14th March 2021

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Ref: MSEC1161 Revision A

Dear Jon,

RE: Metropolitan Mine – 2020 Annual Review Report
Subsidence Monitoring Results

1. Background

Metropolitan Coal submitted an Extraction Plan for Longwall 304 the DPIE on 5 April 2019. Conditional approval for Longwall 304 was granted on 16 July 2019. An Extraction Plan for Longwalls 305 to 307 was submitted to the DPIE on 9 October 2019. Approval for Longwalls 305 to 307 was granted on 16 March 2020.

A summary of the commencement and completion dates for the longwalls in the 300 series of longwall panels at Metropolitan Colliery is provided in Table 1.1.

Table 1.1 Longwall commencement and completion dates

Longwall	Commencement date	Completion date
LW301	20 June 2017	4 February 2018
LW302	29 March 2018	4 October 2018
LW303	13 November 2018	2 June 2019
LW304	28 July 2019	28 January 2020
LW305	14 April 2020	21 November 2020

Longwall extraction during the 2020 reporting period from 1 January to 31 December 2020 included Longwall 304 from chainage 161 m (void length 1125 m) to completion and the full extraction of Longwall 305 from commencing chainage 1547 m to chainage 120 m (extracted void length 1427 m). A decision was made by Metropolitan Colliery to reduce the finishing end of Longwall 305 by 120 m as a result of potential environmental impact considerations in accordance with the approved Longwalls 305-307 Extraction Plan. Mine Subsidence Engineering Consultants (MSEC) has prepared this subsidence review report which will support the Annual Review for 2020. This report provides the review and discussion of the observed and predicted ground movements, impacts and performance measures for the extents mined during 2020.

The Longwall 304 Subsidence Monitoring Program (Version A) (Metropolitan Coal, 2019) and Longwall 305 to 307 Subsidence Monitoring Program (Version B) (Metropolitan Coal, 2020) were prepared to validate subsidence predictions and analyse the relationship between the subsidence effects and subsidence impacts of the Metropolitan Coal Longwall 304 Extraction Plan and Longwalls 305-307 Extraction Plan respectively in accordance with Condition 6, Schedule 3 of the Project Approval.

The objectives of the monitoring program are:

- To monitor the subsidence parameters and subsidence impacts about Longwall 304 and Longwalls 305-307 extraction.
- To provide subsidence parameter and subsidence impact data required as part of the management of environmental consequences as detailed in the Metropolitan Coal Longwall 304 and Longwalls 305-307 Extraction Plans. These include:
    - Water Management Plan;
    - Biodiversity Management Plan;
    - Land Management Plan;
    - Heritage Management Plan;
    - Built Features Management Plans; and
    - Public Safety Management Plan.
- To validate subsidence predictions.
- To provide subsidence data to improve the predictive methods and provide a better understanding of the underlying factors contributing to ground movement.

The Metropolitan Coal Longwall 304 Built Features Management Plans have been prepared to manage the potential environmental consequences of the Longwall 304 Extraction Plan on built features. The Metropolitan Coal Longwalls 305-307 Built Features Management Plans have been prepared to manage the potential environmental consequences of the Longwalls 305-307 Extraction Plan on built features.

2. Monitoring

The Metropolitan Coal Longwall 304 and Longwalls 305-307 Subsidence Monitoring Programs include monitoring of subsidence parameters and comparison with predicted subsidence parameters. The results of subsidence parameter monitoring for Longwall 304 and Longwalls 305-307 from 1 January to 31 December 2020 are described below.

Subsidence monitoring data from the following monitoring components was assessed for the reporting period (i.e 1 January to 31 December 2020) in accordance with the Longwall 304 and Longwalls 305-307 Subsidence Monitoring Programs:

- 300 XL Line;
- Princes Highway Line;
- Optic Water Line;
- M1 North Bound Line;
- Transmission Line;
- Transmission Towers;
- Telecommunication Towers;
- Illawarra Railway Line Culverts;
- Bridge 2 (Old Princes Highway Underpass);
- Cawley Road Overbridge;
- Eastern Tributary Cross Lines;
- Waratah Rivulet Cross Lines;
- Ridge Top Survey Stations;
- Real Time Global Navigation Satellite System (GNSS) Units; and
- Light Detection and Ranging (LiDAR) surveys.

The subsidence parameter monitoring locations for the Longwall 304 and Longwalls 305-307 Subsidence Monitoring Programs are shown on Drawing No. MSEC1161-01 and are described below.

Subsidence movements are surveyed in three dimensions using a total station survey instrument. It can be seen from Drawing No. MSEC1164-01 that some monitoring lines are located outside the currently extracted longwall footprint for Longwall 304 and Longwalls 305-307. In such cases (i.e. away from the extracted longwall footprint), the observed subsidence movements are generally low and within the limits of survey accuracy. At low values of subsidence, observed results may also be affected to a greater extent by environmental factors such as moisture and temperature variation. The adopted limits of survey accuracy for three dimensional (3D) survey methods are of the order of ±20 millimetres (mm) for vertical subsidence, ±0.5 mm/m for tilt (based on a 20 m bay length) and ±0.5 mm/m (based on a 20 m bay length) for tensile and compressive strains based on conventional movements. Low values of predicted subsidence also have a larger limit of accuracy of subsidence predictions as discussed in report No. MSEC285 Rev C (MSEC, 2008), which notes, "*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.*"

Several real time GNSS survey monitoring marks have been installed at selected locations to monitor subsidence movements from the extracted longwalls. The real time monitoring marks are referred to as GNSS stations and comprise a continuous GNSS based monitoring system. The system provides continuous 3D position data (i.e. easting, northing and height) to a precision of ±5 mm.

A brief description of each monitoring component is provided below.

300 XL Line

The 300 XL Line is the main monitoring line across and approximately perpendicular to Longwalls 301 to 305, extending from the M1 Princes Motorway to the Woronora Reservoir full supply level. Towards the completion of Longwall 305, the monitoring line was extended to the west across the Woronora Reservoir for future longwall extraction.

Princes Highway Line

The Princes Highway Line is located along the Old Princes Highway road shoulder and extends from the intersection with the M1 Princes Motorway in the south to the entrance to Garrawarra Centre Complex in the north.

Optic Water Line

The Optic Water Line extends from the Old Princes Highway to within the Garrawarra Centre Complex along the alignment of optical fibre cables and water supply pipelines.

M1 North Bound Line

The M1 North Bound Line extends from M1 Princes Motorway Bridge 2 to the Cawley Road Overbridge along the verge of the M1 Princes Motorway.

Transmission Line

The Transmission Line is located along the easement containing the TransGrid and Endeavour Energy high tension transmission lines and generally the fibre optic cables.

The Transmission Line monitoring extends from the intersection with the Old Princes Highway to the 35º angle of draw north of Longwall 301.

Transmission Towers

The Transmission Tower monitoring includes the TransGrid 330 kilovolts (kV) towers and Endeavour Energy 132 kV towers located to the east of the longwalls.

Telecommunications Towers

The telecommunications towers include three towers to the north and east of Longwall 303 and Longwall 304 respectively (one Telstra Monopole and two Axicom lattice towers), and one tower (Sydney Trains lattice tower) located above the chain pillar between the commencing ends of Longwalls 302 and 303.

Railway Culverts

Railway culverts are located to the east of Longwall 301 at 1.5 km (Cawleys Creek) and 1.8 km (Wilsons Creek) from Longwall 301. Monitoring includes the internal walls of the culverts and the valley sides.

Bridge 2 (Old Princes Highway Underpass)

Structural elements of the bridge are monitored using a combination of total station survey and fibre optic monitoring system.

Cawley Road Overbridge

Structural elements of the bridge are monitored using total station survey.

