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Subsidence Ground Movement Predictions and Impact Assessment

BYLONG COAL PROJECT
Environmental Impact Statement

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REPORT: SUBSIDENCE PREDICTIONS AND IMPACT ASSESSMENTS

mine subsidence ENGINEERING CONSULTANTS

WORLEYPARSONS SERVICES PTY LTD:

Bylong Coal Project

Subsidence Ground Movement Predictions and Subsidence Impact Assessments
for all Natural Features and Surface Infrastructure
in support of the Environmental Impact Statement

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Report produced to:- Support the Bylong Coal Project Environmental Impact Statement that is being prepared for submission to the Department of Planning and Environment (DP&E).

Background reports available at *www.minesubsidence.com*:-

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

EXECUTIVE SUMMARY

WorleyParsons Services Pty Ltd (WorleyParsons) act on behalf of KEPCO Bylong Australia Pty Ltd (KEPCO) who holds Authorisation (A) 287 and A342 over an area of approximately 10,300 ha at Bylong, NSW. KEPCO plan to develop a new thermal coal mine, called the Bylong Coal Project (the Project), which is to consist of both open cut and underground operations. The layout of the proposed longwalls for the underground operations is shown in Drawings Nos. MSEC708-01.

Mine Subsidence Engineering Consultants Pty Limited (MSEC) was commissioned by WorleyParsons to:-

- Review the proposed longwall layouts in the Coggan Seam based on the revised mine plan, which will be adopted as the base layout for the Environmental Impact Statement (EIS).
- Provide subsidence predictions for the natural and built features based on the revised mine plan.
- Provide subsidence predictions along selected prediction lines (cross-sections), plus key linear features such as roads or streams.
- Provide and complete a subsidence prediction and impact assessment report including subsidence predictions and impact assessments on surface features. The report will include the provision of figures and drawings.

This report provides information that will support the EIS which will be issued to the Department of Planning and Environment (DP&E).

The predicted subsidence parameters over the proposed longwalls and panels have been determined using the Incremental Profile Method (IPM).

The subsidence predictions and impact assessments provided in this report have been based on a single mining layout, referred to as the revised mine plan.

The *Subsidence Study Area* has been defined, as a minimum, as the surface area within the predicted limit of vertical subsidence, determined by the greater of the 26.5 degree angle of draw from the limit of the proposed secondary extraction and the predicted 20 mm subsidence contour resulting from the extraction of the proposed longwalls. The features located outside the *Subsidence Study Area* which could be subjected to far-field or valley related movements and could be sensitive to such movements have also been included in the assessments provided in this report.

A number of natural and built features have been identified within or in the vicinity of the *Subsidence Study Area*, including streams, cliffs, steep slopes, local roads, drainage culverts, powerlines, copper telecommunications cables, a quarry, rural building structures, farm dams, archaeological sites, and survey control marks.

The assessments provided in this report should be read in conjunction with the assessments provided in the reports by other specialist consultants on the project. The main findings from this report are as follows:-

- The streams in the *Subsidence Study Area* are ephemeral. The streams typically have shallow incisions into the natural surface soils, but have some rock outcropping. The streams are located across the mining area and, therefore, are expected to experience the full range of predicted subsidence movements. The main stream through the *Subsidence Study Area* is Dry Creek.

  It is expected that there would be areas which would experience increased ponding and flooding, primarily upstream of the chain pillars in the shallower grades at the western end of the streams. It is also possible that there could be areas which could experience increased scouring of the stream beds, primarily downstream of the chain pillars in the shallower grades. After the completion of mining in a particular area, surface remediation is recommended to re-establish the natural grades along the drainage lines, so as to reduce the potential for ponding.

  If necessary, at the completion of mining the drainage lines would be regraded in the areas of increased ponding, so as to re-establish the natural gradients.

  It is possible that increased levels of bed scouring could also occur in the locations of the maximum increasing tilts, during times of high surface water flows. If significant levels of bed scouring were to occur along the drainage lines, it may be necessary to provide rip-rap, or to locally regrade the beds of the drainage lines in these locations.

  Changes in the alignment of drainage lines in topographical areas above the longwalls with steeper grades are unlikely to be significantly affected by changes in topography resulting from extraction of the proposed longwalls. The alignment of drainage lines in topographical areas with shallow grades are more likely to be affected by changes in topography resulting from extraction of the proposed longwalls.

It is likely that fracturing, buckling and dilation would occur in the uppermost bedrock beneath the soil beds of the drainage lines based on the magnitudes of the predicted strains.

The drainage lines are ephemeral and, therefore, surface water flows only occur during and for short periods after rainfall events. In times of heavy rainfall, the majority of the runoff would flow over the natural surface soil beds and would not be diverted into the dilated strata below. In times of low flow, however, surface water flows could be diverted into the dilated strata below the beds. The Surface Water Impact Assessment Report by WRM (2015) estimates negligible loss of surface water to groundwater as a result of surface cracking.

Some remedial measures may be required at the completion of mining. Where necessary, any significant surface cracks in the drainage line beds could be remediated by infilling with the surface soil or other suitable materials, or by locally regrading and compacting the surface.

- The longest and most prominent cliffs are three cliffs located adjacent to the finishing ends of Longwalls 105 to 107. These cliffs are almost entirely outside the *Subsidence Study Area*. The predicted vertical subsidence for Cliffs 24278, 24279 and 24324 are all less than 20 mm. It is unlikely that these cliffs would be adversely impacted by the extraction of the proposed longwalls.

  The observed impacts to the cliffs located above the proposed longwalls can be estimated from the experience of undermining cliff formations at Ulan Colliery, where longwalls have extracted in similar geological conditions directly beneath cliffs and rock formations at similar depths of cover and panel widths as those proposed at Bylong. It is reported that Ulan Colliery has mined directly beneath more than 8km of cliff outcrop and observed rock falls occurred in approximately 20% of the length of the cliffs and visible mining subsidence movements occurred in approximately 50% to 70% of the sandstone formations greater than approximately 3 metres high (SCT 2009). Rock falls were not observed at cliffs located beyond the longwall panel footprint, however some cracking was observed.

  There are several cliffs located within the *Subsidence Study Area* that are outside the proposed longwall footprints. Based on the experience of mining close to, but not directly beneath cliffs in the NSW Coalfields, it is possible that minor and isolated rock falls could occur along these cliffs. Rock falls are more likely to occur at those cliffs which will be partially mined beneath, which is the case for cliffs at the finishing ends of Longwalls 105 and 106.

- The locations of the steep slopes within the *Subsidence Study Area* are shown in Drawing No. MSEC708-08. The steep slopes are likely to be affected by curvatures and strains. The potential impacts would generally result from the downslope movement of the surface soils, causing tension cracks to appear at the tops and sides of the slopes and compression ridges could possibly form at the bottoms of the slopes.

  If tension cracks were to develop as a result of the extraction of the proposed longwalls, it is possible that soil erosion could occur if these cracks were left untreated. It is possible, therefore, that some remediation might be required, including infilling of surface cracks with soil or other suitable materials, or by locally regrading and recompacting the surface. In some cases, erosion protection measures may be needed, such as the planting of additional vegetation in order to stabilise the slopes in the longer term.
- The main local road within the *Subsidence Study Area* is the Bylong Valley Way. It is possible that increased levels of ponding could occur along the roads located in terrain with shallow grades. It is expected, however, that the impacts of increased levels of ponding along the roads could be easily remediated by regrading and re-levelling the roads using standard road maintenance techniques. More extensive works may be required at locations of culverts, particularly in areas of shallow grades as the subsided surface levels may result in a redirection of the natural flow path through the road alignment. It may be necessary to introduce speed restrictions along the road until the appropriate remediation measures have been implemented.

  The maximum predicted conventional tensile and compressive strains within the *Subsidence Study Area* at any time during or after the extraction of the proposed longwalls are expected to result in cracking, heaving and stepping of the road surfaces, particularly at the western end, where depths of cover are shallowest.

  The road is sealed with no kerb and gutter and can be repaired and reconstructed using standard road maintenance techniques as mining proceeds. The repairs could be progressive and, therefore, can be staged to suit the mining of each longwall in sequence.

- It is possible that the drainage culverts will experience tilts greater than the existing grade, resulting in a reversal of grade where the tilts oppose the grade of the culvert. If the flow of water through any drainage culverts were to be adversely affected as a result of the proposed mining this could be remediated by re-levelling the affected culverts.

  The predicted curvatures and strains could be of sufficient magnitudes to result in cracking in the culverts or the headwalls. The potential impacts on the drainage culverts could be managed by visual inspection and, where required, any affected culverts can be repaired or replaced.

- The powerlines are likely to be impacted as a result of the extraction of Longwalls 205 and 206. It may be necessary that preventive measures are implemented, which could include the installation of guy wires, cable sheaves, additional poles or the adjustment of cable catenaries. Extensive experience of mining beneath powerlines in the NSW Coalfields indicates that incidences of impacts requiring remedial measures are very low and that the impacts are readily repairable.
- It is possible that the copper cables along Bylong Valley Way could be impacted as a result of the proposed mining. Extensive experience of mining beneath copper telecommunications cables in the NSW Coalfields where the mine subsidence movements were similar to those predicted for the proposed mining indicates that incidences of impacts is extremely low and of a minor nature. It is unlikely that the proposed mining would result in any significant impacts on the copper telecommunications cables within the *Subsidence Study Area*. Any impacts on these cables would be expected to be relatively infrequent and readily repairable.
- There are two survey control marks located within the *Subsidence Study Area*, one of which is outside the footprint of the Proposed longwalls. The survey control marks located outside and in the vicinity of the *Subsidence Study Area* are also expected to experience small amounts of subsidence and small far-field horizontal movements. It is possible that other survey control marks outside the immediate area could also be affected by far-field horizontal movements, up to 3 kilometres outside the *Subsidence Study Area*. It will be necessary on the completion of the longwalls, when the ground has stabilised, to re-establish any survey control marks that are required for future use in consultation with the Department of Finance and Services Land and Property Information.
- There is one unoccupied rural structure R01, which is located on KEPCO owned land above Longwall 102. Based on previous experiences, it is expected that the rural structure within the *Subsidence Study Area* would remain safe and serviceable during the mining period, provided that it is in sound existing condition. The risk of impact is clearly greater if the structure is in poor existing condition, though the chance of there being a public safety risk remains very low.
- There is one galvanised iron and two concrete tanks within the *Subsidence Study Area,* approximately 10 metres in diameter that are used for refilling of cattle watering troughs. The maximum predicted changes in grade at the tanks are approximately 250 mm over 10 metres and may, therefore, impact on the serviceability of the tank. This could be remediated by re-levelling the tank. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be easily repaired. With these remedial measures in place, it would be unlikely that there would be any adverse impacts on the pipelines associated with the tanks.
- It is possible that some of the wire fences within the *Subsidence Study Area* could be impacted as the result of the extraction of the proposed longwalls. Any impacts on the wire fences are likely to be of a minor nature and relatively easy to remediate by re-tensioning the fencing wire, straightening the fence posts, and if necessary, replacing some sections of fencing.
- There are 11 farm dams which have been identified within the *Subsidence Study Area.* The farm dams are typically of earthen construction and have been established by localised cut and fill operations within the natural drainage lines. It is possible that the storage capacities of some of the farm dams which are located directly above the proposed panels could be reduced. If the storage capacities of any farm dams were adversely affected they could be re-established by raising the earthen walls, if required. It is also likely that fracturing and buckling of the uppermost bedrock would occur beneath these farm dams. Any surface cracking or leakages in the farm dams could be identified by visual inspections and remediated by re-instating the bases and walls of the dams with cohesive materials.
- There are three registered groundwater bores that are located within the *Subsidence Study Area.* The bores are used for groundwater monitoring purposes. It is likely that the groundwater bores will experience impacts as the result of mining of the longwalls, particularly as they are located directly above the longwalls. Impacts may include temporary lowering of the piezometric surface, blockage of the bore due to differential horizontal displacements at different horizons within the strata and changes to groundwater quality.

- There is one silo within the *Subsidence Study Area* supported on a concrete pad approximately 7 metres in diameter. The concrete pad is resting on natural ground and, therefore, is unlikely to experience the curvatures and ground strains resulting from the extraction of the proposed longwalls. The maximum predicted conventional tilt at the location of the silo is 60 mm/m (i.e. 6 %), which represents a change in grade of 1 in 17. The predicted changes in grade are approximately 420mm over 7 metres, and may therefore, impact on the silo. This could be remediated by re-levelling the silo.
- There is one business operating within the *Subsidence Study Area,* Bylong Quarries. The likelihood of rock falls at the high walls in the quarry will be dependent on the position and geometry of the high walls at the time of longwall extraction. If the longwalls mine directly beneath the high walls, there is a high risk that the high walls would experience impacts in a similar manner to those described for the cliffs. It is also likely that surface cracking and deformation will occur within the quarry in areas located above the extracted longwalls, and this may pose a hazard to personnel and equipment working within the quarry.
- There are 146 archaeological/cultural sites which have been identified within the *Subsidence Study Area* and an additional 5 sites in close proximity that have been included in the subsidence impact assessments.

  The artefact scatter sites and isolated finds can potentially be affected by cracking of the surface soils as a result of mine subsidence movements. It is unlikely, however, that the scattered artefacts or isolated finds themselves would be impacted by surface cracking. It is recommended that any plans to remediate the surface cracking after mining include mitigation measures to ensure the artefact sites are not impacted.

  Potential impacts for the sandstone overhangs, cavities and rock shelters are similar to those described for the cliffs.

  The rock ledge at the location of the ochre quarry can potentially be affected by rock falls. It is also possible for slippage to occur along the bedding plane at the location of the ochre quarry, which may result in some material at the surface of the seam to spall and increased seepage to occur.

  The predicted conventional strains for grinding groove Site GG04 are large and would be sufficient to result in fracturing of the sandstone bedrock. These fractures may intersect with the grinding grooves. The potential for impacts on the three grinding groove sites that are located outside the *Subsidence Study Area* are considered to be very low. Preventive measures could be implemented at the grinding groove site, if required, including slotting of the bedrock around the sites to isolate them from the ground curvatures and strains. It is possible, however, that the preventive measures could result in greater impacts on the sites than those which would have occurred as a result of mine subsidence movements.

The assessments provided in this report indicate that the levels of impact on the natural and built features can be managed by the preparation and implementation of the appropriate management strategies. It should be noted, however, that more detailed assessments of some natural and built features 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.

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LIST OF TABLES, FIGURES AND DRAWINGS

Tables

Tables are prefixed by the number of the chapter or the letter of the appendix in which they are presented.

Figures

All figures are prefixed by the number of the chapter and section numbers or the letter of the appendix in which they are presented.

Drawings

Drawings referred to in this report are included in Appendix F at the end of this report.

1.0 INTRODUCTION

1.1. Background

WorleyParsons Services Pty Ltd (WorleyParsons) act on behalf of KEPCO Bylong Australia Pty Ltd (KEPCO) who holds Authorisation (A) 287 and A342 over an area of approximately 10,300 ha at Bylong, NSW. KEPCO plan to develop a new thermal coal mine, called the Bylong Coal Project (the Project), which is to consist of both open cut and underground operations. The layout of the proposed longwalls for the underground operations is shown in Drawings Nos. MSEC708-01.

KEPCO applied for a Gateway Certificate pursuant to clause 17F of the *NSW State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007.* MSEC prepared report number MSEC660 Rev A dated January 2014 in support of that application. The Project was granted a conditional gateway certificate on 15 April 2014.

1.2. Purpose of the Report

1.2.1. Scope of Work and Report structure

The scope of work for completion of the Subsidence Impact Assessment report has been defined as follows:

1. Review the proposed longwall layouts in the Coggan Seam based on the revised mine plan, which will be adopted as the base layout for the Environmental Impact Statement (EIS).
2. Provide subsidence predictions for the natural and built features based on the revised mine plan.
3. Provide subsidence predictions along selected prediction lines (cross-sections), plus key linear features such as roads or streams.
4. Provide a subsidence prediction and impact assessment report including subsidence predictions and impact assessments on surface features. The report includes the provision of figures and drawings.

The proposed scope of work does not include modelling to assess impacts of proposed mining on surface and groundwater, which are provided by other specialists. The proposed scope of work does, however, provide information to inform these studies.

Chapter 1 of this report provides an overview of the mining geometry, seam information and the overburden geology for the project.

Chapter 2 provides a summary of the natural and built features that will be affected by the proposed mining.

Chapter 3 provides an overview of conventional and non-conventional subsidence movements and the methods which have been used to predict the mine subsidence movements for the Project.

Chapter 4 provides a summary of the maximum predicted subsidence parameters resulting from the extraction of the proposed longwalls in the Coggan Seam.

Chapter 5 provides the predictions and impact assessments for the natural and built features within the proposed mining area, based on the predicted mine subsidence movements. Recommendations of management strategies for the potential mine subsidence impacts have also been provided in this chapter.

1.2.2. Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements (SEARs) that were issued for the Project on 23 June 2014 and subsequently updated to reflect the revised Project description on 11 November 2014 have been addressed where relevant within this Subsidence Impact Assessment Report.

The key matters raised for consideration in the Subsidence Impact Assessment, are outlined in Table 1.1.

Table 1.1 Secretary's Environmental Assessment Requirements applicable to the Subsidence Impact Assessment

Secretary's Environmental Assessment Requirement
The EIS must address the following specific issues: • **Subsidence** – including an assessment of the likely conventional and non-conventional subsidence effects and impacts of the development, and the potential environmental consequences of these effects and impacts on both the natural and built environment, paying particular attention to those features that are considered to have significant economic, social or environmental values. • **Land** – including: - an assessment of the likely impacts of the development on the soils and land capability of the site and surrounds, paying particular attention to any biophysical strategic agricultural land (BSAL), having regards to the Mining & Petroleum Gateway Panel's and Department of Primary Industries' requirements; - an assessment of the likely agricultural impacts of the development, paying particular attention to the mapped equine critical industry cluster in the area - an assessment of the likely impacts of the development on landforms (topography), including: o the potential subsidence impacts on cliffs, rock formations and steep slopes; and o the long term geotechnical stability of any new landforms (such as mine waste emplacements); - an assessment of the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements in Clause 12 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 • **Water** – including: - an assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, having regard to the Mining & Petroleum Gateway Panel's, EPA's, Department of Primary Industries' and (Commonwealth) Department of the Environment's requirements - an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users; and - an assessment of the likely flooding impacts of the development; • **Public Safety** - including an assessment of the likely risks to public safety, paying particular attention to potential subsidence risks, bushfire risks, and the transport, handling and use of any dangerous goods;

1.2.3. Subsidence Impact Assessment Objectives

This Subsidence Impact Assessment Report contributes to the responses to these and other key matters raised by the Secretary regarding Land Resources, Water Resources, Biodiversity and Heritage issues.

This report should be read in conjunction with the EIS being prepared by Hansen Bailey for the Project and in conjunction with the reports from the other specialist consultants engaged for the Project.

1.3. Mining Geometry

The layout of the proposed longwalls is shown in Drawings Nos. MSEC708-01. A summary of the proposed longwall dimensions is provided in Table 1.2. It is noted that the longwall numbering presented in this report represents the proposed extraction sequence for the longwalls.

A *Subsidence Study Area*, which is based on a 26.5 degree angle of draw line, is presented in Drawings Nos. MSEC708-01 to 14. The *Subsidence Study Area* defines the area that is likely to be affected by the proposed mining of the longwalls and is discussed in Section 2.1.

Table 1.2 Geometry of the Proposed Longwalls

Longwall	Overall Void Length* Including Installation Heading (m)	Overall Void Width* Including First Workings (m)	Overall Tailgate Chain Pillar Width (m)
LW101	3,204	315	-
LW102	2,817	315	31
LW103	2,912	315	34
LW104	2,663	315	37
LW105	1,957	315	34
LW106	1,918	315	36
LW107	1,528	315	36
LW108	1,726	315	37
LW109	1,541	315	42
LW201	3,338	355	69
LW202	3,053	355	31
LW203	2,978	355	31
LW204	3,236	355	30
LW205	3,728	355	34
LW206	4,005	355	34

* Total distance between longwall panel voids, including chain pillars and barrier pillar.

1.4. Surface Topography

The surface level contours within the vicinity of the proposed longwalls are shown in Drawing No. MSEC708-03, which were generated from an airborne laser scan of the area by AAM. The surface levels above the proposed longwalls vary from approximately 275 metres AHD along Dry Creek above the middle of Longwall 206 to 520 metres AHD at the finishing end of Longwall 106.

The depth of cover contours are provided in Drawing No. MSEC708-06 and vary from approximately 105 metres above Longwall 206 to 310 metres above Longwalls 107 to 109.

1.5. Seam Information

The seam thickness contours are provided in Drawing No. MSEC708-05 and vary from approximately 3.4 metres at the tailgate of Longwall 206 to 5.1 metres near the commencing end of Longwall 109. The Coggan Seam generally dips from the south-west down towards the north-east. The proposed longwall extraction height in the Coggan Seam will vary from a minimum of 3.5 metres to a maximum of 4.8 metres.

1.6. Geological Details

Tamplin Resources (2010) and Cockatoo Coal (2014) provide a detailed assessment of the geology of the Project.

The Bylong Project Boundary (incorporating A287 and A342) is located in the Western Coalfield in the Permo-Triassic Sydney-Gunnedah Basin, within which the main coal bearing sequence is the Illawarra Coal Measures, of Late Permian age. The Illawarra Coal Measures within the Project contain several seams; the

Farmers Creek Seam, Goulburn Seam, Ulan seam and the Coggan Seam. The lowermost seam, the Coggan Seam, has been targeted for underground extraction.

A typical stratigraphic section for the Project has been provided by Tamplin Resources (2010) and this has been reproduced in Fig. 1.1.

The Blackmans Flat Conglomerate forms the roof of the Coggan Seam. Based on the typical stratigraphic section, the conglomerate roof appears to be less than 5 metres in thickness.

The Triassic Narrabeen Group consists predominantly of sandstone and conglomerate and forms the ridges and cliff lines within the Project Area.

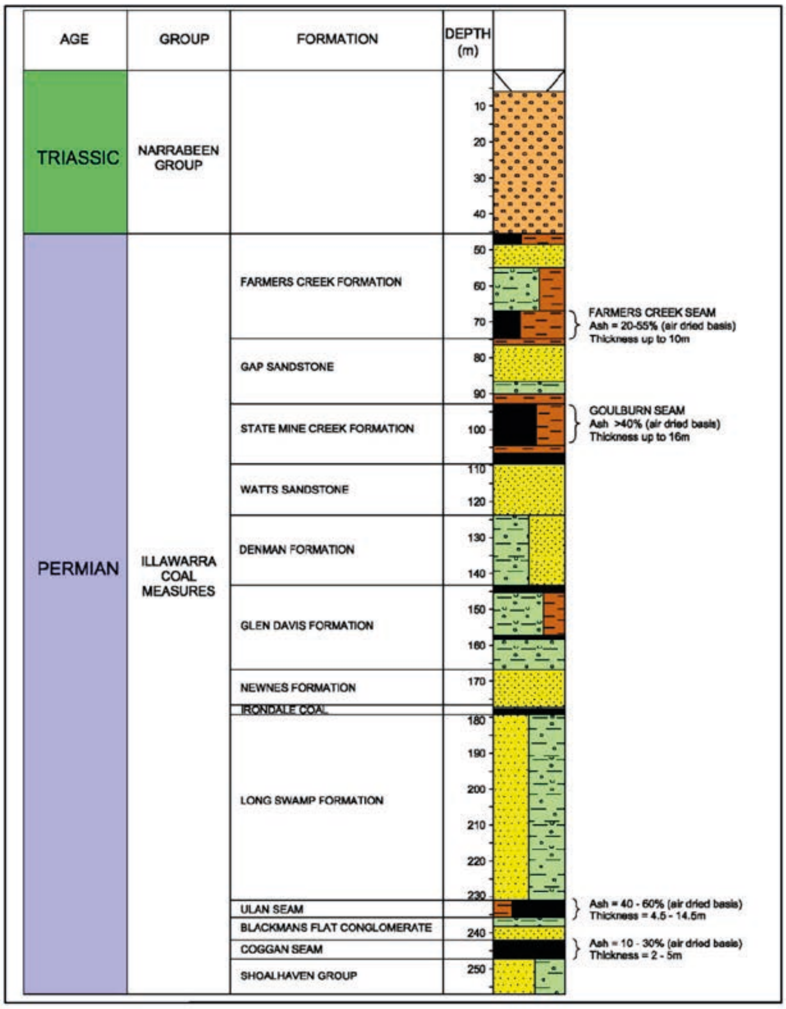

Fig. 1.1 Stratigraphy of Bylong Coal Project (Tamplin Resources, 2010)

The surface geology within the vicinity of the proposed longwalls is shown in Fig. 1.2, which is based on Geological Series Sheet including part of 8832, 8833, 8834, 8932, 8933 and 8934, Edition 1 1998, published by the now NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).

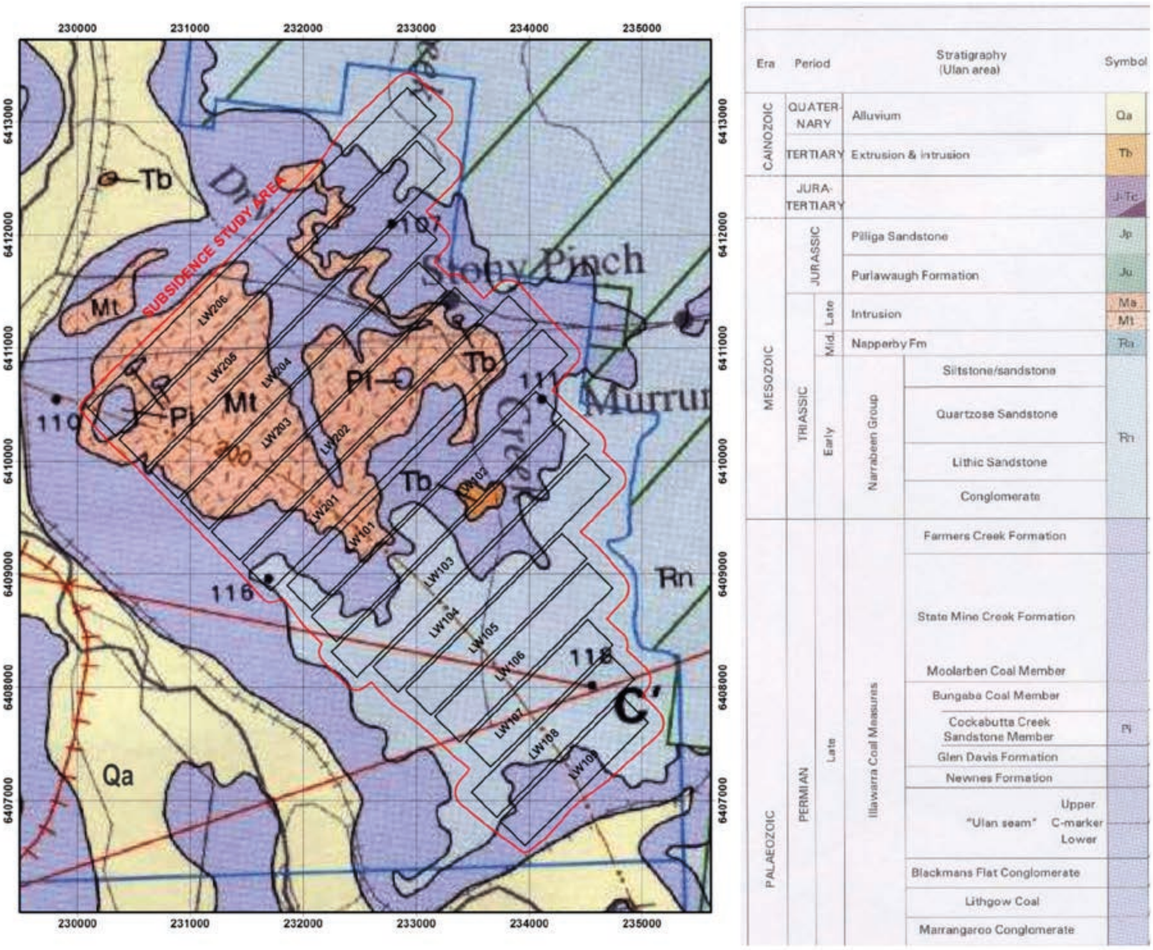

Fig. 1.2 Surface Geology within Bylong Coal Project Authorisation A287 and A342 Geological Series Sheet including part of 8832, 8833, 8834, 8932, 8933 and 8934 (DTIRIS)

It can be seen from the above figure, that the surface geology above the proposed longwalls includes intrusive materials Teschenite (Mt) and Basalt (Tb), Illawarra Coal Measures (Pi), and Narrabeen Group sandstone/conglomerate (Rn).

The major geological features identified above and in the vicinity of the proposed longwalls are shown in Drawing No. MSEC708-07. Details of the geological features are provided in the report by Cockatoo Coal (2014). A summary of the features is provided below.

Folding

A series of anticline/syncline folds are present in the western part of the proposed longwall footprint as shown on Drawing No. MSEC708-07. The folding runs North South with displacements of 3 to 12 metres over a 100 metres zone.

Faulting

No faulting greater than 5 metres has been identified. Faulting is expected to be associated with the folding deformation zones described above. Both normal and reverse faulting has been identified.

Basalt Cover

The material mapped in Fig. 1.2 as Teschenite (Mt) above the proposed longwalls has been identified as intrusive basalt in the geological report by Cockatoo Coal (2014). The mapped area of basalt (Cockatoo Coal, 2014) is shown in Drawing No. MSEC708-07. The following description of the basalt is provided in the geological report by Cockatoo Coal (2014):

"The basalt cover is located at the topographic surface and is typically overlain by soil/alluvium. The thickness varies from 10-40m and is blocky (Highly fractured sub 10cm scale). Commonly calcite infill can be seen along fracture planes as well as pervasive oxidisation. Both infill and oxidisation indicates water flow."

Cross sections showing the mapped basalt thickness are shown below in Fig. 1.3 and Fig. 1.4. The locations of the cross section lines are shown in Drawing No. MSEC708-07.

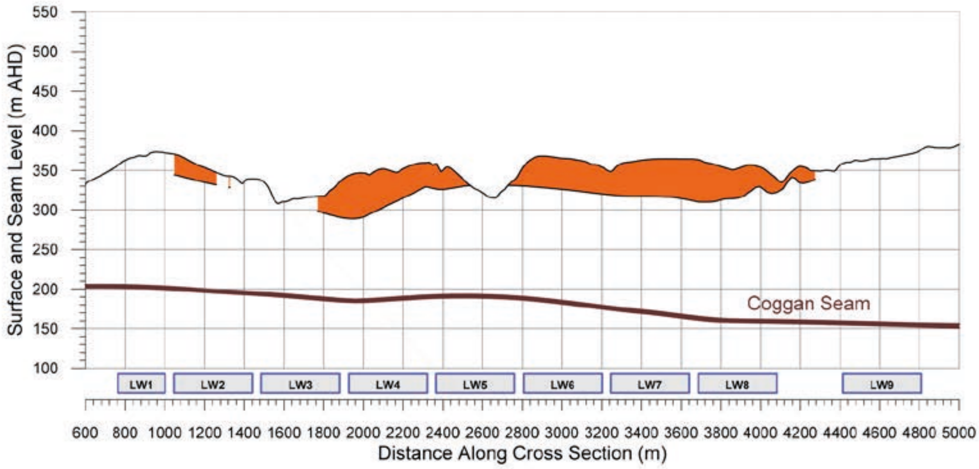

Fig. 1.3 Section A-A Basalt Thickness

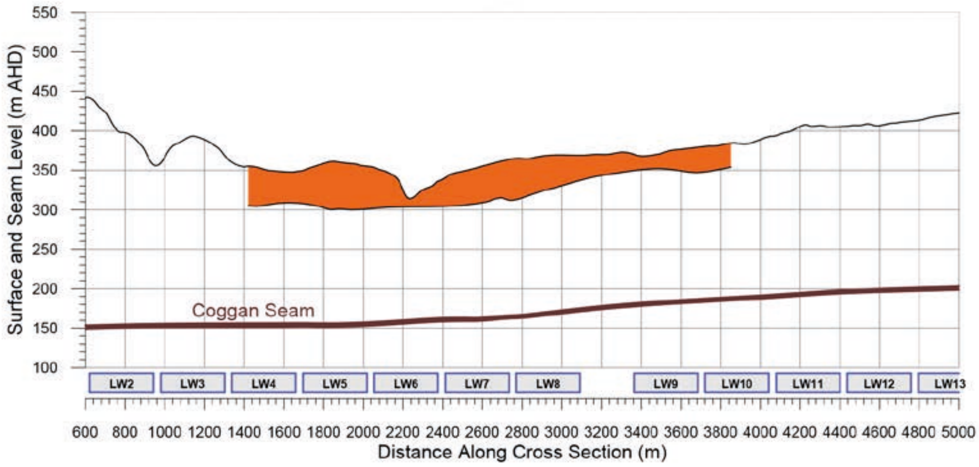

Fig. 1.4 Section B-B Basalt Thickness

The presence of a potentially very strong and stiff rock mass within the overburden may influence the magnitude and nature of subsidence movements on the surface. If the basalt is capable of spanning the void width, for example, it is possible that reduced subsidence would be observed in those areas. A literature search has found, for example, that dolerite sills with exceptional strength have reduced or delayed subsidence behaviour in South Africa (Deats, 1971, Galvin, 1981, Wagner and Shümann, 1991). In these cases it was found that dolerite sills with thicknesses greater than 30 to 40 metres can span several hundred metres, resulting in significantly reduced or delayed subsidence.

Based on the blocky nature of the basalt as described above, it is considered that the basalt layers above the proposed longwalls are unlikely to result in reduced subsidence and/or significantly large ground steps or cracks.

Sills

Igneous sills are located to the south-west of the proposed longwalls and outside the longwall footprint. The location of the igneous sills is shown in Drawing No. MSEC708-07. The sills are described in the geological report by Cockatoo Coal (2014) as being *“irregular in nature, and should not be considered continuous features (vertically or horizontally) however they are connected in places. They are typically solid with little jointing evident, unlike the basalt cover.”*

Dykes

Dykes have been identified to the north-west and south of the proposed longwalls, and outside the longwall footprint as shown in Drawing No. MSEC708-07. The dykes are basalt and range in thickness from 1 metre to 2 meters.

2.0 IDENTIFICATION OF SURFACE FEATURES

2.1. Definition of the Subsidence Study Area

The *Subsidence Study Area* is the surface area within which natural surface features and items of infrastructure have been identified and assessed for their potential to experience mine subsidence impacts as a result of the proposed extraction of Longwalls 101 to 109 and 201 to 206 for the Project.

The extent of this *Subsidence Study Area* has been conservatively defined by combining the areas bounded by the following limits:-

- A 26.5 degree angle of draw line from the proposed extents of the longwalls, and
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of the longwalls.

The 26.5 degree angle of draw line is described as the "surface area defined by the cover depths, angle of draw of 26.5 degrees, and the limit of the proposed extraction area in mining leases of all other NSW Coalfields" (includes Western Coalfield), as stated in Section 6.2 of the Department of Primary Industries (now DP&E) SMP Guideline 2003. The predicted limit of vertical subsidence, taken as the predicted total 20 mm subsidence contour, has been determined using the Incremental Profile Method (IPM), which is described in Chapter 3. The predicted total subsidence contours, resulting from the extraction of Longwalls 101 to 109 and 201 o 206, are shown in Drawing No. MSEC708-14.

The depth of cover contours are shown in Drawing No. MSEC708-06. It can be seen from this drawing that the depth of cover directly above the proposed longwalls varies between a minimum of 105 metres and a maximum of 310 metres. The 26.5 degree angle of draw line, therefore, has been determined by drawing a line that is a horizontal distance varying between 53 metres and 155 metres around the limits of the proposed extraction areas. The predicted 20 mm subsidence contour is wholly within the 26.5 degree angle of draw line.

There are features that lie outside the above limits that are expected to experience either far-field movements, or valley related movements. The surface features which are considered significant or are sensitive to such movements have been identified and have been included in the assessments provided in this report. These features are listed below and details of these are provided in later sections of the report:-

- Sandy Hollow to Gulgong Railway Line,
- Bylong River,
- Cliffs to the south of the proposed longwalls, and
- Survey Control Marks.

2.2. Natural Features and Items of Surface Infrastructure within the Subsidence Study Area

The major natural and built features within the vicinity of the proposed longwalls can be seen in the 1:25,000 Topographic Map of the area, published by the Central Mapping Authority (CMA), number 89333S. The proposed longwalls have been overlaid on an extract of this CMA map in Fig. 2.1. The proposed longwalls have also been overlaid on the aerial photograph of the area in Fig. 2.2. The surface topography, land usage and the larger natural features can also be seen in this figure.

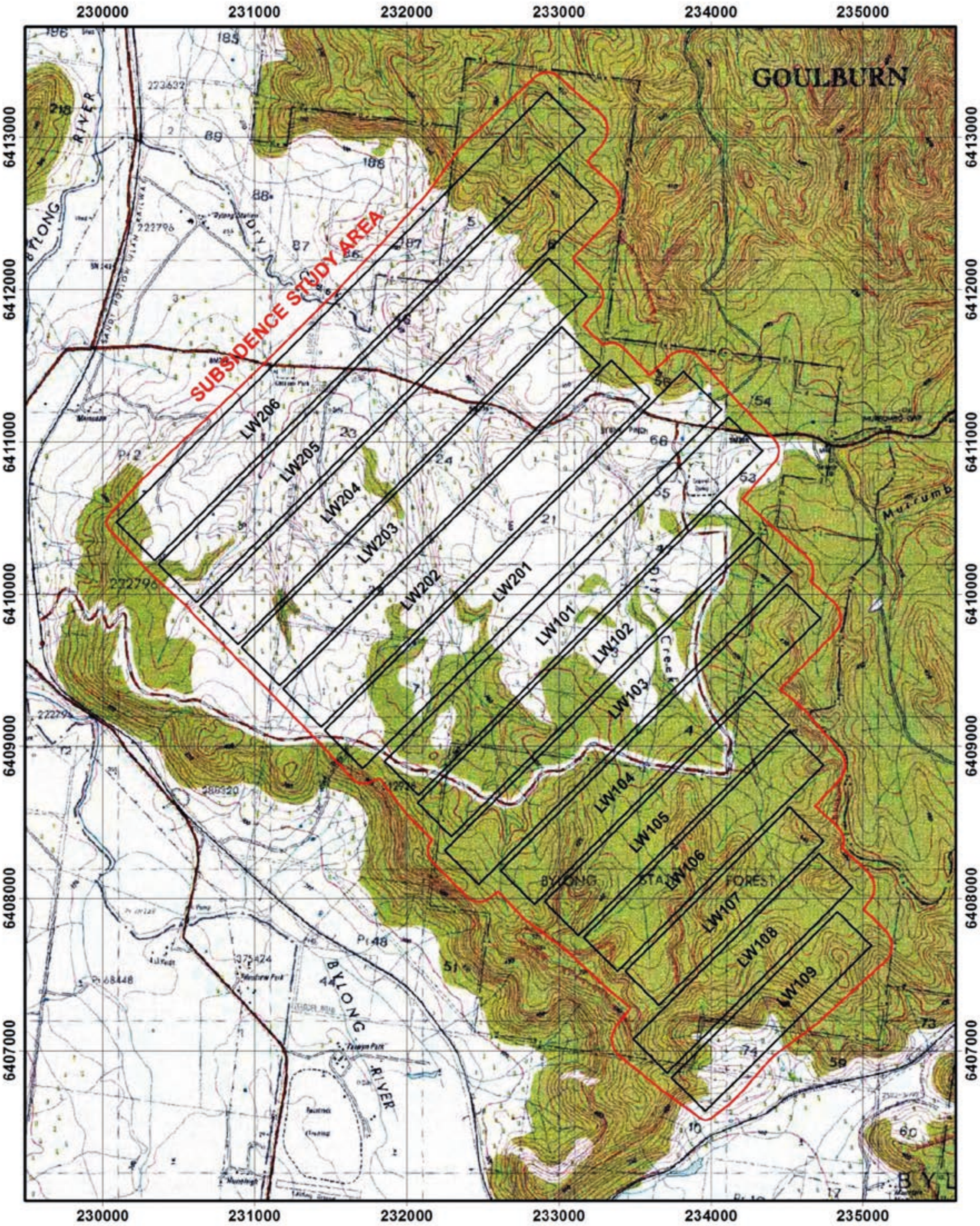

Fig. 2.1 Bylong Coal Project Proposed Longwalls Overlaid on CMA Map No. 89333S

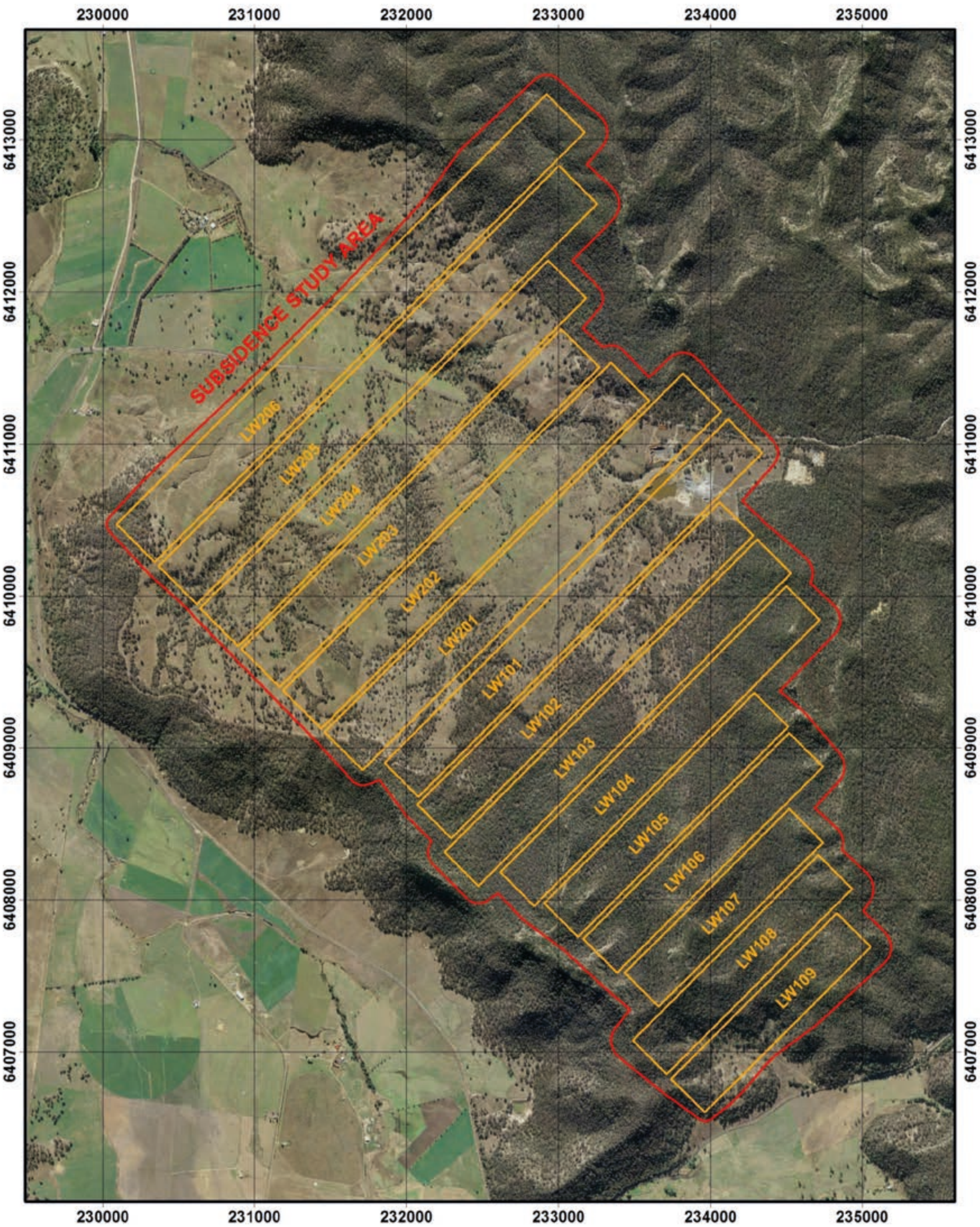

Fig. 2.2 Bylong Coal Project proposed Longwalls Overlaid on the Aerial Photograph

A summary of the natural features and items of surface infrastructure within the *Subsidence Study Area* is provided in Table 2.1. The locations of these features are shown in Drawing Nos. MSEC708-08 to MSEC708-13, in Appendix D.

The descriptions, predictions and impact assessments for the natural features and items of surface infrastructure are provided in Chapters 5 though to 9. The relevant chapter and section number references in this report that address these features and items are provided in Table 2.1.

