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 metres (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.

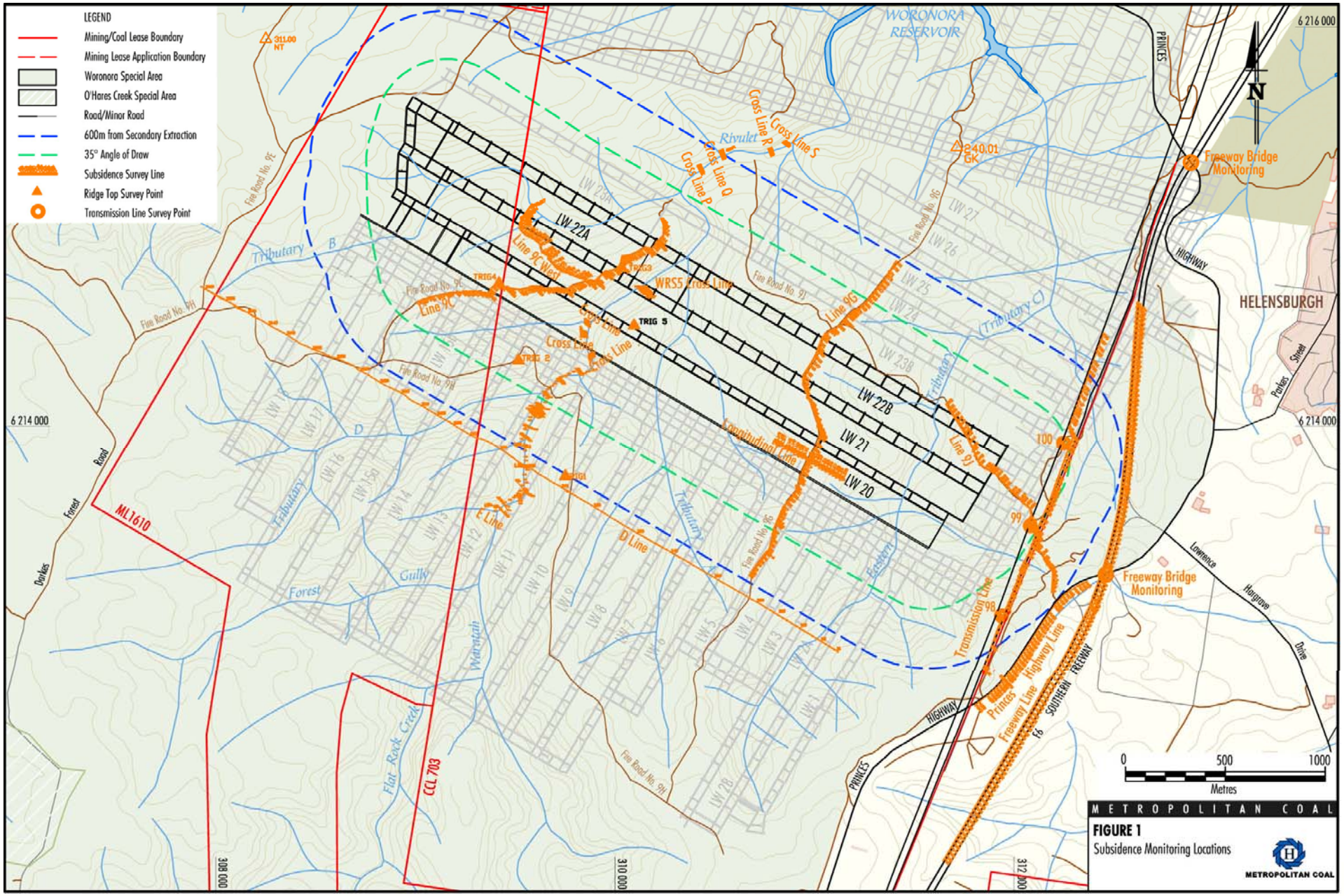
Monitoring of subsidence impacts on natural features (such as stream features, cliffs and slopes) are described in the relevant sections of this Environmental Monitoring Summary.

In accordance with the Subsidence Monitoring Program, several monitoring lines above or near Longwalls 20-22 were observed for subsidence movements to the end of July 2012. Longwall 20 was completed in August 2011 and Longwall 21 advanced 2,165 m as at 31 July 2012.

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

- D line;
- Ling 9G;
- Ling 9C;
- Line 9C West;
- Longitudinal Line;
- Line 9J;
- Transmission Line;
- Princes Highway Line;
- Freeway lines;
- Waratah rivulet cross lines; and
- Ridge to Ridge Monitoring Points.

A review of the subsidence survey results and comparison between the predicted and observed subsidence movements over the review period was conducted by Mine Subsidence Engineering Consultants (MSEC). Subsidence measurements were generally within survey tolerance of predicted movements or represented disturbed survey marks. A summary of the observed and predicted subsidence movements is provided in Tables 1 to 13.


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
Cross Line R
Cross Line S
Cross Line Q
Cross Line P
LW 22A
LW 22B
LW 21
LW 20
Line 9C West
Line 9C
Line 9S
Line 9J
WRS5 Cross Line
TRIG 5
TRIG 4
TRIG 2
Longitudinal Line
E Line
D Line
Tributary B
Tributary C
Tributary D
Eastern Tributary
Fire Road No. 9E
Fire Road No. 9H
Fire Road No. 9I
Fire Road No. 9J
Fire Road No. 9S
Fire Road No. 9T
Gully
Forest
Waratah
Flat Rock Creek
ML1610
CCL 703
311.00 NT
240.01 GK
Freeway Bridge Monitoring
HELENSBURGH
PRINCES HIGHWAY
SOUTHERN FREEWAY
Transmission Line
Highway Line
Freeway Line
Parkes Street
Lawrence Hargrave Drive
Forest Road
Parkes
6 216 000
6 214 000
308 000
310 000
312 000
0
500
1000
Metres
METROPOLITAN COAL
FIGURE 1
Subsidence Monitoring Locations
METROPOLITAN COAL

D Line

Subsidence monitoring over completed Longwalls 1-18 includes a main subsidence line (D Line) established perpendicular to the longwall panels (Figure 1). D Line is monitored as part of the Subsidence Monitoring Program to provide general information regarding the movement of the landscape over time (over Longwalls 1-18), in addition to general information regarding ground movement in response to Longwalls 20-22.

D Line was monitored within three months of the completion of Longwall 20.

The profiles of the observed incremental and total subsidence, tilt and strain along D Line are shown on Figure 2. The observed incremental movements are the additional movements since the survey that was measured on the 19 May 2010 prior to the commencement of Longwall 20. The profile of the predicted total subsidence due to the full extraction of Longwall 20 is also shown on Figure 2.

The maximum observed incremental subsidence due to the extraction of Longwall 20 was 92 millimetres (mm) at Peg D133. The maximum observed incremental tilt was 1 millimetre per month (mm/m) between Pegs D136 and D137. The maximum incremental tensile and compressive strains of 0.6 mm/m and 0.7 mm/m, respectively, occur in survey bays D78-D79 and D74-D75.

Figure 2 indicates that the maximum observed total subsidence is less than the maximum predicted total subsidence. The maximum observed incremental subsidence and tilt are greater than predicted as shown in Table 1, however, these movements occur above the previously extracted Longwall 18 and are likely to be the result of residual subsidence due to Longwall 18, which occurs over time following the completion of a longwall. The maximum observed tensile and compressive strains in Table 1 occur within the valley of the Waratah Rivulet which experienced significant valley closure movement during the extraction of Longwalls 1 to 18 and these strains may be the result of reactivation of these movements.

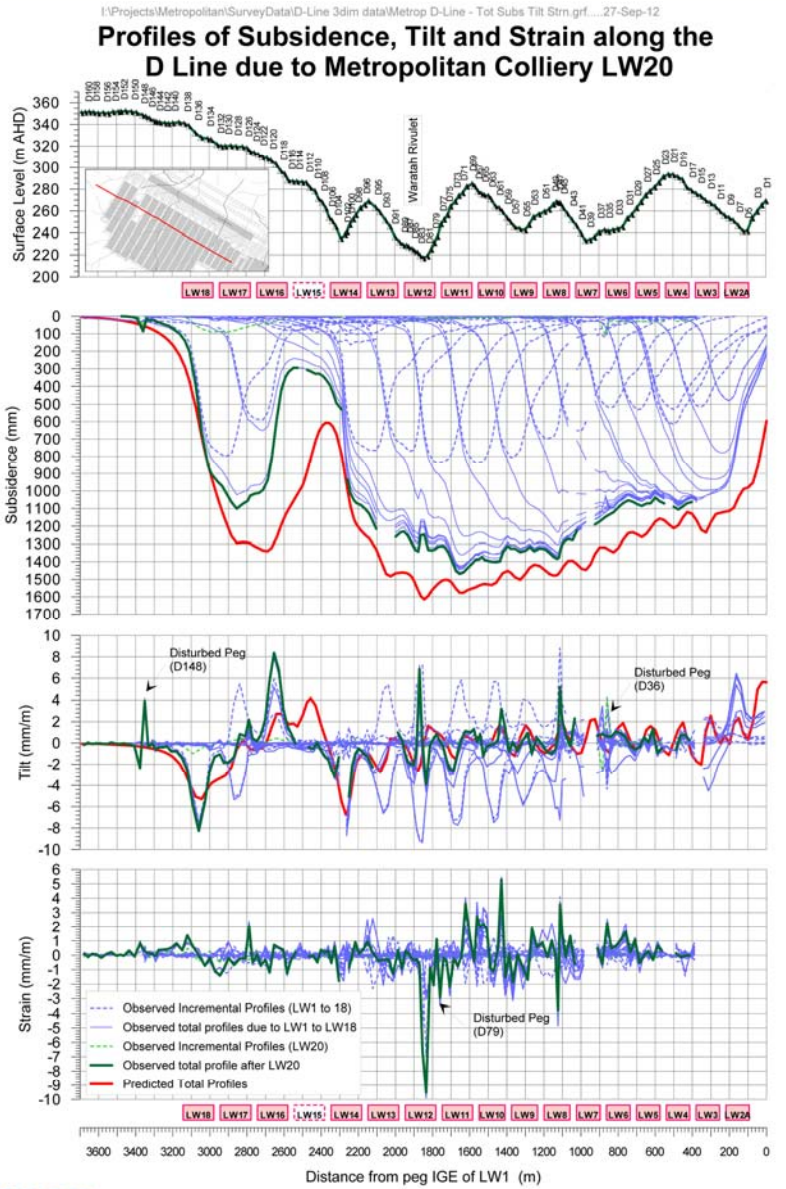


Figure 2

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

Monitoring Summary			
Initial Survey Date		19 May 2010	
Latest Survey Date		10 August 2011	
Longwall Chainage at Latest Survey Date		3 m	
Face Distance from D Line at Latest Survey Date		650 m to Mark D92	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 20 (mm)	92	<20	Maximum observed incremental subsidence at Peg D133
Maximum total subsidence due to the extraction of Longwall 20 (mm)	1,469	1,620	Maximum observed total subsidence at Peg D72
Maximum incremental tilt due to the extraction of Longwall 20 (mm/m)	1.0	Within limits of survey accuracy*	Maximum observed incremental tilt between Pegs D136 and D137
Maximum incremental tensile strain due to the extraction of Longwall 20 (mm/m)	0.6		Maximum observed incremental tensile strain between Pegs D78 and D79
Maximum incremental compressive strain due to the extraction of Longwall 20 (mm/m)	0.7		Maximum observed incremental compressive strain between Pegs D74 and D75

Line 9G

Line 9G is located along Fire Road 9G, extending from D Line to beyond the Longwalls 20-22 35 degree (°) angle of draw (Figure 1). The purpose of Line 9G is to measure the subsidence parameters (subsidence, tilt, strain) associated with the extraction of each longwall and the cumulative subsidence parameters associated with overall extraction (Figure 3). Line 9G was monitored within three months of the completion of Longwall 20.

The observed incremental movements are the additional movements since the survey that was measured prior to the commencement of each longwall indicates that only small subsidence movements had developed due to the extraction of Longwall 20. Only small subsidence movements had developed, since Longwall 21 had not extracted beneath Line 9G at the time of the latest survey. Similarly, the profiles of the observed total subsidence, tilt and strain along Line 9G resulting from the extraction of Longwall 21 shown on Figure 3 show only small subsidence movements. The observed subsidence movements therefore predominantly reflect the movements due to the extraction of Longwall 20.

The maximum observed incremental and total subsidence, tilt and strain due to the extraction of Longwall 21 are significantly less than predicted since Longwall 21 is only partially extracted. The maximum observed incremental subsidence due to the extraction of Longwall 20 was 124 mm at Peg G27, which is located above Longwall 20. The maximum observed incremental tilt due to the extraction of Longwall 20 was 1.1 mm/m between Pegs G29 and G30. The maximum incremental tensile and compressive strains of 0.2 mm/m and 0.5 mm/m occur in survey bays G18-G19 and G25-G26.

