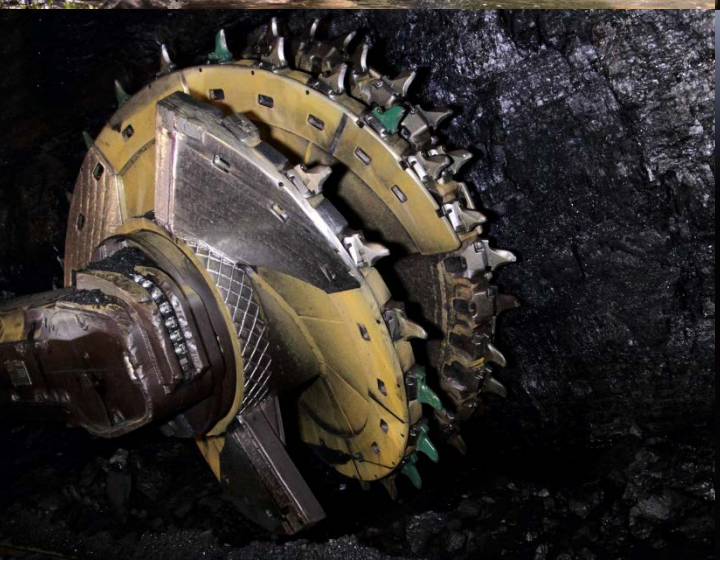
LONGWALL 37 END OF PANEL REPORT ILLLAWARRA COAL



ATTACHMENT B – LONGWALL 37 END OF PANEL REPORT

END OF PANEL SUBSIDENCE MONITORING REPORT FOR WEST CLIFF LONGWALL 37

MSEC, APRIL 2015

BHP BILLITON ILLAWARRA COAL:

West Cliff Colliery - Longwall 37

End of Panel Subsidence Monitoring Report for West Cliff Longwall 37

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Associated reports:-

MSEC404 (Revision D – August 2009) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Bulli Seam Operations in Support of the Part 3A Application.

MSEC326 (Revision C – December 2007) - The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Longwalls 34 to 36 in Area 5 at West Cliff Colliery (In Support of the SMP Application).

MSEC533 (Revision B – June 2013) – West Cliff Collieries – Longwalls 37 and 38 Subsidence Predictions and Impact Assessments for the Natural Features and Surface Infrastructure in Support of the Extraction Plan.

MSEC626 (Letter Report – 23rd April 2014) – Subsidence Predictions for the Sydney Catchment Authority Wrought Iron and Concrete Aqueducts based on the Actual Commencing Ends of the West Cliff Longwalls 34 and 35 and the Currently Proposed Commencing Ends of West Cliff Longwalls 36 and 37.

MSEC628 (Letter Report – 30th April 2013) – Subsidence Predictions for the 330 kV Transmission Line Based on the Currently Proposed Commencing Ends of West Cliff Longwalls 36 and 37.

MSEC630 (Letter Report – 14th May 2013) – Subsidence Predictions for the Gas and Water Pipelines Based on the Currently Proposed Commencing Ends of West Cliff Longwalls 36 and 37.

MSEC683 (Revision A – March 2014) – Review of the Observed Movements at the Sydney Catchment Authority Infrastructure due to Longwall Mining at Appin and West Cliff Collieries.

MSEC701 (Revision A – July 2014) – End of Panel Report for West Cliff Longwall 36.

MSEC705 (Revision A – June 2014) – The Effects of the Proposed Modified Commencing End of Longwall 37 on Previous Subsidence Predictions and Impact Assessments.

MSEC728 (Report Nos. R01 to R17) – Review of the Observed Subsidence Movements along the B-Line Monitoring Line Resulting from the Extraction of West Cliff Longwall 37.

MSEC734 (Report No. R01) – Report on the Observed Mine Subsidence Movements along the J-Line Monitoring Line due to the Extraction of West Cliff Longwall 37.

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)

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Drawings

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

1.1. Introduction

Illawarra Coal (IC) has completed the extraction of Longwall 37 at West Cliff Colliery, which is located in the Southern Coalfield of New South Wales. The locations of the longwalls in Area 5 at West Cliff Colliery are shown in Drawing No. MSEC740-01, in Appendix B. The extraction of Longwall 37 commenced on the 10th June 2014 and was completed on the 30th January 2015.

Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by Illawarra Coal (IC) to prepare subsidence predictions and impact assessments for the proposed Longwalls 37 and 38 at West Cliff Colliery. Longwalls 37 and 38 are included in the Bulli Seam Operations Project. Report No. MSEC404 (Revision D) was issued in August 2009 in support of the Bulli Seam Operations Part 3A application, which was approved by the Department of Planning and Infrastructure on 22 December 2011. Report No. MSEC533 (Revision B) was issued in June 2012, which supported the Extraction Plan Application for these longwalls. The Department of Planning and Environment (DoPE) and Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) granted IC approval for extraction of Longwalls 37 and 38 on the 24th and 28th March 2014 respectively.

IC proposed to shorten the commencing (i.e. western) end of Longwall 37 by 223 metres from that indicated in the Extraction Plan Approval. MSEC prepared Report No. MSEC705 Revision A, in June 2014, in support of this Variation to the Approved Extraction Plan. The DTIRIS and DoPE granted IC approval for this Variation to the Extraction Plan of Longwall 37 on the 6th July 2014.

This report provides the following information for the completion of Longwall 37:-

- Comparisons between the predicted and observed subsidence movements at the monitoring lines and monitoring points resulting from the extraction of Longwall 37, and
- Comparisons between the assessed (i.e. predicted) and observed impacts on the natural features and surface infrastructure resulting from the extraction of Longwall 37.

Further details on the assessed and observed impacts for natural features, resulting from the extraction of Longwall 37, are provided in reports by other consultants. The observations provided in this report should be read in conjunction with those and all other relevant reports.

The results of the monitoring associated with the Water and Gas Pipelines in the easement located to the west of Longwall 37 were provided in the subsidence monitoring report MSEC734 – Revision R01, which was issued on the 22nd August 2014. The results of the monitoring associated with Appin Road and the Telstra Optical Fibre Cable, during the extraction of Longwall 37, were provided in the subsidence monitoring reports MSEC727 – Revisions R01 to R17, which were issued between the 08th October 2014 and the 29th January 2015.

Chapter 2 of this report describes the locations of the ground monitoring lines and points which were surveyed during the extraction of Longwall 37. This chapter also provides comparisons between the predicted and observed movements resulting from the extraction of Longwall 37.

Chapter 3 of this report describes the natural features and surface infrastructure in the vicinity of Longwall 37. This chapter also provides comparisons between the assessed (i.e. predicted) and observed impacts for the natural features and surface infrastructure resulting from the extraction of Longwall 37. Further details on the assessed and observed impacts for natural features are provided in reports by other consultants. Appendices A and B include all of the figures and drawings associated with this report.

1.2. Mining Geometry

The overall approved void width of Longwall 37, including the first workings, was 282 metres and the solid chain tailgate pillar width was 32 metres. As discussed in Section 1.1 of this report, the position of the commencing end of Longwall 37 was modified and the final as-extracted length of Longwall 37 was 1,572 metres.

The depth of cover to the Bulli Seam, directly above Longwall 37, varies between a minimum of 480 metres at the eastern end of the longwall and a maximum of 520 metres towards the western end of the longwall. The seam thickness within the goaf area of Longwall 37 varies from 2.3 metres to 2.4 metres. The minimum extraction height for Longwall 37 was 2.4 metres due to the constraints of the longwall mining equipment.

The geological structures which have been mapped at seam level are shown in Drawing No. MSEC740-01, in Appendix B. O'Hares Fault is located just north of the commencing end of Longwall 37. The results of the surface seismic surveys indicate that the throw of this normal fault varies between around 15 metres and 76 metres, with the up throw (i.e. footwall) block on the southern side and the down throw (i.e. hanging wall) block on the northern side of this structure. The fault was encountered in the main headings for West Cliff Longwalls 20 to 24, to the east of the current longwall series, and it is projected that the dip of the fault is around 75 degrees to 80 degrees, which is typical for normal faults.

2.1. Introduction

The mine subsidence movements resulting from the extraction of West Cliff Longwall 37 were measured along a number of monitoring lines and points including the following:-

- The Georges River cross lines,
- The J-Line and the Mallaty Creek 3D Monitoring Area,
- The B-Line along Appin Road,
- Monitoring points at the towers along the TransGrid 330 kV Transmission Line,
- Monitoring points at the poles along the Endeavour Energy powerlines, and
- Monitoring lines and points at the Sydney Catchment Authority infrastructure.

The locations of these monitoring lines and points are shown in Drawing No. MSEC740-01, in Appendix B. Comparisons between the observed and predicted subsidence movements at these monitoring lines and points are provided in the following sections.

2.2. The Georges River Cross Lines

The mine subsidence movements across the Georges River valley were measured by IC along six monitoring lines, being the L-Line to the P-Line and the R-Line. The locations of these monitoring lines are shown in Drawing No. MSEC740-01, in Appendix B. A summary of the survey dates for the Georges River cross lines, during the extraction of Longwall 37, is provided in Table 2.1.

Table 2.1 Summary of Survey Dates for the Georges River Cross Lines during Longwall 37

SMP Commitments	Date	Monitoring Line			Proposed Future Monitoring
		L-Line	M-Line to P-Line	R-Line	
Initial survey of cross lines L to R at start of LW37 Survey L to R Lines at nominally 600m and 500m from end of LW37, then weekly surveys once the longwall is within 400 metres of the finishing end. Final survey after the completion of LW37.	17-Jun-14	Initial	Initial	Initial	Initial 3D survey start of LW38 for lines G to R. L to R lines then surveyed in 2D monthly for the first 1,500m of extraction Lines G to L surveyed in 2D monthly for the remaining extraction. Final 3D survey for lines G to R at end of LW38.
	30-Oct-14	✓	✓	✓	
	07-Nov-14	✓	✓	✓	
	20-Nov-14	✓	✓	✓	
	27-Nov-14	✓	✓	✓	
	02-Dec-14	✓	✓	✓	
	09-Dec-14	✓	✓	✓	
	16-Dec-14	✓	✓	✓	
	24-Dec-14	✓	✓		
	30-Dec-14	✓	✓	✓	
	06-Jan-15	✓	✓	✓	
	15-Jan-15	✓	✓	✓	
	20-Jan-15	✓	✓	✓	
	28-Jan-15	✓	✓	✓	
	3-Feb-15		✓		
	10-Feb-15	✓	✓	✓	

It is noted that the Q line was not installed as it was not possible to access the proposed location of the monitoring line. The predicted subsidence, upsidence and closure movements at the Georges River, resulting from the extraction of Longwalls 37 and 38, were provided in Report No. MSEC533. It is noted these predictions for upsidence and closure for the Georges River cross lines are slightly lower than those predicted in Report No. MSEC326, because of the setback of longwall panels from the Georges River. The predicted profiles of incremental and total upsidence, net vertical movement and closure along the centreline of the river, resulting from the extraction of Longwall 37, have been reproduced in Figs. A.01 and A.02, in Appendix A.

The predicted and observed movements for each cross line have been indicated as blue and red circles, respectively, in these figures. The observed net vertical movement for each monitoring line has been taken at the survey mark nearest the centreline of the river, so as to match the location of the predicted net vertical movement.

The observed profile of total net vertical movement and the observed developments of total upsidence and closure for each of the Georges River cross lines, resulting from the extraction of Longwall 37, are provided in Figs. A.03 to A.08, in Appendix A.

It should be noted, that the actual upsidence and closure movements at the Georges River cross lines could be greater than those measured, as the monitoring lines do not extend to the tops of the valley sides. It can be seen from Figs. A.03 to A.08, however, that the net vertical movements and compressive strains are generally concentrated near the valley base and, therefore, it is likely that the majority of these movements have been recorded.

A summary of the predicted and observed incremental and total upsidence and closure movements for each of the Georges River cross lines after the completion of Longwall 37, is provided in Table 2.2. The observed movements provided in this table are based on the survey carried out on the 10th February 2015, after the completion of Longwall 37.

Table 2.2 Summary of the Predicted and Observed Upsidence and Closure Movements at the Georges River Cross Lines after the Completion of Longwall 37

Location	Parameter	Incremental Movements Resulting from the Extraction of Longwall 37		Total Movements Resulting after the extraction of Longwall 37	
		Predicted (mm)	Observed (mm)	Predicted (mm)	Observed (mm)
L-Line	Upsidence	<-20	-24	-55	-214
	Closure	<20	15	80	176
M-Line	Upsidence	<-20	-45	-105	-404
	Closure	<20	20	180	235
N-Line	Upsidence	<-20	-32	-135	-183
	Closure	30	43	210	245
O-Line	Upsidence	-95	-8	-185	-22
	Closure	70	9	205	9
P-Line	Upsidence	-50	-3	-85	-9
	Closure	75	6	125	8
R-Line	Upsidence	-25	-1	-40	-1
	Closure	35	5	45	7

The accuracies of the measured relative horizontal and vertical positions along the Georges River cross lines are in the order ±5 mm. The accuracies of the measured absolute horizontal and vertical positions are in the order of ±20 mm and ±30 mm, respectively.

The maximum observed incremental and total upsidence and closure movements at the Georges River cross lines O, P and R, after the completion of Longwall 37, were less than the maxima predicted. The maximum observed incremental and total upsidence and closure movements at the Georges River cross lines L, M, and N lines, after the completion of Longwall 37, were greater than the maxima predicted. The incremental exceedances of upsidence and closure for the L, M and N lines were small, with most of the total upsidence and closure exceedance during mining of the previous longwalls. As discussed in Report No. MSEC533, "*Upsidence is the measure of micro valley movements in the base of the valley, which can vary significantly between adjacent cross-sections due to variations in near surface geology, whether failure of the bedrock occurs and the nature of bedrock failure. As a result, there is greater scatter in the observed upsidence movement data…… the predicted closure movements are considered to be more reliable than the predicted upsidence movements".* The bend in the Georges River also further complicates the prediction of upsidence and closure for these lines.

2.3. The J-Line and Pipeline Easement 3D Monitoring Points

The mine subsidence movements along the J-Line were measured by IC using 2D monitoring techniques. The monitoring line follows the alignment of the pipeline easement, which is located beyond the western end of Longwall 37, the location of which is shown in Drawing No. MSEC740-01, in Appendix B. There are also a number of 3D monitoring points within the pipeline easement which were monitored by IC. A summary of the survey dates for the J-Line, during the extraction of Longwall 37, is provided in Table 2.3.

Table 2.3 Summary of Survey Dates for the J-Line during the Extraction of Longwall 37

SMP Commitments	Monitoring Dates	Proposed Future Monitoring
Initial survey prior to LW37. Subsequent survey after 500m extraction. Cessation allowed only if agreed by Technical Committee. Final survey after the completion of Longwall 37	20th May 2014 (Initial Survey) 22nd August 2014 6th March 2015 (Final Survey)	Nil

The results from these surveys were described in the subsidence monitoring report MSEC734 – Report No. R01, which was issued on the 13th October 2014.

The observed profiles of incremental subsidence, strain and curvature along the alignment of the J-Line, resulting from the extraction of Longwall 37, are shown in Fig. A.09, in Appendix A. The observed profiles of total subsidence, strain and curvature along the alignment of the J-Line, resulting from the extraction of Longwalls 30 to 37, are shown in Fig. A.10, in Appendix A.

A summary of the maximum predicted and maximum observed subsidence along the J-Line, after the completion of extraction of Longwall 37, is provided in Table 2.4. The observed movements are based on the survey carried out on the 06th March 2015.

Table 2.4 Summary of the Maximum Predicted and Maximum Observed Subsidence Parameters along the J-Line after the Completion of Longwall 37

Parameter	Incremental Movements		Total Movements	
	Predicted	Observed	Predicted	Observed
Subsidence (mm)	< 20	8	1025	840

The accuracies of the measured relative horizontal and vertical positions along the J-Line are in the order of ±3 to ±5 mm. The accuracies of the measured absolute horizontal and vertical positions along the J-Line are in the order of ±20 mm.

Predictions for the J-Line were originally provided in Report No. MSEC326, in Tables 5.13 to 5.15. The predicted movements in the above Table 2.4 have been updated from those in Report MSEC326 to reflect the effect of the modified commencing and finishing ends of Longwall 37 in Report No. MSEC533.