Table 2.1 Natural Features and Surface Infrastructure

Item	Within *Study Area*	Section Number Reference
NATURAL FEATURES		
Catchment Areas or Declared Special Areas	×	
Rivers or Creeks	✓	5.2
Aquifers or Known Groundwater Resources	✓	5.3
Springs	×	
Sea or Lake	×	
Shorelines	×	
Natural Dams	×	
Cliffs or Pagodas	✓	5.4
Steep Slopes	✓	5.5
Escarpments	×	
Land Prone to Flooding or Inundation	✓	5.7
Swamps, Wetlands or Water Related Ecosystems	✓	5.8
Threatened or Protected Species	✓	5.9
National Parks	✓	5.10
State Forests	✓	5.11
State Conservation Areas	×	
Natural Vegetation	✓	5.12
Areas of Significant Geological Interest	×	
Any Other Natural Features Considered Significant	×	
PUBLIC UTILITIES		
Railways	✓	6.1
Roads (All Types)	✓	6.2
Bridges	×	
Tunnels	×	
Culverts	✓	6.2
Water, Gas or Sewerage Infrastructure	×	
Liquid Fuel Pipelines	×	
Electricity Transmission Lines or Associated Plants	✓	6.8
Telecommunication Lines or Associated Plants	✓	6.9
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*	Section Number Reference
FARM LAND AND FACILITIES		
Agricultural Utilisation or Agricultural Suitability of Farm Land	✓	7.1
Farm Buildings or Sheds	✓	7.2
Tanks	✓	7.3
Gas or Fuel Storages	×	
Poultry Sheds	×	
Glass Houses	×	
Hydroponic Systems	×	
Irrigation Systems	×	
Fences	✓	7.9
Farm Dams	✓	7.10
Wells or Bores	✓	7.11
Any Other Farm Features – Silos	✓	7.12
INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS	×	
Factories	×	
Workshops	×	
Business or Commercial Establishments or Improvements	✓	8.1
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	✓	8.1
Mine Infrastructure Including Tailings Dams or Emplacement Areas	×	
Any Other Industrial, Commercial or Business Features	×	
AREAS OF ARCHAEOLOGICAL OR HERITAGE SIGNIFICANCE	✓	9.1
ITEMS OF ARCHITECTURAL SIGNIFICANCE	×	
PERMANENT SURVEY CONTROL MARKS	✓	6.11
RESIDENTIAL ESTABLISHMENTS		
Houses	×	
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	×	
Any Other Residential Features	×	
ANY OTHER ITEM OF SIGNIFICANCE	×	
ANY KNOWN FUTURE DEVELOPMENTS	×	

3.0 OVERVIEW OF CONVENTIONAL AND NON-CONVENTIONAL SUBSIDENCE MOVEMENTS AND THE METHODS USED TO PREDICT THESE MOVEMENTS FOR THE PROPOSED LONGWALLS

3.1. Introduction

This chapter provides a brief overview of longwall mining and the development of mine subsidence and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the longwalls. Further details on longwall mining, the development of subsidence and the methods used to predict mine subsidence movements can be obtained in the background reports entitled *Introduction to Longwall Mining and Subsidence* and *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*.

3.2. Overview of Longwall Mining

Longwall mining is a method used to extract large rectangular panels (i.e. blocks) of coal, typically 150 metres to 400 metres wide and 1 kilometre to 5 kilometres long. The coal is progressively mined by a shearer that shaves off slices of coal up to 1 metre thick from the longwall face, under the protection of hydraulic supports, until all the panel is fully extracted. While the technology has changed considerably over the years, the basic idea of longwall mining is to maintain a safe working space for the miners along a wide coal face whilst removing all of the coal and allowing the roof and overlying rock to collapse into the void behind. The Project proposes to extract the underground panels using longwall mining techniques.

Firstly a large rectangular panel or pillar is initially formed using continuous miners or road headers. Gate roads are first driven all around the large rectangular pillar before longwall mining begins. The gate road along one long side of the panel is called the maingate where fresh air and mine workers are carried to the face and the extracted coal is conveyed along conveyors. The gate road on the other side of the panel is called the tailgate where air is carried away from the face and also provides a secondary means of egress.

A number of hydraulic jacks, called powered roof supports, chocks or shields, provide support to the roof along the coalface at one end of the longwall panel. Each chock or shield is typically 1.75 metres wide and the supports are placed in a long line, side by side, for the full width of the coal face. An individual support can weigh 30 tonnes to 40 tonnes, can extend to a maximum cutting height of up to 6 metres and can support 1,000 tonnes to 1,250 tonnes of the overlying strata weight. Each chock can hydraulically advance itself around 1 metre forward after each slice of coal is extracted.

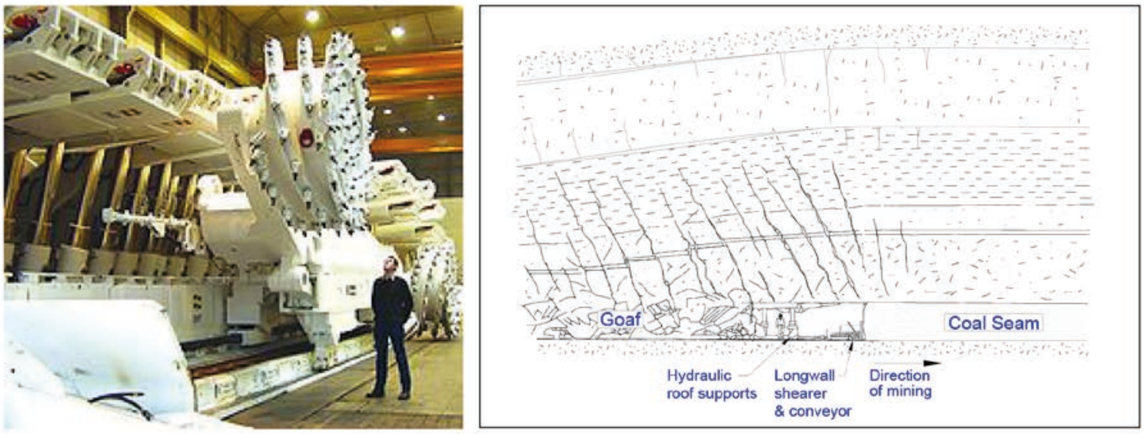

Fig. 3.1 Cross-section along the Length of a Typical Longwall at the Coal Face and a photograph of a typical Shearer, Conveyor and Hydraulic Support Chocks

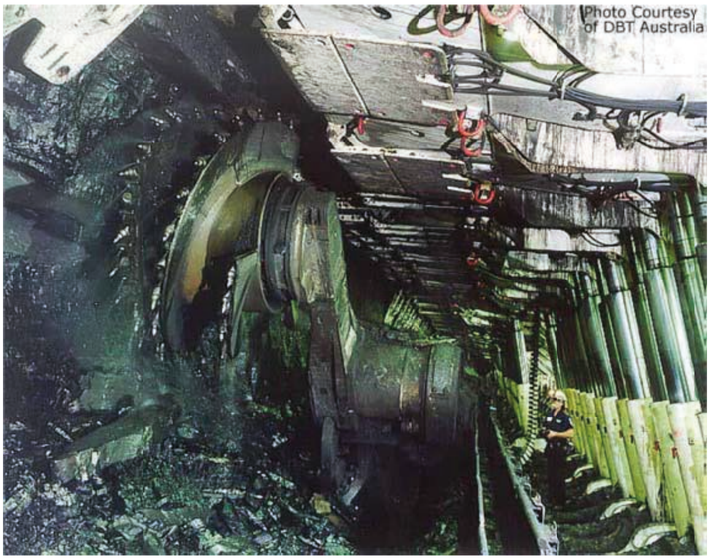

Fig. 3.2 An Operating Longwall Face

Note: The following features can be seen: coal seam under extraction, the coal shearer, the face conveyor and system of self-advancing hydraulic roof supports ('chocks' or 'shields').

The coal is cut in slices from the coalface by a shearer and the coal falls onto an armoured face conveyor (AFC), which is placed in front of the powered roof supports, and carries the coal from the longwall face to the maingate. From here it is loaded onto a network of conveyor belts for transport to the surface. At the maingate, the coal is often reduced in size in a crusher and loaded onto the first conveyor belt by the beam stage loader (BSL). As the shearer removes the coal, the AFC is snaked over behind the shearer and the powered roof supports move forward into the newly created cavity.

As the longwall face progresses through the seam, the overlying roof strata falls into the mined void (goaf) and the subsidence process of the overburden strata commences. The collapsed roof strata comprises loose blocks and can contain large voids depending on the loading and compaction that follows. Immediately above the mined void and the collapsed zone, the strata can remain relatively intact and bends into the void, resulting in new vertical factures, opening up of existing vertical fractures and bed separation. The strata layers above that bend and shear with the amount of strata sagging, fracturing and bed separation reducing towards the surface.

The basic idea behind longwall mining was developed many years ago, but it has only been in the last thirty years that mining equipment has become powerful and reliable enough to successfully and safely extract large longwall blocks. Safety, productivity and cost considerations dictate that longwall mining is now the major, viable, high production method of coal mining adopted in the majority of Australian underground coal mines that operate at depths greater than about 300 metres.

Longwall mining has a better level of resource recovery when compared to the bord and pillar extraction method, has less need for roof support consumables, has higher volume coal clearance systems and has minimal manual handling. In addition, the safety of the miners is enhanced by the fact that they are always under the hydraulic roof supports when they are extracting coal.

It takes typically two longwall development heading panels to delineate the first longwall block. Thereafter, only one set of longwall gateroads needs to be driven for each new adjacent longwall panel because the new panel also makes use of one of the gateroads left over from the previous panel. The interpanel pillars that separate each gateroad are known as chain pillars.

Longwall extraction operations effectively result in the formation of very wide and very long excavations separated by a single or double row of relatively narrow chain pillars. Longwall mining therefore involves both first workings and second workings. The mains development and gateroads are first workings, which result in no measurable subsidence at the surface, and the longwall panels are a type of second workings. As with pillar extraction, significant subsidence and resulting disturbance of the subsurface and surface may occur, depending on the mining layout.

3.3. Overview of Conventional Subsidence Parameters

The normal ground movements resulting from the extraction of longwalls are referred to as conventional or 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 beyond the longwall goaf edges, can be greater than the vertical subsidence.
- Unlike mining induced vertical subsidence, which has a magnitude only, **Horizontal Displacements** have both a magnitude and a direction, i.e. they can be referred to as a vector. Early researchers generally only measured and predicted vertical subsidence and ground strains and rarely measured or predicted the horizontal displacements of points. Subsidence and horizontal movements are 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 bending of the ground as a result of differential subsidence, 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* (km^{-1}), 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 the relative differential horizontal movements of the ground. **Normal 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 strains** occur where the distance between two points increases and **Compressive strains** occur 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. When strains are measured over longer bay lengths lower averaged values are generally observed.

  Whilst mining induced normal strains are measured along monitoring lines, **ground shearing** can also occur both vertically and horizontally across the directions of monitoring lines. Most of the published mine subsidence literature discusses the differential ground movements that are measured along subsidence monitoring lines, however, differential ground movements can also be measured across monitoring lines using 3D survey monitoring techniques.
- **Horizontal shear deformation** across monitoring lines can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index. However, is not possible to determine the horizontal shear strain across a monitoring line using standard 2D or 3D monitoring techniques. High deformations along monitoring lines (i.e. normal strains) are generally measured where high deformations have been measured across the monitoring line (i.e. shear deformations) and vice versa.

High resolution surveying techniques using GPS technology and satellite based differential interferometry are providing far more data and a much better basis for understanding the extent and the mechanics of the mining induced vertical and horizontal ground movements. Modern surveyors now provide the current easting, northing and reduced level of each installed peg from which three dimensional subsidence and mining induced horizontal movements and directions can be derived for each epoch. Because of these improvements in subsidence surveying our understanding of both the magnitude and direction of mining induced vertical and horizontal ground movements and the lateral extent of these mining induced ground movements has improved substantially.

The **total** subsidence, tilts, curvatures and strains are the accumulated parameters which result from the extraction of a series of longwalls. **Incremental** subsidence, tilts, curvatures and strains are the additional movements due to the extraction of each longwall and are determined from monitored data by subtracting the movements monitored before a longwall was mined from the movements monitored after that longwall was mined. The **travelling** tilts, curvatures and strains are the transient movements as the longwall extraction face mines directly beneath a given point.

Residual subsidence is defined as the additional, time-dependent subsidence that develops after active mining has been completed or has moved sufficiently far enough away from the affected area to no longer have an immediate influence. As the amount of subsidence being measured reduces asymptotically to smaller and smaller levels, the shrinking and swelling of the soil due to changes in moisture content and the survey accuracy can form a large proportion of the measured subsidence.

3.4. Overview of Conventional and Non-Conventional Subsidence Movements

Some subsidence terms and definitions were first published in an Independent Inquiry report entitled "*Strategic Review of Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield*", (Southern Coalfield Inquiry Report), which was published in July 2008, (NSW DP, 2008). The terms and definitions draw a distinction between subsidence effects, subsidence impacts, environmental consequences, consequences, secondary consequences, conventional effects and non-conventional effects.

Conventional subsidence profiles are typically smooth in shape and can be explained by the expected caving mechanisms associated with overlying strata spanning the extracted void. Normal conventional subsidence movements due to longwall extraction are easy to identify where longwalls are regular in shape, the extracted coal seams are relatively uniform in thickness, the geological conditions are consistent and surface topography is relatively flat.

As a general rule, the smoothness of the profile is governed by the depth of cover and lithology of the overburden, particularly the near surface strata layers. Where the depth of cover is greater than 400 metres, the observed subsidence profiles along monitoring survey lines are generally smooth. Where the depth of cover is less than 100 metres, the observed subsidence profiles along monitoring lines are generally irregular. Very irregular subsidence movements are observed with much higher tilts, curvatures and strains at very shallow depths of cover where the collapsed zone above the extracted longwalls extends up to or near to the surface.

Irregular subsidence movements are occasionally observed at the deeper depths of cover along an otherwise smooth subsidence profile. The cause of these irregular subsidence movements can be associated with:-

- sudden or abrupt changes in geological conditions,
- steep topography, and
- valley related mechanisms.

Non-conventional movements due to geological conditions, steep topography and valley related movements are discussed in the following sections.

3.4.1. Non-conventional Subsidence Movements due to Changes in Geological Conditions

For those sites where the depth of cover is less than 100 metres, the observed subsidence profiles along monitoring lines are generally irregular with much higher tilts, curvatures and strains principally because the collapsed zone has extended up to or near to the surface. Where the depth of cover is around 400 metres, the observed subsidence profiles along monitoring survey lines will generally be smooth as is typical in the Southern Coalfields. However, irregular subsidence movements can occasionally be observed at these deeper depths of cover along an otherwise smooth subsidence profile and these localised irregular subsidence movements, that are called non-conventional subsidence movements, are often associated with sudden or abrupt changes in geological conditions, steep topography, and valley related mechanisms.

Accordingly non-conventional subsidence movements may occur or could be expected within the river and creek valleys, near the major fault zones, near the outcrop of the interface between sandstone and shale strata layers. It is believed that most of the unexpected irregular subsidence movements, i.e. the non-conventional ground movements, are a result of the reaction of near surface strata to increased horizontal compressive stresses due to mining operations. Some of the geological conditions that are believed to influence these irregular subsidence movements are the blocky nature of near surface sedimentary strata layers and the possible presence of unknown faults, dykes or other geological structures, cross bedded strata, thin and brittle near surface strata layers and pre-existing natural joints. The presence of these geological features near the surface can result in bumps in an otherwise smooth subsidence profile which are usually accompanied by locally increased tilts, curvatures and strains.

Even though it may be possible to attribute a reason behind many of the observed non-conventional ground movements, there remain some observed irregular ground movements that still cannot be explained with the available geological information. The term "anomaly" is therefore reserved for those non-conventional ground movement cases that were not expected to occur and cannot be explained by any of the above possible causes.

It is not possible to predict the locations and magnitudes of non-conventional anomalous movements. In some cases, approximate predictions for the non-conventional ground movements can be made where the underlying geological or topographic conditions are known in advance. It is expected that these methods will improve as further knowledge is gained through ongoing research and investigation.

In this report, the analyses of non-conventional ground movements have been carried out statistically in the predictions and impact assessments, by basing these on the frequency of past occurrence of both the conventional and non-conventional ground movements and impacts. The analysis of strains provided in Section 4.3 includes those resulting from both conventional and non-conventional anomalous movements.

3.4.2. Non-conventional Subsidence Movements due to Valley Related Movements

Valley bulging movements are a natural phenomenon, resulting from the formation and ongoing weathering, erosion and development of valleys, as illustrated in Fig. 3.3. These naturally occurring valley bulging movements include inward movement of the valley sides and the bulging or upwards movement of the valley floor. The potential for these natural movements are influenced by the geomorphology of the valleys.

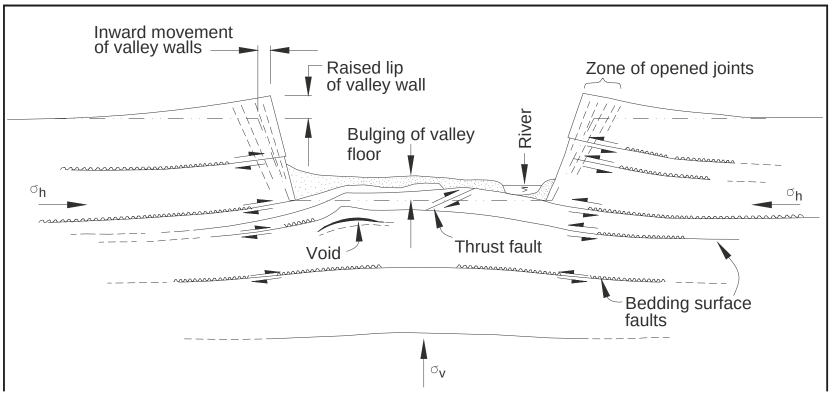

Fig. 3.3 Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)

The streams within the *Subsidence Study Area* may also be subjected to mining induced valley related movements, which result in similar consequences to the naturally occurring valley bulging movements that are discussed above. These mining induced valley closure result in closure movements across the valley and upsidence in the floor of the valley. The potential for these mining induced movements are influenced by the geomorphology of the valleys and the proximity and magnitude of the mining induced subsidence movements. As discussed in Section 3.4 and in the Southern Coalfield Inquiry Report (DoP 2008), mining induced valley related movements are commonly observed across river and creek alignments, particularly in the Southern Coalfield and extensive studies have been carried out to predict the extent of these valley related movements.

Valley related movements are normally described by the following parameters:-

- **Upsidence** is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.
- **Closure** is the reduction in the horizontal distances across the valley sides. The magnitude of maximum valley closure, which is typically expressed in the units of *millimetres (mm)* and is defined as the greatest reduction in distance between any two points on the opposing valley sides, is generally measured from pegs located at the top of the sides of the valley, however, sometimes the greatest closure is observed between pegs located in the base of the valley.
- **Compressive valley closure strains** occur within the bases of valleys as a result of valley closure and upsidence movements. **Tensile strains** tend to occur in the sides and near the tops of the valleys as a result of valley closure movements. The magnitudes of these strains, which are typically expressed in the units of *millimetres per metre (mm/m)*, are calculated as the changes in horizontal distance over a standard bay length, divided by the original bay length.

The predicted valley related movements resulting from the extraction of the proposed longwalls were made using the empirical method outlined in Australian Coal Association Research Programme (ACARP) Research Project No. C9067 (Waddington and Kay, 2002). Further details can be obtained from the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be found at *www.minesubsidence.com*.

3.4.3. Non-conventional Subsidence Movements due to Steep Topography

Non-conventional subsidence movements can also result from slope instability movements where longwalls are extracted beneath steep slopes. In these cases, elevated tensile strains develop near the tops of the steep slopes and elevated compressive strains develop near the bases of the steep slopes. The potential impacts resulting from slope instability movements include the development of tension cracks at the tops and the sides of the steep slopes and compression ridges at the bottoms of the steep slopes.

Further discussions on the potential for slope instability movements for the steep slopes within the *Subsidence Study Area* are provided in Section 5.5.

3.5. Review of Subsidence Profiles around the Corners of Longwall Panels

Subsidence surveys in NSW and QLD have shown that less subsidence develops at corners compared to subsidence beyond the ends and sides of longwalls. This is understandable as the overburden is supported on two sides.

A comprehensive study of subsidence at corners of longwalls was carried out at West Wallsend Colliery in NSW. A large number of survey pegs were placed in the vicinity of the corner of numerous longwalls to monitor subsidence behaviour as mining progressed for each of the longwalls. This study was carried out because of the importance of infrastructure located close to the corners and edges of longwalls at West Wallsend Colliery.

Some of the results of this subsidence monitoring programme are illustrated in the plots of subsidence contours shown in Fig. 3.4. From this figure, it can be seen that a large number of survey pegs were located beyond the edges and corners of the extracted panels at West Wallsend Colliery and, as a result, the level of confidence in the predicted subsidence movements is relatively high.

The maximum subsidence observed immediately above the longitudinal end of a longwall panel was 30 mm. It should be noted, however, that in both of these cases there had been previous extraction nearby in an overlying seam, which would have increased the extent of the subsidence. Where there were no overlying workings, it was noted that subsidence did not extend very far outside the longitudinal goaf edges.

Because the contours of subsidence wrap around the corners of the longwall, the subsidence in the corner is less than at the longitudinal goaf edge of the longwall. The observed subsidence at the corners of the longwall panels ranged from 5 mm to 20 mm at West Wallsend.

The example at West Wallsend Colliery demonstrated that less subsidence is observed around corners of longwall panels compared to subsidence beyond the sides and ends of longwall panels. Subsidence surveys at other longwall mine sites in NSW and QLD have provided similar results but the West Wallsend study is the most comprehensive.

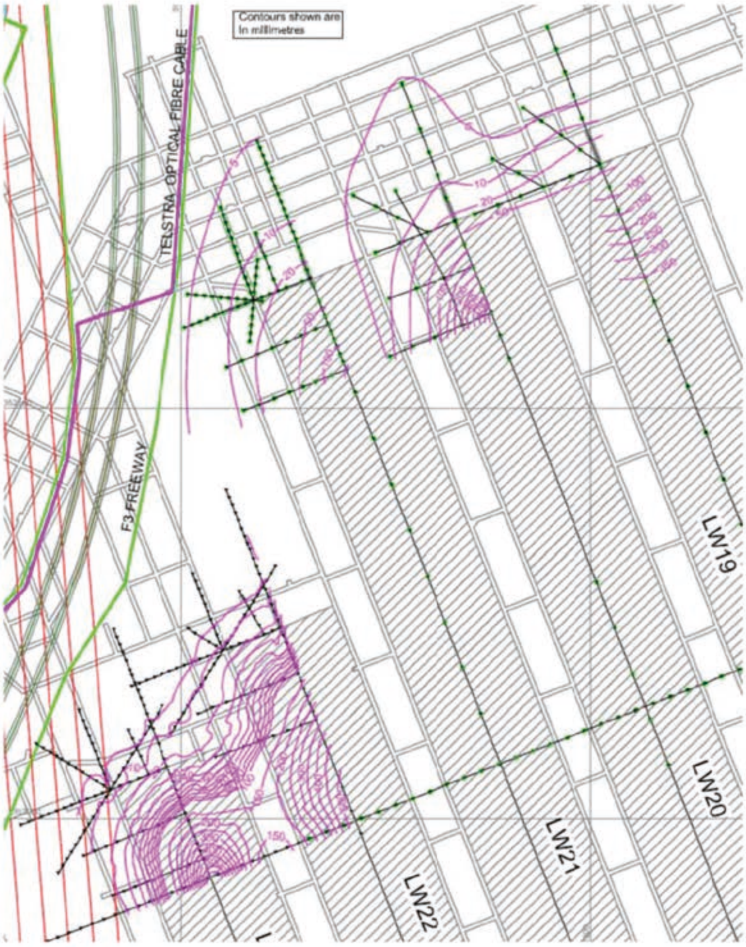

Fig. 3.4 Observed subsidence around corners of longwall panels at West Wallsend Colliery

3.6. Far-field Movements

The measured horizontal movements at survey marks which are located beyond the longwall goaf edges and over solid unmined coal areas are often much greater than the observed vertical movements at those marks. These movements are often referred to as *far-field horizontal movements*.

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 impacts on natural features or surface infrastructure, except where they are experienced by large structures which are very sensitive to differential horizontal movements.

These observed far field horizontal movements appear to occur as a result of a number of mechanisms or components, however, the main mechanism thought to be responsible for the observed far-field movements in flat terrain is the partial relief or relaxation of the in situ horizontal stresses of the immediate strata around the goaf towards the goaf areas. For the strata around the goaf to expand towards the collapsed zone there has to be slippage along some bedding planes.

The extent to which a particular stratum can expand into the goaf is dependent on the height of the void formation, the dilation in the neighbouring strata and the elastic properties of each stratum, and hence, the horizontal expansion varies from stratum to stratum with the greatest expansion occurring near, or just above, seam level. The measured far-field horizontal movements on the surface would, therefore, be expected to increase wherever the in situ compressive stresses are higher and where the height and extent of the goaf is more extensive, i.e. where the mining activity is more extensive.

Where narrow sub-critical panels are being mined and the height of collapse may only extend part of the way up to the surface, the strata that is overlying the collapsed zone may be able accommodate increased horizontal stresses. However, around wide supercritical panels where the cracking and goafing can extend up to the surface, there would be greater disturbance to the strata over the goaf and less stiffness within the collapsed strata to accommodate increased horizontal stresses. It is likely therefore that greater redistribution of in situ horizontal stresses would occur under and around these supercritical panels, greater stress relief and far field movements can occur towards these supercritical panels and these far field movements would extend well beyond a mined area before equilibrium is regained in the rock mass.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data from the NSW Coalfields, but predominately the database includes measurements from the Southern Coalfield. The far-field horizontal movements resulting from longwall mining are generally observed to be orientated towards the extracted longwall. At very low levels of far-field horizontal movements, however, there is a higher scatter in the orientation of the observed movements.

Far-field horizontal movements can be predicted with reasonable accuracy and the method used to predict such movements are described further in Section 4.4.

3.7. The Incremental Profile Method (IPM)

The predicted conventional subsidence parameters due to the extraction of the proposed longwalls were determined using the IPM, which was developed by MSEC in 1994, when formally known as Waddington Kay and Associates. This method is an empirical model based on a large database of observed subsidence monitoring data from previous mining within the Southern, Newcastle, Hunter and Western Coalfields of New South Wales and the Bowen Basin in Queensland.

The database of detailed subsidence monitoring data from various coalfields includes data from the following Collieries or Mines: Abel, Angus Place, Appin, Ashton, Awaba, Austar, Baal Bone, Bellambi, Beltana, Blakefield South, Bulga, Bulli, Burwood, Carborough Downs, Chain Valley, Clarence, Coalcliff, Cook, Cooranbong, Cordeaux, Corrimal, Crinum, Cumnock, Dartbrook, Delta, Dendrobium, Donaldson, Eastern Main, Ellalong, Elouera, Fernbrook, Glennies Creek, Grasstree, Gretley, Invincible, John Darling, Kenmare, Kemira, Kestrel, Lambton, Liddell, Mandalong, Metropolitan, Moranbah North, Mt. Kembla, Munmorah, Narrabri, Nardell, Newpac, Newstan, Newvale, Newvale 2, NRE Wongawilli, Oaky Creek, Ravensworth, South Bulga, South Bulli, Southern, Springvale, Stockton Borehole, Tasman, Teralba, Tahmoor, Tower, Wambo, Wallarah, Western Main, Ulan, United, West Cliff, West Wallsend, and Wyee.

Observed incremental subsidence profiles show the additional subsidence that resulted from the extraction of an individual longwall panel and these can be derived by subtracting the observed subsidence profiles of points along monitoring lines before mining from the observed subsidence profiles after mining. Reviews of the available incremental and total subsidence profiles showed that, whilst the final observed total subsidence profiles measured over a series of longwalls were irregular, the observed incremental subsidence profiles due to the extraction of individual longwalls were more consistent in both shape and magnitude.

The observed incremental subsidence at a point has been shown to vary according to local geology, depth of cover, panel width, the pillar widths, the extracted seam thickness, the extent and proximity of adjacent previously mined panels in the currently mined seam and/or in the overlying or underlying seams, the stability of the chain pillars, the strength of the coal seams and the overburden strata and a time-related subsidence component.

The regularity in shape between observed incremental subsidence profiles was first noticed whilst carrying out an empirical study in the Southern Coalfields of NSW using monitoring data from more than 72 longwall panels. A prediction model was then developed to predict the incremental subsidence at points for each of the longwalls in a series of longwalls and then adding together the appropriate subsidence values to derive the total subsidence at each point. MSEC then developed standard subsidence prediction curves and shapes of predicted incremental subsidence profiles using observed profiles from monitoring lines with similar mining geometry and overburden geology. This IPM subsidence prediction model has been continually developed, revised and updated since 1994, as the new additional monitoring data became available, to suite specific local geology and conditions.

The prediction of subsidence using the IPM is now fully automated and subsidence predictions can be made anywhere above or outside the extracted longwalls, based on the local surface and seam information. Details as to how this model was developed have been outlined in various published papers, which include information that would allow others to use this method to predict mine subsidence ground movements resulting from underground coal mining operations, based on local observed data. MSEC can use the current IPM model to predict subsidence contours over complex underground mine layouts within days of receiving the necessary data.

MSEC has used this IPM for more than 600 studies for proposed mines and numerous comparisons have been provided between the predicted subsidence movements and the subsequently monitored ground movements. The results of these comparisons have been included in many prediction reports, government inquiry reports and end of panel monitoring reports, and these comparisons and reviews confirm the use of this IPM subsidence prediction model provides reasonable, if not, slightly conservative predictions for both single seam and multi-seam conditions in NSW and QLD for those cases where the mining geometry and overburden geology are similar to and within the range of the empirical data from which the IPM model was developed. When the mining geometry and overburden geology are outside the ranges of the empirical data from which the IPM model was developed then additional advice is sought from relevant mathematical models.

Further details on the IPM are provided in the background report entitled General Discussion on Mine Subsidence Ground Movements which can be obtained from *www.minesubsidence.com*. The following section describes the calibration of the IPM for local single-seam conditions.

3.8. Calibration of Incremental Profile Method

The Project is a Greenfield site. There is therefore no monitoring data available from this site or from nearby collieries for local calibration of the IPM model. The geology at the Project is, however, similar to that found at other mines in the Western Coalfield.

The proposed longwalls have overall void widths of 315 metres and 355 metres and are at depths of cover ranging between 105 metres and 310 metres. The width-to-depth ratios for the proposed longwalls therefore vary between 1.0 and 3.4 and, therefore, are subcritical to supercritical in width. The maximum achievable subsidence adopted in the Western Coalfield, for single-seam super-critical conditions, is generally 60 % to 65 % of the effective extracted thickness.

The nearest active longwall mining operations is at Ulan Mine, which is located in the Western Coalfield approximately 40km to the north west of the Project

A comparison of typical overburden profiles indicates similarities between the Project and Ulan Mine, which are both located in the NSW Western Coalfield. Ulan Coal Mines extracts coal from the Ulan seam at depths of cover varying from approximately 100 metres to 410 metres, and with width-to-depth ratios for the longwalls varying between approximately 0.6 and 3. The target seam at the Project is the Coggan Seam. This seam is regionally correlated with the Lithgow Seam, which lies close to and beneath the Ulan seam, separated by Blackmans Flat Conglomerate. A plot of the IPM subsidence prediction curves used for the Western Coalfield is shown in Fig. 3.5, and a summary of the observed maximum subsidence as a proportion of extracted seam thickness versus panel width-to-depth ratio at Ulan is also plotted in this figure.

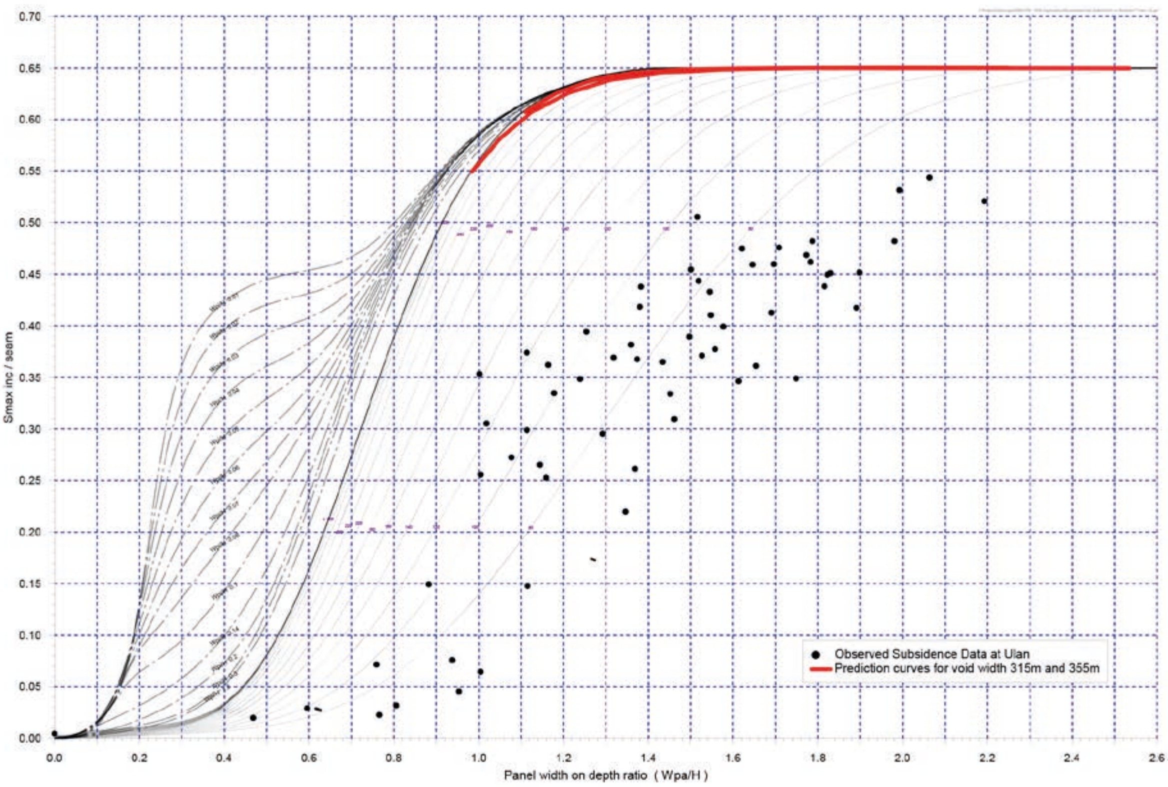

Fig. 3.5 Prediction Curves for Maximum Incremental Subsidence

It can be seen from Fig. 3.5 that the majority of maximum observed incremental subsidence at Ulan Mine is less than 50%, with one result at approximately 53% of the extracted seam thickness. It is thought that the presence of thick Triassic sandstone units in the overburden is a significant factor that limits the maximum subsidence at the Ulan Mine. Triassic sediments are present with variable thicknesses, above the northern and south eastern parts of the proposed longwall footprint at the Project, but the unit does not appear to be as extensive as at the Ulan Mine. It is therefore considered that a more conservative approach to predictions is warranted for the Bylong Coal Project. It is proposed to use the IPM prediction curves as shown in Fig. 3.5, which predict maximum incremental subsidence of up to 65% of the extracted seam thickness. This could be revised after the commencement of mining if it could be verified from initial monitoring data that maximum subsidence as a proportion of seam thickness was less than 65%. The prediction curve for the proposed longwall void widths of 315 metres and 355 metres at the Project is shown in red in Fig. 3.5.

A comparison between the observed and predicted profiles of subsidence, tilt and strain for monitoring Line D at Ulan is shown in Fig. 3.6.

It can be seen from Fig. 3.6, that the observed profiles of subsidence, tilt and strain along this monitoring line reasonably match but are less than those predicted using the standard IPM. In some locations, there are small lateral shifts between the observed and predicted profiles, which could be the result of surface dip, seam dip, or variations in the overburden geology.

The magnitudes of the maximum observed subsidence along the monitoring line were less than the maxima predicted using the standard IPM. The observed subsidence results represent 30% to 40% of the 3.2 metre seam thickness extracted. This observed subsidence is considerably lower than the predicted subsidence profiles which predict up to 60% to 65% of the extracted seam thickness.

Comparisons between the observed and predicted profiles of subsidence, tilt and curvature were also made for monitoring lines in the Hunter and Newcastle Coalfields, where the longwall width-to-depth ratios are 0.4, 0.7 and greater than 2.0, are shown in Fig. 3.7, Fig. 3.8 and Fig. 3.9, respectively. The Hunter and Newcastle Coalfields are located to the east of the Project.

It can be seen from Fig. 3.7, Fig. 3.8 and Fig. 3.9, that the observed profiles of subsidence, tilt and curvature along these monitoring lines reasonably match those predicted using the standard IPM. In some locations, there are small lateral shifts between the observed and predicted profiles, which could be the result of surface dip, seam dip, or variations in the overburden geology.

The magnitudes of the maximum observed subsidence along the monitoring lines were similar to or less than the maxima predicted using the standard IPM. In Fig. 3.9, the longwall was super-critical and, in this case, the standard Incremental Profile Method adopted a maximum achievable subsidence of 65 % of extracted seam thickness, whereas the maximum observed subsidence was around 45 % of the extracted seam thickness.

The magnitudes of the observed tilts and curvatures along the monitoring lines were also reasonably similar to those predicted using the standard IPM. It can be seen, however, that the observed tilts and curvatures were less than those predicted, in some locations, whilst the observed tilts and curvatures exceed those predicted in other locations. This demonstrates the difficultly in predicting tilts and curvatures at a point, especially at shallow depths of cover. It is important then to recognise that there is greater potential for variation between observed and predicted movements at a point, as the depth of cover decreases.

As noted above, the overburden profiles at the Project are similar to those present at Ulan, however it cannot be confirmed that the overburden at the Project with have a similar subsidence reducing behaviour as the overburden at Ulan. It is recommended that a survey monitoring program be developed to validate the predicted subsidence parameters, and to monitor the impacts that are assessed in Sections 5.0 to 9.0 .

Comparison of Observed & Predicted Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Line D at Ulan

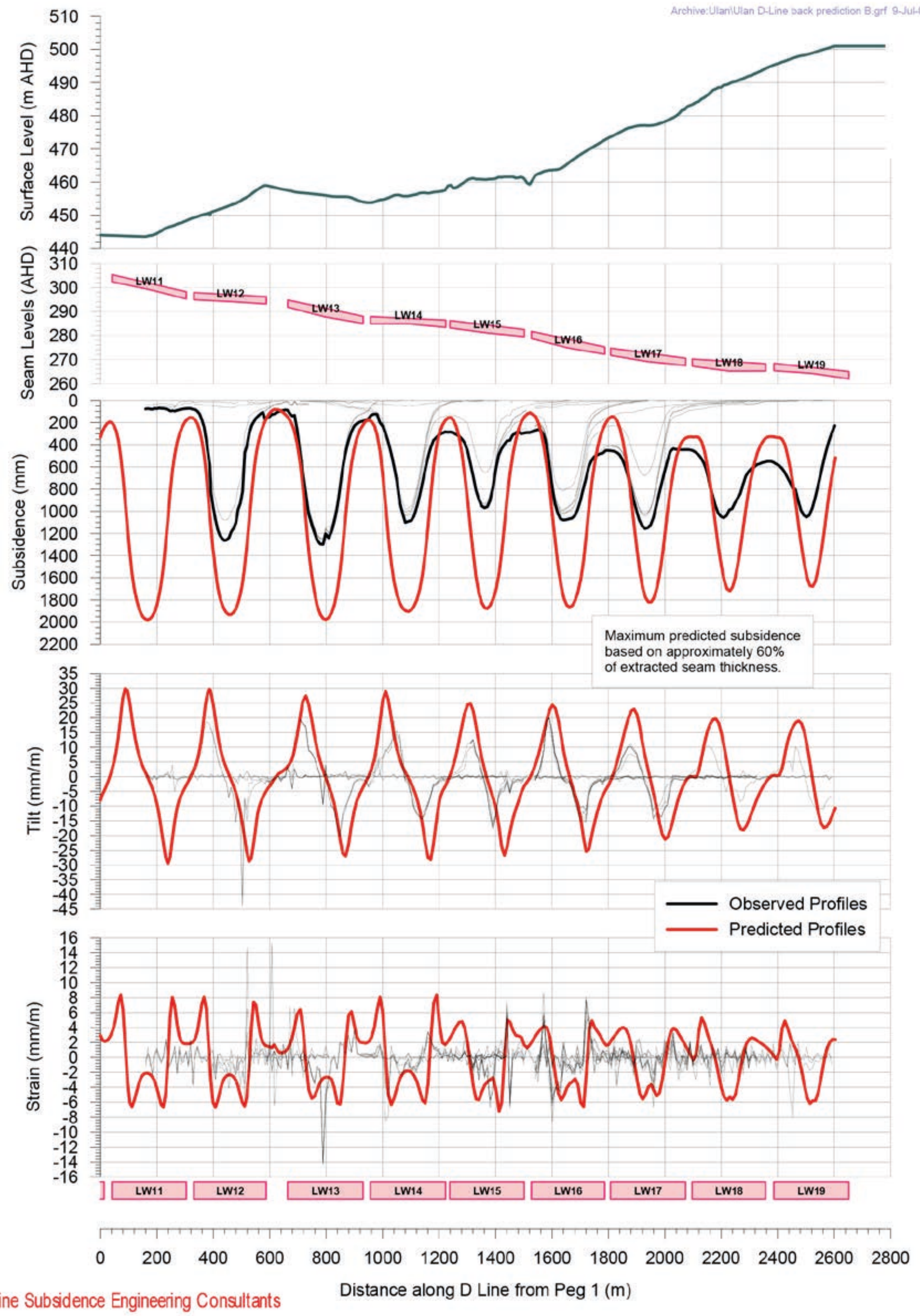

Fig. 3.6 **Ulan Mine Longwalls 11 to 19 Monitoring Results along Monitoring Line D in the Ulan Seam**

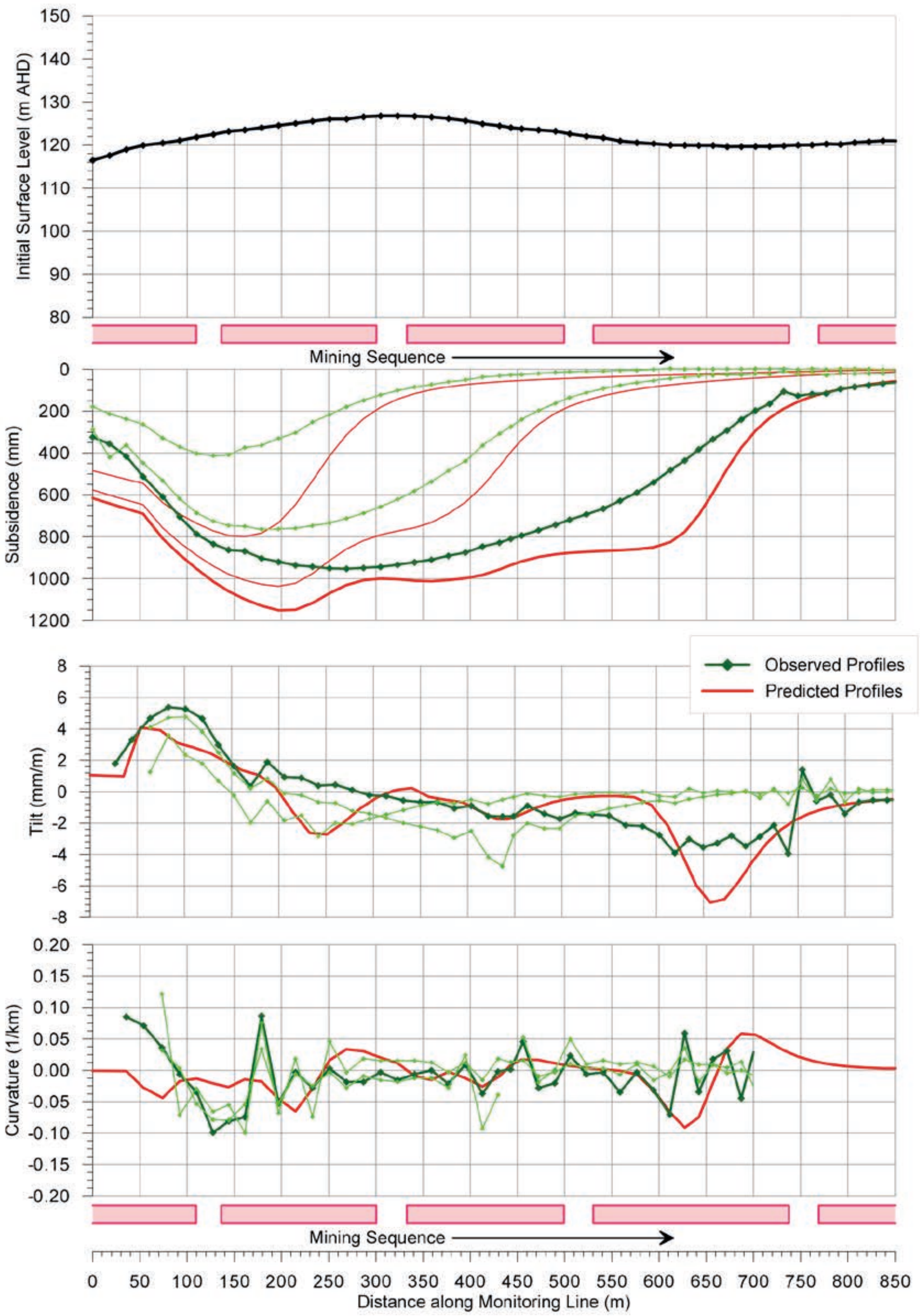

Fig. 3.7 Comparison of Observed and Predicted Subsidence, Tilt and Curvature along a Monitoring Line in the Newcastle Coalfield with Longwall W/H Ratio around 0.4

