Subsidence

The Metropolitan Coal Subsidence Monitoring Program includes subsidence parameter monitoring (i.e. the actual movement of the ground surface) and subsidence impact monitoring (e.g. surface cracking).

The results of the subsidence parameter monitoring are described below. The results of the subsidence impact monitoring are described in the Surface Water, Groundwater, Biodiversity, Land, Aboriginal Heritage and Built Features Environmental Monitoring Summaries.

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

- D Line (existing line traversing Longwalls 1-18);
- Line 9G (along Fire Road 9G);
- Line 9C (along Fire Road 9C);
- Line 9C West (from Fire Road 9C to Tributary B);
- Line 9J (along Fire Road 9J);
- Transmission Line (along the transmission lines);
- Princes Highway Line (along the Princes Highway);
- Freeway Line (along the M1 Princes Motorway, previously known as the F6 Southern Freeway);
- Waratah Rivulet Cross Lines (across the Waratah Rivulet); and
- Ridge to Ridge Monitoring Points (locations on ridge tops about the Waratah Rivulet).

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

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 December 2013. The reporting period covers the extraction of the finishing end of Longwall 21, Longwall 22A and part of Longwall 22B.

A review of the subsidence survey results and comparison between the predicted and observed subsidence movements over the reporting period was conducted by Mine Subsidence Engineering Consultants (MSEC). Subsidence measurements were generally within survey tolerance of predicted movements.

A summary of the observed and predicted subsidence movements is provided below.

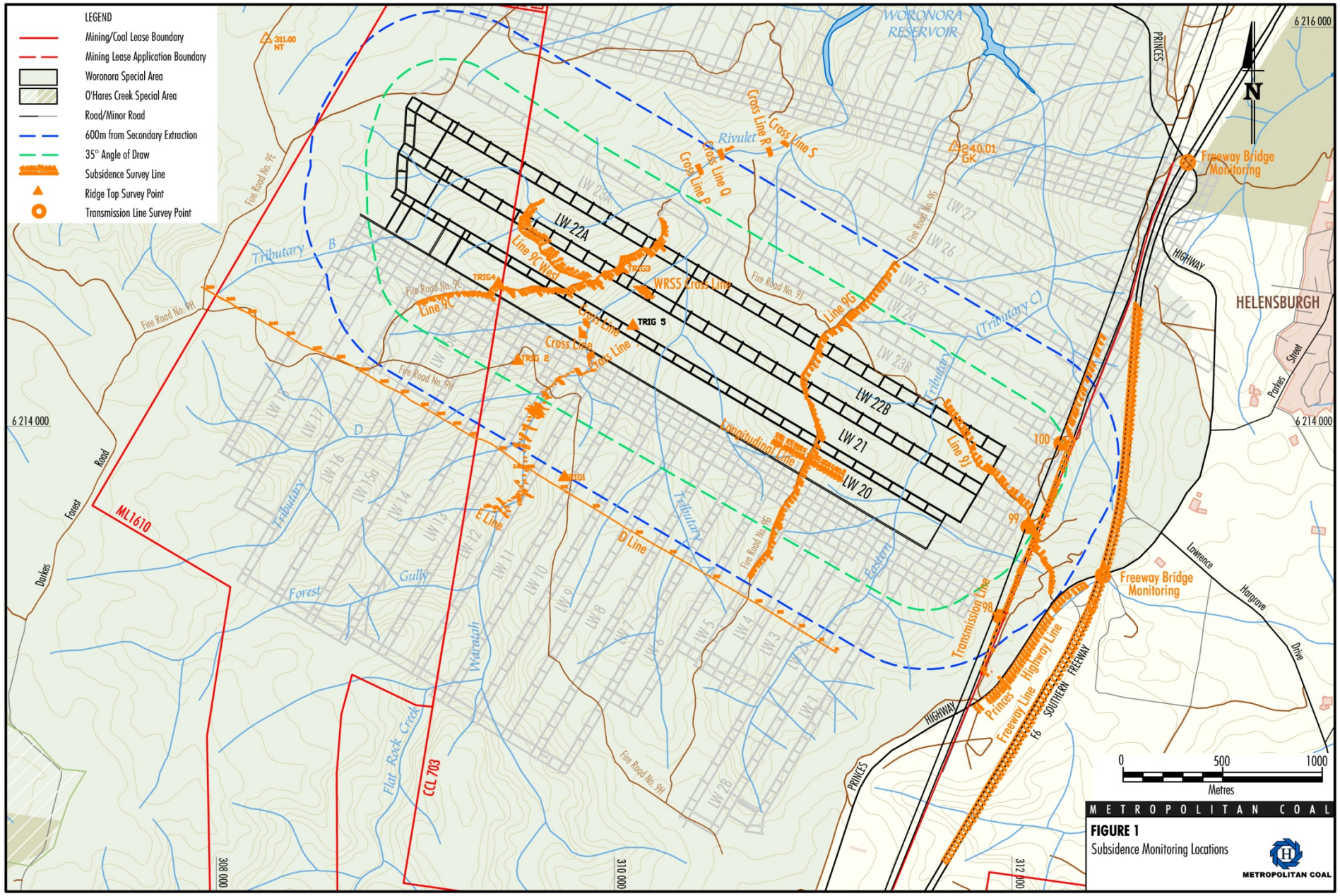
D Line

D Line was monitored after the completion of Longwall 21, and approximately 1 month after the commencement of Longwall 22A. A summary of the observed and predicted subsidence movements along D Line is presented in Table 1.

