above the proposed longwalls of 10 mm/m were to occur at the rural building structures, it is possible that these structures would experience minor serviceability impacts, including door swings and issues with roof gutter and pavement drainage. It would still be unlikely that stabilities of these rural building structures would be affected at this magnitude of tilt.

If the maximum upperbound systematic tensile and compressive strains anywhere above the proposed longwalls of 1.2 mm/m and 3.1 mm/m, respectively, were to occur at the rural building structures, it is likely that these structures would experience slight or moderate impacts. It would still be expected, however, that all rural building structures would remain in safe conditions throughout the mining period and that any impacts could be remediated using well established building techniques.

5.13.5. Recommendations for the Rural Building Structures

The assessed impacts on the rural building structures resulting from the predicted and upperbound systematic subsidence parameters can be managed with the implementation of suitable management strategies.

It is recommended that each rural building structure above the proposed longwalls should be inspected, prior to being mined beneath, to assess the existing condition and whether any preventive measures may be required. It is also recommended that the rural building structures are visually monitored during the extraction of the proposed longwalls.

5.14. Tanks

There are a number of larger tanks (Structure Type T) which have been identified within the Study Area, which include water and fuel storage tanks. The locations of these tanks are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and details are provided in Tables G.01 to G.05 in Appendix G. In addition to this, there are also a number of smaller rainwater and fuel storage tanks associated with the residences on each rural property which are not shown in the drawings or in the tables. The predicted and upperbound subsidence parameters and impact assessments for the tanks within the Study Area are provided in the following sections.

5.14.1. Predicted Subsidence Parameters for the Tanks

Predictions of subsidence, tilt and strain have been made at the centroid of each identified tank, as well as eight equally spaced points placed radially around the perimeter of each tank at a distance of 20 metres.

The maximum predicted systematic tilt at the identified tanks, after the completion of any of the proposed longwalls, is 4.0 mm/m (ie: 0.4 %), or a change in grade of 1 in 250. The maximum predicted systematic tensile and compressive strains at the identified tanks, at any time during or after the extraction of the proposed longwalls, are 0.8 mm/m and 1.3 mm/m, respectively, and the associated minimum radii of curvature 19 kilometres and 12 kilometres, respectively.

The maximum predicted systematic subsidence parameters at the tanks associated with the residences are similar to those at residences themselves, as these parameters are the maximum predicted values within 20 metres of these structures.

The maximum predicted systematic tilt at the tanks associated with the residences, after the completion of any of the proposed longwalls, is 5.6 mm/m (ie: 0.6 %), or a change in grade of 1 in 180. The maximum predicted systematic tensile and compressive strains at the tanks associated with the residences, at any time during or after the extraction of the proposed longwalls, are 0.8 mm/m and 1.1 mm/m, respectively, and the associated minimum radii of curvature 19 kilometres and 14 kilometres, respectively.

5.14.2. Upperbound Subsidence Parameters for the Tanks

The upperbound systematic subsidence parameters at the tanks have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The maximum upperbound systematic tilt at the identified tanks, after the completion of any of the proposed longwalls, is 6.9 mm/m (ie: 0.7 %), or a change in grade of 1 in 145. The maximum upperbound systematic tensile and compressive strains at the identified tanks, at any time during or after the extraction of the proposed longwalls, are 1.0 mm/m and 2.0 mm/m, respectively, and the associated minimum radii of curvature 15 kilometres and 7.5 kilometres, respectively.

The maximum upperbound systematic subsidence parameters at the tanks associated with the residences are similar to those at residences themselves, as these parameters are the maximum upperbound values within 20 metres of these structures.

The maximum upperbound systematic tilt at the tanks associated with the residences, after the completion of any of the proposed longwalls, is 8.0 mm/m (ie: 0.8 %), or a change in grade of 1 in 125. The maximum upperbound systematic tensile and compressive strains at the tanks associated with the residences, at any time during or after the extraction of the proposed longwalls, are 1.1 mm/m and 1.9 mm/m, respectively, and the associated minimum radii of curvature 14 kilometres and 7.9 kilometres, respectively.

5.14.3. Impact Assessments for the Tanks

Tilt can affect the serviceability of tanks by altering the water or fuel levels in the tanks, which can in turn affect the minimum level of water or fuel which can be released from the taps. The maximum upperbound systematic tilt at the tanks within the Study Area of 8.0 mm/m represents a change in grade of less than 1 % and is unlikely, therefore, to have any significant impact on the serviceability of the tanks.

The maximum upperbound systematic tensile and compressive strains at the tanks are 1.1 mm/m and 2.0 mm/m, respectively. The ground strains are unlikely to be transferred into the tanks where the tanks are founded on a ground slab or on the natural ground. In these cases, it is unlikely that the tanks would be impacted by the predicted or upperbound systematic strains.

It is possible, however, that buried water pipelines associated with the tanks within the Study Area could be impacted by the predicted and upperbound systematic strains if they are anchored by the tanks, or by other structures in the ground. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be easily repaired. With any necessary remediation measures implemented, it would be unlikely that there would be any significant impacts on the pipelines associated with the tanks.

5.14.4. Impact Assessments for the Tanks Based on Increased Predictions

If the predicted systematic subsidence parameters at the tanks were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the tanks. It is unlikely that the upperbound systematic subsidence parameters at the tanks would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound systematic tilt anywhere above the proposed longwalls of 10 mm/m were to occur at the tanks, the maximum change in grade at the tanks would be 1 % and unlikely, therefore, to have any significant impact on the serviceability of the tanks.

If the maximum upperbound systematic tensile and compressive strains anywhere above the proposed longwalls of 1.2 mm/m and 3.0 mm/m, respectively, were to occur at the tanks, the potential impacts on the buried water pipelines associated with the tanks would increase accordingly. It would still be unlikely that there would be any significant impacts on the tanks themselves, where the tanks are founded on a ground slab or on the natural ground.

5.14.5. Recommendations for the Tanks

The assessed impacts on the tanks resulting from the predicted and upperbound systematic subsidence parameters can be managed with the implementation of suitable management strategies. It is recommended that the tanks are visually monitored during the mining period.

5.15. Fences

There are a number of fences within the Study Area which are constructed in a variety of ways, generally using either timber or metal materials. Wire fences could be affected by tilting of the fence posts and changes of tension in the fence wires due to strain as mining occurs. Wire fences are generally flexible in construction and can usually tolerate tilts of up to 10 mm/m and strains of up to 5 mm/m without any significant impact.

The fences are located across the Study Area and are likely to be subjected to the full range of systematic subsidence parameters. The maximum predicted systematic subsidence parameters within the Study Area are summarised in Table 4.1 to Table 4.3. The maximum upperbound systematic subsidence parameters within the Study Area are summarised in Table 4.4 and Table 4.6.

The maximum upperbound systematic tilt within the Study Area is 10 mm/m (ie: 1.0 %), or a change in gradient of 1 in 100, which occurs above the proposed Longwall A7 after the extraction of the proposed Longwall A8. It is possible that the fences above the proposed Longwall A7 could be impacted by the upperbound systematic tilts. It is also possible that the fences elsewhere above the proposed longwalls could be impacted by the upperbound systematic tilts, where the fence posts have high existing tilts.

The maximum upperbound systematic tensile and compressive strains within the Study Area are 1.2 mm/m and 3.0 mm/m, respectively. The maximum upperbound systematic tensile strain occurs above the proposed Longwall A7 and the maximum upperbound systematic compressive strain occurs above the chain pillar between the proposed Longwalls A7 and A8. The maximum upperbound systematic strains are less than 5 mm/m and are unlikely, therefore, to have a significant impact on the fences.

Any impacts on the fences that occur as the result of mining are likely to be of a minor nature and relatively easy to rectify by re-tensioning the fencing wires, straightening the fence posts, and if necessary, replacing some sections of fencing.

If the predicted systematic subsidence parameters at the fences were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the fences. It is unlikely that the upperbound systematic subsidence parameters at the fences would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

The assessed impacts on the fences resulting from the predicted and upperbound systematic subsidence parameters can be managed with the implementation of suitable management strategies.

5.16. Farm Dams

There are 134 farms dams identified within the Study Area, the locations of which are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and details are provided in Table G.06 in Appendix G. The predicted and upperbound subsidence parameters and impact assessments for the farm dams within the Study Area are provided in the following sections.

5.16.1. Predicted Subsidence Parameters for the Farm Dams

Predictions of systematic subsidence, tilt and strain have been made at the centroid and around the perimeters of each farm dam, as well as eight equally spaced points placed radially around the centroid and around points on the dam perimeters at a distance of 20 metres.

The maximum predicted values of systematic subsidence, tilt and strain have been determined during and after the extraction of each of the proposed longwalls. The maximum predicted systematic subsidence parameters at each farm dam are provided in Table G.06 in Appendix G and are summarised in Fig. 5.5, Fig. 5.6 and Fig. 5.7 below.

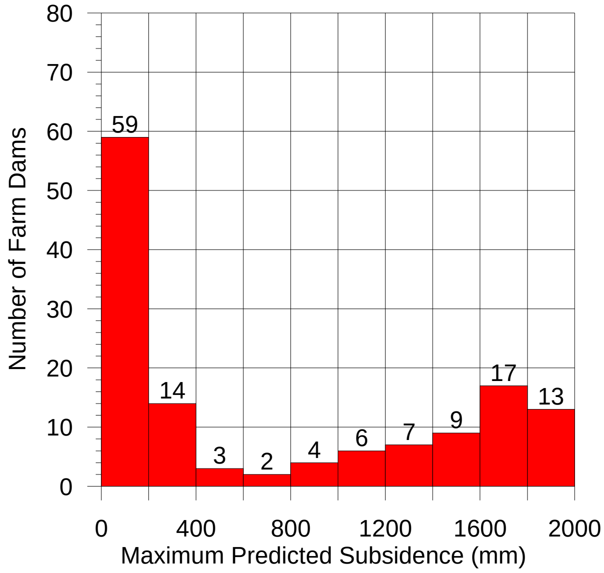

Fig. 5.5 Maximum Predicted Total Systematic Subsidence at the Farm Dams Resulting from the Extraction of the Proposed Longwalls

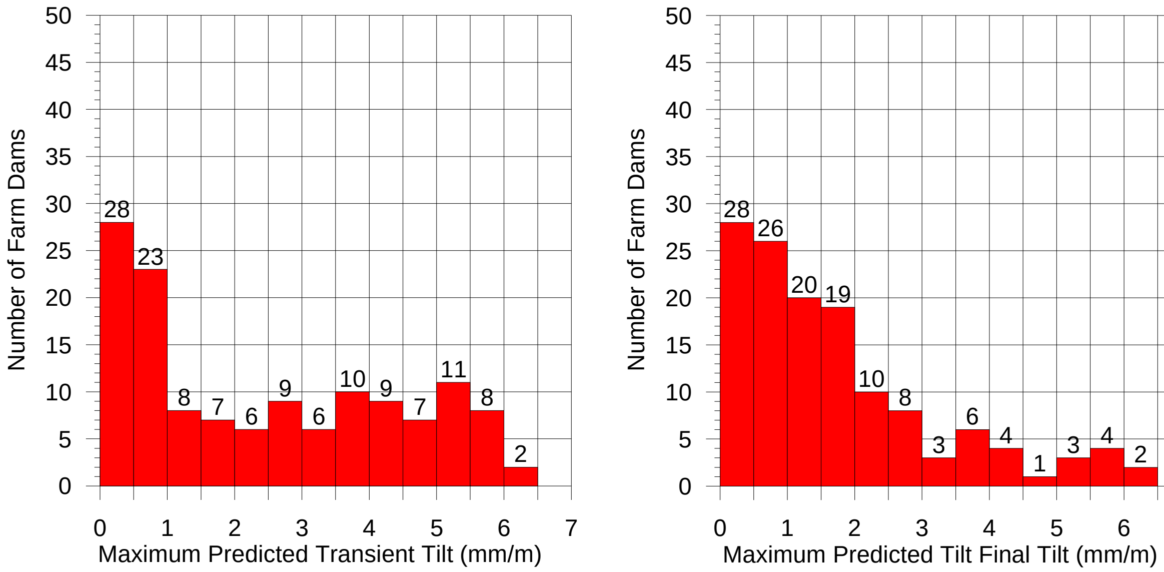

Fig. 5.6 Maximum Predicted Travelling and Cumulative Tilt (Left) and Maximum Predicted Total Tilt (Right) at the Farm Dams Resulting from the Extraction of the Proposed Longwalls

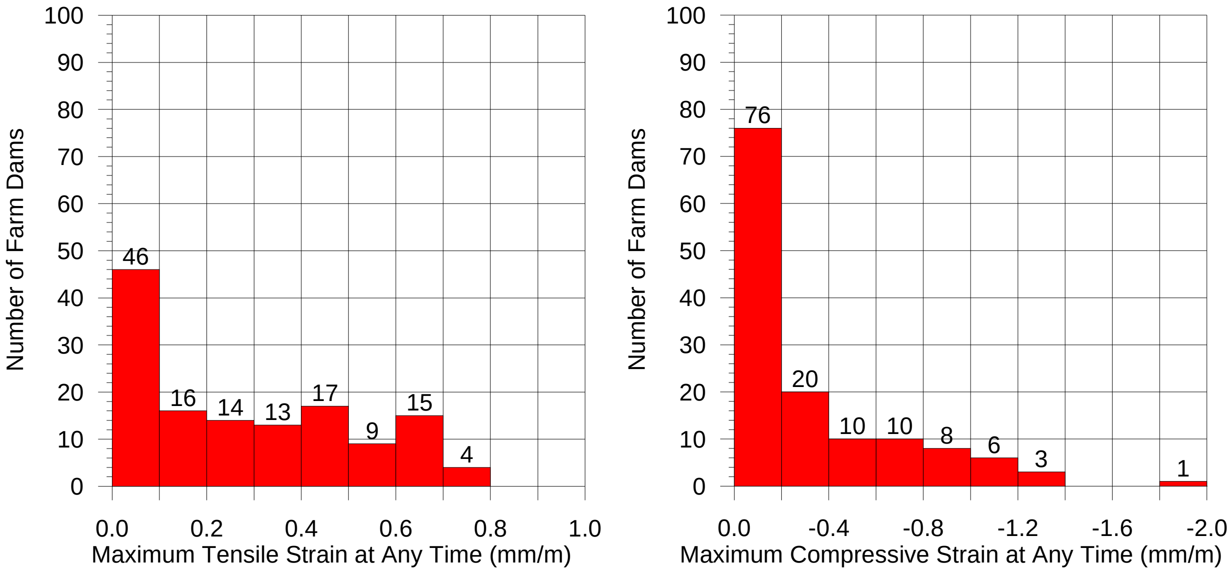

Fig. 5.7 Maximum Predicted Systematic Tensile Strain (Left) and Compressive Strain (Right) at the Farm Dams Resulting from the Extraction of the Proposed Longwalls

The dams have typically been constructed within drainage lines and, therefore, may be subjected to valley related movements resulting from the extraction of the proposed longwalls. The equivalent valley heights at the dams are very small and the predicted valley related upsidence and closure movements at the dam walls are likely, therefore, to be much less than the predicted systematic subsidence movements.

5.16.2. Upperbound Subsidence Parameters for the Farm Dams

The upperbound systematic subsidence parameters at the farm dams have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The maximum upperbound values of systematic subsidence, tilt and strain have been determined during and after the extraction of each of the proposed longwalls. The maximum upperbound systematic subsidence parameters at each farm dam are provided in Table G.06 in Appendix G and are summarised in Fig. 5.8, Fig. 5.9 and Fig. 5.10 below.

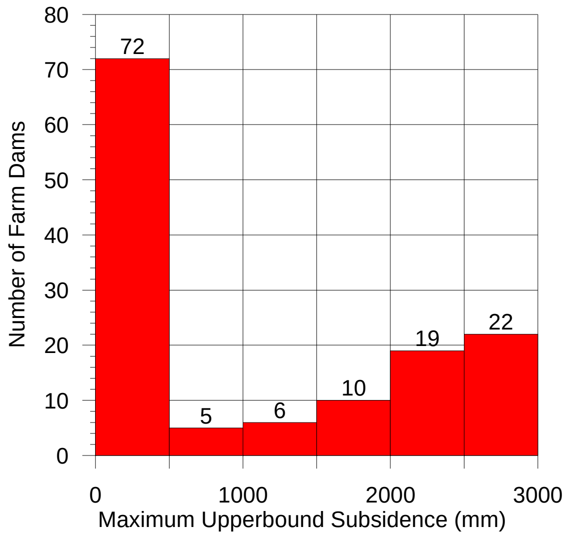

Fig. 5.8 Maximum Upperbound Systematic Subsidence at the Farm Dams Resulting from the Extraction of the Proposed Longwalls

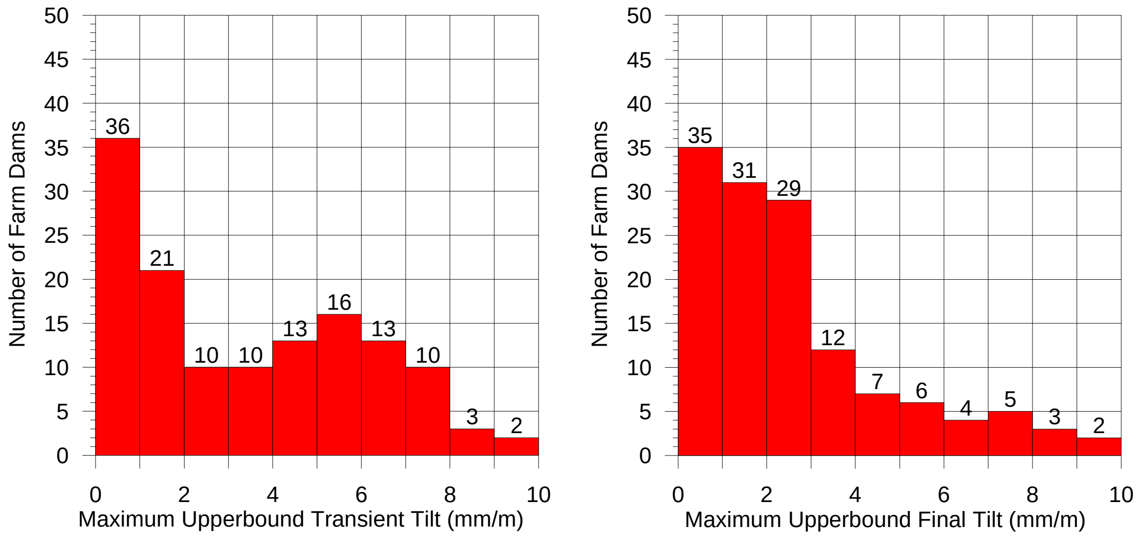

Fig. 5.9 Maximum Upperbound Systematic Tilt at the Farm Dams at Any Time (Left) and at the Completion (Right) of the Proposed Longwalls

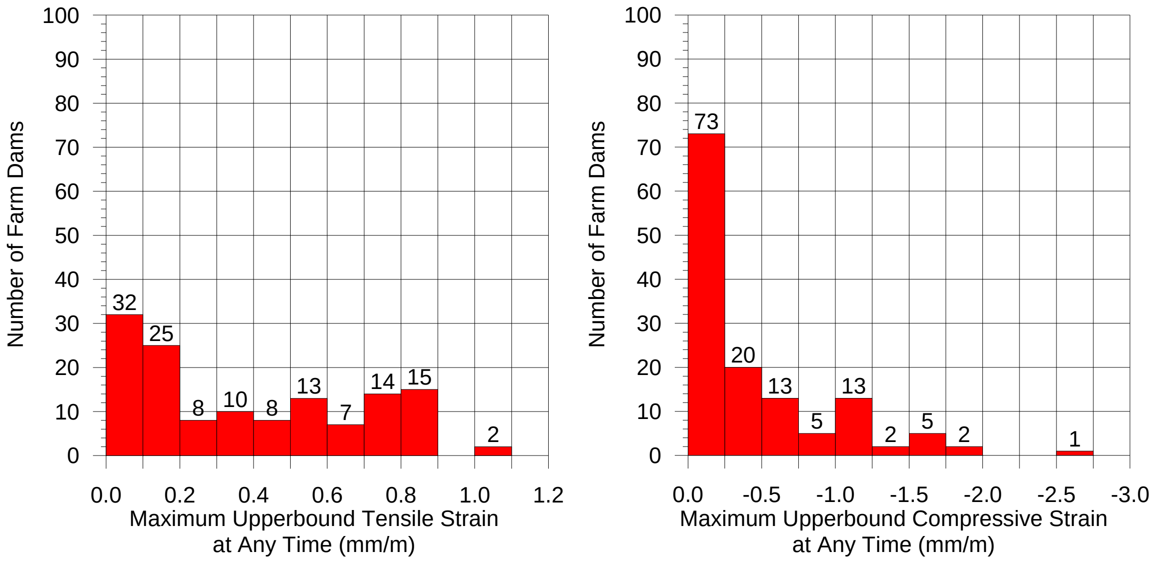

Fig. 5.10 Maximum Upperbound Systematic Tensile Strain (Left) and Compressive Strain (Right) at the Farm Dams Resulting from the Extraction of the Proposed Longwalls

5.16.3. Impact Assessments for the Farm Dams

The maximum predicted systematic tilt at the farm dams, at any time during or after the extraction of the proposed longwalls, is 6.1 mm/m (ie: 0.6 %), or a change in grade in 1 in 165. The maximum upperbound systematic tilt at the farm dams, at any time during or after the extraction of the proposed longwalls, is 9.3 mm/m (ie: 0.9 %), or a change in grade of 1 in 110.

Mining induced tilts can affect the water levels around the perimeters of farm dams, with the freeboard increasing on one side, and decreasing on the other. Tilt can potentially reduce the storage capacity of farm dams, by causing them to overflow, or can affect the stability of the dam walls.

The maximum predicted changes in freeboard at the farm dams within the Study Area were conservatively determined by applying the maximum predicted systematic tilts along the longest sides of the dams. The maximum upperbound changes in freeboard at the farm dams within the Study Area were conservatively determined by applying the maximum upperbound systematic tilts along the longest sides of the dams. The maximum predicted and maximum upperbound changes in freeboard at the farm dams are summarised in Table G.06.

The maximum predicted change in freeboard at the farm dams is 430 mm, which occurs at Dam A35d01 after the extraction of the proposed Longwall A9. The maximum upperbound change in freeboard at the farm dams is 640 mm, which also occurs at Dam A35d01 after the extraction of the proposed Longwall A9. The maximum predicted and upperbound changes in freeboard are less than 1000 mm and are unlikely, therefore, to have a significant impact on the stability of the dam walls. It is possible, however, that the larger changes in freeboard could result in reductions in the capacities of the farm dams, where the maximum tilts increase the water levels at the dam walls.

The maximum upperbound systematic tensile and compressive strains at the farm dams, at any time during or after the extraction of the proposed longwalls, are 1.0 mm/m and 2.7 mm/m, respectively. The minimum radii of curvature associated with the maximum upperbound systematic tensile and compressive strains at the farm dams are 15 kilometres and 5.6 kilometres, respectively.

Farm dams, such as those identified within the Study Area, are typically constructed of cohesive soils with reasonably high clay content. The walls of the farm dams should be capable of withstanding tensile strains of up to 3 mm/m without impact, because of their inherent elasticity. It is unlikely, therefore, that the maximum predicted and maximum upperbound systematic strains would result in any significant impact on the farm dams.

It is possible, however, that some minor cracking and leakage of water may occur in the farm dam walls that are subjected to the higher strains, though any minor cracking or leakage can be easily identified and repaired as required. It is not expected that any significant loss of water will occur from the farm dams, and any loss that did occur would flow into the tributary in which the dam was formed.

There is a possibility that high concentrations of strain could occur at faults, fissures and other geological features, or points of weaknesses in the strata, and such occurrences could be coupled with localised stepping in the surface. If this type of phenomenon coincided with a farm dam wall, then, there is a possibility that an impact on the dam could occur, but the likelihood of this occurring is very small.

5.16.4. Impact Assessments for the Farm Dams Based on Increased Predictions

If the predicted systematic subsidence parameters at the farm dams were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the farm dams. It is unlikely that the upperbound systematic subsidence parameters at the farm dams would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound tilt anywhere above the proposed longwalls of 10 mm/m were to occur at the farm dams, the changes in freeboard at the dam walls would increase accordingly. The maximum change in grade at the dam walls would be approximately 1 % and unlikely, therefore, to result in any significant impact on the stability of the dam walls.

If the maximum upperbound systematic tensile and compressive strains anywhere above the proposed longwalls of 1.2 mm/m and 3.0 mm/m, respectively, were to occur at the farm dams, the likelihood and extent of cracking in the dam walls would increase accordingly. As the maximum systematic tensile strain is still less than 3 mm/m, any cracking in the dam walls would still expected to be of a minor nature and easily repaired.

With any necessary remediation measures implemented, it is unlikely that any significant impact on the farm dams would occur resulting from the extraction of the proposed longwalls.

5.16.5. Recommendations for the Farm Dams

The assessed impacts on the farm dams resulting from the predicted and upperbound systematic subsidence parameters can be managed with the implementation of suitable management strategies. It is recommended that all water retaining structures be visually monitored during the extraction of the proposed longwalls, to ensure that they remain in a safe and serviceable condition.

5.17. Predictions and Impact Assessments for the Groundwater Bores

There is one registered groundwater bore within the general Study Area, being Ref. GW038372, the location of which is shown in Drawing No. MSEC309-20. The bore is located on the edge of the Study Area and is unlikely, therefore, to be subjected to any significant systematic subsidence movements resulting from the extraction of the proposed longwalls.

The groundwater bores in the vicinity of the Study Area may be affected by far-field horizontal movements, which can occur up to 2 or 3 kilometres from the proposed longwalls. The locations of the groundwater bores in the vicinity of the proposed longwalls are shown in Drawing No. MSEC309-20. Differential horizontal movements at different strata horizons could reduce the capacities of these groundwater bores, or increase the ingress of water into the bores at different strata horizons.

The work summary sheets for these groundwater bores indicate that they are low yielding and the water quality is poor. There are no known bores yielding water that is used by the property holders within the Study Area. The assessed impact on the groundwater bores within the Study Area is, therefore, not significant.

5.18. Archaeological Sites

There are a number of archaeological sites which have been identified within the Study Area, including a number of artefact scatters, isolated finds and potential archaeological deposits, as well as one grinding groove site. The locations of the archaeological sites within the Study Area are shown in Drawing No. MSEC309-21. The predictions and impact assessments for the archaeological sites within the Study Area are provided in the following sections.

5.18.1. Predicted Subsidence Parameters for the Archaeological Sites

The artefact scatters, isolated finds and potential archaeological deposits are located across the Study Area and are likely, therefore, to be subjected to the full range of predicted systematic subsidence movements. The maximum predicted systematic subsidence parameters, resulting from the extraction of the proposed longwalls, are provided in Section 4.2.

The grinding groove site is located above the chain pillar between Longwalls A7 and A8, towards the western ends of these longwalls. A summary of the maximum predicted systematic subsidence parameters at the grinding groove site, at any time during or after the extraction of each of the proposed longwalls, is provided in Table 5.36.

Table 5.36 Maximum Predicted Systematic Subsidence Parameters at the Grinding Groove Site Resulting from the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Tensile Strain (mm/m)	Maximum Predicted Compressive Strain (mm/m)
After LWA6	< 20	< 0.1	< 0.1	< 0.1
After LWA7	335	1.5	0.2	0.1
After LWA8	1320	2.8	0.5	1.8
After LWA9	1430	3.5	0.5	1.9
After LWA17	1445	3.6	0.5	1.9

The values provided in the above table are the maximum predicted systematic subsidence parameters within 20 metres of the grinding groove site.

The grinding groove site is located near the base of a small tributary and could, therefore, experience valley related upsidence and closure movements resulting from the extraction of the proposed longwalls. A summary of the maximum predicted upsidence and closure movements at the grinding groove site, after the extraction of each of the proposed longwalls, is provided in Table 5.37.

Table 5.37 Maximum Predicted Upsidence and Closure Movements at the Grinding Groove Site Resulting from the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Predicted Upsidence (mm)	Maximum Predicted Closure (mm)
After LWA6	< 20	< 20
After LWA7	25	35
After LWA8	95	70
After LWA9	115	80
After LWA17	115	80

5.18.2. Upperbound Subsidence Parameters for the Archaeological Sites

The artefact scatters, isolated finds and potential archaeological deposits could be subjected to the full range of upperbound systematic subsidence movements. The maximum upperbound systematic subsidence parameters, resulting from the extraction of the proposed longwalls, are provided in Section 4.3.

The upperbound systematic subsidence parameters at the grinding groove site have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6. A summary of the maximum upperbound systematic subsidence parameters at the grinding groove site, at any time during or after the extraction of each of the proposed longwalls, is provided in Table 5.38.

Table 5.38 Maximum Upperbound Systematic Subsidence Parameters at the Grinding Groove Site Resulting from the Extraction of the Proposed Longwalls

Site	Maximum Upperbound Subsidence (mm)	Maximum Upperbound Tilt (mm/m)	Maximum Upperbound Tensile Strain (mm/m)	Maximum Upperbound Compressive Strain (mm/m)
After LWA6	< 20	< 0.1	< 0.1	< 0.1
After LWA7	565	2.4	0.3	0.2
After LWA8	2130	4.2	0.8	2.5
After LWA9	2320	5.2	0.8	2.6
After LWA17	2345	5.3	0.8	2.6

The values provided in the above table are the maximum upperbound systematic subsidence parameters within 20 metres of the grinding groove site.

A summary of the maximum upperbound upsidence and closure movements at the grinding groove site, after the extraction of each of the proposed longwalls, is provided in Table 5.39.

Table 5.39 Maximum Upperbound Upsidence and Closure Movements at the Grinding Groove Site Resulting from the Extraction of the Proposed Longwalls

Longwall	Maximum Upperbound Upsidence (mm)	Maximum Upperbound Closure (mm)
After LWA6	< 20	< 20
After LWA7	30	40
After LWA8	100	75
After LWA9	120	85
After LWA17	120	85

5.18.3. Impact Assessments for the Archaeological Sites

The sites comprising the artefact scatters, isolated finds and potential archaeological deposits can potentially be affected by cracking in the surface soils as a result of mine subsidence movements. It is unlikely, however, that the artefacts themselves would be impacted by surface cracking.

The maximum predicted systematic tensile and compressive strains within the Study Area, at any time during or after the extraction of the proposed longwalls, are 0.8 mm/m and 1.8 mm/m. The maximum upperbound systematic tensile and compressive strains within the Study Area, at any time during or after the extraction of the proposed longwalls, are 1.2 mm/m and 3.1 mm/m, respectively.

Tensile strains greater than 0.5 mm/m or compressive strains greater than 2 mm/m may be of sufficient magnitude to result in the fracturing of the uppermost bedrock. The maximum predicted and maximum upperbound systematic strains within the Study Area are likely, therefore, to be of sufficient magnitude to result in fracturing of the uppermost bedrock, which could result in surface cracking where the depths of cover to bedrock are shallow.

Surface cracking in soils as the result of systematic subsidence movements is not commonly seen at depths of cover greater than 500 metres, such as at Austar, and any cracking that has been observed has generally been isolated and of a minor nature. It would be expected, therefore, that any surface cracking that occurs in the vicinity of the artefact scatters, isolated finds and potential archaeological deposits would be of a minor nature due to the relatively small magnitudes of predicted and upperbound systematic strains and due to the relatively high depths of cover.

Minor surface tensile cracking is generally limited to the top few metres of the surface soils and tends to heal naturally. If any significant cracking in the soil were to occur and were to be left untreated, however, erosion channels could potentially develop. It is recommended that Austar seek the required approvals from the appropriate authorities, prior to the remediation of any surface cracking in the locations of the artefact scatters, isolated finds and potential archaeological deposits.

Further discussions on the artefact scatters, isolated finds and potential archaeological deposits and the potential impacts resulting from the extraction of the proposed longwalls on these sites are provided in the report by Umwelt (2008b).

The maximum predicted systematic tensile and compressive strains at the grinding groove site, at any time during or after the extraction of the proposed longwalls, are 0.5 mm/m and 1.9 mm/m. The maximum upperbound systematic tensile and compressive strains at the grinding groove site, at any time during or after the extraction of the proposed longwalls, are 0.8 mm/m and 2.6 mm/m, respectively.

Elevated compressive strains could also occur at the grinding groove site due to valley related upsidence and closure movements. The maximum upperbound upsidence and closure movements at the grinding groove site, resulting from the extraction of the proposed longwalls, are 120 mm and 85 mm, respectively.

The compressive strains resulting from valley related movements are more difficult to predict than systematic strains. It has been observed in the past, however, that compressive strains greater than 6 mm/m have occurred at the magnitude of the upperbound closure movement at the grinding groove site, as can be seen in Fig. D.22 in Appendix D.

As described previously, tensile strains greater than 0.5 mm/m or compressive strains greater than 2 mm/m may be of sufficient magnitude to result in the fracturing of the bedrock. It is possible, therefore, that the grinding groove site could be impacted if fracturing of the bedrock were to occur at the site.

Further discussions on the grinding groove site and the potential impacts resulting from the extraction of the proposed longwalls on this site are provided in the reports by and Umwelt (2008b).

5.19. Historical Sites

There are 11 historical sites within the Study Area, the locations of which are shown in Drawing No. MSEC309-21. The predictions and impact assessments for these sites are provided in the following sections.

The other historical sites located in the vicinity of the Study Area, including the quarry sites (Items 2 and 3), the cut tree (Item 11) and the tree stump (Item 12) are not expected to be subjected any significant systematic subsidence movements. The historical sites located outside the Study Area are not expected, therefore, to experience any significant impacts resulting from the extraction of the proposed longwalls.

5.19.1. Predicted Subsidence Parameters for the Historical Sites

A summary of the maximum predicted systematic subsidence parameters at the historical sites within the Study Area, at any time during or after the extraction of the proposed longwalls, is provided in Table 5.40.

Table 5.40 Maximum Predicted Systematic Subsidence Parameters at the Historical Sites Resulting from the Extraction of the Proposed Longwalls

Item	Site Type	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Tensile Strain (mm/m)	Maximum Predicted Compressive Strain (mm/m)
1	Bridge	35	0.3	< 0.1	< 0.1
4	Ford	145	1.2	< 0.1	< 0.1
5	Culvert 1	60	0.5	< 0.1	< 0.1
6	Culvert 2	80	0.8	0.1	< 0.1
7	Culvert 3	150	1.4	0.1	< 0.1
8	Artefact Scatter	50	0.5	< 0.1	< 0.1
9	Fencing 1	1865	5.1	0.6	0.9
10	Fencing 2	25	0.2	< 0.1	< 0.1
14	Potential House Site	1770	5.4	0.3	0.5
16	Homestead Site 1	45	0.4	< 0.1	< 0.1
17	Homestead Site 2	20	0.1	< 0.1	< 0.1

The values provided in the above table are the maximum predicted systematic subsidence parameters which occur at any time during or after the extraction of the proposed longwalls, within 20 metres of each historical site.

5.19.2. Upperbound Subsidence Parameters for the Historical Sites

The upperbound systematic subsidence parameters at the historical sites have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

A summary of the maximum upperbound systematic subsidence parameters at the historical sites, at any time during or after the extraction of the proposed longwalls, is provided in Table 5.41.

Table 5.41 Maximum Upperbound Systematic Subsidence Parameters at the Historical Sites Resulting from the Extraction of the Proposed Longwalls

Item	Site Type	Maximum Upperbound Subsidence (mm)	Maximum Upperbound Tilt (mm/m)	Maximum Upperbound Tensile Strain (mm/m)	Maximum Upperbound Compressive Strain (mm/m)
1	Bridge	60	0.5	< 0.1	< 0.1
4	Ford	210	1.8	< 0.1	< 0.1
5	Culvert 1	95	0.9	0.1	< 0.1
6	Culvert 2	130	1.3	0.1	< 0.1
7	Culvert 3	250	2.2	0.2	< 0.1
8	Artefact Scatter	95	1.0	0.2	< 0.1
9	Fencing 1	2760	7.0	0.7	1.3
10	Fencing 2	50	0.4	< 0.1	< 0.1
14	Potential House Site	2640	7.3	0.4	0.9
16	Homestead Site 1	85	0.8	0.1	< 0.1
17	Homestead Site 2	30	0.2	< 0.1	< 0.1

The values provided in the above table are the maximum upperbound systematic subsidence parameters which occur at any time during or after the extraction of the proposed longwalls, within 20 metres of each historical site.

5.19.3. Impact Assessments for the Historical Sites

The impact assessments for the historical sites are provided below. Further discussions on the historical sites and the potential impacts resulting from the extraction of the proposed longwalls are provided in the report by Umwelt (2008c).

Item 1 – Bridge Site

The *Bridge Site* (Ref. BR-QR01) is located 250 metres east of the proposed Longwall A6, at its closest point to the proposed longwalls. The maximum upperbound tilt at the bridge is 0.5 mm/m (ie: < 0.1 %), or a change in grade of 1 in 2000. The maximum upperbound systematic strains at the bridge are less than 0.1 mm/m and the associated minimum radii of curvature are greater than 150 kilometres.

As described in Section 5.6, the bridge could also be subjected to small valley related movements resulting from the extraction of the proposed longwalls. The maximum upperbound upsidence and closure movements at the bridge, after the extraction of the proposed longwalls, are both less than 20 mm.

The bridge is a timber structure, with three intermediate timber supports, having an overall span of approximately 22 metres. The bridge is of flexible construction and is expected, therefore, to accommodate these very small upperbound systematic and valley related movements without any significant impacts.

Items 4 & 8 – Ford Site and Artefact Scatter Site

The *Ford Site* comprises remnants of a ford crossing, including bricks, stone, lumps of pebble cement and timber planks. The *Artefact Scatter Site* comprises machine-made brick, glass, concrete, salt glazed ceramic services pipe and metal fragments.

The *Ford Site* and *Artefact Scatter Site* are located at distances of 440 metres west of proposed Longwall A16 and 510 metres north of proposed Longwall A7, respectively, at their closest points to the proposed longwalls. It is unlikely, at these distances, that any significant cracking in the surface soils and, hence, any significant impacts on these sites would occur as a result of the extraction of the proposed longwalls.

Items 5 to 7 – Culverts 1 to 3

The *Historical Culverts 1 to 3* are located at distances between 65 metres west and 115 metres south-west of the proposed Longwall A9, at their closest points to the proposed longwalls.

The maximum upperbound systematic tilt at the historical culverts is 2.2 mm/m (ie: 0.2 %), or a change in grade of 1 in 455. The maximum upperbound tilt is less than 1 % and is unlikely, therefore, to result in any significant impacts the serviceability of the historical culverts.

The maximum upperbound tensile and compressive strains at the historical culverts are 0.2 mm/m and less than 0.1 mm/m, respectively, and the associated minimum radii of curvature are 75 kilometres and greater than 150 kilometres, respectively. The maximum upperbound strains and the minimum radii of curvature are very small and are unlikely to result in any significant impacts on the historical culverts.

The historical culverts are located along drainage lines and could, therefore, experience some valley related upsidence and closure movements. The historical culverts are orientated along the drainage lines and since the upsidence and closure movements will be orientated perpendicular to the main axes of the culverts, they are unlikely to result in any significant impacts.

Items 9 & 10 – Fencing Sites 1 and 2

The *Fencing Sites 1 and 2* each comprise a single timber post. The maximum upperbound tilt at the fencing sites is 7.0 mm/m (ie: 0.7 %), or a change in grade of 1 in 143. The maximum upperbound tilting of the fence posts is less than 1 % and is not expected, therefore, to be noticeable to the human eye. The fence posts are not expected to be impacted by the upperbound ground strains, as the differential movements over the widths of the posts will be negligible.

Item 14 – Potential House Site

The *Potential House Site* is located above the proposed Longwall A14 and comprises brick rubble. There are no standing structures or foundations identified on the site. The site could potentially be affected by cracking in the surface soils as a result of mine subsidence movements. It is unlikely, however, that the brick rubble would be impacted by surface cracking.

Surface cracking in soils as the result of systematic subsidence movements is not commonly seen at depths of cover greater than 500 metres, such as at Austar, and any cracking that has been observed has generally been isolated and of a minor nature. It is recommended that Austar seek the required approvals from the appropriate authorities, prior to the remediation of any surface cracking in the location of the potential house site.

Items 16 & 17 – Homestead Sites 1 and 2

The *Homestead Sites 1 and 2* (Refs. A44a and A85a) are located at distances of 500 metres north of proposed Longwall A8 and 500 metres east of proposed Longwall A17, respectively, at their closest points to the proposed longwalls.

The maximum upperbound tilt at the homestead sites is 0.8 mm/m (ie: 0.1 %), or a change in grade of 1 in 1250. The maximum upperbound tilt at the homesteads is very small and is unlikely, therefore, to result in any significant impacts on the serviceability of the homesteads.

The maximum upperbound strain at the homestead sites is 0.1 mm/m tensile and the associated minimum radius of curvature is 150 kilometres. The maximum upperbound strain and curvature at the homesteads are very small and unlikely, therefore, to result in any significant impacts.

5.20. Survey Control Marks

There are eight survey control marks within the general Study Area, the locations of which are shown in Drawing No. MSEC309-20. There are a number of other survey control marks in the vicinity of the Study Area which are also shown in this drawing. The predicted and upperbound subsidence parameters and impact assessments for the survey control marks within the Study Area are provided in the following sections.

5.20.1. Predicted Subsidence Parameters for the Survey Control Marks

A summary of the maximum predicted values of total systematic subsidence and horizontal movements at the survey control marks within the general Study Area, after the extraction of all of the proposed longwalls, is provided in Table 5.42.

Table 5.42 Maximum Predicted Systematic Subsidence Parameters at the Survey Control Marks within the General Study Area Resulting from the Extraction of the Proposed Longwalls

Survey Mark	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Horizontal Movement (mm)
SS 89024	1020	85
SS 89025	20	< 5
PM 69715	60	10
PM 70277	160	15
PM 72586	85	10
PM 72587	20	< 5
PM 76248	< 5	< 5
PM 109448	5	< 5

The values provided in the above table are the maximum predicted systematic subsidence parameters which occur at any time during or after the extraction of the proposed longwalls, within 20 metres of each survey control mark.

5.20.2. Upperbound Subsidence Parameters for the Survey Control Marks

The upperbound systematic subsidence parameters at the survey control marks have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

A summary of the maximum upperbound values of total systematic subsidence and horizontal movements at the survey control marks within the general Study Area, after the extraction of all proposed longwalls, is provided in Table 5.43.

Table 5.43 Maximum Upperbound Systematic Subsidence Parameters at the Survey Control Marks within the General Study Area Resulting from the Extraction of the Proposed Longwalls

Survey Mark	Maximum Upperbound Total Subsidence (mm)	Maximum Upperbound Total Horizontal Movement (mm)
SS 89024	1535	125
SS 89025	30	< 5
PM 69715	85	15
PM 70277	230	25
PM 72586	120	15
PM 72587	30	< 5
PM 76248	10	< 5
PM 109448	10	< 5

The values provided in the above table are the maximum upperbound systematic subsidence parameters which occur at any time during or after the extraction of the proposed longwalls, within 20 metres of each survey control mark.

5.20.3. Impact Assessments for the Survey Control Marks

The survey control marks within the general Study Area are expected to experience the full range of predicted systematic subsidence movements. Other survey control marks in the vicinity of the proposed longwalls may also experience either small amounts of subsidence or some small far-field horizontal movements as the proposed longwalls are mined. It is possible that other marks outside the immediate area could also be affected by small far-field horizontal movements, more than 1 kilometre outside the general Study Area.

It will be necessary on completion of the proposed longwalls, when the ground has stabilised, to re-establish these marks. Consultation between Austar and the Department of Lands will be required throughout the mining period to ensure that these survey marks are reinstated at an appropriate time, as required.

5.20.4. Impact Assessments for the Survey Control Marks Based on Increased Predictions

If the predicted systematic subsidence parameters at the survey control marks were increased by factors of up to 2 times, the extent of the remediation measures would not significantly increase. If the predicted far-field horizontal movements were increased by factors up to 2 times, it is likely that additional survey control marks further afield would be affected and, therefore, could require re-establishment. It is anticipated that with appropriate remediation measures implemented, that there would be no significant impact on the survey marks as a result of the proposed mining.

5.20.5. Recommendations for the Survey Control Marks

It is recommended that management strategies are developed, in consultation with the Department of Lands, such that the survey control marks can be re-established, as required, at the appropriate time.

5.21. Houses

There are 32 houses located within the Study Area, of which 29 are single-storey houses with lengths less than 30 metres (Type H1) and three are single-storey houses with lengths greater than 30 metres (Type H2). There are no double-storey houses (Types H3 and H4) within the Study Area. The locations of the houses within the Study Area are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and details are provided in Tables G.01 to G.05 in Appendix G. The predicted and upperbound subsidence parameters and impact assessments for the houses within the Study Area are provided in the following sections.

5.21.1. Predicted Subsidence Parameters for the Houses

Predictions of systematic subsidence, tilt, curvature and strain have been made at the centroid and at the vertices of each house, as well as eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

At these points, the maximum predicted values of systematic subsidence, tilt, curvature and strain have been determined, during and after the extraction of each of the proposed longwalls, for each house. An additional strain of 0.2 mm/m has been added to the magnitude of the predicted strains, when the predicted subsidence is greater than 20 mm, to account for the scatter in observed strain profiles.

The maximum predicted systematic subsidence parameters for each house within the Study Area are provided in Tables G.01 and G.02. A summary of the number of houses within various ranges of predicted systematic subsidence and tilts, after the extraction of each of the proposed longwalls, is provided in Table 5.44. A summary of the number of houses within various ranges of predicted systematic curvatures and strains, after the extraction of each of the proposed longwalls, is provided in Table 5.45.

Table 5.44 Summary of the Maximum Predicted Subsidence and Tilts for the Houses within the Study Area after the Extraction of Each of the Proposed Longwalls

Longwall	Predicted Subsidence (mm)						Predicted Tilt (mm/m)			
	< 500	≥ 500 & < 1000	≥ 1000 & < 1500	≥ 1500 & < 2000	≥ 2000 & < 2500	≥ 2500	< 5	≥ 5 & < 7	≥ 7 & < 10	≥ 10
After LWA6	32	0	0	0	0	0	32	0	0	0
After LWA7	32	0	0	0	0	0	32	0	0	0
After LWA8	32	0	0	0	0	0	32	0	0	0
After LWA9	32	0	0	0	0	0	32	0	0	0
After LWA10	29	3	0	0	0	0	31	1	0	0
After LWA11	28	1	0	3	0	0	31	1	0	0
After LWA12	26	1	2	3	0	0	32	0	0	0
After LWA13	26	0	2	4	0	0	32	0	0	0
After LWA14	26	0	1	5	0	0	32	0	0	0
After LWA15	26	0	1	5	0	0	32	0	0	0
After LWA16	24	0	3	5	0	0	32	0	0	0
After LWA17	24	0	2	6	0	0	32	0	0	0

Table 5.45 Summary of the Maximum Predicted Systematic Curvatures and Strains for the Houses within the Study Area after the Extraction of Each of the Proposed Longwalls

Longwall	Predicted Curvature (1/km)				Predicted Systematic Strain (mm/m)					
	< 0.05	≥ 0.05 & < 0.10	≥ 0.10 & < 0.15	≥ 0.15	< 0.25	≥ 0.25 & < 0.5	≥ 0.5 & < 1.0	≥ 1.0 & < 1.5	≥ 1.5 & < 2.0	≥ 2.0
After LWA6	32	0	0	0	27	4	1	0	0	0
After LWA7	32	0	0	0	27	4	1	0	0	0
After LWA8	32	0	0	0	26	5	1	0	0	0
After LWA9	32	0	0	0	23	8	1	0	0	0
After LWA10	31	1	0	0	22	6	4	0	0	0
After LWA11	30	2	0	0	19	8	3	2	0	0
After LWA12	30	2	0	0	19	5	6	2	0	0
After LWA13	30	2	0	0	18	6	6	2	0	0
After LWA14	30	2	0	0	17	7	6	2	0	0
After LWA15	30	2	0	0	16	7	7	2	0	0
After LWA16	30	2	0	0	15	7	8	2	0	0
After LWA17	30	2	0	0	8	12	10	2	0	0

It can be seen from Table 5.44, that no houses are assessed to experience a predicted tilt greater than 7 mm/m. It can be seen from Table 5.45, that no houses are assessed to experience a predicted systematic strain greater than 1.5 mm/m. It is possible, however, that some houses could experience strains greater than 1.5 mm/m, due to anomalous non-systematic movements, which is discussed further in the impact assessments for the houses.

5.21.2. Upperbound Subsidence Parameters for the Houses

The upperbound systematic subsidence parameters at the houses have been determined by scaling up the predicted systematic subsidence parameters, such that a maximum total subsidence of 65 % of effective extracted seam height is achieved above the proposed longwalls, as discussed in Section 3.6.

The maximum upperbound systematic subsidence parameters for each house within the Study Area are provided in Tables G.03 and G.04. A summary of the number of houses within various ranges of upperbound subsidence and tilts, after the extraction of each of the proposed longwalls, is provided in Table 5.46. A summary of the number of houses within various ranges of upperbound systematic curvatures and strains, after the extraction of each of the proposed longwalls, is provided in Table 5.47.

Table 5.46 Summary of the Maximum Upperbound Systematic Subsidence and Tilts for the Houses within the Study Area after the Extraction of Each of the Proposed Longwalls

Longwall	Upperbound Subsidence (mm)						Upperbound Tilt (mm/m)			
	< 500	≥ 500 & < 1000	≥ 1000 & < 1500	≥ 1500 & < 2000	≥ 2000 & < 2500	≥ 2500	< 5	≥ 5 & < 7	≥ 7 & < 10	≥ 10
After LWA6	31	1	0	0	0	0	31	0	1	0
After LWA7	31	1	0	0	0	0	31	0	1	0
After LWA8	31	1	0	0	0	0	31	0	1	0
After LWA9	31	1	0	0	0	0	31	0	1	0
After LWA10	28	1	3	0	0	0	28	2	2	0
After LWA11	27	1	1	0	3	0	30	0	2	0
After LWA12	24	2	1	1	1	3	27	4	1	0
After LWA13	24	2	0	0	2	4	28	3	1	0
After LWA14	24	2	0	0	2	4	28	3	1	0
After LWA15	23	3	0	0	1	5	28	3	1	0
After LWA16	22	2	0	2	1	5	27	4	1	0
After LWA17	22	2	0	1	2	5	28	3	1	0

Table 5.47 Summary of the Maximum Upperbound Systematic Curvatures and Strains for the Houses within the Study Area after the Extraction of Each of the Proposed Longwalls

Longwall	Upperbound Curvature (1/km)				Upperbound Systematic Strain (mm/m)					
	< 0.05	≥ 0.05 & < 0.10	≥ 0.10 & < 0.15	≥ 0.15	< 0.25	≥ 0.25 & < 0.5	≥ 0.5 & < 1.0	≥ 1.0 & < 1.5	≥ 1.5 & < 2.0	≥ 2.0
After LWA6	32	0	0	0	26	4	1	1	0	0
After LWA7	32	0	0	0	26	4	1	1	0	0
After LWA8	32	0	0	0	25	5	1	1	0	0
After LWA9	32	0	0	0	22	8	1	1	0	0
After LWA10	31	1	0	0	20	7	3	2	0	0
After LWA11	28	2	2	0	18	7	2	3	1	1
After LWA12	27	3	2	0	18	5	4	3	1	1
After LWA13	27	3	2	0	17	6	3	4	1	1
After LWA14	27	3	2	0	16	7	3	4	1	1
After LWA15	27	3	2	0	15	7	4	4	1	1
After LWA16	27	3	2	0	14	7	5	4	1	1
After LWA17	27	3	2	0	7	12	6	5	1	1

It can be seen from Table 5.46, that one house is assessed to experience an upperbound tilt greater than 7 mm/m, at the completion of the proposed longwalls, and that no houses are assessed to experience an upperbound tilt greater than 10 mm/m at any time. It can be seen from Table 5.47, that one house is assessed to experience an upperbound systematic strain greater than 2 mm/m. It is also possible, that some houses could experience strains greater than 2 mm/m, due to anomalous non-systematic movements, which is discussed further in the impact assessments for the houses.

5.21.3. Impact Assessments for the Houses

There are no houses assessed to experience a predicted tilt greater than 7 mm/m (ie: Category C or D) at any stage of the mining period. There are three houses which are assessed to experience an upperbound tilt greater than 7 mm/m (ie: Category C), at some stage during the mining period, however, only one house is assessed to experience an upperbound tilt greater than 7 mm/m at the completion of mining.

It has been found from past longwall mining experience, that tilts less than 7 mm/m (ie: Category A or B) generally do not result in any significant impacts on houses. It is unlikely, therefore, that the maximum predicted or the maximum upperbound tilts at the houses within the Study Area would be of sufficient magnitude to result in any significant impacts on the stability of these structures. It is possible, however, that the larger upperbound tilts could result in some minor serviceability impacts, including door swings and issues with gutter and wet area drainage, which may require some remediation measures during or after the mining period.

The maximum predicted systematic strains at the houses within the Study Area, at any time during or after the extraction of the proposed longwalls, vary between 1.0 mm/m tension and 1.3 mm/m compression. The maximum upperbound systematic strains at houses within the Study Area, at any time during or after the extraction of the proposed longwalls, vary between 1.3 mm/m tension and 2.1 mm/m compression.

It should be noted, that some additional conservatism has been used in deriving the predicted and upperbound systematic strains for the houses, which includes the following:-

- The predicted and upperbound systematic strains at each house have been taken as the maximum values at the centroid, at the vertices, or at eight points radially placed around each centroid and vertex at a distance of 20 metres. This is conservative as the maximum strains in many cases occur at one of the points located 20 metres from the perimeter of the houses, and the strains at the remaining points are less.
- The maximum predicted and maximum upperbound systematic strains have been taken as the maximum values in any direction. This is conservative as the maximum strains are in many cases orientated obliquely to the houses within the Study Area and, therefore, the strains along the main axes of the houses are less.
- The maximum predicted and maximum upperbound systematic strains have been taken at the tops of the external walls of the houses, by adding the ground strains to the strains obtained by taking the ground curvatures over the heights of the external walls.
- An additional strain of 0.2 mm/m has been added to the magnitude of the predicted strains, when the predicted subsidence is greater than 20 mm, to account for the scatter in observed strain profiles.

This additional conservatism is considered appropriate given the less certain nature of strain predictions and the necessity for providing conservative predictions for houses.

The distribution of the maximum predicted systematic strains at the houses, resulting from the extraction of the proposed longwalls, is provided Fig. 5.11. The distribution of the maximum upperbound systematic strains at the houses, resulting from the extraction of the proposed longwalls, is provided Fig. 5.12.

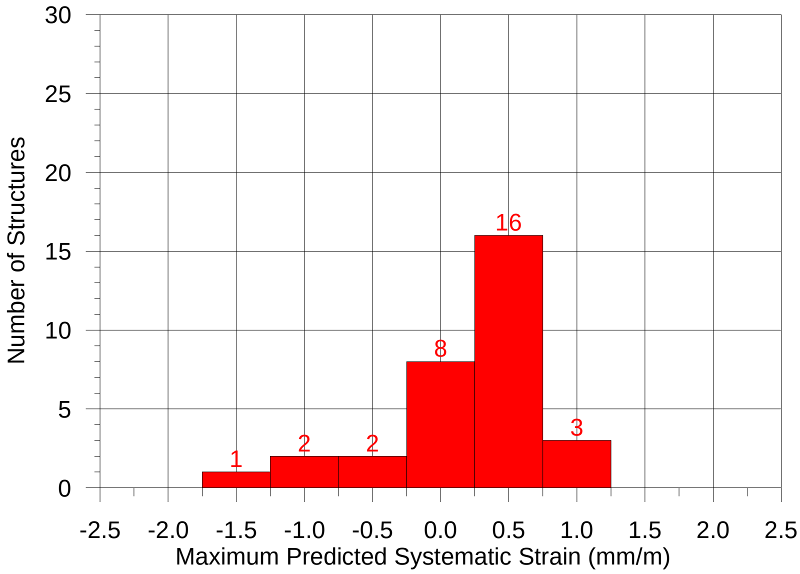

Fig. 5.11 Distribution of the Maximum Predicted Systematic Strains at the Houses within the Study Area Resulting from the Extraction of the Proposed Longwalls

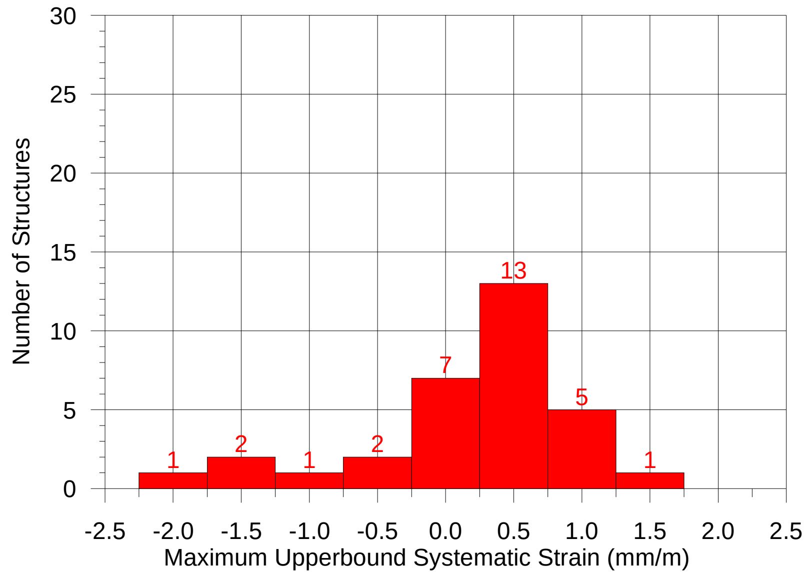

Fig. 5.12 Distribution of the Maximum Upperbound Systematic Strains at the Houses within the Study Area Resulting from the Extraction of the Proposed Longwalls

As highlighted in Section 4.7, the confidence levels assigned to the prediction of strain at a point are less than those assigned to the prediction of subsidence and tilt at a point. It is likely, therefore, that the actual strains for some houses will be greater than those predicted and that the actual strains for other houses will be less than those predicted. It is also likely, that houses would experience tension, where compression was predicted, and visa versa. It is expected, however, that the overall range of actual systematic strains at the houses within the Study Area would be similar to that predicted.

The assessed strain impacts on the houses have been determined using the method outline in Appendix E. The distribution of the assessed strain impacts for the houses within the Study Area, based on the predicted systematic subsidence parameters, is provided Fig. 5.13. The distribution of the assessed strain impacts for the houses within the Study Area, based on the upperbound systematic subsidence parameters, is provided Fig. 5.14.

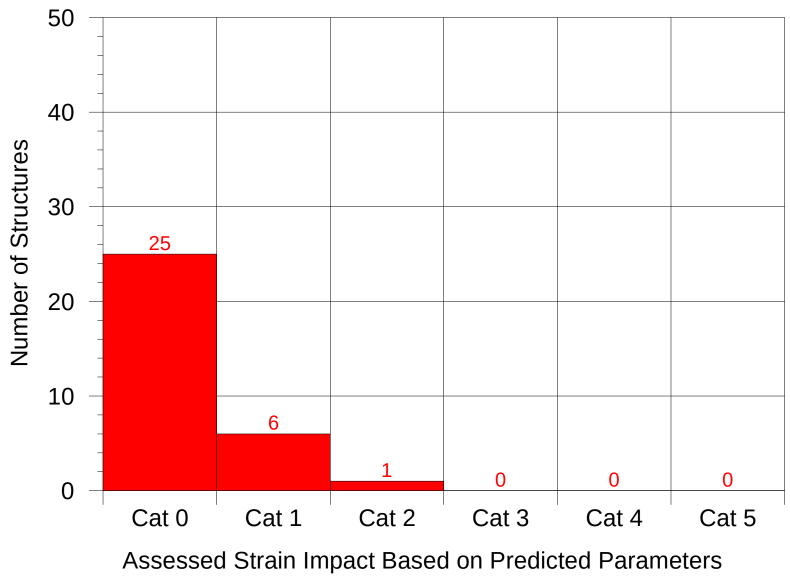

Fig. 5.13 Distribution of the Assessed Strain Impacts for the Houses within the Study Area Based on the Predicted Systematic Subsidence Parameters

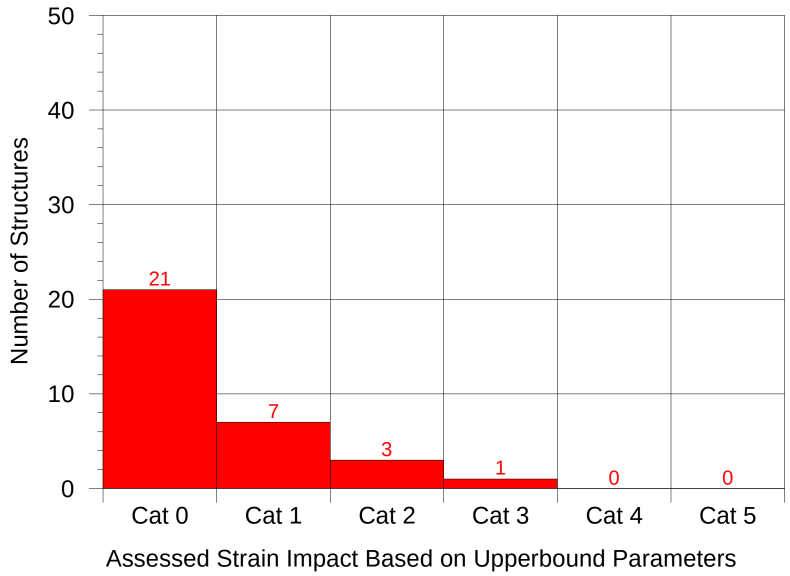

Fig. 5.14 Distribution of the Assessed Strain Impacts for the Houses within the Study Area Based on the Upperbound Systematic Subsidence Parameters

Based on the predicted systematic subsidence parameters, it has been assessed that six houses within the Study Area (ie: 19 % of the total) could experience very slight impacts (ie: Category 1) and one house (ie: 3 % of total) could experience slight impacts (ie: Category 2) as a result of the extraction of the proposed longwalls.

Based on the upperbound systematic subsidence parameters, it has been assessed that seven houses within the Study Area (ie: 22 % of the total) could experience very slight impacts (ie: Category 1), three houses (ie: 9 % of the total) could experience slight impacts (ie: Category 2) and one house (ie: 3 % of total) could experience a moderate impact (ie: Category 3) as a result of the extraction of the proposed longwalls.

Although one house, being Structure Ref. A34a, is assessed to experience a moderate impact based on the upperbound systematic subsidence parameters, it is expected to remain in a safe, serviceable and repairable condition throughout the mining period. It is recommended that a structural engineer inspect this house, prior to the proposed Longwall A10 mining beneath it, to assess its existing condition and to make recommendations for any necessary preventive measures, if required, in consultation with the subsidence engineer.

The assessed strain impacts for the remaining houses within the Study Area are Category 2 or less, based on both the predicted and the upperbound systematic subsidence parameters. It is expected that these houses would remain in safe, serviceable and repairable conditions throughout the mining period. It is also expected that any impacts on these houses, as the result of systematic strains of these magnitudes, could be remediated using normal building maintenance techniques.

It is possible, that some houses within the Study Area could experience strains greater than those predicted as the result of non-systematic anomalous movements, due to near surface geological features, the locations of which cannot be predicted prior to mining. The likelihood of impacts resulting from non-systematic movements can only be assessed by considering past longwall mining experience.

The maximum predicted systematic tensile and compressive strains resulting from the extraction of the proposed Longwalls A6 to A17 are similar to the maximum predicted systematic tensile and compressive strains resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B, which were 0.7 mm/m and 1.7 mm/m, respectively. To date, all building structures at Tahmoor Colliery have remained in safe conditions throughout the mining period.

At the time of writing this report, there were 603 building structures located directly above Tahmoor Longwalls 22, 23A, 23B and 24B, of which 114 structures (ie: 19 % of the structures over goaf) had reported impacts as the result of mining. There were 210 building structures located outside of Tahmoor Longwalls 22, 23A, 23B and 24B, but within the predicted limit of vertical subsidence (ie: predicted 20 mm subsidence contour), of which 12 structures (ie: 6 % of the structures outside of goaf) had reported impacts as the result of mining.

The reported impacts for all building structures within the predicted limit of vertical subsidence, resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B was, therefore, 126 building structures out of a total of 813 building structures, or 15 % of the total. The majority of the impacts have been assessed as very slight or slight (ie: Category 1 or 2), which consisted of sticky doors and minor impacts to internal walls, ceilings or floor finishes.

Less than 1 % of all houses at Tahmoor Colliery had reported impacts that were assessed as moderate or greater (ie: Category 3 or greater). In all of these cases, however, the impacts were considered to have occurred as the result of non-systematic anomalous movements, due to near surface geological features, the locations of which cannot be predicted prior to mining. In two of these cases (ie: 0.3 % of all building structures), the impacts were substantial and the costs to repair these structures were deemed to be greater than the costs to rebuild these structures.

There were no claims made on the remaining 85 % of the building structures as a result of the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B. In overall terms, it was found that the number of impacted structures at Tahmoor Colliery was less than half the total number predicted. The observed impacts at some houses, however, exceeded those predicted, particularly where anomalous movements had occurred. It is expected that the likelihood of an anomalous movement being coincident with a structure within the Study Area is significantly less than that at Tahmoor Colliery, as the density of structures above the proposed longwalls is significantly less.

The maximum upperbound systematic tensile and compressive strains resulting from the extraction of the proposed Longwalls A6 to A17 are, however, greater than the maximum predicted systematic tensile and compressive strains resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B. If the upperbound strains were fully realised, the likelihood of impacts resulting from systematic subsidence movements would increase accordingly, as illustrated by Fig. 5.13 and Fig. 5.14, however, the likelihood of impacts resulting from non-systematic anomalous movements would not significantly increase. The reason for this is that impacts resulting from non-systematic anomalous movements are governed by the coincidence of near surface geological features with the houses, rather than by relatively small increases in the systematic subsidence parameters.

The observations at Tahmoor Colliery provide a valuable empirical guide to the level of impact that could occur as the result of the extraction of the proposed Austar Longwalls A6 to A17. While specific subsidence predictions have been provided for each structure within the Study Area, these should only be used as guide to the expected range of movements at the building structures. The predictions for individual structures do not include, for example, the predictions resulting from non-systematic anomalous movement. Based on the observations at Tahmoor Colliery, the expected incidence of anomalous movements being coincident with structures is less than 1 % of the total number of structures directly mined beneath.

The locations of the houses within the Study Area, relative to the proposed longwall extractions at each stage of mining, are provided in Table G.05 in Appendix G. The locations have been categorised into the following:-

- *Above Goaf* where the houses are located directly above the longwall extractions,
- *Inside Draw Line* where the houses are located outside the longwall extractions but are within the 26½ degree angle of draw line from the longwall extractions, and
- *Outside Draw Line* where the houses are located outside the 26½ degree angle of draw line from the longwall extractions.

The distribution of the positions of the houses within the Study Area, at each stage of mining, is provided in Fig. 5.15.

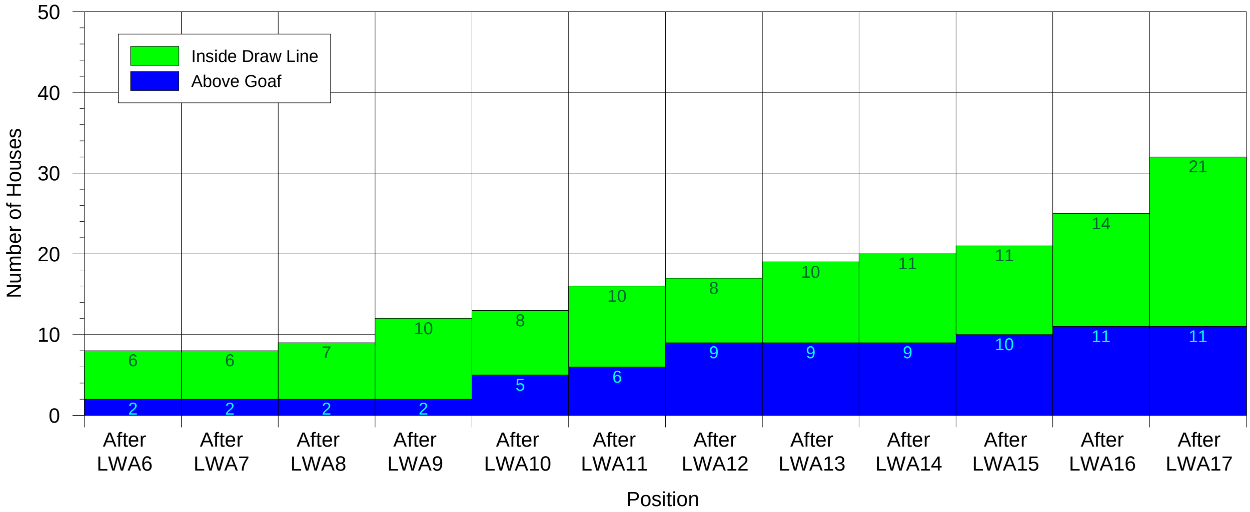

Fig. 5.15 Distribution of the Positions of Houses within the Study Area at Each Stage of Mining

Based on the experience at Tahmoor Colliery, it would be expected at each stage of mining, that approximately 19 % of the houses located directly above the extracted longwalls (ie: *Above Goaf*) and approximately 6 % of houses located outside the extracted longwalls, but within the limit of vertical subsidence (ie: *Inside Draw Line*), would experience very slight or slight impacts (ie: Category 1 or 2). It would also be expected that up to 1 % of the houses located directly above the extracted longwalls or within the predicted limit of vertical subsidence would experience a moderate (ie: Category 3) strain impact, or greater, as a result of non-systematic anomalous movements.

At the completion of the proposed Austar Longwalls A6 to A17, there are 11 houses within the Study Area which will be located directly above the extracted longwalls (ie: *Above Goaf*) and 21 houses within the Study Area which will be located outside the extracted longwalls but inside the 26½ degree angle of draw line from the extracted longwalls (ie: *Inside Draw Line)*.

Based on the experience at Tahmoor Colliery, therefore, it would be expected that approximately three or four houses within the Study Area (ie: 19 % of 11 houses above goaf plus 6 % of 21 houses within draw line) would experience very slight or slight strain impacts (ie: Category 1 or 2) and that possibly one house within the Study Area could experience a moderate (ie: Category 3) or greater strain impact as the result of the extraction of the proposed longwalls.

If the upperbound systematic strains were fully realised, the likelihood of impacts resulting from systematic subsidence movements would increase accordingly and, as illustrated in Fig. 5.14, it would be expected that approximately ten houses (ie: 31 % of total) could experience very slight or slight impacts (ie: Category 1 or 2) and that one house within the Study Area could experience moderate impacts (ie: Category 3 or greater).

Impacts on the houses resulting from the extraction of the proposed Austar Longwalls A6 to A17 are generally assessed to be of a minor nature, which could be remediated using well established building techniques. With these remediation measures in implemented, it is unlikely that there would be any significant impacts on the houses resulting from the extraction of the proposed longwalls. It is expected that all houses would remain safe, serviceable and repairable throughout the mining period.

It is noted that further research is currently being conducted by MSEC on the impacts of longwall mining on building structures as part of an ACARP research project. It is hoped that the findings of this research will be available by the time a SMP Application is lodged for the proposed Austar Longwalls A6 to A17.

It is also noted, that there are seven houses located directly above and adjacent to the proposed Austar Stage 2 Longwalls A3 to A5, The predictions and impact assessments for the houses in Stage 3 can, therefore, be further refined based on the observed movements and impacts resulting from the Stage 2 longwalls.

5.21.4. Impact Assessments for the Houses Based on Increased Predictions

If the predicted systematic subsidence parameters at the houses were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the houses. It is unlikely that the upperbound systematic subsidence parameters at the houses would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

If the maximum upperbound systematic tilt anywhere above the proposed longwalls of 10 mm/m were to occur at the houses, it is likely that these structures would experience some serviceability impacts, including door swings and issues with gutter and wet area drainage, which may require some remediation measures during the mining period. It would still be unlikely that the stabilities of these houses would be affected at this magnitude of tilt.

If the maximum upperbound systematic tensile and compressive strains anywhere above the proposed longwalls of 1.2 mm/m and 3.1 mm/m, respectively, were to occur at the houses, it is likely that these structures would experience very slight or slight impacts (ie: Category 1 or 2) and, in some cases, could experience moderate impacts (ie: Category 3 or greater). It would still be expected, that the likelihood of impact resulting of an anomalous non-systematic movement would still be less than 1 % for each of the houses directly mined beneath.

Based on the experience at Tahmoor Colliery, it would still be expected, that all houses would remain in a safe condition throughout the mining period and that any impacts resulting from systematic movements could be easily remediated using well established building techniques.

5.21.5. Recommendations for the Houses

The assessed impacts on the houses resulting from the predicted and upperbound systematic subsidence parameters can be managed with the implementation of suitable management strategies.

It is recommended that each house located above the proposed longwalls should be inspected, prior to being mined beneath, to assess the existing condition and whether any preventive measures are required. It is also recommended that the houses are visually monitored during the extraction of the proposed longwalls.

5.21.6. Other Associated Structures

The predicted and upperbound subsidence parameters and impact assessments for the rural building structures and tanks are provided in Sections 5.13 and 5.14, respectively. The predicted and upperbound subsidence parameters and impact assessments for the swimming pools and on-site waste water systems are provided in the following sections.

5.21.6.1. Swimming Pools

There are 11 privately owned swimming pools (Structure Type P) which have been identified within the Study Area, the locations of which are shown in Drawings Nos. MSEC309-11 to MSEC309-19 and details provided in Tables G.01 to G.05 in Appendix G.

Predictions of systematic subsidence, tilt and strain have been made at the centroid and at the corners of each pool, as well as eight equally spaced points placed radially around the centroid and corners at a distance of 20 metres. The maximum predicted and maximum upperbound systematic subsidence, tilts and strains at each pool are provided in Tables G.01 to G.04.

The maximum predicted and maximum upperbound systematic tilts at the pools are 5.0 mm/m (ie: 0.5 %) and 7.0 mm/m (ie: 0.7 %), respectively, or changes in grade of 1 in 200 and 1 in 145, respectively. The maximum predicted and maximum upperbound changes in gradient at the pools are less than 1 % and are unlikely, therefore, to result in any significant impacts on the serviceability of the pools. While the predicted and upperbound systematic tilts are not expected to result in a loss of capacity for the pools, it is noted that tilts are more readily noticeable to property owners, particularly if the walls of the pools are tiled, as the height of the freeboard will vary along the length of the pool.

The maximum predicted systematic tensile and compressive strains at the pools are 0.9 mm/m and 1.1 mm/m, respectively, and the associated minimum radii of curvature are 17 kilometres and 14 kilometres, respectively. The maximum upperbound systematic tensile and compressive strains at the pools are 1.1 mm/m and 1.9 mm/m, respectively, and the associated minimum radii of curvature are 14 kilometres and 7.9 kilometres.

Tahmoor Colliery Longwalls 22, 23A, 23B and 24B mined directly beneath 46 pools, of which nine pools (ie: 20 %) were impacted, which included cracking of the pool linings, cracking of the copings and impacts on associated infrastructure such as skimmer boxes. Of the nine pools impacted at Tahmoor Colliery, seven pools (ie: 15 %) could be repaired and two pools (ie: 5 %) required replacement. It was also observed, that the in-ground fibreglass pools were more susceptible to impact than the in-ground concrete pools.

The maximum predicted systematic tensile and compressive strains resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B, were 0.8 mm/m and 1.7 mm/m, respectively, which are similar to the maximum predicted systematic strains resulting from the extraction of Austar Longwalls A6 to A17. It is expected, therefore, that the percentage of pools impacted as a result of the extraction of Longwalls A6 to A17 would be similar to that observed at Tahmoor Colliery. There are seven pools located directly above or immediately adjacent to Austar Longwalls A6 to A17 and, therefore, it is expected that one or two pools (ie: 20 %) could be impacted as a result of the extraction of the proposed longwalls.

If the predicted systematic subsidence parameters at the pools were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the pools. It is unlikely that the upperbound systematic subsidence parameters at the pools would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

5.21.6.2. On-Site Waste Water Systems

The residences on the rural properties within the Study Area have on-site waste water systems. The predicted and upperbound systematic subsidence parameters at the on-site waste water systems are similar to those at the houses which they serve, which are summarised in Tables G.01 to G.04 in Appendix G, as these are the maximum values which occur within 20 metres of the houses.

A summary of the maximum predicted systematic subsidence parameters at the on-site waste water systems, at any time during or after the extraction of the proposed longwalls, whichever is the greater, is provided in Table 5.48.

Table 5.48 Maximum Predicted Systematic Subsidence Parameters at the On-Site Waste Water Systems due to the Extraction of the Proposed Longwalls

Location	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Systematic Tensile Strain (mm/m)	Maximum Predicted Systematic Compressive Strain (mm/m)
On-site Waste Water Systems	1835	5.6	1.0	1.3

A summary of the maximum upperbound systematic subsidence parameters at the on-site waste water systems, at any time during or after the extraction of the proposed longwalls, whichever is the greater, is provided in Table 5.49.

Table 5.49 Maximum Upperbound Systematic Subsidence Parameters at the On-Site Waste Water Systems due to the Extraction of the Proposed Longwalls

Location	Maximum Upperbound Subsidence (mm)	Maximum Upperbound Tilt (mm/m)	Maximum Upperbound Systematic Tensile Strain (mm/m)	Maximum Upperbound Systematic Compressive Strain (mm/m)
On-site Waste Water Systems	2855	8.0	1.3	2.1

The maximum upperbound systematic tilt at the on-site waste water systems is 8.0 mm/m (ie: 0.8 %), or a change in grade of 1 in 125, which represents a change in grade of less than 1 % and is unlikely, therefore, to have any significant impact on the systems.

The maximum upperbound systematic tensile and compressive strains at the on-site waste water systems are 1.3 mm/m and 2.1 mm/m, respectively, and the associated minimum radii of curvature are 12 kilometres and 7.1 kilometres, respectively. The on-site waste water system tanks are generally small, typically less than 3 metres in diameter, and are constructed from reinforced concrete and are usually bedded in sand and backfilled. It is unlikely, therefore, that the maximum predicted or maximum upperbound systematic strains would result in any significant impacts on the tank structures themselves.

It is possible, however, that the buried pipelines associated with the on-site waste water tanks could be impacted by the upperbound systematic strains if they are anchored by the tanks or other structures in the ground. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be easily repaired. With the necessary remediation measures implemented, it would be unlikely that there would be any long term impact on the pipelines associated with the on-site waste water systems.

If the predicted systematic subsidence parameters at the on-site waste water systems were to be increased by factors of 1.25 to 1.5 times, the predicted parameters would still be less than the upperbound systematic subsidence parameters at the systems. It is unlikely that the upperbound systematic subsidence parameters at the systems would be exceeded, as these parameters are based on achieving a maximum total subsidence of 65 % of effective extracted seam thickness above the proposed longwalls, as discussed in Section 3.6.

5.21.7. Fences

The predictions and impact assessments for fences are provided in Section 5.15.

5.22. Other Potential Subsidence Movements and Impacts

The following sections provide discussions on other potential subsidence movements and impacts resulting from the extraction of the proposed Longwalls A6 to A17.

5.22.1. Predicted Systematic Horizontal Movements

The predicted systematic horizontal movements over the proposed longwalls are calculated by applying a factor to the predicted systematic tilt values. In the Newcastle Coalfield a factor of 10 is generally adopted, being the same factor as that used to determine strains from curvatures, and this has been found to give a reasonable correlation with measured data.

The comparisons between observed and back-predicted strains along the monitoring lines above the previously extracted longwalls at the Colliery, as described in Section 3.4.1, indicates that a factor of 15 provides a better correlation for prediction of systematic horizontal movements. This factor will in fact vary and will be higher at low tilt values and lower at high tilt values. The application of this factor will therefore lead to over-prediction of horizontal movements where the tilts are high and under-prediction of the movements where the tilts are low.

The maximum predicted systematic tilt within the Study Area, at any time during or after the extraction of the proposed longwalls, is 6.7 mm/m, which occurs above Longwall A7 after the extraction of Longwall A8. This area will experience the greatest predicted systematic horizontal movement towards the centre of the overall goaf area resulting from the extraction of the proposed longwalls. The maximum predicted systematic horizontal movement is, therefore, approximately 100 mm, i.e. 6.7 mm/m multiplied by a factor of 15.

The maximum upperbound systematic tilt within the Study Area, at any time during or after the extraction of the proposed longwalls, is 10 mm/m, which also occurs above Longwall A9 after the extraction of Longwall A10. The maximum upperbound systematic horizontal movement is, therefore, approximately 150 mm, i.e. 10 mm/m multiplied by a factor of 15.

Systematic horizontal movements do not directly impact on natural features or items of surface infrastructure, rather impacts occur as the result of differential horizontal movements. Systematic strain is the rate of change of systematic horizontal movement. The impacts of systematic strain on the natural features and items of surface infrastructure are addressed in impact assessments for each feature, which have been provided in Sections 5.2 to 5.21.

5.22.2. Predicted Far-Field Horizontal Movements

In addition to the systematic subsidence movements that have been predicted above and adjacent to the proposed longwalls, and the predicted valley related movements along the creeks, it is also likely that some far-field horizontal movements will be experienced during the extraction of the proposed longwalls.

Far-field horizontal movements result from the redistribution of horizontal in situ stresses in the strata around the collapsed and fractured zones above longwall extractions. Such movements are to some extent predictable and occur whenever significant excavations occur at the surface or underground.

The horizontal in situ stresses in the strata within the Study Area have already been affected by the previously extracted Longwalls SL2 to SL4 to the north of the proposed longwalls, and by the previously extracted Longwalls SL1 and 1 to 13A to the west of the proposed longwalls. It is also likely that the in situ stresses in the strata will be affected by the mining of future Longwalls A3 to A5 to the west of the proposed longwalls. As the proposed Longwalls A6 to A17 are mined, it is likely that further redistribution of the horizontal in situ stresses would result in far-field horizontal movements towards the new goaf area.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data primarily from the Southern Coalfield, from Collieries including Appin, Bellambi, Dendrobium, Douglas, Newstan, Tower and West Cliff. The far-field horizontal movements resulting from longwall mining were generally observed to be orientated towards the extracted longwall. At very low levels of far-field horizontal movements, however, there was a high scatter in the orientation of the observed movements.

The observed incremental far-field horizontal movements, resulting from the extraction of a single longwall, for all monitoring points within the database, is provided in Fig. D.26 in Appendix D. The observed incremental far-field horizontal movements, resulting from the extraction of a single longwall, for monitoring points within the database where there was solid coal between the longwall and monitoring points, is provided in Fig. D.27 in Appendix D.