Eastern Tributary Cross Lines

Four cross lines established across the Eastern Tributary rock bars (ETAQ, ETAR, ETAT and ETAU) immediately upstream of the Woronora Reservoir full supply level.

Waratah Rivulet Cross Lines

Four cross lines established across the Waratah Rivulet rock bars (P, Q, R, S, T, U, V, and W) immediately upstream of the Woronora Reservoir full supply level.

Ridge Top Survey Stations

Ridge Top Survey Stations comprise seven ridge top trig stations set up on the ridges around the Woronora Reservoir.

GNSS Units

Real time monitoring using GNSS units has been adopted to supplement monitoring using conventional terrestrial survey methods at Metropolitan Colliery.

LiDAR Survey

LiDAR surveys are currently being trialled at Metropolitan Colliery to provide remote sensing methods to supplement conventional terrestrial survey methods.

3. Comparison Between Predicted and Observed Movements

The period of monitoring during January to December 2020 includes the completion of Longwall 304 (January 2020), and full extraction of Longwall 305. A discussion of the subsidence effects observed during this period of monitoring is provided in the following sections.

300 XL Line

The location of the 300 XL Line is shown in Drawing No. MSEC1161-01. A summary of the observed and predicted subsidence movements along the 300 XL Line for the latest survey is presented in Table 3.1. The latest survey for the 300 XL Line was conducted after the completion of Longwall 305.

Table 3.1 Summary of Predicted and Observed Subsidence Movements for the 300 XL Line

Monitoring Summary		
Initial Survey Date	17th June 2017	
Latest Survey Date	14th January 2021	
Longwall 305 Chainage at Latest Survey Date	120 m	
Parameter	**Total Movements (LW301 to 305)**	
	Predicted	**Observed**
Subsidence (mm)	1100	1317
Tilt (mm/m)	5.0	8.3
Tensile Strain (mm/m)	1.0*	0.9
Compressive Strain (mm/m)	2.0*	3.4

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

The maximum observed total subsidence, tilt and strain due to the extraction of Longwalls 301 to 305 are similar to or greater than the maximum predicted subsidence parameters. The greater than predicted subsidence at the northern end of the longwalls is believed to have been influenced by variation in extracted seam thickness due to operational and geotechnical reasons at the northern end of Longwall 301. Based on the survey monitoring lines, and LiDAR surveys presented at the end of this section, the surface extent of the increased subsidence zone is limited to the area around the topographical high point above Longwalls 301 and 302. The increased subsidence is potentially also influenced by the local topographical features in this area. The natural or built features within the area of increased subsidence include the Sydney Water pipeline, Optus optical fibre cable, Waterfall cemetery, and two swamps (S41 and S53). Based on the relevant Metropolitan Coal Built Features Management Plan Trigger Action Response Plans (TARPs), the sections of Sydney Water pipeline and Optus optical fibre cable within the area of increased subsidence are at Level 3.

Princes Highway Line

The location of the Princes Highway Line is shown in Drawing No. MSEC1161-01. A summary of the observed and predicted subsidence movements along the Princes Highway Line for the latest survey is presented in Table 3.2.

Table 3.2 Summary of Predicted and Observed Subsidence Movements for the Princes Highway Line

Monitoring Summary		
Initial Survey Date	11th May 2017	
Latest Survey Date	24th November 2020	
Longwall 305 Chainage at Latest Survey Date	120 m	
Face Distance of LW305 from Princes Highway Line	375 m	
Parameter	**Total Movements (LW301 to 305)**	
	Predicted	**Observed**
Subsidence (mm)	1050	1007
Tilt (mm/m)	2.5	5.2
Tensile Strain (mm/m)	1.0*	0.8
Compressive Strain (mm/m)	1.0*	1.0

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

The maximum observed total subsidence of 1007 mm is less than the predicted value of 1050 mm. The maximum observed tilt of 5.2 mm/m is greater than the predicted tilt of 2.5 mm/m. The maximum observed tilt occurs adjacent to the finishing end and corner of Longwall 301 and the monitoring line crosses the corner of Longwall 301 at an acute angle to the longwall longitudinal axis. At such locations, predicted parameters can be sensitive to the

transverse variation in subsidence profiles. While the magnitude of maximum tilt is greater than the predicted tilt, the shape of the tilt profile reasonably matches the predicted profile. The maximum observed strains are consistent with predicted strains.

Based on the relevant Metropolitan Coal Built Features Management Plan TARP the Princes Highway is at Level 1. The higher than predicted tilt observed along the Princes Highway has not impacted the performance of the built feature.

It is considered that the ground movements measured along the Princes Highway Line are reasonably consistent with the predictions.

Optic Water Line

The location of the Optic Water Line is shown in Drawing No. MSEC1161-01. A summary of the observed and predicted subsidence movements along the Optic Water Line for the latest survey is presented in Table 3.3.

Table 3.3 Summary of Predicted and Observed Subsidence Movements for the Optic Water Line

Monitoring Summary		
Initial Survey Date	9th May 2017	
Latest Survey Date	2nd December 2020	
Longwall 305 Chainage at Latest Survey Date	120 m	
Distance of LW305 from Optic Water Line	240 m from commencing end 770 m from finishing end	
Parameter	**Total Movements (LW301 to 305)**	
	Predicted	**Observed**
Subsidence (mm)	1050	1218
Tilt (mm/m)	4.5	4.9
Tensile Strain (mm/m)	1.0*	1.2
Compressive Strain (mm/m)	2.0*	0.9

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

The maximum observed total subsidence of 1218 mm is greater than the maximum predicted total subsidence value of 1050 mm. The maximum observed subsidence occurs above the chain pillar between Longwalls 301 and 302. The maximum observed tilt and tensile strain are greater than predicted. The maximum observed compressive strain is less than predicted.

The greater than predicted subsidence at the northern end of the longwalls is believed to have been influenced by variation in extracted seam thickness due to operational and geotechnical reasons at the northern end of Longwall 301. Based on the survey monitoring lines, and LiDAR surveys presented at the end of this section, the surface extent of the increased subsidence zone is limited to the area around the topographical high point above Longwalls 301 and 302. The increased subsidence is potentially influenced by the local topographical features in this area. The natural or built features within the area of increased subsidence include the Sydney Water pipeline, Optus optical fibre cable, Waterfall cemetery, and two swamps (S41 and S53). Based on the relevant Metropolitan Coal Built Features Management Plan Trigger Action Response Plans (TARPs), the sections of Sydney Water pipeline and Optus optical fibre cable within the area of increased subsidence are at Level 3.

M1 North Bound Line

The location of the M1 North Bound Line is shown in Drawing No. MSEC1161-01. A summary of the observed and predicted subsidence movements along the M1 North Bound Line for the latest survey is presented in Table 3.4. The latest survey for the M1 North Bound Line was conducted after the completion of Longwall 305.

Table 3.4 Summary of Predicted and Observed Subsidence Movements for the M1 North Bound Line

Monitoring Summary		
Initial Survey Date	1st May 2017	
Latest Survey Date	27th November 2020	
Longwall 305 Chainage at Latest Survey Date	120 m	
Distance of LW305 from M1 North Bound Line	1050 m	
Parameter	**Total Movements (LW301 to 305)**	
	Predicted	**Observed**
Subsidence (mm)	50	49
Tilt (mm/m)	< 0.5	0.3
Tensile Strain (mm/m)	< 0.5*	0.4
Compressive Strain (mm/m)	< 0.5*	0.6

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

The maximum observed subsidence, tilt and strain at the completion of Longwall 305 are less than or similar to predictions.

Based on the relevant Metropolitan Coal Built Features Management Plan TARP the Roads and Maritime Services (RMS) built features are at Level 1. It is considered that the ground movements measured along the M1 North Bound Line are consistent with the predictions.