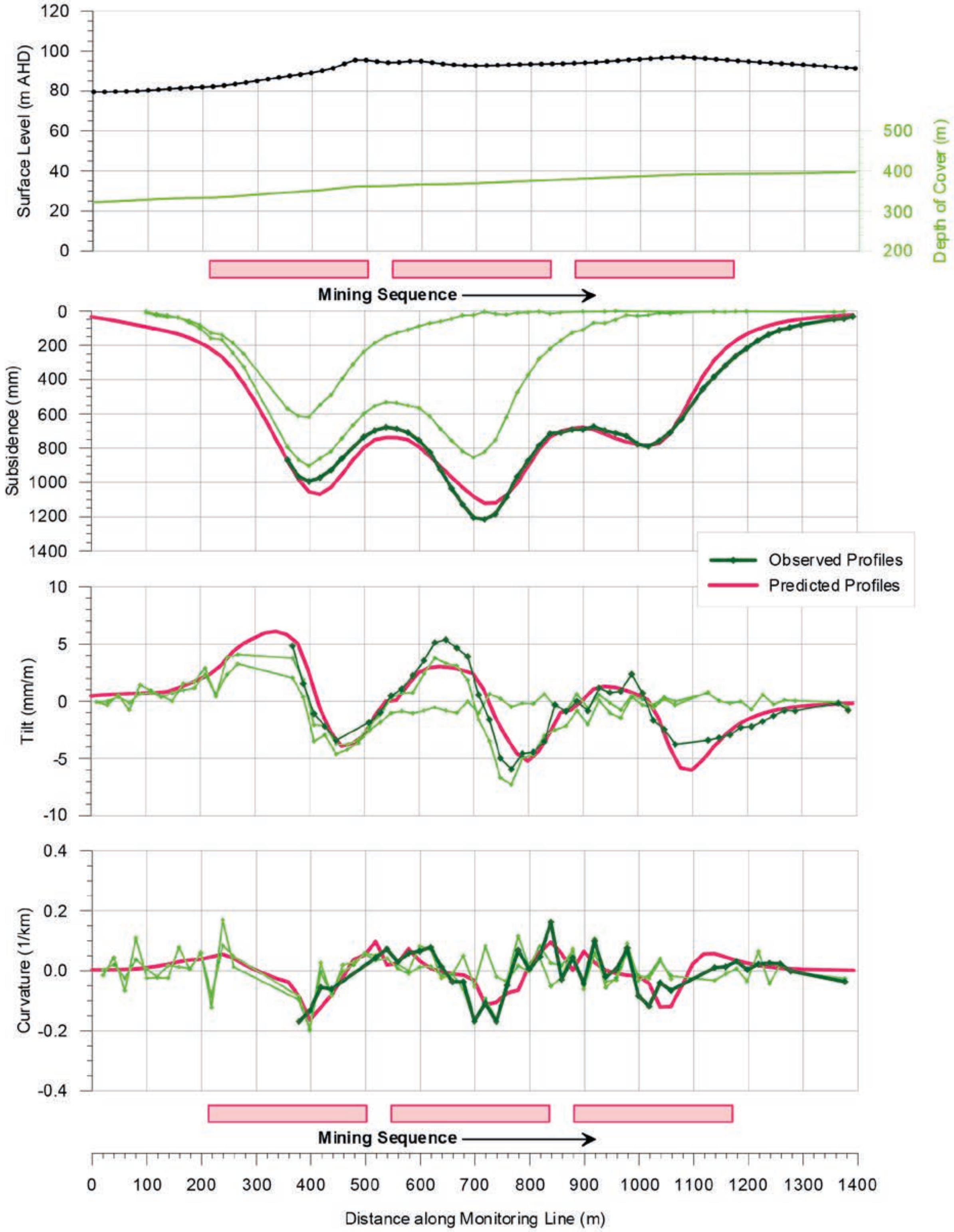

Fig. 3.8 Comparison of Observed and Predicted Subsidence, Tilt and Curvature along a Monitoring Line in the Hunter Coalfield with Longwall W/H Ratio around 0.7

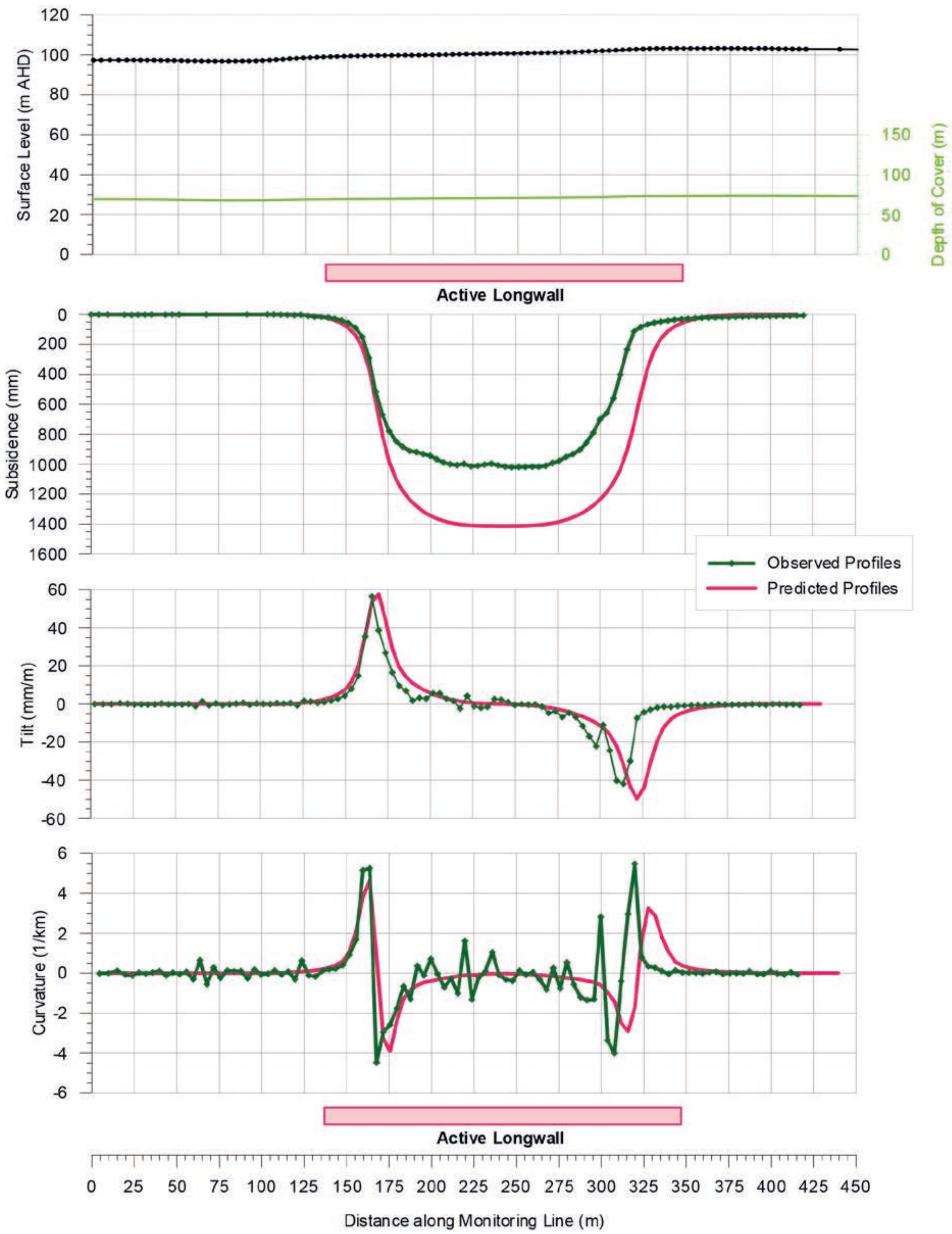

Fig. 3.9 Comparison of Observed and Predicted Subsidence, Tilt and Curvature along a Monitoring Line in the Hunter Coalfield with Longwall W/H Ratio Greater than 2.0

4.0 MAXIMUM PREDICTED SUBSIDENCE PARAMETERS FOR THE PROPOSED LONGWALLS

4.1. Introduction

The following sections provide the maximum predicted conventional subsidence parameters resulting from the extraction of the proposed Longwalls 101 to 109 and 201 to 206 using the calibrated IPM model. The predicted subsidence parameters and the impact assessments for the natural features and surface infrastructure are provided in Chapters 5 through to 9.

The predicted subsidence, tilt and curvature have been obtained using the IPM, which was calibrated for local conditions as described in Section 3.8. The predicted strains have been determined by analysing the strains measured at other nearby collieries.

The maximum predicted subsidence parameters and the predicted subsidence contours provided in this Chapter describe and show the conventional movements and do not include the valley related upsidence and closure movements, nor the effects of faults and other geological structures. Such effects have been addressed separately in the impact assessments for each feature provided in Chapter 5 through to 9.

4.2. Maximum Predicted Conventional Subsidence, Tilt and Curvature

The maximum predicted conventional subsidence parameters resulting from the extraction of the proposed longwalls were determined using the calibrated IPM, which was described in Chapter 3.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature, due to the extraction of each of the proposed longwalls, is provided in Table 4.1. The predicted ground strains are discussed in Section 4.3. The predicted tilts provided in this table are the maxima after the completion of each of the proposed longwalls. The predicted curvatures are the maxima at any time during or after the extraction of each of the proposed longwalls.

Table 4.1 Maximum Predicted Incremental Conventional Subsidence, Tilt and Curvature Resulting from the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Predicted Incremental Conventional Subsidence (mm)	Maximum Predicted Incremental Conventional Tilt (mm/m)	Maximum Predicted Incremental Conventional Hogging Curvature (km^{-1})	Maximum Predicted Incremental Conventional Sagging Curvature (km^{-1})
LW101	2,900	45	1.5	1
LW102	3,000	45	1	0.8
LW103	3,000	40	0.9	0.7
LW104	3,100	40	0.8	0.8
LW105	3,000	40	0.5	0.8
LW106	3,100	40	0.5	0.8
LW107	3,100	40	0.6	0.8
LW108	3,100	45	0.9	0.9
LW109	3,100	70	2.5	2
LW201	2,900	50	2	1.5
LW202	2,900	60	2	1.5
LW203	3,000	60	2	2
LW204	3,100	65	3	2.5
LW205	3,000	60	3.5	2.5
LW206	2,700	65	3.5	2.5

The predicted total conventional subsidence contours are shown in Drawing No. MSEC708-14. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature, after the extraction of each of the proposed longwalls, is provided in Table 4.2. The predicted ground strains are discussed in Section 4.3. The predicted tilts provided in this table are the maxima after the completion of each of the proposed longwalls. The predicted curvatures are the maxima at any time during or after the extraction of each of the proposed longwalls.

Table 4.2 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature after the Extraction of the Proposed Longwalls in Each Area

Longwalls	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
LW101 to LW109 and LW201 to 206	3,300	75	3.5	2.5

The maximum predicted total subsidence, after the completion of the proposed longwalls, is 3,300 mm which represents around 68% of the extraction height. The maximum predicted total conventional tilt is 75 mm/m (i.e. 7.5 %), which represents a change in grade of 1 in 13. The maximum predicted total conventional curvatures are 3.5 km^{-1} hogging and 2.5 km^{-1} sagging, which represent minimum radii of curvature of 290 metres and 400 metres, respectively.

The predicted conventional subsidence parameters vary across the *Subsidence Study Area* as the result of, amongst other factors, variations in the depths of cover, longwall geometry and extraction heights. To illustrate this variation, the predicted profiles of conventional subsidence, tilt and curvature have been prepared along one prediction line, the location of which is shown in Drawing No. MSEC708-14. The predicted profiles of conventional subsidence, tilt and curvature along Prediction Line 1, resulting from the extraction of the proposed longwalls, are shown in Fig. D.01 in Appendix D.

The predicted incremental profiles along the prediction lines, due to the extraction of each of the proposed longwalls, are shown as dashed black lines. The predicted total profiles along the prediction lines, after the extraction of each of the proposed longwalls, are shown as solid blue lines.

4.3. Predicted Strains

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock. Survey tolerance can also represent a substantial portion of the measured strain, in cases where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

For this reason, the predicted strains provided in this report have been based on statistical analyses of strains measured in the NSW Coalfields to account for this variability.

It has been found, for single-seam mining conditions, that applying a constant factor to the predicted maximum curvatures provides a reasonable prediction for the maximum normal or conventional strains. The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones. In the Hunter and Western Coalfields, it has been found that a factor of 10 provides a reasonable relationship between the predicted maximum curvatures and the predicted maximum conventional strains, for single-seam mining conditions.

The maximum predicted conventional curvatures resulting from the extraction of the proposed longwalls are 3.5 km^{-1} hogging and 2.5 km^{-1} sagging. Adopting a factor of 10, the maximum predicted conventional strains, due to the proposed mining are 35 mm/m tensile and 25 mm/m compressive. Localised and elevated strains greater than the predicted conventional strains can also occur, as the result of non-conventional movements, which was discussed in Section 3.4.

At a point, however, there can be considerable variation from the linear relationship, resulting from non-conventional movements or from the normal scatters which are observed in strain profiles. When expressed as a percentage, observed strains can be many times greater than the predicted conventional strain for low magnitudes of curvature.

The range of potential strains above the proposed longwalls has been assessed using monitoring data from previously extracted panels in the Hunter and Newcastle Coalfields, for single-seam conditions, where the width-to-depth ratios and extraction heights were similar to those of the proposed longwalls. Comparisons of the void widths, depths of cover, width-to-depth ratios and extraction heights for the proposed longwalls with those for the historical cases are provided in Table 4.3.

Table 4.3 Comparison of the Mine Geometry for the Proposed Longwalls with Longwalls in the Hunter and Newcastle Coalfields used in the Strain Analysis

Parameter	Proposed Longwalls		Longwalls Used in Strain Analysis	
	Range	Average	Range	Average
Width	315 and 355	331	135 ~ 410	205
Depth of Cover	105 ~ 310	200	110 ~ 340	180
W/H Ratio	1.0 ~ 3.4	2.0	0.8 ~ 2.0	1.2
Extraction Height	3.4 ~ 5.1	4.0	2.1 ~ 5.0	3.9

It can be seen from the above table that the range of the panel width-to-depth ratios used in the strain analysis was between 0.8 and 2.0, with an average ratio of 1.2, which is slightly less than that for the proposed longwalls. The range of extraction heights for the longwalls used in the strain analysis was between 2.1 metres and 5.0 metres, with an average of 3.9 metres, which is similar to the average extraction height for the proposed longwalls. The strain analysis, therefore, should provide a reasonable indication of the range of potential strains for the proposed longwalls.

The data used in the analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements, but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed survey marks have also been excluded.

A number of probability distribution functions were fitted to the empirical monitored strain data. It was found that a *Generalised Pareto Distribution (GPD)* provided a good fit to the raw strain data. Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

4.3.1. Analysis of Strains Measured in Survey Bays

For features that are in discrete locations, such as building structures, farm dams and archaeological sites, it is appropriate to assess the frequency of the observed maximum strains for individual survey bays.

Predictions of Strain Above Goaf

The survey database has been analysed to extract the maximum tensile and compressive strains that have been measured at any time during mining, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls. The frequency distribution of the maximum observed tensile and compressive strains measured in survey bays above goaf is provided in Fig. 4.1. The probability distribution functions, based on the fitted GPDs, are also shown in this figure.

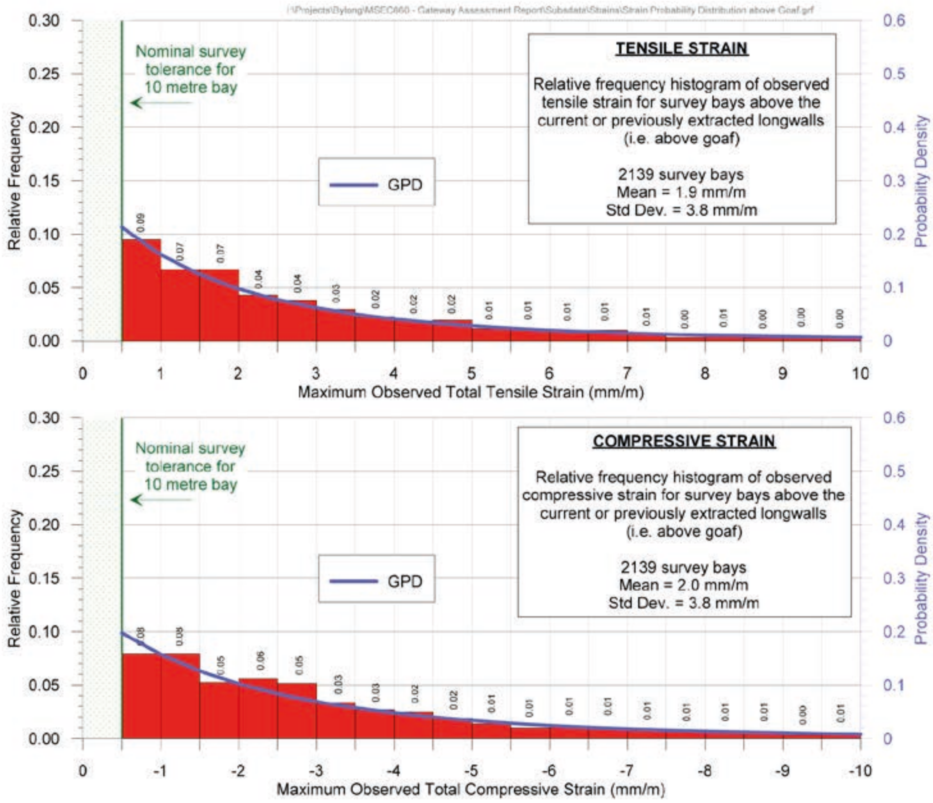

Fig. 4.1 Distributions of the Measured Maximum Tensile and Compressive Strains in the Hunter, Newcastle and Western Coalfields for Longwalls having W/H Ratios between 0.8 and 2.0

Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

The 95 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 8 mm/m tensile and 9 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 18 mm/m tensile and 17 mm/m compressive. The maximum strains measured along the monitoring lines were greater than 20 mm/m tensile and compressive.

It is noted, that these strains are based on monitoring data having an average width-to-depth ratio of 1.2 and, therefore, the strains above the proposed longwalls are expected to be greater, on average, where the width-to-depth ratios are greater than 1.2 (i.e. depths of cover less than 265 to 300 metres) and are expected to be less, on average, where the width-to-depth ratios are less than 1.2 (i.e. depths of cover greater than 265 to 300 metres).

Predictions of Strain Above Solid Coal

The survey database has also been analysed to extract the maximum tensile and compressive strains that have been measured at any time during mining for survey bays that were located beyond the goaf edges of the mined panels and positioned on unmined areas of coal, i.e. outside panels but within 200 metres of the nearest longwall goaf edge.

The histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal is provided in Fig. 4.2. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

The 95 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining were 2.8 mm/m tensile and 1.7 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining were 7.5 mm/m tensile and 6.0 mm/m compressive.

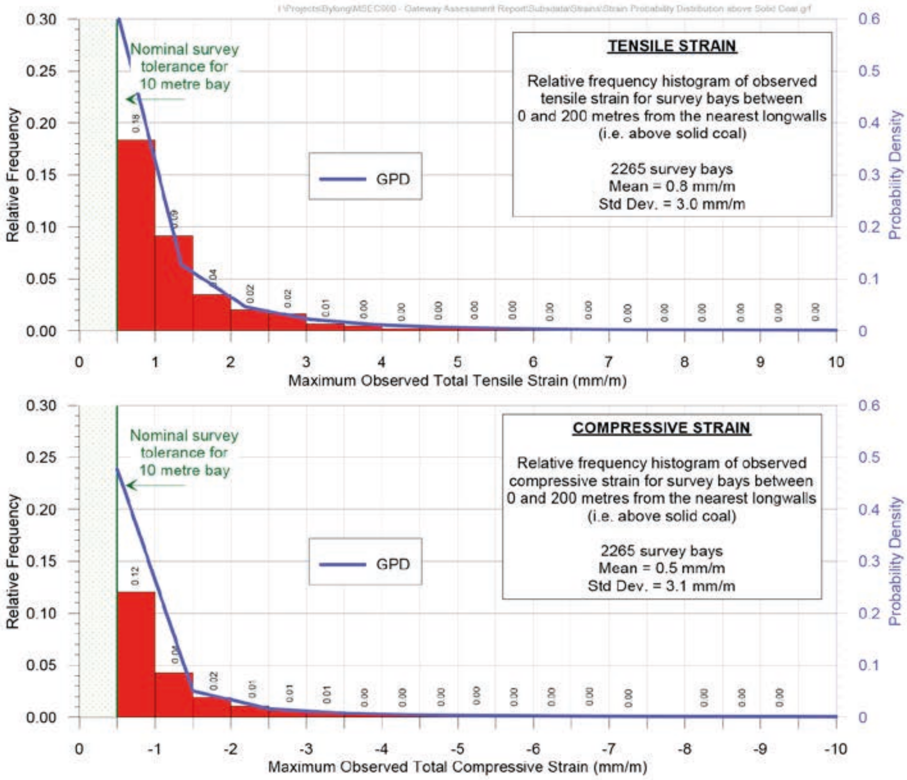

Fig. 4.2 Distributions of the Measured Maximum Tensile and Compressive Strains in the Hunter, Newcastle and Western Coalfields for Survey Bays located above Solid Coal

4.3.2. Analysis of Strains Measured Along Whole Monitoring Lines

For linear features such as roads, cables and pipelines, it is more appropriate to assess the frequency of the maximum observed strains along whole monitoring lines, rather than for individual survey bays. That is, an analysis of the maximum strains measured anywhere along the monitoring lines, regardless of where the strain actually occurs.

The histogram of maximum observed total tensile and compressive strains measured anywhere along the monitoring lines, at any time during or after mining, is provided in Fig. 4.3.

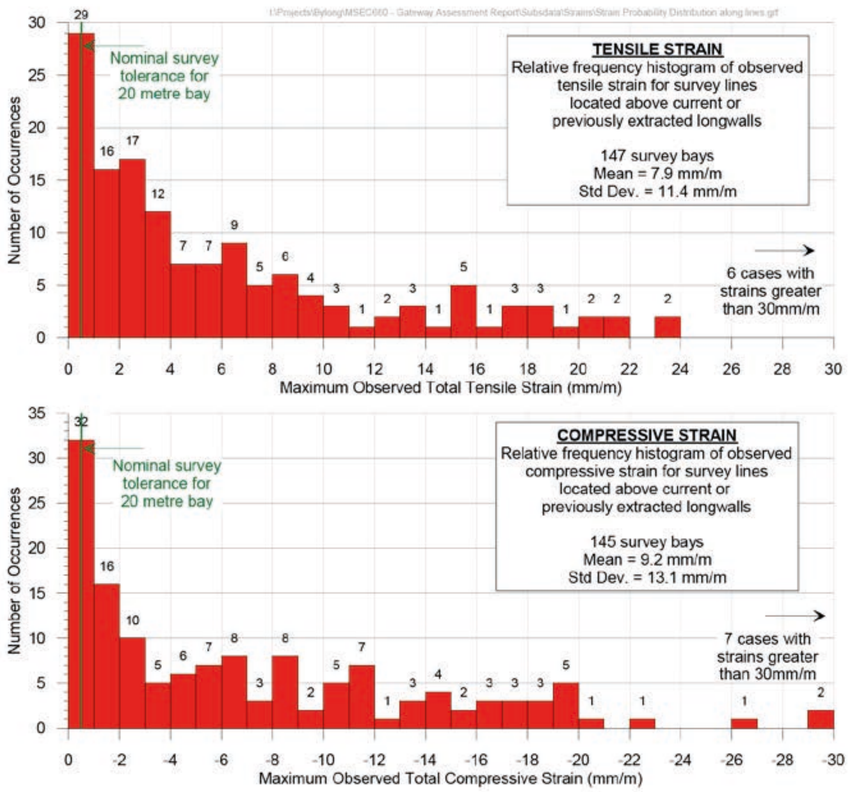

Fig. 4.3 Distributions of Measured Maximum Tensile and Compressive Strains Anywhere along the Monitoring Lines in the Hunter, Newcastle and Western Coalfields

It can be seen from the above figure, that 112 of the 147 monitoring lines (i.e. 76 %) have recorded maximum total tensile strains of 10 mm/m, or less, and that 135 monitoring lines (i.e. 92 %) have recorded maximum total tensile strains of 20 mm/m, or less. Also, 97 of the 145 monitoring lines (i.e. 67 %) have recorded maximum compressive strains of 10 mm/m, or less, and that 133 of the monitoring lines (i.e. 92 %) have recorded maximum compressive strains of 20 mm/m, or less.

4.4. Predicted Far-field Horizontal Movements

As discussed in Section 3.6, in addition to the conventional subsidence movements that have been predicted above and adjacent to the proposed longwalls, far-field horizontal movements will also be experienced during the extraction of the proposed longwalls.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data from the NSW Coalfields, but predominately from the Southern Coalfield. 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, are provided in Fig. 4.4. The confidence levels, based on fitted GPDs, have also been shown in this figure to illustrate the spread of the data.

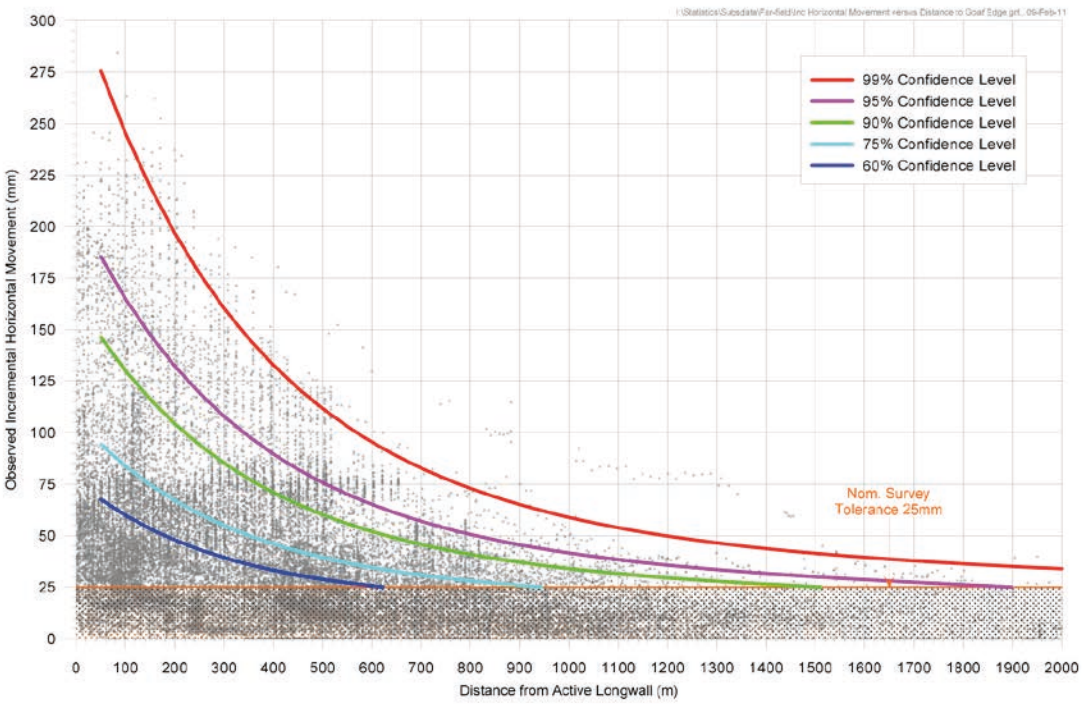

Fig. 4.4 Observed Incremental Far-Field Horizontal Movements

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 have been redistributed around the collapsed zones above the first few extracted longwalls, the potential for further movement is reduced. The total far-field horizontal movement may be less, therefore, than the sum of the incremental far-field horizontal movements for the individual longwalls.

The above referenced far field horizontal movement database only includes a few monitoring lines over the adjacent Ulan Mine, but, further far-field horizontal movement data has been published after monitoring at Ulan Mine, as discussed below, which supports the above prediction graph.

In a letter report, dated September 2012 and titled "*Ulan Longwall 26 End Of Panel Subsidence Report*", Mills advised;

> *"Longwall 26 is 410m wide (rib to rib). Horizontal movements in a north-south direction across the panel exhibit far-field movements similar to those observed previously over the western series longwall panels (Longwall W1 and W2) and over Longwalls 23-25, although the magnitude of movement over Longwall 26 is much greater."*
>
> *"Within the boundary of Longwall 26, horizontal compression of 0.86m is observed across the panel, concentrated mainly across the topographic low point of Bobadeen Creek. Outside the panel, horizontal movements toward the Longwall 26 goaf reduce with distance from the longwall goaf edge from approximately 0.45m at the northern goaf edge of Longwall 26 to less than 0.1 m at 700m from the goaf edge, and become imperceptible (less than 0.02m, the effective resolution of the surveying) at a distance of about 2-2.5km from the goaf edge."*
>
> *"The horizontal movement appears to increase with proximity to the longwall panel goaf edge. The Figure below shows a plot of distance from the south-west corner of Longwall 26 plotted against the incremental horizontal displacement observed during mining of Longwall 26 only. Monitoring results from F Line north of Longwall 26 and H Line from both the northern and southern edges of Longwall W1 and the northern edge of Longwall W2 are also shown below."*
>
> *"These results indicate perceptible horizontal movements are observed outside the goaf edge of each longwall panel to a distance of about 2km from the goaf edge, with most of the movement occurring within about 1 km of the goaf edge. The incremental horizontal movements for each longwall panel range from about 150-380mm at the goaf edge to less than 70mm at 1 km and less than 20mm at about 2-2.5km, although there is a step change noted on F Line to about 40mm, the reasons for which are not clear. "*

The valley height where the F-Line crosses Bobadeen Creek and Longwall 26 at Ulan Mine is 55 metres, which is relatively deep. In this report, Mills (2012) noted that the highest horizontal strains occurred at the base of Bobadeen Creek and he noted that the highest far field horizontal movements were observed on the side of this Bobadeen Creek where he notes the normal far field horizontal movements and valley closure movements combine.

> *"The surface terrain above Longwall 26 comprises a broad valley on either side of Bobadeen Creek. Horizontal compression of 0.86m is observed across this panel, concentrated mainly across the topographic low point of Bobadeen Creek. Maximum horizontal strains are generally less than 4mm/m in tension and 6mm/m in compression, however, there is a significant spike at the topographic low point at Bobadeen Creek where the horizontal compressive strains reach a peak of 13mm/m. Maximum horizontal strains were predicted to be in the range 5-10 mm/m, which for the most part they are, but the compressive strain peak at Bobadeen Creek is higher than predicted. This strain peak appears to be a result of the coincidence of far-field horizontal stress relief movements and downslope movements concentrating at the topographic low part."*

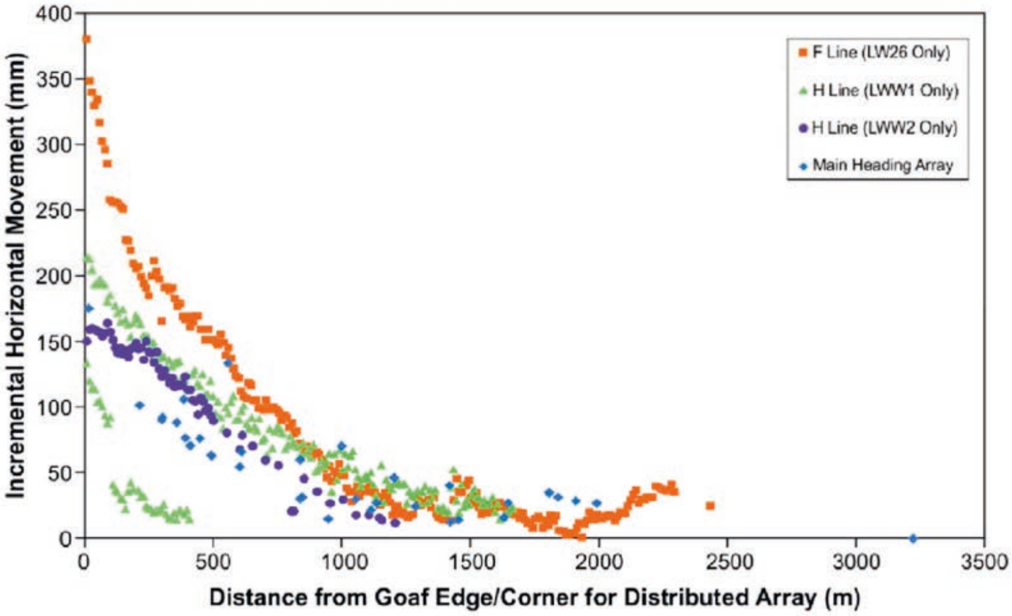

Fig. 4.5 Observed Incremental Far-Field Horizontal Movements at Ulan Mine (Mills, 2012)

The observed far field horizontal movements at the Ulan Mine are, therefore, similar to the other far field horizontal movement data plotted in Fig. 4.4, (excluding the far field horizontal movements measured across this Bobadeen Creek), and those graphs can be used to predict future far field horizontal movement movements for the Project.

The predicted far-field horizontal movements resulting from the extraction of the proposed longwalls are 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 the order of survey tolerance (i.e. less than 0.3 mm/m). The impacts of far-field horizontal movements on the natural features and items of surface infrastructure within the vicinity of the proposed longwalls and panels is not expected to be significant, except where they occur at large structures which are sensitive to small differential movements.

4.5. Surface Cracking and Deformations

Longwall mining can result in surface cracking, heaving, buckling, humping and stepping at the surface. The extent and severity of these mining induced ground deformations are dependent on a number of factors, including the mine geometry, depth of cover, overburden geology, locations of natural joints in the bedrock, the presence of near surface geological structures and mining conditions.

Fractures and joints in bedrock occur naturally during the formation of the strata and from subsequent erosion and weathering processes. Longwall mining can result in additional fracturing in the bedrock, which tends to occur in the tensile zones, but fractures can also occur due to buckling of the surface beds in the compressive zones. The incidence of visible cracking at the surface is dependent on the pre-existing jointing patterns in the bedrock as well as the thickness and inherent plasticity of the soils that overlie the 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 perimeters. Most of the cracks will occur within a radius of approximately 0.1 times the depth of cover from the longwall perimeters. The cracks will generally be parallel to the longitudinal edges or the ends of the longwalls. Surface cracking normally develops behind the extraction face up to a horizontal distance equal to around half the depth of cover and, hence, the cracking in any location normally develops over a period of around two to four weeks.

At shallow depths of cover, it is also likely that transient surface cracks will occur above and parallel to the moving extraction face, i.e. at right angles to the longitudinal edges of the longwall, as the subsidence trough develops. The larger and more permanent cracks, however, are usually located in the final tensile zones around the perimeters of the longwalls. Open fractures and heaving, however, can also occur due to the buckling of surface beds that are subject to compressive strains. An example of crack patterns that develop in shallow depths of cover is shown in Fig. 4.6 below.

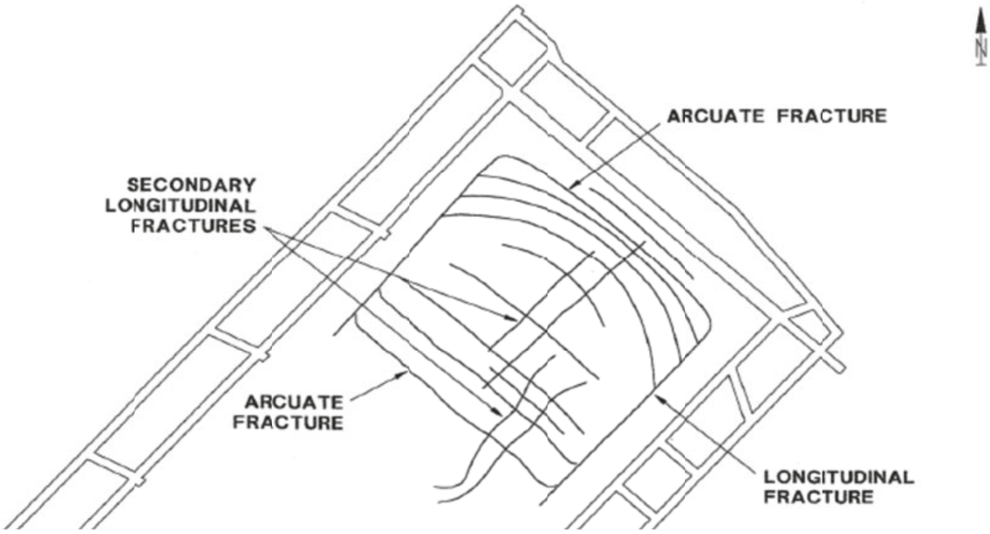

Fig. 4.6 Survey of Major Fracture Pattern at Approx. 110m Cover (Source: Klenowski, ACARP C5016, 2000)

Over previously mined longwalls, typical surface crack widths up to the order of 100 mm and step heights in the order of 100 mm have been commonly observed at shallow depths of cover, say less than 200 metres. Larger crack widths have been observed with shallow depths of cover where thicker seams are extracted, near steep terrain or where thick massive strata beams are present. These larger tensile cracks tend to be isolated and located around the perimeters of the longwalls and along the tops of steep slopes, due to down slope movements resulting from the extraction of the proposed longwalls. The typical surface cracks and these larger isolated cracks can normally be easily identified and remediated to prevent loss of surface water – Klenowski (ACARP C5016, 2000).

Experience in NSW has found that the severity and frequency of surface cracking reduces as the depth of cover to the extraction increases. Most of the mining-induced surface cracking that is observed in NSW occurs where the depths of cover are less than 200 metres. Mining at depths of cover greater than about 400 metres in NSW results in few surface cracks being observed, however significant isolated cracking can still occur. The following photographic records provide examples of surface cracking resulting from NSW longwall mining operations.

Fig. 4.7 Photographs of Isolated Surface Cracking above multi-seam longwall extraction above Blakefield South Mine in the Hunter Coalfield around 200m cover

Fig. 4.8 Isolated Surface Step 0.8m high, above Longwall E at Ulan Coal Mine. 260m void width, 1.31m maximum observed subsidence, 130 to 145m cover. (Ulan Longwall E End of Panel Subsidence Report)

Fig. 4.9 Photographs of Isolated Surface Cracking parallel to longwall tailgate above Longwall 26 at Ulan Coal Mine. 410m void width, 1.38m maximum observed subsidence, 240m cover (Ulan Longwall 26 End of Panel Subsidence Report)

Detailed crack mapping was undertaken above the commencing end of the Beltana No. 1 Underground Mine Longwall 1 (Beltana LW1), which was mined under single-seam conditions. The longwall had a void width of 275 metres and was extracted in the Whybrow Seam at a depth of cover around 175 metres. The width-to-depth ratio for Beltana LW1 was around 1.6 and extraction height was around 2.5m. It was found from the detailed crack mapping, that 62 % of the cracks had widths less than 25 mm, 26 % had widths between 25 mm and 50 mm, and 12 % had widths between 50 mm and 100 mm. There were a total 72 cracks recorded having a total length of 494 metres and a total area of 17.7 m^2. The surveyed area was 112,476 m^2 and, therefore, it is estimated that less than 0.02 % of the surface was affected by cracking.

Several trial pits were excavated above Beltana LW1 to determine the nature and the depths of the cracks. It was found that the cracks up to 25 mm in width were relatively shallow, having depths less than 0.5 metres below the surface. The wider cracks were found to extend more than 1 metre below the surface. In all cases, the crack widths reduced as the depth below the surface increased.

Detailed crack mapping was also undertaken above the Blakefield South Mine Longwalls 1 and 2 (BSLW1 and BSLW2), which were extracted beneath the existing South Bulga longwalls in the Whybrow Seam (i.e. multi-seam conditions). The void widths of BSLW1 and BSLW2 were 330 metres and 400 metres, respectively, and were extracted in the Blakefield Seam at depths of cover ranging between 170 metres and 230 metres. The interburden thickness between the Whybrow and Blakefield Seams typically varied between 70 metres and 90 metres.

It was found from the detailed crack mapping, that 93 % of the cracks had widths less than 100 mm, with the majority of these having widths less than 50 mm. The maximum observed crack width was around 450 mm.

There were more than 1,200 cracks recorded above BSLW1 and BSLW2 having a total length of around 27 kilometres. The total surface area above these longwalls was around 1.9 km^2 and it is estimated, therefore, that less than 0.10 % of this area was affected by cracking. The compression heaving and step heights observed during the extraction of BSLW1 and BSLW2 were typically less than 25 mm, with a maximum step height around 50 mm.

Photographs of the larger isolated surface cracking resulting from the extraction of BSLW1 and BSLW2 at the Blakefield South Mine (i.e. multi-seam conditions) are provided in Fig. 4.7. Photographs of other isolated surface cracks and steps identified at Ulan Mine are provided in Fig. 4.7 to Fig. 4.9.

For the Project, it is expected that the extent of cracking will be greater than observed at the abovementioned case study sites where the depths of cover are shallower than say 150 metres to 200 metres, and less than observed at the case study sites where the depths of cover are greater than 150 metres to 200 metres.

An estimate was made of potential surface cracking over the *Subsidence Study Area* that may develop in tensile zones around the ends and sides of longwalls using a cut off for the development of tensile cracks of 0.5mm/m predicted tensile strain and an allowance for surface cracks that may develop across the panel as the transient tensile/compressive zone travels along the length of the longwall. The estimated area of cracking was less than 1% of the total *Subsidence Study Area* for the proposed longwalls.

The area of disturbance due to remediation activities can vary significantly subject to the method used and the number of cracks identified. In areas with tall grasses and dense vegetation cover, it would be difficult to identify small cracks and such cracks may not require remediation as they are protected from erosion by the vegetation cover and would infill with time. The areas of dense vegetation cover can be seen in Fig. 2.2 and include predominantly the areas of Bylong State Forest as well as areas of steeper terrain near the north eastern portion overlying the Proposed longwalls. This may partly explain the identified surface cracking of only 0.02% in the above case study which is much less than the estimated 1% based on subsidence predictions (i.e. many smaller cracks could not be identified). Conservatively assuming a 5m width of disturbance for remediation of the cracks in the case study, the total area disturbed is approximately 2%. A conservative approach to remediation for the cracking based on the subsidence predictions indicates the area of disturbance to be less than 10%. As noted above however, the area of disturbance can vary significantly subject to the method of remediation adopted. It is thought that with careful management, the area of disturbance could reasonably be less than 5%. The area of disturbance is likely to affect only grassed surfaces, with trees unlikely to be removed during the remediation process. The incidence of for tree falls resulting from surface subsidence effects is expected to be infrequent, with falls most likely to occur indirectly as a result of cliff falls and at locations coincident with large cracks and steps in the ground surface. Following suitable remediation, is expected that the grass will re-grow.

Based on previous longwall mining experience in the NSW Coalfields, the surface cracking in the flatter areas above the proposed longwalls is expected to be typically between 25 mm and 50 mm, with some isolated cracking around 100 mm or greater. The surface cracking along the steeper slopes are expected to be typically in the order of 50 mm to 100 mm, with isolated cracking around 200 mm or greater.

The surface cracking and deformation could result in safety issues (i.e. trip hazards to people and stock), affect vehicle access (i.e. large deformations in access tracks), or result in increased erosion (especially along the drainage lines and the steeper slopes).

Management strategies and remediation measures can be developed for the surface cracking and deformations, which could include the following:-

- Visual monitoring of the surface in the active subsidence zone, to identify the larger surface cracking and deformations would could affect safety, access, or increase erosion,
- Establish methods for surface remediation, which could include infilling of surface cracks with soil or other suitable materials, or by locally regrading and compacting the surface. In some cases, erosion protection measures may be needed, such as the planting of vegetation in order to stabilise the steeper slopes in the longer term, and
- Develop Property Subsidence Management Plans (PSMPs) incorporating the agreed methods to manage surface cracking and deformations.

5.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE NATURAL FEATURES WITHIN THE SUBSIDENCE STUDY AREA

The following sections provide the descriptions, predictions and impact assessments for the natural features that have been identified within the *Subsidence Study Area*. The natural features located outside the *Subsidence Study Area*, which may be subjected to far-field movements or valley related movements and may be sensitive to these movements, have also been included as part of these assessments.

5.1. Catchment Areas or Declared Special Areas

There are no Catchment Areas or Declared Special Areas within the *Subsidence Study Area*.

5.2. Streams

5.2.1. Descriptions of the Streams

The locations of the drainage lines within the *Subsidence Study Area* are shown in Drawing No. MSEC708-08. The only named drainage line above the proposed longwalls is Dry Creek which is the main drainage line within the *Subsidence Study Area*.

The other minor drainage lines above the proposed longwalls comprise tributaries that flow into Dry Creek which flows into Bylong River approximately 2 kilometres north west of the proposed longwalls. The Bylong River is located approximately 530m from the proposed Longwall 109 at its nearest point, with the majority of the river greater than 1 kilometre from the proposed longwalls. The drainage lines within the Project Boundary are ephemeral in nature, where surface water only flows during and for short periods after rainfall events, although some isolated natural ponding is evident along the flatter sections of the streams.

The drainage lines generally have shallow incisions into the natural surface soils, which are generally derived from the outcropping materials shown in Fig. 1.2. Some isolated sections of Dry Creek are steep with deeper incisions into the landscape. Photographs of Dry Creek are shown in Fig. 5.1.

Fig. 5.1 Dry Creek

The natural grades along Dry Creek vary from approximately 60 mm/m (6%) along the upper reaches to less than 20 mm/m (1%), with an average of approximately 3%.

5.2.2. Predictions for the Streams

The predicted profiles of subsidence tilt and curvature along Dry Creek are shown in Fig. D.03 in Appendix D. The predicted profiles of subsidence, upsidence and closure along Dry Creek are shown in Fig. D.04 in Appendix D. The drainage lines are incised with relatively shallow depths below the adjoining ground surface level and the impacts to the drainage lines resulting from valley related upsidence and closure movements are not expected to be significant when compared with the predicted conventional movements.

The maximum predicted total conventional curvatures for Dry Creek are 3.4 km^{-1} hogging and 2.5 km^{-1} sagging, which represent minimum radii of curvature of 290 metres and 400 metres respectively. The predicted maximum strains for the drainage lines, based on applying a factor of 10 to the predicted curvatures are 34 mm/m tensile and 25 mm/m compressive. An analysis of predicted strain is provided in Section 4.3.

The other drainage lines are distributed over the proposed longwalls and will experience the full range of predicted conventional movements, which are presented in Section 4.0 .

5.2.3. Impact Assessments for the Streams

The impact assessments for the Streams are provided in the following sections.

Potential for Increased Levels of Ponding, Flooding and Scouring

Mining can potentially result in increased levels of ponding and flooding in the locations where the mining induced tilts oppose and are greater than the natural stream gradients that exist before mining. Mining can also potentially result in an increased scouring of the stream beds and banks in the locations where the mining induced tilts considerably increase the natural stream gradients that exist before mining.

