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18 June 2013

Director General
Department of Trade and Investment- Division of Resources and Energy
PO Box 344
Hunter Regional Mail Centre NSW 2310

Attention: Mr Paul Langley

Dear Paul,

END OF PANEL REPORT- STAGE 2 LONGWALL A5a

Austar Coal Mine Pty Ltd (Austar) completed extraction of Longwall A5a on 18 February 2013. Austar submits this End of Panel report for Longwall A5a in accordance with Condition 18 of Subsidence Management Plan (SMP) Approval for Austar Coal Mine Longwall A5a (File No. 10/22, approved on 27 April 2011).

This report encompasses the monitoring undertaken during the extraction of Longwall A5a. There has been no abnormal behavior that has required particular review. The report consists of the analysis from:

- Appendix 1: Surface subsidence monitoring program;
- Appendix 2: Public safety monitoring and management plan;
- Appendix 3: Vibration monitoring plan
- Appendix 4: Groundwater monitoring as per the Site Water Management Plan (SWMP)
- Appendix 5: Surface water monitoring per the SWMP
- Appendix 6: Ecological monitoring per the Stage 2 Ecological Monitoring Program

In summary, surface subsidence was of the order of 1210mm and at its maximum over the chain pillar as predicted. No perceptible impacts to the environment or increase in public safety risk have occurred. Ground and groundwater behaviour indicated by the monitoring is as predicted by the assessment reports.

Please contact myself on (02) 4993 7293 if you require further information regarding any of the data or interpretations summarised in this report.

Yours faithfully,

Adrian Moodie
Technical Services Manager

Austar Coal Mine

Appendix 1: Surface Subsidence Monitoring

1.1 Monitoring Results Summary

Subsidence monitoring has been undertaken in accordance with the Subsidence Monitoring Programme. Summary results are displayed below and compared against maximum predicted and upper bound subsidence from MSEC Report MSEC275 which supported the original SMP application; MSEC Report MSEC391 which supported a modification to the Longwall A5 geometry (shortened length, increased void width and chain pillar width); MSEC Report MSEC417 which supported the Proposed Longwall A5a; and MSEC Report MSEC529 which supported a modification to the commencing end of Longwall A5a. Included in **Table 1 and 2** are the Maximum Predicted and Upper Bound subsidence parameters. The Maximum Predicted case was determined using the calibrated Incremental Profile Method and the Upper Bound case was determined by scaling up the predicted systematic subsidence parameters such that the maximum subsidence of 65% of effective extracted seam thickness is achieved above the longwalls.

Table 1: Actual vs Maximum Predicted Subsidence Parameters

LW	Maximum Predicted Cumulative Subsidence (mm)	Actual Cumulative Subsidence	Maximum Predicted Cumulative Tilt (mm/m)	Actual Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Actual Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)	Actual Cumulative Compressive Strain (mm/m)
After A3	295	157	1.5	0.7	0.2	0.2	0.4	0.4
After A4	1130	850	5.1	5.4	0.7	<1.0	1.7	<1.0
After A5	1380	1150	5.6	7.0	1.0	2.2	2.0	3.4
After A5a	1490	1210	5.8	7.6	0.75	2.8	1.8	3.3

Note: Predictions for strain after A5a have been converted from curvature predictions from the MSEC529 using the relationship strain = 15 x curvature. The factor of 15 was adopted (rather than 10 which is typically used in the Newcastle Coalfield) due to the higher depths of cover and better correlation with the local monitoring at Austar and Ellalong. .

Table 2: Actual vs Upper Bound Subsidence Parameters

LW	Upper Bound Cumulative Subsidence (mm)	Actual Cumulative Subsidence	Upper Bound Cumulative Tilt (mm/m)	Actual Cumulative Tilt (mm/m)	Upper Bound Cumulative Tensile Strain (mm/m)	Actual Cumulative Tensile Strain (mm/m)	Upper Bound Cumulative Compressive Strain (mm/m)	Actual Cumulative Compressive Strain (mm/m)
After A3	630	157	2.9	0.7	0.4	0.2	0.8	0.4
After A4	2335	850	9.4	5.4	1.1	<1.0	3.1	<1.0
After A5	2955	1150	10.9	7.0	1.2	2.2	3.7	3.4
After A5a	3000	1210	12	7.6	1.2	2.8	3.75	3.3

Further detailed analysis of the individual monitoring lines can be found in the attached report '*MSEC631 Longwall A5a End of Panel Subsidence Review Report'* as attached.

1.2 Analysis of Monitoring Results

See attached report *MSEC631 Longwall A5a End of Panel Subsidence Review Report*.

1.2.1 Comparison to Impact Assessment Criteria

Chapter 5 of the subsidence prediction report (MSEC417) details the anticipated impacts on natural features and surface infrastructure. The following table summarises these impacts and makes comment as to the level of impact created by A3 to A5a subsidence as compared to maximum predicted subsidence parameters.

Table 3- Impact Assessment Criteria Post Longwall A5a Mining

Item	Subsidence Impact Assessment	Actual Observation / Occurrence	Action
Cracking of alluvial creek beds	Strains 0.7 to 1.5mm/m with minor cracking possible around perimeters of the longwalls. Cracks only shallow and would infill with material.	Strains <1.0mm/m. No observed cracking.	Nil
Drainage lines	Potential for shallow cracking around tensile zones of perimeter of longwalls	None observed.	Nil
Steep slopes (south-eastern side A3 and above A4)	Tilts 3.7mm/m, Strains ≤1.0mm/m after LWA5a. Potential for minor cracking and unlikely to cause any slippage event after full subsidence.	Tilt <2.0mm/m, Tensile Strain 1.5mm/m potentially as a result of downward slope movement near top of hill. In ground water tank reported to be damaged in vicinity.	Temporary water supply established. Continue to monitor.
Nash Lane	After LWA5a 1000mm, Tilt 3.7mm/m, Strains 0.3-1.0mm/m. No impact on serviceability due to LWA5a subsidence	Nearby <0.5mm/m strain, Tilt ~3.0mm/m No impact. Road serviceable. No observed cracking.	Nil
Services	Unlikely to create any significant impact even under full subsidence.	No impact observed.	Nil
Rural building structures	All Category A Tilt and Category 0 to 1 for Strain after LWA5a (Max Predicted)	Tilt Category B in vicinity of structure A04 and all Strains less than Category 2. Whilst no tilt related impacts reported around structure A04, an in ground concrete water tank nearby (Austar owned) has been reported to be damaged and leaking.	Temporary water supply established. Continue to monitor for impacts of tilt and strain in vicinity of structures A04
Other structures	Minimal impact	In ground concrete water tank (Austar owned) has been reported to be damaged and leaking.	Temporary water supply established.

1.2.2 Comparison to Previous Panels

Monitoring of subsidence parameters and impacts for the mining of two Top Coal Caving panels in Stage 1 confirmed Maximum Predicted Subsidence to be an accurate prediction of actual subsidence. The same observation has been recorded for extraction of A3, A4, A5 and A5a in the Stage 2 mining area. Minimal physical impacts were observed in Stage 1 which is the same for the extraction to date in Stage 2. In summary parameters and impacts for A3 to A5a combined are in line with previous mining and impact assessments.

1.2.3 Comparisons to Predictions in SMP

See sections 1.2 and 1.2.1 above.

1.3 Trends in Monitoring Results

Monitoring data is revealing trends that match predicted profiles, with subsidence parameters around maximum predicted and subsidence being controlled by compression of the strata surrounding the chain pillars. The most recent survey conducted for A5a was approximately 3 weeks after the completion of mining. The trends in the monitoring data and overall levels of subsidence indicate that final subsidence parameters due to A5a will be less than maximum predicted with only a minor exceedence in tilt (~2mm/m, or 0.2%) and strain (~0.5mm/m tensile) observed. The area of increased tilt on the western side of Longwall A3 is believed to be associated with stronger strata locally reducing subsidence as it cantilevers from the adjacent solid strata further over the extracted void than predicted. The one location of increased strain (not attributable to disturbed markers) appears potentially associated with downward slope movement near the top of a hill creating some increased tensile strain. This coincides with the reported cracking of an in-ground concrete water tank located on the Austar owned property in the vicinity of this measurement.

1.4 Subsidence Management Actions

The only action required to be undertaken to date has been the establishment of a temporary water supply on the Austar owned property where the in-ground concrete water tanks were noted as leaking.

On the same Austar owned property it has been reported for one farm dam, which has two overflow weirs, that dam overflow water used to drain from one particular weir, and now favours the other weir. There has been no action required with this dam to date.

No other impact to structure or natural features has been observed or reported. Subsidence monitoring should continue per the Subsidence Monitoring Strategy with particular attention to final tilts and strains in the vicinity of the hill located over the A3 to A4 chain pillar where slightly increased tilts and strains have been recorded. As mining has now been completed in the Stage 2 area, subsidence is anticipated to be complete within the next 12 months based on the monitoring from Stage 1.

Appendix 2: Public Safety Monitoring and Management Plan

2.0 Summary

During routine subsidence monitoring and on occasions the area was being accessed for other purposes the following items were inspected as per the Public Safety Management Plan:

- Surface cracking;
- Surface humps;
- Step changes in landform;
- Serviceability of access tracks;
- Slope or boulder instability;
- Other sign of subsidence.

Of all the inspection occasions no evidence of any of the above could be observed (Also refer to **Table 3**). Correspondence with the landholders in the area surrounding longwalls A3 to A5a also confirmed that no safety issues manifested and no physical signs of subsidence were observed other than some minor plasterboard cracking around an archway and damage to an in-ground water tank.

Appendix 3: Vibration Monitoring

3.1 Monitoring Results Summary

Vibration monitoring has been undertaken in accordance with the Vibration Monitoring Plan for Longwall Panels A3, A4, A5 and A5a.

Monitoring was undertaken at locations V5 and JB during extraction of LWA5a (refer to **Figure 3.1**).

Monitors were set to monitor vibration continuously, and also to record a waveform when vibration exceeded 1mm/sec in any axis. Results of vibration monitoring greater than 1mm/sec are shown in **Figures 3.2** and **3.3**. Periods which recorded vibration less than 1mm/sec are not shown on the graphs.

Guideline values for annoyance (*Assessing Vibration: a technical guideline, DECC February 2006*), and for minimal risk of cosmetic damage (*BS7385:1993*) are included with the graphed results.

