Subsidence

Metropolitan Coal's subsidence monitoring program includes the monitoring of subsidence parameters (i.e. the actual movement of the ground surface) and subsidence impacts (e.g. surface cracking).

The subsidence parameter monitoring locations are shown on Figure 1 and include:

- D Line (existing line traversing Longwalls 1-18).
- Line 9C (along Fire Road 9C).
- Line 9C West (from Fire Road 9C to Tributary B).
- Line 9G (along Fire Road 9G).
- Line 9J (along Fire Road 9J).
- Longitudinal Line (400 m along the centreline of Longwall 20).
- Transmission Line (along the transmission lines).
- Freeway Line (along the F6 Southern Freeway).
- Princes Highway Line (along the Princes Highway).
- Ridge Top Survey Stations (five locations on ridge tops about the Waratah Rivulet).
- Existing 13 Waratah Rivulet Cross Lines (from WRS3 rock bar [Line 'E'] to 150 m downstream of Flat Rock Crossing).
- Additional 3 Waratah Rivulet Cross Lines (over Longwalls 20-22).
- Additional 2 Waratah Rivulet Cross Lines downstream of Longwall 23 Maingate (at Rock Bars P and Q).

Subsidence movements are surveyed in three dimensions using a total station survey instrument.

Monitoring of subsidence impacts on built features are described in the Built Features section of this Environmental Monitoring Summary.

Monitoring of subsidence impacts on natural features (such as stream features, cliffs and slopes) are described in the relevant sections of this Environmental Monitoring Summary.

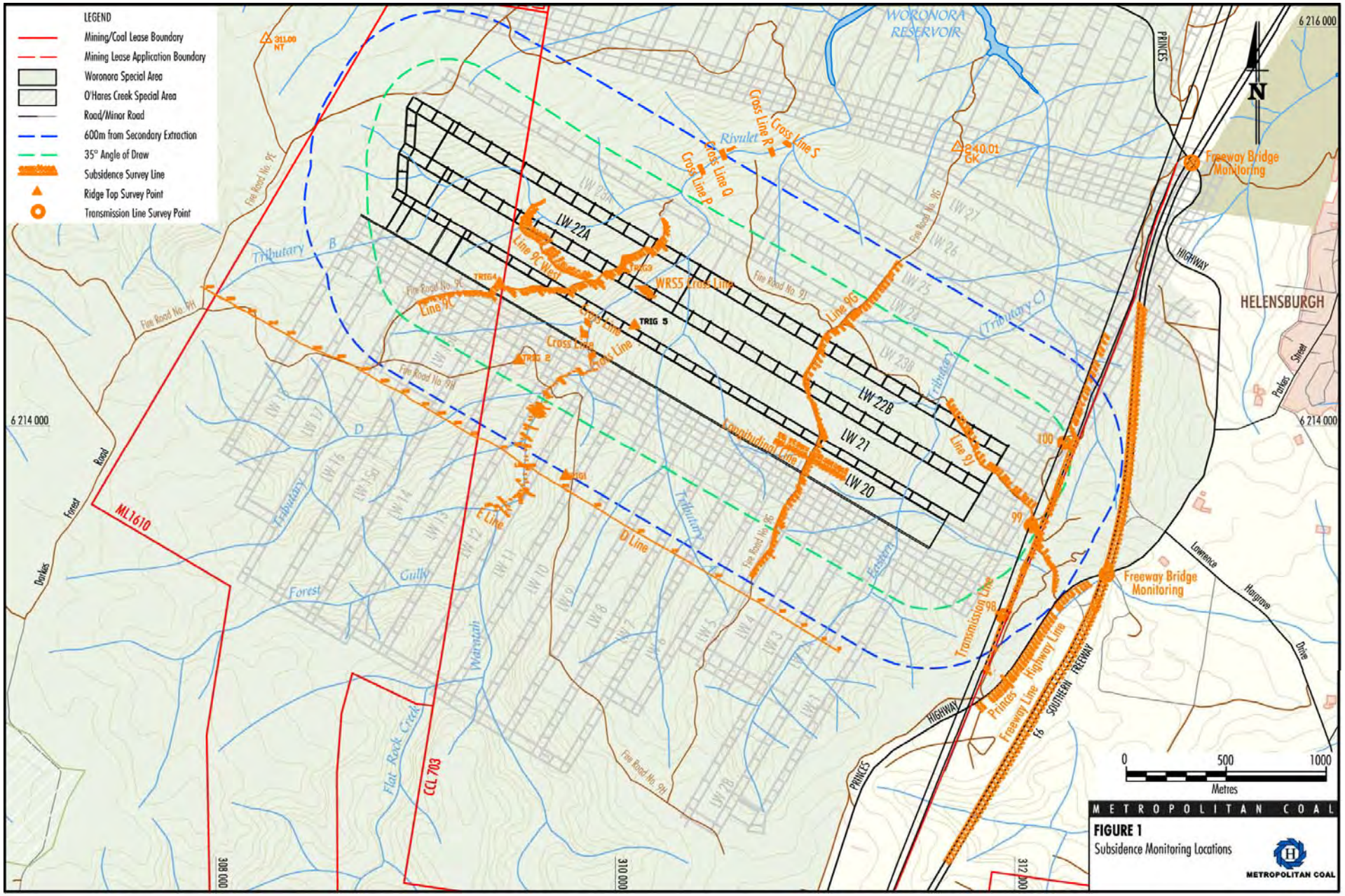
Longwall 20 had advanced 2,782 m as at 31 July 2011. Accordingly, only limited subsidence surveys have been completed since the commencement of Longwall 20.

Subsidence monitoring data from the following monitoring lines and points is available (Figure 1):

- Line 9C;
- Line 9C West;
- Longitudinal Line;
- Waratah Rivulet Cross Lines 14, 15 and 16; and
- Ridge to Ridge Monitoring Points.

A review of the subsidence survey results and comparison between the predicted and observed subsidence movements associated with Longwall 20 extraction over the review period was conducted by Mine Subsidence Engineering Consultants (MSEC). The assessment found that subsidence impacts were less than that predicted within the accuracy expected from re-survey. As shown in Tables 1 to 4, observed impacts on natural features were similar to or less than predicted.

Additional survey lines, including Princes Highway Line, Freeway Line, Transmission Line, Line 9J, Line 9G and D Line will be surveyed within three months of the completion of Longwall 20.


LEGEND
Mining/Coal Lease Boundary
Mining Lease Application Boundary
Woronora Special Area
O'Hares Creek Special Area
Road/Minor Road
600m from Secondary Extraction
35° Angle of Draw
Subsidence Survey Line
Ridge Top Survey Point
Transmission Line Survey Point
WORONORA RESERVOIR
Rivulet
Tributary B
Tributary C
Gully
Forest
Flat Rock Creek
LW 22A
LW 22B
LW 21
LW 20
WRS5 Cross Line
Cross Line P
Cross Line Q
Cross Line R
Cross Line S
Line 9C
Line 9C West
Line 9J
Longitudinal Line
TRIG 5
TRIG 2
TRIG4
Fire Road No. 9C
Fire Road No. 9H
Fire Road No. 9J
Fire Road No. 9K
Fire Road No. 9L
ML1610
CCL 703
Freeway Bridge Monitoring
Transmission Line
Highway Line
Princes Freeway Line
HELENSBURGH
HIGHWAY
PRINCES
SOUTHERN FREEWAY
Parkes Street
Lawrence Hargrave Drive
Forest Road
6 216 000
6 214 000
308 000
310 000
312 000
0
500
1000
Metres
METROPOLITAN COAL
FIGURE 1
Subsidence Monitoring Locations

Line 9C

Line 9C has been surveyed monthly while subsidence has been above 20 mm/month (i.e. in June and July 2010). Line 9C was also monitored once Longwall 20 passed beyond the subsidence line by at least 600 m, yet prior to the commencement of Longwall 21. A summary of the observed and predicted subsidence movements along the monitoring Line 9C for the latest survey is presented in Table 1.