It can be seen from Fig. A.09 that only low level subsidence movements developed along the J-Line during the extraction of Longwall 37. The maximum observed incremental subsidence along the J-Line was 8 mm at Mark J139 which is located directly above the previously extracted Longwall 35 and may be associated with long term residual movements from these longwalls. These movements represent around 10 % of the maximum total subsidence, which is similar to the levels of long term residual movements measured elsewhere in the Southern Coalfield. It is noted however that the magnitude of the observed incremental subsidence movements are within the accuracy of the survey method.

There were no identifiable incremental upsidence or closure movements at Mallaty Creek and Leafs Gully resulting from the extraction of Longwall 37. That is, the maximum observed incremental upsidence and closure movements were less than 5 mm (i.e. not measureable).

The 3D horizontal movements measured along the J-Line (3D) in the Mallaty Creek Monitoring Area indicated ground movements up to 54 mm due to the extraction of Longwall 37, moving in an easterly direction over the length of the monitoring line. These far-field horizontal movements are within the 99 % confidence level of observed far-field movements in the Southern Coalfield, at the distance from the active longwall.

2.4. The B-Line

The mine subsidence movements along the B-Line were measured by IC using both 2D and 3D monitoring techniques. The monitoring line follows the alignment of Appin Road, crossing the eastern end of Longwall 37, and is shown in Drawing No. MSEC740-01, in Appendix B. A summary of the survey dates for the B-Line, during the extraction of Longwall 37, is provided in Table 2.5.

Table 2.5 Summary of Survey Dates for the B-Line during the Extraction of Longwall 37

SMP Commitments	Survey Dates	Proposed Future Monitoring
Initial survey prior to Longwall 37. Weekly (or nominally every 50 metres of extraction from when the longwall face is 100 metres before Appin Road until the longwall face is 500 metres past Appin Road. Final survey after the completion of Longwall 37.	23rd June 2014 (Initial survey) Weekly from the 1st October 2014 to the 29th January 2015 Final Survey 2nd March 2015	Nil

The survey at the completion of Longwall 36 (23rd June 2014) was not adopted as the initial survey as small residual movements have occurred above the previously extracted longwalls since that time. Adopting the 1st October 2014 survey as the initial survey means that the residual movements immediately following the completion of Longwall 36 were not included in the observed incremental profiles.

The results from these surveys were described in the subsidence monitoring reports MSEC728 – Report Nos. R01 to R17, which were issued between the 10th October 2014 and the 30th January 2015.

The observed profiles of incremental subsidence, tilt and strain along the B-Line, resulting from the extraction of Longwall 37, are shown in Fig. A.11, in Appendix A. The observed profiles of total subsidence, tilt and strain along the B-Line, resulting from the extraction of Longwalls 29 to 37, are shown in Fig. A.12, in Appendix A.

The predicted profiles of incremental and total subsidence and tilt along the B-Line, after the completion of Longwall 37, are also shown in these figures, which were based on the subsidence predictions that were provided for Appin Road in Report No. MSEC533 Rev B. The modified commencing end of Longwall 37 had no significant effect on these predicted movements.

It can be seen from Fig. A.11, that the shape of the observed incremental subsidence profile reasonably matches the predicted incremental subsidence profile of Longwall 37. The profile on the tailgate side was affected by irregular movement which is described below. The observed maximum incremental subsidence over Longwall 37 was 740 mm, whereas the predicted was 760 mm.

It can be seen from Fig. A.12, that total observed subsidence exceeds predicted total subsidence over the previously extracted Longwalls 33, 34 and 35. Report MSEC728-R17 discusses how monitoring data indicates that some residual subsidence has occurred above the previously extracted goaf since the completion of Longwall 36 representing approximately 5 to 10 percent of the maximum observed incremental subsidence since the completion of Longwall 36.

A summary of the maximum predicted and maximum observed incremental and total subsidence parameters along the B-Line, after the completion of Longwall 37, is provided in Table 2.6. The observed movements are based on the latest survey carried out on 2nd March 2015, after the completion of Longwall 37.

Table 2.6 Summary of the Maximum Predicted and Maximum Observed Subsidence Parameters along the B-Line after the Completion of Longwall 37

Parameter	Incremental Movements		Total Movements	
	Predicted	Observed	Predicted	Observed
Subsidence (mm)	760	740	1125	1335
Tilt (mm/m)	5.5	5.2 5.7 8.0		
Tensile Strain (mm/m)	1.0*	0.8 1.0* 1.0		
Compressive Strain (mm/m)	2.0*	2.6 2.0* 5.7		

Note: * denotes that the maximum predicted tensile and compressive strains are based on conventional movements.

The accuracies of the measured relative Eastings, Northings and levels along the B-Line are in the order of ±5 mm. The accuracies of the measured absolute Eastings, Northings and levels along the B-Line are in the order of ±10 mm.

Predictions of subsidence, tilt, tensile strain and compressive strain for Appin Road due to the extraction of Longwall 37 were originally provided in report MSEC533. Values of these parameters, reported above in Table 2.6, have been updated for the modified Longwall 37 commencing end.

The maximum observed incremental and total tensile strains were less than or equal to the maxima predicted systematic strain. The maximum observed incremental tilt was less than the maxima predicted, and the maximum total tilt was greater than predicted systematic tilt.

The maximum observed incremental and total compressive strains were greater than the maxima predicted systematic strain, as irregular ground movements developed during the extraction of Longwall 37, which resulted in elevated compressive strains between Marks B222 to B223 and B230 to B231.

The development of the observed incremental compressive strains between Marks B222 to B223 and B230 to B231, during the extraction of Longwall 37, is shown in Fig. 2.1. The development of the observed incremental compressive strains between selected marks during the extraction of Longwall 32, Longwall 33, Longwall 34 and Longwall 35 are also shown in this figure for comparison, as irregular movements were also observed during the extraction of the previous longwalls.

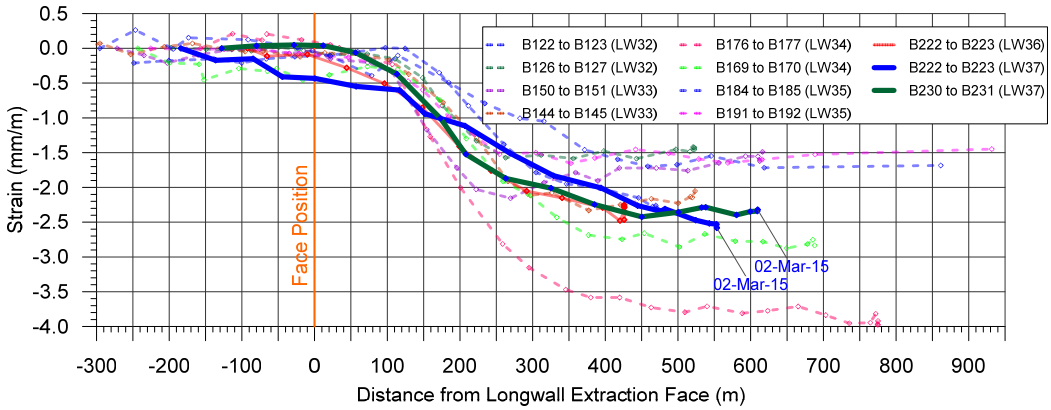


Fig. 2.1 Observed Incremental Strain versus Distance from Longwall Extraction Face for Selected Survey Bays during the Extraction of Longwalls 32 to 37

The observed development of incremental compressive strain for Marks B222 to B223 has been plotted against date in Fig. 2.2 to show the minor changes in survey epochs after the completion of Longwall 37.

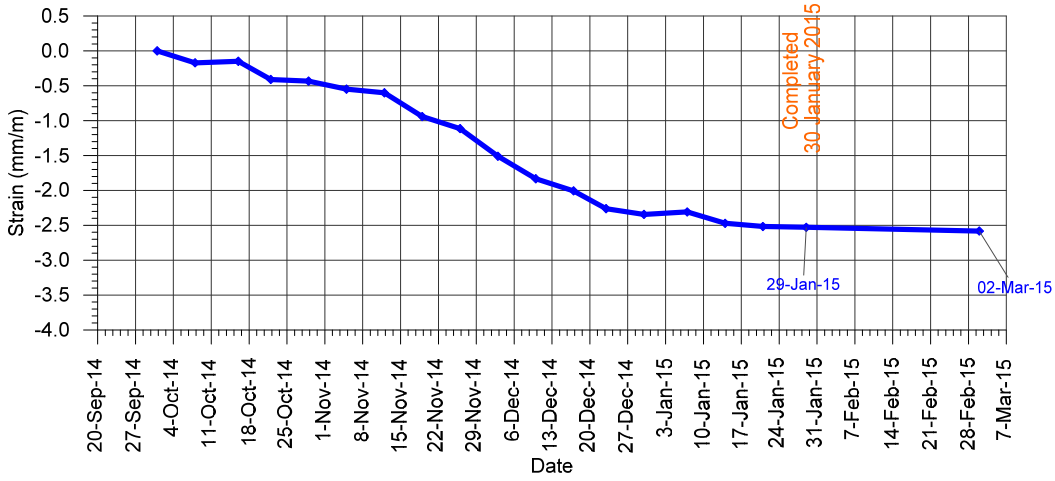


Fig. 2.2 Observed Incremental Strain versus Date Survey Bay B222-B223 during the Extraction of Longwall 37

It can be seen in Fig. 2.1 that the maximum compressive strain between Marks B222 and B223 developed early but the rate of development of compressive strain, during Longwall 37, was similar to the maximum rates (indicated by the slopes) for the irregular strains measured during the previous longwalls.

The observed incremental horizontal movement vectors and loci along the B-Line, resulting from the extraction of Longwall 37, are shown in Fig. 2.3. These plots are based on the latest 3D survey undertaken on the 2nd March 2015. The vectors and loci indicate that shear movement has occurred at the locations of high compressive strain between Marks B222 to B223 and Marks B230 to B233.

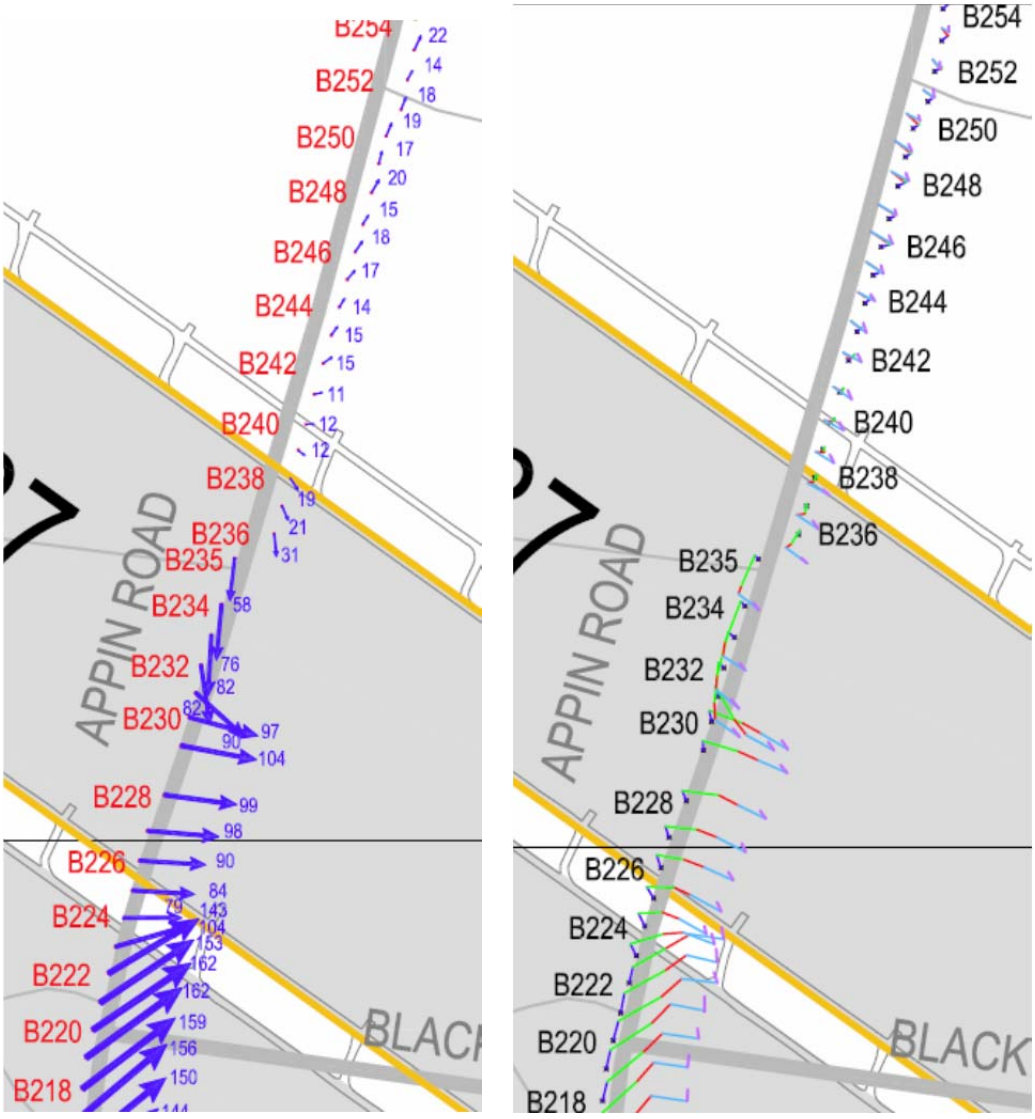


Fig. 2.3 Observed Incremental Horizontal Movement Vectors and Loci along the B-Line Resulting from the Extraction of Longwall 37

The irregular movement and elevated compressive strain between survey Marks B222 and B223 was initially identified in report MSEC728-R03 dated 24th October 2014. The elevated compressive strain between survey Marks B230 and B233 was initially identified in report MSEC728-R05, dated 6th November 2014. Subsequent surveys further confirmed the development of these compressive strains and irregular movements between Marks B222 and B223 and Marks B230 and B233.

2.5. Monitoring of the TransGrid 330 kV Transmission Line Towers

The mine subsidence movements of the TransGrid 330 kV transmission line towers were measured by IC using 3D monitoring techniques. Four towers were monitored during the extraction of Longwall 37, being Towers Nos. 3779 to 3782, the locations of which are shown in Drawings Nos. MSEC740-01 and MSEC740-03, in Appendix B.

A summary of the survey dates for the 330 kV transmission line towers, during the extraction of Longwall 37, is provided in Table 2.7.

Table 2.7 Summary of Survey Dates for the TransGrid 330 kV Transmission Line Towers during the Extraction of Longwall 37

SMP Commitments	Survey Dates	Future Monitoring
Towers 3779 to 3782: Initial survey prior to Longwall 37. Surveys after 500 metres, extraction. Final survey after the completion of Longwall 37.	19th May 2014 (Initial survey) 8th August 2014 5th February 2015. (final survey)	Nil

The accuracies of the measured absolute vertical movements are in the order ±15 mm. The accuracies of the measured distances between the towers are in the order of ±10 mm. The accuracies of the measured K-Point tilts and K-Point spans are in the order of ±2 mm. The accuracies of the measured tilts at the earth wire are in the order of ±10 mm.

A summary of the maximum predicted and maximum observed total subsidence parameters at the transmission line towers, after the completion of Longwall 37, is provided in Table 2.8. The observed movements are based on the latest survey carried out on the 5th February 2015.

Table 2.8 Summary of the Maximum Predicted and Maximum Observed Total Subsidence Parameters at the Transmission Line Towers after the Completion of Longwall 37

Parameter		Tower ID			
		3779	3780	3781	3782
Subsidence (mm)	Predicted	480	720	32	<10
	Observed	122	252	41	7
Change in Inter-Tower Distance (mm)	Span	3779~3780	3780~3781	3781~3782	-
	Predicted	-106	<-20	<+20	-
	Observed	-3	-4	+33	-
Change in K-Point Distance (mm)	Predicted	-2~+2	-2~+2 -2~+2		-2~+2
	Observed	0~+1	-1~+1	-1~+1	-1~0
Tilt of Earth Wire (mm)	Predicted	<20	<20 <20		<20
	Observed	57	28 12		13

The predicted values of total subsidence, change in K-Point distances and tilts of earth wire are based on subsidence predictions provided in Report No. MSEC326, and updated for the shortened commencing end of Longwall 37. It is noted, that Towers 3779, 3780, 3781 and 3782 were referred to as Towers 104, 105, 106 and 107 respectively, in Report No. MSEC326. The predictions provided for Longwall 37 are the same as those predicted for the end of Longwall 36, as the towers lie outside of the Study Area for Longwall 37, and were therefore not predicted to be impacted by conventional subsidence movements as a result of the mining of Longwall 37.