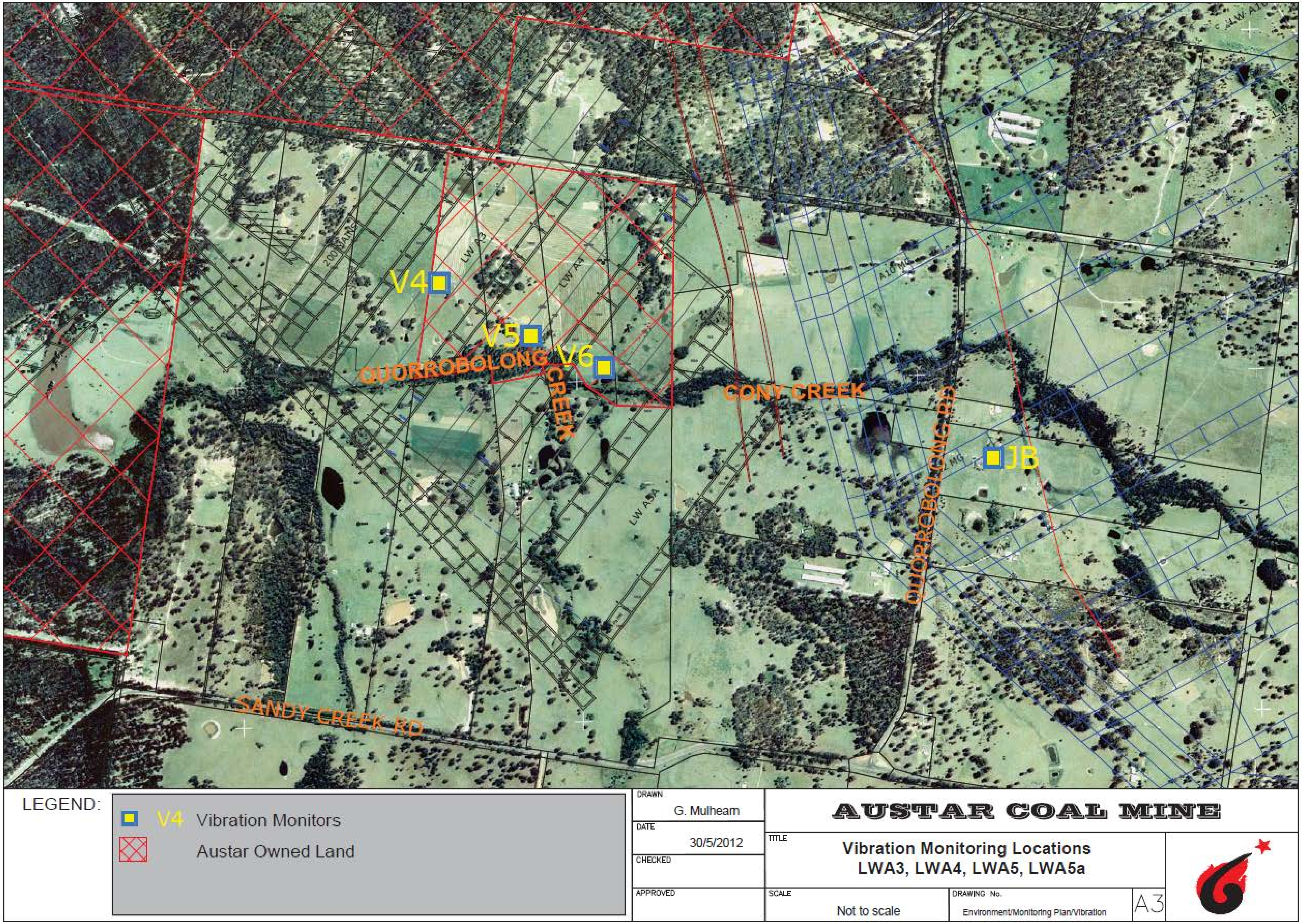


Figure 3.1 Austar Vibration Monitoring Network

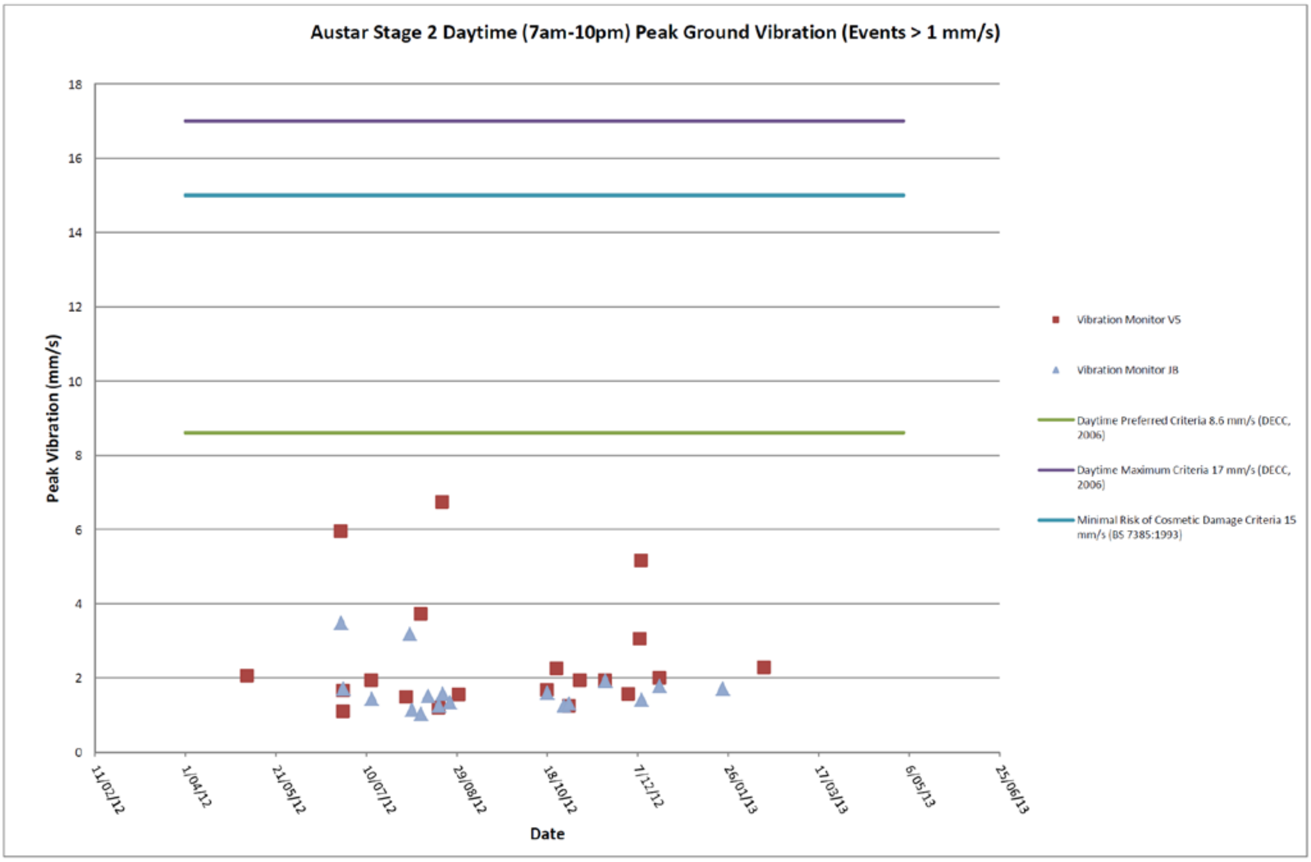


Figure 3.2 Vibration Monitoring Results – Daytime

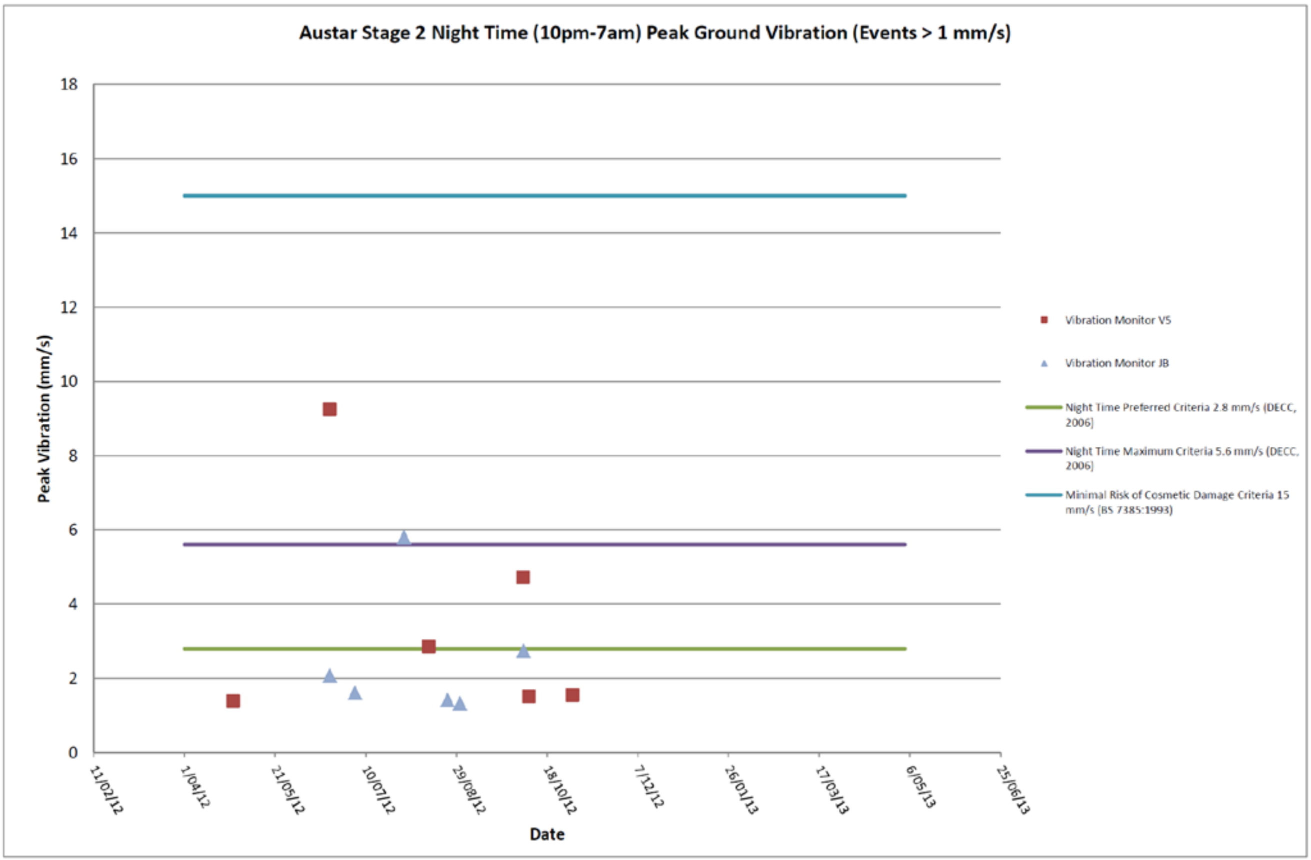


Figure 3.3 Vibration Monitoring Results – Night

3.2 Analysis of Monitoring Results

Results indicate that vibration from extraction of Longwall A5a has been event based in nature, typically generated by strata failures from material overlying the mining area. The majority of vibration events are less than 4 mm/sec, with only 2 events greater than 6 mm/sec over the period of extraction of A5a. There were no events greater than 9.25 mm/sec.

Over the period of monitoring (April 2012 to May 2013), 2 events exceeded the maximum criteria for human response to vibration during the night period. Two exceedances of the maximum criteria over the extraction of Longwall A5a are not considered to be significant. It is important to note that the vibration criteria are non-mandatory (*DECC 2006*) so are used as a monitoring tool to assess possible annoyance. Also, due to the vibration being strata generated, the timing of vibration events cannot be controlled, as would be the case in say pile driving, so operational controls are not feasible in this case.

No events exceeded the guideline value where a minimal risk of cosmetic damage to building structures may occur (15mm/sec).

Ditton Geotechnical Services (DGS) conducted a review of adequacy of the Stage 2 Vibration Monitoring Program as part of the Independent Environmental Audit Austar Coal Mine November 2011 (Trevor Brown and Associates, April 2012). DGS noted:

"The only issue of concern from this audit period is whether the frequency of vibration events is becoming a significant issue with local residents. It is noted that the magnitude of the vibrations do not exceed minimum limits for cosmetic damage and it is not practical to impose operational constraints on the mine to reduce the frequency of the vibration events from occurring."

As noted in the DGS comment, it is not practical to impose operational constraints on the mine to reduce vibration events. To manage vibration, Austar has continued to provide adequate community access to vibration monitoring information in regular underground mine status reports to landholders over the active Stage 2 mining area. These status reports include vibration monitoring and mining status information to affected residents.

3.3 Trends in Monitoring Results

There were fewer vibration events measured at >1mm/sec between completion of Longwall A5 and commencement of Longwall A5a than during the extraction period. The last vibration event >1mm/sec was recorded on 15 February 2013. Mining of longwall A5a was concluded on 17 February 2013. No further events have been recorded since A5a was completed.

Results are similar in magnitude to those from the previous Longwall A5 extraction, with only two events above 6mm/sec.

3.4 Management Actions

No management actions relating to vibration have been necessary. Vibration monitoring should continue for Stage 3 as per the Stage 3 Noise and Vibration Management Plan.

Appendix 4: Ground Water Monitoring

4.1 Monitoring Results Summary

Groundwater monitoring continued in established alluvial monitoring wells AQD1073a, WBH1, WBH2 and WBH3, and in the sandstone water bearing zone in the Branxton formation in monitoring well NER1010 during longwall extraction of A5a.

Water level monitoring results are presented with rainfall data in **Figure 4.1** for the monitoring period April 2012 to May 2013. The location of groundwater monitoring wells is shown in **Figure 4.2**.