Figures 3 indicates that the maximum observed subsidence due to Longwall 20 is less than the maximum predicted subsidence. The observed subsidence profile is, however, greater than the predicted subsidence profile away from the maximum subsidence as small vertical movements, with negligible tilts and strains, have occurred on both sides of Longwalls 20 and 21. The small vertical movements extending several hundred metres to the north of Longwall 21 may be the result of redistribution of *in situ* stresses due to the extraction of Longwalls 20 and 21. 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 Environmental Assessment (EA), 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.*" The small vertical movements extending to the south of Longwall 20 are likely to be the result of reactivation of the goaf due to Longwalls 1 to 18.

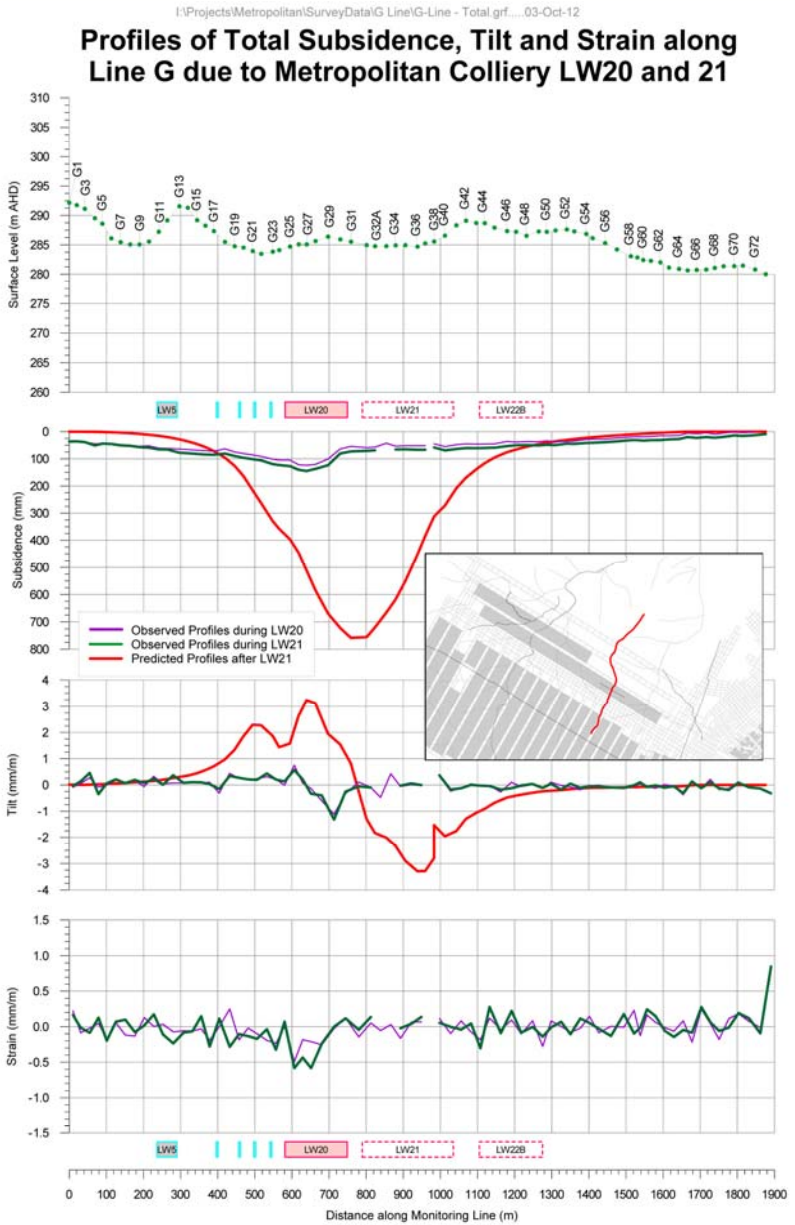


Figure 3

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

Table 2
Summary of Predicted and Observed Subsidence Movements for Line 9G Resulting from Longwalls 20 and 21 Extraction

Monitoring Summary			
Initial Survey Date		4 May 2010	
Latest Survey Date		30 May 2012	
Longwall Chainage at Latest Survey Date		1,305 m	
Face Distance from Line 9G at Latest Survey Date		300 m before on maingate side, 470 m before on tailgate side	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 21 (mm)	23	740	Maximum observed incremental subsidence at Peg G29
Maximum total subsidence due to the extraction of Longwalls 20 and 21 (mm)	145	758	Maximum observed total subsidence at Peg G27
Maximum incremental tilt due to the extraction of Longwall 21 (mm/m)	0.3	3.8	Maximum observed incremental tilt between Pegs G12 and G13
Maximum incremental tensile strain due to the extraction of Longwall 21 (mm/m)	0.2	0.8*	Maximum observed incremental tensile strain between Pegs G7 and G8
Maximum incremental compressive strain due to the extraction of Longwall 21 (mm/m)	0.5	0.9*	Maximum observed incremental compressive strain between Pegs G18 and G19

* Denotes that the maximum predicted tensile and compressive strains are based on conventional movements.

Line 9C

Line 9C has been surveyed monthly while subsidence has been above 20 mm/m (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 3.

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 21 was 647 mm at Peg C34, which is located above the chain pillar between Longwalls 20 and 21. The maximum observed incremental tilt was 4.4 mm/m between Pegs C44 and C45.

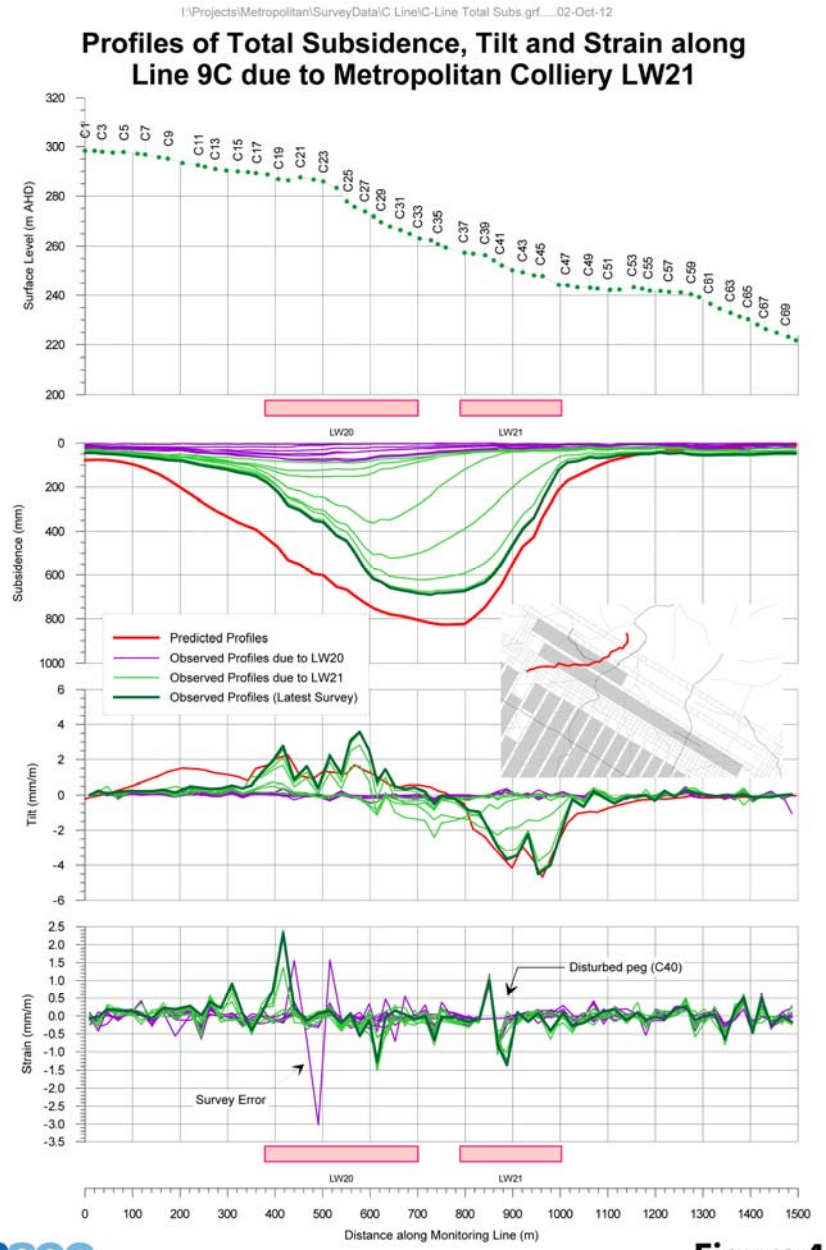
The maximum incremental tensile and compressive strains of 1.0 mm/m and 1.1 mm/m occur in survey bays C64-C65 and C34-C35. The maximum tensile and compressive strains ignore the high strains at the location of the disturbed peg and survey error. Only small subsidence movements had developed due to the extraction of Longwall 20.

Figure 4 indicates that the maximum observed subsidence is less than the maximum predicted subsidence. 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 Longwalls 20 and 21. These small vertical movements extend several hundred metres to the north of Longwalls 20 and 21 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 EA, 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 3
Summary of Predicted and Observed Subsidence Movements for Line 9C Resulting from Longwalls 20 and 21 Extraction

Monitoring Summary			
Initial Survey Date		29 March 2010 (Longwall 18 Chainage 85 m)	
Latest Survey Date		14 May 2012	
Longwall Chainage at Latest Survey Date		1,419 m	
Face Distance from Line 9C at Latest Survey Date		766 m past Line 9C on maingate side, 887 m past Line 9C on the tailgate side	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 21 (mm)	647	805	Maximum observed incremental subsidence at Peg C34
Maximum total subsidence due to the extraction of Longwalls 20 and 21 (mm)	690	827	Maximum observed incremental subsidence at Peg C34
Maximum incremental tilt due to the extraction of Longwall 21 (mm/m)	4.4	4.6	Maximum observed incremental tilt between Pegs 44 and C45
Maximum incremental tensile strain due to the extraction of Longwall 21 (mm/m)	1.0	1.0*	Maximum observed incremental tensile strain between Pegs C14 and C15
Maximum incremental compressive strain due to the extraction of Longwall 21 (mm/m)	1.1	0.7*	Maximum observed incremental compressive strain between Pegs C28 and C29. Disturbed pegs ignored.

* Denotes that the maximum predicted tensile and compressive strains are based on conventional movements.



msec

Figure 4

Line 9C West

Line 9C West has been surveyed monthly while subsidence has been above 20 mm/m (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 4.

The maximum observed incremental subsidence due to the extraction of Longwall 21 was 537 mm at Peg 9CW7, which is located above Longwall 21. The maximum observed incremental tilt was 6.3 mm/m between Pegs 9CW9 and 9CW10. The maximum incremental tensile and compressive strains of 1 mm/m and 0.3 mm/m occur in survey bays 9CW9-9CW10 and 9CW13-9CW14.

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 due to Longwall 20 are very small and are within expected limits of accuracy of predictions as discussed above for Line 9C.

Figure 5 indicates that the maximum observed subsidence is less than the maximum predicted subsidence. The maximum observed tilt is slightly higher than the maximum predicted tilt, however the majority of the predicted profile of tilt matches the observed tilt.

Table 4
Summary of Predicted and Observed Subsidence Movements for Line 9C West Resulting from Longwalls 20 and 21 Extraction

Monitoring Summary			
Initial Survey Date		29 March 2010 (Longwall 18 Chainage 85 m)	
Latest Survey Date		14 May 2012	
Longwall Chainage at Survey Date		1,419 m	
Face Distance from Line 9C West at Latest Survey Date		827 m past peg 9CW1	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 21 (mm)	537	660	Maximum observed incremental subsidence at Peg 9CW7
Maximum total subsidence due to the extraction of Longwalls 20 and 21 (mm)	576	670	Maximum observed incremental subsidence at Peg 9CW8A
Maximum incremental tilt due to the extraction of Longwall 21 (mm/m)	6.3	5.2	Maximum observed incremental tilt between Pegs 9CW9 and 9CW10
Maximum incremental tensile strain due to the extraction of Longwall 21 (mm/m)	1.0	0.6*	Maximum observed incremental tensile strain between Pegs 9CW9 and 9CW10
Maximum incremental compressive strain due to the extraction of Longwall 21 (mm/m)	0.3	0.3*	Maximum observed incremental compressive strain between Pegs 9CW13 and 9CW14

* Denotes that the maximum predicted tensile and compressive strains are based on conventional movements.