It can be seen from Table 2.8 that observed total subsidence at the towers, after the completion of Longwall 37, was smaller than that predicted for Towers 3778, 3779 and 3782, and slightly greater than predicted for Towers 3781. However, the exceedances for Tower 3781 were within survey tolerance. The observed total changes in the inter-tower distance was greater than that predicted for the inter-tower distance between Towers 3781 to 3782, however this movement occurred previously during Longwall 36. Survey accuracy of ±20 mm was achieved, based on the survey accuracy for absolute position of each tower of ±10 mm.

The maximum observed total changes in the K-Point distances (i.e. differential horizontal movements between the tower legs), after the extraction of Longwall 37, were of a similar order of magnitude to the maxima predicted, and were all less than predicted. The maximum observed total horizontal movements at the earth wire, after the extraction of Longwall 37, were similar to those predicted, with the exception of tower 3779, which had an observed value about 37mm greater than predicted at the earth wire. However, this exceedance occurred previously, during the mining of Longwall 36.

2.6. Monitoring of the Endeavour Energy Powerline Poles

The mine subsidence movements of the Endeavour Energy powerline poles were measured by IC using 2D monitoring techniques. Five power poles were monitored during and after the extraction of Longwall 37, being Poles 12, 23, 31, 55, 761599 and 815245. Pole locations are shown in Drawing No. MSEC740-03, in Appendix B. A summary of the survey dates for the Endeavour Energy powerline poles, during the extraction of Longwall 37, is provided in Table 2.9.

Table 2.9 Summary of Survey Dates for the Integral Powerline Poles during the Extraction of Longwall 37

SMP Commitments	Survey Dates	Proposed Future Monitoring
Initial survey prior to Longwall 37. Monthly from 100 metres prior to the line until 500 metres past the line. Final survey after the completion of Longwall 37.	21st May 2014 (Initial survey) 2nd October 2014, 30th October 2014, 11th December 2014, 2nd March 2015 (final survey).	Initial survey prior to Longwall 38. Monthly from 100 metres prior to the line until 400 metres past the line. Final survey after the completion of Longwall 38.

The accuracies of the measured absolute subsidence are in the order ±15 mm. The accuracies of the measured tilts relative to the bases are in the order of ±10 mm.

A summary of the observed total subsidence parameters at the powerpoles, after the completion of Longwall 37, is provided in Table 2.10. The observed movements are based on the latest survey carried out on the 2nd March 2015.

Specific subsidence predictions at the power poles along the 11 kV powerlines were not provided in Report No. MSEC326. The maximum predicted total subsidence parameters provided in the table below are the maximums which occur anywhere along the powerline adjacent to Appin Road, which was provided in Table 5.9 in Report No. MSEC326. It is noted, that the maximum predicted horizontal movement is based on the addition of the maximum predicted horizontal movement at the ground of 71mm and the maximum predicted tilt of 4.6 mm/m over a pole height of 10 metres.

Table 2.10 Summary of the Maximum Predicted and Maximum Observed Total Subsidence Parameters at the Power Poles after the Completion of Longwall 37

Parameter	Maximum Predicted (mm)	Observed at Pole ID					
		12	23	31	55	761599	815245
Subsidence (mm)	1175	391	<20	<20	910	391	<20
Horizontal Movement at Top Relative to Base (mm)	117	54	<20	<20	127	<20	62

It can be seen from the above table, that the observed subsidence at the powerline poles, after the completion of Longwall 37, were less than the maximums predicted anywhere along the powerline. The observed horizontal movements at the tops of the power poles relative to the base were less than predicted for all except Power Pole 55, which was 10mm greater than predicted.

2.7. Sydney Catchment Authority Infrastructure

The following sections describe the observed and predicted movements at the Sydney Catchment Authority (SCA) infrastructure, during the extraction of Longwall 37, including the Upper Canal, Devines Tunnels, at the Ousedale Creek, Mallaty Creek and Leafs Gully Aqueducts and at Concrete Aqueducts C and D.

2.7.1. The Upper Canal and Devines Tunnels

The mine subsidence movements were measured by the SCA along a number of monitoring lines, including the Upper Canal and Devines Tunnel Lines EM-Line, MO-Line, OM-Line, MD-Line and DT-Line, the locations of which are shown in Drawing No. MSEC740-01, in Appendix B. A summary of the survey dates for the Upper Canal and Devines Tunnels, during the extraction of Longwall 37, is provided in Table 2.11.

Table 2.11 Summary of Survey Dates for the Upper Canal and Devines Tunnels during the Extraction of Longwall 37

SMP Commitments	Survey Dates	Proposed Future Monitoring
Initial survey prior to Longwall 37. Surveys at 350 m and 700 m of extraction. Final survey after the completion of Longwall 37.	April 2014 (Base, Series 6, Epoch 5) July 2014 (Series 6, Epoch 6) August 2014 (Series 6, Epoch 7) September 2014 (Series 6, Epoch 8) September 2014 (Series 6, Epoch 9) February 2015 (Series 6, Epoch 10)	Nil

The latest survey, Series 6 Epoch 10, was carried out in February 2015, after the completion of mining of Longwall 37, which was completed in January 2014. The results of the latest survey were provided in the SCA spreadsheet entitled “Upper Canal (North Survey Line) Movement Monitoring Survey Series 6 Epoch 10.xlsx”.

A summary of the maximum observed horizontal movement, vertical movement and strains, after the completion of Longwall 37, is provided in Table 2.12, which were extracted from the SCA spreadsheet.

Table 2.12 Summary of the Maximum Observed Incremental Subsidence Parameters along the Upper Canal and Devines Tunnels due to Longwall 37

Parameter	Maximum Observed Total Movements
Vertical Movement – Net Downward (mm)	11
Vertical Movement – Net Upward (mm)	31
Horizontal Movement (mm)	21
Tensile Strain (mm/m)	0.2
Compressive Strain (mm/m)	0.2

The accuracies of the measured horizontal movements provided in the SCA report are ±10mm for horizontal movement, ±15mm for vertical movement, and ~±0.25mm/m for differential movement (i.e. strain).

It can be seen from these results, that small movements have been observed at the Upper Canal and at Devines Tunnels. It is noted that this infrastructure is located between West Cliff and Appin Area 7 mining domains. The results represent the period April 2014 to February 2015, which coincide with the extraction of the completion of Longwall 37 and approximately 2,000 metres of Longwall 706 at Appin Area 7. The Upper Canal and Devines Tunnels are approximately 2.2km from Longwall 37.

2.7.2. Ousedale Creek, Mallaty Creek and Leafs Gully Aqueducts and Bridges and Nepean Creek

The mine subsidence movements were measured by IC at the Ousedale Creek, Nepean Creek, Mallaty Creek and Leafs Gully aqueducts and bridges during the extraction of Longwall 37. The locations of these structures are shown in Drawing No. MSEC740-01, in Appendix B.

A summary of the survey dates for the wrought iron aqueducts and bridges, during the extraction of Longwall 37, is provided in Table 2.13.

Table 2.13 Summary of Survey Dates for the Wrought Iron Aqueducts and Bridges during the Extraction of Longwall 37

SMP Commitments	Date	Location				Proposed Future Monitoring
		Ousedale	Mallaty	Nepean	Leafs	
Initial survey prior to Longwall 37. Surveys at 350 m and 700 m of extraction. Final survey after the completion of Longwall 37.	29/05/2014	Initial	Initial	Initial	Initial	Nil
	30/06/2014	✓	✓	✓	✓	
	08/08/2014	✓	✓	✓	✓	
	17/09/2014	✓	✓	✓	✓	
	13/03/2015	✓	✓	✓	✓	

A summary of the maximum predicted and maximum observed total subsidence parameters at the wrought iron aqueducts, after the completion of Longwall 37, is provided in Table 2.14. The observed movements are based on the latest surveys carried out on the 13th March 2015.

Table 2.14 Summary of the Maximum Predicted and Maximum Observed Total Subsidence Parameters at the Wrought Iron Aqueducts after the Completion of Longwall 37

Parameter	Ousedale		Mallaty		Leafs		Nepean	
	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed
Subsidence (mm)	<3	<-2	<3	<-2 <3		<-2	<3	<-2
Upsidence (mm)	<3	3	<3	<-2 <3		<-2	<3	<-2
Closure (mm)	<3	-16 (reduction)	<3	5 <3		<-2	<3	3

The accuracies of the measured relative vertical and horizontal positions are in the order of ±2 mm. The accuracies of the measured closure movements between the headwalls are in the order of ±2 mm.

The predicted mine subsidence movements in the above table are those which were provided in Report No. MSEC626, based on the shortened commencing end of Longwall 37. Observed closure values summarised above are taken as the change in distance between the headwalls, and do not include the movements of the pipe, which can be affected by change in temperature and water flow.

It can be seen from Table 2.14, that the observed movements at the wrought iron aqueducts, after the completion of Longwall 37, were all less than those predicted, with the exception of closure at Mallaty Creek, which increased by 5 mm. Horizontal movements were observed to develop during times of shut-down and high water flows, and it is expected that these movements were thermal movements, as the water flow normally moderates the temperature of the aqueduct pipes.

2.7.3. Concrete Aqueducts C and D

The mine subsidence movements were measured by IC at Concrete Aqueducts C and D during the extraction of Longwall 37. The locations of these aqueducts are shown in Drawing No. MSEC740-01, in Appendix B.

A summary of the survey dates for the concrete aqueducts, during the extraction of Longwall 37, is provided in Table 2.16.

Table 2.15 Summary of Survey Dates for the Concrete Aqueducts C and D during the Extraction of Longwall 37

SMP Commitments	Survey Dates	Proposed Future Monitoring
Initial survey prior to Longwall 37. Surveys at 350 m and 700 m of extraction. Final survey after the completion of Longwall 37.	29th May 2014 (Initial survey) 30th June 2014, 08thAugust 2014, 17th September 2014, 13th March 2015 (final survey)	Nil

The initial surveys at Concrete Aqueducts C and D were carried out on the 29th May 2014. The latest surveys at these aqueducts were carried out on the 13th March 2015, after the completion of Longwall 37.

As demonstrated in Report MSEC626 it was considered unlikely that the concrete aqueducts would be subjected to any significant systematic or valley related movements resulting from the extraction of Longwall 37 at West Cliff. The maximum observed vertical and horizontal movements at Concrete Aqueducts C and D, after the completion of Longwall 37, were generally less than 3mm, which is in the order of survey accuracy. The one exception to this was at Mark 1WB for Concrete Aqueduct D, which was observed to have an incremental vertical movement of 5mm between the last and second last survey epochs. Given that mining of Longwall 37 was in excess of 3,000 metres minimum away from Mark 1WB, this vertical movement is not considered to be related to mining at West Cliff.

3.1. Natural Features

The natural features in the vicinity of Longwall 37 are shown in Drawing No. MSEC740-02, in Appendix B. These features include the following:-

- The Georges River,
- Mallaty Creek, Leafs Gully and associated tributaries,
- Rock outcrops, and
- Steep slopes.

The assessments for the natural features, resulting from the extraction of Longwalls 37 and 38, were provided by MSEC in Report No. MSEC533. More detailed assessments for some natural features were also provided in other consultants reports. Comparisons between the MSEC assessments and the observed impacts for the natural features, resulting from the extraction of Longwall 37, are provided in Table 3.1.

Table 3.1 Summary of the MSEC Assessments and the Observed Impacts for the Natural Features Resulting from the Extraction of Longwall 37

Natural Feature	MSEC Assessed Impacts	Observed Impacts
The Georges River	Increased levels of **ponding**, **flooding**, **scouring** and **desiccation** are unlikely to be significant	No reported impacts
	Minor fracturing could occur in the bed of the river, with isolated fracturing up to 400 metres from the extracted longwalls	No reported impacts.
	The potential for **surface water flow diversions** assessed as low	Five previously reported low pool water level triggers were reached during LW 37, during periods of low flow. These were considered as recurring impacts from LW35. Previous impacts resulting from Longwall 35 continued to show low pool levels during low flow periods.
	Possible that mining-induced **springs** could occur	No reported impacts
	Possible that minor isolated **gas emissions** could occur in the river	No reported impacts
	Water quality – Refer to the included report by *EcoEngineers* **Terrestrial ecology** – Refer to the included report by *Illawarra Coal Environmental Field Team* **Aquatic ecology** – Refer to the included report by *Cardno Ecology Lab*	
Creeks and Tributaries	Increased levels of **ponding**, **flooding** and **scouring** are unlikely to be significant	No reported impacts
	Some **fracturing** could occur in the bedrock beneath the watercourses which are directly mined beneath	No reported impacts from LW37. However impact was identified resulting from Longwall 36, with this being a fracture on Georges River tributary GR104_Pool 1 (Impact .WCA5_LW36_001).
	Some **surface water flow diversions** into the dilated strata beneath the watercourses which are directly mined beneath	No reported impacts
	Possible that minor isolated **gas emissions** could occur	No reported impacts
Rock Outcrops	Possible that **rockfalls** could occur along the exposed rockfaces	No reported impacts from LW37. However impact was identified resulting from Longwall 35, The LW35 impact was Impact WCA5_LW35_026, which was a minor rockfall 10 m upslope of the Georges River, at 190 m from LW35 goaf edge.
Archaeological Sites	Possibility of some minor fracturing in the sandstone bed of the Georges River within 400 metres of the proposed longwalls	Refer to the report by Niche
Steep Slopes	Potential for **soil slippage**	No reported impacts

It can be seen from Table 3.1 that the observed impacts on the natural features, resulting from the extraction of Longwall 37, were similar to or less than the MSEC assessments. Further assessments of natural features have been provided by other consultants, which are described in the relevant reports attached to the *End of Panel Report*.

3.2. Surface Infrastructure

The surface infrastructure in the vicinity of Longwall 37 is shown in Drawing No. MSEC740-03, in Appendix B. The assessed (i.e. predicted) impacts for the surface infrastructure, resulting from the extraction of Longwalls 37 and 38, were provided in Report No. MSEC533. Comparisons between the assessed and observed impacts for surface infrastructure, after the extraction of Longwall 37, are provided in Table 3.2.

Table 3.2 Summary of the Assessed and Observed Impacts for Surface Infrastructure Resulting from the Extraction of Longwall 37

Surface Infrastructure	Assessed Impacts	Observed Impacts
Appin Road	Cracking and minor localised buckling which are likely to be infrequent and minor in nature	Minor cracking and buckling of road surface. Refer to Section 3.3 for further details.
The Upper Canal, Devines Tunnel and Associated Infrastructure	Impacts unlikely after the implementation of necessary preventive measures at the concrete and wrought iron aqueducts	No reported impacts
Sydney Water Service Line along Appin Road	Impacts unlikely	No reported impacts
Macarthur Water 1200 mm diameter Treated Water Gravity Main	Impacts unlikely after the implementation of preventive measures at Mallaty Creek	Impacts to the pipeline in late 2014 were identified but assessed as non-mining related.
Alinta EGP and AGN Natural Gas and Gorodok Ethane Pipelines	Impacts unlikely after the implementation of preventive measures at Mallaty Creek	No reported impacts
TransGrid 330 kV Transmission Line	Impacts unlikely after the implementation of preventive measures including roller sheaves	No reported impacts
Endeavour Energy 66 kV, 11 kV and low voltage powerlines	Impacts unlikely	No reported impacts
Telstra Optical Fibre Cable along Appin Road	Impacts unlikely	No reported impacts
Telstra Copper Cables	Impacts unlikely	No reported impacts
Rural Building Structures	Category A or B Tilt Impacts Category 0 to 1 Strain Impacts Negligible to very slight impacts	No reported impacts
Tanks	Tilts up to 4.0 mm/m Systematic strains up to 1.1 mm/m Impacts unlikely	No reported impacts
Farm Dams	Tilts up to 6.5 mm/m Systematic strains up to 1.8 mm/m Potential for some minor cracking or leakage in farm dams	No reported impacts
Houses	Category A or B Tilt Impacts Category 0 to 2 Strain Impacts Negligible to slight impacts	Three properties have reported impacts during LW37 at the time of preparation of this report. However, one of these properties is being dealt with separately between the home owner and Campbelltown Council rather than the MSB.
Pools	Tilt could be visible along waterline and inground pools could be more susceptible to strain impacts	No reported impacts
Fences	Possible that some fences could experience slight impacts	No reported impacts
Survey control marks	Small far-field horizontal movements which could require re-establishment	Small far-field horizontal movements observed.