The maximum predicted tilt for Dry Creek is 65 mm/m (i.e. 6.5 %) towards the western (and lower) end of the drainage line and 40 mm/m (i.e. 4 %) in the eastern (and upper) part of the creek. The maximum predicted changes in grade are generally greater than the natural grades along the western part of the creek and less than the natural grades in the eastern part of the creek.

It is expected, therefore, that there would be areas which would experience increased ponding and flooding, primarily upstream of the chain pillars in the shallower grades at the western end of the creek. It is also possible, that there could be areas which could experience increased scouring of the stream beds, primarily downstream of the chain pillars in the shallower grades. After the completion of mining in a particular area, surface remediation would be undertaken to re-establish the natural grades along the drainage lines, so as to reduce the potential for ponding. The areas of ponding along Dry Creek are predicted to be of the order of 50 metres to 100 metres in length and less than approximately 1 metre depth. The majority of the other drainage lines have gradients typically greater than the predicted tilts, however it is expected that localised areas of ponding will develop, particularly in the areas of drainage lines with shallow grades.

It is noted, that the predicted ponding depths and extents are likely to be conservative, as these have been based on the predicted changes in surface levels along the original alignments of the drainage lines and, therefore, do not consider the natural grades across the alignments of the drainage lines. The proposed mining will result in some changes in the stream alignments, due to the natural cross-grades and, in consequence, the actual ponding depths are expected to be less than those predicted.

At the completion of mining, the drainage lines would be regraded in the areas of increased ponding, so as to re-establish the natural gradients. The drainage lines have shallow incisions in the natural surface soils and, therefore, it is expected that the extents of ponding could be reduced by locally excavating the drainage line channels downstream of these areas.

It is possible that increased levels of bed scouring could also occur in the locations of the maximum increasing tilts, during times of high surface water flows, where the velocities of the flows exceed 1 m/sec. If significant levels of bed scouring were to occur along the drainage lines, it may be necessary to provide rip-rap, or to locally regrade the beds of the drainage lines in these locations.

Potential for Changes in Alignment of the Drainage Lines

The potential for changes in stream alignment of the drainage lines can occur due to changes in topography resulting from mining-induced conventional movements or valley related movements. The majority of the surface above the proposed longwalls has natural grades greater than 5% and approximately greater than half of the area has natural grades greater than 10%. The predicted conventional tilts resulting from longwall mining vary from approximately 30 mm/m to 65 mm/m (i.e. 3% to 6%). Based on these results, the alignment of drainage lines in topographical areas above the longwalls with steeper grades are unlikely to be significantly affected by changes in topography resulting from extraction of the proposed longwalls and the alignment of drainage lines in topographical areas with shallow grades are more likely to be affected by changes in topography resulting from extraction of the proposed longwalls.

A comparison of drainage lines based on the pre and post mining surface level contours is shown in Fig. 5.2.

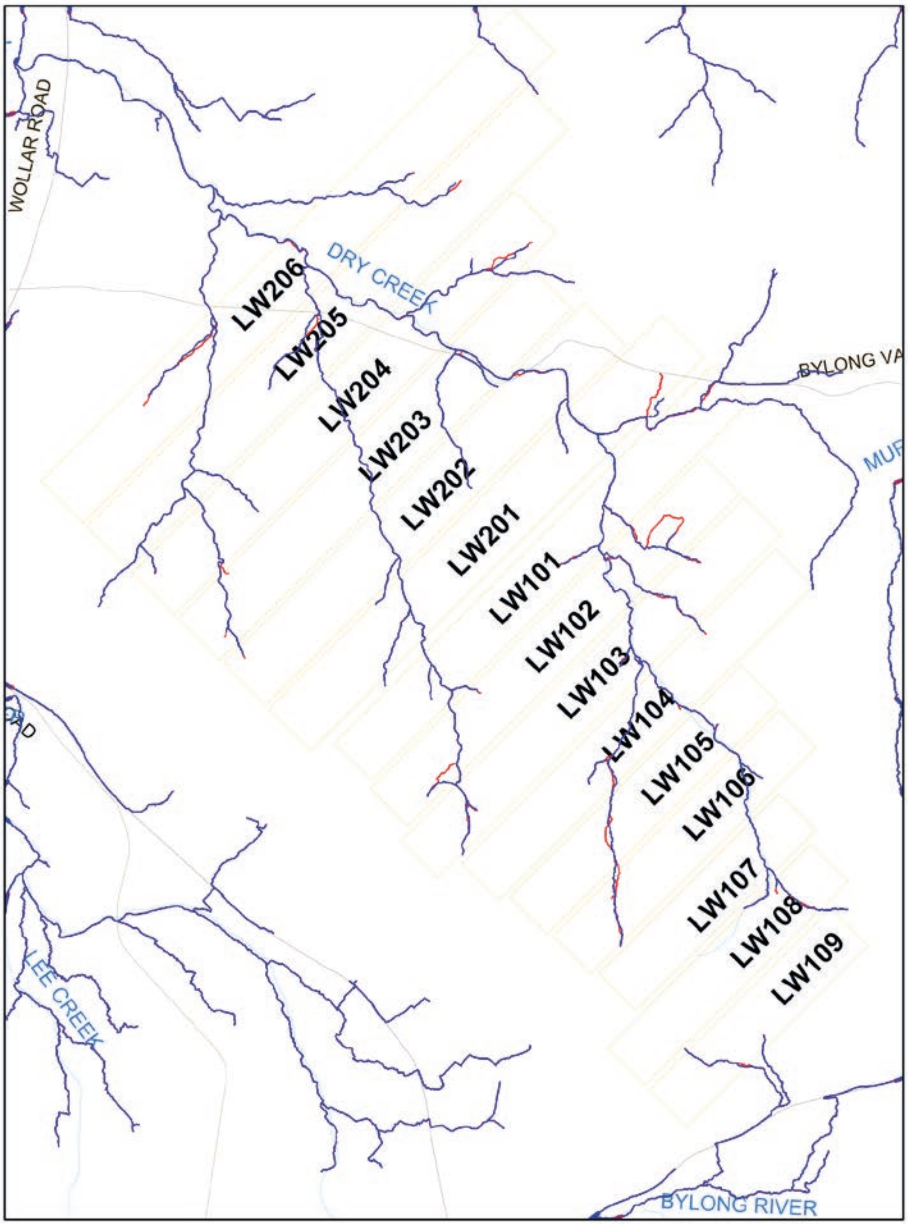

Fig. 5.2 Comparison of Pre-mining (Blue) and Post-mining (Red) Drainage Lines

It can be seen from the above figure that the majority of the drainage line alignments remain unchanged with only minor localised changes in alignment in areas with shallow grades. One noted change in alignment occurs above proposed Longwall 205 where a drainage line crosses Bylong Valley Way and could impact the flow of water through the road drainage culverts depending on the elevation of the road embankment, in which case regrading, or remediation measures may be required to restore adequate flow through the area.

Potential for Cracking in the Drainage Line Beds and Fracturing of the Bedrock

Fracturing of the uppermost bedrock has been observed in the past, as a result of longwall mining, where the tensile strains have been greater than 0.5 mm/m. Buckling and dilation of the uppermost bedrock have also been observed where the compressive strains have been greater than 2 mm/m. It is likely, therefore, that fracturing, buckling and dilation would occur in the uppermost bedrock beneath the soil beds of the drainage lines based on the magnitudes of the predicted strains.

The drainage lines are ephemeral and, therefore, surface water flows only occur during and for short periods after rainfall events. In times of heavy rainfall, the majority of the runoff would flow over the natural surface soil beds and would not be diverted into the dilated strata below. In times of low flow, however, surface water flows could be diverted into the dilated strata below the beds. The Surface Water Impact Assessment Report by WRM (2015) estimates negligible loss of surface water to groundwater as a result of surface cracking.

It would be expected, that the fracturing in the underlying bedrock would gradually be filled with the surface soils during subsequent flow events, especially during times of heavy rainfall. If the surface cracks were found not to fill naturally, some remedial measures may be required at the completion of mining. Where necessary, any significant surface cracks in the drainage line beds could be remediated by infilling with the surface soil or other suitable materials, or by locally regrading and compacting the surface.

The extraction of supercritical longwalls is expected to result in fracturing from the seam up to the surface. This does not however imply direct hydraulic connection between the surface and the seam. At the magnitudes of the predicted subsidence, the overburden is expected to have undergone large blocky movements, resulting in a network of fractures which is likely to increase the hydraulic conductivity between the surface and the seam at the areas of shallowest cover, with reducing potential for connectivity as depth of cover increases. It is possible therefore, that some of the surface water flows in the ephemeral streams at shallow depths of cover may be lost into the mine workings during high rainfall events. It may be necessary, in some locations, to remediate and reinstate the drainage line beds with highly cohesive soils, or to locally grout the bedrock along the streams, especially where the depths of cover are the shallowest.

Experience from mining in the Hunter, Newcastle and Western Coalfields indicates that impacts on ephemeral streams are low where the depths of cover are greater than the order of 200 metres, which is the case over approximately half of the proposed mining area.

Further discussion on the potential impacts from hydraulic connectivity between the surface and seam are provided in the Surface Water Impact Assessment report by WRM (2015) and the Groundwater Impact Assessment report by AGE (2015). SCT (2014) provided the relevant inputs for the Groundwater Impact Assessment in relation to the changes to the hydraulic conductivity between the surface and the longwall mining areas.

5.2.4. Impact Assessments for the Streams Based on Increased Predictions

If the conventional subsidence movements exceeded those predicted by a factor of 2 times, the maximum tilt within the *Subsidence Study Area* would be greater than 100 mm/m (i.e. > 10 %), which represents a change in grade greater than 1 in 10. In this case, increased levels of ponding and flooding are likely to occur along the streams immediately upstream of the panel edges. Increased change in alignment and cracking of stream beds would also occur. The extent of remediation would also be expected to increase, however, the methods of remediation would not be expected to change significantly.

5.2.5. Management of potential impacts on the Streams

Management strategies and remediation measures can be developed for the drainage lines, which could include the following:-

- Visual monitoring of the surface in the active subsidence zone, to identify the larger surface cracking and deformations would could result in the loss of surface water flows or increase erosion,
- Establish methods to regrade the drainage lines in the locations where adverse impacts occur as a result to increase ponding, and
- Establish methods of remediation for the surface cracking, which could include infilling with soil or other suitable materials, or by locally regrading and compacting the surface. In some cases, erosion protection measures may be needed.

If the longwalls were shifted to the north, south, east or west, or reorientated to varying angles within the Underground Extraction Area, the likelihood of impacts to streams above the proposed longwalls would remain the same and the same method of subsidence management would be recommended.

5.3. Aquifers or Known Groundwater Resources

The Subsidence Study Area contains perched Triassic aquifers and Permian bedrock aquifers as discussed in the report by AGE (2015). SCT (2014) completed some modelling in relation to the extent of hydraulic fracturing as a result of subsidence from the proposed longwall mining, which has been considered within the modelling completed within AGE (2015).

Further discussions on the potential impacts to groundwater resources as a result of the Project are provided in the specialist groundwater report by AGE (2015).

5.4. Cliffs

5.4.1. Descriptions of the Cliffs

For the purposes of this report, a cliff has been defined as a continuous rockface having a maximum height greater than 10 metres, a minimum length of 20 metres and a minimum slope of 2 in 1, i.e. having a minimum angle to the horizontal of 63°. The locations and heights of cliffs within the *Subsidence Study Area* were determined by detailed analysis of LiDAR survey data and by field survey.

A number of cliffs (41) have been identified within the *Subsidence Study Area.* The locations of the cliffs are shown in Drawing No. MSEC708-08.

The number of cliffs within the *Subsidence Study Area* represents a small proportion of the total number of cliffs within AUTH 287 and 342. The approximate number and variation in cliff dimensions within AUTH 287 and 342 is represented in the histograms provided in Fig. 5.3.

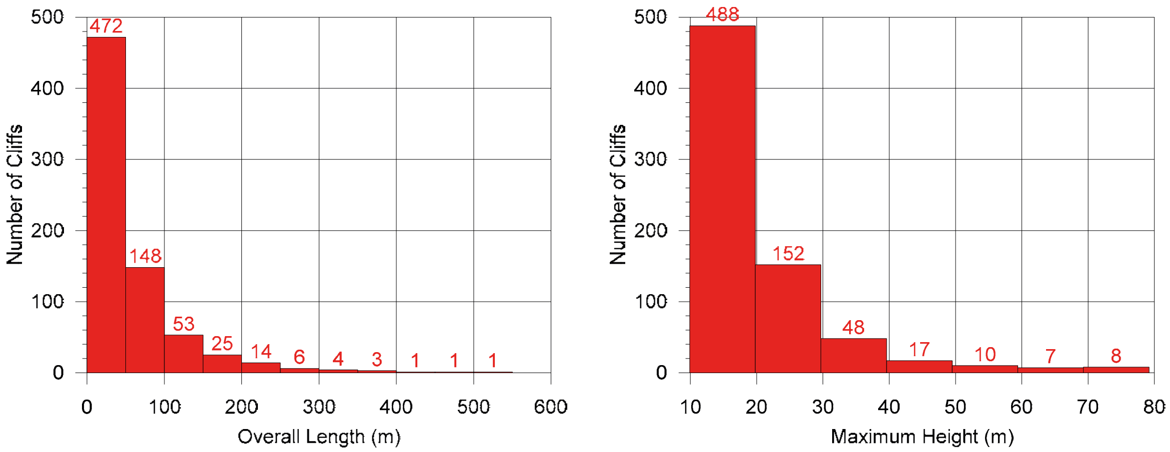

Fig. 5.3 Summary of Cliff Length and Height for Cliffs within AUTH 287 and AUTH 342

A key feature of the layout of the proposed longwalls is the protection of cliffs to the south west of Longwalls 101 to 109, as these cliffs form a prominent feature of the Bylong Valley. This has been achieved by offsetting the longwalls from these cliffs.

The cliffs within the *Subsidence Study Area* are predominantly located within the Bylong State Forest, overlying Longwalls 105 to 107 and Longwall 109. A small number of cliffs are also located in the north of the *Subsidence Study* Area above Longwall 206. Histograms of the dimensions of the cliffs that are located within the Subsidence Study Area are provided in Fig. 5.4.

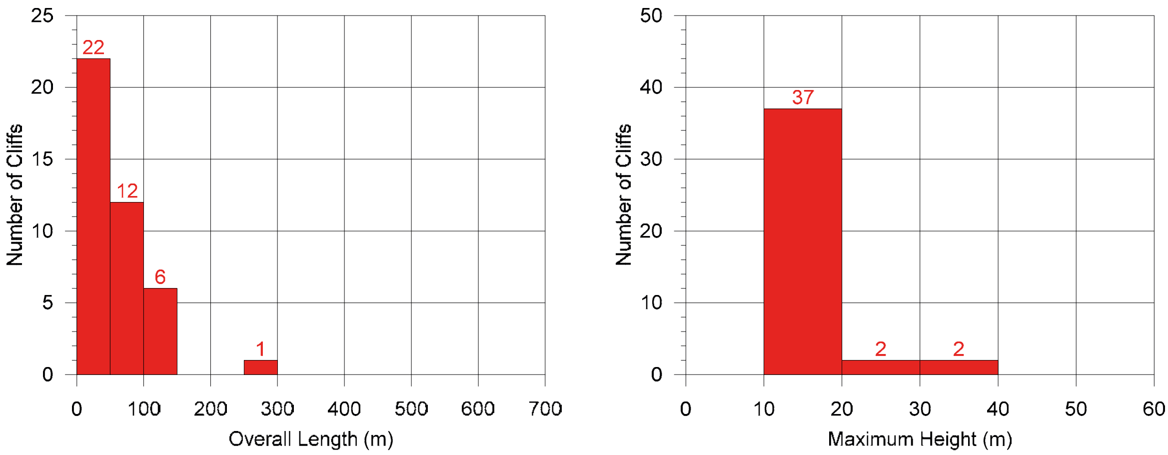

Fig. 5.4 Summary of Cliff Length and Height for Cliffs within the Subsidence Study Area

It can be seen from Fig. 5.4 that the cliffs are typically between 10 and 20 metres in height and less than 100 metres in length. Histograms of the dimensions of the cliffs that are located above the proposed longwalls are provided in Fig. 5.5. It can be seen from Fig. 5.5 that 30 of the 41 cliffs located within the *Subsidence Study Area* will be mined beneath by the proposed longwalls.

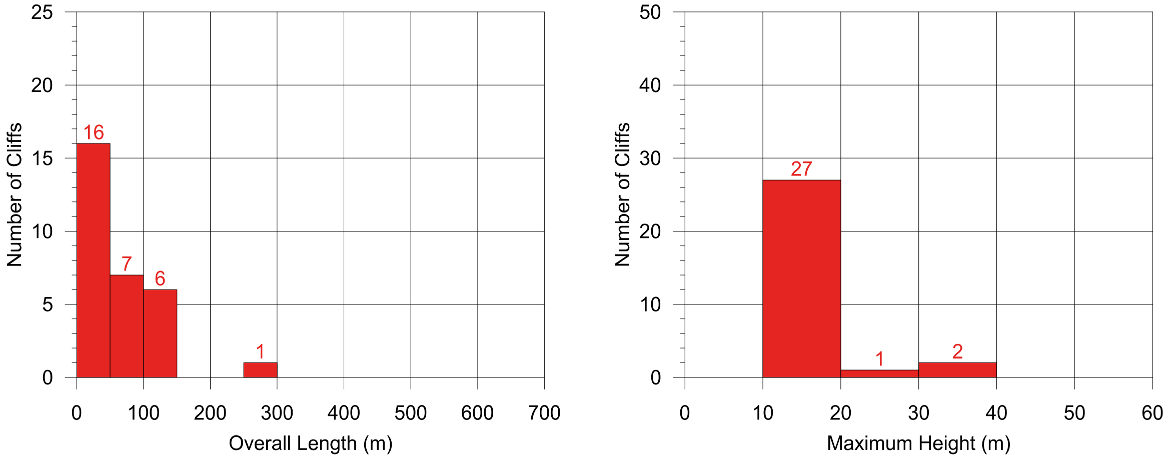

Fig. 5.5 Summary of Cliff Length and Height for Cliffs above the proposed longwalls

Histograms of the dimensions of the cliffs that are located to the south west of the proposed longwalls (i.e. protected by longwall set backs) are provided in Fig. 5.6. There are 56 cliffs located to the south west of the Proposed longwalls.

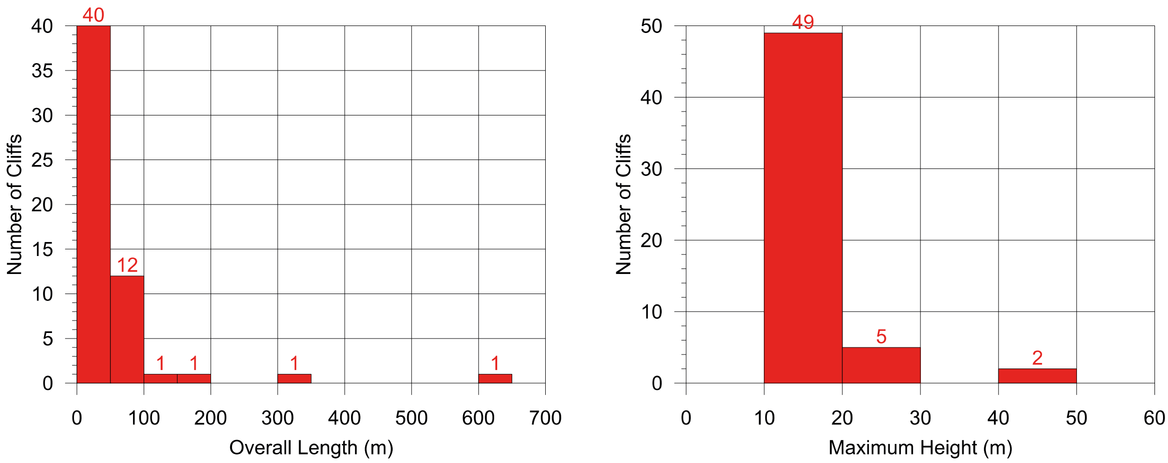

Fig. 5.6 Summary of Cliff Length and Height for Cliffs to the South West of the proposed longwalls

Photographs of the typical cliff faces within the *Subsidence Study Area* are shown in Fig. 5.7 to Fig. 5.11.

Fig. 5.7 Cliff 24330 above the finishing end of Longwall 107

Fig. 5.8 Cliff 24324 beyond the Subsidence Study Area

Fig. 5.9 Cliff 24422 located above Longwall 107

Fig. 5.10 Cliff 24166 adjacent to Longwall 101

Fig. 5.11 Cliff 24128 adjacent to Longwall 206

The longest and most prominent cliffs are three cliffs located beyond the finishing ends of Longwalls 105 to 107 and predominantly outside of the *Subsidence Study Area*. These cliff numbers, 24324, 24279, and 24278, have been labelled in Drawing No. MSEC708-08 and the cliffs are visible from Upper Bylong Road and other parts of the Bylong Valley. These cliffs are almost entirely outside the *Subsidence Study Area* but due to their size and prominence, they have been included in the study. Details of these cliffs are provided in Table 5.1

Table 5.1 Selected Cliff Details

Cliff Ref.	Cliff Length (m)	Maximum Cliff Height (m)	Location
24324	642	45	170m to 280m from the end of Longwalls 105 to 107
24279	347	50	160m to 270m from the end of Longwalls 104 and 105
24278	161	30	140m to 180m from the end of Longwalls 104 and 105

The cliffs are formed in the eroded faces of the Triassic Narrabeen Group, comprising interbedded fine to coarse grained sandstone and conglomeratic sandstone. Overhangs are typically less than approximately 3m with isolated overhangs up to approximately 10m. In addition to the rock fragments observed in the talus at the base of the cliffs, many of the cliffs have fresh sandstone fragments indicating relatively rapid weathering and associated rock falls is occurring. An example of the fresh rock fragments is shown in Fig. 5.12.

Fig. 5.12 Natural Rock Falls

5.4.2. Predictions for the Cliffs

A summary of the maximum predicted total subsidence, tilts and curvatures for the cliffs included in the study, at any time during or after mining, is provided in Table 5.2. The values are the maximum predicted parameters within 20 metres of their mapped extents.

Table 5.2 Maximum Predicted Total Subsidence, Tilts and Curvatures for the Cliffs Resulting from the Extraction of LW101 to 109 and 201 to 206

Label	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt (mm/m)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
24278	< 20	< 0.5	< 0.01	< 0.01
24279	< 20	< 0.5	< 0.01	< 0.01
24324	< 20	< 0.5	< 0.01	< 0.01
Cliffs within Subsidence Study Area	3300	40	2.0	1.5

5.4.3. Impact Assessments for the Cliffs 24278, 24279, 24324

The predicted vertical subsidence for Cliffs 24278, 24279 and 24324 are all less than 20 mm. These cliffs are not predicted to experience any significant conventional tilts, curvatures or strains, even if the predicted vertical subsidence were exceeded by a factor of 2 times.

The cliffs could also experience low level far-field horizontal movements of up to around 150 mm to 200 mm. These movements are expected to be bodily movements towards the extracted longwalls and are not expected to be associated with any significant strains. It is unlikely, therefore, that Cliffs 24278, 24279 and 24324 would be adversely impacted by the far-field horizontal movements, even if these predictions were exceeded by a factor of 2 times.

It is recommended that ground monitoring lines are established at the commencing ends of selected longwalls to measure the actual angles of draw to the limits of vertical subsidence. It is also recommended that the cliffs are periodically visually monitored during and after the completion of the longwalls. Monitoring during longwall extraction must be undertaken from suitable vantage points away from the areas of active subsidence.

5.4.4. Impact Assessments for the Cliffs Within the Subsidence Study Area

The cliffs located above the proposed longwalls are predicted to experience up to 3300 mm vertical subsidence. These movements are predicted to be associated with conventional tilt of up to 40 mm/m, or 1 in 25, and curvature up to 2 km^{-1}, or a minimum radius of curvature of 500 metres.

The cliffs directly above the proposed longwalls, have lengths up to approximately 300m, and typically between 20 metres and 80 metres. The cliffs have overall heights typically between 10 metres and 20 metres with isolated higher cliffs up to approximately 40 metres.

It is extremely difficult to assess the likelihood of instabilities for the cliffs based upon predicted ground movements. The likelihood of the cliffs becoming unstable is dependent on a number of factors which are difficult to fully quantify. These factors include jointing, inclusions, weaknesses within the rockmass, groundwater pressure and seepage flow behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors may influence the stability of the cliff naturally or when it is exposed to mine subsidence movements.

The predicted conventional movements and observed impacts to the cliffs located above the proposed longwalls have be estimated from the experience of undermining cliff formations at Ulan Mine, where longwalls have extracted in similar geological conditions directly beneath cliffs and rock formations at similar depths of cover and panel widths as those proposed at Bylong. It is reported that Ulan Mine has mined directly beneath more than 8km of cliff outcrop and observed rock falls occurred in approximately 20% of the length of the cliffs and visible mining subsidence movements occurred in approximately 50% to 70% of the sandstone formations greater than approximately 3 metres high (SCT 2009). Rock falls were not observed at cliffs located beyond the longwall panel footprint, though some cracking was observed.

The 13 of the 41 cliffs located within the *Subsidence Study Area* that are outside the proposed Proposed longwalls. There is extensive experience of mining adjacent to (i.e. not directly beneath) cliffs in the NSW Coalfields which indicates that the likelihood of impacts is very low. Whilst minor and isolated rock falls have occurred at some cliffs which are located outside the extents of active longwalls, there have been no large cliff instabilities where the cliffs have been wholly located outside the extents of mining. These minor rock falls above solid coal represented less than 1 % of the total length of cliff line located within the 26.5 degree angle of draw from the active longwall.

As part of the National Energy Research, Development and Demonstration Program (NERDDP) Study 1446 (1991), an extensive study of the effects of mine subsidence movements on cliffs and escarpments was undertaken, including longwall and bord and pillar mining at collieries in the Western Coalfields including Angus Place, Baal Bone, Hassans Walls and Lithgow Valley, Katoomba and Newnes, and also included several collieries in the Southern Coalfield, including Dombarton, Nattai North and Huntley.

It was found from this study that 96 % of the recorded cliff instabilities occurred directly above the workings, that is, after mining had occurred directly beneath the cliffs. The remaining 4 % were recorded immediately adjacent to the workings and, although located above solid coal, had occurred after another section of the effected cliffline had been directly mined beneath.

In all cases, the recorded cliff instabilities had occurred within a 26.5 degree angle of draw line from the extents of mining. The cliff instabilities also occurred only after part of the cliffline was directly mined beneath, or after mining either side of the cliffline (i.e. behind the cliff as well as beneath the valley).

Based on the experience of mining close to, but not directly beneath cliffs in the NSW Coalfields, it is possible that minor and isolated rock falls could occur along the cliffs located within the *Subsidence Study Area* but not directly above the proposed longwalls. Rock falls are more likely to occur at those cliffs which will be partially mined beneath, which is the case for cliffs at the finishing ends of Longwalls 105 and 106.

When comparing the experiences observed at Ulan Mine with the proposed mining at Bylong, it is noted that while panel widths and depths of cover are similar, the maximum measured subsidence at Ulan Mine is less than predicted at Bylong on account of a lower extraction height. The maximum measured tilt and strain at Ulan Mine are similar in magnitude to those predicted at Bylong near the locations of the cliffs.

The experience from Ulan Mine provides a reasonable indication of the level of impacts that may occur at the cliffs that are located directly above the proposed longwall panels (and chain pillars) at Bylong. It is expected therefore, that the percentage of cliffs above the longwalls that are likely to experience rock falls is of the order of 20% of the length of the cliffs, and visible mining subsidence movements are expected to occur in approximately 50% to 70% of the cliffs. The actual percentage of cliffs affected may be greater than 20% given the greater magnitude of subsidence predicted at Bylong. The percentage of the length of each cliffs likely to experience rock falls is likely to vary considerably due to the variable geological factors noted above. It is however expected that cliffs that have greater height and continuous length, are considered to be more susceptible to impacts. As can be seen in Fig. 5.5, two cliffs located above the longwalls have heights between 30 metres and 40 metres and one of these has a length between 250 metres and 300 metres. These two cliffs are therefore considered to be at greater risk of rock falls resulting from extraction of the longwalls.

A Visual Impact Assessment was carried out by JVP Visual Planning & Design (2015) and indicates that impacts to the larger cliffs above the Proposed longwalls will be screened from public vantage points by the ridge to the south west of the *Subsidence Study Area.* Some smaller cliff impact locations may be visible from isolated locations outside the *Subsidence Study* Area at distances greater than approximately 2km.

The potential for impacts at cliffs that are located beyond the longwall mining area is considered to be very low, though some cracking may be experienced to sites that are located within the *Subsidence Study Area*.

5.4.5. Impact Assessments for the Cliffs Based on Increased Predictions

If the conventional subsidence movements exceeded those predicted by a factor of 2 times, the maximum total subsidence would be 6600 mm. In this case, there would be an expected increase in the frequency and magnitude of cliff falls. The predicted likelihood of cliff falls for cliffs located outside the longwall footprints would not be expected to change even if conventional subsidence movements were doubled.

5.4.6. Management of potential impacts on the Cliffs

It is recommended that management plans be developed to manage potential impacts on cliffs during the mining of the proposed longwalls. The management plan would include monitoring of subsidence movements across the panels, restricted access during active mining and safe visual inspections of cliffs.

If the longwalls were shifted to the north, south, east or west, or reorientated to varying angles within the Underground Extraction Area, the likelihood of impacts to cliffs located above the proposed longwalls would remain the same and the same method of subsidence management would be recommended.

5.5. Steep Slopes

The purpose of identifying steep slopes for this assessment is to highlight areas in which existing ground slopes may be marginally stable. A steep slope has been defined as an area of land having a gradient greater than 1 in 3 (33% or 18.3°). The minimum slope 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 locations of the steep slopes within the *Subsidence Study Area* are shown in Drawing No. MSEC708-08.

The steep slopes are distributed across the *Subsidence Study* Area and are therefore subjected to the full range of predicted subsidence movements which are described in Section 4.0

The maximum predicted tilt for the steep slopes is 75 mm/m (i.e. 7.5 %, or 1 in 13). The predicted tilts are small when compared to the natural grades of the steep slopes, which are greater than 1 in 3 and, therefore, the tilts are unlikely to result in any adverse impact on the stability of the steep slopes.

The steep slopes are more likely to be affected by curvatures and strains. The potential impacts would generally result from the downslope movement of the surface soils, causing tension cracks to appear at the tops and sides of the slopes and compression ridges could possibly form at the bottoms of the slopes.

If tension cracks were to develop, as a result of the extraction of the proposed longwalls, it is possible that soil erosion could occur if these cracks were left untreated. It is possible, therefore, that some remediation might be required, including infilling of surface cracks with soil or other suitable materials, or by locally regrading and recompacting the surface. In some cases, erosion protection measures may be needed, such as the planting of additional vegetation in order to stabilise the slopes in the longer term.

The requirement and methodology for any erosion and sediment control and remediation techniques would be determined in consideration of potential impacts when unmitigated, including potential risks to public safety and the potential for self-healing or long-term degradation, and potential impacts of the control/remediation technique, including site accessibility.

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

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilts would be greater than 100 mm/m (i.e. 10 %, or 1 in 10). In this case, the tilts at the steep slopes would still be small in comparison with the existing natural grades, which exceed 1 in 3.

If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvatures at the steep slopes would be 7 km^{-1} hogging and 5 km^{-1} sagging. Whilst the sizes and extents of the surface cracking would increase, it would still be unlikely that any large scale slope instabilities would occur. This is based on the extensive experience of mining beneath similar steep slopes in the NSW Coalfields.

5.5.2. Management of potential impacts on the Steep Slopes

It is recommended that the steep slopes are visually monitored throughout the mining period and until any necessary rehabilitation measures are completed. In addition to this, it is recommended that any significant surface cracking which could result in increased erosion or restrict access to areas be remediated by infilling with soil or other suitable materials, or by locally regrading and compacting the surface.

It is recommended that management plans be developed to manage potential impacts on slopes during the mining of the proposed longwalls.

If the longwalls were shifted to the north, south, east or west, or reorientated to varying angles within the Underground Extraction Area, the likelihood of impacts to steep slopes located above the proposed longwalls would remain the same and the same method of subsidence management would be recommended.

5.6. Escarpments

There are no major escarpments within the *Subsidence Study Area*. The series of cliffs located along the south west side of the proposed longwalls exhibit escarpment-like characteristics as viewed from the Bylong Valley, but are not considered to constitute an escarpment. The discussions on these cliffs are provided in Section 5.4.

5.7. Land Prone to Flooding and Inundation

The lower reaches of Dry Creek form part of the low lying alluvial areas surrounding Bylong River and are prone to flooding or inundation. A small portion of this section of Dry Creek, approximately 300 metres, is within the *Subsidence Study Area*. Results of flood modelling studies undertaken by WRM Water & the Environment (2015) indicate that potential flow breakout may occur along the lower reaches of a Dry Creek tributary as a result of the extraction of the proposed longwalls. Further discussions of the impacts and consequences of the subsidence ground movements on future floods within the *Subsidence Study Area* are provided in the Surface Water Impact Assessment report by WRM Water & the Environment (2015).

5.8. Swamps, Wetlands and Water Related Ecosystems

As discussed in detail in the ecological impact assessment report by Cumberland Ecology (2015) there are some water related ecosystems in some streams but there are no upland swamps or wetlands within the *Subsidence Study Area*. Please refer to the Ecological Impact Assessment report by Cumberland Ecology (2015).

5.9. Threatened, Protected Species or Critical Habitats

A number of threatened flora and fauna species have been identified within the *Subsidence Study Area.* The Threatened Ecological Communities (TECs) are located predominantly on land in the north western part of the *Subsidence Study Area* as shown on Drawing No. MSEC708-09.

The TECs will be subjected to the full range of predicted subsidence movements which are discussed in Section 4.2. A discussion of potential impacts resulting from surface cracking and remediation is provided in Section 4.5. A detailed discussion of potential impacts to the flora and fauna resulting from the extraction of the proposed longwalls can be found in the Ecological Impact Assessment report by Cumberland Ecology

(2015) and the Biodiversity Offset Strategy (Cumberland Ecology, 2015a). The reports discuss that the impacts to flora and fauna resulting from extraction of the proposed longwalls, are not considered significant or can be readily managed.

The Ecological Impact Assessment (Cumberland Ecology 2015) and the Biodiversity Offset Strategy (Cumberland Ecology, 2015a) describe that due to the ecological values provided by the TECs and the limited impacts that would result to these features as a result of subsidence, a proportion of the land within the Subsidence Study Area has been set aside as a biodiversity offset area (Offset Area 5).

5.10. National Parks or Wilderness Areas

There are no National Parks nor any land identified as wilderness under the Wilderness Act 1987 within the *Subsidence Study Area*. Goulburn River National Park is located immediately to the north east and outside of the *Subsidence Study Area*. Wollemi National Park is located to the east and south east of the *Subsidence Study Area*.

The sections of the *Subsidence Study Area* adjacent to the National Park boundary are predominantly at the corners of the proposed longwall panels. The angle of draw at these locations off the corners of the longwalls are considered to provide a more conservative indication of subsidence movements since the contours are generally closer to the longwall footprint at the corners of the longwalls, as discussed in Section 3.5. That is, less subsidence is typically observed at corners compared to ends and sides of longwalls and the angle of draw included within the *Subsidence Study Area* has conservatively not taken this into account.

5.11. State Recreational or Conservation Areas

The eastern part of the proposed underground mining, including, Longwalls 101 to 109 will be extracted beneath the Bylong State Forest, as shown in Drawing No. MSEC708-08. These areas are not readily accessible by the public.

5.12. Natural Vegetation

The vegetation within the *Subsidence Study Area* comprises undisturbed natural bush within the Bylong State Forest and the remaining land which has predominantly been cleared to the north west of the Bylong State Forest. These areas can be seen in the aerial photograph in Fig. 2.2.

A detailed discussion of potential impacts to vegetation resulting from the extraction of the proposed longwalls can be found in the Ecological Impact Assessment report by Cumberland Ecology (2015) and the Biodiversity Offset Strategy (Cumberland Ecology, 2015a). The reports discuss that the impacts to vegetation resulting from extraction of the proposed longwalls, are not considered significant or can be readily managed. The incidence of tree falls resulting from surface subsidence effects is expected to be infrequent, with falls most likely to occur indirectly as a result of cliff falls and at locations coincident with large cracks and steps in the ground surface as discussed in Section 4.5. It is possible that vegetation die back due to underground mining could also occur as a result of factors including the pre mining state of health of the vegetation, gas release during mining, water ponding, changes to surface water flow or groundwater level, ground surface cracking and root shear. Reported incidences of vegetation death are infrequent and generally limited to small isolated locations. We understand that there is only one known case of larger scale dieback of large trees in the NSW coalfields that was recorded following the extraction of Longwalls 101 and 102 at Narrabri North Mine. A summary of an investigation into the cause of the tree death provided in the Longwall 103 end of panel report for Narrabri Mine (Whitehaven 2015) indicated that root shearing was a likely cause, and that "*It was likely that root shearing is exacerbated by dry conditions, heavy soil texture with associated high consistence."*

5.13. Areas of Significant Geological Interest

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

5.14. Any Other Natural Feature Considered Significant

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

6.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE PUBLIC UTILITIES

The following sections provide the descriptions, predictions and impact assessments for the Public Utilities within the *Subsidence Study Area*. The public utilities located outside the *Subsidence Study Area*, which may be subjected to far-field movements or valley related movements and may be sensitive to these movements, have also been included as part of these assessments.

6.1. Sandy Hollow to Gulgong Railway

There are no railways within the *Subsidence Study Area*, however, the Sandy Hollow to Gulgong Railway Line is located to the west and to the south of the *Subsidence Study Area* and is shown in Drawing No. MSEC708-02. The proposed longwalls to the railway line is approximately 170 metres from the nearest edge of Longwall 109. The majority of the railway (including tunnel) is greater than 800 metres from the proposed longwalls. At this location the rail track will not be subjected to measurable systematic mine subsidence ground movements; however, it may experience small far field horizontal movements.

The railway line may experience minor far-field horizontal movement as a result of extraction of the proposed longwalls. Based on a 95% confidence level as discussed in Section 4.4, far-field movements up to approximately 150 mm but typically less than 50 mm may be experienced. It is recommended that survey monitoring is conducted at the early stages of mining to assess the observed far-field horizontal movement data. Far-field horizontal movements are unlikely to result in impacts to the railway line. A discussion of far-field horizontal movement is provided in Section 4.4.

6.2. Roads

6.2.1. Descriptions of the Roads

The only road within the *Subsidence Study Area* is Bylong Valley Way which connects Castlereagh Highway to the south west to Golden Highway in the east and is maintained by the Mid-Western Regional Council. The road was unsealed prior to 2008, after which an asphaltic concrete road was constructed. The location of Bylong Valley Way is shown in Drawing No. MSEC708-14. The road passes above Longwalls 101 and Longwalls 201 to 206. There are also a number of tracks above the proposed longwalls within the property boundaries that are used for access by 4WD vehicles.

6.2.2. Predictions for the Roads

The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Bylong Valley Way are shown in Fig. D.04, in Appendix D.

A summary of the maximum predicted total conventional subsidence parameters for Bylong Valley Way, after the extraction of each of the proposed longwalls, is provided in Table 6.1. The predicted tilts are the maxima along the alignment of the road after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Table 6.1 Maximum Predicted Total Conventional Subsidence Parameters for Bylong Valley Way

Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt Along Alignment (mm/m)	Maximum Predicted Hogging Curvature (km^{-1})	Maximum Predicted Sagging Curvature (km^{-1})
LW101	450	5	0.3	<0.01
LW201	2,900	30	0.6	0.5
LW202	3,000	30	0.6	0.6
LW203	3,000	50	2.0	1.5
LW204	3,000	60	2.5	2.5
LW205	3,000	60	3.0	2.5
LW206	3,000	60	3.0	2.5

The maximum predicted conventional strains for Bylong Valley Way, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 30 mm/m tensile and 25 mm/m compressive.

Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The road is a linear feature and, therefore, the most relevant distribution of strain is the maximum strains measured along whole monitoring lines. The analysis of strains along whole monitoring lines is discussed in Section 4.3 and the results are provided in Fig. 4.3.

The 4WD tracks above the proposed longwalls will experience the full range of predicted subsidence parameters as discussed in Section 4.0 .

If the proposed longwalls were to be shifted or reorientated, it would be expected that the maximum predicted conventional movements for the Bylong Valley Way and the 4WD tracks would be similar to those provided above. Whilst different sections of the road would be predicted to experience greater or lesser movements, depending on their locations relative to the positions of the longwalls, the overall levels of movement along the extent of the road would not be expected to change substantially.

6.2.3. Impact Assessments for the Roads

It is possible that increased levels of ponding could occur along the roads located in terrain with shallow grades. It is expected, however, that the impacts of increased levels of ponding along the roads could be easily remediated by regrading and relevelling the roads using standard road maintenance techniques. More extensive works may be required at locations of culverts, particularly in areas of shallow grades as the subsided surface levels may result in a redirection of the natural flow path through the road alignment. It may be necessary to introduce speed restrictions along Bylong Valley Way until the appropriate remediation measures have been implemented.

The maximum predicted conventional tensile and compressive strains within the *Subsidence Study* Area, at any time during or after the extraction of the proposed longwalls, are expected to result in cracking, heaving and stepping of the road surfaces, particularly at the western end, where depths of cover are shallowest. Predicted crack widths are discussed further in Section 4.5.

The predicted curvatures and strains above the proposed longwalls are similar orders of magnitude to those where longwalls at the Beltana No. 1 Underground Mine were extracted directly beneath Charlton Road. The impacts observed along Charlton Road should, therefore, provide a reasonable guide to the potential impacts along the roads in these mining areas at shallow depths of cover. The depth of cover along Bylong Valley Way varies from approximately 100 metres to over 200 metres. The frequency of impacts is expected to reduce with increased depth of cover.

Beltana Longwalls 1 to 10 had void widths of 275 metres and a solid chain pillar width of 25 metres and were extracted from the Whybrow Seam at depths of cover ranging between 80 metres and 115 metres, i.e. width-to-depth ratios between 2.4 and 3.4. The crack widths observed along Charlton Road, due to the extraction of Beltana Longwalls 1 to 10, typically varied between 50 mm and 100 mm, with a maximum observed crack width around 380 mm. The heave and step heights observed along the road were typically in the order of 25 mm. Examples of the impacts observed along Charlton Road at Beltana are provided in Fig. 6.1.

Fig. 6.1 Impacts Observed along Charlton Road at the Beltana No. 1 Underground Mine

Bylong Valley Way is sealed with no kerb and gutter and can be repaired and reconstructed using standard road maintenance techniques as mining proceeds. The repairs could be progressive and, therefore, can be staged to suit the mining of each longwall in sequence.

It is recommended that the roads are monitored as the extraction faces of the proposed longwalls are mined beneath them, such that any impacts can be identified and remediated accordingly. It may be necessary to control traffic along the affected section of road during remediation works. With the implementation of suitable management strategies, it is expected that the roads can be maintained in safe and serviceable conditions throughout the mining period.

6.2.4. Impact Assessments for the Road Culverts

There are 12 culverts along Bylong Valley Way within the *Subsidence Study Area* with pipe diameters varying from 375 mm to 1200 mm. Photos of the typical culverts are shown in Fig. 6.2.

Fig. 6.2 Culverts along Bylong Valley Way

The maximum predicted tilt within the *Subsidence Study Area* is greater than 50 mm/m (i.e. 5 %), which represents a change in grade of 1 in 20. It is possible that the drainage culverts will experience tilts greater than the as constructed grade, resulting in a reversal of grade where the tilts oppose the grade of the culvert.

If the flow of water through any drainage culverts were to be adversely affected, as a result of the proposed mining, this could be remediated by re-levelling the affected culverts.

The predicted curvatures and strains could be of sufficient magnitudes to result in cracking in the culverts or the headwalls. The potential impacts on the drainage culverts could be managed by visual inspection and, where required, any affected culverts can be repaired or replaced.

The drainage culverts are located along drainage lines and could, therefore, experience valley related upsidence and closure movements. The drainage culverts are however, orientated along the alignments of the drainage lines and, therefore, the upsidence and closure movements are orientated perpendicular to the main axes of the culverts and unlikely to result in any adverse impacts.

6.2.5. Impact Assessments for the Roads Based on Increased Predictions

If the conventional subsidence movements exceeded those predicted by a factor of 2 times, the maximum subsidence along Bylong Valley Way would be 6000 mm, maximum predicted tilt would be greater than 100 mm/m and maximum predicted conventional strains based on predicted curvature would be greater than 50 mm/m tensile and compressive.

In this case, increased levels of ponding are likely to occur along Bylong Valley Way. The increased depth of ponding may be proportional to the increased subsidence, however the area of possible ponding may be greater than double that based on the predicted conventional subsidence.

There would also be an increase in the extent of impacts to the road surface and culverts as noted above. The extent of remediation would also be expected to increase, however the methods of remediation would not be expected to change significantly.

6.2.6. Management of potential impacts on Roads

Mining beneath roads at similar shallow depths of cover have been successfully managed at other collieries in the Hunter Coalfield. It is recommended that a Management Plan be developed in consultation with Mid-Western Regional Council to manage potential impacts on Bylong Valley Way within the *Subsidence Study Area*. Management plans should also be developed for the 4WD tracks within the property boundaries. With the implementation of these management strategies, it would be expected that Bylong Valley Way and

4WD tracks could be maintained in safe and serviceable conditions during and after the extraction of the proposed longwalls.

If the longwalls were shifted to the north, south, east or west, or reorientated to varying angles within the Underground Extraction Area, the likelihood of impacts to Bylong Valley Way and the 4WD tracks would remain the same and the same method of subsidence management would be recommended.

