XSTRATA COAL:

Tahmoor Colliery - Longwall 27

Subsidence Monitoring Programme – Revision F

AUTHORISATION OF MANAGEMENT PLAN

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Date:	22 August 2013

DOCUMENT REGISTER

Date	Report No.	Rev	Comments
Mar-11	MSEC446-00	A	Draft for Longwall 26
Jun-11	MSEC446-00	B	Revised to include monitoring for railway infrastructure
Jul-11	MSEC446-00	C	Revised to include weekly surveys of Moorland Rd, Struan St, Krista Pl
Aug-11	MSEC446-00	D	Revised to include extra surveys across Redbank Creek, and along Main Southern Railway and Remembrance Drive
Aug-11	MSEC446-00	E	Timing of relative 3D surveys revised
Sep-11	MSEC446-00	F	Update on monitoring at Skew Culvert on Main Southern Railway, include survey marks along Hilton Park Road, which have been installed with baseline survey complete.
Mar-12	MSEC446-00	G	Update on monitoring at Redbank Creek
Sep-12	MSEC567-00	A	Updated for Longwall 27
Oct-12	MSEC567-00	B	Final for Longwall 27
May-13	MSEC567-00	C	Updated for Main Southern Railway
May-13	MSEC567-00	D	Minor clarifications following feedback from DTIRIS
Jun-13	MSEC567-00	E	Update of locations of new monitoring points along railway corridor
Aug-13	MSEC567-00	F	Information on monitoring of Redbank Creek Culvert updated.

References:-

AS/NZS 4360:1999 Risk Management

Tahmoor Colliery Longwalls 27 to 30 - The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Items of Surface Infrastructure due to mining Longwalls 27 to 30 at Tahmoor Colliery in support of the SMP Application. (Report MSEC355, Revision B, July 2009), prepared by Mine Subsidence Engineering Consultants

Gale, W. and Sheppard, I. (2011). Investigation into Abnormal Increased Subsidence above Longwall Panels at Tahmoor Colliery. Mine Subsidence Technological Society, Proceedings of the 8th Triennial Conference on Mine Subsidence, May 2011.

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Drawings

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

1.0 INTRODUCTION

1.1. Background

Tahmoor Colliery is located approximately 80 kilometres south west of Sydney in the township of Tahmoor NSW. It is managed and operated by Xstrata Coal. Tahmoor Colliery has previously mined 26 longwalls to the north and west of the mine's current location.

Longwall 27 is a continuation of a series of longwalls that extend into the Tahmoor North Lease area, which began with Longwall 22. The longwall panels are located between the Bargo River in the south-east, the township of Thirlmere in the west and Picton in the north. A portion of each longwall is located beneath the urban area of Tahmoor.

Longwall 27 is approximately 283 metres wide (rib-to-rib) and approximately 3.0 kilometres long. The width of the chain pillar between Longwalls 26 and 27 is 40 metres.

This Subsidence Monitoring Programme describes the inspection regimes, layout of monitoring points, parameters to be measured, monitoring methods and accuracy, timing and frequencies of surveys and inspections, and recording and reporting of monitoring results.

The Subsidence Monitoring Programme is also consistent with detailed Subsidence Management Plans that have been developed by Tahmoor Colliery in consultation with stakeholders. Each of these management plans describe measures that will be undertaken to monitor subsidence movements and physical changes and/or impacts that occur during mining. The management plans include:

- *Tahmoor Colliery Longwall 27 Natural Features Surface Safety and Serviceability Management Plan* (Revision I), February 2012.
- *Tahmoor Colliery Longwall 27 Wollondilly Shire Council Management Plan* (Revision A), Report No. MSEC567-02, September 2012.
- *Tahmoor Colliery Management Plan for Potential Impacts to Potable Water Infrastructure due to the mining of Longwall 27* (Revision A), Report No. MSEC567-03, September 2012.
- *Tahmoor Colliery Management Plan for Potential Impacts to Sydney Water Sewer Infrastructure due to the mining of Longwall 27* (Revision A), Report No. MSEC567-04, September 2012.
- *Tahmoor Colliery Management Plan for Potential Impacts to Gas Infrastructure due to the mining of Longwall 27* (Revision A), Report No. MSEC567-05, September 2012.
- *Tahmoor Colliery Management Plan for Potential Impacts to Endeavour Energy Infrastructure due to the mining of Longwalls 27* to 30 (Revision A), Report No. MSEC567-06, September 2012.
- *Management Plan Longwall Mining (LW 27) beneath Telstra Plant @ Tahmoor and Thirlmere NSW*, Colin Dove, 2012.
- *Tahmoor Colliery Management Plan for Potential Impacts to Lands Department Permanent Survey Control Marks due to the mining of Longwalls 27 to 30* (Revision A), Report No. MSEC567-11, September 2012.
- *Tahmoor Colliery Management Plan for Potential Impacts to Public, Commercial and Residential Structures due to the mining of Longwall 27* (Revision A), Report No. MSEC567-12, September 2012.
- *Tahmoor Colliery Management Plan for Potential Impacts to Items of Heritage Significance due to the mining of Longwall 27* (Revision A), Report No. MSEC567-13, September 2012.
- *Tahmoor Colliery Management Plan for longwall mining beneath the Main Southern Railway,* Revision C (Longwall 27 only), Report No. MSEC534, March 2013

In a small number of cases, monitoring measures described in this Subsidence Monitoring Programme are in excess of commitments that have been made in the above-mentioned management plans.

The Subsidence Monitoring Programme is a live document that can be amended at any stage of mining, to meet the changing needs of Tahmoor Colliery and its stakeholders.

1.2. Definition of Active Subsidence Zone

As a longwall progresses, subsidence begins to develop at a point in front of the longwall face and continues to develop after the longwall passes. The majority of subsidence movement typically occurs within an area 150 metres in front of the longwall face to an area 450 metres behind the longwall face.

This is termed the "active subsidence zone" for the purposes of this Management Plan, where surface monitoring is generally conducted. The active subsidence zone for each longwall is defined by the area bounded by the predicted 20 mm subsidence contour for the active longwall and a distance of 150 metres in front of and 450 metres behind the active longwall face, as shown by Fig. 1.1.

Fig. 1.1 Diagrammatic Representation of Active Subsidence Zone

1.3. Maximum Predicted Systematic Parameters

Predicted mining-induced systematic subsidence movements were provided in Report No. MSEC355, which was prepared in support of Tahmoor Colliery's SMP Application for Longwalls 27 to 30.

A summary of the maximum predicted incremental systematic subsidence parameters, due to the extraction of each of the proposed longwalls, is provided in Table 1.1. A summary of the maximum predicted cumulative systematic subsidence parameters, after the extraction of each of the proposed longwalls, is provided in Table 1.2. A summary of the maximum predicted travelling parameters, during the extraction of each of the proposed longwalls, is provided in Table 1.3.

Table 1.1 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Each of the Proposed Longwalls 27 to 30

Longwall	Maximum Predicted Incremental Subsidence (mm)	Maximum Predicted Incremental Tilt (mm/m)	Maximum Predicted Incremental Hogging Curvature (1/km)	Maximum Predicted Incremental Sagging Curvature (1/km)
After LW27	755	6.0	0.07	0.14
After LW28	735	5.9	0.07	0.13
After LW29	735	5.9	0.06	0.13
After LW30	725	5.8	0.06	0.13

Table 1.2 Maximum Predicted Cumulative Systematic Subsidence Parameters after the Extraction of Each of the Proposed Longwalls 27 to 30

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Hogging Curvature (1/km)	Maximum Predicted Cumulative Sagging Curvature (1/km)
After LW27	1260	6.3	0.09	0.15
After LW28	1270	6.2	0.09	0.14
After LW29	1270	6.1	0.09	0.14
After LW30	1270	6.3	0.09	0.14

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 22 to 30.