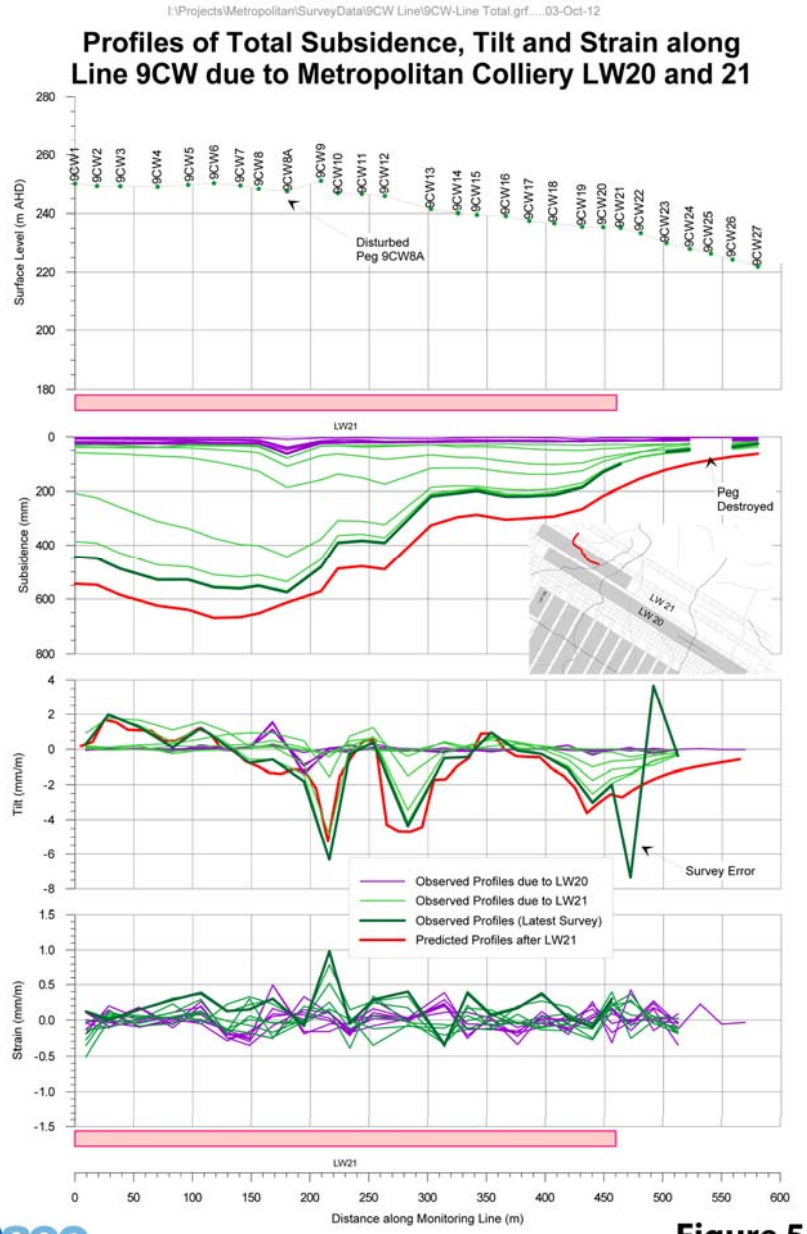


Figure 5

Longitudinal Line

The Longitudinal Line was monitored within three months of the completion of Longwall 20. A summary of the observed and predicted subsidence movements along the Longitudinal Line for the latest survey is presented in Table 5.

The profiles of the observed incremental subsidence, tilt and strain along Longitudinal Line are shown on Figure 6. 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 6.

The maximum observed incremental subsidence due to the extraction of Longwall 20 was 129 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. The maximum observed subsidence is less than the maximum predicted subsidence.

Table 5
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		10 August 2011	
Longwall Chainage at Latest Survey Date		3 m	
Face Distance from Longitudinal Line at Latest Survey Date		550 m past Mark GLE10, 935 m past Mark GLW9	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 20 (mm)	129	138	Maximum observed incremental subsidence at Peg GLE6
Maximum total subsidence due to the extraction of Longwall 20 (mm)	129	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	Within limits of survey accuracy*	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		Maximum observed incremental compressive strain between Pegs GLW6 and GLW5

* Denotes that the maximum predicted tensile and compressive strains are based on conventional movements.

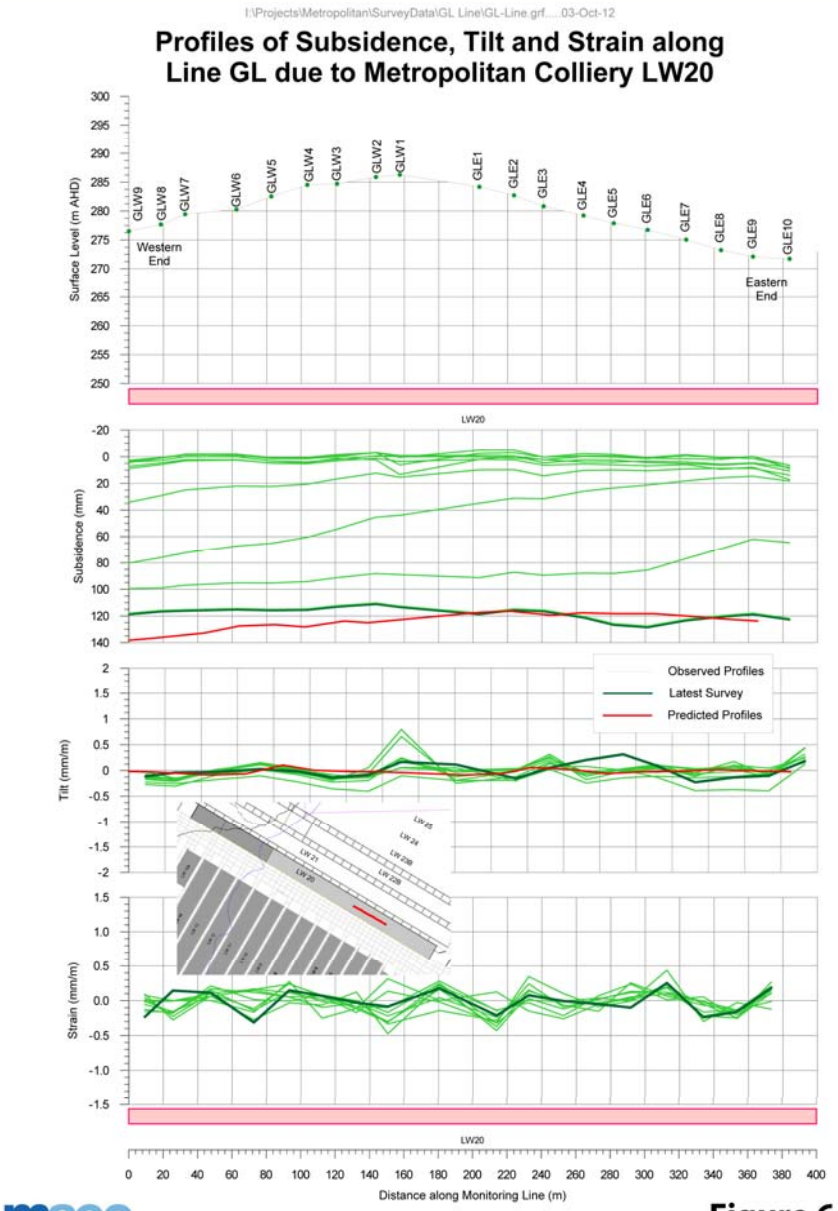


Figure 6

Line 9J

A summary of the observed and predicted subsidence movements along Line 9J for the latest survey is presented in Table 6.

Table 6
Summary of Predicted and Observed Subsidence Movements for Line 9J Resulting from Longwalls 20 and 21 Extraction

Monitoring Summary			
Initial Survey Date		6 May 2010	
Latest Survey Date		21 June 2012	
Longwall Chainage at Latest Survey Date		1,224 m	
Face Distance from Line 9J at Latest Survey Date		909 m to nearest mark (J53); Line 9J does not pass above Longwall 21	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 21 (mm)	21	29	Maximum observed incremental subsidence at Peg J3
Maximum total subsidence due to the extraction of Longwalls 20 and 21 (mm)	23	30	Maximum observed incremental subsidence at Peg J16
Maximum incremental tilt due to the extraction of Longwall 21 (mm/m)	0.6	Within limits of survey accuracy*	Maximum observed incremental tilt between Pegs J7 and J8
Maximum incremental tensile strain due to the extraction of Longwall 21 (mm/m)	0.4		Maximum observed incremental tensile strain between Pegs J15 and J16
Maximum incremental compressive strain due to the extraction of Longwall 21 (mm/m)	0.5		Maximum observed incremental compressive strain between Pegs J10 and J11

* Denotes that the maximum predicted tensile and compressive strains are based on conventional movements.

Figure 7 indicates that only small subsidence movements have developed, since Longwall 21 had not been fully extracted at the time of the latest survey. Similarly, the profiles of the observed total subsidence, tilt and strain along Line 9J resulting from the extraction of Longwall 21 show only small movements. The observed subsidence movements therefore predominantly reflect the subsidence movements due to the extraction of Longwall 20.

The maximum observed incremental subsidence due to the extraction of Longwall 21 was 21 mm at Peg J3. The maximum observed incremental tilt was 0.6 mm/m between Pegs J7 and J8. The maximum incremental tensile and compressive strains of 0.4 mm/m and 0.5 mm/m, respectively, occur in survey bays J15-J16 and J10-J11. These maxima occur near the south eastern end of Line 9J, which is the furthest distance from Longwall 21.

Line 9J is located approximately 330 m to the north east of Longwall 20 at its nearest point and is currently more than 900 m from the Longwall 21 face position. As a result, observed values of subsidence, tilt and strain are small, being less than 20 mm, which is within the expected limits of accuracy of predictions.

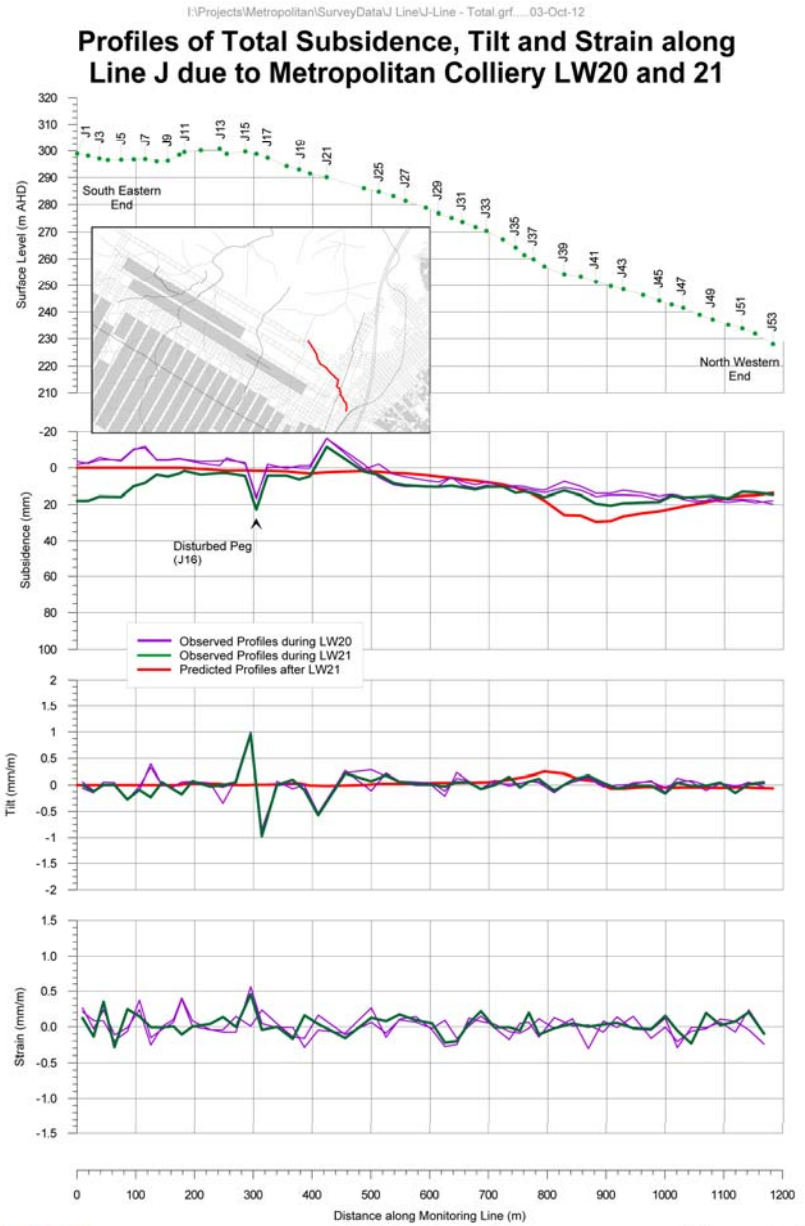


Figure 7

Transmission Line

A summary of the observed and predicted subsidence movements along the Transmission Line for the latest survey is presented in Table 7.