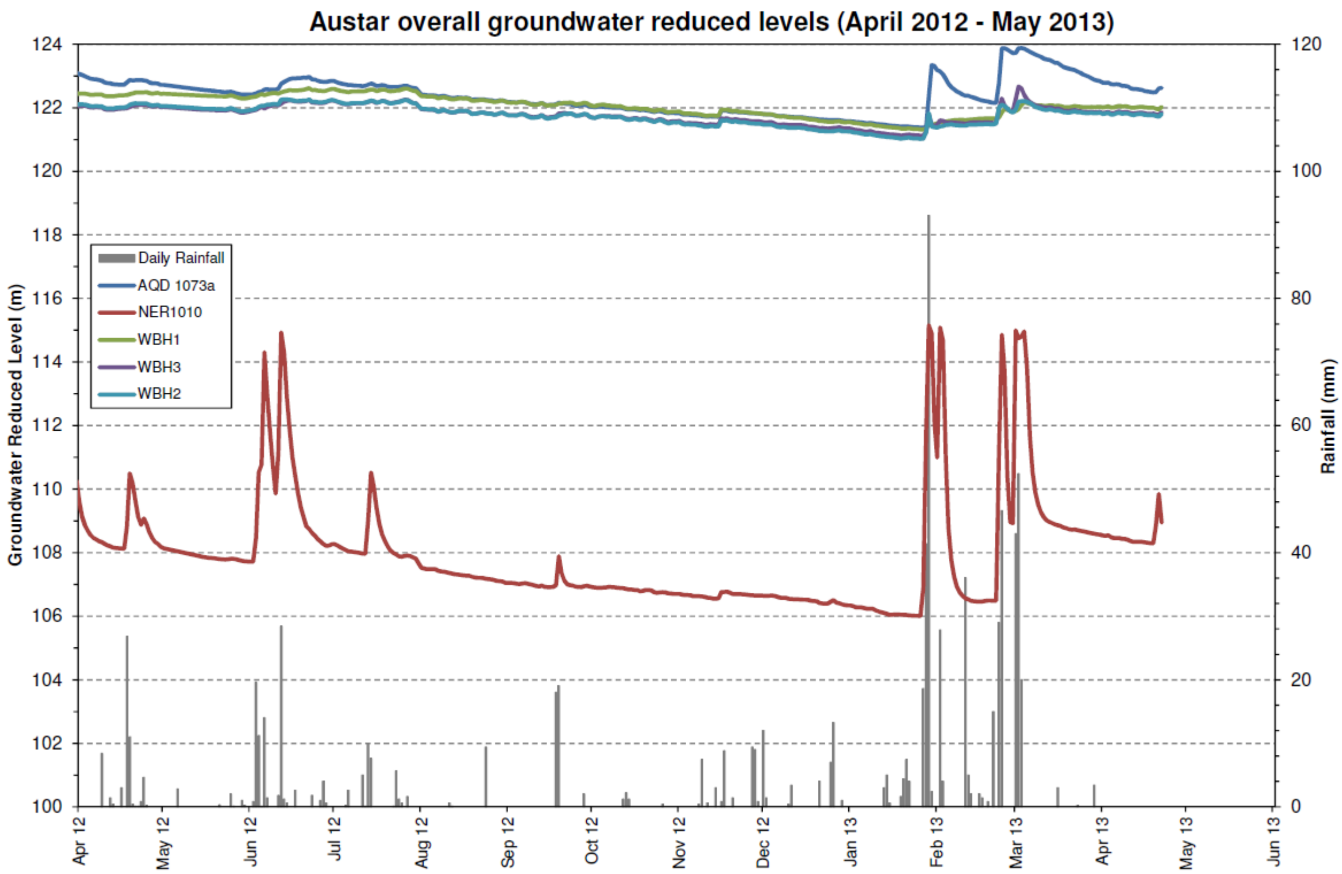


Figure 4.1 – Groundwater monitoring results

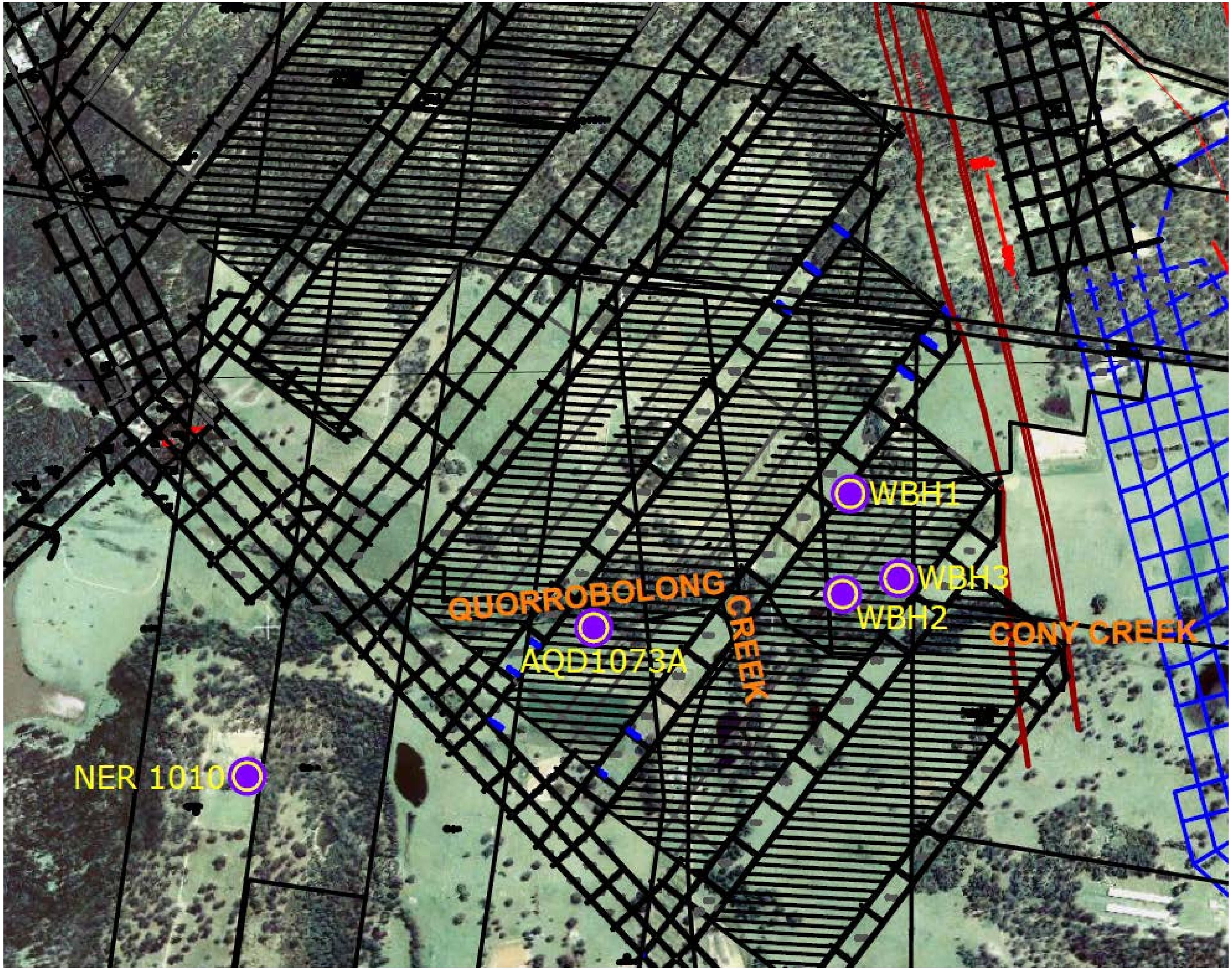


Figure 4.2 Austar Groundwater Monitoring Network

4.2 Analysis of Monitoring Results

There are no criteria for groundwater monitoring results in the Site Water Management Plan. Trends are discussed below.

4.3 Trends in Monitoring Results

Water level depth in the monitoring wells closely correlates with rainfall data. June 2012 was a wetter than average month with approximately 89mm of rain falling, and a correlating increase in groundwater levels is observed for the month (**Figure 4.1**). August to December 2012 were drier than average months (145mm below average) and groundwater levels dropped slightly. January to March 2013 were significantly wetter than the long term average (194mm above average) and **Figure 4.1** shows the groundwater levels spiking with the rainfall events and plateauing above drier period levels.

4.4 Management Actions

No management actions relating to groundwater level have been necessary. Groundwater monitoring should continue.

Appendix 5: Surface Water Monitoring

5.1 Monitoring Results Summary

Surface water monitoring was conducted in Quorrobolong Creek (locations SWQ1, SWQ2, and SWQ3) and Coney Creek (SWC1) in accordance with the Site Water Management Plan. Monitoring in these water courses is undertaken upstream and downstream of the Stage 2 longwall mining area. The confluence of these creeks resides above the Stage 2 mining area. Longwall A5a was extracted beneath Quorrobolong and Coney Creeks between May 2012 and February 2013. Monitoring locations are presented in **Figure 5.1.**

Water samples are analysed for pH, electrical conductivity (EC), total suspended solids (TSS) and iron (Fe). Results of monitoring are presented in **Figures 5.2** to **5.5**.

Where the creek was dry at the time of sampling, no sample results appear in the relevant graph.