The base survey for Line 9C was undertaken on 29 March 2010 when Longwall 18 still had 85 m of extraction remaining. Hence the survey results along this Line 9C include a small component from the extraction of Longwall 18 which is predicted to be 20 mm.

The maximum observed incremental subsidence due to the extraction of Longwall 20 was 83 mm at Peg C25, which is located above Longwall 20. The maximum observed incremental tilt was 0.5 mm/m between Pegs C58 and C59, however, as can be seen on Figure 2, this small value is considered to be affected by more by survey tolerance than by effects of mining.

The maximum incremental tensile and compressive strains of 0.5 mm/m and 1.0 mm/m occur in survey bays C58-C59 and C39-C40. The maximum tensile and compressive strains ignore the high strains at the location of the bumped peg C40, which has been labelled in Figure 2. However these values are considered to be affected more by survey tolerance than by effects of mining.

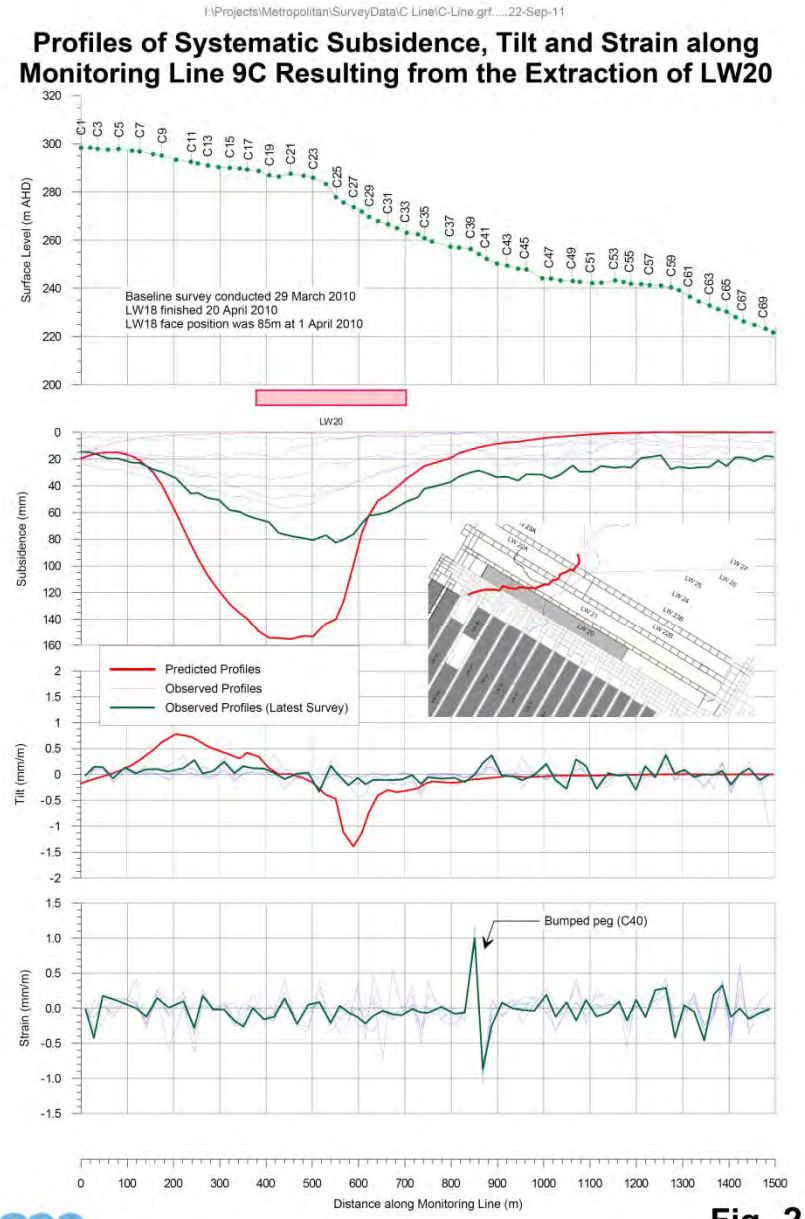
The profiles of the observed subsidence, tilt and strain along Line 9C are shown on Figure 2. The profiles of the predicted incremental subsidence and tilt due to the full extraction of Longwall 20 are also shown in this figure.

It can be seen in Figure 2 that the maximum observed subsidence (83 mm) is less than the maximum predicted subsidence (155 mm). The observed subsidence profile is, however, greater than the predicted subsidence profile away from the centre of the panel as small vertical movements, with negligible tilts and strains, have occurred to the north of Longwall 20. These small vertical movements extend several hundred metres to the north of Longwall 20 and may be the result of redistribution of *in-situ* stresses due to the extraction of Longwall 20. Such movements were not observed along the D Line monitoring line during the extraction of Longwalls 1 to 18. The movements are within the level of accuracy of predictions as discussed in the Metropolitan Coal Environmental Assessment, specifically "*where subsidence is predicted at points beyond the goaf edge, which are likely to experience low values of subsidence, the predictions should generally be accurate to within 50 mm of subsidence*".

Table 1
Summary of Predicted and Observed Subsidence Movements for Line 9C Resulting from Longwall 20 Extraction

Monitoring Summary			
Initial Survey Date		29 March 2010 (Longwall 18 Chainage 85 m)	
Latest Survey Date		29 March 2011	
Longwall Chainage at Latest Survey Date		995 m	
Face Distance from Line 9C at Latest Survey Date		1305 m past Line 9C on maingate side, 1050 m from the nearest Line 9C Peg	
Subsidence parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 20 (mm)	83	155	Maximum observed incremental subsidence at Peg C25
Maximum total subsidence after the extraction of Longwall 20 (mm)	83	155	Maximum observed incremental subsidence at Peg C25
Maximum incremental tilt due to the extraction of Longwall 20 (mm/m)	0.5	1.4	Maximum observed incremental tilt between Pegs C58 and C59
Maximum incremental tensile strain due to the extraction of Longwall 20 (mm/m)	1.0	0.2*	Maximum observed incremental tensile strain between Pegs C39 and C40
Maximum incremental compressive strain due to the extraction of Longwall 20 (mm/m)	0.9	0.2*	Maximum observed incremental compressive strain between Pegs C40 and C41

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


I:\Projects\Metropolitan\SurveyData\C Line\C-Line.grf.....22-Sep-11
Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Line 9C Resulting from the Extraction of LW20
Surface Level (m AHD)
Baseline survey conducted 29 March 2010
LW18 finished 20 April 2010
LW18 face position was 85m at 1 April 2010
LW20
Subsidence (mm)
Predicted Profiles
Observed Profiles
Observed Profiles (Latest Survey)
Tilt (mm/m)
Strain (mm/m)
Bumped peg (C40)
Distance along Monitoring Line (m)

msec

Fig. 2

Line 9C West

Line 9C West has been surveyed monthly while subsidence has been above 20 mm/month (i.e. in June and July 2010). Line 9C West was also monitored once Longwall 20 passed beyond the subsidence line by at least 600 m, yet prior to the commencement of Longwall 21.

A summary of the observed and predicted subsidence movements along the monitoring Line 9C West for the latest survey is presented in Table 2.