Transmission Line

The location of the Transmission Line is shown in Drawing No. MSEC1161-01. Survey monitoring of the transmission line was discontinued following the completion of Longwall 304. A summary of the observed and predicted subsidence movements along the Transmission Line for the latest survey is presented in Table 3.5. The latest and final survey of the Transmission Line was conducted after the completion of Longwall 304.

Table 3.5 Summary of Predicted and Observed Subsidence Movements for the Transmission Line

Monitoring Summary		
Initial Survey Date	1st May 2017	
Latest Survey Date	27th February 2020	
Longwall 304 Chainage at Latest Survey Date	0 m	
Distance of LW304 from Transmission Line	670 m	
Parameter	**Total Movements (LW301 to 304)**	
	Predicted	**Observed**
Subsidence (mm)	130	117
Tilt (mm/m)	1.0	0.4
Tensile Strain (mm/m)	< 0.5*	0.3
Compressive Strain (mm/m)	< 0.5*	0.8

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

The Transmission Line is located approximately 50 m to the east of Longwall 301 at its nearest point. Some survey marks have been disturbed along the Transmission Line as a result of maintenance vehicles accessing the TransGrid and Endeavour Energy transmission lines. Disturbed marks have been removed from the data where possible.

The maximum observed subsidence for the Transmission Line of 117 mm is less than the predicted subsidence value of 130 mm. The observed tilt and strain for the Transmission Line are similar to the predicted tilt and strain, with maximum compressive strain of 0.8 mm/m slightly higher than predicted.

It is considered that the ground movements measured along the Transmission Line are consistent with the predictions.

Transmission Towers

The locations of the Transmission Towers are shown in Drawing No. MSEC1161-01. The mine subsidence movements of the TransGrid 330 kV and Endeavour Energy 132 kV transmission line towers were measured using 3D monitoring techniques and GNSS monitoring stations.

During the 2020 review period, five TransGrid towers were monitored (Tower Nos. 104 to 108) and five Endeavour Energy towers were monitored (Tower Nos. 8 to 12).

A summary of the maximum observed total subsidence parameters at the TransGrid 330 kV transmission line Tower Nos. 104 to 108 for the reporting period is presented in Table 3.6. The observed movements are based on the latest survey carried out on the 27th November 2020. Several prisms at Tower Nos. 104 to 107 were destroyed by vandals and have since been replaced. Observed monitoring data for Tower Nos. 105 and 106 are total values based on the survey data at 17 April 2019 following reinstatement of prisms. Observed monitoring data for Tower No. 104 and 107 are total values based on the latest survey data at 20 May 2019, following reinstatement of the prisms. GNSS units 06, 07 and 08 have been vandalised and have not been replaced. The latest GNSS data for units 04 and 05 is at the end of the review period, 31st December 2020.

Table 3.6 Summary of Maximum Observed Subsidence Movements for the TransGrid 330 kV Transmission Line Towers 104 to 108

Parameter	Tower ID				
	104	**105**	**106**	**107**	**108**
Observed Subsidence at GNSS units (mm)	53	98	-	-	-
Predicted Subsidence (mm)	50	125	100	100	50
Change in distance between tower legs (mm)	-1 to 0	-1 to 0	-1 to +2	0 to +3	-1 to +1
Change in distance between ground pegs (mm)	-11 to +12	-13 to +13	0 to +12	-6 to +5	-8 to 1
GNSS Horizontal Movement (mm)	44	110	-	-	-
Tower Tilt (mm/m)	0.2	1.8	1.6	1.3	0.1

The maximum observed vertical subsidence at the TransGrid 330 kV transmission tower GNSS units is similar to the magnitudes of observed vertical subsidence along the Transmission Line.

The maximum observed total changes in distance between the tower legs at the towers monitored during the reporting period are less than the performance criteria of 4 mm. The change in distance between ground pegs are less than limits of survey accuracy of 20 mm. The horizontal movement of the GNSS stations are similar to or less than predicted horizontal movements of 100 mm to 140 mm.

The maximum tower tilts at Tower Nos. 105 to 107 are greater than the maximum predicted tilt of 1.0 mm/m.

A summary of the maximum observed total subsidence parameters at the Endeavour Energy 132 kV transmission line Tower Nos. 8 to 12 for the reporting period is presented in Table 3.7. The observed movements are based on the latest survey carried out on the 27th November 2020.

Table 3.7 Summary of Maximum Observed Subsidence Movements for the Endeavour Energy 132 kV Transmission Line Towers 8 to 12

Parameter	Tower ID				
	8	9	10	11	12
Observed Subsidence at GNSS units (mm)	-	-	-	98	53
Predicted Subsidence (mm)	70	80	90	90	50
Change in distance between tower legs (mm)	-2 to +2	-1 to +2	0 to +4	0 to 1	-1 to 0
Tower Tilt (mm/m)	0.1	0.9	1.0	0.6	0.2

The maximum observed vertical subsidence at the GNSS units near the Endeavour Energy transmission towers is similar to the predicted values of vertical subsidence. It is noted that the GNSS units are positioned closer to the extracted longwalls, adjacent to the TransGrid 330 kV towers, and are therefore expected to experience greater vertical subsidence. The maximum observed total changes in distance between the tower legs at the towers monitored during the reporting period are less than or equal to the performance criteria of 4 mm.

The maximum tower tilts at Towers 9, 10 and 11 are greater than the maximum predicted tilt of 0.5 mm/m. The maximum observed tilt of 1.0mm/m represents a tower tilt of 0.06 degrees.

It is considered that the ground movements measured at the transmission towers are generally consistent with the predictions.

Telecommunications Towers

The locations of the Telecommunications Towers are shown in Drawing No. MSEC1094-01. The mine subsidence movements of the Telecommunications Towers were measured using 3D monitoring and levelling techniques. Monitoring commenced on 29th March 2018, prior to the commencement of Longwall 302 extraction. During the reporting period, four towers were monitored.

A summary of the maximum observed total subsidence parameters at the Telecommunications Towers for the reporting period is presented in Table 3.8. The observed movements are based on the latest survey carried out on the 27th November 2020.

Table 3.8 Summary of Predicted and Observed Total Subsidence Movements for the Telecommunications Towers due to Longwalls 302 to 305

Monitoring Summary	
Initial Survey Date	29th March 2018
Latest Survey Date	27th November 2020
Longwall 305 Chainage at Latest Survey Date	120 m
Face Distance of LW305 from nearest Telecommunications Tower	1270 m

Parameter	Sydney Trains		Telstra		Axicom (Vodafone)		Axicom (Optus)	
	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed
Subsidence (mm)	425	324	225	95	175	73	150	45
Tilt (mm/m)	3.5	3.7	2.0	1.8	1.5	1.0	1.5	0.1
Tensile Strain (mm/m)	0.5*	0.9	0.5*	0.5	0.5*	0.4	0.5*	0.2
Compressive Strain (mm/m)	0.5*	0.1	0.5*	0.0	< 0.5*	0.1	0.5*	0.0

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

The observed subsidence, tilt and strain at the Telecommunications Towers due to the extraction of Longwalls 302 to 305 are similar to or less than predicted.

Railway Culverts

Two culverts are located along the Illawarra Railway at Cawleys and Wilsons Creeks as shown on Drawing No. MSEC1161-01. The mine subsidence movements within the culverts have been measured since the commencement of Longwall 301 using total station survey methods. The mine subsidence movements of the valley sides have been monitored since the commencement of Longwall 303 using real time GNSS units. The latest internal culvert survey was conducted after the completion of Longwall 304. Internal culvert survey monitoring was discontinued following the completion of Longwall 304. GNSS19 was vandalised Dec 2019 therefore closure across Cawleys Creek is not available. GNSS units are scheduled to be decommissioned following the completion of Longwall 305.