Table 1.3 Maximum Predicted Travelling Subsidence Parameters during the Extraction of Each of the Proposed Longwalls 27 to 30

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Hogging Curvature (1/km)	Maximum Predicted Travelling Sagging Curvature (1/km)
During LW27	3.1	0.04	0.03
During LW28	3.0	0.03	0.03
During LW29	3.0	0.03	0.03
During LW30	3.0	0.03	0.03

1.4. Observed Subsidence during the mining of Longwalls 22 to 26

Extensive ground monitoring within the urban areas of Tahmoor has allowed detailed comparisons to be made between predicted and observed subsidence, tilt, strain and curvature during the mining of Longwalls 22 to 26.

In summary, there is generally a good correlation between observed and predicted subsidence, tilt and curvature. Observed subsidence was generally slightly greater than predicted in areas that were located directly above previously extracted areas and areas of low level subsidence (typically less than 100 mm) was generally observed to extend further than predicted.

While there is generally a good correlation between observed and predicted subsidence, substantially increased subsidence has been observed above most of Longwall 24A and the southern end of Longwall 25. This was a very unusual event for the Southern Coalfield.

Observed Increased Subsidence during the mining of Longwall 24A

Observed subsidence was greatest above the southern half of Longwall 24A, and gradually reducing in magnitude towards the northern half of the longwall, which was directly beneath the urban area of Tahmoor. These observations are shown graphically in Fig. 1.2, which shows observed subsidence at survey pegs located along the centreline of Longwall 24A.

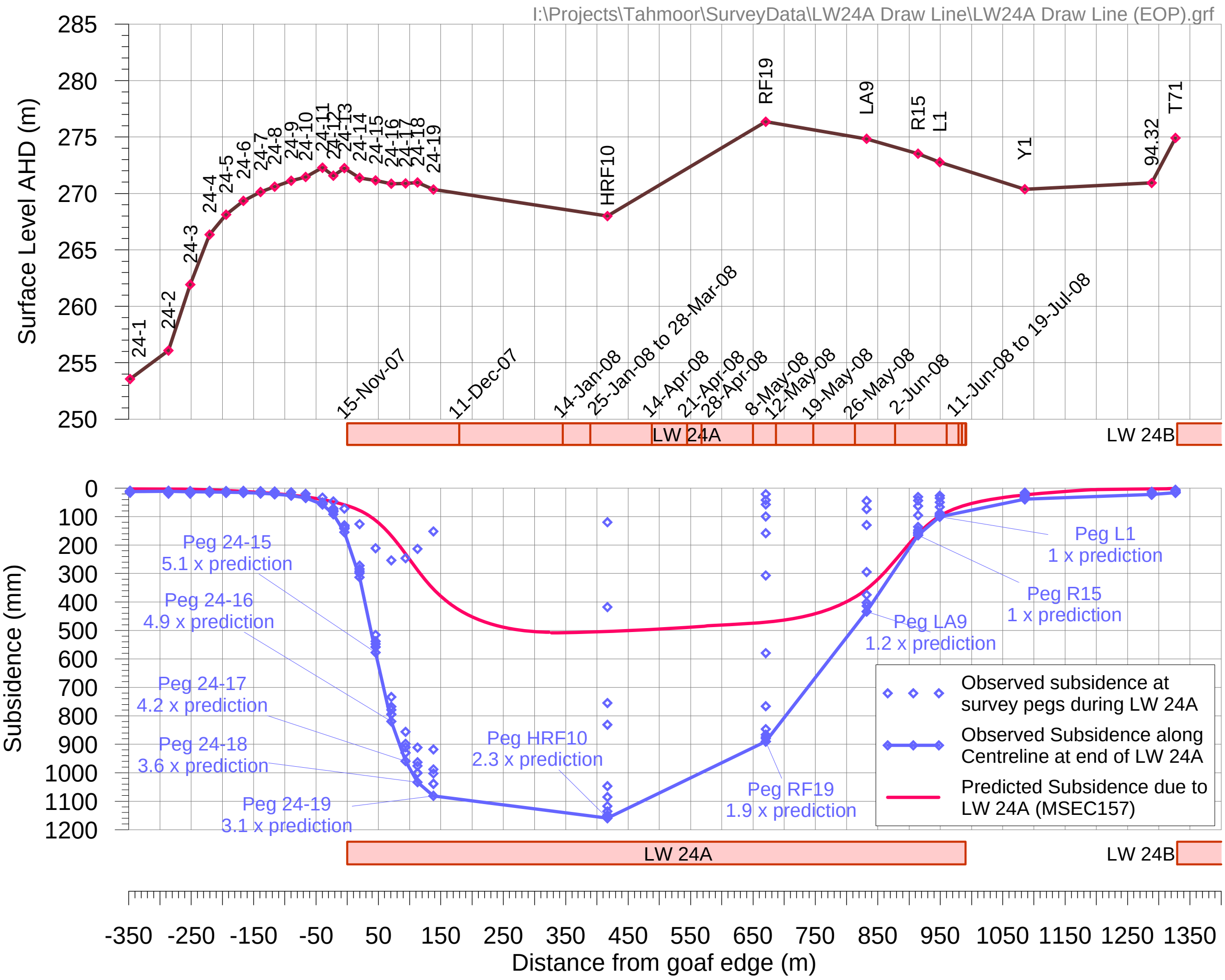


Fig. 1.2 Observed Subsidence along Centreline of Longwall 24A

It can be seen from Fig. 1.2 that observed subsidence was more than twice the predicted maximum value, reaching to a maximum of 1169 mm at Peg HRF10. It is possible that actual maximum subsidence developed somewhere between Pegs HRF10 and RF19, though this was not measured. Observed subsidence was similar to prediction near Peg R15 on Remembrance Drive. Survey pegs RF19 and LA9 are located within a transition zone where subsidence gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

Observed Increased Subsidence during the mining of Longwall 25

Increased subsidence was observed during the first stages of mining Longwall 25. These observations are shown graphically in Fig. 1.3, which shows observed subsidence at survey pegs located along the centreline of Longwall 25.

It can be seen from Fig. 1.3 that observed subsidence was approximately twice the predicted maximum value, with maximum subsidence of 1216 mm at Peg 25-28.