It can be seen from Table 3.2, that the observed impacts on the surface infrastructure, after the extraction of Longwall 37, were similar to or less than the assessed (i.e. predicted) impacts.

A water leak from the 1200 mm diameter treated water gravity main was observed during mining of Longwall 37, however examination of survey data showed that the changes in strain were less than survey tolerance, and the leak was not attributed to mining.

3.3. Observed Impacts along Appin Road

Surface inspections along Appin Road were regularly conducted during the mining of Longwall 37. Some minor impacts developed along the section of road above the extracted Longwall 37 and partly over the previous Longwall 36.

The surface impacts in this area included small compression bumps in the road pavement, and the opening of minor cracks along and across the road surface. A surface bump occurred at the location of the identified irregular movement between Marks B222 and B223. The inspections have noted the following features during the extraction of Longwall 37:

- A small bump 9m north of B223 (B223 plus 9m)
- A bump at 15m north of B222 (B222 plus 15m) across the road, which became more pronounced as mining progressed.
- A small bump in the northbound shoulder at 19m north of B230 (B230 plus 19m), and a slight dip across the carriageway in this location. Minor cracking in the road shoulder was also observed.

Photographs are provided in the following Fig. 3.1 to Fig. 3.3. The bump at B222 plus 15m developed across northbound and southbound lanes of the pavement on 01st December 2014. The bump was remediated on 05th December 2014 by milling and patching the pavement from B222+7 metres to B222+15 metres. This location corresponded with a bump in the subsidence profile and an associated increase in compressive strain at B222 to B223. Incremental strain also increased in this area. An anomalous movement was initially identified at Marks B222 to B223 during the extraction of Longwall 36; however no remedial works were required during Longwall 36 extraction.

Rehabilitation of the mining affects along Appin Road is being planned. The section of Appin Road from Brian's Road to the LGA boundary has been assessed by the Roads and Maritime Services (RMS) and the Mine Subsidence Board (MSB), with cost sharing agreed for this section. It is planned that the section of Appin Road, to the north of the LGA boundary covering the area influenced by Longwalls 35 to 37, will be assessed by the RMS and the MSB in coming months to identify mine subsidence related damage and cost responsibilities.

Fig. 3.1 Bump at B222 + 15m, 1st December 2014 (Courtesy of Colin Dove)

Fig. 3.2 Pavement repair at B222 + 15m, 8th December 2014 (Courtesy of Colin Dove)

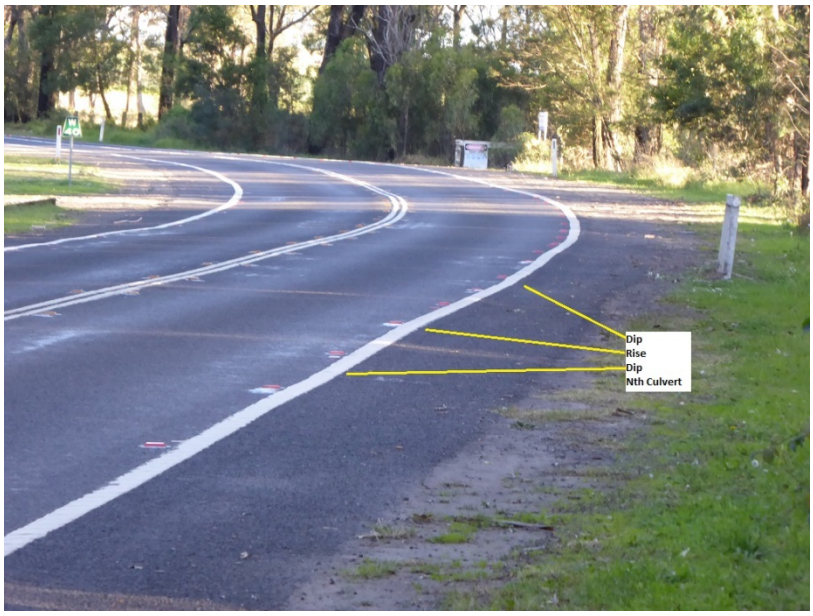
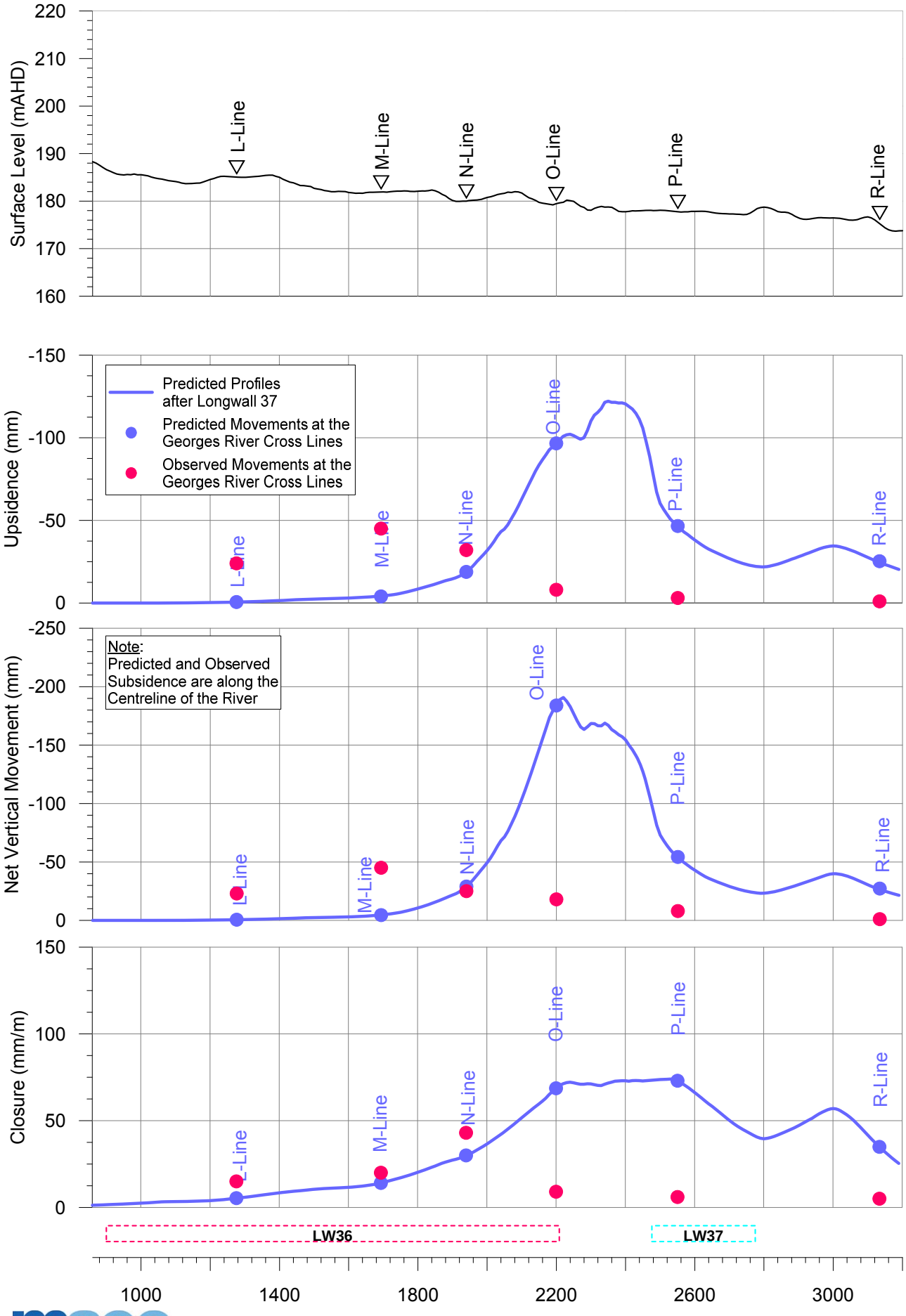


Fig. 3.3 Cracking in road shoulder at B230 + 19m, 4th December 2014 (Courtesy of Colin Dove)

APPENDIX A. FIGURES

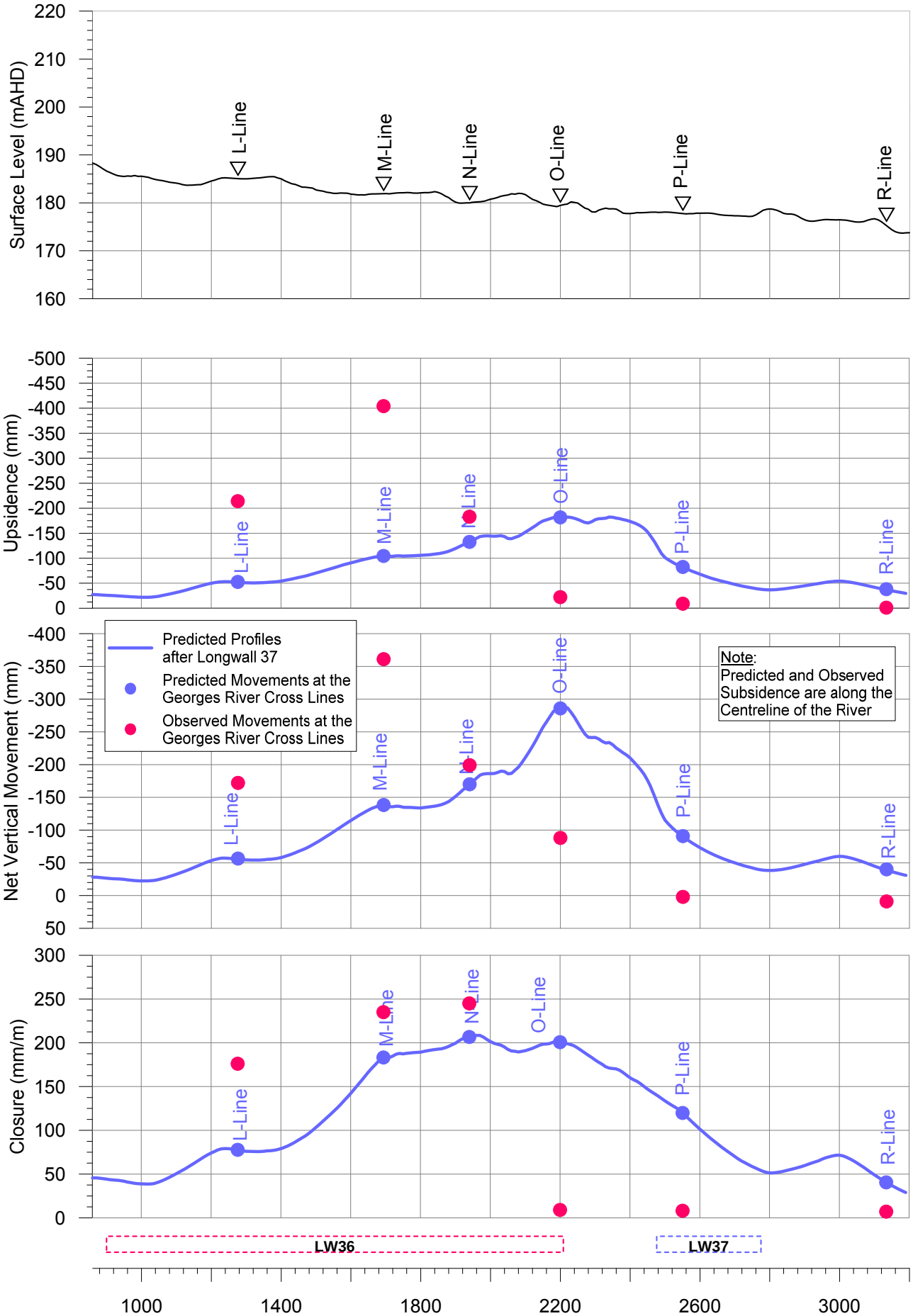
West Cliff Colliery - Longwall 37
Predicted and Observed Incremental Subsidence, Upsidence and Closure along the Centreline of the Georges River



msec

Fig. A.01

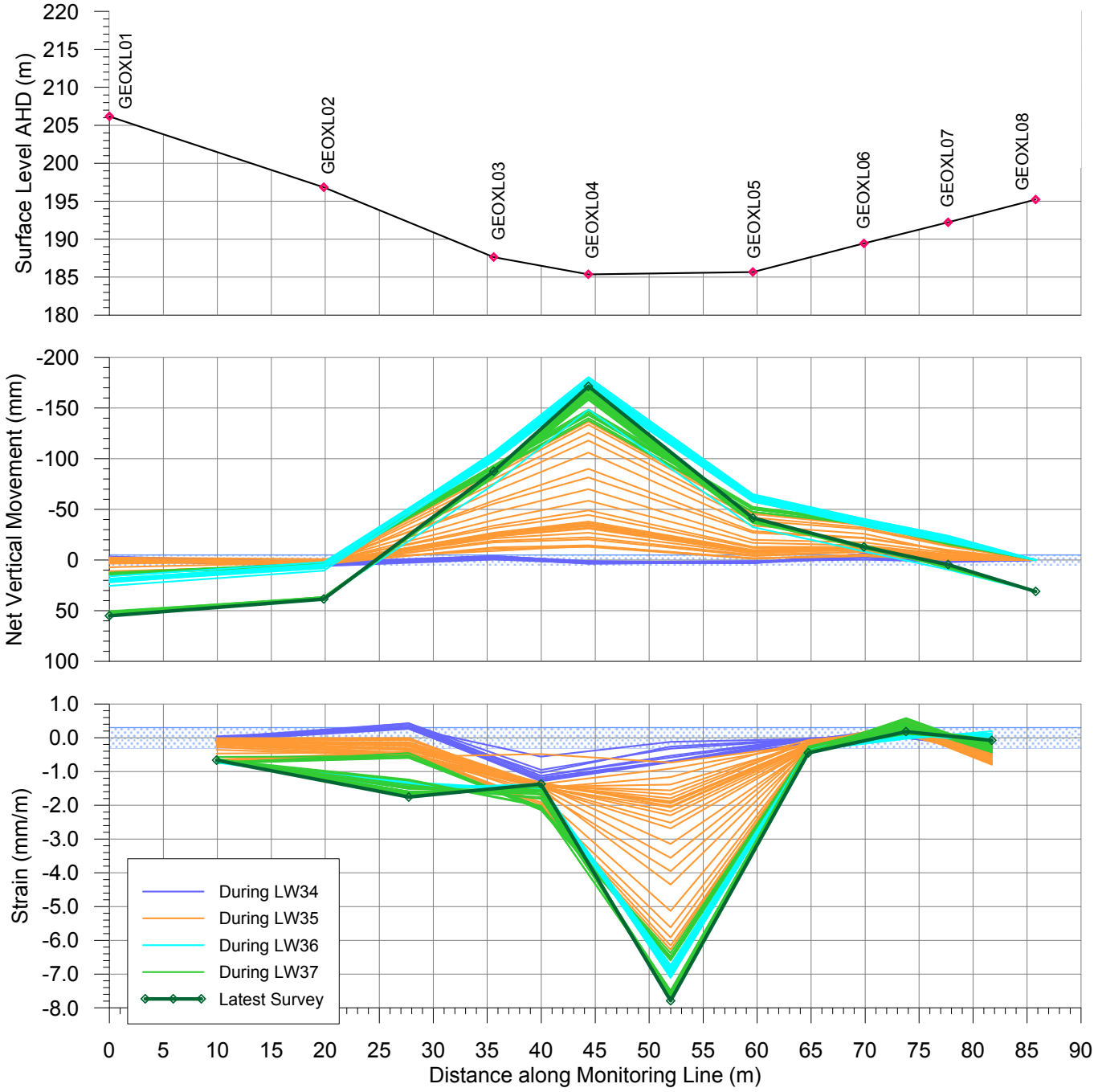
West Cliff Colliery - Longwall 37
Predicted and Observed Total Subsidence, Upsidence and Closure along the Centreline of the Georges River