The profiles of the observed subsidence, tilt and strain along Line 9C West are shown in Figure 3. The base survey for Line 9C West was undertaken on 29 March 2010 when Longwall 18 still had 85 m of extraction remaining. The profiles of the predicted incremental subsidence and tilt due to the full extraction of Longwall 20 are also shown on Figure 3.

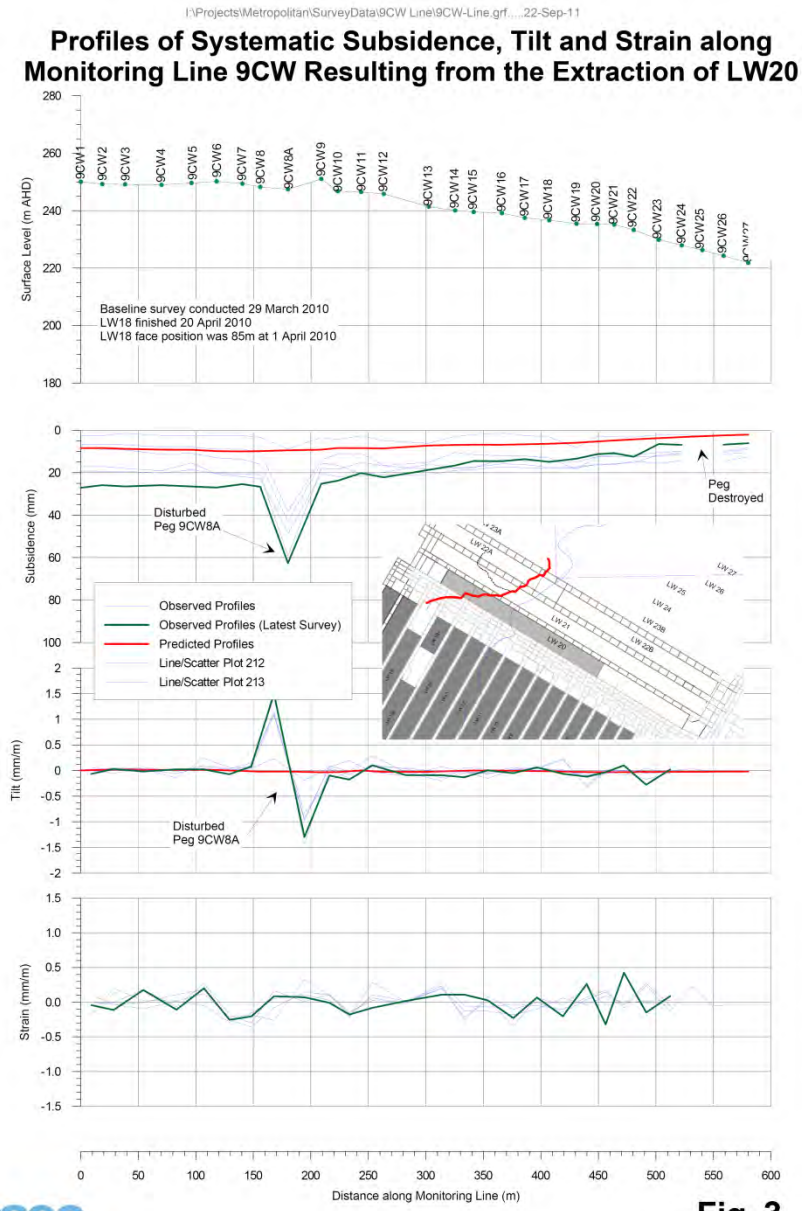
Predictions for Line 9C West were not previously prepared, therefore a new prediction line was prepared for Line 9C West.

Line 9C West is located approximately 100 m to the north of Longwall 20 at its nearest point. As a result, predicted and observed values of subsidence, tilt and strain are very small at this stage. Nevertheless, the subsidence profile indicates that small vertical movements (of the order of 20 mm), with negligible tilts and strains have occurred in this area and are within expected limits of accuracy of predictions as discussed above for Line 9C.

Table 2
Summary of Predicted and Observed Subsidence Movements for Line 9C West Resulting from Longwall 20 Extraction

Monitoring Summary			
Initial Survey Date		29 March 2010 (Longwall 18 Chainage 85 m)	
Latest Survey Date		29 March 2011	
Longwall Chainage at Survey Date		995 m	
Face Distance from Line 9C West at Latest Survey Date		Line 9C West does not pass above Longwall 20, 1175 m from the nearest Line 9C Peg	
Subsidence parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 20 (mm)	27	10	Maximum observed incremental subsidence at Peg 9CW8
Maximum total subsidence after to the extraction of Longwall 20 (mm)	27	10	Maximum observed incremental subsidence at Peg 9CW8
Maximum incremental tilt due to the extraction of Longwall 20 (mm/m)	0.3	<0.1	Maximum observed incremental tilt between Pegs 9CW22 and 9CW23
Maximum incremental tensile strain due to the extraction of Longwall 20 (mm/m)	0.2	<0.1*	Maximum observed incremental tensile strain between Pegs 9CW14 and 9CW14
Maximum incremental compressive strain due to the extraction of Longwall 20 (mm/m)	0.3	<0.1*	Maximum observed incremental compressive strain between Pegs 9CW23 and 9CW24

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


I:\Projects\Metropolitan\SurveyData\9CW Line\9CW-Line.grf....22-Sep-11
Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Line 9CW Resulting from the Extraction of LW20
Surface Level (m AHD)
9CW1
9CW2
9CW3
9CW4
9CW5
9CW6
9CW7
9CW8
9CW8A
9CW9
9CW10
9CW11
9CW12
9CW13
9CW14
9CW15
9CW16
9CW17
9CW18
9CW19
9CW20
9CW21
9CW22
9CW23
9CW24
9CW25
9CW26
Baseline survey conducted 29 March 2010
LW18 finished 20 April 2010
LW18 face position was 85m at 1 April 2010
Subsidence (mm)
Disturbed Peg 9CW8A
Peg Destroyed
Observed Profiles
Observed Profiles (Latest Survey)
Predicted Profiles
Line/Scatter Plot 212
Line/Scatter Plot 213
Tilt (mm/m)
Disturbed Peg 9CW8A
Strain (mm/m)
Distance along Monitoring Line (m)

msec

Fig. 3

Longitudinal Line

In accordance with the Built Features Management Plan – Roads and Traffic Authority (RTA), the Longitudinal Line has been monitored monthly while Longwall 20 has been within 1,000 m of the Longitudinal Line and until Longwall 20 passed the Longitudinal Line by 200 m.

A summary of the observed and predicted subsidence movements along the Longitudinal Line for the latest survey is presented in Table 3.

The profiles of the observed incremental subsidence, tilt and strain along Longitudinal Line are shown Figure 4. The observed incremental movements are the additional movements since the base survey that was measured on 4 May 2010 prior to the commencement of Longwall 20. The profile of the predicted incremental subsidence due to the full extraction of Longwall 20 is also shown on Figure 4.

The maximum observed incremental subsidence due to the extraction of Longwall 20 was 127 mm at Peg GLE6. The maximum observed incremental tilt was 0.3 mm/m between Pegs GLE4 and GLE5. The maximum incremental tensile and compressive strains of 0.3 mm/m occur in survey bays GLE6-GLE7 and CGLW6-GLW5.

It can be seen on Figure 4 that the maximum observed subsidence is less than the maximum predicted subsidence.