Figure 5.1 Austar Surface Water Monitoring Network

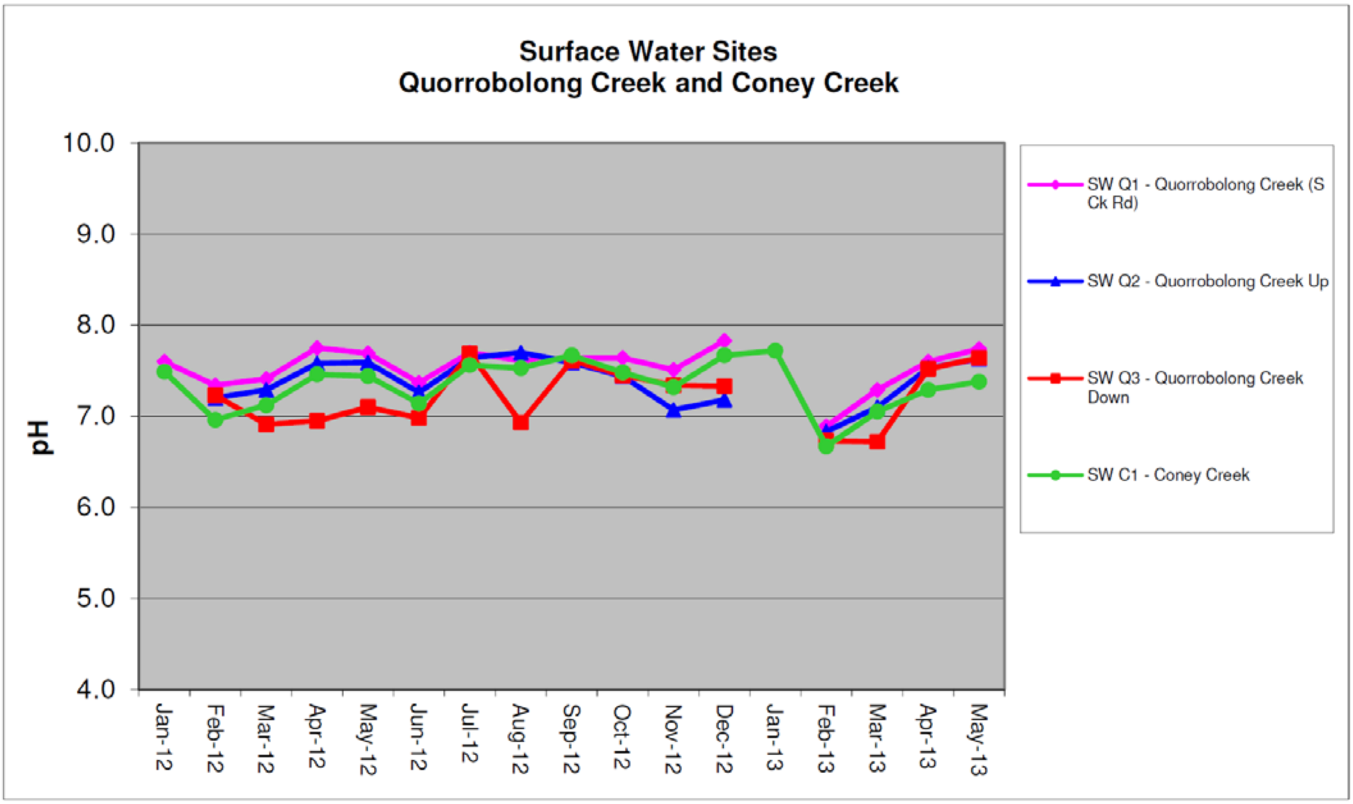


Figure 5.2 – Surface water results – pH

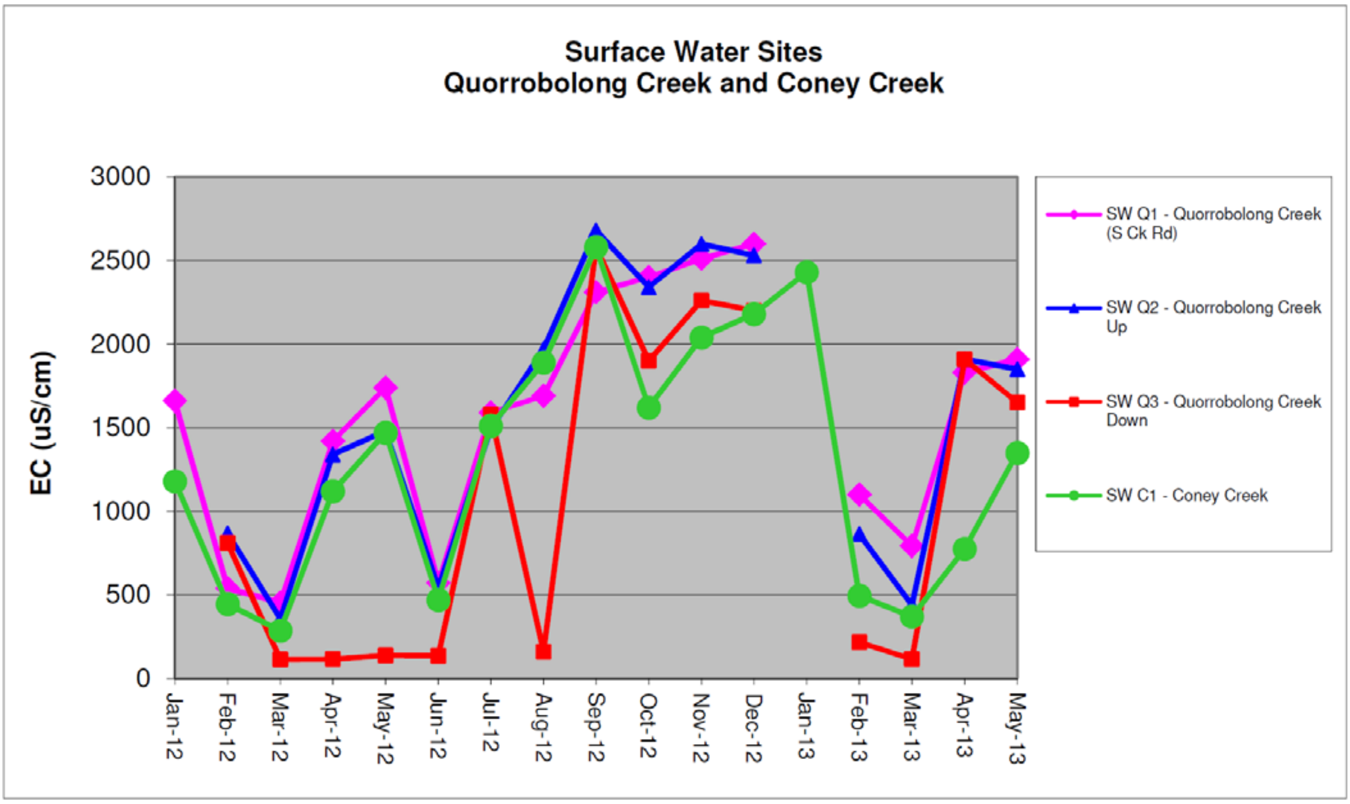


Figure 5.3 – Surface water results - EC

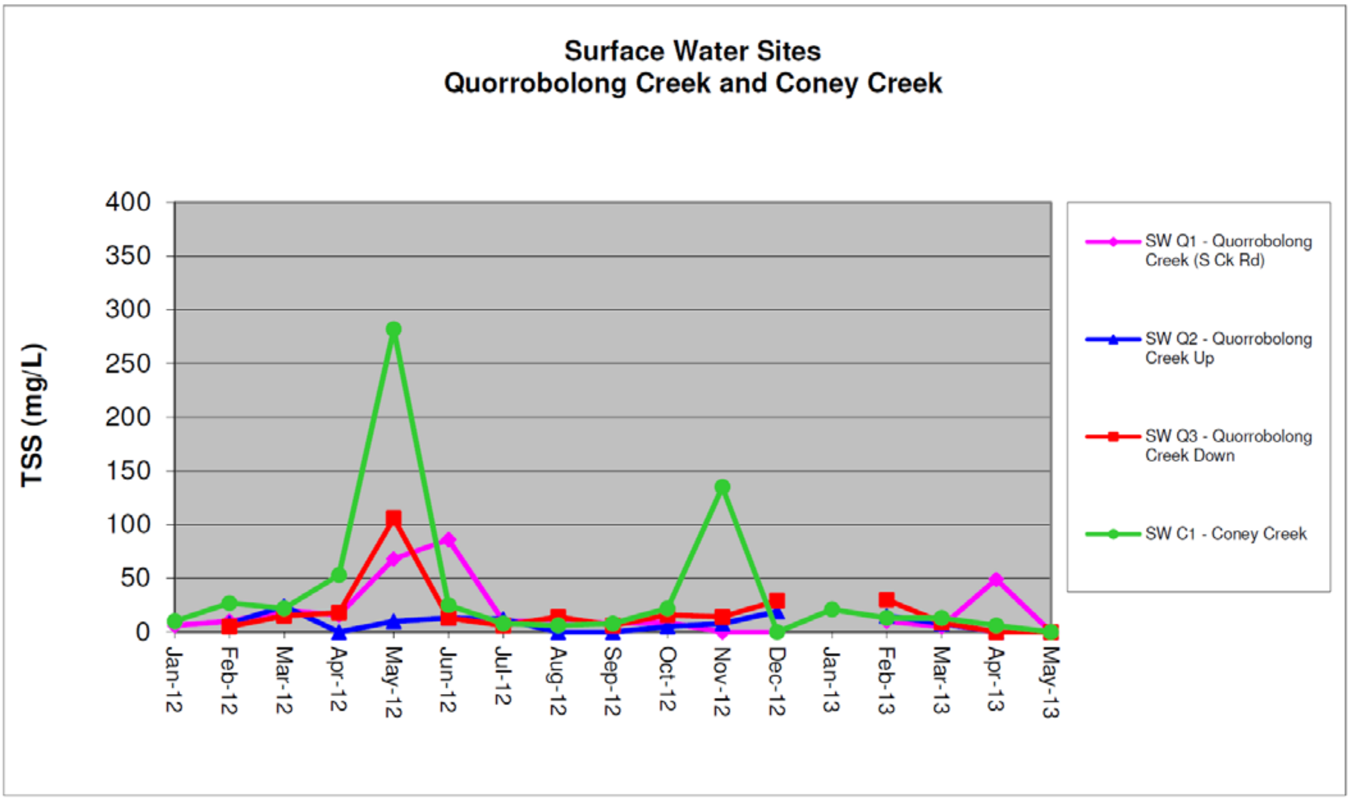


Figure 5.4 – Surface water results - TSS

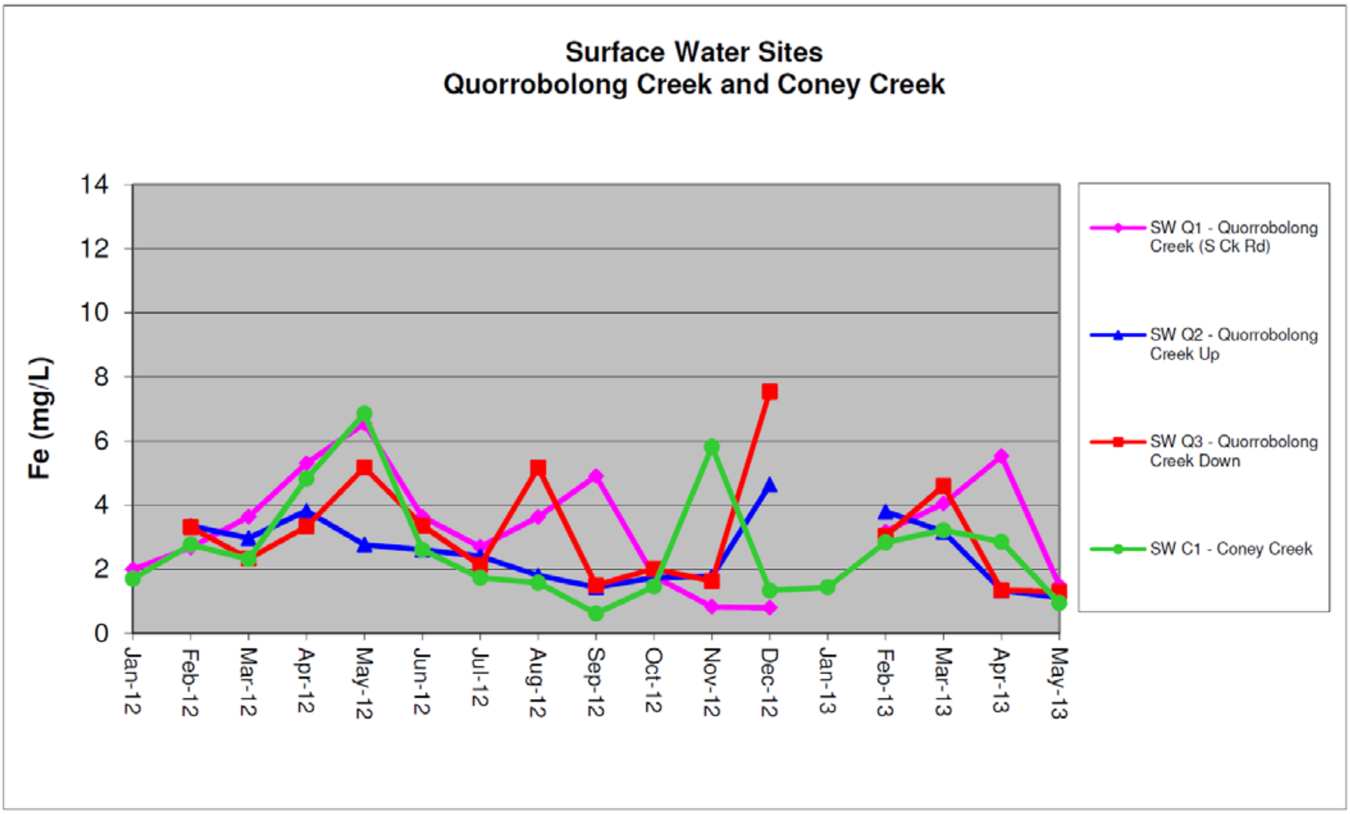


Figure 5.5 – Surface water results – Fe

5.2 Analysis of Monitoring Results

There are no criteria or predictions for surface water results. pH remained within the range 6.5−8.0, the pH of most natural freshwaters (ANZECC, October 2000), throughout mining of LWA5a (April 2012 to May 2013). EC was variable, however similar at all sampling locations except SWQ3 throughout mining of LWA5a. Monitoring location SWQ3 recorded periods of low EC from March – June and August 2012, which also corresponded with a neutral pH. TSS and Fe were variable, but generally trending similarly for all sampling locations.

The results from Coney Creek and Quorrobolong Creek both upstream and downstream of the longwall LWA5a extraction area have been similar. There appears to be no effect from longwall extraction in LWA5a.

5.3. Trends in Monitoring Results

pH has remained relatively steady during 2012-2013. EC was variable in results but similar between sites, with the exception of SWQ3 which remained lower than other sites during March – June and August 2012. TSS and Fe were variable, but generally trending similarly for all sampling locations. TSS did record noticeably higher results than the other locations at SWC1 in May and November 2012. Both were lower than average rainfall periods.

5.4 Management Actions

No management actions relating to surface water have been necessary. The monitoring program should continue.

Appendix 6: Ecological Monitoring

6.1 Monitoring Results Summary

An ecological monitoring program has been implemented both prior to and during Stage 2 longwall mining. Six ecological monitoring sites are monitored on a bi-annual basis in the season of spring and autumn, with a baseline monitoring survey undertaken in 2008, and ongoing monitoring being undertaken during mining of Longwall A3, A4, A5 and A5a.

The monitoring program incorporates three key survey methods:

- permanent vegetation sampling quadrats;
- ecological condition assessment and
- photographic monitoring.

Over five years of monitoring, three permanent quadrats have been set up for semi-quantitative vegetation sampling. These are sites 1, 2 and 3. Vegetation quadrat sampling, ecological condition assessment and photo monitoring were carried out at each of these sites. Three permanent sites (4, 5 and 6) were set up for condition assessment and photo monitoring only. Monitoring locations are presented in **Figure 6.1**.

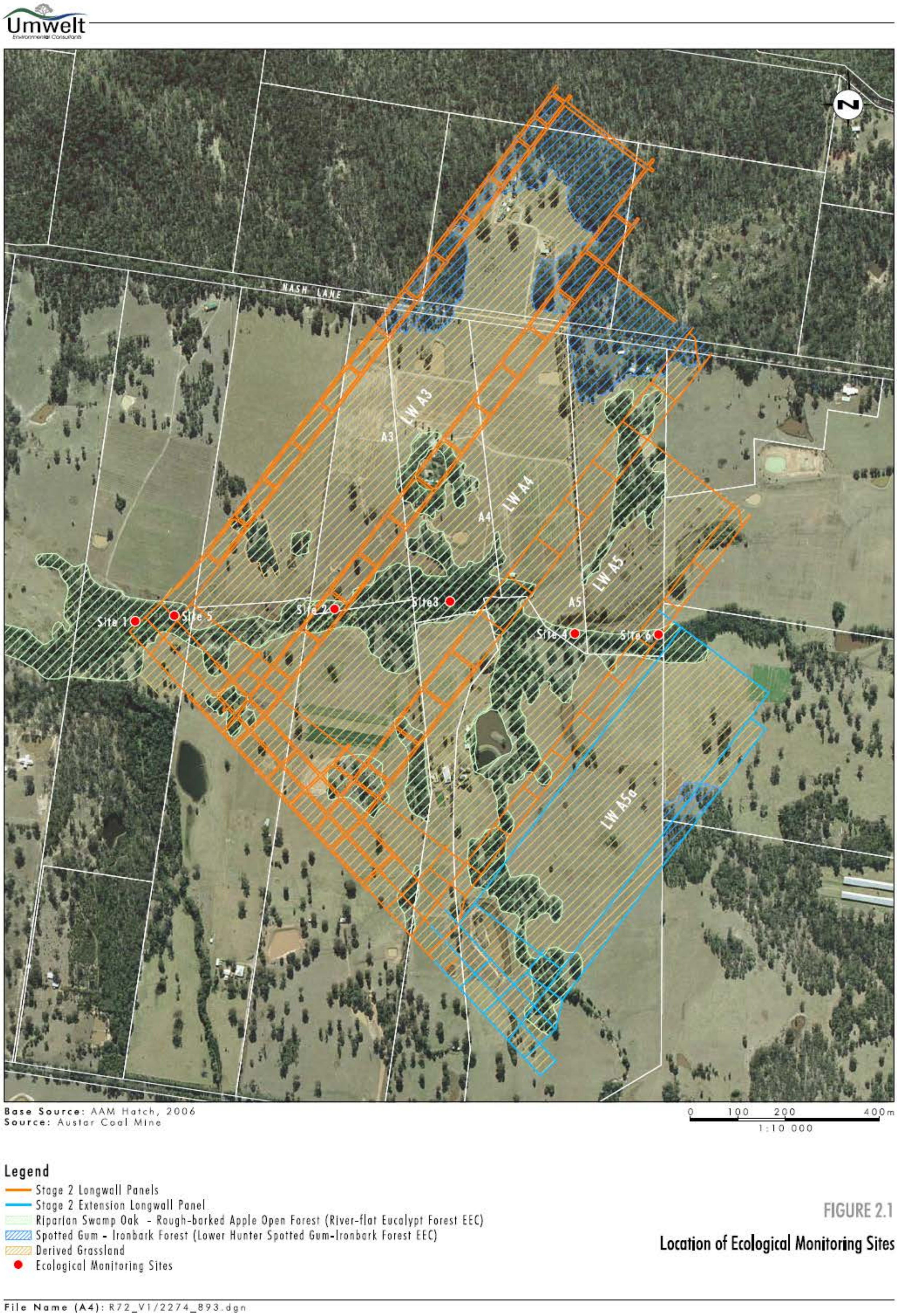


Figure 6.1 – Ecological Monitoring Locations

6.2 Analysis of Monitoring Results

The key points, as summarised in the *2012 Ecological Monitoring Report for Stage 2 Longwalls* (Umwelt, April 2013), of the results arising from the data obtained from the monitoring surveys undertaken to date are detailed below.

- Longwall mining has now passed under monitoring Sites 1, 2, 3, 4, 5 and 6. Ongoing monitoring will consequently be tracking potential impacts resulting from longwall mining.
- None of the sites currently appear to be experiencing impacts as a result of longwall mining (in particular surface cracking, subsidence, or resulting fluctuations to species numbers).
- No obvious increase in rates of erosion or bank stability has been recorded at any of the sites monitored, or elsewhere in the Study Area.
- No obvious increase in dieback has been recorded at any of the sites monitored; however areas of dieback have been recorded along the length of the creek outside of monitoring areas that may be an unintentional result of weed control works.
- Good levels of regeneration of canopy species were observed along the length of the creekline and are considered likely to be a result of stock exclusion from the riparian zone.
- The photo monitoring indicates there have been no obvious visual changes to the health of the vegetation since the baseline photos were taken.
- The biggest threat to the ecological integrity of the sites continues to be weed infestation by blackberry (*Rubus fruticosus* sp. agg.) and wandering Jew (*Tradescantia fluminensis*).
- There has been a significant reduction in the ground coverage of wandering Jew at Site 2, as a direct result of a weed control program conducted by Austar.