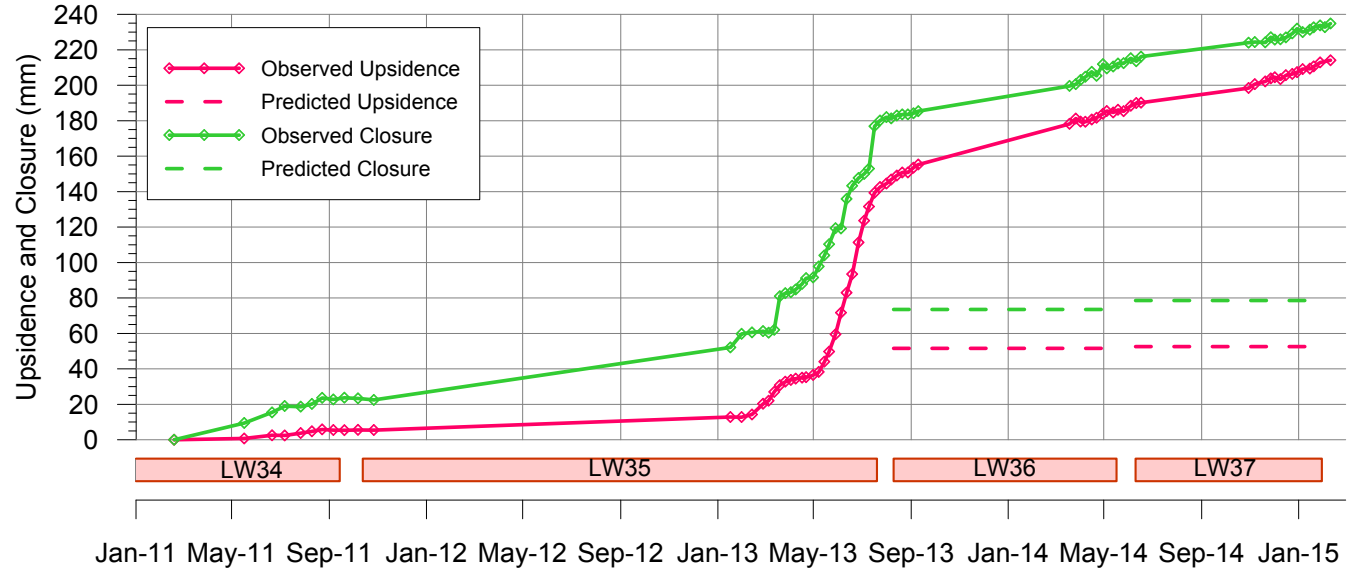


msec

Fig. A.02

West Cliff Colliery - Longwall 37 - Georges River L-Line
Total Subsidence, Strain, Upsidence and Closure Profiles

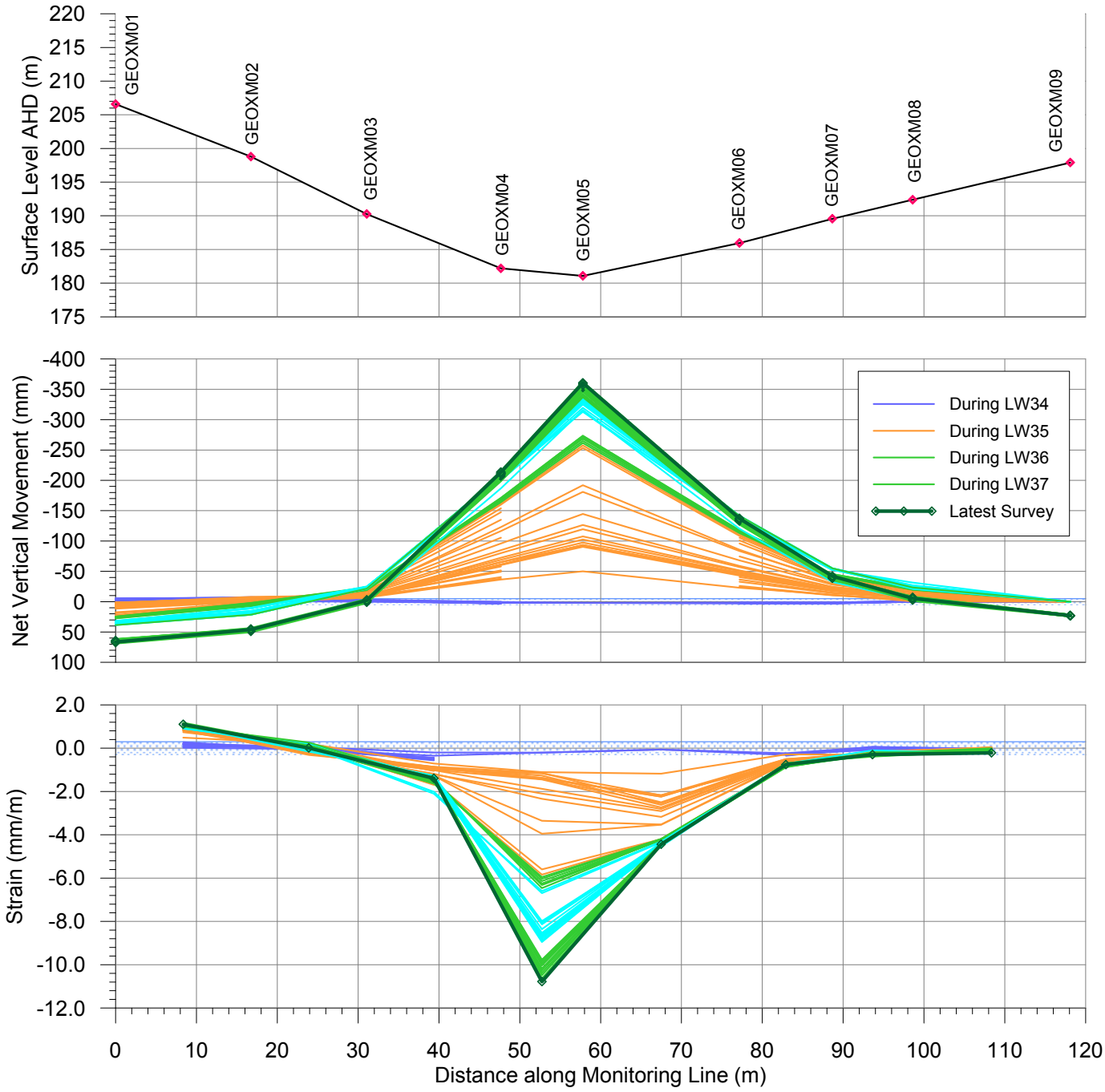


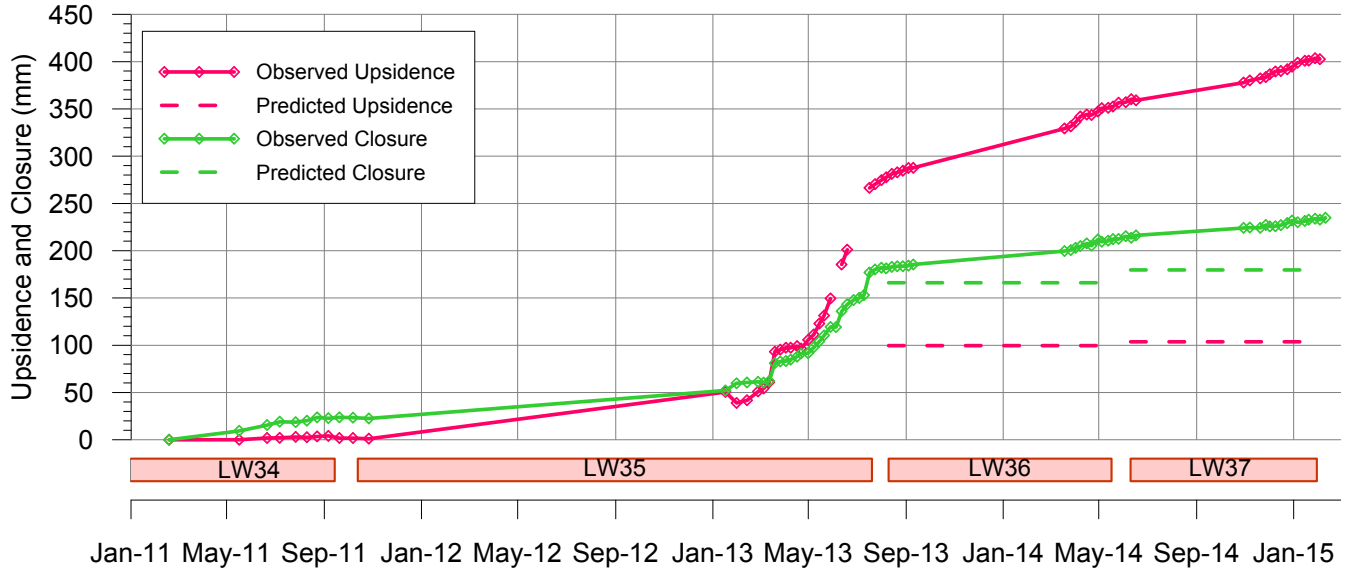


msec

Fig. A.03

West Cliff Colliery - Longwall 37 - Georges River M-Line
Total Subsidence, Strain, Upsidence and Closure Profiles

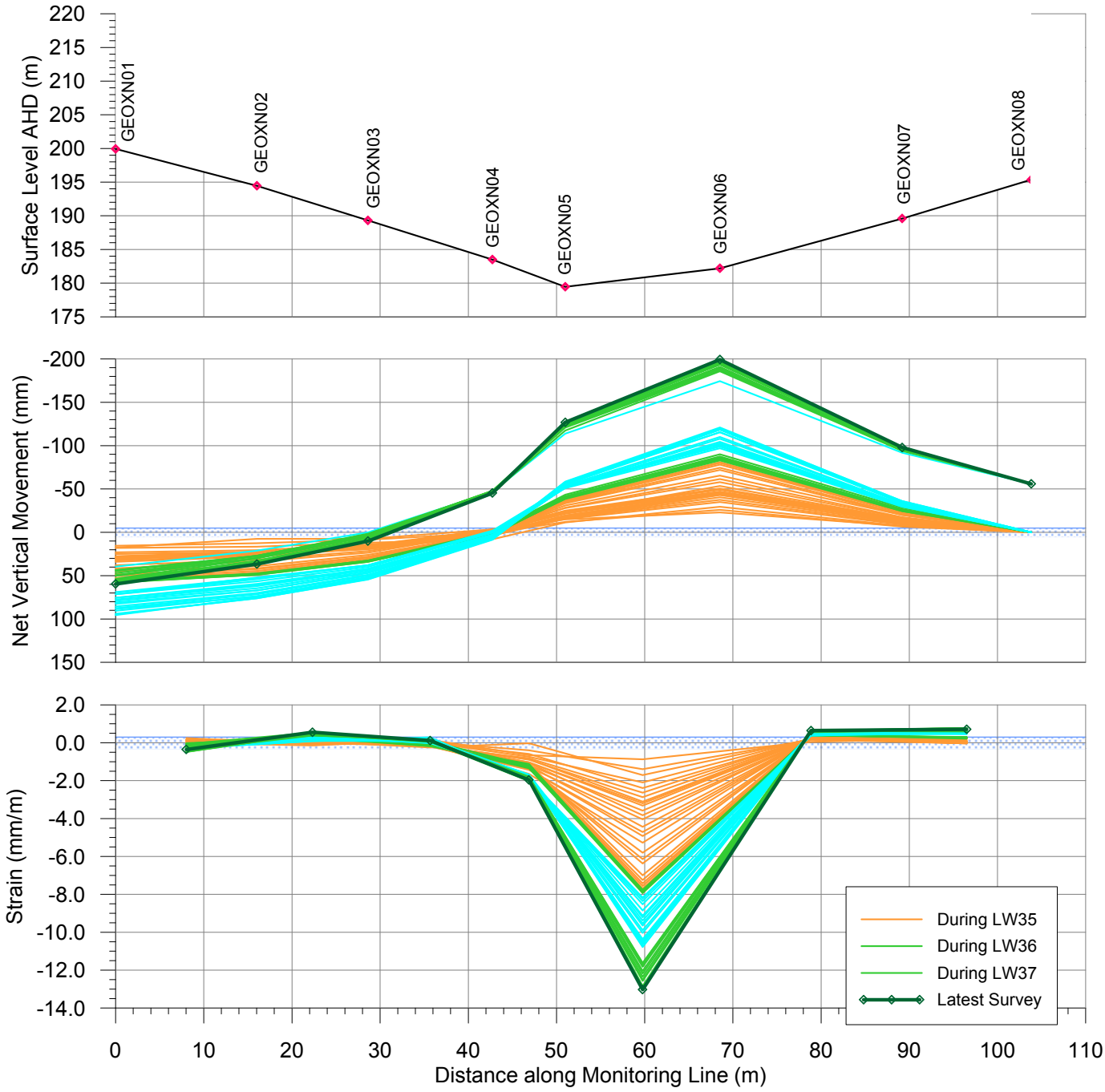


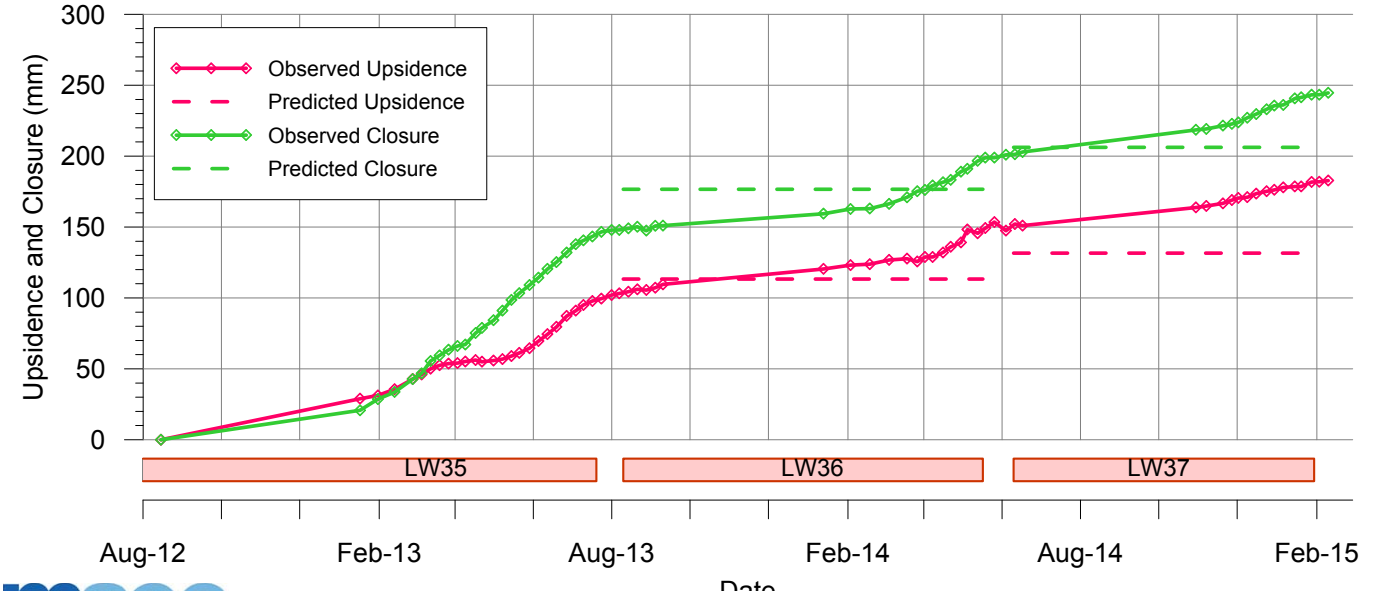


msec

Fig. A.04

West Cliff Colliery - Longwall 37 - Georges River N-Line
Total Subsidence, Strain, Upsidence and Closure Profiles