Table 3
Summary of Predicted and Observed Subsidence Movements for Longitudinal Line Resulting from Longwall 20 Extraction

Monitoring Summary			
Initial Survey Date		4 May 2010	
Latest Survey Date		28 July 2011	
Longwall Chainage at Latest Survey Date		30 m	
Face Distance from Longitudinal Line at Latest Survey Date		521 m to Mark GLE10	
Subsidence parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 20 (mm)	127	138	Maximum observed incremental subsidence at Peg GLE6
Maximum total subsidence after to the extraction of Longwall 20 (mm)	127	138	Maximum observed incremental subsidence at Peg GLE6
Maximum incremental tilt due to the extraction of Longwall 20 (mm/m)	0.3	0.1	Maximum observed incremental tilt between Pegs GLE4 and GLE5
Maximum incremental tensile strain due to the extraction of Longwall 20 (mm/m)	0.3	<0.1*	Maximum observed incremental tensile strain between Pegs GLE6 and GLE7
Maximum incremental compressive strain due to the extraction of Longwall 20 (mm/m)	0.3	<0.1*	Maximum observed incremental compressive strain between Pegs GLW6 and GLW5

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

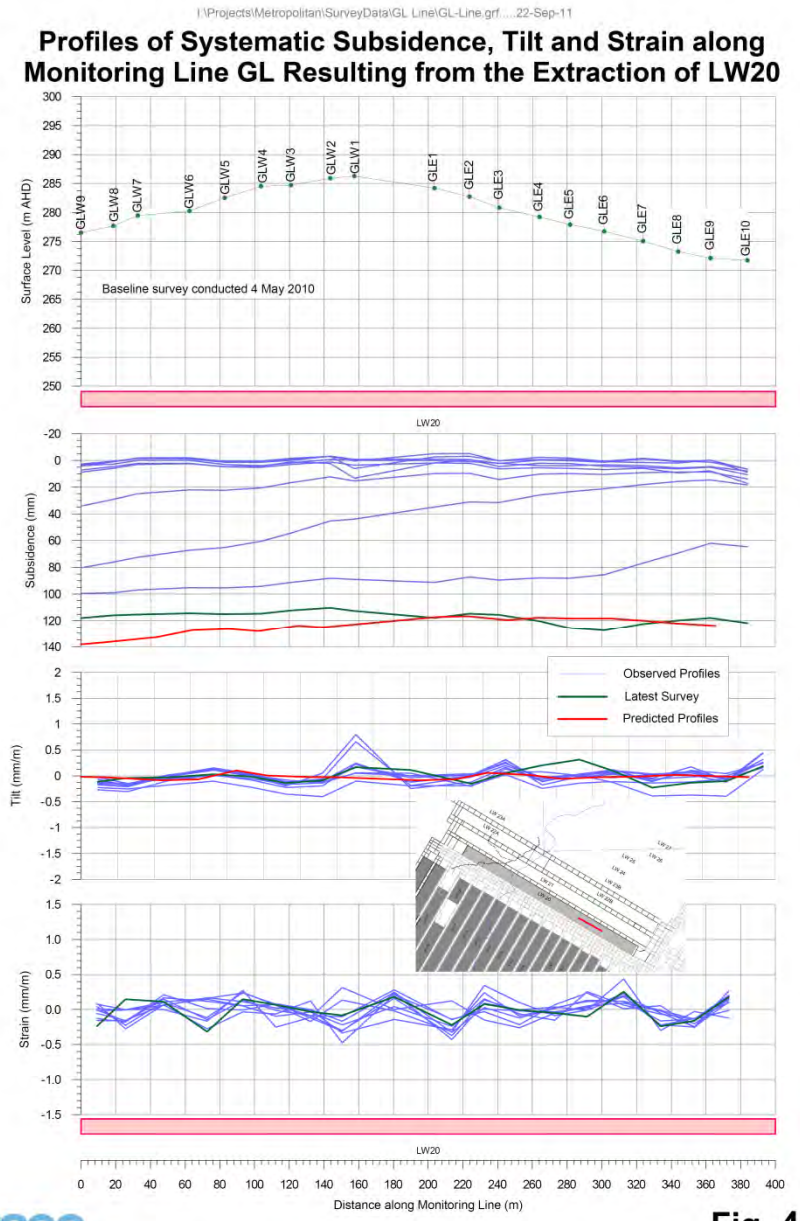

I:\Projects\Metropolitan\SurveyData\GL Line\GL-Line.grf.....22-Sep-11
Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Line GL Resulting from the Extraction of LW20
Surface Level (m AHD)
GLW9
GLW8
GLW7
GLW6
GLW5
GLW4
GLW3
GLW2
GLW1
GLE1
GLE2
GLE3
GLE4
GLE5
GLE6
GLE7
GLE8
GLE9
GLE10
Baseline survey conducted 4 May 2010
LW20
Subsidence (mm)
Observed Profiles
Latest Survey
Predicted Profiles
Tilt (mm/m)
Strain (mm/m)
LW20
Distance along Monitoring Line (m)
msec

Fig. 4

Waratah Rivulet Cross Lines 14, 15 and 16

Waratah Rivulet Cross Lines 14, 15 and 16 were surveyed monthly until the longwall passed the Waratah Rivulet and subsidence was less than 20 mm/month.

A summary of the observed and predicted subsidence movements along Waratah Rivulet Cross Lines 14, 15 and 16 for the latest survey is presented in Table 4.

The profiles of the observed net vertical movement, strain, upsidence and closure along Waratah Rivulet Cross Lines 14, 15 and 16 are shown on Figures 5, 6 and 7. The observed incremental movements are the additional movements since the base survey that was measured on the 17th June 2010 when the Longwall 20 extraction face was at chainage 2,689 m, and was approximately 630 m from the nearest cross line.

The maximum observed net vertical movement of 52 mm at Line 14 was less than the predicted net vertical movement of 86 mm. The maximum observed net vertical movement of 85 mm and 83 mm at Line 15 and Line 16 respectively, are greater than the predicted net vertical movement. The predicted net vertical movement include predicted upsidence which is recognised as providing a conservative prediction of subsidence movements. As described in the EA, if the observed upsidence is much less than the predicted upsidence values, then the predicted net vertical movement may be greater than is currently predicted. The predicted value of net vertical movement may not eventuate and small amounts of subsidence may be observed instead of uplift. Given the low levels of observed strain for Waratah Rivulet Cross Lines 14, 15 and 16 and the zero observed upsidence for these short lines, it is possible that only negligible overall valley upsidence has developed, in which case it is considered appropriate to use the predicted subsidence rather than net vertical movement for comparison with the observed results. The observed net vertical movements are less than the predicted subsidence.

There was negligible measured upsidence and closure at each of the monitoring lines which are approximately 25 m in length and represent a small portion of the overall valley profile. The lines represent the full width of the rockbars present over Longwall 20 and indicate generally low levels of strain. The maximum compressive strain of 2.2 mm/m occurred along Line 15 between Pegs 15002 and 15003.