A summary of the observed and predicted subsidence movements at the culverts is presented in Table 3.9.

Table 3.9 Summary of Predicted and Observed Subsidence Movements for the Railway Culverts

Parameter	Latest Survey Date	Total Movements at Wilsons Creek		Total Movements at Cawleys Creek	
		Predicted	Observed	Predicted	Observed
Internal culvert opening (+ve) / closure (-ve) (mm)	20th Mar 2020 LW304 chainage 0 m	4	-0 to +1	4	-1 to +0
Maximum observed subsidence (mm)	GNSS Stations 31st Dec 2020 LW305 at Ch 120 m	< 20	-10	< 20	0
Maximum observed horizontal movement (mm)		< 20	5	< 20	7
Maximum observed opening (+ve) / closure (-ve) (mm)		< 20	8	< 20	-

The observed movements at the culverts are consistent with predicted movements of less than survey accuracy.

Bridge 2 (Old Princes Highway Underpass)

Bridge 2 is located approximately 300 m to the south east of Longwall 301 and is approximately 950 m from the finishing end of Longwall 305. The location of Bridge 2 is shown in Drawing No. MSEC1161-01.

The mine subsidence movements at Bridge 2 are monitored using absolute 3D monitoring movement at the bridge, and relative movement of the structural elements of the bridge using both 3D total station survey and a fibre optic monitoring system. The absolute 3D monitoring movement is supported by accurate real time monitoring by GNSS station (GNSS03) which is located 130 m to the north west of Bridge 2.

Data on absolute movement of Bridge 2 is no longer available for reporting due to vandalism of the reference pillar used for measurement of absolute movement. GNSS03 had moved 41 mm in a NNW direction at 31st December 2020, representing total horizontal movement since the commencement of Longwall 301. Total vertical subsidence at GNSS03 was 30 mm at 31st December 2020. The absolute horizontal movement is less than predicted horizontal movement in the order of 95 mm. The vertical subsidence at GNSS03 is greater than the predicted vertical subsidence of less than 20 mm at the bridge. It is noted that GNSS03 is positioned closer to the extracted longwalls and predicted vertical subsidence at the location of GNSS03 is 60 mm.

An assessment of the bridge structure is undertaken regularly by Cardno as part of the ongoing assessment of RMS assets by the RMS technical committee. At the latest survey to the end of December 2020, the assessment by Cardno reported no issues with Bridge 2 relating to extraction of Longwalls 301 to 305.

Cawley Road Overbridge

Cawley Road Overbridge is located approximately 1.5 kilometres (km) to the north east of Longwall 301. The location of the Cawley Road Overbridge is shown in Drawing No. MSEC1161-01.

The mine subsidence movements at Cawley Road Overbridge are monitored using absolute GNSS station (GNSS09) and relative movement of the structural elements of the bridge using 3D total station survey. GNSS09 is located 190 m to the west of Cawley Road Overbridge.

GNSS09 had moved 8 mm at the 31st December 2020, representing total horizontal movement due to extraction of Longwalls 301 to 305. Total vertical subsidence at GNSS09 was -13 mm (uplift) for the reporting period. The absolute horizontal and vertical movements are consistent with predicted movements of less than survey accuracy.

Survey of bridge marks were undertaken 27th November 2020 following the completion of Longwall 305. Total maximum relative movement between survey marks at the bridge footings was less than or equal to 3mm. Total maximum relative movement between survey marks at the bridge structure was less than or equal to 6.5mm.

Designated bridge structure inspections are undertaken by Cardno as part of the ongoing monitoring of TfNSW assets. The most recent designated inspection by Cardno occurred 10 March 2020 following the completion of Longwall 304. The next and final scheduled inspection will occur at the end of LW309. At the latest survey in March 2020, the assessment by Cardno reported no issues with Cawley Road Overbridge relating to extraction of Longwalls 301 to 304.

Eastern Tributary Cross Lines

Monitoring of rockbars ETAQ, ETAR, and ETAT are undertaken using relative survey of Cross Lines ETAQ, ETAR and ETAT. A summary of the observed and predicted valley closure movements along the Cross Lines ETAQ, ETAR and ETAT for the latest survey is presented in Table 3.10. Due to limited satellite coverage in the base of the valley, relative surveys have been adopted.

Table 3.10 Summary of Predicted and Observed Valley Closure Movements for ETAQ, ETAR and ETAT Cross Lines Resulting from Longwalls 301 to 305

Monitoring Summary			
Initial Survey Date		1st June 2017	
Latest Survey Date		24th November 2020	
Longwall 305 Chainage at Latest Survey Date		120 m	
Face Distance of LW304 from cross lines		670 m to Line ETAQ, 606 m to Line ETAR, 506 m to Line ETAT	
Parameter	**Line**	**Total Movements (LW301 to 305)**	
		Predicted	**Observed**
Subsidence (mm)	ETAQ	< 20	5
	ETAR	< 20	1
	ETAT	25	-7
Upsidence (mm)	ETAQ	30	8
	ETAR	30	1
	ETAT	30	11
Closure (mm)	ETAQ	50	5
	ETAR	60	32
	ETAT	60	27

The maximum observed relative subsidence includes any upsidence that may have occurred at the rock bar and is also referred to as net vertical movement. 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 compare the observed net vertical movement with the predicted subsidence. The observed total subsidence values are less than the predicted subsidence. Observed total upsidence was negligible for the reporting period. The observed total closure was less than predicted.

Monitoring of rockbar ETAU was undertaken in accordance with an adaptive management process using a TARP to provide high accuracy monitoring data and assessment by a Technical Committee. Monitoring of ETAU during the extraction of Longwall 305 included the following:

- Cross line ETAU with permanently installed prisms across the rockbar. The prisms are surveyed using conventional total station survey methods. Expected accuracy of closure measurement for these lines is ±3mm.
- Three high resolution fixed lines, A Line, B Line and C Line, using prisms attached to sandstone across the base of the Eastern Tributary Valley near Pool ETAU. The lines are surveyed using a high precision total station. Expected accuracy for these lines is ±1mm.
- Three real time GNSS monitoring stations providing real time closure monitoring around Pool ETAU. The expected accuracy of measurement between GNSS stations is ±10mm.

A maximum total closure of 38 mm was observed across Rockbar ETAU at 21 December 2020. Upsidence of 22 mm was also observed in the relative subsidence monitoring data. Metropolitan Coal made a decision to cease mining of Longwall 305 on 6 November 2020 based on the increasing rate of closure observed at ETAU. Longwall 305 was completed 21 November 2020 at chainage 120 m with no observed impact to the pool upstream of Rockbar ETAU.

Waratah Rivulet Cross Lines

Monitoring of rockbars P, Q, R, S, T, U, V, and W are undertaken using relative survey of cross lines at each of the rockbars. Relative surveys of these monitoring lines commenced in April 2020 prior to the extraction of Longwall 305.

Table 3.11 Summary of Predicted and Observed Valley Closure Movements for P, Q, R, S, T, U, V and W Lines Resulting from Longwall 305

Monitoring Summary	
Initial Survey Date	1st April 2020
Latest Survey Date	19th January 2021
Longwall 305 Chainage at Latest Survey Date	120 m
Face Distance of LW305 from cross lines	940m to W Line, 1,760m to P Line

Parameter	**Total Movements (LW305)**							
	P	Q	R	S	T	U	V	W
Predicted Subsidence (mm)	<20	<20	<20	<20	<20	<20	<20	<20
Observed Subsidence (mm)	1	0	0	1	0	1	1	0
Predicted Upsidence (mm)	<20	<20	<20	<20	<20	<20	<20	<20
Observed Upsidence (mm)	2	1	2	1	1	1	1	1
Predicted Closure (mm)	<20	<20	<20	<20	<20	<20	<20	<20
Observed Closure (mm)	2	3	2	2	3	1	1	7*

*possible bumped survey peg

The maximum observed relative subsidence includes any upsidence that may have occurred at the rock bar and is also referred to as net vertical movement. 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 compare the observed net vertical movement with the predicted subsidence. The observed total subsidence values are less than the predicted subsidence. Observed total upsidence was negligible for the reporting period. The observed total closure was less than predicted.