It can be seen from these figures, that incremental far-field horizontal movements of up to 20 mm have been observed at distances of 2000 metres from extracted longwalls. As successive longwalls within a series of longwalls are mined, the magnitudes of the incremental far-field horizontal movements decrease. This is possibly due to the fact that once the in situ stresses within the strata in the collapsed zones above the first few extracted longwalls has been redistributed, the potential for further movement is reduced. The total far-field horizontal movement is not, therefore, the sum of the incremental far-field horizontal movements for the individual longwalls.

The predicted far-field horizontal movements resulting from the extraction of the proposed longwalls are very small and could only be detected by precise surveys. Such movements tend to be bodily movements towards the extracted goaf area, and are accompanied by very low levels of strain, which are generally less than 0.1 mm/m. The impacts of far-field horizontal movements on the natural features and items of surface infrastructure within the vicinity of the Study Area is expected to be insignificant.

5.22.3. The Potential Impacts of Ground Vibration on Structures due to Mining

The settlement of the ground resulting from systematic subsidence is generally a series of gradual and progressive movements, the effect of which is not apparent to an observer at the surface. The major breakage and collapse of strata into the voids left by the extraction of the seam occur in the strata layers immediately above the seam. Above that level, the breakage and collapse of the strata reduces to become a bending and sagging of the upper layers of rock with less sudden and much smaller movements occurring. In some instances, the movements can be concentrated at faults or other points of weakness in the strata with minor stepping at the surface.

Where the strata layers immediately above the seam are thick, massive, and competent, then any major collapse below ground would result in some vibration in the layers of rock above it, which might be felt as a minor effect at the surface. However, these effects would normally be associated with mining at shallow depths of cover and would not generally be expected to occur at deeper mines, such as for the proposed longwalls where the depth of cover generally exceeds 500 metres.

Higher ground vibrations and noise were observed during the extraction of previous longwalls at the Colliery, which resulted in some minor structural impacts. The peak particle velocities (PPV) at the surface were monitoring during the extraction of Longwalls 6 to 9. The maximum measured PPV were 22 mm/sec and 26 mm/m, which occurred in early 1991 during the extraction of Longwall 7, and 28 mm/sec, which occurred in early 1992 during the extraction of Longwall 8. The remaining measured PPV were all less than 8 mm/sec. PPV above 6 mm/sec are clearly noticeable and PPV above 13 mm/m can potentially result in minor structural impacts. The high PPV measured at the Colliery were believed to be the result of a dyke which is located above the previously extracted longwalls at the Colliery.

It is possible, therefore, as the proposed longwalls are mined and the strata subsides, for some vibrations to be felt at the surface, though these are more likely to occur directly above, or close to the proposed longwalls. As there are no identified significant geological features above the proposed longwalls, the levels of vibration would generally be expected to be low and would not be of sufficient amplitude to result in any significant structural impact. Any structural impact which occurs due to vibration, resulting from the extraction of the proposed longwalls, is expected to be of a minor nature, and easily repaired using normal building maintenance techniques.

5.22.4. The Potential for Noise at the Surface due to Mining

It is very unusual for noise to be noticed at the surface due to longwall mining at depths of cover of 500 metres, such as for the proposed longwalls. As discussed in Section 5.22.3, however, noise resulting from strata collapsing into the goaf was observed at the surface during the extraction of previous longwalls at the Colliery.

As systematic subsidence occurs and the near surface rocks are affected by tensile and compressive strains, the rocks open up at joints and planes of weakness, and displace due to rotation and shear. Generally the movements are gradual and cannot be detected by an observer at the surface. These movements are also generally shielded by the more plastic surface soils which tend to distribute the strains more evenly and insulate against any sounds from below.

In some cases, the stresses in the rock can build up to the point that the rock suddenly shears to form a new fracture and if the rock is exposed or has only a thin covering of surface soil, the noise resulting from the fracturing can be heard at the surface. Normally the background level of noise in the countryside is such that the sound is not noticed, although in the stillness of night, it might occasionally be noticed when it occurs in close proximity. The structural impact due to noise at the surface, resulting from the extraction of the proposed longwall, is predicted to be insignificant.

5.22.5. The Potential for Increased Subsidence due to Earthquake

It is unlikely that a seismic event would result in additional subsidence to occur above the proposed longwalls, as this has not been observed in the past. After the 1989 Newcastle earthquake, there was no recorded significant damage to mine workings and no additional subsidence measured above mined areas within the Newcastle Coalfield.

After the 1989 Newcastle earthquake, no movement could be detected in any of the fault zones and along joint plane traces outcropping in the Newcastle City district. There were no convincing evidence for liquefaction processes in the Newcastle district, nor were significant changes of surface levels observed. Operating mines suffered negligible structural damage as a result of the earthquake but several reported changes in hydrological regimes lasting 4 to 6 months (Moelle, 1995).

Although subsidence due to longwall mining results in voids being formed within the collapsed zone and bedding separations occurring within the fractured zone, the consolidation of these zones occur shortly after mining and the strata reaches a state of equilibrium, after which no further significant movement occurs. Following the original subsidence event, residual subsidence of up to 10 % occurs, but usually movement ceases within a period of 5 to 10 years. Once this equilibrium is reached, it is unlikely that any further consolidation would occur as a result of an earthquake event.

It should also be noted that the impact assessments for the natural features and items of surface infrastructure provided in this report have been made for an upperbound case, which assumes that the maximum possible subsidence of 65 % of effective extracted seam thickness is achieved, as described in Section 3.6. Any small additional consolidation resulting from an earthquake event is unlikely to result in the maximum upperbound systematic subsidence parameters being exceeded.

The impacts on buildings and surface infrastructure, resulting from earthquake events, occur when the structures are set in motion, starting with the foundations, which then propagates up through the structures. The differential movement, or sway, of the structures induces forces within the structures that can then result in structural impact. Below the surface, at the level of underground mine workings, the strata are confined and move en masse, which does not result in differential movements between the different horizons and, hence, does not result in any significant impact. The movements resulting from earthquake events in the past have generally only been observed at the surface, rather than underground. It has also been reported, in the past, that miners working underground during earthquake events were totally unaware of the events.

5.22.6. The Likelihood of Surface Cracking in Soils and Fracturing of Bedrock

As subsidence occurs, surface cracks will generally appear in the tensile zone, i.e. within 0.1 to 0.4 times the depth of cover from the longwall perimeter. Most of the cracks will occur within a radius of approximately 0.1 times the depth of cover from the longwall perimeter. The residual cracks will generally be above and parallel to the longitudinal edges of the longwalls.

It is also possible that surface cracks could occur above and parallel to the moving longwall extraction faces, ie: at right angles to the longitudinal edges of the longwalls, as the subsidence trough develops. This cracking is, however, likely to be transient, since the tensile phase, which causes the cracks to open up, is generally followed by a compressive phase, that partially closes them.

Fracturing of exposed sandstone or near surface bedrock is likely to occur coincident with the maximum tensile strains, but open fractures could also occur due to buckling of surface beds that are subject to compressive strains. Fracture widths tend to increase as the depth of cover reduces, and only minor fracturing is expected for the proposed longwalls, where the depth of cover generally exceeds 500 metres.

Fractures are less likely to be observed in exposed bedrock where the systematic strain levels are low, typically less than 2 mm/m, as has been predicted within the Study Area. A joint spacing of ten metres is not unusual for sandstone and, therefore, fractures at joints could be as wide as 10 mm, based on the maximum upperbound systematic tensile strain of 1.2 mm/m resulting from the extraction of the proposed longwalls.

The incidence of cracks on the surface due to mine subsidence is additionally dependent on the thickness and inherent plasticity of the soils that overlie the bedrock. Surface soils above the proposed longwalls are generally weathered to some degree. The widths and frequencies of any cracks are also dependent upon the pre-existing jointing patterns in the bedrock. Large joint spacing can lead to concentrations of strain and possibly the development of fissures at the rockhead, which are not necessarily coincident with the joints.

Based on the graph in Fig. D.8 in Appendix D, it is unlikely that surface cracks from systematic subsidence movements would exceed 25 mm in width above the proposed longwalls, where the depth of cover generally exceeds 500 metres. If a reasonable thickness of surface soil exists, it is more likely that the surface soil would exhibit a number of narrower cracks, rather than a single larger crack.

Surface cracking in soils as the result of systematic subsidence movements is not commonly seen at depths of cover greater than 500 metres, such as at Austar, and any cracking that has been observed has generally been isolated and of a minor nature.

Cracking is found more often in the bases of creek and river valleys due to the compressive strains associated with upsidence and closure movements. The likelihood and extent of cracking along the creeks within the Study Area are discussed in Sections 5.2 and 5.3.

The surface cracking resulting from the extraction of the proposed longwalls is expected to be of a minor nature, which is expected to be easily remediated by infilling with soil or other suitable materials, or by locally regrading and recompacting the surface.

5.22.7. The Likelihood of Irregular Profiles

Wherever faults, dykes, or abrupt changes in geology are present at the surface, it is possible that irregularities in the subsidence profiles could occur. Similarly, where surface rocks are thinly bedded, and where cross-bedded strata exist close to the surface, it is possible for surface buckling to occur, leading to irregular movements. Most irregularities in subsidence profiles, however, can be explained by the presence of surface incisions such as gorges, river valleys, and creeks.

Several geological structures have been identified at seam level in the vicinity of the proposed longwalls, and these are shown in Drawing No. MSEC309-06. No major faults or dykes have been identified at the locations of the proposed longwalls. The *Central Dyke* is located to the west of the proposed Longwall A6. The *Quorrobolong Fault Zone* is located between the proposed Longwall A6 and the proposed Longwalls A7 to A17. The *Abernethy Fault Zone* is located to the north and to the east of the proposed Longwalls A7 to A17.

As discussed in Section 3.3.2, irregularities also occur in shallow mining situations, where the collapsed zone, which develops above the extracted seam, extends near to the surface. This type of irregularity is generally only seen where the depth of cover is less than 100 metres, and is unlikely to occur above the proposed longwalls, where the depth of cover generally exceeds 500 metres.

Irregular subsidence profiles can also occur where longwall mining is carried out beneath previous workings, especially beneath bord and pillar extractions which have extensive stooks preventing immediate subsidence. In such situations, the pillars or stooks left in the upper seam can collapse, when mining occurs beneath them, leading to local increased subsidence and irregular subsidence profiles. There are no existing workings above the proposed longwalls, and this kind of irregularity will not occur in this case.

It is also possible that anomalous movements could also occur at unknown geological structures above the proposed longwalls. These have occurred in the past within the NSW Coalfields, and are discussed in Appendix D.5.8. Given the relatively low density of surface features within the Study Area, the probability of an anomalous movement coinciding with a surface feature is assessed as low.

5.22.8. Likely Height of the Fractured Zone above the Proposed Longwalls

The background to sub-surface strata movements has been discussed in Appendix D.6, and the following conclusions should be read in that context.

The height of the collapsed zone, which forms immediately above extracted longwalls, is generally between 21 to 33 times the extracted seam thickness. The effective extracted seam thickness for the proposed longwalls varies between 3.2 and 5.0 metres, as discussed in Section 3.6, and the predicted height of the collapsed zone for the proposed longwalls, therefore, varies between 65 and 165 metres.

The height of the fractured zone is dependent upon the angle of break (a), the width of the panel (W) and the spanning capacity of a competent stratum at the top of the fracture zone, span (w). These are illustrated in Fig. 5.16. From the mining geometry it can be shown that the height of the fractured zone equals the panel width (W) minus the span (w) divided by twice the tangent of the angle of break.

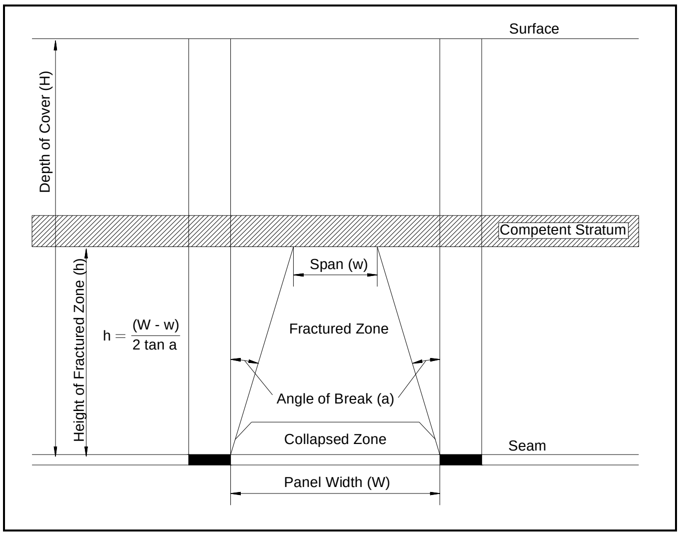

Fig. 5.16 Theoretical Model illustrating the Development and Limit of the Fractured Zone

Using this relationship, the theoretical height of the fractured zone, as a proportion of the width of the extracted panel, has been determined for a range of panel width-to-depth ratios. These values have been plotted in the graph shown in Fig. 5.17, together with the values that have been reported in literature. The red data points are those which have been reported in literature whilst the theoretical values are shown in green, magenta and blue for angles of break of 17°, 20° and 23°, respectively.

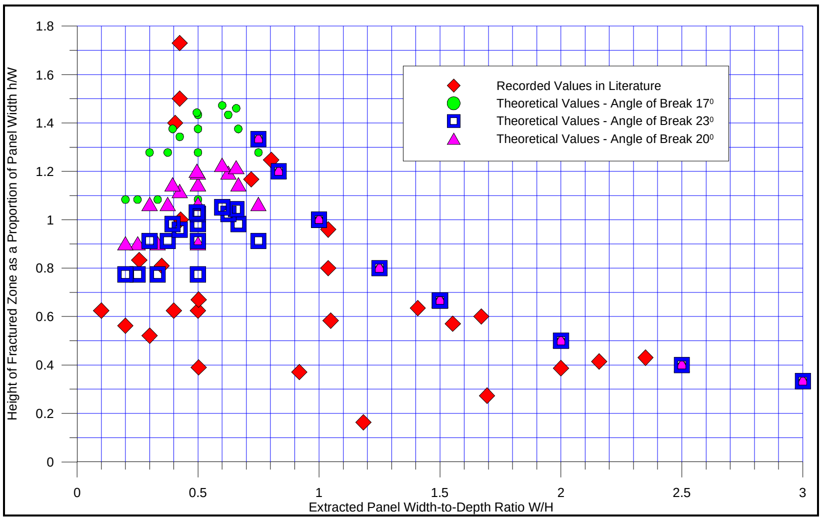

Fig. 5.17 Graph showing Height of Fractured Zone as a Proportion of Panel Width for different Width-to-Depth Ratios

It can be seen that the height of the fractured zone in the database is reasonably represented by the theoretical model using an angle of draw of 20°. Only three red data points appear above the magenta data points and these are the heights of the fractured zone over Longwall 2 at Ellalong Colliery (now Austar), and over Longwall 3 at Tahmoor Colliery, which were given by Holla (1986) and Holla and Buizen (1991).

In both of these cases, the apparent heights of the fractured zone were determined from extensometer readings which could have included horizontal shear as well as vertical dilation. The stated heights of the fractured zone at Tahmoor, which are the highest data points in the graph, are not supported by the measured vertical strains, which averaged only 0.6 mm/m in the top 160 metres of the overburden. A more realistic assessment is that the fractured zone extended only to the Bald Hill Claystone.

In some cases, it is likely that the upwards progression of the fractured zone was limited by the levels of vertical strain that could be developed, which is dependent upon the extracted seam thickness, the surface subsidence and the depth of cover.

The upper limit of the fractured zone will be reached when the strata above that zone are sufficiently strong to span the goaf area without significant bending or shear strains being developed. In the Newcastle Coalfield, the upper layers in the overburden strata are relatively strong sandstones. These sandstone strata are particularly strong and would be expected to be capable of spanning at least 35 metres. If an average angle of break of 20° is assumed, with an extracted panel width of 227 metres, then a height of 265 metres would be required above the seam to reduce the effective span to 35 metres. If an angle of break of 23° is assumed, then a height of 225 metres would be required above the seam to reduce the effective span to 35 metres.

The depth of cover above the proposed longwall generally exceeds 500 metres and it is unlikely, therefore, that the fractured zone would extend up to the surface. It is expected that a *Constrained Zone*, also called a *Continuous Deformation Zone*, would occur between the fractured zone and the surface, which is illustrated in Fig. 5.18 and Fig. 5.19.

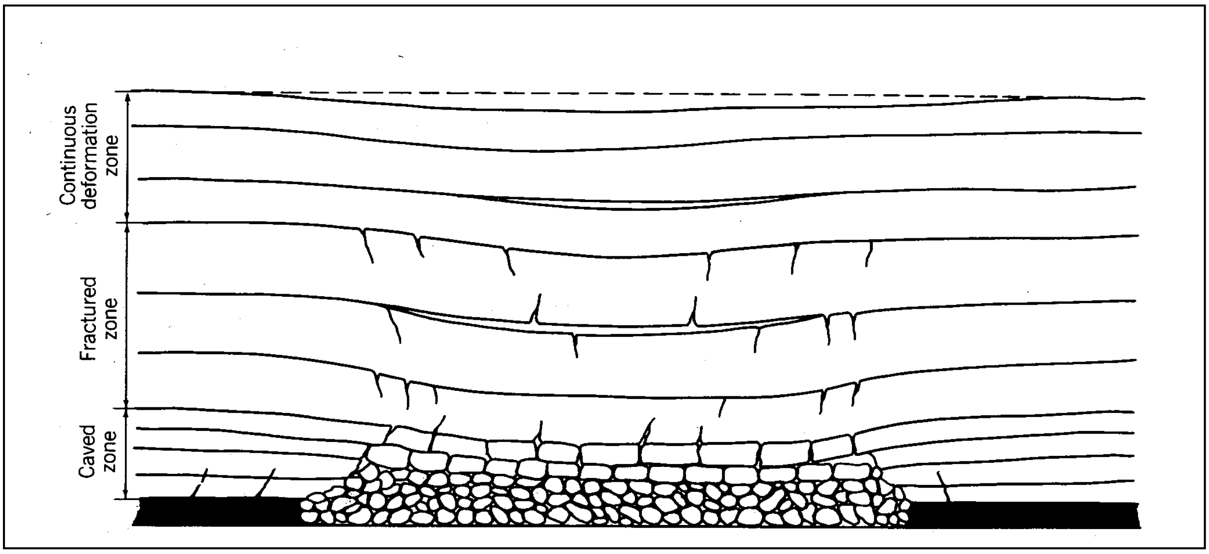

Fig. 5.18 Zones in the Overburden According to Peng and Chiang (1984)

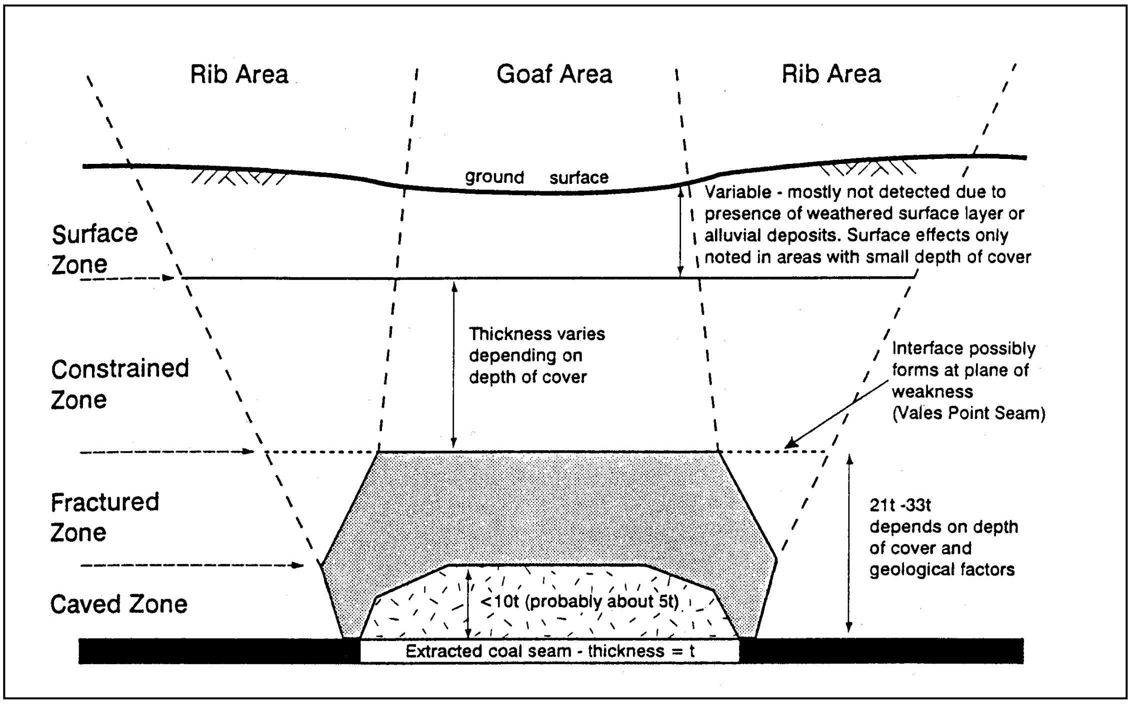

Fig. 5.19 Zones in the Overburden according to Forster (1995)

The constrained zone comprises confined rock strata which have sagged slightly, but, because they are constrained, have absorbed most of the strain energy without suffering significant fracturing or alteration to the original physical properties. Some bed separation or slippage can be present as well as discontinuous vertical cracks (usually on the underside of thick strong beds). Weak or soft beds in this zone may suffer plastic deformation.

APPENDIX A. GLOSSARY OF TERMS AND DEFINITIONS

Glossary of Terms and Definitions

Some of the mining terms used in the report are defined below:-

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections.
Extracted seam thickness	The thickness of coal that is extracted. The extracted seam thickness is normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel. Refer to Section 3.4.
Face length	The width of the coalface measured across the longwall panel.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Overlap adjustment factor	A factor that defines the ratio between the maximum incremental subsidence of a panel and the maximum incremental subsidence of that panel if it were the first panel in a series.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points.

Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel.
Super-critical area	An area of panel greater than the critical area.
Tilt	The difference in subsidence between two points divided by the horizontal distance between the points.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	A reduction in the expected subsidence at a point, being the difference between the predicted subsidence and the subsidence actually measured.

The structure classifications used in this report are defined below:-

C	Commercial
D	Dams
H1	Single storey houses with a maximum plan dimension less than 30 metres
H2	Single storey houses with a maximum plan dimension greater than 30 metres
H3	Double storey houses with a maximum plan dimension less than 30 metres
H4	Double storey houses with a maximum plan dimension greater than 30 metres
P	Pools
PA	Public amenities
PU	Public utilities
R	Other non-residential structures
T	Tanks

APPENDIX B. REFERENCES

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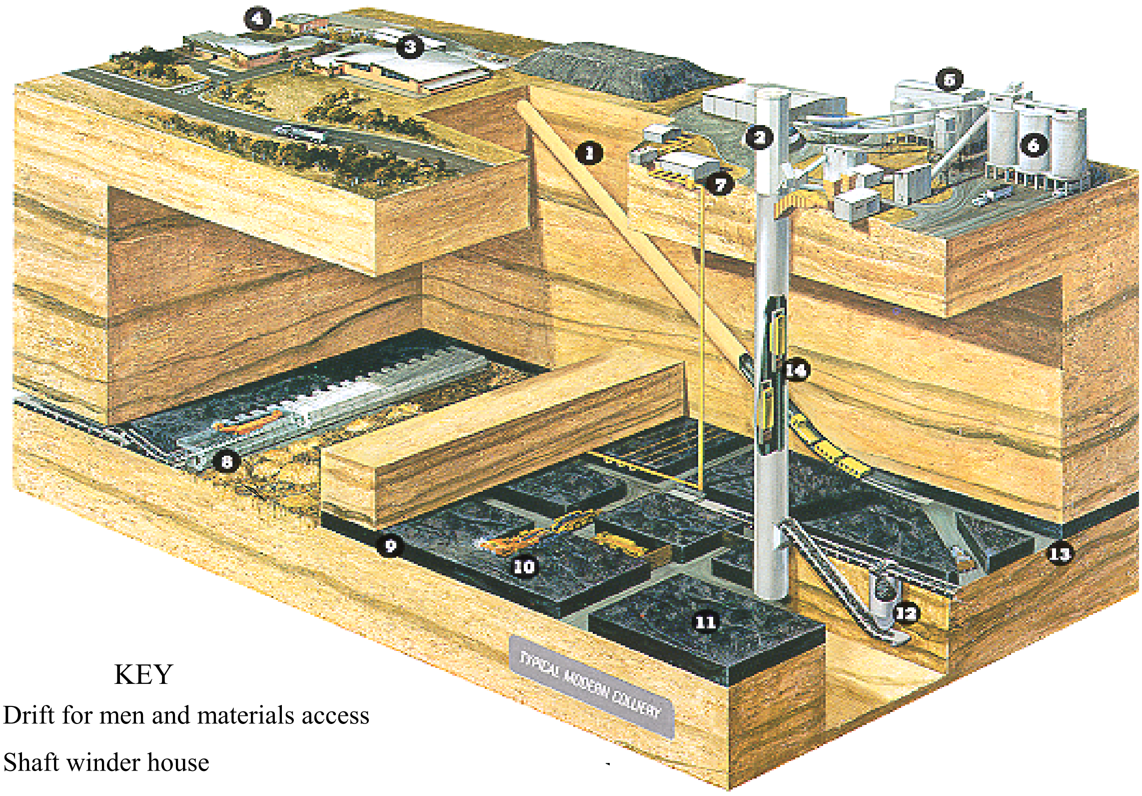
APPENDIX C. INTRODUCTION TO LONGWALL MINING AND SUBSIDENCE

C.1. The Longwall Mining Process

Fig. C.1, below, shows a cutaway diagram of a typical longwall mine. The main features of the mine are indicated in the key below the diagram. The longwall face is indicated by the number 8 in the diagram.



KEY

1. Drift for men and materials access
2. Shaft winder house
3. Bathhouse and administration building
4. Workshops
5. Coal preparation plant
6. Coal storage bins
7. Gas drainage system
8. Longwall face equipment
9. Coal seam
10. Continuous miner unit
11. Coal pillar
12. Underground coal bin
13. Main roadway or heading
14. Coal skips to carry coal to the surface

Fig. C.1 Cutaway View of a Typical Longwall Mine

In longwall mining, a panel of coal, typically around 150 to 300 metres wide, 1000 to 3500 metres long and 2 to 5 metres thick, is totally removed by longwall shearing machinery, which travels back and forth across the coalface. A typical section through a coal face is shown in Fig. C.2 and a photograph of typical longwall face equipment is shown in Fig. C.3. The shearer cuts a slice of coal from the coalface on each pass and a face conveyor, running along the full length of the coalface, carries this away to discharge onto a belt conveyor, which carries the coal out of the mine.

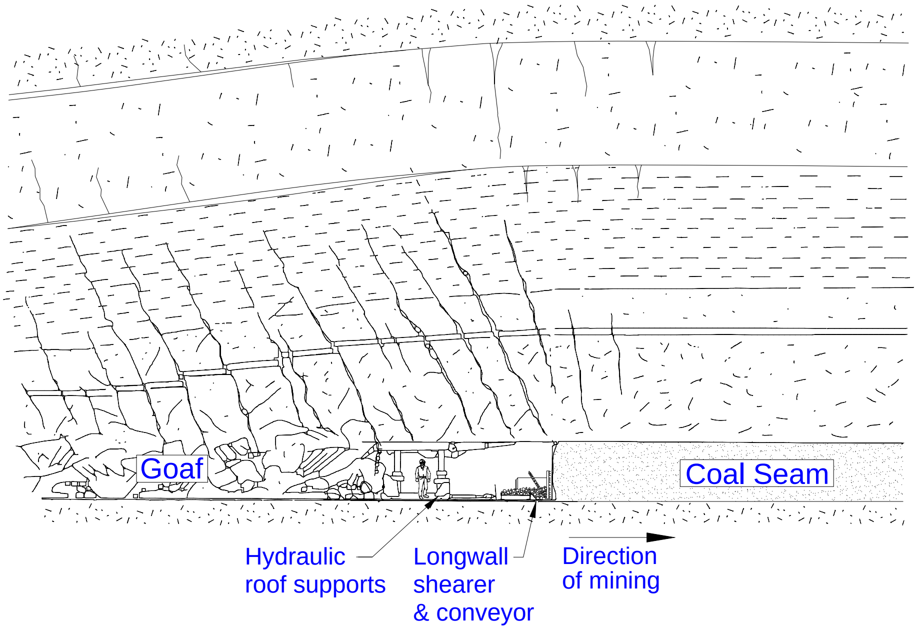


Fig. C.2 Cross Section of a Typical Longwall Face

The area immediately in front of the coalface is supported by a series of hydraulic roof supports, which temporarily hold up the roof strata and provide a working space for the shearing machinery and face conveyor. After each slice of coal is removed, the hydraulic roof supports, the face conveyor and the shearing machinery are moved forward. Fig. C.3 shows the arrangement of machinery on a typical longwall face, with the hydraulic roof supports on the left hand side and the coal face on the right hand side of the picture. The drum in the background is the rotating cutting head of the coal shearer and the chain conveyor can be seen in the foreground.

Fig. C.3 Typical Longwall Face Equipment

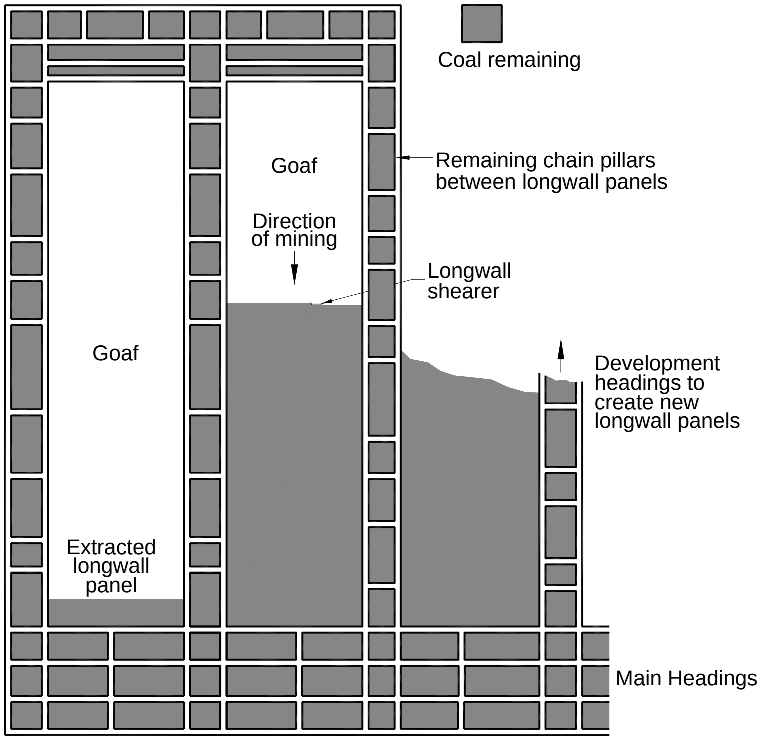


Fig. C.4 Typical Plan View of a Series of Longwall Panels

Fig. C.4 shows a typical layout of a group of longwalls. Before the extraction of a longwall panel commences, continuous mining equipment extracts coal to form roadways (known as headings) around the longwall panel. These roadways form the mine ventilation passages and provide access for people, machinery, electrical supply, communication systems, water pump out lines, compressed air lines and gas drainage lines. The roadways, which provide access from the mine entrance to the longwalls, are referred to as the main headings. Once the main headings have been established additional roadways, known as development headings, are driven on both sides of the longwall panel and are connected together across the end of the longwall.

The longwall face equipment is established at the end of the panel that is remote from the main headings and coal is extracted within the panel as the longwall equipment moves towards the main headings. This configuration is known as retreat mining. Typically, a longwall face retreats at a rate of 50 metres to 100 metres per week, depending on the seam thickness and mining conditions. The coal between the development headings and between the main headings is left in place as pillars to protect the roadways as mining proceeds. The pillars between the development headings are referred to as chain pillars.

When coal is extracted using this method, the roof immediately above the seam is allowed to collapse into the void that is left as the face retreats. This void is referred to as the goaf. Miners working along the coalface, operating the machinery, are shielded from the collapsing strata by the canopy of the hydraulic roof supports. As the roof collapses into the goaf behind the roof supports, the fracturing and settlement of the rocks progresses through the overlying strata and results in sagging and bending of the near surface rocks and subsidence of the ground above, as illustrated in Fig. C.2.

If the width of an extracted panel of coal is small and the rocks above the seam are sufficiently strong, it is possible that the roof will not collapse and hence no appreciable subsidence will occur at the surface. However, to maximise the utilisation of coal resources and for other economic reasons, wide panels of coal are generally extracted and, in most cases, the roof is unable to support itself.

Longwall panel widths between 250 metres and 300 metres are becoming common as collieries strive towards more cost-efficient production and some collieries are now considering longwall widths of 400 metres or more.

C.2. The Development of Subsidence.

C.2.1. Subsidence Mechanisms.

As the immediate roof strata, i.e. the rocks immediately above the seam, collapse into the goaf, the rocks above them lose support and sag to fill the void beneath them. The mechanism progresses towards the surface and the affected width increases so that at the surface, an area somewhat larger than the extracted panel of coal undergoes settlement. Fig. C.5 shows a typical subsidence profile above an extracted longwall panel and it can be seen that the majority of the subsidence occurs over the centre of the longwall and tapers off around the perimeter of the longwall. The subsidence is typically less than the thickness of coal extracted underground.

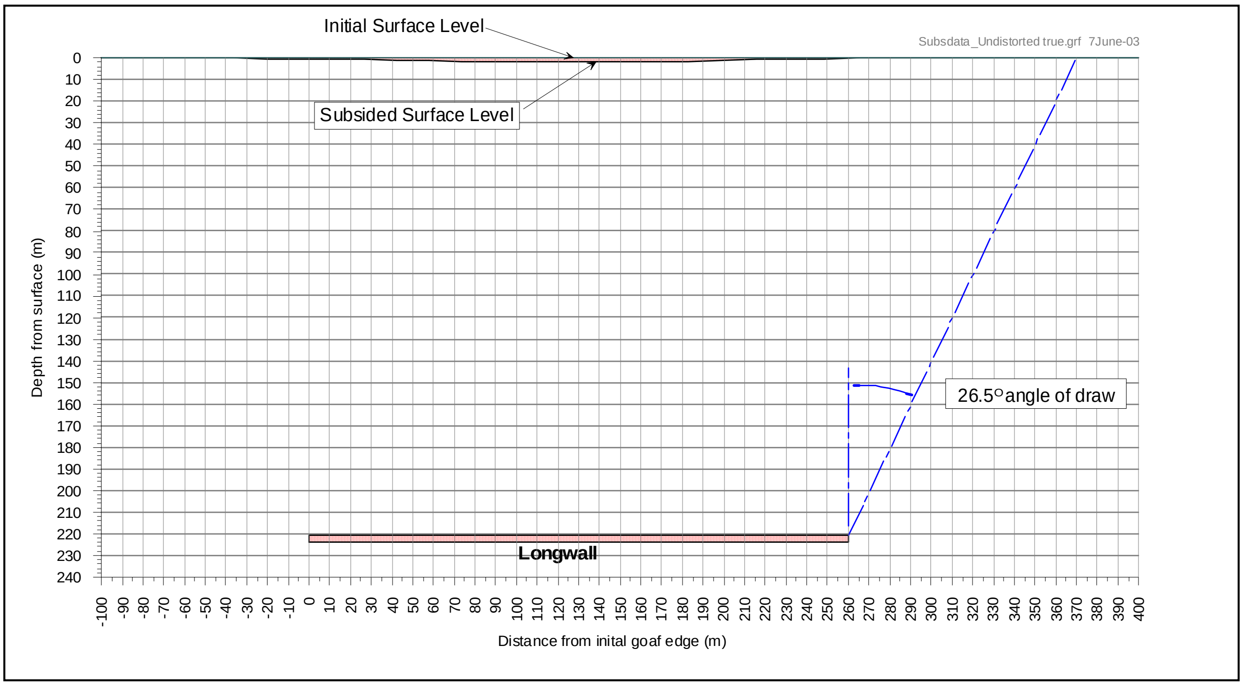


Fig. C.5 Typical Subsidence Profile Drawn to a True Scale

The angle at which the subsidence spreads out towards the limit of subsidence, at the surface, is referred to as the angle of draw. The angle of draw depends upon the strength of the strata and the depth of cover to the coal seam and typically lies between 10 and 35 degrees from the vertical, depending on how the limit of subsidence is defined.

It is generally accepted that subsidence of less than 20 mm will have negligible effect on surface infrastructure and this is generally adopted as the cut-off point for determination of the angle of draw. In the Coalfields of NSW, if local data is not available, the cut-off-point is taken as a point on the surface defined by an angle of draw of 26½ degrees from the edge of the extraction, i.e. a point on the surface at a distance of half the depth of cover from the goaf edge. Where local data exists and it can be shown that the angle is generally less than 26½ degrees, then, the lower angle of draw can be used.

The subsidence of the surface is considerably less than the thickness of coal removed, due to the voids that are left within the collapsed strata. The extent of the settlement at the surface is therefore dependent upon the strength and nature of the rocks overlying the coal seam and is a direct function of their capacity to bridge over the voids.

When a panel has a width that is small, relative to the depth of the seam below the surface, the fractured rocks have a tendency to bridge over the goaf by arching between the solid abutments on each side of the panel, thus reducing the amount of subsidence.

As the panel width is increased, however, the overlying rocks are less able to arch over the goaf and a limiting panel width is reached where no support is available and maximum subsidence occurs. This limiting panel width is referred to as the critical width and is usually taken to be 1.4 times the depth of cover. It does, however, depend upon the nature of the strata.

Where several panels are mined in a series and chain pillars are left between the panels, the maximum subsidence does not occur unless each panel is, at least, of critical width. The chain pillars crush and distort as the coal is removed from both sides of them, but, usually, they do not totally collapse and, hence, the pillars provide a considerable amount of support to the strata above them.

Where large supercritical areas are extracted, the maximum possible subsidence is typically 55% to 65% of the extracted seam thickness, but, because chain pillars are normally left in place, and provide some support, this maximum possible subsidence is rarely reached.

Research has shown that the incremental subsidence of a second or subsequent panel in a series is greater than the subsidence of an individual isolated panel of identical geometry. Because the subsidence effects above a panel extend beyond its goaf edges, these effects can overlap those of neighbouring panels.

Where the width to depth ratios of the panels in a series are sub-critical, which is normally the case at higher depths of cover, such as in the Southern Coalfield, the amount of subsidence in each panel is determined by the extent of these overlaps, which are further influenced by the widths of the chain pillars. In this situation, the first panel in a series will generally exhibit the least subsidence and the second and subsequent panels will exhibit greater subsidence due to disturbance of the strata caused by mining the preceding panels and consequential redistribution of stresses within the strata.

The subsidence at the surface does not occur suddenly but develops progressively as the coal is extracted within the area of influence of the extracted panel. In many cases, when the depth of cover over the coal seam is high, a point on the surface will be affected by the extraction of several adjacent panels.

When extraction of coal from a panel is commenced, there is no immediate surface subsidence, but as the coal within the panel is extracted and the resulting void increases in size, subsidence develops gradually above the goaf area. As mining continues, a point is reached within the panel where a maximum value of subsidence occurs and despite further mining beyond this point, within the panel, this level of subsidence is not increased.

As further adjacent panels are extracted, additional subsidence is experienced, above the previously mined panel or panels. However, a point is also reached where a maximum value of subsidence is attained over the series of panels irrespective of whether more panels are later extracted.

The subsidence effect at the surface occurs in the form of a wave, which moves across the ground at approximately the same speed as the longwall face retreats within the longwall panel. The extraction of each panel creates its own wave as the panels are mined in sequence.

The development of subsidence at any point on the surface of the ground can be seen to be a very complex mechanism and the cumulative effect of a number of separate movements.

C.2.2. Subsidence Parameters

Subsidence, tilt, horizontal displacement, curvature and strain are the subsidence parameters normally used to define the extent of the surface movements that will occur as mining proceeds and generally form the basis for the assessment of the impacts of subsidence on surface infrastructure. These parameters are illustrated in Fig. C.6. which shows a typical subsidence profile drawn to an exaggerated vertical scale.

Subsidence

Subsidence usually refers to vertical displacement of a point, but subsidence of the ground actually includes both vertical and horizontal displacements. These horizontal displacements can in many cases be greater than the vertical subsidence, where the subsidence is small. The amplitude of subsidence is usually expressed in millimetres.

Tilt

Tilt is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. The sign of tilt is not important, but the convention usually adopted is for a positive tilt to indicate the ground increasing in subsidence in the direction of measurement.

The maximum tilt, or the steepest portion of the subsidence profile, occurs at the point of inflection in the subsidence trough, where the subsidence is roughly equal to one half of the maximum subsidence. Tilt is usually expressed in millimetres per metre.

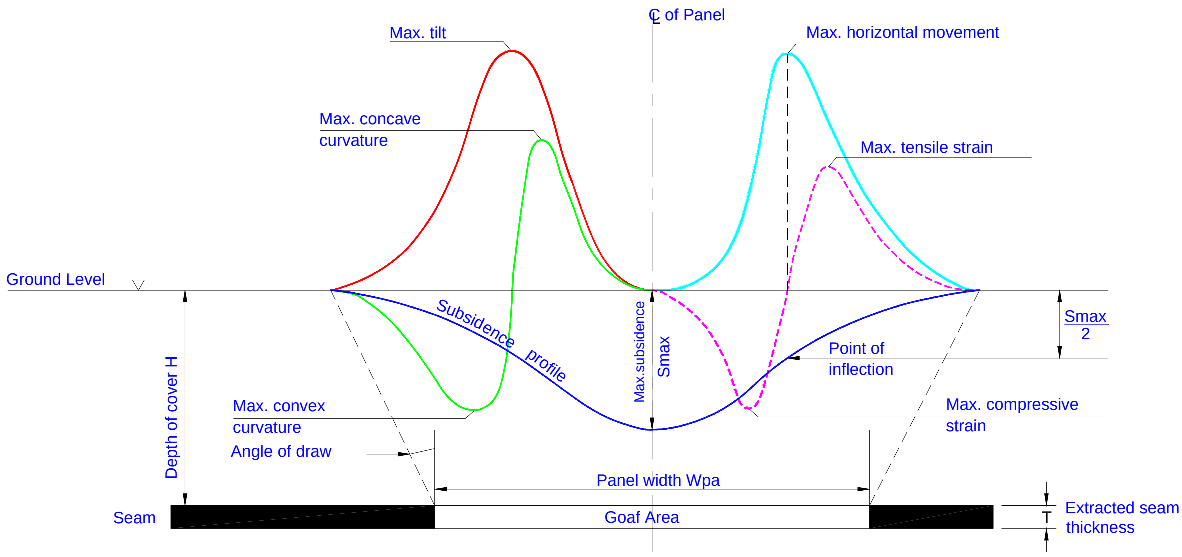


Fig. C.6 Subsidence Parameter Profiles above a Single Longwall Panel

Horizontal Displacement

The horizontal component of subsidence, or horizontal displacement, is greatest at the point of maximum tilt and declines to zero at the limit of subsidence and at the point of maximum subsidence. Horizontal displacement is usually expressed in millimetres.

Curvature

Curvature is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the radius of curvature with the units of 1/km, or km^{-1}, but the values of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in kilometres.

Curvature is convex or 'hogging' over the goaf edges and concave or 'sagging' toward the bottom of the subsidence trough. The convention usually adopted is for convex curvature to be positive and concave curvature to be negative.

Strain

Strain is caused by bending and differential horizontal movements in the strata. Measured strain is determined from monitored survey data by calculating the horizontal change in length of a section of a subsidence profile and dividing this by the initial horizontal length of that section.

If the section has been extended, the ground is in tension and the change in length and the resulting strain are positive. If the section has been shortened, the ground is in compression and the change in length and the resulting strain are negative.

The unit of measurement adopted for strain is millimetres per metre. The maximum systematic strains coincide with the maximum curvature and hence the maximum tensile strains occur towards the sides of the panel whilst the maximum compressive strains occur towards the bottom of the subsidence trough.

C.2.3. Subsidence Impacts at the Surface

The most significant impacts on surface infrastructure are experienced during the development of the subsidence trough, when maximum ground movements normally occur.

As the subsidence wave approaches a point on the surface, the ground starts to settle, is displaced horizontally towards the mined void and is subjected to tensile strains, which build from zero to a maximum over the length of convex or hogging curvature, as shown in Fig. C.7.

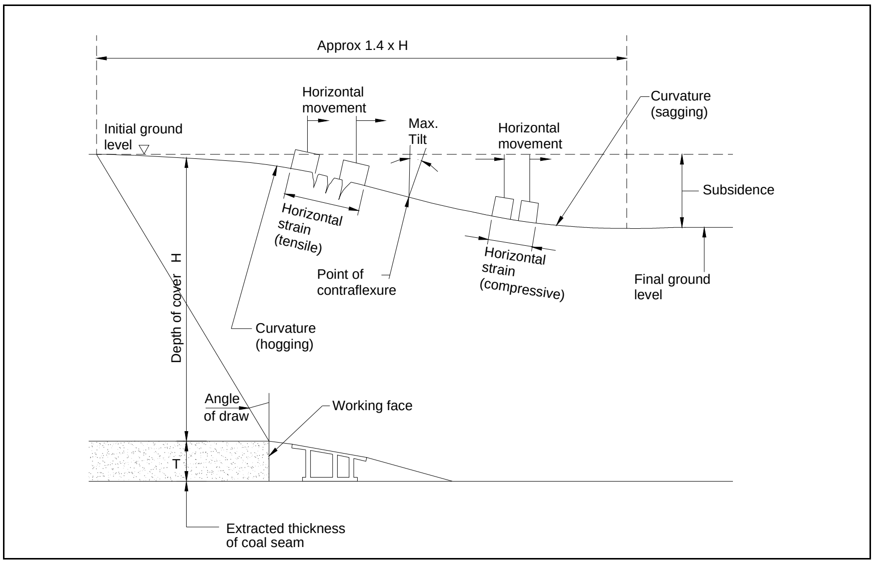


Fig. C.7 Development of a Subsidence Trough (to an exaggerated vertical scale)

The position of maximum hogging curvature is the position of maximum tensile strain. When vertical subsidence is approximately half of the maximum subsidence, i.e., as the face passes under the surface point, the ground reaches its maximum horizontal displacement and the strain reduces to zero again.

As the longwall face moves further away from the surface point the settlement continues, horizontal displacement reduces and the ground is subjected to compressive strains, which build from zero to a maximum over the length of concave or sagging curvature and then decline to zero as maximum subsidence is reached. The position of maximum sagging curvature is the position of maximum compressive strain. When the subsidence is complete, the ground is commonly left with no horizontal displacement and little residual tilt or strain.

Between the tensile and compressive zones is the point of inflection, which is the point at which maximum tilt and maximum horizontal displacement occurs. For critical extraction conditions, it is also the point at which the subsidence is, approximately, equal to half the maximum subsidence.

As the longitudinal wave passes, the transverse subsidence profile gradually develops and is completed as maximum subsidence is reached. The transverse subsidence profiles over each side of the panel are similar in shape to the longitudinal subsidence profile and have the same distribution of tilts, curvatures and strains. Most of the points on the surface will thus be subjected to three-dimensional movements, with tilt, curvature and strain in both the transverse and longitudinal directions. The impact of subsidence on surface infrastructure is therefore dependent upon its position within the trough.

The above sequence of ground movements, along the length of a panel, only applies to surface structures if they are located at a point where the maximum subsidence is likely to occur. Elsewhere, the impacts, in the both the transverse and longitudinal direction are reduced.

If a structure is located on the perimeter of the subsidence trough, it will only be slightly affected, will suffer little settlement and will have little residual tilt or strain.

A structure or surface feature on the side of the trough between the tension and compression zones will experience some subsidence, and will be left with residual horizontal displacement and tilt, but will be subjected to lower curvatures and strains. Structures or surface features located at the positions of maximum curvature and strain would generally suffer the greatest impact.

As each panel within a series is extracted in turn, an incremental subsidence trough is formed above it. If the width-to-depth ratios of the panels are low, the incremental subsidence troughs overlap at the surface and the resulting subsidence at any point, in these circumstances, is a combination of the effects of a number of panels.

A point on the surface may then be subjected to a series of subsidence waves, which occur as each panel is extracted, and the duration of these impacts will depend upon the position of the point relative to each of the subsidence troughs that are formed.

APPENDIX D. METHODS OF SUBSIDENCE PREDICTION

D.1. The Prediction of Subsidence Parameters

D.1.1. Alternative Methods of Prediction

Several alternative methods have been used in the past to predict subsidence parameters, including:

- Graphical Methods, such as the National Coal Board Method used in the U.K.
- Profile Function Methods.
- Influence Function Methods.
- Numerical Modelling Methods.
- Empirical Methods.

Profile function methods seek to define the shape of the subsidence profile using a single mathematical formula. These are generally only applicable to single panels, since they assume the profiles to be symmetrical and fail to recognise the way in which subsidence profile shapes are modified over adjacent and previously mined longwall goaf areas.

Influence function methods predict subsidence profiles based on the theory of an area of influence at the surface around a point of extraction at seam level. These methods can be applied to a wide range of mining geometries, but are more difficult to calibrate and check than profile function methods.

Numerical modelling techniques have been developed in recent years using finite element and discrete element models such as FLAC, UDEC and FLOMEC. These are particularly useful tools for investigating strata mechanisms and hydrological impacts, but have not been found to produce sufficiently accurate predictions of mine subsidence parameters.

Empirical methods can be developed for the prediction of subsidence parameters whenever a large database of measured subsidence parameters is available. These methods can be advantageously employed over a wide range of mining geometries, taking into account local variations in strata lithology. Other modelling methods can also be successful where sufficient local data is available for model calibration. To be successful, all methods of prediction have to be checked against measured data and calibrated to reflect local geology.

An empirical approach has generally been adopted in the coalfields of New South Wales, and this has been expanded in recent years by the development of the Incremental Profile Method. The Standard Empirical methods and the Incremental Profile Method are described in the following sections. Further information on alternative methods of subsidence prediction can be found in Kratzsch (1983) and Whittaker and Reddish (1989).

D.1.2. Standard Empirical Methods

At collieries in New South Wales, the maximum subsidence of the surface has generally been predicted using empirical methods. In the past, subsidence predictions were based upon the methods outlined in the Subsidence Engineers Handbook, first published by the National Coal Board of the United Kingdom in 1965 and revised in 1975. This involved the use of a series of graphs derived from numerous field observations in British mines, which allowed the shapes of the subsidence, tilt and strain profiles to be predicted.

The method gave good results when applied to British mining situations, but when the method was adopted in Australia, it became clear that the field observations differed considerably from predicted values and were generally much less than theory would suggest.

This is because the strata that overlie the coal seams in British coalfields differ from those that occur in the coalfields of Australia and because the subsidence measurements in British coalfields were in some cases affected by multi-seam mining. The rocks in Britain are generally less competent and less able to bridge the extracted voids and, therefore, for a given seam thickness, the maximum subsidence is greater than it would normally be for the same mining geometry in Australian conditions.

An intensive research program was therefore undertaken by the then New South Wales Department of Mineral Resources (DMR), to develop a predictive model that was more appropriate for Australian conditions. It was noted that the subsidence behaviour varied significantly between the Southern Coalfield, the Newcastle Coalfield and the Western Coalfield of New South Wales. Subsidence data from collieries in New South Wales were therefore studied separately for the three coalfields. The work resulted in three publications which provide guidelines for the prediction of mine subsidence parameters in each coalfield. The handbook for the Southern Coalfield was completed in 1975 (Holla, 1975) and the handbooks for the Newcastle and Western Coalfields were completed in 1987 (Holla, 1987a) and 1991 (Holla, 1991a) respectively. It should be noted that the method of prediction given in the New South Wales handbooks is only applicable to single, isolated panels.

Additional research by Dr L. Holla of the DMR led to the publishing of a paper (Holla, 1988) which included a graph which can be used to predict the maximum subsidence above a series of longwall panels, for critical extraction conditions. This graph is reproduced as Fig. D.1, where S_{max} is the maximum subsidence, T is the seam thickness and H is the depth of cover.

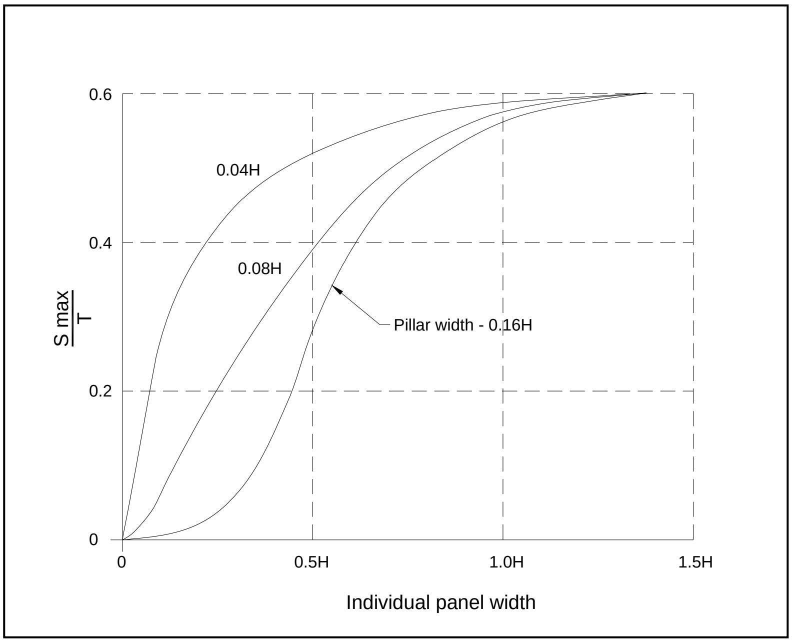


Fig. D.1 Graph for the Prediction of Maximum Subsidence over a Series of Panels for Critical Extraction Conditions (after Holla, 1988)

Following further study, a revised handbook was produced by the DMR for the Southern Coalfield in 2000 (Holla and Barclay). This later handbook included graphs that allow prediction of the maximum subsidence over a series of longwall panels. The handbook can also be used to establish an approximate subsidence profile and to predict the maximum tilt, curvature and strain above a mined area, for single panels.

When the width of an extracted panel, the depth of cover, and the extracted seam thickness are known, the following parameters can be predicted:

- The maximum subsidence value
- The location of the inflection point
- The average goaf edge subsidence
- The limit of subsidence

Once these parameters have been determined, an appropriate subsidence profile can be produced as a line of best fit between the points of maximum subsidence, inflection, goaf edge subsidence and limit of subsidence. This method thus allows the approximate shape of subsidence profile to be determined for a single isolated panel.

The predicted maximum tensile strain, compressive strain and tilt can be determined from the maximum subsidence and depth of cover, using, respectively, factors obtained from the graphs shown in Figs. 4.6, 4.7 and 4.10 of the DMR handbook (Holla and Barclay, 2000). The predicted maximum curvatures can be derived from the predicted maximum strains using the graph shown in Fig. 4.9 of the handbook.

The limit of subsidence is determined from the depth of cover and the angle of draw. The DMR recommends a practical angle of draw of 26½ degrees for general use in the Southern Coalfield, and hence the limit of subsidence would generally be positioned at half the depth of cover from the perimeter of the extracted area.

Whilst the DMR method normally provides reasonable predictions of the maximum subsidence above a series of longwall panels, it does not predict the subsidence profiles across a series of panels and does not allow the variations in tilt, curvature and strain to be determined across a series of longwalls. This method therefore could not be used to provide the detailed predictions required for this study. However, it was used to provide a check against the maximum predicted subsidence parameters which have been obtained using the Incremental Profile Method.

D.1.3. The Incremental Profile Method

The Incremental Profile Method was developed by Mr A.A. Waddington and Mr. D.R. Kay during the course of a study for BHP Collieries Division, the Water Board and AGL during the latter part of 1994 (Waddington and Kay, 1995). The purpose of the study was to develop an empirical method which could be used to predict the subsidence, tilts, curvatures and strains likely to be experienced as longwall mining occurred at Appin and Tower Collieries, and to assess the likely effects of mining on surface infrastructure.

The first step in the development of the model was to study detailed records of subsidence movements which had been observed over previous longwalls at Appin and Tower Collieries and over longwalls at neighbouring mines, including Tahmoor, West Cliff, Cordeaux and South Bulli Collieries. The measured subsidence data was plotted in a variety of ways to establish whether or not any regular patterns of ground behaviour could be found. The most significant patterns were illustrated in the shapes of the observed incremental subsidence profiles measured along survey lines located transversely across the longwalls.

The incremental subsidence profile for each longwall was derived by subtracting the initial subsidence profile (measured prior to mining the longwall) from the final subsidence profile (measured after mining the longwall). The incremental subsidence profile for a longwall therefore shows the change in the subsidence profile caused by the mining of the individual longwall.

The consistency in the shapes of the incremental subsidence profiles led to the development of the Incremental Profile Method. This consistency can be observed in the typical incremental subsidence profiles presented in Fig. D.2.

The Incremental Profile Method of prediction is based upon predicting the incremental subsidence profile for each longwall in a series of longwalls and then adding the respective incremental profiles to show the cumulative subsidence profile at any stage in the development of a series of longwalls.

The incremental subsidence profiles are also used to derive incremental tilts, systematic curvatures and systematic strains which can be added to show the transient and final values of each parameter as a series of longwalls are mined.

Profiles can be predicted in both the transverse and longitudinal directions, thus allowing the subsidence, tilts, systematic curvatures and systematic strains to be predicted at any point on the surface above a series of longwalls. The method also explains the development of undulations that occur within the subsidence trough and allows the magnitude of both transient and residual tilts and curvatures within the trough to be determined.

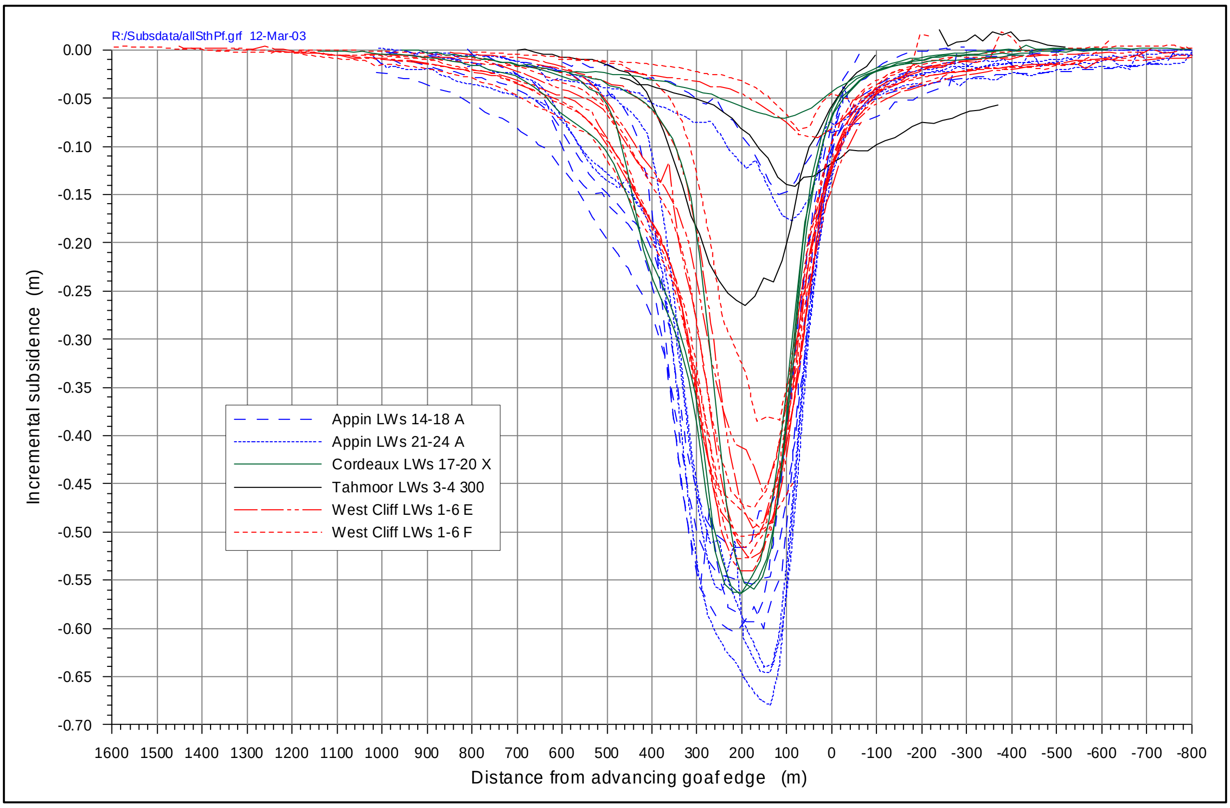


Fig. D.2 Typical Incremental Subsidence Profiles – NSW Southern Coalfield

The model was initially tested by comparing the predicted values of subsidence, tilt, curvature and strain against the measured values for a number of longwalls at Appin, Cordeaux, Tahmoor and West Cliff Collieries. Following that study, the method was used to analyse and predict subsidence over other longwall panels at Appin, South Bulli, Bulli, Corrimal, Tahmoor, Teralba, North Cliff, Metropolitan, Tower and West Cliff Collieries. These studies found that the shapes of the measured incremental profiles conformed to the patterns and magnitudes observed during the initial 1994 study.

During 1996 and 1997, the method was extended for use in the Newcastle Coalfield. The shapes of incremental profiles over extracted longwall panels at Cooranbong, West Wallsend, Newstan, Teralba, and Wyee Collieries were studied and a subsidence model was developed for the Cooranbong Life Extension Project. These studies have shown that the shapes of the incremental profiles in the southern part of the Newcastle Coalfield conform to the patterns observed in the Southern Coalfield. Since that study, the method has been used to analyse and predict subsidence over other longwall panels at West Wallsend, Cooranbong, Wyong and South Bulga Collieries.

The collection of additional data has allowed further refinement of the method and the database now includes more than 475 measured examples. A wide range of longwall panel and pillar widths and depths of cover is included within the database and hence, the shapes of the observed incremental profiles in the database reflect the behaviour of typical strata over a broad spectrum.

Further research during the last few years has identified the shapes of the incremental profiles in a number of multi-seam situations. These profiles are generally greater in amplitude than the single seam profiles and differ in shape from the standard profiles over single seams.

The incremental profiles have been modelled in two halves, the point of maximum subsidence being the point at which the two halves of the profile meet. A library of mathematically defined profile shapes has been established, which allows the incremental profiles to be modelled, depending on the width to depth ratio of the longwall and the position of the longwall in the series.

The mathematical formulae that define the profile shapes are of the form given in Equation 1 below. The library of profile shapes simply comprises the values *a* to *k* in these formulae.

$$y = \frac{a + cx + ex^2 + gx^3 + ix^4 + kx^5}{1 + bx + dx^2 + fx^3 + hx^4 + jx^5} \qquad \text{Equation 1}$$

Different formulae apply, with unique *a* to *k* values, for first, second, third, fourth, and fifth or subsequent panels in a series, and for different width-to-depth ratios, within the range 0.3 to 5.0. For second, third, fourth and fifth or subsequent panels, the left and right hand sides of the profiles have different formulae.

The library of profile shapes thus contains a to k values for 693 different half-profile shapes for single-seam mining situations. In addition the library contains 236 different half-profile shapes for a range of multi-seam mining situations. A selection of model incremental subsidence profiles for various width-to-depth ratios is shown in Fig. D.3, below.

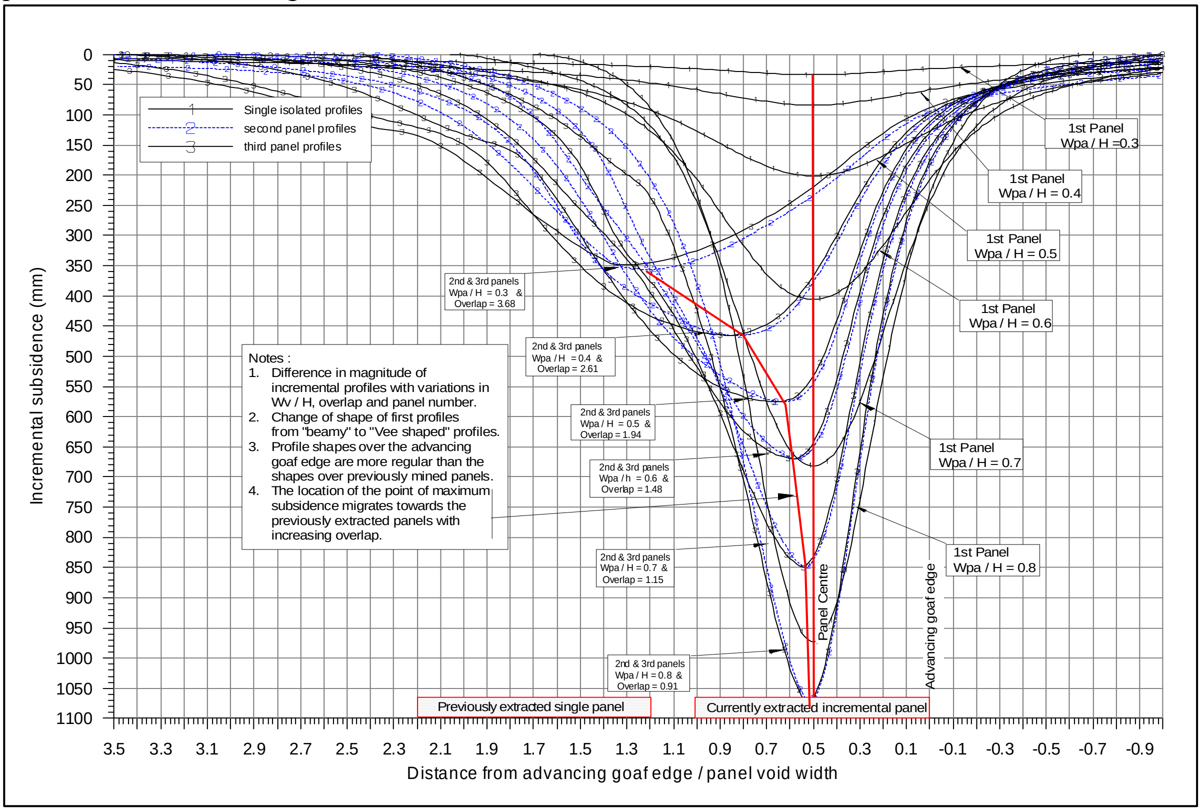


Fig. D.3 Incremental Subsidence Profiles obtained using the Incremental Profile Method

The method has a tendency to over-predict the subsidence parameters because a conservative approach was adopted in preparing the graph that is used for predicting the maximum incremental subsidence. Fig. D.4 shows the maximum incremental subsidence, expressed as a proportion of seam thickness, versus panel width-to-depth ratio.

Since this graph is used to determine the amplitude of the incremental subsidence profile, any over-prediction of the maximum subsidence value also leads to over-predictions of the tilt, curvature and strain values. Once the geometry of a longwall panel is known, the shapes of the two halves of the incremental subsidence profile of the panel can be determined from the appropriate formulae to provide a smooth non-dimensional subsidence profile across the longwall.

The actual incremental profile is obtained by multiplying vertical dimensions by the maximum incremental subsidence value and horizontal dimensions by the local depth of cover. Smooth tilt and curvature profiles are obtained by taking the first and second derivatives of the subsidence profile. Strain profiles are obtained directly from the curvature profiles.

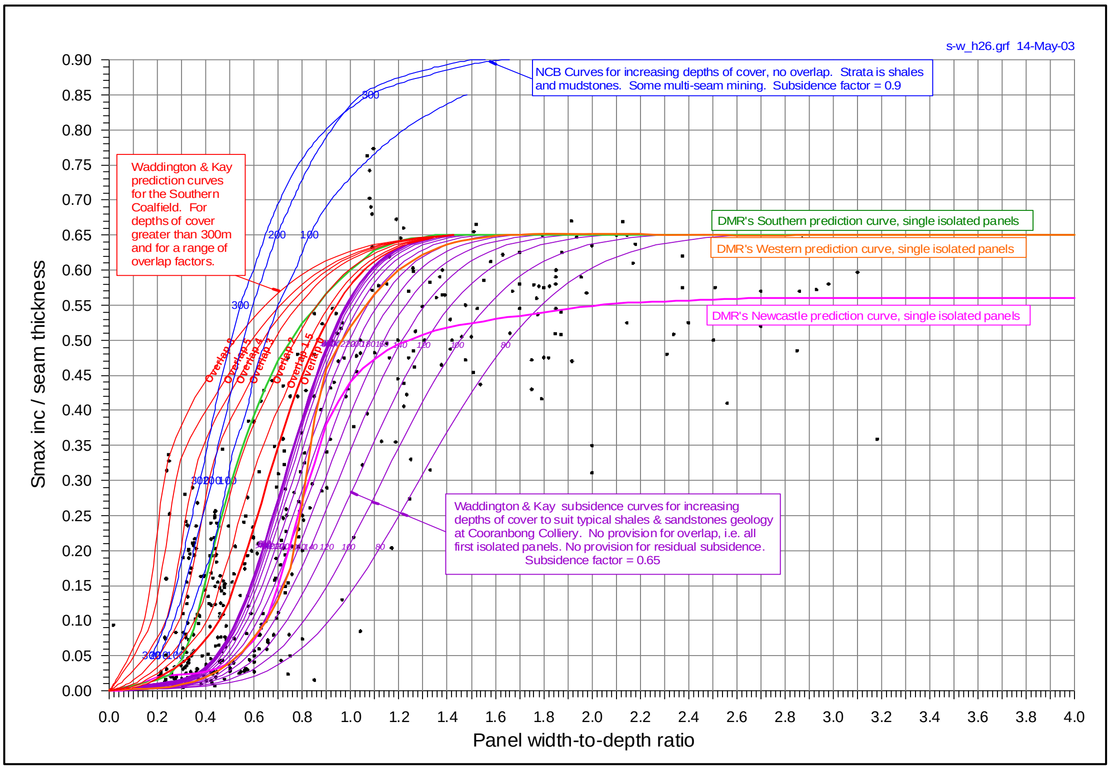


Fig. D.4 Prediction Curves for Maximum Incremental Subsidence

It can be seen from Fig. D.3 and Fig. D.4 that, as panel width to depth ratio (W/H) decreases, the magnitude of the incremental subsidence profile is reduced and the position of the point of maximum subsidence moves closer to the previously extracted panels. It has been found that the amplitude and position of the incremental profile relative to the advancing goaf edge of the longwall is determined by a factor known as the overlap factor. This overlap factor is derived empirically as a function of the panel width, pillar width and depth of cover.

In order to determine strain values from the curvature profiles, it is necessary to select an empirical relationship that will generally provide conservative results. The NCB Subsidence Engineers Handbook (1975) adopts a relationship in which the reciprocal radius of curvature, K, is equal to strain squared divided by 0.024.

This relationship does not provide a good fit when strains derived from predicted curvatures, are compared with measured values. However, if a linear relationship of strain = 15 × curvature is chosen, then a closer fit is achieved between predicted and observed data from the Southern Coalfield. This equates to the bending strain in a beam of 30 metres depth, bending about its centre line. The relationship of 15 × curvature is also reasonably close to the graph of radius of curvature versus maximum strain given in Fig. 4.9 of the DMR's handbook for the Southern Coalfield (Holla and Barclay, 2000), for depths of cover between 300 metres and 400 metres. It will, however, give lower values of strain for greater depths. A factor of 10 has been found to be more applicable in the Newcastle and Hunter Coalfields.

Predicted horizontal displacements in the direction of the prediction line (normal to the longwall), can be derived by accumulating the predicted strains multiplied by the bay lengths, after distributing any displacement closure errors over all bay lengths in proportion to the predicted strains. Alternatively, the predicted horizontal ground movement profiles can be derived by applying a proportionality factor to the predicted tilt profiles, which they resemble in both magnitude and direction.

Experience has shown that the subsidence and tilt profiles predicted using the Incremental Profile Method usually match the systematic observed profiles reasonably well. It is not possible to match the predicted and observed curvature and strain profiles to the same standard, due to the large amount of scatter generally found in the measured data. The range of systematic strains is, however, adequately predicted.

The scatter in the strains is caused by random variations in stratigraphy, rock strength, fracture characteristics and spacing of joints which dictate the way in which the near surface rocks will respond as subsidence occurs.

It should be remembered that the predicted strains obtained using the Incremental Profile Method are the systematic strains, which can, in some cases, be exceeded by local anomalous peaks of strain. In the Incremental Profile Method, such anomalous peaks of strain are dealt with statistically, though in many cases they can be predicted.

The Incremental Profile Method provides a greater understanding of the mechanism of subsidence over a series of panels and allows a detailed prediction of subsidence parameters to be made for any point on the subsidence profile.

Other benefits of the Incremental Profile Method are as follows:

- The method can be used even where the seam thicknesses, pillar and panel widths and depths of cover vary from panel to panel across a series of longwalls. This is possible because the total subsidence predictions are an accumulation of incremental subsidence profiles for each longwall, based on their individual panel and pillar widths, the seam thickness and depth of cover and the position of each longwall within the series of longwalls.
- After superimposing the influence of the incremental subsidence profiles for each longwall it has been found, in subsequent syntheses, that the total subsidence profiles are predicted quite accurately.
- Because the total subsidence profiles are well represented, this method provides improved predictions of tilts, and general background or 'systematic' curvatures and strains.
- The method can be used to model the effects of alternative mine layouts with different pillar and panel configurations and to compare the impact of tilts, curvatures and strains for each alternative.
- By varying the proposed widths of panels and pillars, it is possible to show the variations in the predicted magnitude of the maximum total subsidence and the shape of the subsidence trough.

Because of the inherent advantages of the Incremental Profile Method, this method has been used to make the detailed subsidence predictions for this project.

D.1.4. Typical Subsidence Predictions

Typical predicted incremental and cumulative total subsidence, tilt and strain profiles over a series of longwalls are shown in Fig. D.5. It can be seen that the subsidence parameters vary throughout the subsidence trough.

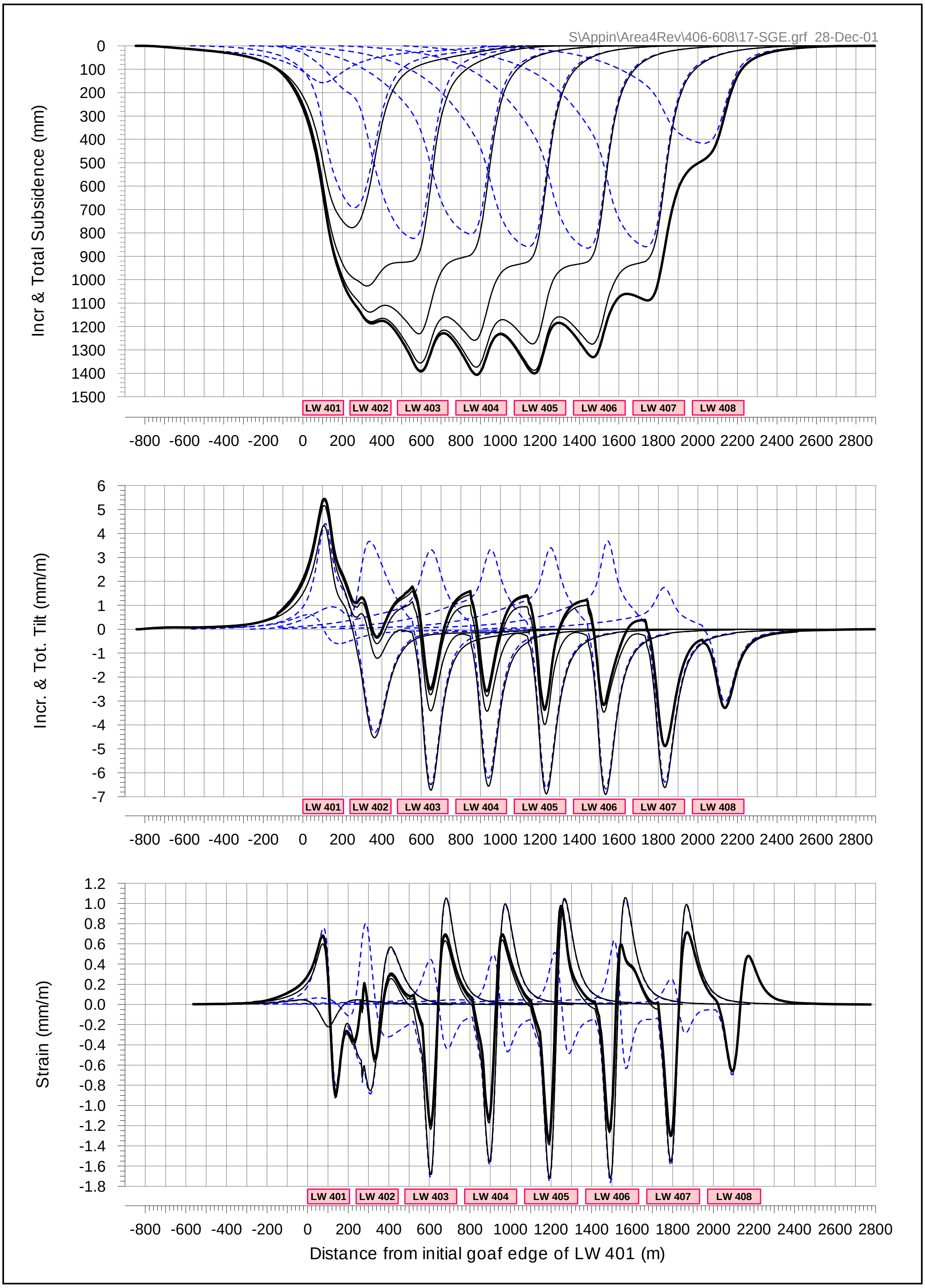


Fig. D.5 Typical Predicted Incremental and Total Subsidence, Tilt and Strain Profiles

Subsidence profiles are generally prepared along a series of parallel prediction lines, orientated at right angles to the centrelines of the longwalls. The prediction lines are generally positioned 25 metres to 100 metres apart, depending on the depth of cover and generally cover the full area of the longwalls, extending outwards as far as the limit of subsidence.

When the predicted subsidence profiles have been developed along each of the prediction lines, the predicted subsidence data is used to develop a three-dimensional model of the subsidence trough, from which subsidence contours are derived.

A typical longwall layout showing predicted subsidence contours over a series of four longwalls is illustrated in Fig. D.6. The variations in these contours reflect the changes in seam thickness and depths of cover from place to place over the area of the
longwalls

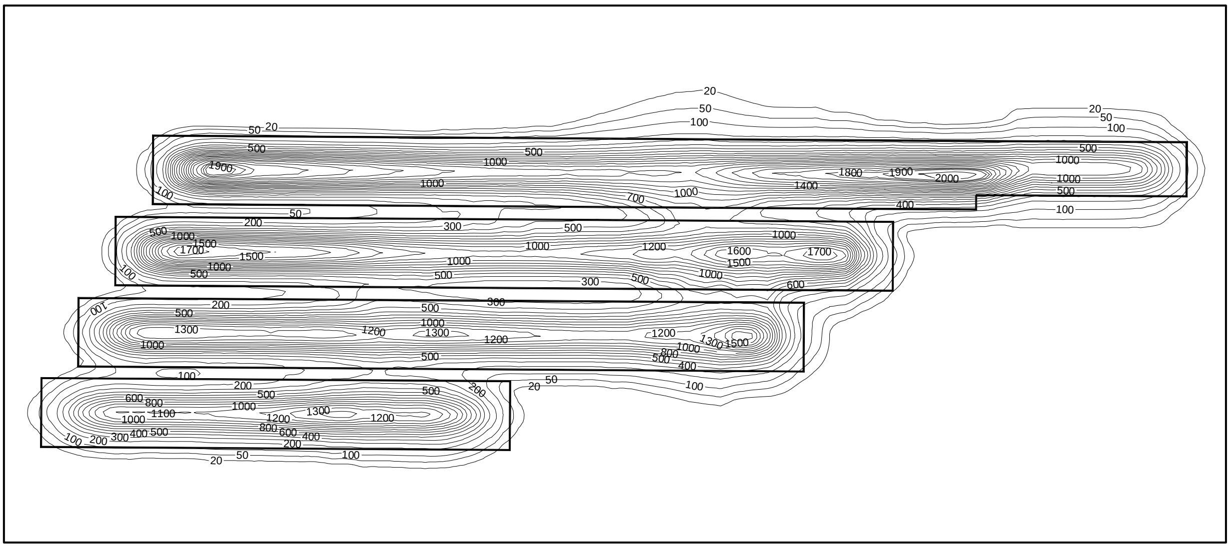


Fig. D.6 Typical Predicted Subsidence Contours over a Series of Longwalls

D.2. Timing and Direction of Predicted Tilts and Strains

It is generally found for longwalls of subcritical width, that the maximum tilts and strains at any point within a mined area are aligned in the transverse direction across the longwalls and occur after the longwalls have been fully extracted. However, there are cases when the maximum tilts and strains are not aligned in the transverse directions. There are also instances where the maximum tilts and strains at a particular point occur during the extraction of a particular longwall and are later reduced by extraction of subsequent longwalls. Treatment of these cases is discussed below.

D.2.1. Travelling, Transient and Final Subsidence Parameters

The Incremental Profile Method allows subsidence parameters to be predicted at any point on the surface when the longwall face is at any position in a panel, and hence for any:

- **travelling** scenario, *during* extraction of a longwall,
- **transient** scenario, *following* the extraction of *each* longwall, or
- **final scenario, following the extraction of all longwalls in a series.**

This is particularly relevant for assessing the impacts of curvature and strain on an item of surface infrastructure, which can be greater at a travelling stage than on completion of mining a particular longwall or all longwalls in a series.

A review of subsidence data from several collieries having high depths of cover, in particular West Cliff Colliery, has indicated that the magnitude of the observed travelling strains in the longitudinal direction are generally smaller than the observed transient or final longitudinal strains over the ends of the longwalls. Using the Incremental Profile Method, the travelling strains at any point in the subsidence trough can be determined by taking into account the maximum predicted longitudinal strains over the ends of each longwall, the maximum predicted incremental subsidence value for the longwall and the predicted subsidence at the point of interest.

D.2.2. Tilts and Strains in the Transverse and Longitudinal Directions

The predicted maximum tilts and strains within the mined areas are, generally, those which are aligned in the transverse direction across the longwalls. However, at the ends of the longwalls, the maximum tilts and strains are at right angles to the subsidence contours, which can be aligned in various directions relative to the longwalls. Also, in some cases, the travelling wave that occurs during the extraction of each longwall can produce travelling longitudinal tilts and strains which can be greater than the transverse values. These cases typically occur at those points within the subsidence trough at which maximum subsidence is developed.