6.3 Trends in Monitoring Results

To date there is no evidence of any impacts on ecological features as a result of longwall mining (Umwelt, April 2013).

6.4 Management Actions

Despite the fact there are no discernable impacts on the ecological values of the Study Area that could be associated with the underground mining, there are existing threats that require appropriate management. In particular, appropriate weed management which will assist in the conservation and enhancement of the ecological values of the riparian vegetation which comprises the River-flat Eucalypt Forest EEC (Umwelt, April 2013).

Monitoring of all sites in the Study Area should continue for at least five years from the commencement of mining to ensure that any adverse impacts are detected and appropriately managed (Umwelt, April 2013).

REPORT: END OF PANEL SUBSIDENCE MONITORING REVIEW REPORT

msec
mine subsidence
ENGINEERING CONSULTANTS

Austar Coal Mine:

Stage 2 – Longwall A5a

Longwall A5a End of Panel Subsidence Monitoring Review Report

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
01	Draft Issue	JB	-	22nd May 13
A	Final Issue	JB	PD	17th Jun 13

Report produced to:- Support the End of Panel Report for Longwall A5a which will be issued to the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).

Associated reports:- MSEC275 (Revision C) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Austar Longwalls A3 to A5 in Support of a SMP Application (February 2007).

MSEC417 (Revision C) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on the Natural Features and Surface Infrastructure Resulting from the Extraction of the Proposed Longwall A5a in Stage 2 at the Austar Coal Mine (July 2010).

MSEC529 (Revision A) – Austar Stage 2 - Longwall A5a Variation to Commencing End (December 2011).

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)

CONTENTS

LIST OF TABLES, FIGURES AND DRAWINGS

Tables

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

Figures

Figures are prefixed by the letter of the appendix in which they are presented.

Drawings

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

1.1. Background

Austar Coal Mine Pty Limited (Austar) has completed the extraction of Longwall A5a in Stage 2 at Austar Coal Mine, which is located in the Newcastle Coalfield in New South Wales. The layout of the longwalls in Stage 2 is shown in Drawing No. MSEC631-01, in Appendix B. The extraction of Longwall A5a commenced on the 22nd May 2012 and was completed on the 18th February 2013.

Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by Austar to prepare subsidence predictions and impact assessments for the Stage 2 Longwalls A3 to A5. Report No. MSEC275 (Revision C) was issued in February 2007, which supported the SMP Application for these longwalls.

Austar then proposed to extract an additional longwall, referred to as Longwall A5a, on the southern side of the existing series within Stage 2. Report No. MSEC417 (Revision C) was issued on the 20th July 2010 in support of the application for the proposed additional longwall.

Austar also proposed to modify the commencing end of Longwall A5a by extending the commencing (i.e. north-eastern) end by 127 metres. Report No. MSEC529 (Revision A) was issued on the 5th December 2011 in support of this modification.

Industry and Investment NSW (now known as DTIRIS) approved the Subsidence Management Plan for Longwall A5a on the 27th April 2011. The Department of Planning and Infrastructure approved the modification of DA 29/95 on the 7th December 2010.

In accordance with Condition 18 of the Subsidence Management Plan Approval for Longwall A5a, this report provides comparisons between the observed and predicted subsidence movements for the monitoring lines in Stage 2 resulting from the extraction of this longwall.

1.2. Mining Geometry

The layout of the longwalls in Stage 2 is shown in Drawing No. MSEC631-01, in Appendix B. The overall length of Longwall A5a is 862 metres and the overall void width, including first workings, is 237 metres. The width of the solid chain pillar between Longwalls A5 and A5a is 60 metres.

The depth of cover to the Greta Seam, directly above Longwall A5a, varies between a minimum of 527 metres at the northern most corner of the longwall and a maximum of 557 metres at the southern most corner of the longwall.

The thickness of the Greta Seam, within the extent of Longwall A5a, varies between a minimum of 5.5 metres at the finishing (i.e. south-western) end of the longwall and a maximum of 6.3 metres at the commencing (i.e. north-eastern) end of the longwall.

The Longwall Top Coal Caving (LTCC) equipment extracted the bottom 3.2 metres of the seam and recovered on average 85 % of the top coal from the commencing end up to chainage 485 metres, then recovered on average 100 % of the top coal up to chainage 195 metres, and then recovered no top coal through to the longwall finishing end.

2.1. Introduction

The mine subsidence movements resulting from the extraction of Austar Longwall A5a were monitored using the following:-

- Line A3,
- Line A3X,
- Line A4, and
- Line A5a.

The locations of these monitoring lines are shown in Drawing No. MSEC631-01, in Appendix B. It is noted, that the proposed Line A5 was not installed due to landowner access issues.

The following sections provide comparisons between the observed and predicted subsidence movements for the monitoring lines which were measured during and after the extraction of Longwall A5a. The predicted movements are based on those provided in Report No. MSEC529 (Rev. A), which included the modified commencing end of this longwall.

The predicted total conventional subsidence contours, resulting from the extraction of Longwalls A3 to A5a, have been reproduced in Drawing No. MSEC631-05, in Appendix B. The predicted subsidence contours are based on extracting 3.0 metres of bottom coal and achieving an 85 % recovery of the top coal.

2.2. Line A3

Line A3 is a longitudinal monitoring line which follows the centreline of Longwall A3. The monitoring line was measured two times during and one time after the extraction of Longwall A5a. The latest survey was carried out on the 6th March 2013, around two weeks after the completion of Longwall A5a. The base survey was carried out on the 9th February 2009, around one week prior to the commencement of Longwall A3.

The observed profiles of total subsidence, tilt and strain along Line A3, resulting from the extraction of Longwalls A3 to A5a, are shown in Fig. A.01, in Appendix A. The predicted profiles of subsidence and tilt along this monitoring line, after the completion of Longwall A5a, are also shown in this figure for comparison.

A summary of the maximum observed and maximum predicted total subsidence parameters along Line A3, resulting from the extraction of Longwalls A3 to A5a, is provided in Table 2.1. The observed values are the maxima at any time during or after the completion of Longwall A5a.

Table 2.1 Maximum Observed and Predicted Total Subsidence Parameters along Line A3 Resulting from the Extraction of Longwalls A3 to A5a

Type	Maximum Total Subsidence (mm)	Maximum Total Tilt (mm/m)	Maximum Total Tensile Strain (mm/m)	Maximum Total Comp. Strain (mm/m)
Observed	500	2.1	1.1	3.3
Predicted	900	3.2	*- Refer to discussions below -*	

The maximum observed total subsidence along Line A3 was 500 mm, which represents 55 % of the maximum predicted subsidence of 900 mm. Caution should be taken when comparing the magnitudes of observed and predicted subsidence for longitudinal monitoring lines, such as Line A3, as they are sensitive to lateral shifts (i.e. transverse to longwall) between the observed and predicted profiles, especially in the location of maximum transverse tilt.

This is illustrated in Fig. A.02, for the cross-line Line A3X, which shows that the difference between the magnitudes of observed and predicted subsidence along Line A3 appears to be partly the result of less subsidence developing above the tailgate of Longwall A3 than was predicted.

The maximum observed additional subsidence along Line A3, due to the extraction of Longwall A5a, was 24 mm, which represents 5 % of the total subsidence measured to date. Only low level subsidence was expected along this monitoring line, due to the extraction of Longwall A5a, as it is located around 750 metres from the active longwall.

The maximum observed total tilt along Line A3 was 2.1 mm/m, which was less than the maximum predicted total tilt of 3.2 mm/m. The magnitude of tilt at the longwall commencing end (i.e. RHS of Fig. A.01) was less than that at the longwall finishing end (i.e. LHS of Fig. A.01), which is partly due to the stagger of the commencing ends of Longwalls A4 to A5a and, hence, less additional subsidence developing in this location during the extraction of these later longwalls.

The maximum observed total strains along Line A3 were 1.1 mm/m tensile and 3.3 mm/m compressive. The maximum predicted conventional strains in Stage 2, based on applying a factor of 15 to the maximum predicted conventional curvatures anywhere above the longwalls, were 1 mm/m tensile and 2 mm/m compressive.

The maximum observed total tensile strain of 1.1 mm/m, between Marks A301 and A302, only slightly exceeded the maximum predicted conventional tensile strain of 1 mm/m. The localised strain in this survey bay developed during the extraction of Longwall A3, with a maximum value of 1.5 mm/m, and has since reduced during the extraction of later longwalls.

The observed total compressive strains exceeded the maximum predicted conventional compressive strain in two locations, between Marks A325 to A326 and between Marks A333 and A334. These localised strains developed during the extraction of Longwall A3, prior to the extraction face mining directly beneath them and, therefore, these strains could have been the result of disturbed survey marks. The magnitudes of these strains reduced slightly during the extraction of Longwalls A4 and A5. The changes in these strains due to the extraction of Longwall A5a were less than the order of survey tolerance (i.e. not measurable).

Elsewhere, the observed strains along Line A3 were in the order of those predicted based on conventional ground movements.

2.3. Line A3X

Line A3X is a cross-line above Longwalls A3 to A5a. The monitoring line was measured four times during and one time after the extraction of Longwall A5a. The latest survey was carried out on the 11th March 2013, around three weeks after the completion of Longwall A5a. The base survey was carried out on the 9th February 2009, around one week prior to the commencement of Longwall A3

The observed profiles of total subsidence, tilt and strain along Line A3X, resulting from the extraction of Longwalls A3 to A5a, are shown in Fig. A.02, in Appendix A. The predicted profiles of subsidence and tilt along this monitoring line, at the completion of Longwall A5a, are also shown in this figure for comparison.

A summary of the maximum observed and maximum predicted total subsidence parameters along Line A3X, resulting from the extraction of Longwalls A3 to A5a, are provided in Table 2.2. The observed values are the maxima at any time during or after the completion of Longwall A5a.

Table 2.2 Maximum Observed and Predicted Total Subsidence Parameters along Line A3X Resulting from the Extraction of Longwalls A3 to A5a

Type	Maximum Total Subsidence (mm)	Maximum Total Tilt (mm/m)	Maximum Total Tensile Strain (mm/m)	Maximum Total Comp. Strain (mm/m)
Observed	1167	7.6	2.4	1.1
Predicted	1400	5.1	*- Refer to discussions below -*	

The maximum observed total subsidence along Line A3X was 1167 mm, which represents 83 % of the maximum predicted subsidence of 1400 mm. It can be seen from Fig. A.02, that the observed subsidence profile reasonably matches the predicted subsidence profile. The observed subsidence is less than that predicted above the tailgate of Longwall A3, which may indicate that the overburden has cantilevered further over the longwall void than was anticipated.

The maximum observed total tilt was 7.6 mm/m, which was greater than the maximum predicted tilt of 5.1 mm/m. It can be seen from Fig. A.02 that, whilst the maximum observed tilt exceeds the maximum predicted, the observed tilt profile reasonably matches the predicted tilt profile. The maximum observed tilt occurs in the area over the tailgate of Longwall A3 and is associated with the reduced subsidence which may be the result of stronger strata cantilevering and reducing the subsidence over the tailgate of Longwall A3 and resulting in greater than expected tilt. As the exceedance in the A3 tailgate area is small (i.e. around 2.5 mm/m, or 0.25 %), it is considered that this has no significant affect on the impact assessments that were provided in Reports Nos. MSEC275, MSEC417 and MSEC529.

The maximum observed total strains along Line A3X were 2.4 mm/m tensile and 1.1 mm/m compressive. The maximum predicted conventional strains in Stage 2, based on applying a factor of 15 to the maximum predicted conventional curvatures anywhere above the longwalls, were 1 mm/m tensile and 2 mm/m compressive.

The observed total tensile strains exceeded the maximum predicted conventional tensile strain in three locations, between AX39 and AX40, between AX47 and AX48, and between AX57 and AX58, which are discussed below.

The localised tensile strain observed between Marks AX39 and AX40 developed during the extraction of Longwall A4, prior to the extraction face mining directly beneath it and, therefore, this strain could have been the result of a disturbed survey mark. The strain in this survey bay reduced during the extraction of Longwall A5 and the changes in strain during the extraction of Longwall A5a were less than the order of survey tolerance (i.e. not measurable).

The tensile strain observed between Marks AX47 and AX48 is located where the monitoring line was extended prior to the commencement of Longwall A5a and, therefore, could be partly the result of this extension. The strain for this survey bay increased by 0.7 mm/m, during the extraction of Longwall A5a, which is in the order of that predicted based on conventional ground movements. The tensile strain between Marks AX57 and AX58 of 1.2 mm/m was only slightly greater than the maximum predicted due to conventional movements.

Elsewhere, the observed strains along Line A3X were in the order of those predicted based on conventional ground movements.

2.4. Line A4

Line A4 is a longitudinal monitoring line which follows the centreline of Longwall A4. The monitoring line was measured two times during and one time after the extraction of Longwall A5a. The latest survey was carried out on the 5th March 2013, around two weeks after the completion of Longwall A5a. The base survey was carried out on the 27th July 2010, around two weeks after the commencement of Longwall A4.

The observed profiles of total subsidence, tilt and strain along Line A4, resulting from the extraction of Longwalls A4 to A5a, are shown in Fig. A.03, in Appendix A. The predicted profiles of subsidence and tilt along this monitoring line, at the completion of Longwall A5a, are also shown in this figure for comparison.

It can be seen from this figure, that the observed profiles of subsidence and tilt reasonably match the predicted profiles near the longwall commencing end (i.e. RHS of the graphs). The observed subsidence is less than that predicted towards the longwall finishing end (i.e. LHS of graph), which could be in part the result of no top coal being recovered in the last few hundred metres of extraction for Longwall A5 and, to a lesser extent, for Longwall A5a.