Table 1
Summary of Predicted and Observed Subsidence Movements for D Line Resulting from Longwall 21 Extraction

Monitoring Summary	
Initial Survey Date	1 May 1997 (during Longwall 2B)
Latest Survey Date	10 March 2013
Longwall 21 Chainage at Latest Survey Date	0 metres
Longwall Distance from D Line at Latest Survey Date	855 metres to Mark D92

Parameter	**Incremental Movements (LW21)**		**Additional Movements (LW20 to 21)**	
	Predicted	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	Within limits of survey accuracy.	24	Within limits of survey accuracy.	110
Tilt (mm)		0.6		1.1
Tensile Strain (mm/m)		0.7		1.9
Compressive Strain (mm/m)		0.8		1.7


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 P
Cross Line Q
Cross Line R
Cross Line S
LW 29A
LW 28A
LW 27
LW 26
LW 25
LW 24
LW 23B
LW 22A
LW 22B
LW 21
LW 20
LW 17
LW 16
LW 15b
LW 14
LW 13
LW 12
LW 11
LW 10
LW 9
LW 8
LW 7
LW 6
LW 5
LW 4
LW 3
LW 2
LW 1
LW 28
WRS5 Cross Line
Line 9C West
Line 9C
Line 9G
Line 9J
Cross Line
Longitudinal Line
E Line
D Line
TRIG 5
TRIG 4
TRIG 3
TRIG 2
TRIG 1
Fire Road No. 9C
Fire Road No. 9H
Fire Road No. 9J
Fire Road No. 9G
Tributary B
Tributary C
Tributary D
Eastern Tributary
Gully
Forest
Flat Rock Creek
Waratah
ML1610
CCL 703
Darkes Forest Road
Transmission Line
Highway Line
Freeway Bridge Monitoring
HELENSBURGH
Parkes Street
Lawrence Hargrave Drive
HIGHWAY
PRINCES
SOUTHERN FREEWAY
F6
311.00 NT
240.01 GK
100
99
98
6 216 000
6 214 000
398 000
310 000
312 000
N
0
500
1000
Metres
METROPOLITAN COAL
FIGURE 1
Subsidence Monitoring Locations
METROPOLITAN COAL

The D Line is approximately parallel to Longwall 21 and is a minimum distance of 855 metres from the Longwall 21 tailgate. As a result, predicted values of subsidence, tilt and strain are within the limits of survey accuracy. The observed values of subsidence, tilt and strain are slightly greater than the survey accuracy limits, which are considered to be predominantly the result of residual subsidence following the completion of Longwall 18.

The incremental and additional subsidence, tilt and strain along the D Line resulting from the extraction of Longwalls 20 and 21 are a small component of the observed parameters due to the extraction of Longwalls 2 to 18. The maximum observed total subsidence is less than the maximum predicted total subsidence.

Line 9G

Line 9G was surveyed at the completion of Longwalls 21 and 22A. A summary of the observed and predicted subsidence movements along Line 9G 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	22 January 2013
Longwall Chainage at Latest Survey Date	0 metres
Face Distance from Line G at Latest Survey Date	1,008 metres past on maingate side, 834 metres past on tailgate side

Parameter	**Incremental Movements (LW21)**		**Total Movements (LW20 to 21)**	
	Predicted	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	740	789	759	843
Tilt (mm/m)	4.1	7.9	4.1	7.3
Tensile Strain (mm/m)	2.8*	0.5	2.8*	0.6
Compressive Strain (mm/m)	1.4*	3.3	1.4*	3.6

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

The finishing end of Longwall 22A is approximately 1 km from Line 9G and therefore does not provide sufficient data for comparison of the predicted subsidence parameters for the full extraction of Longwall 22. Comparisons have therefore been made with data from the completion of Longwall 21.

The base survey for Line 9G was undertaken on the 4 May 2010 when Longwall 18 still had approximately 72 metres of extraction remaining. Given that the distance of Line 9G is greater than 2,200 metres from Longwall 18, it is considered unlikely that the length of remaining extraction would have influenced the observed subsidence parameters for Longwalls 20 and 21.

The maximum observed incremental subsidence due to the extraction of Longwall 21 is 789 millimetres (mm) which is greater than the maximum predicted incremental subsidence of 740 mm. The maximum observed total subsidence due to the extraction of Longwalls 20 and 21 is 843 mm which is greater than the maximum predicted total subsidence of 759 mm.

The maximum observed incremental and total tilt are 7.9 mm/m and 7.3 mm/m, respectively which are both greater than the predicted incremental and total tilt of 4.1 mm/m. The profiles of observed incremental and total subsidence and tilt reasonably match those predicted on the maingate side of Longwall 21, however, the subsidence profiles and resulting tilt over the tailgate side of Longwall 21 are steeper than predicted. A compressive strain spike of 3.3 mm/m incremental and 3.6 mm/m total also occurred in this area.

The observed subsidence profiles are also greater than the predicted subsidence profiles 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 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.

Line 9C

Line 9C has been surveyed monthly while subsidence has been above 20 mm/month. Line 9C was also monitored at the completion of Longwalls 21 and 22A. A summary of the observed and predicted subsidence movements along Line 9C is presented in Table 3.