At points where it is found that longitudinal tilts and strains are greater than those in the transverse direction, it is extremely rare for these tilts and strains to be greater at a transient stage than on completion of mining. There may be isolated cases where the maximum tilts and strains are aligned in a diagonal direction to the orthogonal axes of the longwalls. In such cases, the magnitude of these tilts and strains will exceed the transverse and longitudinal values by a small proportion only and are unlikely to influence the final assessment of potential impacts or the development of management plans to mitigate these potential impacts.

D.3. Statistical Analysis of Curvature and Strain

The peak values of curvature and strain that have frequently been noted along survey monitoring lines have generally been found to be localised effects associated with escarpments, river valleys, creek alignments or geological anomalies. Consequently, many of them are predictable.

Higher values of measured strain can also arise from buckling of near-surface strata at shallow depths of cover, from disturbance of survey pegs and from survey errors. There are, therefore, some anomalies that can not be predicted and it has to be accepted that there is a small risk of peak values of strain and curvature occurring, at some points, in addition to the predicted systematic background strains and the predictable local peaks. It is preferable to deal with such anomalies on a statistical basis and wherever measured records are available, frequency analyses should be prepared in order to determine the likely incidence of such occurrences.

A histogram of measured strains at Appin Colliery, where the depth of cover is approximately 500 metres, is shown in Fig. D.7. It can be seen that the majority of the measured strains were between 1.5 mm/m, tensile, and 2.0 mm/m, compressive, with approximately 2% to 3% of all strains lying in the range 2.0 mm/m to 5.5 mm/m. Very few of the measured strains exceeded 5.5 mm/m, and these were generally associated with creek alignments.

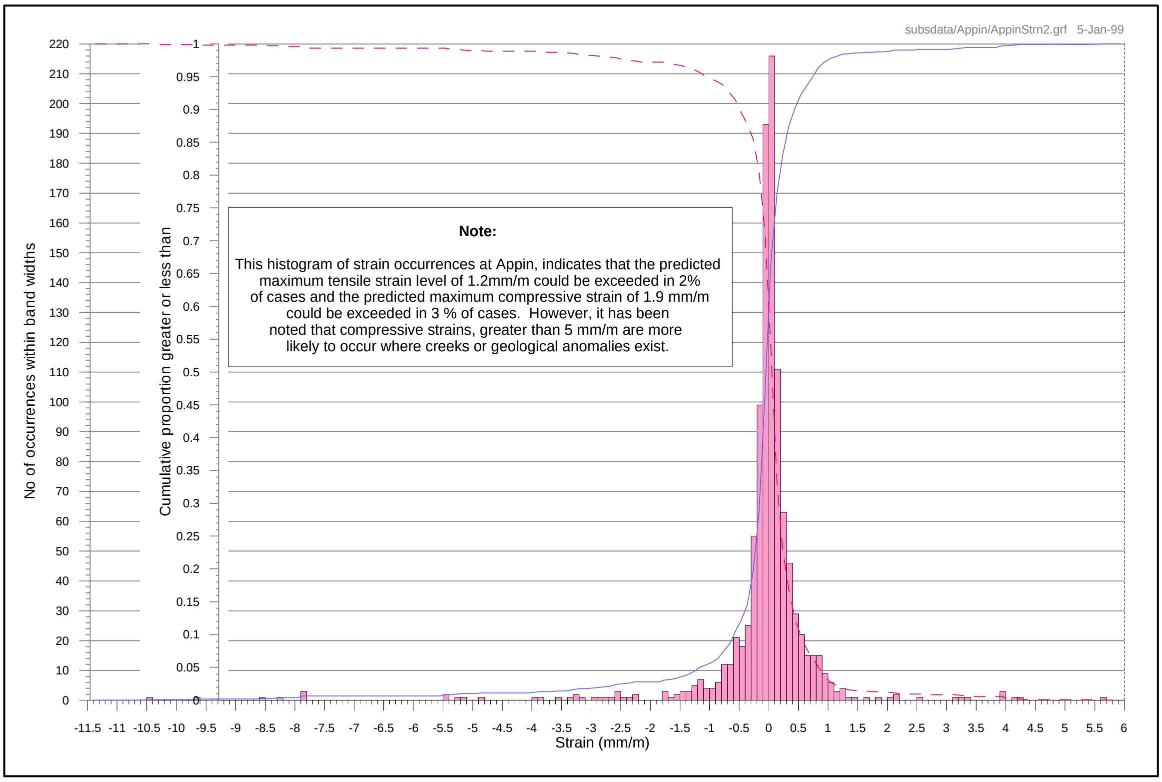


Fig. D.7 Graph showing Histogram of Strain Occurrences at Appin Colliery

D.4. Surface Cracking

As subsidence occurs, cracks will generally appear in the tensile zone, i.e. within 0.1 to 0.4 times the depth of cover from the longwall perimeter. It is also possible that cracking could occur in other locations at right angles to the longitudinal centreline of the longwall as the longwall is mined and the subsidence trough develops. However, this cracking is likely to be transient, since the tensile phase, which results in the cracks opening up, is generally followed by a compressive phase that closes them.

Surface tensile fracturing in exposed sandstone is likely to occur coincident with the maximum tensile strains, but fracturing could also occur due to buckling of surface beds that are subject to compressive strains. Fracture widths tend to increase as the depth of cover reduces and significant cracking would normally be expected where the depth of cover is less than 250 metres.

Noticeable cracks are less likely to occur at low levels of strain, i.e. where the strains are less than 2 mm/m. Kratzsch (1983) indicated that tension cracks had been recorded in Germany, at strains of 3 mm/m to 7 mm/m. Whittaker and Reddish (1989) indicated, however, that noticeable cracking had been recorded in the United Kingdom, in Triassic Sandstone, at strains less than 2 mm/m.

Fig. D.8 shows the relationship between the depth of cover and the width of surface cracks, based upon measured data in the NSW Coalfields and observations over mines in the United Kingdom. The line on the graph represents the upper bound limit of the data in flat terrain. It can be seen that the maximum crack width at a depth of cover of 400 to 500 metres, due to normal subsidence movements, would generally be expected to be around 20 to 30 mm. Where the depth of cover is less than 250 metres, however, larger crack widths can sometimes develop.

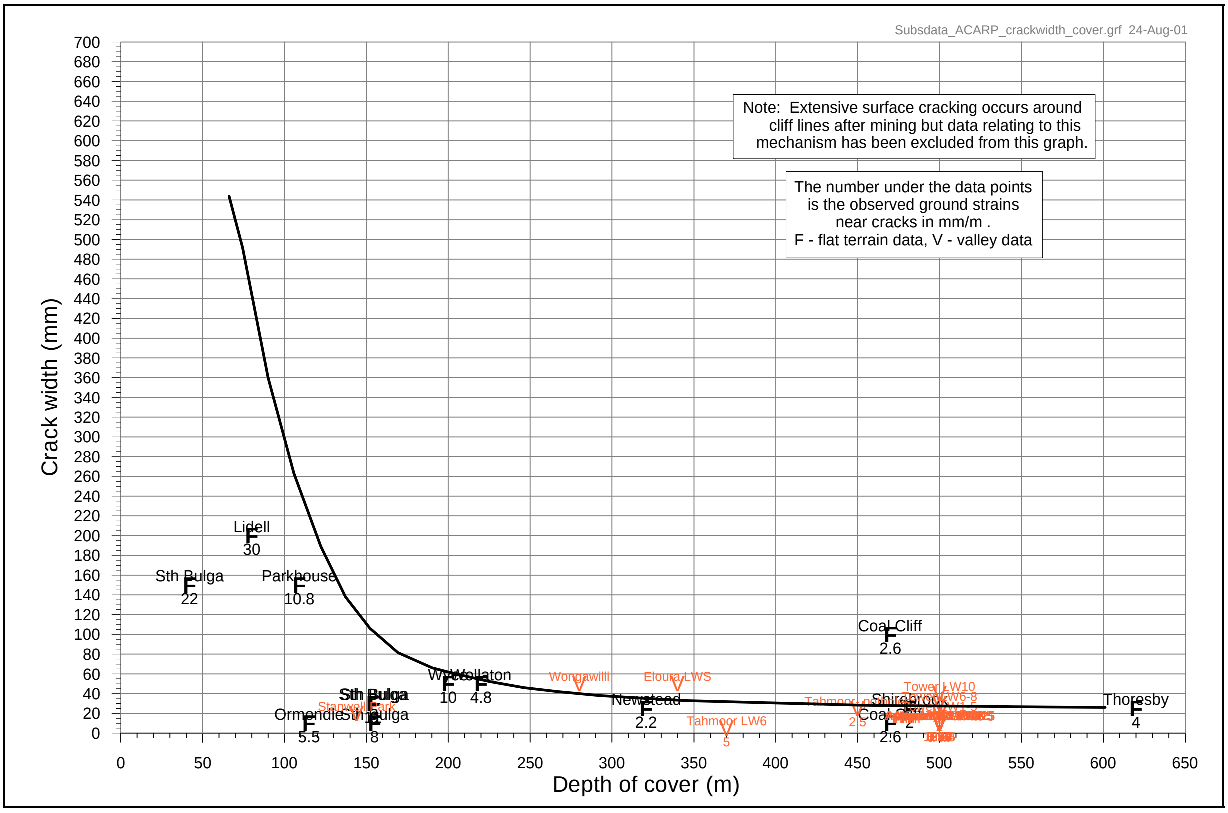


Fig. D.8 Relationship between Crack Width and Depth of Cover

The greater crack widths that have been recorded at depths of cover above 400 metres, occurred in exposed bedrock, and were mainly in the bottoms of valleys and gorges or associated with steep slopes.

D.5. Additional Mining-Induced Ground Movements caused by Topographic or Geological Factors

D.5.1. Analysis of Ground Displacements from Measured Survey Data

When longwalls are extracted beneath steeply incised terrain, the ground movements that occur around the longwalls are very complex, particularly within a high stress regime, and these complex movements result from a number of distinct mechanisms. During research by Mine Subsidence Engineering Consultants, previously known as Waddington Kay & Associates, it was found that measured movements were often a combination of some or all of the following components:

- Normal mining-induced horizontal movements of points on the surface, around an extracted panel, as subsidence occurs, which are generally directed towards the centre of the extracted goaf area.
- Upsidence and closure of creeks, gullies, river valleys and gorges due to valley bulging, which results from the redistribution of pre-existing in-situ stresses, as mine subsidence occurs.
- Predominantly horizontal displacements of surface strata due to release and redistribution of pre-existing regional in-situ stresses as the extracted goaf areas increase in size within a local mining area.
- Mass slippage movements in a downhill direction due to topographic factors.
- Differential movements of the strata on opposite sides of a fault line.
- Continental drift, which is known to change the positions of points on the Australian Plate by moving them approximately 70 mm each year towards the northeast.

Study of data collected over longwalls in the Southern Coalfield during the last twenty years has led to the development of methods that can now be used for the prediction of some of these components which are discussed in this section. Valley related movements are less obvious in the Newcastle and Hunter Coalfields and are usually more difficult to resolve from observed monitoring data. The reason for this is that the systematic movements in the Newcastle and Hunter Coalfields are generally much larger than those in the Southern Coalfield, and these movements tend to overshadow any valley related movements which may occur, especially in smaller, less incised valleys.

In developing predictive methods, it is advantageous if the measured data can be broken down into its various components prior to analysis. This is not an easy task, however, because in most cases the measured survey movements are relative movements rather than absolute movements and in all cases they are total movements. When analysing the closures that have been measured in creeks and river valleys due to valley bulging, however, it appears that many of the other components have little or no effect on the closure measurements.

Mass slippage down steep slopes, due to mining is a relatively rare occurrence and is due to the instability of surface soils in particular locations. Where steep slopes exist and can be affected by mining it is prudent to study the geology of the site and the nature of the surface soils so that any unstable areas can be identified. It is possible that some of the data studied by Waddington Kay & Associates could have been affected by this mechanism, but if so it will have led to overstatement of closure movements.

Differential movements on opposite sides of a fault line are equally rare occurrences and there are only a few known major faults in the study areas. There is no evidence to indicate that any of the measured data used in developing the predictive methods have been affected by differential movements at faults.

In analysing the valley closure data, no allowance was made for differential movements caused by regional horizontal stress redistribution or continental drift, because the differential movements in the two sides of a valley, as a result of these mechanisms, would be negligible.

In the steep-sided Cataract and Nepean River Gorges it was found that the closures in the sides of the gorges were almost mass movements with little differential shear displacement between different horizons in the strata. Almost all of the closure, therefore, occurred in the bases of the gorges. Because the gorge bases are relatively narrow, the differential mining-induced horizontal movement, due to differential tilting in the sides of the gorges, was relatively small in comparison with the closure movements.

In the vee-shaped valleys, a large proportion of the closure occurred in the bases of the valleys, coupled with localised concentration of compressive strain, but in some cases, part of the closure was noted to occur at horizons above the bases of the valleys.

This observation from measured data was supported by numerical modelling work by CSIRO, which indicates that in vee-shaped valleys some of the shearing occurs along weaker horizons in the valley sides. The closure movements are, therefore, spread over a greater width than those measured in the gorges.

It is possible that some of the measured closure data from vee-shaped valleys could have been affected by differential systematic mining-induced horizontal movements in the valley sides. In some cases these differential movements could have caused the sides of the valley to open and the measured closure, being the sum of the two movements, could, therefore, be less than the actual closure caused by valley bulging.

The extent to which the data might have been affected in this way is difficult to determine. This is because many of the surveys that were carried out in the past did not measure the absolute movements of the ground in three dimensions. In these cases the closures have been calculated from the strains.

The method that has been developed for the prediction of closure is, therefore, based upon the overall closure of the valley recognising that, in the case of vee-shaped valleys, some of the movement will occur in the valley sides.

When predicting closures in vee-shaped valleys it would be prudent to ignore the impacts of differential mining-induced horizontal movements in the valley sides, if those movements result in a reduction in the predicted closures.

D.5.2. Normal Mining Induced Horizontal Ground Movements

The 'normal' horizontal component of subsidence, sometimes referred to as horizontal displacement, can be predicted, in flat terrain, i.e. where steep slopes or surface incisions do not influence ground movement patterns. As discussed in Section D.1.3, the magnitude and direction of horizontal displacements can be determined, approximately, from the predicted tilt profiles, by applying the strain-curvature factor. These subsidence induced horizontal displacements are generally directed towards the centre of the mined longwall panel as shown in Fig. D.9.

As also discussed in Section D.1.3, the appropriate strain-curvature factor for the Newcastle Coalfield is 10. If the predicted tilt at a point is 2 mm/m, for example, then the predicted horizontal ground displacement will be approximately 20 mm, directed towards the centre of the mined goaf.

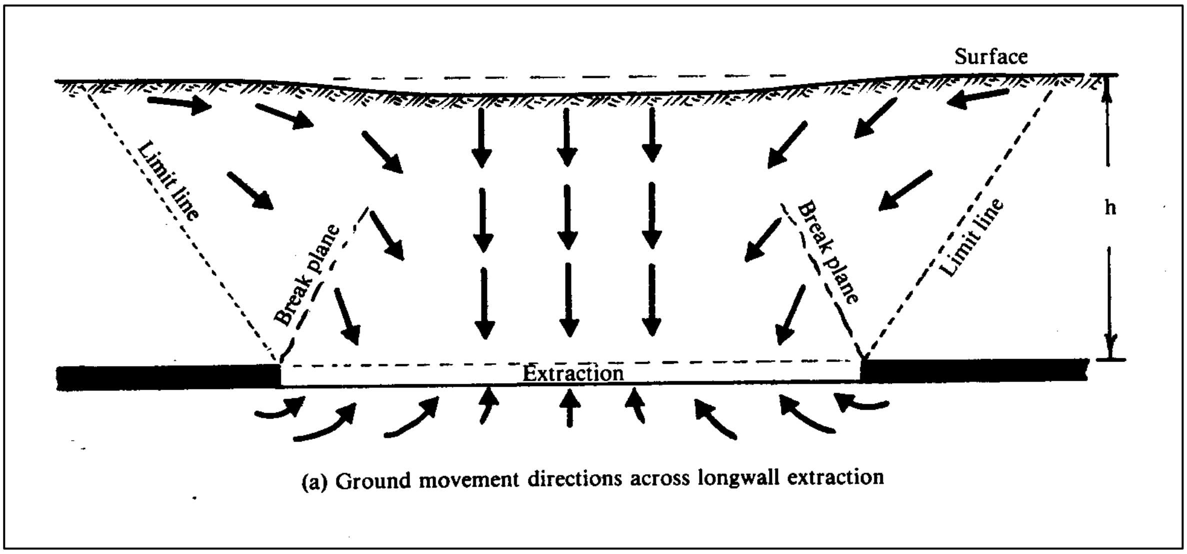


Fig. D.9 Normal Mining Induced Movements above an Extracted Area (after Whittaker, Reddish and Fitzpatrick, 1985)

This method is only approximate and, whilst it tends to be conservative where the tilts are high, it tends to underestimate the horizontal movements where the tilts are low. Where the tilt is low, however, the 'normal' horizontal displacement is generally very small, even though it could be many times greater than the vertical subsidence at the same point. The tilts reduce with increasing distance from the goaf edge of the longwall, and at the edge of the subsidence trough, where the tilts approach zero, any small horizontal displacement at that point could be infinitely greater than the tilt. When large horizontal displacements are measured outside the goaf area, they are more likely to be a result of regional movements, as discussed in Section D.5.9.

D.5.3. Upsidence and Closure due to Mining beneath Gorges, River Valleys and Creeks

When creeks and river valleys are affected by mine subsidence, the observed subsidence in the base of the creek or river is generally less than the level that would normally be expected in flat terrain. This reduced subsidence is due to the floor of the valley buckling upwards. This phenomenon is referred to as valley bulging and results from the redistribution of, and increase in, the horizontal stresses in the strata immediately below the base of the valley as mining occurs. Valley bulging is a natural phenomenon, resulting from the formation and ongoing development of the valley, as indicated in Fig. D.10, but the process is accelerated by mine subsidence. The phenomenon appears to be triggered, to varying degrees, whenever mining occurs beneath or adjacent to escarpments, gorges, river valleys, creeks or other surface incisions.

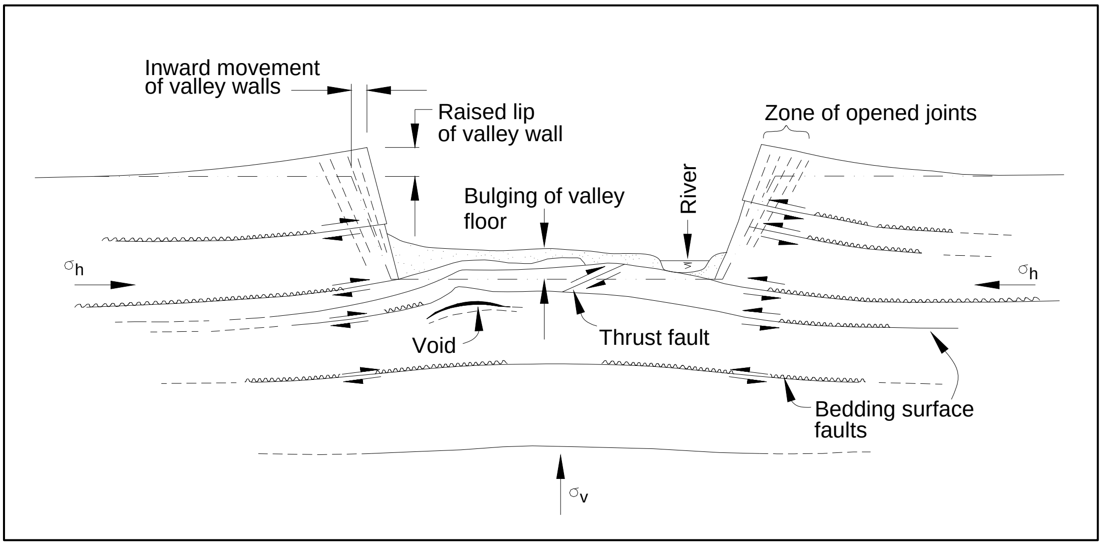


Fig. D.10 Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)

The local reduction in subsidence, which is referred to as 'upsidence', is generally accompanied by localised changes in tilt and curvature leading to high compressive strain in the centre of the valley and horizontal closure of the valley sides. In the case of escarpments and wide river gorges the movements may be limited to the cliffs that are closest to the extracted area.

The phenomenon is clearly seen when subsidence profiles are plotted to an exaggerated vertical scale, when the upsidence can be seen as a localised upwards spike in an otherwise smooth subsidence profile, coincident with a creek alignment. A typical example is illustrated in Fig. D.11, which shows the measured subsidence profiles over Longwalls 1 to 6 at West Cliff Colliery, along a survey line known as the E-Line. The upsidence spike in the subsidence profile, between Longwalls 2 and 3, can be seen to coincide with the alignment of a local creek, leading to a reduced subsidence of approximately 200 mm coupled with a local concentration of compressive strain.

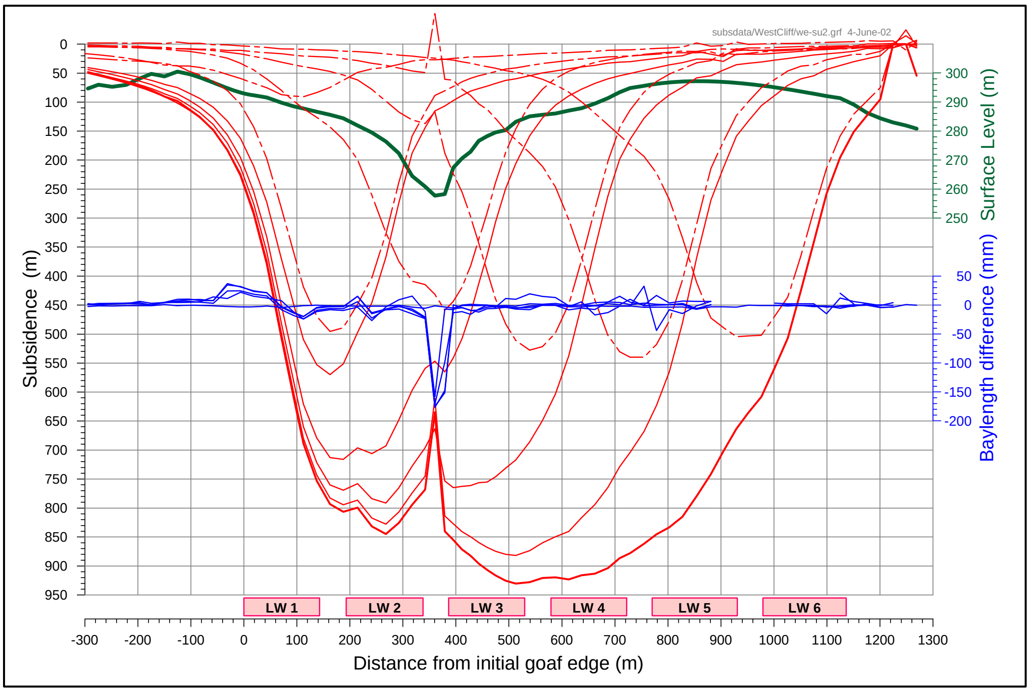


Fig. D.11 Measured Subsidence Profiles over Longwalls 1 to 6 at West Cliff Colliery

In most cases studied, the upsidence effects extend outside the valley and include the immediate cliff lines and the ground beyond them. For example, monitoring within the Cataract Gorge, at Tower Colliery, as Longwalls 8 and 10 were mined, revealed that the upsidence extended up to 300 metres from the centre of the Gorge, on both sides of the Gorge. In that case, the magnitude of the upsidence was greater than the subsidence leading to an overall uplift in the base of the Gorge, consequently leaving it above its original pre-mining level.

In other cases, within creek alignments, upsidence has been observed well outside an extracted panel, apparently due to a beam within the near-surface strata rotating and pivoting as a seesaw, as one end of it rises and the other subsides. However, in these cases, the measured upsidence and strains were less than would be expected to arise from the compressive buckling mechanism described above.

Based upon the empirical evidence, upsidence and closure movements can be expected in cliffs and in the sides of valleys, whenever longwalls are mined beneath or adjacent to them. Such movements, however, tend to be smaller outside the goaf areas and tend to reduce with increasing distance outside the goaf edge. The movements are incremental and increase as each longwall is mined in sequence, and consequently the movements resulting from the mining of one longwall can be spread over several longwalls.

Methods of prediction have been developed for closure and upsidence, as detailed in the ACARP *Management Information Handbook on the Undermining of Cliffs, Gorges and River Systems* (Waddington and Kay, 2002).

The methods used to determine the predicted upsidence and closure for gorges, creek and river valleys were developed using empirical data from the Southern Coalfield. The data was mainly taken from the Nepean and Cataract River Valleys, which are large and steeply incised when compared to many of the valleys within the Newcastle and Hunter Coalfields. It is expected, therefore, that the methods used to determine predicted upsidence and closure movements will provide conservative results for smaller, less incised creek and river valleys within the Newcastle and Hunter Coalfields.

D.5.4. The Prediction of Closure in Creeks and River Valleys

A method has been developed for prediction of closure across creeks and river valleys which is based upon measured data over a wide range of cases, with valley depths varying from 27 metres to 74 metres. This data was mainly collected from collieries in the Southern Coalfield where the valleys are incised into flat lying sedimentary deposits and where the in-situ horizontal stresses are high at seam level. However, valley closure has also been observed in other locations and with lower valley depths.

The method is expected to give superior results in areas with geology and stress regimes similar to those from which it was derived. The method is based upon upper-bound measured values and it is anticipated that the method will over-predict in most cases, especially in areas of lower stress. Further research is required to determine how pre-existing in-situ horizontal stress and variations of local geology specifically influence the closure movements.

The method of valley closure prediction was first fully described in the report tilted "Report on ACARP Research Project No C9067 Research into the Impacts of Mine Subsidence on the Strata and Hydrology of River Valleys and Development of Management Guidelines for Undermining Cliffs, Gorges and River Systems" that was published by Waddington Kay & Associates in 2002. Since then new observations of closure have permitted minor improvements to the method of prediction that allow for the detailed prediction of distribution of closure movement profiles across a valley and allow more realistic upper bound predictions when predicting closure and upsidence at large distances from the lateral and longitudinal edges of longwall panels. The minor modifications in the prediction curves are shown on the following figures.

The method for the prediction of closure is based upon a series of graphs that show the interrelationships between closure and a number of contributory factors. The interrelationships between the factors are illustrated in the following figures:-

- Fig. D.12 shows a graph of closure plotted against the transverse distance from a point in the bottom of the valley to the advancing goaf edge of the longwall divided by the width of the panel plus the width of the pillar.
- Fig. D.13 shows a longitudinal distance adjustment factor plotted against the longitudinal distance from a point in the bottom of the valley to the nearest end of the longwall in metres.
- Fig. D.14 shows a valley depth adjustment factor plotted against valley depth.
- Fig. D.15 shows an incremental subsidence adjustment factor plotted against the maximum incremental subsidence of the panel.

The graphs provide the original and the revised upper bound prediction curves, which are predominantly based upon closure data from the Cataract and Nepean Gorges, where the maximum incremental subsidence was approximately 410 mm and the depth of gorge was approximately 68 metres. The observed raw data values were "normalised" to account for variations in positions of the monitored creeks with respect to the panel edges and for variations in the magnitude of the maximum incremental subsidence over the mined panel and for variations in the valley depths. Large adjustment factors had to be applied to some of the raw observed data points and, where the raw data point is smaller than the survey tolerance, this magnification is also applied to the survey errors. Accordingly judgement was required to determine where to fit the new prediction curves, which are found to be above 90% of the adjusted observed closure data.

The closure is initially predicted from the graph shown in Fig. D.12 and the value so obtained is adjusted with reference to the graphs shown in Fig. D.13 to Fig. D.15, depending on the position of the bottom of the valley relative to the end of the longwall, the valley depth and the maximum incremental subsidence of the longwall.

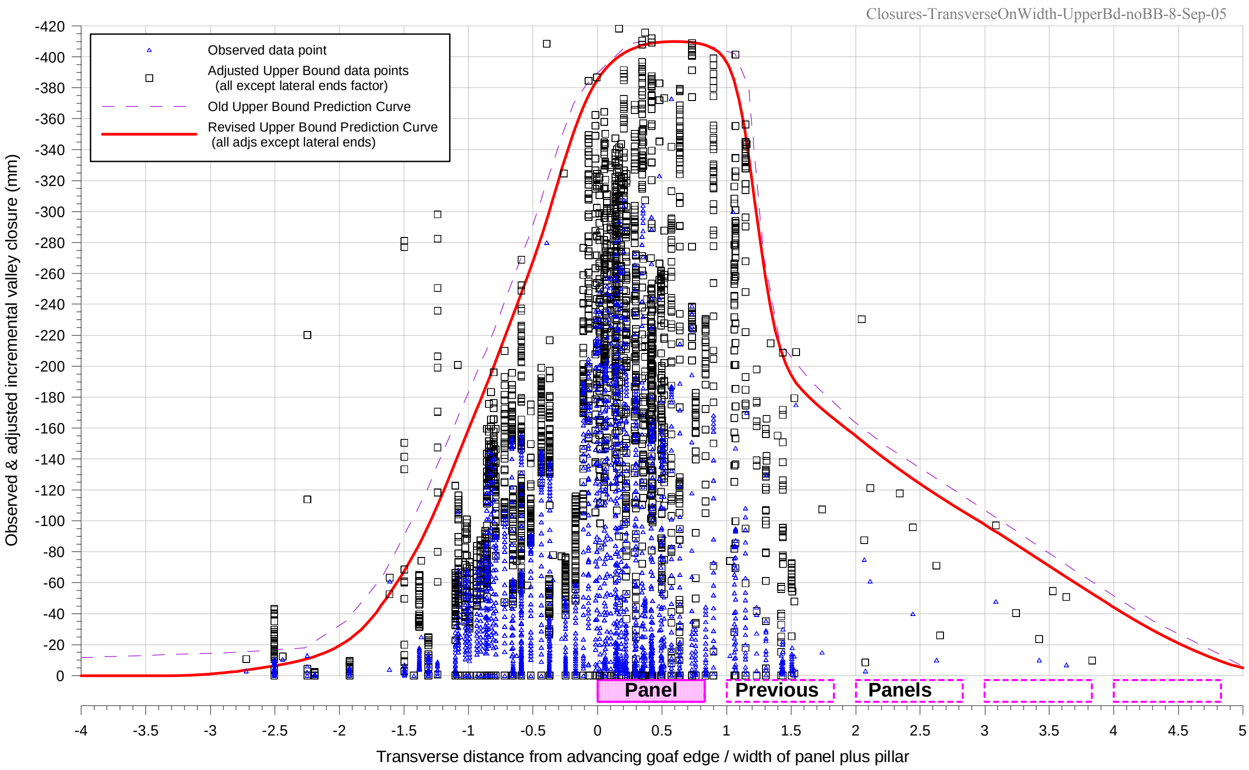


Fig. D.12 Valley Closure versus Distance from the Advancing Goaf Edge of the Longwall relative to the Width of the Panel plus the Width of the Pillar

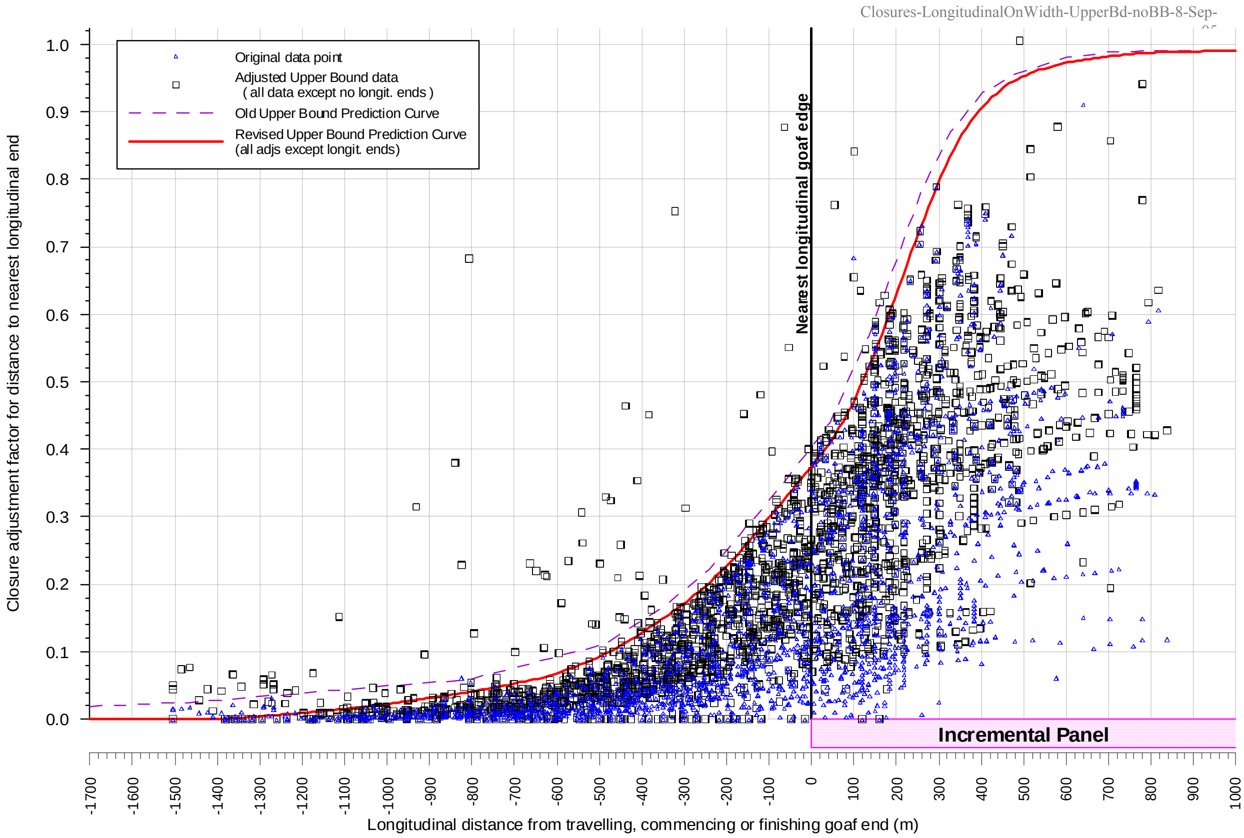


Fig. D.13 Valley Closure Adjustment Factor versus Longitudinal Distance

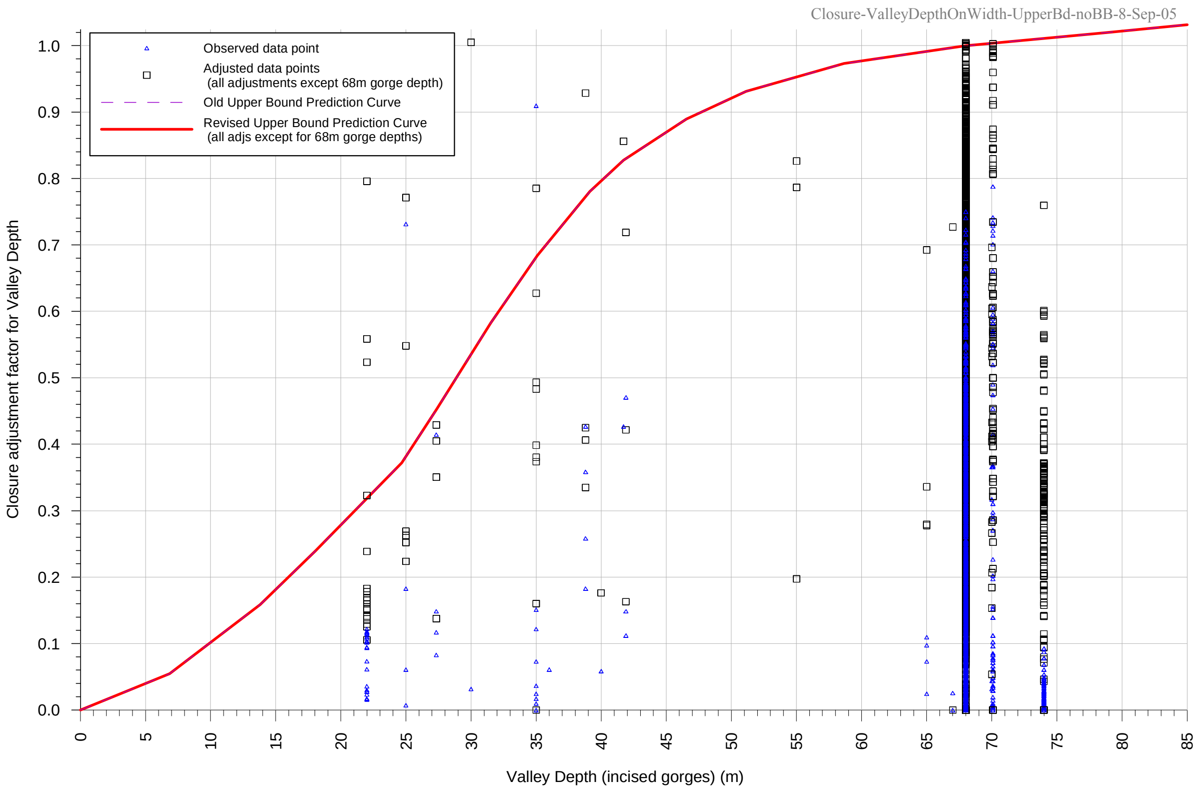


Fig. D.14 Valley Closure Adjustment Factor versus Valley Depth

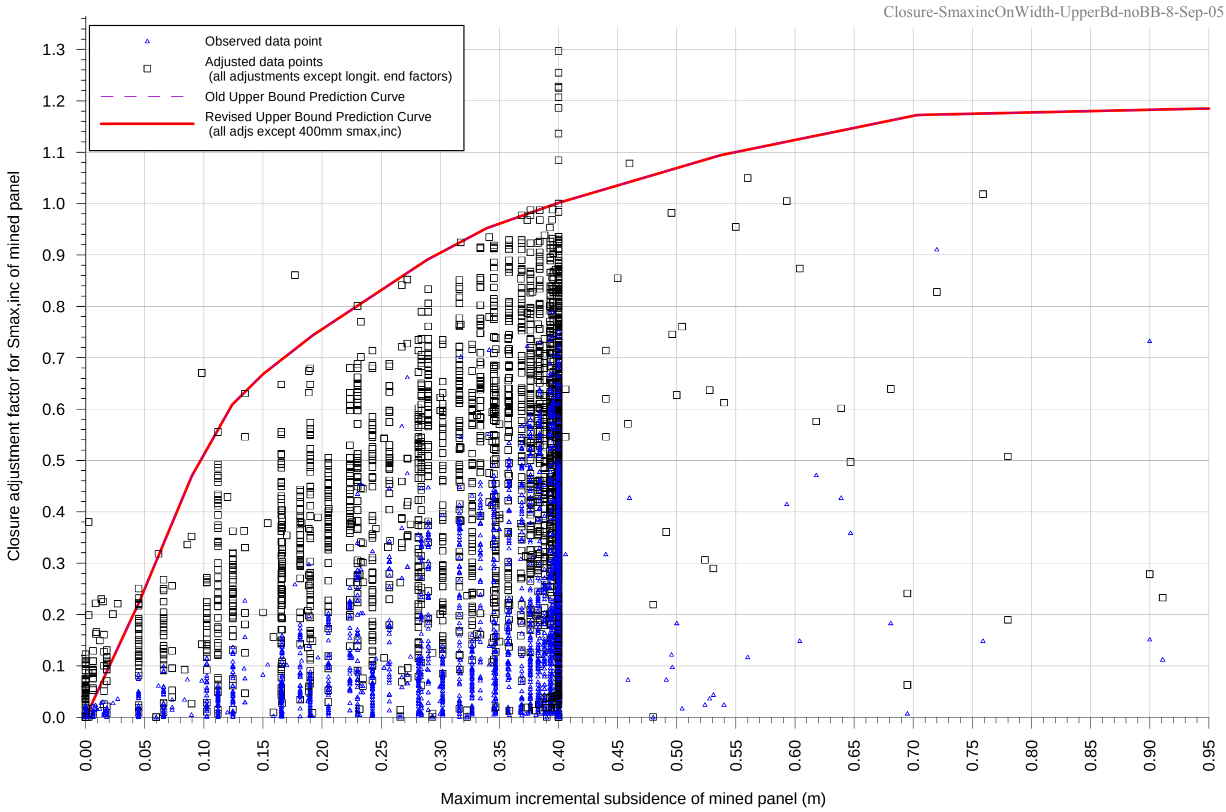


Fig. D.15 Valley Closure Adjustment Factor versus Maximum Incremental Subsidence

Fig. D.16 shows the distance measurement convention used to define the location of the point in the creek for which closure and upsidence predictions are required.

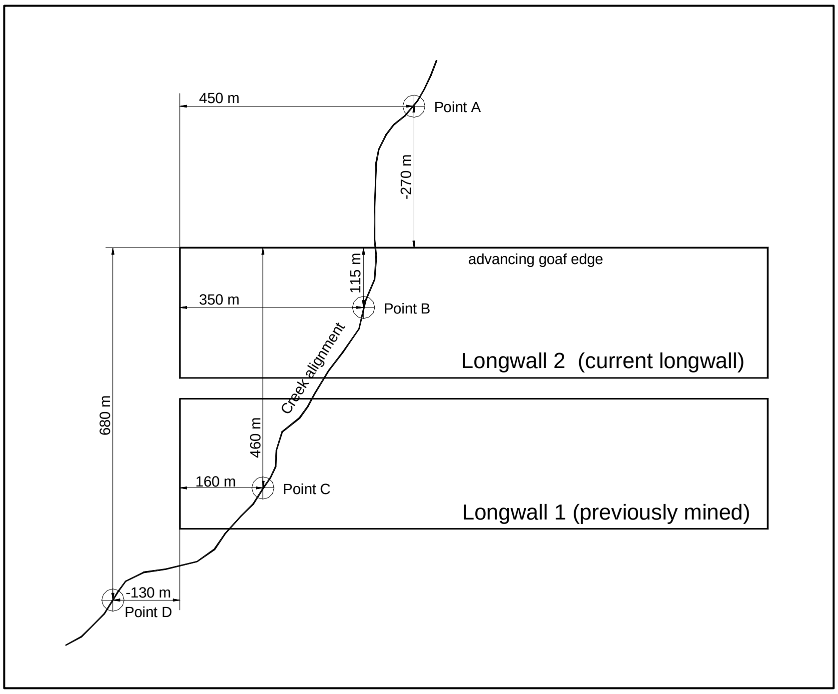


Fig. D.16 Distance Measurement Convention for Closure and Upsidence Predictions

The transverse distances plotted in Fig. D.12 are the distances measured at right angles to the advancing goaf edge of the longwall expressed as a proportion of the width of the panel plus the width of the pillar.

The transverse distances for points A, B, C and D in Fig. D.16 are -270 metres, 115 metres, 460 metres and 680 metres, respectively, distances outside the goaf being negative.

The longitudinal distances plotted in Fig. D.13 are the distances from the nearest end of the longwall, measured parallel to the longitudinal centreline of the longwall. These distances for points A, B, C and D in Fig. D.16 are 450 metres, 350 metres, 160 metres and -130 metres, respectively, distances outside the goaf again being negative.

To make a prediction of closure at a point in the base of a creek or river valley, it is necessary to know the distance of the point from the advancing edge of the longwall, the longitudinal distance from the nearest end of the longwall, the valley depth, the maximum incremental subsidence of the panel that is being mined and the panel and pillar widths.

D.5.5. The Prediction of Upsidence in Creeks and River Valleys

The method developed for the prediction of upsidence in creeks and river valleys is similar to that described above for the prediction of closure. The method is based upon measured data over a wide range of cases, with valley depths varying from 8 metres to 87 metres. The data was mainly collected from collieries in the Southern Coalfield where the valleys are incised into flat lying sedimentary deposits and where the in-situ horizontal stresses are high at seam level.

The method of prediction would therefore be expected to give superior results in areas with similar geology and similar stress regimes. The method has also been modified based on new data received since the ACARP report was published in 2002. The method is based upon upper-bound measured values and it is anticipated that the method will over-predict in most cases, especially in areas of lower stress. Again, further research is required to determine how pre-existing in-situ horizontal stress and local variations in geology specifically influence the upsidence movements.

The prediction of upsidence is based upon a series of graphs that show the interrelationships between upsidence and a number of contributory factors. The interrelationships between the factors are illustrated in the following figures.

- Fig. D.17 shows the graph of upsidence plotted against the transverse distance from a point in the bottom of the valley to the advancing goaf edge of the longwall divided by the width of the panel plus the width of the pillar.
- Fig. D.18 shows a longitudinal distance adjustment factor plotted against the longitudinal distance from a point in the bottom of the valley to the nearest end of the longwall in metres.
- Fig. D.19 shows a valley depth adjustment factor plotted against valley depth.
- Fig. D.20 shows an incremental subsidence adjustment factor plotted against the maximum incremental subsidence of the panel.

The graphs provide the original and the revised upper bound values, which are mainly based upon upsidence data from the Cataract Gorge, where the maximum incremental subsidence was approximately 350 mm and the depth of gorge was approximately 70 metres.

The transverse distances plotted in Fig. D.17 are the distances measured at right angles to the advancing goaf edge of the longwall, expressed as a proportion of the width of the panel plus the width of the pillar. Fig. D.16 shows the distance measurement convention used to define the location of the point in the creek for which closure and upsidence predictions are required.

To make a prediction of upsidence at a point in the base of a creek or river valley, it is necessary to know the distance of the point from the advancing edge of the longwall, the longitudinal distance from the nearest end of the longwall, the valley depth, the maximum incremental subsidence of the panel that is being mined and the panel and pillar widths.

The initial prediction of upsidence is made using the upper-bound curve in Fig. D.17, for the relevant transverse distance divided by panel plus pillar width. The value of upsidence is then adjusted by multiplying it by the factors obtained from the upper-bound graphs from Fig. D.18 to Fig. D.20.

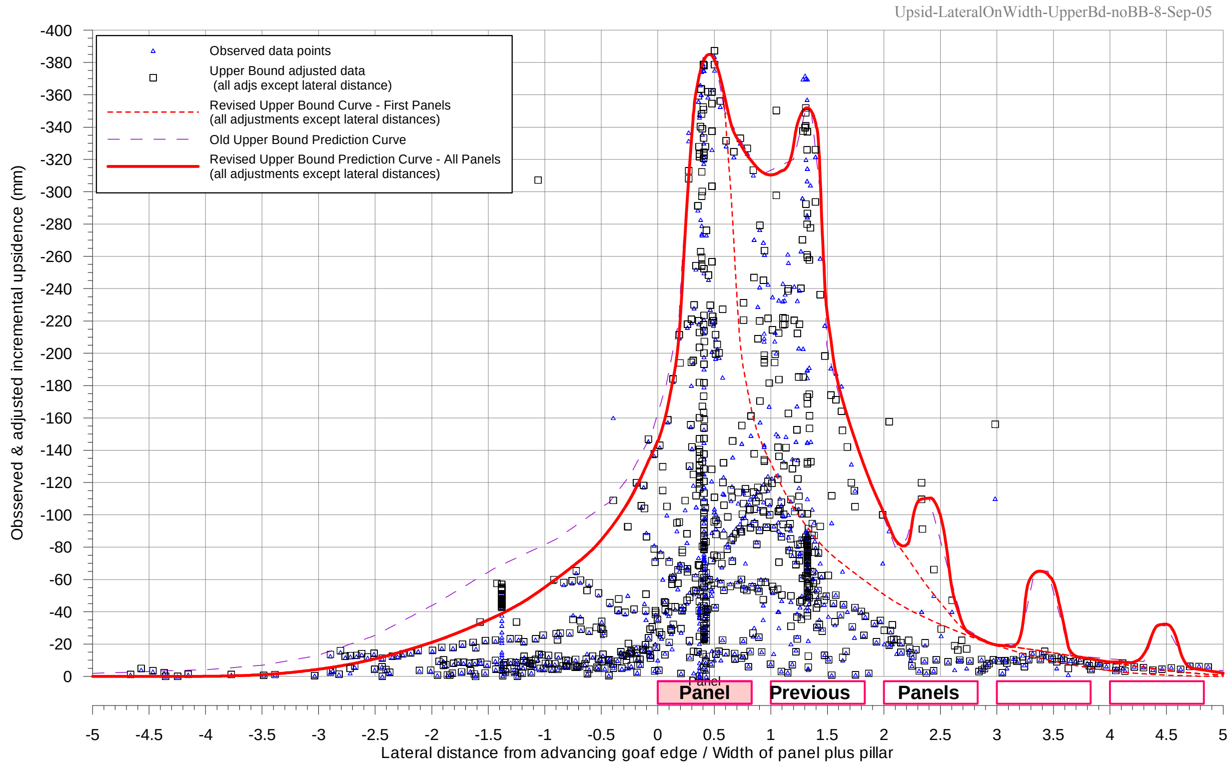


Fig. D.17 Upsidence versus Distance from the Advancing Goaf Edge of the Longwall relative to the Width of the Panel plus the Width of the Pillar

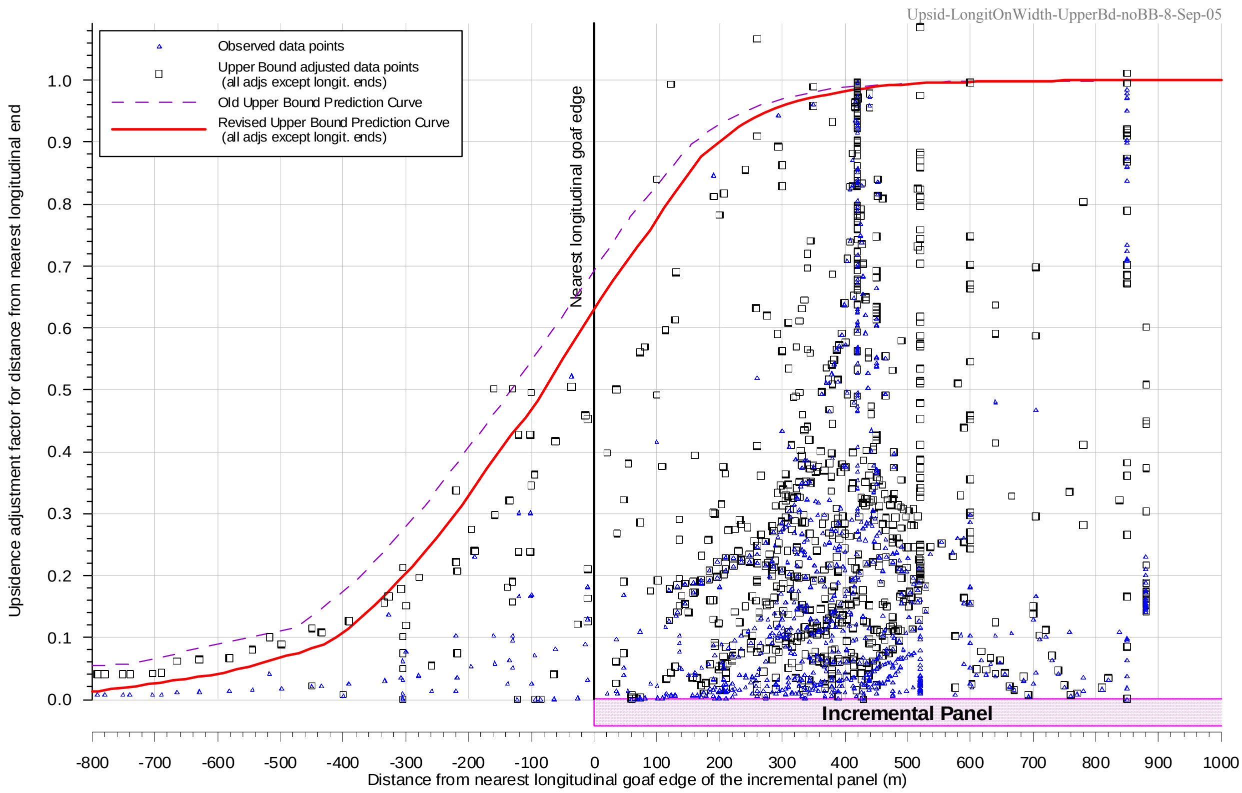


Fig. D.18 Upsidence Adjustment Factor versus Longitudinal Distance

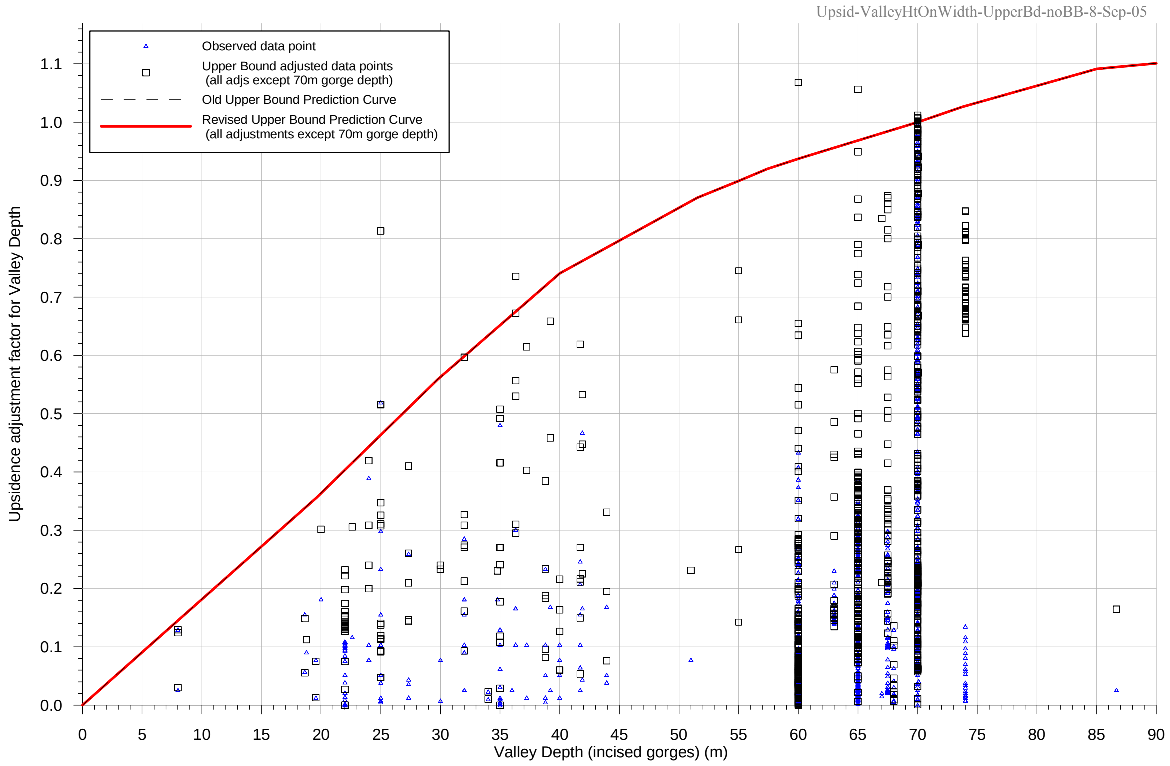


Fig. D.19 Upsidence Adjustment Factor versus Valley Depth

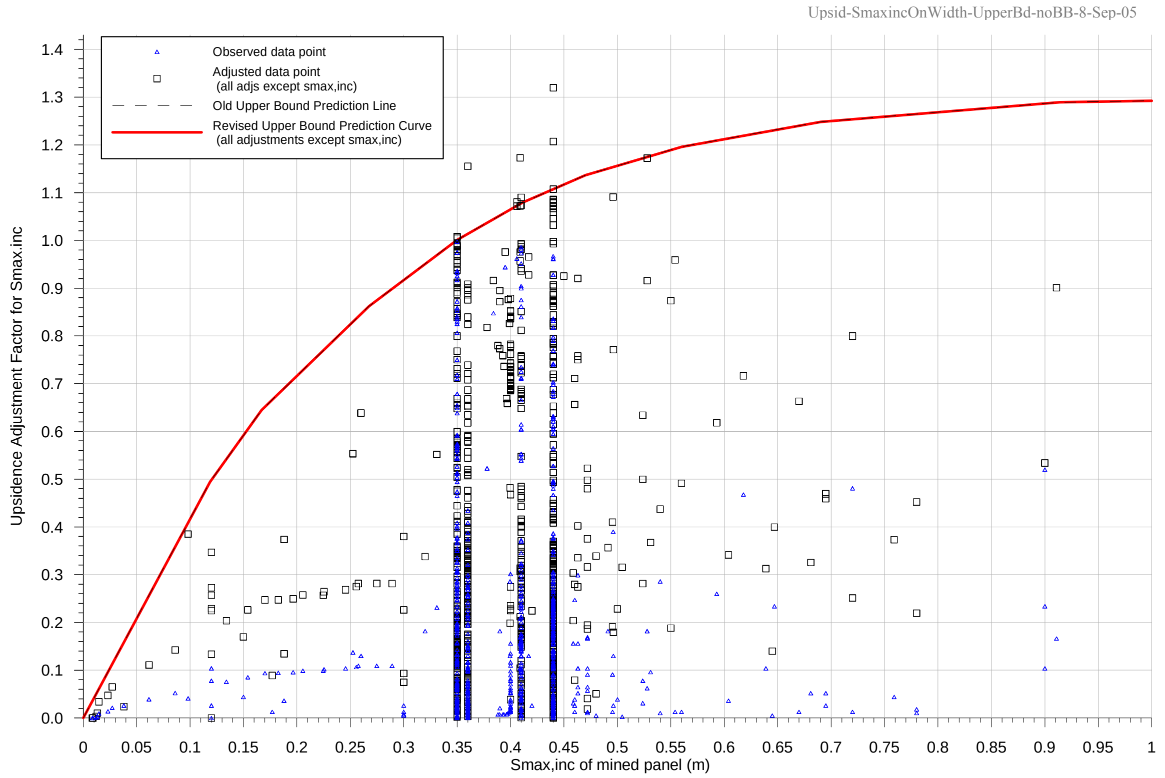


Fig. D.20 Upsidence Adjustment Factor versus Maximum Incremental Subsidence

D.5.6. The Lateral Distribution of Upsidence

Upsidence is the result of two separate mechanisms, namely, valley bulging and buckling of the strata in the base of the valley. The maximum upsidence occurs in the base of a creek or river valley, where the strata buckling occurs, but the upsidence effect spreads outwards under the sides of the valley for a considerable distance due to valley bulging.

For example, in the Cataract Gorge above Longwall 8 at Tower Colliery, whilst the upsidence in the base of the gorge was 350 mm, the upsidence in the clifflines was around 100 mm and the upsidence effect extended for a distance of 300 metres on each side of the gorge.

Fig. D.21 shows idealised profiles of upsidence across the Cataract gorge, both along the goaf edge of a longwall and along the centreline of the longwall. It can be seen that the lateral spread of the upsidence was greater where the amplitude of the upsidence was greater. Further research is required in order to develop a more definitive method for the prediction of upsidence profiles, but in the meantime it seems reasonable to model the profiles on the upper measured profile shown in Fig. D.21. An approximate profile can be obtained by scaling both the width and amplitude of the profile in proportion to the predicted upsidence value. It should be noted, however, that the predicted profile can only be approximated since the actual buckling will depend upon local geology and might not be centrally positioned in the bottom of the valley or gorge.

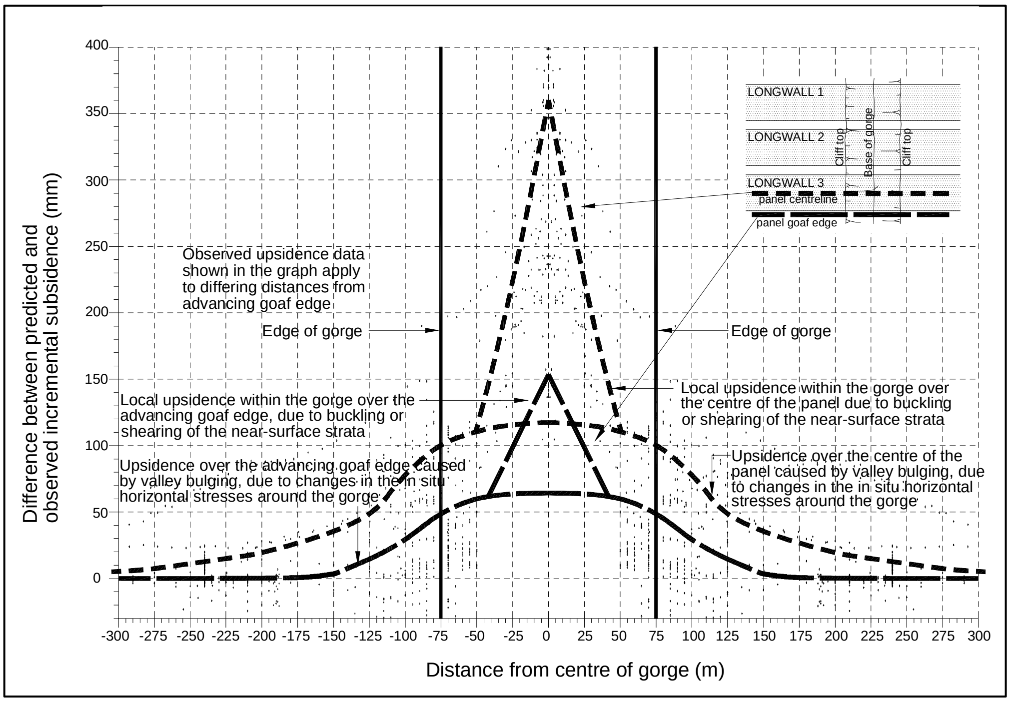


Fig. D.21 Idealised Upsidence Profiles across the Cataract Gorge

D.5.7. The Prediction of Compressive Strains in Creeks and River Valleys

The method of prediction for compressive strain due to closure was developed as part of the ACARP study (2002). The method provides an indication of the maximum compressive strains that might be experienced as a result of mining by adopting an upper bound relationship between observed closure and maximum compressive strain. This relationship is shown in Fig. D.22. The predicted closure, obtained using the method described in Section D.5.4, is the overall closure across the valley.

The predicted strain is the average strain over a bay length of 20 metres and is assumed to occur within the lowest part of the valley. The closure of this bay can, therefore, be determined from the predicted strain. The closure over this bay length can be greater than the overall closure of the valley, due to expansion in the valley sides as the horizontal stresses are relieved.

It is believed that the closure and strain are both driven by the in-situ horizontal stress and it is reasonable to assume that the compressive strains will reduce as the in-situ stress reduces. Since the graph in Fig. D.22 has been based on data that is primarily from observations at Tower Colliery, where the in-situ stress is particularly high, it is expected that the graph will generally be conservative and could over-predict strains by 100% in some cases, particularly where the predicted levels of strain are low. The data spread in the graph shows the variations that have occurred in practice and provides a guide to the potential range of strains that might occur in a particular case.

Since the completion of the ACARP study, an examination of observed ground movements suggest that the predictive method is mainly applicable for creeks and valleys that are located directly above extracted longwalls. However, it has been found that observed maximum compressive strains are substantially less in locations that are not directly above extracted longwalls. An upper bound relationship between compressive strain and lateral and longitudinal distance from longwalls is provided in Fig. D.23 and Fig. D.24. It is hoped that further analysis of observed ground movements will be conducted in the future, so that the method for predicting maximum compressive strains can be improved.

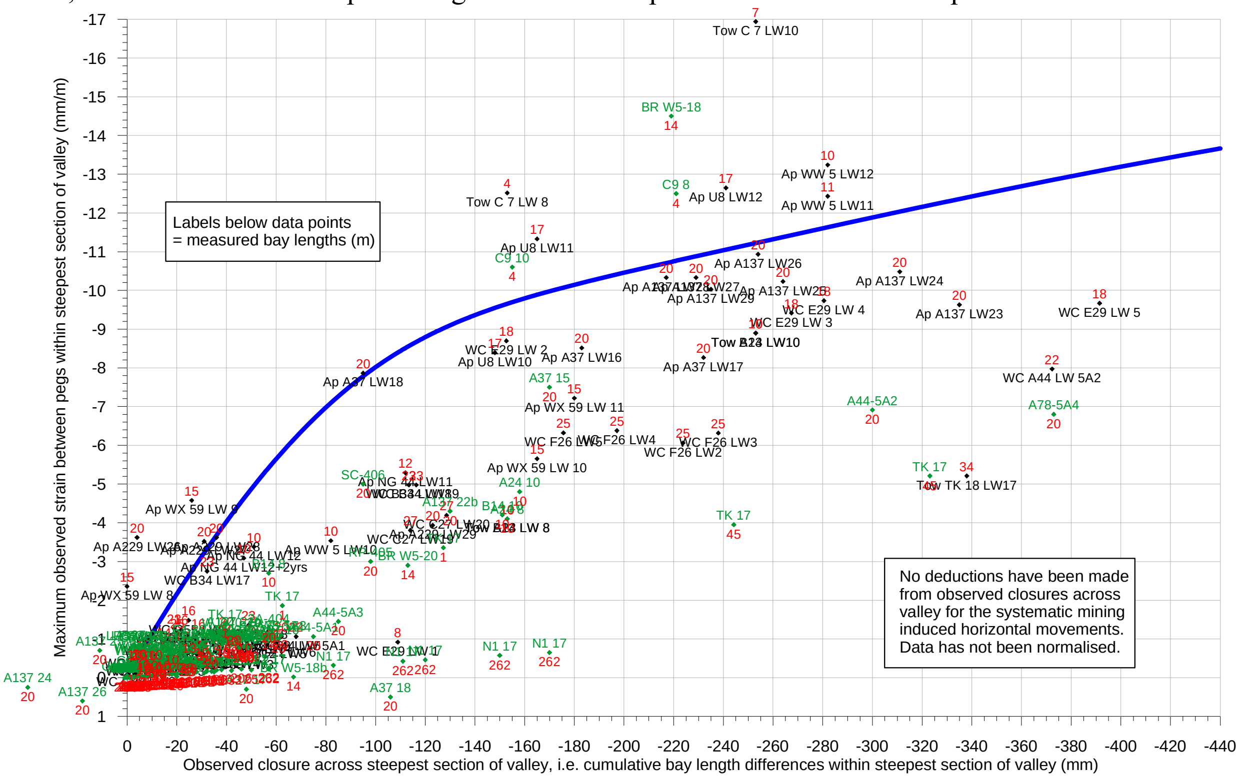


Fig. D.22 Graph of Maximum Compressive Strain versus Valley Closure

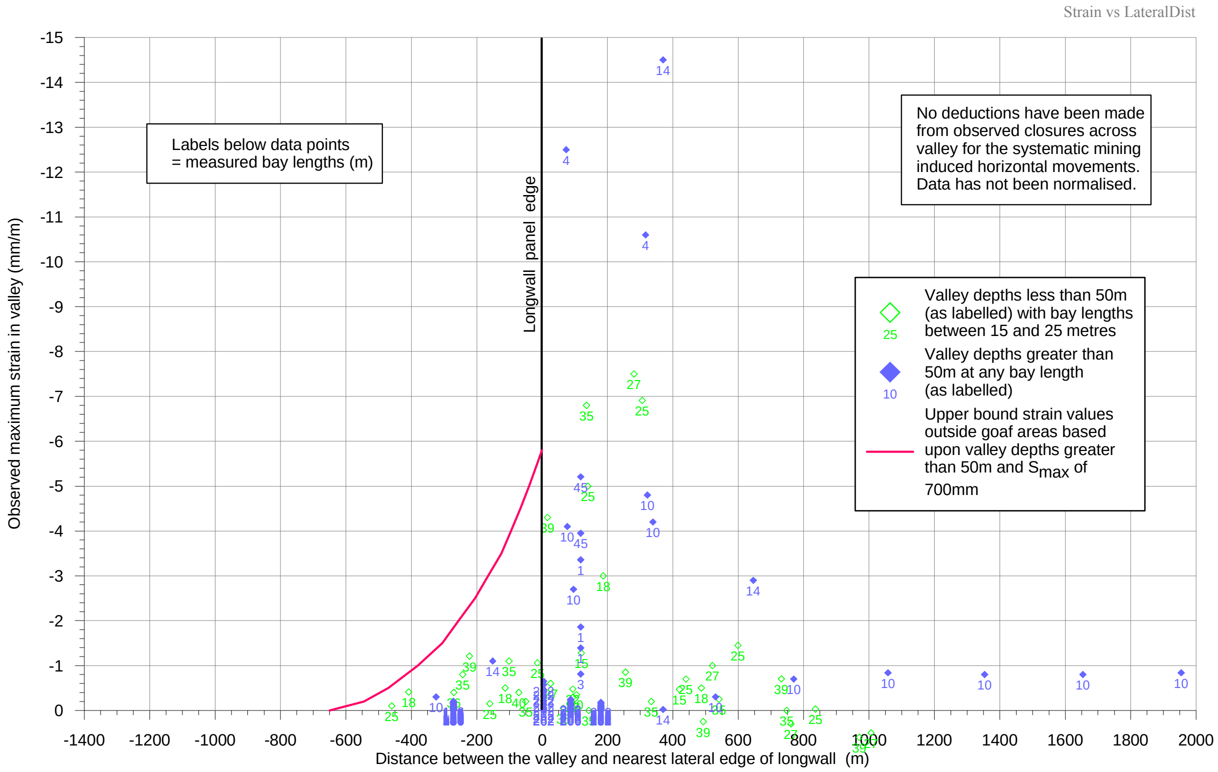


Fig. D.23 Graph of Maximum Compressive Strain versus Lateral Distance

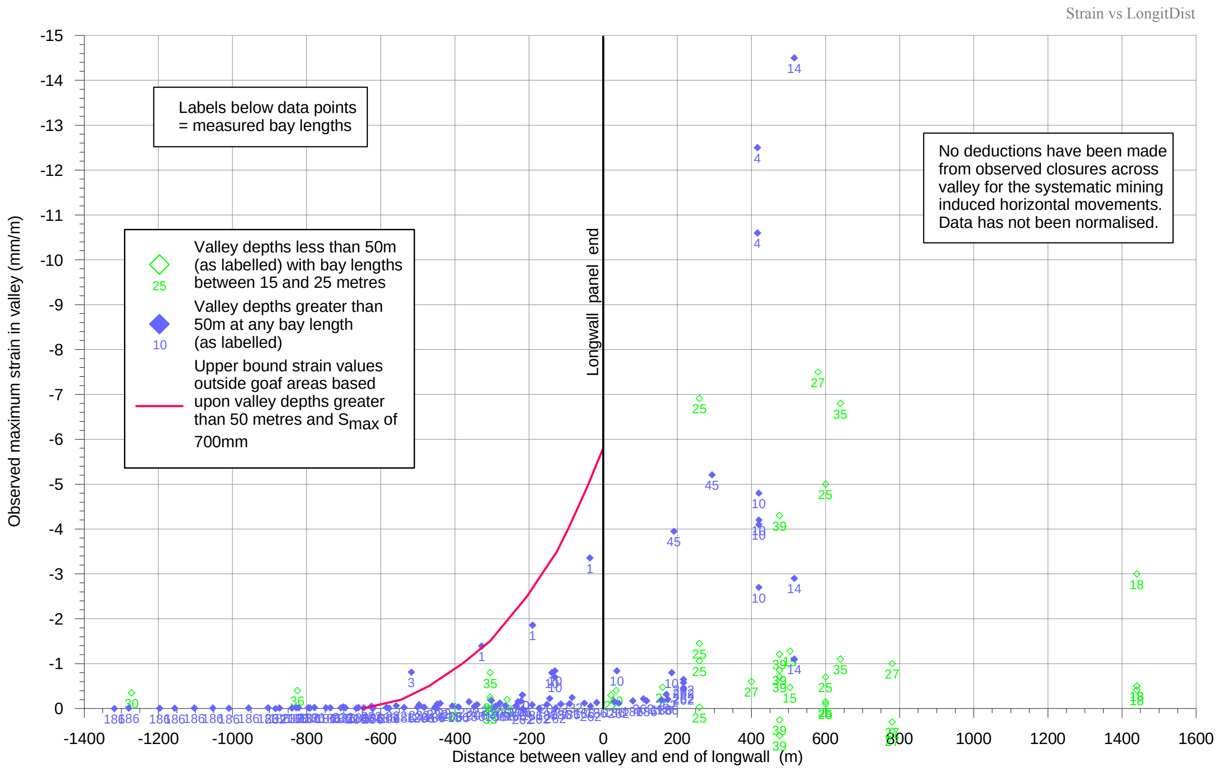


Fig. D.24 Graph of Maximum Compressive Strain versus Longitudinal Distance

D.5.8. Other Surface Anomalies

D.5.8.1. Definition of an Anomaly

An anomaly is defined as a significant irregular or non-systematic ground movement, which was not expected to occur. Small fluctuations in survey lines are not categorised as anomalies as these rarely affect surface features and are often within survey tolerance.

Systematic subsidence movements due to longwall extraction are particularly easy to identify as longwalls are regular in shape and the extracted coal seams are relatively uniform in thickness. Systematic subsidence profiles are typically smooth in shape and can be explained by the expected caving mechanisms associated with overlying strata collapsing into a void.

As a general rule, the smoothness of the profile is governed by the depth of cover and lithology of the overburden. Where the depth of cover is greater than 400 metres, such as in the Southern Coalfield, the subsidence profiles along monitoring lines are generally smooth. Where the depth of cover is less than 100 metres, such as in the Newcastle and Hunter Coalfields, the subsidence profiles along monitoring lines are not generally smooth.

Even where the subsidence profiles are smooth, at locations with a high depth of cover, however, localised non-systematic ground movements have been observed along monitoring lines on some occasions. The causes behind the majority of these movements can be interpreted and are outlined in Section D.5.8.2. These include valley upsidence and closure, the influence of geological structures and issues related to the installation or surveying of monitoring lines.

Even though it is possible to attribute a reason behind most non-systematic ground movements, there remain some movements that still cannot be explained. These are termed "anomalies", and their presence can sometimes impact upon surface features. Suggested reasons for some of these movements are discussed later in the report. In summary, it is believed that these anomalies are a result of the reaction of near-surface strata to the redistribution of horizontal compressive stress due to mine subsidence.

While the causes of anomalies are not yet fully understood, it is hoped that they will be better understood as the development of mine subsidence knowledge progresses. This may then allow these movements to be predicted, so that surface features can be better protected in the future.

D.5.8.2. Method of Identification of Anomalies along Monitoring Lines

Anomalies have been identified from observed subsidence profiles by a process of elimination. If a cause behind an irregularity in a subsidence, tilt or strain profile cannot be determined, the irregularity is recorded as an anomaly. All significant irregularities in the subsidence, tilt and strain profiles have been identified along each monitoring line, and the cause of each irregularity has been described and recorded. The most common causes of irregular or non-systematic movements are listed below.

- Valley upsidence and closure
- Geological Structures
- Change in direction of monitoring line
- Bumped pegs
- Damaged pegs
- Survey Line Discontinuities
- Survey Errors

D.5.8.3. Potential Causes of Anomalies

There are a number of possible causes of anomalies, the majority of which are due to local near-surface geology.

- Upsidence and closure in unknown "hidden" creeks which have been filled in by geological processes or by infrastructure development. This cause could be eliminated by examination of topography and lithology records.
- The possible presence of an unknown fault, dyke or other geological structure.
- Buckling due to increased horizontal stress concentrations, similar to those experienced in valleys.
- Buckling due to cross bedding or blocky behaviour of the near surface strata.
- Rotation of near-surface strata over the goaf edge.
- The presence of a stronger stratum capable of forming a natural corbel at the goaf edge.

It is observed that the major observed anomalies have behaved in a similar manner. The anomalies show an upwards bulge, or upsidence in the subsidence profile, coupled with a local concentration of compressive strain. In some cases, a localised surface "wrinkle" has formed at the point of maximum compression in the surface soils, which does not coincide with the point of maximum upsidence.

It is generally considered that the ground within the subsidence trough is in tension close to the edge of the longwall and in compression close to the centre of the longwall. This, however, is only true for the immediate surface of the bedrock. The strata behaves as a series of distinct beds of varying strengths that separate due to shearing along planes of weakness as subsidence occurs. The strata can therefore be looked upon as a series of relatively thin slabs laying one upon the other.

The underside of the uppermost stratum, following subsidence, is in compression close to the goaf edge and in tension close to the centre of the longwall, contrary to what the upper surface of the stratum is experiencing. It is these changes in stress between the upper surface of one layer and the lower surface of the layer above it that results in the shearing between the beds and the resulting bed separation.

In the Newcastle and Hunter Coalfields, the in-situ horizontal stresses in the strata can be greater than the vertical stresses, even close to the surface. The strata are being compressed on all sides, with the exception of the surface, which is not vertically constrained. As subsidence occurs and the normal collapse mechanisms initiate, the strata above and close to the longwall move inwards to fill the void. This allows the strata outside the subsidence trough to expand towards the goaf area.

At the same time, the horizontal stresses in the strata are redistributed above and below the seam causing increases in stress above the collapse zone, which results in elastic shortening, horizontally, and elastic expansion, vertically. The strata on each side of the collapse zone expands towards the goaf and are partially stress relieved resulting in vertical shortening of the strata and increased subsidence movements well outside the angle of draw.

This redistribution of horizontal stress extends for a considerable distance outside the goaf area, with measurable displacements almost three kilometres away. It is believed that this expansion towards the longwall goaf areas, due to the relaxation of in-situ horizontal stress in the strata is the cause both of the far-field horizontal movements and the unusually high vertical subsidence movements that sometimes occur beyond the angle of draw.

All of the subsidence mechanisms are driven by in-situ stresses and gravitational forces, which are compressive. None of the driving forces behind the subsidence-induced movements are tensile. Generally, when the strata are vertically confined, they behave systematically. The irregularities that occur in subsidence profiles are therefore a surface phenomenon that is driven by compressive forces.

The surface strata can be likened to an ice flow, in which the individual blocks of ice are displaced due to the pressures exerted on them by their neighbours and by the underlying currents in the water beneath them. The blocks can buckle upwards or one block can shear and ride over the top of its neighbour. In some cases the blocks can be forced upwards to form arches or ridges. Not all movements are in the vertical plane and in some circumstances horizontal shearing can occur as one block slides past another, being propelled by a greater force and facing less resistance than its neighbour.

It is conjectured that the major anomalies that have been recorded were due to arching and buckling of near-surface strata as mining resulted in bed separation. It is also possible that shearing in underlying cross-bedded strata could initiate the anomaly, but there has been no stepping in the surface, which suggests that the near-surface strata have buckled rather than sheared.

It is interesting to note that the most likely place for compressive buckling to occur at the surface is where the surface is convex, or hogging. This is because the tendency in that situation is for the rocks to buckle upwards when compressed horizontally and to fail in bending tension or in shear. Where the strata are concave, or sagging, the underlying strata restrain the buckling and, generally, failure would occur only when the applied horizontal stresses exceeded the compressive strength of the strata, which is much greater than its tensile or shear resistance.

The in-situ horizontal stress increases in intensity with depth, but the stresses still exist close to the surface. The stresses are distributed throughout the strata according to the stiffness of each unit and the weaker strata attract a smaller proportion of the stress than the stronger strata. The way in which the surface strata will behave is, therefore, dependent upon the nature of the surface and near-surface rocks.

As mining occurs, subsidence and redistribution of in-situ horizontal stress results in bed separation and each stratum, particularly those at the surface, which are less confined by the weight of the rocks above them, becomes an independent and relatively slender compression member.

In this situation, very little eccentricity of loading or curvature of the member is required to initiate arching, followed by buckling. The initial buckling is a result of the in-situ horizontal stress and the movement is exacerbated as subsequent longwalls are mined and the longwalls get closer to the anomaly.

The increased subsidence over the goaf was initially difficult to understand, because it was anticipated that subsidence would be reduced in the high stress regime. A possible explanation, for the increased subsidence, is that the strata in the collapse zone had already been partially stress relieved by the adjacent goaf areas and thus offered less horizontal confinement, therefore allowing greater subsidence to occur.

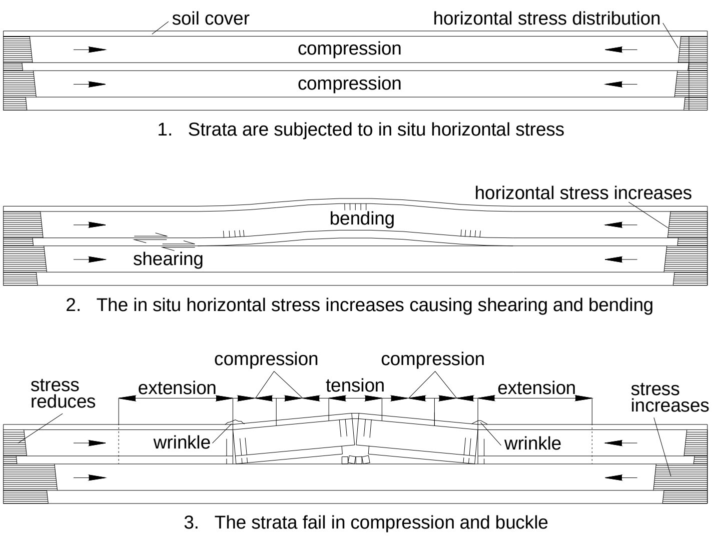


Fig. D.25 Strata Buckling Mechanism due to In-situ Horizontal Stress

The way in which buckling develops is illustrated in Fig. D.25. The phenomenon starts as bed separation occurs in the near-surface strata, due to shearing between beds as the in-situ stresses in the strata are redistributed. The stress in a particular stratum results in bending occurring, either due to eccentricity of loading or curvature of the stratum and the stratum arches upwards.

As the subsidence impact increases, the stratum starts to crack on its convex surfaces as the rock fails in bending tension. If the mining-induced stress continues to increase and the tensile fractures continue to develop to the full depth of the stratum, the stratum eventually fails in compression and buckles upwards. The buckling releases the horizontal confining stress in the stratum on both sides of the buckle and allows the stratum to expand horizontally and locally relieve the compressive stress. The stress relief in the surface stratum transfers additional stress into the strata below it and this can result in progressive failure and buckling through a number of strata, until the buckling of a stratum is prevented by the weight of the rocks above it.

When buckling occurs, the resultant strains measured at the surface can vary considerably from the predicted systematic strains and can alternate between compressive and tensile, even though the strata are consistently being compressed. It is this erratic behaviour of the surface strata that results in the scatter in measured strain profiles. The measurement of strain does not differentiate between a real extension of an unstressed stratum under applied bending stress and the expansion of a stratum due to compressive stress relief. The measured strains can therefore give a false impression of the state of stress in the surface strata.

It is probable that the most substantial impact to building structures in the Southern Coalfield is due to the buckling of surface strata under the influence of in-situ horizontal stress. Generally the underlying systematic levels of tensile and compressive strain are too low to result in significant impact and the worst impact has been associated with anomalous behaviour of the strata, where curvatures, strains and tilts have been increased.

D.5.9. The Prediction of Incremental Far-Field Horizontal Movements

In addition to the 'normal' and topographically related movements, far-field movements have also been recorded in a number of cases, at considerable distances from the longwall goaf areas. Such movements have often been several times higher than the vertical subsidence movements measured at the same locations.