Ridge Top Survey Stations

The locations of the Ridge Top Survey Stations are shown in Drawing No. MSEC1161-02. In late 2019, a series of GNSS units were installed adjacent to the Ridge Top Survey Stations and these will be used for future survey data at these locations.

The maximum total closure between the Ridge Top Survey Stations surveyed due to the extraction of Longwalls 301 to 304 is less than 20 mm.

Installation of the GNSS stations was undertaken during the extraction of Longwall 304 and 305. A summary of the observed and predicted subsidence movements at the GNSS stations is presented in Table 3.12.

Table 3.12 Summary of Predicted and Observed Subsidence Movements for GNSS Stations Resulting from Longwalls 304 to 305

Monitoring Summary				
Latest Survey Date			31st December 2020	
Parameter	**Mark**	**Installation Date and Longwall 304 Chainage**	**Total (LW304 to 305)**	
			Predicted	**Observed**
Total Subsidence	GNSS 38 (near Trig 6)	27 Oct 2019 – 926m	<20	-1
	GNSS 39 (near Trig 7)	5 Nov 2019 – 624m	<20	7
	GNSS 33 (near Trig 8)	16 Sep 2019 – 1013m	<20	6
	GNSS 34 (near VC1)	16 Sep 2019 – 1013m	<20	6
	GNSS 35 (near VC2)	21 Sep 2019 – 976m	<20	-2
	GNSS 37 (near VC3)	22 Sep 2019 – 966m	<20	1
	GNSS 36 (near VC4)	23 Sep 2019 – 958m	<20	1

It can be seen in Table 3.12 that the maximum observed total subsidence is less than predicted. The Ridge Top Survey Stations were set up to monitor the overall movement of the tops of the ridges adjacent to the Woronora Reservoir. The Ridge Top GNSS Stations are 0.4 km to 2.8 km from Longwall 305. The observed total horizontal movement of the GNSS Stations due to Longwalls 304 to 305 are less than 20 mm.

The change in horizontal distance (or closure) is calculated between all combinations of GNSS Survey Stations. The maximum total closure between the GNSS Survey Stations during the extraction of Longwall 304 to 305 is less than 20 mm.

LiDAR Survey

The changes in surface level above the extracted longwalls have been measured using LiDAR surveys. The initial surface level contours have been determined from the base survey carried out 11th May 2017, prior to the extraction of Longwall 301. The most recent LiDAR survey was carried out on 17th December 2020 after the completion of Longwall 305.

The measured total changes in surface level (vertical subsidence) due to the extraction of Longwall 301 to 305304 are shown in Fig. 3.1. These contours have been determined by taking the differences between the surface levels measured before the extraction of Longwall 301 and the surface levels measured on 17th December 2020.

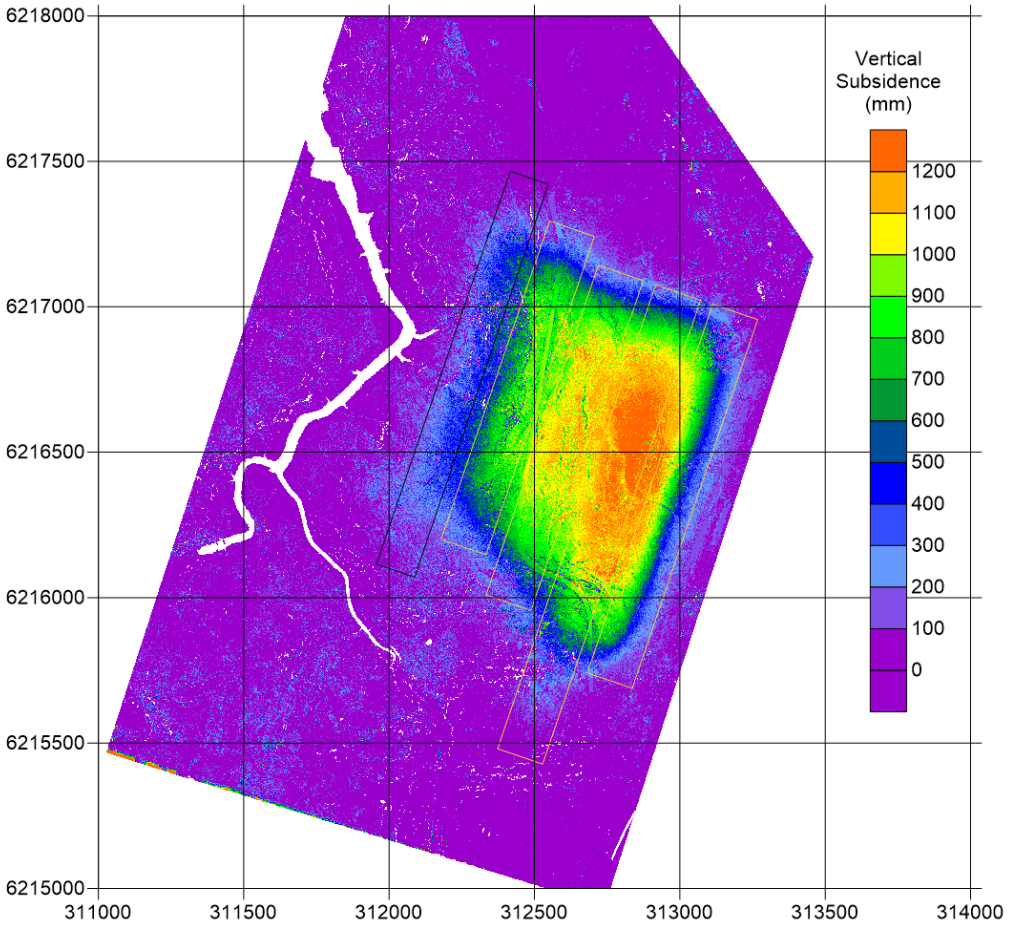

Fig. 3.1 Measured total changes in surface level due to the full extraction of Longwall 301 to 305

The contours of the measured changes in surface level, developed from the LiDAR surveys, show the changes in the heights of points at fixed positions in space (i.e. eastings and northings). This differs from traditional subsidence contours that include both the vertical and horizontal components of the movements of points fixed to the surface. Horizontal movements are usually included in the subsidence profiles, as traditional ground monitoring data is based on the movements of survey marks that are fixed to the ground.

The contours can contain artefacts (i.e. locally increased or decreased movements), particularly in the locations of steeply incised terrain, such as at the cliffs and steep slopes.

The change in surface level at a fixed position in space (i.e. easting and northing), therefore, can be large in the locations of cliffs and steep slopes and does not provide a true indication of the actual vertical subsidence at a point on the ground. However, where the ground is reasonably flat, the contours of the measured changes in surface level should provide a good indication of the actual vertical subsidence.

The LiDAR surveys have an accuracy for absolute level in the order of ±100 mm. The accuracy of the measured changes in surface level (i.e. the difference between two surveys), therefore, is in the order of ±200 mm.

The comparisons of the measured changes in surface level and the predicted vertical subsidence along the 300 XL Line, the Optic Water Line, and Princes Highway Line are provided in Fig. 3.2 to Fig. 3.4.