Table 3
Summary of Predicted and Observed Subsidence Movements for Line 9C Resulting from Longwalls 20 to 22A Extraction

Monitoring Summary	
Initial Survey Date	29 March 2010 (LW18 Chainage ~106 metres)
Latest Survey Date	18 July 2013
Longwall Chainage at Latest Survey Date	0 metres (LW22A)
Face Distance of LW22A from Line 9C at Latest Survey Date	15 metres past Line 9C on maingate side, 146 metres past Line 9C on tailgate side

Parameter	**Incremental Movements (LW21)**		**Incremental Movements (LW22A)**		**Total Movements (LW20 to 22A)**	
	Predicted	**Observed**	**Predicted**	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	822	707	409	113	1,025	746
Tilt (mm/m)	5.6	5.1	2.8	0.7	3.6	5.2
Tensile Strain (mm/m)	1.6*	1.1	1.3	0.9	1.4*	1.0
Compressive Strain (mm/m)	2.6*	1.1	1.3	0.5	1.4*	1.2

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

The base survey for Line 9C was undertaken on 29 March 2010 when Longwall 18 still had approximately 106 metres 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 approximately 20 mm.

The profiles of observed subsidence and tilt reasonably match those predicted. The observed subsidence profile is slightly greater than the predicted subsidence profile over solid coal to the north of Longwall 21 as small vertical movements, with negligible tilts and strains, have occurred to the north of Longwalls 20 to 22.

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 Longwalls 20 to 22. 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.

Line 9C West

Line 9C West has been surveyed monthly while subsidence has been above 20 mm/month. Line 9C West was also monitored at the completion of Longwalls 21 and 22A. A summary of the observed and predicted subsidence movements along Line 9C West (9CW) is presented in Table 4.

The base survey for Line 9C was undertaken on 29 March 2010 when Longwall 18 still had approximately 106 metres of extraction remaining.

Table 4
Summary of Predicted and Observed Subsidence Movements for Line 9CW Resulting from Longwalls 20 and 22A Extraction

Monitoring Summary	
Initial Survey Date	29 March 2010 (LW18 Chainage ~106 metres)
Latest Survey Date	18 July 2013
Longwall Chainage at Latest Survey Date	0 metres (LW22A)
Face Distance from Line 9CW at Latest Survey Date	250 metres from the nearest Line 9CW Peg

Parameter	**Incremental Movements (LW21)**		**Incremental Movements (LW22A)**		**Total Movements (LW20 to 22A)**	
	Predicted	**Observed**	**Predicted**	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	730	602	570	327	990	827
Tilt (mm/m)	5.2	6.7	3.3	2.8	2.2	5.5
Tensile Strain (mm/m)	4.1*	1.1	1.7*	0.4	1.6*	0.6
Compressive Strain (mm/m)	2.8*	0.3	2.6*	0.6	1.2*	0.6

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

The profiles of observed subsidence and tilt reasonably match those predicted. The maximum observed incremental and total subsidence resulting from the extraction of Longwalls 21 and 22A were less than the maximum predicted incremental and total subsidence. The maximum observed incremental tilt due to Longwall 21 and total tilt after Longwall 22A were both slightly higher than predicted.

Line 9J

Line 9J was monitored within three months of the completion of Longwall 21. A summary of the observed and predicted subsidence movements along Line 9J is presented in Table 5. The base survey for Line 9J was undertaken on 6 May 2010 prior to the commencement of Longwall 20.

Table 5
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	5 February 2013
Longwall Chainage at Latest Survey Date	0 metres
Face Distance from Line 9J at Latest Survey Date	126 metres to nearest mark (J36) Line 9J does not pass above Longwall 21

Parameter	**Incremental Movements**		**Total Movements**	
	Predicted	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	29	36	29	45
Tilt (mm)	Within limits of survey accuracy.	0.5	Within limits of survey accuracy.	0.5
Tensile Strain (mm/m)		0.4		0.4
Compressive Strain (mm/m)		0.3		0.2

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

The maximum observed incremental subsidence due to the extraction of Longwall 21 is 36 mm at Peg J39, which is slightly greater than the predicted incremental subsidence of 29 mm. The maximum observed total subsidence due to the extraction of Longwalls 20 and 21 is 45 mm, which is slightly greater than the predicted total subsidence of 29 mm.

The maximum observed incremental and total tilts and strains are within the limits of survey accuracy. The maximum total tilt ignores the high tilt at the location of the bumped Peg J16.

The shape of the profiles of observed subsidence and tilt reasonably match those predicted.

Transmission Line

The Transmission Line was monitored within three months of the completion of Longwall 21. A summary of the observed and predicted subsidence movements along the Transmission Line is presented in Table 6.

Table 6
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	13 February 2013
Longwall Chainage at Latest Survey Date	0 metres
Face Distance from Transmission Line at Latest Survey Date	340 metres to nearest Mark T22 Transmission Line does not pass above Longwall 21

Parameter	**Incremental Movements (LW21)**		**Total Movements (LW20 to 21)**	
	Predicted	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	Within limits of survey accuracy.	15	Within limits of survey accuracy.	10
Tilt (mm)		0.2		0.2
Tensile Strain (mm/m)		0.3		0.3
Compressive Strain (mm/m)		0.3		0.2

The observed incremental movements are the additional movements since the survey that was measured on 5 August 2011 when Longwall 20 had approximately 8 metres of extraction remaining.