It has been conjectured that these far-field movements are caused by redistribution of the stresses in the strata between the seam and the surface due to the regional mining activity. The direction of such movements would tend to be towards the active mining, but the direction of movement could also be dependent upon the scale and proximity of adjacent goaf areas.

It has been suggested by some authors that the far-field movements are generally aligned with the principal horizontal in-situ stress direction. However, it seems more reasonable to suggest that the movements will be directed from areas of high stress towards areas where the confining stresses have been reduced by mining activity, thus allowing expansion of the strata to occur. The stresses within the strata are generally compressive in all directions and until mining occurs the stresses are in equilibrium, the balance being controlled by the shear resistance within and between strata units. As mining occurs, the equilibrium is disturbed and the stresses have to achieve a new balance by shearing through the weaker strata units and by expanding into areas of greatest dilation, i.e. towards the goaf areas, where the confining stresses have been relieved.

An empirical database of observed far-field horizontal movements has been compiled using monitoring data primarily from the Southern Coalfield of New South Wales in Australia. The monitoring data was collected from Collieries including Appin, Bellambi, Dendrobium, Tower and West Cliff. The far-field horizontal movements resulting from longwall mining were generally observed to be orientated towards the extracted longwall. At low levels of far-field horizontal movements, however, there was a high scatter in the orientation of the observed movements.

Fig. D.26 shows the observed incremental far-field horizontal movements, resulting from the extraction of a single longwall, relative to the distance from the longwall. It can be seen from this figure that incremental far-field horizontal movements of up to 20 mm have been observed at distances of 2000 metres from extracted longwalls.

Fig. D.27 shows the observed incremental far-field horizontal movements, resulting from the extraction of a single longwall, relative to the distance from the longwall, for cases where there was solid coal between the longwall and the monitoring points. It can be seen by comparing Fig. D.26 and Fig. D.27, that the magnitudes of observed incremental far-field horizontal movements are generally less where there is solid coal between the longwalls and monitoring points.

The maximum movements tend to occur when the second and third longwalls are mined in a series, and tends to decline as subsequent longwalls are mined. This is possibly due to the fact that once the strata has been stress relieved by the first few longwalls, the potential for further movement is reduced.

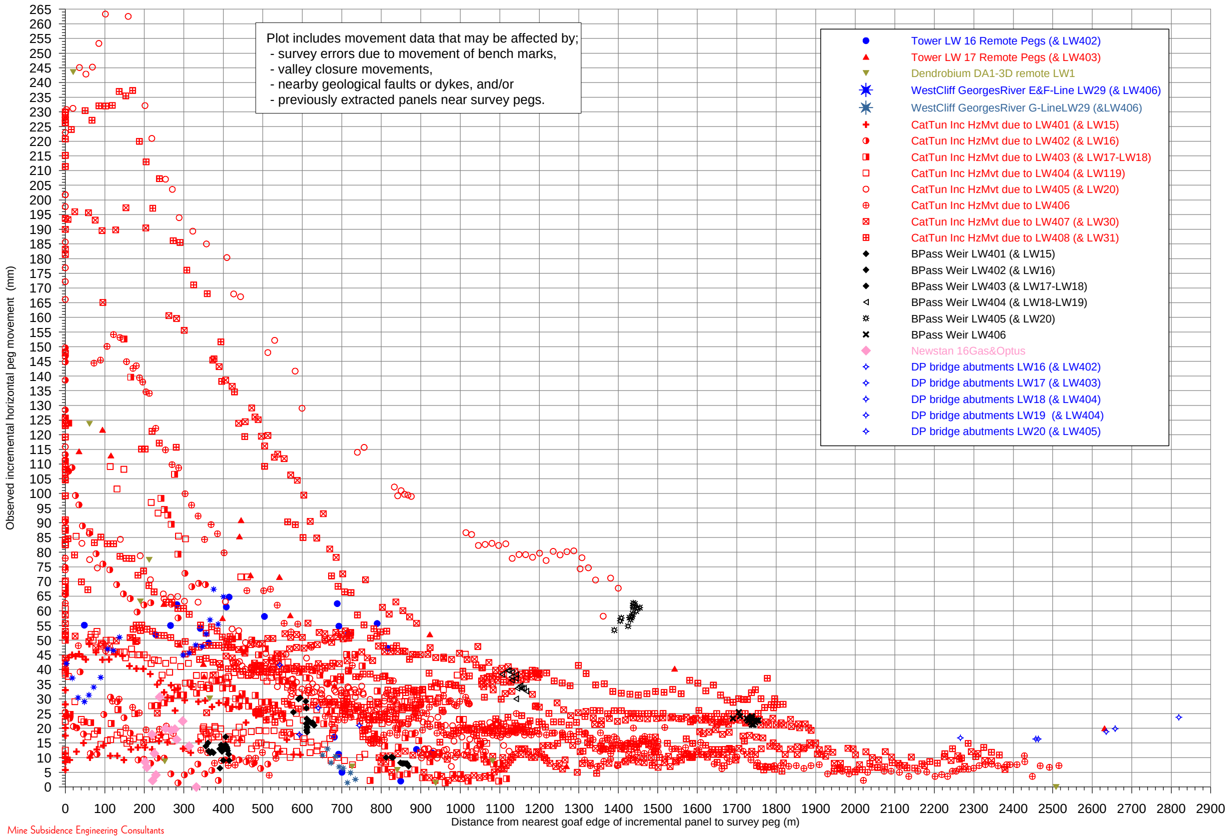


Fig. D.26 Observed Incremental Far-Field Horizontal Movements

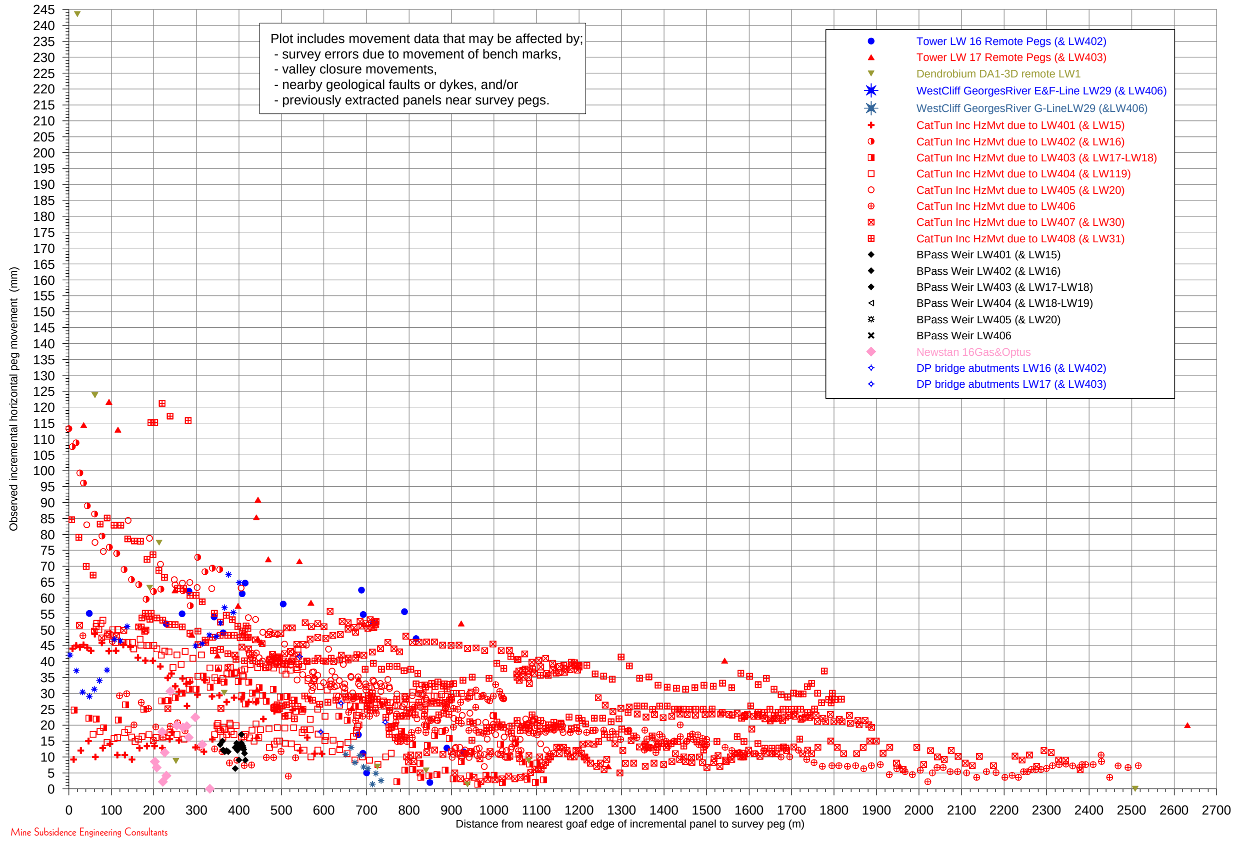


Fig. D.27 Observed Incremental Far-Field Horizontal Movements with Solid Coal between the Monitoring Points and Mined Longwall

D.6. Sub-Surface Strata Movements above Extracted Panels of Coal

D.6.1. Collapse Mechanisms

Before the strata above an underground excavation are disturbed, all points beneath the surface are under compression from the weight of the overburden, and from pre-existing in-situ horizontal stresses, and are in a state of equilibrium. The extraction of panels of coal, by continuous miner or longwall mining operations, creates voids, which upset the balance of forces in the strata, causing displacements to occur until a new state of equilibrium is reached.

The overall force field in the strata, outside and around the extracted void, remains unchanged and the stresses have to readjust locally around the void to achieve this new state of equilibrium. The void provides the compressed rock with a space into which it can expand, and in so doing relieve the stresses that initiated the movement.

Because the extracted voids are generally much wider than the height of the seam, the initial movements tend to be vertical displacements of the roof and floor of the void, movements of the roof being assisted to a greater extent by gravity. Once the vertical movement occurs, generally by failure of the immediate roof strata, the strata outside the void, which are no longer constrained by the roof strata can relieve some of their stress by expanding horizontally into the goaf area. A state of equilibrium is achieved when the desire of the strata to expand is balanced by the frictional shear forces, developed by the weight of the overburden, which tend to resist the expansion.

The collapse of the immediate roof strata will generally be followed by the collapse of the rocks above them, unless the remaining overburden strata are sufficiently strong and homogeneous to span over the width of the void. Failure generally occurs due to the separation of an individual stratum along a bedding plane, which, being unable to carry the loads imposed by the weight of the overburden and the horizontal compressive stress, shears or buckles in bending and falls into the goaf.

The collapse progresses upwards until a stronger and more homogeneous strata beam is reached with the capacity to bridge the void. Such strata beam could be a thicker homogeneous rock of a particular type, such as a massive sandstone or conglomerate layer, or could be a combination of rock strata, which, acting together as a laminated beam, have sufficient strength to span the void. The height at which the progressive collapse of the strata towards the surface is arrested, i.e. the height of the fractured zone, is dictated by the width of the extracted void and the nature of the overburden strata.

The mechanism of collapse and the subsidence at the surface is further complicated by the cantilevering of the strata from the abutments on each side of the void and the elastic compression of the coal pillars and the strata above and below them.

After failure of the immediate roof, the lateral expansion of the strata at the abutments into the extracted void tends to form natural corbels, which support the strata above them and reduce the effective span. As the collapse progresses upwards the corbels extend further and further towards the centre of the goaf and form an irregular cantilever of strata at each abutment which transfer the weight of the overburden strata above the collapsed zone into the abutments. The angle, measured from the vertical, at which these corbels extend into the goaf area, is referred to as the angle of break.

The cantilevering strata and the overburden above the collapse zone span between the abutments and sag across the void and are partially supported by the collapsed rocks beneath them. At the same time, because the loads on the abutments are increased by the spanning strata, elastic compression occurs in the abutment coal pillars and in the strata above and below the pillars, causing settlement over the pillars. This settlement above the pillars is greatest where the depth of cover is high and the width to depth ratio of the extracted panel is relatively small. At higher width to depth ratios the settlement over the pillars reduces, because the strata collapses more freely into the goaf and less load is shed to the abutments. Additional settlement over the pillars occurs due to the lateral expansion of the strata at the abutments and the resultant vertical dilation caused by horizontal stress relief.

These separate mechanisms combine to cause subsidence at the surface, which extends over the extracted void and beyond the edges of the void to the limit of subsidence. Vertical subsidence at the surface is generally less than the thickness of the extracted coal seam, because the collapsed strata and the sagging strata above the collapsed zone contain a significant number of voids.

Rocks within the collapsed zone tend to fail by blocky delamination from the strata above them and collapse into the void in an irregular manner, which causes bulking of the collapsed strata to occur. Sometimes this can be sufficient to choke off the collapsed zone and prevent further progression of the collapsed zone towards the surface. In other cases it is possible that significant voids could be left at the top of the collapsed zone beneath a competent strata beam.

Above the collapsed zone is the fractured zone in which the strata are subject to significant vertical displacement and bending, which result in fracturing, joint opening, shearing on bedding planes and bed separation. The more competent rocks tend to span over the gaps beneath them, whilst weaker rocks tend to sag onto the stronger rocks beneath them. This results in vertical bed separation and void formation beneath the more competent strata with increased horizontal permeability. In this zone, it is possible that cracks could extend for the full depth of a stratum, thus increasing vertical permeability and connectivity between near surface aquifers and the mine workings.

Above the fractured zone is the constrained zone, in which the strata tend to sag and bend without failing and are laterally constrained by the horizontal in-situ stresses within the strata. In this zone, the bending of the strata results in the development of shear stresses at the interfaces between adjacent beds, causing horizontal displacements along the bedding planes and increased horizontal permeability. At low curvatures it is likely that some strata would crack on their convex surfaces, though the tension cracks would not penetrate the full depth of a stratum and hence would not provide hydraulic connectivity to the underlying strata. In the constrained zone, it is therefore possible that the horizontal permeability could increase due to subsidence, without an increase in vertical permeability.

Above the constrained zone is the surface zone, which comprises vertically unconfined strata and alluvial soils that essentially follow the bedrock movements downwards, but can still experience tensile cracking and surface buckling due to ground curvatures and strains.

D.6.2. Angle of break

The extent to which the corbels develop at the abutments and cantilever into the collapse zone is dependent upon the strength and thickness of the strata in the immediate roof and overburden, the locations of pre-existing joints and faults and the level of in-situ horizontal stress. The units that are thicker, stronger and more homogeneous will tend to cantilever further than those which are thinly bedded, weaker and more frequently jointed. The angle of break is therefore dependent upon local geology. It can also be affected by the choice of mining method and the speed of mining.

In a sequence of rocks comprising sandstones, conglomerates, shales, claystones and mudstones of moderate thickness it would appear, from the literature that has been reviewed, that the angle of break will be somewhere between 17^0 and 23^0. Based upon an angle of break of 17^0 the collapse zone would only extend through to the surface if the width to depth ratio was greater than 0.6 and if there was no significant stratum to span the void and arrest the upward development of the collapse zone at some horizon in the sequence. At an angle of break of 23^0, the width to depth ratio would have to exceed 0.84.

D.6.3. Variations in Terminology used to describe Strata Displacement Zones

A study of the various papers and texts that are listed in the references in Appendix B, reveals that the terminology used by different authors to describe the strata displacement zones above an extracted panel is inconsistent. Forster (1995) noted that most studies had recognised four separate zones, with some variations in the definitions of each zone. Peng and Chiang (1984) as illustrated in Fig 8.4.1 of the text book by Peng, which is reproduced in Fig. D.28, below, had recognised only three zones, namely the caved zone, the fractured zone and the continuous deformation zone. McNally et al (1996) also recognised three zones, which they referred to as the caved zone, the fractured zone and the elastic zone.

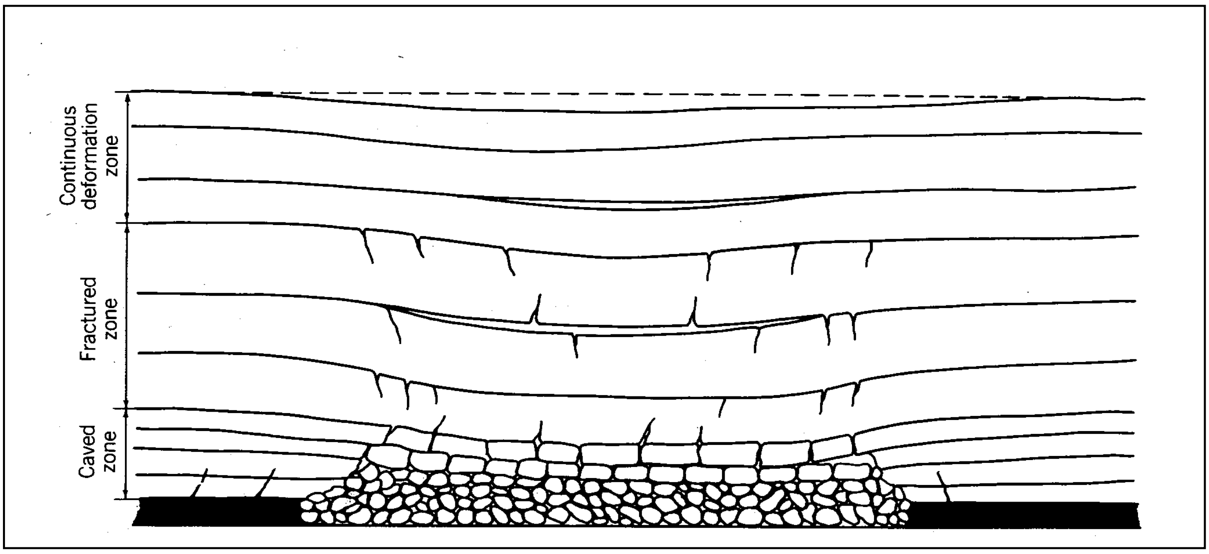


Fig. D.28 Zones in the Overburden According to Peng and Chiang (1984)

Kratzsch (1983) identified four zones, namely the immediate roof, the main roof, the intermediate zone and the surface zone. For the purpose of this study, the following zones, as described by Singh and Kendorski (1981) and proposed by Forster (1995), have been adopted. These are further illustrated in Fig. D.29, below.

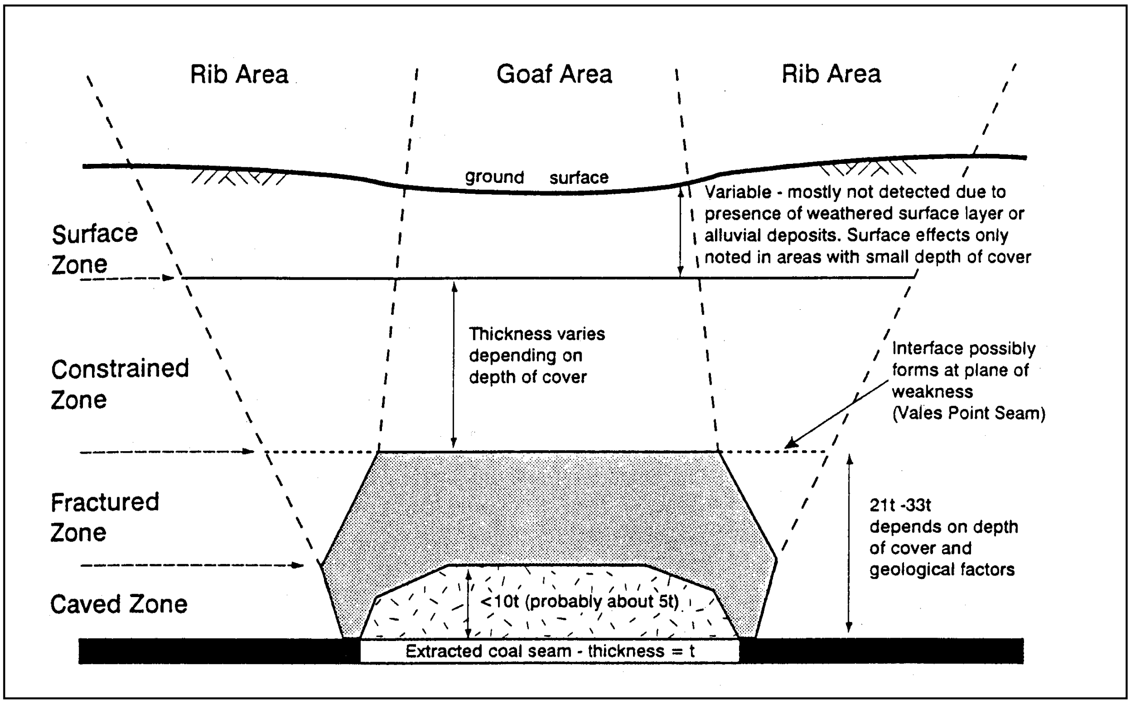


Fig. D.29 Zones in the Overburden according to Forster (1995)

- *Caved or collapsed Zone.* (Some authors note primary and secondary caving zones.) Comprises loose blocks of rock detached from the roof and occupying the cavity formed by mining. Can contain large voids
- *Disturbed or Fractured Zone.* (Some authors include the secondary caving zone.) Basically in-situ material lying immediately above the caved zone which has sagged downwards and consequently suffered significant bending, fracturing, joint opening and bed separation.
- *Constrained or Aquiclude Zone.* (Also called the Intermediate Zone.) Comprises confined rock strata above the disturbed zone which have sagged slightly but, because they are constrained, have absorbed most of the strain energy without suffering significant fracturing or alteration to the original physical properties. Some bed separation or slippage can be present as well as discontinuous vertical cracks (usually on the underside of thick strong beds). Weak or soft beds in this zone may suffer plastic deformation.
- *Surface Zone.* Unconfined strata at the ground surface in which mining induced tensile and compressive strains may result in the formation of surface cracking or ground heaving.

D.6.4. Permeability, Vertical Dilation and Collapse and Fracture Zones

The likely heights of the collapsed, fractured and constrained zones have been provided by various authors and these have been reviewed during the course of preparing this report. Generally, the height of the caved zone has been indicated to fall within the range 1.5 to 14 times the extraction height, with the majority of cases in the range 5 to 10 times the extracted height. Forster concluded that the maximum height would be less than 10 times and probably around 5 times the extraction height.

The height of the fractured zone has been indicated to lie within the range 10 to 105 times the extracted height, though Holla and Buizen (1991) indicated that the height of the fractured zone over Longwall 3 at Tahmoor Colliery extended to a height of 143 times the extracted seam thickness, based upon extensometer readings. Forster (1995) concluded that the height of the fractured zone should be taken as 21 to 33 times the extracted height of the seam.

An alternative method of measuring the heights of the collapsed and fractured zones is to express the height as a function of the extracted width. This method appears to be favoured by some authors, though definitive relationships have yet to be determined. The height of the disturbed zone, being the overall height of the collapsed and fractured zones, has generally been found to vary from 0.16 to 1.4 times the extracted width. A height of 1.73 times the extracted width was indicated by Holla and Buizen (1991) over Longwall 3 at Tahmoor Colliery, based upon extensometer readings.

Some of the difficulties in establishing the heights of the various zones of disturbance above an extracted panel stem from the imprecise definitions of the fracture and constrained zones and the interpretation of extensometer readings. The definition of constrained zone is based upon the assumption that bed separation in this zone will increase horizontal permeability without increasing vertical permeability. It is possible for considerable dilation to occur as differential bending of the strata layers occurs, but this is not considered to be the same kind or extent of fracturing that is to be found in the fractured zone, where vertical permeability is likely to be affected by bending or shear induced vertical fractures.

Where vertical dilation is measured by extensometer readings, it is possible that bed separation in the constrained zone could be misinterpreted as fracturing in the fractured zone. The measurement of vertical tensile strain is of some assistance in identifying the extent of the strata disturbance at different horizons, but where bed separation occurs in the constrained zone a large vertical strain at that point can be confined by low vertical strains above and below the point.

The interpretation of extensometer readings has to be undertaken with care, particularly where the extensometers are limited in depth and do not penetrate the full depth of the overburden. The researchers at the University of New South Wales (1984) noted that since there had been no direct permeability measurements, it was difficult to establish a relationship between the vertical strain variation and the permeability of the strata.

Another issue with regard to extensometer readings that should be highlighted is that the extensometers were affected by horizontal shear and displacement, which resulted in total extension readings that were greater than the extracted thickness of coal. Quite clearly the extensions included horizontal movements between strata units at particular horizons and such movements would give a totally wrong impression of the vertical strains between anchors.

D.6.5. Relationship between Vertical Dilation Heights and Mining Geometry

The effect of mining geometry on the heights of the collapse and fractured zones is not well documented. Theory would suggest that the height of the collapse zone would be directly related to the width of the extraction, the height of extraction, the depth of cover and the nature of the rocks in the overburden. Where the panel width-to-depth ratio is high and the depth of cover is shallow, it is clear that the fractured zone can extend from seam to surface. This is clearly indicated in the extensometer readings from boreholes above shallow areas of extraction, where the vertical strains close to the surface are as high as they are close to seam level.

This was apparent in the results of the extensometer readings above Longwall 2 at Invincible Colliery, where the longwall width was 135 metres, the height of extraction was 2.7 metres and the depth of cover was 116 metres. The width-to-depth ratio of the panel was, therefore, 1.16. In this case, the collapsed zone extended to approximately 9 times the extracted seam thickness above the seam roof. Above the collapsed zone, the vertical strain was almost linear through to the surface at approximately 8 mm/m, indicating that the fractured zone extended to the full depth of the overburden.

It was also apparent in the movements of the strata above Longwall 11 at Angus Place Colliery. In that case, the longwall width was 211 metres, the height of extraction was 2.47 metres and the depth of cover was 263 metres. The width-to-depth ratio of the panel was, therefore, 0.8. Bhattacharyya and Zang (1993) estimated that the height of the collapsed zone was 25 metres, or 10 times the extracted seam height. Above the collapsed zone, the vertical strain was almost linear through to the surface at approximately 5.6 mm/m, indicating that the fractured zone extended to the full depth of the overburden.

The extent of the collapsed zone has generally been defined with reference to the extracted seam thickness and the height to which collapse occurs before the bulking of the collapsed rocks chokes off further vertical progression of the collapsed zone. The extent of the fractured zone above the collapsed zone would appear to be more dependent upon the width of the extraction and the angle of break. The vertical strain would appear to be dependent upon the extracted seam thickness, the amount of subsidence and the depth of cover.

It is reasonable to suppose that as the width to depth ratio reduces, the height of the fractured zone would also reduce. Conversely, the height of the fractured zone would be expected to increase as the width-to-depth ratio increased.

APPENDIX E. CLASSIFICATION OF DAMAGE TO BUILDING STRUCTURES

E.1. Introduction

The major mining-induced ground movements and subsidence parameters that are used to assess the impacts of subsidence on building structures are discussed in the following sections. The classification system for impact levels due to subsidence induced ground movements are also explained.

E.2. Mining Induced Ground Movements

E.2.1. Vertical Subsidence

Vertical, rigid body, subsidence has little or no effect on buildings or other surface structures where the subsidence occurs uniformly. The structures are, naturally, left at a lower level but normally this has little or no adverse effect upon them. Drainage systems and services to a building normally subside with the building and impact only results when differential subsidence occurs.

E.2.2. Horizontal Displacement

Horizontal displacements due to mining subsidence occur in such a way that points on the surface generally move towards the centre of the subsidence trough. Where one part of a structure is moved differently relative to other parts, then the structure experiences tensile stretching or compressive squashing. Differential horizontal movements give rise to strains but uniform horizontal movement of a surface structure would not normally have any adverse effect as the ground and structure move together.

E.2.3. Tilt

Ground tilt does not generally lead to structural impact. Severe tilts, however, may cause serviceability problems, such as doors tending to close themselves, or drainage problems, resulting from changes in the slopes of roof gutters, wet area floors and external paved areas. Single storey buildings usually remain serviceable when the residual tilts are less than 7 mm/m, although taller structures can be more sensitive to tilt. Swimming pools and large water storage tanks are also sensitive to tilting and, in some cases, are more sensitive than residential buildings.

E.2.4. Curvature

Curvature resulting from differential tilting is one of the major causes of impact to buildings and structures. Normally, curvature is defined as the reciprocal of the radius of curvature but it can also be defined by a deflection ratio for a particular length of structure, or by the radius of curvature itself. The deflection ratio is the maximum vertical displacement occurring between two points at opposite sides of a structure, expressed as a fraction of the horizontal distance between them.

An acceptable, or allowable, deflection ratio is that which can be tolerated by a structure without impairing its structural adequacy or serviceability, despite visible cracking that may occur in the superstructure. It is therefore a measure of the resistance of a structure to bending and shear strain.

Allowable deflection ratios are given in the Australian Standard AS 2870 (1996) for different types of construction and these, together with ratios established in research by various authors, are discussed in Sections 4.5 to 4.8. Cracking in rendered walls will normally be more apparent than in face brickwork and the allowable deflection ratios are therefore reduced for structures with rendered walls.

Modern brick structures are generally built with vertical joints at frequent intervals to allow for thermal expansion and other building movements. These structures can normally accommodate some curvature without damage but older brick structures, which were not designed to accommodate such movements, are more likely to be adversely affected.

E.2.5. Horizontal Strain

As discussed in Section 4.2.2, differential horizontal movements give rise to ground strains, however, most of the horizontal movements are proportional to ground curvature. Within the subsidence trough, convex or hogging curvature is accompanied by tensile strain and concave or sagging curvature is accompanied by compressive strain. Both tensile and compressive strains can cause cracking in a building structure but tensile strains are more difficult to accommodate since almost all components of a structure are weaker in tension than compression.

High levels of tensile strain cause stepped cracking in brickwork and masonry, cracking in plaster wall linings, pulled joints in plumbing and separation at joints in paving and roadways. High levels of compressive strain are characterised by crushing and spalling of faces in brickwork and masonry, closure of door and window openings, shear fractures, buckling of pipes, wall linings, floors, ceilings and external paving.

The transfer of ground strains into the structure occurs through friction on the underside of the foundations and ground pressure on the sides of the foundations. The transfer is thus dependent upon the configuration and type of foundation and its orientation to the subsidence trough.

The transfer of strain is also dependent upon the types of soil that are immediately below the foundation. Buildings founded on rock can, in some cases, experience a full transfer of strain whilst those founded on clay or sandy soils generally only attract a proportion of the ground strain. The transfer is a function of soil to foundation interaction and, in many cases, shearing of the soil layers reduces the transfer of strain.

Colwell and Thorne (1991), in their paper that referred to the monitoring of subsidence movements at a house above Longwall 3 at West Wallsend Colliery, indicated that the strains transferred into the walls of a brick veneer home were an order of magnitude less than those measured in the ground.

Horizontal tensile strains will affect all types of structure to the same degree once they have been cracked, since any increase in strain will tend to increase the width of the existing cracks rather than develop new ones.

E.2.6. Strain and Curvature Combinations

In practice, structural impact results from combinations of ground curvature and strain. The ground movements are generally three dimensional, adding the further complication of twisting in a structure. As subsidence occurs, the foundations settle and deform to match the subsided shape of the ground, the deformations being concentrated mainly at weak joints in the structure.

New cracks are generally formed where the shear or tensile strength of structural elements is exceeded. The cracking patterns depend upon the extent of the vertical displacements, the length to height ratio of the walls, the structural capacity of the building elements, and the shear strength and stiffness of the foundations.

In masonry and brickwork, the cracks generally follow the mortar joints either vertically or diagonally in steps. Bending and shear cracks can also occur due to curvature and strain along a wall. Once the cracks have formed, further ground deformations and extensions will be consumed in extending or expanding the cracks.

Where buildings are founded on sandy soils or clays and the ground strains are not fully transmitted into the structure, the level of impact is mostly dictated by curvature rather than horizontal strain.

Generally, the worst impacts will result from a combination of convex (hogging) curvature and tensile strain, rather than concave (sagging) curvature and compressive strain. The impact assessments, given in Chapter 6, have reviewed each combination, but are based upon the worst combination of the bending and horizontal tensile strains, which have been predicted to occur at each structure as the longwalls are mined. For each longwall panel, the travelling and transient strains at each structure have both been considered, and the maximum of these strains was used in the impact assessment for the structure.

E.3. Effect of Building Structure Type

The design and configuration of buildings and the materials of which they are built will determine the effects which mining subsidence will have upon them and the extent to which they will be affected. The bending strains resulting from ground curvature will affect different types of buildings in different ways.

A full masonry building of, for example, 15 metres in length, can tolerate a maximum differential foundation movement of 10 mm before damage occurs, whilst a timber framed building can tolerate a differential movement of 50 mm due to its greater flexibility.

A well designed building on foundations that allow for differential movement of the superstructure, constructed of flexible materials, with proper attention to the design of movement joints, will suffer less than a rigid brick structure on concrete strip foundations.

Buildings founded upon clay strata will not, normally, be subjected to the total horizontal ground strain. Buildings on piled foundations, on the other hand, would be affected to a greater extent due to lateral earth pressure on the piles and if the piles are rigidly connected to the building foundations this could result in a greater level of strain being applied to the building superstructure. Foundations built directly onto bedrock are more likely to transmit the total amount of ground strain into the building causing greater levels of impact.

Buildings that have raft foundations, built on a layer of sand and provided with a sliding membrane, often allow the ground to move without causing damage to the superstructure. Other buildings that are founded on stumps or short brick piers will generally allow the ground to move with only slight impact to the building above. These buildings also provide easy access for temporary and permanent adjustment of the piers and the structure.

The length of the building is also an important factor, since longer buildings will experience greater extension due to direct ground strain and bending strain, and the levels of impact will consequently be increased.

For many long structures, however, the maximum predicted strain will only apply over part of the length of the structure. In normal circumstances, therefore, the movements caused by mine subsidence will not be fully transmitted to the buildings and structures on the surface. However, a cautious approach is normally adopted and impact assessments are generally carried out assuming full transfer of displacements and strains from the ground into the structures. This approach was adopted in the present study.

E.4. Damage Thresholds on Building Structures

Much has been written on the subject of impact to buildings resulting from ground movements and the way in which different types of building, with different forms of construction, are likely to respond to applied curvatures and strains.

In 1974, Burland and Wroth prepared a thorough review of published papers to that date and recorded the findings of various researchers, which are summarised below. They presented the results to a conference of the British Geotechnical Society on the Settlement of Structures. Most of the literature referred to by the authors related to impact resulting from differential settlement or curvature rather than horizontally induced mining strains but it is nevertheless useful in establishing guidelines for determination of the effects of mine subsidence.

Burland and Wroth concluded that for brickwork and blockwork, in cement mortar, the critical tensile strain lay in the range 0.5 mm/m to 1.0 mm/m and for reinforced concrete in the range 0.3 mm/m to 0.5 mm/m. Below these levels, no cracking was apparent.

To place this in context with normal building movements, it is worth noting that strains likely to occur in clay brickwork, due to thermal expansion and contraction, can be of the order of 0.2 mm/m to 0.3 mm/m for a temperature differential of 30°C. Expansion of brickwork due to brick growth can also be of this order of magnitude.

The expansion and contraction of concrete structures, due to changes in temperature or moisture content, can be twice as high as for clay bricks. British Standards permit shrinkage strains of 0.3 mm/m to 0.9 mm/m in walls and panels.

Fig. 11 of the paper by Burland and Wroth compares the relative sag and hog for load-bearing walls and frame buildings, as determined by various researchers, and provides further guidance on the relationship between impact levels, deflection ratios and length to height ratios. The authors' view was that allowable deflection ratios for hogging structures should be less than for sagging structures.

The methods used to define the threshold levels for differential movement and strain varied from author to author and Burland and Wroth clarified the terminology, to enable direct comparisons to be made. Some statements concerning levels of impact were rather subjective and it was not easy to compare 'severe' by Littlejohn, with 'substantial' from Cheney and Burford and 'considerable' from Bjerrum. The relative values of strain provided some assistance in making comparisons.

It is clear that mining induced curvatures and strains will in some cases cause significant impact to building structures unless they are designed to accommodate these movements.

E.5. Allowable Deflection Ratios

Various authors in Australia have considered the effects of differential movement of buildings and many papers have been published which contain valuable data. This information has been incorporated in compiling Table E.1, which shows allowable deflection ratios for various types of building. The table has been extended to show the equivalent radii of curvature, for buildings of different length, at the allowable deflection ratios.

Bray and Branch (1988) provided a table showing allowable deflection ratios and limiting radii of curvature for different types of construction. Dr Lax Holla (1987b) also published a table of allowable deflection ratios, which was derived from a paper by Woodburn (1979), entitled Interaction of Soils, Footings and Structures.

Australian Standard, AS 2870 - 1996, provides guidance on the allowable deflection ratios for various types of structure, to be used in the design of foundations for domestic buildings and also gives tolerable levels of differential vertical movement in foundations.

Granger (1991) gives tolerable values of deflection ratio and maximum acceptable deflections for reinforced and articulated brick walls. The deflection ratio for brick veneer of 1:600 has been assumed to apply to normal face brickwork and the lower allowable deflection ratio of 1:800 has been adopted for rendered masonry, which is more susceptible to impact.

Where different authors have stated slightly different values, the lower ratio has been assumed in compiling Table E.1. Allowable deflection ratio, for a particular type of building, has been taken to mean the deflection ratio which would cause only slight impact if applied to a building of that type.

Not all structures, however, will be situated at the position of maximum curvature. The curvature and strain will vary considerably throughout the longwall area and the levels of impact on buildings and structures will be dependent upon their positions within the subsidence troughs.

E.6. Classification of Impact Levels to Walls

The 'National Coal Board Classification of Subsidence Damage' for building structures, was given in Table 8 of the *Subsidence Engineers Handbook*, which was published by the National Coal Board, in 1975. The scale of damage was classified by description and was related to specific changes in the lengths of building structures.

The National Coal Board classification would appear to have been in use in 1962, when it was referred to, in a slightly amended form, in a paper presented to the Institution of Structural Engineers by J.D. Geddes (1962). This descriptive classification of impact was adopted and extended by the Department of the Environment, of the U.K., in 1981, at which time the impact categories were linked to crack width, rather than to specific changes in the length of a structure. The classification, in this form, was shown in Table 8.5 of a book titled *Ground Movements and their Effect on Structures* (Geddes, 1984).

Table E.1 Allowable Deflection Ratios for Building Structures

Form of Construction		Allowable Deflection Ratio	Length in Metres			
			10	20	30	40
Loadbearing walls			**Acceptable Radius of Curvature in Kilometres**			
1	Solid masonry, rendered	1:4000	5.00	10.00	15.00	20.00
2	Solid masonry	1:3000	3.75	7.50	11.25	15.00
Non-loadbearing or lightly loaded walls			**Acceptable Radius of Curvature in Kilometres**			
3	Solid masonry, rendered	1:2000	2.50	5.00	7.50	10.00
4	Solid masonry	1:1500	1.87	3.75	5.62	7.50
5	Articulated masonry, rendered	1:800	1.00	2.00	3.00	4.00
6	Articulated masonry	1:600	0.75	1.50	2.25	3.00
7	Reinforced articulated masonry, rendered	1:600	0.75	1.50	2.25	3.00
8	Reinforced articulated masonry	1:400	0.50	1.00	1.50	2.00
9	Masonry veneer, rendered	1:800	1.00	2.00	3.00	4.00
10	Masonry veneer	1:600	0.75	1.50	2.25	3.00
11	Articulated masonry veneer, rendered	1:600	0.75	1.50	2.25	3.00
12	Articulated masonry veneer	1:500	0.62	1.25	1.87	2.50
13	Reinforced articulated masonry veneer, rendered	1:400	0.50	1.00	1.50	2.00
14	Reinforced articulated masonry veneer	1:300	0.38	0.75	1.12	1.50
15	Timber or steel clad in fibro or weatherboard	1:300	0.38	0.75	1.12	1.50
16	Steel or concrete frame with brick infill	1:1000	1.25	2.50	3.75	5.00
17	Steel or concrete frame without infill	1:500	0.62	1.25	1.87	2.50

The same classification has been incorporated, with some minor revisions to the wording, within Appendix C of Australian Standard, AS 2870 - 1996. Table C1 in the standard shows the classification of impact with reference to walls, related to crack width, and Table C2 gives a classification of impact with reference to concrete floors, related to both crack width and differential vertical movement.

The Australian Standard Classification, reproduced from Table C1, is presented in Table E.2 and has been used in this report as the basis for describing levels of impact to building structures, resulting from mine subsidence. The classification has, however, been extended to include a Category 5, which corresponds to the Very Severe Damage Category of the National Coal Board Classification and represents crack widths greater than 25 mm.

Table E.2 Classification of Impact with Reference to Walls

Impact Category	Description of typical impact to walls and required repair	Approximate crack width limit
0	Hairline cracks.	< 0.1 mm
1	Fine cracks which do not need repair.	0.1 mm to 1.0 mm
2	Cracks noticeable but easily filled. Doors and windows stick slightly.	1 mm to 5 mm
3	Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weather-tightness often impaired	5 mm to 15 mm, or a number of cracks 3 mm to 5 mm in one group
4	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window or door frames distort. Walls lean or bulge noticeably. Some loss of bearing in beams. Service pipes disrupted.	15 mm to 25 mm but also depends on number of cracks
5	As above but worse, and requiring partial or complete rebuilding. Roof and floor beams lose bearing and need shoring up. Windows broken with distortion. If compressive damage, severe buckling and bulging of the roof and walls.	> 25 mm

E.7. Classification of Impact Levels due to Tilt

There is no standard method for classifying the level of impact caused by tilt. However, Australian Standard AS 2870 - 1996 indicates that local deviations in vertical or horizontal slope of more than 1 in 100, (10 mm/m), will normally be clearly visible and that slopes greater than 1 in 150 (approximately 7 mm/m) are undesirable.

However, it is recognised that structures are constructed to varying levels of accuracy. As reported by Burton (1995), research commissioned by the Mine Subsidence Board in 1991 indicated that a sample of 83 dwellings built at Woodrising in the preceding ten years in areas unaffected by mining, had a mean deviation from level of 2.39 mm/m, with a maximum deviation of 8.7 mm/m. The Mine Subsidence Board, in its *Annual Review* (1992), published further details of the research project. Fig. E.1 shows the distribution of measured tilts arising from this and other pre-mining surveys, and indicates that 21% of 156 houses had tilts of more than 4 mm. The maximum tilt measured at a building prior to mining was 15 mm/m, with nine cases being reported between 9 mm/m and 15 mm/m. The acceptable change in tilt, due to mining, will thus vary from case to case and will be dependent upon the tilts existing before mining occurs.

The Mine Subsidence Board has adopted the policy that tilts caused by mine subsidence, which affect serviceability, constitute impact that is to be compensated. When the tilts are between 4 mm/m and 7 mm/m, the Board recognises that the tilt, in some instances, could cause problems to roof drainage and wet area floors and, in those circumstances, would expect to carry out remedial works. It is also possible that some adjustment could be required to doors and windows.

Where the tilt is greater than 7 mm/m and the roof drainage, wet area floors or pools can not be correctly graded or levelled without major structural work, then the Board would consider jacking the building to level. If, in extreme cases, the tilt caused impact to a building structure that could not be repaired economically, the Board, depending on the merits of each case, may be prepared to demolish the structure and rebuild it, or negotiate with the owner to pay monetary compensation, or purchase the property.

There appears to be some agreement that final overall tilts in buildings which are less than 7 mm/m are tolerable and that tilts above 10 mm/m are undesirable. Overall tilts in buildings less than 5 mm/m would generally have negligible impact on building structures though this level of tilt could affect swimming pools and could possibly affect roof, floor or land drainage systems, where existing gradients are less than normal design requirements.

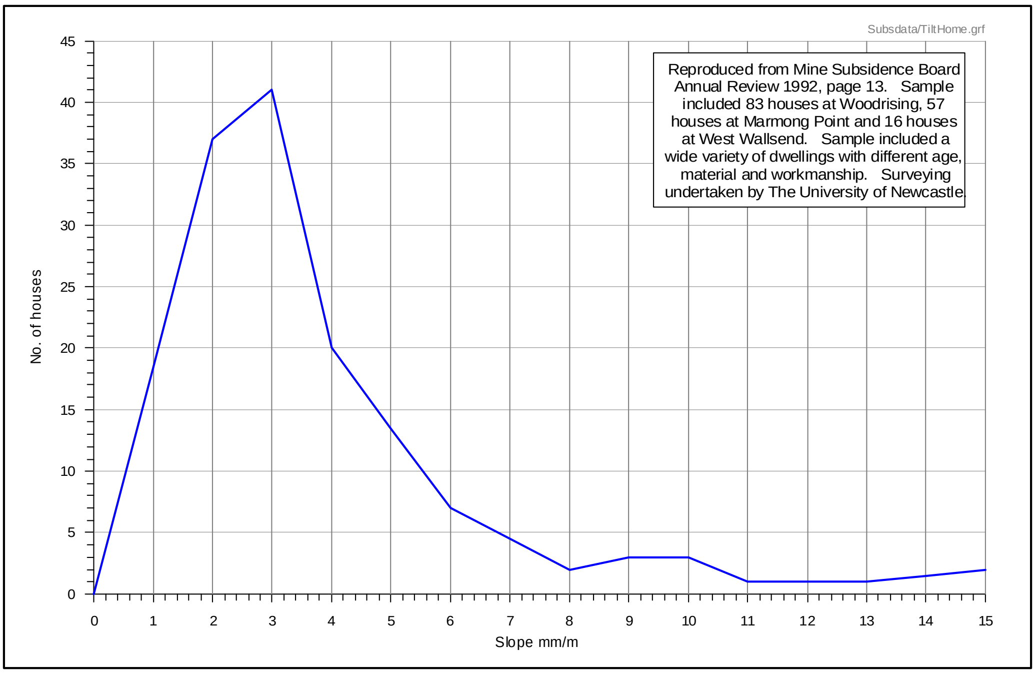


Fig. E.1 Tilts of Surveyed Dwellings located outside Mine Subsidence Areas

The impact classification shown in Table E.3, was developed by Waddington Kay & Associates. This has generally been accepted for a number of previous projects and Commissions of Inquiry. It is noted, however, that the Mine Subsidence Board, in some cases, might consider jacking houses to rectify Category C levels of tilt.

Table E.3 Classification of Impact with Reference to Tilt

Impact Category	Mining Induced Ground Tilt (mm/m)	Description
A	< 5	Unlikely that remedial work will be required.
B	5 to 7	Adjustment to roof drainage and wet area floors might be required.
C	7 to 10	Minor structural work might be required to rectify tilt. Adjustments to roof drainage and wet area floors will probably be required and remedial work to surface water drainage and sewerage systems might be necessary.
D	> 10	Considerable structural work might be required to rectify tilt. Jacking to level or rebuilding could be necessary in the worst cases. Remedial work to surface water drainage and sewerage systems might be necessary.

E.8. Classification of Impact due to Ground Strains

In 1975, the National Coal Board, in the *Subsidence Engineers Handbook*, published a graph showing the relationship between impact, horizontal ground strain and the length of a building structure. It was based upon empirical data obtained from studying the effects of subsidence along 165 observation lines at numerous collieries in the U.K.

It has been generally accepted as providing a reasonable basis for assessing the levels of impact that are likely to result from mining subsidence and has been adopted in other countries around the world. When used in Australia for the prediction of impact, it has been shown to provide reasonable agreement with observed impact levels (Holla, 1988 and 1995; Bray and Branch, 1988).

The graph is reproduced, in an extended form, in Fig. E.2 and illustrates the various impact categories, shown in Table E.2. These are separated by lines that represent specific extensions to the length of a structure. These extensions, which define the various categories of impact, were originally published in Table 8 of the *Subsidence Engineers Handbook* (NCB, 1975). It follows that the strain values referred to in Fig. E.2, should be seen as those occurring in the building structure. Normally these are taken to be the mining-induced horizontal ground strains. However, ground strains should be converted into structure strains by adding or subtracting the effect of mining-induced hogging or sagging curvature in the structure.

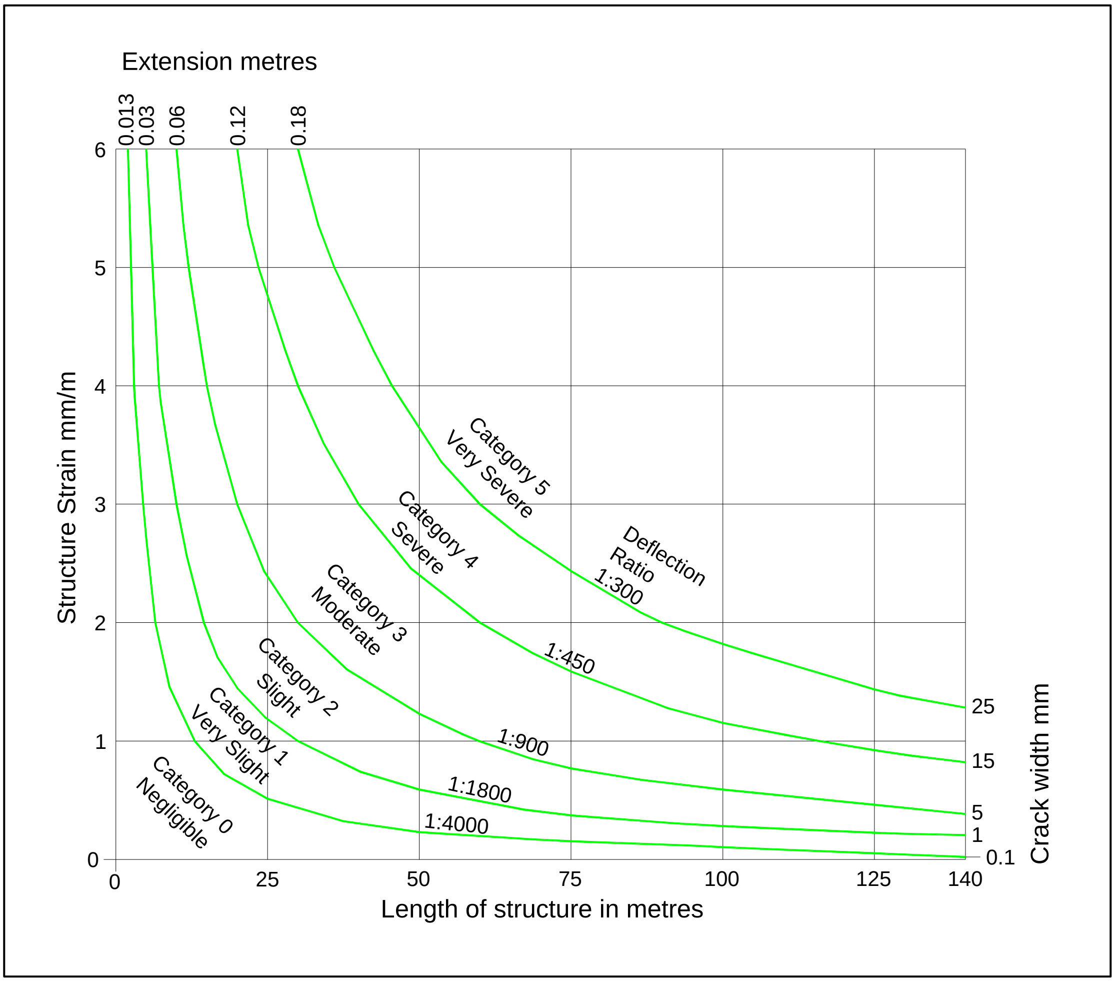


Fig. E.2 Impact Classification with Deflection Ratios for Two Storey Brick Structures

The impact categories shown in Fig. E.2 relate to typical two-storey brick or masonry building structures, which were the norm in mining areas in the U.K. Brick veneer homes and timber framed structures, with fibro or weatherboard cladding, which are commonly built in Australia, are not normally found in the mining areas of the U.K. The impact classifications are, therefore, somewhat conservative for these more typical Australian structures.

As previously discussed, the horizontal ground strains are associated with ground curvatures and both contribute to the strain which is experienced by a building structure. Often the horizontal strain is only partially transferred into the building and the curvature, which causes bending strain, provides the greater contribution to the total strain.

The bending strain in a building structure, resulting from hogging curvature of the ground, is dependent upon the height of the building, *H*, and the radius of curvature of the ground, *R*, and can be expressed simply as strain = *H/R*, as shown in Fig. E.3.

In this calculation, it is assumed that the curvature of the ground, at foundation level, is transferred into the structure by differential settlement of the foundations and that the structure bends to accommodate the curvature. It is assumed that hogging curvature will result in bending about the underside of the foundation. In practice, some shearing may take place in the structure and the calculated bending strain might not be fully developed.

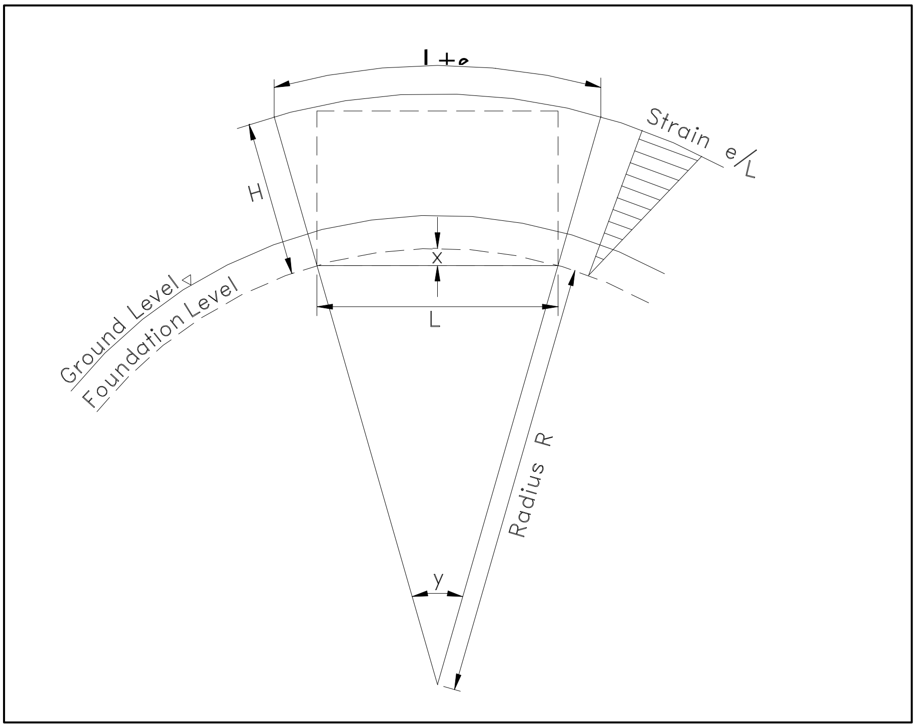
In the sagging mode, some resistance to bending will occur in the lower part of the wall. Normally slippage will occur at damp course level but, if no damp course exists, the foundations or ground slab will provide resistance. The effective neutral axis will therefore be in the lower part of the wall but its location will vary from structure to structure. In general, it seems reasonable to assume that walls, subjected to concave, or sagging, curvature, will bend about their centre line.

To determine the tensile strains in a building structure, the horizontal tensile ground strains have been added to the tensile bending strains, which are determined from a structure height measured from the underside of the foundation. To determine the compressive strains in a building structure, the compressive bending strains, determined from the mid-height of a structure, have been deducted from the horizontal compressive ground strains. This combined strain has then been used in predicting impact intensity from Fig. E.2.

In practice, much of the horizontal ground strain could be lost in the transfer. The impact assessments, provided in Chapter 6, are therefore cautious assessments that represent the worst possible scenario based upon the predicted subsidence parameters.

E.9. The Relationship between Impact Classification and Allowable Deflection Ratio

The elongation of a structure, due to curvature of the ground is directly related to the deflection ratio of a structure, as shown in Fig. E.3.



Note: Curvature exaggerated for clarity

Fig. E.3 Symbols used in the Analysis of Structures Bending by Hogging

From the geometry of a circle it can be shown that:

elongation of structure, $e = \text{deflection ratio} \times 8\,H$ Equation 2

The relationship between the elongation of a structure, due to bending, and the deflection ratio is therefore dependent upon the height of the structure.

From the curve shown in Fig. E.2, a two-storey building with a height of 6.75 metres represents an extension of 0.03 metres for an impact category between 1 and 2. This can be related to a deflection ratio using the formula given above.

Hence, $\text{Deflection Ratio} = \dfrac{\text{elongation}}{8H} = \dfrac{0.03}{54} = \dfrac{1}{1800}$ Equation 3

Using the method above, the deflection ratios have been calculated for other values of extension and these have been shown in Fig. E.2. The calculations indicate that for two-storey brick structures, with a height of 6.75 metres, the upper limit of impact for Category 2 represents a deflection ratio of 1:900. Similarly, the upper limits of Impact Categories 3 and 4 are represented by deflection ratios of 1:450 and 1:300, respectively.

It is reasonable to assume that the level of impact at a deflection ratio of less than 1:4000 would be negligible for a two storey brick structure. A curve has been included in Fig. E.2, based upon this value of deflection ratio, in order to provide a division between Impact Categories 0 and 1.

E.10. Relationship between Impact Classification and Crack Width

The deflection ratios and maximum crack widths which separate each Impact Category, for two-storey brick structures of 6.75 metres height, are shown in Fig. E.2. Based upon these factors, Fig. E.4 has been produced, to show the relationship between the inverse of deflection ratio and the maximum crack width.

The impact categories given in Table E.2 are related to maximum crack widths and these have been shown for each of the categories in Fig. E.2. Impact Category 0 relates to a maximum crack width of less than 0.1 mm, which would not be visible, and hence represents negligible impact. Categories 1 to 4 relate to maximum crack widths of 1 mm, 5 mm, 15 mm and 25 mm respectively. Category 5 has been added to represent crack widths greater than 25 mm.

In a paper presented by P.F. Walsh (1991), a graph was published showing the relationship between crack widths and inverse deflection ratios for single storey, brick veneer houses, subject to reactive clay movements. The graph was reproduced from a paper which was published in 1981 by D.A. Cameron and P.F. Walsh, and is based upon actual deflections and crack widths.

This graph has been added to Fig. E.4 to show the comparison between the theoretical relationships and measured results and a very close agreement can be seen. The classification of impact with reference to both extension and crack width would, therefore, appear to have some scientific basis.

It can be seen from Table E.1, that all other types of building structure have an allowable deflection ratio greater than that of brick structures. A timber-framed building, for example, has an allowable deflection ratio of 1:300 compared with 1:2000 for lightly loaded rendered brickwork. Rendered brick veneer structures have an allowable ratio of 1:800.

The effect of bending strains on building structures is dependent upon their flexibility and their capacity to absorb curvature by shearing. The level of impact caused to a building, by curvature of the ground, therefore reduces as the allowable deflection ratio increases.

The use of the graphs in Fig. E.2 to predict the levels of impact to buildings of flexible construction would, therefore, be an over-cautious approach and would result in excessively conservative assessments. The management strategies have therefore been adjusted for sheds and other light structures to compensate for this conservatism.

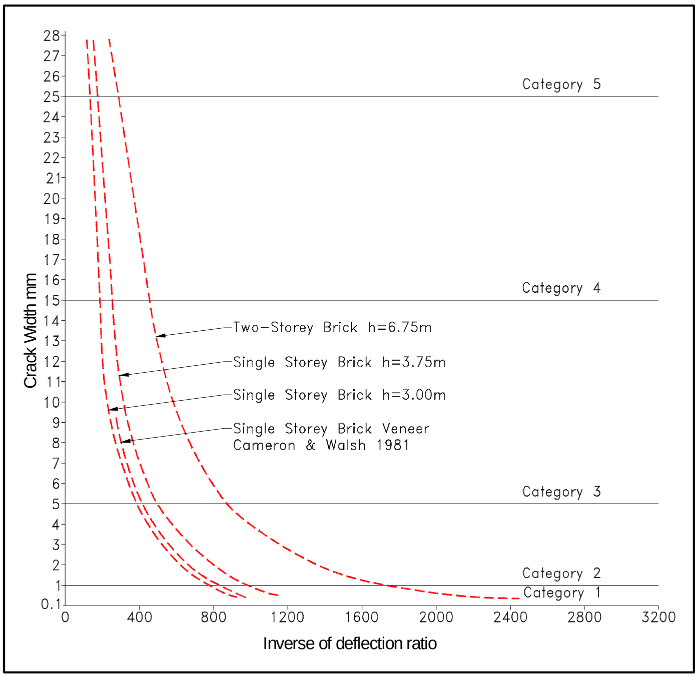


Fig. E.4 Variation of Crack Width with Deflection Ratio for Brick Structures

APPENDIX F. COMPARISONS BETWEEN OBSERVED AND BACK-PREDICTED SUBSIDENCE PROFILES FOR THE PREVIOUSLY EXTRACTED LONGWALLS

Comparison of Predicted and Observed Profiles along Sandy Creek Road Monitoring Line - LW2 to LW4

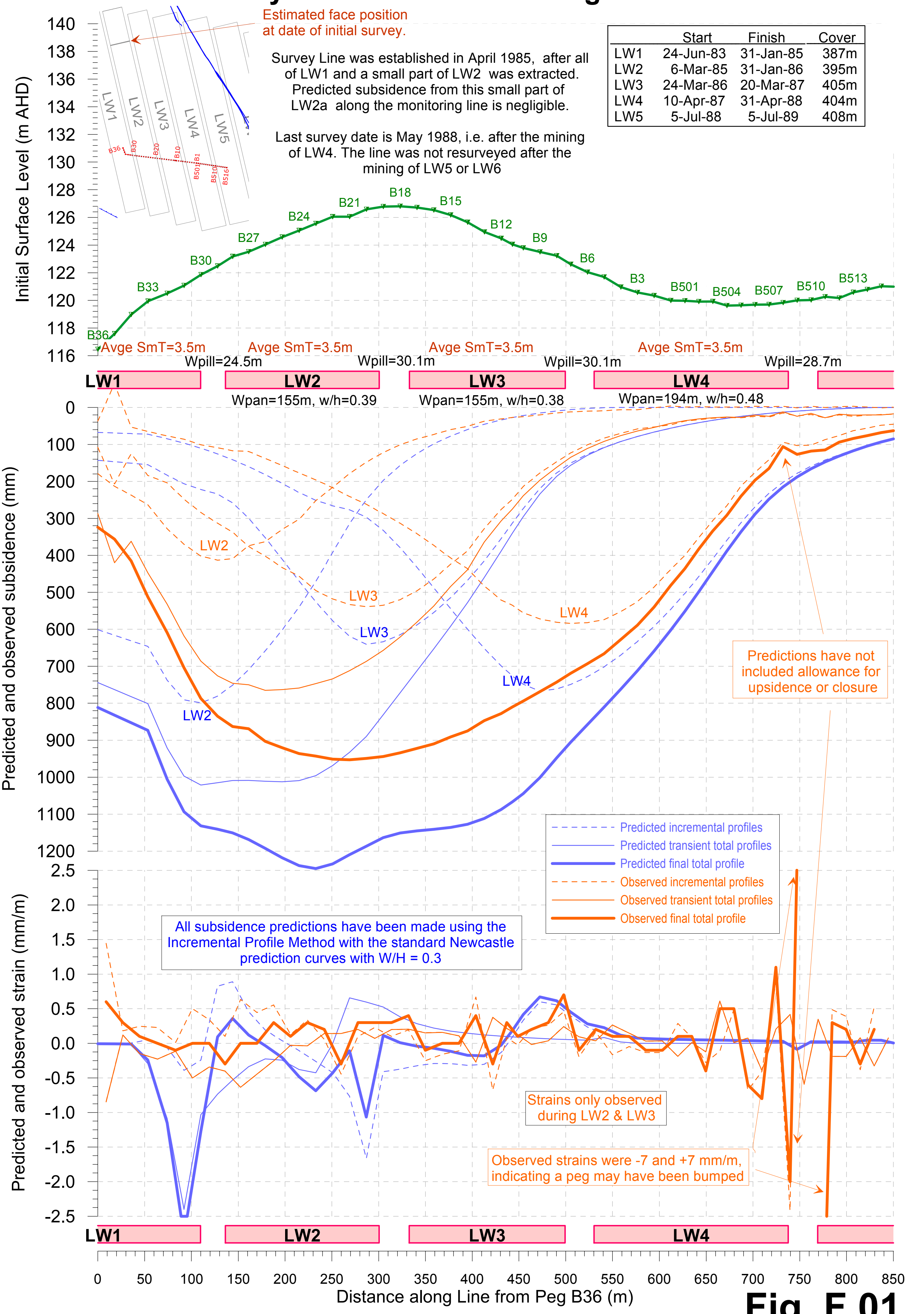
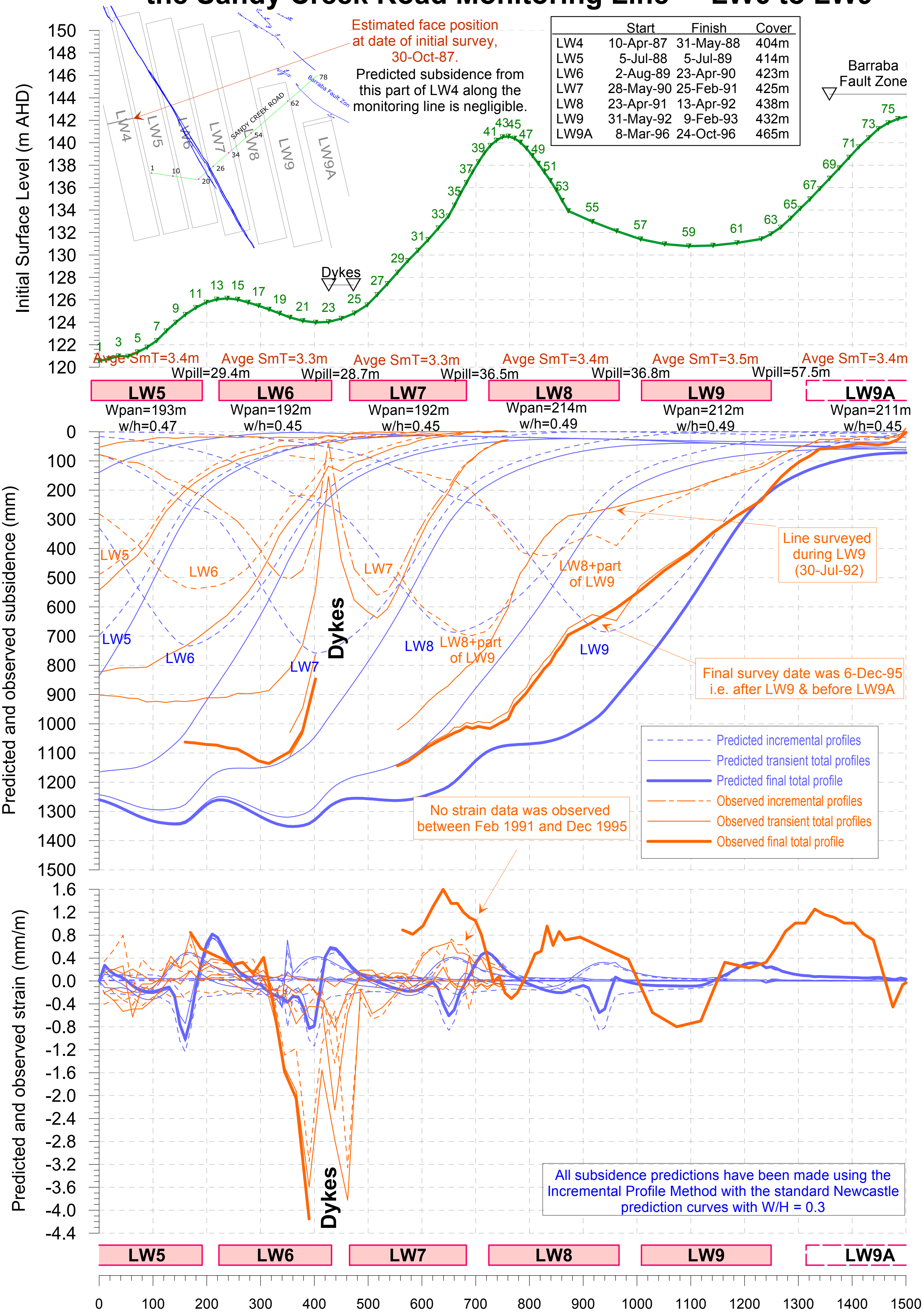


Fig. F.01

Comparison of Predicted and Observed Profiles along the Sandy Creek Road Monitoring Line - LW6 to LW9



	Start	Finish	Cover
LW4	10-Apr-87	31-May-88	404m
LW5	5-Jul-88	5-Jul-89	414m
LW6	2-Aug-89	23-Apr-90	423m
LW7	28-May-90	25-Feb-91	425m
LW8	23-Apr-91	13-Apr-92	438m
LW9	31-May-92	9-Feb-93	432m
LW9A	8-Mar-96	24-Oct-96	465m

Fig. F.02

Comparison of Predicted and Observed Profiles along the Dry Creek Road Monitoring Line

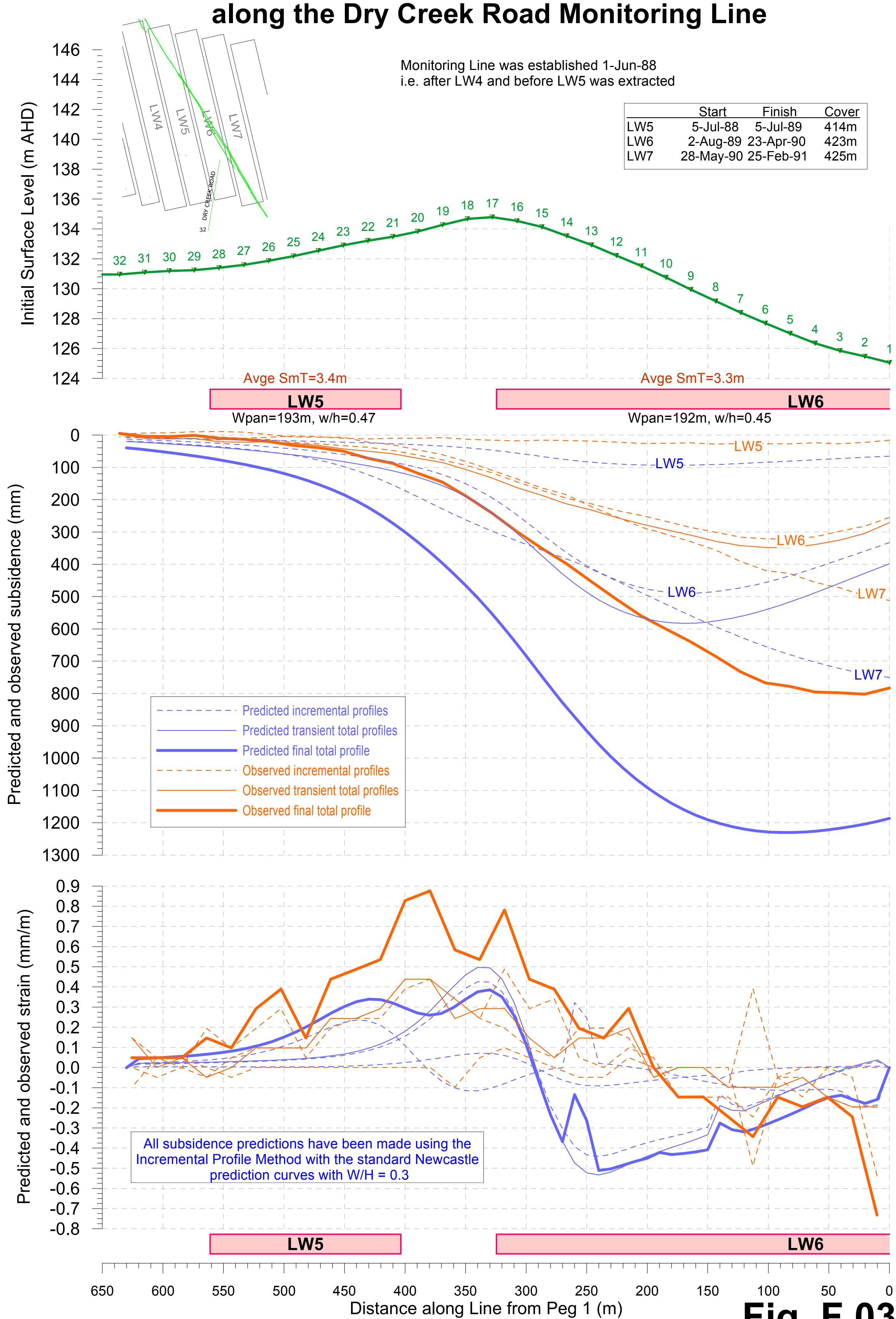


Fig. F.03

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Comparison of Predicted and Observed Profiles along Monitoring Line LW9A

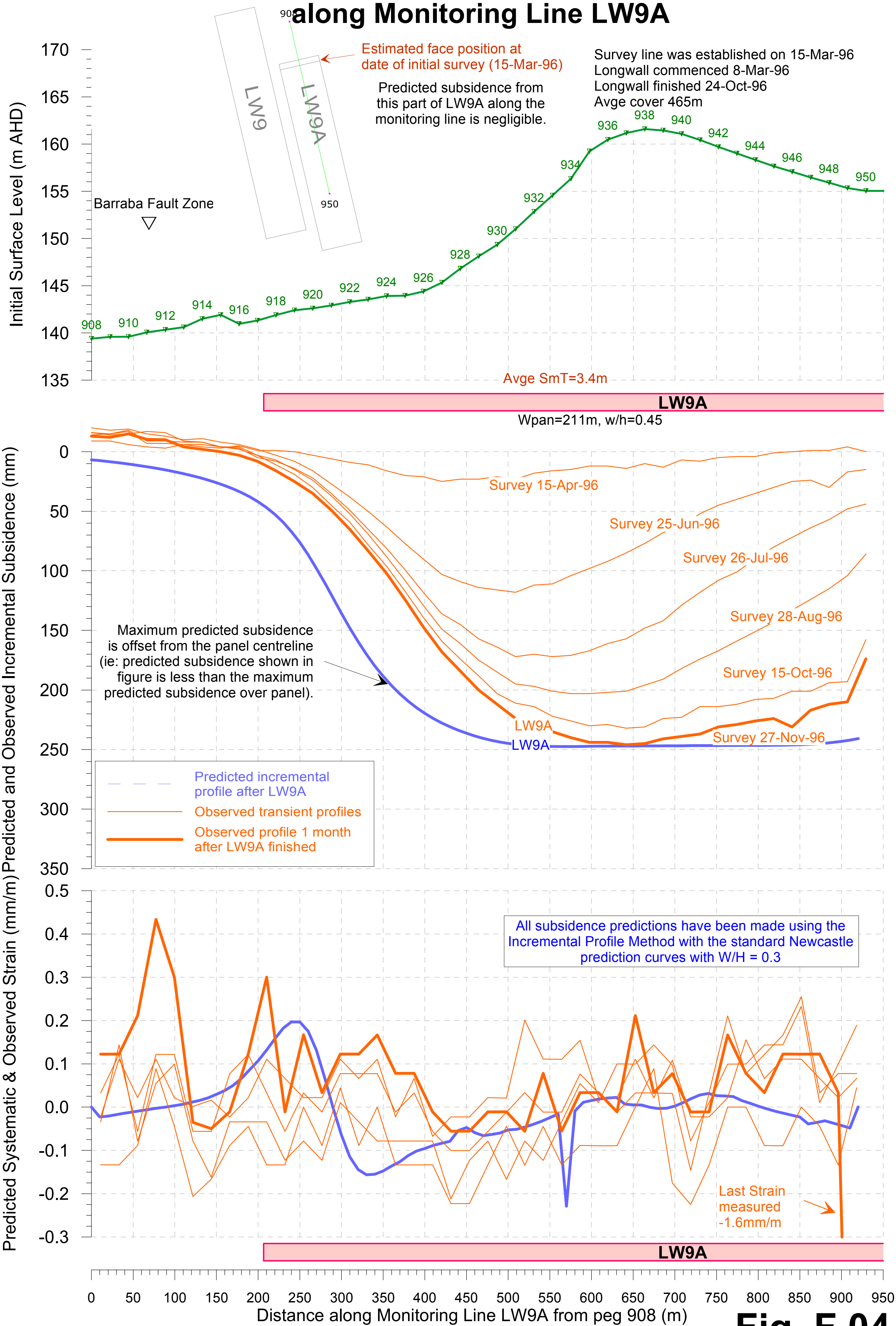


Fig. F.04

Comparison of Predicted and Observed Profiles across Monitoring Line LW10-12A

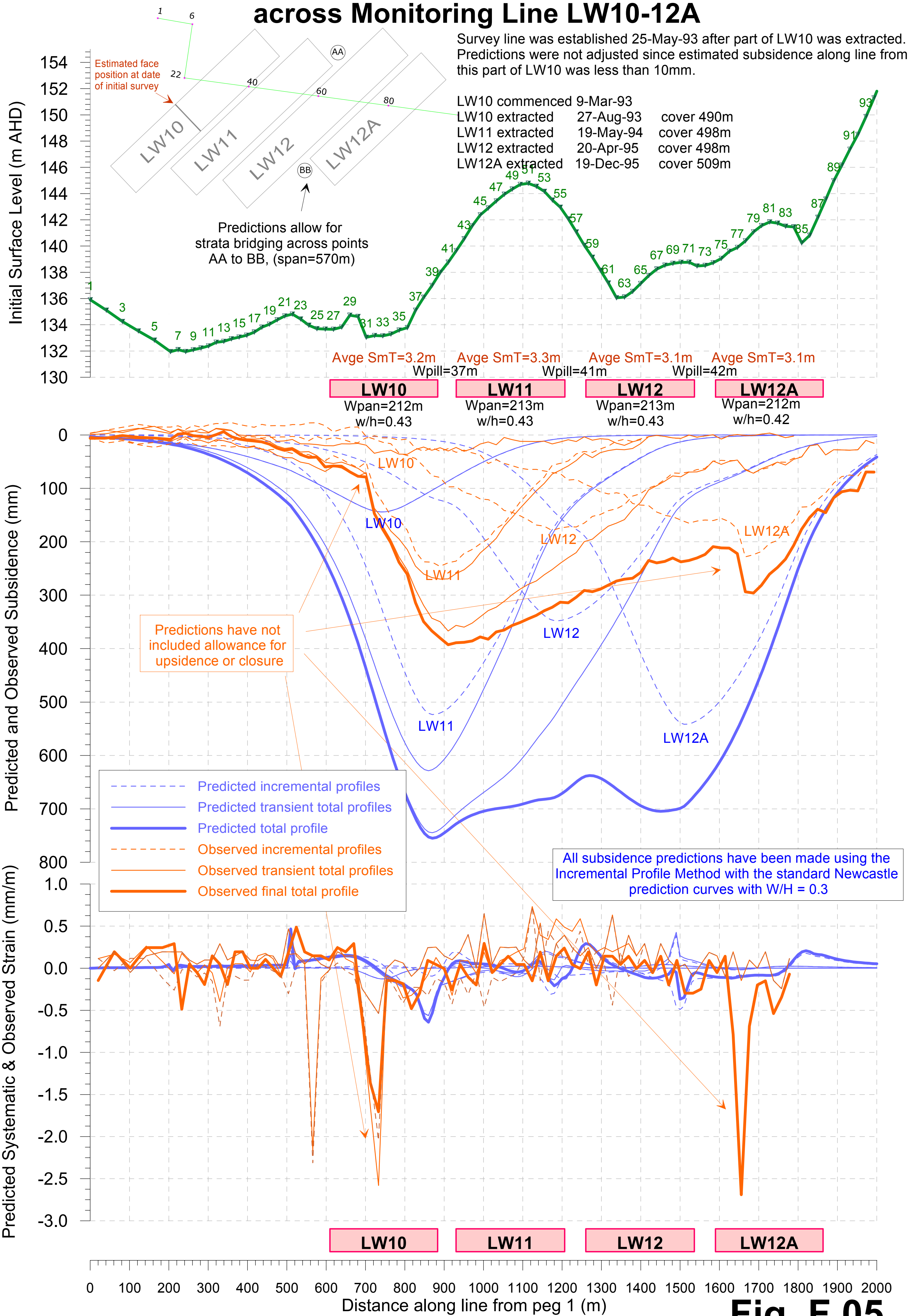


Fig. F.05

Comparison of Predicted and Observed Profiles along Monitoring Line LWSL1

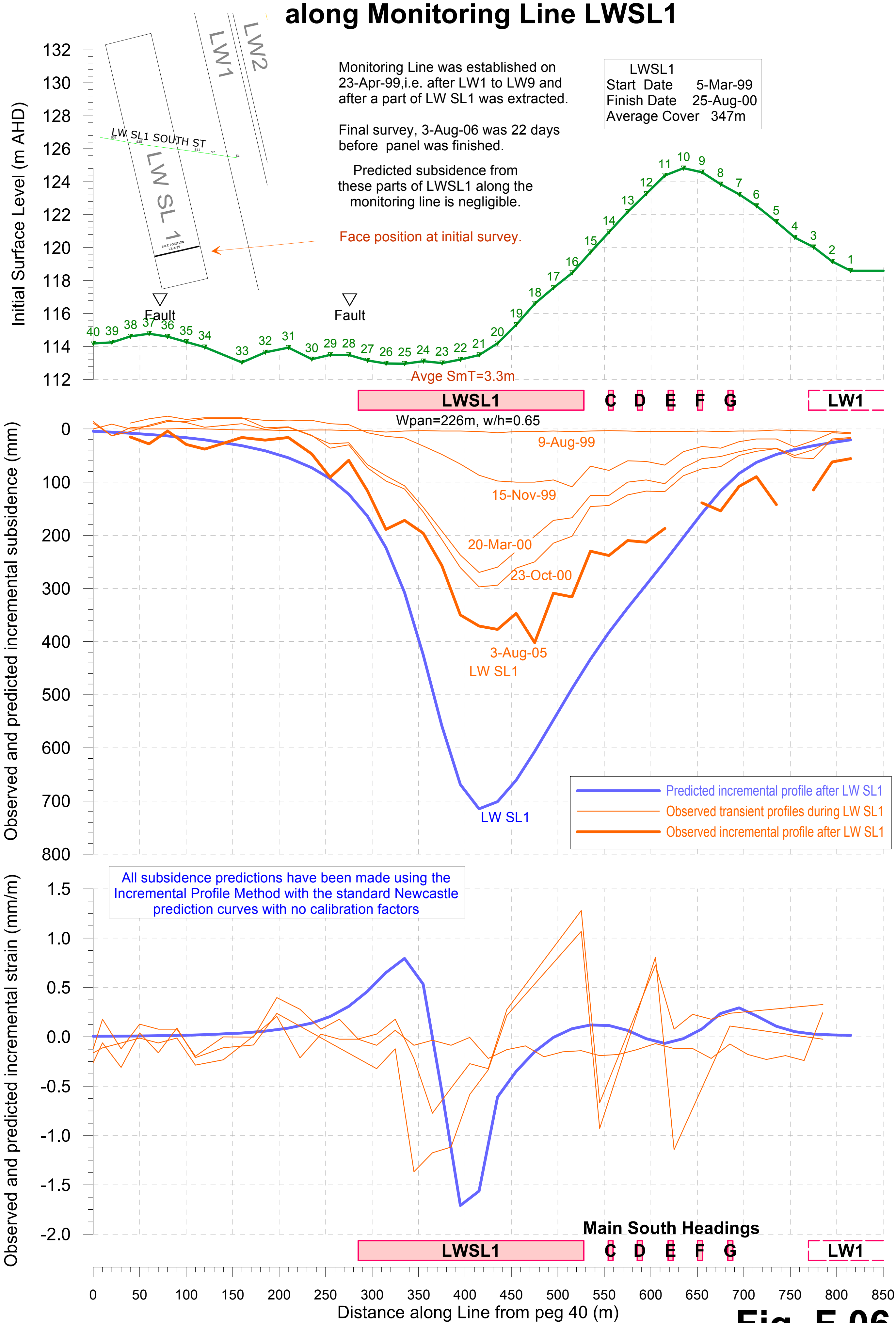


Fig. F.06

Comparison of Predicted and Observed Profiles along Monitoring Line LW13-Line2

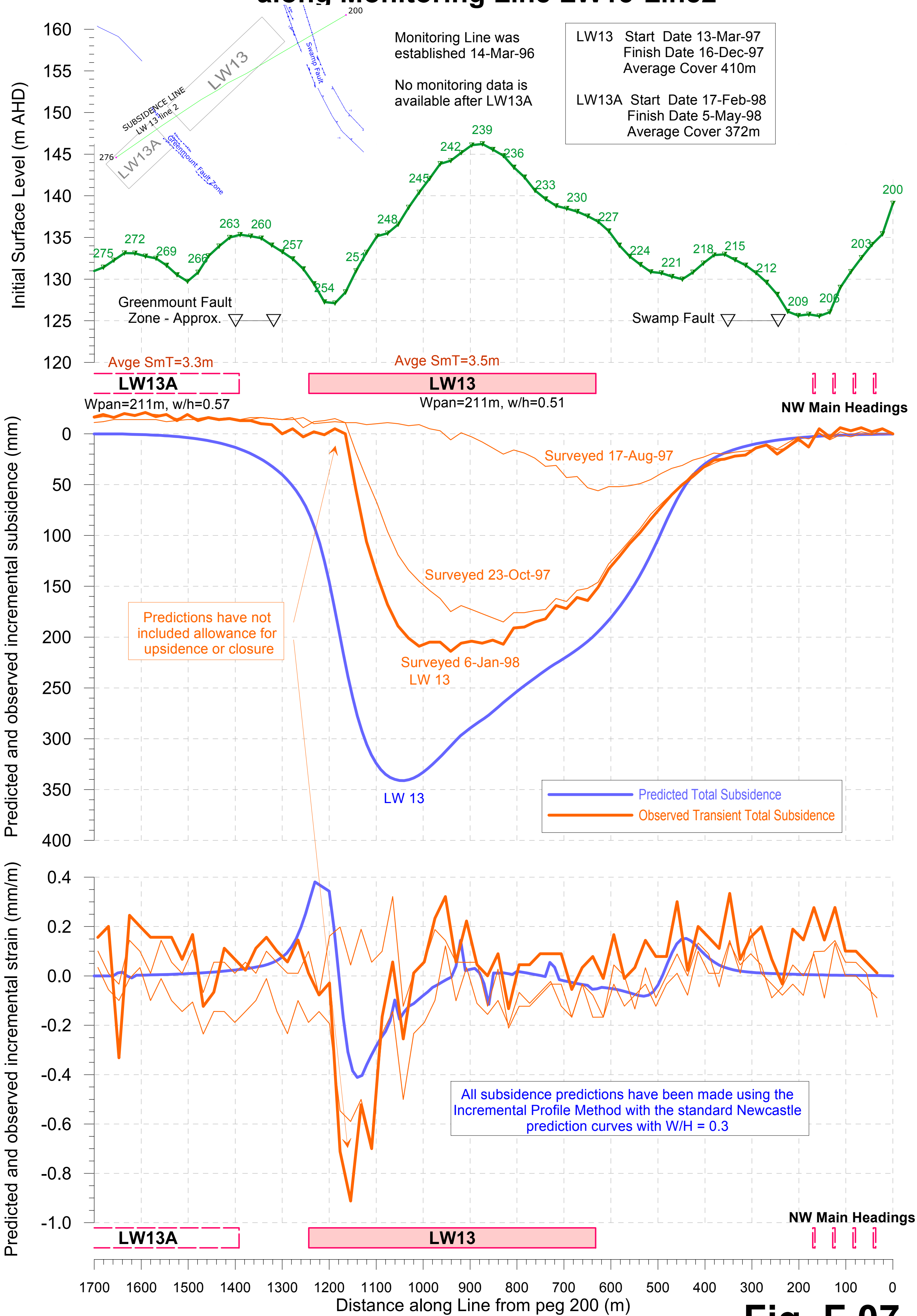
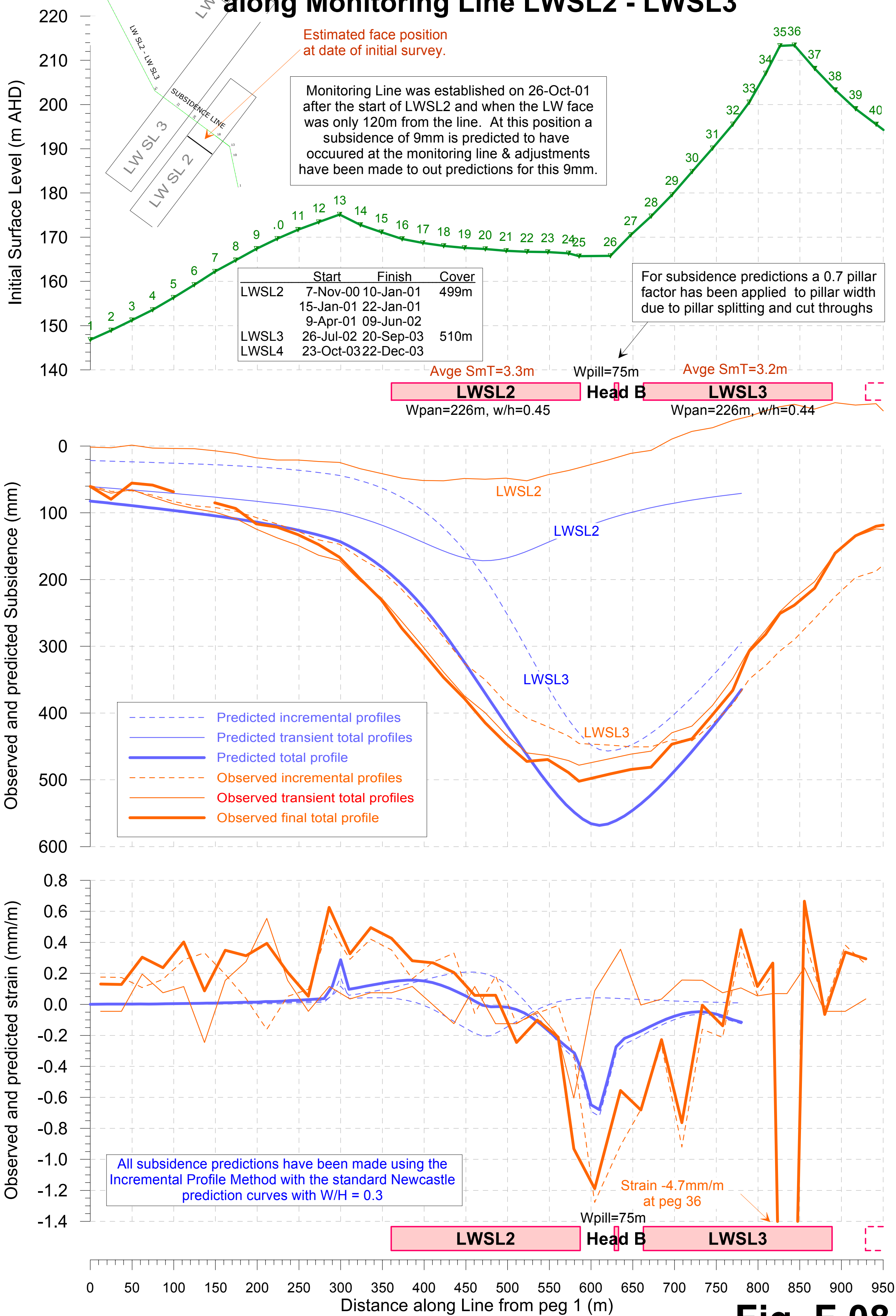