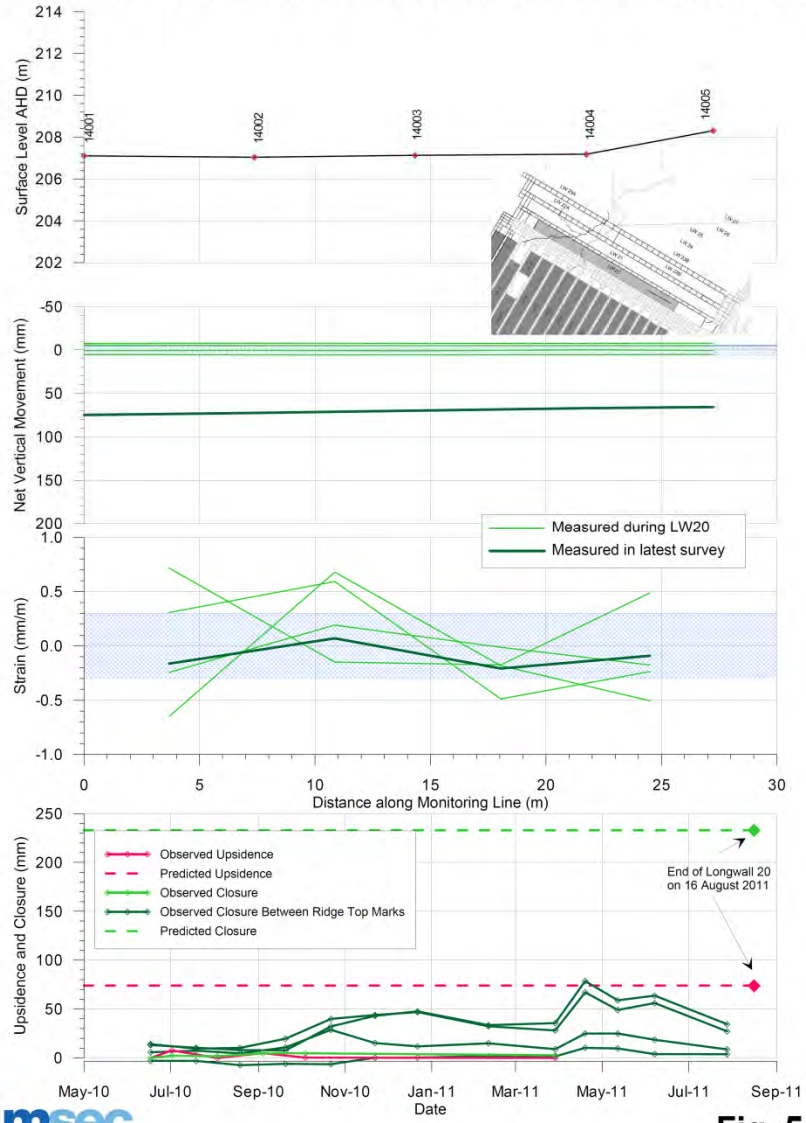
Table 4
Summary of Predicted and Observed Subsidence Movements for Waratah Rivulet Cross Lines 14, 15 and 16 Resulting from Longwall 20 Extraction

Monitoring Summary					
Initial Survey Date			29 May 2010		
Latest Survey Date			17 June 2011		
Longwall Chainage at Latest Survey Date			459 m		
Face Distance from Monitoring Line at Latest Survey Date			1476 m to Line 14 1557 m to Line 15 1566 m to Line 16		
Subsidence parameter	**Line**	**Observed Value**	**Predicted Final Value**		
			Subsidence	**Upsidence**	**Net Vertical Movement**
Maximum incremental net vertical movement due to the extraction of Longwall 20 (mm)	14	52	160	74	86
	15	85	203	177	25
	16	83	157	176	-19

Subsidence parameter	**Line**	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental closure due to the extraction of Longwall 20 (mm)	14	3	233	Monitoring line length of 22 m to 27 m represents a small portion of the total valley profile used for closure predictions
	15	5	253	
	16	3	254	
Maximum incremental upsidence due to the extraction of Longwall 20 (mm)	14	0	74	Monitoring line length of 22 m to 27 m represents a small portion of the total valley profile used for upsidence predictions
	15	0	177	
	16	0	176	

I:\Projects\Metropolitan\SurveyData\x-Lines 14001-14005\Fig. A X-Line 14001-14005.grf

Profiles of Net Vertical Movement, Strain, Upsidence and Closure along Monitoring line 1400 Resulting from the Extraction of LW20



msec

Fig. 5

I:\Projects\Metropolitan\SurveyData\x-Lines 15001-15006\Fig. A X-Line 15001-15006.grf

Profiles of Net Vertical Movement, Strain, Upsidence and Closure along Monitoring line 1500 Resulting from the Extraction of LW20