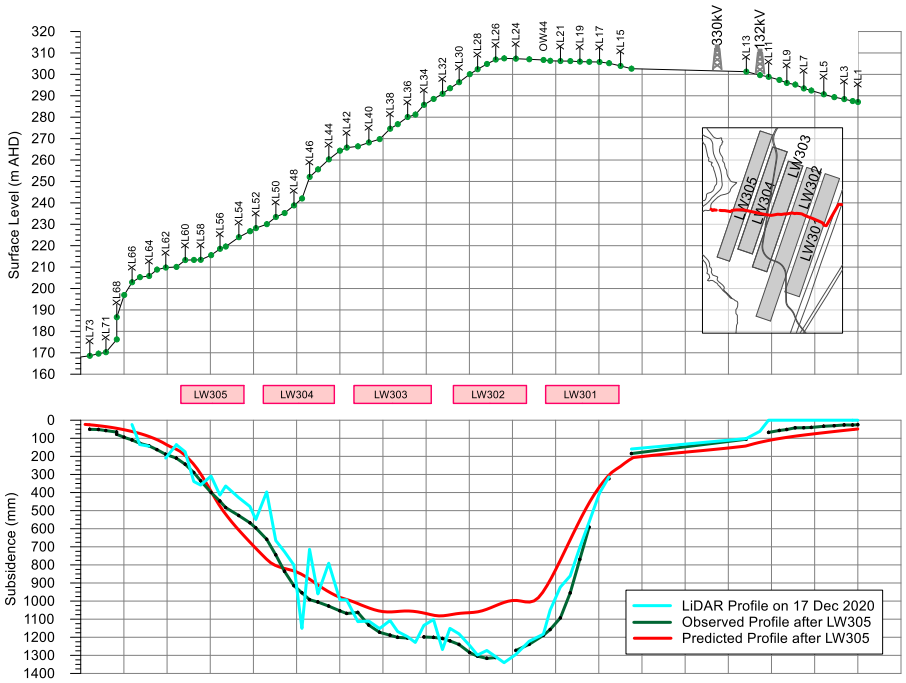

Fig. 3.2 Measured changes in surface level and predicted vertical subsidence along 300 XL Line

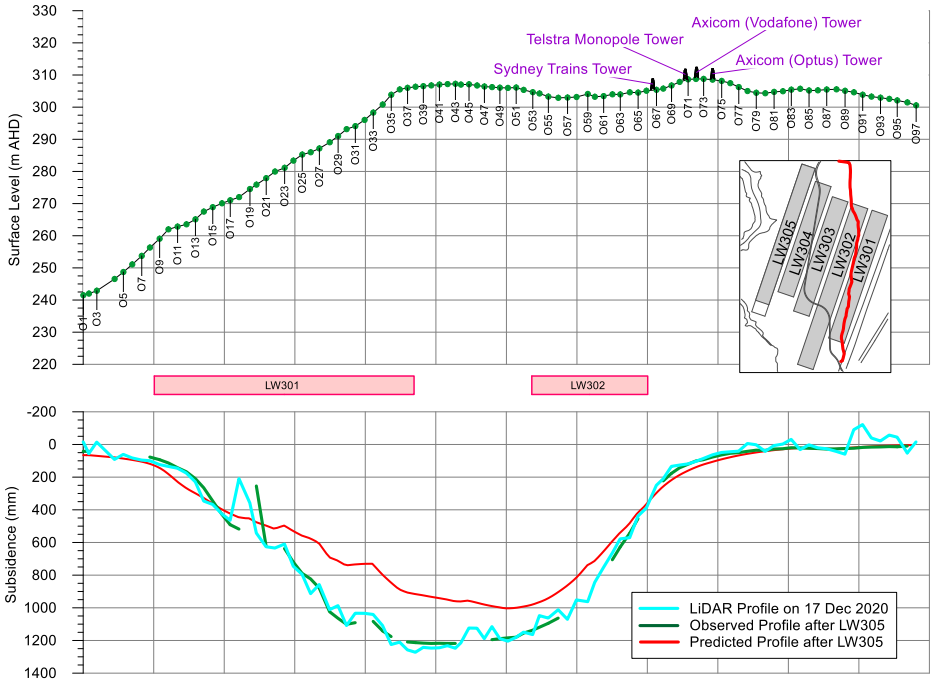

Fig. 3.3 Measured changes in surface level and predicted vertical subsidence along Optic Water Line

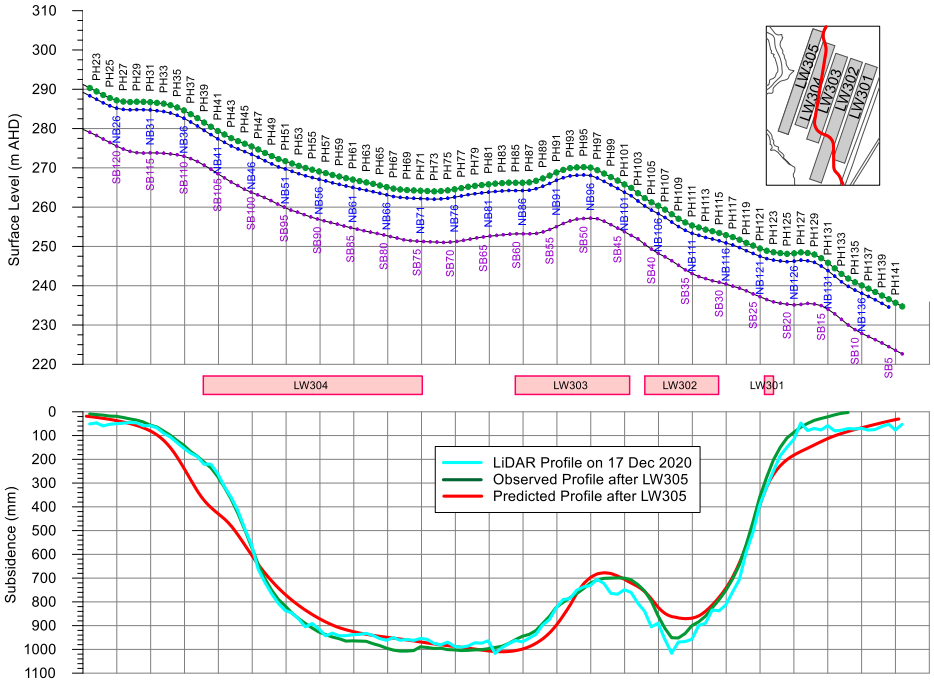

Fig. 3.4 Measured changes in surface level and predicted vertical subsidence along Princes Highway Line

The LiDAR profiles of the measured changes in surface level reasonably match the observed profiles of vertical subsidence along each of the monitoring lines. The observed profiles reasonably match the predicted profile shapes, however observed vertical subsidence is greater than predicted above Longwalls 302 and 303 along the Optic Water Line and 300 XL Line. The location of the maximum observed subsidence coincides with the crest of the hill that can be observed in the surface profiles along both monitoring lines. Further investigation may be undertaken on the potential causes of the increased subsidence at this location.

The greater than predicted subsidence at the northern end of the longwalls is believed to have been influenced by variation in extracted seam thickness due to operational and geotechnical reasons at the northern end of Longwall 301. Based on Fig. 3.1, and the survey monitoring lines, the surface extent of the increased subsidence zone is limited to the area around the topographical high point above Longwalls 301 and 302. The increased subsidence is potentially also influenced by the local topographical features in this area. The natural or built features within the area of increased subsidence include the Sydney Water pipeline, Optus optical fibre cable, Waterfall cemetery, and two swamps (S41 and S53).

The LiDAR survey profiles show subsidence slightly less or greater than the monitoring lines at different locations. This difference may be due to the different survey dates and also horizontal movement of the slopes, that can result in increases or reductions in the observed vertical movement in LiDAR data.