Fig. F.07

Comparison of Predicted and Observed Profiles along Monitoring Line LWSL2 - LWSL3



	Start	Finish	Cover
LWSL2	7-Nov-00	10-Jan-01	499m
	15-Jan-01	22-Jan-01	
	9-Apr-01	09-Jun-02	
LWSL3	26-Jul-02	20-Sep-03	510m
LWSL4	23-Oct-03	22-Dec-03	

Fig. F.08

Comparison of Back-Predicted and Observed Profiles Maximum Incremental Subsidence

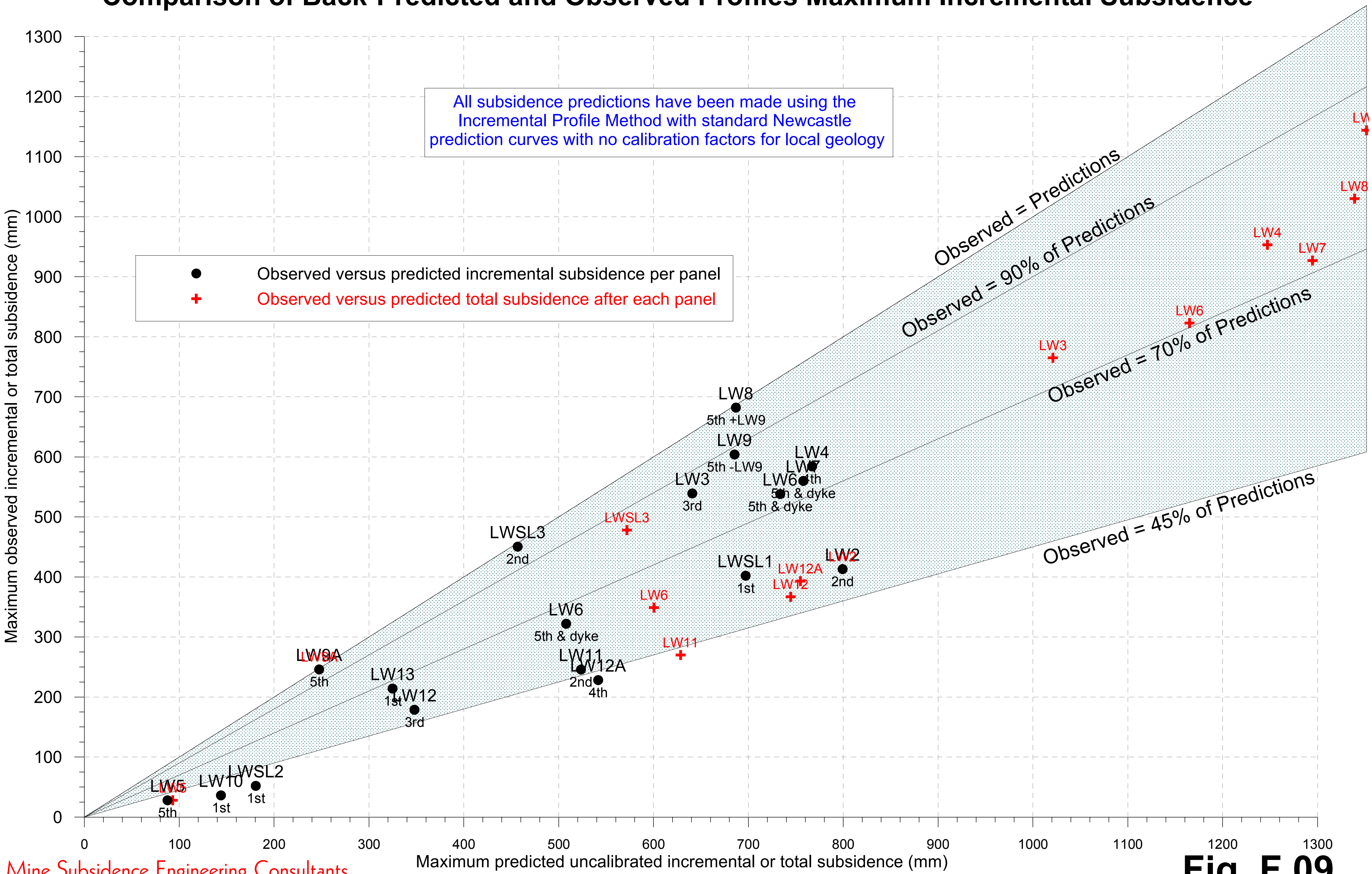


Fig. F.09

Austar Coal Mine - Total Subsidence Profiles along Subsidence Line 1A

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Fig. F.10

Austar Coal Mine - Total Subsidence Profiles along Subsidence Line 1B

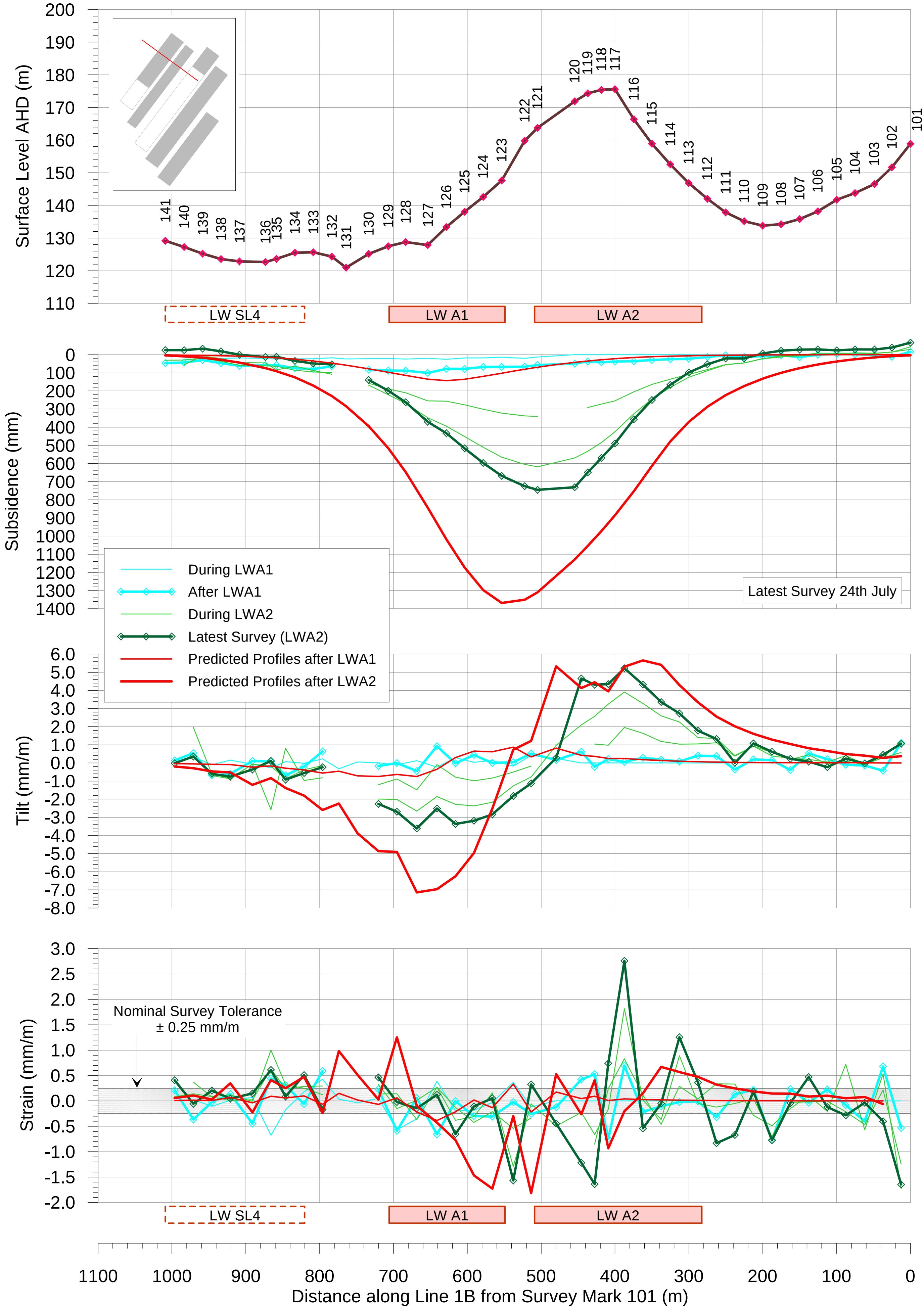

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Fig. F.11

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Austar Coal Mine - Total Subsidence Profiles along Subsidence Line 2

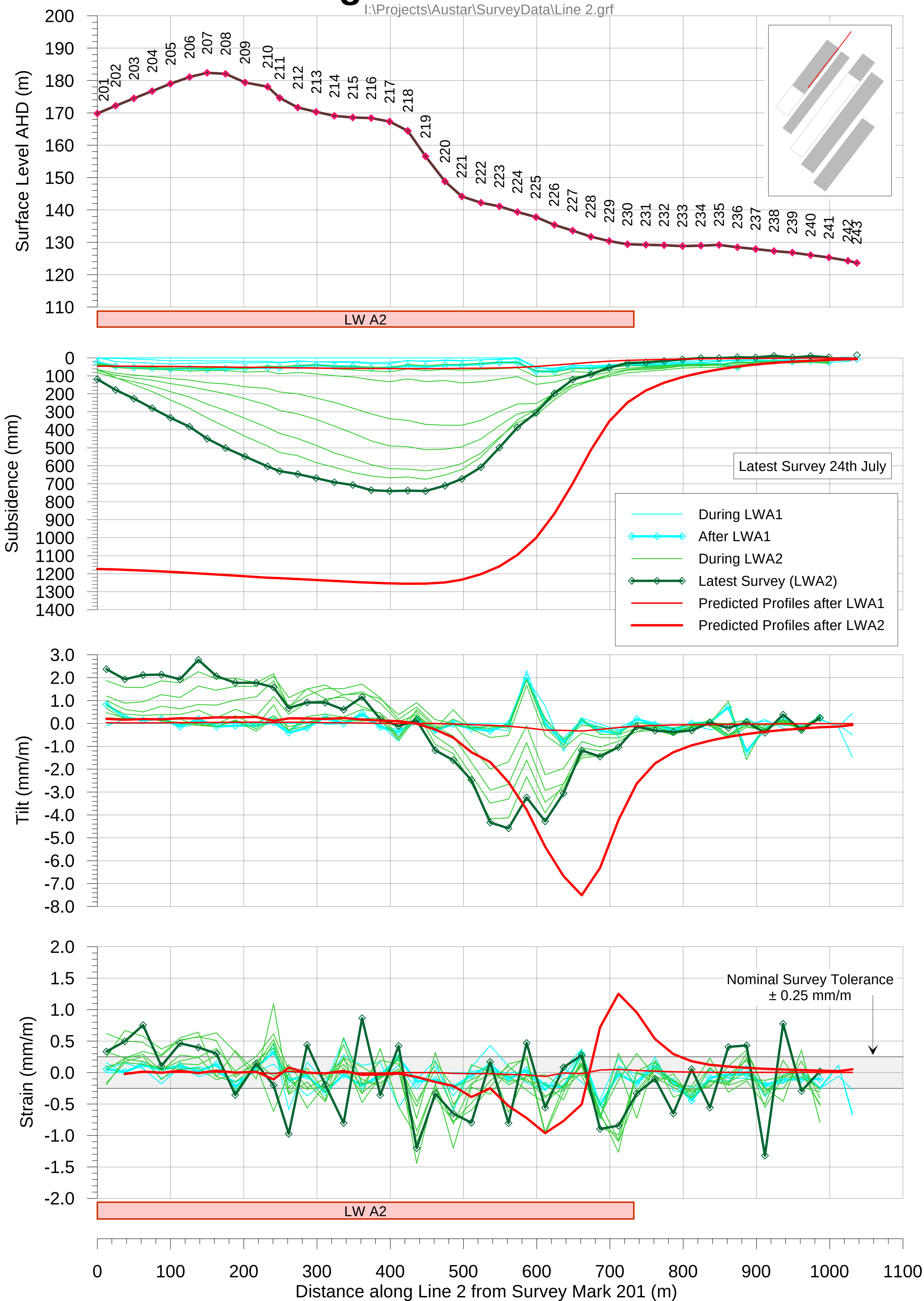

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Fig. F.12

APPENDIX G. TABLES

Table G.01 - Austar Stage 3 - Proposed Longwalls A6 to A17
Predicted Systematic Subsidence and Tilt for Building Structures

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Total Predicted Subs after LWA6 (mm)	Total Predicted Subs after LWA7 (mm)	Total Predicted Subs after LWA8 (mm)	Total Predicted Subs after LWA9 (mm)	Total Predicted Subs after LWA10 (mm)	Total Predicted Subs after LWA11 (mm)	Total Predicted Subs after LWA12 (mm)	Total Predicted Subs after LWA13 (mm)	Total Predicted Subs after LWA14 (mm)	Total Predicted Subs after LWA15 (mm)	Total Predicted Subs after LWA16 (mm)	Total Predicted Subs after LWA17 (mm)	Total Predicted Tilt after LWA6 (mm/m)	Total Predicted Tilt after LWA7 (mm/m)	Total Predicted Tilt after LWA8 (mm/m)	Total Predicted Tilt after LWA9 (mm/m)	Total Predicted Tilt after LWA10 (mm/m)	Total Predicted Tilt after LWA11 (mm/m)	Total Predicted Tilt after LWA12 (mm/m)	Total Predicted Tilt after LWA13 (mm/m)	Total Predicted Tilt after LWA14 (mm/m)	Total Predicted Tilt after LWA15 (mm/m)	Total Predicted Tilt after LWA16 (mm/m)	Total Predicted Tilt after LWA17 (mm/m)
A03a	346315	6357814	H1	19.0	3.75	350	350	350	350	350	350	350	350	350	350	350	350	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
A05a	346748	6357769	H2	30.1	3.75	245	245	245	245	245	245	245	245	245	245	245	245	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
A05p01	346739	6357751	P	8.2	-	240	240	240	240	240	240	240	240	240	240	240	240	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
A09a	347040	6357590	H2	32.0	3.75	90	90	90	90	90	90	90	90	90	90	90	90	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
A09b	347031	6357610	R	10.0	2.50	85	85	85	85	85	85	85	85	85	85	85	85	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
A09c	347019	6357631	R	37.0	2.50	100	100	100	100	100	100	100	100	100	100	100	100	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
A09p01	347018	6357605	P	9.0	-	95	95	95	95	95	95	95	95	95	95	95	95	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
A12a	347474	6357848	H1	24.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	0.1	0.1
A12b	347473	6357887	R	14.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	0.1	0.1	0.1
A12c	347460	6357879	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	0.1	0.1
A12f	347355	6357999	R	123.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	0.1	0.1	0.1
A12g	347361	6358028	R	122.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.2	0.2	0.2	0.2	0.2
A12h	347360	6358060	R	90.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.2	0.2	0.2	0.2	0.2
A13a	347823	6357987	H2	33.0	3.75	< 20	< 20	< 20	< 20	< 20	90	330	405	410	410	410	410	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7	3.5	3.8	3.8	3.8	3.8	3.8
A13b	347810	6358042	R	18.0	2.50	< 20	< 20	< 20	< 20	< 20	130	375	430	435	440	440	440	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.0	3.4	3.6	3.7	3.7	3.7	3.7
A13c	347829	6358008	R	4.0	2.50	< 20	< 20	< 20	< 20	< 20	100	360	425	430	435	435	435	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.8	3.6	3.9	3.9	3.9	3.9	3.9
A13p01	347833	6357998	P	7.5	-	< 20	< 20	< 20	< 20	< 20	95	355	425	435	435	435	435	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7	3.6	3.9	4.0	4.0	4.0	4.0
A13t01	347806	6358000	T	6.9	2.50	< 20	< 20	< 20	< 20	< 20	90	285	345	350	355	355	355	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7	3.0	3.2	3.3	3.3	3.3	3.3
A14a	348074	6358041	H1	21.0	3.75	< 20	< 20	< 20	< 20	20	205	1115	1370	1395	1400	1400	1400	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.5	3.8	3.9	4.0	4.0	4.0	4.0
A14b	348059	6358048	R	11.0	2.50	< 20	< 20	< 20	< 20	20	205	1110	1325	1345	1350	1350	1350	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.5	3.7	4.0	4.0	4.0	4.0	4.0
A14c	348031	6358057	R	15.0	2.50	< 20	< 20	< 20	< 20	25	215	1100	1270	1290	1290	1290	1290	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.6	3.7	4.0	4.1	4.1	4.1	4.1
A14d	347911	6358055	R	14.0	2.50	< 20	< 20	< 20	< 20	< 20	175	770	850	860	860	860	860	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.3	4.5	4.8	4.8	4.8	4.8	4.8
A14t01	348116	6358041	T	8.2	2.50	< 20	< 20	< 20	< 20	20	210	1155	1445	1475	1475	1475	1475	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.5	3.6	3.3	3.4	3.4	3.4	3.4
A15a	346975	6356731	H1	24.0	3.75	175	175	175	175	175	175	175	175	175	175	175	175	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
A15b	346945	6356705	R	27.0	2.50	170	170	170	170	170	170	170	170	170	170	170	170	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A15c	346939	6356712	R	15.0	2.50	170	170	170	170	170	170	170	170	170	170	170	170	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A15d	346945	6356678	R	13.0	2.50	165	165	165	165	165	165	165	165	165	165	165	165	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A15e	346949	6356692	R	4.0	2.50	170	170	170	170	170	170	170	170	170	170	170	170	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A15f	346797	6356724	R	125.0	2.50	140	140	140	140	140	140	140	140	140	140	140	140	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
A15g	346792	6356693	R	124.0	2.50	135	135	135	135	135	135	135	135	135	135	135	135	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
A15p01	346974	6356712	P	10.4	-	170	170	170	170	170	170	170	170	170	170	170	170	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A15t01	346861	6356719	T	3.3	2.50	145	145	145	145	145	145	145	145	145	145	145	145	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
A17a	347721	6357468	H1	22.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	30	30	30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.2	0.3	0.3	0.3
A17b	347783	6357456	R	11.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	40	40	40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	0.4	0.4	0.4
A17c	347799	6357462	R	12.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	50	50	50	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.4	0.4	0.4	0.4
A17p01	347738	6357446	P	7.0	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	25	25	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.3	0.3	0.3
A17t01	347778	6357458	T	2.5	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	40	40	40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	0.3	0.3	0.3
A17t02	347778	6357455	T	2.5	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	40	40	40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	0.3	0.3	0.3
A17t03	347809	6357461	T	3.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	50	50	50	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.4	0.4	0.4	0.4
A18a	347988	6357529	H1	18.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	20	135	235	255	260	260	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.3	2.0	2.0	2.0	2.0
A18t01	347998	6357536	T	3.7	2.50	< 20	< 20	< 20	< 20	< 20	< 20	20	140	245	265	265	265	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.4	2.0	2.1	2.1	2.1
A19a	347242	6357038	H1	16.0	3.75	30	30	30	30	30	30	30	30	30	30	30	30	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
A19b	347257	6357046	R	6.0	2.50	25	25	25	25	25	25	25	25	25	25	25	25	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A19c	347263	6357025	R	3.0	2.50	25	25	25	25	25	25	25	25	25	25	25	25	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A19d	347272	6357040	R	5.0	2.50	25	25	25	25	25	25	25	25	25	25	25	25	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A19e	347271	6357028	R	4.0	2.50	25	25	25	25	25	25	25	25	25	25	25	25	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A20a	347338	6356771	H1	20.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A20b	347365	6356773	R	14.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
A20c	347356	6356756	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A20d	347332	6356817	R	7.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A22a	347091	6356183	H1	17.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A22b	347112	6356203	R	9.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A22c	347079	6356191	R	4.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A22p01	347097	6356205	P	9.9	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A25a	348471	6356349	H1	24.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	95	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.0
A25b	348424	6356386	H1	21.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	85	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.9
A25p01	348458	6356364	P	11.2	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	85	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.9
A25t01	348452	6356345	T	7.9	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	75	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.8
A26a	348178	6356677	H1	13.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.4	0.6
A26b	348170	6356733	R	18.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	50	75	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.5	0.7
A26c	348127	6356760	R	20.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	60	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.4	0.5
A27a	348335	6356906	R	22.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	170	360	400	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.4	2.6	2.7
A29a	349194	6356711	H2	31.4	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	185	1205	1725	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.3	4.4	1.1
A29b	349238	6356747	R	10.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	245	1325	1760	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.8	3.4	1.5
A31a	347896	6358532	H1	11.0	3.75	< 20	< 20	< 20	115	935	1560	1645	1655	1660	1660	1660	1660	< 0.1	< 0.1	< 0.1	0.8	5.6	2.9	3.2	3.3	3.3	3.3	3.3	3.3
A31b	347922	6358547	R	9.0	2.50	< 20	< 20	< 20	130	990	1575	1675	1685	1685	1685	1685	1685	< 0.1	< 0.1	< 0.1	0.9	5.2	1.7	2.3	2.3	2.3	2.3	2.3	2.3
A31c	347931	6358555	R	4.0	2.50	< 20	< 20	< 20	135	1015	1580	1680	1690	1690	1690	1690	1690	< 0.1	< 0.1	< 0.1	0.9	4.6	1.2	2.0	2.1	2.1	2.1	2.1	2.1
A31t01	347927	6358552	T	3.3	2.50	< 20	< 20	< 20	130	1000	1575	1675	1685	1685	1685	1685	1685	< 0.1	< 0.1	< 0.1	0.9	4.8	1.3	2.0	2.1	2.1	2.1	2.1	2.1
A32a	348634	6358091	H1	12.0	3.75	< 20	< 20	< 20	< 20	75	685	1485	1730	1805	1825	1825	1825	< 0.1	< 0.1	< 0.1	< 0.1	0.6	5.3	1.9	1.3	1.2	1.1	1.1	1.1
A32b	348641	6358140	R	18.0	2.50	< 20	< 20	< 20	< 20	110	890	1495	1715	1785	1800	1800	1800	< 0.1	< 0.1	< 0.1	< 0.1	0.8	5.3	0.7	1.3	1.6	1.6	1.6	1.6
A32c	348615	6358144	R	25.0	2.50	< 20	< 20	< 20	< 20	110	895	1500	1720	1790	1800	1805	1805	< 0.1	< 0.1	< 0.1	< 0.1	0.8	5.3	0.8	1.3	1.6	1.6	1.6	1.6
A32d	348182	6357612	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	70	565	1020	1055	1060	1060	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.9	5.5	5.6	5.6	5.6
A32p01	348630	6358071	P	11.7	-	< 20	< 20	< 20	< 20	60	555	1465	1725	1810	1825	1830	1830	< 0.1	< 0.1	< 0.1	< 0.1	0.5	5.0	2.4	1.4	1.3	1.3	1.2	1.2
A32t01	348432	6358096	T	3.8	2.50	< 20	< 20	< 20	< 20	60	510	1475	1750	1820	1830	1830	1830	< 0.1	< 0.1	< 0.1	< 0.1	0.5	4.6	2.9	1.8	1.4	1.3	1.3	1.3
A32t02	348746	6357707	T	3.7	2.50	< 20	< 20	< 20	< 20	< 20	35	300	1330	1675	1785	1805	1810	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.5	3.0	1.7	1.1	0.9	0.9
A33a	349484	6357714	H2	31.2	3.75	< 20	< 20	< 20	< 20	< 20	115	880	1420	1635	1700	1715	1715	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.8	4.9	1.1	1.4	1.6	1.7	1.7
A33b	349563	6357680	R	12.0	2.50	< 20	< 20	< 20	< 20	< 20	90	765	1380	1590	1650	1665	1670	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7	4.7	1.5	1.2	1.4	1.5	1.5
A33t01	349492	6357746	T	3.2	2.50	< 20	< 20	< 20	< 20	< 20	130	935	1415	1595	1650	1660	1660	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	3.4	1.1	1.3	1.6	1.7	1.7
A33t02	349496	6357748	T	3.4	2.50	< 20	< 20	< 20	< 20	< 20	130	940	1410	1590	1645	1655	1655	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	3.3	1.1	1.3	1.6	1.7	1.7
A33t03	349563	6357671	T	2.9	2.50	< 20	< 20	< 20	< 20	< 20	80	710	1375	1585	1650	1665	1670	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.7	1.6	0.8	1.1	1.1	1.2
A33t04	349567	6357672	T	3.0	2.50	< 20	< 20	< 20	< 20	< 20	80	715	1370	1585	1645	1660	1665	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.7	1.6	0.8	1.1	1.2	1.2
A33t05	349466	6357684	T	2.6	2.50	< 20	< 20	< 20	< 20	< 20	80	715	1415	1640	1710	1725	1730	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.9	1.5	0.8	1.0	1.1	1.1
A33t06	349359	6357923	T	3.2	2.50	< 20	< 20	< 20	< 20	35	435	1370	1635	1720	1740	1745	1745	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.9	2.8	1.7	1.2	1.1	1.1	1.1
A33t07	349364	6357924	T	3.2	2.50	< 20	< 20	< 20	< 20	35	445	1375	1635	1720	1740	1745	1745	< 0.1	< 0.1	< 0.1	< 0.1	0.4	4.0	2.8	1.7	1.2	1.2	1.1	1.1
A34a	348990	6358342	H2	35.1	3.75	< 20	< 20	< 20	75	835	1530	1750	1815	1830	1835	1835	1835	< 0.1	< 0.1	< 0.1	0.9	4.6	2.1	1.8	1.7	1.7	1.7	1.7	1.7
A34b	349001	6358366	R	10.0	2.50	< 20	< 20	< 20	95	910	1525	1730	1790	1805	1805	1805	1805	< 0.1	< 0.1	< 0.1	1.0	4.3	0.8	1.4	1.6	1.7	1.7	1.7	1.7
A34c	349051	6358380	R	30.0	2.50	< 20	< 20	< 20	120	995	1530	1705	1755	1770	1775	1775	1775	< 0.1	< 0.1	< 0.1	1.2	4.1	1.0	1.2	1.4	1.5	1.5	1.5	1.5
A34d	348950	6358346	R	4.0	2.50	< 20	< 20	< 20	65	785	1530	1755	1815	1835	1835	1835	1835	< 0.1	< 0.1	< 0.1	0.8	4.6	1.5	1.4	1.6	1.7	1.7	1.7	1.7
A34p01	348990	6358361	P	11.0	-	< 20	< 20	< 20	85	880	1525	1735	1795	1810	1815	1815	1815	< 0.1	< 0.1	< 0.1	1.0	4.4	0.8	1.4	1.6	1.7	1.7	1.7	1.7
A34t01	348961	6358327	T	5.4	2.50	< 20	< 20	< 20	55	720	1530	1755	1820	1835	1840	1840	1840	< 0.1	< 0.1	< 0.1	0.7	4.6	2.8	2.1	2.0	2.0	2.0	2.0	2.0
A34t02	349034	6358375	T	3.1	2.50	< 20	< 20	< 20	105	940	1520	1705	1755	1770	1775	1775	1775	< 0.1	< 0.1	< 0.1	1.1	4.0	0.9	1.2	1.4	1.5	1.5	1.5	1.5
A44a	348853	6359343	H1	21.0	3.75	< 20	< 20	40	40	50	50	50	50	50	50	50	50	< 0.1	< 0.1	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A44b	348817	6359365	R	10.0	2.50	< 20	< 20	35	35	40	45	45	45	45	45	45	45	< 0.1	< 0.1	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
A44c	348814	6359344	R	4.0	2.50	< 20	< 20	40	45	50	50	50	50	50	50	50	50	< 0.1	< 0.1	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A44t01	348842	6359335	T	2.4	2.50	< 20	< 20	40	40	50	50	50	50	50	50	50	50	< 0.1	< 0.1	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A50a	350108	6355775	H1	20.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A50b	350078	6355805	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3

Table G.01 - Austar Stage 3 - Proposed Longwalls A6 to A17
Predicted Systematic Subsidence and Tilt for Building Structures

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Total Predicted Subs after LWA6 (mm)	Total Predicted Subs after LWA7 (mm)	Total Predicted Subs after LWA8 (mm)	Total Predicted Subs after LWA9 (mm)	Total Predicted Subs after LWA10 (mm)	Total Predicted Subs after LWA11 (mm)	Total Predicted Subs after LWA12 (mm)	Total Predicted Subs after LWA13 (mm)	Total Predicted Subs after LWA14 (mm)	Total Predicted Subs after LWA15 (mm)	Total Predicted Subs after LWA16 (mm)	Total Predicted Subs after LWA17 (mm)	Total Predicted Tilt after LWA6 (mm/m)	Total Predicted Tilt after LWA7 (mm/m)	Total Predicted Tilt after LWA8 (mm/m)	Total Predicted Tilt after LWA9 (mm/m)	Total Predicted Tilt after LWA10 (mm/m)	Total Predicted Tilt after LWA11 (mm/m)	Total Predicted Tilt after LWA12 (mm/m)	Total Predicted Tilt after LWA13 (mm/m)	Total Predicted Tilt after LWA14 (mm/m)	Total Predicted Tilt after LWA15 (mm/m)	Total Predicted Tilt after LWA16 (mm/m)	Total Predicted Tilt after LWA17 (mm/m)
A50c	350088	6355814	R	14.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3
A50t01	350123	6355772	T	5.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A50t02	350089	6355835	T	3.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3
A52a	346760	6358368	H1	19.0	3.75	185	185	185	185	185	185	185	185	185	185	185	185	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A52b	346772	6358365	R	11.0	2.50	175	175	175	175	175	175	175	175	175	175	175	175	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A52c	346760	6358324	R	15.0	2.50	200	200	200	200	200	200	200	200	200	200	200	200	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A52d	346760	6358381	R	5.0	2.50	175	175	175	175	175	175	175	175	175	175	175	175	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A52e	346754	6358381	R	5.0	2.50	180	180	180	180	180	180	180	180	180	180	180	180	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A52f	346758	6358303	R	3.0	2.50	200	200	200	200	200	200	200	200	200	200	200	200	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A52g	346763	6358308	R	6.0	2.50	195	195	195	195	195	195	195	195	195	195	195	195	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A52t01	346759	6358316	T	3.0	2.50	195	195	195	195	195	195	195	195	195	195	195	195	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A54a	350264	6355890	H1	29.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5
A54p01	350244	6355901	P	9.7	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	70	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5
A54t01	350279	6355885	T	3.3	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	60	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A54t02	350278	6355889	T	2.7	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5
A61a	350782	6355822	H1	18.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	70	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6
A61b	350766	6355820	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5
A61c	350766	6355812	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5
A61d	350764	6355786	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	55	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A61e	350727	6355794	R	11.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	55	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A61f	350771	6355821	R	3.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5
A62a	351031	6355781	H1	19.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A62b	351045	6355788	R	4.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A63a	350576	6356037	R	21.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	260	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.2
A63b	350553	6356014	R	5.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	205	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.6
A63t01	350559	6356022	T	5.5	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	220	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.7
A63t02	350601	6356037	T	4.1	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	260	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.1
A63t03	350546	6356094	T	2.9	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	390	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.4
A64a	350830	6355980	H1	17.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	240	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.9
A64b	350814	6356008	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	280	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.2
A64c	350824	6356013	R	5.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	295	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.4
A64d	350862	6355988	R	12.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	250	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	2.1
A64e	350873	6355988	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	255	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	2.1
A64f	350858	6355982	R	5.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	235	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.9
A64g	350844	6356014	R	5.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	305	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.6
A64p01	350864	6355981	P	4.9	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	235	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.9
A64t01	350822	6355995	T	3.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	255	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	2.0
A64t02	350821	6355990	T	3.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	245	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.9
A64t03	350870	6355981	T	3.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	235	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.9
A65a	350308	6356662	H2	34.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	55	390	1145	1380	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.3	2.6	1.7
A65b	350333	6356656	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	50	375	1135	1375	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.2	2.6	1.7
A65c	350435	6356674	R	18.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	495	1190	1400	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	4.0	2.4	1.5
A65d	350432	6356649	R	19.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	55	395	1150	1385	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.4	2.6	1.7
A65e	350475	6356641	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	55	390	1145	1380	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.3	2.5	1.7
A73t01	350970	6357013	T	3.8	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	165	350	430	455	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.3	2.4	2.7	2.8
A83a	351267	6356226	H1	16.7	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	315	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.6
A83b	351315	6356248	R	29.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	230	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.0
A83c	351319	6356231	R	4.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	205	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.6
A83d	351337	6356252	R	4.2	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	175	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.4
A83t01	351301	6356234	T	3.3	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	235	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.9
A84a	351492	6356055	H2	31.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3
A84b	351517	6356090	R	6.4	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A84c	351537	6356124	R	2.9	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A84d	351467	6356110	R	12.3	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	60	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A85a	351581	6356030	H1	20.2	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
A85b	351570	6356004	R	9.9	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
A85c	351600	6356008	R	8.1	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
A85d	351637	6356023	R	7.5	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A85t01	351590	6356028	T	2.4	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
A85t02	351594	6356030	T	2.4	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
A90c	351301	6355642	R	14.7	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A98a	348590	6358440	H1	20.0	3.75	< 20	< 20	< 20	105	965	1585	1795	1855	1870	1870	1870	1870	< 0.1	< 0.1	0.1	1.1	4.5	0.8	1.4	1.7	1.8	1.8	1.8	1.8

Table G.02 - Austar Stage 3 - Proposed Longwalls A6 to A17
Predicted Systematic Curvature and Strain for Building Structures

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Predicted Cuvature during or after LWA6 (1/km)	Predicted Strain during or after LWA6 (mm/m)	Predicted Cuvature during or after LWA7 (1/km)	Predicted Strain during or after LWA7 (mm/m)	Predicted Cuvature during or after LWA8 (1/km)	Predicted Strain during or after LWA8 (mm/m)	Predicted Cuvature during or after LWA9 (1/km)	Predicted Strain during or after LWA9 (mm/m)	Predicted Cuvature during or after LWA10 (1/km)	Predicted Strain during or after LWA10 (mm/m)	Predicted Cuvature during or after LWA11 (1/km)	Predicted Strain during or after LWA11 (mm/m)	Predicted Cuvature during or after LWA12 (1/km)	Predicted Strain during or after LWA12 (mm/m)	Predicted Cuvature during or after LWA13 (1/km)	Predicted Strain during or after LWA13 (mm/m)	Predicted Cuvature during or after LWA14 (1/km)	Predicted Strain during or after LWA14 (mm/m)	Predicted Cuvature during or after LWA15 (1/km)	Predicted Strain during or after LWA15 (mm/m)	Predicted Cuvature during or after LWA16 (1/km)	Predicted Strain during or after LWA16 (mm/m)	Predicted Cuvature during or after LWA17 (1/km)	Predicted Strain during or after LWA17 (mm/m)
A03a	346315	6357814	H1	19.0	3.75	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6	0.023	0.6
A05a	346748	6357769	H2	30.1	3.75	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5
A05p01	346739	6357751	P	8.2	-	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5
A09a	347040	6357590	H2	32.0	3.75	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3
A09b	347031	6357610	R	10.0	2.50	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3
A09c	347019	6357631	R	37.0	2.50	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3
A09p01	347018	6357605	P	9.0	-	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2
A12a	347474	6357848	H1	24.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.002	0.1	0.002	0.1	0.002	0.1
A12b	347473	6357887	R	14.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A12c	347460	6357879	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A12f	347355	6357999	R	123.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.1	0.005	0.1	0.005	0.1	0.005	0.1	0.005	0.1
A12g	347361	6358028	R	122.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.1	0.005	0.1	0.005	0.1	0.005	0.1	0.005	0.1
A12h	347360	6358060	R	90.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.006	0.2	0.006	0.2	0.006	0.2	0.006	0.2	0.006	0.2
A13a	347823	6357987	H2	33.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.006	0.3	0.021	0.6	0.024	0.7	0.024	0.7	0.024	0.7	0.024	0.7	0.024	0.7
A13b	347810	6358042	R	18.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.007	0.3	0.026	0.7	0.028	0.7	0.029	0.7	0.029	0.7	0.029	0.7	0.029	0.7
A13c	347829	6358008	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.006	0.3	0.023	0.6	0.025	0.6	0.026	0.6	0.026	0.6	0.026	0.6	0.026	0.6
A13p01	347833	6357998	P	7.5	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.006	0.3	0.021	0.5	0.024	0.6	0.025	0.6	0.025	0.6	0.025	0.6	0.025	0.6
A13t01	347806	6358000	T	6.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.006	0.3	0.021	0.6	0.024	0.6	0.024	0.6	0.024	0.6	0.024	0.6	0.024	0.6
A14a	348074	6358041	H1	21.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.012	0.4	0.022	0.6	0.022	0.6	0.022	0.6	0.022	0.6	0.022	0.6	0.022	0.6
A14b	348059	6358048	R	11.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.012	0.4	0.021	0.6	0.021	0.6	0.021	0.6	0.021	0.6	0.021	0.6	0.021	0.6
A14c	348031	6358057	R	15.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.013	0.4	0.021	0.6	0.021	0.6	0.021	0.6	0.021	0.6	0.021	0.6	0.021	0.6
A14d	347911	6358055	R	14.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.009	0.4	-0.023	-0.5	-0.025	-0.5	-0.025	-0.5	-0.025	-0.5	-0.025	-0.5	-0.025	-0.5
A14t01	348116	6358041	T	8.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.013	0.4	0.022	0.6	0.022	0.6	0.022	0.6	0.022	0.6	0.022	0.6	0.022	0.6
A15a	346975	6356731	H1	24.0	3.75	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4
A15b	346945	6356705	R	27.0	2.50	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4
A15c	346939	6356712	R	15.0	2.50	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4
A15d	346945	6356678	R	13.0	2.50	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4
A15e	346949	6356692	R	4.0	2.50	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4	-0.015	-0.4
A15f	346797	6356724	R	125.0	2.50	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3
A15g	346792	6356693	R	124.0	2.50	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2
A15p01	346974	6356712	P	10.4	-	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4	-0.016	-0.4
A15t01	346861	6356719	T	3.3	2.50	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3
A17a	347721	6357468	H1	22.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A17b	347783	6357456	R	11.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.002	0.2	0.004	0.3	0.004	0.3
A17c	347799	6357462	R	12.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.002	0.2	0.003	0.2	0.004	0.3	0.004	0.3
A17p01	347738	6357446	P	7.0	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A17t01	347778	6357458	T	2.5	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.002	0.2	0.004	0.3	0.004	0.3
A17t02	347778	6357455	T	2.5	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.002	0.2	0.004	0.3	0.004	0.3
A17t03	347809	6357461	T	3.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.002	0.2	0.003	0.3	0.004	0.3	0.004	0.3
A18a	347988	6357529	H1	18.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.009	0.4	0.009	0.4	0.009	0.4	0.009	0.4	0.009	0.4
A18t01	347998	6357536	T	3.7	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.010	0.4	0.010	0.4	0.010	0.4	0.010	0.4	0.010	0.4
A19a	347242	6357038	H1	16.0	3.75	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A19b	347257	6357046	R	6.0	2.50	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A19c	347263	6357025	R	3.0	2.50	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A19d	347272	6357040	R	5.0	2.50	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A19e	347271	6357028	R	4.0	2.50	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A20a	347338	6356771	H1	20.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A20b	347365	6356773	R	14.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A20c	347356	6356756	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A20d	347332	6356817	R	7.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A22a	347091	6356183	H1	17.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A22b	347112	6356203	R	9.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A22c	347079	6356191	R	4.0	2.50	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1
A22p01	347097	6356205	P	9.9	-	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1
A25a	348471	6356349	H1	24.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.007	0.3
A25b	348424	6356386	H1	21.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.006	0.3
A25p01	348458	6356364	P	11.2	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.006	0.3
A25t01	348452	6356345	T	7.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.005	0.3
A26a	348178	6356677	H1	13.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.003	0.3
A26b	348170	6356733	R	18.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	-0.001	-0.1	0.002	0.1	0.003	0.3	0.004	0.3
A26c	348127	6356760	R	20.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.003	0.2	0.004	0.3
A27a	348335	6356906	R	22.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.010	0.4	0.017	0.5	0.018	0.5
A29a	349194	6356711	H2	31.4	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.010	0.4	-0.033	-0.6	0.028	0.7
A29b	349238	6356747	R	10.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.016	0.5	0.023	0.6	0.024	0.6
A31a	347896	6358532	H1	11.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	-0.052	-0.9	-0.060	-1.0	-0.060	-1.0	-0.060	-1.0	-0.060	-1.0	-0.060	-1.0	-0.060	-1.0	-0.060	-1.0
A31b	347922	6358547	R	9.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	-0.052	-0.9	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0
A31c	347931	6358555	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	-0.052	-0.9	-0.054	-0.9	-0.054	-0.9	-0.054	-0.9	-0.054	-0.9	-0.054	-0.9	-0.054	-0.9	-0.054	-0.9
A31t01	347927	6358552	T	3.3	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	-0.052	-0.9	-0.057	-1.0	-0.057	-1.0	-0.057	-1.0	-0.057	-1.0	-0.057	-1.0	-0.057	-1.0	-0.057	-1.0
A32a	348634	6358091	H1	12.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.044	1.0	0.044	1.0	0.044	1.0	0.044	1.0	0.044	1.0	0.044	1.0	0.044	1.0
A32b	348641	6358140	R	18.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9
A32c	348615	6358144	R	25.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9	-0.048	-0.9
A32d	348182	6357612	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.039	0.9	0.039	0.9	0.039	0.9	0.039	0.9	0.039	0.9
A32p01	348630	6358071	P	11.7	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.044	0.9	-0.059	-1.1	-0.059	-1.1	-0.059	-1.1	-0.059	-1.1	-0.059	-1.1	-0.059	-1.1
A32t01	348432	6358096	T	3.8	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3	0.043	1.0	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0	-0.061	-1.0
A32t02	348746	6357707	T	3.7	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.028	0.7	0.028	0.7	0.028	0.7	0.028	0.7	0.028	0.7	0.028	0.7
A33a	349484	6357714	H2	31.2	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	-0.044	-0.8	-0.044	-0.8	-0.044	-0.8	-0.044	-0.8	0.031	0.8	0.031	0.8
A33b	349563	6357680	R	12.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	-0.042	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8
A33t01	349492	6357746	T	3.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.006	0.3	-0.034	-0.7	0.035	0.8	0.038	0.9	0.039	0.9	0.039	0.9	0.039	0.9
A33t02	349496	6357748	T	3.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.006	0.3	-0.031	-0.6	0.035	0.8	0.038	0.9	0.039	0.9	0.039	0.9	0.040	0.9
A33t03	349563	6357671	T	2.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	-0.039	-0.7	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8
A33t04	349567	6357672	T	3.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	-0.039	-0.7	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8
A33t05	349466	6357684	T	2.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.030	0.7	-0.040	-0.7	-0.040	-0.7	-0.040	-0.7	-0.040	-0.7	-0.040	-0.7
A33t06	349359	6357923	T	3.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3	0.035	0.8	-0.046	-0.8	-0.046	-0.8	-0.046	-0.8	-0.046	-0.8	-0.046	-0.8	-0.046	-0.8
A33t07	349364	6357924	T	3.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3	0.035	0.8	-0.046	-0.8	-0.046	-0.8	-0.046	-0.8	-0.046	-0.8	-0.046	-0.8	-0.046	-0.8
A34a	348990	6358342	H2	35.1	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.007	0.3	0.019	0.6	-0.087	-1.3	-0.087	-1.3	-0.087	-1.3	-0.087	-1.3	-0.087	-1.3	-0.087	-1.3	-0.087	-1.3
A34b	349001	6358366	R	10.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.009	0.4	0.020	0.6	0.030	0.7	0.033	0.8	0.034	0.8	0.034	0.8	0.034	0.8	0.034	0.8	0.034	0.8
A34c	349051	6358380	R	30.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.011	0.4	0.022	0.6	0.031	0.7	0.034	0.8	0.035	0.8	0.035	0.8	0.036	0.8	0.036	0.8	0.036	0.8
A34d	348950	6358346	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.007	0.3	0.018	0.5	-0.078	-1.3	-0.078	-1.3	-0.078	-1.3	-0.078	-1.3	-0.078	-1.3	-0.078	-1.3	-0.078	-1.3
A34p01	348990	6358361	P	11.0	-	0.001	0.1	0.001	0.1	0.001	0.1	0.008	0.3	0.020	0.5	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8	-0.043	-0.8
A34t01	348961	6358327	T	5.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.006	0.3	0.016	0.5	-0.096	-1.5	-0.096	-1.5	-0.096	-1.5	-0.096	-1.5	-0.096	-1.5	-0.096	-1.5	-0.096	-1.5
A34t02	349034	6358375	T	3.1	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.009	0.4	0.021	0.6	0.031	0.7	0.034	0.8	0.035	0.8	0.035	0.8	0.035	0.8	0.035	0.8	0.035	0.8
A44a	348853	6359343	H1	21.0	3.75	0.001	0.1	0.001	0.1	0.003	0.3	0.005	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3
A44b	348817	6359365	R	10.0	2.50	0.001	0.1	0.001	0.1	0.003	0.2	0.003	0.3	0.003	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A44c	348814	6359344	R	4.0	2.50	0.001	0.1	0.001	0.1	0.003	0.3	0.005	0.3	0.005	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3
A44t01	348842	6359335	T	2.4	2.50	0.001	0.1	0.001	0.1	0.003	0.3	0.005	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3	0.006	0.3
A50a	350108	6355775	H1	20.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1
A50b	350078	6355805	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A50c	350088	6355814	R	14.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A50t01	350123	6355772	T	5.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1
A50t02	350089	6355835	T	3.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A52a	346760	6358368	H1	19.0	3.75	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A52b	346772	6358365	R	11.0	2.50	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A52c	346760	6358324	R	15.0	2.50	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3

Table G.02 - Austar Stage 3 - Proposed Longwalls A6 to A17
Predicted Systematic Curvature and Strain for Building Structures

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Predicted Cuvature during or after LWA6 (1/km)	Predicted Strain during or after LWA6 (mm/m)	Predicted Cuvature during or after LWA7 (1/km)	Predicted Strain during or after LWA7 (mm/m)	Predicted Cuvature during or after LWA8 (1/km)	Predicted Strain during or after LWA8 (mm/m)	Predicted Cuvature during or after LWA9 (1/km)	Predicted Strain during or after LWA9 (mm/m)	Predicted Cuvature during or after LWA10 (1/km)	Predicted Strain during or after LWA10 (mm/m)	Predicted Cuvature during or after LWA11 (1/km)	Predicted Strain during or after LWA11 (mm/m)	Predicted Cuvature during or after LWA12 (1/km)	Predicted Strain during or after LWA12 (mm/m)	Predicted Cuvature during or after LWA13 (1/km)	Predicted Strain during or after LWA13 (mm/m)	Predicted Cuvature during or after LWA14 (1/km)	Predicted Strain during or after LWA14 (mm/m)	Predicted Cuvature during or after LWA15 (1/km)	Predicted Strain during or after LWA15 (mm/m)	Predicted Cuvature during or after LWA16 (1/km)	Predicted Strain during or after LWA16 (mm/m)	Predicted Cuvature during or after LWA17 (1/km)	Predicted Strain during or after LWA17 (mm/m)
A52d	346760	6358381	R	5.0	2.50	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A52e	346754	6358381	R	5.0	2.50	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A52f	346758	6358303	R	3.0	2.50	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3
A52g	346763	6358308	R	6.0	2.50	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3
A52t01	346759	6358316	T	3.0	2.50	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3
A54a	350264	6355890	H1	29.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.004	0.3
A54p01	350244	6355901	P	9.7	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.004	0.3
A54t01	350279	6355885	T	3.3	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3
A54t02	350278	6355889	T	2.7	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3
A61a	350782	6355822	H1	18.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.004	0.3
A61b	350766	6355820	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.004	0.3
A61c	350766	6355812	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.004	0.3
A61d	350764	6355786	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A61e	350727	6355794	R	11.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A61f	350771	6355821	R	3.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.004	0.3
A62a	351031	6355781	H1	19.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3
A62b	351045	6355788	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2
A63a	350576	6356037	R	21.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.024	0.6
A63b	350553	6356014	R	5.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.016	0.5
A63t01	350559	6356022	T	5.5	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.018	0.5
A63t02	350601	6356037	T	4.1	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.024	0.6
A63t03	350546	6356094	T	2.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.030	0.7
A64a	350830	6355980	H1	17.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	0.021	0.6
A64b	350814	6356008	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	0.023	0.6
A64c	350824	6356013	R	5.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.025	0.6
A64d	350862	6355988	R	12.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	-0.001	-0.1	0.004	0.3	0.023	0.6
A64e	350873	6355988	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.024	0.6
A64f	350858	6355982	R	5.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.1	0.022	0.6
A64g	350844	6356014	R	5.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.027	0.7
A64p01	350864	6355981	P	4.9	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.1	0.022	0.5
A64t01	350822	6355995	T	3.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	0.021	0.6
A64t02	350821	6355990	T	3.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	0.020	0.5
A64t03	350870	6355981	T	3.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.1	0.022	0.6
A65a	350308	6356662	H2	34.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3	0.030	0.8	-0.043	-0.8	-0.043	-0.8
A65b	350333	6356656	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.030	0.7	-0.040	-0.8	-0.040	-0.8
A65c	350435	6356674	R	18.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.031	0.7	-0.043	-0.8	-0.043	-0.8
A65d	350432	6356649	R	19.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.031	0.7	-0.043	-0.8	-0.043	-0.8
A65e	350475	6356641	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.031	0.7	-0.043	-0.8	-0.043	-0.8
A73t01	350970	6357013	T	3.8	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.014	0.4	0.018	0.5	0.021	0.6	0.022	0.6
A83a	351267	6356226	H1	16.7	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.019	0.6
A83b	351315	6356248	R	29.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2	0.018	0.5
A83c	351319	6356231	R	4.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2	0.017	0.5
A83d	351337	6356252	R	4.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2	0.014	0.4
A83t01	351301	6356234	T	3.3	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2	0.018	0.5
A84a	351492	6356055	H2	31.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A84b	351517	6356090	R	6.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A84c	351537	6356124	R	2.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A84d	351467	6356110	R	12.3	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	-0.001	-0.1	0.001	0.1	0.001	0.1	0.002	0.2
A85a	351581	6356030	H1	20.2	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A85b	351570	6356004	R	9.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A85c	351600	6356008	R	8.1	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	-0.001	-0.1	0.001	0.1	0.001	0.1
A85d	351637	6356023	R	7.5	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A85t01	351590	6356028	T	2.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A85t02	351594	6356030	T	2.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A90c	351301	6355642	R	14.7	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A98a	348590	6358440	H1	20.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.010	0.4	0.022	0.6	0.032	0.8	0.035	0.9	0.036	0.9	0.036	0.9	0.036	0.9	0.037	0.9	0.037	0.9

Table G.03 - Austar Stage 3 - Proposed Longwalls A6 to A17
Upperbound Systematic Subsidence and Tilt for Building Structures

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Upperbound Subs after LWA6 (mm)	Upperbound Subs after LWA7 (mm)	Upperbound Subs after LWA8 (mm)	Upperbound Subs after LWA9 (mm)	Upperbound Subs after LWA10 (mm)	Upperbound Subs after LWA11 (mm)	Upperbound Subs after LWA12 (mm)	Upperbound Subs after LWA13 (mm)	Upperbound Subs after LWA14 (mm)	Upperbound Subs after LWA15 (mm)	Upperbound Subs after LWA16 (mm)	Upperbound Subs after LWA17 (mm)	Upperbound Tilt after LWA6 (mm/m)	Upperbound Tilt after LWA7 (mm/m)	Upperbound Tilt after LWA8 (mm/m)	Upperbound Tilt after LWA9 (mm/m)	Upperbound Tilt after LWA10 (mm/m)	Upperbound Tilt after LWA11 (mm/m)	Upperbound Tilt after LWA12 (mm/m)	Upperbound Tilt after LWA13 (mm/m)	Upperbound Tilt after LWA14 (mm/m)	Upperbound Tilt after LWA15 (mm/m)	Upperbound Tilt after LWA16 (mm/m)	Upperbound Tilt after LWA17 (mm/m)
A03a	346315	6357814	H1	19.0	3.75	775	775	775	775	775	775	775	775	775	775	775	775	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
A05a	346748	6357769	H2	30.1	3.75	395	395	395	395	395	395	395	395	395	395	395	395	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A05p01	346739	6357751	P	8.2	-	390	390	390	390	390	390	390	390	390	390	390	390	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A09a	347040	6357590	H2	32.0	3.75	160	160	160	160	160	160	160	160	160	160	160	160	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A09b	347031	6357610	R	10.0	2.50	150	150	150	150	150	150	150	150	150	150	150	150	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A09c	347019	6357631	R	37.0	2.50	175	175	175	175	175	175	175	175	175	175	175	175	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
A09p01	347018	6357605	P	9.0	-	165	165	165	165	165	165	165	165	165	165	165	165	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A12a	347474	6357848	H1	24.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	25	25	25	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.2	0.2	0.2	0.2	0.2
A12b	347473	6357887	R	14.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	25	25	25	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.2	0.2	0.2	0.2	0.2
A12c	347460	6357879	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	20	20	20	20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.2	0.2	0.2	0.2	0.2
A12f	347355	6357999	R	123.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	25	25	25	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.2	0.2	0.2	0.2	0.2
A12g	347361	6358028	R	122.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	25	25	25	25	25	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3
A12h	347360	6358060	R	90.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	25	30	30	30	30	30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3
A13a	347823	6357987	H2	33.0	3.75	< 20	< 20	< 20	< 20	< 20	150	515	625	635	640	640	640	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.1	5.2	5.7	5.8	5.8	5.8	5.8
A13b	347810	6358042	R	18.0	2.50	< 20	< 20	< 20	< 20	20	210	585	675	685	685	685	685	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.5	5.2	5.6	5.6	5.6	5.6	5.6
A13c	347829	6358008	R	4.0	2.50	< 20	< 20	< 20	< 20	< 20	165	560	665	675	675	675	675	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.2	5.4	5.9	5.9	6.0	6.0	6.0
A13p01	347833	6357998	P	7.5	-	< 20	< 20	< 20	< 20	< 20	155	555	665	675	675	675	675	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.2	5.4	5.9	6.0	6.0	6.0	6.0
A13t01	347806	6358000	T	6.9	2.50	< 20	< 20	< 20	< 20	< 20	150	450	540	550	550	550	550	< 0.1	< 0.1	< 0.1	< 0.1	0.2	1.1	4.6	5.0	5.1	5.1	5.1	5.1
A14a	348074	6358041	H1	21.0	3.75	< 20	< 20	< 20	< 20	40	320	1630	2040	2080	2085	2085	2085	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.2	5.5	5.7	5.9	5.9	5.9	5.9
A14b	348059	6358048	R	11.0	2.50	< 20	< 20	< 20	< 20	40	325	1625	1970	2005	2010	2010	2010	< 0.1	< 0.1	< 0.1	< 0.1	0.5	2.3	5.4	5.8	5.9	5.9	6.0	6.0
A14c	348031	6358057	R	15.0	2.50	< 20	< 20	< 20	< 20	45	340	1610	1890	1920	1920	1925	1925	< 0.1	< 0.1	< 0.1	< 0.1	0.5	2.4	5.3	5.8	6.0	6.0	6.0	6.0
A14d	347911	6358055	R	14.0	2.50	< 20	< 20	< 20	< 20	35	285	1160	1285	1300	1300	1300	1300	< 0.1	< 0.1	< 0.1	< 0.1	0.4	1.9	6.5	6.9	7.0	7.0	7.0	7.0
A14t01	348116	6358041	T	8.2	2.50	< 20	< 20	< 20	< 20	40	330	1685	2145	2190	2195	2195	2195	< 0.1	< 0.1	< 0.1	< 0.1	0.5	2.3	5.2	4.6	4.7	4.8	4.8	4.8
A15a	346975	6356731	H1	24.0	3.75	270	270	270	270	270	270	270	270	270	270	270	270	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
A15b	346945	6356705	R	27.0	2.50	270	270	270	270	270	270	270	270	270	270	270	270	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
A15c	346939	6356712	R	15.0	2.50	270	270	270	270	270	270	270	270	270	270	270	270	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
A15d	346945	6356678	R	13.0	2.50	260	260	260	260	260	260	260	260	260	260	260	260	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
A15e	346949	6356692	R	4.0	2.50	265	265	265	265	265	265	265	265	265	265	265	265	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
A15f	346797	6356724	R	125.0	2.50	225	225	225	225	225	225	225	225	225	225	225	225	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A15g	346792	6356693	R	124.0	2.50	210	210	210	210	210	210	210	210	210	210	210	210	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A15p01	346974	6356712	P	10.4	-	270	270	270	270	270	270	270	270	270	270	270	270	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
A15t01	346861	6356719	T	3.3	2.50	230	230	230	230	230	230	230	230	230	230	230	230	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A17a	347721	6357468	H1	22.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	40	40	40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.4	0.4	0.4	0.4
A17b	347783	6357456	R	11.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	50	60	60	60	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.5	0.6	0.6	0.6
A17c	347799	6357462	R	12.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	60	70	75	75	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	0.6	0.6	0.7	0.7
A17p01	347738	6357446	P	7.0	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	40	40	40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.3	0.4	0.4	0.4
A17t01	347778	6357458	T	2.5	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	50	60	60	60	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.5	0.5	0.5	0.5
A17t02	347778	6357455	T	2.5	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	50	55	55	55	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.5	0.5	0.5	0.5
A17t03	347809	6357461	T	3.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	65	75	75	75	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	0.6	0.7	0.7	0.7
A18a	347988	6357529	H1	18.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	40	215	365	395	395	395	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.0	2.9	3.0	3.0	3.0
A18t01	347998	6357536	T	3.7	2.50	< 20	< 20	< 20	< 20	< 20	< 20	40	225	380	405	410	410	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	2.1	3.0	3.1	3.1	3.1
A19a	347242	6357038	H1	16.0	3.75	55	55	55	55	55	55	55	55	55	55	55	55	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A19b	347257	6357046	R	6.0	2.50	50	50	50	50	50	50	50	50	50	50	50	50	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
A19c	347263	6357025	R	3.0	2.50	45	45	45	45	45	45	45	45	45	45	45	45	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
A19d	347272	6357040	R	5.0	2.50	40	40	40	40	40	40	40	40	40	40	40	40	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
A19e	347271	6357028	R	4.0	2.50	45	45	45	45	45	45	45	45	45	45	45	45	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
A20a	347338	6356771	H1	20.0	3.75	35	35	35	35	35	35	35	35	35	35	35	35	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
A20b	347365	6356773	R	14.0	2.50	25	25	25	25	25	25	25	25	25	25	25	25	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A20c	347356	6356756	R	13.0	2.50	30	30	30	30	30	30	30	30	30	30	30	30	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
A20d	347332	6356817	R	7.0	2.50	35	35	35	35	35	35	35	35	35	35	35	35	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
A22a	347091	6356183	H1	17.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A22b	347112	6356203	R	9.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A22c	347079	6356191	R	4.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A22p01	347097	6356205	P	9.9	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A25a	348471	6356349	H1	24.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	50	145	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	1.5
A25b	348424	6356386	H1	21.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	50	130	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	1.3
A25p01	348458	6356364	P	11.2	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	135	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	1.3
A25t01	348452	6356345	T	7.9	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	115	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	1.1
A26a	348178	6356677	H1	13.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	20	55	95	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.6	0.8
A26b	348170	6356733	R	18.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	75	110	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	0.8	1.0
A26c	348127	6356760	R	20.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	65	90	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.6	0.8
A27a	348335	6356906	R	22.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	260	530	590	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.0	3.8	3.9
A29a	349194	6356711	H2	31.4	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	280	1675	2450	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	1.9	6.0	1.1
A29b	349238	6356747	R	10.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	360	1845	2485	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	2.5	4.7	2.1
A31a	347896	6358532	H1	11.0	3.75	< 20	< 20	< 20	190	1390	2425	2575	2590	2590	2590	2590	2590	< 0.1	< 0.1	< 0.1	1.3	8.0	4.9	5.4	5.4	5.4	5.4	5.4	5.4
A31b	347922	6358547	R	9.0	2.50	< 20	< 20	< 20	210	1475	2450	2620	2635	2635	2635	2635	2635	< 0.1	< 0.1	< 0.1	1.4	7.5	2.8	3.7	3.8	3.8	3.8	3.8	3.8
A31c	347931	6358555	R	4.0	2.50	< 20	< 20	< 20	220	1510	2455	2625	2645	2645	2645	2645	2645	< 0.1	< 0.1	< 0.1	1.4	6.8	1.9	3.2	3.3	3.3	3.3	3.3	3.3
A31t01	347927	6358552	T	3.3	2.50	< 20	< 20	< 20	215	1490	2455	2620	2635	2640	2640	2640	2640	< 0.1	< 0.1	< 0.1	1.4	6.9	2.0	3.2	3.3	3.4	3.4	3.4	3.4
A32a	348634	6358091	H1	12.0	3.75	< 20	< 20	< 20	< 20	125	1015	2275	2640	2760	2785	2790	2790	< 0.1	< 0.1	< 0.1	< 0.1	0.9	7.5	4.4	2.8	2.1	2.0	1.9	1.9
A32b	348641	6358140	R	18.0	2.50	< 20	< 20	< 20	< 20	175	1310	2295	2645	2760	2785	2785	2790	< 0.1	< 0.1	< 0.1	< 0.1	1.2	7.5	1.7	2.4	2.9	3.0	3.0	3.0
A32c	348615	6358144	R	25.0	2.50	< 20	< 20	< 20	< 20	175	1315	2300	2650	2765	2790	2790	2795	< 0.1	< 0.1	< 0.1	< 0.1	1.2	7.5	1.8	2.4	2.9	3.0	3.0	3.0
A32d	348182	6357612	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	115	825	1535	1590	1600	1600	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.8	6.7	8.2	8.4	8.4	8.4
A32p01	348630	6358071	P	11.7	-	< 20	< 20	< 20	< 20	105	835	2220	2620	2750	2780	2785	2785	< 0.1	< 0.1	< 0.1	< 0.1	0.8	7.0	4.8	3.2	2.5	2.3	2.3	2.3
A32t01	348432	6358096	T	3.8	2.50	< 20	< 20	< 20	< 20	100	770	2220	2645	2765	2780	2785	2785	< 0.1	< 0.1	< 0.1	< 0.1	0.8	6.6	5.0	3.4	2.8	2.7	2.7	2.7
A32t02	348746	6357707	T	3.7	2.50	< 20	< 20	< 20	< 20	< 20	55	455	1920	2445	2620	2665	2670	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	3.6	4.5	2.7	1.9	1.7	1.7
A33a	349484	6357714	H2	31.2	3.75	< 20	< 20	< 20	< 20	< 20	180	1275	2125	2465	2570	2595	2605	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.2	6.8	2.2	2.3	2.7	2.9	2.9
A33b	349563	6357680	R	12.0	2.50	< 20	< 20	< 20	< 20	< 20	145	1115	2060	2385	2485	2510	2520	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.0	6.6	2.9	1.9	2.3	2.5	2.5
A33t01	349492	6357746	T	3.2	2.50	< 20	< 20	< 20	< 20	< 20	200	1355	2100	2400	2490	2510	2515	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.3	5.0	1.2	2.3	2.8	2.9	2.9
A33t02	349496	6357748	T	3.4	2.50	< 20	< 20	< 20	< 20	< 20	205	1365	2095	2395	2480	2500	2505	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.3	4.8	1.2	2.3	2.7	2.9	2.9
A33t03	349563	6357671	T	2.9	2.50	< 20	< 20	< 20	< 20	< 20	130	1035	2050	2375	2485	2510	2520	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	6.6	3.1	1.7	1.5	1.6	1.7
A33t04	349567	6357672	T	3.0	2.50	< 20	< 20	< 20	< 20	< 20	130	1045	2050	2375	2480	2505	2515	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	6.6	3.0	1.7	1.6	1.8	1.8
A33t05	349466	6357684	T	2.6	2.50	< 20	< 20	< 20	< 20	< 20	130	1040	2120	2470	2580	2610	2615	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	6.8	2.9	1.5	1.4	1.5	1.5
A33t06	349359	6357923	T	3.2	2.50	< 20	< 20	< 20	< 20	65	665	2045	2455	2590	2625	2635	2635	< 0.1	< 0.1	< 0.1	< 0.1	0.6	5.6	4.6	3.1	2.4	2.2	2.1	2.1
A33t07	349364	6357924	T	3.2	2.50	< 20	< 20	< 20	< 20	65	670	2055	2460	2595	2630	2635	2635	< 0.1	< 0.1	< 0.1	< 0.1	0.6	5.7	4.6	3.1	2.4	2.2	2.1	2.1
A34a	348990	6358342	H2	35.1	3.75	< 20	< 20	< 20	130	1250	2370	2715	2820	2850	2855	2855	2855	< 0.1	< 0.1	0.1	1.4	6.6	4.9	3.5	2.9	2.8	2.7	2.7	2.7
A34b	349001	6358366	R	10.0	2.50	< 20	< 20	< 20	160	1360	2365	2700	2800	2830	2835	2835	2835	< 0.1	< 0.1	0.2	1.6	6.3	0.7	2.0	2.4	2.5	2.6	2.6	2.6
A34c	349051	6358380	R	30.0	2.50	< 20	< 20	< 20	205	1485	2345	2660	2755	2780	2785	2785	2785	< 0.1	< 0.1	0.2	2.0	5.9	1.0	2.0	2.4	2.5	2.6	2.6	2.6
A34d	348950	6358346	R	4.0	2.50	< 20	< 20	< 20	115	1175	2375	2720	2825	2855	2865	2865	2865	< 0.1	< 0.1	0.1	1.2	6.6	3.8	2.4	2.3	2.4	2.5	2.5	2.5
A34p01	348990	6358361	P	11.0	-	< 20	< 20	< 20	150	1315	2365	2705	2810	2840	2845	2845	2845	< 0.1	< 0.1	0.1	1.5	6.4	1.2	2.0	2.4	2.5	2.6	2.6	2.6
A34t01	348961	6358327	T	5.4	2.50	< 20	< 20	< 20	95	1080	2365	2715	2825	2855	2860	2860	2860	< 0.1	< 0.1	0.1	1.1	6.7	5.8	4.4	3.8	3.6	3.6	3.6	3.6
A34t02	349034	6358375	T	3.1	2.50	< 20	< 20	< 20	175	1405	2350	2660	2755	2780	2785	2785	2785	< 0.1	< 0.1	0.2	1.7	5.9	0.7	2.0	2.4	2.5	2.6	2.6	2.6
A44a	348853	6359343	H1	21.0	3.75	< 20	< 20	70	75	90	90	95	95	95	95	95	95	< 0.1	< 0.1	0.6	0.7	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A44b	348817	6359365	R	10.0	2.50	< 20	< 20	60	65	80	80	80	80	80	80	80	80	< 0.1	< 0.1	0.5	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
A44c	348814	6359344	R	4.0	2.50	< 20	< 20	70	75	90	90	95	95	95	95	95	95	< 0.1	< 0.1	0.6	0.7	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A44t01	348842	6359335	T	2.4	2.50	< 20	< 20	70	75	90	90	90	90	90	90	90	90	< 0.1	< 0.1	0.6	0.7	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
A50a	350108	6355775	H1	20.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A50b	350078	6355805	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A50c	350088	6355814	R	14.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A50t01	350123	6355772	T	5.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3
A50t02	350089	6355835	T	3.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	50	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5
A52a	346760	6358368	H1	19.0	3.75	310	310	310	310	310	310	310	310	310	310	310	310	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
A52b	346772	6358365	R	11.0	2.50	295	295	295	295	295	295	295	295	295	295	295	295	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
A52c	346760	6358324	R	15.0	2.50	330	330	330	330	330	330	330	330	330	330	330	330	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
A52d	346760	6358381	R	5.0	2.50	295	295	295	295	295	295	295	295	295	295	295	295	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
A52e	346754	6358381	R	5.0	2.50	300	300	300	300	300	300	300	300	300	300	300	300	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
A52f	346758	6358303	R	3.0	2.50	330	330	330	330	330	330	330	330	330	330	330	330	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
A52g	346763	6358308	R	6.0	2.50	325	325	325	325	325	325	325	325	325	325	325	325	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
A52t01	346759	6358316	T	3.0	2.50	325	325	325	325	325	325	325	325	325	325	325	325	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
A54a	350264	6355890	H1	29.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	100	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7
A54p01	350244	6355901	P	9.7	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	100	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7
A54t01	350279	6355885	T	3.3	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	90	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6
A54t02	350278	6355889	T	2.7	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	90	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6
A61a	350782	6355822	H1	18.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	105	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.8
A61b	350766	6355820	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	100	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7
A61c	350766	6355812	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	90	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7
A61d	350764	6355786	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	80	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6

Table G.03 - Austar Stage 3 - Proposed Longwalls A6 to A17
Upperbound Systematic Subsidence and Tilt for Building Structures

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Upperbound Subs after LWA6 (mm)	Upperbound Subs after LWA7 (mm)	Upperbound Subs after LWA8 (mm)	Upperbound Subs after LWA9 (mm)	Upperbound Subs after LWA10 (mm)	Upperbound Subs after LWA11 (mm)	Upperbound Subs after LWA12 (mm)	Upperbound Subs after LWA13 (mm)	Upperbound Subs after LWA14 (mm)	Upperbound Subs after LWA15 (mm)	Upperbound Subs after LWA16 (mm)	Upperbound Subs after LWA17 (mm)	Upperbound Tilt after LWA6 (mm/m)	Upperbound Tilt after LWA7 (mm/m)	Upperbound Tilt after LWA8 (mm/m)	Upperbound Tilt after LWA9 (mm/m)	Upperbound Tilt after LWA10 (mm/m)	Upperbound Tilt after LWA11 (mm/m)	Upperbound Tilt after LWA12 (mm/m)	Upperbound Tilt after LWA13 (mm/m)	Upperbound Tilt after LWA14 (mm/m)	Upperbound Tilt after LWA15 (mm/m)	Upperbound Tilt after LWA16 (mm/m)	Upperbound Tilt after LWA17 (mm/m)
A61e	350727	6355794	R	11.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	80	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6
A61f	350771	6355821	R	3.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	100	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7
A62a	351031	6355781	H1	19.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6
A62b	351045	6355788	R	4.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6
A63a	350576	6356037	R	21.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	370	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.0
A63b	350553	6356014	R	5.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	290	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.2
A63t01	350559	6356022	T	5.5	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	310	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.4
A63t02	350601	6356037	T	4.1	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	365	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.0
A63t03	350546	6356094	T	2.9	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	70	550	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.7
A64a	350830	6355980	H1	17.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	345	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.6
A64b	350814	6356008	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	395	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.1
A64c	350824	6356013	R	5.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	415	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.3
A64d	350862	6355988	R	12.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	355	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.9
A64e	350873	6355988	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	360	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	3.0
A64f	350858	6355982	R	5.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	340	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.7
A64g	350844	6356014	R	5.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	430	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	3.5
A64p01	350864	6355981	P	4.9	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	335	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.6
A64t01	350822	6355995	T	3.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	360	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.7
A64t02	350821	6355990	T	3.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	35	345	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.6
A64t03	350870	6355981	T	3.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	335	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.7
A65a	350308	6356662	H2	34.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	80	560	1640	1980	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.7	3.9	2.6
A65b	350333	6356656	R	8.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	80	540	1625	1970	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.5	3.9	2.6
A65c	350435	6356674	R	18.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	100	715	1715	2020	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7	5.6	3.8	2.6
A65d	350432	6356649	R	19.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	85	575	1655	1990	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.8	3.8	2.6
A65e	350475	6356641	R	13.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	80	560	1645	1985	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	4.7	3.8	2.6
A73t01	350970	6357013	T	3.8	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	240	520	645	685	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.0	3.6	4.0	4.2
A83a	351267	6356226	H1	16.7	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	50	450	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	3.7
A83b	351315	6356248	R	29.0	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	45	335	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.8
A83c	351319	6356231	R	4.6	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	295	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.4
A83d	351337	6356252	R	4.2	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	255	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	2.0
A83t01	351301	6356234	T	3.3	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40	335	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	2.8
A84a	351492	6356055	H2	31.0	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4
A84b	351517	6356090	R	6.4	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	55	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3
A84c	351537	6356124	R	2.9	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	50	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3
A84d	351467	6356110	R	12.3	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	80	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.5
A85a	351581	6356030	H1	20.2	3.75	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A85b	351570	6356004	R	9.9	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A85c	351600	6356008	R	8.1	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A85d	351637	6356023	R	7.5	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
A85t01	351590	6356028	T	2.4	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A85t02	351594	6356030	T	2.4	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
A90c	351301	6355642	R	14.7	2.50	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
A98a	348590	6358440	H1	20.0	3.75	< 20	< 20	25	180	1440	2450	2800	2905	2935	2940	2940	2940	< 0.1	< 0.1	0.3	1.8	6.5	0.8	2.1	2.5	2.6	2.7	2.7	2.7