Table 7
Summary of Predicted and Observed Subsidence Movements for the Transmission Line Resulting from Longwalls 20 and 21 Extraction

Monitoring Summary			
Initial Survey Date		4 May 2010	
Latest Survey Date		2 July 2012	
Longwall Chainage at Latest Survey Date		1,296 m	
Face Distance from Transmission Line at Latest Survey Date		1,600 m from LW21 to nearest Mark 450 m from LW20 to nearest Mark The Transmission Line does not pass above Longwalls 20 or 21	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 20 (mm) **	13	Within limits of survey accuracy*	Maximum observed incremental subsidence at Peg T45
Maximum total subsidence due to the extraction of Longwalls 20 and 21 (mm)	13		Maximum observed incremental subsidence at Peg T45
Maximum incremental tilt due to the extraction of Longwall 20 (mm/m)**	0.6		Maximum observed incremental tilt between Pegs E/T60 to D
Maximum incremental tensile strain due to the extraction of Longwall 20 (mm/m)**	0.2		Maximum observed incremental tensile strain between Pegs T29 and T30
Maximum incremental compressive strain due to the extraction of Longwall 20 (mm/m)**	0.3		Maximum observed incremental compressive strain between Pegs T27 and T28

* Denotes that the maximum predicted tensile and compressive strains are based on conventional movements.

** Results shown for LW20 which is nearer to the monitoring line.

The maximum observed incremental subsidence due to the extraction of Longwall 20 was 13 mm at Peg T45. The maximum observed incremental tilt was 0.6 mm/m between Pegs E/T60 and D. The maximum incremental tensile and compressive strains of 0.2 mm/m and 0.3 mm/m, respectively, occur in survey bays T29-T30 and T27-T28.

The Transmission Line is located approximately 450 m to the east of Longwall 20 at its nearest point. As a result, predicted and observed values of subsidence, tilt and strain are very small. Observed movements are within expected limits of accuracy of predictions. Some survey marks were disturbed near the southern end of the transmission line as the result of maintenance vehicles accessing the transmission line. Figure 8 indicates that there is greater scatter in the observed subsidence parameters at the southern end of this monitoring line. The disturbance from maintenance vehicles may have contributed to the greater scatter in this part of the monitoring line.

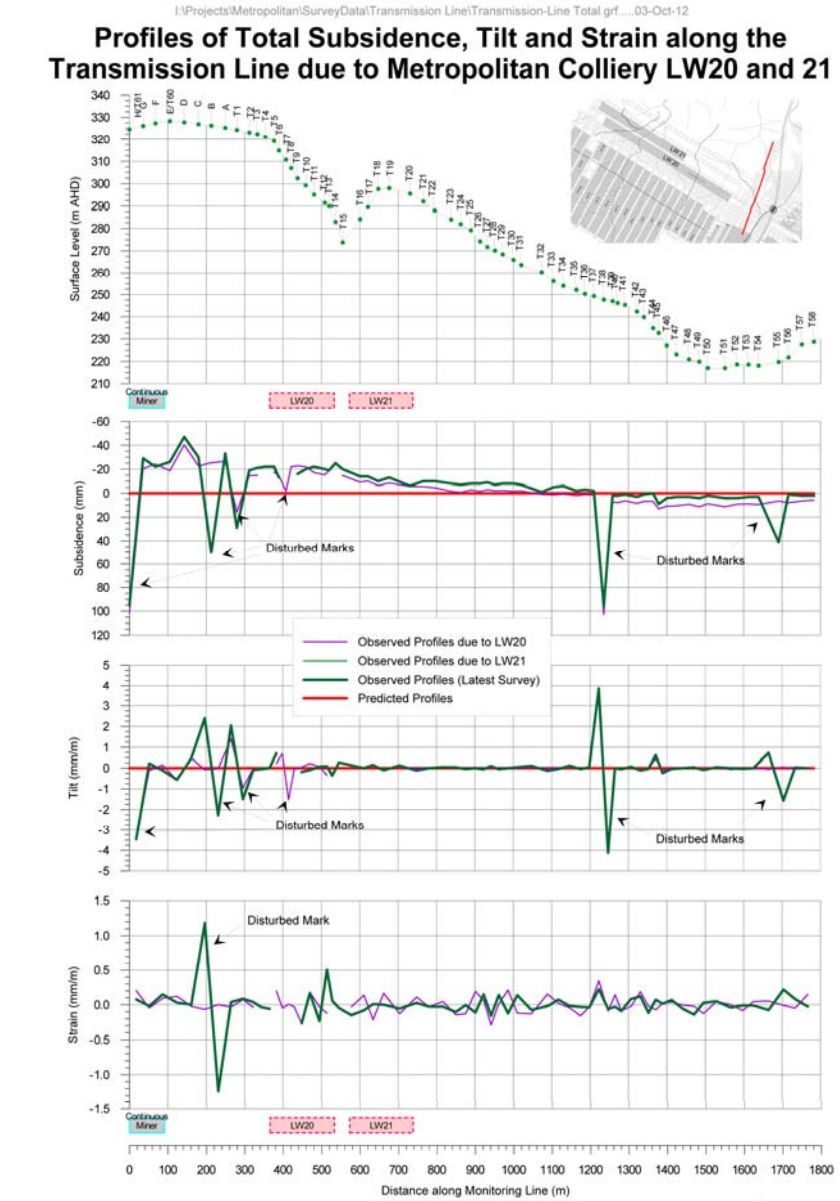


Figure 8

Princes Highway Line

A summary of the observed and predicted subsidence movements along the Princes Highway Line for the latest survey is presented in Table 8.

Table 8
Summary of Predicted and Observed Subsidence Movements for the Princes Highway Line Resulting from Longwalls 20 and 21 Extraction

Monitoring Summary			
Initial Survey Date		25 May 2010	
Latest Survey Date		20 June 2012	
Longwall Chainage at Latest Survey Date		1,233 m	
Face Distance from Princes Highway Line at Latest Survey Date		1,850 m to nearest mark; the Princes Highway Line does not pass above Longwall 21	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 21 (mm)	8	Within limits of survey accuracy*	Maximum observed incremental subsidence at Peg PH1
Maximum total subsidence due to the extraction of Longwall 21 (mm)	4		Maximum observed incremental subsidence at Peg PH1
Maximum incremental tilt due to the extraction of Longwall 21 (mm/m)	0.9		Maximum observed incremental tilt between Pegs PH1 and PH2
Maximum incremental tensile strain due to the extraction of Longwall 21 (mm/m)	0.2		Maximum observed incremental tensile strain between Pegs PH4 and PH5
Maximum incremental compressive strain due to the extraction of Longwall 21 (mm/m)	0.4		Maximum observed incremental compressive strain between Pegs PH1 and PH2

* Denotes that the maximum predicted tensile and compressive strains are based on conventional movements.

The profiles of the observed total subsidence, tilt and strain along the Princes Highway Line are shown on Figure 9.

The observed incremental movements are the additional movements since the base survey that was measured on the 27 September 2011. The Longwall 21 face position was approximately 1.8 kilometres from the nearest mark on the Princes Highway line and at this distance, Longwall 21 is not anticipated to have had any effect on the observed incremental or total subsidence results for Longwall 21. Some survey marks have either been disturbed or destroyed as indicated in Figure 9.

The maximum observed incremental subsidence due to the extraction of Longwall 21 was 8 mm at Peg PH1. The maximum observed incremental tilt was 0.9 mm/m between Pegs PH1 and PH2. The maximum incremental tensile and compressive strains of 0.2 mm/m and 0.4 mm/m occur in survey bays PH4-PH5 and PH1-PH2.

The Princes Highway Line is located approximately 690 m and 615 m to the south east of Longwall 20 and Longwall 21, respectively, at its nearest point. As a result, predicted and observed values of subsidence, tilt and strain are very small and within the limits of survey accuracy. Observed movements are within expected limits of accuracy of predictions.

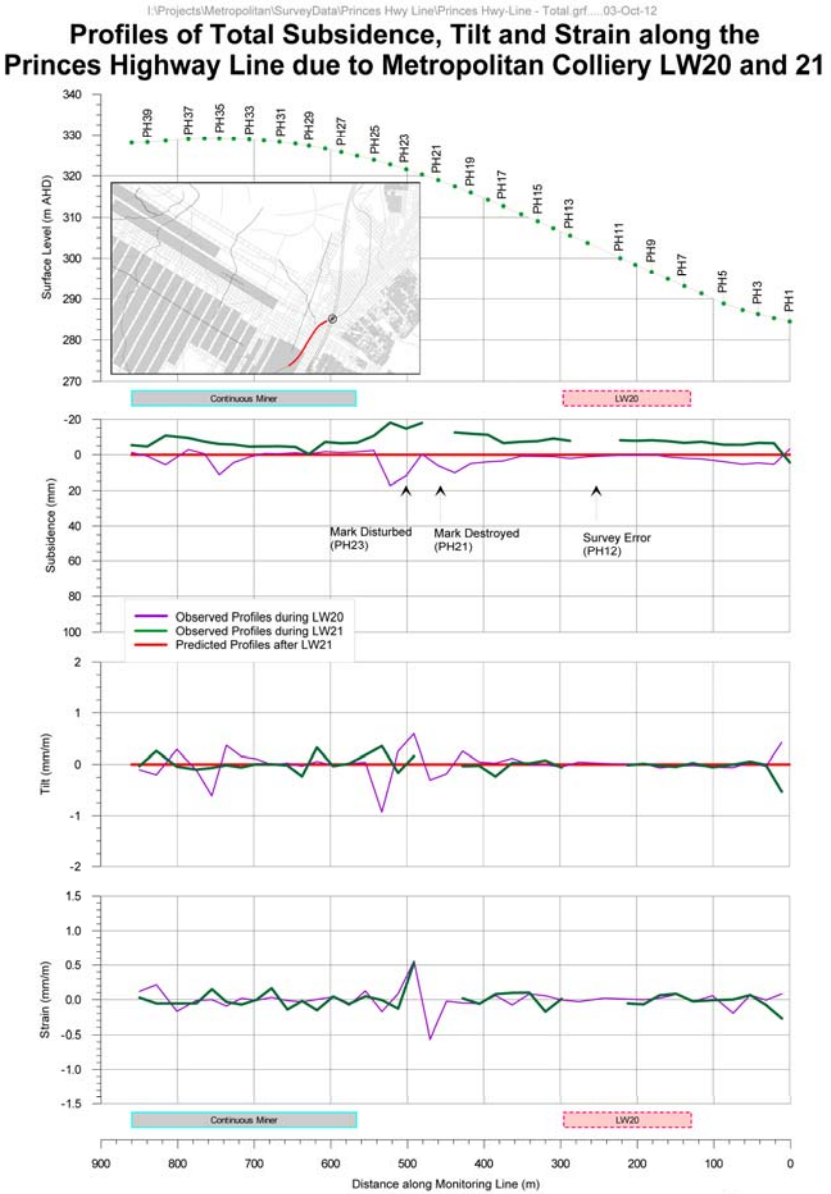


Figure 9

Freeway Line

The Freeway Line is located along the Southern Freeway to the east of the finishing end of Longwall 20 and Longwall 21 over a total length of approximately 3,000 m.

During the review period, many of the survey marks for the Freeway Line were disturbed or destroyed as the result of resurfacing operations undertaken by RMS during the extraction of Longwall 20. In addition to this, restricted access to the freeway resulted in greater than anticipated errors in the survey results during the extraction of Longwall 20. The survey methods for the Freeway Line were subsequently modified to produce an accuracy of results to within normal limits and destroyed or disturbed marks have been reinstated. As a result of these complications the latest survey (i.e. 15 June 2012) will be used as a baseline for future survey results.

Waratah Rivulet Cross Lines 14, 15 and 16

Cross Lines 14, 15 and 16

Lines 14, 15 and 16 have been surveys monthly until the longwall passes the Waratah Rivulet and subsidence is less than 20 mm/m. Lines 14, 15 and 16 have also been surveyed within 1 month of the completion of Longwall 20.

A summary of the observed and predicted subsidence movements along Waratah Rivulet Cross Lines 14, 15 and 16 due to the extraction of Longwall 20 is presented in Table 9.

The profiles of the observed incremental net vertical movement, strain, upsidence and closure along Waratah Rivulet Cross Lines 14, 15 and 16 due to the extraction of Longwall 20 are shown on Figures 10, 11 and 12 respectively. The observed incremental movements are the additional movements since the base survey that was measured on the 17 June 2010 when the Longwall 20 extraction face was at chainage 2,689 m (113 m extracted), and was approximately 630 m from the nearest cross line.

The maximum observed net vertical movement of 65 mm at Line 14 was less than the predicted net vertical movement of 86 mm. The maximum observed net vertical movement of 80 mm and 79 mm at Line 15 and Line 16, respectively, are greater than the predicted net vertical movement.