The Transmission Line is located approximately 340 metres 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 and within the limits of survey accuracy. Some survey marks have been disturbed along the transmission line as a result of maintenance vehicles accessing the transmission line.

Princes Highway Line

The Princes Highway Line was monitored within three months of the completion of Longwall 21. A summary of the observed and predicted subsidence movements along the Princes Highway Line is presented in Table 7.

Table 7
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	13 March 2013
Longwall Chainage at Latest Survey Date	0 metres
Face Distance from Princes Highway Line at Latest Survey Date	621 metres to nearest Mark PH10 The Princes Highway Line does not pass above Longwall 21

Parameter	**Incremental Movements (LW21)**		**Total Movements (LW20 to 21)**	
	Predicted	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	Within limits of survey accuracy.	15	Within limits of survey accuracy.	14
Tilt (mm)		0.6		0.3
Tensile Strain (mm/m)		0.4		0.5
Compressive Strain (mm/m)		0.6		0.5

The observed incremental movements are the additional movements since the survey that was measured on 27 September 2011 prior to the commencement of Longwall 21.

The Princes Highway Line is located approximately 620 metres to the south east of Longwall 21 at its nearest point. As a result, predicted values of subsidence, tilt and strain are within the limits of survey accuracy. The observed values of subsidence, tilt and strain are predominantly within the limits of survey accuracy.

Freeway Line

The Freeway Line was monitored within three months of the completion of Longwall 21. A summary of the observed and predicted subsidence movements along the Freeway Line is presented in Table 8.

Since the baseline survey that was conducted prior to the commencement of Longwall 20, many of the survey marks for the Freeway Line have been disturbed as a result of resurfacing operations undertaken during the extraction of Longwall 20. Several survey pegs were also destroyed during these operations. The destroyed or disturbed survey marks have since been reinstated. The survey undertaken immediately following reinstatement of the survey pegs, 15 June 2012, has been adopted as a new baseline survey for monitoring of the M1 Princes Motorway. At the time of this survey, the face position of Longwall 21 was at approximately 1,272 metres (approximately 1,825 metres extracted). The face position at the time of this survey was approximately 1,975 metres from the M1 Princes Motorway and it is considered unlikely that the M1 Princes Motorway would have experienced subsidence movements due to that extracted length of Longwall 21.

Table 8
Summary of Predicted and Observed Subsidence Movements for the Freeway Line Resulting from Longwall 21 Extraction

Monitoring Summary	
Initial Survey Date	15 June 2012 (LW21 Chainage ~1,272 metres)
Latest Survey Date	20 March 2013
Longwall Chainage at Latest Survey Date	0 metres
Face Distance from Freeway Line at Latest Survey Date	696 metres Freeway Line does not pass above Longwall 21

Parameter	**Incremental Movements**		**Total Movements**	
	Predicted	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	Within limits of survey accuracy.	20	Within limits of survey accuracy.	-
Tilt (mm)		0.8		-
Tensile Strain (mm/m)		0.5		-
Compressive Strain (mm/m)		0.5		-

The observed incremental movements are the additional movements due to the extraction of Longwall 21 since the survey that was measured on 15 June 2012.

The Freeway Line is located approximately 695 metres to the east of Longwall 21 at its nearest point. As a result, predicted values of subsidence, tilt and strain are within the limits of survey accuracy. The observed values of subsidence, tilt and strain are predominantly within the limits of survey accuracy.

Waratah Rivulet Cross Lines

Cross Lines 14, 15 and 16

Cross Lines 14, 15 and 16 were surveyed monthly until the longwalls passed the Waratah Rivulet and subsidence was less than 20 mm/month. Lines 14, 15 and 16 have also been surveyed within one month of the completion of each longwall.

A summary of the observed and predicted subsidence movements along Waratah Rivulet Cross Lines 14, 15 and 16 due to the extraction of Longwalls 20 to 22 is presented in Table 9.

The maximum observed incremental and total net vertical movements are greater than the predicted net vertical movements. The predicted net vertical movements include predicted upsidence which is recognised as providing a conservative prediction of subsidence movements. As discussed in the Project Environmental Assessment (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 negligible observed upsidence for these short lines, it is likely 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 in all cases except incremental subsidence due to Longwall 21 which is slightly greater than predicted subsidence for all three monitoring lines.

There was negligible measured upsidence and closure at each of the monitoring lines which are approximately 25 metres in length and represent only 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.