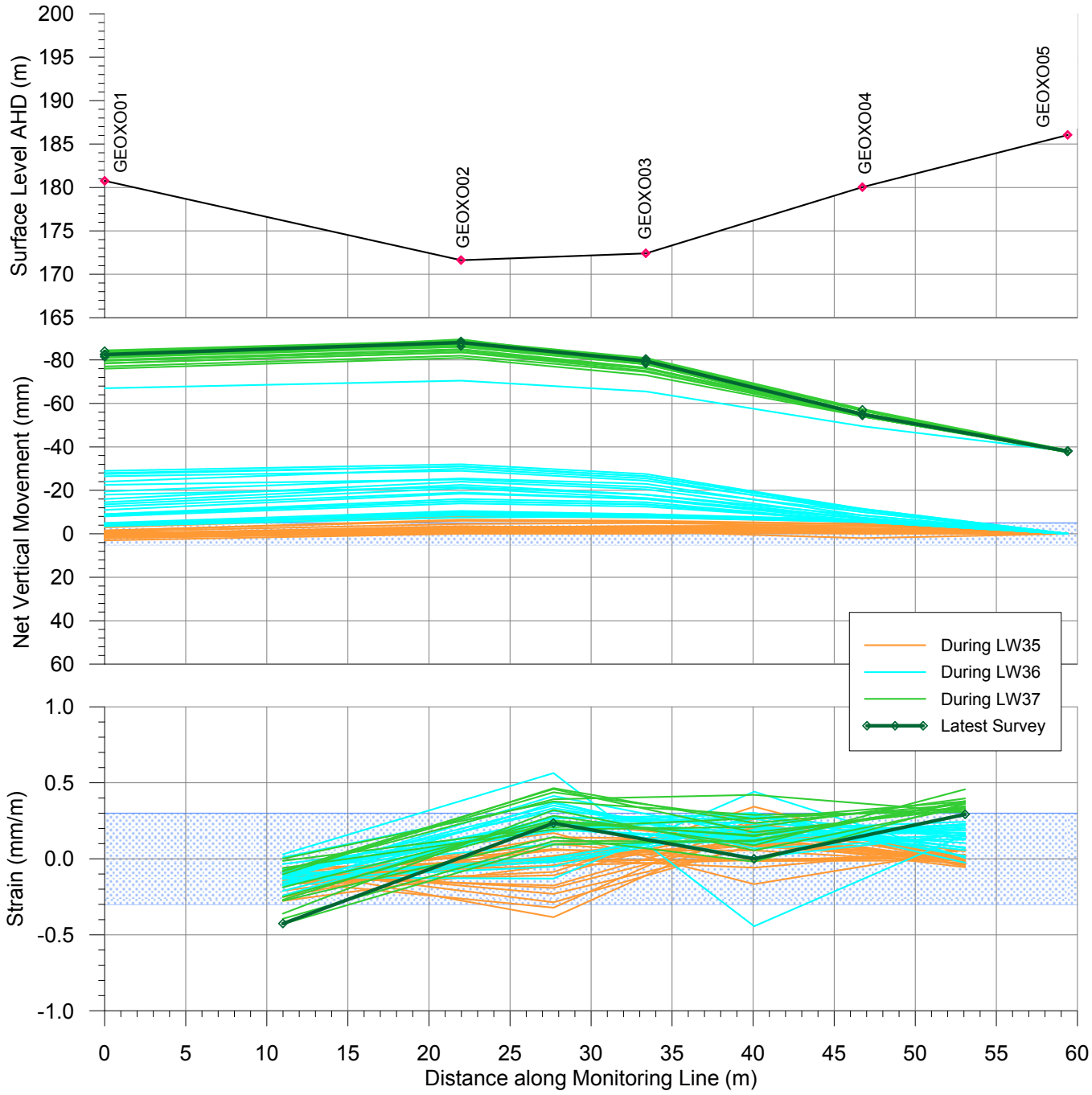


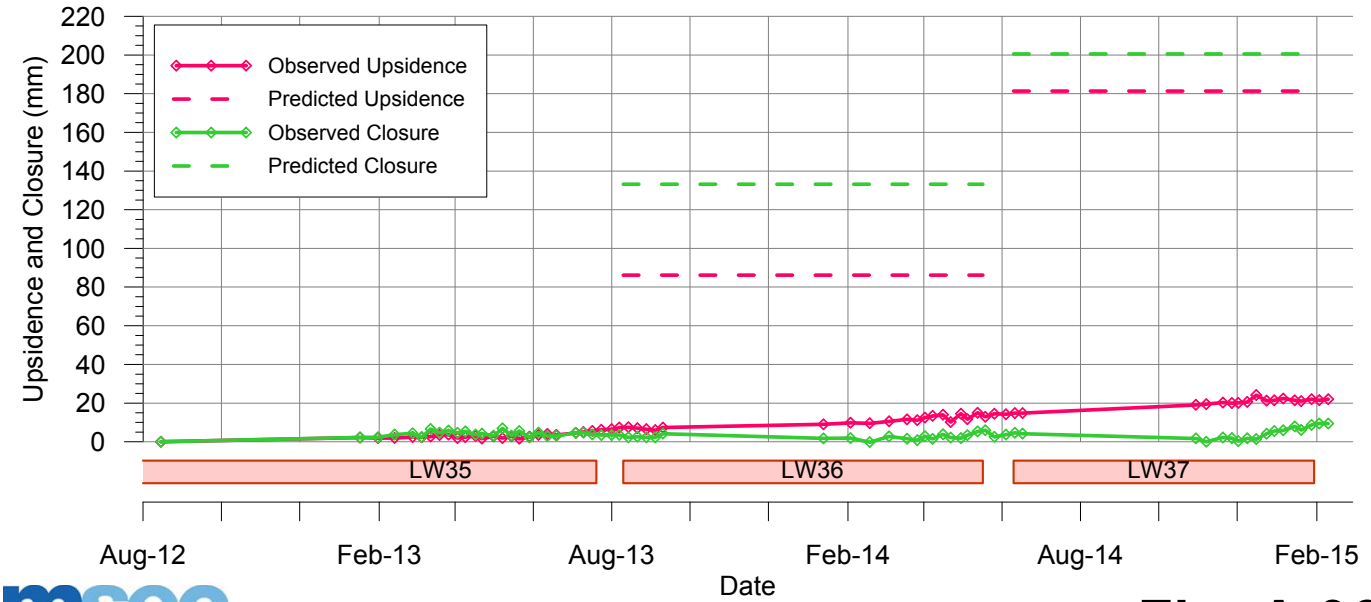


msec

Fig. A.05

West Cliff Colliery - Longwall 37 - Georges River O-Line
Total Subsidence, Strain, Upsidence and Closure Profiles

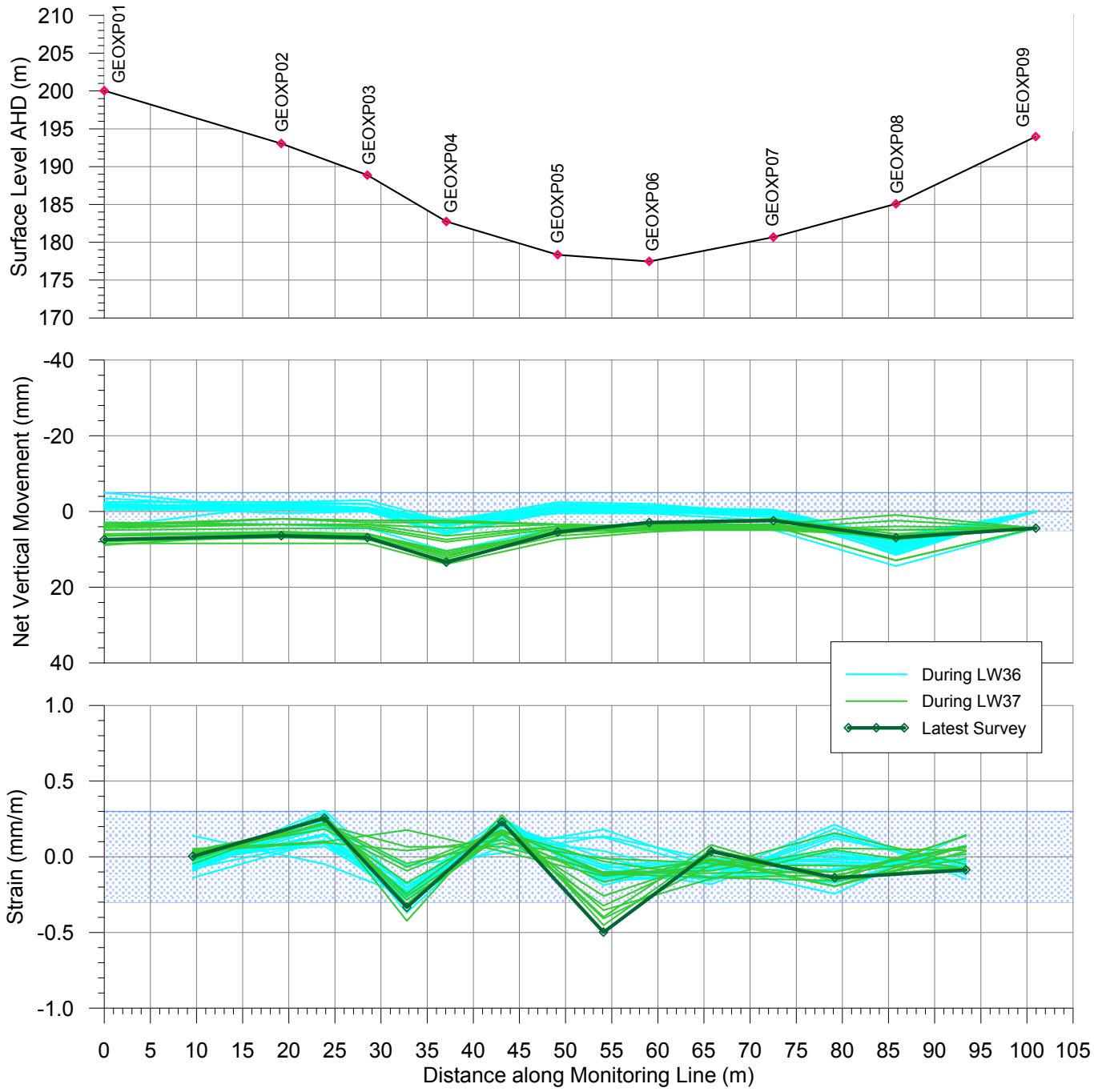


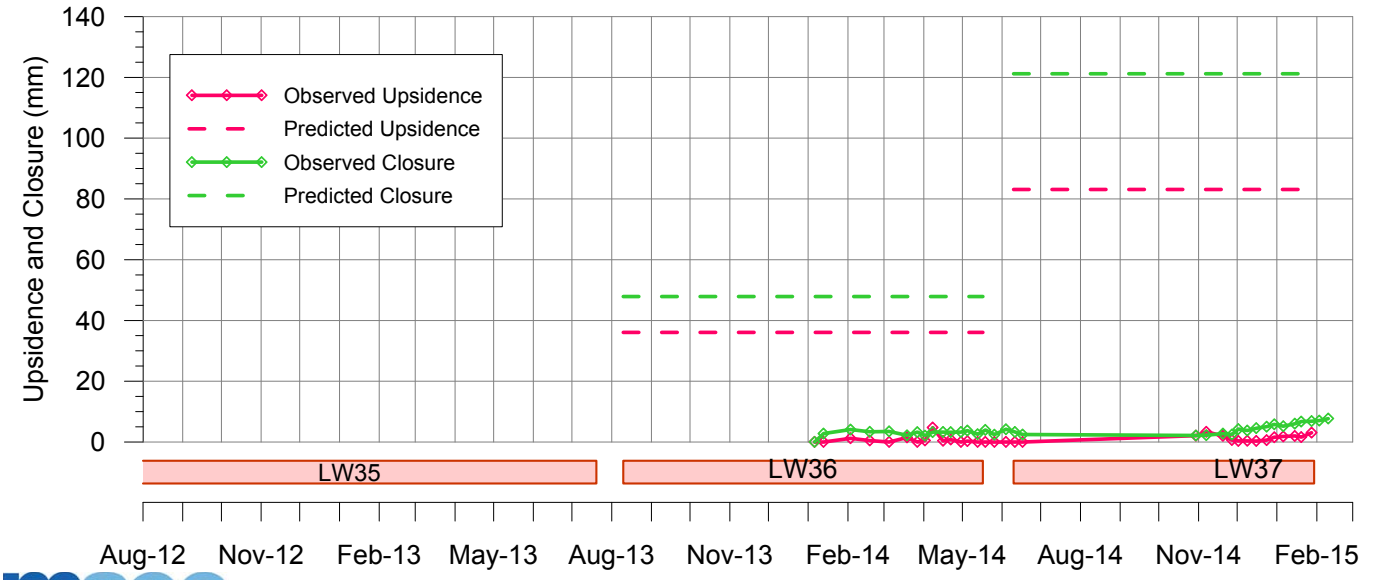


msec

Fig. A.06

West Cliff Colliery - Longwall 37 - Georges River P-Line
Total Subsidence, Strain, Upsidence and Closure Profiles

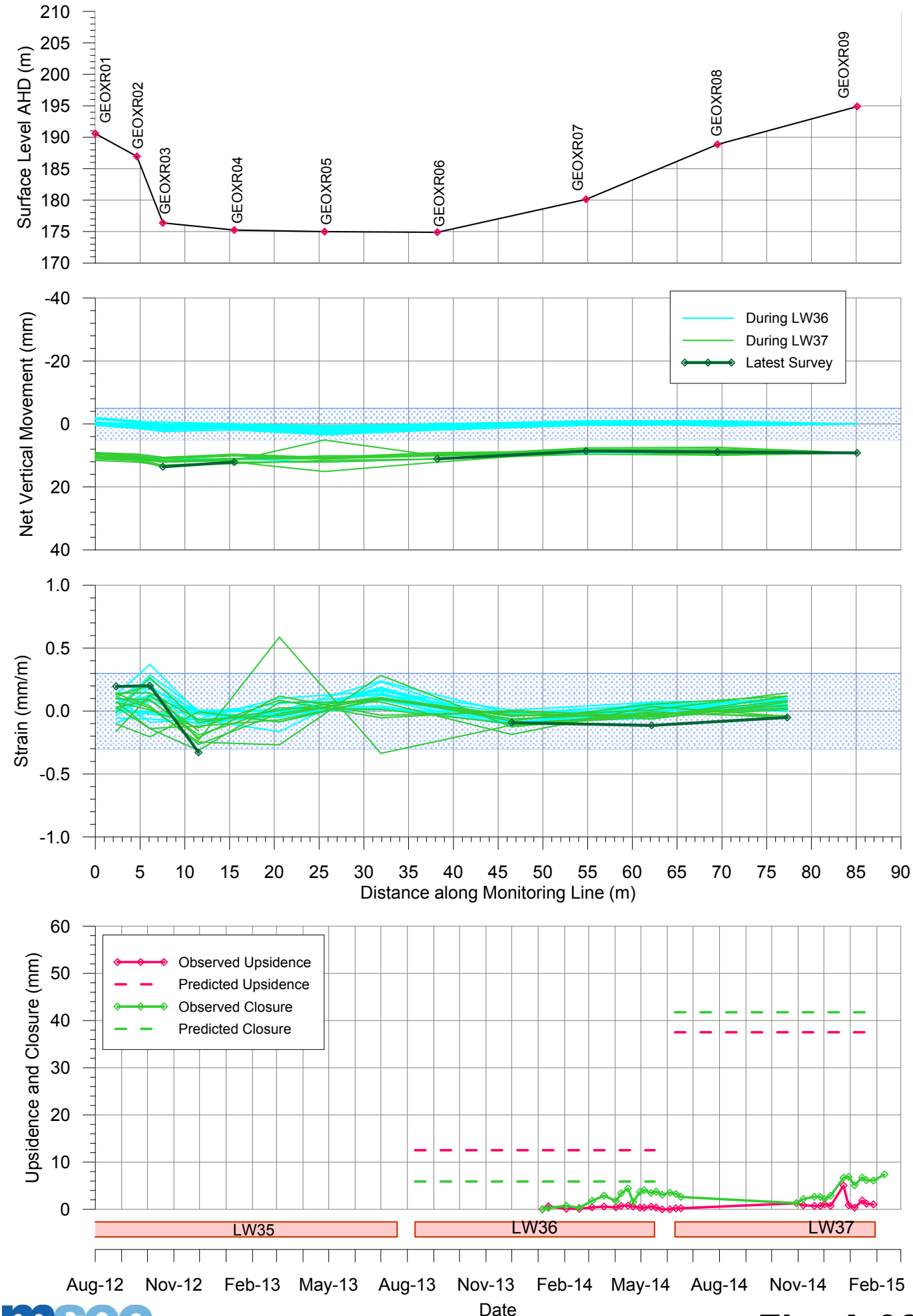




msec

Fig. A.07

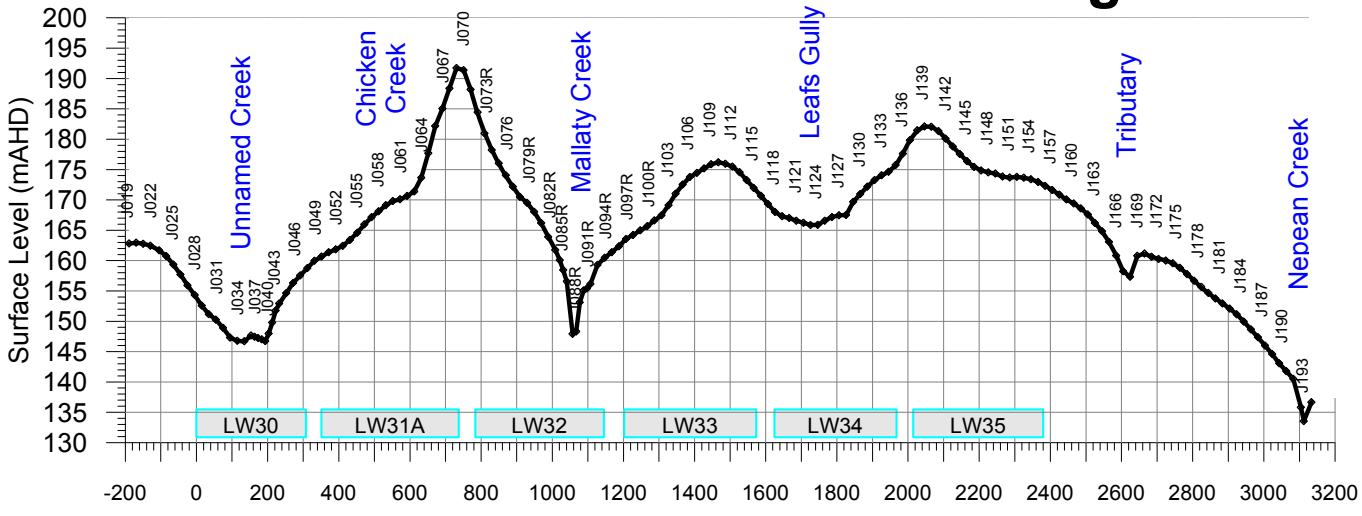
West Cliff Colliery - Longwall 37 - Georges River R-Line
Total Subsidence, Strain, Upsidence and Closure Profiles