Table 9
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			17 June 2011		
Latest Survey Date			30 August 2011		
Longwall Chainage at Latest Survey Date			0 m		
Face Distance from Monitoring Line at Latest Survey Date			2,030 m to Line 14 2,020 m to Line 15 1,940 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 15 16	65 80 79	160 203 157	74 177 176	86 25 -19
Subsidence Parameter	**Line**	**Observed Value**	**Predicted Final Value**	**Comments**	
Maximum incremental closure due to the extraction of Longwall 20 (mm)	14 15 16	5 1 3	233 253 254	Monitoring line length of 22 to 27 m represents a small portion of the total valley profile used for closure predictions	
Maximum incremental upsidence due to the extraction of Longwall 20 (mm)	14 15 16	0 0 2	74 177 176	Monitoring line length of 22 to 27 m represents a small portion of the total valley profile used for upsidence predictions	

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Profiles of Total Net Vertical Movement, Strain, Upsidence and Closure along the 14000 Line due to LW20 and 21

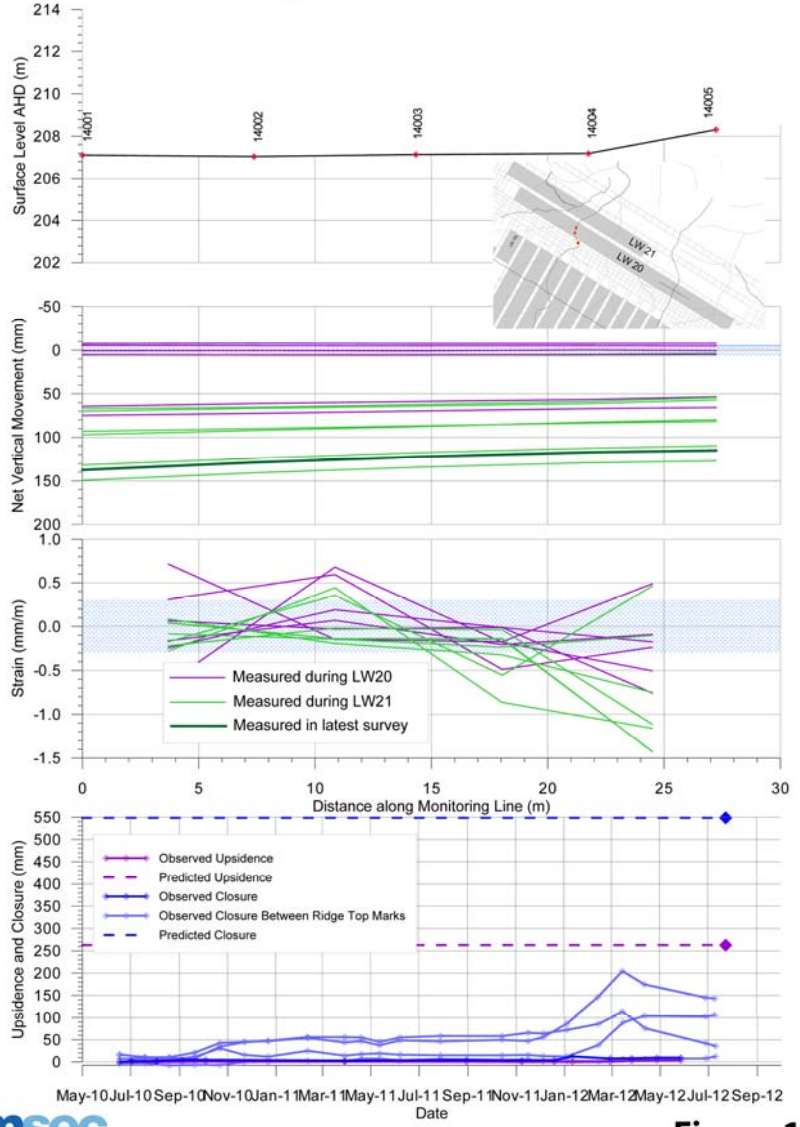

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Figure 10

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Profiles of Total Net Vertical Movement, Strain, Upsidence and Closure along the 15000 Line due to LW20 and 21

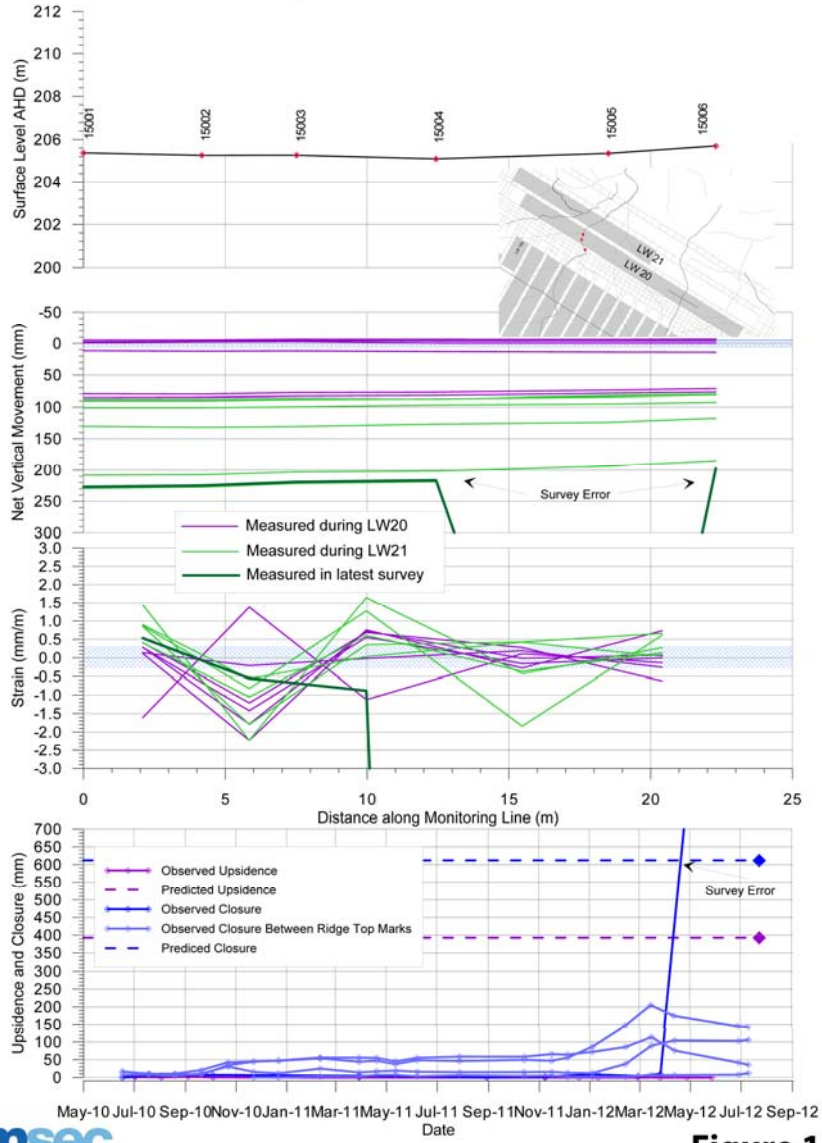

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Figure 11

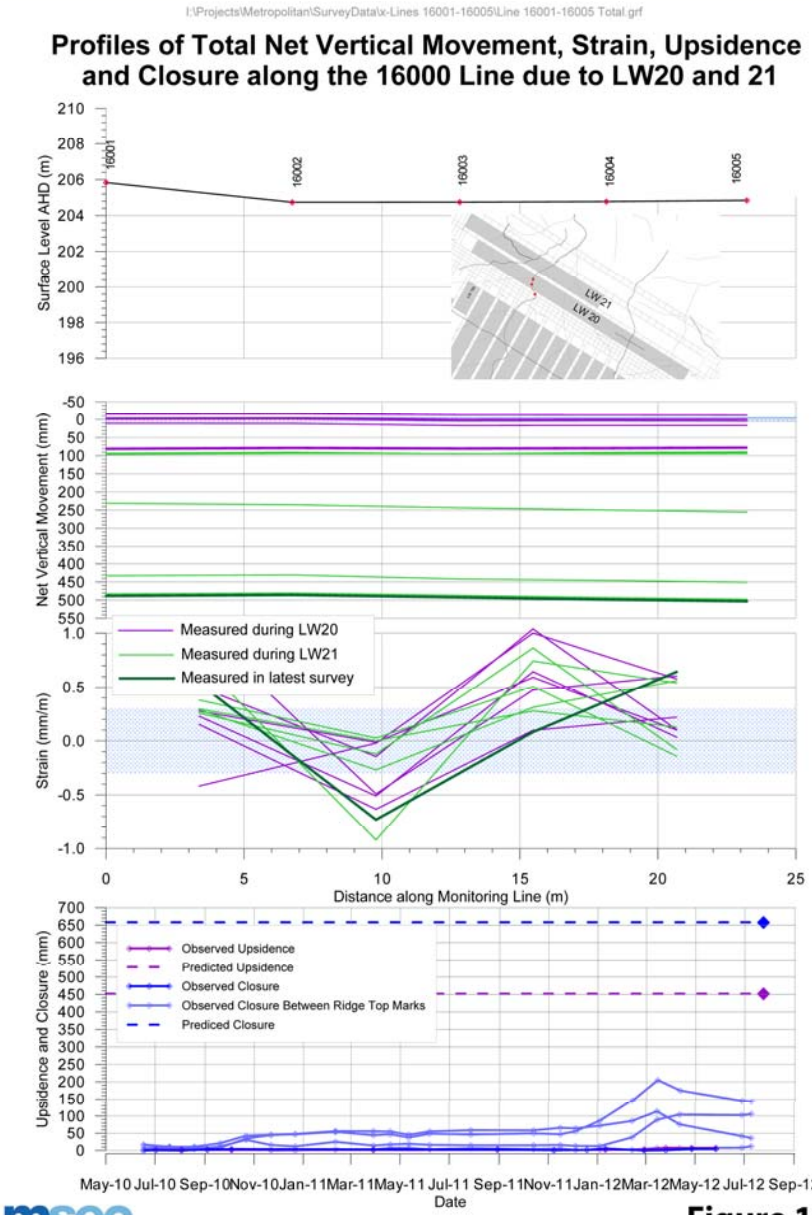

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Figure 12

A summary of the observed and predicted subsidence movements along Waratah Rivulet Cross Lines 14, 15 and 16 due to the extraction of Longwall 21 is presented in Table 10.

Table 10
Summary of Predicted and Observed Subsidence Movements for Waratah Rivulet Cross Lines 14, 15 and 16 Resulting from Longwall 21 Extraction

Monitoring Summary					
Initial Survey Date			30 August 2011		
Latest Survey Date			27 April 2012		
Longwall Chainage at Latest Survey Date			1442 m		
Face Distance from Monitoring Line at Latest Survey Date			1,292 m past Line 14 1,375 m past Line 15 1,388 m past 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 21 (mm)	14 15 16	73 147 426	191 294 554	76 122 228	115 172 326
Subsidence Parameter	**Line**	**Observed Value**	**Predicted Final Value**	**Comments**	
Maximum incremental closure due to the extraction of Longwall 21 (mm)	14 15 16	5 11 7	134 207 274	Monitoring line length of 22 to 27 m represents a small portion of the total valley profile used for closure predictions	
Maximum incremental upsidence due to the extraction of Longwall 21 (mm)	14 15 16	3 0 5	76 122 228	Monitoring line length of 22 to 27 m represents a small portion of the total valley profile used for upsidence predictions	

The profiles of the observed net vertical movement, strain, upsidence and closure along Waratah Rivulet Cross Lines 14, 15 and 16 due to the extraction of Longwall 21 are shown on Figures 10, 11 and 12 respectively. The observed incremental movements are the additional movements since the survey that was measured on the 30 August 2011 prior to the extraction of Longwall 21.

The maximum observed net vertical movement of 73 mm and 147 mm at Line 14 and Line 15, respectively, were less than the predicted net vertical movements. The maximum observed net vertical movement of 426 mm at Line 16, was greater than the predicted net vertical movement.

The predicted net vertical movements for Longwalls 20 and 21 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 that 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 low values of 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 rock bars present over Longwall 20 and indicate generally low levels of strain.

WRS5 Line

A summary of the observed and predicted subsidence movements along Waratah Rivulet Cross Line WRS5 due to the extraction of Longwall 20 is presented in Table 11.

Table 11
Summary of Predicted and Observed Subsidence Movements for Waratah Rivulet Cross Line WRS5 Resulting from Longwall 20 Extraction

Monitoring Summary				
Initial Survey Date	17 June 2011			
Latest Survey Date	31 August 2011			
Longwall Chainage at Latest Survey Date	0 m			
Face Distance from Monitoring Line at Latest Survey Date	1,908 m from the nearest WRS5 Peg. The WRS5 Line does not pass above Longwall 20			
Subsidence Parameter	**Observed Value**	**Predicted Final Value**		
		Subsidence	**Upsidence**	**Net Vertical Movement**
Maximum incremental net vertical movement due to the extraction of Longwall 20 (mm)	24	3	14	-11
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**	
Maximum incremental closure due to the extraction of Longwall 20 (mm)	3	59	Monitoring line length of 41 m represents a small portion of the total valley profile used for closure predictions	
Maximum incremental upsidence due to the extraction of Longwall 20 (mm)	1	14	Monitoring line length of 41 m represents a small portion of the total valley profile used for upsidence predictions	

The observed incremental movements are the additional movements since the base survey that was measured on the 17 June 2010 when the Longwall 20 extraction face was at chainage 2,689 m (113 m extracted), and was approximately 780 m from the nearest cross line.