Table 9
Summary of Predicted and Observed Subsidence Movements for Waratah Rivulet Cross Lines 14, 15 and 16 Resulting from Longwalls 20 to 22

Monitoring Summary	
Initial Survey Date	17 June 2010
Latest Survey Date	17 December 2013
Longwall Chainage at Latest Survey Date	1,088 metres (LW22B)
Distance from Longwall to Monitoring Line	Line 14000 220 metres from LW21, 440 metres from LW22 Line 15000 156 metres from LW21, 375 metres from LW22 Line 16000 102 metres from LW21, 320 metres from LW22

Parameter	**Line**	**Incremental Movements (LW21)**		**Incremental Movements (LW22A)**		**Incremental Movements (LW22B)**		**Total Movements (LW20 to 22)**	
		P	**O**	**P**	**O**	**P**	**O**	**P**	**O**
Subsidence (mm)	14000	184	-	<20	-	<20	-	379	-
	15000	275	-	29	-	<20	-	512	-
	16000	511	-	51	-	<20	-	745	-
Net Vertical Movement (mm)	14000	100	132	<20	42	<20	<20	96	241
	15000	161	210	<20	54	<20	<20	86	347
	16000	322	487	<20	74	<20	<20	224	647
Upsidence (mm)	14000	76	<20	<20	<20	<20	<20	275	<20
	15000	130	<20	36	<20	<20	<20	451	<20
	16000	229	<20	67	<20	<20	<20	549	<20
Closure (mm)	14000	132	<20	51	<20	<20	<20	598	<20
	15000	209	<20	67	<20	<20	<20	683	<20
	16000	275	<20	71	<20	<20	<20	737	<20

P Predicted; O Observed

WRS5 Line

WRS5 Line was surveyed monthly until the longwalls 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 Line WRS5 due to the extraction of Longwalls 20 to 22 is presented in Table 10.

Table 10
Summary of Predicted and Observed Subsidence Movements for Waratah Rivulet Cross Line WRS5 Resulting from Longwalls 20 to 22

Monitoring Summary	
Initial Survey Date	17 June 2010
Latest Survey Date	17 December 2013
Longwall Chainage at Latest Survey Date	1,088 metres (LW22B)
Distance from Longwall to Monitoring Line	25 metres from Longwall 21 43 metres from Longwall 22A 220 metres from Longwall 22B

Parameter	**Incremental Movements (LW21)**		**Incremental Movements (LW22A)**		**Incremental Movements (LW22B)**		**Total Movements (LW20 to 22)**	
	P	**O**	**P**	**O**	**P**	**O**	**P**	**O**
Subsidence (mm)	135	-	58	-	15	-	216	-
Net Vertical Movement (mm)	45	-98	-90	14	-20	-36	-49	-93
Upsidence (mm)	90	158	148	21	35	<20	298	192
Closure (mm)	240	74	88	>20	57	<20	469	86

P Predicted; O Observed

The monitoring line is approximately 41 metres in length and represents only a small portion of the overall valley profile.

The maximum observed incremental and total net vertical movements are less than the predicted net vertical movements, with an overall observed net uplift occurring at WRS5.

The maximum observed incremental upsidence due to the extraction of Longwall 21 is greater than predicted. Incremental upsidence due to Longwalls 22A and 22B and total observed upsidence are less than predicted. The observed incremental and total closure values are all less than predicted.

There was negligible measured upsidence and closure at WRS5 during the extraction of Longwalls 22A and 22B. Upsidence and closure developed between the surveys of 11 January 2012 and 28 February 2012. During this period, the Longwall 21 face position was approaching WRS5 and was approximately 10 metres past WRS5 on 28 February 2012.

Cross Lines P, Q, R and S

Cross lines at rock bars P, Q, R and S have been surveyed within three months of the completion of Longwall 21. A summary of the observed and predicted subsidence movements along Waratah Rivulet Cross Lines P, Q, R, and S due to the extraction of Longwalls 20 and 21 is presented in Table 11.

The maximum observed and predicted incremental and total net vertical movement, strain, upsidence and closure are negligible and within the limits of survey accuracy.

Ridge to Ridge Monitoring Points

The ridge to ridge monitoring points have been surveyed monthly as each longwall approaches and passes the Waratah Rivulet and subsidence reduces to less than 20 mm/month. The ridge to ridge monitoring points have also been surveyed within one month of the completion of Longwall 21. A summary of the observed and predicted subsidence movements at the ridge to ridge monitoring points is presented in Table 12.

Table 12 indicates that the maximum observed subsidence is similar to or less than the maximum predicted subsidence for the majority of monitored locations. The exceedance of predicted subsidence predominantly occurs at low levels of subsidence and the margins are within limits of accuracy.

Table 11
Summary of Predicted and Observed Subsidence Movements for Waratah Rivulet Cross Lines P, Q, R and S Resulting from Longwalls 20 and 21

Monitoring Summary	
Initial Survey Date	1 May 2010
Latest Survey Date	18 February 2013
Longwall Chainage at Latest Survey Date	0 metres (LW21)
Distance from Longwall 21 to Monitoring Line	P Line 677 metres from LW21, Q Line 797 metres from LW21, R Line 935 metres from LW21, S Line 1,021 metres from LW21

Parameter	**Line**	**Incremental Movements (LW21)**		**Total Movements (LW20 to 21)**	
		Predicted	**Observed**	**Predicted**	**Observed**
Subsidence (mm)	P	<20	-	<20	-
	Q	<20	-	<20	-
	R	<20	-	<20	-
	S	<20	-	<20	
Net Vertical Movement (mm)	P	<20	<20	<20	<20
	Q	<20	<20	<20	<20
	R	<20	<20	<20	<20
	S	<20	<20	<20	<20
Upsidence (mm)	P	<20	<20	<20	<20
	Q	<20	<20	<20	<20
	R	<20	<20	<20	<20
	S	<20	<20	<20	<20
Closure (mm)	P	<20	<20	<20	<20
	Q	<20	<20	<20	<20
	R	<20	<20	<20	<20
	S	<20	<20	<20	<20