Observed subsidence is similar to but slightly more than predicted at Peg RE7 and is similar to prediction at Peg Y20 and at all pegs located further along the panel. Survey pegs A6, A7, A8 and A9 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

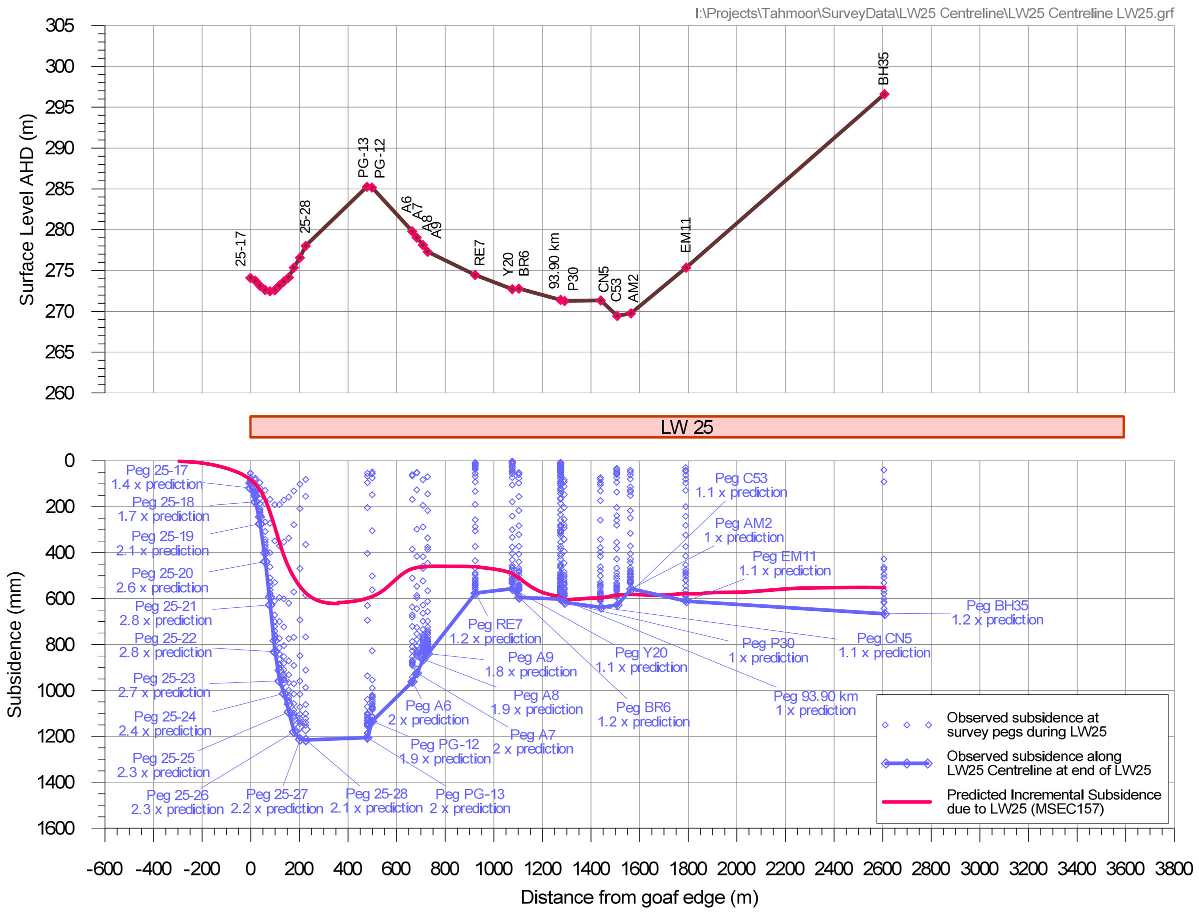


Fig. 1.3 Observed Subsidence along Centreline of Longwall 25

Observed Increased Subsidence during the mining of Longwall 26

Increased subsidence was observed during the first stages of mining Longwall 26, but at a reduced magnitude compared to the subsidence observed above Longwalls 24A and 25. These observations are shown graphically in Fig. 1.4, which shows observed subsidence at survey pegs located along the centreline of Longwall 26. The graph shows the latest survey results for each monitoring line as at August 2012. It is likely that further small increases in subsidence will be observed at these pegs when they are surveyed at the completion of Longwall 26.

It can be seen from Fig. 1.4 that observed subsidence was approximately 1.3 times the predicted maximum value, with maximum subsidence of 867 mm at Peg TM26.

Observed subsidence reduced along the panel until Peg Y40 on York Street, where it was less than prediction. Survey pegs S9, and RE27 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence between Pegs TM26 and MD4 to areas of normal subsidence at Peg Y40 and beyond.

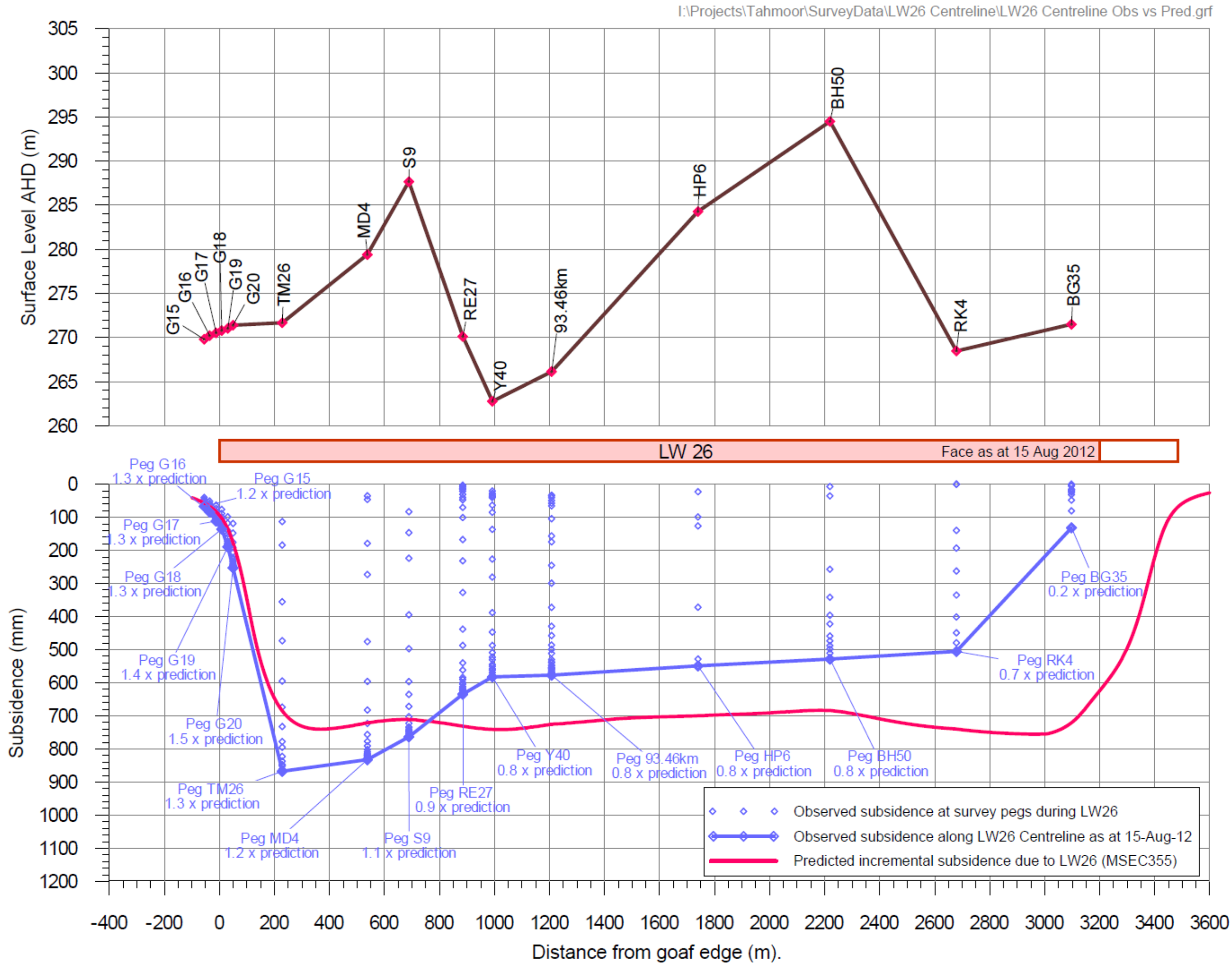


Fig. 1.4 Observed Subsidence along Centreline of Longwall 26 as at August 2012

Analysis and commentary

The cause for the increased subsidence has been investigated by Strata Control Technologies on behalf of Tahmoor Colliery (Gale and Sheppard, 2011). The investigations concluded that the increased subsidence is consistent with localised weathering of joint and bedding planes above a depressed water table adjacent to an incised gorge.