6.3. Road Bridges

There are no road bridges located within the *Subsidence Study Area.*

6.4. Tunnels

There are no tunnels within the *Subsidence Study Area*. A rail tunnel for the Sandy Hollow to Gulgong Railway is located approximately 1km to the east of the longwalls. At this distance the tunnel will not be subjected to measurable systematic mine subsidence ground movements; however, it may experience small far field horizontal movements, but negligible differential movements.

Far-field horizontal movements are unlikely to result in impacts to the rail tunnel. A discussion of far-field horizontal movement is provided in Section 4.4.

6.5. Potable Water Infrastructure

There is no potable water infrastructure within the *Subsidence Study Area*.

6.6. Sewerage Pipelines and Sewage Treatment Works

There are no sewerage pipelines and sewage treatment works within the *Subsidence Study Area*.

6.7. Gas Infrastructure

There is no gas infrastructure within the *Subsidence Study Area*.

6.8. Electricity Transmission Lines or Associated Plants

The locations of the electrical infrastructure within the *Subsidence Study Area* are shown in Drawing No. MSEC708-13. The descriptions, predictions and impact assessments for the powerlines are provided in the following sections.

6.8.1. Description of the Electrical Infrastructure

A powerline owned and maintained by Endeavour Energy is located along Bylong Valley Way extending from the east of the longwall layout over Longwalls 206 and 205. The powerline is 22kV and is supported on timber poles along the public road and timber and concrete poles into the properties north and south of the road, providing power supply for water pumps. Photos of the power poles are provided in Fig. 6.3.

Fig. 6.3 Electrical Power Poles

6.8.2. Predictions for the Electrical Infrastructure

A summary of the maximum predicted subsidence and tilts for the powerline is provided in Table 6.2. The tilts are the maximum predicted values which occur anywhere along or across the alignments (i.e. not necessarily at the pole locations), after the completion of any or all of the proposed longwalls.

Table 6.2 Maximum Predicted Total Conventional Subsidence, Tilt Along and Tilt Across the Powerline within the Subsidence Study Area

Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt Along Alignment (mm/m)	Maximum Predicted Total Conventional Tilt Across Alignment (mm/m)
2,500	50	45

If the proposed longwalls were to be shifted or reorientated, it would be expected that the maximum predicted conventional movements for the powerline would be similar to those provided above. Whilst different sections of the powerline would be predicted to experience greater or lesser movements, depending on the location relative to the positions of the longwalls, the overall levels of movement along the extents of the powerline would not be expected to change substantially.

6.8.3. Impact Assessments for the Electrical Infrastructure

The maximum predicted tilt for the powerline is 50 mm/m (i.e. 5 %, or 1 in 20). A rule of thumb used by some electrical engineers is that the tops of the poles may displace up to 2 pole diameters horizontally before remediation works are considered necessary. Based on pole heights of 15 metres and pole diameters of 250 mm, the maximum tolerable tilt at the pole locations is in the order of 33 mm/m.

It is likely, therefore, that the powerlines would be impacted as a result of the extraction of Longwalls 205 and 206. It may be necessary that preventive measures are implemented, which could include the installation of guy wires, cable sheaves, additional poles or the adjustment of cable catenaries.

Extensive experience of mining beneath powerlines in the NSW Coalfields, indicates that incidences of impacts requiring remedial measures are very low and that the impacts are readily repairable.

6.8.4. Impact Assessments for the Electrical Services Based on Increased Predictions

If the predicted conventional tilts at the powerline were increased by a factor of 2 times, the maximum predicted tilt would be 100 mm/m, which is approximately 3 times the above estimate of tolerable tilt. As a result, the degree of impact would therefore increase, however, the same preventive measures and management measures would be adopted. It would still be expected, however, that these impacts could be managed by the implementation of suitable management strategies.

6.8.5. Management of potential impacts on the Powerline

It is recommended that the powerline is monitored as the extraction faces of the longwalls are mined beneath it, such that any impacts can be identified and remediated accordingly.

With the implementation of these management strategies, it would be expected that the powerline could be maintained in safe and serviceable conditions during and after the extraction of the proposed longwalls.

If the longwalls were shifted to the north, south, east or west, or reorientated to varying angles within the Underground Extraction Area, the likelihood of impacts to the powerlines located above the proposed longwalls would remain the same and the same method of subsidence management would be recommended.

6.9. Telecommunications Infrastructure

6.9.1. Description of the Telecommunications Infrastructure

The locations of the telecommunications infrastructure are shown in Drawing No. MSEC708-13.

The telecommunications infrastructure within the *Subsidence Study Area* comprises Telstra owned direct buried copper cables, predominantly following the alignment of Bylong Valley Way. The cables within the *Subsidence Study Area* are approximately 3,450 metres in length.

A Telstra owned fibre optic cable is located outside the *Subsidence Study Area* as shown in Drawing No. MSEC708-13. The fibre optic cable is more than 600m from the nearest longwall will not be impacted by the extraction of the proposed longwalls.

6.9.2. Predictions for the Telecommunications Infrastructure

The cables follow the alignment of Bylong Valley Way and are therefore, are expected to experience subsidence movements similar to this road. The predicted profiles of conventional subsidence, tilt and curvature along Bylong Valley Way are shown in Fig. D.04, in Appendix D. A summary of the maximum predicted total conventional subsidence parameters for Bylong Valley Way and, hence, the copper cables is provided in Table 6.3.

Table 6.3 Maximum Predicted Total Conventional Subsidence Parameters for Bylong Valley Way

Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt Along Alignment (mm/m)	Maximum Predicted Hogging Curvature (km^{-1})	Maximum Predicted Sagging Curvature (km^{-1})
LW101 to 109	450	5	0.3	<0.01
LW201	2,900	30	0.6	0.5
LW202	3,000	30	0.6	0.6
LW203	3,000	50	2.0	1.5
LW204	3,000	60	2.5	2.5
LW205	3,000	60	3.0	2.5
LW206	3,000	60	3.0	2.5

The copper cables cross Dry Creek and other tributaries, however the drainage lines have relatively shallow incisions into the natural surface soils and impacts to the copper cables resulting from valley related upsidence and closure movements are not expected to be significant when compared with the predicted conventional movements.

The maximum predicted conventional strains for the copper cables, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 30 mm/m tensile and 25 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The copper cables are linear features and, therefore, the most relevant distribution of strain is the maximum strains measured along whole monitoring lines above previous longwall mining. The analysis of strains along whole monitoring lines during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.

6.9.3. Impact Assessments for the Copper Telecommunications Cables

Copper telecommunications cables can typically tolerate tensile strains of up to 20 mm/m without adverse impacts. It is possible, therefore, that the copper cables could be impacted as a result of the proposed mining.

Extensive experience of mining beneath copper telecommunications cables in the NSW Coalfields, where the mine subsidence movements were similar to those predicted for the proposed mining, indicates that incidences of impacts is extremely low and of a minor nature.

For example, copper telecommunications cables were directly mined beneath in the Hunter coalfield with observed strains of 26 mm/m tensile and 24 mm/m compressive and there were no reported impacts on these cables as a result of mining.

Based on this experience, it is unlikely that the proposed mining would result in any significant impacts on the copper telecommunications cables within the *Subsidence Study Area*. Any impacts on these cables would be expected to be relatively infrequent and readily repairable.

6.9.4. Impact Assessments for the Telecommunications Cables Based on Increased Predictions

If the actual curvatures or strains at the copper telecommunications cables exceeded those predicted by a factor of 2 times, the likelihoods of impacts would increase. Any impacts on these cables would still be expected to be relatively infrequent and readily repairable.

6.9.5. Management of potential impacts on the Telecommunications Infrastructure

It is recommended that management strategies are developed, in consultation with Telstra, for the copper telecommunications cables, which could include methods to repair or replace cables which are adversely impacted by mining.

If the longwalls were shifted to the north, south, east or west, or reorientated to varying angles within the Underground Extraction Area, the likelihood of impacts to the telecommunications infrastructure located above the proposed longwalls would remain the same and the same method of subsidence management would be recommended.

6.10. Dams, Reservoirs or Associated Works

There are no dams or reservoirs within in the *Subsidence Study Area.* A discussion on farm dams is provided in Section 7.10

6.11. Survey Control Marks

The locations of the survey control marks in the vicinity of the proposed longwalls are shown in Drawing No. MSEC708-10. The locations and details of the survey control marks were obtained from the *Land and Property Management Authority* using the *SCIMS Online* website (SCIMS, 2013).

There are two survey control marks located within the *Subsidence Study Area*, one of which is outside the longwall footprint.

The survey control marks located outside and in the vicinity of the *Subsidence Study Area* are also expected to experience small amounts of subsidence and small far-field horizontal movements. It is possible that other survey control marks outside the immediate area could also be affected by far-field horizontal movements, up to 3 kilometres outside the *Subsidence Study Area*. Far-field horizontal movements and the methods used to predict such movements are described further in Sections 3.6 and 4.4.

It is recommended that Management Plans be developed to manage potential impacts on the survey marks within the *Subsidence Study Area*. It will be necessary on the completion of the longwalls, when the ground has stabilised, to re-establish any survey control marks that are required for future use in consultation with the Land and Property Information.

6.12. Public Amenities

There are no public amenities within the *Subsidence Study Area.*

7.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE FARM LAND AND FARM FACILITIES

The following sections provide the descriptions, predictions and impact assessments for the farm land and farm facilities within the *Subsidence Study Area*.

7.1. Agricultural Utilisation

With the exception of the Bylong State Forest, the land above the proposed longwalls has been extensively cleared of natural timber other than on the steeper slopes and is currently used for cattle grazing on natural and improved pasture. A small section of land above the finishing end of Longwall 109 is identified as Mapped Equine CIC, however this area has steep slopes and is not cleared of natural vegetation.

The potential impacts on the agricultural land use include:-

- Surface cracking and deformations – which was discussed in Section 4.5,
- Changes in surface water and drainage – which was discussed in Sections 5.2 and 5.7,
- Changes to the groundwater resources – which is discussed in the report by AGE (2015), and
- Impacts to built features – which is discussed in Sections 6.0 to 9.0 .

The following sections provide the impact assessments on the agricultural utilisation.

7.1.1. Cattle Grazing

There is grazing of cattle on the land above the proposed longwalls on land owned by KEPCO, as well as on some sections of privately owned land in the south eastern extent of the Underground Extraction Area. A risk to this type of agricultural land use is the potential for the mining induced surface cracking and deformations to injury the cattle or workers on these properties, as discussed in Section 4.5. Management strategies can be developed for the grazing properties, which could include the following:-

- Visual monitoring of the surface in the active subsidence zone, to identify any surface cracking and deformations would could potentially injure the stock or people,
- Consider the installation of temporary fencing and/or the temporary relocation of stock to areas outside the active subsidence zone,
- Establish methods of remediation, which could include infilling of surface cracks with soil or other suitable materials, or by locally regrading and compacting the surface, and
- Develop Property Subsidence Management Plans (PSMPs) incorporating the agreed methods to manage surface cracking and deformations with the property owners.

7.1.2. Equine Use

There is a small portion of land overlying Longwall 109 that is identified as equine CIC. KEPCO holds ownership of this land. However a Property Subsidence Management Plans (PSMP) would need to be developed for this property, prior to active subsidence, incorporating agreed management strategies. There are currently no built features within this area of land over Longwall 109. A risk to this type of agricultural land use is the potential for the mining induced surface cracking and deformations to injury the horses or workers on this property, as discussed in Section 4.5. Management strategies can be developed for the property, which could include the following:-

- Visual monitoring of the surface in the active subsidence zone, to identify any surface cracking and deformations would could potentially injure the horses or people,
- Consider the installation of temporary fencing and/or the temporary relocation of horses to areas outside the active subsidence zone, and
- Establish methods of remediation, which could include infilling of surface cracks with soil or other suitable materials, or by locally regrading and compacting the surface.

7.2. Rural Structures

7.2.1. Descriptions of the Rural Structures

The locations of the rural structures (Structure Type R) within the *Subsidence Study Area* are shown in Drawing No. MSEC708-13.

There is one rural structure R01, which is located above Longwall 102. The structure is a galvanised shed, known as the "shooters hut", measuring approximately 10 metres by 8 metres. A photograph of the shooters hut is shown in Fig. 7.1.

Fig. 7.1 Shooters Hut

7.2.2. Predictions for the Rural Structure

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at the vertices of the rural structure, as well as at 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.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for the rural structure within the *Subsidence Study Area* is provided in Table 7.1. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Table 7.1 Maximum Predicted Total Conventional Subsidence Parameters for The Rural Structure

Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Hogging Curvature in Any Direction (km^{-1})	Maximum Predicted Sagging Curvature in Any Direction (km^{-1})
950	35	1.0	0.4

The maximum predicted conventional strains for the rural structure, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 10 mm/m tensile and 4 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The rural structure is at a discrete location and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1.

7.2.3. Impact Assessments for the Rural Structure

The maximum predicted tilt for the rural structure is 35 mm/m (i.e. 3.5 %), which represents a change in grade of 1 in 30. The rural structure within the *Subsidence Study Area* is of lightweight construction and is able to tolerate mining-induced tilt. It has been found from past longwall mining experience that tilts of the magnitudes predicted for the rural structure generally do not result in adverse impacts. Some minor serviceability impacts could occur at higher levels of predicted tilt, including door swings and issues with roof and pavement drainage, all of which can be remediated using normal building maintenance techniques.

The maximum predicted conventional curvatures for the rural structures are 1.0 km^{-1} hogging and 0.4 km^{-1} sagging, which equate to minimum radii of curvature of 1 kilometres and greater than 2.5 kilometres, respectively.

There is extensive experience of mining directly beneath rural structures in the NSW Coalfields which indicates that the incidence of impacts on these structures is very low and the structures have remained in safe and serviceable conditions. This is not surprising as rural structures are generally small in size and of light-weight construction, which makes them less susceptible to impact than houses which are typically more rigid.

Based on previous experiences, it is expected that the rural structure within the *Subsidence Study Area* would remain safe and serviceable during the mining period, provided that it is in sound existing condition. The risk of impact is clearly greater if the structure is in poor existing condition, though chances of there being a public safety risk remain very low.

Impacts on the rural structure that occur as the result of the extraction of the proposed longwalls are expected to be remediated using well established building techniques. With these remediation measures available, it is unlikely that there would be long term impacts on rural structure resulting from the extraction of the proposed longwalls.

7.2.4. Impact Assessments for the Rural Structures Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the rural structures would be 70 mm/m (i.e. 7 %), or a change in grade of 1 in 14. In this case, the incidence of serviceability impacts, such as door swings and issues with gutter and pavement drainage, would increase. It would still be unlikely that stability of the rural structure would be affected by tilts of these magnitudes.

If the actual curvatures exceeded those predicted by a factor of 2 times, the likelihood of impacts would increase. Since rural structure is small in size and of light-weight construction, it would still be expected to remain safe, serviceable and repairable using normal building maintenance techniques. With the implementation of any necessary remediation measures, it is unlikely that there would be any substantial long term impacts on the rural structure.

7.2.5. Management of potential impacts on the Rural Structure

It is recommended that management plans are developed to manage potential impacts on the shed during the mining of the proposed longwalls. A pre-mining inspection should be carried out to assess the condition of the structure prior to the commencement of mining.

7.3. Tanks

7.3.1. Descriptions of the Tanks

There is one galvanised iron and two concrete tanks within the *Subsidence Study Area,* approximately 10 metres in diameter that are used for refilling of cattle watering troughs. The locations of the tanks (Structure Type T) within the *Subsidence Study Area* are shown in Drawing No. MSEC708-13. Photographs of the tanks are shown in Fig. 7.2.

Fig. 7.2 Concrete and Galvanised Iron Tanks

There are a number of concrete watering troughs within the *Subsidence Study Area* that are filled via buried polyethylene pipes. The round troughs measure approximately 1.9 metres diameter and the rectangular troughs measure approximately 2.5 metres x 4 metres. The troughs are small and supported directly on the ground surface and are unlikely to be impacted by the predicted subsidence movements.

Fig. 7.3 Concrete watering troughs

7.3.2. Predictions for the Tanks

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of each tank, as well as at points located at a distance of 20 metres from the perimeter of each tank.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for the tanks within the *Subsidence Study Area* is provided in Table 7.2. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures provided in this table are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Table 7.2 Maximum Predicted Total Conventional Subsidence Parameters for The Tanks

Tank ID	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Hogging Curvature in Any Direction (km^{-1})	Maximum Predicted Sagging Curvature in Any Direction (km^{-1})
T01	1100	25	0.5	0.3
T02	1100	25	0.5	0.3
T03	2400	0.5	1.5	1.2

The maximum predicted conventional strains for the tanks, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 15 mm/m tensile and 12 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The tanks are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls is discussed in Section 4.3.1.

7.3.3. Impact Assessments for the Tanks

Tilt can potentially affect the serviceability of tanks by altering the water levels in the tanks, which can in turn affect the minimum level of water which can be released from the outlets. The maximum predicted conventional tilt for the tanks is 25 mm/m (i.e. 2.5 %), which represents a change in grade of 1 in 40. The predicted changes in grade are approximately 250 mm over 10 metres, and may therefore, impact on the serviceability of the tank. This could be remediated by re-levelling the tank.

The tank structures are resting on natural ground and, therefore, are unlikely to experience the curvatures and ground strains resulting from the extraction of the proposed longwalls. It is possible, that any buried water pipelines associated with the tanks within the *Subsidence Study Area* could be impacted by the ground 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 these remedial measures in place, it would be unlikely that there would be any adverse impacts on the pipelines associated with the tanks.

7.3.4. Impact Assessments for the Tanks Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the tanks would be 50 mm/m (i.e. 5.0 %), or a change in grade of 1 in 20. This would increase the impact to serviceability of the tank. Impacts would be expected to be remediated by re-levelling the tanks.

If the actual curvatures exceeded those predicted by a factor of 2 times, the incidence of impacts on the tank structures would not be expected to change substantially, as they are not expected to experience these ground movements. The incidence of impacts on the buried pipelines would, however, be expected to increase in the locations directly above the proposed longwalls. Impacts would still be expected to be of a minor nature which could be easily repaired. With these remediation measures in place, it would be unlikely that there would be long term impacts on the pipelines associated with the tanks.

7.3.5. Management of potential impacts on the Tanks

It is recommended that management plans be developed to manage potential impacts on the tanks during the mining of the proposed longwalls.

7.4. Gas and Fuel Storages

There are no gas and fuel storages within the *Subsidence Study Area*.

7.5. Poultry Sheds

There are no poultry sheds within the *Subsidence Study Area*.

7.6. Glass Houses

There are no glass houses within the *Subsidence Study Area.*

7.7. Hydroponic Systems

There are no known hydroponic systems within the *Subsidence Study Area*.

7.8. Irrigation Systems

There are no known irrigation systems within the *Subsidence Study Area*. A number of buried polyethylene pipes are located within the *Subsidence Study Area* for watering troughs. The buried pipes are unlikely to be impacted by the predicted subsidence movements, however connections which act as anchor points may be impacted, as discussed in Section 7.3.

7.9. Farm Fences

The fences are located across the *Subsidence Study Area* and, therefore, are expected to experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the *Subsidence Study Area* is provided in Chapter 4.

The fences are linear features and, therefore, the most relevant distribution of strain is the maximum strains measured along whole monitoring lines above previous longwall mining. The analysis of strains along whole monitoring lines during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3 and the results are provided in Fig. 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

Wire fences can be affected by tilting of the fence posts and by changes of tension in the fence wires due to strain as mining occurs. These types of 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 adverse impacts. It is possible, that some of the wire fences within the *Subsidence Study Area* could be impacted as the result of the extraction of the proposed longwalls. Any impacts on the wire fences are likely to be of a minor nature and relatively easy to remediate by re-tensioning the fencing wire, straightening the fence posts, and if necessary, replacing some sections of fencing.

It is recommended that management plans be developed to manage potential impacts on fences during the mining of the proposed longwalls.

7.10. Farm Dams

7.10.1. Description of the Farm Dams

The locations of the farm dams within the *Subsidence Study Area* are shown in Drawing No. MSEC708-13.

There are 11 farm dams which have been identified within the *Subsidence Study Area.* The farm dams are typically of earthen construction and have been established by localised cut and fill operations within the natural drainage lines.

A photograph of a typical farm dam in the area is provided in Fig. 7.4.

Fig. 7.4 Photograph of Typical Farm Dam (D02)

The largest dam is located within the quarry (i.e. D11), partially overlying Longwall 101 and Longwall 201, and has a surface area of approximately 21,000 m^2 and a maximum plan dimension of approximately 200 metres. The remaining dams have areas between approximately 150 m^2 and 1,800 m^2, and maximum plan dimensions between 15 metres and 60 metres.

7.10.2. Predictions for the Farm Dams

The predicted conventional subsidence, tilt and curvatures for each of the farm dams within the *Subsidence Study Area* are provided in Table D.02, in Appendix D. A summary of the maximum predicted subsidence parameters for these dams is provided in Table 7.3. The parameters provided in this table are the maximum values within 20 metres of the perimeters of the dams, at any time during or after the extraction of the proposed panels.

Table 7.3 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Farm Dams

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After Longwall 101	2750	35	0.8	0.8
After Longwall 102	2750	40	1	0.8
After Longwall 103	2750	40	1	0.8
After Longwall 109	2750	40	1	1.0
After Longwall 201	2900	40	1.5	1.5
After Longwall 202	2900	40	1.5	1.5
After Longwall 203	2900	40	1.5	1.5
After Longwall 204	3000	65	3.5	1.5
After Longwall 205	3150	70	3.5	2
After Longwall 206	3150	70	3.5	2

The maximum predicted conventional curvatures for the farm dams are 3.5 km^{-1} hogging and 2.0 km^{-1} sagging, which represent minimum radii of curvature of less than 290 metres and 500 meters respectively. The maximum predicted conventional strains for these dams, based on applying a factor of 10 to the maximum predicted conventional curvatures, are greater than 35 mm/m tensile and 20 mm/m compressive.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

7.10.3. Impact Assessments for the Farm Dams

The predicted tilts for the farm dams located directly above the proposed panels vary between 2 mm/m (i.e. 0.2 %, or 1 in 500) and 70 mm/m (i.e. 7.0 %, or 1 in 14). 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.

The predicted changes in freeboard for the farm dams have been determined by taking the difference between the maximum predicted subsidence and the minimum predicted subsidence anywhere around the perimeter of each farm dam. A summary of the maximum predicted changes in freeboard for the farm dams within the *Subsidence Study Area* is provided in Table 7.4.

Table 7.4 Maximum Predicted Changes in Freeboard for the Farm Dams

Ref.	Maximum Predicted Change in Freeboard after Longwalls (mm)									
	LW101	LW102	LW103	LW109	LW201	LW202	LW203	LW204	LW205	LW206
D01	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	100
D02	< 50	< 50	< 50	< 50	< 50	< 50	< 50	1600	1600	1600
D03	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
D04	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	150
D05	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	1800	1750
D06	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
D07	< 50	< 50	< 50	< 50	< 50	< 50	< 50	1950	2000	2000
D08	< 50	< 50	< 50	< 50	< 50	< 50	1700	1700	1700	1700
D09	< 50	< 50	< 50	< 50	500	450	450	450	450	450
D10	< 50	2200	2300	2300	2300	2300	2300	2300	2300	2300
D11	2750	2750	2750	2750	2700	2700	2700	2700	2700	2700

It can be seen from the above table, that Dams Refs. D02, D05, D07, D08, D10 and D11 are predicted to experience changes in freeboard of 1,000 mm or more. The predicted changes in freeboard at the remaining dams are 450 mm, or less. It is unlikely, at the magnitudes of the predicted changes in freeboards that there would be any adverse impacts on the stability of the dam walls.

It is possible that the storage capacities of some of the farm dams which are located directly above the proposed panels could be reduced. If the storage capacities of any farm dams were adversely affected, they could be re-established by raising the earthen walls, if required.

The predicted conventional strains for the farm dams located directly above the proposed panels vary between 2 mm/m and 35 mm/m tensile, and between 1 mm/m and 20 mm/m compressive. It is likely, at these magnitudes of strain, that these farm dams could be affected by cracking, heaving or stepping in the bases or dam walls. It is also likely that fracturing and buckling uppermost bedrock would occur beneath these farm dams.

There is also 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 cracking in the dam wall or base could occur resulting in loss of the stored water.

Any surface cracking or leakages in the farm dams could be identified by visual inspections and remediated by re-instating the bases and walls of the dams with cohesive materials. Any loss of water from the farm dams would flow into the drainage line in which the dam was formed. There are no principal residences or other building structures located within the alignments of the drainage lines downstream of the farm dams.

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

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum final tilt at the farm dams would be greater than 100 mm/m (i.e. 10 %, or 1 in 10). In this case, the maximum changes in freeboard would be 2,000 mm, or greater, at Dams Refs. D02, D05, D07, D08, D10 and D11. It would still be unlikely to affect the stability of the dam walls and, if required, the storage capacities could be restored by raising the dam walls or excavating the dams to deepen them.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, the likelihood and extents of cracking in the bases and dam walls would increase for the dams located directly above the proposed longwalls. It would still be expected, that any adverse impacts could be repaired, as required, by re-instating the bases and walls of the dams with cohesive materials.

7.10.5. Recommendations for the Farm Dams

Dam monitoring management strategies should be developed for the farm dams which are located directly above the proposed longwalls, which could include lowering the stored water levels prior to mining directly beneath them. It is also recommended that the farm dams are visually monitored, during active subsidence, such that any impacts can be identified and remediated accordingly.

If the longwalls were shifted to the north, south, east or west, or reorientated to varying angles within the Underground Extraction Area, the impacts to the dams would change but the same method of subsidence management would be recommended.

7.11. Groundwater Bores

There are three groundwater bores registered to KEPCO that are located within the *Subsidence Study Area.* The bores are used for groundwater monitoring purposes. There are several registered bores outside the *Subsidence Study Area*. The nearest privately owned bore to the proposed longwalls is approximately 500 metres from Longwall 109. The locations of the groundwater bores are shown on Drawing No. MSEC708-10.

The maximum predicted conventional subsidence, tilt and curvature are provided Table 7.5. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures provided in this table are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Table 7.5 Maximum Predicted Total Conventional Subsidence Parameters for the Groundwater Bores

Tank ID	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt Along Alignment (mm/m)	Maximum Predicted Hogging Curvature in Any Direction (km^{-1})	Maximum Predicted Sagging Curvature in Any Direction (km^{-1})
GW201536	2650	37	1.1	1.1
GW201539	1450	54	2.3	2.5
GW201541	2800	12	2.9	2.5

The maximum predicted conventional strains for the bores, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 29 mm/m tensile and 25 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The bores are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls is discussed in Section 4.3.1.

It is likely that the groundwater bores will experience impacts as the result of mining of the longwalls, particularly as they are located directly above the longwalls. Impacts may include lowering of the piezometric surface, blockage of the bore due to differential horizontal displacements at different horizons within the strata, changes to groundwater quality, and horizontal shearing of the bores.

It is recommended that management of potential impacts during the mining of the proposed longwalls be included as part of the Water Management Plan.

7.12. Silo

7.12.1. Descriptions of the Silo

There is one silo within the *Subsidence Study Area* supported on a concrete pad approximately 7 metres in diameter. The location of the silo (Structure Type S) within the *Subsidence Study Area* is shown in Drawing No. MSEC708-13. A photograph of the silo is shown in Fig. 7.5.

Fig. 7.5 Silo

7.12.2. Predictions for the Silo

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of the silo, as well as at points located at a distance of 20 metres from the perimeter of the silo.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for the silo is provided in Table 7.6. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures provided in this table are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Table 7.6 Maximum Predicted Total Conventional Subsidence Parameters for The Silo

Tank ID	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Hogging Curvature in Any Direction (km^{-1})	Maximum Predicted Sagging Curvature in Any Direction (km^{-1})
S01	2400	60	1.6	2.5

The maximum predicted conventional strains for the silo, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 16 mm/m tensile and 25 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The silo is at a discrete location and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls is discussed in Section 4.3.1.

7.12.3. Impact Assessments for the Silo

The silo and its concrete pad is resting on natural ground and, therefore, is unlikely to experience the curvatures and ground strains resulting from the extraction of the proposed longwalls. The maximum predicted conventional tilt at the location of the silo is 60 mm/m (i.e. 6 %), which represents a change in grade of 1 in 17. The predicted changes in grade are approximately 420mm over 7 metres, and may therefore, impact on the silo. This could be remediated by re-levelling the silo.

7.12.4. Impact Assessments for the Silo Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the tanks would be greater than 100 mm/m (i.e. 10.0 %), or a change in grade of 1 in 10. This would increase the impact to tilt of the silo. Impacts would be expected to be remediated by re-levelling the silo.

If the actual curvatures exceeded those predicted by a factor of 2 times, the incidence of impacts on the tank structures would not be expected to change substantially, as they are not expected to experience these ground movements.

7.12.5. Management of potential impacts on the Silo

It is recommended that management plans be developed to manage potential impacts on the silo during the mining of the proposed longwalls.

8.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE INDUSTRIAL, COMMERICAL AND BUSINESS ESTABLISHMENTS

8.1. Industrial, Commercial and Business Establishments in general

There is one business operating within the *Subsidence Study Area,* Bylong Quarries. The quarry supplies dolomite and lime products. The location of the quarry is show on Drawing No. MSEC708-13.

There are no permanent structures at the site. The high walls at the quarry are up to approximately 10 metres in height.

The ground surface at the quarry will be subjected to the full range of predicted subsidence parameters, which are discussed in Section 4.0 .

The likelihood of rock falls at the high walls in the quarry will be dependent on the position and geometry of the high walls at the time of longwall extraction. If the longwalls mine directly beneath the high walls, there is a high risk that the high walls would experience impacts in a similar manner to those described for the cliffs in Section 5.4.

It is likely that surface cracking and deformation will occur within the quarry in areas located above the extracted longwalls. This may pose a hazard to personnel and equipment working within the quarry. A discussion of potential surface cracking and deformations due to the extraction of the proposed longwalls is provided in Section 4.5.

It is recommended that a subsidence management plan be developed in consultation with the owners of the quarry. The management strategy would include:

- Consultation with the owner,
- Pre-mining inspections by a suitably qualified geotechnical engineer and subsidence engineer,
- Identification and assessment of potential impacts to the operation of each business and safety of workers and the general public,
- Consideration of mitigation measures to reduce risk prior to the commencement of subsidence movements,
- Consideration of appropriate monitoring measures,
- Consideration of appropriate triggered responses during mining, and
- Development of an agreed detailed subsidence management plan.

8.2. Gas or Fuel Storages and Associated Plant

There are no known gas or fuel storages within the *Subsidence Study Area.*

8.3. Mine Infrastructure Including Tailings Dams or Emplacement Areas

There is no mine infrastructure located within the *Subsidence Study Area.*

9.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR AREAS OF ARCHAEOLOGICAL AND HERITAGE SIGNIFICANCE

The descriptions, predictions and impact assessments for the archaeological and heritage sites within the *Subsidence Study Area* are provided in the following sections.

9.1. Archaeological Sites

There are no lands within the *Subsidence Study Area* declared as an Aboriginal Place under the *National Parks and Wildlife Act 1974*. There are 146 archaeological/cultural sites which have been identified within the *Subsidence Study Area* and an additional 5 sites in close proximity that have been included in the subsidence impact assessments. A total of 151 archaeological/cultural sites have therefore been included in the subsidence impact assessments below. A summary of these sites is provided in Table D. 01, in Appendix D, based on information provided by Hansen Bailey and its archaeological consultant RPS Australia. The sites consist of the following types:

- Artefact Scatter – 56 sites
- Isolated Find – 48 sites
- Rockshelter – 12 sites
- Ochre Quarry – 1 site
- Grinding Grooves – 4 sites
- Sandstone Cavity – 27 sites
- Sandstone Formation – 3 sites

Of these sites, three grinding groove sites (GG001, GG002 and GG003) and two rockshelter sites (RS004,RS005) are located outside the Subsidence Study Area, but have been considered in this assessment due to their significance.

Detailed descriptions of the archaeological sites within the *Subsidence Study Area* are provided by RPS (2015). Sites classified as having high regional significance include rock shelters RS007 and RS013, grinding grove sites GG01, GG02, GG03, and the ochre quarry site OQ001. Rock shelter site RS003 has high regional significance but is located approximately 3.3 km outside the *Subsidence Study Area.*

9.1.1. Predictions for the Archaeological Sites

The predicted conventional subsidence, tilts and curvatures for the archaeological sites within the *Subsidence Study Area* are provided in Table D.01, in Appendix D. A summary of the maximum predicted conventional subsidence parameters for the archaeological sites is provided in Table 9.1. The predicted tilts are the maxima after the completion of any or all of the proposed longwalls. The predicted curvatures are the maxima at any time during or after the extraction of the proposed longwalls.

Table 9.1 Maximum Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site Type	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
Artefact Scatter	3225	60	3.8	1.6
Isolated Find	3025	60	3.1	3.2
Rockshelter	2900	30	2.0	1.4
Ochre Quarry	875	16	0.6	0.5
Grinding Groove	2275	75	1.6	1.1
Sandstone Cavity	3200	35	2.2	1.6
Sandstone Formation	3175	30	2.2	1.6

The maximum predicted conventional strains for the archaeological sites, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 38 mm/m tensile and 32 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The archaeological sites are predominantly at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1.

The grinding groove sites are located along the valleys of the streams and, therefore, may experience valley related movements. For Site GG04, which is located directly above the proposed longwall panels, the valley related movements will be masked by the large conventional subsidence movements that are predicted to occur at the site. There are three sites (GG01 to GG03) located outside the *Subsidence Study Area* by a distance greater than 100 metres from the ends of the proposed longwalls. The sites are predicted to experience less than 20 mm of vertical subsidence and while they may experience some small horizontal movements, ground strains are expected to be very low.

The current ACARP method of prediction for valley closure is based on subsidence data collected from mining at depths of cover greater than 400 metres in the Southern Coalfield of NSW and the method, therefore, is not considered applicable to this site with a depth of cover of approximately 120 metres.

9.1.2. Impact Assessments for the Artefact Scatters and Isolated Finds

There are 56 artefact scatter sites and 48 isolated finds located within the *Subsidence Study Area*, the majority of which are located directly above or immediately adjacent to the proposed longwalls.

The maximum predicted final tilt for the artefact scatter sites and isolated finds is 60 mm/m (i.e. 6.0 %), which represents a change in grade of 1 in 17. It is unlikely that these sites would experience any adverse impacts resulting from mining induced tilts.

The maximum predicted curvatures for the artefact scatter sites and isolated finds are 3.8 km^{-1} hogging and 3.2 km^{-1} sagging, which represent minimum radii of curvature of 260 metres and 310 metres, respectively. The maximum predicted conventional strains for these sites, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 38 mm/m tensile and 32 mm/m compressive.

These artefact scatter sites and isolated finds can potentially be affected by cracking of the surface soils as a result of mine subsidence movements. It is unlikely, however, that the scattered artefacts or isolated finds themselves would be impacted by surface cracking. It is recommended that plans to remediate the surface after mining include measures to avoid impacting on these sites.

Heritage mitigation in relation to these impacts is provided in the Aboriginal Archaeology and Cultural Heritage Impact Assessment (AACHIA) by RPS (2015).

9.1.3. Impact Assessments for the Sandstone Cavities and Sandstone Formations

There are 27 sandstone cavities and 3 sandstone formations located within the *Subsidence Study Area*, the majority of which are located directly above or immediately adjacent to the proposed Longwalls 103 to 108. The sites mainly comprise sandstone overhangs or cavities, which are potential sites for shelter, storage or as a burial chamber (although there was no evidence to support the latter). Two of the natural rock formations are features that may have been recognised by Aboriginal people to represent a birds head and a face.

The maximum predicted final tilt for the sandstone cavities and sandstone formations is 35 mm/m (i.e. 3.5 %), which represents a change in grade of 1 in 29.

The maximum predicted curvatures for the cultural features are 2.2 km^{-1} hogging and 1.6 km^{-1} sagging, which represent minimum radii of curvature of 450 metres and 630 metres, respectively. The maximum predicted conventional strains for these sites, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 22 mm/m tensile and 16 mm/m compressive.

Potential impacts for the sandstone overhangs and cavities are discussed below in Section 9.1.5 and in Section 5.4. The sandstone formations representing a bird and a face could potentially be impacted by rockfalls or by cracking as discussed in Section 5.4. Ground surface cracking is discussed in Section 4.5.

Heritage mitigation in relation to these impacts is provided in the AACHIA by RPS (2015).

9.1.4. Impact Assessments for the Ochre Quarry

The ochre quarry is located above the proposed Longwall 107. The ochre quarry consists of an iron rich bedding plane near the base of a rock ledge approximately 5m in height. A photograph of the Ochre Quarry is provided in Fig. 9.1.

Fig. 9.1 Photograph of Ochre Quarry

The maximum predicted final tilt for the ochre quarry is 16 mm/m (i.e. 1.6 %), which represents a change in grade of 1 in 63.

The maximum predicted curvatures for the cultural features are 0.6 km^{-1} hogging and 0.5 km^{-1} sagging, which represent minimum radii of curvature of 1.7 kilometres and 2 kilometres, respectively. The maximum predicted conventional strains for these sites, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 6 mm/m tensile and 5 mm/m compressive.

The rock ledge at the location of the ochre quarry can potentially be affected by rock falls, which are discussed below in Section 9.1.5 and in Section 5.4. It is also possible for slippage to occur along the bedding plane at the location of the ochre quarry, which may result in some material at the surface of the seam to spall and increased seepage to occur. Heritage mitigation in relation to these impacts is discussed in the AACHIA by RPS (2015), which recommends that all reasonable and feasible actions be taken to avoid impacts to this site. Such actions may include engineering solutions for the cliff or other measures to minimise the subsidence movements at the location of the cliff.

9.1.5. Impact Assessments for the Rock Shelters

There are 10 rock shelters identified within the *Subsidence Study Area*, with the majority if these sites located above the Longwalls 104 to 108.

The maximum predicted tilt for the rock shelters is 30 mm/m (i.e. 3.0 %), which represents a change in grade of 1 in 33. It is unlikely that these sites would experience any adverse impacts as a result of result the mining induced tilt.

The maximum predicted curvatures for the rock shelters are 2.0 km^{-1} hogging and 1.4 km^{-1} sagging, which represent minimum radii of curvature of 0.5 kilometres and 0.7 kilometres, respectively. The maximum predicted conventional strains for these sites, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 20 mm/m tensile and 14 mm/m compressive.

It is extremely difficult to assess the likelihood of instabilities for the rock shelters based upon predicted ground movements. The likelihood of the shelters becoming unstable is dependent on a number of factors which are difficult to fully quantify. These factors include jointing, inclusions, weaknesses within the rockmass, groundwater pressure and seepage flow behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors may influence the stability of the shelter naturally or when it is exposed to mine subsidence movements.

The predicted conventional movements and observed impacts to the rock shelters can be estimated from the experience of undermining cliff formations at Ulan Colliery, where longwalls have extracted in similar geological conditions directly beneath cliffs and rock formations at similar depths of cover and panel widths as those proposed at Bylong. It is reported that Ulan Colliery has mined directly beneath more than 8km of cliff outcrop and observed rock falls occurred in approximately 20% of the cliffs and visible mining subsidence movements occurred in approximately 50% to 70% of the sandstone formations greater than approximately 3 metres high (SCT 2009). Rock falls were not observed at cliffs located beyond the longwall panel footprint, though some cracking was observed.

When comparing the experiences observed at Ulan Colliery with the proposed mining at Bylong, it is noted that while panel widths and depths of cover are similar, the maximum measured subsidence at Ulan Mine is less than predicted at Bylong on account of a lower extraction height. The maximum measured tilt and strain at Ulan Mine are similar in magnitude to those predicted at Bylong near the locations of the cliffs.

On balance, therefore, the experience from Ulan Colliery provides a reasonable indication of the level of impacts that may occur at the rock shelters that are located directly above the proposed longwall panels (and chain pillars) at Bylong. The actual percentage of archaeological sites affected may be slightly higher or lower than the Ulan experience on account of the differences between the two sites as described above.

The potential for rock falls at rock shelters that are located beyond the longwall mining area is considered to be very low, though some cracking may be experienced to sites that are located within the *Subsidence Study Area*.

9.1.6. Impact Assessments for the Grinding Groove Sites

There is one grinding groove site located within the *Subsidence Study Area* and three grinding groove sites located outside but close to the *Subsidence Study Area*. A summary of the locations of these sites is provided in Table 9.2.

Table 9.2 Locations of the Grinding Groove Sites

Site Ref.	Location
GG01	Along an unnamed tributary approximately 105m to the south west of LW204
GG02	Along an unnamed tributary approximately 130m to the south west of LW204
GG03	Along an unnamed tributary approximately 180m to the south west of LW204
GG04	Above LW204 along an unnamed tributary approximately 60m from the nearest longwall end

The predicted maximum tilt for the grinding groove sites (site GG04) is 75 mm/m (i.e. 7.5 %), which represents changes in grade of 1 in 13. It is unlikely that these sites would experience any adverse impacts resulting from mining induced tilt.

The predicted maximum curvatures at site GG04 is 1.6 km^{-1} hogging and 1.1 km^{-1} sagging, which represent minimum radii of curvature of 620 metres and 910 metres, respectively. The maximum predicted conventional strains for this site, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 16 mm/m tensile and 11 mm/m compressive. The grinding groove sites located outside the *Subsidence Study Area* are unlikely to experience any significant conventional subsidence movements but may experience minor upsidence and closure movements.

Fracturing in bedrock has been observed in the past, as a result of longwall mining, where tensile strains were greater than 0.5 mm/m or where compressive strains were greater than 2 mm/m. The predicted conventional strains for Site GG04 are large and would be sufficient to result in fracturing of the sandstone bedrock, as discussed in Section 4.5. These fractures may intersect with the grinding grooves at site GG04.

The potential for impacts on the three grinding groove sites that are located outside the *Subsidence Study Area* are considered to be very low.

Preventive measures could be implemented at the grinding groove sites, if required, including slotting of the bedrock around the sites to isolate them from the ground curvatures and strains. It is possible, however, that the preventive measures could result in greater impacts on the sites than those which would have occurred as a result of mine subsidence movements.

Heritage mitigation in relation to these impacts is provided in the AACHIA by RPS (2015).

9.1.7. Impact Assessments for the Archaeological Sites Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilts for the sites would vary from 40 mm/m to greater than 100 mm/m (i.e. 4.0% to 10 %, or 1 in 25 to 1 in 10). These types of archaeological sites are not adversely affected by tilt and, therefore, the likelihoods of impact would not be expected to increase.

If the actual curvatures or strains at the artefact scatters and isolated finds exceeded those predicted by a factor of 2 times, the likelihoods and extents of cracking in the surface soils would also increase. It would still be unlikely that these sites would be impacted by the surface cracking and the methods of subsidence management would not be expected to change.

If the actual curvatures or strains at the grinding groove, shelter sites and cultural features exceeded those predicted by a factor of 2 times, the likelihoods and extents of fracturing in the bedrock would also increase. The likelihood of fracturing occurring at locations coincident with grinding grooves would also increase. Preventive measures could be implemented at the grinding groove sites, however, the preventive measures could result in greater impacts on the site than those which would have occurred as a result of mine subsidence movements.

If the actual curvatures at the rock shelters exceeded those predicted by a factor of 2 times, the maximum curvature at the rock shelters would be 1.6 km^{-1} hogging and 2.0 km^{-1} sagging, which represent minimum radii of curvature of 625 metres and 500 metres respectively. The maximum predicted conventional strains for these sites, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 16 mm/m tensile and 20 mm/m compressive. It is difficult to estimate the increase in the percentage of rock shelters expected to experience rock falls. The increased predicted strains are significantly greater than the strains observed at Ulan Colliery, therefore the percentage of rock shelters expected to experience rock falls would also be expected to increase.

9.1.8. Management of potential impacts on the Archaeological Sites

It is recommended that management plans be developed to manage potential impacts on archaeological sites during the mining of the proposed longwalls. The management plan would include monitoring of subsidence movements across the panels, restricted access during active mining, safe visual inspections of archaeological sites and consultation with the community before, during and after mining. The potential for impacts to selected sites, such as those of high significance, can be reduced by adopting preventive measures or by avoidance of mining beneath the features. As discussed above, however, preventive measures may result in significant disturbance to the surface surrounding the features.

If the longwalls were shifted to the north, south, east or west, or reorientated to varying angles within the Underground Extraction Area, the predicted movements for each archaeological site would increase or decrease, depending on their position relative to the longwalls but the overall levels of movement at the sites across the *Subsidence Study Area* would generally not change substantially. The potential for impacts at some sites, particularly the rock shelters, cultural sites and grinding groove sites may accordingly increase or decrease but the overall level of impacts would not change substantially and the same method of subsidence management would be recommended.

9.2. Heritage Sites

There are no heritage sites located within the *Subsidence Study Area.*

9.3. Items on the Register of the National Estate

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

9.4. Items of Architectural Significance

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

9.5. Residential Establishments

There are no residential building structures within the *Subsidence Study Area.*

APPENDIX A. GLOSSARY OF TERMS AND DEFINITIONS

Glossary of Terms and Definitions

Some of the more common 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.
Closure	**T**he reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides. It should be noted that the observed closure movement across a valley is the total movement resulting from various mechanisms, including conventional mining induced movements, valley closure movements, far-field effects, downhill movements and other possible strata mechanisms.
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, i.e. curvature is the second derivative of subsidence. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (km-1)*, but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*. Curvature can be either **hogging** (i.e. convex) or **sagging** (i.e. concave).
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness 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.
Face length	The width of the coalface measured across the longwall panel.
Far-field movements	The measured horizontal movements at pegs that are located beyond the longwall panel edges and over solid unmined coal areas. Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain.
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.
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, i.e. from rib to rib.