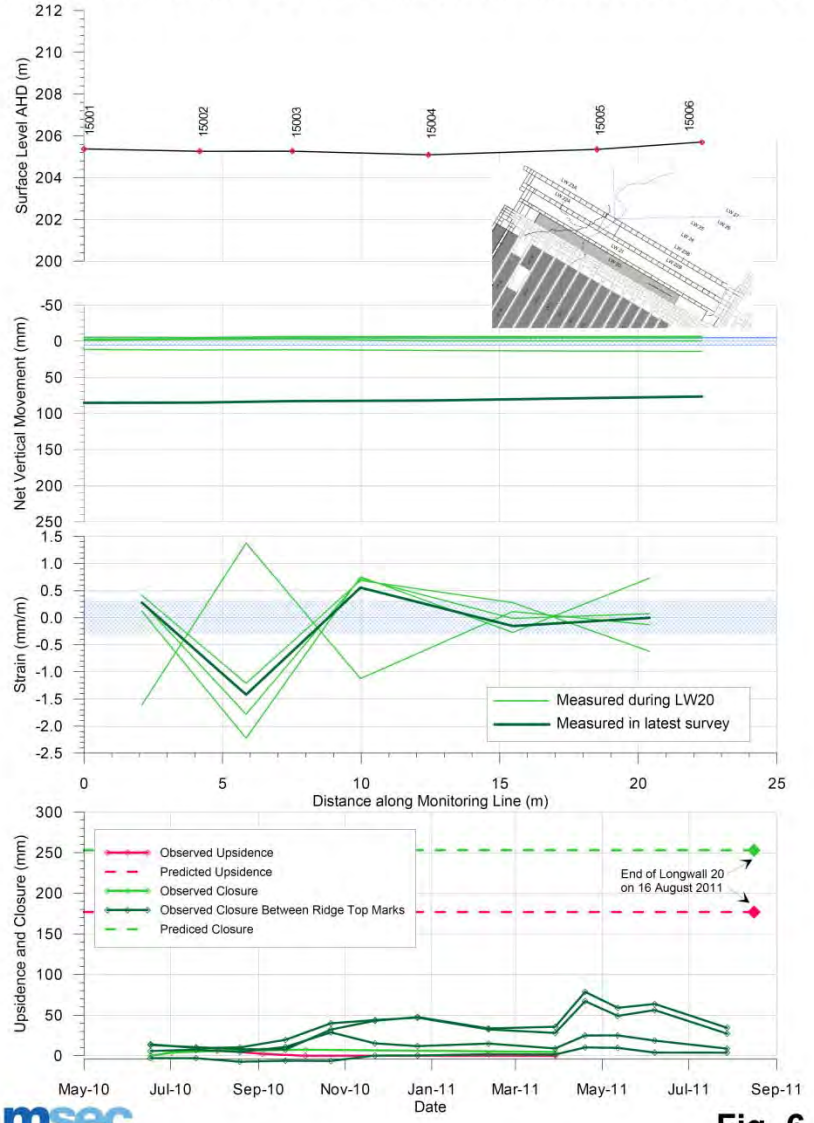


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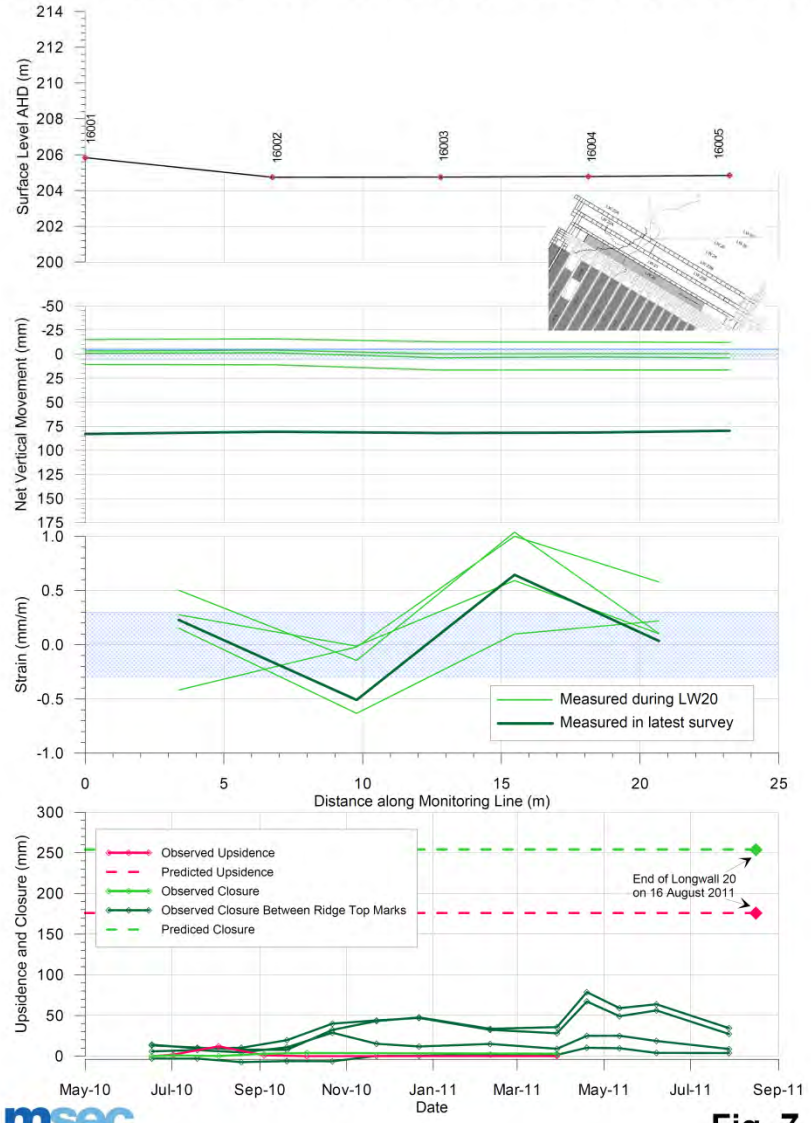
Fig. 6

I:\Projects\Metropolitan\SurveyData\x-Lines 16001-16005\Fig. A X-Line 16001-16005.grf

Profiles of Net Vertical Movement, Strain, Upsidence and Closure along Monitoring line 1600 Resulting from the Extraction of LW20



msec

Fig. 7

Ridge to Ridge

The ridge to ridge monitoring points were surveyed monthly until the longwall passed the Waratah Rivulet and subsidence reduced to less than 20 mm/month.

The Ridge to Ridge monitoring points were set up to monitor the overall movement of the tops of the ridges adjacent to the Waratah Rivulet Valley. The incremental horizontal movement of the Ridge to Ridge are shown on Drawing No. MSEC 471-102 in Appendix 1. The horizontal movement vectors show a general movement towards the Longwall 20 goaf and the base of the Waratah Rivulet Valley.

The measured closures of the Ridge to Ridge monitoring points are plotted on Figures 5, 6 and 7 for the Ridge to Ridge monitoring points across the Waratah Rivulet (i.e. Trig 1-Trig 2, Trig 2-Trig 5, Trig 4-Trig 5, and Trig 3-Trig 5). The greatest observed closures of 67 mm and 79 mm were measured between marks Trig 4-Trig 5 and Trig 2-Trig 5 respectively, both of which cross Longwall 20.

Incremental Vectors

A plot of the observed incremental horizontal movement vectors for the monitoring lines discussed in this Annual Review, based on the latest 3D survey results, is shown on Drawing No. MSEC471-102.

The vectors show a general movement towards the extracted goaf of Longwall 20. The vectors towards the western end of the Line 9C show more movement towards the previously extracted longwalls and towards the steep slope on the south eastern side of the monitoring line.

The vector movements of the Waratah Rivulet Cross Lines 14, 15 and 16 do not indicate significant closure movement towards the centre of the stream. Some closure movement can be seen in the Line 15 vectors at the location of the highest compressive strain of 2.2 mm/m.

Horizontal Movements

A plot of observed incremental horizontal movement versus distance from nearest goaf edge for the monitoring lines discussed in this Annual Review is provided in Figure 8. It can be seen from Figure 8 that the horizontal movements are consistent with the horizontal movements for the D Line, which was monitored for the previously extracted Longwalls 1 to 18, and fit within the horizontal movement data set for the southern coalfield.

Plots of Incremental Relative Longitudinal peg movement and Incremental Relative Lateral peg movement are presented in Figure 9 and Figure 10, respectively. The plot includes survey pegs with spacing of 20m ±10m, which includes Line 9C, Line 9C West, and the Longitudinal Line. The relative lateral and longitudinal horizontal movements for the monitored lines fit within the data set for the Southern Coalfield.

Impacts on Natural Features

The observed impacts to the stream beds, cliffs and overhangs are presented below. Impacts to other natural features are presented in other sections of the Annual Review. The major streams, cliffs and overhangs located above or adjacent to Longwall 20 are listed below:

- Tributary B, Waratah Rivulet, Tributary A, Eastern Tributary.
- Cliff/Overhang COH1 and COH2.

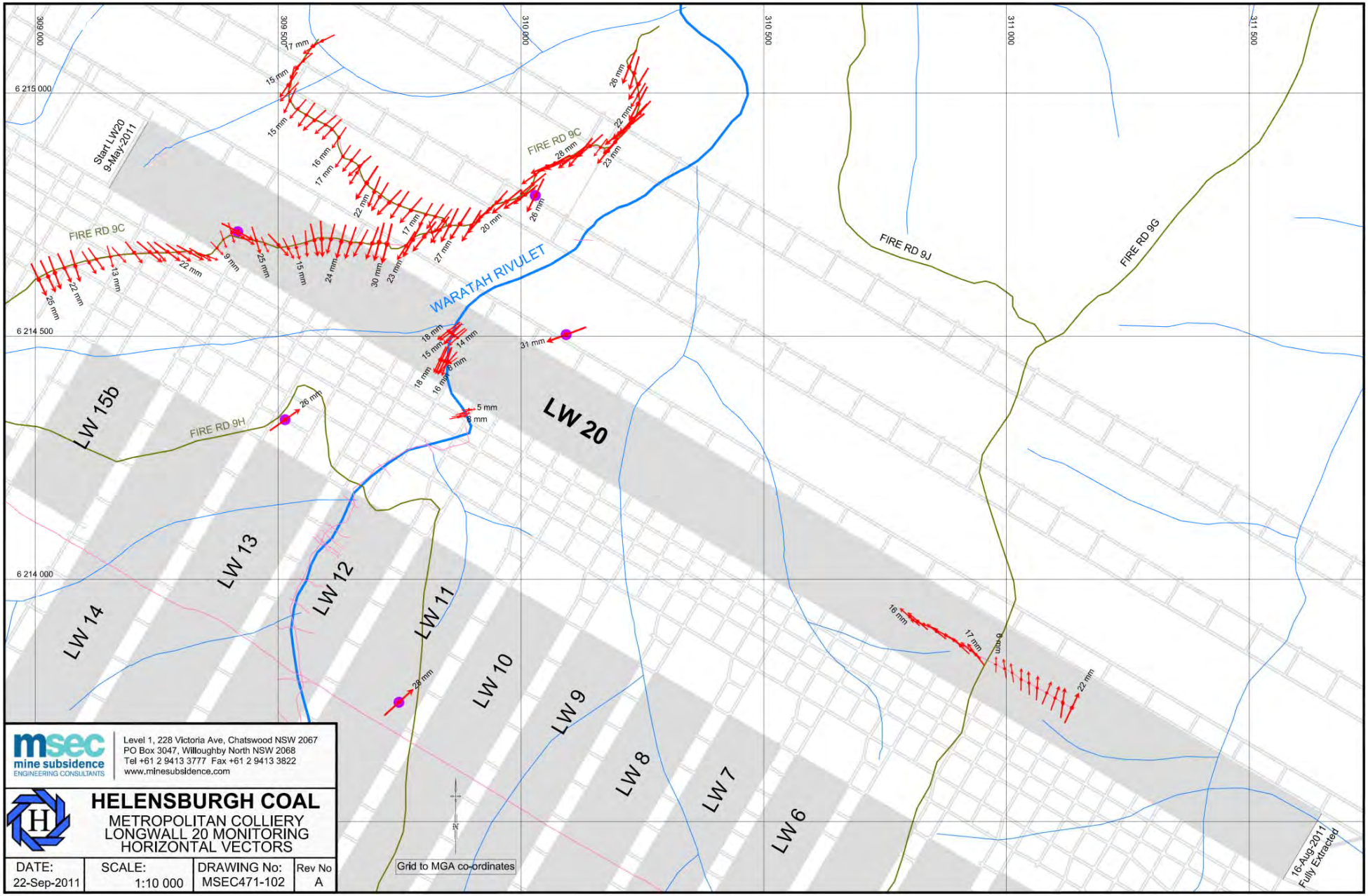
Comparison between Predicted and Observed Impacts on Natural Features