In light of the above observations, the region above the extracted longwalls at Tahmoor has been partitioned into three zones:

1. Normal subsidence zone – where the observed vertical subsidence is within the normal range and correlates well with predictions
2. Maximum increased subsidence zone – where the observed vertical subsidence is substantially greater than predictions but has reached it upper limit. Maximum subsidence above the centreline of the longwalls appears to be approximately 1.2 metres above Longwalls 24A and 25, and 900 mm above Longwall 26.
3. Transition zone – where the subsidence behaviour appears to have transitioned between areas of maximum increased subsidence and normal subsidence.

When the locations of the three zones are plotted on a map, as shown in Drawing No. MSEC567-00-01 (refer Appendix), it can be seen that the transition zone is roughly consistent in width above Longwall 24A, Longwall 25 and Longwall 26. The orientation of the transition zone is also roughly parallel to the Nepean Fault and not the Bargo River.

Prior to the mining of Longwall 26, it was not yet known whether the location of the transition zone was related to the alignment of the Nepean Fault or the Bargo River as both features were aligned approximately parallel to each other adjacent to previously extracted Longwalls 24A and 25.

The Bargo River, however, abruptly turns a sharp bend near the end of Longwalls 25 and 26 and observations during the mining of Longwall 26 were able to provide a first indication that the location of the transition zone was related to the alignment of the Nepean Fault, rather than the Bargo River.

The magnitude of subsidence above Longwall 26 is reduced compared to Longwalls 24A and 25. Given that the alignment of the Nepean Fault moves away from the Bargo River above Longwall 26, it appears that the magnitude of increased subsidence is linked to the proximity of the Bargo River. This observation confirms the findings of Gale and Sheppard that the increased subsidence is linked to localised weathering of joint and bedding planes above a depressed water table adjacent to the incised gorge of the Bargo River.

In summary, it appears that the location of increased subsidence is linked to the alignment of the Nepean Fault and the magnitude of the increased subsidence is linked to the proximity to the Bargo River.

The zones have been projected above Longwalls 27 to 30 from the observed zones above Longwalls 24A and 26, as shown in Drawing No. MSEC567-00-02 (refer Appendix). The projection is based on the orientation of the Nepean Fault. It can be seen that the transition zone extends to sections of Myrtle Creek Avenue, Remembrance Drive, Myrtle Creek and the Main Southern Railway.

Given that Longwall 27 is located further away from the Bargo River than Longwall 26, it was expected that the magnitude of maximum subsidence at the commencing end of Longwall 27 will be less than 900 mm. The amount of reduction in maximum subsidence is difficult to predict and observations during the extraction of Longwall 27 have measured a reduction of approximately 100 mm. Subsidence above the panel is observed to be gradually reducing up the panel as mining continues. The observed location of the transition zone between increased and normal subsidence roughly correlates with the projection shown in Drawing No. MSEC567-00-02.

It is recognised that despite the above analysis and projections, substantially increased subsidence could develop as the mining of Longwall 27 progresses. This Management Plan has been developed to manage potential impacts if substantial additional subsidence were to occur.

2.1. Layout of Monitoring Points

The layout of monitoring points is provided in Drawing No. MSEC567-00-03. Due to the density of survey marks, detailed layouts of monitoring points are provided for the Railway Cutting in Drawing No. MSEC534-02 and the Railway Embankment in Drawing No. MSEC534-03.

A layout of monitoring points for the Deviation Overbridge at 92.400 km is provided in Fig. 2.2.

2.2. Monitoring Methods and Accuracy

With the exception of surveys undertaken within the railway corridor, the monitoring methods and accuracy are described in the report entitled *Specifications for Subsidence Monitoring Lines for Longwall 27*, by SMEC Urban. This specification is appended to this Subsidence Monitoring Programme.

With respect to surveys undertaken within the railway corridor, the monitoring methods and accuracy are described in the report entitled *Main Southern Rail Line- Survey Monitoring Plan for LW27*, by Meadows Consulting. This specification is appended to this Subsidence Monitoring Programme.

With respect to specialist monitoring undertaken within the railway corridor, including automated monitoring of rail stress, rail temperature, switch displacement, Myrtle Creek Culvert steel stress and tilt, please refer to details provided in the Railway Management Plan (Report No. MSEC534).

2.3. Recording and reporting of monitoring results

The recording and reporting of monitoring results is described in the report entitled *Specifications for Subsidence Monitoring Lines for Longwall 27*, by SMEC Urban. This specification is appended to this Subsidence Monitoring Programme.

Survey results will be issued to NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS) within 48 hours of survey.

2.4. Inspection regimes, parameters to be measured, timing and frequencies of surveys and inspections

The inspection regimes, parameters to be measured, timing and frequencies of surveys and inspections are outlined in Table 2.1. The information is sorted by features that are being monitored.

To clarify, where the timing of the monitoring or inspection frequency is described as "*Monthly after x metres of extraction"*, or *"Every 200 metres of extraction after x metres of extraction*", this means that the first survey will commence within one week of the longwall face passing "*x metres of extraction*".

In the case of the Main Southern Railway, the extent of ground surveys, track geometry surveys and track inspections along the rail corridor will grow to the north with the advancing longwall face during the mining of Longwall 27, such that the northern extent will be at least 200 metres in front of the longwall face. Please refer to Fig. 2.1.

Survey frequencies will not be reduced until agreed by DTIRIS and relevant stakeholders. Unless stated in the attached table, inspection frequencies will not be reduced until agreed by DTIRIS and relevant stakeholders.

Increased subsidence

Increased subsidence was observed at the southern or commencing ends of Longwalls 24A, 25 and 26. It is defined as observations of subsidence that are similar in magnitude to those observed within the red zones highlighted in Drawing No. MSEC567-00-01.

While slightly reduced in magnitude, increased subsidence was observed above the commencing end of Longwall 27. The survey frequency along Myrtle Creek Avenue was increased from once every 200 metres of extraction to weekly on 29 January 2013. Surveys along Myrtle Creek Avenue continued on a weekly basis until 15 April when the rate of subsidence development was observed to reduce to small weekly increments. Surveys along streets have returned to the normal frequency of once every 200 metres of extraction within the active subsidence zone, with inspections at the normal frequency of a detailed visual inspection once per week with a second vehicle based inspection once per week.