Table G.04 - Austar Stage 3 - Proposed Longwalls A6 to A17

Upperbound Systematic Curvature and Strain for Building Structures

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Upperbound Curvature during or after LWA6 (1/km)	Upperbound Strain during or after LWA6 (mm/m)	Upperbound Curvature during or after LWA7 (1/km)	Upperbound Strain during or after LWA6 to LWA7 (mm/m)	Upperbound Curvature during or after LWA8 (1/km)	Upperbound Strain during or after LWA6 to LWA8 (mm/m)	Upperbound Curvature during or after LWA9 (1/km)	Upperbound Strain during or after LWA6 to LWA9 (mm/m)	Upperbound Curvature during or after LWA10 (1/km)	Upperbound Strain during or after LWA6 to LWA10 (mm/m)	Upperbound Curvature during or after LWA11 (1/km)	Upperbound Strain during or after LWA6 to LWA11 (mm/m)	Upperbound Curvature during or after LWA12 (1/km)	Upperbound Strain during or after LWA6 to LWA12 (mm/m)	Upperbound Curvature during or after LWA13 (1/km)	Upperbound Strain during or after LWA6 to LWA13 (mm/m)	Upperbound Curvature during or after LWA14 (1/km)	Upperbound Strain during or after LWA6 to LWA14 (mm/m)	Upperbound Curvature during or after LWA15 (1/km)	Upperbound Strain during or after LWA6 to LWA15 (mm/m)	Upperbound Curvature during or after LWA16 (1/km)	Upperbound Strain during or after LWA6 to LWA16 (mm/m)	Upperbound Curvature during or after LWA17 (1/km)	Upperbound Strain during or after LWA6 to LWA17 (mm/m)
A03a	346315	6357814	H1	19.0	3.75	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1	0.048	1.1
A05a	346748	6357769	H2	30.1	3.75	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6	-0.032	-0.6
A05p01	346739	6357751	P	8.2	-	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7	-0.032	-0.7
A09a	347040	6357590	H2	32.0	3.75	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A09b	347031	6357610	R	10.0	2.50	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A09c	347019	6357631	R	37.0	2.50	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A09p01	347018	6357605	P	9.0	-	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A12a	347474	6357848	H1	24.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A12b	347473	6357887	R	14.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A12c	347460	6357879	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A12f	347355	6357999	R	123.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.009	0.4	0.009	0.4	0.009	0.4	0.009	0.4	0.009	0.4
A12g	347361	6358028	R	122.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.010	0.4	0.010	0.4	0.010	0.4	0.010	0.4	0.010	0.4
A12h	347360	6358060	R	90.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3
A13a	347823	6357987	H2	33.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.1	0.008	0.3	0.031	0.8	0.035	0.9	0.035	0.9	0.035	0.9	0.035	0.9	0.035	0.9
A13b	347810	6358042	R	18.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.009	0.4	0.038	0.9	0.041	0.9	0.042	0.9	0.042	0.9	0.042	0.9	0.042	0.9
A13c	347829	6358008	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.007	0.3	0.031	0.8	0.036	0.8	0.036	0.8	0.036	0.8	0.036	0.8	0.036	0.8
A13p01	347833	6357998	P	7.5	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.1	0.007	0.3	0.030	0.6	0.034	0.7	0.035	0.7	0.035	0.7	0.035	0.7	0.035	0.7
A13t01	347806	6358000	T	6.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.1	0.007	0.3	0.030	0.7	0.035	0.8	0.035	0.8	0.035	0.8	0.035	0.8	0.035	0.8
A14a	348074	6358041	H1	21.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3	0.018	0.5	0.032	0.8	0.032	0.8	0.032	0.8	0.032	0.8	0.032	0.8	0.032	0.8
A14b	348059	6358048	R	11.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.018	0.5	0.031	0.7	0.031	0.7	0.031	0.7	0.031	0.7	0.031	0.7	0.031	0.7
A14c	348031	6358057	R	15.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.020	0.5	0.030	0.7	0.030	0.7	0.030	0.7	0.030	0.7	0.030	0.7	0.030	0.7
A14d	347911	6358055	R	14.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.014	0.4	-0.034	-0.7	-0.037	-0.7	-0.037	-0.7	-0.037	-0.7	-0.037	-0.7	-0.037	-0.7
A14t01	348116	6358041	T	8.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.019	0.5	0.032	0.8	0.032	0.8	0.032	0.8	0.032	0.8	0.032	0.8	0.032	0.8
A15a	346975	6356731	H1	24.0	3.75	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5
A15b	346945	6356705	R	27.0	2.50	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5
A15c	346939	6356712	R	15.0	2.50	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5
A15d	346945	6356678	R	13.0	2.50	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5	-0.021	-0.5
A15e	346949	6356692	R	4.0	2.50	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5
A15f	346797	6356724	R	125.0	2.50	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3
A15g	346792	6356693	R	124.0	2.50	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3	0.004	0.3
A15p01	346974	6356712	P	10.4	-	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5	-0.022	-0.5
A15t01	346861	6356719	T	3.3	2.50	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3	0.005	0.3
A17a	347721	6357468	H1	22.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.002	0.1	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A17b	347783	6357456	R	11.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.003	0.2	0.003	0.2	0.003	0.3	0.006	0.3	0.006	0.3
A17c	347799	6357462	R	12.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.003	0.3	0.003	0.3	0.004	0.3	0.006	0.3	0.006	0.3
A17p01	347738	6357446	P	7.0	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.002	0.1	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A17t01	347778	6357458	T	2.5	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.003	0.2	0.003	0.2	0.003	0.3	0.006	0.3	0.006	0.3
A17t02	347778	6357455	T	2.5	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.003	0.2	0.003	0.2	0.003	0.3	0.006	0.3	0.006	0.3
A17t03	347809	6357461	T	3.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.003	0.3	0.004	0.3	0.004	0.3	0.006	0.3	0.006	0.3
A18a	347988	6357529	H1	18.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.014	0.5	0.014	0.5	0.014	0.5	0.014	0.5	0.014	0.5
A18t01	347998	6357536	T	3.7	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.014	0.5	0.014	0.5	0.014	0.5	0.014	0.5	0.014	0.5
A19a	347242	6357038	H1	16.0	3.75	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3
A19b	347257	6357046	R	6.0	2.50	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3
A19c	347263	6357025	R	3.0	2.50	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3	0.003	0.3
A19d	347272	6357040	R	5.0	2.50	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2
A19e	347271	6357028	R	4.0	2.50	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2	0.003	0.2
A20a	347338	6356771	H1	20.0	3.75	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A20b	347365	6356773	R	14.0	2.50	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A20c	347356	6356756	R	13.0	2.50	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A20d	347332	6356817	R	7.0	2.50	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2	0.002	0.2
A22a	347091	6356183	H1	17.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A22b	347112	6356203	R	9.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A22c	347079	6356191	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A22p01	347097	6356205	P	9.9	-	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1	-0.001	-0.1
A25a	348471	6356349	H1	24.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.009	0.4
A25b	348424	6356386	H1	21.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.008	0.3
A25p01	348458	6356364	P	11.2	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.008	0.3
A25t01	348452	6356345	T	7.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.007	0.3
A26a	348178	6356677	H1	13.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.003	0.3	0.005	0.3
A26b	348170	6356733	R	18.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	-0.001	-0.1	0.003	0.3	0.005	0.3	0.006	0.3
A26c	348127	6356760	R	20.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.2	0.004	0.3	0.005	0.3
A27a	348335	6356906	R	22.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.014	0.5	0.025	0.6	0.027	0.7
A29a	349194	6356711	H2	31.4	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.013	0.5	-0.042	-0.8	0.047	1.1
A29b	349238	6356747	R	10.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.023	0.6	0.031	0.7	0.046	1.0
A31a	347896	6358532	H1	11.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.006	0.3	-0.068	-1.1	-0.110	-1.6	-0.110	-1.6	-0.110	-1.6	-0.110	-1.6	-0.110	-1.6	-0.110	-1.6	-0.110	-1.6
A31b	347922	6358547	R	9.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.007	0.3	-0.068	-1.1	-0.111	-1.7	-0.111	-1.7	-0.111	-1.7	-0.111	-1.7	-0.111	-1.7	-0.111	-1.7	-0.111	-1.7
A31c	347931	6358555	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.008	0.3	-0.068	-1.1	-0.107	-1.7	-0.107	-1.7	-0.107	-1.7	-0.107	-1.7	-0.107	-1.7	-0.107	-1.7	-0.107	-1.7
A31t01	347927	6358552	T	3.3	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.007	0.3	-0.068	-1.1	-0.110	-1.7	-0.110	-1.7	-0.110	-1.7	-0.110	-1.7	-0.110	-1.7	-0.110	-1.7	-0.110	-1.7
A32a	348634	6358091	H1	12.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	0.058	1.3	0.058	1.3	0.058	1.3	0.058	1.3	0.058	1.3	0.058	1.3	0.058	1.3
A32b	348641	6358140	R	18.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.007	0.3	-0.063	-1.1	-0.080	-1.3	-0.080	-1.3	-0.080	-1.3	-0.080	-1.3	-0.080	-1.3	-0.080	-1.3
A32c	348615	6358144	R	25.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.007	0.3	-0.063	-1.1	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3
A32d	348182	6357612	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.1	0.007	0.3	0.049	1.1	0.049	1.1	0.049	1.1	0.049	1.1	0.049	1.1
A32p01	348630	6358071	P	11.7	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	0.058	1.1	-0.068	-1.2	-0.068	-1.2	-0.068	-1.2	-0.068	-1.2	-0.068	-1.2	-0.068	-1.2
A32t01	348432	6358096	T	3.8	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.057	1.2	0.057	1.2	0.057	1.2	0.057	1.2	0.057	1.2	0.057	1.2	0.057	1.2
A32t02	348746	6357707	T	3.7	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3	0.039	0.9	0.039	0.9	0.039	0.9	0.039	0.9	0.039	0.9	0.039	0.9
A33a	349484	6357714	H2	31.2	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.006	0.3	-0.056	-0.9	-0.080	-1.2	-0.080	-1.2	-0.080	-1.2	-0.080	-1.2	-0.080	-1.2
A33b	349563	6357680	R	12.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.006	0.3	-0.056	-1.0	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3
A33t01	349492	6357746	T	3.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.008	0.3	-0.047	-0.9	0.053	1.1	0.056	1.2	0.058	1.2	0.059	1.2	0.059	1.2
A33t02	349496	6357748	T	3.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.008	0.3	-0.044	-0.8	0.054	1.1	0.057	1.2	0.059	1.2	0.059	1.2	0.059	1.2
A33t03	349563	6357671	T	2.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	-0.051	-0.9	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3
A33t04	349567	6357672	T	3.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.005	0.3	-0.051	-0.9	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3	-0.081	-1.3
A33t05	349466	6357684	T	2.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.006	0.3	0.039	0.9	-0.079	-1.3	-0.079	-1.3	-0.079	-1.3	-0.079	-1.3	-0.079	-1.3
A33t06	349359	6357923	T	3.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.047	1.0	0.047	1.0	0.047	1.0	0.047	1.0	0.047	1.0	0.047	1.0	0.047	1.0
A33t07	349364	6357924	T	3.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.047	1.0	0.047	1.0	0.047	1.0	0.047	1.0	0.047	1.0	0.047	1.0	0.047	1.0
A34a	348990	6358342	H2	35.1	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.011	0.4	0.028	0.7	-0.143	-2.1	-0.143	-2.1	-0.143	-2.1	-0.143	-2.1	-0.143	-2.1	-0.143	-2.1	-0.143	-2.1
A34b	349001	6358366	R	10.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.013	0.4	0.030	0.7	-0.097	-1.5	-0.097	-1.5	-0.097	-1.5	-0.097	-1.5	-0.097	-1.5	-0.097	-1.5	-0.097	-1.5
A34c	349051	6358380	R	30.0	2.50	0.001	0.1	0.001	0.1	0.002	0.1	0.016	0.5	0.032	0.8	0.045	1.0	0.048	1.0	0.050	1.1	0.051	1.1	0.051	1.1	0.051	1.1	0.051	1.1
A34d	348950	6358346	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.010	0.4	0.027	0.7	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2
A34p01	348990	6358361	P	11.0	-	0.001	0.1	0.001	0.1	0.001	0.1	0.012	0.4	0.029	0.6	-0.114	-1.9	-0.114	-1.9	-0.114	-1.9	-0.114	-1.9	-0.114	-1.9	-0.114	-1.9	-0.114	-1.9
A34t01	348961	6358327	T	5.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.009	0.4	0.025	0.6	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2	-0.144	-2.2
A34t02	349034	6358375	T	3.1	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.014	0.4	0.031	0.7	0.045	1.0	0.048	1.0	0.050	1.1	0.050	1.1	0.051	1.1	0.051	1.1	0.051	1.1
A44a	348853	6359343	H1	21.0	3.75	0.001	0.1	0.001	0.1	0.005	0.3	0.011	0.4	0.012	0.4	0.013	0.4	0.013	0.5	0.013	0.5	0.013	0.5	0.013	0.5	0.013	0.5	0.013	0.5
A44b	348817	6359365	R	10.0	2.50	0.001	0.1	0.001	0.1	0.004	0.3	0.005	0.3	0.005	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3
A44c	348814	6359344	R	4.0	2.50	0.001	0.1	0.001	0.1	0.005	0.3	0.010	0.4	0.011	0.4	0.012	0.4	0.013	0.4	0.013	0.4	0.013	0.4	0.013	0.4	0.013	0.4	0.013	0.4
A44t01	348842	6359335	T	2.4	2.50	0.001	0.1	0.001	0.1	0.005	0.3	0.010	0.4	0.011	0.4	0.013	0.4	0.013	0.4	0.013	0.4	0.013	0.4	0.013	0.4	0.013	0.4	0.013	0.4
A50a	350108	6355775	H1	20.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A50b	350078	6355805	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A50c	350088	6355814	R	14.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A50t01	350123	6355772	T	5.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A50t02	350089	6355835	T	3.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A52a	346760	6358368	H1	19.0	3.75	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3
A52b	346772	6358365	R	11.0	2.50	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3
A52c	346760	6358324	R	15.0	2.50	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3

Table G.04 - Austar Stage 3 - Proposed Longwalls A6 to A17
Upperbound Systematic Curvature and Strain for Building Structures

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Upperbound Cuvature during or after LWA6 (1/km)	Upperbound Strain during or after LWA6 (mm/m)	Upperbound Cuvature during or after LWA7 (1/km)	Upperbound Strain during or after LWA6 to LWA7 (mm/m)	Upperbound Cuvature during or after LWA8 (1/km)	Upperbound Strain during or after LWA6 to LWA8 (mm/m)	Upperbound Cuvature during or after LWA9 (1/km)	Upperbound Strain during or after LWA6 to LWA9 (mm/m)	Upperbound Cuvature during or after LWA10 (1/km)	Upperbound Strain during or after LWA6 to LWA10 (mm/m)	Upperbound Cuvature during or after LWA11 (1/km)	Upperbound Strain during or after LWA6 to LWA11 (mm/m)	Upperbound Cuvature during or after LWA12 (1/km)	Upperbound Strain during or after LWA6 to LWA12 (mm/m)	Upperbound Cuvature during or after LWA13 (1/km)	Upperbound Strain during or after LWA6 to LWA13 (mm/m)	Upperbound Cuvature during or after LWA14 (1/km)	Upperbound Strain during or after LWA6 to LWA14 (mm/m)	Upperbound Cuvature during or after LWA15 (1/km)	Upperbound Strain during or after LWA6 to LWA15 (mm/m)	Upperbound Cuvature during or after LWA16 (1/km)	Upperbound Strain during or after LWA6 to LWA16 (mm/m)	Upperbound Cuvature during or after LWA17 (1/km)	Upperbound Strain during or after LWA6 to LWA17 (mm/m)
A52d	346760	6358381	R	5.0	2.50	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3
A52e	346754	6358381	R	5.0	2.50	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3	0.007	0.3
A52f	346758	6358303	R	3.0	2.50	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3
A52g	346763	6358308	R	6.0	2.50	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3
A52t01	346759	6358316	T	3.0	2.50	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3	0.008	0.3
A54a	350264	6355890	H1	29.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.006	0.3
A54p01	350244	6355901	P	9.7	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.006	0.3
A54t01	350279	6355885	T	3.3	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.005	0.3
A54t02	350278	6355889	T	2.7	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.005	0.3
A61a	350782	6355822	H1	18.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.007	0.3
A61b	350766	6355820	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.007	0.3
A61c	350766	6355812	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.007	0.3
A61d	350764	6355786	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3
A61e	350727	6355794	R	11.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3
A61f	350771	6355821	R	3.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.1	0.007	0.3
A62a	351031	6355781	H1	19.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3
A62b	351045	6355788	R	4.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3
A63a	350576	6356037	R	21.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.033	0.8
A63b	350553	6356014	R	5.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.021	0.6
A63t01	350559	6356022	T	5.5	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.024	0.6
A63t02	350601	6356037	T	4.1	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.032	0.8
A63t03	350546	6356094	T	2.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.004	0.3	0.039	0.9
A64a	350830	6355980	H1	17.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.027	0.7
A64b	350814	6356008	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.032	0.8
A64c	350824	6356013	R	5.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.034	0.8
A64d	350862	6355988	R	12.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	-0.001	-0.1	0.002	0.2	0.031	0.7
A64e	350873	6355988	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.033	0.8
A64f	350858	6355982	R	5.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.029	0.7
A64g	350844	6356014	R	5.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.036	0.8
A64p01	350864	6355981	P	4.9	-	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.029	0.6
A64t01	350822	6355995	T	3.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.027	0.7
A64t02	350821	6355990	T	3.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.025	0.6
A64t03	350870	6355981	T	3.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.030	0.7
A65a	350308	6356662	H2	34.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.1	0.005	0.3	0.041	1.0	0.041	1.0	0.041	1.0
A65b	350333	6356656	R	8.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.041	0.9	0.041	0.9	0.041	0.9
A65c	350435	6356674	R	18.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.042	0.9	-0.055	-1.0	-0.055	-1.0
A65d	350432	6356649	R	19.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.004	0.3	0.042	0.9	-0.055	-1.0	-0.055	-1.0
A65e	350475	6356641	R	13.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.003	0.3	0.042	0.9	-0.054	-0.9	-0.054	-0.9
A73t01	350970	6357013	T	3.8	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.021	0.6	0.027	0.7	0.031	0.8	0.033	0.8
A83a	351267	6356226	H1	16.7	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.027	0.7
A83b	351315	6356248	R	29.0	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.026	0.7
A83c	351319	6356231	R	4.6	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2	0.024	0.6
A83d	351337	6356252	R	4.2	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2	0.020	0.6
A83t01	351301	6356234	T	3.3	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2	0.026	0.7
A84a	351492	6356055	H2	31.0	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A84b	351517	6356090	R	6.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A84c	351537	6356124	R	2.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.002	0.2
A84d	351467	6356110	R	12.3	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	-0.001	-0.1	0.001	0.1	0.001	0.1	0.003	0.2
A85a	351581	6356030	H1	20.2	3.75	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A85b	351570	6356004	R	9.9	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A85c	351600	6356008	R	8.1	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	-0.001	-0.1	0.001	0.1	0.001	0.2
A85d	351637	6356023	R	7.5	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A85t01	351590	6356028	T	2.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A85t02	351594	6356030	T	2.4	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.2
A90c	351301	6355642	R	14.7	2.50	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1
A98a	348590	6358440	H1	20.0	3.75	0.001	0.1	0.001	0.1	0.002	0.2	0.015	0.5	0.032	0.8	-0.094	-1.4	-0.094	-1.4	-0.094	-1.4	-0.094	-1.4	-0.094	-1.4	-0.094	-1.4	-0.094	-1.4

Table G.05 - Austar Stage 3 - Proposed Longwalls A6 to A17
Locations of Building Structures Relative to the Extracted Longwalls

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Position of Structure after LWA6	Position of Structure after LWA7	Position of Structure after LWA8	Position of Structure after LWA9	Position of Structure after LWA10	Position of Structure after LWA11	Position of Structure after LWA12	Position of Structure after LWA13	Position of Structure after LWA14	Position of Structure after LWA15	Position of Structure after LWA16	Position of Structure after LWA17
A03a	346315	6357814	H1	19.0	3.75	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A05a	346748	6357769	H2	30.1	3.75	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A05p01	346739	6357751	P	8.2	-	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A09a	347040	6357590	H2	32.0	3.75	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A09b	347031	6357610	R	10.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A09c	347019	6357631	R	37.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A09p01	347018	6357605	P	9.0	-	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A12a	347474	6357848	H1	24.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A12b	347473	6357887	R	14.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A12c	347460	6357879	R	13.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A12f	347355	6357999	R	123.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A12g	347361	6358028	R	122.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A12h	347360	6358060	R	90.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A13a	347823	6357987	H2	33.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A13b	347810	6358042	R	18.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A13c	347829	6358008	R	4.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A13p01	347833	6357998	P	7.5	-	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A13t01	347806	6358000	T	6.9	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A14a	348074	6358041	H1	21.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A14b	348059	6358048	R	11.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A14c	348031	6358057	R	15.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A14d	347911	6358055	R	14.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A14t01	348116	6358041	T	8.2	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15a	346975	6356731	H1	24.0	3.75	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15b	346945	6356705	R	27.0	2.50	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15c	346939	6356712	R	15.0	2.50	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15d	346945	6356678	R	13.0	2.50	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15e	346949	6356692	R	4.0	2.50	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15f	346797	6356724	R	125.0	2.50	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15g	346792	6356693	R	124.0	2.50	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15p01	346974	6356712	P	10.4	-	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A15t01	346861	6356719	T	3.3	2.50	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A17a	347721	6357468	H1	22.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A17b	347783	6357456	R	11.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A17c	347799	6357462	R	12.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A17p01	347738	6357446	P	7.0	-	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A17t01	347778	6357458	T	2.5	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A17t02	347778	6357455	T	2.5	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A17t03	347809	6357461	T	3.6	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A18a	347988	6357529	H1	18.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A18t01	347998	6357536	T	3.7	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A19a	347242	6357038	H1	16.0	3.75	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A19b	347257	6357046	R	6.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A19c	347263	6357025	R	3.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A19d	347272	6357040	R	5.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A19e	347271	6357028	R	4.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A20a	347338	6356771	H1	20.0	3.75	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A20b	347365	6356773	R	14.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A20c	347356	6356756	R	13.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A20d	347332	6356817	R	7.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A22a	347091	6356183	H1	17.0	3.75	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A22b	347112	6356203	R	9.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A22c	347079	6356191	R	4.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A22p01	347097	6356205	P	9.9	-	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A25a	348471	6356349	H1	24.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A25b	348424	6356386	H1	21.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A25p01	348458	6356364	P	11.2	-	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A25t01	348452	6356345	T	7.9	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A26a	348178	6356677	H1	13.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A26b	348170	6356733	R	18.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A26c	348127	6356760	R	20.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A27a	348335	6356906	R	22.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A29a	349194	6356711	H2	31.4	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf
A29b	349238	6356747	R	10.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf
A31a	347896	6358532	H1	11.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A31b	347922	6358547	R	9.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A31c	347931	6358555	R	4.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A31t01	347927	6358552	T	3.3	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A32a	348634	6358091	H1	12.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A32b	348641	6358140	R	18.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A32c	348615	6358144	R	25.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A32d	348182	6357612	R	8.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A32p01	348630	6358071	P	11.7	-	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A32t01	348432	6358096	T	3.8	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A32t02	348746	6357707	T	3.7	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A33a	349484	6357714	H2	31.2	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A33b	349563	6357680	R	12.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A33t01	349492	6357746	T	3.2	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A33t02	349496	6357748	T	3.4	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A33t03	349563	6357671	T	2.9	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A33t04	349567	6357672	T	3.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A33t05	349466	6357684	T	2.6	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A33t06	349359	6357923	T	3.2	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf

Table G.05 - Austar Stage 3 - Proposed Longwalls A6 to A17
Locations of Building Structures Relative to the Extracted Longwalls

Label	Easting	Northing	Type	Longest Side (m)	Height (m)	Position of Structure after LWA6	Position of Structure after LWA7	Position of Structure after LWA8	Position of Structure after LWA9	Position of Structure after LWA10	Position of Structure after LWA11	Position of Structure after LWA12	Position of Structure after LWA13	Position of Structure after LWA14	Position of Structure after LWA15	Position of Structure after LWA16	Position of Structure after LWA17
A33t07	349364	6357924	T	3.2	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A34a	348990	6358342	H2	35.1	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A34b	349001	6358366	R	10.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A34c	349051	6358380	R	30.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A34d	348950	6358346	R	4.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A34p01	348990	6358361	P	11.0	-	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A34t01	348961	6358327	T	5.4	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A34t02	349034	6358375	T	3.1	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf
A44a	348853	6359343	H1	21.0	3.75	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A44b	348817	6359365	R	10.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line
A44c	348814	6359344	R	4.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line
A44t01	348842	6359335	T	2.4	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line
A50a	350108	6355775	H1	20.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A50b	350078	6355805	R	8.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A50c	350088	6355814	R	14.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A50t01	350123	6355772	T	5.6	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A50t02	350089	6355835	T	3.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A52a	346760	6358368	H1	19.0	3.75	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A52b	346772	6358365	R	11.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A52c	346760	6358324	R	15.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A52d	346760	6358381	R	5.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A52e	346754	6358381	R	5.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A52f	346758	6358303	R	3.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A52g	346763	6358308	R	6.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A52t01	346759	6358316	T	3.0	2.50	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A54a	350264	6355890	H1	29.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A54p01	350244	6355901	P	9.7	-	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A54t01	350279	6355885	T	3.3	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A54t02	350278	6355889	T	2.7	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A61a	350782	6355822	H1	18.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A61b	350766	6355820	R	8.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A61c	350766	6355812	R	8.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A61d	350764	6355786	R	13.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A61e	350727	6355794	R	11.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A61f	350771	6355821	R	3.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A62a	351031	6355781	H1	19.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A62b	351045	6355788	R	4.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A63a	350576	6356037	R	21.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A63b	350553	6356014	R	5.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A63t01	350559	6356022	T	5.5	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A63t02	350601	6356037	T	4.1	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A63t03	350546	6356094	T	2.9	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf
A64a	350830	6355980	H1	17.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64b	350814	6356008	R	13.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64c	350824	6356013	R	5.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64d	350862	6355988	R	12.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64e	350873	6355988	R	8.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64f	350858	6355982	R	5.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64g	350844	6356014	R	5.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64p01	350864	6355981	P	4.9	-	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64t01	350822	6355995	T	3.6	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64t02	350821	6355990	T	3.6	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A64t03	350870	6355981	T	3.6	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A65a	350308	6356662	H2	34.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf
A65b	350333	6356656	R	8.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf
A65c	350435	6356674	R	18.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf
A65d	350432	6356649	R	19.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf
A65e	350475	6356641	R	13.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf
A73t01	350970	6357013	T	3.8	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line	Inside Draw Line
A83a	351267	6356226	H1	16.7	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A83b	351315	6356248	R	29.0	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A83c	351319	6356231	R	4.6	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A83d	351337	6356252	R	4.2	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A83t01	351301	6356234	T	3.3	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Inside Draw Line
A84a	351492	6356055	H2	31.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A84b	351517	6356090	R	6.4	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A84c	351537	6356124	R	2.9	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A84d	351467	6356110	R	12.3	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A85a	351581	6356030	H1	20.2	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A85b	351570	6356004	R	9.9	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A85c	351600	6356008	R	8.1	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A85d	351637	6356023	R	7.5	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A85t01	351590	6356028	T	2.4	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A85t02	351594	6356030	T	2.4	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A90c	351301	6355642	R	14.7	2.50	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line
A98a	348590	6358440	H1	20.0	3.75	Outside Draw Line	Outside Draw Line	Outside Draw Line	Inside Draw Line	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf	Above Goaf

Table G.06 - Austar Stage 3 - Proposed Longwalls A6 to A17
Predicted and Upperbound Systematic Subsidence Parameters for the Farm Dams

Label	Easting	Northing	Type	Longest Side (m)	Maximum Predicted Subsidence after LWA6 to LWA17 (mm)	Maximum Predicted Travelling or Cumulative Tilt due to LWA6 to LWA17 (mm/m)	Maximum Predicted Total Tilt after the Completion of LWA6 to LWA17 (mm/m)	Maximum Predicted Change in Freeboard (mm)	Maximum Predicted Tensile Strain due to LWA6 to LWA17 (mm/m)	Maximum Predicted Comp. Strain due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Subsidence after LWA6 to LWA17 (mm)	Maximum Predicted Travelling or Cumulative Tilt due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Total Tilt after the Completion of LWA6 to LWA17 (mm/m)	Maximum Upperbound Change in Freeboard (mm)	Maximum Upperbound Tensile Strain due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Comp. Strain due to LWA6 to LWA17 (mm/m)
A05d01	346633	6357695	Dam	71.585	185	0.8	0.8	30	< 0.1	< -0.1	305	1.2	1.2	40	0.1	< -0.1
A09d01	346621	6357622	Dam	135.9861	190	0.8	0.8	50	< 0.1	< -0.1	315	1.2	1.2	80	0.1	< -0.1
A09d02	346543	6357540	Dam	33.084	85	0.6	0.6	10	< 0.1	< -0.1	145	1.0	1.0	20	< 0.1	< -0.1
A09d03	346816	6357578	Dam	31.5235	230	0.7	0.7	10	< 0.1	-0.3	365	1.1	1.1	20	0.1	-0.5
A09d04	347022	6357657	Dam	25.726	90	0.7	0.7	10	< 0.1	< -0.1	160	1.0	1.0	10	< 0.1	< -0.1
A09d05	347115	6357669	Dam	21.6095	45	0.4	0.4	< 10	< 0.1	< -0.1	80	0.6	0.6	10	< 0.1	< -0.1
A09d06	347115	6357607	Dam	32.4675	50	0.4	0.4	10	< 0.1	< -0.1	90	0.7	0.7	10	< 0.1	< -0.1
A09d07	347111	6357539	Dam	16.7273	55	0.4	0.4	< 10	< 0.1	< -0.1	95	0.7	0.7	10	< 0.1	< -0.1
A10d02	347005	6356792	Dam	45.839	175	0.6	0.6	10	< 0.1	-0.2	275	0.9	0.9	20	< 0.1	-0.3
A10d03	346958	6357117	Dam	184.734	195	0.7	0.7	60	< 0.1	-0.3	310	1.0	1.0	90	0.1	-0.4
A10d04	346766	6357238	Dam	132.3171	205	0.7	0.7	50	< 0.1	-0.3	325	1.1	1.1	70	0.1	-0.4
A12d02	347429	6357948	Dam	50.876	< 20	0.2	0.2	< 10	< 0.1	< -0.1	25	0.2	0.2	10	< 0.1	< -0.1
A12d06	347370	6358181	Dam	13.5192	25	0.2	0.2	< 10	< 0.1	< -0.1	35	0.3	0.3	< 10	0.2	< -0.1
A13d01	347761	6357952	Dam	41.9113	210	1.9	1.9	40	0.2	< -0.1	330	3.0	3.0	60	0.3	< -0.1
A13d02	347688	6357831	Dam	33.0679	75	0.7	0.7	10	< 0.1	< -0.1	120	1.1	1.1	20	0.1	< -0.1
A13d03	347798	6357725	Dam	27.7381	130	1.2	1.2	20	0.1	< -0.1	205	1.8	1.8	30	0.2	< -0.1
A13d04	347881	6358230	Dam	38.4911	1125	6.0	6.0	120	0.6	-0.4	1735	9.3	9.3	180	0.8	-0.6
A14d01	348028	6358184	Dam	64.3239	1600	5.4	4.6	170	0.6	-0.8	2460	7.7	7.3	250	0.8	-1.1
A14d02	348141	6358119	Dam	47.5277	1705	4.5	3.5	110	0.6	-0.8	2555	7.1	5.4	170	0.8	-0.7
A14d03	348095	6358147	Dam	17.5509	1635	4.5	3.9	40	0.6	-0.9	2470	7.1	6.1	60	0.8	-1.1
A14d04	348045	6357925	Dam	23.9976	1120	5.7	5.7	70	0.6	-0.3	1715	8.6	8.6	100	0.8	-0.5
A15d01	346841	6356766	Dam	38.1477	150	0.6	0.6	10	< 0.1	< -0.1	235	0.9	0.9	20	< 0.1	< -0.1
A15d03	346638	6356430	Dam	29.0627	< 20	0.2	0.2	< 10	< 0.1	< -0.1	25	0.3	0.3	< 10	< 0.1	< -0.1
A17d01	347755	6357373	Dam	35.9417	30	0.3	0.3	10	< 0.1	< -0.1	40	0.4	0.4	10	0.1	< -0.1
A17d02	347605	6357611	Dam	136.1546	35	0.3	0.3	20	< 0.1	< -0.1	55	0.5	0.5	40	0.1	< -0.1
A17d03	347756	6357621	Dam	96.1383	90	0.9	0.9	40	< 0.1	< -0.1	140	1.3	1.3	60	0.1	< -0.1
A19d01	347258	6356951	Dam	28.4605	35	0.3	0.3	< 10	< 0.1	< -0.1	60	0.5	0.5	10	< 0.1	< -0.1
A20d01	347245	6356855	Dam	40.6394	45	0.4	0.4	10	< 0.1	< -0.1	75	0.6	0.6	10	< 0.1	< -0.1
A21d08	347183	6356616	Dam	32.9916	70	0.5	0.5	10	< 0.1	< -0.1	115	0.7	0.7	10	< 0.1	< -0.1
A25d01	348340	6356277	Dam	62.5754	25	0.3	0.3	10	< 0.1	< -0.1	40	0.4	0.4	10	< 0.1	< -0.1
A25d02	348567	6356099	Dam	25.9205	35	0.4	0.4	< 10	< 0.1	< -0.1	55	0.5	0.5	10	< 0.1	< -0.1
A25d03	348393	6356573	Dam	25.0703	195	1.6	1.6	20	0.1	< -0.1	290	2.4	2.4	30	0.2	< -0.1
A25d04	348548	6356147	Dam	30.876	40	0.4	0.4	10	< 0.1	< -0.1	65	0.6	0.6	10	< 0.1	< -0.1
A26d01	348109	6356635	Dam	23.3279	35	0.3	0.3	< 10	< 0.1	< -0.1	50	0.4	0.4	10	< 0.1	< -0.1
A26d02	348069	6356507	Dam	14.2797	< 20	0.1	0.1	< 10	< 0.1	< -0.1	20	0.2	0.2	< 10	< 0.1	< -0.1
A27d01	348159	6357528	Dam	28.6764	825	5.3	5.3	80	0.5	-0.2	1230	7.7	7.7	110	0.6	-0.3
A27d02	348471	6357028	Dam	64.5158	1285	5.8	5.7	190	0.6	-0.5	1890	8.3	8.3	270	0.7	-0.6
A27d03	348209	6357012	Dam	21.9149	240	2.1	2.1	20	0.2	< -0.1	360	3.1	3.1	30	0.3	< -0.1
A27d04	348215	6357042	Dam	16.7804	285	2.5	2.5	20	0.3	< -0.1	420	3.7	3.7	30	0.4	< -0.1
A28d01	348679	6356004	Dam	124.3183	25	0.3	0.3	20	< 0.1	< -0.1	45	0.5	0.5	30	< 0.1	< -0.1
A28d02	348615	6356368	Dam	39.7878	310	3.0	3.0	60	0.5	-0.1	460	4.1	4.1	80	0.6	-0.2
A28d03	348756	6356815	Dam	135.4449	1715	5.4	3.2	360	0.4	-0.7	2415	7.2	4.3	490	0.7	-1.0
A28d04	348594	6357001	Dam	47.6151	1605	5.6	4.4	130	0.6	-0.6	2355	7.5	6.6	180	0.8	-1.0
A28d05	348897	6357292	Dam	51.743	1895	5.4	1.6	140	0.5	-0.6	2825	7.3	2.6	190	0.7	-1.0
A28d06	349259	6357182	Dam	44.7404	1890	5.3	1.6	120	0.4	-0.6	2805	7.1	2.3	160	0.5	-0.9
A29d01	349062	6356092	Dam	120.2087	125	0.9	0.9	60	0.1	< -0.1	190	1.4	1.4	80	0.1	< -0.1
A29d02	348965	6356165	Dam	58.8685	160	1.1	1.1	30	0.1	< -0.1	235	1.6	1.6	50	0.2	< -0.1
A29d03	349022	6356166	Dam	36.0035	165	1.2	1.2	20	0.1	< -0.1	245	1.7	1.7	30	0.2	< -0.1
A29d04	349072	6356169	Dam	20.2995	180	1.3	1.3	10	0.1	< -0.1	265	1.8	1.8	20	0.2	< -0.1

Table G.06 - Austar Stage 3 - Proposed Longwalls A6 to A17
Predicted and Upperbound Systematic Subsidence Parameters for the Farm Dams

Label	Easting	Northing	Type	Longest Side (m)	Maximum Predicted Subsidence after LWA6 to LWA17 (mm)	Maximum Predicted Travelling or Cumulative Tilt due to LWA6 to LWA17 (mm/m)	Maximum Predicted Total Tilt after the Completion of LWA6 to LWA17 (mm/m)	Maximum Predicted Change in Freeboard (mm)	Maximum Predicted Tensile Strain due to LWA6 to LWA17 (mm/m)	Maximum Predicted Comp. Strain due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Subsidence after LWA6 to LWA17 (mm)	Maximum Predicted Travelling or Cumulative Tilt due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Total Tilt after the Completion of LWA6 to LWA17 (mm/m)	Maximum Upperbound Change in Freeboard (mm)	Maximum Upperbound Tensile Strain due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Comp. Strain due to LWA6 to LWA17 (mm/m)
A29d05	348969	6356387	Dam	46.1101	915	6.1	6.1	140	0.7	-0.5	1255	8.0	8.0	180	0.9	-0.5
A29d06	349005	6356558	Dam	24.534	1565	4.5	3.6	60	0.5	-0.3	2160	6.3	5.1	80	0.7	-0.4
A29d07	348903	6356731	Dam	61.8385	1730	5.8	1.5	180	0.4	-0.7	2475	7.6	2.4	230	0.7	-1.1
A29d08	348966	6356931	Dam	59.1478	1915	5.6	1.8	160	0.6	-1.1	2765	7.5	3.2	220	0.8	-1.3
A29d09	349261	6357093	Dam	75.8622	1915	4.6	1.6	170	0.6	-1.0	2785	6.5	2.4	250	0.8	-1.3
A29d10	348932	6356243	Dam	23.0233	255	1.9	1.9	20	0.3	< -0.1	370	2.6	2.6	30	0.3	< -0.1
A30d01	349204	6356135	Dam	36.0429	185	1.3	1.3	20	0.1	< -0.1	275	1.9	1.9	30	0.2	< -0.1
A30d02	349468	6356091	Dam	133.506	210	1.5	1.5	100	0.2	< -0.1	310	2.1	2.1	140	0.2	< -0.1
A30d03	349353	6356623	Dam	32.165	1680	5.5	1.0	90	0.3	-0.7	2440	7.3	1.7	120	0.5	-1.0
A30d04	349445	6356682	Dam	36.7399	1675	3.8	1.3	70	0.4	-0.4	2365	5.2	1.6	100	0.7	-0.5
A30d05	349340	6356744	Dam	63.2156	1790	4.0	1.7	130	0.5	-0.3	2535	5.7	2.5	180	0.7	-0.4
A30d06	349293	6356971	Dam	53.8264	1820	4.5	1.2	120	0.4	-0.5	2655	6.2	2.2	170	0.7	-0.6
A30d07	349834	6356799	Dam	89.9039	1520	3.8	2.2	170	0.4	-0.8	2195	5.3	2.5	240	0.6	-1.1
A30d08	349872	6356700	Dam	81.9755	1490	3.5	1.9	150	0.4	-0.8	2115	5.1	2.4	210	0.6	-1.0
A30d09	349326	6357174	Dam	19.8663	1860	5.2	1.8	50	0.4	-0.6	2760	7.0	2.6	70	0.5	-0.9
A30d11	349142	6355968	Dam	16.7985	40	0.4	0.4	< 10	< 0.1	< -0.1	65	0.6	0.6	10	< 0.1	< -0.1
A31d01	347987	6358406	Dam	30.1825	1715	4.6	3.6	70	0.6	-0.6	2595	7.2	5.4	110	0.9	-0.4
A31d02	347881	6358512	Dam	17.6159	1625	5.6	4.1	50	0.7	-1.0	2530	8.0	6.7	70	0.8	-1.7
A31d03	348254	6358631	Dam	52.43	1860	5.0	2.0	130	0.7	-0.4	2880	7.6	3.3	200	1.0	-0.5
A32d01	348464	6358082	Dam	123.2757	1840	5.4	1.5	330	0.7	-1.0	2805	7.5	2.7	460	0.9	-1.2
A32d02	348570	6357634	Dam	63.0508	1835	5.1	1.6	160	0.5	-0.7	2760	7.0	2.7	220	0.8	-1.1
A32d03	348811	6357707	Dam	165.8592	1855	4.2	1.3	350	0.6	-1.0	2755	6.4	2.1	530	0.8	-1.2
A33d01	349164	6357928	Dam	111.558	1770	4.0	1.2	220	0.6	-0.9	2665	6.1	1.9	340	0.8	-1.0
A33d02	348986	6357700	Dam	35.7867	1835	4.2	1.3	80	0.6	-1.0	2745	6.3	2.1	110	0.8	-1.2
A34d01	348902	6358210	Dam	62.6324	1725	4.0	1.0	130	0.7	-0.3	2630	6.1	1.7	190	1.0	-0.4
A34d02	348543	6358512	Dam	30.3614	1830	4.0	1.1	60	0.5	-0.3	2825	6.1	1.9	90	0.9	-0.4
A34d03	349008	6358403	Dam	32.4483	1765	3.9	1.3	60	0.5	-0.3	2760	5.7	2.5	90	0.8	-0.4
A35d01	349291	6358686	Dam	150.1925	1555	5.8	5.8	430	0.7	-1.9	2445	8.5	8.5	640	0.8	-2.7
A35d02	348407	6358774	Dam	40.511	1880	4.6	2.0	90	0.6	-0.4	2955	6.7	2.2	140	0.7	-0.5
A35d03	348835	6358912	Dam	29.5906	1305	5.9	5.9	90	0.3	-0.6	2135	9.2	9.2	140	0.5	-0.7
A35d04	348519	6359122	Dam	30.8236	1085	5.2	5.2	80	0.5	-0.9	1725	7.2	7.2	110	0.7	-1.2
A36d01	349306	6358386	Dam	181.6754	1725	4.3	1.9	390	0.6	-1.2	2695	6.3	2.6	570	0.7	-1.6
A36d02	349483	6358629	Dam	46.7817	1310	3.7	3.7	90	0.7	-0.4	2120	6.0	6.0	140	0.8	-0.4
A36d03	349466	6359006	Dam	40.3742	245	2.1	2.1	40	0.2	< -0.1	445	3.7	3.7	70	0.4	-0.1
A37d01	349816	6357466	Dam	34.5568	1350	2.8	1.0	50	0.5	-0.2	1975	4.1	1.5	70	0.8	-0.3
A37d02	349697	6357786	Dam	26.4647	1540	3.1	0.8	40	0.4	-0.6	2280	4.7	1.3	60	0.6	-0.5
A37d03	349491	6357975	Dam	54.4242	1740	4.4	1.9	120	0.4	-1.1	2645	6.3	2.8	170	0.5	-1.8
A37d04	349639	6358041	Dam	102.4656	1615	3.4	2.1	180	0.5	-1.2	2435	4.9	2.2	250	0.7	-1.6
A37d05	349825	6357949	Dam	41.5287	1405	3.4	2.8	70	0.5	-0.2	2120	4.8	3.8	100	0.6	-0.3
A37d06	349785	6358130	Dam	34.7052	1410	5.1	5.1	90	0.2	-1.1	2175	7.2	7.2	120	0.3	-1.9
A44d01	348941	6359295	Dam	19.312	55	0.6	0.6	10	0.1	< -0.1	105	1.2	1.2	10	0.2	< -0.1
A44d02	348840	6359192	Dam	61.8643	240	2.1	2.1	60	0.2	< -0.1	425	3.3	3.3	100	0.3	< -0.1
A44d03	348707	6359198	Dam	23.9818	305	2.5	2.5	30	0.2	< -0.1	525	3.9	3.9	50	0.3	< -0.1
A44d04	349310	6359098	Dam	30.0106	175	1.6	1.6	20	0.2	< -0.1	320	2.7	2.7	40	0.3	< -0.1
A44d05	349440	6359077	Dam	22.7602	140	1.3	1.3	20	0.2	< -0.1	260	2.3	2.3	30	0.2	-0.1
A44d06	348791	6359205	Dam	7.2581	205	1.8	1.8	10	0.2	< -0.1	365	3.0	3.0	10	0.3	< -0.1
A44d07	348796	6359264	Dam	13.9602	120	1.2	1.2	10	0.2	< -0.1	225	2.1	2.1	10	0.2	< -0.1
A44d08	349575	6359053	Dam	25.7626	80	0.8	0.8	10	0.1	< -0.1	155	1.5	1.5	20	0.2	< -0.1
A52d01	346900	6358169	Dam	38.1144	120	0.8	0.8	20	< 0.1	< -0.1	210	1.2	1.2	20	< 0.1	< -0.1

Table G.06 - Austar Stage 3 - Proposed Longwalls A6 to A17
Predicted and Upperbound Systematic Subsidence Parameters for the Farm Dams

Label	Easting	Northing	Type	Longest Side (m)	Maximum Predicted Subsidence after LWA6 to LWA17 (mm)	Maximum Predicted Travelling or Cumulative Tilt due to LWA6 to LWA17 (mm/m)	Maximum Predicted Total Tilt after the Completion of LWA6 to LWA17 (mm/m)	Maximum Predicted Change in Freeboard (mm)	Maximum Predicted Tensile Strain due to LWA6 to LWA17 (mm/m)	Maximum Predicted Comp. Strain due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Subsidence after LWA6 to LWA17 (mm)	Maximum Predicted Travelling or Cumulative Tilt due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Total Tilt after the Completion of LWA6 to LWA17 (mm/m)	Maximum Upperbound Change in Freeboard (mm)	Maximum Upperbound Tensile Strain due to LWA6 to LWA17 (mm/m)	Maximum Upperbound Comp. Strain due to LWA6 to LWA17 (mm/m)
A52d02	346961	6358236	Dam	20.8948	65	0.5	0.5	10	< 0.1	< -0.1	120	0.9	0.9	10	< 0.1	< -0.1
A52d03	346853	6358293	Dam	21.1042	130	0.8	0.8	10	< 0.1	< -0.1	225	1.3	1.3	10	< 0.1	< -0.1
A55d02	350569	6355941	Dam	43.0413	140	1.0	1.0	20	0.1	< -0.1	205	1.4	1.4	30	0.2	< -0.1
A61d01	350893	6355812	Dam	27.7656	75	0.6	0.6	10	< 0.1	< -0.1	110	0.8	0.8	10	< 0.1	< -0.1
A61d02	350666	6355793	Dam	54.629	55	0.4	0.4	10	< 0.1	< -0.1	80	0.6	0.6	20	< 0.1	< -0.1
A61d03	350615	6355900	Dam	94.7477	130	0.9	0.9	40	0.1	< -0.1	185	1.3	1.3	60	0.1	< -0.1
A63d01	350457	6356126	Dam	56.6241	510	4.0	4.0	110	0.5	-0.1	710	5.5	5.5	160	0.6	-0.1
A63d02	350318	6356259	Dam	47.7862	885	3.5	3.5	80	0.2	-0.4	1235	4.8	4.8	120	0.3	-0.5
A63d03	350214	6356303	Dam	26.9994	960	2.8	2.8	40	0.2	-0.2	1335	3.9	3.9	50	0.3	-0.3
A64d01	350959	6355980	Dam	17.7712	260	2.4	2.4	20	0.4	< -0.1	365	3.4	3.4	30	0.6	< -0.1
A64d02	350842	6356248	Dam	36.5125	1010	2.7	2.6	50	0.3	-0.3	1410	3.7	3.6	70	0.4	-0.3
A64d03	350908	6356343	Dam	102.5528	1210	3.2	2.8	170	0.3	-1.3	1720	4.5	4.1	230	0.4	-1.7
A64d04	350895	6356512	Dam	31.1945	1150	2.4	2.2	40	0.3	-0.7	1630	3.2	2.9	50	0.4	-0.8
A64d05	350840	6356785	Dam	22.9131	1150	2.9	2.9	30	0.3	-0.3	1665	4.1	4.1	50	0.5	-0.4
A65d01	350413	6356828	Dam	69.1054	1375	3.1	1.3	110	0.5	-0.3	1985	4.5	1.9	150	0.8	-0.4
A65d02	350409	6356982	Dam	85.0923	1505	3.8	1.8	160	0.4	-1.1	2195	5.5	2.8	230	0.5	-1.5
A65d03	350002	6356915	Dam	36.0475	1375	3.0	0.9	50	0.4	-0.2	1990	4.3	1.4	80	0.6	-0.3
A70d01	346807	6358031	Dam	41.6626	220	0.9	0.9	20	< 0.1	< -0.1	360	1.3	1.3	30	0.1	-0.1
A70d02	347082	6357819	Dam	29.8231	45	0.4	0.4	10	< 0.1	< -0.1	85	0.7	0.7	10	< 0.1	< -0.1
A71d01	350063	6357369	Dam	35.6588	1405	3.0	1.5	50	0.4	-0.4	2090	4.3	2.3	80	0.6	-0.6
A71d02	350591	6357620	Dam	61.5467	680	3.9	3.9	120	0.4	-0.1	1020	5.8	5.8	180	0.5	-0.2
A72d01	350822	6357888	Dam	26.993	30	0.3	0.3	< 10	< 0.1	< -0.1	45	0.5	0.5	10	0.1	< -0.1
A72d02	350900	6357857	Dam	23.3028	< 20	0.3	0.3	< 10	< 0.1	< -0.1	30	0.5	0.5	10	0.1	< -0.1
A73d01	351003	6356047	Dam	22.9306	470	3.3	3.3	40	0.3	-0.2	655	4.4	4.4	50	0.4	-0.2
A73d02	350998	6357010	Dam	52.0298	445	2.7	2.7	70	0.3	< -0.1	670	4.1	4.1	110	0.5	< -0.1
A74d01	350902	6357306	Dam	71.2356	640	4.1	4.1	150	0.4	-0.5	965	6.1	6.1	220	0.6	-0.7
A77d01	351216	6357053	Dam	36.235	85	0.6	0.6	10	< 0.1	< -0.1	130	0.8	0.8	10	< 0.1	< -0.1
A77d03	351445	6356620	Dam	58.5117	45	0.4	0.4	10	< 0.1	< -0.1	70	0.5	0.5	20	< 0.1	< -0.1
A77d04	351493	6356583	Dam	36.1057	35	0.3	0.3	< 10	< 0.1	< -0.1	50	0.4	0.4	10	< 0.1	< -0.1
A77d05	351392	6356389	Dam	38.0639	100	0.8	0.8	10	0.1	< -0.1	145	1.1	1.1	20	0.1	< -0.1
A83d01	351340	6356182	Dam	51.4939	190	1.6	1.6	40	0.3	-0.2	270	2.2	2.2	60	0.4	-0.2
A85d01	351462	6355872	Dam	56.3615	20	0.2	0.2	10	< 0.1	< -0.1	30	0.3	0.3	10	< 0.1	< -0.1
A85d02	351606	6355926	Dam	12.8023	< 20	0.1	0.1	< 10	< 0.1	< -0.1	<20	0.1	0.1	< 10	< 0.1	< -0.1
A90d01	351319	6355686	Dam	9.1423	< 20	< 0.1	< 0.1	< 10	< 0.1	< -0.1	<20	< 0.1	< 0.1	< 10	< 0.1	< -0.1
A91d01	351512	6355712	Dam	122.3716	< 20	< 0.1	< 0.1	< 10	< 0.1	< -0.1	<20	0.1	0.1	10	< 0.1	< -0.1
A97d01	351355	6356003	Dam	49.7632	80	0.7	0.7	20	< 0.1	< -0.1	115	1.0	1.0	20	0.1	< -0.1

APPENDIX H. FIGURES (PREDICTED SUBSIDENCE PARAMETERS)

Predicted Profiles of Systematic Subsidence, Tilt and Strain along Prediction Line A Resulting from the Extraction of Longwall A6

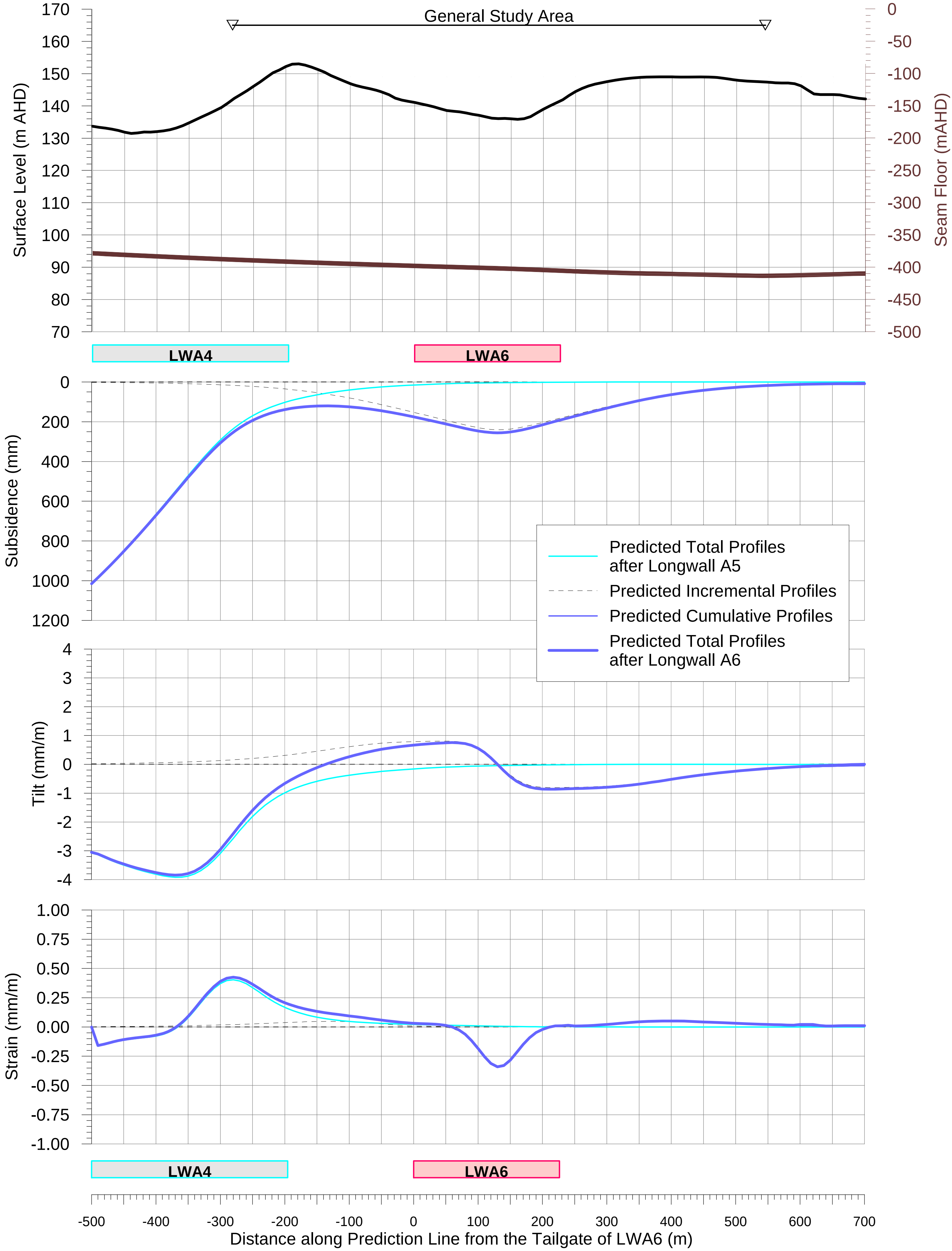

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Fig. H.01

Predicted Profiles of Systematic Subsidence, Tilt and Strain along Prediction Line B Resulting from the Extraction of Longwalls A7 to A17

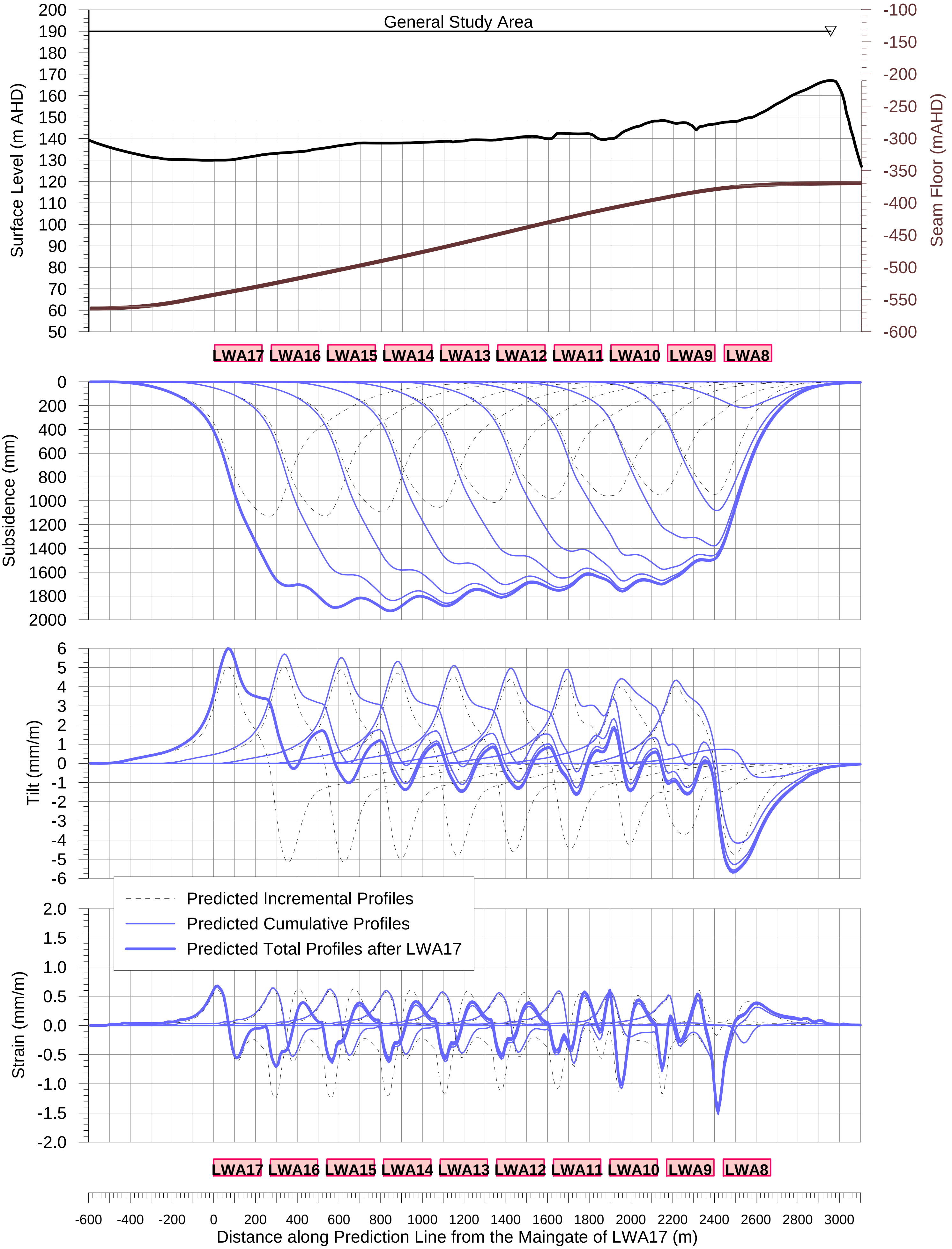

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Fig. H.02

Predicted Profiles of Subsidence, Upsidence and Closure along Cony Creek Resulting from the Extraction of Longwalls A3 to A17

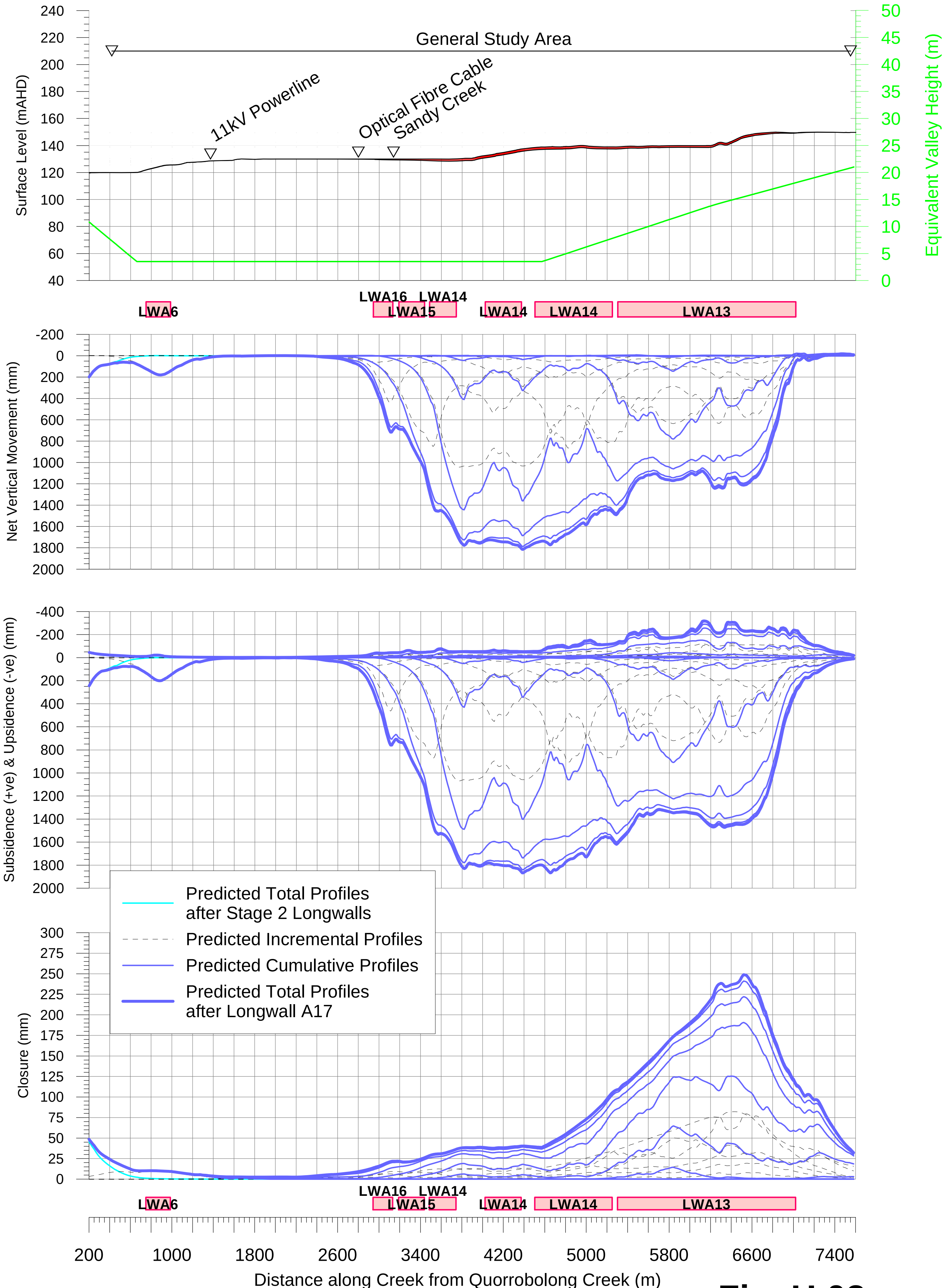

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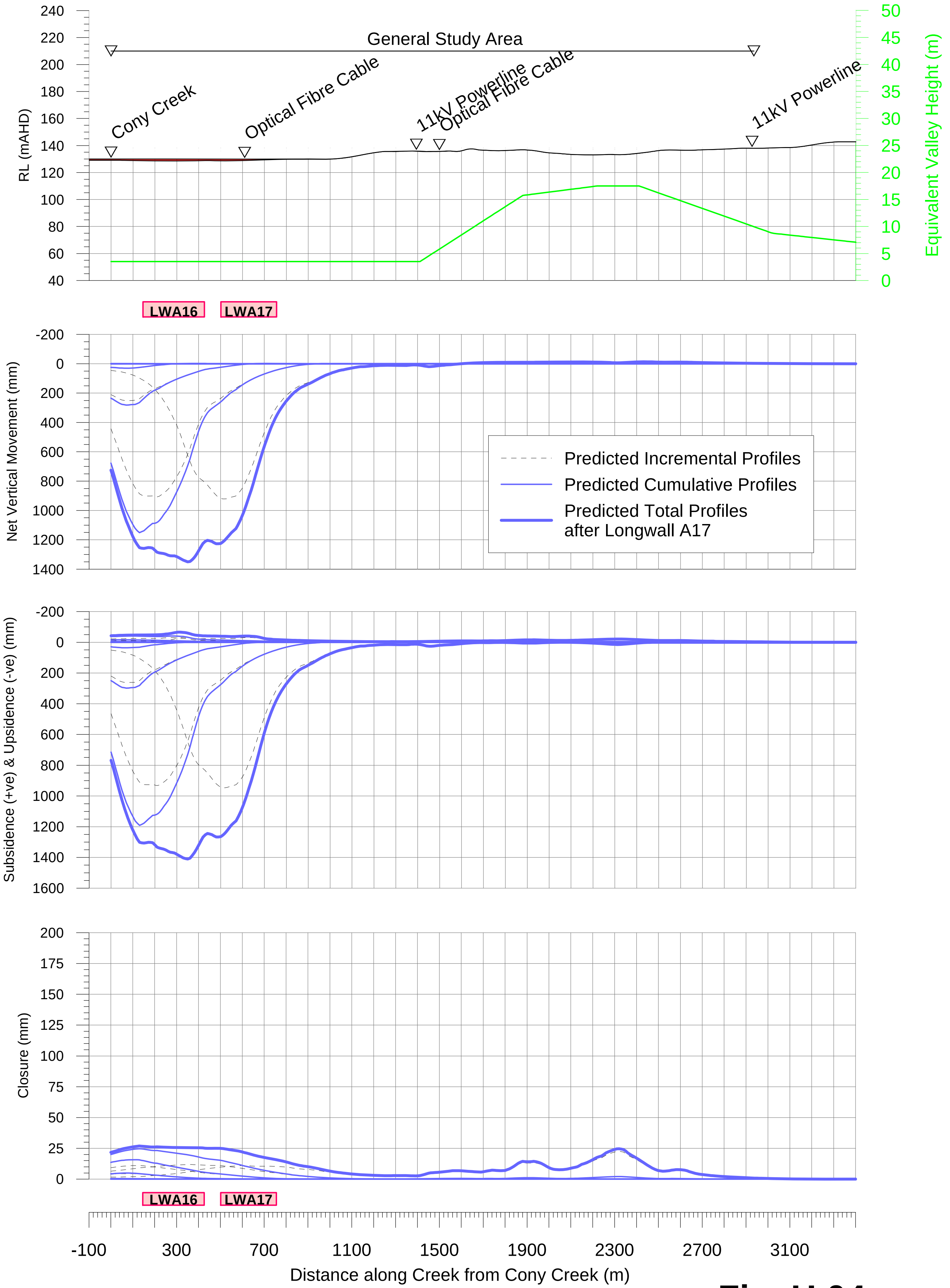
Fig. H.03

Predicted Profiles of Subsidence, Upsidence and Closure along Sandy Creek Resulting from the Extraction of Longwalls A6 to A17



Predicted Profiles of Systematic Subsidence, Tilt and Strain along Sandy Creek Road Resulting from the Extraction of Longwalls A6 to A17

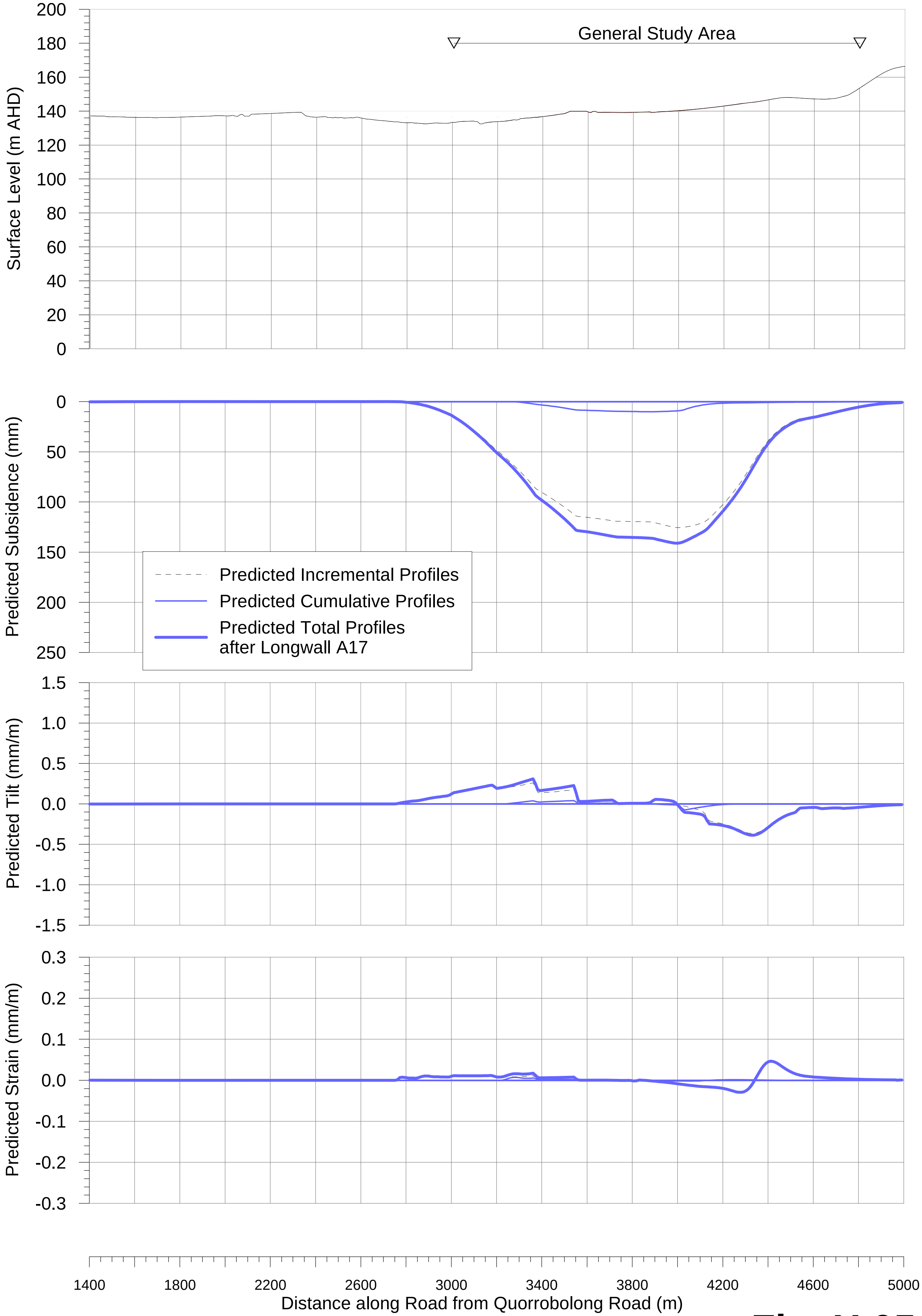


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Fig. H.05

Predicted Profiles of Systematic Subsidence, Tilt and Strain along Quorrobolong Road Resulting from the Extraction of Longwalls A6 to A17

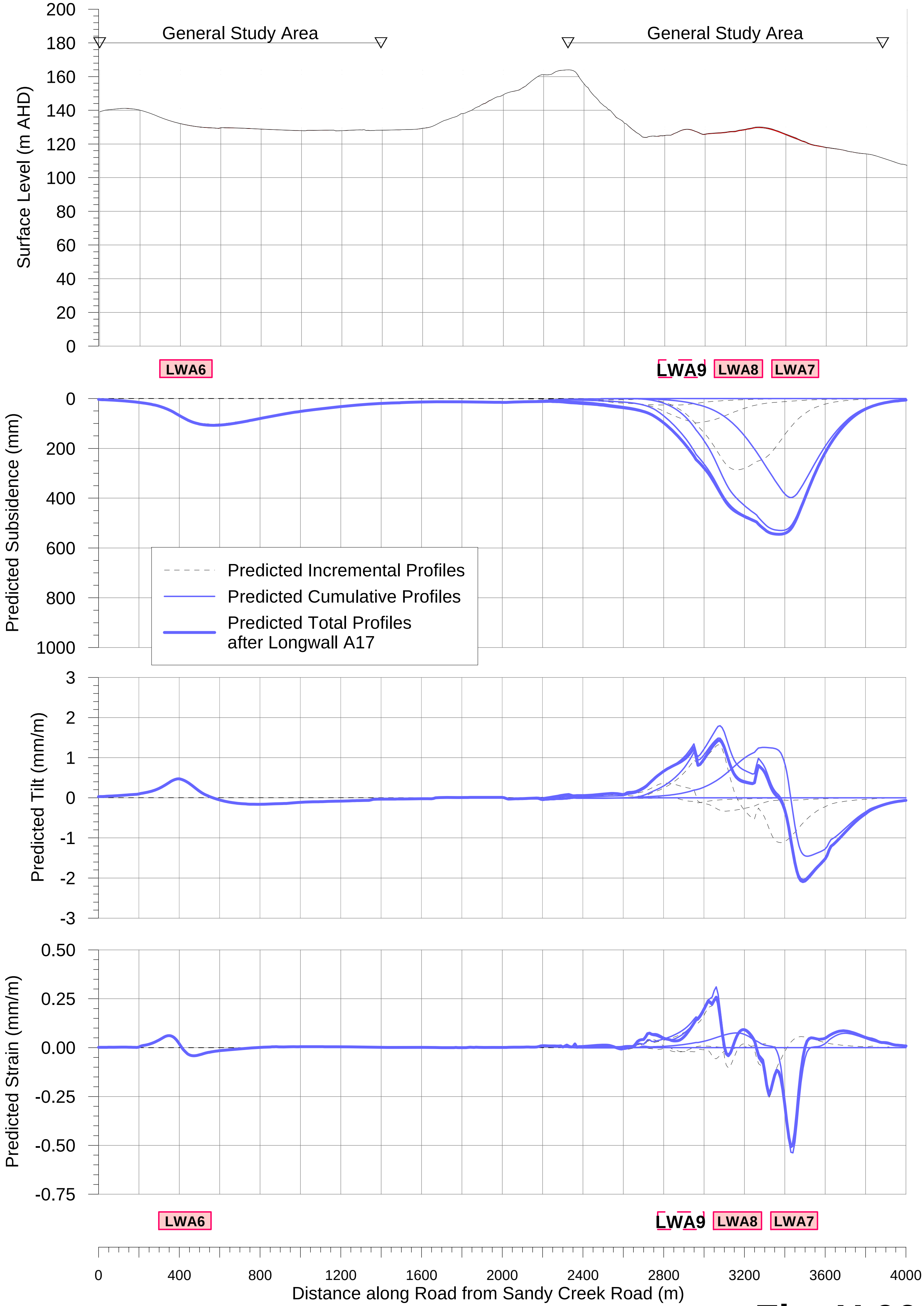

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Fig. H.06

Predicted Profiles of Systematic Subsidence, Tilt and Strain along Coney Creek Road and Nash Lane Resulting from the Extraction of Longwalls A3 to A17

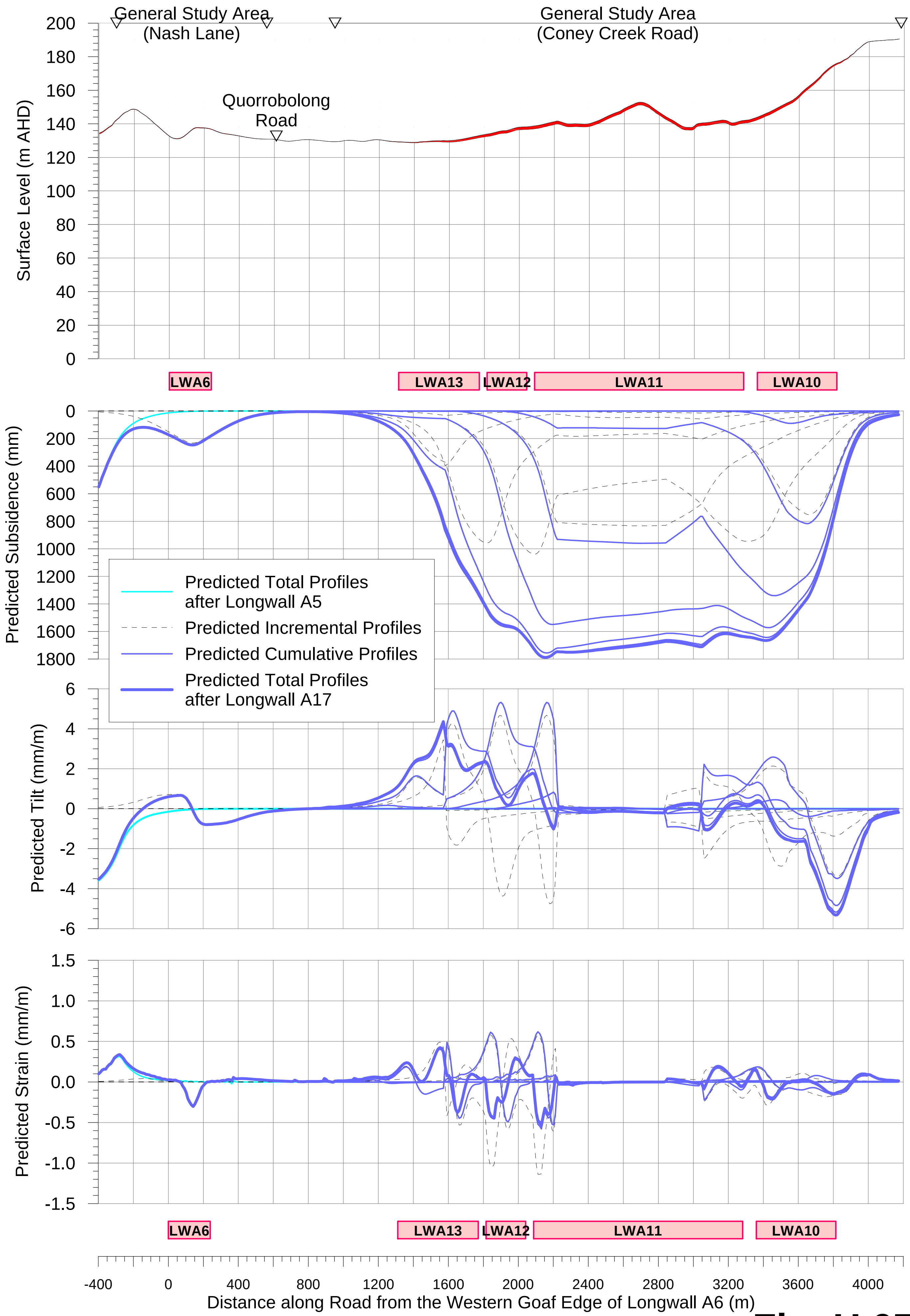

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Fig. H.07

Predicted Profiles of Systematic Subsidence, Tilt and Strain along Pelton Fire Trail and Big Hill Road Resulting from the Extraction of Longwalls A6 to A17