A comparison between the observed and the predicted impacts on the stream bed and cliffs and overhangs above or adjacent to Longwall 20 is summarised in Table 5.

Table 5
Summary of Predicted and Observed Impacts Resulting from Longwall 20

Feature	Predicted Impacts	Observed Impacts
Tributary B, Waratah Rivulet, Tributary A, Eastern Tributary	Cracking in the bedrock along the valleys and fracturing and dilation of the underlying strata. Diversion of a portion of surface flow into underlying bedrock.	Some minor widening of existing cracks but no new cracks observed.
Cliff/Overhang COH1 and COH2	Potential cliff instabilities to less than 3% of the lengths of the cliffs.	No instabilities observed.
Rock Ledges	Isolated rockfalls.	No rockfalls observed.

METROPOLITAN COAL - ENVIRONMENTAL MONITORING SUMMARY



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www.minesubsidence.com

HELENSBURGH COAL

METROPOLITAN COLLIERY
LONGWALL 20 MONITORING
HORIZONTAL VECTORS

DATE:	SCALE:	DRAWING No:	Rev No
22-Sep-2011	1:10 000	MSEC471-102	A

Peabody ENERGY

METROPOLITAN COAL

I:\Projects\Metropolitan\MSEC471 - LW20 Monitoring\SurveyDatabase\Compiled Incr HMvts-Peg to Solid coal-A3-ALL PEGS-Consolidated.grf 22-Sep-11

Observed Incremental Horizontal Peg Movements for Pegs with Solid Coal between Peg and Mined LW