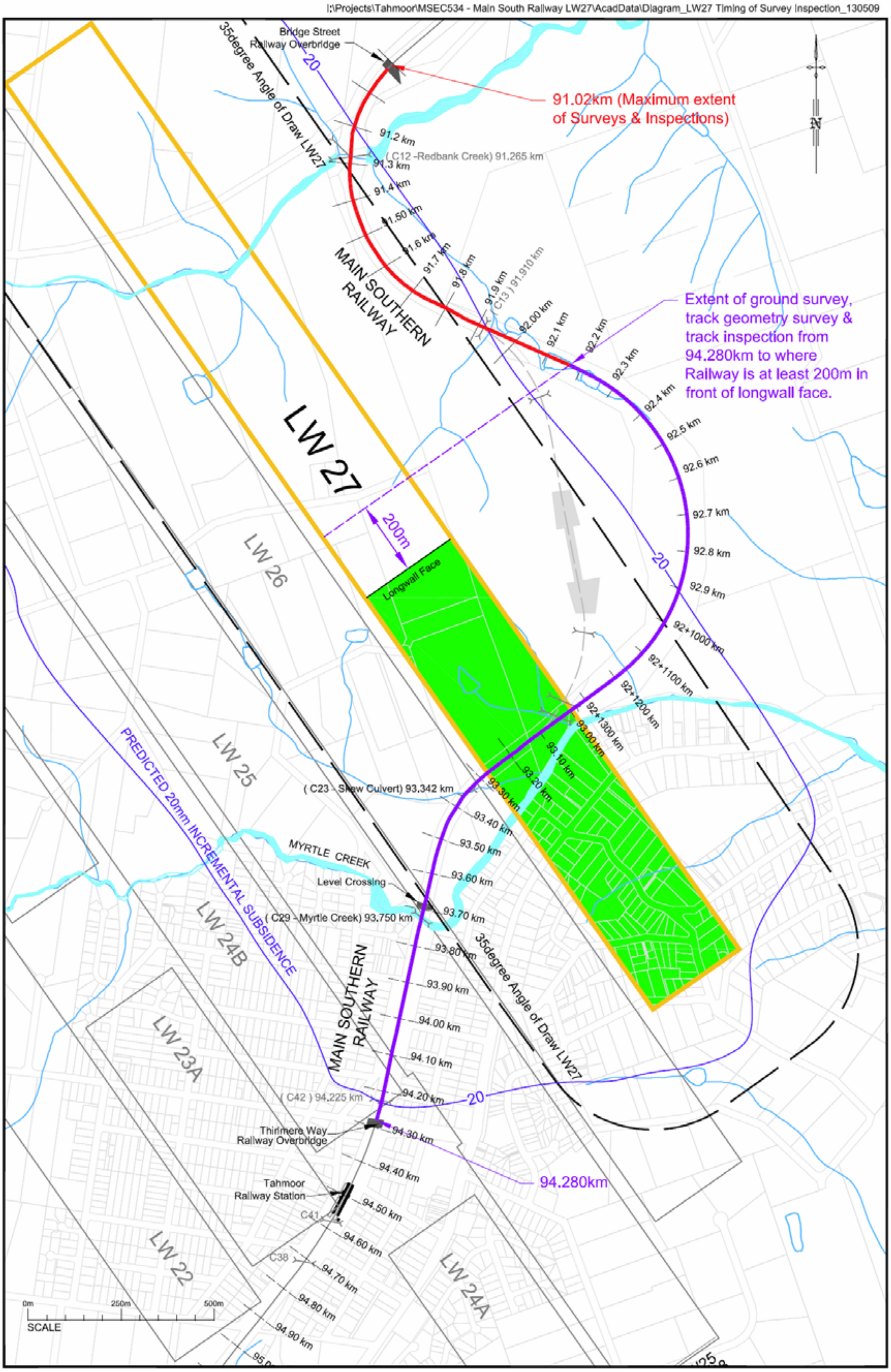


Fig. 2.1 Extent of surveys and inspection along Main Southern Railway during mining

2.5. Surveys at Redbank Creek

The ability to survey subsidence movements along and across Redbank Creek has been significantly restricted due to refusal of landowners to permit access.

No access to private land is available on the northern bank of Redbank Creek upstream of the Main Southern Railway crossing. On the southern side of Redbank Creek, one landowner has refused access.

The lack of access on the northern bank has led to a reappraisal of the monitoring strategy for Redbank Creek, as it is not possible to install survey lines across the valley.

The revised strategy is to monitor valley closure over long bay lengths using absolute and relative 3D survey techniques. A survey line has been installed with pegs spaced approximately every 50 metres along the southern side of the valley, where the land has already been cleared. Valley closure can be calculated from changes in horizontal distance between these pegs and those located every 20 metres along Bridge Street.

A partial cross line has been installed above Longwall 26 along a fence line, where surveyors have found a clear line of sight to Bridge Street from the southern bank. A complete cross line has also been installed within the rail corridor and at three other locations downstream of the railway crossing. These cross line will provide information on the distribution of valley closure across Redbank Creek plus enable the surveyors to connect between the two main monitoring lines.

A 3D baseline survey has been undertaken in absolute coordinates and a final end of panel survey will also be undertaken in absolute coordinates. A local, relative 3D survey will be undertaken on a weekly basis for pegs located directly above Longwall 27.

2.6. Surveys at the Railway Cutting

Ground survey marks have been installed in the Railway Cutting in the new Deviation. The purposes of the surveys are listed below:

- to provide a baseline survey prior to the majority of subsidence movements that will develop at the cutting during the mining of Longwalls 28 and 29; and
- to detect potential differential subsidence movements across the identified fault near 92.85 km in the cutting face on the Up side. The fault cannot be seen in the face of the cutting of the Down (south–eastern) side and it is not known if the fault extends from the Up side directly under the track.

Pegs have been installed and initially surveyed in the cutting at the locations shown in Drawing No. MSEC534-02 and the monthly surveys have been undertaken. The ground surveys are undertaken by Meadows Consulting.

The ground surveys are part of a broader monitoring plan that includes daily track geometry surveys and visual inspections in the vicinity of the fault and rail stress gauges.

2.7. Surveys at the Railway Embankment

Ground survey marks have been installed at the Railway Embankment in the new Deviation. The purpose of the surveys is to measure absolute and differential movements at the embankment, which will provide information areas of focus during visual inspections for signs of distress in the embankment.

The locations of the survey marks are shown in Drawing No. MSEC534-03. All marks have been initially surveyed and the monthly surveys have been undertaken.

The ground surveys within the railway corridor are undertaken by Meadows Consulting. Surveys across Myrtle Creek (MXB and MXC lines) are undertaken by SMEC Urban.

The ground surveys are part of a broader monitoring plan that includes track geometry surveys, visual inspections, rail stress gauges and expansion switch displacement sensors.

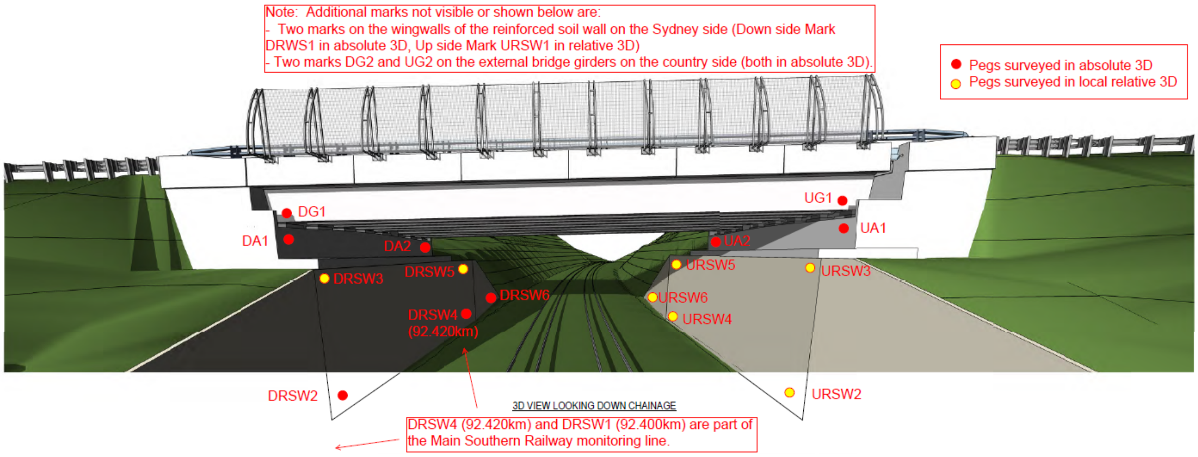
2.8. Surveys of Deviation Overbridge at 92.400 km

A network of pegs have been installed and initially surveyed at the Deviation Overbridge at 92.400 km and the monthly surveys have been undertaken.