The maximum observed net vertical movement of 24 mm is greater than the predicted net vertical movement of -11 mm. The predicted net vertical movement includes 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 that 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 the WRS5 Line and the negligible observed upsidence for this short line, 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 also greater than the predicted subsidence. This is likely to be the result of the far field vertical movements and is within the level of accuracy for the method of prediction.

There was negligible measured subsidence and closure at the monitoring line due to the extraction of Longwall 20.

A summary of the observed and predicted subsidence movements along Waratah Rivulet Cross Line WRS5 due to the extraction of Longwall 21 is presented in Table 12.

The observed incremental movements are the additional movements since the base survey that was measured on the 31 August 2011 prior to the extraction of Longwall 21.

The maximum observed net vertical movement of -61 mm is less than the predicted net vertical movement of 59 mm. It can be seen on Figure 13 that upsidence and closure has developed during the extraction of Longwall 21. The incremental compressive strain at the location of maximum upsidence is 9.5 mm/m.

Table 12
Summary of Predicted and Observed Subsidence Movements for Waratah Rivulet Cross Line WRS5 Resulting from Longwall 21 Extraction

Monitoring Summary				
Initial Survey Date	31 August 2011			
Latest Survey Date	10 July 2012			
Longwall Chainage at Latest Survey Date	1,075 m			
Face Distance from Monitoring Line at Latest Survey Date	896 m past WRS5 WRS5 Line is not located above Longwall 21			
Subsidence Parameter	**Observed Value**	**Predicted Final Value**		
		Subsidence	**Upsidence**	**Net Vertical Movement**
Maximum incremental net vertical movement due to the extraction of Longwall 21 (mm)	-61	124	65	59
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**	
Maximum incremental closure due to the extraction of Longwall 21 (mm)	75	260	Monitoring line length of 41 m represents a small portion of the total valley profile used for closure predictions	
Maximum incremental upsidence due to the extraction of Longwall 21 (mm)	150	65	Monitoring line length of 41 m represents a small portion of the total valley profile used for upsidence predictions	

Ridge to Ridge

A summary of the observed and predicted subsidence movements at the ridge to ridge monitoring points for the latest survey is presented in Table 13.

Table 13 indicates that the maximum observed subsidence is less than the maximum predicted subsidence. The horizontal movement vectors show a general movement towards the longwall goaf and towards the bases of nearby valleys.

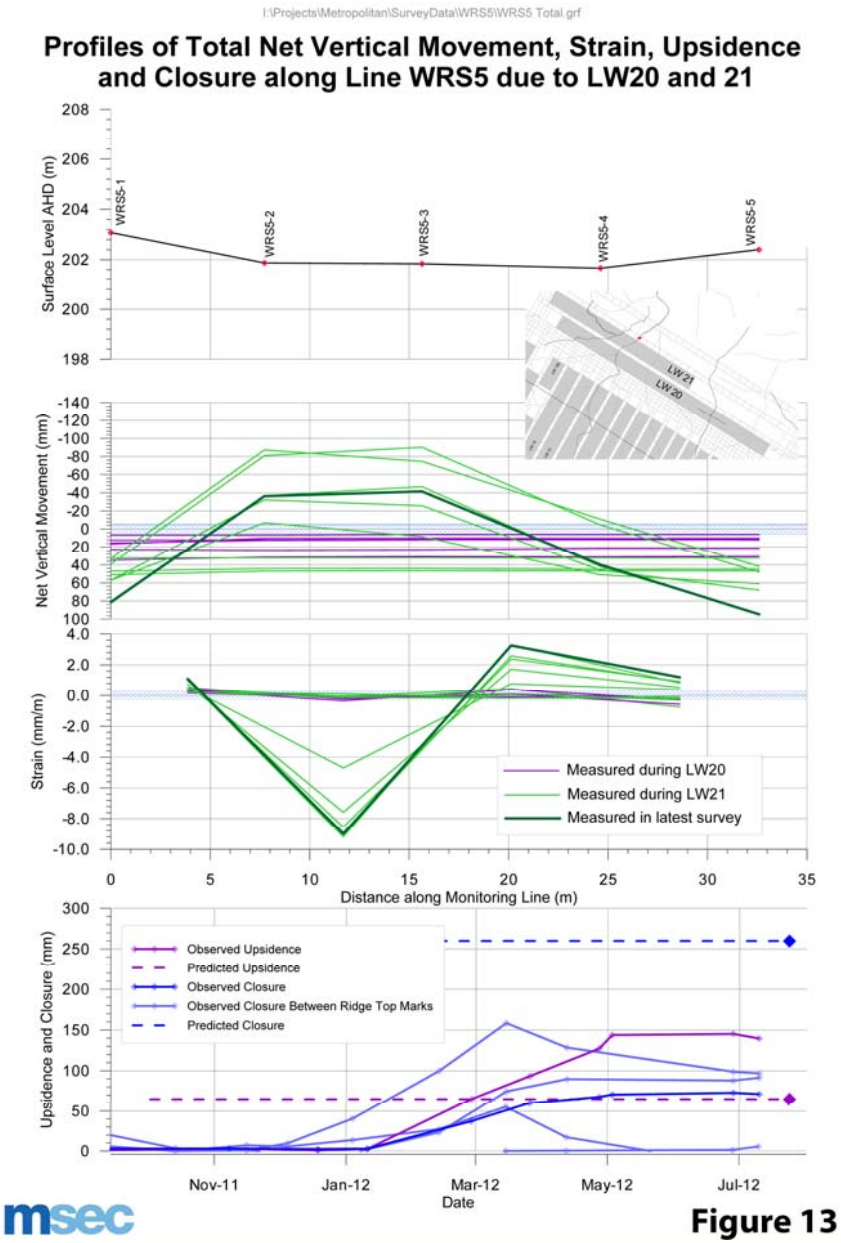


Figure 13

Table 13
Summary of Predicted and Observed Subsidence Movements for Ridge to Ridge Monitoring Points Resulting from Longwalls 20 and 21 Extraction

Monitoring Summary			
Initial Survey Date		12 May 2010	
Latest Survey Date		10 July 2012	
Longwall Chainage at Latest Survey Date		1,075 m	
Face Distance from nearest Peg at Latest Survey Date		845 m to Mark Trig 5	
Subsidence Parameter	**Observed Value**	**Predicted Final Value**	**Comments**
Maximum incremental subsidence due to the extraction of Longwall 21 (mm)	710	826	Maximum observed incremental subsidence at Trig 5
Maximum total subsidence due to the extraction of Longwalls 20 and 21 (mm)	771	916	Maximum observed incremental subsidence at Trig 5
Incremental Closure between Trig 1 and Trig 2	6	-	Crosses Waratah Rivulet
Incremental Closure between Trig 1 and Trig 3	39	-	Crosses Longwalls 20 and 21
Incremental Closure between Trig 1 and Trig 4	-76	-	Trig 4 located above Longwall 20
Incremental Closure between Trig 1 and Trig 5	-63	-	Located along same ridge line and crosses Longwall 20
Incremental Closure between Trig 2 and Trig 3	41	-	Crosses minor tributary and Longwalls 20 and 21
Incremental Closure between Trig 2 and Trig 4	-95	-	Crosses minor tributary
Incremental Closure between Trig 2 and Trig 5	-23	-	Crosses Waratah Rivulet and Longwall 20
Incremental Closure between Trig 3 and Trig 4	169	-	Located along same ridge line
Incremental Closure between Trig 3 and Trig 5	91	-	Crosses Waratah Rivulet and Longwall 21
Incremental Closure between Trig 4 and Trig 5	97	-	Crosses Waratah Rivulet

The greatest observed closure of 170 mm occurred between marks Trig 3 and Trig 4. These marks are located along the same ridgeline (i.e. they do not cross a valley) indicating that the observed closure may be predominantly conventional closure across the Longwalls 20 and 21.

The observed upsidence, closure and strain values of Waratah Rivulet Cross Lines 14, 15 and 16 did not indicate that any significant valley related movements had occurred, as discussed above. Since the cross lines in the base of the Waratah Rivulet valley do not indicate that any valley related closure had occurred and largest closure movements of the ridge to ridge monitoring points occur between marks that cross Longwall 20, it is likely that the closure movements predominantly represent the conventional closure of the ground surface across Longwalls 20 and 21. This is also supported by the observed movements of Line 9G. This monitoring line crosses Longwall 20 perpendicular to the longwall orientation and is located along a ridge line and is therefore unlikely to be affected by valley closure movements. The sum of differential bay length differences in the vicinity of Longwall 20 show a measured closure of approximately 50 mm to 60 mm, which represents the conventional closure across Longwall 20.

Incremental Vectors

Drawing No. MSEC586-105 to MSEC586-107 show the horizontal movement vectors for the extraction of Longwall 21 based on the face position at the latest survey date.

The vectors show a general movement towards the extracted goaf of Longwalls 20 and 21. With increased distance away from the goaf, the vectors are generally within survey tolerance and show an increasing trend for movements in the downslope direction and towards nearby valleys. Survey marks along the Freeway Line have been destroyed or disturbed and have greater survey error, as discussed in the Freeway Line section above.

The vector movements of the Waratah Rivulet cross lines 14, 15 and 16 do not indicate any significant closure movement towards the centre of the stream.

Horizontal Movements

A plot of the observed horizontal movement versus face distance from the nearest goaf edge of the active longwall for only pegs located over solid coal is provided on Figure 14. This plot includes pegs that have solid coal between the peg and active longwall which is representative of the majority of locations of the surface infrastructure to the east of the Metropolitan Coal longwalls.

Figure 14 indicates that the horizontal movements fit consistently within the horizontal movement data set for the southern coalfield.

Plots of Incremental Relative Lateral peg movement and Relative Longitudinal peg movement are presented in Figures 15 and 16, respectively. A plot of Incremental observed mid ordinate deviation is presented in Figure 17. The plots includes survey pegs that are located over solid coal and with solid coal between the peg and the active longwall and include all survey lines with the exception of the Freeway Line, which is considered to have significant horizontal errors as discussed above.

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:

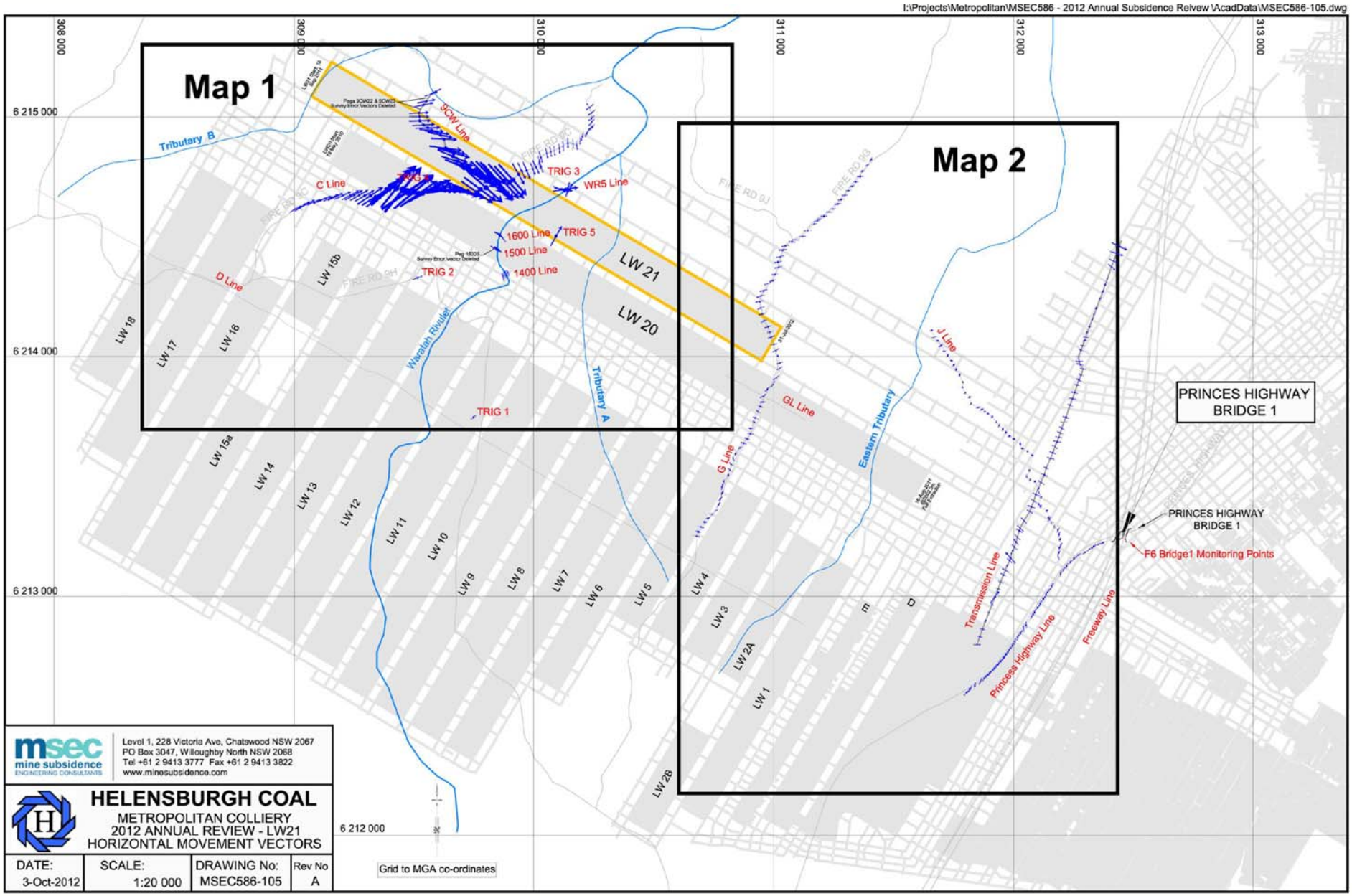
- Tributary B, Waratah Rivulet, Tributary A, Eastern Tributary.
- Cliff/Overhang COH1 and COH2.