Shear deformations	The horizontal displacements that are measured across monitoring lines and these can be described by various parameters including; horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points, i.e. strain is the relative differential displacement of the ground along or across a subsidence monitoring line. Strain is dimensionless and can be expressed as a decimal, a percentage or in parts per notation. **Tensile Strains** are measured where the distance between two points or survey pegs increases and **Compressive Strains** where the distance between two points decreases. Whilst mining induced **strains** are measured **along** monitoring lines, ground **shearing** can occur both vertically, and horizontally **across** the directions of the monitoring lines.
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, but, 'subsidence of the ground' in some references can include both a vertical and horizontal movement component. The vertical component of subsidence is measured by determining the change in surface level of a peg that is fixed in the ground before mining commenced and this vertical subsidence is usually expressed in units of *millimetres (mm)*. Sometimes the horizontal component of a peg's movement is not measured, but in these cases, the horizontal distances between a particular peg and the adjacent pegs are measured.
Super-critical area	An area of panel greater than the critical area.
Tilt	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 horizontal 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.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	Upsidence results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.

APPENDIX B. REFERENCES

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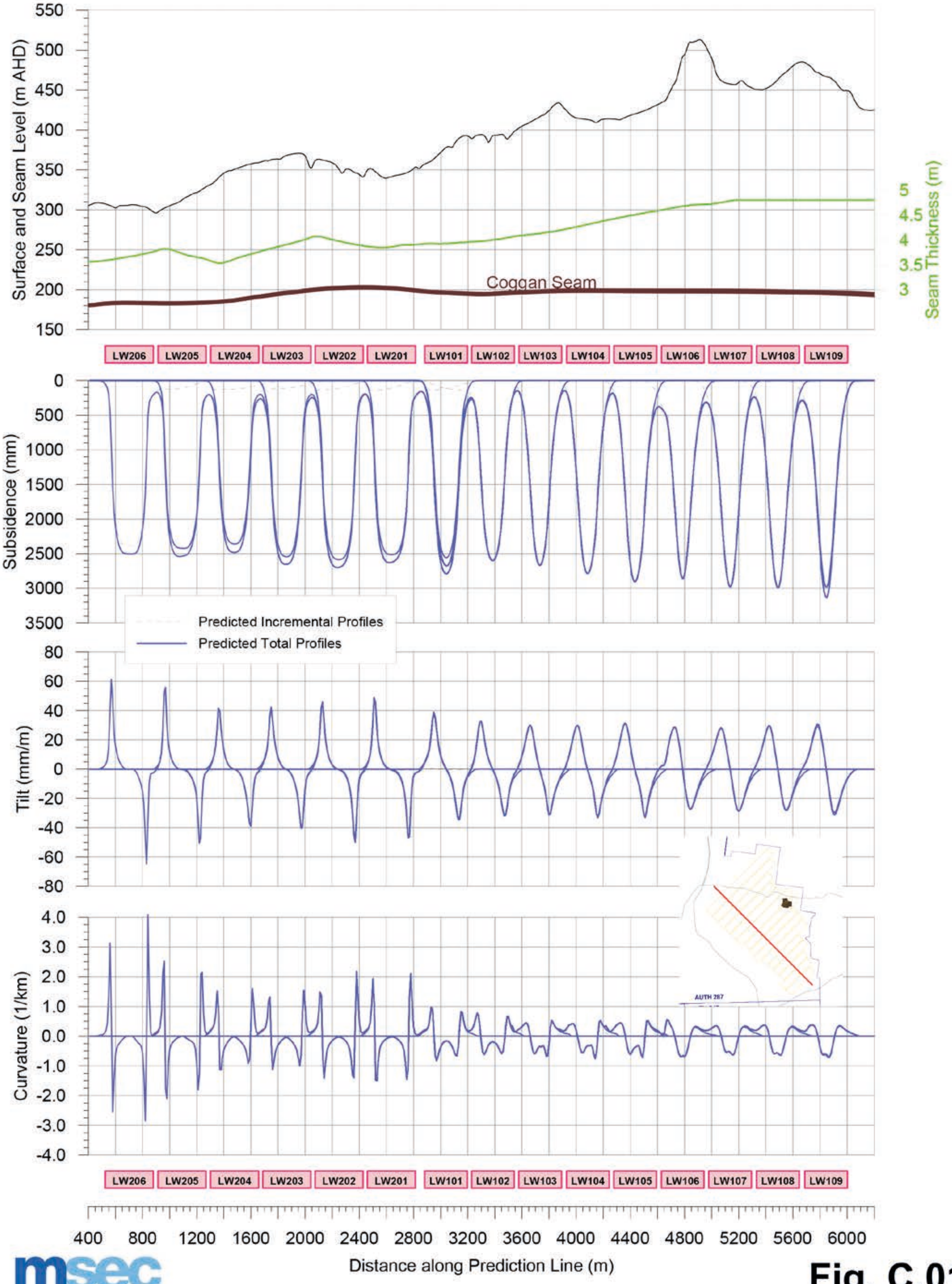
APPENDIX C. FIGURES

I:\Projects\Bylong\MSEC708 - EIS Application\Subsdata\Impacts\Prediction Line\Fig. C.01 - Prediction Line 1.grf.....05-Dec-14

Predicted Profiles of Total Conventional Subsidence, Tilt and Curvature along Prediction Line 1

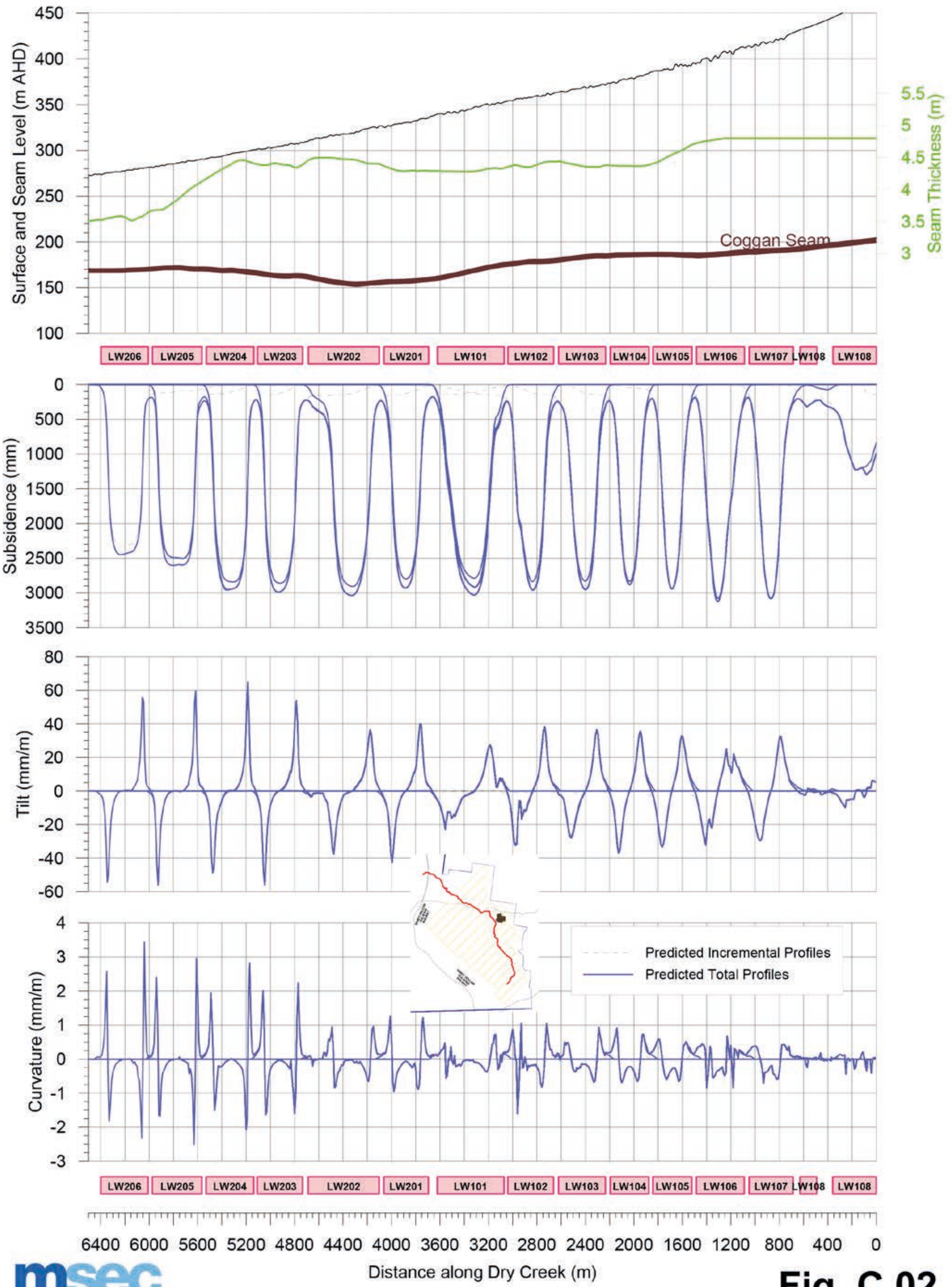


msec

Fig. C.01

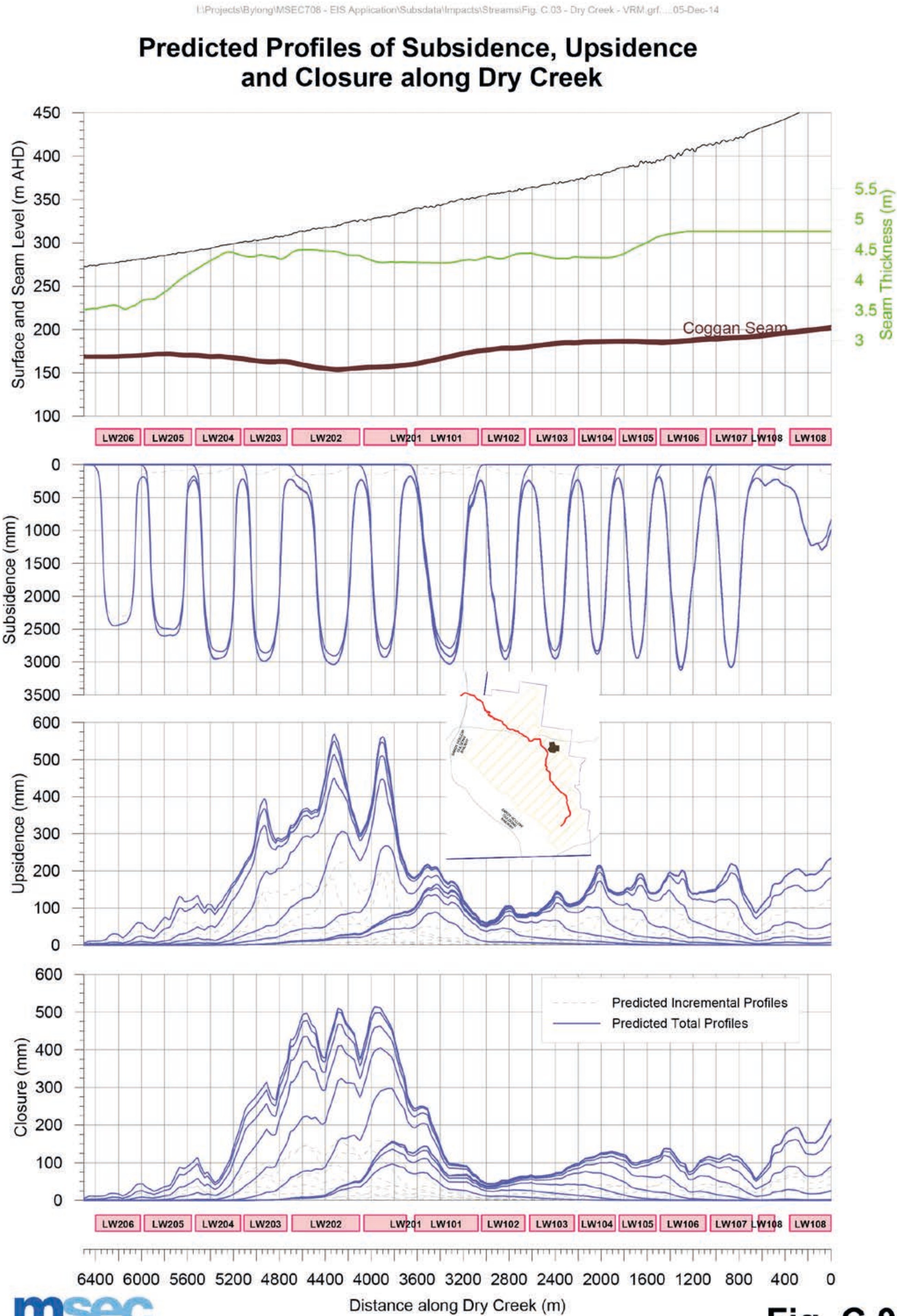
I:\Projects\Bylong\MSEC708 - EIS Application\Subsdata\Impacts\Streams\Fig. C.02 - Dry Creek-Subs Tilt Curvature.grf.....05-Dec-14

Predicted Profiles of Subsidence, Tilt and Curvature along Dry Creek



msec

Fig. C.02


I:\Projects\Bylong\MSEC708 - EIS Application\Subsdata\Impacts\Streams\Fig. C.03 - Dry Creek - VRM.grf.....05-Dec-14
Predicted Profiles of Subsidence, Upsidence and Closure along Dry Creek
Surface and Seam Level (m AHD)
Seam Thickness (m)
Coggan Seam
LW206
LW205
LW204
LW203
LW202
LW201
LW101
LW102
LW103
LW104
LW105
LW106
LW107
LW108
Subsidence (mm)
Upsidence (mm)
Closure (mm)
Predicted Incremental Profiles
Predicted Total Profiles
Distance along Dry Creek (m)

msec

Fig. C.03

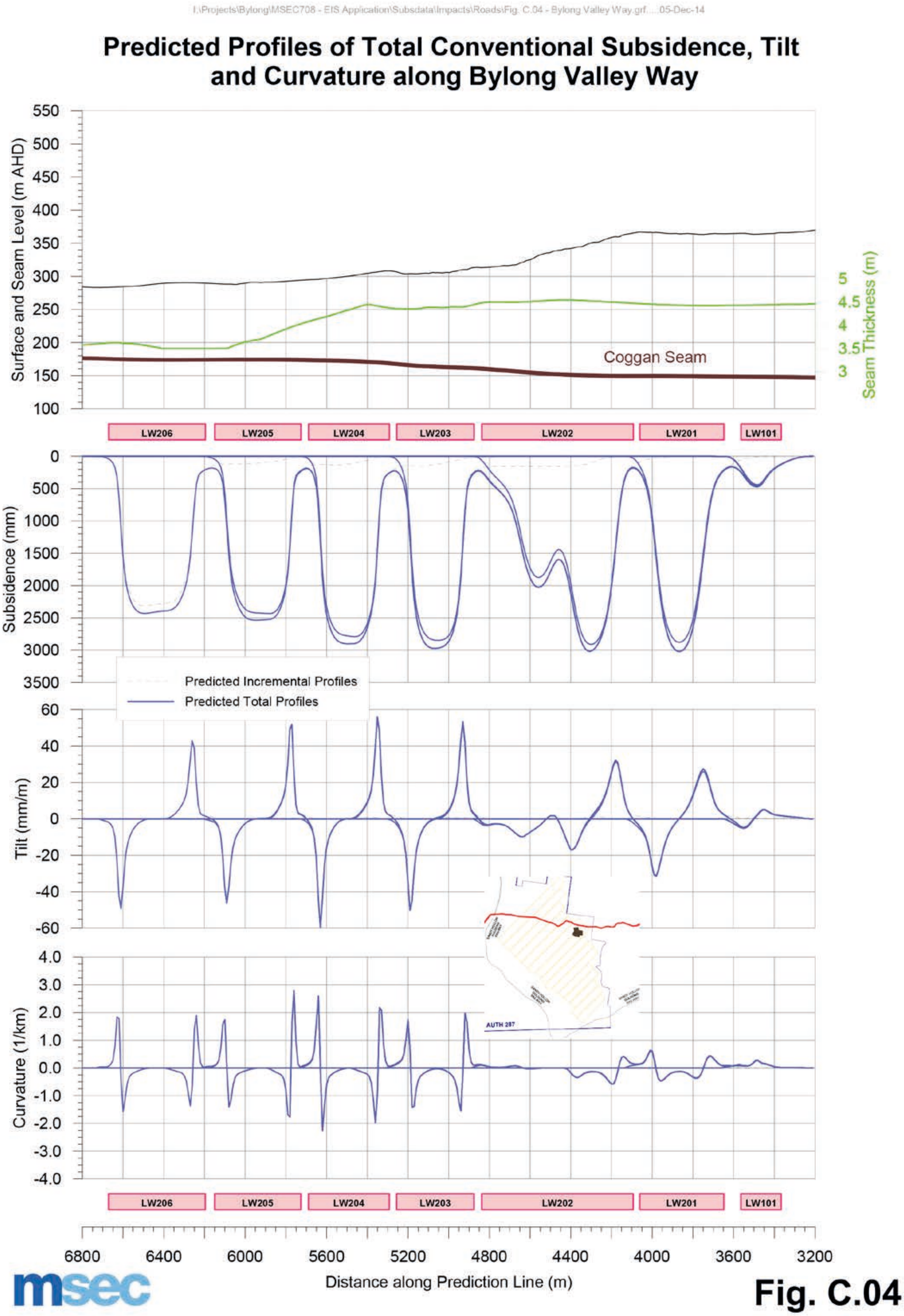

I:\Projects\Bylong\MSEC708 - EIS Application\Subsdata\Impacts\Roads\Fig. C.04 - Bylong Valley Way.grf.....05-Dec-14
Predicted Profiles of Total Conventional Subsidence, Tilt and Curvature along Bylong Valley Way
Surface and Seam Level (m AHD)
Seam Thickness (m)
Coggan Seam
LW206
LW205
LW204
LW203
LW202
LW201
LW101
Subsidence (mm)
Predicted Incremental Profiles
Predicted Total Profiles
Tilt (mm/m)
Curvature (1/km)
AUTH 287
Distance along Prediction Line (m)
msec

Fig. C.04

APPENDIX D. TABLES

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	MGA Easting	MGA Northing	AHIMS Site No.	Type	Total Subs after LW101	Total Subs after LW102	Total Subs after LW103	Total Subs after LW104	Total Subs after LW105	Total Subs after LW106	Total Subs after LW107	Total Subs after LW108	Total Subs after LW109	Total Subs after LW201	Total Subs after LW202	Total Subs after LW203	Total Subs after LW204	Total Subs after LW205	Total Subs after LW206
AS008	233246	6410598	37-1-0724	Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2675	2825	2825	2825	2825	2825
AS016	234310	6408807		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	1425	1500	1500	1500	1500	1500	1500	1500	1500	1500
AS017	234263	6408740		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	1925	1975	1975	1975	1975	1975	1975	1975	1975	1975
AS018	233595	6408770		Artefact Scatter	< 20	< 20	< 20	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150
AS019	231755	6412198		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
AS020	233916	6409767		Artefact Scatter	< 20	< 20	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025
AS021	233239	6410258		Artefact Scatter	625	650	650	650	650	650	650	650	650	775	775	775	775	775	775
AS022	233306	6410277		Artefact Scatter	1725	1800	1800	1800	1800	1800	1800	1800	1800	1925	1925	1925	1925	1925	1925
AS023	234581	6408166		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	150	325	325	325	325	325	325	325	325
AS024	234225	6407619		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3025	3025	3025	3025	3025	3025	3025	3025
AS025	234278	6407660		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3025	3025	3025	3025	3025	3025	3025	3025
AS026	234280	6408486		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	1375	1375	1375	1375	1375	1375	1375	1375	1375	1375
AS027	234280	6408643		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	3075	3100	3100	3100	3100	3100	3100	3100	3100	3100
AS028	234111	6408826		Artefact Scatter	< 20	< 20	< 20	< 20	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775
AS030	232004	6411347		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	425	450
AS031	233463	6410233		Artefact Scatter	2750	2875	2875	2875	2875	2875	2875	2875	2875	2975	2975	2975	2975	2975	2975
AS032	233417	6409851		Artefact Scatter	< 20	2525	2625	2625	2625	2625	2625	2625	2625	2625	2625	2625	2625	2625	2625
AS033	233423	6409936		Artefact Scatter	< 20	900	925	925	925	925	925	925	925	925	925	925	925	925	925
AS036	233240	6410290		Artefact Scatter	300	300	300	300	300	300	300	300	300	450	450	450	450	450	450
AS037	233484	6409747		Artefact Scatter	< 20	2700	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825
AS038	233998	6410491		Artefact Scatter	< 20	1075	1075	1075	1075	1075	1075	1075	1075	1075	1075	1075	1075	1075	1075
AS039	233627	6409880		Artefact Scatter	< 20	2725	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825
AS054	230521	6404469		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
AS060	233759	6409661		Artefact Scatter	< 20	< 20	2875	2875	2875	2875	2875	2875	2875	2875	2875	2875	2875	2875	2875
AS061	233780	6409999		Artefact Scatter	< 20	2400	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450
AS062	233734	6409858		Artefact Scatter	< 20	425	575	575	575	575	575	575	575	575	575	575	575	575	575
AS063	233498	6409289		Artefact Scatter	< 20	< 20	2725	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825
AS065	231549	6409160		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	400	525	525	525	525	525
AS066	232332	6409467		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	250	250	250	250	250	250
AS080	232123	6411488		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	950	1025
AS081	233902	6411210		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2450	2575	2575	2575	2575	2575
AS082	234029	6411164		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	100	100	100	100	100	100
AS083	233134	6411513		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2225	2325	2325	2325
AS084	233061	6411504		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2975	3125	3125	3125
AS085	232878	6411614		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	225	400	425	425
AS086	232542	6412133		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3025	3150
AS087	232582	6411852		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	350	525	525
AS088	233354	6408747		Artefact Scatter	< 20	< 20	< 20	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
AS089	233386	6408849		Artefact Scatter	< 20	< 20	< 20	2050	2050	2050	2050	2050	2050	2050	2050	2050	2050	2050	2050
AS090	233738	6410474		Artefact Scatter	2575	2650	2650	2650	2650	2650	2650	2650	2650	2750	2750	2750	2750	2750	2750
AS091	233480	6410305		Artefact Scatter	2800	2925	2925	2925	2925	2925	2925	2925	2925	3050	3050	3050	3050	3050	3050
AS094	231804	6412157		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	450
AS095	232608	6411956		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	25	500	550
AS096	232546	6412055		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2975	3075
AS097	232731	6408014		Artefact Scatter	< 20	< 20	< 20	75	75	75	75	75	75	75	75	75	75	75	75
AS098	232755	6407963		Artefact Scatter	< 20	< 20	< 20	25	25	25	25	25	25	25	25	25	25	25	25
AS099	233802	6410496		Artefact Scatter	1900	1950	1950	1950	1950	1950	1950	1950	1950	2025	2025	2025	2025	2025	2025
AS100	233638	6410265		Artefact Scatter	550	700	700	700	700	700	700	700	700	750	750	750	750	750	750
AS101	231890	6412225		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	1000
AS102	232083	6411821		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	1875	2025

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	MGA Easting	MGA Northing	AHIMS Site No.	Type	Total Subs after LW101	Total Subs after LW102	Total Subs after LW103	Total Subs after LW104	Total Subs after LW105	Total Subs after LW106	Total Subs after LW107	Total Subs after LW108	Total Subs after LW109	Total Subs after LW201	Total Subs after LW202	Total Subs after LW203	Total Subs after LW204	Total Subs after LW205	Total Subs after LW206
AS103	232721	6411826		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3000	3150	3150
AS104	232762	6411792		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3100	3225	3225
AS105	231942	6411525		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2475	2600
AS106	232849	6411666		Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	850	925	925
AS107	233606	6411193	37-1-0740	Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	1000	1075	1075	1075	1075	1075
AS108	233712	6411327	37-1-0741	Artefact Scatter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	600	625	625	625	625	625
CUL001	234500	6408457		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	1825	1825	1825	1825	1825	1825	1825	1825	1825
CUL002	234512	6408574		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	75	100	100	100	100	100	100	100	100	100
CUL003	234191	6407574		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3025	3175	3175	3175	3175	3175	3175	3175
CUL004	234192	6407574		Sandstone Formation	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3025	3175	3175	3175	3175	3175	3175	3175
CUL005	234197	6407551		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3025	3175	3200	3200	3200	3200	3200	3200
CUL006	233651	6408027		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	2925	2975	2975	2975	2975	2975	2975	2975	2975	2975
CUL007	233720	6408195		Sandstone Formation	< 20	< 20	< 20	< 20	< 20	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
CUL008	233110	6407790		Sandstone Cavity	< 20	< 20	< 20	< 20	75	100	100	100	100	100	100	100	100	100	100
CUL009	233121	6407836		Sandstone Cavity	< 20	< 20	< 20	< 20	275	275	275	275	275	275	275	275	275	275	275
CUL012	231219	6409611		Sandstone Formation	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2250	2350	2350	2350
CUL013	234525	6408792		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	2675	2800	2800	2800	2800	2800	2800	2800	2800	2800
CUL015	233994	6407439		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2525	2675	2700	2700	2700	2700	2700	2700
CUL016	233773	6407483		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	1225	1225	1325	1325	1325	1325	1325	1325	1325
CUL017	234672	6408897		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	250	275	275	275	275	275	275	275	275	275
CUL018	234438	6410397		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
CUL019	234672	6408899		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	250	250	250	250	250	250	250	250	250	250
CUL020	234682	6408132		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	< 20	1975	2075	2075	2075	2075	2075	2075	2075
CUL021	234513	6408513		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	400	400	400	400	400	400	400	400	400
CUL022	234553	6408553		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	100	125	125	125	125	125	125	125	125
CUL023	233769	6407404		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	350	400	475	475	475	475	475	475	475
CUL024	233902	6407508		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	225	350	475	475	475	475	475	475	475
CUL025	233185	6408708		Sandstone Cavity	< 20	< 20	25	700	700	700	700	700	700	700	700	700	700	700	700
CUL026	233203	6408639		Sandstone Cavity	< 20	< 20	< 20	2325	2325	2325	2325	2325	2325	2325	2325	2325	2325	2325	2325
CUL027	233772	6407404		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	< 20	325	400	475	475	475	475	475	475	475
CUL028	233759	6408131		Sandstone Cavity	< 20	< 20	< 20	< 20	< 20	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950
CUL029	233371	6408150		Sandstone Cavity	< 20	< 20	< 20	< 20	2675	2675	2675	2675	2675	2675	2675	2675	2675	2675	2675
CUL030	232690	6408359		Sandstone Cavity	< 20	< 20	1025	1025	1025	1025	1025	1025	1025	1025	1025	1025	1025	1025	1025
CUL031	234143	6409544		Sandstone Cavity	< 20	< 20	< 20	3000	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
CUL032	234128	6409572		Sandstone Cavity	< 20	< 20	< 20	2450	2575	2575	2575	2575	2575	2575	2575	2575	2575	2575	2575
CUL033	234122	6409590		Sandstone Cavity	< 20	< 20	< 20	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
GG001	230539	6409895		Grinding Groove	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
GG002	230518	6409881		Grinding Groove	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
GG003	230485	6409844		Grinding Groove	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
GG004	230598	6410072		Grinding Groove	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2200	2275
IF001	231589	6409697	37-1-0484	Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	1775	1900	1925	1925	1925
IF002	233023	6410074	37-1-0486	Isolated Find	275	300	300	300	300	300	300	300	300	450	450	450	450	450	450
IF010	234137	6409000		Isolated Find	< 20	< 20	< 20	< 20	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950
IF011	233940	6407402		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2300	2450	2475	2475	2475	2475	2475	2475
IF012	234215	6408408		Isolated Find	< 20	< 20	< 20	< 20	< 20	1125	1125	1125	1125	1125	1125	1125	1125	1125	1125
IF013	234337	6407954		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	275	300	300	300	300	300	300	300	300
IF014	234396	6408059		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	625	625	625	625	625	625	625	625	625
IF015	234289	6408424		Isolated Find	< 20	< 20	< 20	< 20	< 20	400	425	425	425	425	425	425	425	425	425
IF016	234341	6408489		Isolated Find	< 20	< 20	< 20	< 20	< 20	525	525	525	525	525	525	525	525	525	525
IF017	234208	6408772		Isolated Find	< 20	< 20	< 20	< 20	75	400	400	400	400	400	400	400	400	400	400

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	MGA Easting	MGA Northing	AHIMS Site No.	Type	Total Subs after LW101	Total Subs after LW102	Total Subs after LW103	Total Subs after LW104	Total Subs after LW105	Total Subs after LW106	Total Subs after LW107	Total Subs after LW108	Total Subs after LW109	Total Subs after LW201	Total Subs after LW202	Total Subs after LW203	Total Subs after LW204	Total Subs after LW205	Total Subs after LW206
IF018	233681	6408338		Isolated Find	< 20	< 20	< 20	< 20	700	750	750	750	750	750	750	750	750	750	750
IF020	234454	6409872		Isolated Find	< 20	< 20	< 20	2525	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650
IF021	234105	6410023		Isolated Find	< 20	< 20	2725	2725	2725	2725	2725	2725	2725	2725	2725	2725	2725	2725	2725
IF022	232237	6410722		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2400	2525	2525	2525
IF024	233103	6410104		Isolated Find	900	950	950	950	950	950	950	950	950	1075	1075	1075	1075	1075	1075
IF025	234550	6408327		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	2700	2700	2700	2700	2700	2700	2700	2700	2700
IF026	234288	6408850		Isolated Find	< 20	< 20	< 20	< 20	75	400	425	425	425	425	425	425	425	425	425
IF027	234287	6408920		Isolated Find	< 20	< 20	< 20	< 20	425	450	450	450	450	450	450	450	450	450	450
IF031	233285	6407818		Isolated Find	< 20	< 20	< 20	< 20	< 20	625	625	625	625	625	625	625	625	625	625
IF034	234036	6410406		Isolated Find	< 20	2850	2850	2850	2850	2850	2850	2850	2850	2850	2850	2850	2850	2850	2850
IF035	233867	6410423		Isolated Find	75	300	300	300	300	300	300	300	300	325	325	325	325	325	325
IF036	233090	6410095		Isolated Find	825	875	875	875	875	875	875	875	875	1000	1000	1000	1000	1000	1000
IF037	233477	6410212		Isolated Find	2575	2725	2725	2725	2725	2725	2725	2725	2725	2800	2800	2800	2800	2800	2800
IF042	233292	6408521		Isolated Find	< 20	< 20	< 20	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975
IF048	233529	6410310		Isolated Find	2800	2925	2925	2925	2925	2925	2925	2925	2925	3025	3025	3025	3025	3025	3025
IF049	233542	6409925		Isolated Find	< 20	2850	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950
IF050	232991	6409255		Isolated Find	< 20	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450
IF051	233639	6409249		Isolated Find	< 20	< 20	250	400	400	400	400	400	400	400	400	400	400	400	400
IF052	233471	6409385		Isolated Find	< 20	< 20	2650	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
IF053	231467	6411234		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	1800	1925
IF055	232550	6408932		Isolated Find	< 20	2550	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600
IF062	232955	6408816		Isolated Find	< 20	< 20	2675	2675	2675	2675	2675	2675	2675	2675	2675	2675	2675	2675	2675
IF063	231885	6411539		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2450	2575
IF064	234046	6410042		Isolated Find	< 20	< 20	1225	1225	1225	1225	1225	1225	1225	1225	1225	1225	1225	1225	1225
IF065	233258	6408467		Isolated Find	< 20	< 20	< 20	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450
IF075	233248	6410117		Isolated Find	2725	2850	2850	2850	2850	2850	2850	2850	2850	2950	2950	2950	2950	2950	2950
IF082	233118	6410096		Isolated Find	1450	1525	1525	1525	1525	1525	1525	1525	1525	1650	1650	1650	1650	1650	1650
IF083	233271	6409943		Isolated Find	1450	1575	1575	1575	1575	1575	1575	1575	1575	1650	1650	1650	1650	1650	1650
IF084	233790	6409538		Isolated Find	< 20	< 20	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650
IF085	233795	6409831		Isolated Find	< 20	25	575	575	575	575	575	575	575	575	575	575	575	575	575
IF086	233682	6409152		Isolated Find	< 20	< 20	< 20	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
IF087	231556	6411379		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	200	325
IF088	231305	6409222		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	50	50	50	50	50
IF089	231336	6409353		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2225	2350	2350	2350	2350
IF107	230663	6410252		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2375	2475
IF110	232512	6411976		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2725	2825
IF111	232345	6412534		Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2725
IF112	233140	6411587	37-1-0742	Isolated Find	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	525	650	650	650
OQ001	233770	6407449		Ochre Quarry	< 20	< 20	< 20	< 20	< 20	< 20	775	800	875	875	875	875	875	875	875
RS001	234741	6408053		Rockshelter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2725	2850	2850	2850	2850	2850	2850	2850
RS002	234369	6410474		Rockshelter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
RS004	232228	6412806		Rockshelter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
RS005	232223	6412794		Rockshelter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
RS006	232635	6408306		Rockshelter	< 20	< 20	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
RS007	233218	6408199		Rockshelter	< 20	< 20	< 20	< 20	1525	1525	1525	1525	1525	1525	1525	1525	1525	1525	1525
RS008	233347	6408190		Rockshelter	< 20	< 20	< 20	< 20	2875	2875	2875	2875	2875	2875	2875	2875	2875	2875	2875
RS009	232613	6408303		Rockshelter	< 20	< 20	1375	1375	1375	1375	1375	1375	1375	1375	1375	1375	1375	1375	1375
RS010	233428	6407806		Rockshelter	< 20	< 20	< 20	< 20	< 20	2900	2900	2900	2900	2900	2900	2900	2900	2900	2900
RS011	234216	6408406		Rockshelter	< 20	< 20	< 20	< 20	< 20	1075	1075	1075	1075	1075	1075	1075	1075	1075	1075
RS012	232717	6412605		Rockshelter	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	100	300
RS013	233234	6408462		Rockshelter	< 20	< 20	< 20	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Total Tilt after LW101	Total Tilt after LW102	Total Tilt after LW103	Total Tilt after LW104	Total Tilt after LW105	Total Tilt after LW106	Total Tilt after LW107	Total Tilt after LW108	Total Tilt after LW109	Total Tilt after LW201	Total Tilt after LW202	Total Tilt after LW203	Total Tilt after LW204	Total Tilt after LW205	Total Tilt after LW206
AS008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	8.0	8.5	8.5	8.5	8.5	8.5
AS016	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	32.0	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5
AS017	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	33.5	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
AS018	< 0.5	< 0.5	< 0.5	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0
AS019	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.5
AS020	< 0.5	< 0.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
AS021	21.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
AS022	37.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0
AS023	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.0	5.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0
AS024	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
AS025	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
AS026	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5
AS027	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
AS028	< 0.5	< 0.5	< 0.5	< 0.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5
AS030	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	25.0	25.5
AS031	19.0	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	19.0	19.0	19.0	19.0	19.0	19.0
AS032	< 0.5	38.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5
AS033	0.5	33.0	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5
AS036	10.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
AS037	< 0.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5
AS038	< 0.5	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
AS039	< 0.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
AS054	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
AS060	< 0.5	< 0.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5
AS061	< 0.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5
AS062	< 0.5	14.5	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
AS063	< 0.5	< 0.5	18.0	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
AS065	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	14.5	14.5	14.5	14.5	14.5	14.5
AS066	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.0	4.5	4.5	4.5	4.5	4.5
AS080	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	61.5	62.5
AS081	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	33.0	34.5	34.5	34.5	34.5	34.5
AS082	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	4.0	4.0	4.0	4.0	4.0	4.0
AS083	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	46.5	46.5	46.5	46.5
AS084	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	11.5	12.0	12.0	12.0
AS085	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	8.0	7.5	6.5	6.5
AS086	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.0	4.0
AS087	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	12.0	11.5	11.5
AS088	< 0.5	< 0.5	< 0.5	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
AS089	< 0.5	< 0.5	< 0.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
AS090	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	36.0	36.0	36.0	36.0	36.0	36.0
AS091	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
AS094	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	26.5
AS095	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.0	16.0	16.5
AS096	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	13.5	14.5
AS097	< 0.5	< 0.5	< 0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
AS098	< 0.5	< 0.5	< 0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
AS099	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.5	35.5	35.5	35.5	35.5	35.5
AS100	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.5	19.5	19.5	19.5	19.5	19.5
AS101	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	52.0
AS102	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	44.5	44.5

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Total Tilt after LW101	Total Tilt after LW102	Total Tilt after LW103	Total Tilt after LW104	Total Tilt after LW105	Total Tilt after LW106	Total Tilt after LW107	Total Tilt after LW108	Total Tilt after LW109	Total Tilt after LW201	Total Tilt after LW202	Total Tilt after LW203	Total Tilt after LW204	Total Tilt after LW205	Total Tilt after LW206
AS103	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	19.5	19.5	19.5
AS104	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3.0	2.5	2.5
AS105	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
AS106	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.0	31.5	32.0	32.0
AS107	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	30.0	30.5	30.5	30.5	30.5	30.5
AS108	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	15.5	16.5	16.5	16.5	16.5	16.5
CUL001	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
CUL002	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
CUL003	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
CUL004	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
CUL005	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
CUL006	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	19.5	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
CUL007	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
CUL008	< 0.5	< 0.5	< 0.5	< 0.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
CUL009	< 0.5	< 0.5	< 0.5	< 0.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
CUL012	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	11.0	11.5	11.5	11.5
CUL013	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	34.0	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5
CUL015	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	29.0	29.5	29.5	29.5	29.5	29.5	29.5	29.5
CUL016	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	24.0	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
CUL017	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	8.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
CUL018	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CUL019	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	8.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
CUL020	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	28.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
CUL021	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
CUL022	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
CUL023	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	9.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0
CUL024	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.0	4.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5
CUL025	< 0.5	< 0.5	1.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
CUL026	< 0.5	< 0.5	< 0.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
CUL027	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	9.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5
CUL028	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
CUL029	< 0.5	< 0.5	< 0.5	< 0.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
CUL030	< 0.5	< 0.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
CUL031	< 0.5	< 0.5	< 0.5	33.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
CUL032	< 0.5	< 0.5	< 0.5	35.5	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0
CUL033	< 0.5	< 0.5	< 0.5	35.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0
GG001	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
GG002	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
GG003	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
GG004	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	71.0	73.0
IF001	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	42.5	42.5	42.0	42.0	42.0
IF002	9.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
IF010	< 0.5	< 0.5	< 0.5	< 0.5	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
IF011	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
IF012	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
IF013	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	7.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
IF014	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
IF015	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	11.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
IF016	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	14.0	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
IF017	< 0.5	< 0.5	< 0.5	< 0.5	3.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Total Tilt after LW101	Total Tilt after LW102	Total Tilt after LW103	Total Tilt after LW104	Total Tilt after LW105	Total Tilt after LW106	Total Tilt after LW107	Total Tilt after LW108	Total Tilt after LW109	Total Tilt after LW201	Total Tilt after LW202	Total Tilt after LW203	Total Tilt after LW204	Total Tilt after LW205	Total Tilt after LW206
IF018	< 0.5	< 0.5	< 0.5	< 0.5	16.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
IF020	< 0.5	< 0.5	< 0.5	30.0	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5
IF021	< 0.5	< 0.5	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0
IF022	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.5	1.5	1.5	1.5
IF024	29.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
IF025	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	32.5	32.5	32.0	32.0	32.0	32.0	32.0	32.0	32.0
IF026	< 0.5	< 0.5	< 0.5	< 0.5	3.5	12.5	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
IF027	< 0.5	< 0.5	< 0.5	< 0.5	12.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
IF031	< 0.5	< 0.5	< 0.5	< 0.5	1.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
IF034	< 0.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
IF035	4.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
IF036	27.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5
IF037	35.5	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	36.0	36.0	36.0	36.0	36.0	36.0
IF042	< 0.5	< 0.5	< 0.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
IF048	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.5	14.5	14.5	14.5	14.5	14.5
IF049	< 0.5	16.5	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
IF050	< 0.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
IF051	< 0.5	< 0.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
IF052	< 0.5	< 0.5	28.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
IF053	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	59.5	59.5
IF055	< 0.5	13.0	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
IF062	< 0.5	< 0.5	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
IF063	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.5	4.5
IF064	< 0.5	< 0.5	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
IF065	< 0.5	< 0.5	< 0.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
IF075	14.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	14.5	14.5	14.5	14.5	14.5	14.5
IF082	35.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5
IF083	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	37.0	37.0	37.0	37.0	37.0	37.0
IF084	< 0.5	< 0.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5
IF085	< 0.5	2.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
IF086	< 0.5	< 0.5	< 0.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5
IF087	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	16.5	16.0
IF088	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.0	2.0	2.0	2.0	2.0
IF089	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	56.5	59.0	59.0	59.0	59.0
IF107	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.0	0.5
IF110	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	34.5	35.5
IF111	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	13.0
IF112	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	21.0	21.0	21.0	21.0
OQ001	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	18.0	17.0	16.5	16.5	16.5	16.5	16.5	16.5	16.5
RS001	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	27.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
RS002	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
RS004	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
RS005	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
RS006	< 0.5	< 0.5	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
RS007	< 0.5	< 0.5	< 0.5	< 0.5	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
RS008	< 0.5	< 0.5	< 0.5	< 0.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
RS009	< 0.5	< 0.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5
RS010	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
RS011	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
RS012	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.0	7.5
RS013	< 0.5	< 0.5	< 0.5	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Maximum Total Hogging Curvature after LW101	Maximum Total Hogging Curvature after LW102	Maximum Total Hogging Curvature after LW103	Maximum Total Hogging Curvature after LW104	Maximum Total Hogging Curvature after LW105	Maximum Total Hogging Curvature after LW106	Maximum Total Hogging Curvature after LW107	Maximum Total Hogging Curvature after LW108	Maximum Total Hogging Curvature after LW109	Maximum Total Hogging Curvature after LW201	Maximum Total Hogging Curvature after LW202	Maximum Total Hogging Curvature after LW203	Maximum Total Hogging Curvature after LW204	Maximum Total Hogging Curvature after LW205	Maximum Total Hogging Curvature after LW206
AS008	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.23	1.29	1.29	1.59	1.78	1.89
AS016	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.47	0.49	0.49	0.66	0.69	0.69	0.69	0.85	0.95	1.01
AS017	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.52	0.53	0.53	0.87	0.90	0.90	0.90	1.11	1.25	1.32
AS018	< 0.01	< 0.01	< 0.01	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.72	0.77
AS019	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.06
AS020	< 0.01	< 0.01	0.87	0.86	0.82	0.82	0.82	0.82	1.33	1.39	1.39	1.39	1.71	1.92	2.03
AS021	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
AS022	0.89	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	1.09	1.22	1.29
AS023	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.10	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.28
AS024	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.82	1.34	1.39	1.39	1.39	1.72	1.92	2.03
AS025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.82	1.33	1.39	1.39	1.39	1.71	1.92	2.03
AS026	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.59	0.59	0.59	0.61	0.64	0.64	0.64	0.78	0.88	0.93
AS027	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.83	0.84	0.84	1.36	1.42	1.42	1.42	1.75	1.96	2.07
AS028	< 0.01	< 0.01	< 0.01	< 0.01	0.56	0.56	0.56	0.56	0.78	0.81	0.81	0.81	1.00	1.12	1.19
AS030	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	3.10	3.10
AS031	0.82	0.84	0.83	0.82	0.78	0.78	0.78	0.78	1.27	1.37	1.37	1.37	1.69	1.89	2.00
AS032	< 0.01	0.74	0.75	0.74	0.71	0.71	0.71	0.71	1.15	1.20	1.20	1.20	1.48	1.66	1.76
AS033	0.07	1.08	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
AS036	0.29	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.32	0.32	0.32	0.32	0.32	0.32
AS037	< 0.01	0.79	0.82	0.81	0.77	0.77	0.77	0.77	1.25	1.30	1.30	1.30	1.60	1.80	1.90
AS038	0.05	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.48	0.50	0.50	0.50	0.61	0.69	0.73
AS039	< 0.01	0.80	0.82	0.81	0.77	0.77	0.77	0.77	1.25	1.30	1.30	1.30	1.60	1.80	1.90
AS054	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AS060	< 0.01	< 0.01	0.83	0.82	0.78	0.78	0.78	0.78	1.26	1.32	1.32	1.32	1.62	1.82	1.93
AS061	< 0.01	0.72	0.72	0.72	0.72	0.72	0.72	0.72	1.08	1.13	1.13	1.13	1.39	1.56	1.65
AS062	< 0.01	0.49	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
AS063	< 0.01	< 0.01	0.78	0.81	0.77	0.77	0.77	0.77	1.25	1.30	1.30	1.30	1.60	1.80	1.90
AS065	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.61	0.62	0.62	0.62	0.62	0.62
AS066	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.18	0.20	0.20	0.20	0.20	0.20
AS080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	3.77	3.77
AS081	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.12	1.18	1.18	1.46	1.63	1.73
AS082	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.12	0.12	0.12	0.12	0.12	0.12
AS083	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.04	1.32	1.48	1.57
AS084	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.37	1.76	1.98	2.09
AS085	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.20	0.23	0.27	0.29
AS086	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.92	2.11
AS087	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.35	0.36	0.37
AS088	< 0.01	< 0.01	< 0.01	0.78	0.75	0.75	0.75	0.75	1.22	1.27	1.27	1.27	1.56	1.75	1.85
AS089	< 0.01	< 0.01	< 0.01	0.59	0.57	0.57	0.57	0.57	0.91	0.94	0.94	0.94	1.16	1.31	1.38
AS090	0.77	0.77	0.76	0.75	0.72	0.72	0.72	0.72	1.17	1.27	1.27	1.27	1.56	1.75	1.85
AS091	0.84	0.85	0.84	0.83	0.79	0.79	0.79	0.79	1.29	1.39	1.39	1.39	1.72	1.93	2.04
AS094	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.94
AS095	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.10	0.92	0.92
AS096	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.88	2.07
AS097	< 0.01	< 0.01	< 0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.05	0.05
AS098	< 0.01	< 0.01	< 0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
AS099	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.85	0.93	0.93	0.93	1.15	1.28	1.36
AS100	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
AS101	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2.29
AS102	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.49	1.50