Table 12
Summary of Predicted and Observed Subsidence Movements for Ridge to Ridge Monitoring Points Resulting from Longwalls 20 to 22 Extraction

Monitoring Summary	
Initial Survey Date	12 May 2010
Latest Survey Date	27 December 2012
Longwall Chainage at Latest Survey Date	5 metres
Face Distance from nearest peg at Latest Survey Date	1,925 metres to Mark Trig 5

Parameter	**Mark**	**Incremental (LW21)**		**Incremental (LW22A)**		**Incremental (LW22B)**		**Total (LW20 to 2B)**	
		P	**O**	**P**	**O**	**P**	**O**	**P**	**O**
Subsidence	Trig 1	<20	20	<20	<20	<20	<20	<20	59
	Trig 2	35	69	<20	<20	<20	<20	51	146
	Trig 3	105	50	281	105	<20	63	451	248
	Trig 4	363	277	64	82	<20	<20	598	457
	Trig 5	826	782	<20	48	<20	52	912	943
Closure	Trig 1 – Trig 2	-	<20	-	<20	-	<20	-	<20
	Trig 1 – Trig 3	-	47	-	<20	-	<20	-	103
	Trig 1 – Trig 4	-	-72	-	-30	-	<20	-	-72
	Trig 1 – Trig 5	-	-72	-	<20	-	<20	-	-44
	Trig 2 – Trig 3	-	45	-	<20	-	<20	-	123
	Trig 2 – Trig 4	-	91	-	-28	-	<20	-	-96
	Trig 2 – Trig 5	-	35	-	24	-	<20	-	33
	Trig 3 – Trig 4	-	169	-	55	-	<20	-	261
	Trig 3 – Trig 5	-	102	-	<20	-	<20	-	142
	Trig 4 – Trig 5	-	90	-	44	-	<20	-	172

P Predicted; O Observed

Incremental Vectors

A plot of the observed incremental horizontal movement vectors for the monitoring lines discussed in this Environmental Summary, based on the latest 3D survey results for Longwalls 21 and 22A, are shown on Drawings Nos. MSEC677-102 and MSEC677-103, respectively. A plot of the observed total horizontal movement vectors for the monitoring lines, based on the latest 3D survey results for Longwalls 20 to 21, are shown on Drawing No. MSEC677-104.

The vectors show a general movement towards the extracted goaf. 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.