A summary of the maximum observed and maximum predicted total subsidence parameters along Line A4, resulting from the extraction of Longwalls A4 to A5a, is provided in Table 2.3. The observed values are the maxima at any time during or after the completion of Longwall A5a.

Table 2.3 Maximum Observed and Predicted Total Subsidence Parameters along Line A4 Resulting from the Extraction of Longwalls A4 to A5a

Type	Maximum Total Subsidence (mm)	Maximum Total Tilt (mm/m)	Maximum Total Tensile Strain (mm/m)	Maximum Total Comp. Strain (mm/m)
Observed	1210	4.1	2.8	1.2
Predicted	1400	3.7	*- Refer to discussions below -*	

The maximum observed total subsidence along Line A4 was 1210 mm, which represents 86 % of the maximum predicted subsidence of 1400 mm. The maximum observed total tilt of 4.1 mm/m was slightly greater than the maximum predicted tilt of 3.7 mm/m. This exceedance was localised and was less than +15 % of the prediction, which is generally considered acceptable for subsidence prediction methods.

The maximum observed total strains along Line A4 were 2.8 mm/m tensile and 1.2 mm/m compressive. The maximum predicted conventional strains in Stage 2, based on applying a factor of 15 to the maximum predicted conventional curvatures anywhere above the longwalls, were 1 mm/m tensile and 2 mm/m compressive.

The observed total tensile strains exceeded the maximum predicted conventional strain in two locations, between Marks A408 to A409 and between Marks A447 and A448. The localised tensile strain between Marks A408 to A409 was measured prior to Longwall A4 mining directly beneath this location and, hence, this strain could be the result of a disturbed ground mark. Similarly, the localised tensile strain between Marks A447 and A448 is located adjacent to other disturbed survey marks and, therefore, it is possible that it is also the result of a disturbed ground mark.

Elsewhere, the observed strains along Line A4 were in the order of those predicted based on conventional ground movements.

2.5. Line A5a

Line A5a is a longitudinal monitoring line which follows the centreline of Longwall A5a. The monitoring line was measured five times during and one time after the extraction of Longwall A5a. The latest survey was carried out on the 7th March 2013, around two weeks after the completion of Longwall A5a. The base survey was carried out on the 23rd March 2012, around the completion of Longwall A5.

The observed profiles of total subsidence, tilt and strain along Line A5a, resulting from the extraction of Longwall A5a only, are shown in Fig. A.04, in Appendix A. The predicted profiles of subsidence and tilt along this monitoring line, at the completion of Longwall A5a, are also shown in this figure for comparison.

It can be seen from this figure, that the observed profiles of subsidence and tilt reasonably match the predicted profiles. The observed tilt profile is slightly irregular which may be partly the result of survey tolerance due to the low level of measured subsidence.

A summary of the maximum observed and maximum predicted total subsidence parameters along Line A5a, resulting from the extraction of Longwall A5a, is provided in Table 2.4. The observed values are the maxima at any time during or after the completion of Longwall A5a.

Table 2.4 Maximum Observed and Predicted Total Subsidence Parameters along Line A5a Resulting from the Extraction of Longwall A5a

Type	Maximum Total Subsidence (mm)	Maximum Total Tilt (mm/m)	Maximum Total Tensile Strain (mm/m)	Maximum Total Comp. Strain (mm/m)
Observed	357	2.2	0.5	0.9
Predicted	575	2.3	*- Refer to discussions below -*	

The maximum observed total subsidence along Line A5a was 357 mm, which represents 62 % of the maximum predicted subsidence of 575 mm. It is likely that some low level subsidence resulting from the earlier longwalls (i.e. around 50 mm) was not measured along this monitoring line, due to its installation around the completion of Longwall A5 but, in any case, it is expected that the actual subsidence would still have been less than that predicted. The maximum observed total tilt of 2.2 mm/m was similar to but slightly less than the maximum predicted tilt of 2.3 mm/m.

The maximum observed total strains along Line A5a were 0.5 mm/m tensile and 0.9 mm/m compressive. The maximum predicted conventional strains in Stage 2, based on applying a factor of 15 to the maximum predicted conventional curvatures anywhere above the longwalls, were 1 mm/m tensile and 2 mm/m compressive. The observed strains were, therefore, less than those predicted based on conventional ground movements.

2.6. Summary

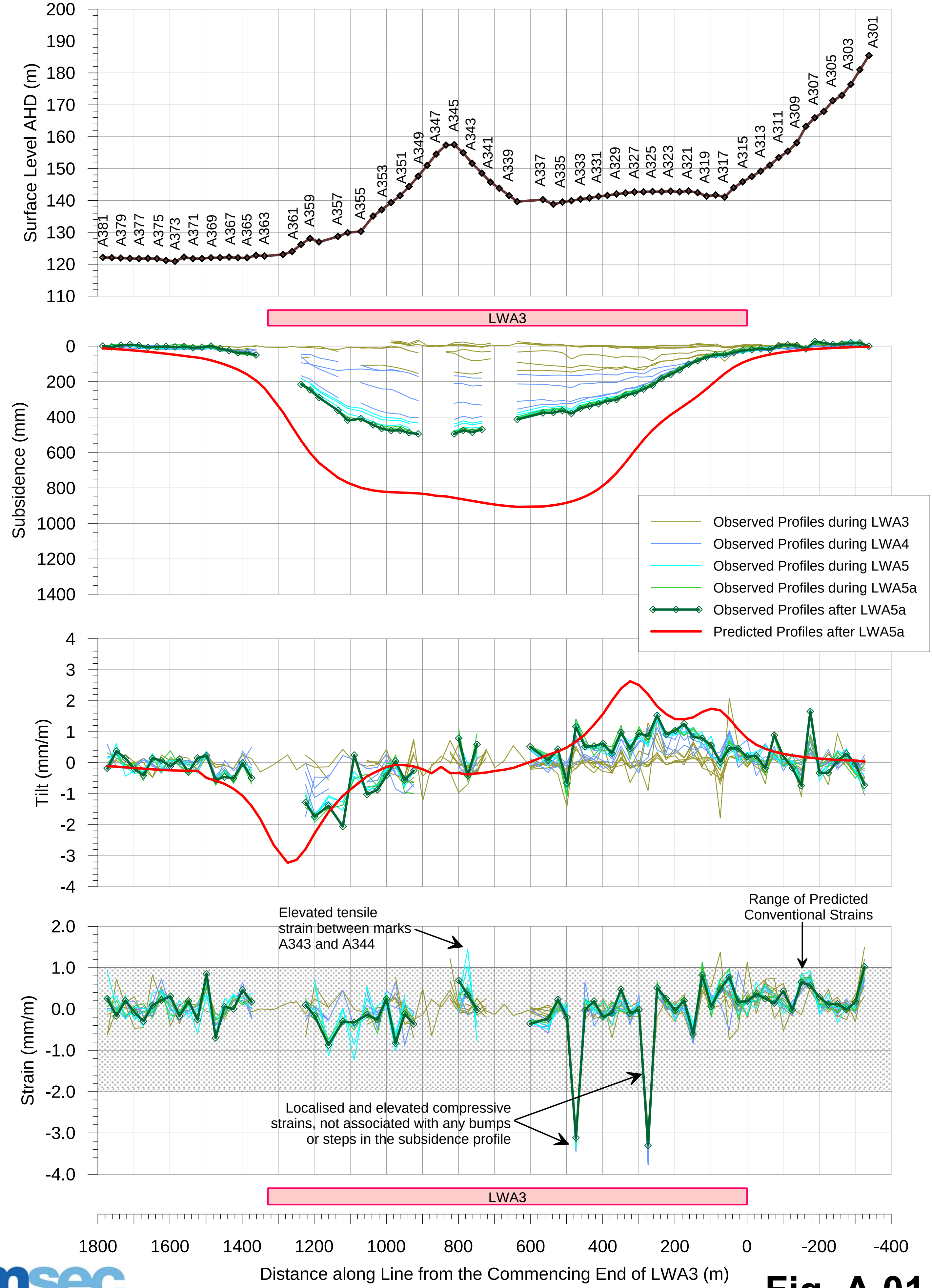
The ground movements measured along Lines A3, A3X, A4 and A5a indicate that the observed subsidence and tilt, resulting from the extraction of Longwalls A3 to A5a, were reasonably similar to those predicted. The maximum observed tilt along Line A3X was greater than the maximum predicted over a portion of Longwall A3, however, this exceedance was small and appears to be the result of reduced subsidence above the tailgate of Longwall A3.

The ground strains were typically in the order of those predicted based on conventional ground movements. There were some localised ground strains which exceeded the maximum predicted conventional strains, however, these generally developed during the extraction of the earlier longwalls. In most cases, these localised strains occurred prior to the longwall extraction faces mining directly beneath them and, therefore, appear to be the result of disturbed survey marks.

It has been considered, therefore, that the Incremental Profile Method has provided adequate predictions of the mine subsidence movements for Austar Stage 2 Longwalls A3 to A5a. It has also been considered that it is not necessary to undertake any further calibration of the prediction model, based on the monitoring data, or to update the impact assessments which have been provided in Reports Nos. MSEC275, MSEC417 and MSEC529.

APPENDIX A. FIGURES

Observed and Predicted Total Subsidence, Tilt and Strain Along Monitoring Line A3 due to Longwalls A3, A4, A5 and A5a



msec

Fig. A.01

Observed and Predicted Total Subsidence, Tilt and Strain Along Monitoring Line A3X due to Longwalls A3, A4, A5 and A5a

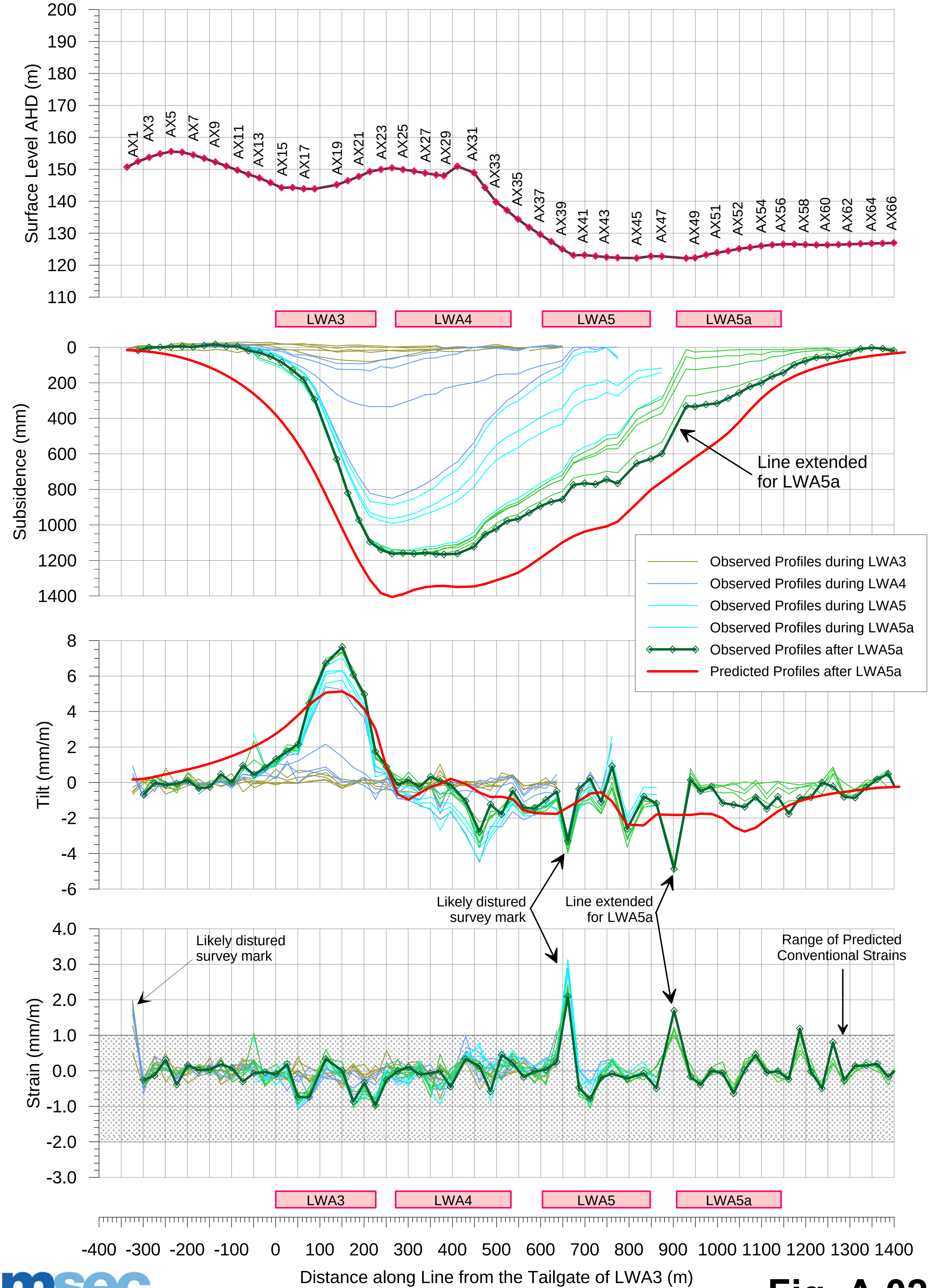


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Fig. A.02

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Observed and Predicted Total Subsidence, Tilt and Strain Along Monitoring Line A4 due to Longwalls A4 to A5a