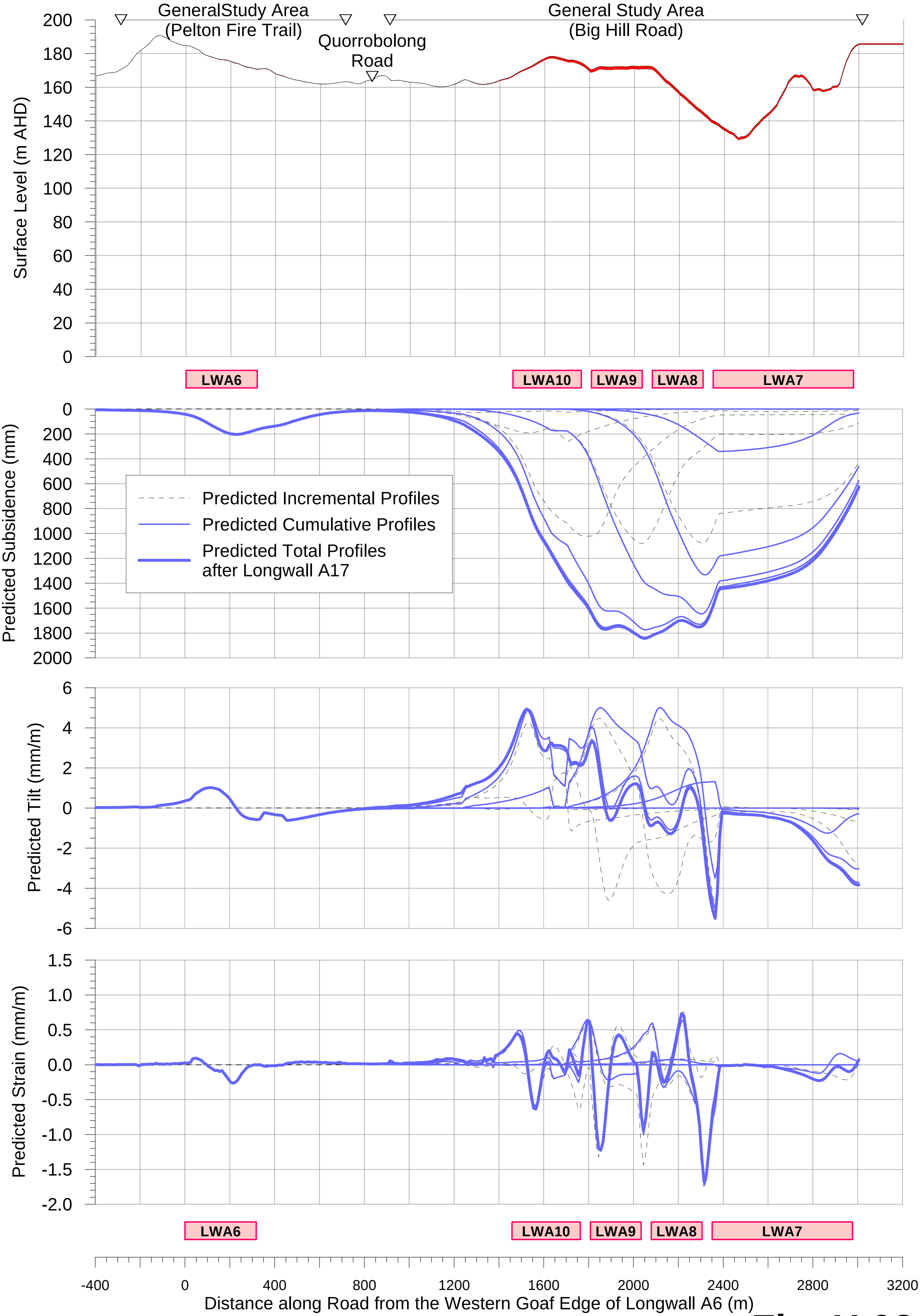
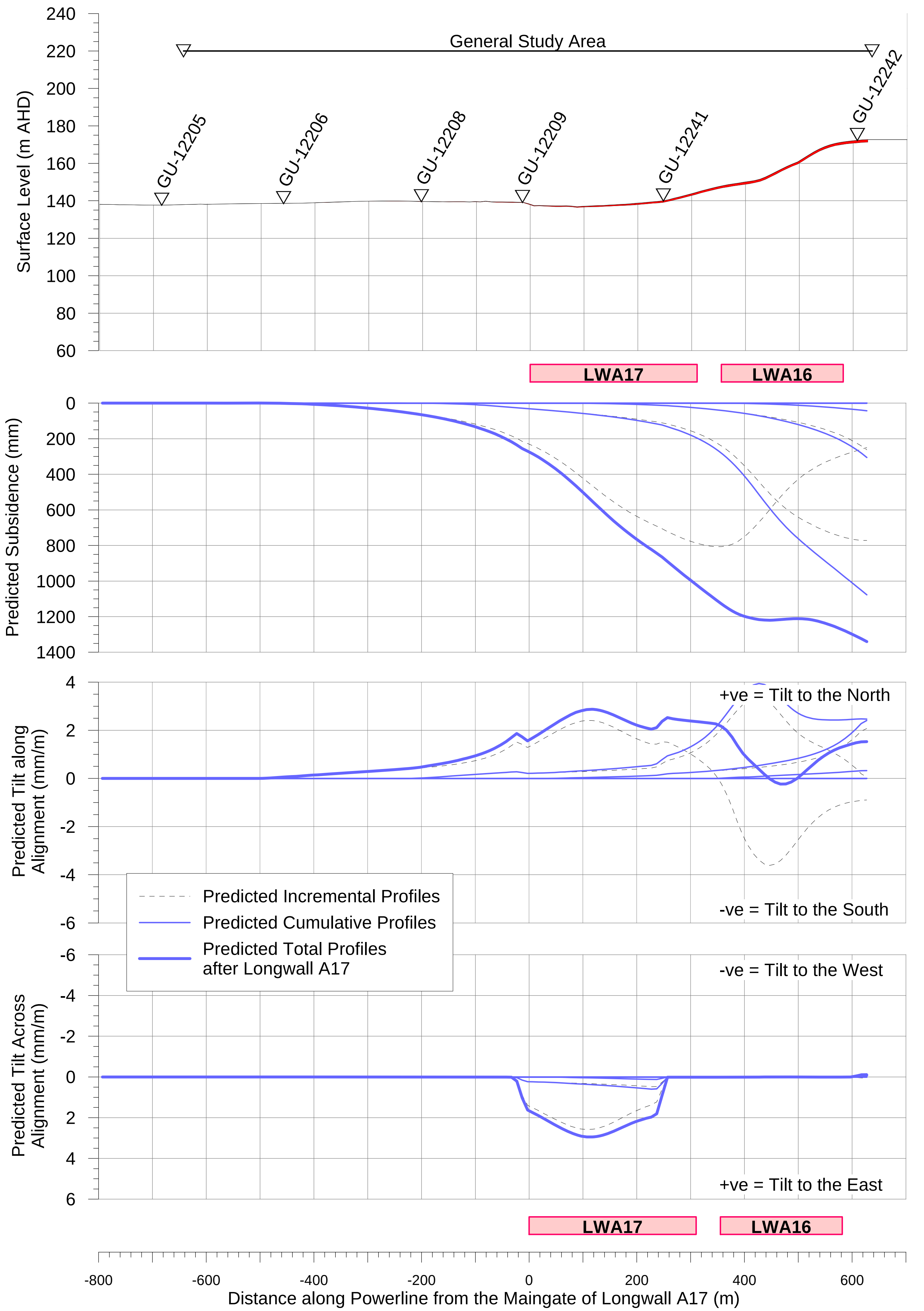
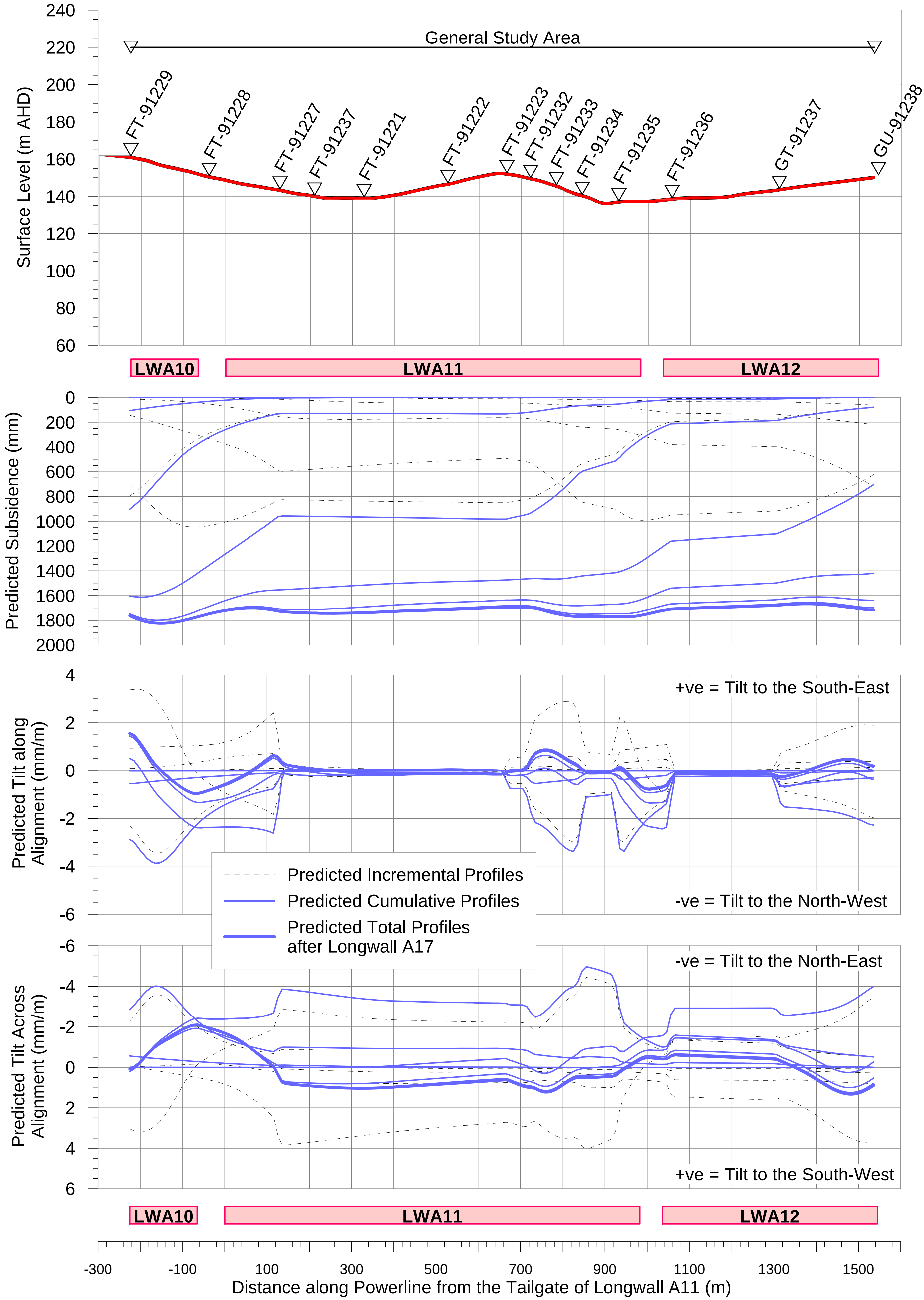


Fig. H.08

Predicted Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 11 kV Powerline Branch 1 Resulting from Longwalls A6 to A17



Predicted Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 11 kV Powerline Branch 2 Resulting from Longwalls A6 to A17



Predicted Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 11 kV Powerline Branch 3 Resulting from Longwalls A6 to A17

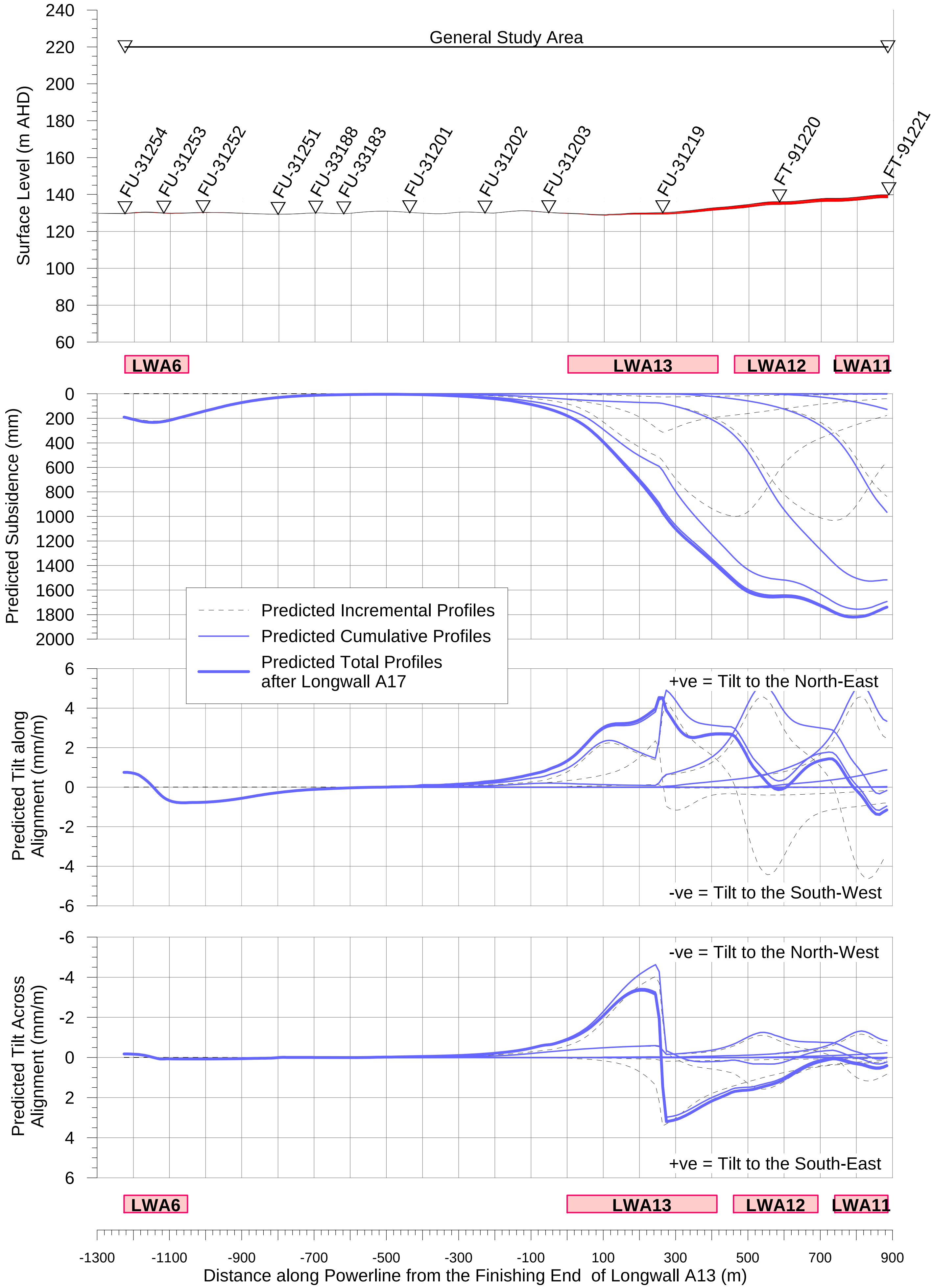


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Fig. H.11

Predicted Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 11 kV Powerline Branch 4 Resulting from Longwalls A6 to A17

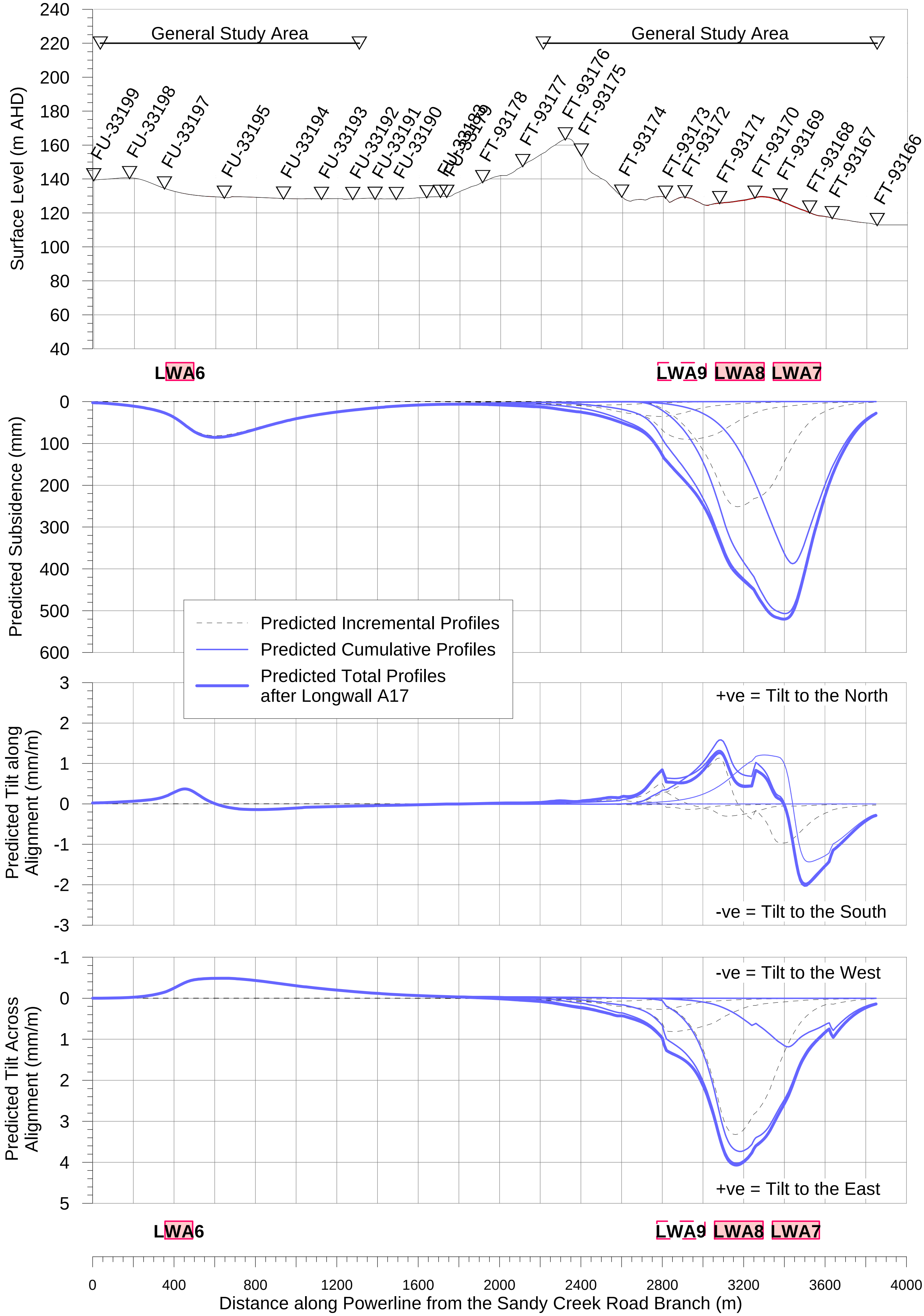

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Fig. H.12

Predicted Profiles of Systematic Subsidence, Tilt and Strain along the Optical Fibre Cable Resulting from the Extraction of Longwalls A6 to A17

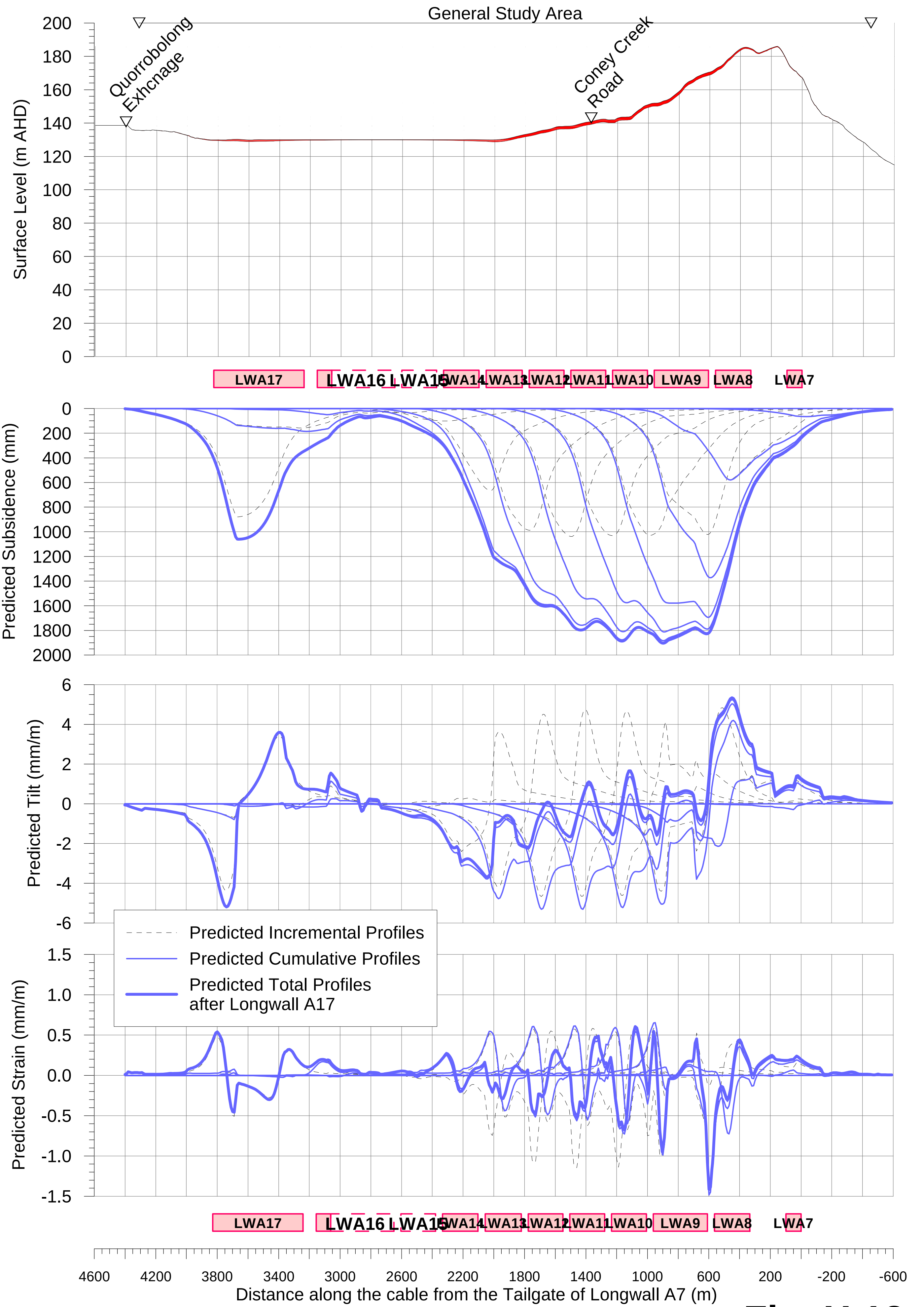

Fig. H.13

APPENDIX I. FIGURES (UPPERBOUND SUBSIDENCE PARAMETERS)

Upperbound Profiles of Systematic Subsidence, Tilt and Strain along Prediction Line A Resulting from the Extraction of Longwall A6

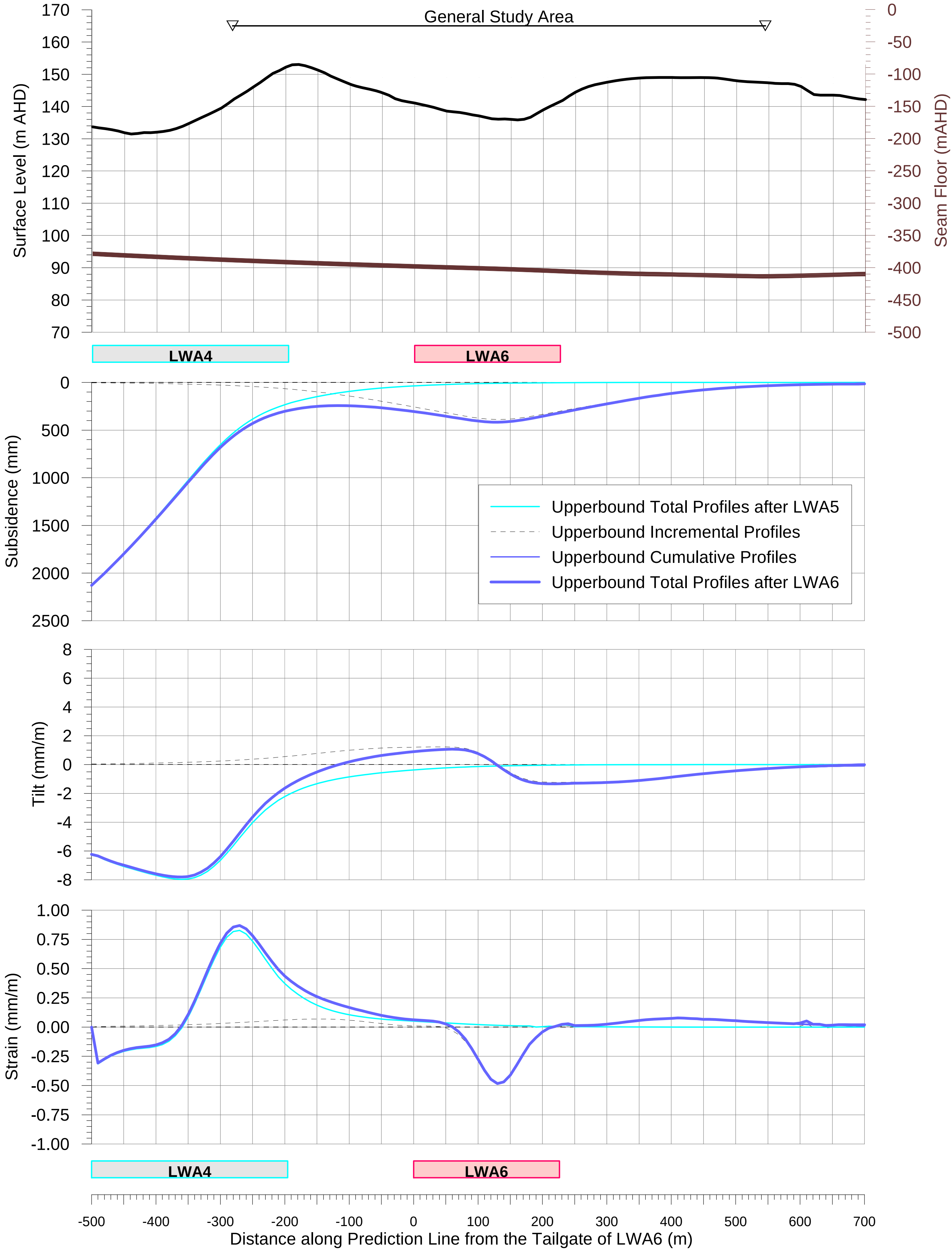

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Fig. I.01

Upperbound Profiles of Systematic Subsidence, Tilt and Strain along Prediction Line B Resulting from the Extraction of Longwalls A7 to A17

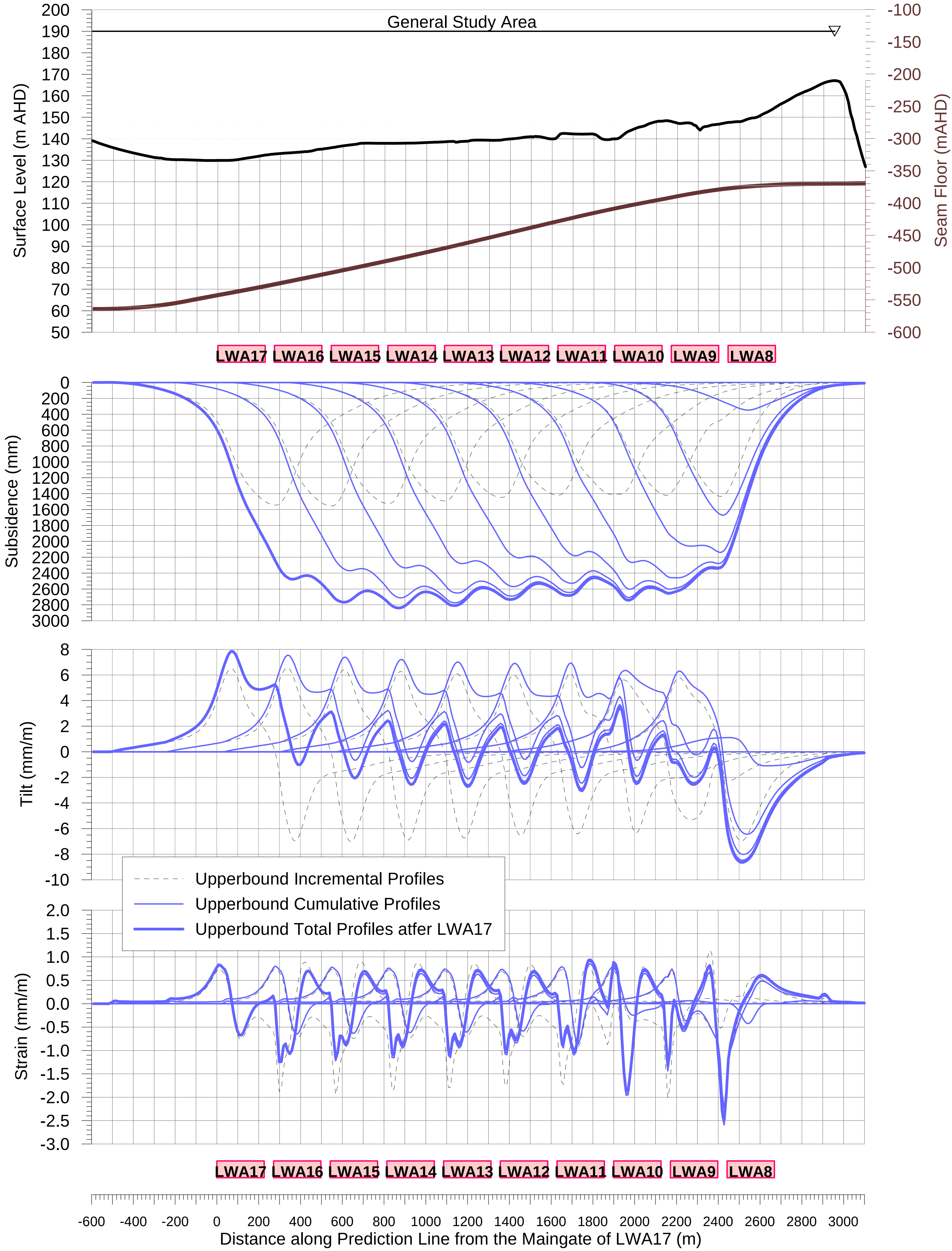

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Fig. I.02

Upperbound Profiles of Subsidence, Upsidence and Closure along Cony Creek Resulting from the Extraction of Longwalls A3 to A17

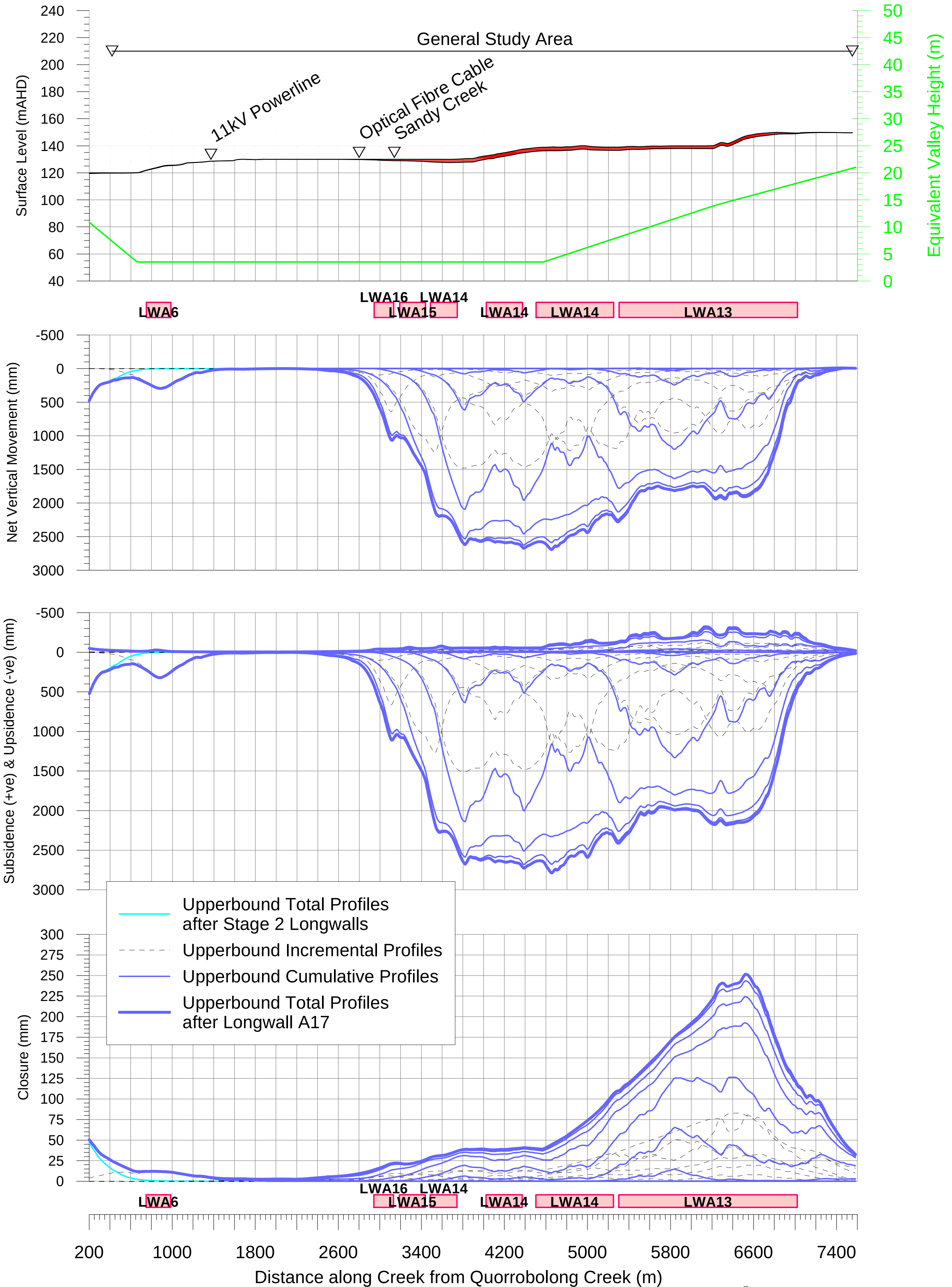

Fig. I.03

Upperbound Profiles of Subsidence, Upsidence and Closure along Sandy Creek Resulting from the Extraction of Longwalls A6 to A17

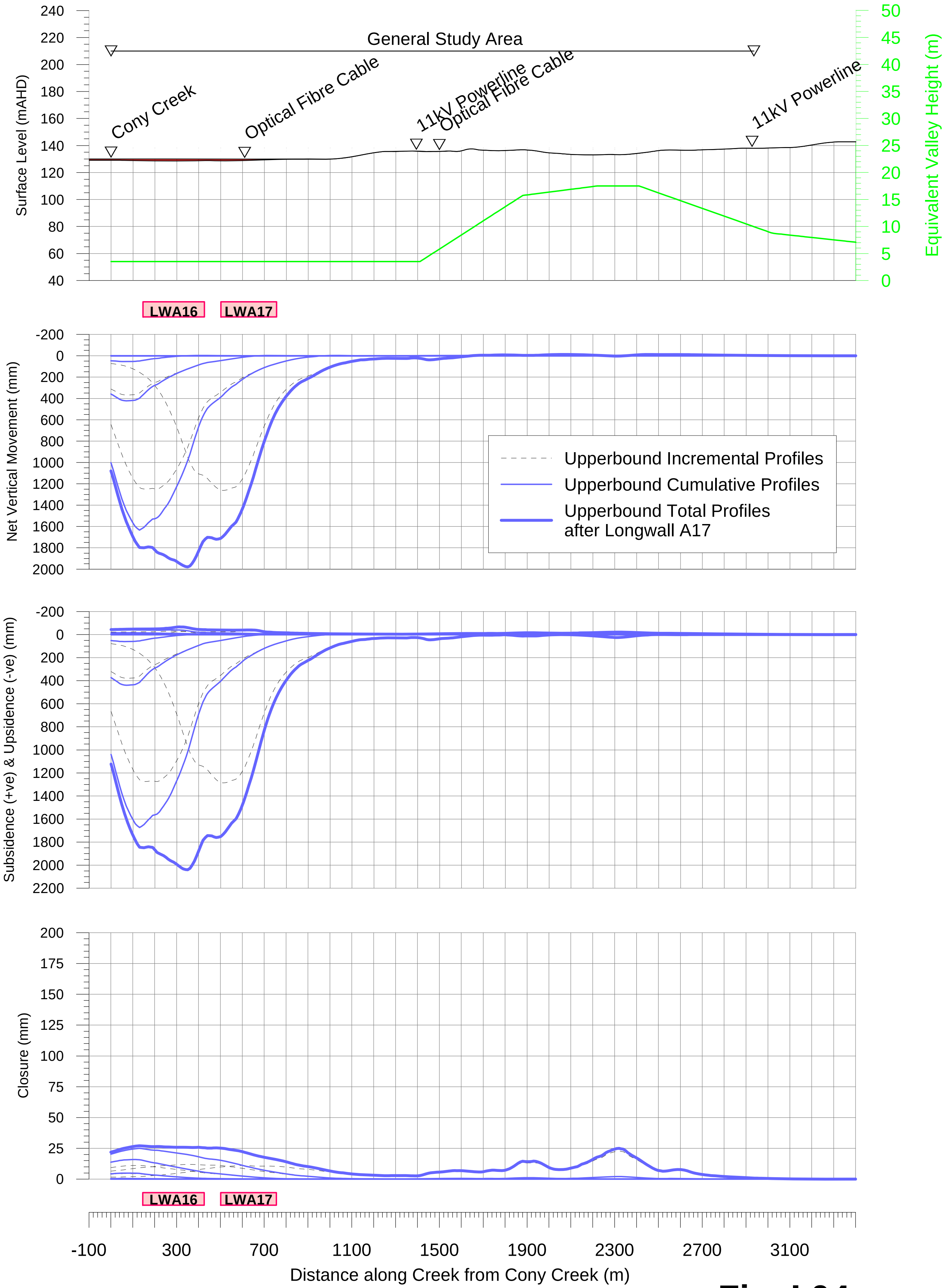

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Fig. I.04

Upperbound Profiles of Systematic Subsidence, Tilt and Strain along Sandy Creek Road Resulting from the Extraction of Longwalls A6 to A17

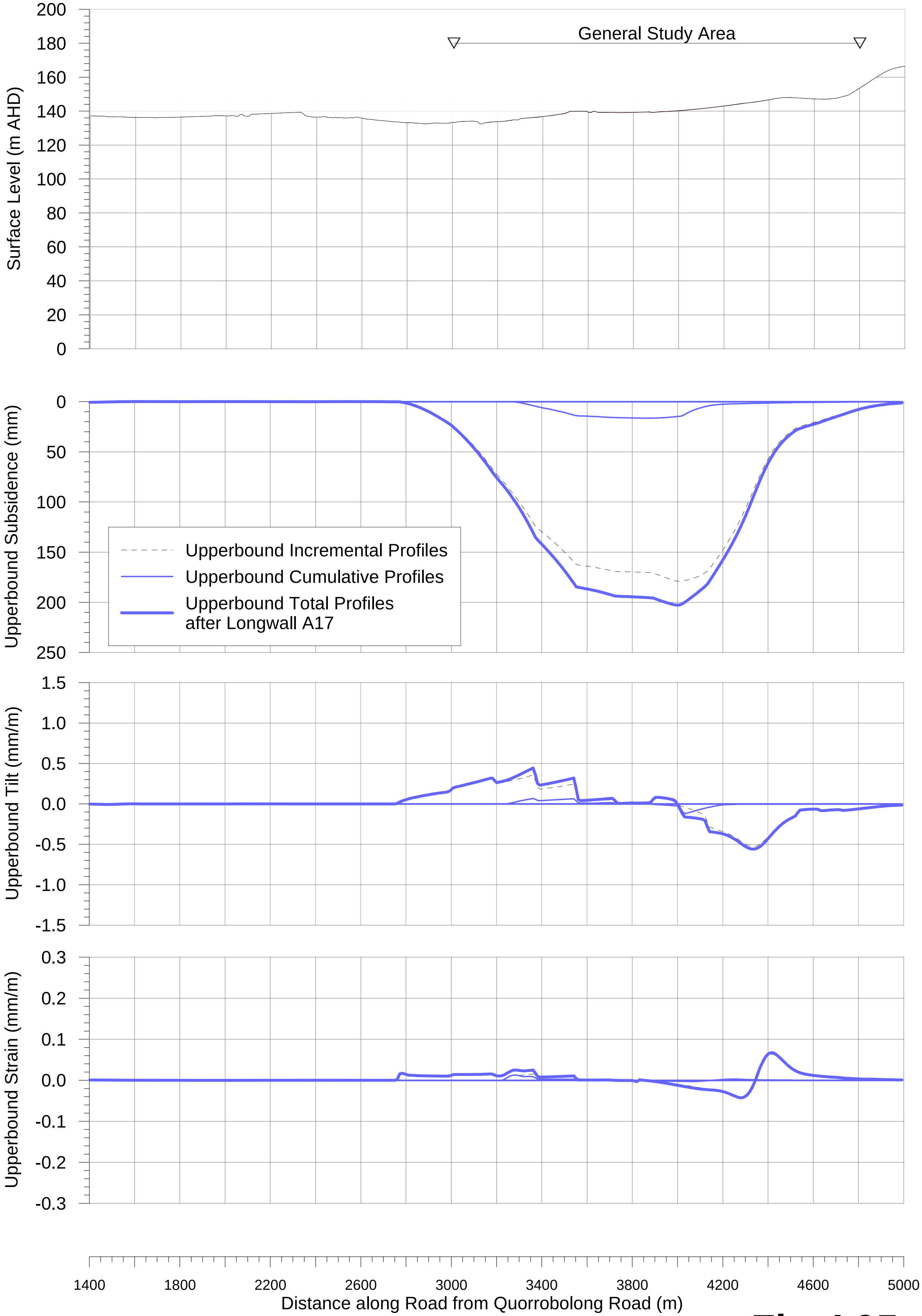

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Fig. I.05

Upperbound Profiles of Systematic Subsidence, Tilt and Strain along Quorrobolong Road Resulting from the Extraction of Longwalls A6 to A17

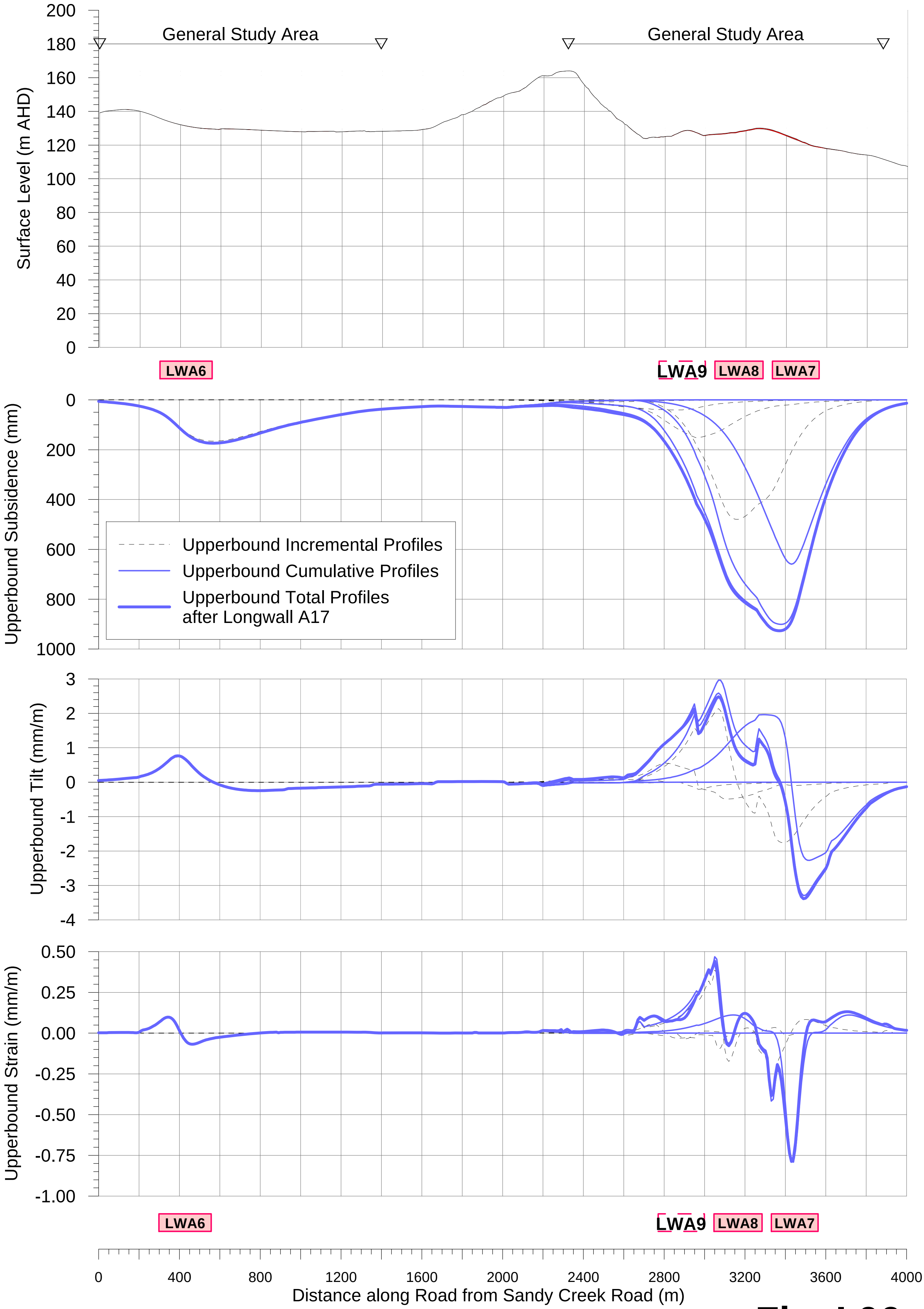

Fig. I.06

Upperbound Profiles of Systematic Subsidence, Tilt and Strain along Coney Creek Road and Nash Lane Resulting from the Extraction of Longwalls A3 to A17

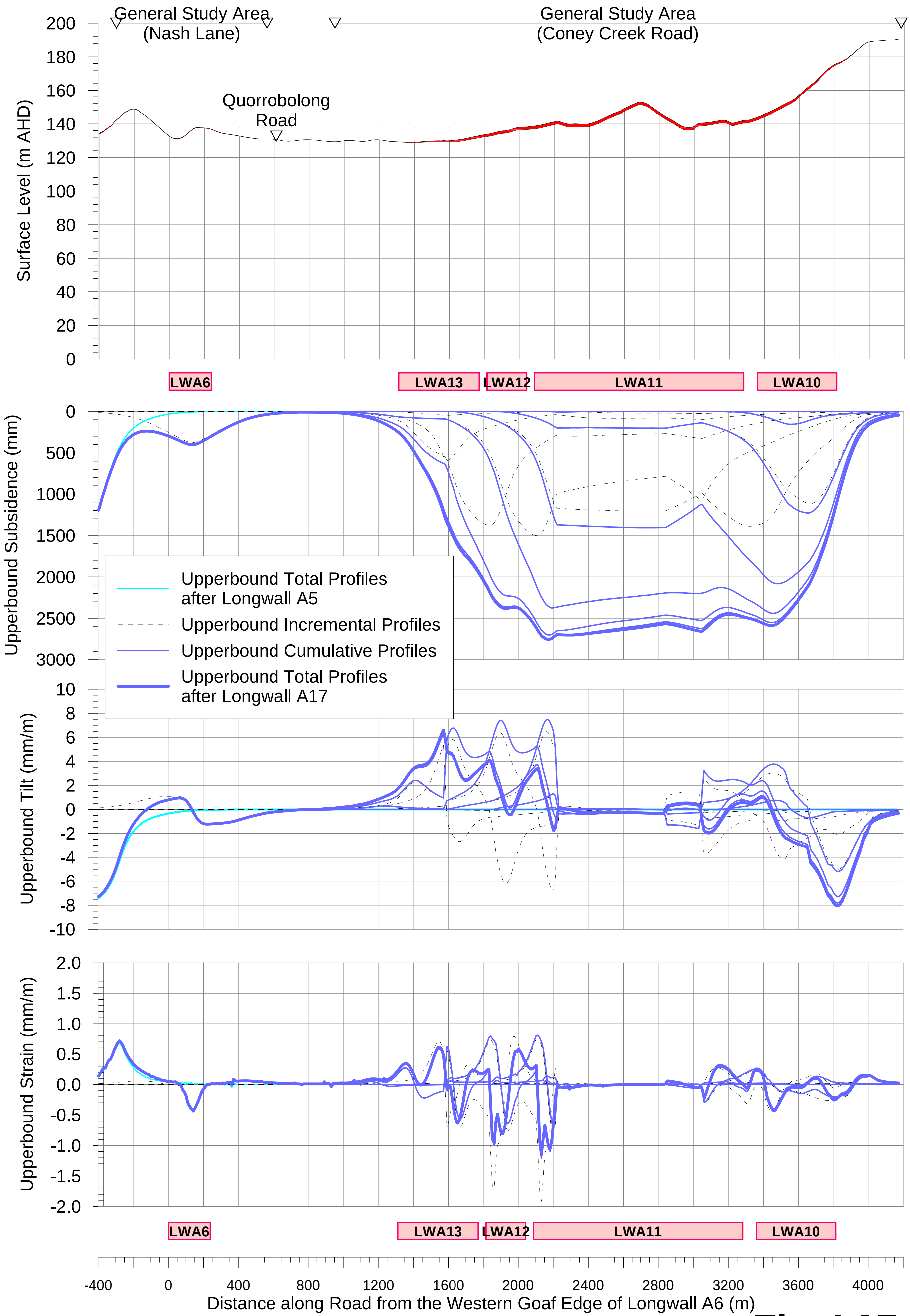

Fig. I.07

Upperbound Profiles of Systematic Subsidence, Tilt and Strain along Pelton Fire Trail and Big Hill Road Resulting from the Extracion of Longwalls A6 to A17

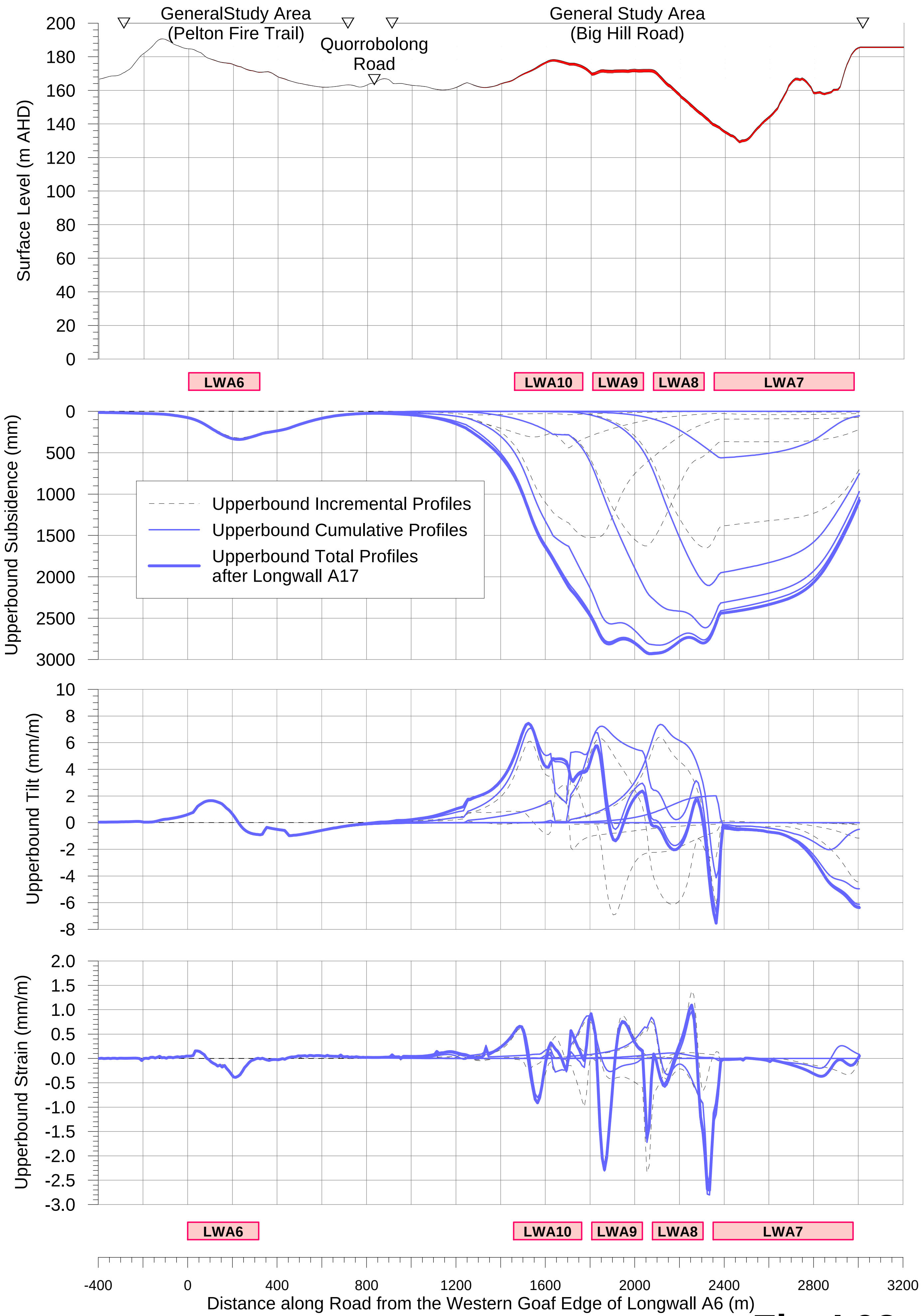

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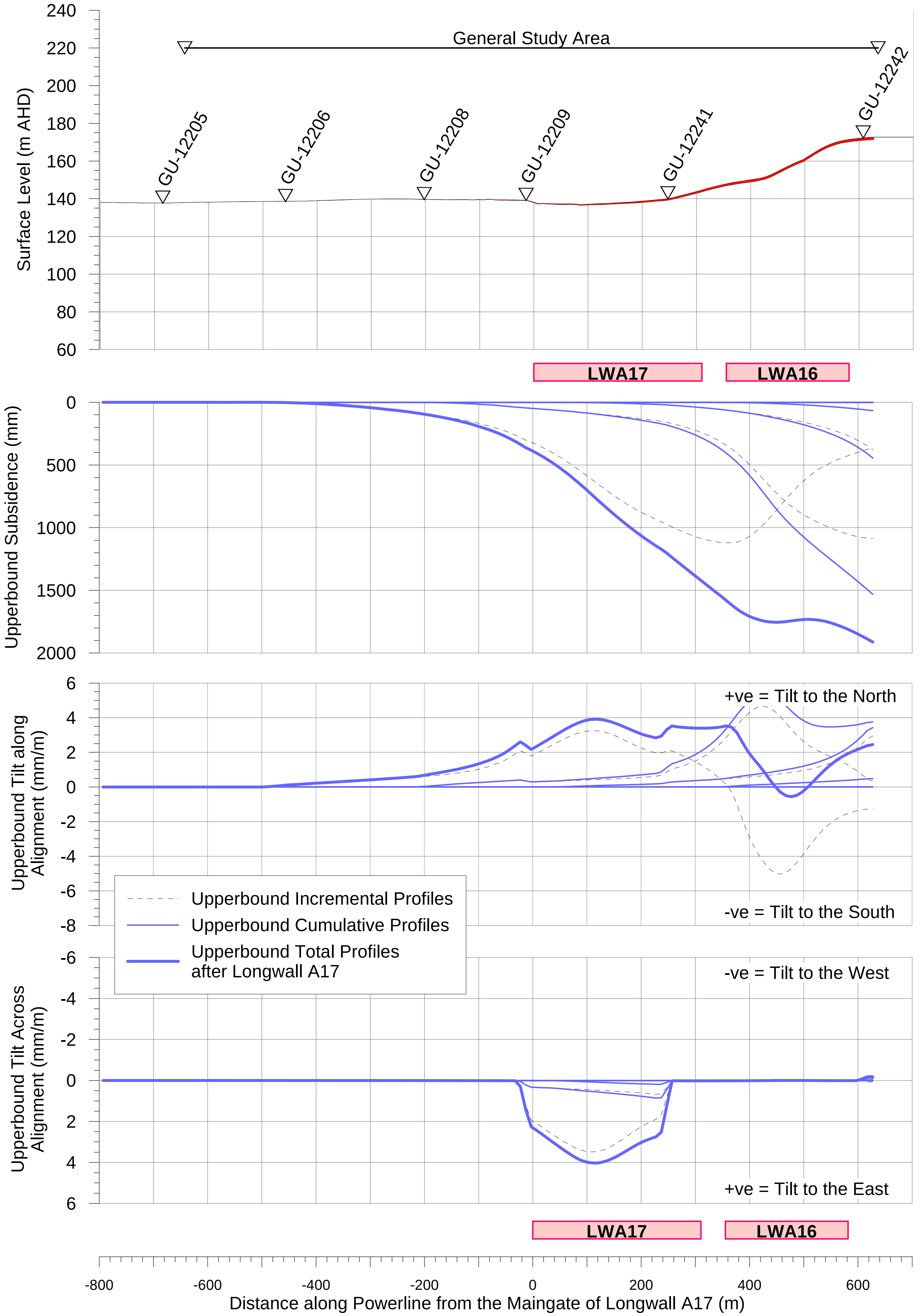
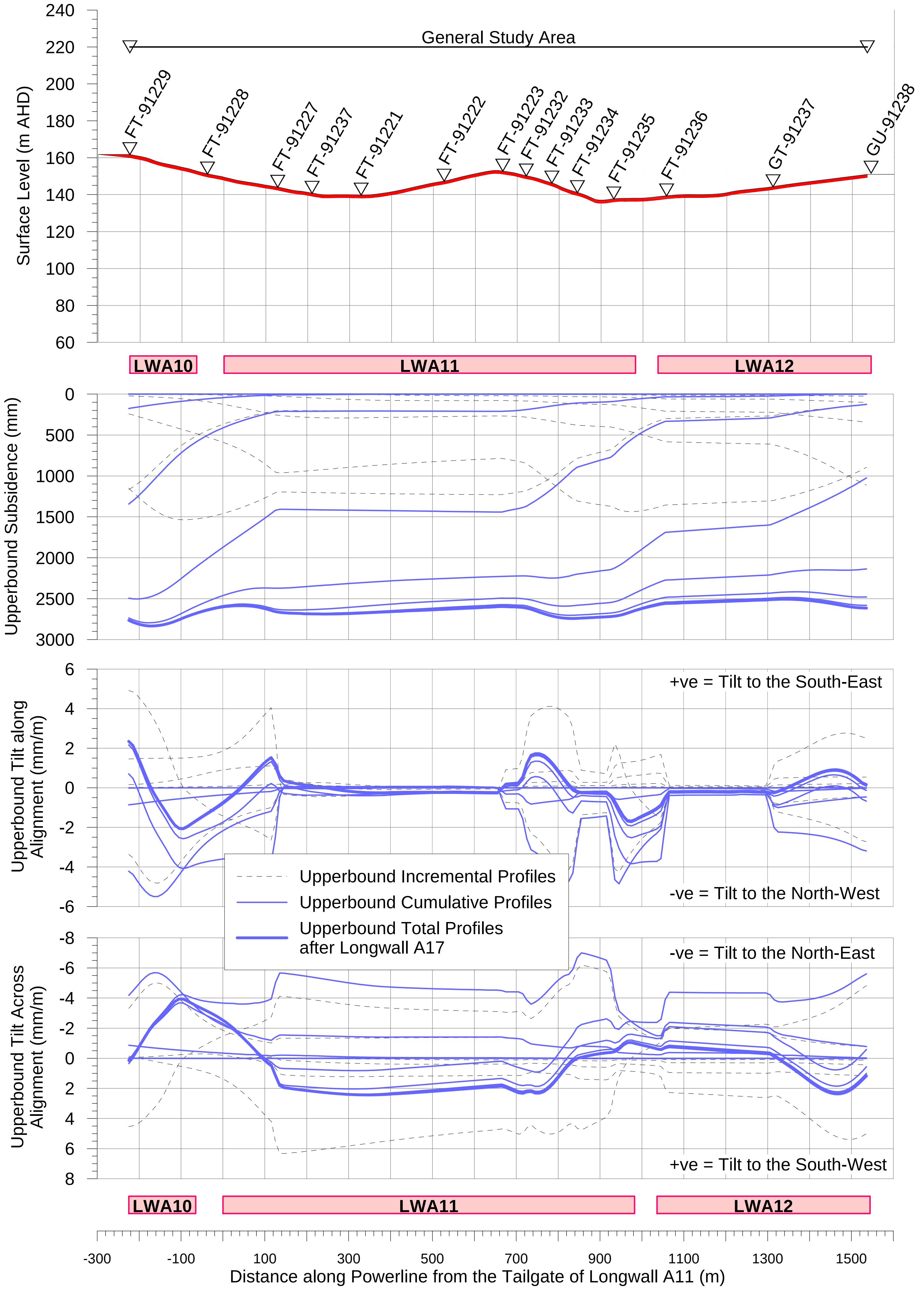
Fig. I.08

Upperbound Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 11 kV Powerline Branch 1 Resulting from Longwalls A6 to A17



Upperbound Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 11 kV Powerline Branch 2 Resulting from Longwalls A6 to A17



Upperbound Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 11 kV Powerline Branch 3 Resulting from Longwalls A6 to A17

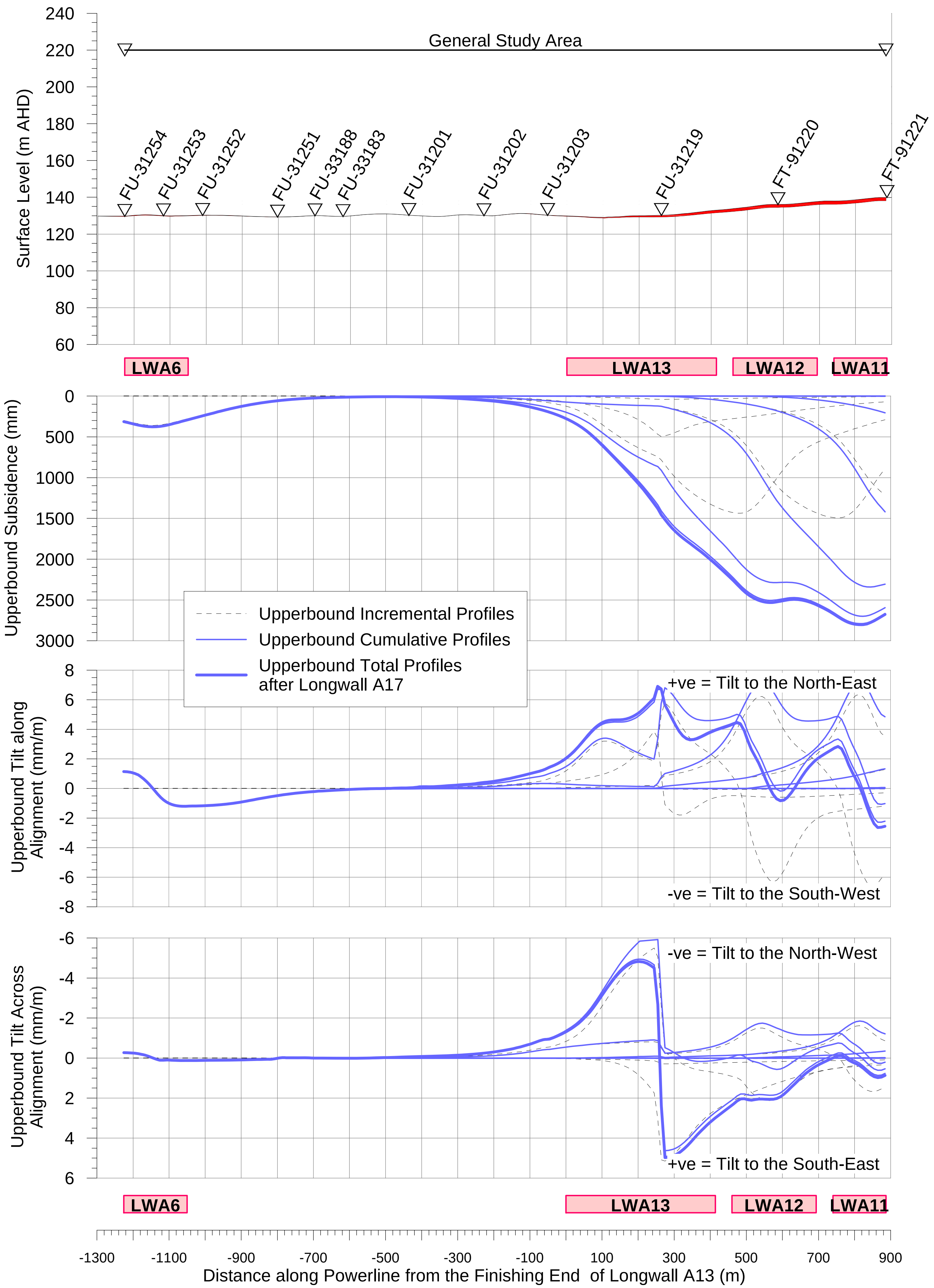


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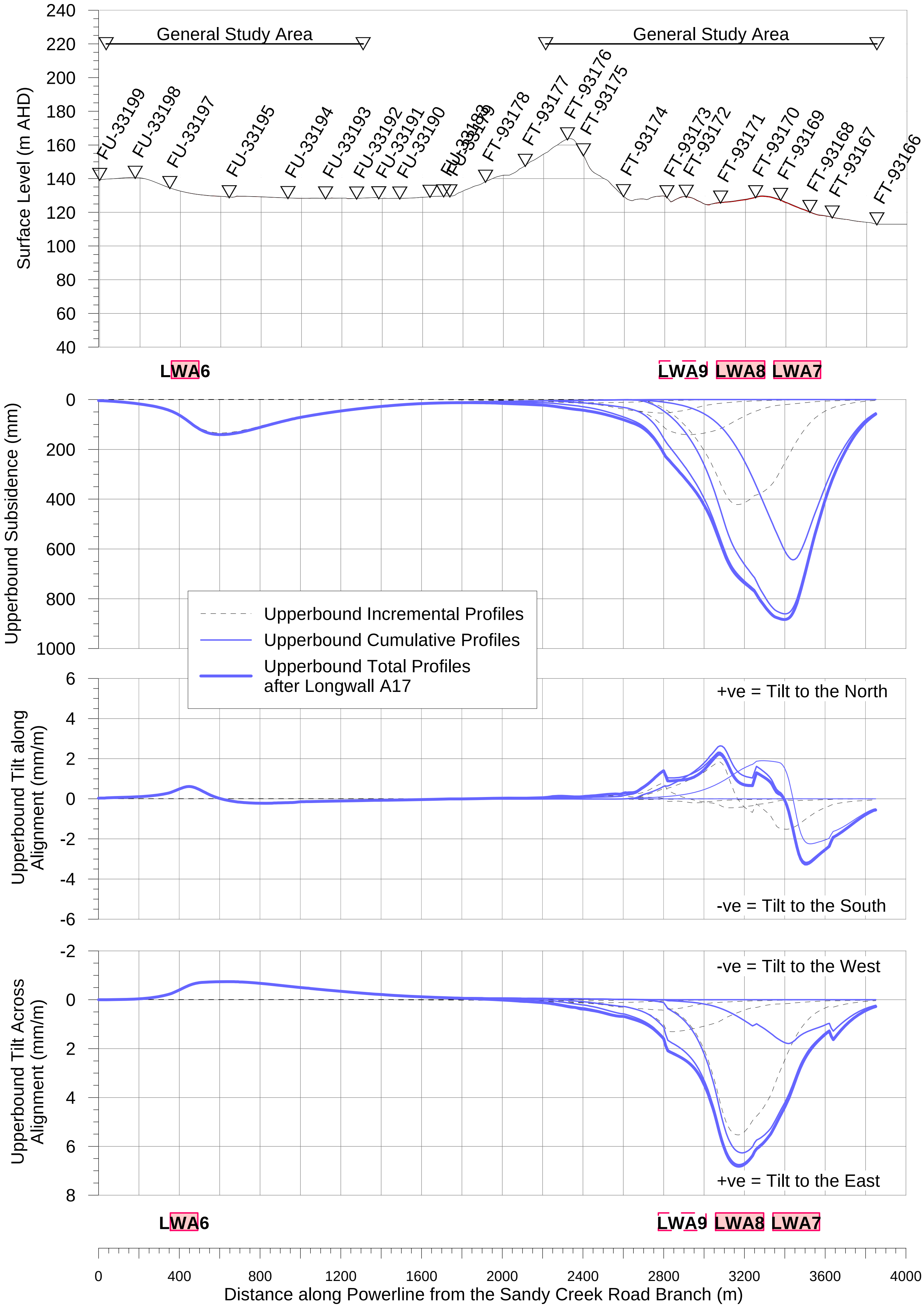
Fig. I.11

Upperbound Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 11 kV Powerline Branch 4 Resulting from Longwalls A6 to A17



Upperbound Profiles of Systematic Subsidence, Tilt and Strain along the Optical Fibre Cable Resulting from the Extraction of Longwalls A6 to A17

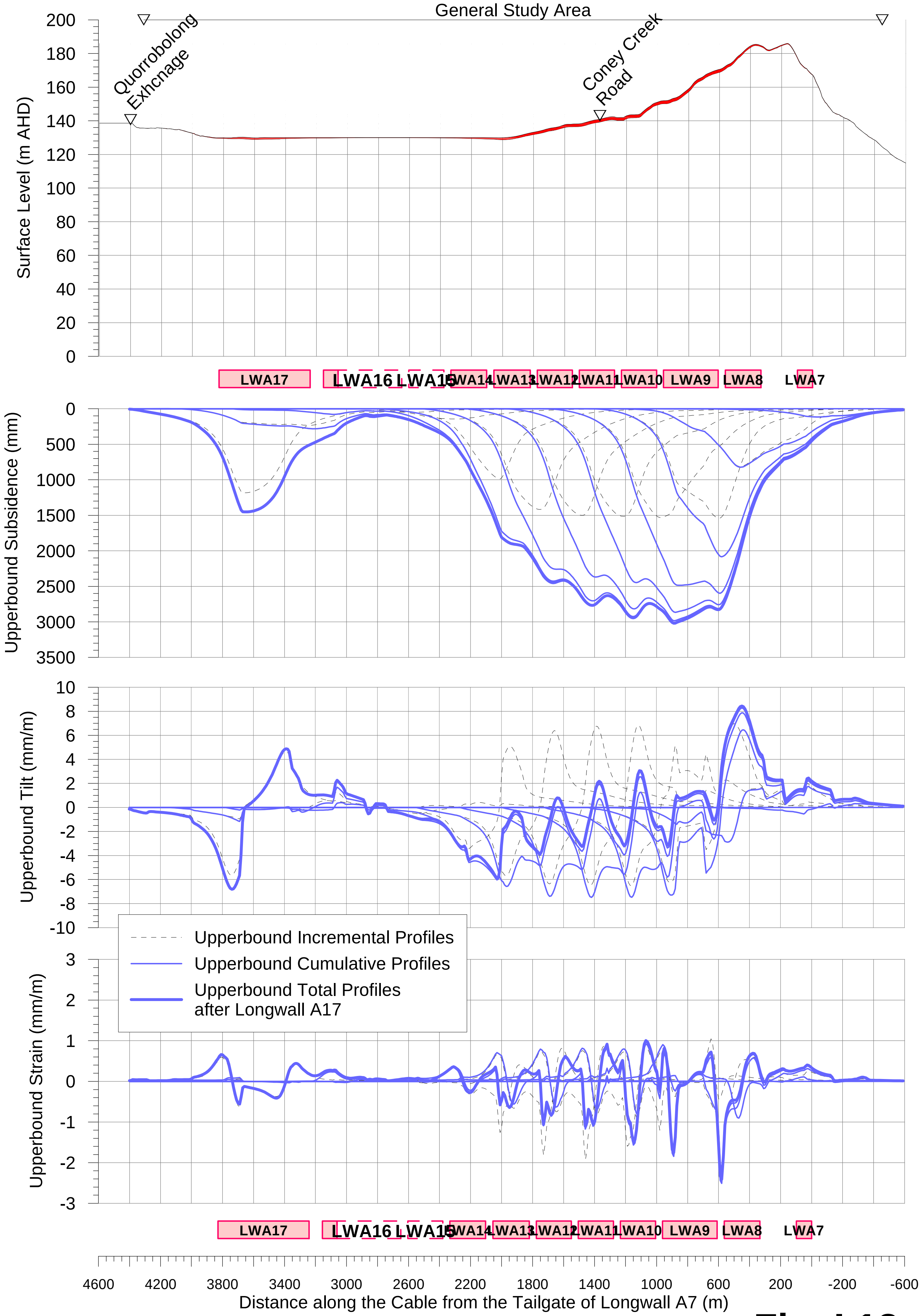
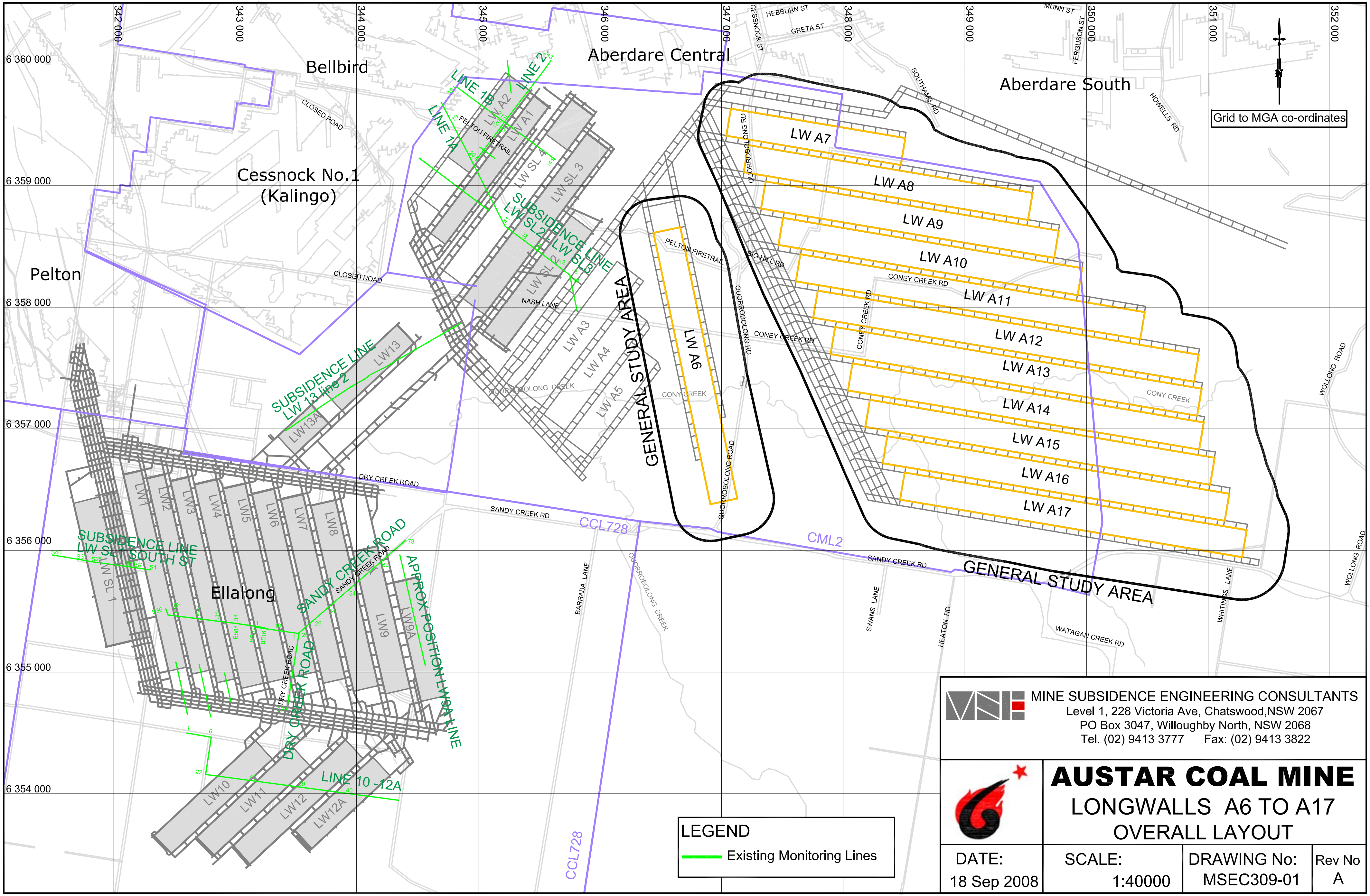


Fig. I.13

APPENDIX J. DRAWINGS



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AUSTAR COAL MINE LONGWALLS A6 TO A17 OVERALL LAYOUT			
DATE: 18 Sep 2008	SCALE: 1:40000	DRAWING No: MSEC309-01	Rev No A

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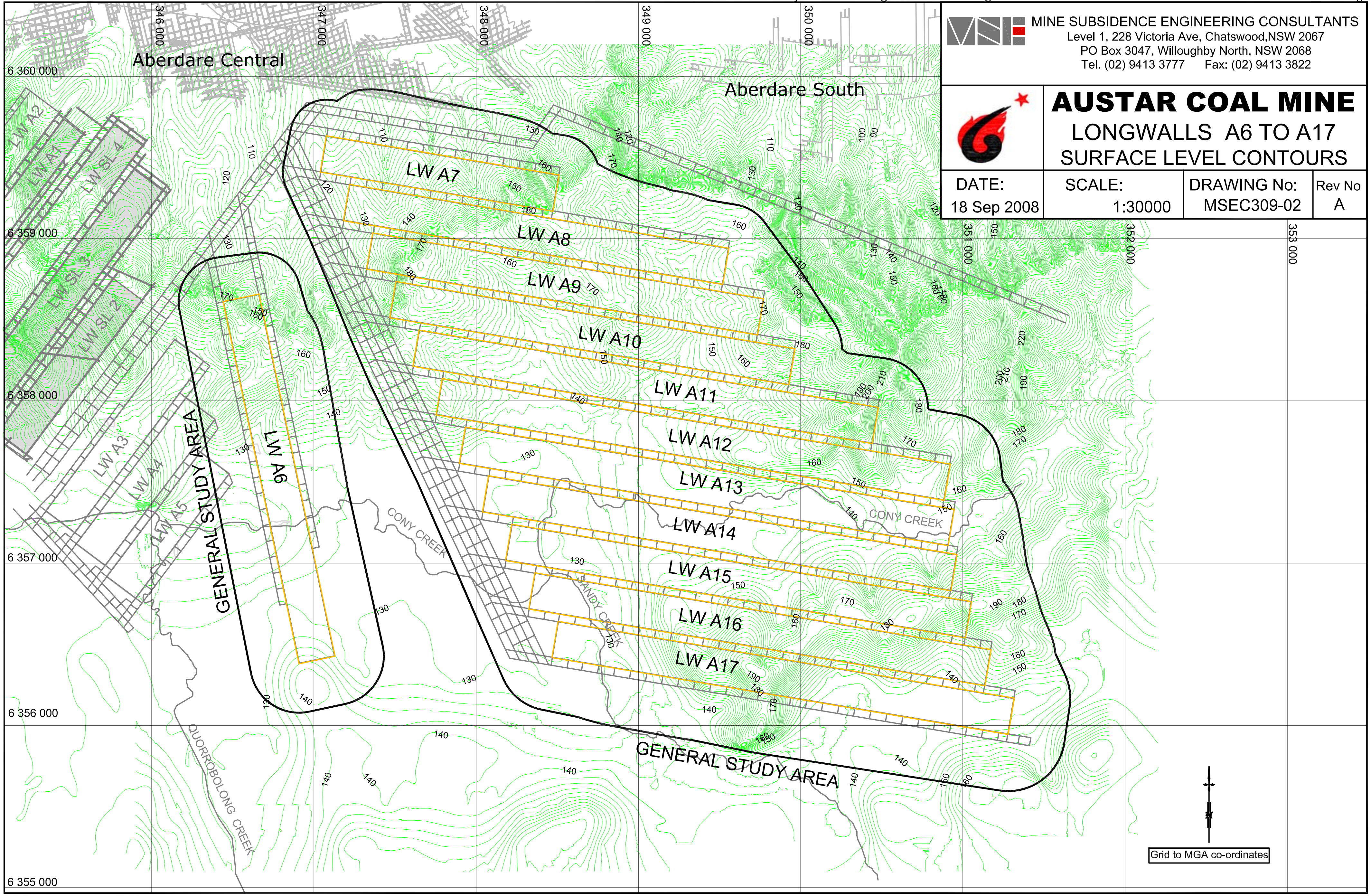

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LONGWALLS A6 TO A17
SURFACE LEVEL CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-02	A

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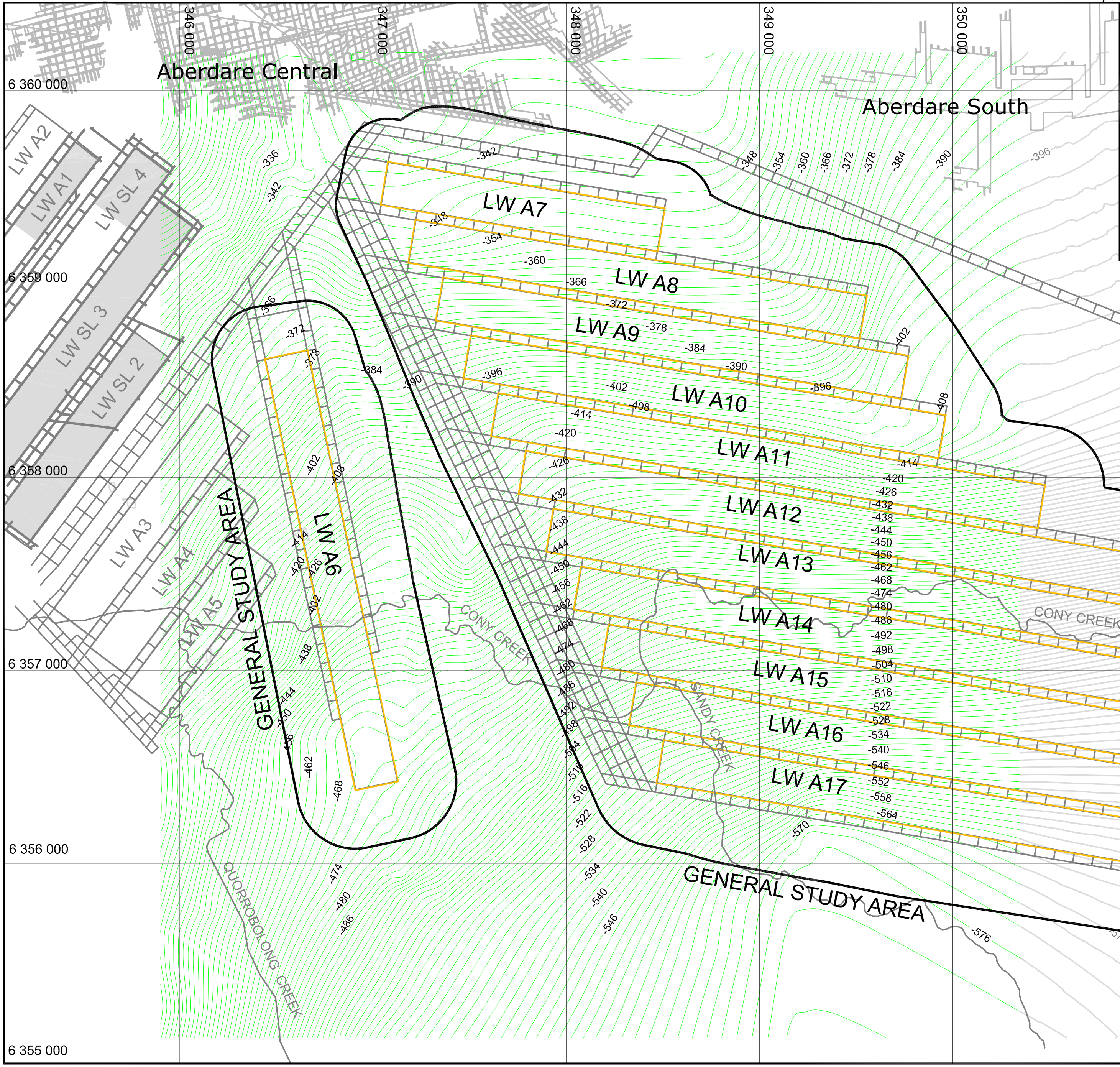

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LONGWALLS A6 TO A17
SEAM FLOOR CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
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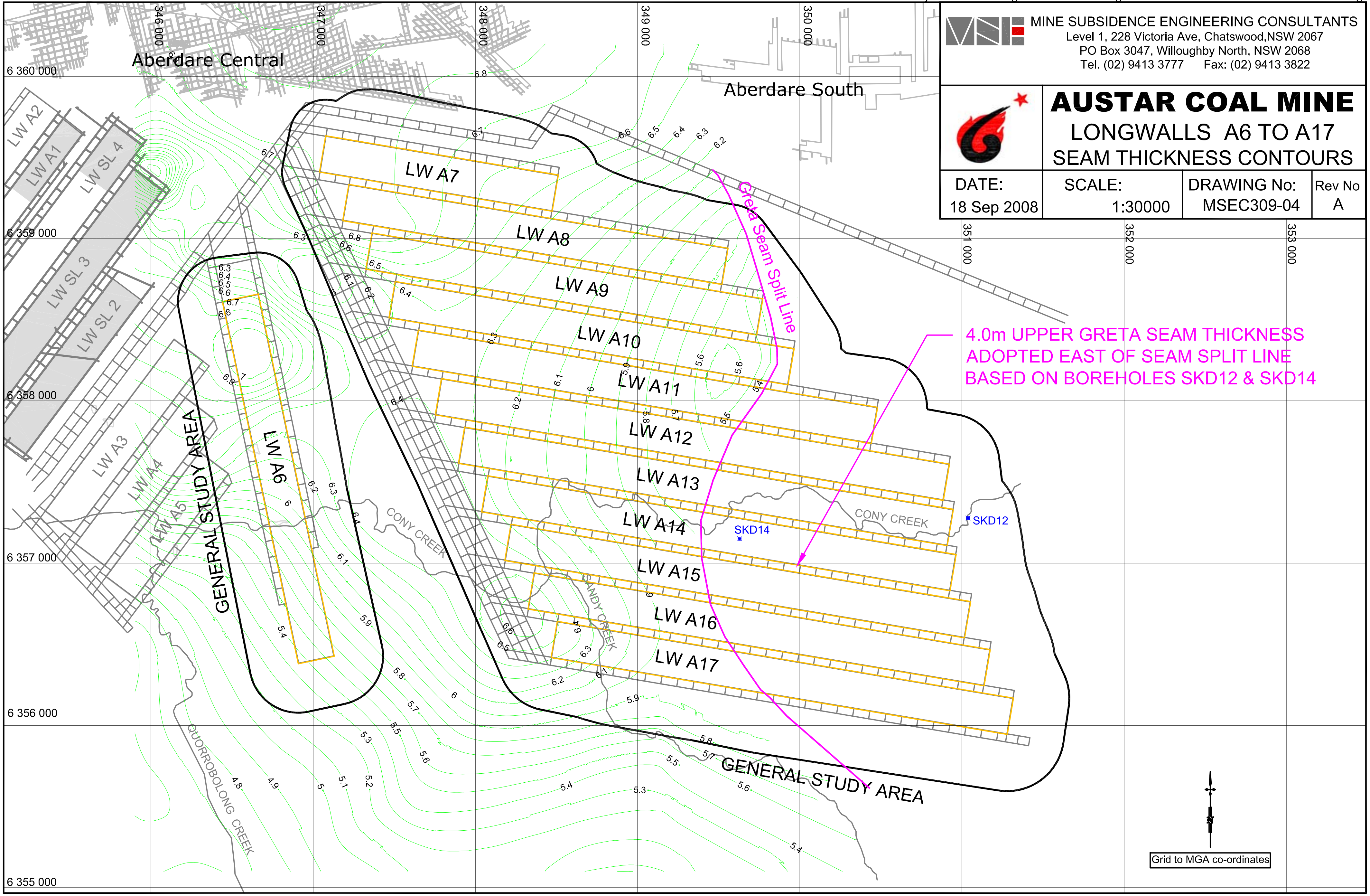