A diagram showing the location of survey marks on the Deviation Overbridge is provided in Fig. 2.2. The layout of marks in plan view is shown in Drawing No. MSEC534-02. A photograph showing survey prisms is provided in Fig. 2.3.

The purposes of the surveys are listed below:

- to provide a baseline survey prior to the majority of subsidence movements that will develop at the Overbridge during the mining of Longwalls 28 and 29; and
- to differential movements between the abutments, the reinforced soil walls, the bridge deck, the natural ground and the engineered fill between the abutments and the natural ground behind them.



Design Image courtesy GHD

Fig. 2.2 Location of monitoring points on Deviation Overbridge at 92.400 km

Fig. 2.3 Survey prisms located on abutment and bridge deck of Deviation Overbridge at 92.400 km

2.9. Surveys at Redbank Creek Culvert and Railway Embankment

A network of survey pegs will be installed along the crest and toe of the Redbank Creek Railway embankment prior to 2200 metres of extraction. The locations of the pegs are shown in Drawing No. MSEC534-04. Survey pegs are already installed and initially surveyed along the crest on the Down side and the remainder of the pegs will be installed and surveyed once the vegetation is cleared.

Survey marks will also be placed on the culvert structure in the following locations:

- Marks on both sides of the culvert barrel near the springing points at the inlet and outlet
- Marks on both sides of the tops of the headwalls at the inlet and outlet
- Marks on both ends of wingwalls at the inlet and outlet
- Marks at mid-length of the culvert on both sides of arch near the springing points

The proposed approximate locations of the survey marks at the downstream headwall and wingwalls are indicated in Fig. 2.4 by red dots. The proposed layout at the upstream headwall and wingwalls is similar.

Photograph courtesy David Christie

Fig. 2.4 Proposed locations of monitoring points at downstream headwall and wingwalls of the Redbank Creek Culvert

2.10. Surveys of Telstra Mobile Phone Tower and Optical Fibre line

As described in the Telstra Management Plan, the following survey marks are undertaken of the Telstra Mobile Phone Tower. A map of survey marks in the vicinity of the Tower is shown in

- Survey marks HP41, HP42 and HP43 on the Hilton Park Road survey line
- Survey marks 92.620 km, 92.640 km and 95.660 km on the old Main Southern Railway survey line
- Changes in verticality of the Tower, using a mark at the base of the tower and a reflectorless mark near the top of the Tower.
- Tiltmeters have been installed on the base slab of the Tower.
    - The primary tiltmeters are installed in due North and due West directions.
    - Back-up secondary tiltmeters have been installed. Tiltmeter A1 points to 330 degrees clockwise from north, and Tiltmeter A2 points to 200 degress clockwise from north. These directions match the approximate bearing of the two antennae on the Tower.
    - Data is displayed on the Lynton Surveys website.

It is understood from Telstra that the operating tolerances of the antennae are approximately 1 degree change in tilt. The predicted maximum changes in tilt due to the mining of Longwall 27 are less than 0.1 degrees, which is substantially less than operating tolerances. The predicted maximum changes in tilt due to the mining of all longwalls is approximately 0.3 degrees, which is also well within the operating tolerances of the antennae.

In the extremely unlikely event of tilts occurring that are greater than 1 degree, the following responses can be undertaken:

a) Remote controlled adjustment of the antennae, by rotating supports that connect the antennae to the tower.

b) Manual adjustment of the antennae, if the rotation is greater than the capacity of the rotating supports.

c) Manual adjustment of the lean of the tower by adjusting the bolt cage assembly at the base of the Tower.

A new monitoring line has been installed and initially surveyed along the route of the Telstra Optical Fibre Cable, which runs from the Telstra Mobile Phone Tower to Stilton Lane. The optical fibre cable was re-located as part of the Deviation Works and access was available to install pegs in the first week of June 2013. The locations of the proposed marks along the survey line and are shown in Drawing No. MSEC567-00-03. The pegs will be installed and initially surveyed by the end of June 2013.