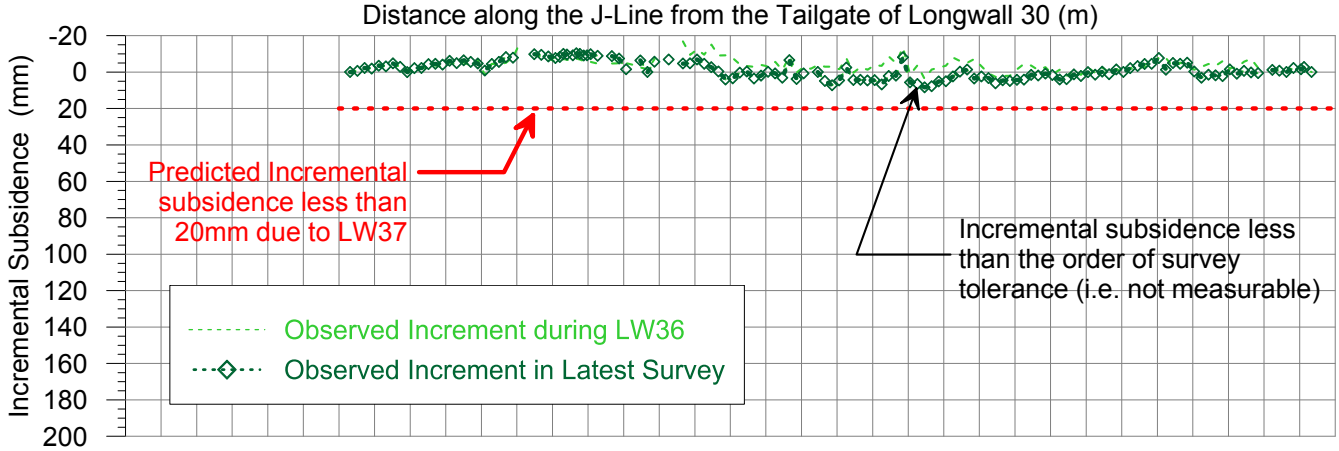


msec

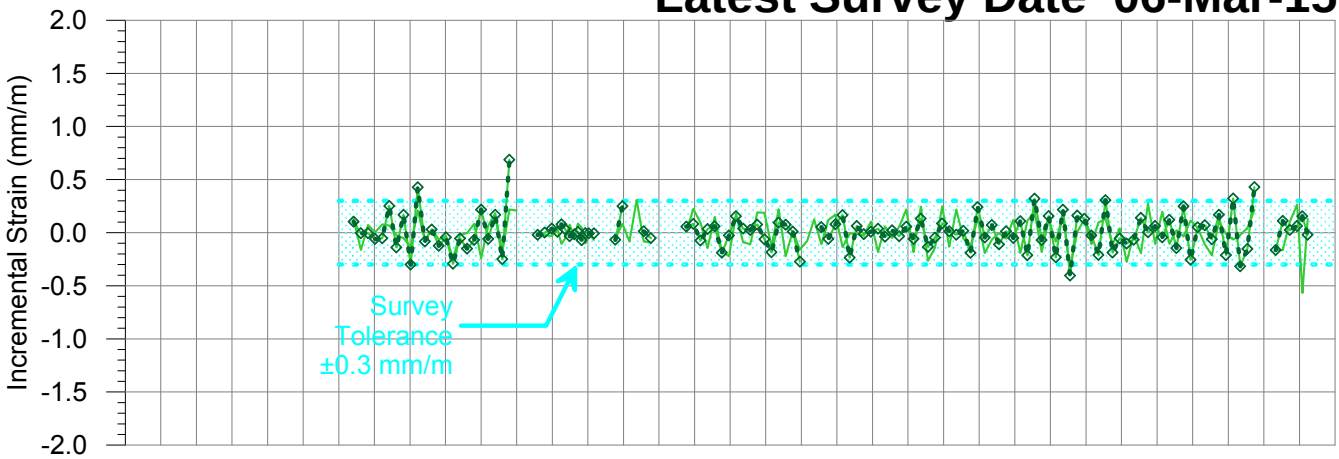
Fig. A.08

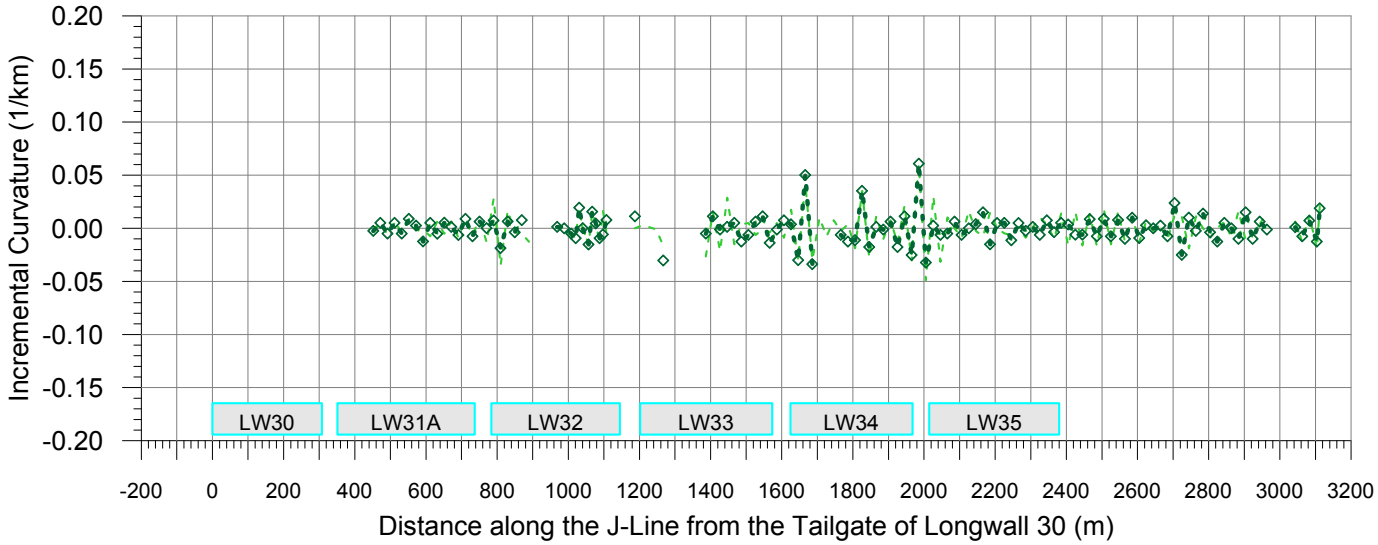
West Cliff - J Line - Increment of Longwall 37