Greater variation in the LiDAR survey profiles can be observed where the ground surface slopes increase. These variations are considered to be artefacts of the LiDAR surveys and are not real movements.

It can be inferred from the slopes of the profiles, that the measured changes in grade are similar to the observed tilts along each of the monitoring lines. It is not possible to derive the curvature nor the horizontal movements from the LiDAR surveys.

It is considered that the ground movements measured using the LiDAR surveys are generally consistent with the predictions and observed survey data along the monitoring lines.

4. Condition 3, Schedule 3 of the Project Approval

Condition 3, Schedule 3 of the Project Approval states:

If the subsidence effects and subsidence impacts of the project exceed the relevant predictions by more than 15% at any time after mining has progressed beyond the halfway mark of Longwall 21, or if the profile of vertical displacement does not reflect predictions, then the Proponent shall use appropriate numerical modelling to supplement the subsequent predictions of subsidence effects and subsidence impacts for the project to the satisfaction of the Director-General.

A comparison of the maximum observed and maximum predicted total conventional subsidence for the Project after each longwall for Longwalls 3 to 27 and Longwalls 301 to 305 is shown in Fig. 4.1. The comparison of conventional subsidence effects excludes the valley cross lines which represent non-conventional subsidence movements.

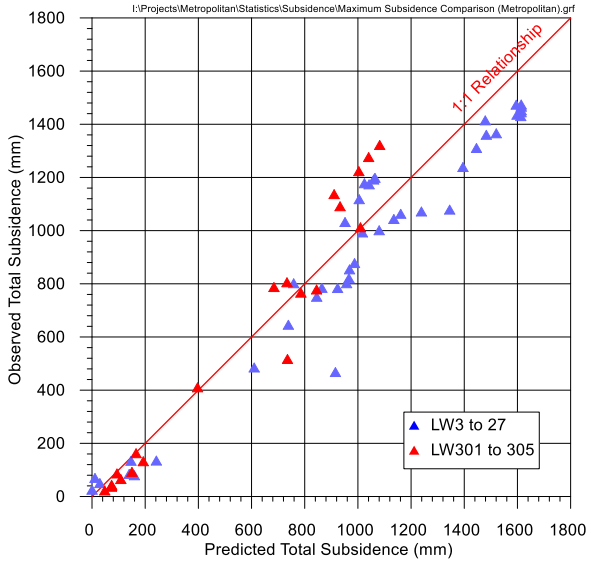

Fig. 4.1 Comparison between the maximum observed and maximum predicted total conventional subsidence for Longwalls 3 to 27 and Longwalls 301 to 305 at Metropolitan Colliery

A histogram of the maximum observed divided by the maximum predicted vertical subsidence is shown in Fig. 4.2.

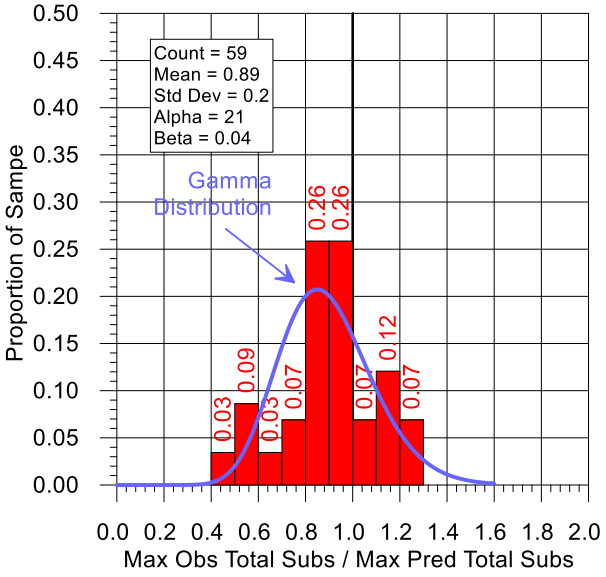

Fig. 4.2 Histogram of maximum observed/maximum predicted total vertical subsidence with gamma distribution

The mean of the maximum observed divided by the maximum predicted vertical subsidence for the project shown in Fig. 4.2 is 0.89, indicating that, on average, observed subsidence is 11% less than predicted for the project. Based on the results of survey data to date and comparison with predicted conventional subsidence parameters, the profiles of vertical displacement adequately reflect the predictions. The overall subsidence effects of the project do not exceed predictions by more than 15%.

5. Southern Sydney Sheltered Forest

In accordance with the Metropolitan Coal Biodiversity Management Plans for Longwall 304 (Version E) and Longwalls 305 to 307 (Version A), an assessment of the subsidence effects at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion Endangered Ecological Community situated over 575 m to the north east of Longwall 304 and over 700 m to the north east of Longwall 305. The assessment of subsidence effects included assessment of the M1 North Bound Line (from Peg 245 to 275), Transmission Line (from Peg TL90 to TL97), TransGrid Transmission Tower T108, Endeavour Energy Transmission Tower T8, and GNSS Station 08, which are located between the Endangered Ecological Community and the extracted longwalls. The subsidence monitoring results are discussed in Section 3.

The results of the assessment indicate that the subsidence parameters to the north east of Longwalls 304 and 305 were negligible and as predicted or less than those predicted for the reporting period. Assessment of subsidence parameters indicates subsidence effects at the occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils EEC situated to the north east of Longwalls 304 and 305 are within typical magnitudes of survey accuracy and equate to a Level 1 significance level consistent with the Biodiversity Management Plans for Longwall 304 (Version E) and Longwalls 305 to 307 (Version A).

6. Summary

The observed profile shapes and subsidence parameters are generally similar to those predicted or within limits of accuracy of the predicted subsidence parameters. The maximum observed total conventional subsidence along the 300 XL Line and Optic Water Line is greater than predicted. Based on Fig. 3.1, and the survey monitoring lines, the surface extent of the increased subsidence zone is limited to the area around the topographical high point above Longwalls 301 and 302. The increased subsidence is potentially influenced by the local topographical features in this area. The natural or built features within the area of increased subsidence include the Sydney Water pipeline, Optus optical fibre cable, Waterfall cemetery, and two swamps (S41 and S53). Based on the relevant Metropolitan Coal Built Features Management Plan Trigger Action Response Plans (TARPs), the sections of Sydney Water pipeline and Optus optical fibre cable within the area of increased subsidence are at Level 3. The greater than predicted subsidence at the northern end of the longwalls is believed to have also been influenced by variation in extracted seam thickness due to operational and geotechnical reasons at the northern end of Longwall 301. The maximum observed total conventional subsidence above Longwalls 301-303 may be assessed further to analyse the potential influence of topographical features in the area of increased subsidence.

Based on the results of survey data to date and comparison with predicted conventional subsidence parameters, the profiles of vertical displacement adequately reflect the predictions. The overall subsidence effects of the project do not exceed predictions by more than 15%.

Yours sincerely,

Peter DeBono
Mine Subsidence Engineering Consultants

Attachments:

Drawing No. MSEC1161-01 Rev. A - General Layout and Monitoring Lines

Drawing No. MSEC1161-02 Rev. A – Ridge Top Survey Stations

References:

MSEC 2008. MSEC285 Revision C (August 2008) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Proposed Extraction of Longwalls 20 to 44 at Metropolitan Colliery in support of a Part 3a Application.

Metropolitan Coal, 2019. Metropolitan Coal Longwall 304 Subsidence Monitoring Program (Rev. SMP-R01-A, April 2019).