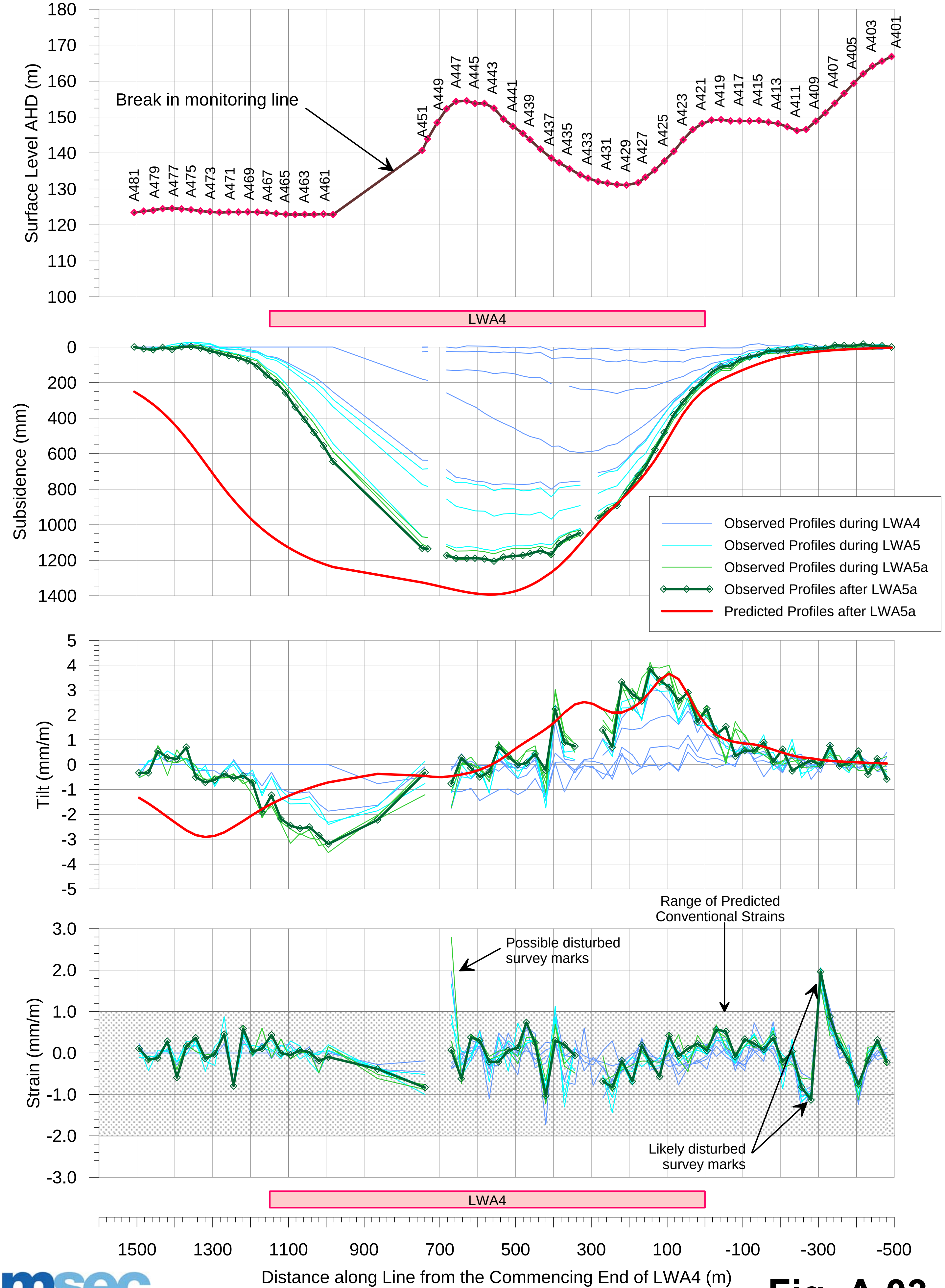

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Fig. A.03

Observed and Predicted Total Subsidence, Tilt and Strain Along Monitoring Line A5a due to Longwall A5a

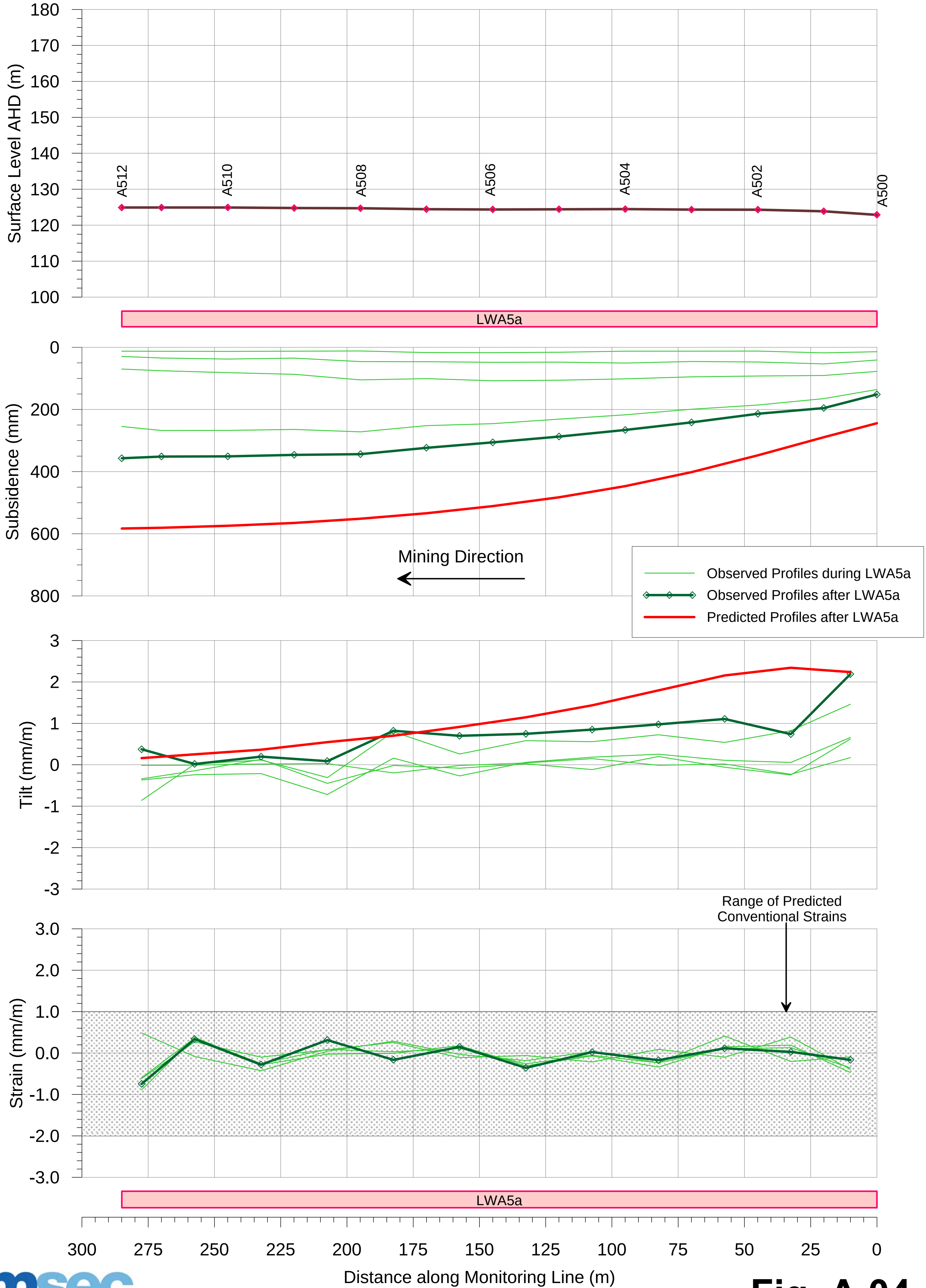

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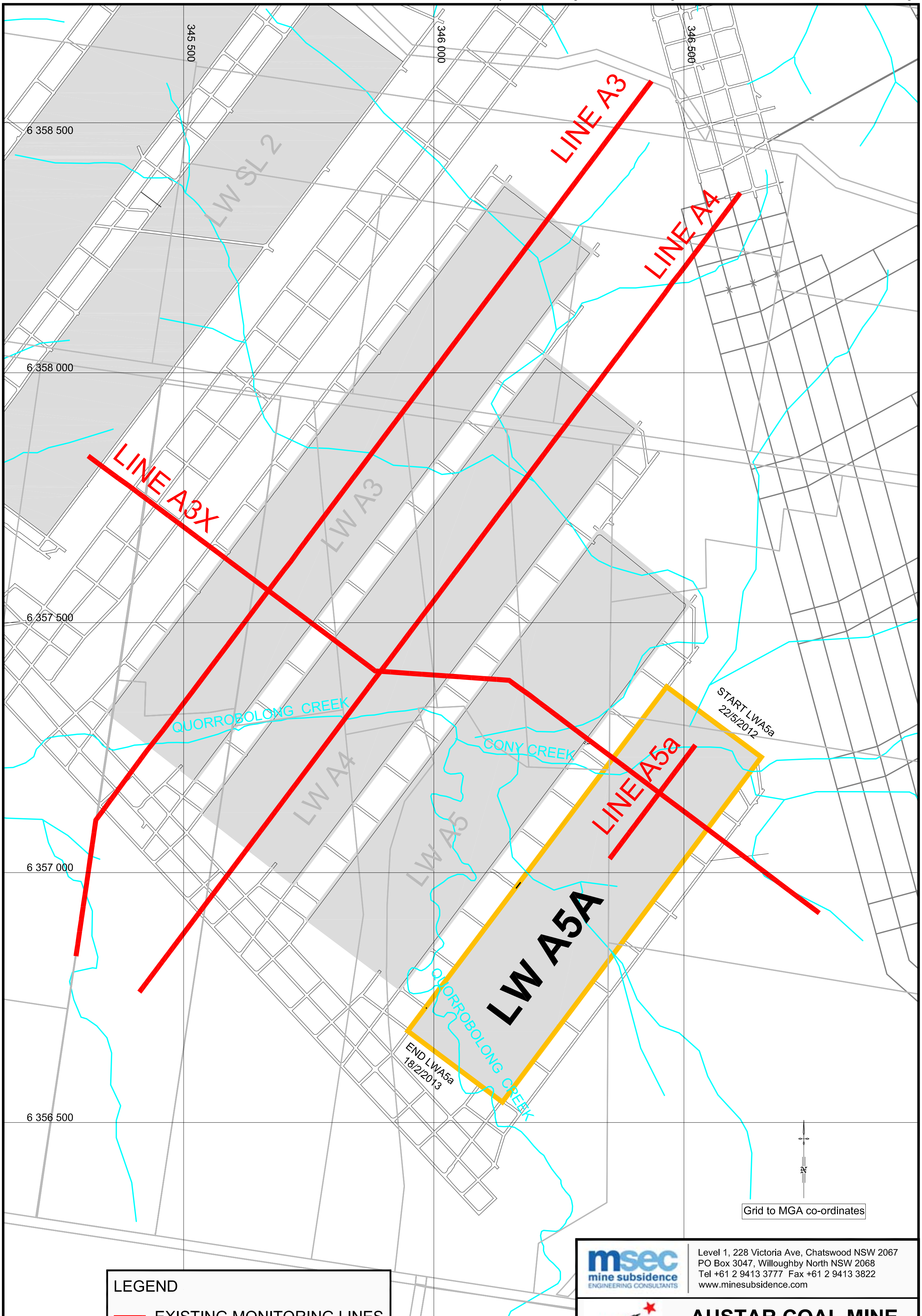
Fig. A.04

APPENDIX B. DRAWINGS



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AUSTAR COAL MINE
LONGWALL A5a END OF PANEL
GENERAL LAYOUT

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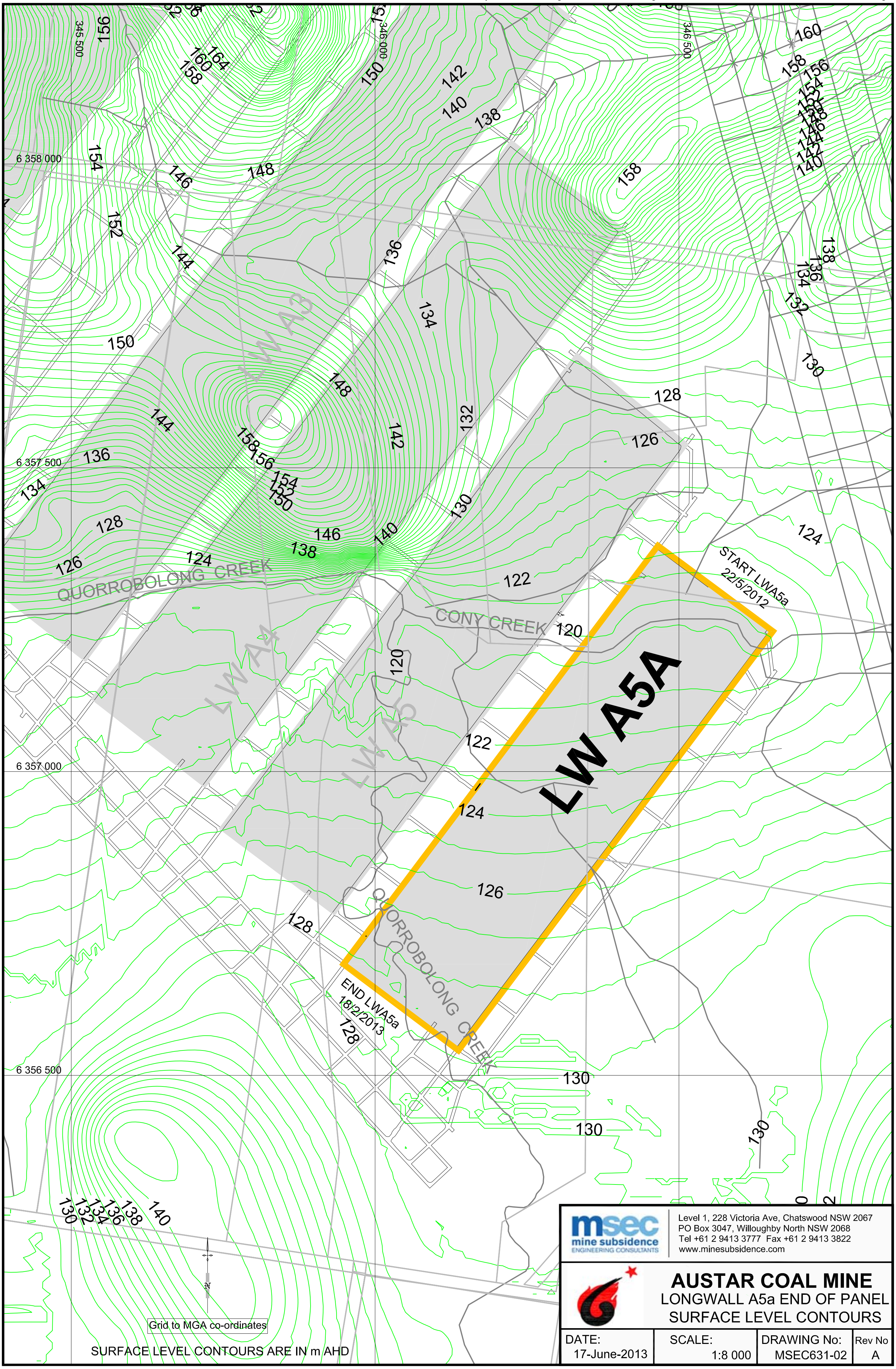