Horizontal Movements

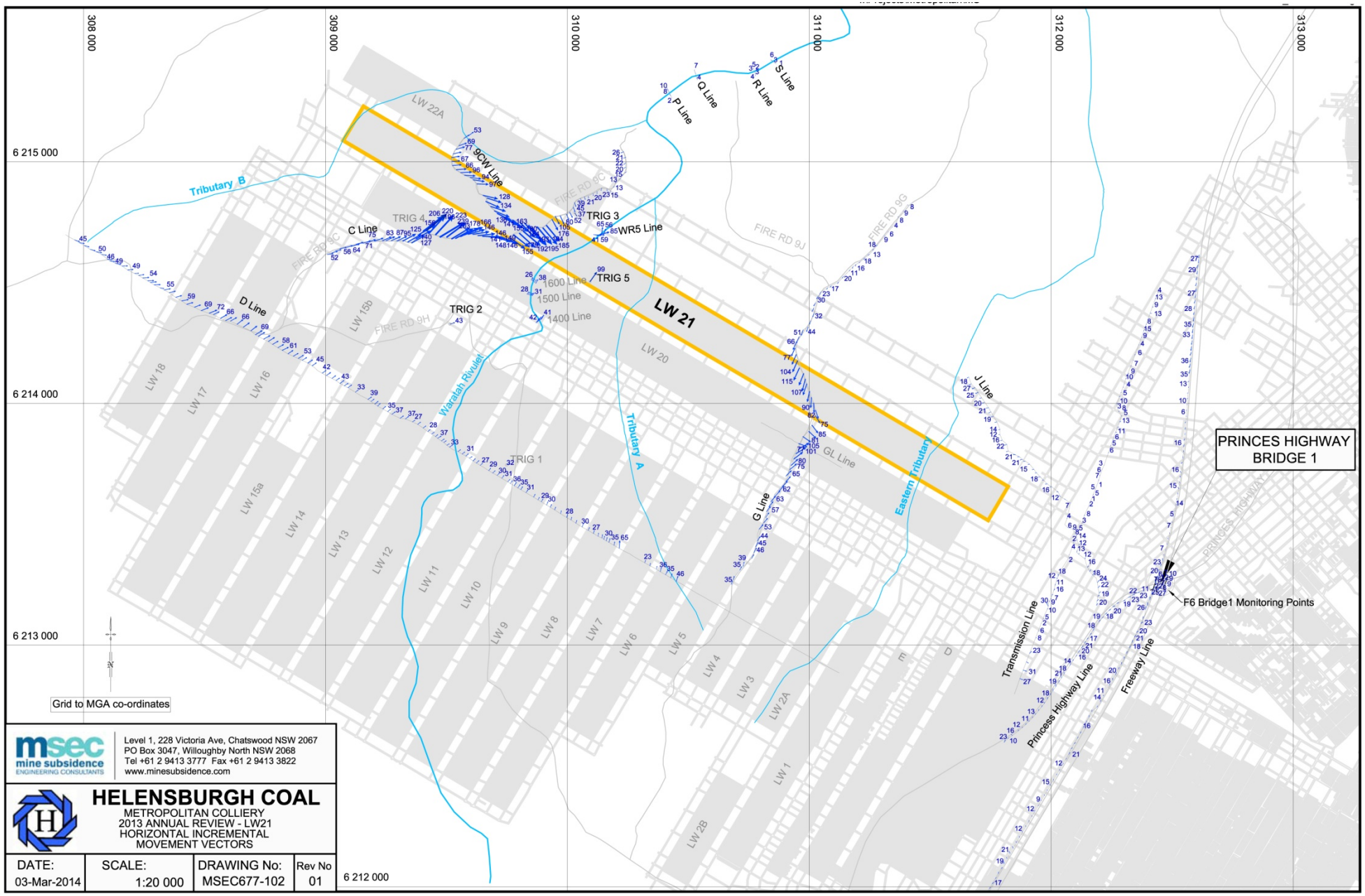
Absolute Horizontal Movements

Absolute horizontal movements of the survey marks have been used for assessment of potential far-field movements at infrastructure resulting from the Longwalls 20 to 22 and indicate that the horizontal movements fit consistently within the horizontal movement data set for the southern coalfield.

Relative Horizontal Movements

Mine subsidence impacts to surface features occur due to the influence of differential movements. The assessment of potential differential horizontal movements at infrastructure resulting from Longwalls 20 to 22A extraction included assessment of relative lateral and longitudinal movements and mid ordinate deviation. The observed relative horizontal movements for the monitored lines fit within the data sets for the southern coalfield.

METROPOLITAN COAL - ENVIRONMENTAL MONITORING SUMMARY



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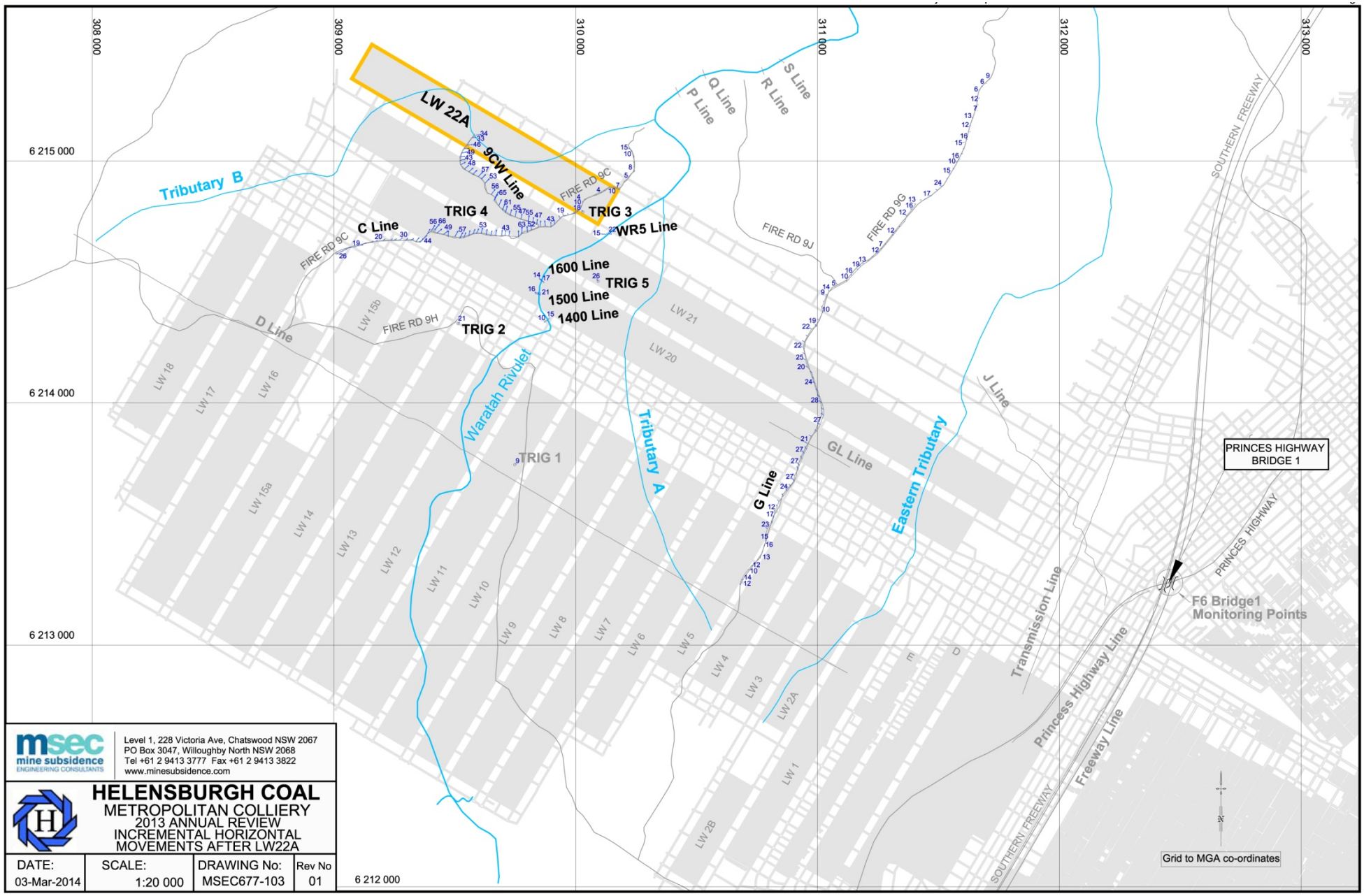
HELENSBURGH COAL