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 14.

Table 14
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.	Stream bed cracking was observed at rock bar of Pool H and at rock bar of Pool N.
Cliff/Overhang COH1 and COH2	Potential cliff instabilities to less than 3 percent of the lengths of the cliffs.	No instabilities observed.



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METROPOLITAN COLLIERY
2012 ANNUAL REVIEW - LW21
HORIZONTAL MOVEMENT VECTORS

DATE:	SCALE:	DRAWING No:	Rev No
3-Oct-2012	1:20 000	MSEC586-105	A

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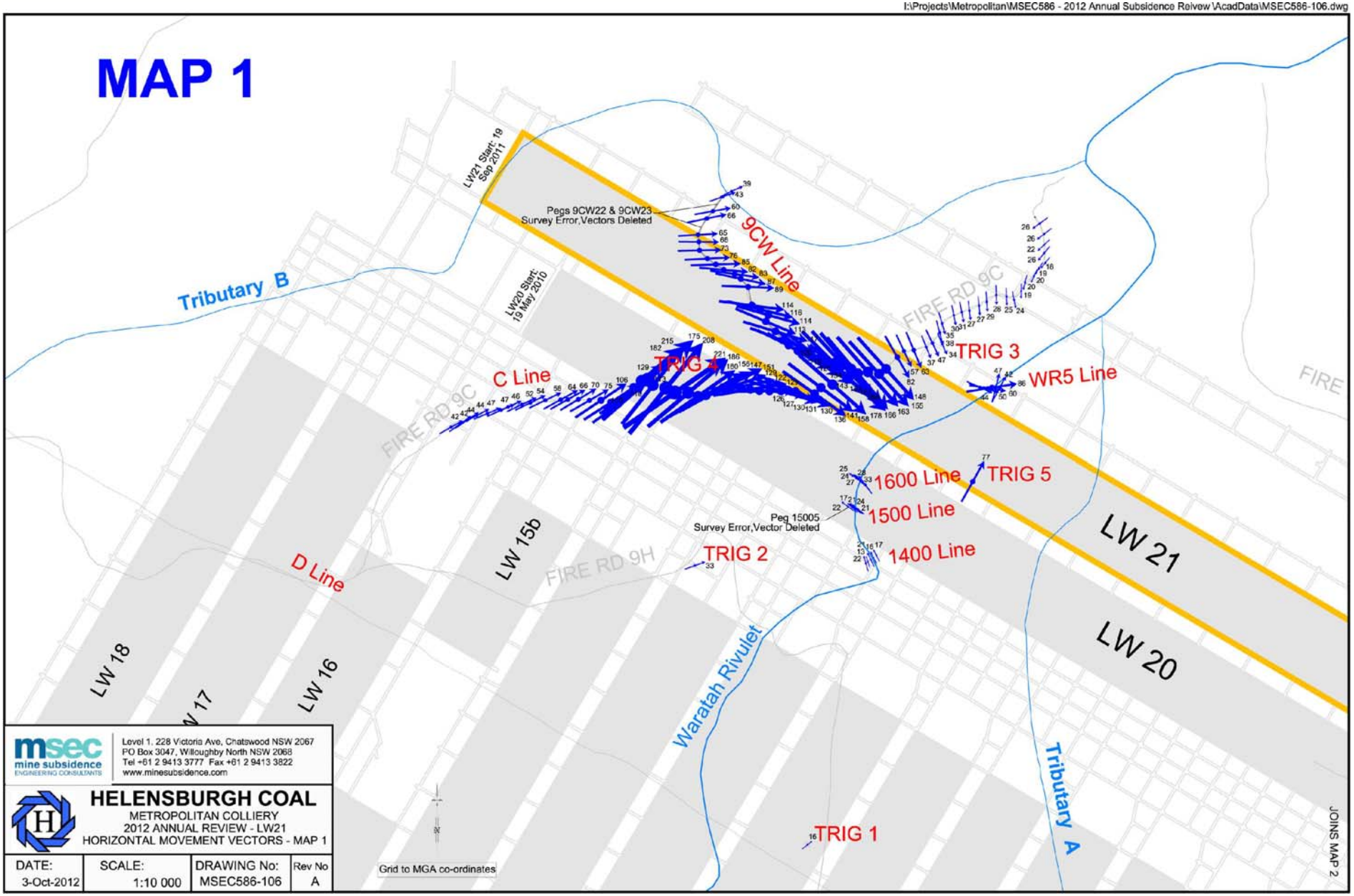
MAP 1



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2012 ANNUAL REVIEW - LW21
HORIZONTAL MOVEMENT VECTORS - MAP 1

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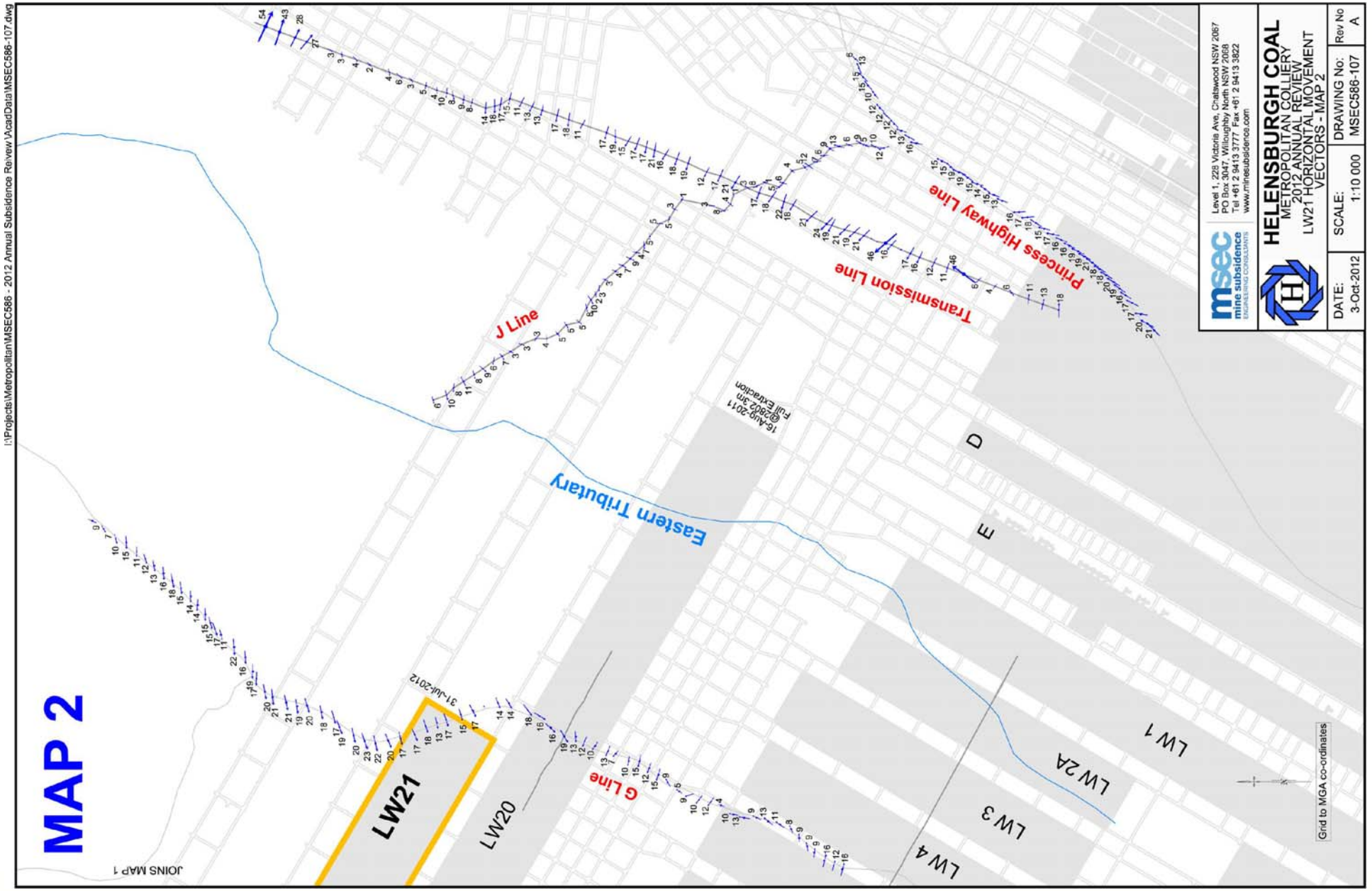
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MAP 2
JOINS MAP 1
J Line
Transmission Line
Princess Highway Line
Eastern Tributary
G Line
LW21
LW20
LW 4
LW 3
LW 2A
LW 1
D
E
16-Aug-2011
@2802.2m
Full Extraction
31-Jul-2012
Grid to MGA co-ordinates
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LW21 HORIZONTAL MOVEMENT
VECTORS - MAP 2
DATE: 3-Oct-2012
SCALE: 1:10 000
DRAWING No: MSEC586-107
Rev No A