Latest Survey Date 06-Mar-15

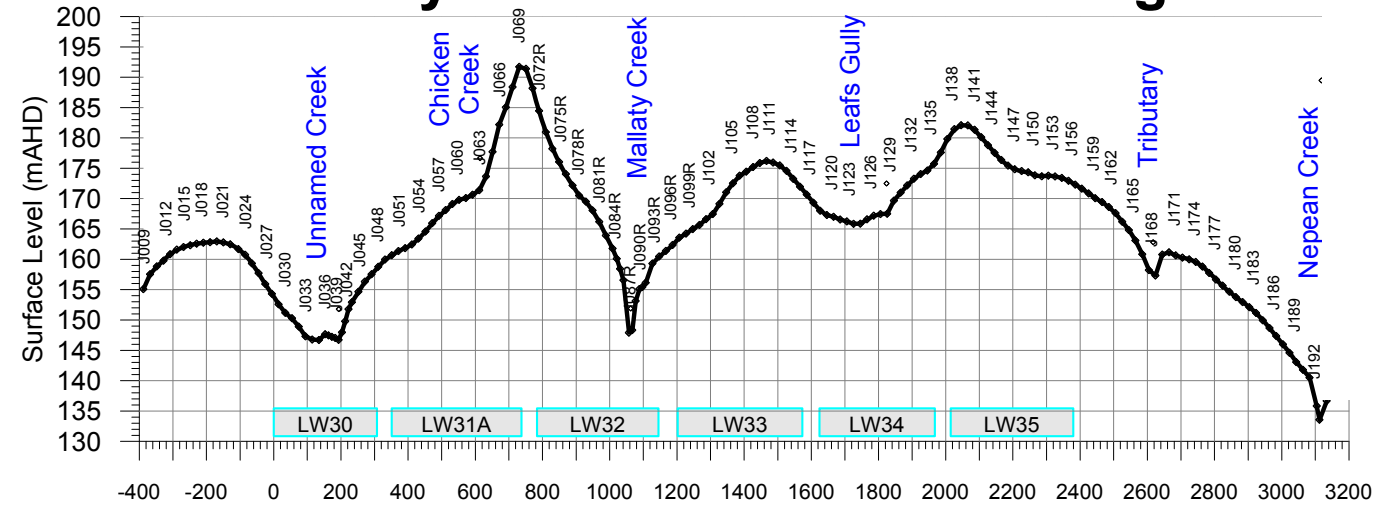


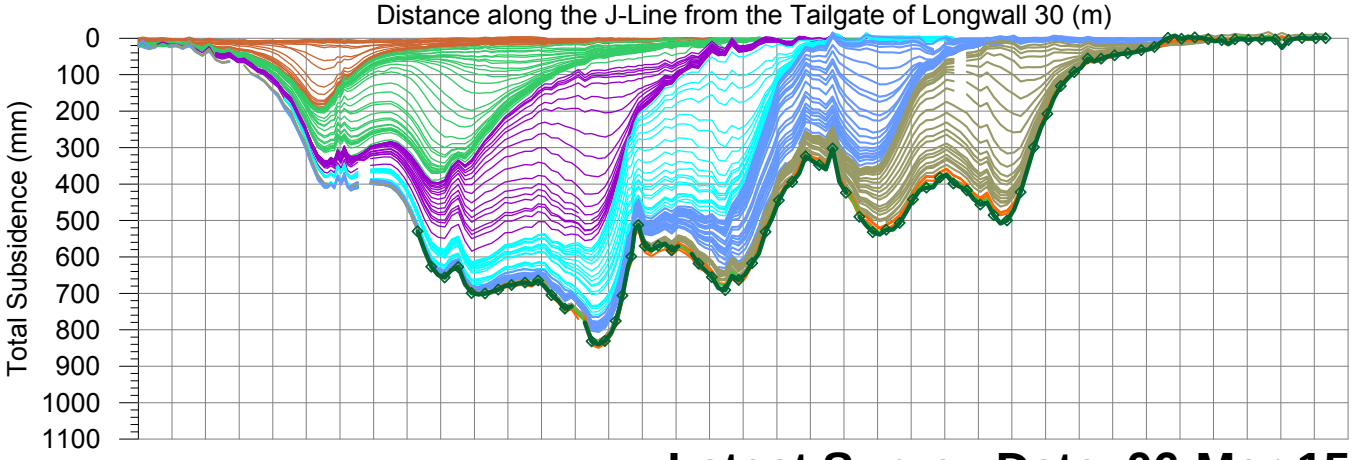


msec

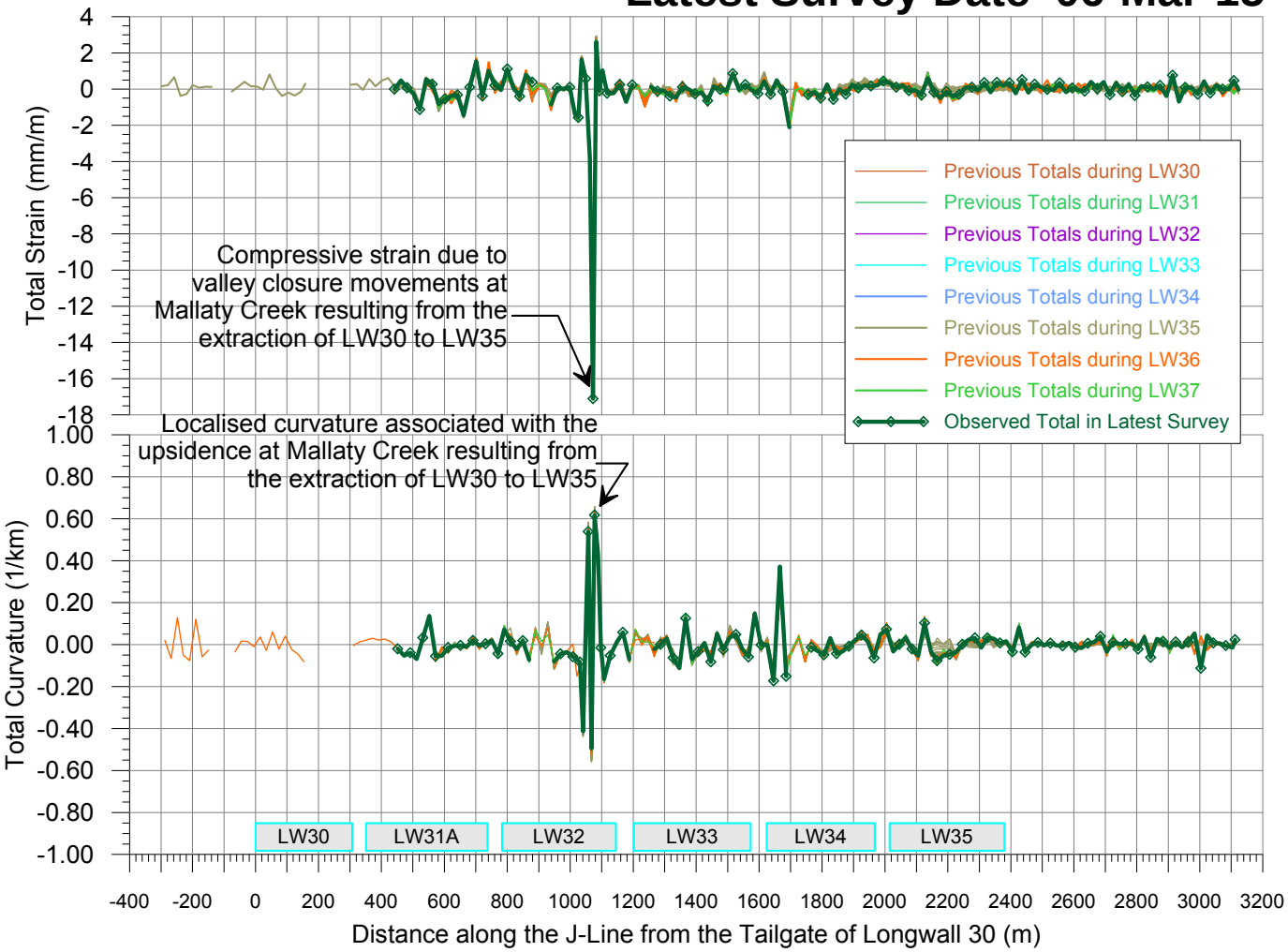
Fig. A.09

West Cliff Colliery - J Line - Total after Longwall 37





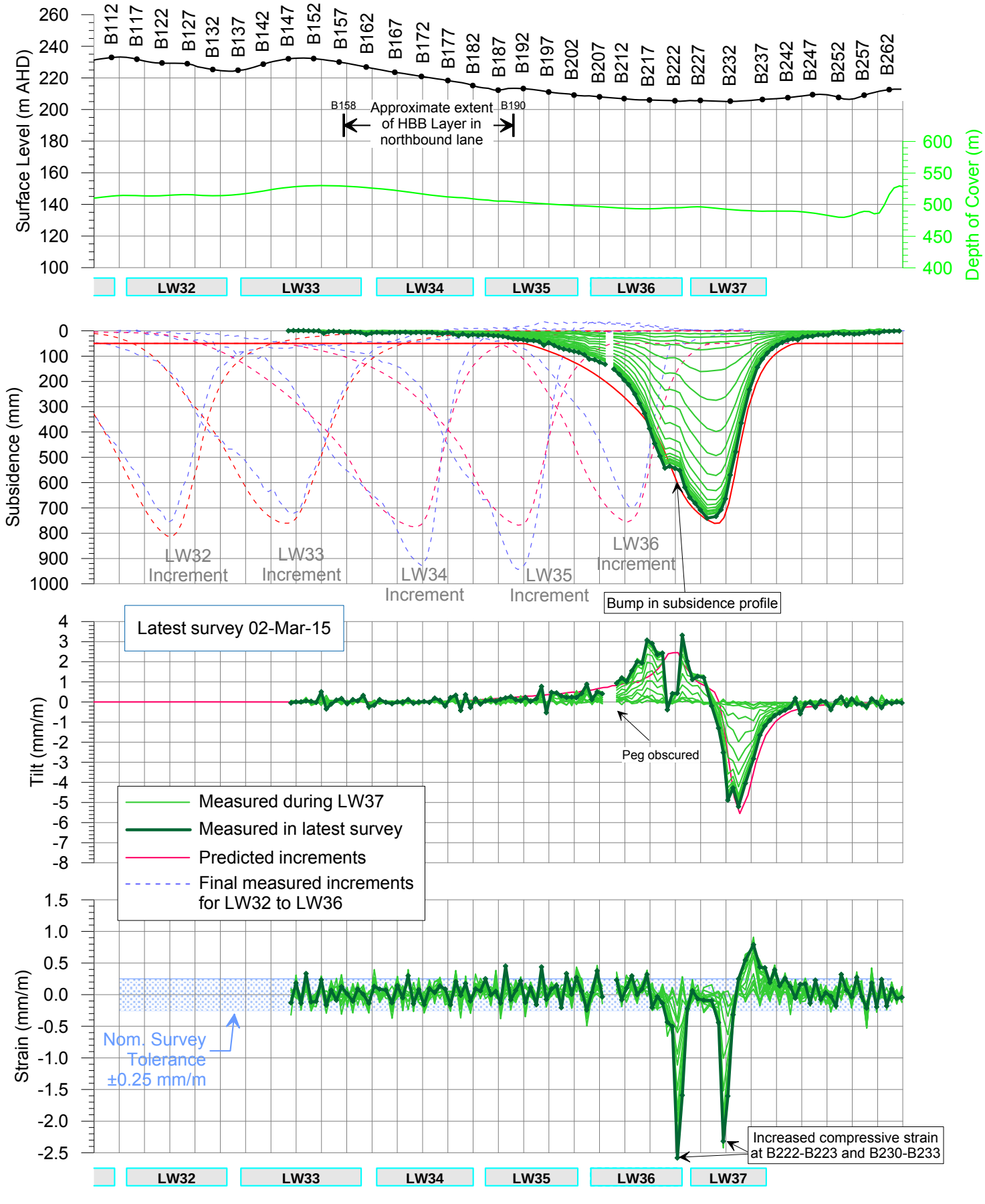
Latest Survey Date 06-Mar-15



msec

Fig. A.10

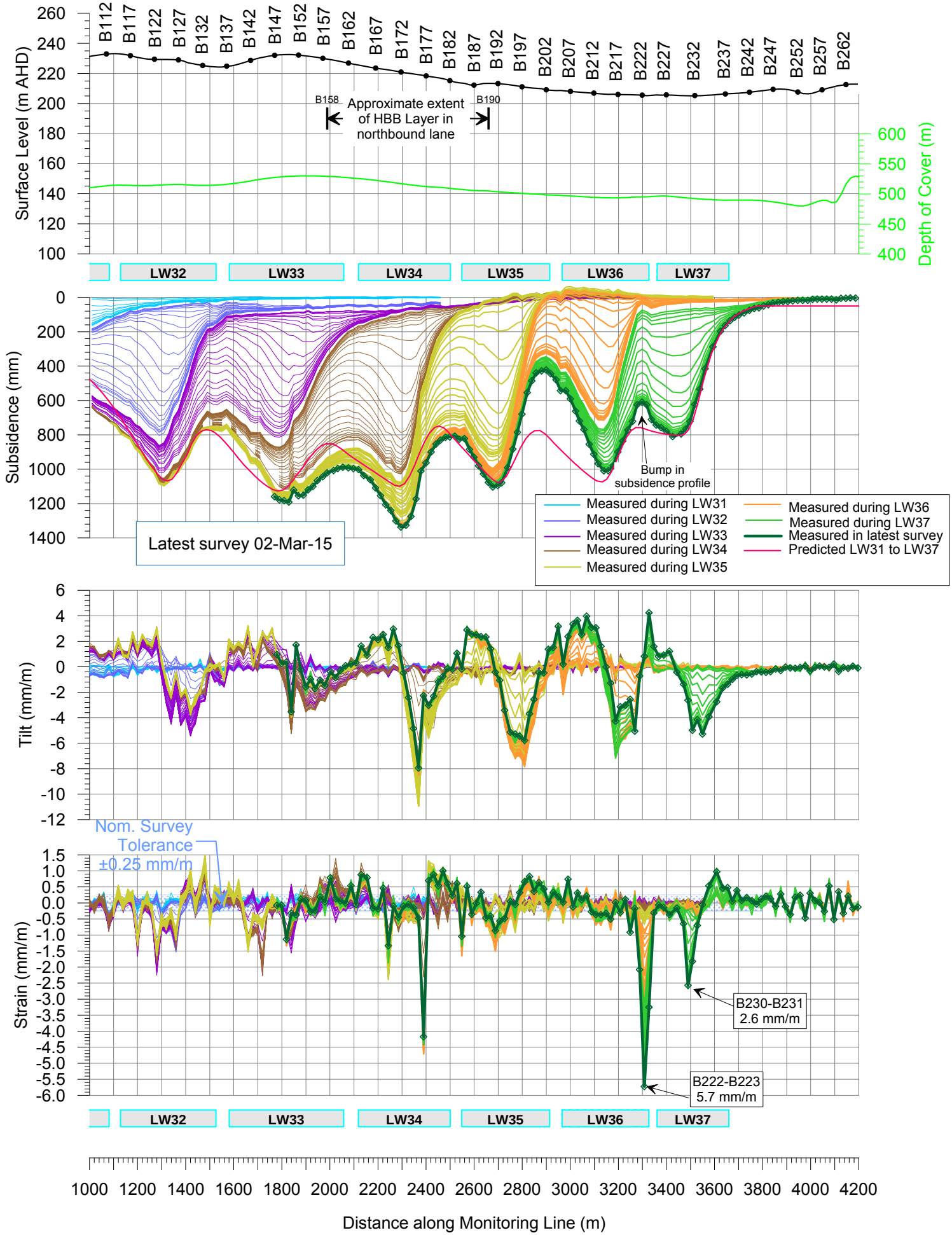
Observed and Predicted Profiles of Incremental Subsidence, Tilt and Strain along the B-Line during the Extraction of West Cliff LW37



msec

Fig. A.11

Observed and Predicted Profiles of Total Subsidence, Tilt and Strain along the B-Line during the Extraction of West Cliff LW37

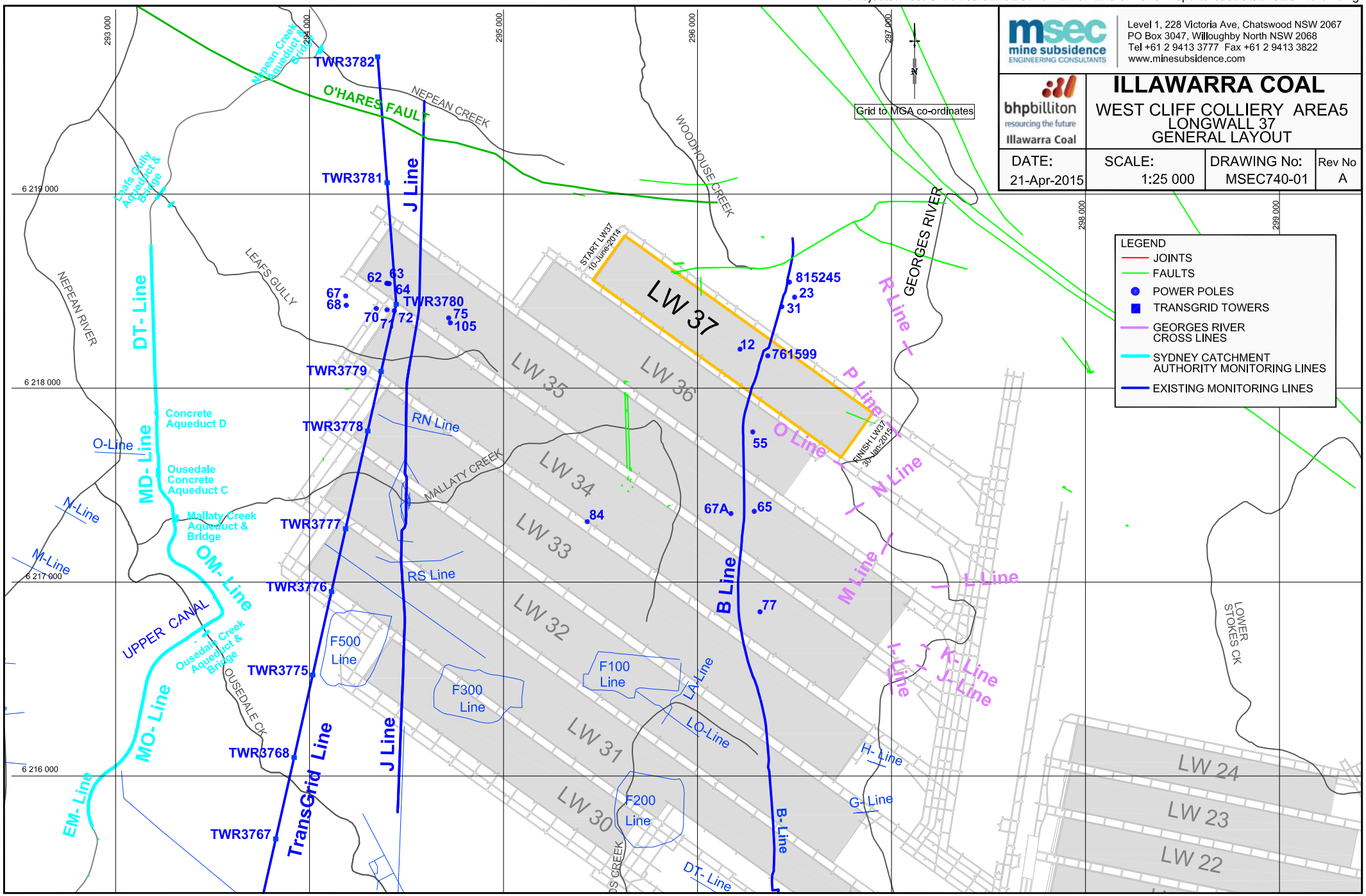


msec

Fig. A.12

APPENDIX B. DRAWINGS

I:\Projects\West Cliff\Area 5\MSEC740 - LW37 End of Panel Report\AcadData\MSEC740-01.dwg



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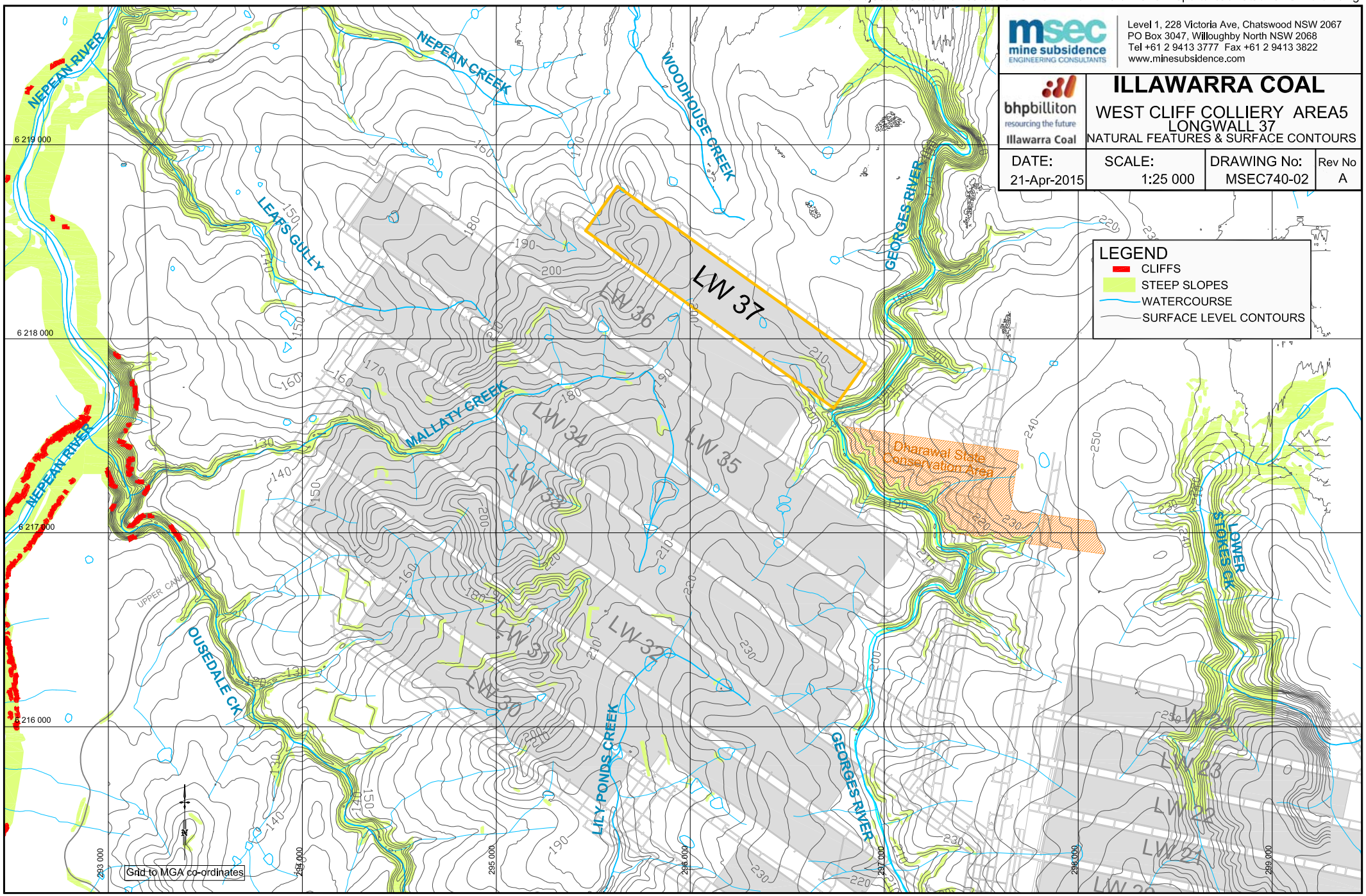

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WEST CLIFF COLLIERY AREA5
LONGWALL 37
NATURAL FEATURES & SURFACE CONTOURS

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