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AUSTAR COAL MINE

LONGWALLS A6 TO A17

SEAM THICKNESS CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
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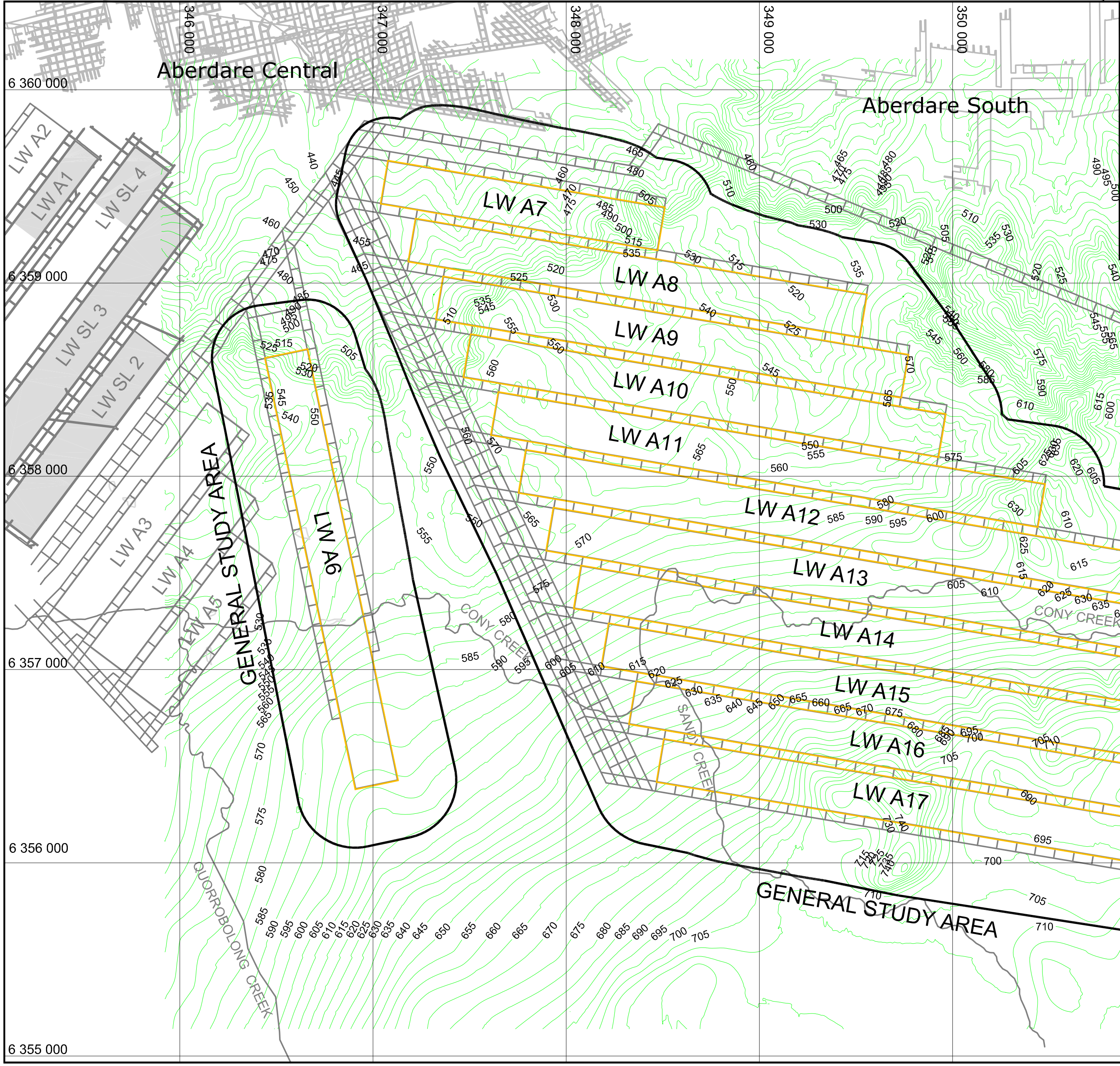

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AUSTAR COAL MINE

LONGWALLS A6 TO A17
DEPTH OF COVER

DATE:	SCALE:	DRAWING No:	Rev No
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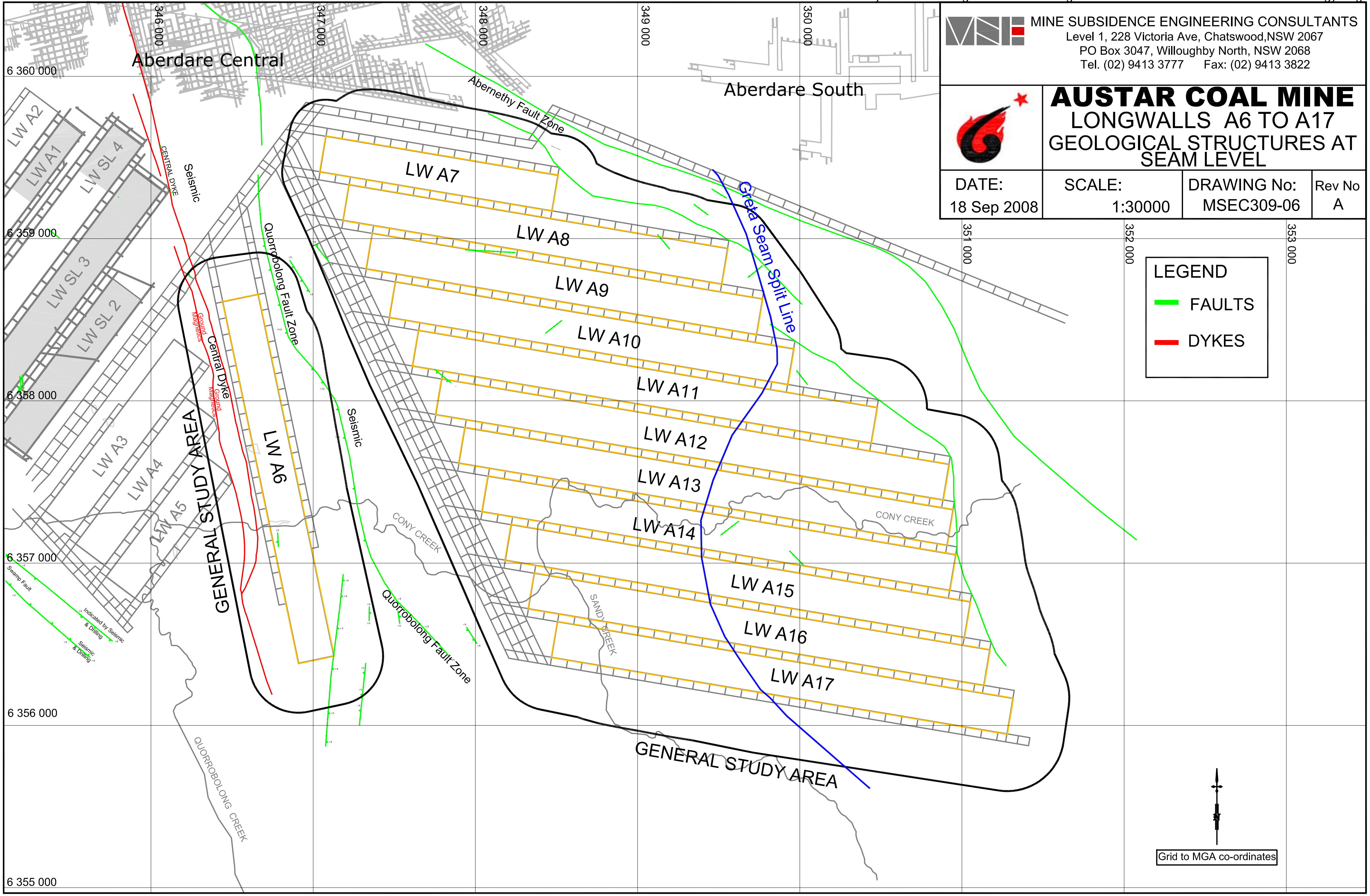

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PO Box 3047, Willoughby North, NSW 2068
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AUSTAR COAL MINE
LONGWALLS A6 TO A17
GEOLOGICAL STRUCTURES AT SEAM LEVEL

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-06	A

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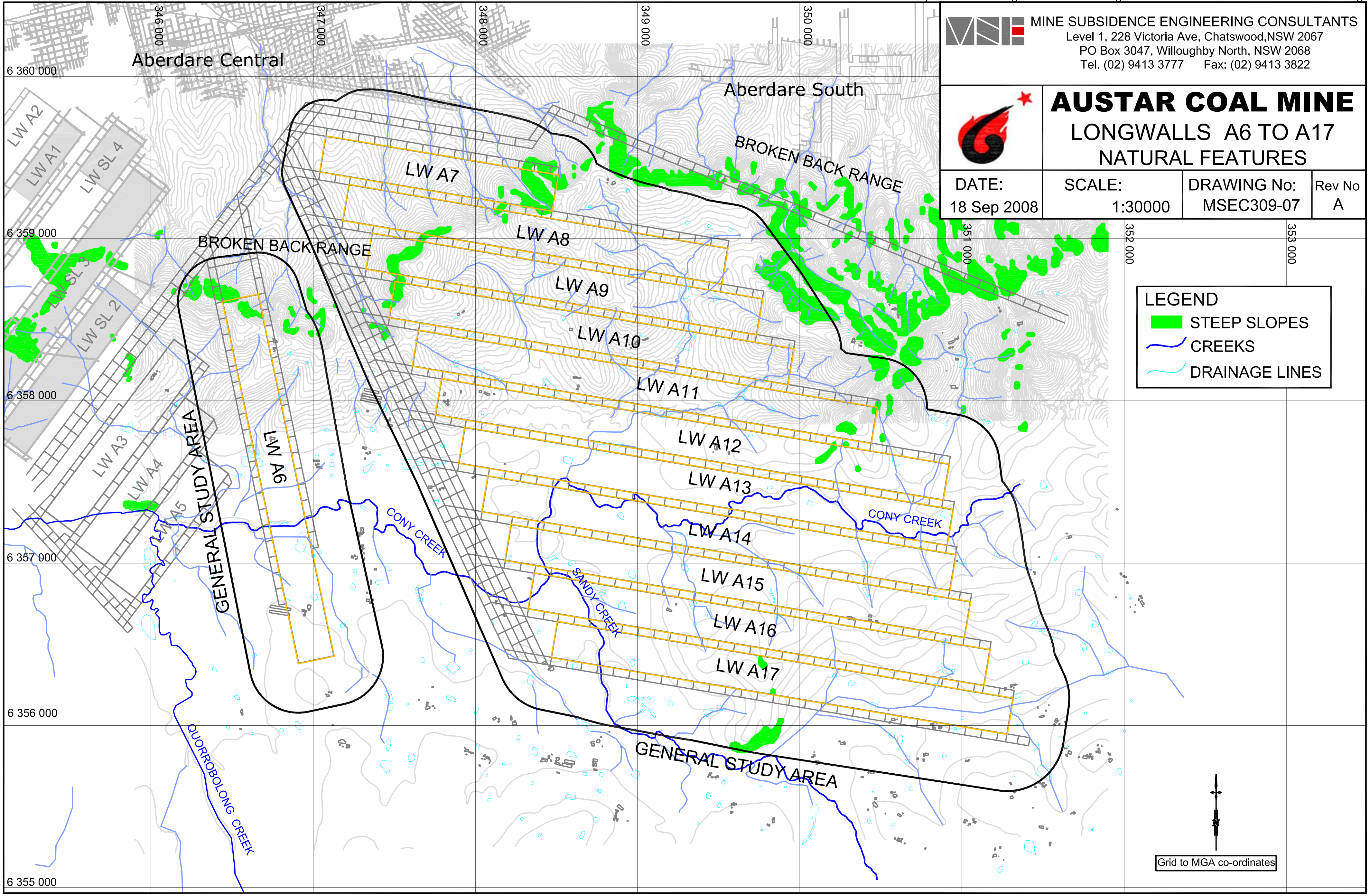
AUSTAR COAL MINE

LONGWALLS A6 TO A17
NATURAL FEATURES

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-07	A



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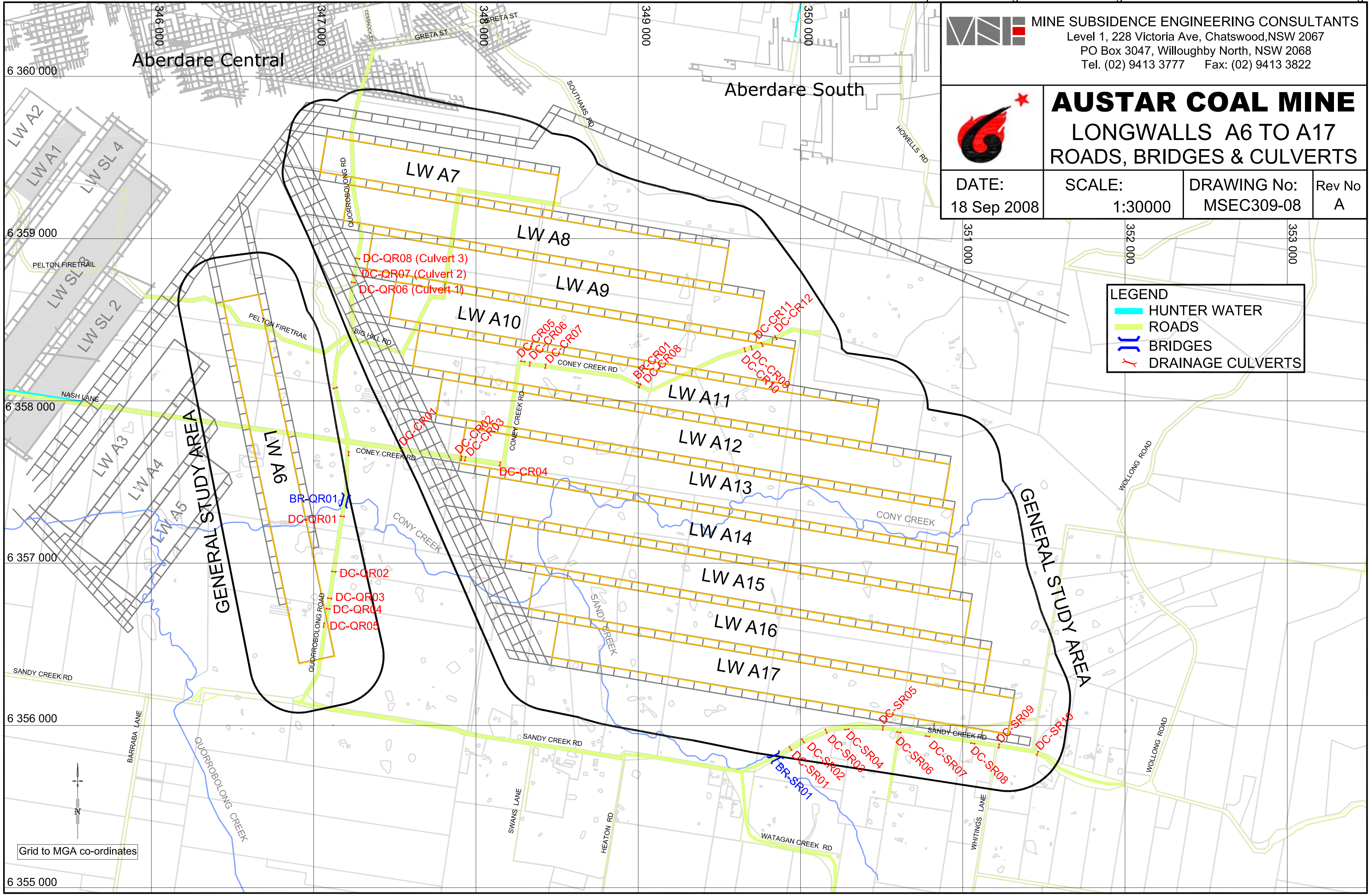
AUSTAR COAL MINE
LONGWALLS A6 TO A17
ROADS, BRIDGES & CULVERTS

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-08	A



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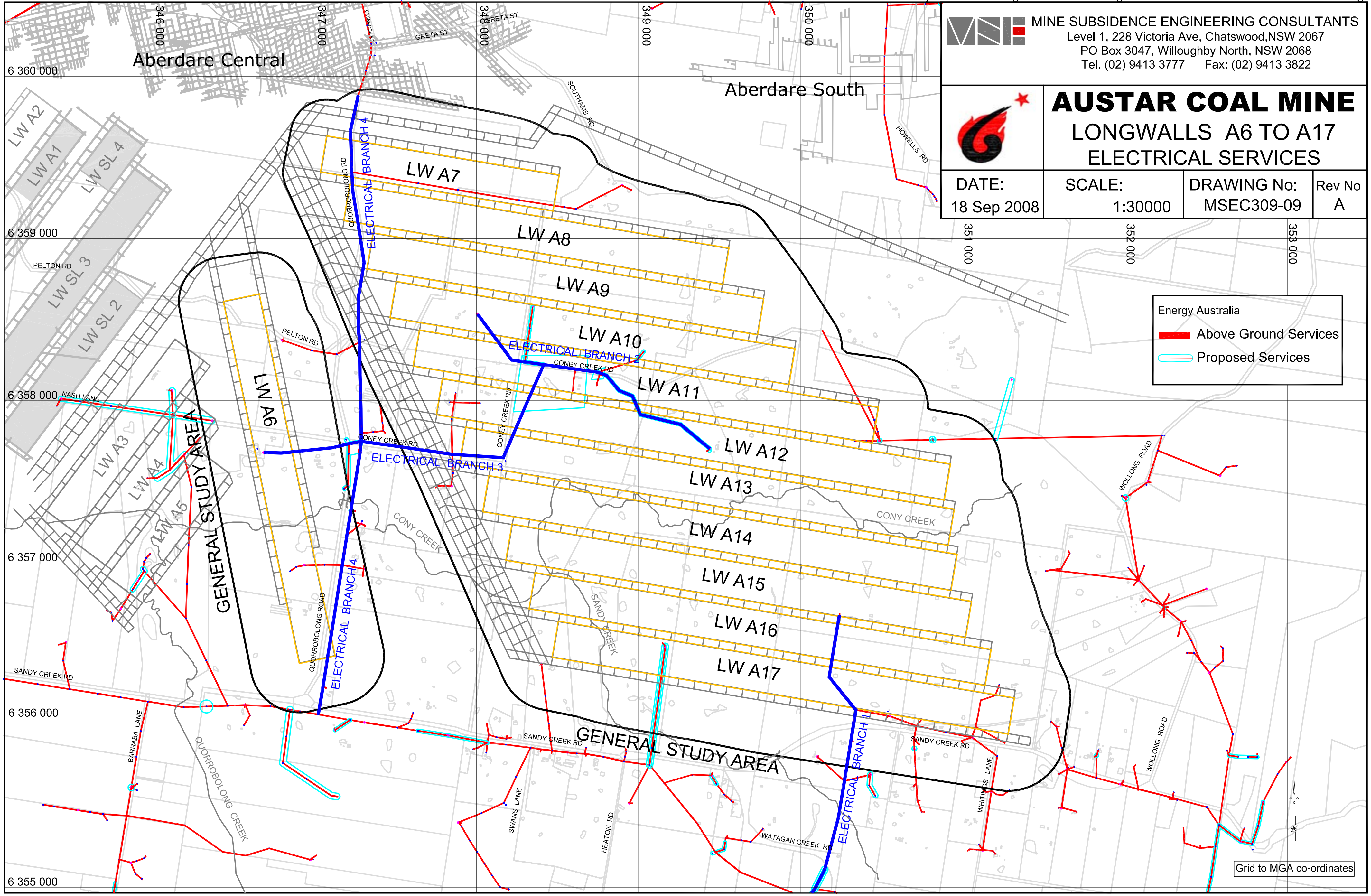

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AUSTAR COAL MINE

LONGWALLS A6 TO A17
ELECTRICAL SERVICES

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-09	A

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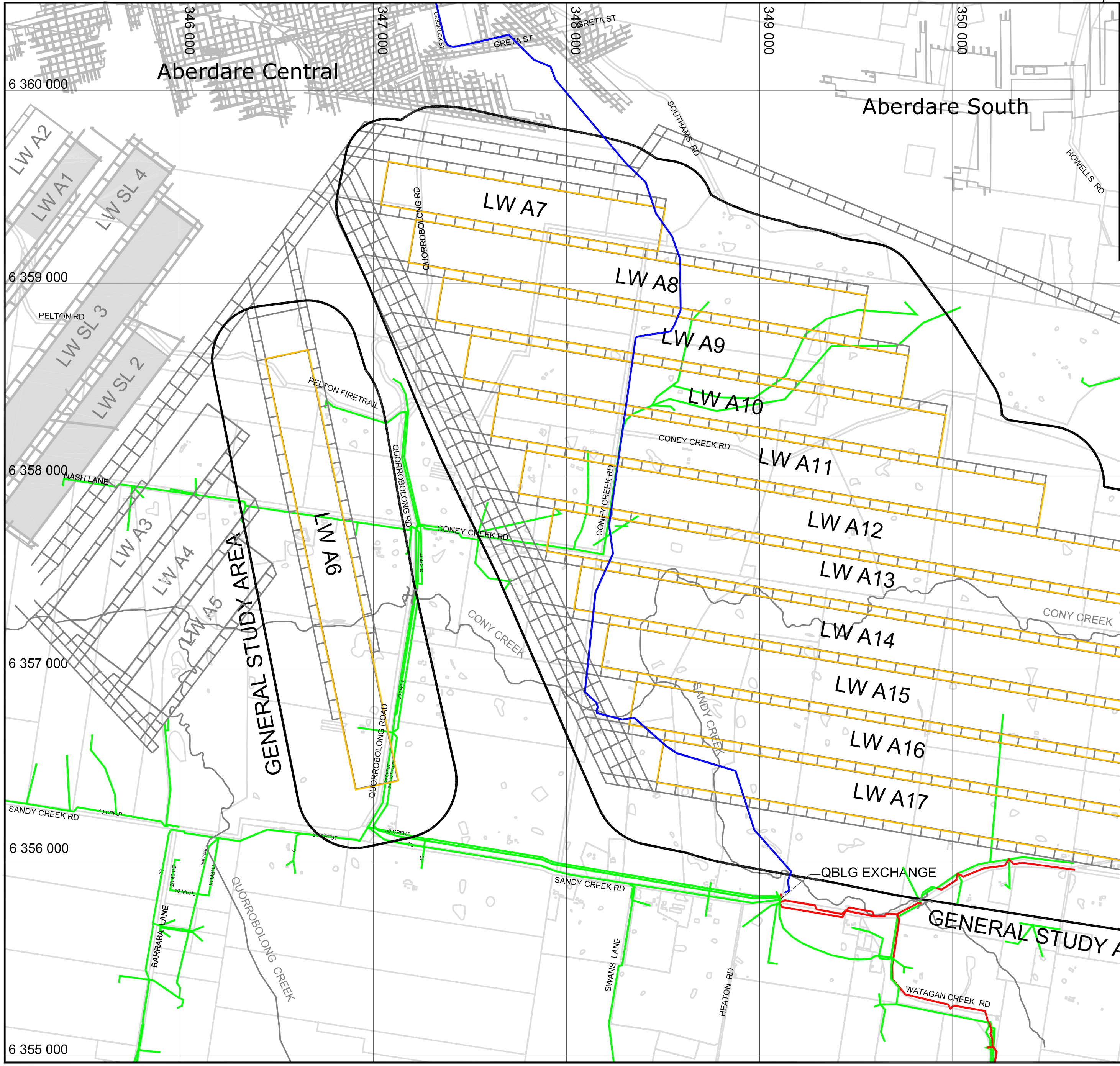

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LONGWALLS A6 TO A17
TELECOMMUNICATIONS SERVICES

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-10	A

I:Projects\Austar\Stage3\MSEC390-Longwalls A6 t0 A18\AcadData\MSEC390-11.dwg

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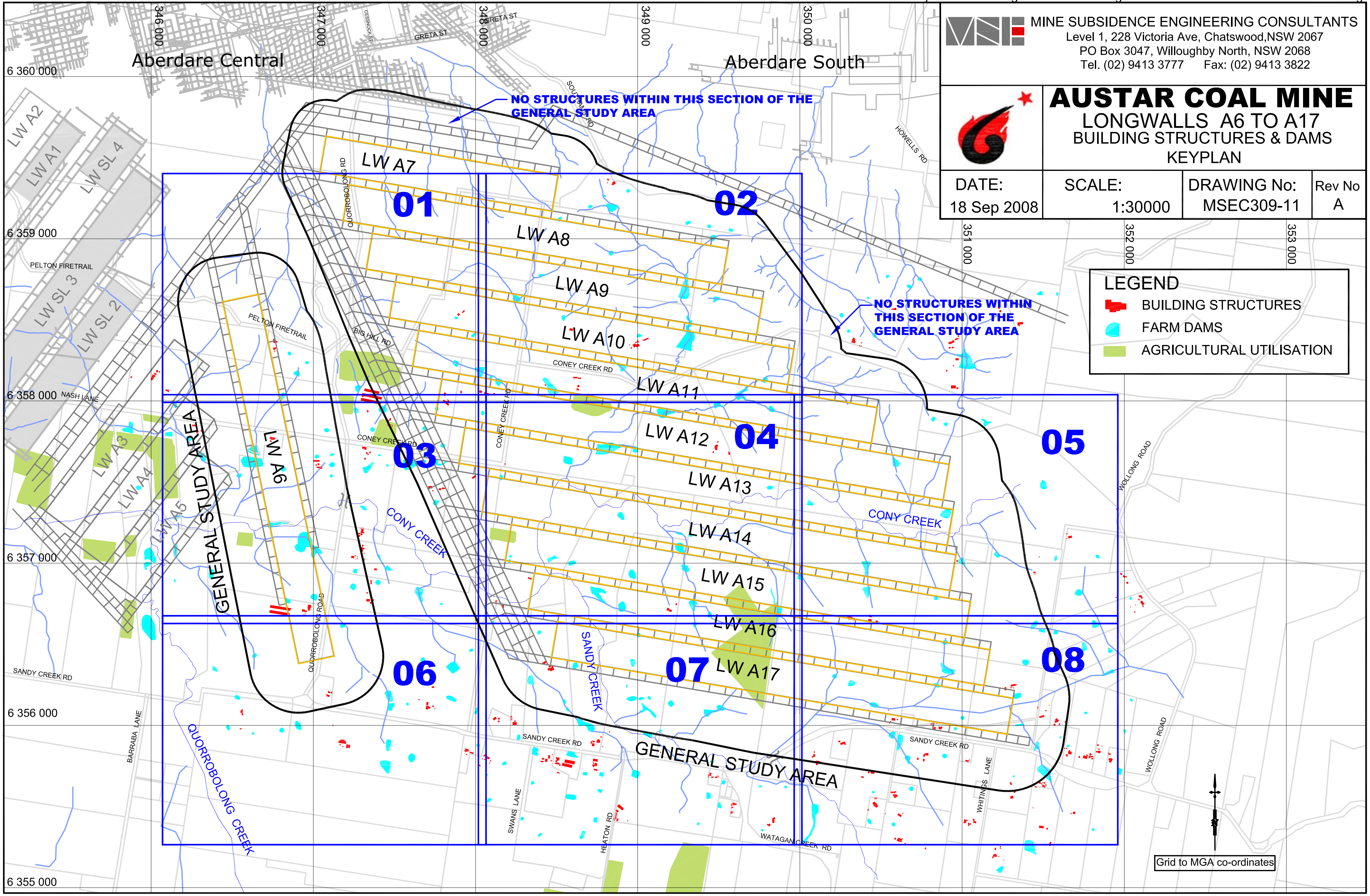
AUSTAR COAL MINE

LONGWALLS A6 TO A17

BUILDING STRUCTURES & DAMS KEYPLAN

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-11	A



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DATE:	SCALE:	DRAWING No:	Rev No:
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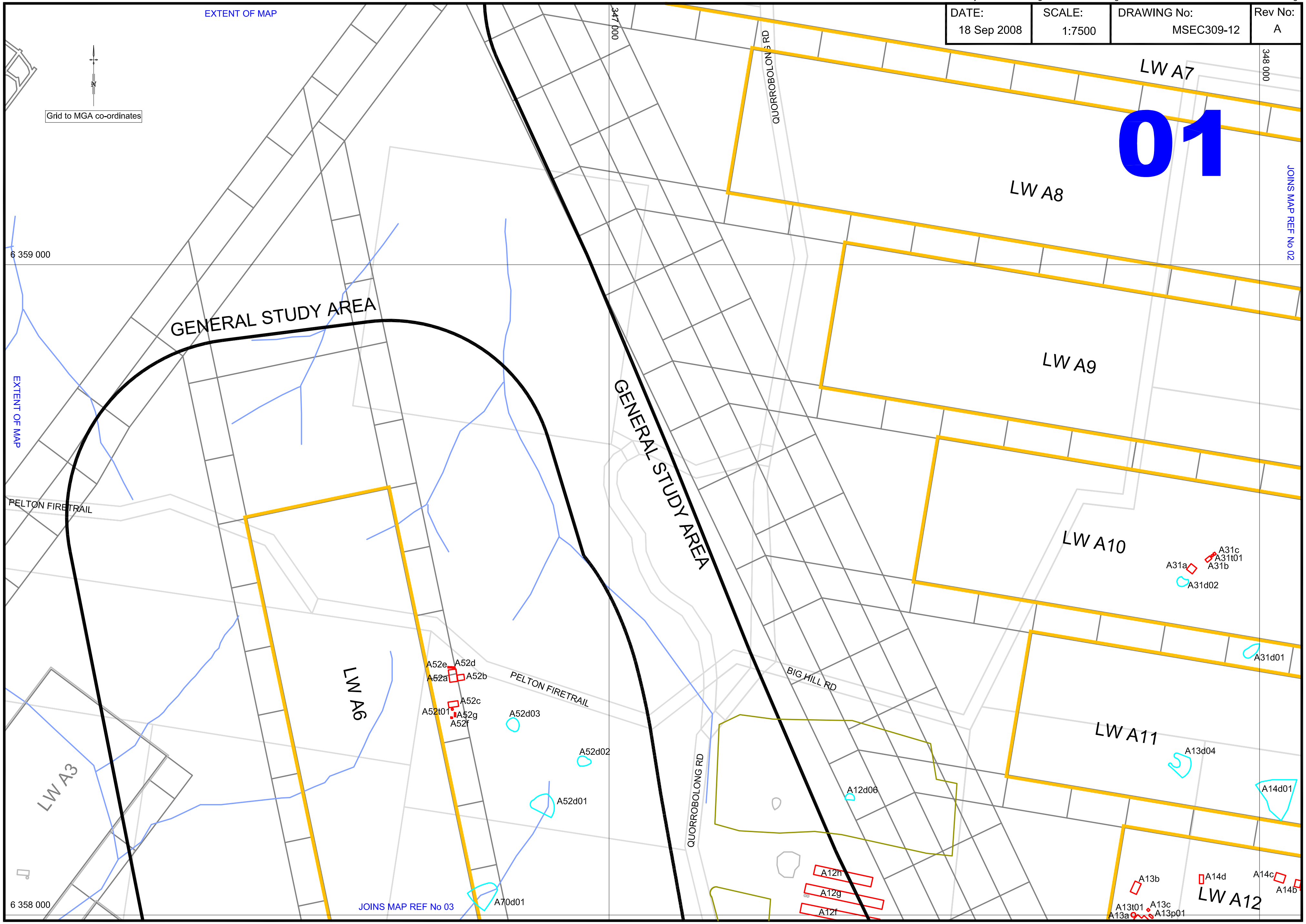

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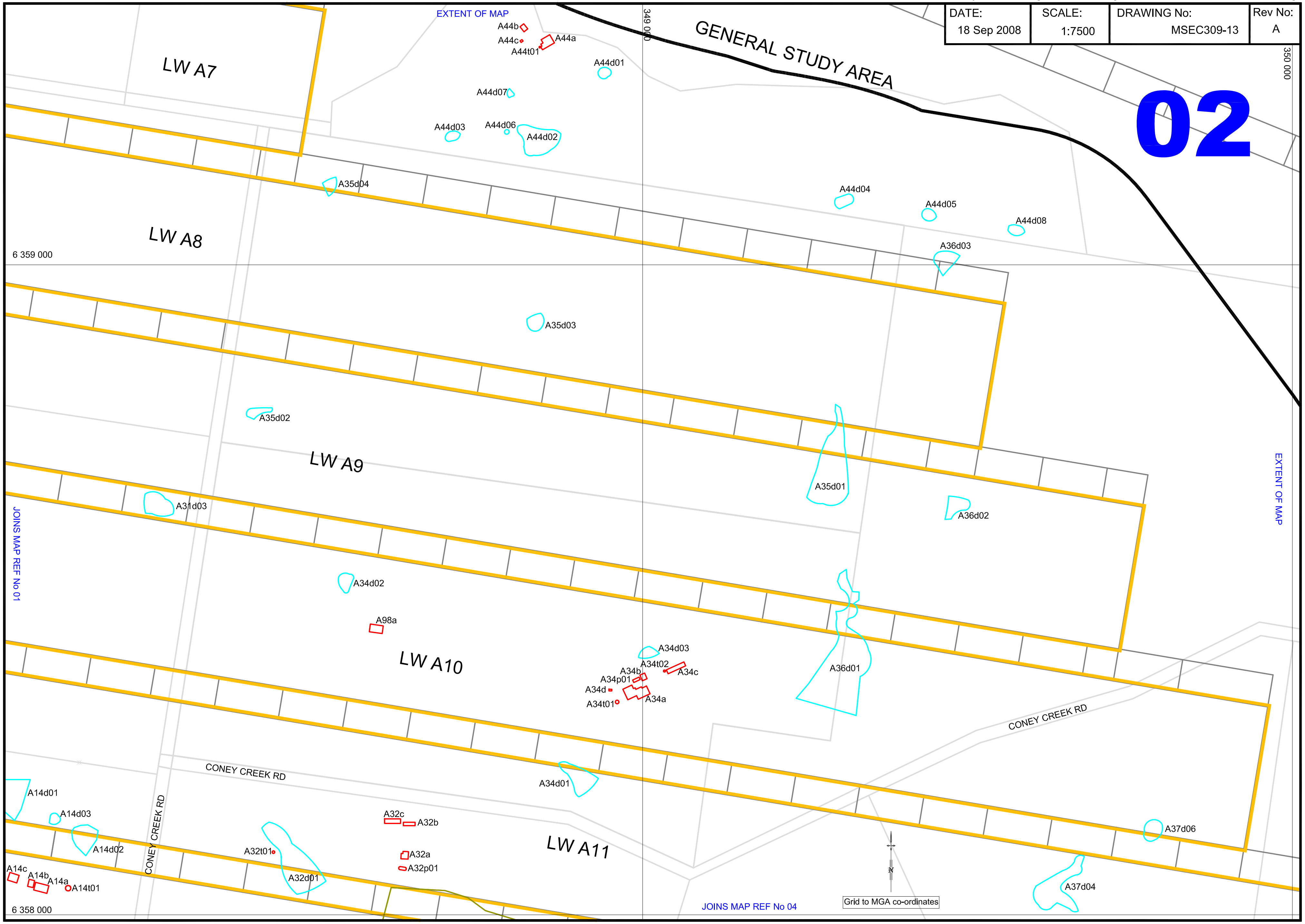

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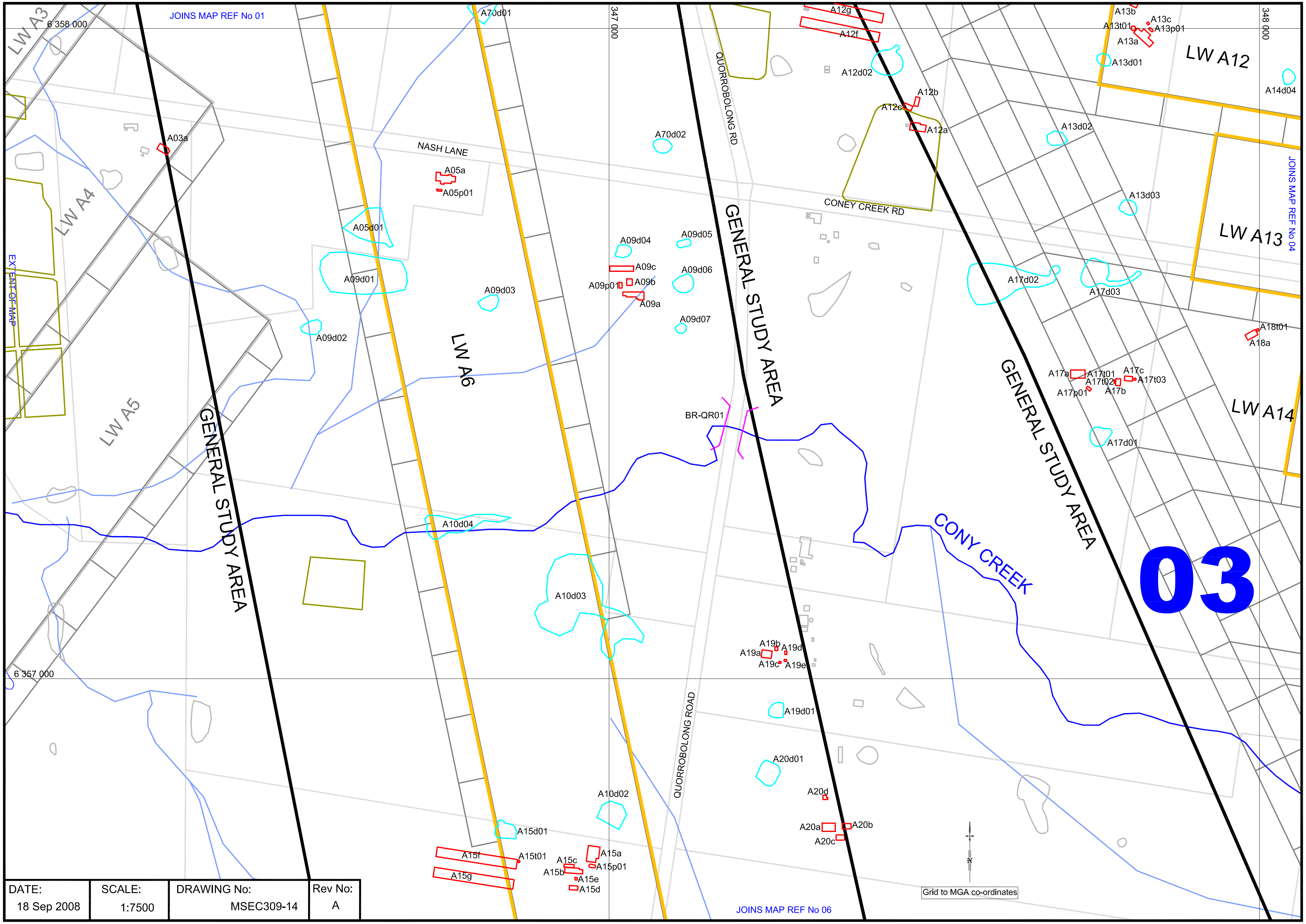

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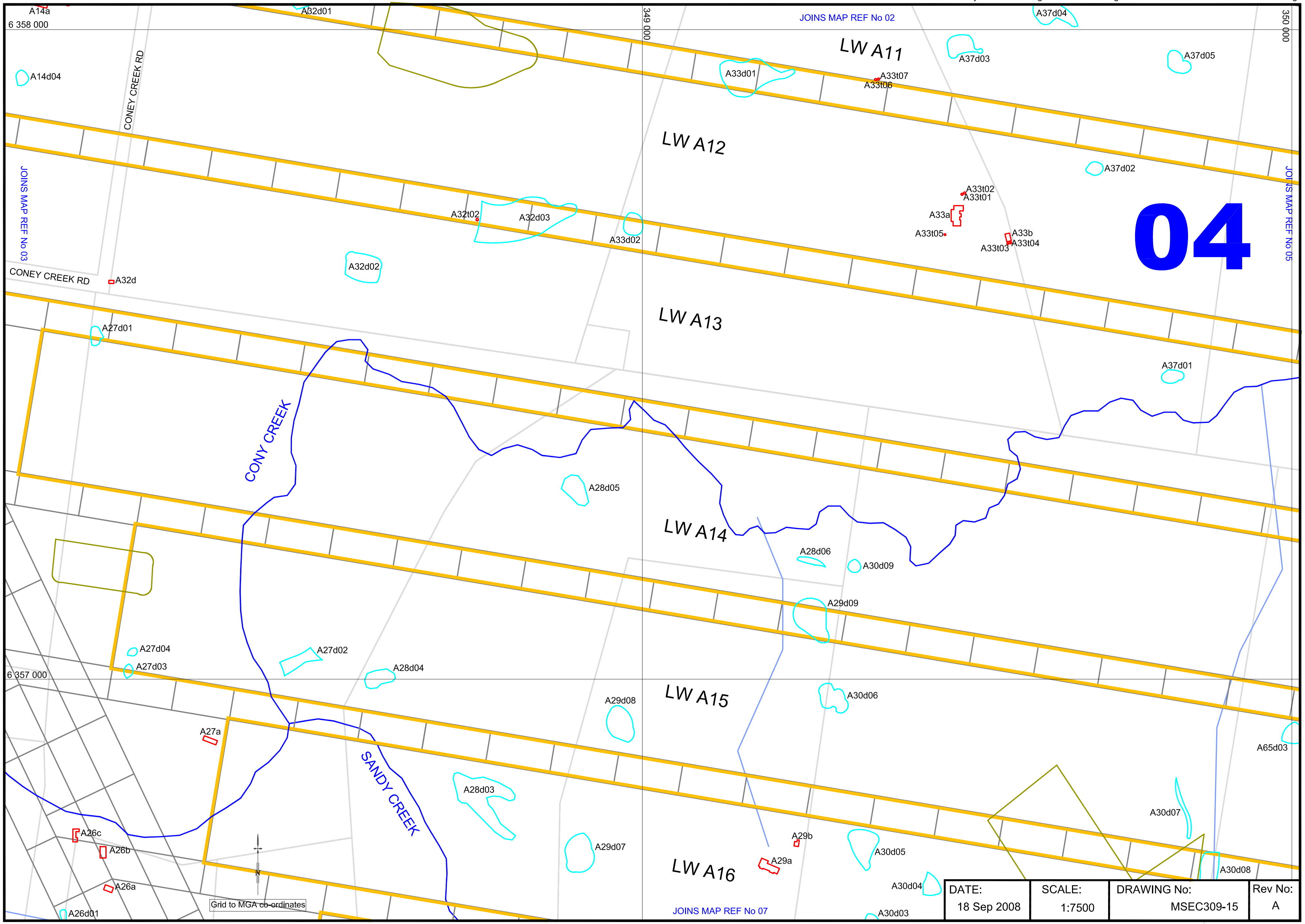

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18 Sep 2008	1:7500	MSEC309-15	A

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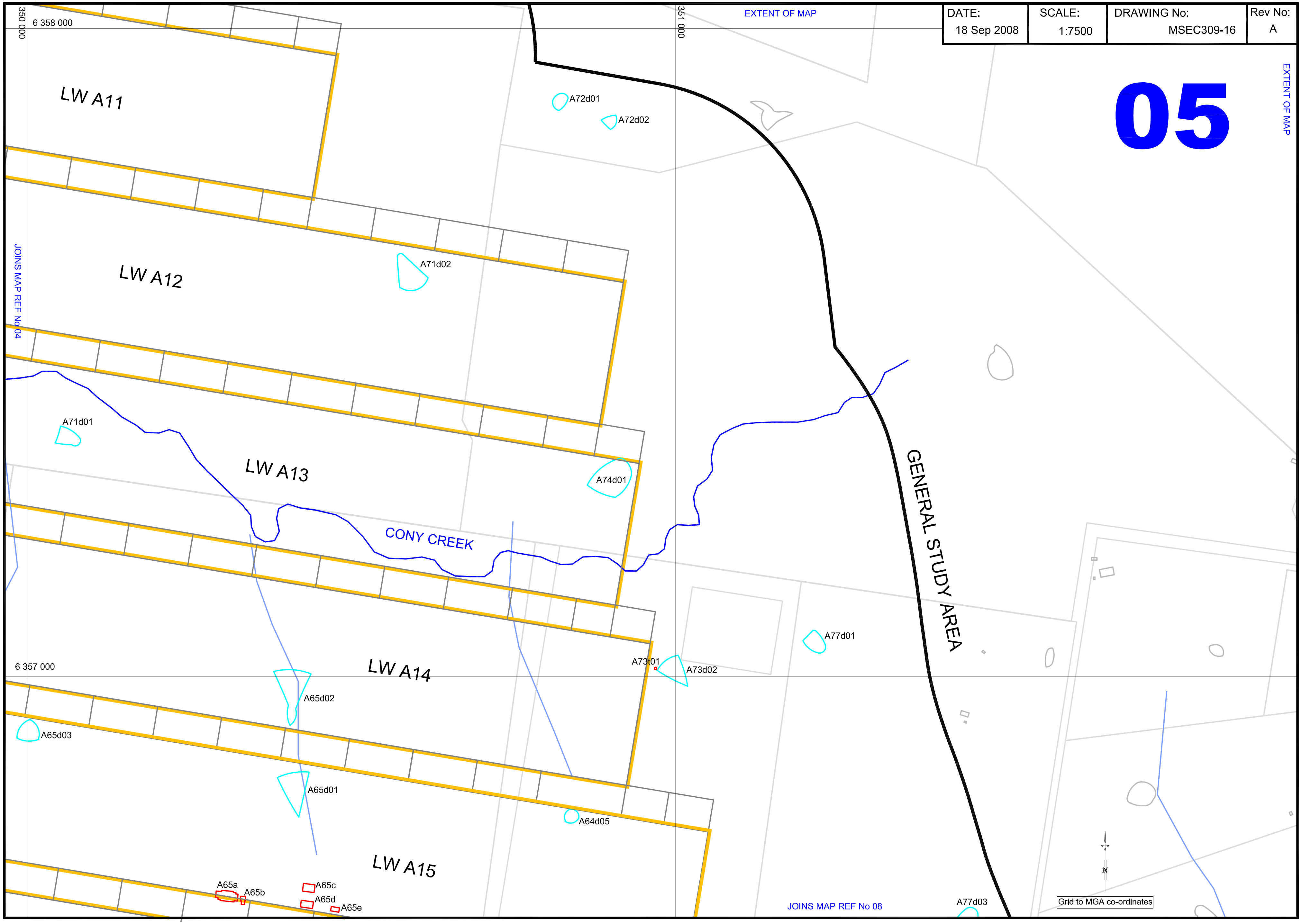

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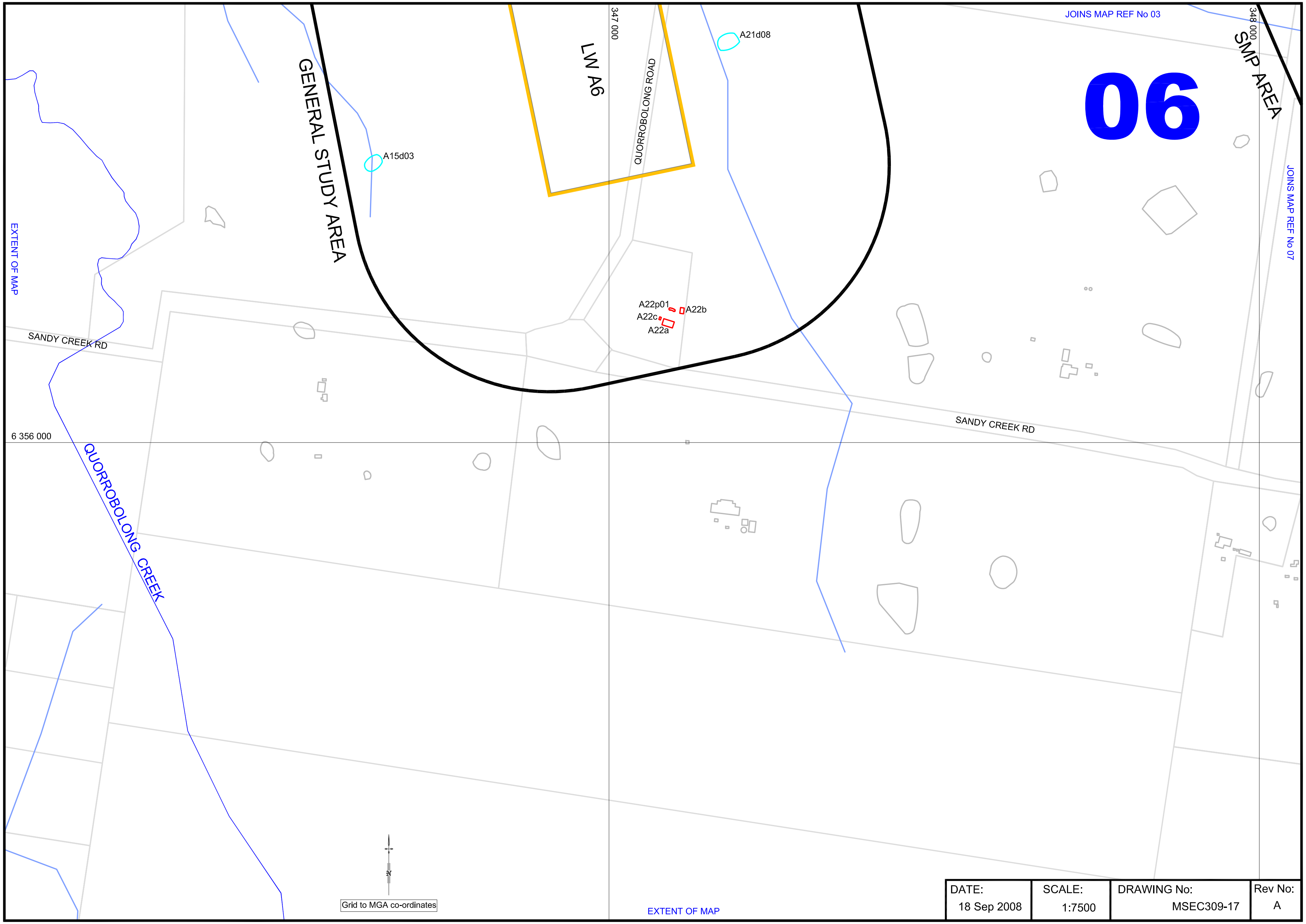

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18 Sep 2008	1:7500	MSEC309-17	A

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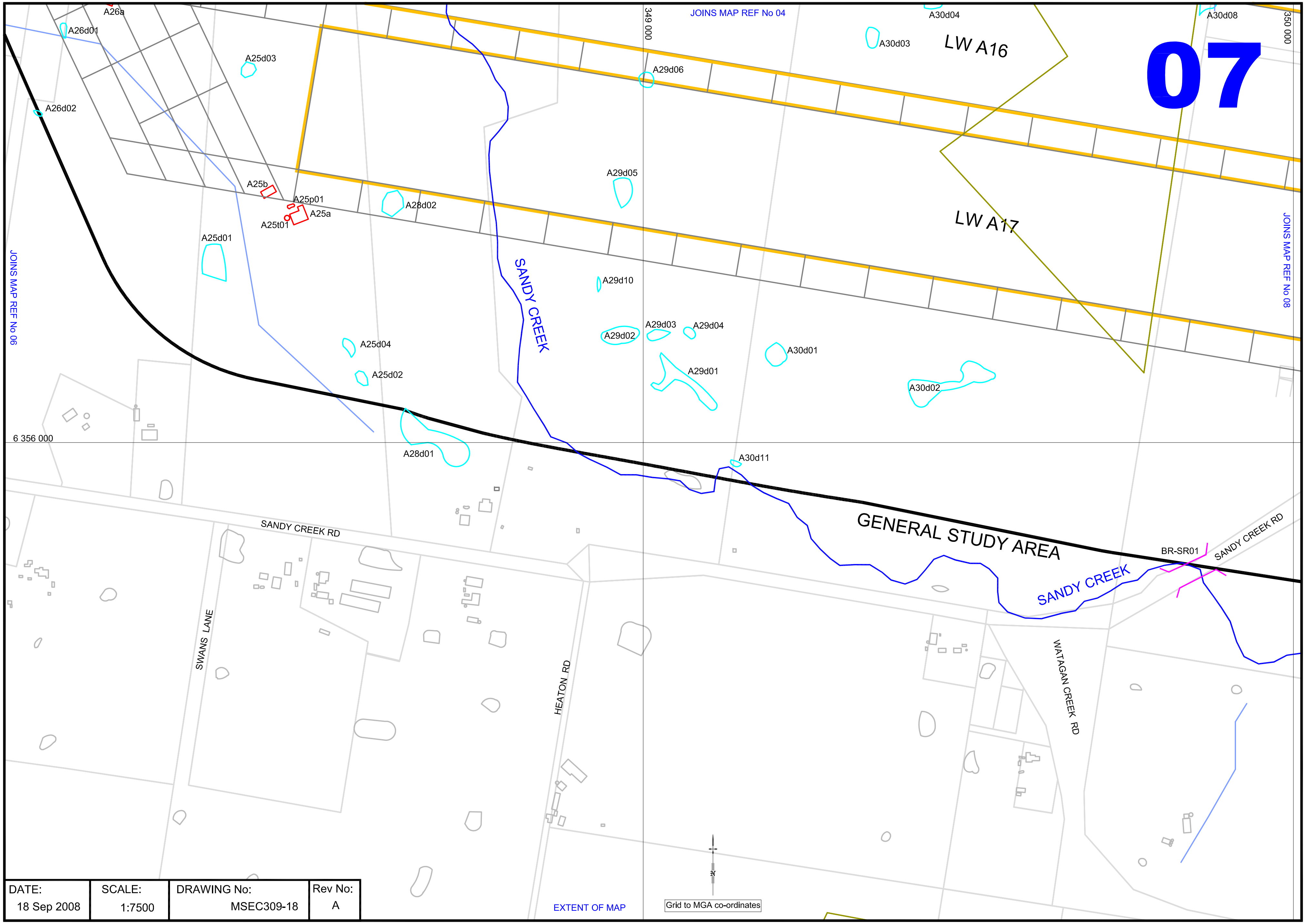

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18 Sep 2008	1:7500	MSEC309-18	A

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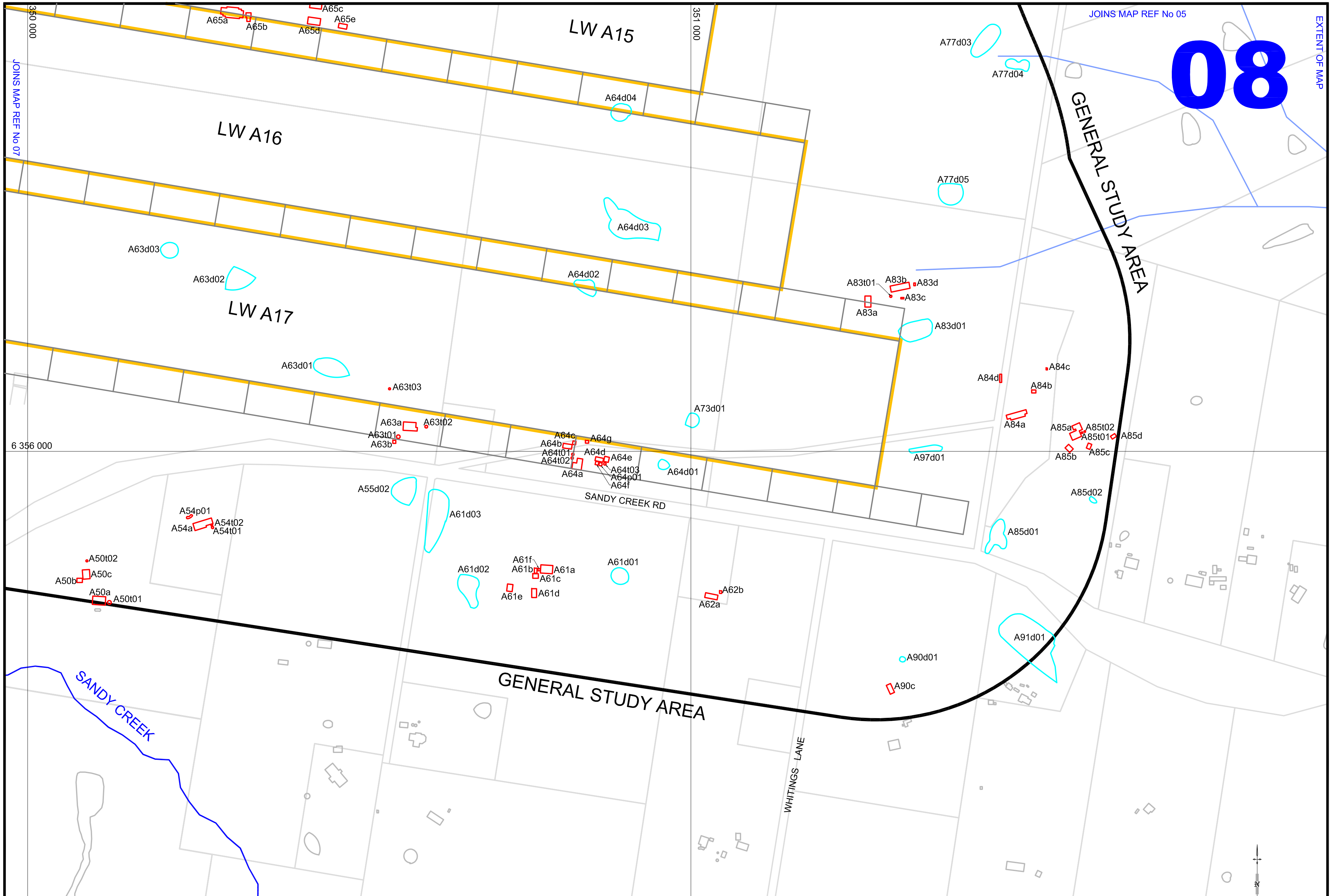

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18 Sep 2008	1:7500	MSEC309-19	A

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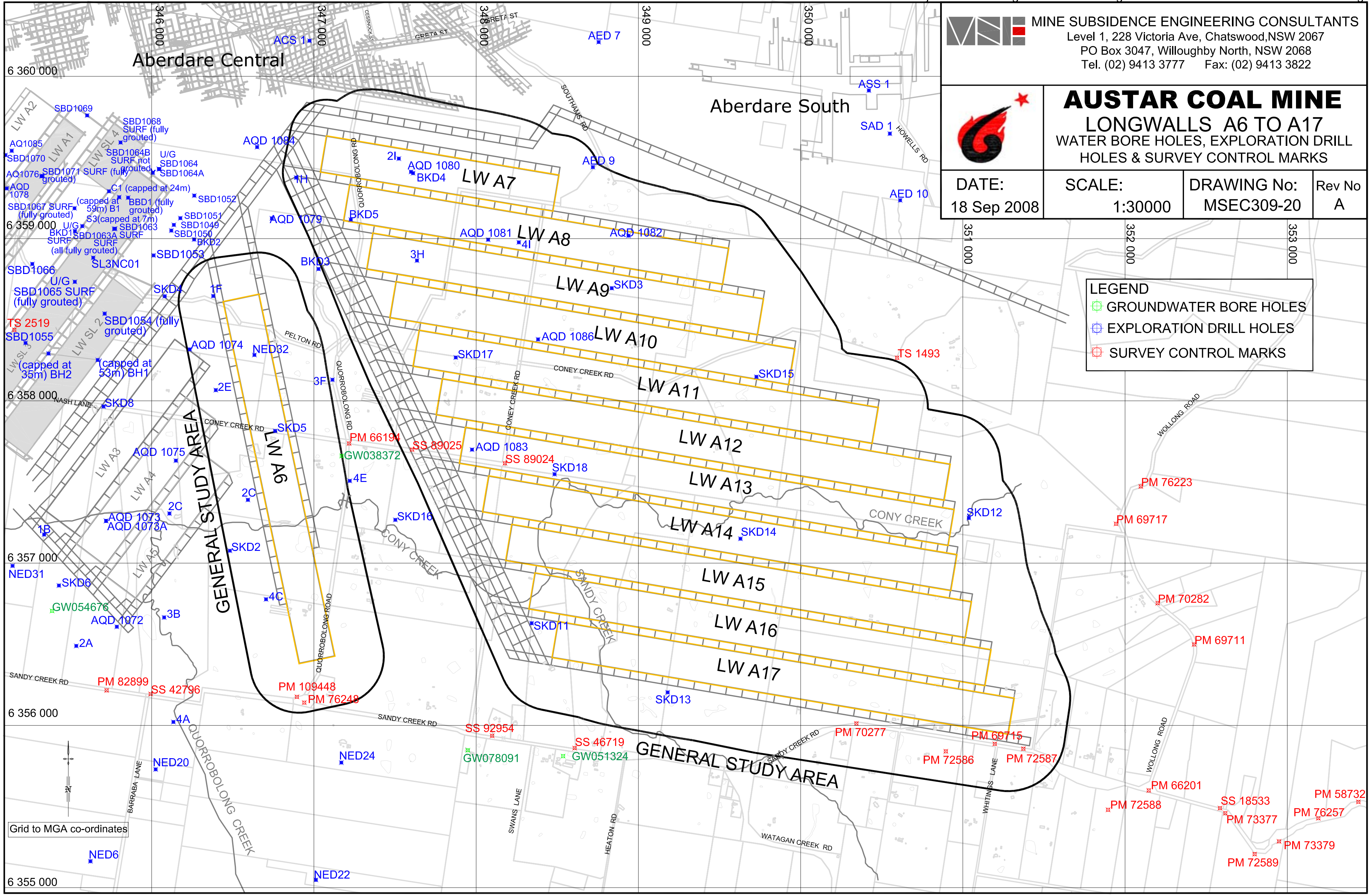

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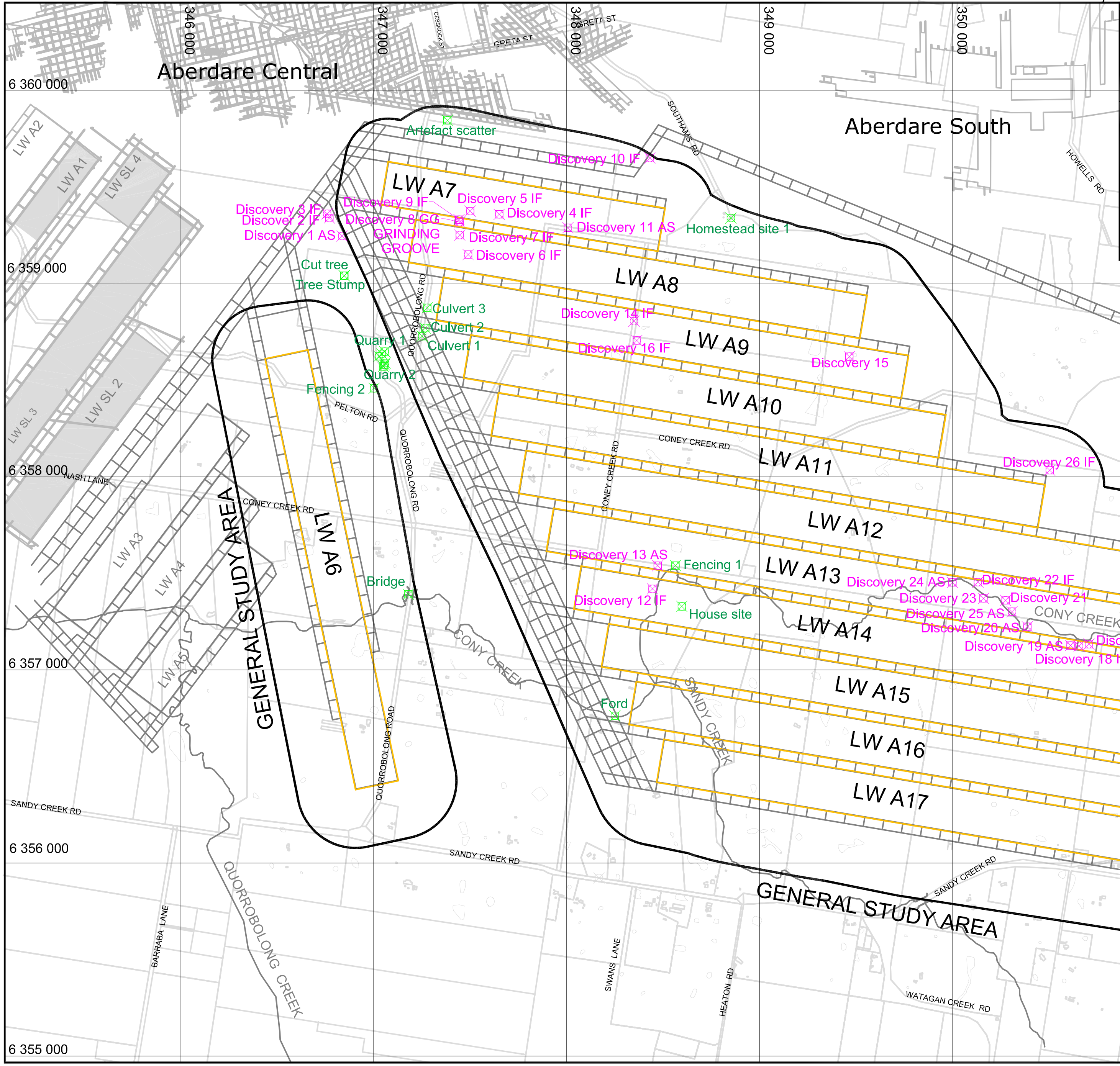

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AUSTAR COAL MINE
LONGWALLS A6 TO A17
ARCHAEOLOGICAL & HERITAGE SITES

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-21	A

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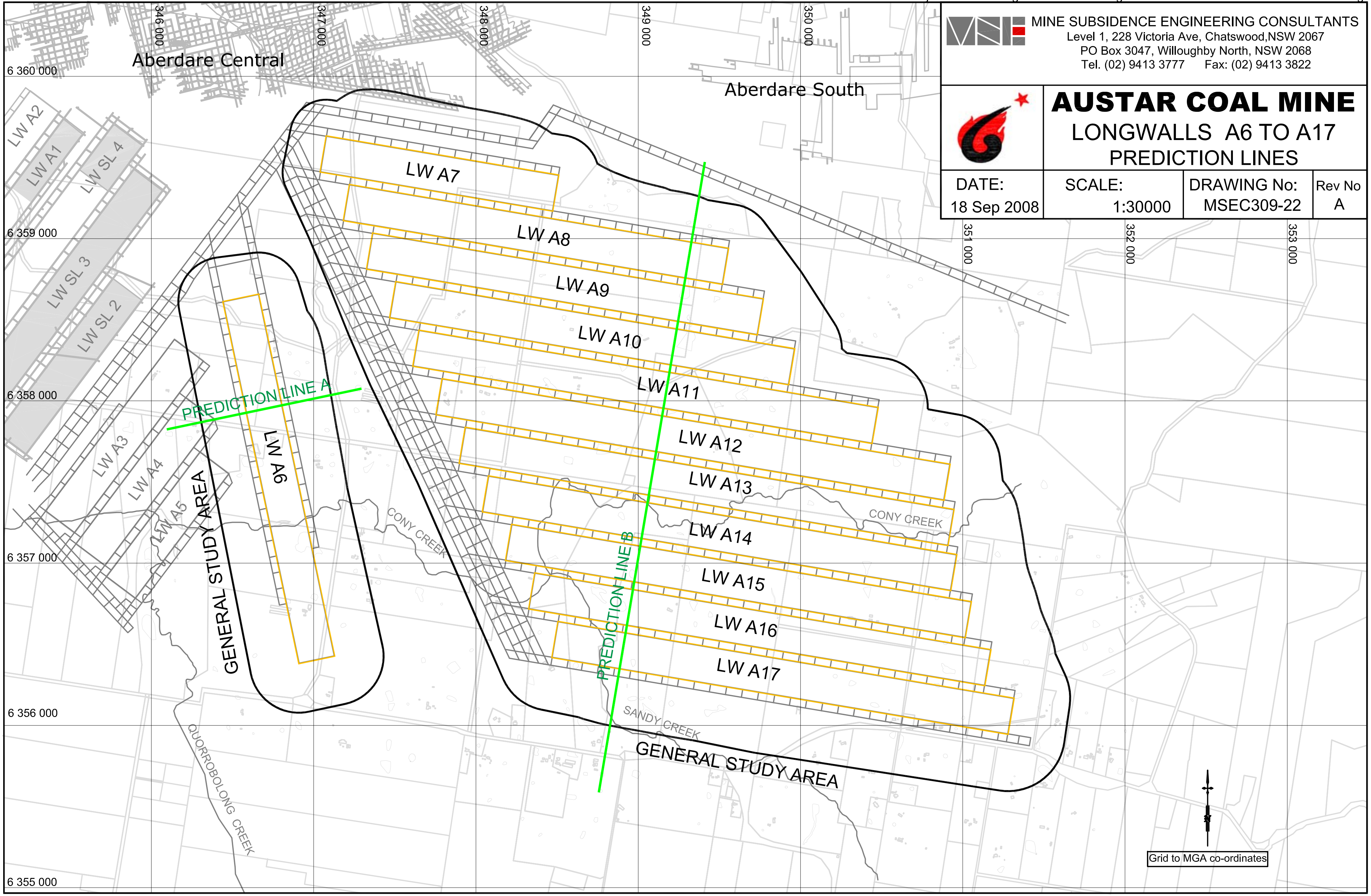

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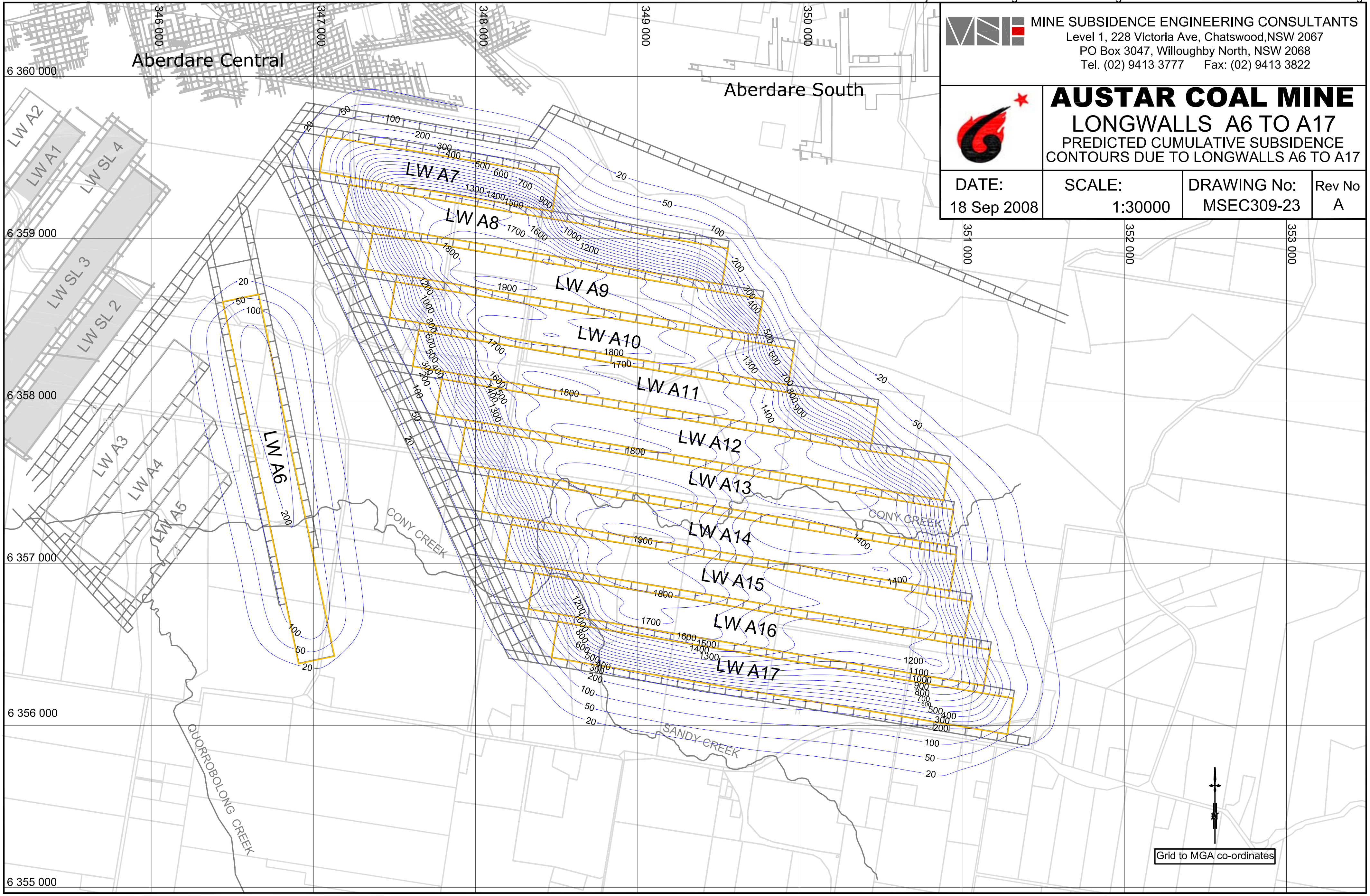

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AUSTAR COAL MINE

LONGWALLS A6 TO A17

PREDICTED CUMULATIVE SUBSIDENCE CONTOURS DUE TO LONGWALLS A6 TO A17

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I:Projects\Austar\Stage3\MSEC390-Longwalls A6 t0 A18\AcadData\MSEC390-24.dwg

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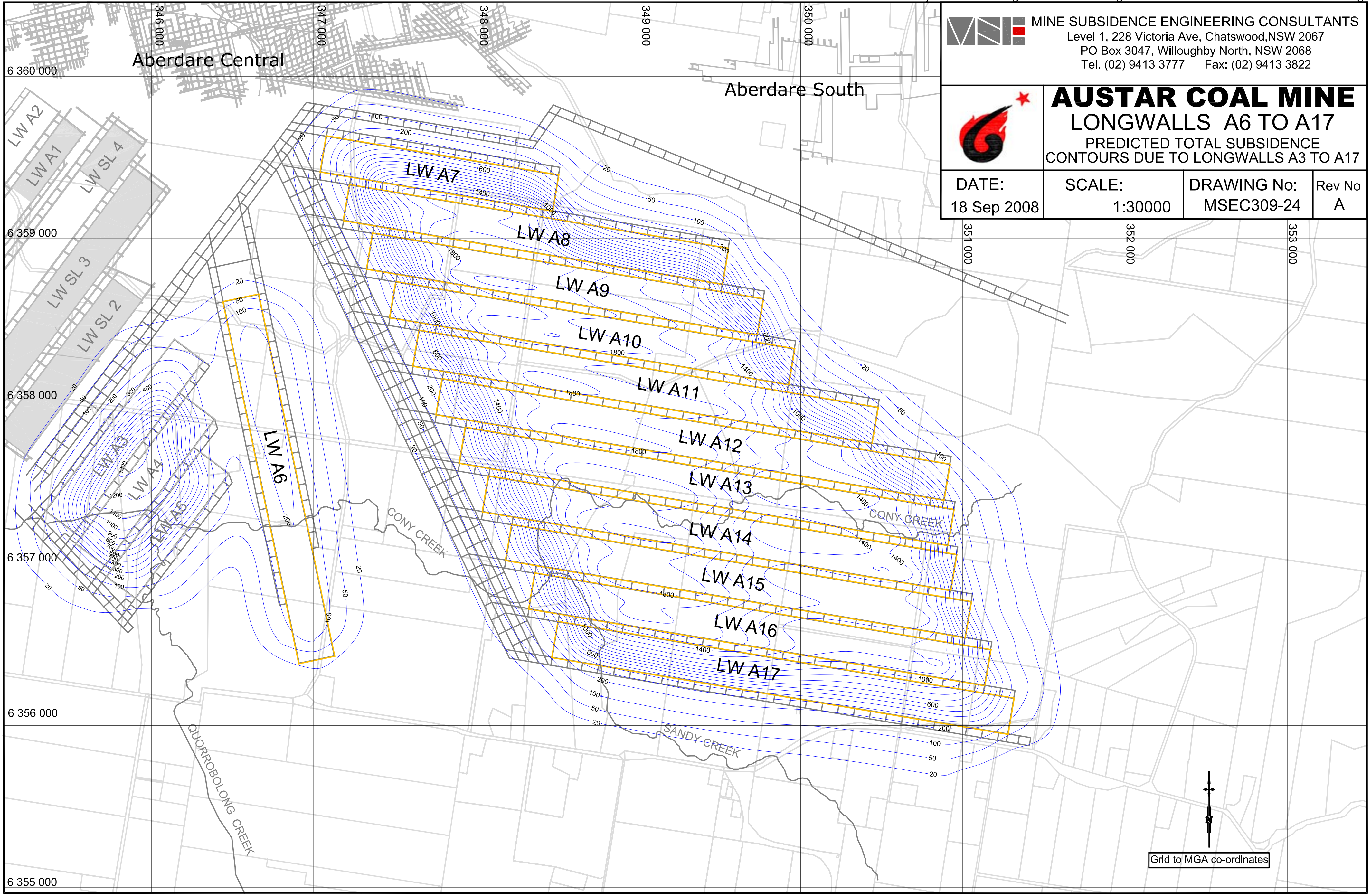
AUSTAR COAL MINE

LONGWALLS A6 TO A17

PREDICTED TOTAL SUBSIDENCE
CONTOURS DUE TO LONGWALLS A3 TO A17

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-24	A



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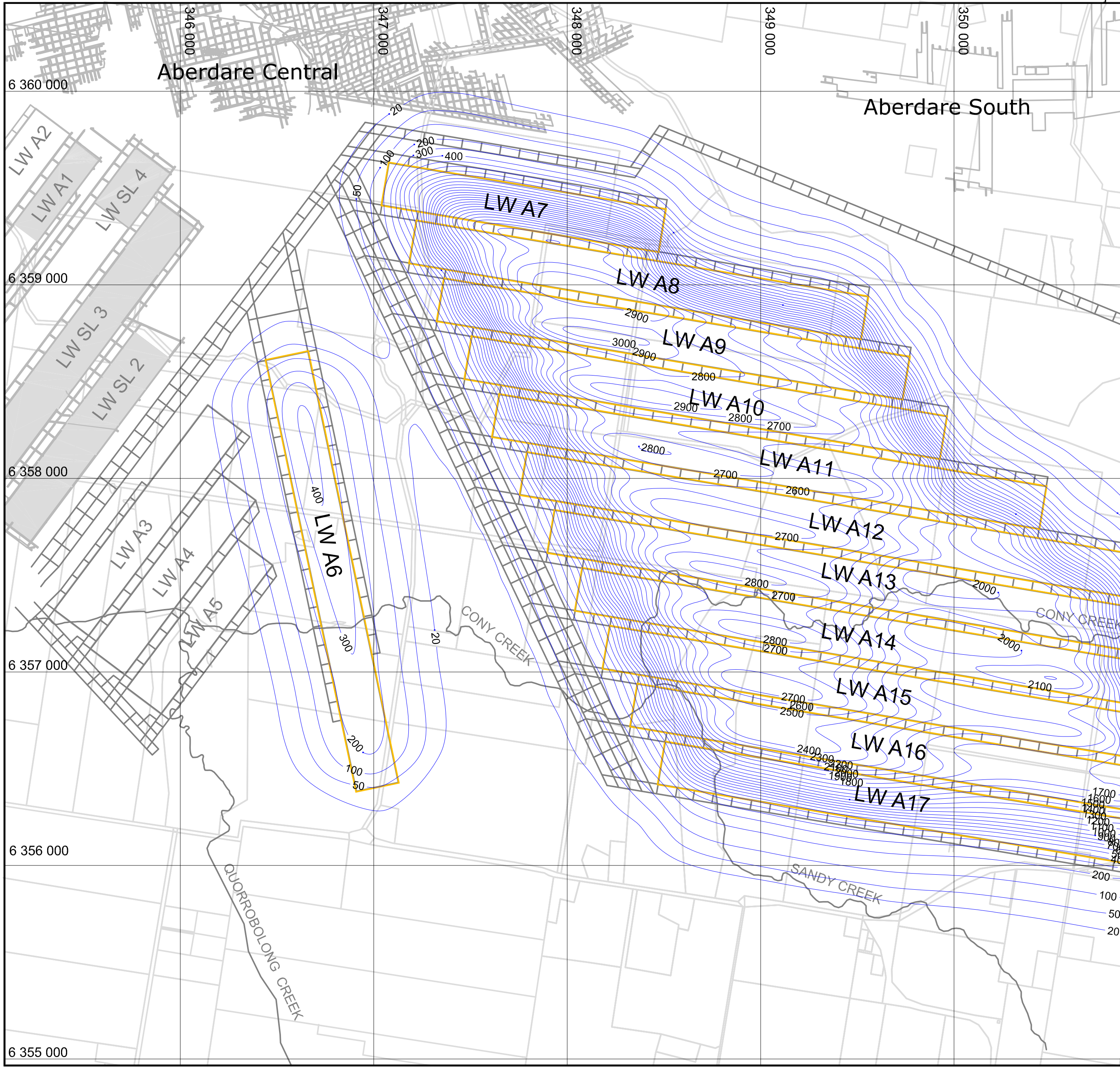

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AUSTAR COAL MINE

LONGWALLS A6 TO A17

OPPERBOUIND CUMULATIVE SUBSIDENCE CONTOURS DUE TO LONGWALLS A6 TO A17

DATE:	SCALE:	DRAWING No:	Rev No
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I:Projects\Austar\Stage3\MSEC390-Longwalls A6 t0 A17\AcadData\MSEC390-26.dwg

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AUSTAR COAL MINE

LONGWALLS A6 TO A17

UPPERBOUND TOTAL SUBSIDENCE CONTOURS DUE TO LONGWALLS A3 TO A17

DATE:	SCALE:	DRAWING No:	Rev No
18 Sep 2008	1:30000	MSEC309-26	A