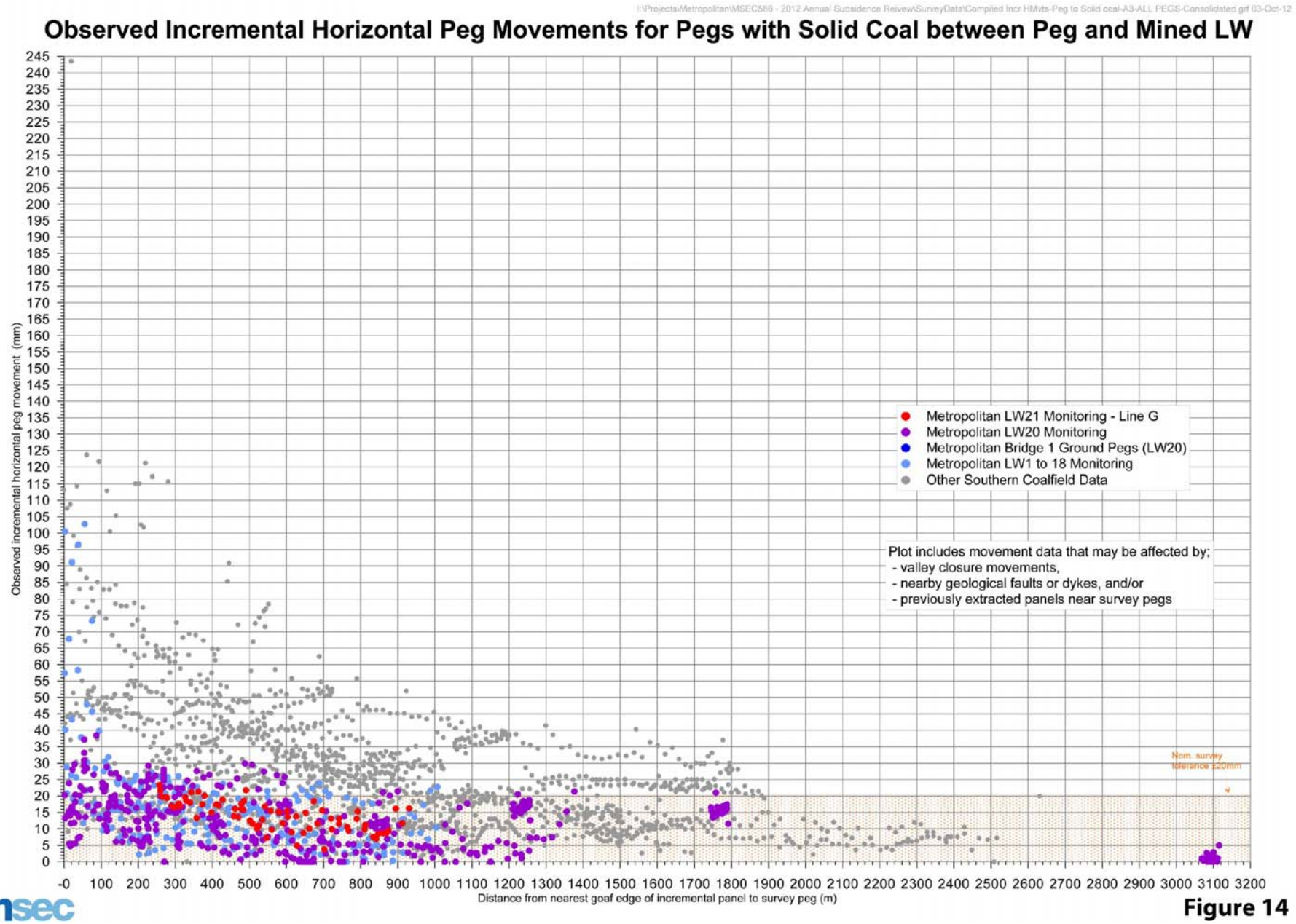

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Figure 14

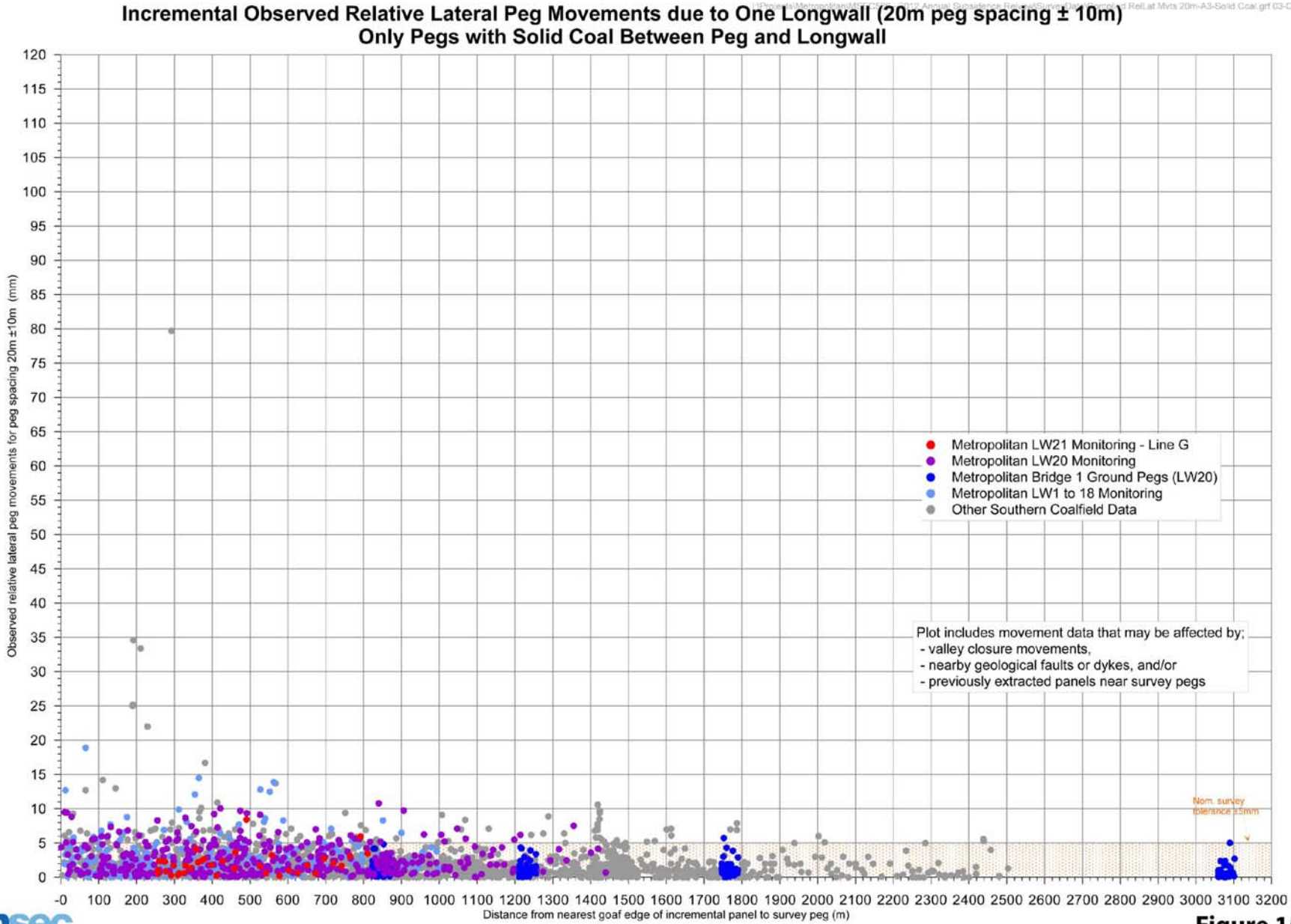

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Figure 15

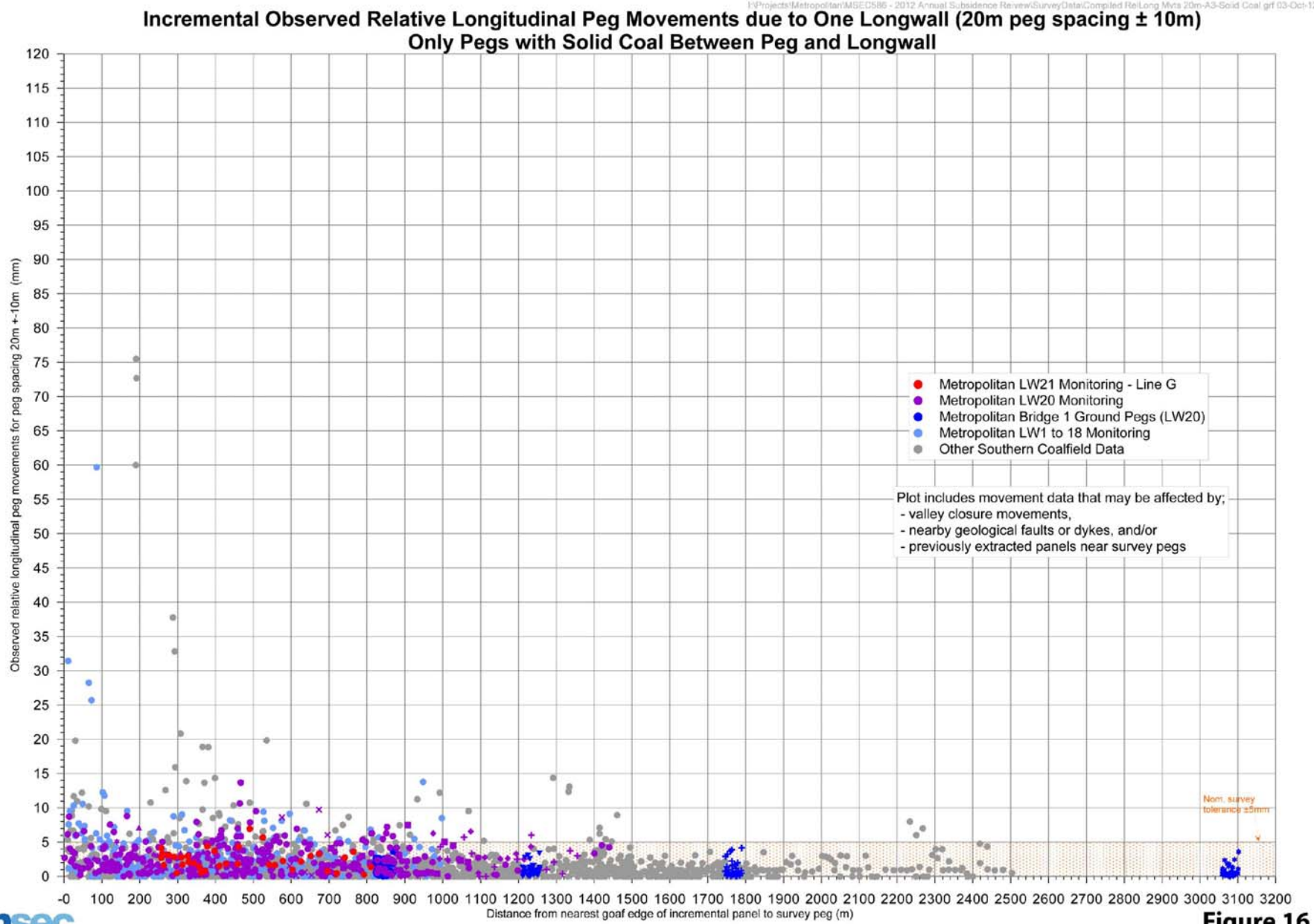

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Figure 16

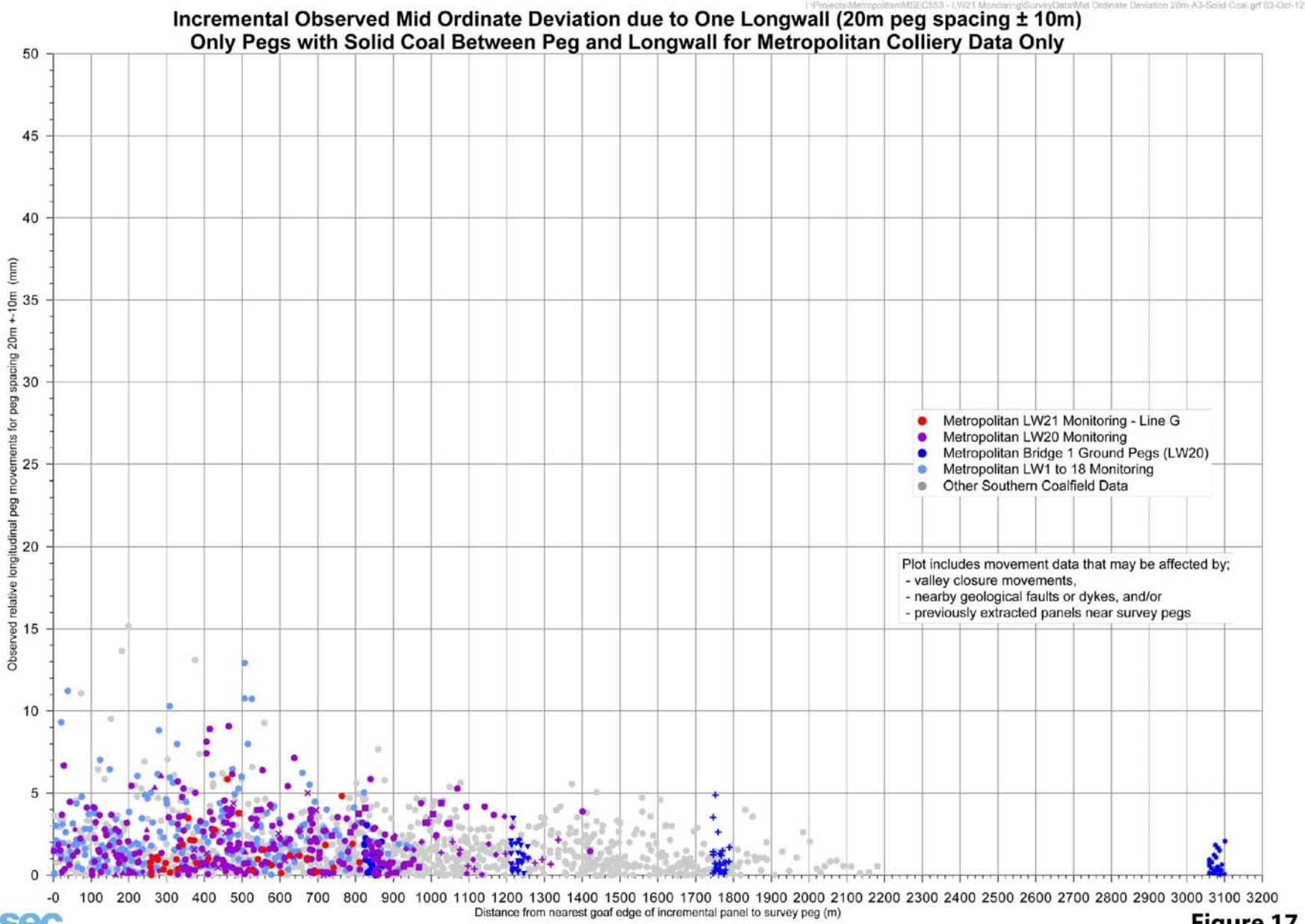

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Figure 17