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LONGWALL A5a END OF PANEL SURFACE LEVEL CONTOURS

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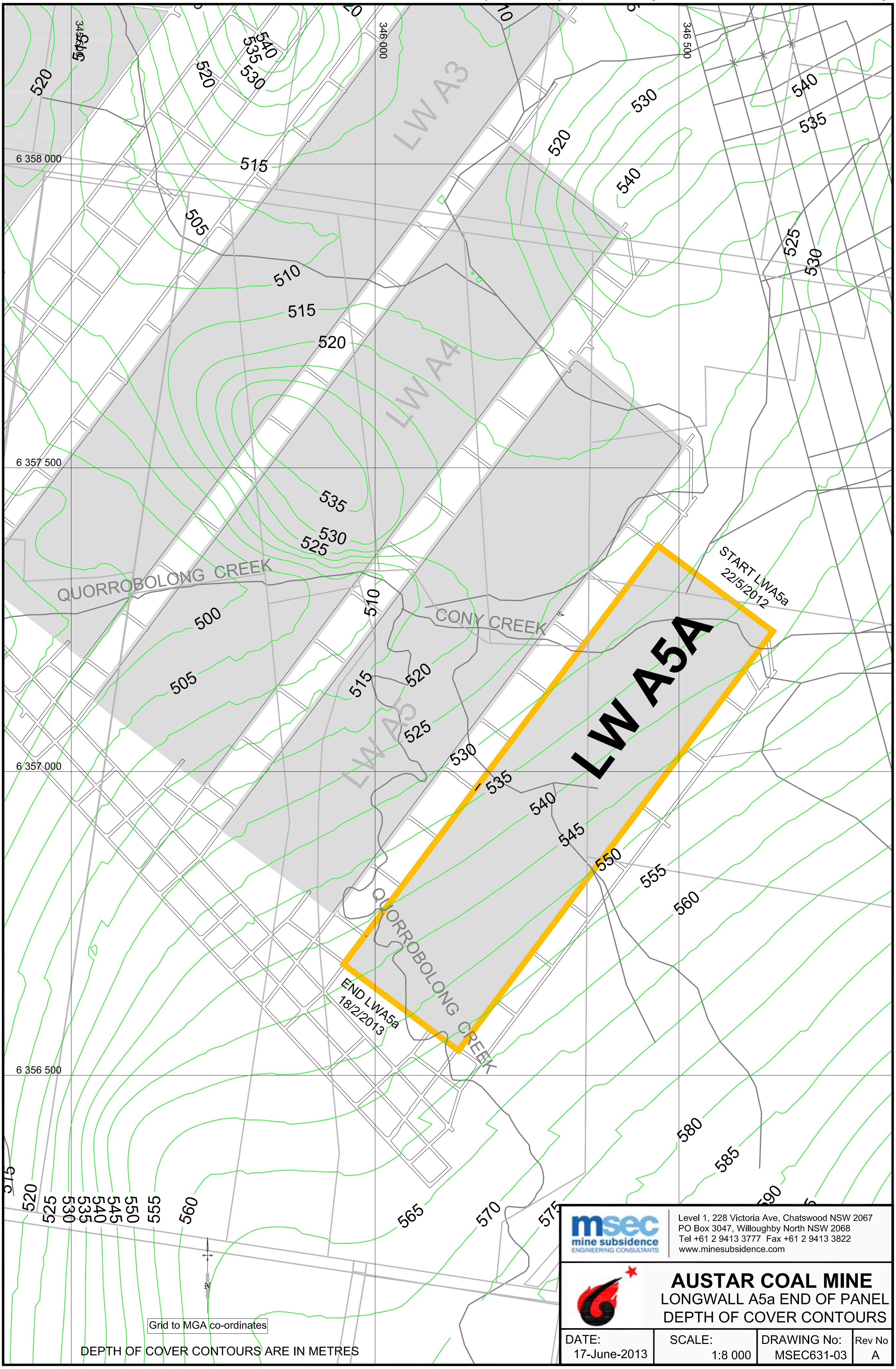

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LONGWALL A5a END OF PANEL
DEPTH OF COVER CONTOURS

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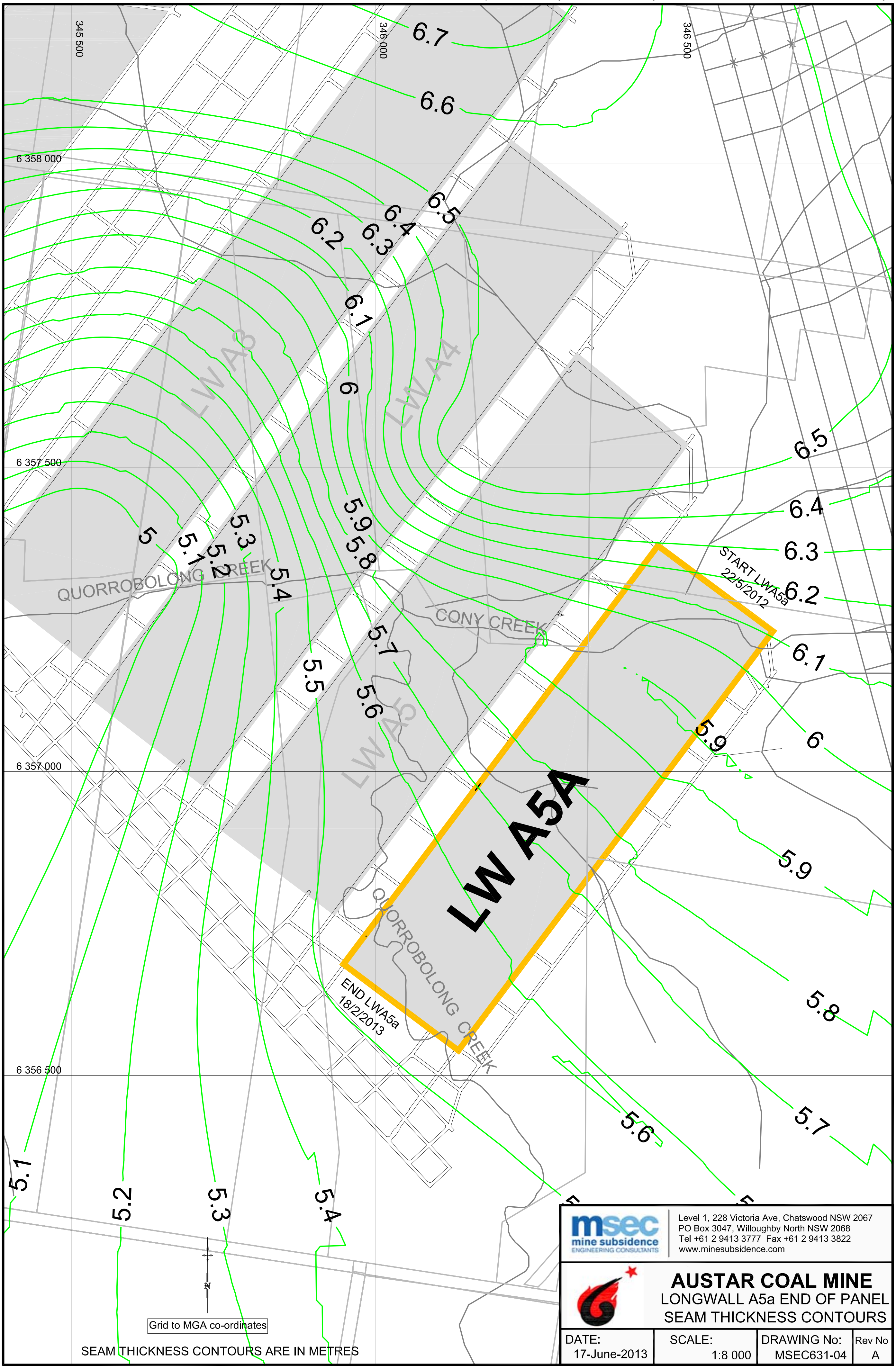

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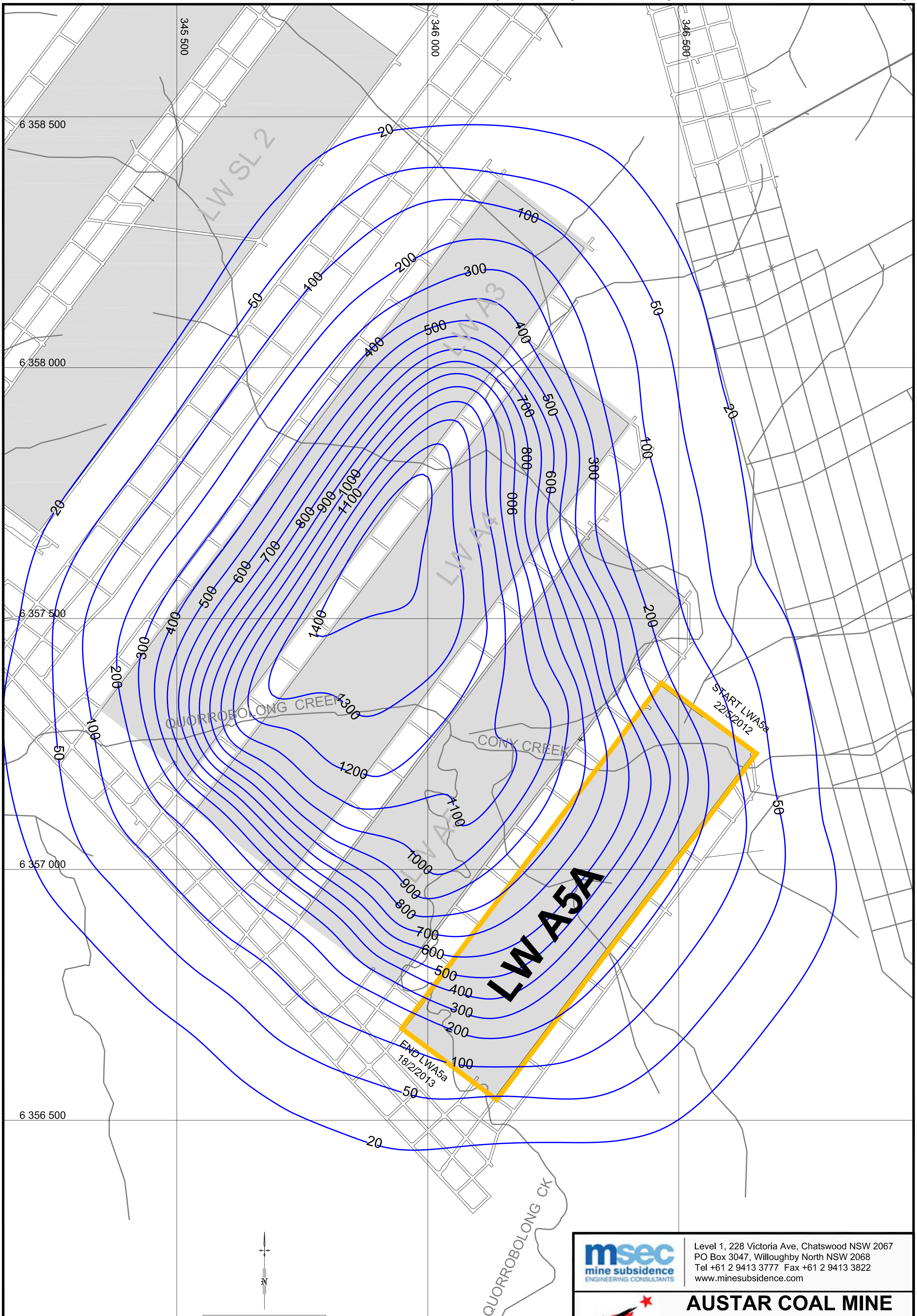

Grid to MGA co-ordinates

PREDICTED SUBSIDENCE CONTOURS ARE IN MILLIMETRES (mm)

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LONGWALL A5a END OF PANEL

PREDICTED TOTAL SUBSIDENCE CONTOURS AFTER LONGWALL A5a

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