METROPOLITAN COLLIERY
2013 ANNUAL REVIEW - LW21
HORIZONTAL INCREMENTAL
MOVEMENT VECTORS

DATE:	SCALE:	DRAWING No:	Rev No
03-Mar-2014	1:20 000	MSEC677-102	01

METROPOLITAN COAL - ENVIRONMENTAL MONITORING SUMMARY



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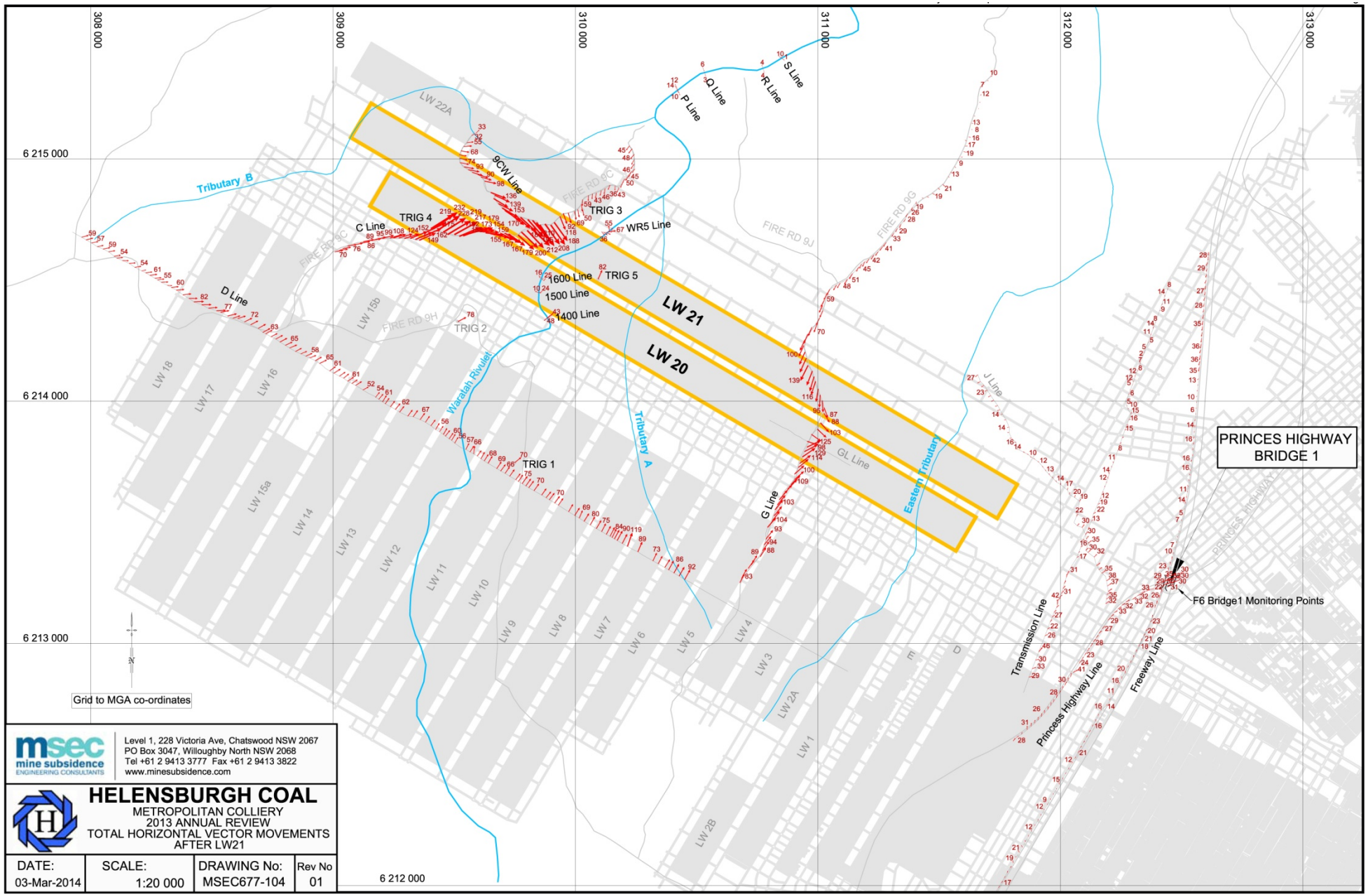
METROPOLITAN COLLIERY
2013 ANNUAL REVIEW
INCREMENTAL HORIZONTAL MOVEMENTS AFTER LW22A

DATE:	SCALE:	DRAWING No:	Rev No
03-Mar-2014	1:20 000	MSEC677-103	01

Peabody ENERGY

METROPOLITAN COAL

METROPOLITAN COAL - ENVIRONMENTAL MONITORING SUMMARY



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METROPOLITAN COLLIERY
2013 ANNUAL REVIEW
TOTAL HORIZONTAL VECTOR MOVEMENTS
AFTER LW21

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03-Mar-2014	1:20 000	MSEC677-104	01