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Maximum Total Hogging Curvature after LW101	Maximum Total Hogging Curvature after LW102	Maximum Total Hogging Curvature after LW103	Maximum Total Hogging Curvature after LW104	Maximum Total Hogging Curvature after LW105	Maximum Total Hogging Curvature after LW106	Maximum Total Hogging Curvature after LW107	Maximum Total Hogging Curvature after LW108	Maximum Total Hogging Curvature after LW109	Maximum Total Hogging Curvature after LW201	Maximum Total Hogging Curvature after LW202	Maximum Total Hogging Curvature after LW203	Maximum Total Hogging Curvature after LW204	Maximum Total Hogging Curvature after LW205	Maximum Total Hogging Curvature after LW206
AS103	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.69	1.99	2.11
AS104	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.75	2.05	2.17
AS105	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.57	1.74
AS106	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.07	1.14	1.14	1.14
AS107	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.71	0.73	0.73	0.73	0.73	0.73
AS108	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.45	0.47	0.47	0.47	0.47	0.47
CUL001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.49	0.49	0.80	0.83	0.83	0.83	1.03	1.15	1.22
CUL002	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
CUL003	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.82	1.40	1.46	1.46	1.46	1.80	2.02	2.14
CUL004	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.82	1.40	1.46	1.46	1.46	1.80	2.02	2.14
CUL005	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.82	1.40	1.46	1.46	1.46	1.80	2.02	2.14
CUL006	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.79	0.81	0.81	1.31	1.36	1.36	1.36	1.68	1.89	2.00
CUL007	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.46	0.46	0.46	0.75	0.78	0.78	0.78	0.96	1.08	1.14
CUL008	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
CUL009	< 0.01	< 0.01	< 0.01	< 0.01	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
CUL012	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.03	1.33	1.49	1.57
CUL013	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.72	0.76	0.76	1.24	1.29	1.29	1.29	1.59	1.78	1.88
CUL015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.69	1.18	1.24	1.24	1.24	1.52	1.71	1.81
CUL016	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.33	0.34	0.58	0.60	0.60	0.60	0.75	0.84	0.88
CUL017	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.33	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
CUL018	< 0.01	< 0.01	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
CUL019	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.31	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
CUL020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.54	0.92	0.95	0.95	0.95	1.18	1.32	1.40
CUL021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
CUL022	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08
CUL023	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.20	0.21	0.21	0.22	0.22	0.22	0.27	0.31	0.33
CUL024	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.12	0.22	0.22	0.22	0.22	0.22	0.27	0.30	0.32
CUL025	< 0.01	< 0.01	0.07	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.45	0.47
CUL026	< 0.01	< 0.01	< 0.01	0.66	0.63	0.63	0.63	0.63	1.03	1.07	1.07	1.07	1.32	1.48	1.57
CUL027	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.19	0.22	0.22	0.22	0.22	0.22	0.27	0.30	0.31
CUL028	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.80	0.80	0.80	1.30	1.35	1.35	1.35	1.67	1.87	1.98
CUL029	< 0.01	< 0.01	< 0.01	< 0.01	0.73	0.73	0.73	0.73	1.18	1.23	1.23	1.23	1.52	1.70	1.80
CUL030	< 0.01	< 0.01	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
CUL031	< 0.01	< 0.01	< 0.01	0.85	0.85	0.85	0.85	0.85	1.39	1.44	1.44	1.44	1.78	1.99	2.11
CUL032	< 0.01	< 0.01	< 0.01	0.70	0.70	0.70	0.70	0.70	1.13	1.18	1.18	1.18	1.45	1.63	1.72
CUL033	< 0.01	< 0.01	< 0.01	0.54	0.54	0.54	0.54	0.54	0.88	0.91	0.91	0.91	1.12	1.26	1.33
GG001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
GG002	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
GG003	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
GG004	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.40	1.53
IF001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.53	1.54	1.54	1.54	1.54
IF002	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.28	0.30
IF010	< 0.01	< 0.01	< 0.01	< 0.01	0.80	0.80	0.80	0.80	1.30	1.35	1.35	1.35	1.67	1.87	1.98
IF011	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.62	1.08	1.13	1.13	1.13	1.39	1.56	1.65
IF012	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.50	0.50	0.50	0.50	0.51	0.51	0.51	0.63	0.71	0.75
IF013	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.17	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
IF014	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.38	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.42
IF015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.23	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
IF016	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.28	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.36
IF017	< 0.01	< 0.01	< 0.01	< 0.01	0.12	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Maximum Total Hogging Curvature after LW101	Maximum Total Hogging Curvature after LW102	Maximum Total Hogging Curvature after LW103	Maximum Total Hogging Curvature after LW104	Maximum Total Hogging Curvature after LW105	Maximum Total Hogging Curvature after LW106	Maximum Total Hogging Curvature after LW107	Maximum Total Hogging Curvature after LW108	Maximum Total Hogging Curvature after LW109	Maximum Total Hogging Curvature after LW201	Maximum Total Hogging Curvature after LW202	Maximum Total Hogging Curvature after LW203	Maximum Total Hogging Curvature after LW204	Maximum Total Hogging Curvature after LW205	Maximum Total Hogging Curvature after LW206
IF018	< 0.01	< 0.01	< 0.01	< 0.01	0.32	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.43	0.48	0.51
IF020	< 0.01	< 0.01	< 0.01	0.72	0.72	0.72	0.72	0.72	1.17	1.21	1.21	1.21	1.50	1.68	1.78
IF021	< 0.01	< 0.01	0.79	0.78	0.74	0.74	0.74	0.74	1.20	1.25	1.25	1.25	1.54	1.73	1.83
IF022	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.10	1.43	1.61	1.70
IF024	0.84	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
IF025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.73	0.73	1.18	1.23	1.23	1.23	1.52	1.70	1.80
IF026	< 0.01	< 0.01	< 0.01	< 0.01	0.12	0.42	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
IF027	< 0.01	< 0.01	< 0.01	< 0.01	0.24	0.31	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
IF031	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.35	0.39	0.42
IF034	< 0.01	0.83	0.82	0.81	0.77	0.77	0.77	0.77	1.26	1.31	1.31	1.31	1.62	1.81	1.92
IF035	0.14	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.43	0.43	0.43	0.43	0.43	0.43
IF036	0.83	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
IF037	0.77	0.79	0.78	0.77	0.74	0.74	0.74	0.74	1.20	1.29	1.29	1.29	1.59	1.78	1.88
IF042	< 0.01	< 0.01	< 0.01	0.56	0.54	0.54	0.54	0.54	0.88	0.91	0.91	0.91	1.12	1.26	1.33
IF048	0.83	0.85	0.84	0.83	0.79	0.79	0.79	0.79	1.29	1.39	1.39	1.39	1.72	1.92	2.03
IF049	< 0.01	0.83	0.85	0.84	0.80	0.80	0.80	0.80	1.30	1.35	1.35	1.35	1.67	1.87	1.98
IF050	< 0.01	0.72	0.71	0.70	0.67	0.67	0.67	0.67	1.08	1.13	1.13	1.13	1.39	1.56	1.65
IF051	< 0.01	< 0.01	0.22	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.25	0.27
IF052	< 0.01	< 0.01	0.76	0.78	0.74	0.74	0.74	0.74	1.21	1.26	1.26	1.26	1.55	1.74	1.84
IF053	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3.05	3.07
IF055	< 0.01	0.74	0.75	0.74	0.70	0.70	0.70	0.70	1.14	1.19	1.19	1.19	1.47	1.65	1.74
IF062	< 0.01	< 0.01	0.77	0.76	0.72	0.72	0.72	0.72	1.18	1.22	1.22	1.22	1.51	1.69	1.79
IF063	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.56	1.73
IF064	< 0.01	0.03	0.51	0.51	0.51	0.51	0.51	0.51	0.54	0.56	0.56	0.56	0.69	0.78	0.82
IF065	< 0.01	< 0.01	< 0.01	0.46	0.46	0.46	0.46	0.46	0.64	0.67	0.67	0.67	0.82	0.92	0.97
IF075	0.81	0.83	0.82	0.81	0.77	0.77	0.77	0.77	1.25	1.36	1.36	1.36	1.67	1.88	1.99
IF082	0.84	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.93	1.04	1.10
IF083	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.94	1.05	1.11
IF084	< 0.01	< 0.01	0.76	0.75	0.72	0.72	0.72	0.72	1.17	1.21	1.21	1.21	1.50	1.68	1.78
IF085	< 0.01	0.10	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
IF086	< 0.01	< 0.01	< 0.01	0.81	0.81	0.81	0.81	0.81	0.88	0.92	0.92	0.92	1.13	1.26	1.34
IF087	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.72	1.74
IF088	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.22	0.22	0.22	0.22	0.22
IF089	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.02	1.08	1.33	1.49	1.58
IF107	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.51	1.67
IF110	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.73	1.90
IF111	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.83
IF112	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.09	1.09	1.09	1.09
OQ001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.30	0.34	0.39	0.40	0.40	0.40	0.50	0.56	0.59
RS001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.74	1.25	1.30	1.30	1.30	1.61	1.80	1.91
RS002	< 0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
RS004	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
RS005	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
RS006	< 0.01	< 0.01	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
RS007	< 0.01	< 0.01	< 0.01	< 0.01	0.42	0.42	0.42	0.42	0.67	0.70	0.70	0.70	0.87	0.97	1.03
RS008	< 0.01	< 0.01	< 0.01	< 0.01	0.78	0.78	0.78	0.78	1.27	1.32	1.32	1.32	1.63	1.82	1.93
RS009	< 0.01	< 0.01	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.78	0.87	0.92
RS010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.79	0.79	0.79	1.28	1.33	1.33	1.33	1.64	1.84	1.94
RS011	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.50	0.49	0.49	0.49	0.49	0.49	0.49	0.60	0.67	0.71
RS012	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.09	0.27
RS013	< 0.01	< 0.01	< 0.01	0.52	0.50	0.50	0.50	0.50	0.81	0.84	0.84	0.84	1.04	1.17	1.23

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Maximum Total Sagging Curvature after LW101	Maximum Total Sagging Curvature after LW102	Maximum Total Sagging Curvature after LW103	Maximum Total Sagging Curvature after LW104	Maximum Total Sagging Curvature after LW105	Maximum Total Sagging Curvature after LW106	Maximum Total Sagging Curvature after LW107	Maximum Total Sagging Curvature after LW108	Maximum Total Sagging Curvature after LW109	Maximum Total Sagging Curvature after LW201	Maximum Total Sagging Curvature after LW202	Maximum Total Sagging Curvature after LW203	Maximum Total Sagging Curvature after LW204	Maximum Total Sagging Curvature after LW205	Maximum Total Sagging Curvature after LW206
AS008	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.02	1.07	1.07	1.30	1.30	1.37
AS016	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.31	0.32	0.32	0.55	0.57	0.57	0.57	0.70	0.70	0.73
AS017	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.41	0.42	0.42	0.72	0.75	0.75	0.75	0.91	0.91	0.96
AS018	< 0.01	< 0.01	< 0.01	0.26	0.25	0.25	0.25	0.25	0.42	0.43	0.43	0.43	0.53	0.53	0.56
AS019	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AS020	< 0.01	< 0.01	0.69	0.68	0.65	0.65	0.65	0.65	1.11	1.15	1.15	1.15	1.40	1.40	1.47
AS021	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.24	0.30	0.30	0.30	0.36	0.36	0.38
AS022	0.55	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.66	0.73	0.73	0.73	0.89	0.89	0.94
AS023	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.07	0.12	0.13	0.13	0.13	0.15	0.15	0.16
AS024	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.65	1.11	1.15	1.15	1.15	1.40	1.40	1.48
AS025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.65	1.11	1.15	1.15	1.15	1.40	1.40	1.47
AS026	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.30	0.30	0.30	0.51	0.53	0.53	0.53	0.64	0.64	0.67
AS027	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.66	0.66	0.66	1.13	1.18	1.18	1.18	1.43	1.43	1.51
AS028	< 0.01	< 0.01	< 0.01	< 0.01	0.38	0.38	0.38	0.38	0.65	0.67	0.67	0.67	0.82	0.82	0.86
AS030	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.19	0.22
AS031	0.67	0.66	0.66	0.65	0.62	0.62	0.62	0.62	1.05	1.13	1.13	1.13	1.38	1.38	1.45
AS032	< 0.01	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.96	1.00	1.00	1.00	1.21	1.21	1.27
AS033	< 0.01	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.34	0.35	0.35	0.35	0.43	0.43	0.45
AS036	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.11	0.17	0.17	0.17	0.21	0.21	0.22
AS037	< 0.01	0.75	0.75	0.75	0.75	0.75	0.75	0.75	1.04	1.08	1.08	1.08	1.31	1.31	1.38
AS038	< 0.01	0.25	0.25	0.24	0.23	0.23	0.23	0.23	0.40	0.41	0.41	0.41	0.50	0.50	0.53
AS039	< 0.01	0.75	0.75	0.75	0.75	0.75	0.75	0.75	1.04	1.08	1.08	1.08	1.31	1.31	1.38
AS054	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AS060	< 0.01	< 0.01	0.72	0.72	0.72	0.72	0.72	0.72	1.05	1.09	1.09	1.09	1.33	1.33	1.40
AS061	< 0.01	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.90	0.93	0.93	0.93	1.14	1.14	1.20
AS062	< 0.01	0.10	0.13	0.13	0.12	0.12	0.12	0.12	0.21	0.22	0.22	0.22	0.26	0.26	0.28
AS063	< 0.01	< 0.01	0.62	0.64	0.61	0.61	0.61	0.61	1.03	1.08	1.08	1.08	1.31	1.31	1.38
AS065	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.26	0.33	0.33	0.33	0.33	0.33
AS066	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.09	0.10	0.10	0.12	0.12	0.12
AS080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.43	0.49
AS081	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.97	1.01	1.01	1.19	1.19	1.25
AS082	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.04	0.04	0.04	0.04	0.05
AS083	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.34	1.34	1.34	1.34
AS084	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.13	1.44	1.44	1.52
AS085	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.09	0.19	0.20	0.21
AS086	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.40	1.53
AS087	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.16	0.24	0.25
AS088	< 0.01	< 0.01	< 0.01	0.62	0.59	0.59	0.59	0.59	1.01	1.05	1.05	1.05	1.28	1.28	1.34
AS089	< 0.01	< 0.01	< 0.01	0.48	0.48	0.48	0.48	0.48	0.75	0.78	0.78	0.78	0.95	0.95	1.00
AS090	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.97	1.05	1.05	1.05	1.28	1.28	1.34
AS091	0.69	0.68	0.67	0.66	0.63	0.63	0.63	0.63	1.07	1.16	1.16	1.16	1.41	1.41	1.48
AS094	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.21
AS095	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.24	0.27
AS096	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.37	1.50
AS097	< 0.01	< 0.01	< 0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04
AS098	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
AS099	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.71	0.77	0.77	0.77	0.94	0.94	0.99
AS100	0.14	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.26	0.29	0.29	0.29	0.35	0.35	0.37
AS101	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.48
AS102	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.15	1.15

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Maximum Total Sagging Curvature after LW101	Maximum Total Sagging Curvature after LW102	Maximum Total Sagging Curvature after LW103	Maximum Total Sagging Curvature after LW104	Maximum Total Sagging Curvature after LW105	Maximum Total Sagging Curvature after LW106	Maximum Total Sagging Curvature after LW107	Maximum Total Sagging Curvature after LW108	Maximum Total Sagging Curvature after LW109	Maximum Total Sagging Curvature after LW201	Maximum Total Sagging Curvature after LW202	Maximum Total Sagging Curvature after LW203	Maximum Total Sagging Curvature after LW204	Maximum Total Sagging Curvature after LW205	Maximum Total Sagging Curvature after LW206
AS103	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.39	1.45	1.53
AS104	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.43	1.49	1.57
AS105	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.15	1.26
AS106	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.40	0.43	0.46
AS107	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.38	0.41	0.41	0.50	0.49	0.52
AS108	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.23	0.24	0.24	0.29	0.29	0.30
CUL001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.58	0.58	0.66	0.69	0.69	0.69	0.84	0.84	0.88
CUL002	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.02	0.02	0.04	0.04	0.04	0.04	0.05	0.05	0.05
CUL003	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.65	1.16	1.21	1.21	1.21	1.47	1.47	1.55
CUL004	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.65	1.16	1.21	1.21	1.21	1.47	1.47	1.55
CUL005	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.69	1.16	1.21	1.21	1.21	1.48	1.47	1.55
CUL006	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.63	0.64	0.64	1.09	1.13	1.13	1.13	1.38	1.37	1.45
CUL007	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.37	0.37	0.37	0.62	0.65	0.65	0.65	0.79	0.79	0.83
CUL008	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04
CUL009	< 0.01	< 0.01	< 0.01	< 0.01	0.06	0.06	0.06	0.06	0.10	0.11	0.11	0.11	0.13	0.13	0.14
CUL012	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.86	1.08	1.08	1.14
CUL013	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.66	0.70	0.70	1.03	1.07	1.07	1.07	1.30	1.30	1.37
CUL015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.54	0.98	1.02	1.02	1.02	1.25	1.25	1.31
CUL016	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.26	0.26	0.48	0.50	0.50	0.50	0.61	0.61	0.64
CUL017	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.06	0.06	0.10	0.10	0.10	0.10	0.12	0.12	0.13
CUL018	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
CUL019	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.06	0.06	0.09	0.10	0.10	0.10	0.12	0.12	0.13
CUL020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.44	0.76	0.79	0.79	0.79	0.96	0.96	1.01
CUL021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.09	0.09	0.15	0.16	0.16	0.16	0.19	0.19	0.20
CUL022	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.02	0.04	0.04	0.04	0.04	0.05	0.05	0.05
CUL023	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.07	0.09	0.18	0.18	0.18	0.18	0.22	0.22	0.24
CUL024	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.07	0.17	0.18	0.18	0.18	0.22	0.22	0.23
CUL025	< 0.01	< 0.01	< 0.01	0.16	0.15	0.15	0.15	0.15	0.26	0.27	0.27	0.27	0.33	0.33	0.34
CUL026	< 0.01	< 0.01	< 0.01	0.57	0.57	0.57	0.57	0.57	0.85	0.89	0.89	0.89	1.08	1.08	1.14
CUL027	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.07	0.08	0.17	0.18	0.18	0.18	0.22	0.22	0.23
CUL028	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.63	0.63	0.63	1.08	1.12	1.12	1.12	1.36	1.36	1.43
CUL029	< 0.01	< 0.01	< 0.01	< 0.01	0.68	0.68	0.68	0.68	0.98	1.02	1.02	1.02	1.24	1.24	1.31
CUL030	< 0.01	< 0.01	0.23	0.23	0.22	0.22	0.22	0.22	0.38	0.39	0.39	0.39	0.48	0.48	0.50
CUL031	< 0.01	< 0.01	< 0.01	0.72	0.75	0.75	0.75	0.75	1.15	1.20	1.20	1.20	1.46	1.45	1.53
CUL032	< 0.01	< 0.01	< 0.01	0.60	0.62	0.62	0.62	0.62	0.94	0.98	0.98	0.98	1.19	1.19	1.25
CUL033	< 0.01	< 0.01	< 0.01	0.43	0.43	0.43	0.43	0.43	0.73	0.76	0.76	0.76	0.92	0.92	0.97
GG001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
GG002	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
GG003	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
GG004	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.02	1.11
IF001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.21	1.21	1.21	1.21	1.21
IF002	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.11	0.17	0.17	0.17	0.20	0.20	0.21
IF010	< 0.01	< 0.01	< 0.01	< 0.01	0.63	0.63	0.63	0.63	1.08	1.12	1.12	1.12	1.36	1.36	1.43
IF011	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.49	0.90	0.94	0.94	0.94	1.14	1.14	1.20
IF012	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.24	0.24	0.24	0.41	0.42	0.42	0.42	0.52	0.52	0.54
IF013	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.06	0.06	0.11	0.12	0.12	0.12	0.14	0.14	0.15
IF014	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.13	0.13	0.23	0.24	0.24	0.24	0.29	0.29	0.30
IF015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.09	0.09	0.09	0.15	0.16	0.16	0.16	0.19	0.19	0.20
IF016	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.11	0.11	0.11	0.20	0.20	0.20	0.20	0.25	0.25	0.26
IF017	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.09	0.09	0.09	0.15	0.16	0.16	0.16	0.19	0.19	0.20

Table D.01 - Bylong Coal Project - Longwalls 101 to 109 and 201 to 206
Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site ID	Maximum Total Sagging Curvature after LW101	Maximum Total Sagging Curvature after LW102	Maximum Total Sagging Curvature after LW103	Maximum Total Sagging Curvature after LW104	Maximum Total Sagging Curvature after LW105	Maximum Total Sagging Curvature after LW106	Maximum Total Sagging Curvature after LW107	Maximum Total Sagging Curvature after LW108	Maximum Total Sagging Curvature after LW109	Maximum Total Sagging Curvature after LW201	Maximum Total Sagging Curvature after LW202	Maximum Total Sagging Curvature after LW203	Maximum Total Sagging Curvature after LW204	Maximum Total Sagging Curvature after LW205	Maximum Total Sagging Curvature after LW206
IF018	< 0.01	< 0.01	< 0.01	< 0.01	0.15	0.16	0.16	0.16	0.28	0.29	0.29	0.29	0.35	0.35	0.37
IF020	< 0.01	< 0.01	< 0.01	0.57	0.57	0.57	0.57	0.57	0.97	1.01	1.01	1.01	1.22	1.22	1.29
IF021	< 0.01	< 0.01	0.65	0.65	0.65	0.65	0.65	0.65	1.00	1.04	1.04	1.04	1.26	1.26	1.33
IF022	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.91	1.17	1.17	1.23
IF024	0.22	0.22	0.22	0.21	0.20	0.20	0.20	0.20	0.35	0.41	0.41	0.41	0.50	0.50	0.52
IF025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.62	0.62	0.98	1.02	1.02	1.02	1.24	1.24	1.31
IF026	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.09	0.09	0.09	0.15	0.16	0.16	0.16	0.19	0.19	0.20
IF027	< 0.01	< 0.01	< 0.01	< 0.01	0.09	0.09	0.10	0.10	0.16	0.17	0.17	0.17	0.21	0.20	0.22
IF031	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.14	0.14	0.14	0.23	0.24	0.24	0.24	0.29	0.29	0.30
IF034	< 0.01	0.66	0.65	0.64	0.61	0.61	0.61	0.61	1.04	1.09	1.09	1.09	1.32	1.32	1.39
IF035	0.02	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.11	0.12	0.12	0.12	0.14	0.14	0.15
IF036	0.20	0.20	0.20	0.20	0.19	0.19	0.19	0.19	0.32	0.38	0.38	0.38	0.46	0.46	0.49
IF037	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.99	1.07	1.07	1.07	1.30	1.30	1.37
IF042	< 0.01	< 0.01	< 0.01	0.50	0.50	0.50	0.50	0.50	0.73	0.76	0.76	0.76	0.92	0.92	0.97
IF048	0.68	0.67	0.67	0.66	0.63	0.63	0.63	0.63	1.07	1.15	1.15	1.15	1.40	1.40	1.48
IF049	< 0.01	0.66	0.67	0.66	0.63	0.63	0.63	0.63	1.08	1.12	1.12	1.12	1.36	1.36	1.43
IF050	< 0.01	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.90	0.93	0.93	0.93	1.14	1.14	1.20
IF051	< 0.01	< 0.01	0.06	0.09	0.09	0.09	0.09	0.09	0.15	0.15	0.15	0.15	0.18	0.18	0.19
IF052	< 0.01	< 0.01	0.69	0.69	0.69	0.69	0.69	0.69	1.00	1.04	1.04	1.04	1.27	1.27	1.34
IF053	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2.57	2.56
IF055	< 0.01	0.59	0.59	0.58	0.56	0.56	0.56	0.56	0.95	0.99	0.99	0.99	1.20	1.20	1.26
IF062	< 0.01	< 0.01	0.61	0.60	0.57	0.57	0.57	0.57	0.97	1.01	1.01	1.01	1.23	1.23	1.30
IF063	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.13	1.25
IF064	< 0.01	< 0.01	0.28	0.28	0.26	0.26	0.26	0.26	0.45	0.47	0.47	0.47	0.57	0.57	0.60
IF065	< 0.01	< 0.01	< 0.01	0.33	0.31	0.31	0.31	0.31	0.53	0.55	0.55	0.55	0.67	0.67	0.71
IF075	0.67	0.66	0.65	0.64	0.61	0.61	0.61	0.61	1.04	1.13	1.13	1.13	1.37	1.37	1.44
IF082	0.35	0.35	0.34	0.34	0.32	0.32	0.32	0.32	0.55	0.63	0.63	0.63	0.76	0.76	0.80
IF083	0.35	0.37	0.36	0.36	0.34	0.34	0.34	0.34	0.58	0.63	0.63	0.63	0.76	0.76	0.80
IF084	< 0.01	< 0.01	0.67	0.67	0.67	0.67	0.67	0.67	0.97	1.01	1.01	1.01	1.22	1.22	1.29
IF085	< 0.01	< 0.01	0.13	0.13	0.12	0.12	0.12	0.12	0.21	0.22	0.22	0.22	0.26	0.26	0.28
IF086	< 0.01	< 0.01	< 0.01	0.62	0.62	0.62	0.62	0.62	0.73	0.76	0.76	0.76	0.92	0.92	0.97
IF087	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.10	0.16
IF088	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.02	0.02	0.02	0.02
IF089	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3.01	3.18	3.18	3.18	3.18
IF107	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.10	1.21
IF110	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.26	1.38
IF111	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.33
IF112	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.20	0.30	0.30	0.32
OQ001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.17	0.17	0.32	0.33	0.33	0.33	0.41	0.41	0.43
RS001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.66	1.04	1.08	1.08	1.08	1.32	1.31	1.38
RS002	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
RS004	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
RS005	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
RS006	< 0.01	< 0.01	0.22	0.22	0.21	0.21	0.21	0.21	0.36	0.38	0.38	0.38	0.46	0.46	0.48
RS007	< 0.01	< 0.01	< 0.01	< 0.01	0.33	0.33	0.33	0.33	0.56	0.58	0.58	0.58	0.71	0.71	0.75
RS008	< 0.01	< 0.01	< 0.01	< 0.01	0.62	0.62	0.62	0.62	1.05	1.09	1.09	1.09	1.33	1.33	1.40
RS009	< 0.01	< 0.01	0.31	0.31	0.30	0.30	0.30	0.30	0.50	0.52	0.52	0.52	0.64	0.64	0.67
RS010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.62	0.62	0.62	1.06	1.10	1.10	1.10	1.34	1.34	1.41
RS011	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.23	0.23	0.23	0.39	0.40	0.40	0.40	0.49	0.49	0.52
RS012	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.14
RS013	< 0.01	< 0.01	< 0.01	0.41	0.39	0.39	0.39	0.39	0.67	0.70	0.70	0.70	0.85	0.85	0.90

Table D.02 - Predicted Conventional Subsidence, Tilt and Curvature for the Farm Dams within the Subsidence Study Area

Ref.	Total Subsidence after LW101 (mm)	Total Subsidence after LW102 (mm)	Total Subsidence after LW103 (mm)	Total Subsidence after LW109 (mm)	Total Subsidence after LW201 (mm)	Total Subsidence after LW202 (mm)	Total Subsidence after LW203 (mm)	Total Subsidence after LW204 (mm)	Total Subsidence after LW205 (mm)	Total Subsidence after LW206 (mm)
D01	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	100
D02	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3000	3200	3200
D03	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
D04	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	150
D05	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	1800	2000
D06	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
D07	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2000	2000	2000
D08	< 20	< 20	< 20	< 20	< 20	< 20	2100	2200	2200	2200
D09	< 20	< 20	< 20	< 20	500	650	650	650	650	650
D10	< 20	2500	2600	2600	2600	2600	2600	2600	2600	2600
D11	2800	2800	2800	2800	2900	2900	2900	2900	2900	2900

Table D.02 - Predicted Conventional Subsidence, Tilt and Curvature for the Farm Dams within the Subsidence Study Area

Ref.	Total Tilt after LW101 (mm/m)	Total Tilt after LW102 (mm/m)	Total Tilt after LW103 (mm/m)	Total Tilt after LW109 (mm/m)	Total Tilt after LW201 (mm/m)	Total Tilt after LW202 (mm/m)	Total Tilt after LW203 (mm/m)	Total Tilt after LW204 (mm/m)	Total Tilt after LW205 (mm/m)	Total Tilt after LW206 (mm/m)
D01	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6
D02	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	40	40	40
D03	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2
D04	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	8
D05	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50	50
D06	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
D07	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	65	70	70
D08	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	40	45	45	45
D09	< 0.5	< 0.5	< 0.5	< 0.5	25	25	25	25	25	25
D10	< 0.5	40	40	40	40	40	40	40	40	40
D11	35	35	35	35	35	35	35	35	35	35

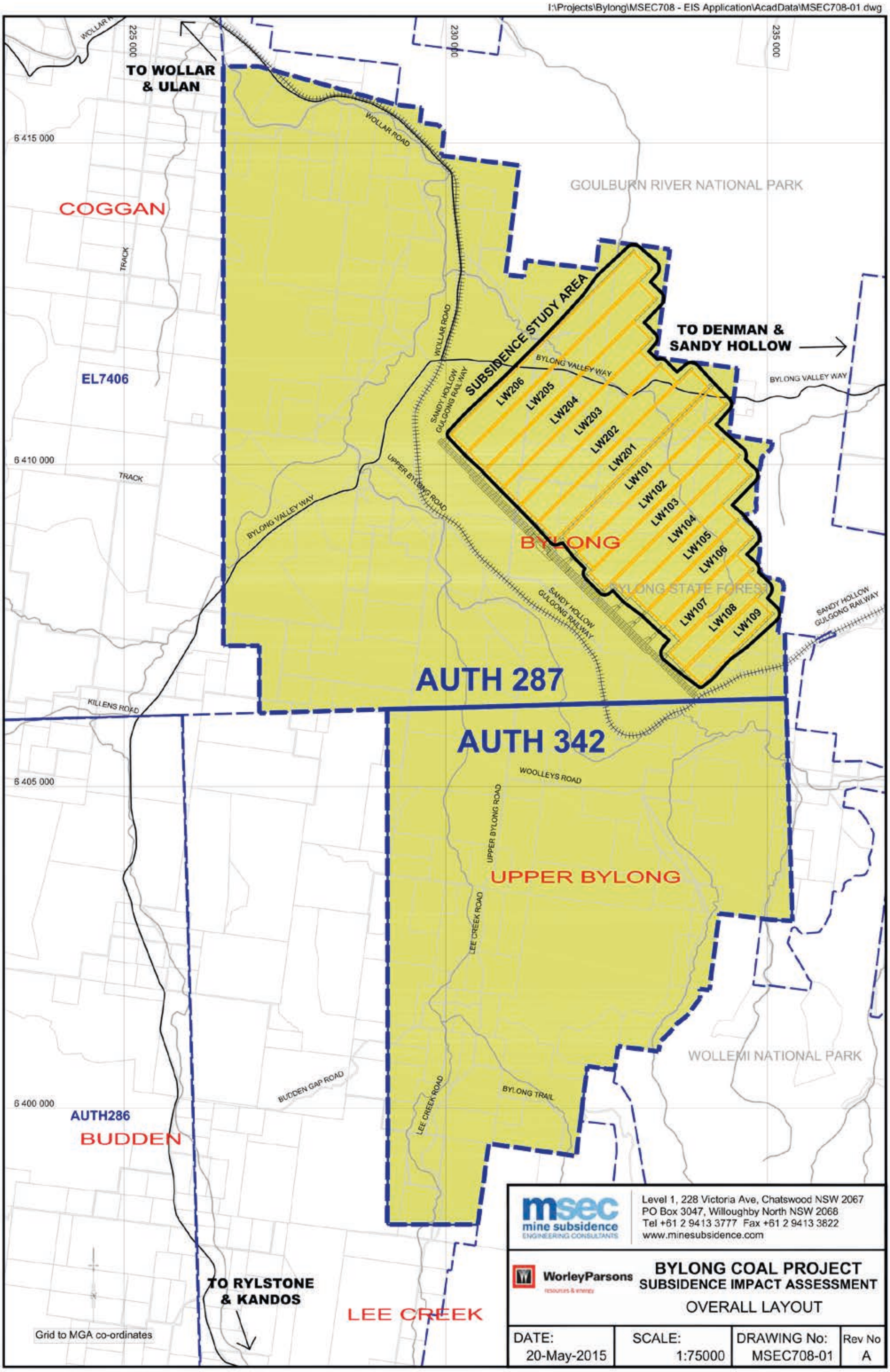
Table D.02 - Predicted Conventional Subsidence, Tilt and Curvature for the Farm Dams within the Subsidence Study Area

Ref.	Total Maximum Hogging Curvature after LW101 (km-1)	Total Maximum Hogging Curvature after LW102 (km-1)	Total Maximum Hogging Curvature after LW103 (km-1)	Total Maximum Hogging Curvature after LW109 (km-1)	Total Maximum Hogging Curvature after LW201 (km-1)	Total Maximum Hogging Curvature after LW202 (km-1)	Total Maximum Hogging Curvature after LW203 (km-1)	Total Maximum Hogging Curvature after LW204 (km-1)	Total Maximum Hogging Curvature after LW205 (km-1)	Total Maximum Hogging Curvature after LW206 (km-1)
D01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.30
D02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.50	2.00	2.00
D03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.10
D04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.30
D05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2.00	2.00
D06	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.20	0.20	0.20
D07	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3.00	3.50	3.50
D08	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.50	1.50	1.50	1.50
D09	< 0.01	< 0.01	< 0.01	< 0.01	1.50	1.50	1.50	1.50	1.50	1.50
D10	0.03	1.00	1.00	1.00	1.00	1.00	1.00	1.50	1.50	2.00
D11	0.80	0.80	0.80	1.00	1.50	1.50	1.50	1.50	2.00	2.00

Table D.02 - Predicted Conventional Subsidence, Tilt and Curvature for the Farm Dams within the Subsidence Study Area

Ref.	Total Maximum Sagging Curvature after LW101 (km-1)	Total Maximum Sagging Curvature after LW102 (km-1)	Total Maximum Sagging Curvature after LW103 (km-1)	Total Maximum Sagging Curvature after LW109 (km-1)	Total Maximum Sagging Curvature after LW201 (km-1)	Total Maximum Sagging Curvature after LW202 (km-1)	Total Maximum Sagging Curvature after LW203 (km-1)	Total Maximum Sagging Curvature after LW204 (km-1)	Total Maximum Sagging Curvature after LW205 (km-1)	Total Maximum Sagging Curvature after LW206 (km-1)
D01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.10
D02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.50	2.00	2.00
D03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
D04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.10
D05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.00	1.50
D06	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
D07	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.00	1.50	1.50
D08	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1.00	1.50	1.50	1.50
D09	< 0.01	< 0.01	< 0.01	< 0.01	0.20	0.30	0.30	0.40	0.40	0.40
D10	< 0.01	0.70	0.80	1.00	1.00	1.00	1.00	1.50	1.50	2.00
D11	0.80	0.80	0.80	1.00	1.50	1.50	1.50	1.50	2.00	2.00

APPENDIX E. DRAWINGS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COGGAN
TRACK
SUBSIDENCE STUDY AREA
TO DENMAN & SANDY HOLLOW
BYLONG VALLEY WAY
EL7406
SANDY HOLLOW GULGONG RAILWAY
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UPPER BYLONG ROAD
BYLONG
BYLONG STATE FOREST
AUTH 287
AUTH 342
KILLENS ROAD
WOOLLEYS ROAD
UPPER BYLONG
LEE CREEK ROAD
WOLLEMI NATIONAL PARK
BUDDEN GAP ROAD
BYLONG TRAIL
AUTH286
BUDDEN
TO RYLSTONE & KANDOS
LEE CREEK
Grid to MGA co-ordinates
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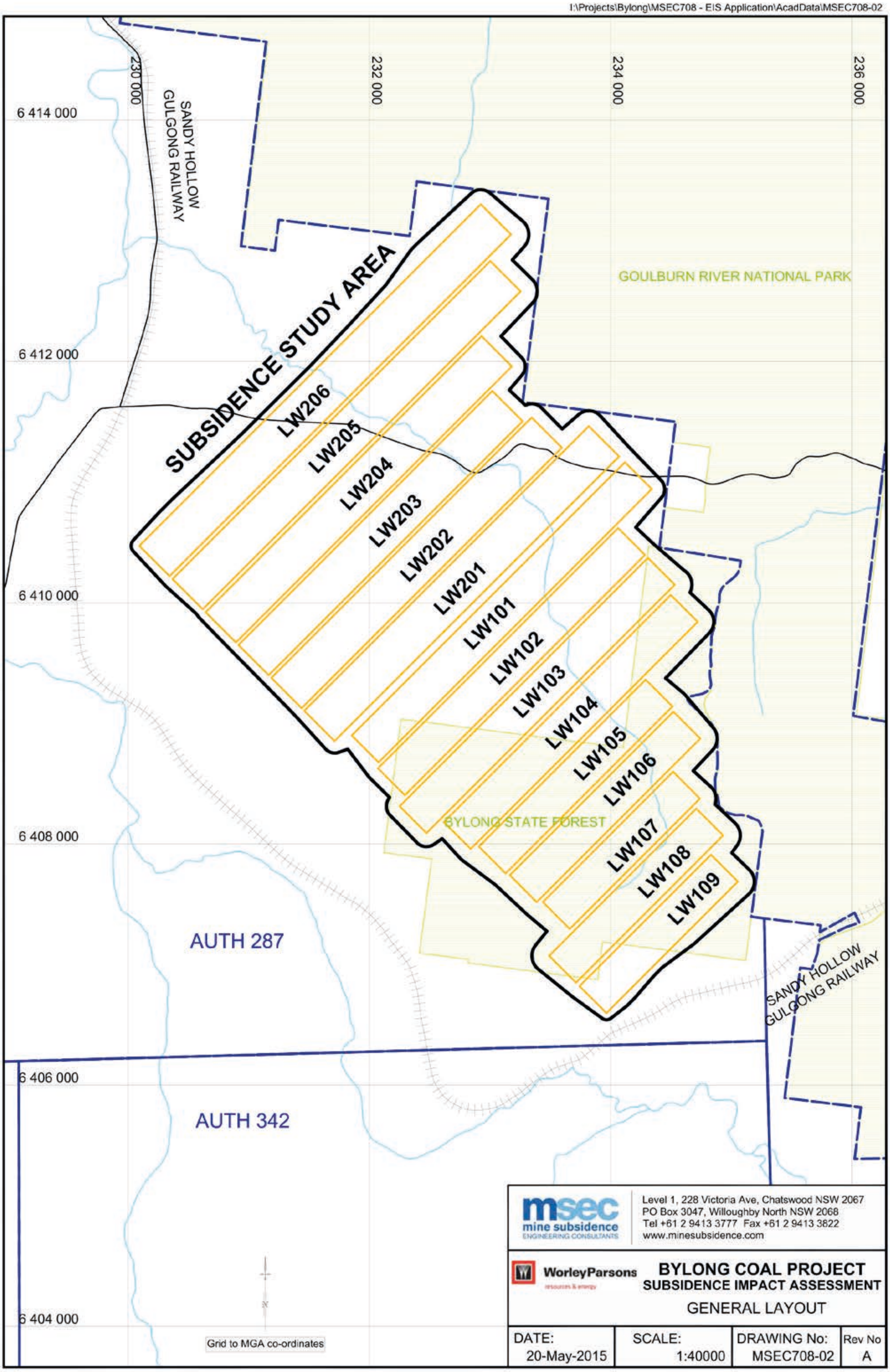
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AUTH 342
SANDY HOLLOW GULGONG RAILWAY
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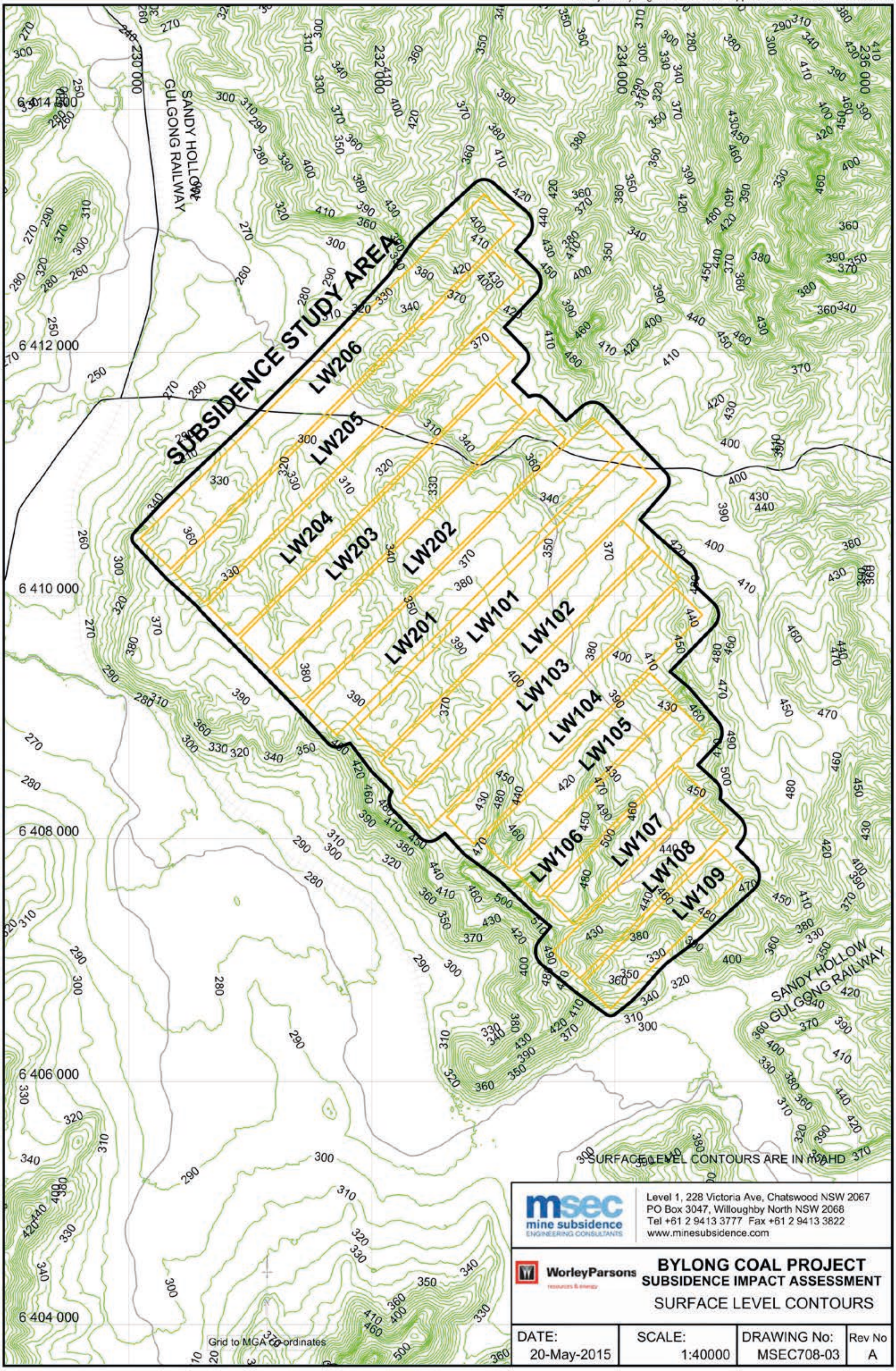