Metropolitan Coal, 2020. Metropolitan Coal Longwalls 305-307 Subsidence Monitoring Program (Rev. SMP-R01-B, January 2020).`

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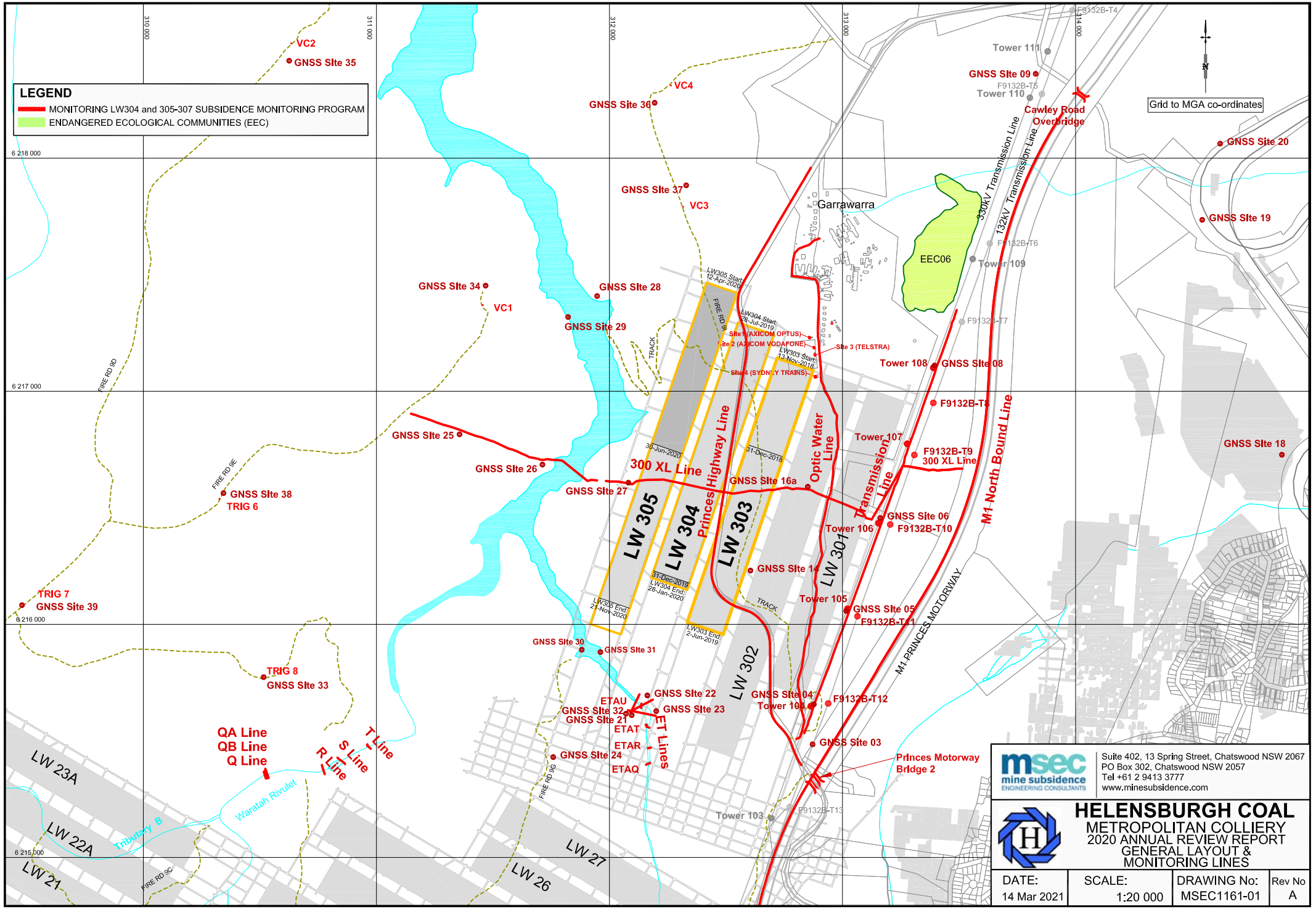

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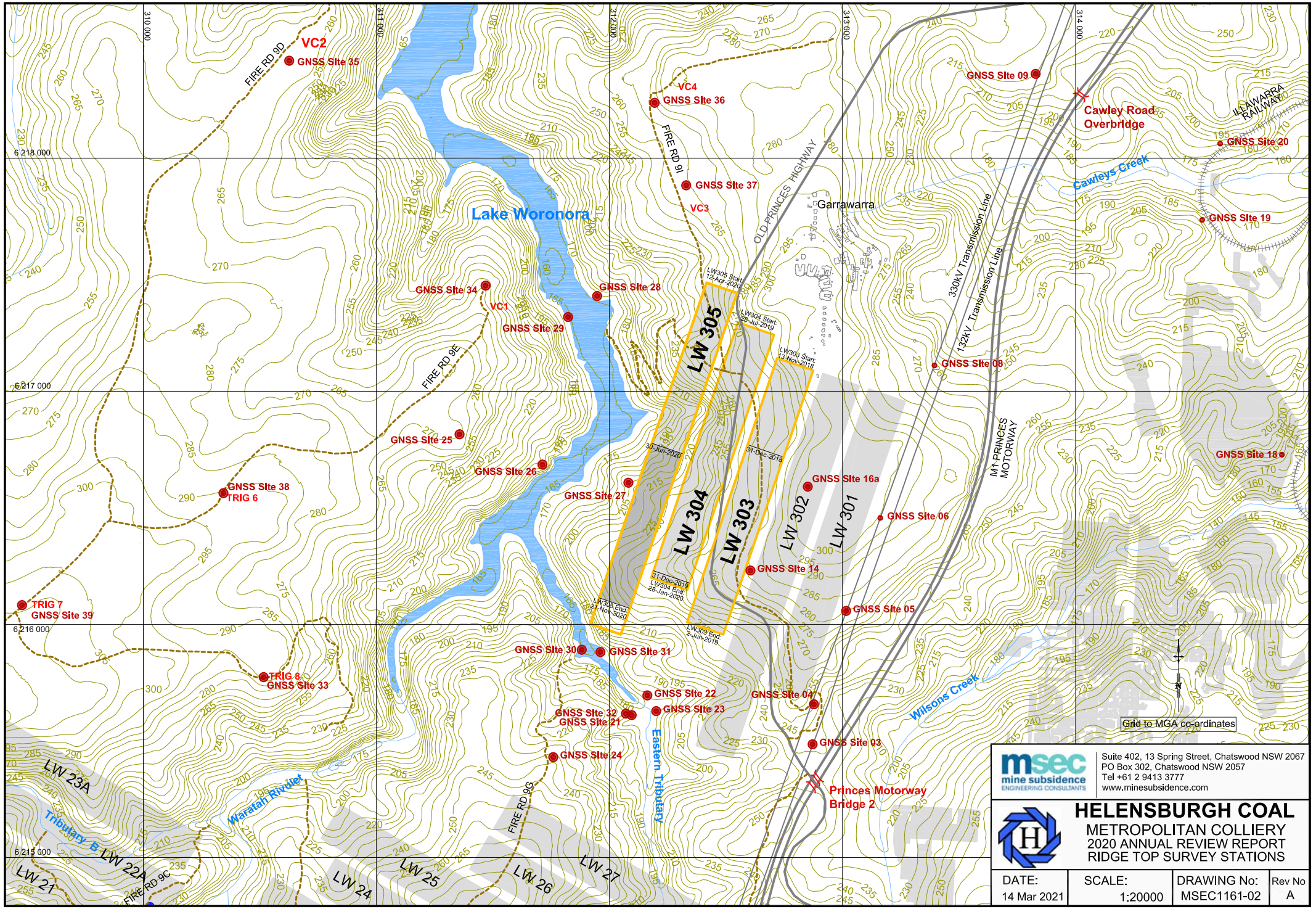

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