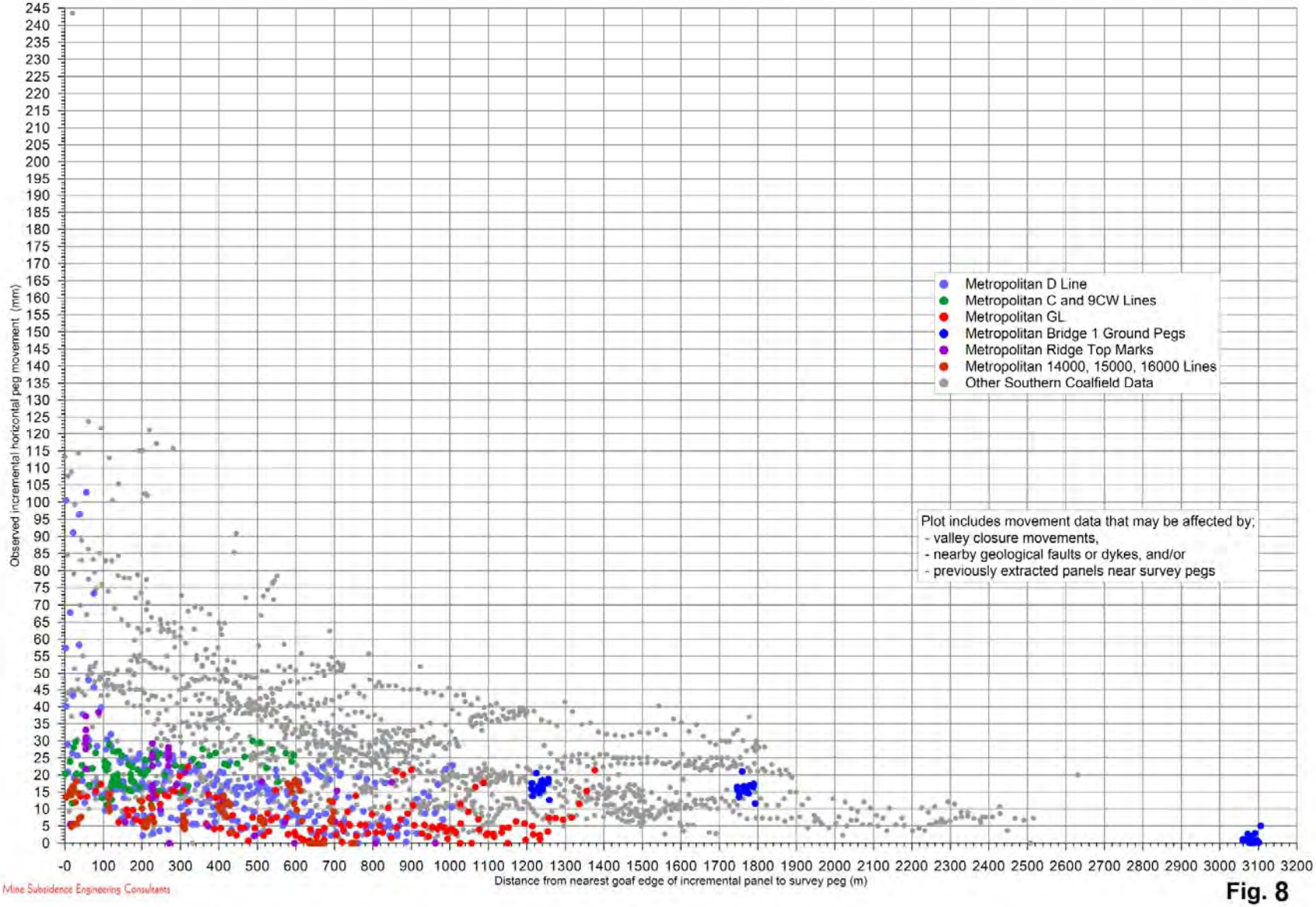

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Fig. 8

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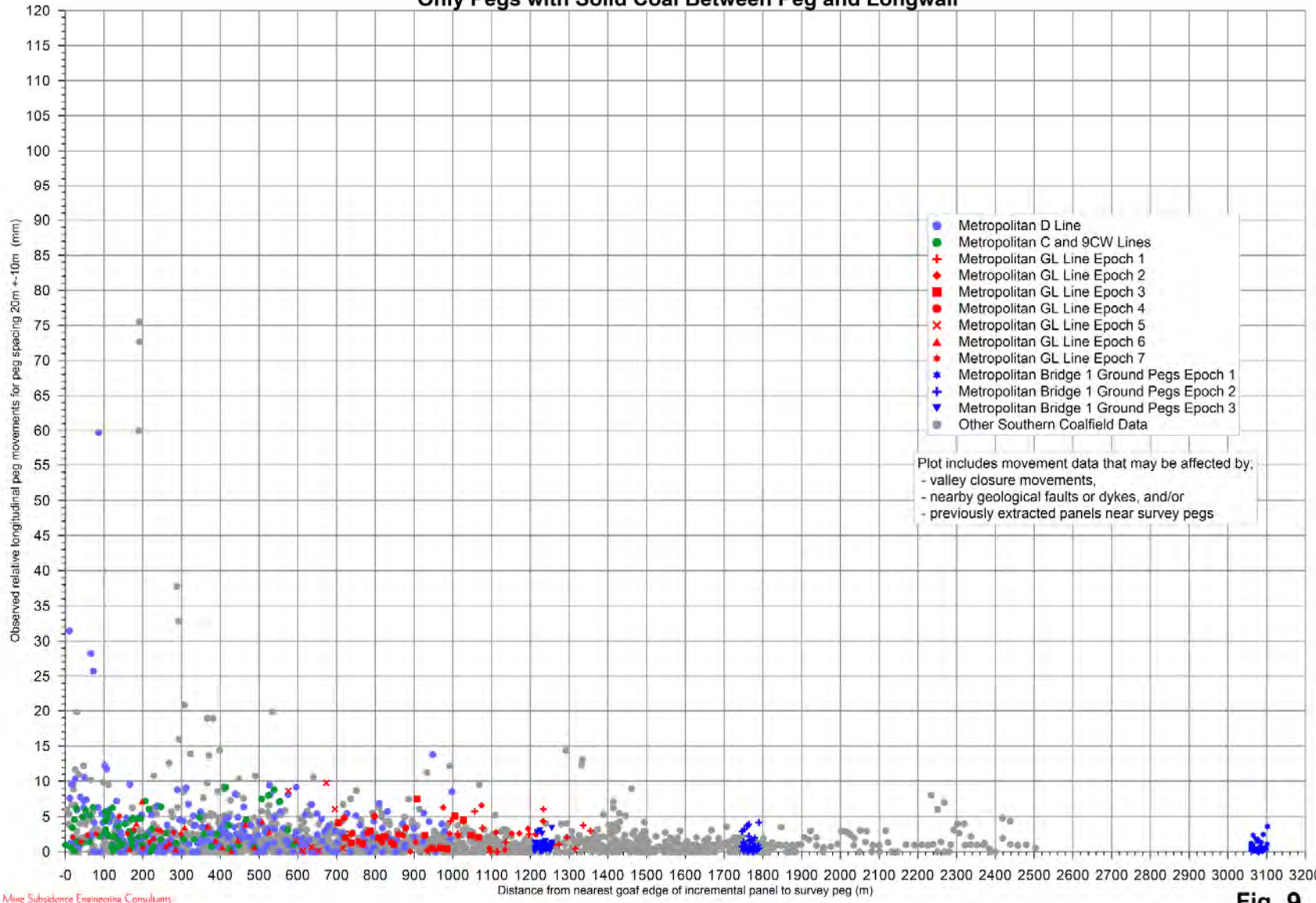
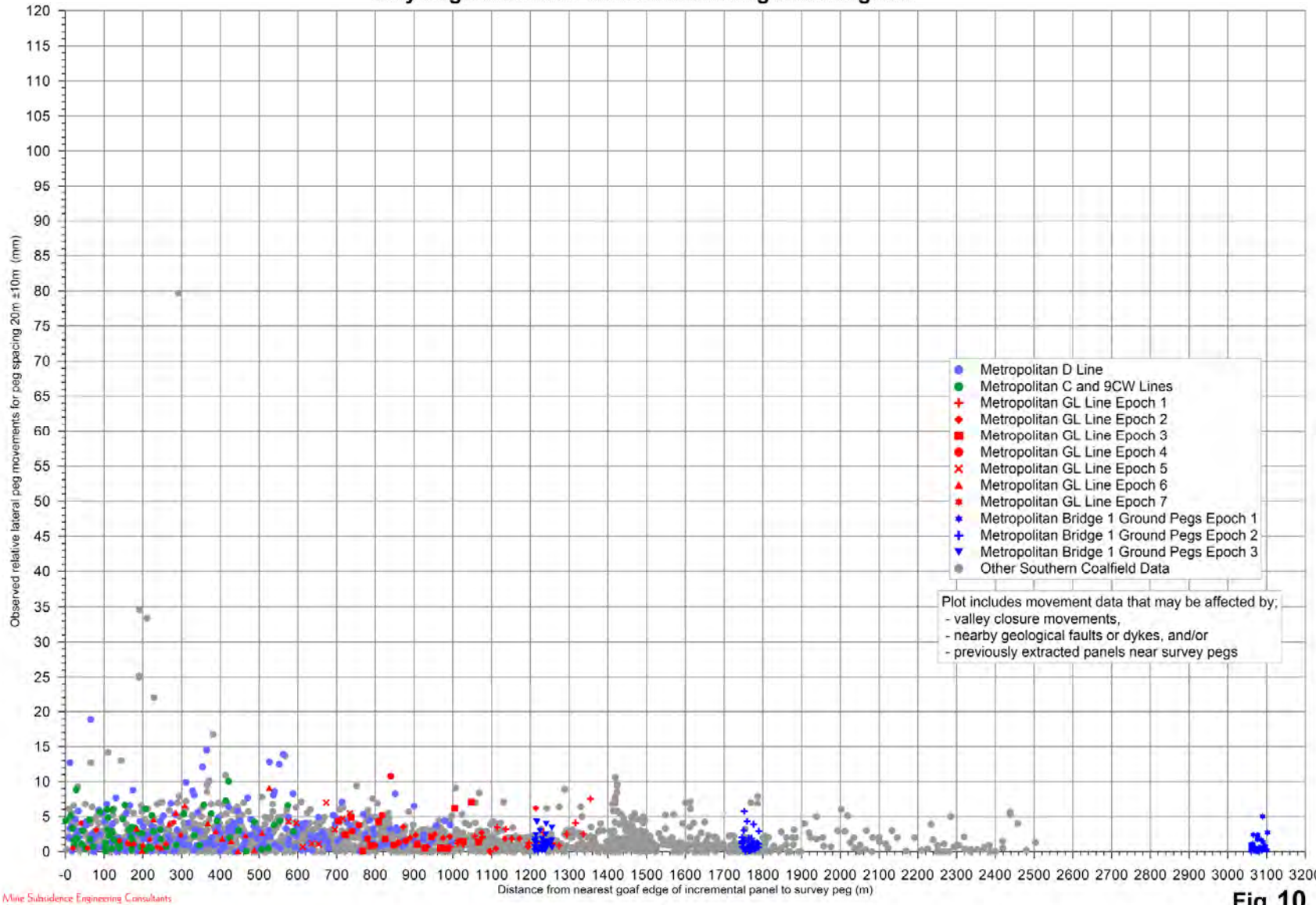
Incremental Observed Relative Longitudinal Peg Movements due to One Longwall (20m peg spacing ± 10m)
Only Pegs with Solid Coal Between Peg and Longwall



Mine Subsidence Engineering Consultants

Fig. 9

Incremental Observed Relative Lateral Peg Movements due to One Longwall (20m peg spacing ± 10m)
Only Pegs with Solid Coal Between Peg and Longwall



Mine Subsidence Engineering Consultants

Fig. 10