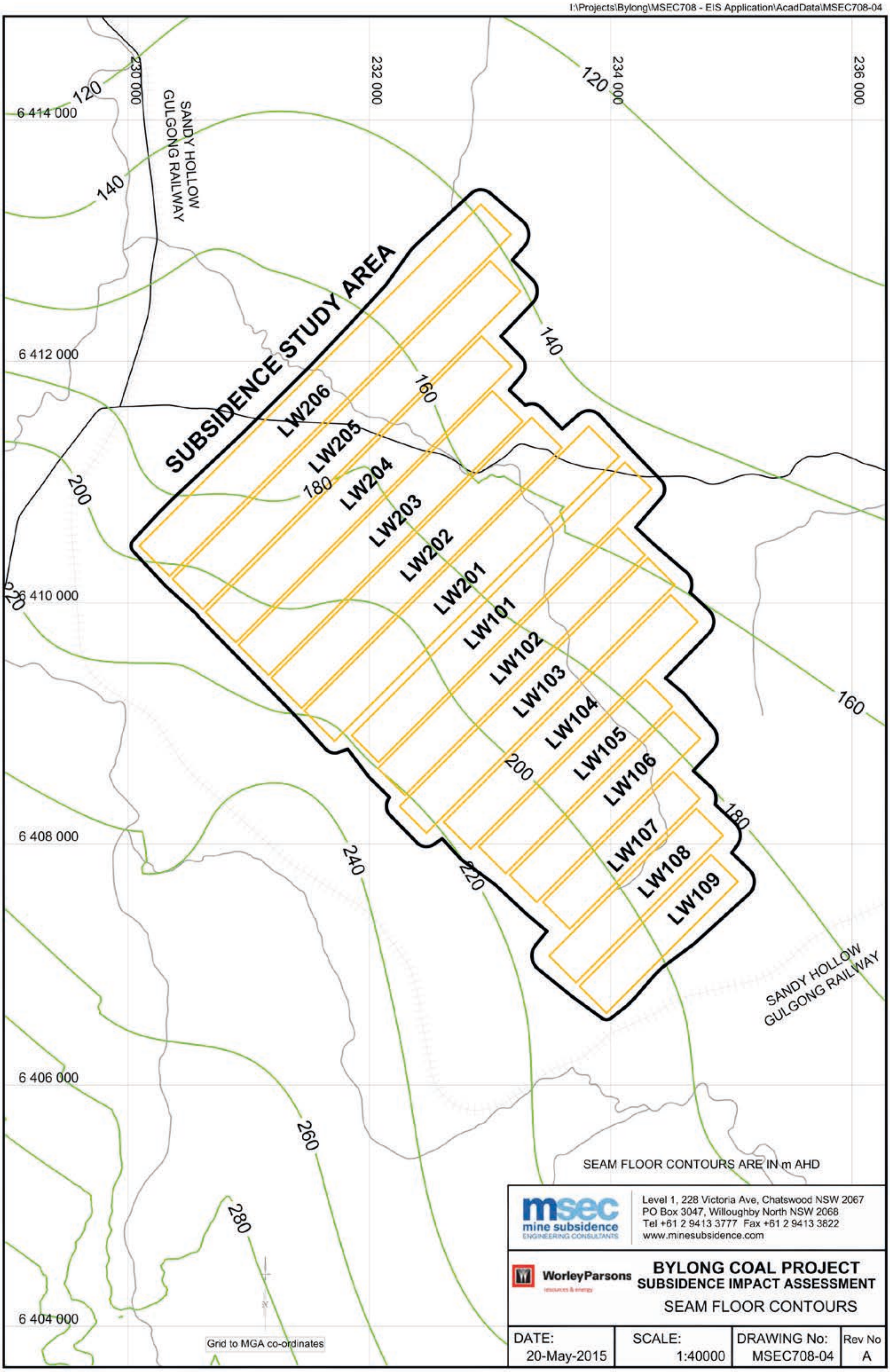
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SEAM FLOOR CONTOURS ARE IN m AHD
Grid to MGA co-ordinates
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DATE: 20-May-2015
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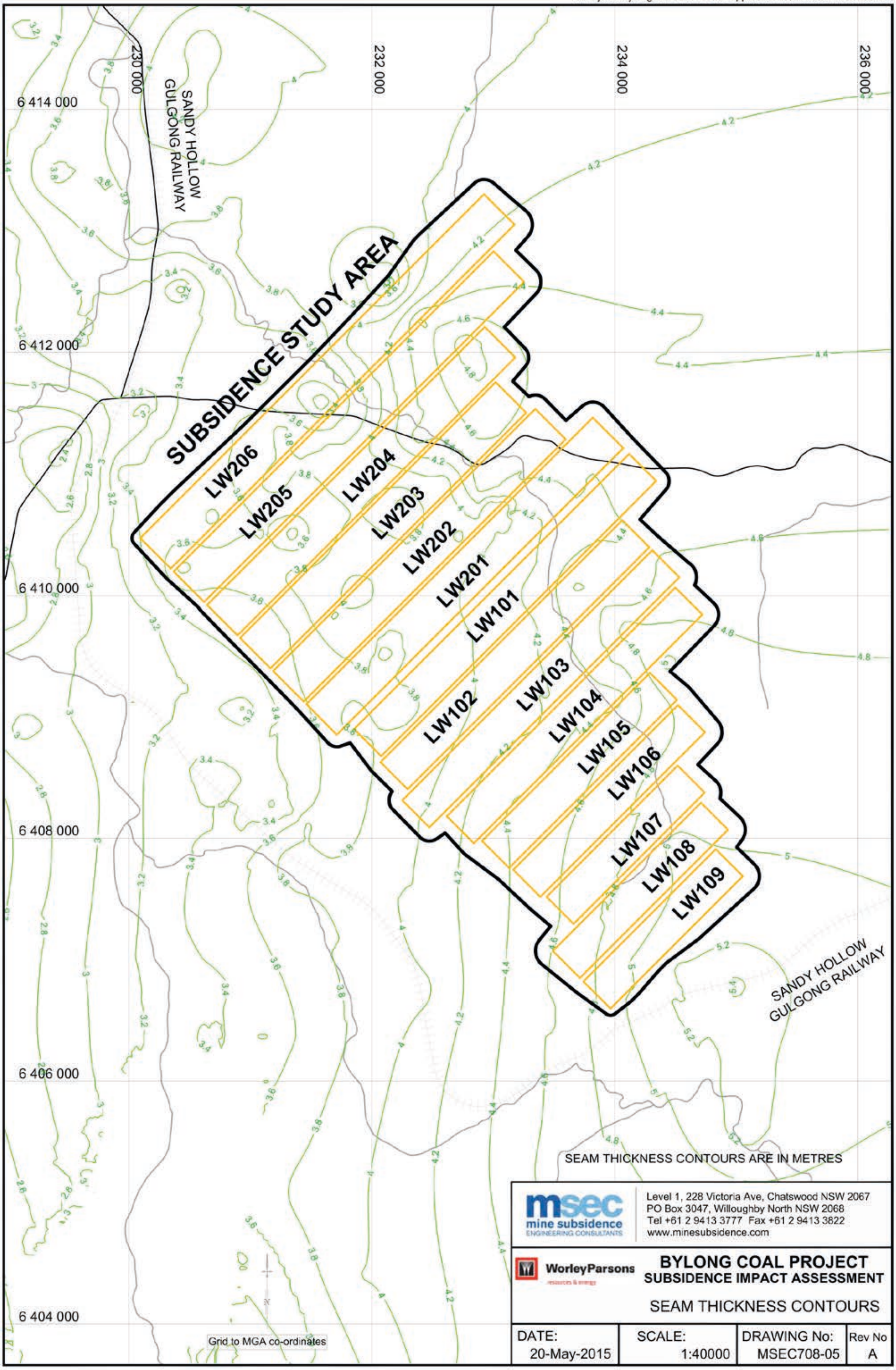

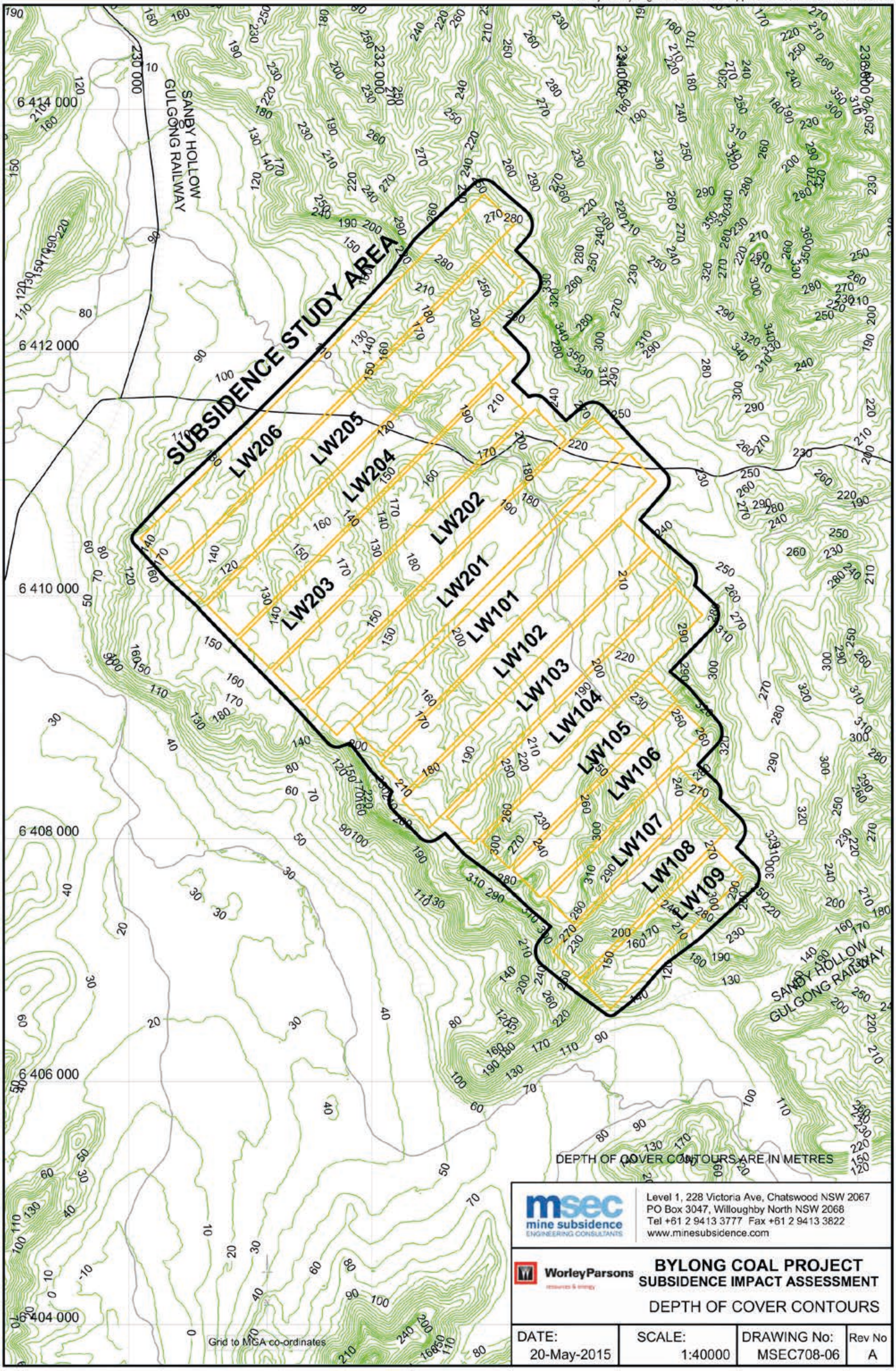
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DEPTH OF COVER CONTOURS ARE IN METRES
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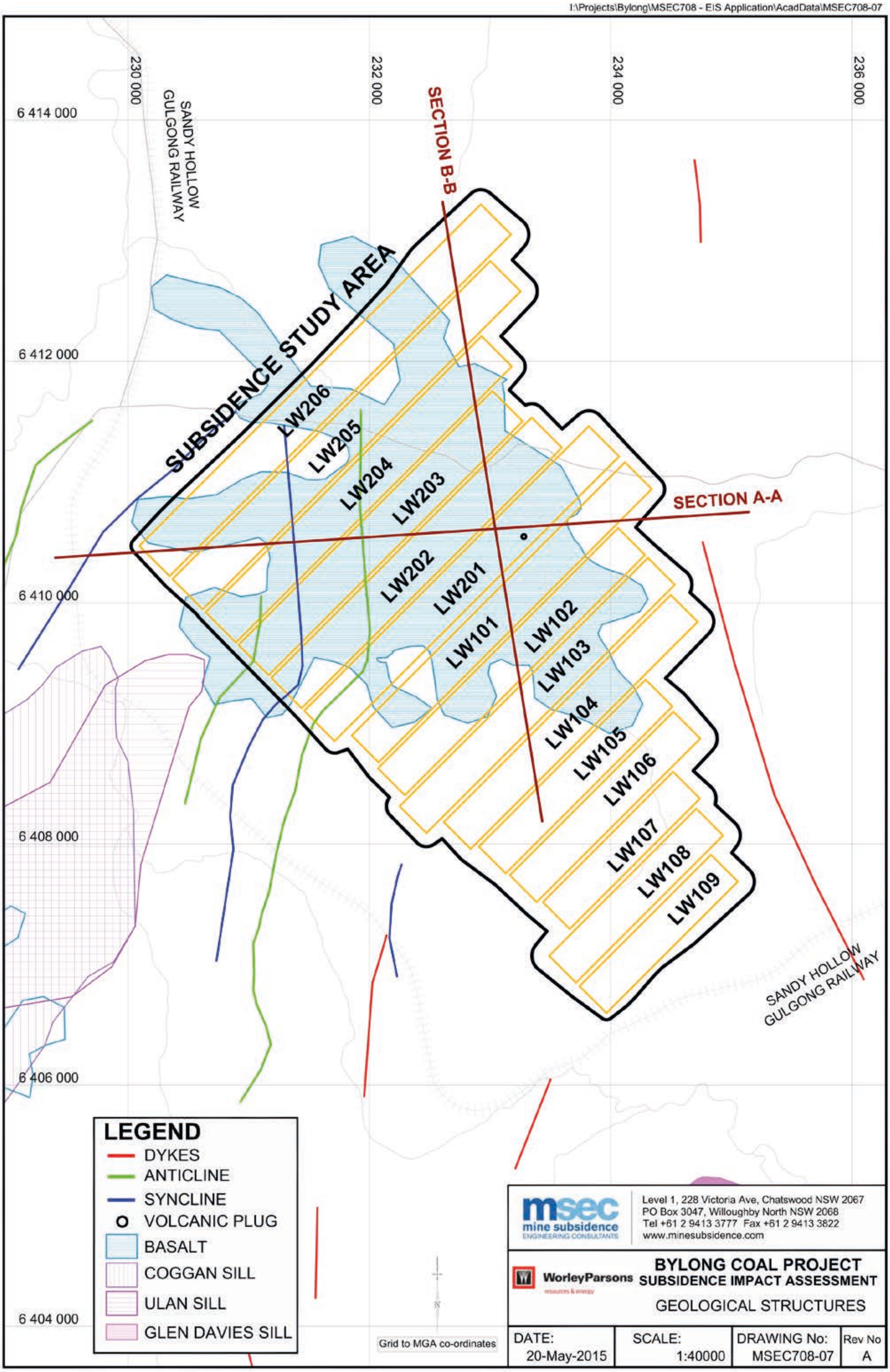
Rev No A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SANDY HOLLOW GULGONG RAILWAY
LEGEND
DYKES
ANTICLINE
SYNCLINE
VOLCANIC PLUG
BASALT
COGGAN SILL
ULAN SILL
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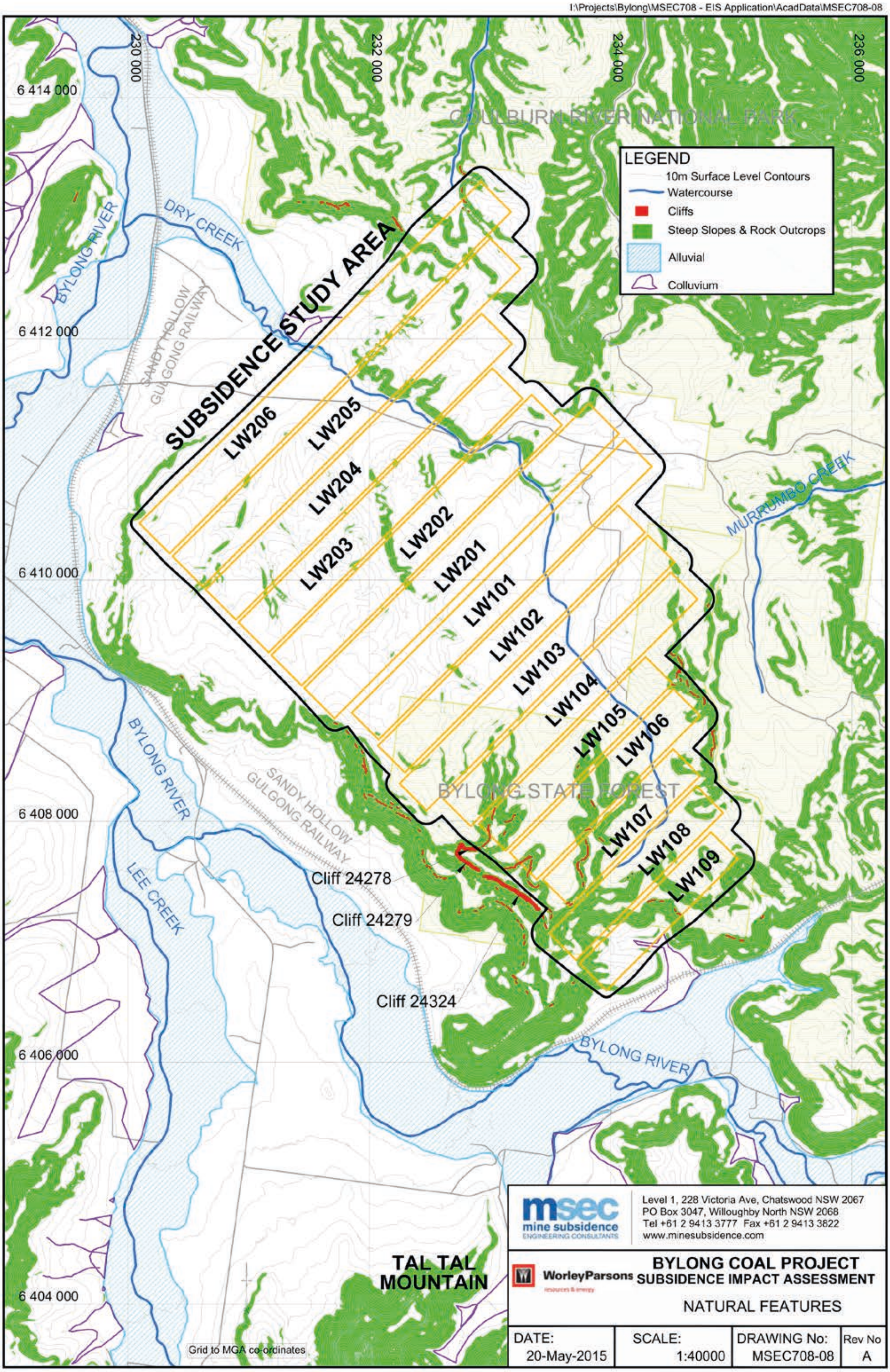
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GOULBURN RIVER NATIONAL PARK
LEGEND
10m Surface Level Contours
Watercourse
Cliffs
Steep Slopes & Rock Outcrops
Alluvial
Colluvium
DRY CREEK
BYLONG RIVER
SANDY HOLLOW GULGONG RAILWAY
SUBSIDENCE STUDY AREA
LW206
LW205
LW204
LW203
LW202
LW201
LW101
LW102
LW103
LW104
LW105
LW106
LW107
LW108
LW109
MURRUMBO CREEK
BYLONG STATE FOREST
LEE CREEK
Cliff 24278
Cliff 24279
Cliff 24324
TAL TAL MOUNTAIN
Grid to MGA co-ordinates
msec
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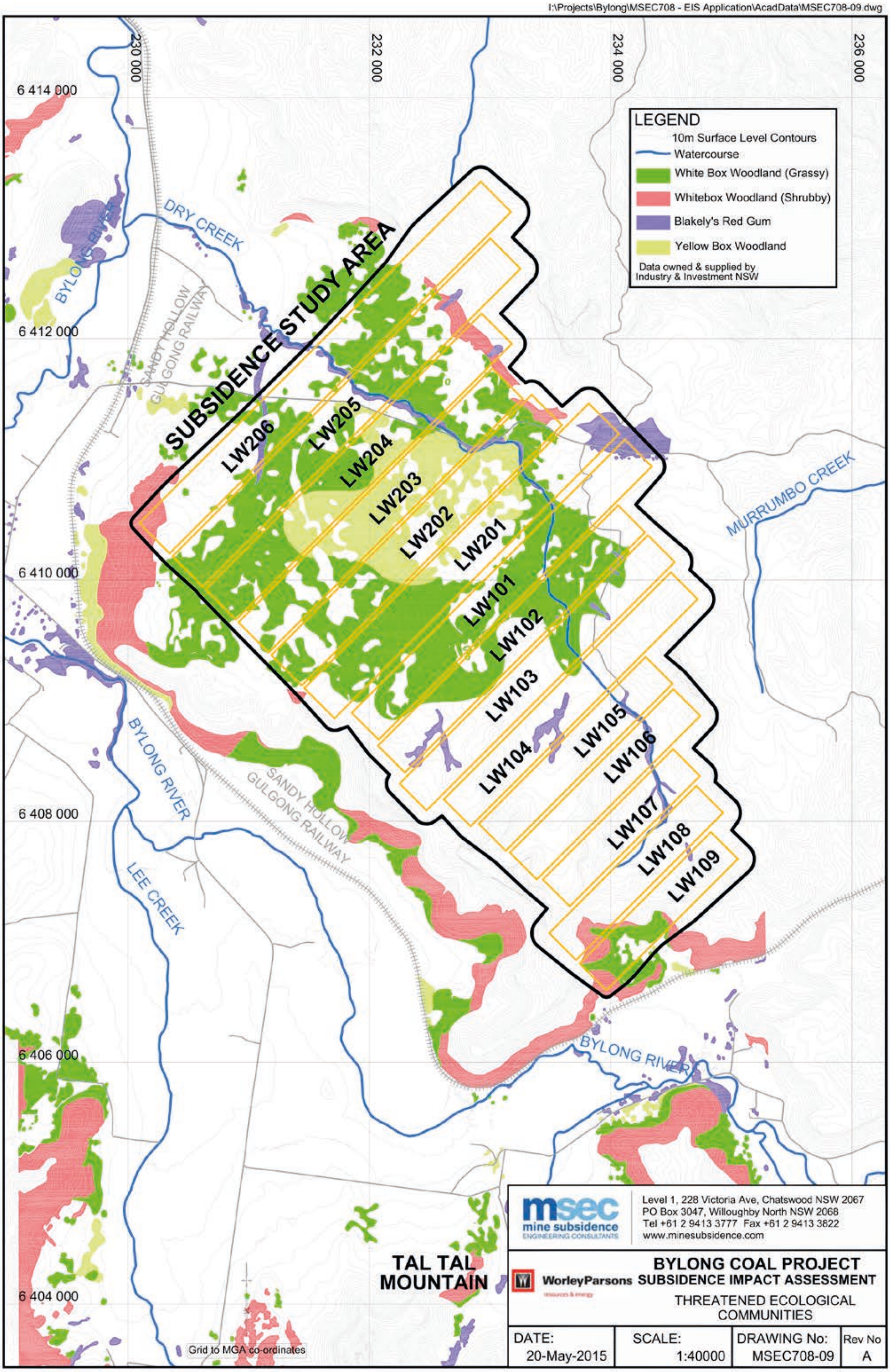
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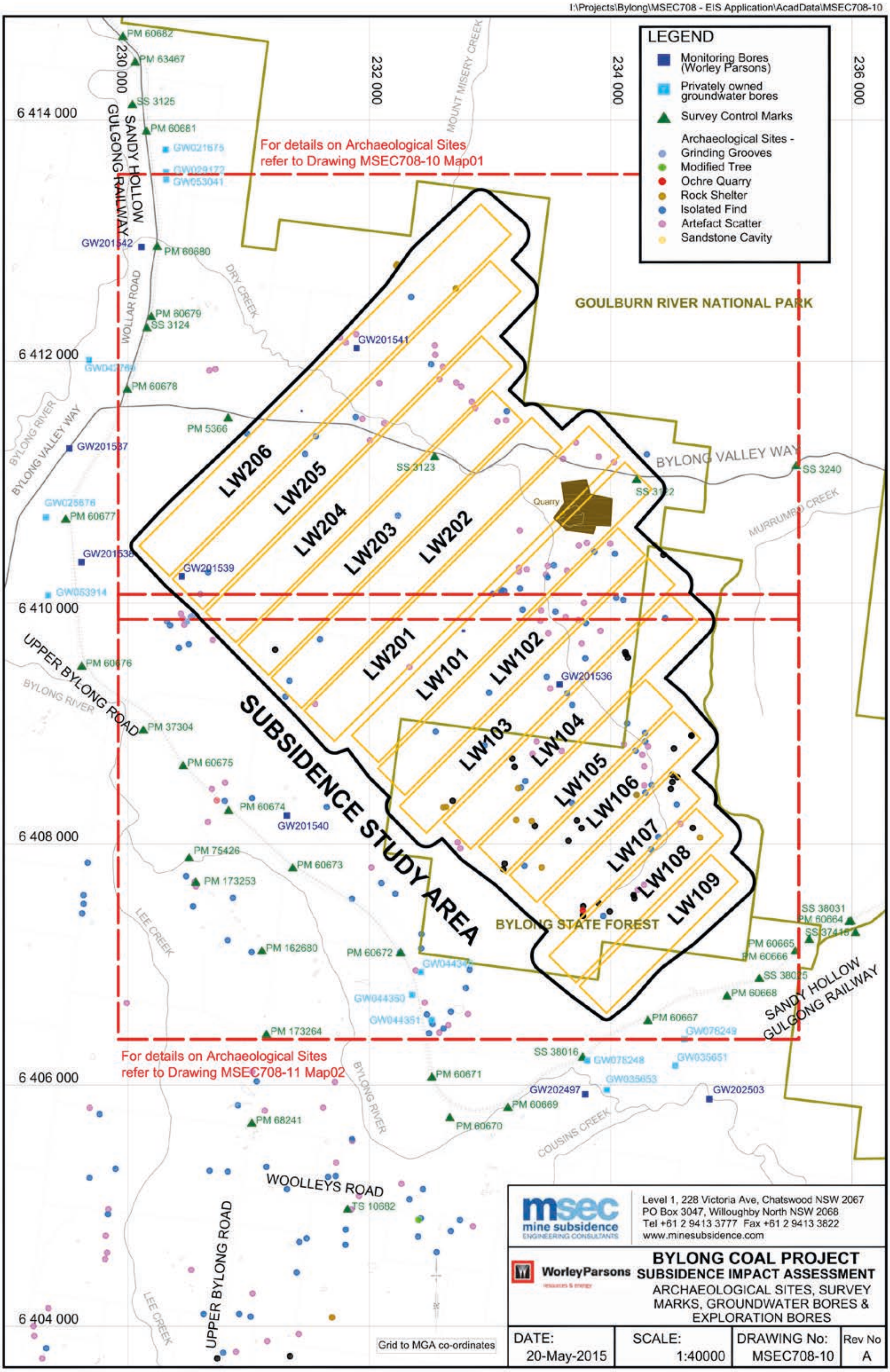
LEGEND
10m Surface Level Contours
Watercourse
White Box Woodland (Grassy)
Whitebox Woodland (Shrubby)
Blakely's Red Gum
Yellow Box Woodland
Data owned & supplied by Industry & Investment NSW
SUBSIDENCE STUDY AREA
DRY CREEK
BYLONG RIVER
SANDY HOLLOW GULGONG RAILWAY
MURRUMBO CREEK
LEE CREEK
TAL TAL MOUNTAIN
LW206
LW205
LW204
LW203
LW202
LW201
LW101
LW102
LW103
LW104
LW105
LW106
LW107
LW108
LW109
Grid to MGA co-ordinates
msec mine subsidence ENGINEERING CONSULTANTS
Level 1, 228 Victoria Ave, Chatswood NSW 2067
PO Box 3047, Willoughby North NSW 2068
Tel +61 2 9413 3777 Fax +61 2 9413 3822
www.minesubsidence.com
WorleyParsons
BYLONG COAL PROJECT
SUBSIDENCE IMPACT ASSESSMENT
THREATENED ECOLOGICAL COMMUNITIES
DATE: 20-May-2015
SCALE: 1:40000
DRAWING No: MSEC708-09
Rev No A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LEGEND
Monitoring Bores (Worley Parsons)
Privately owned groundwater bores
Survey Control Marks
Archaeological Sites -
Grinding Grooves
Modified Tree
Ochre Quarry
Rock Shelter
Isolated Find
Artefact Scatter
Sandstone Cavity
For details on Archaeological Sites refer to Drawing MSEC708-10 Map01
For details on Archaeological Sites refer to Drawing MSEC708-11 Map02
GOULBURN RIVER NATIONAL PARK
BYLONG STATE FOREST
SUBSIDENCE STUDY AREA
BYLONG VALLEY WAY
SANDY HOLLOW GULGONG RAILWAY
UPPER BYLONG ROAD
WOOLLEYS ROAD
WOLLAR ROAD
LW206
LW205
LW204
LW203
LW202
LW201
LW101
LW102
LW103
LW104
LW105
LW106
LW107
LW108
LW109
Quarry
Grid to MGA co-ordinates
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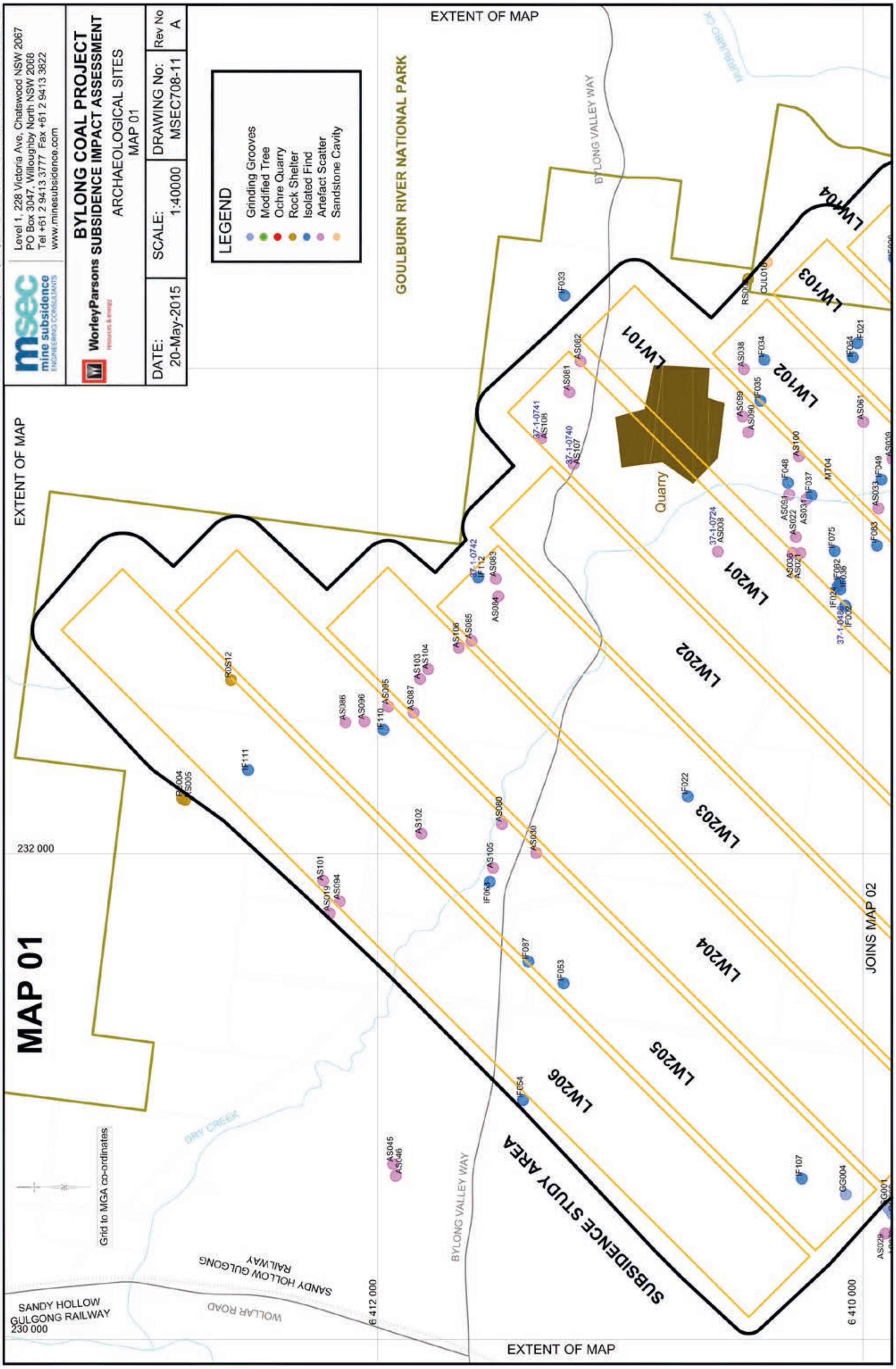
WorleyParsons
BYLONG COAL PROJECT
SUBSIDENCE IMPACT ASSESSMENT
ARCHAEOLOGICAL SITES, SURVEY MARKS, GROUNDWATER BORES & EXPLORATION BORES
DATE: 20-May-2015
SCALE: 1:40000
DRAWING No: MSEC708-10
Rev No A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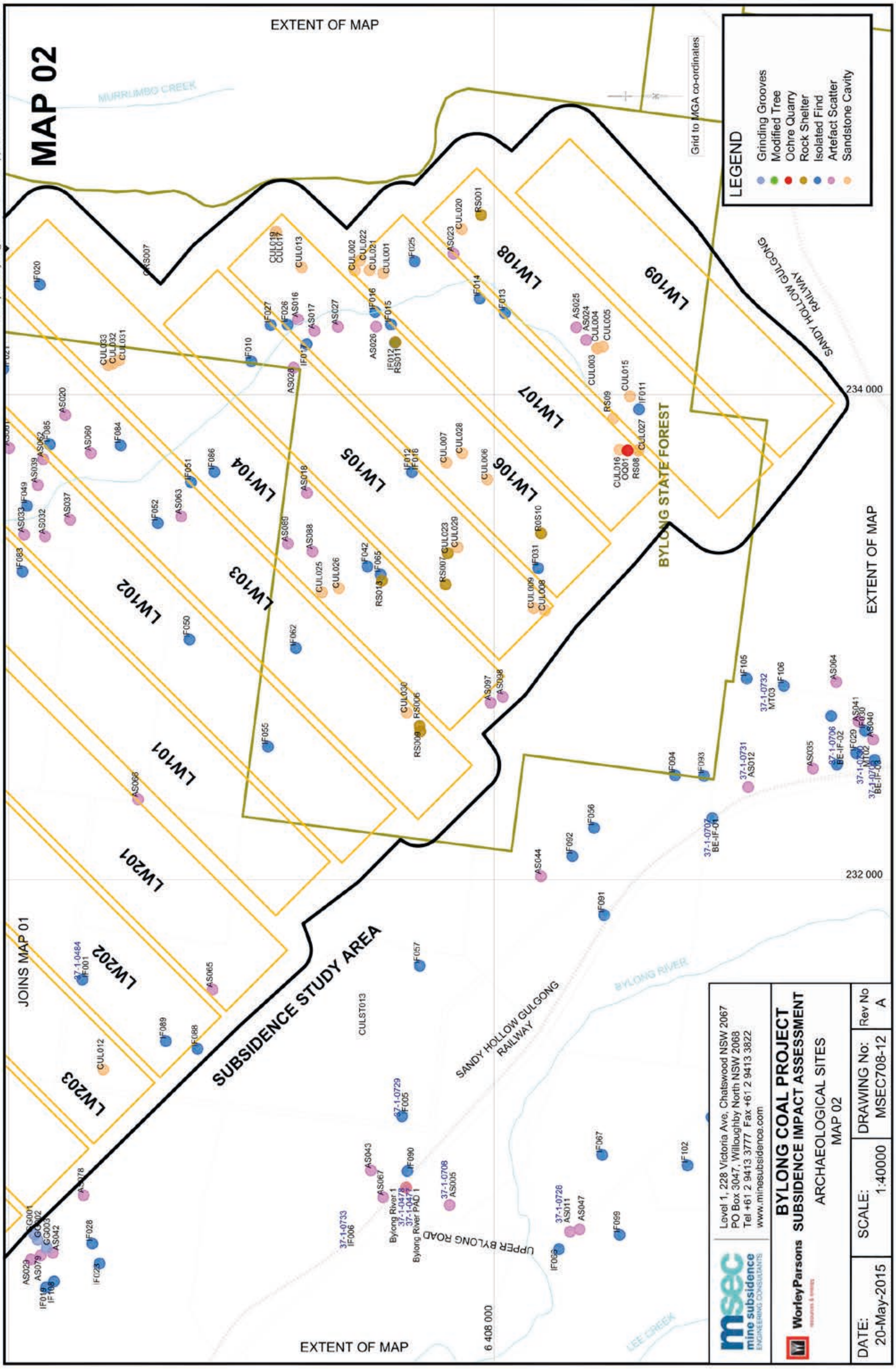
SUBSIDENCE IMPACT ASSESSMENT
ARCHAEOLOGICAL SITES
MAP 01
DATE: 20-May-2015
SCALE: 1:40000
DRAWING No: MSEC708-11
Rev No A
LEGEND
Grinding Grooves
Modified Tree
Ochre Quarry
Rock Shelter
Isolated Find
Artefact Scatter
Sandstone Cavity
MAP 01
EXTENT OF MAP
GOULBURN RIVER NATIONAL PARK
BYLONG VALLEY WAY
SUBSIDENCE STUDY AREA
JOINS MAP 02
Quarry
LW101
LW102
LW103
LW104
LW201
LW202
LW203
LW204
LW205
LW206
DRY CREEK
SANDY HOLLOW GULGONG RAILWAY
WOLLAR ROAD
Grid to MGA co-ordinates
232 000
230 000
6 412 000
6 410 000


MAP 02
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EXTENT OF MAP
MURRUMBO CREEK
Grid to MGA co-ordinates
LEGEND
Grinding Grooves
Modified Tree
Ochre Quarry
Rock Shelter
Isolated Find
Artefact Scatter
Sandstone Cavity
SANDY HOLLOW GULGONG RAILWAY
BYLONG STATE FOREST
SUBSIDENCE STUDY AREA
JOINS MAP 01
UPPER BYLONG ROAD
BYLONG RIVER
LEE CREEK
LW101
LW102
LW103
LW104
LW105
LW106
LW107
LW108
LW109
LW201
LW202
LW203
234 000
232 000
6 408 000
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ARCHAEOLOGICAL SITES
MAP 02
DATE: 20-May-2015
SCALE: 1:40000
DRAWING No: MSEC708-12
Rev No A

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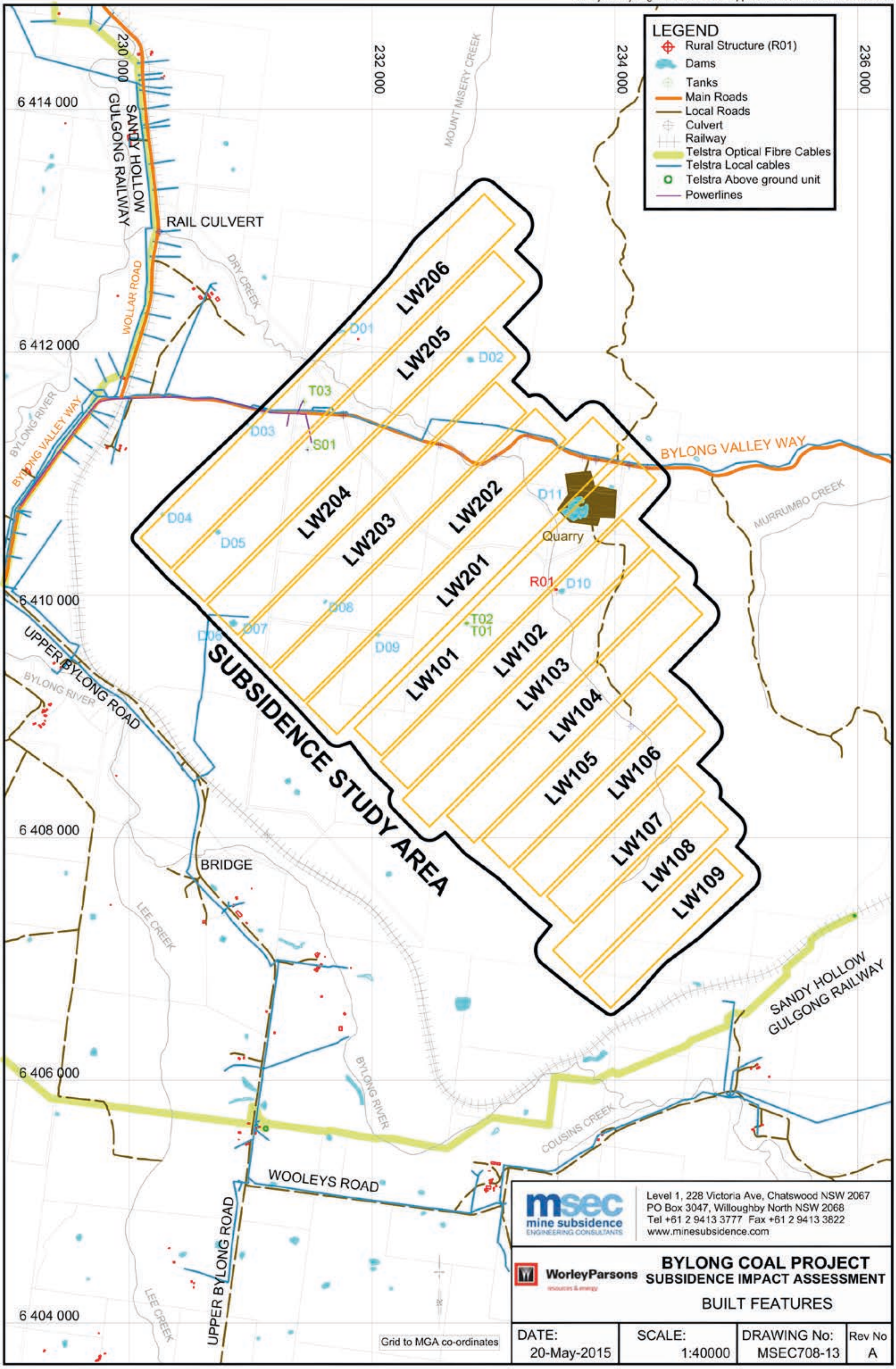

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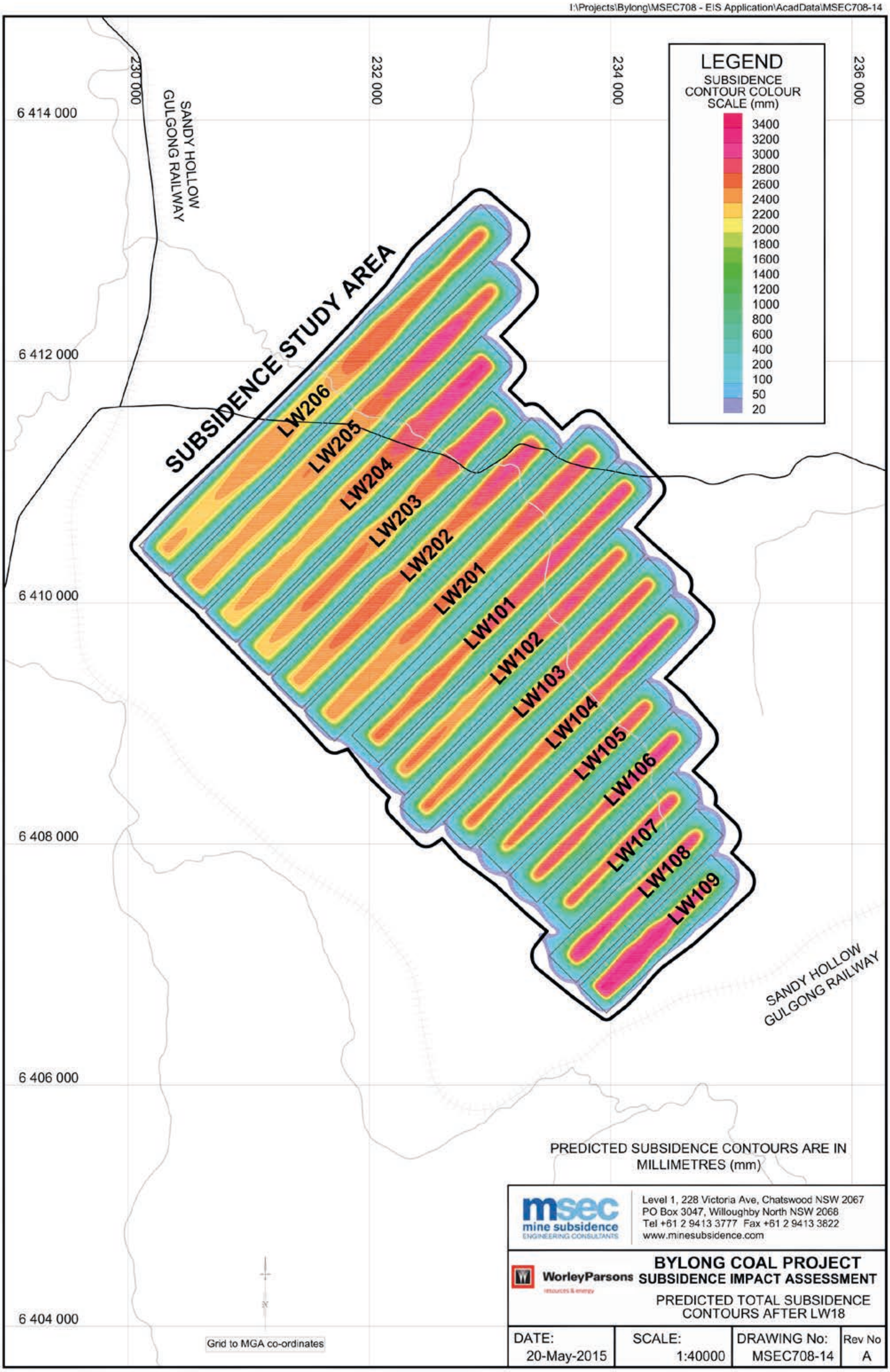
BYLONG COAL PROJECT
SUBSIDENCE IMPACT ASSESSMENT
BUILT FEATURES

DATE:	SCALE:	DRAWING No:	Rev No
20-May-2015	1:40000	MSEC708-13	A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230 000
232 000
234 000
236 000
6 414 000
6 412 000
6 410 000
6 408 000
6 406 000
6 404 000
SANDY HOLLOW GULGONG RAILWAY
SUBSIDENCE STUDY AREA
LW206
LW205
LW204
LW203
LW202
LW201
LW101
LW102
LW103
LW104
LW105
LW106
LW107
LW108
LW109
SANDY HOLLOW GULGONG RAILWAY
LEGEND
SUBSIDENCE CONTOUR COLOUR SCALE (mm)
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
100
50
20
PREDICTED SUBSIDENCE CONTOURS ARE IN MILLIMETRES (mm)
Grid to MGA co-ordinates
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WorleyParsons resources & energy
BYLONG COAL PROJECT
SUBSIDENCE IMPACT ASSESSMENT
PREDICTED TOTAL SUBSIDENCE CONTOURS AFTER LW18
DATE: 20-May-2015
SCALE: 1:40000
DRAWING No: MSEC708-14
Rev No A