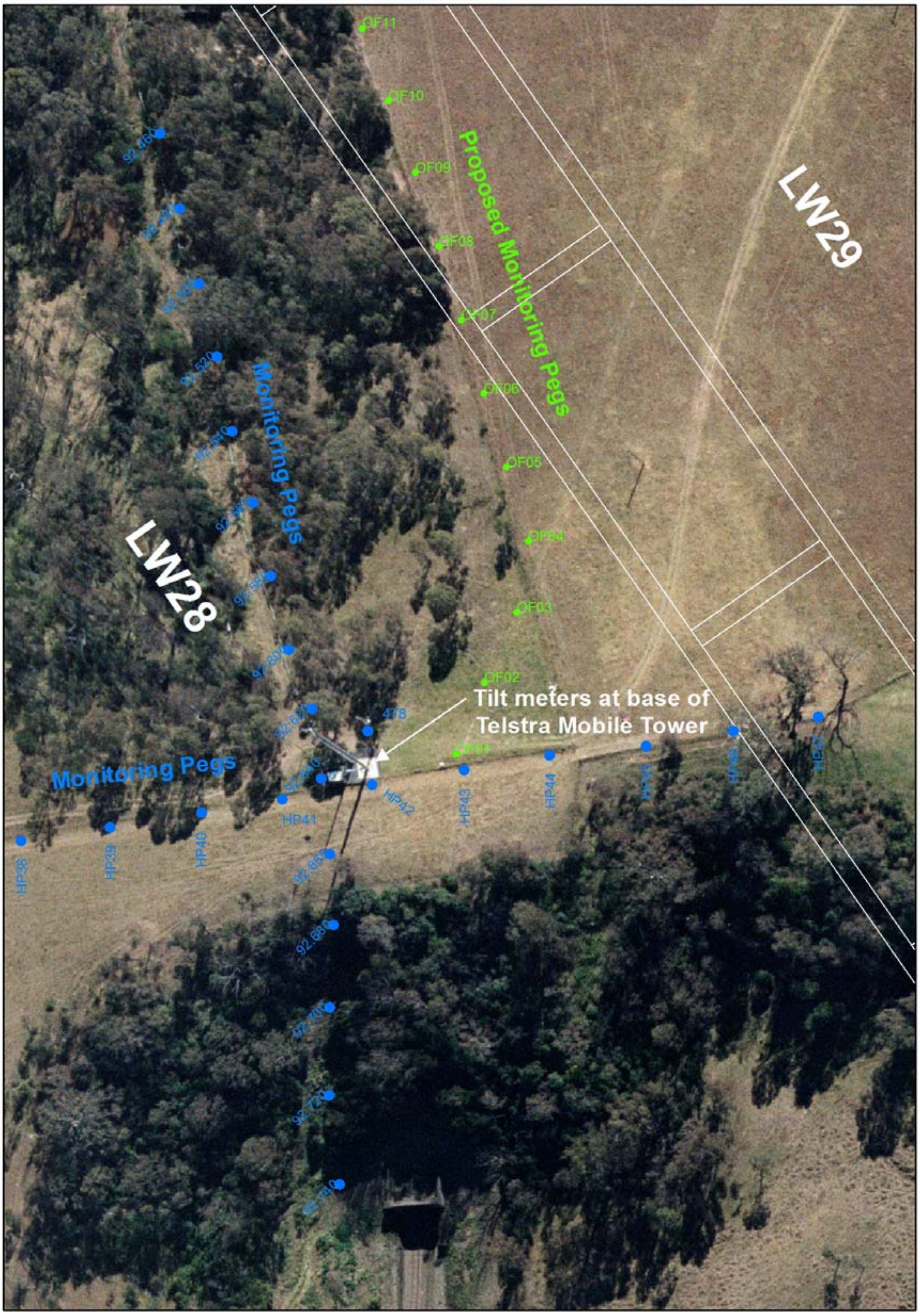


Fig. 2.5 Location of monitoring points in vicinity of Telstra Mobile Tower

Table 2.1 Subsidence Monitoring Programme for Longwall 27

Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
Natural Features			
Myrtle Creek	York St (Y64) survey line *(N.B. Unfortunately, no access has been permitted to the Y67 survey line during the mining of LW27)*	2D subsidence and distance	Weekly within active subsidence zone, commencing after 500m of extraction End of LW27
	Castlereagh-Myrtle survey line	2D subsidence and distance	Weekly within active subsidence zone, commencing after 600m of extraction End of LW27
	Elphin-Myrtle survey line	2D subsidence and distance	End of LW27
	Elphin Street survey line	2D subsidence and distance	End of LW27
	Huen Place survey line	2D subsidence and distance	End of LW27
	Survey lines MXA, MXB and MXC across Myrtle Creek near centreline of LW27 and maingate of LW27	2D subsidence and distance	Install and baseline survey as soon as access was permitted Weekly for lines MXA and MXB within active subsidence zone, commencing after 550m of extraction Monthly for MXC line within active subsidence zone, commencing after 550m of extraction End of LW27
	Survey lines MXD across Myrtle Creek near centreline of LW28 and maingate of LW28	2D subsidence and distance	Install and baseline survey as soon as access was permitted Baseline survey End of LW27
	Visual inspection of Myrtle Creek, including archaeological site 52-2-2078	-	Weekly, commencing after 500m of extraction
Redbank Creek	Absolute and relative 3D survey	Local easting, northing and level to calculate valley closure (refer Section 2.5)	Weekly when within active subsidence zone, commencing after 2100m of extraction End of LW27 for all lines
	Visual inspection of Redbank Creek	-	Weekly, commencing after 2100m of extraction
Wollondilly Council Infrastructure			
Local roads	Ground surveys along streets	2D subsidence and distance	Please refer Dwg. No. MSEC567-00-03 *For street surveys with lines coloured red and labelled as "Surveys during LW27":* Weekly surveys along Remembrance Drive after 350m of extraction Weekly surveys along York Street after 500m of extraction Weekly surveys along Bridge Street after 2300m of extraction For other street survey lines: Conduct surveys every 200m of extraction for survey pegs located within the active subsidence zone, commencing after 200m of extraction *For street surveys with lines coloured yellow and labelled as "Monitoring Lines Before & End of LW27":* Before and end of LW27
	Visual inspections of streets	-	Detailed inspection once a week within the active subsidence zone, commencing after 200m of extraction Vehicle based inspection once a week within the active subsidence zone (on alternate day to detailed inspection), commencing after 200m of extraction
Castlereagh St Bridge	Bridge surveys	2D subsidence and distance	Weekly within active subsidence zone, commencing after 600m of extraction End of LW27
	Castlereagh Street Pegs C54 to C62	2D subsidence and distance	Weekly within active subsidence zone, commencing after 600m of extraction End of LW27
	Castlereagh-Myrtle survey line	2D subsidence and distance	Weekly within active subsidence zone, commencing after 600m of extraction End of LW27
	Detailed visual inspections of bridge	-	Weekly, commencing after 600m of extraction End of LW27
Remembrance Drive Road Bridge and Pedestrian Bridge	Conduct surveys of Bridges, and survey of ground pegs located in the valley sides between the two bridges	2D subsidence and distance	Marks installed on Road Bridge Install marks on Pedestrian Bridge prior to start of LW27 Survey weekly from start of LW End of LW27
	Detailed visual inspections of bridges	-	Weekly from start of LW

Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
Bridge Street Railway Overbridge	Conduct surveys of bridge (note weekly surveys along Bridge Street incl Overbridge, and monthly surveys along Railway incl Overbridge)	2D subsidence and distance	Install marks prior to 2000m of extraction Survey weekly after 2300m of extraction
	Detailed visual inspections of bridge	-	Weekly after 2300m of extraction
Potable Water Infrastructure			
Potable water infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
Water main crossing Myrtle Creek near Castlereagh Street	Visual inspections	-	Twice weekly when crossing is within active subsidence zone
Sewer Infrastructure			
Sewer infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
	Surveys of sewer pipes along Tahmoor Carrier Pipe on private properties behind Remembrance Drive from Peg Y52 to Peg RE74 (shown as a dashed red line in Dwg. No. MSEC567-00-03)	2D subsidence and distance	Install and baseline survey of full length prior to start of LW (if access is available) *For pipe section from northern end of York Street to Tahmoor House Court:* Weekly after 500m of extraction *For full length of survey line:* Every 200m of extraction when within active subsidence zone
	Valley closure and relative vertical height difference at Huen Place and Brundah Rd pipe crossings over Myrtle Creek	Local 2D survey (not linked to datum) of changes in vertical height and horizontal distance	Start and End of LW27
	Survey of ground pegs installed around the perimeter of Pumping Station SP1045	2D subsidence and distance	Weekly, commencing after 600m of extraction End of LW27
	Automated continuous tilt monitoring of chamber wall (9 tiltmeters, consisting of 3 vertical lines in three radial locations, placed at top, base and mid-point)	Vertical tilt	Ongoing, every 10 minutes
	CCTV inspection of Tahmoor and Thirlmere Carrier pipes	-	Tahmoor Carrier (York St and behind Remembrance Drive) – prior to 400m of extraction Thirlmere Carrier (Bridge St) – prior to 2300m of extraction
	CCTV inspections of replaced buried and horizontal bore 225 mm diameter sewer main behind Amblecote Place	-	Baseline after construction of replacement sewer Once after 1000m of extraction
Gas Infrastructure			
Gas infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
Remembrance Drive Bridge over Myrtle Creek	Survey and visual inspections	2D subsidence and distance	As described for Wollondilly Council
Electrical Infrastructure			
Electrical infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
Critical power poles	Power pole surveys, as shown in Drawing No. MSEC567-06-02.	Subsidence at base and vertical offset (or tilt)	Monthly for each pole within active subsidence zone, and for following three months thereafter End of LW27 for all poles within limit of subsidence for panel

Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
Telecommunications Infrastructure			
Telstra infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
	Detailed visual inspections of pits and streets	-	Weekly when active subsidence zone is within Tahmoor urban area, and monthly at other times.
	Ground survey at base of mobile phone tower above former Redbank Railway Tunnel	Subsidence and tilt of the tower	Every 200m of extraction when Tower is within active subsidence zone
	Automated continuous tilt monitoring of mobile phone tower in two orthogonal directions.	Change in tilt	Installed Readings every hour
	Ground survey along path of cable optical fibre cable from Mobile Phone Tower above former Redbank Railway Tunnel to Stilton Lane	2D subsidence and distance	Install and baseline survey of full length after completion of Deviation works End of LW27
Department of Lands			
Permanent survey marks	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
Structures			
Houses, units, public amenities, Business and Commercial Establishments, pools	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
	Visual inspections of specific structures, including pools	Varies depending on structure	Refer Structures Management Plan (Weekly when within active subsidence zone or as required by geotechnical or structural engineer)
No. 55-59 Remembrance Drive, Tahmoor			
55-59 Remembrance Drive, Tahmoor	Ground surveys along Remembrance and York Street outside property	2D subsidence and distance	Weekly surveys along Remembrance Drive after 350m of extraction adjacent to house Weekly surveys along York Street after 500m of extraction adjacent to house
	Visual inspection of house from kerbside	-	Weekly, commencing after 250m of extraction until 850m of extraction
Tahmoor House (27 Remembrance Drive, Tahmoor)			
Tahmoor House	Ground survey of pegs around perimeter of main building (subject to landowner approval)	Local easting, northing and 2D subsidence with levels linked to datum	Install and baseline survey prior to start of LW (subject to landowner approval) Weekly survey after 500m of extraction End of LW27
	Visual inspections of Tahmoor House, including tilt measurements of column and internal distance measurements across the roof	-	Weekly after 500m of extraction

Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
Main Southern Railway			
Railway Track	3D ground survey along rail corridor *Initial extent from 92.600 km to 94.280 km and then extend to the north to include pegs that are at least 200 metres in front of the longwall face, up to 91.02 km (Bridge Street Overbridge). Refer Fig. 2.1.* *Note: Pegs have been installed up to 92.440 km and are in the process of being extended further to the north as access permits.*	Subsidence, changes in easting and northing (MGA coordinates)	Monthly after 350m (~400m from track) Full length at end of LW
	2D ground survey along rail corridor *Initial extent from 92.600 km to 94.280 km and then extend to the north to include pegs that are at least 200 metres in front of the longwall face, up to 91.02 km (Bridge Street Overbridge). Refer Fig. 2.1.*	2D subsidence and distance	Weekly after 550m, (~220m from track) Full length at end of LW
	Second 2D ground survey along rail corridor *Extent of survey is based on active zone of ground movement from previous survey results*	2D subsidence and distance	Weekly after 750m at alternate day to Tahmoor weekly 2D survey so that the 2D/3D survey frequency is twice a week. Survey will not be undertaken if there has been less than 10m of LW progress within 3 days of the previous Weekly 2D survey
	Conduct 3D ground survey of survey lines along tops, benches and base of cuttings. Pegs every 20m, with additional pegs located where monitoring lines intersect identified geological structures (Refer Drawing No. MSEC534-02 for peg locations).	Subsidence, changes in easting and northing (MGA coordinates)	Monthly after installation
	Conduct 3D ground survey of embankment monitoring lines at 92+1340 km km and 92+1180 km, and monitoring line along the toe of the embankment on the Down side (Refer Drawing No. MSEC534-03 for peg locations)	Subsidence, changes in easting and northing (MGA coordinates)	Monthly after 550 m of extraction
	Conduct 2D survey of MXB and MXC survey lines across Myrtle Creek	2D subsidence and distance	As described for Natural Features
	Conduct 2D ground surveys of monitoring lines along streets in Tahmoor. *Includes, in particular, Remembrance Drive*	2D subsidence and distance	As described for Wollondilly Council
	Rail creep surveys of expansion switches, anchor points and CWR track	Rail creep (differential horizontal longitudinal movement between rails and ground)	Monthly after 350m of extraction (~400m from track) Weekly after 550m of extraction (~220m from track)
	2D long bay length surveys between anchor points, expansion switches and two additional 100 metre long bays beyond the last anchor points	2D distance	Monthly after 350m of extraction (~400m from track) Weekly after 550m of extraction (~220m from track)
	Continuously monitor rail stress, rail temperature and switch displacement *Extent from 92.740 km to 94.280 km and from 91.193 km to 91.900 km*	Rail stress, rail temperature and switch displacement	Every 5 minutes • 92.740 km to 94.280 km is installed and operational • Install and commission 91.193 km to 91.900 km prior to 1700m
	Track geometry surveys using Amber track mounted device or equivalent *Initial extent from 92.400 km to 94.280 km and then extend to the north to include track that is at least 200 metres in front of the longwall face, up to 91.02 km (Bridge Street Overbridge). Refer Fig. 2.1.*	Superelevation (cant), twist, gauge	Monthly after 350m (~400m from track) Weekly after 550m (~220m from track_ Twice weekly after 750m (~25m from track)
	Track geometry surveys using Amber track mounted device or equivalent between 92.600 km and 92+1000 km where a geological fault may intersect the railway track.	Superelevation (cant), twist, gauge	Daily after 800 m
	Track inspection by qualified track certifier *The extent of visual inspections is the same as the extent of track geometry surveys. Refer Fig. 2.1.*	The inspection will check ARTC infrastructure within the rail corridor, including the track, track expansion system, integrity of monitoring systems, culverts, cuttings, embankments and fences	Twice weekly after start of LW27 Daily after 650m of extraction (~125m from track)
Myrtle Creek Culvert and Skew Culvert	3D survey of points inside and around the outside of Myrtle Creek Culvert, including downstream and upstream monitoring lines	3D survey: subsidence, changes in easting and northing (MGA coordinates) 2D survey: subsidence and distance	Monthly after 350m of extraction
	3D survey of points inside and around the outside of Skew	3D survey: subsidence, changes in easting and northing	Monthly after 350m of extraction

Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
	Culvert, including downstream and upstream monitoring lines	(MGA coordinates) 2D survey: subsidence and distance	
	Local 3D survey of points inside and around the outside of Skew Culvert, including downstream and upstream monitoring lines	Local easting, northing and level	Weekly after 550m of extraction
	Tape extensometer monitoring in Myrtle Creek Culvert and Skew Culvert	Changes in distance	Myrtle Creek Culvert: Monthly after 350m of extraction Skew Culvert: Monthly after 350m of extraction, weekly after 550m of extraction
	Continuously monitor structural steel stress in Myrtle Creek Culvert	Steel stress,	Hourly
	Visual inspection of track, culvert, headwalls and embankment (including look to side of baulk) of Myrtle Creek Culvert	-	Monthly after 350m of extraction
	Visual inspection of track, culvert, headwalls and embankment of Skew Culvert, including measurement of crack gauges	-	Monthly after 350m of extraction weekly after 550m of extraction
Other culverts and embankments	Survey changes in level and horizontal distance between survey marks installed at the inlet and outlet of the new Deviation concrete pipes after installation	2D subsidence and distance	Baseline survey complete End of LW
	Measure gaps between the pipe joints of the new Deviation concrete pipes after installation	Steel tape or caliper	Baseline survey complete
Redbank Creek Culvert and Embankment	Ground surveys along the crest and toe of the embankment on the Up and Down sides of the Redbank Creek Culvert and the culvert structure.	3D survey: subsidence, changes in easting and northing (MGA coordinates)	Monthly after 2200m of extraction
	Tape extensometer monitoring in Redbank Creek Culvert	Changes in distance	Monthly after 2200m of extraction
Bridge Street Railway Overbridge	Conduct surveys of bridge (note weekly surveys along Bridge Street incl Overbridge, and monthly surveys along Railway incl Overbridge)	2D subsidence and distance	As described for Wollondilly Council
Deviation Overbridge at 92.400 km	3D survey of abutment and bridge deck at locations shown in Fig. 2.2. *Note: Pegs DRSW1 and DRSW4 on base of reinforced soil wall on Down side will also be surveyed in absolute 3D as part of the main railway corridor survey line.*	Subsidence, changes in easting and northing (MGA coordinates)	Initial survey complete Monthly surveys
	Local relative 3D survey of bridge abutment, bridge deck and reinforced soil wall at locations shown in Fig. 2.2. *Note: Surveyor will attempt to record positions of these survey marks in absolute easting and northing*	Local easting, northing and level	Initial survey complete Monthly surveys

APPENDIX A. DRAWINGS

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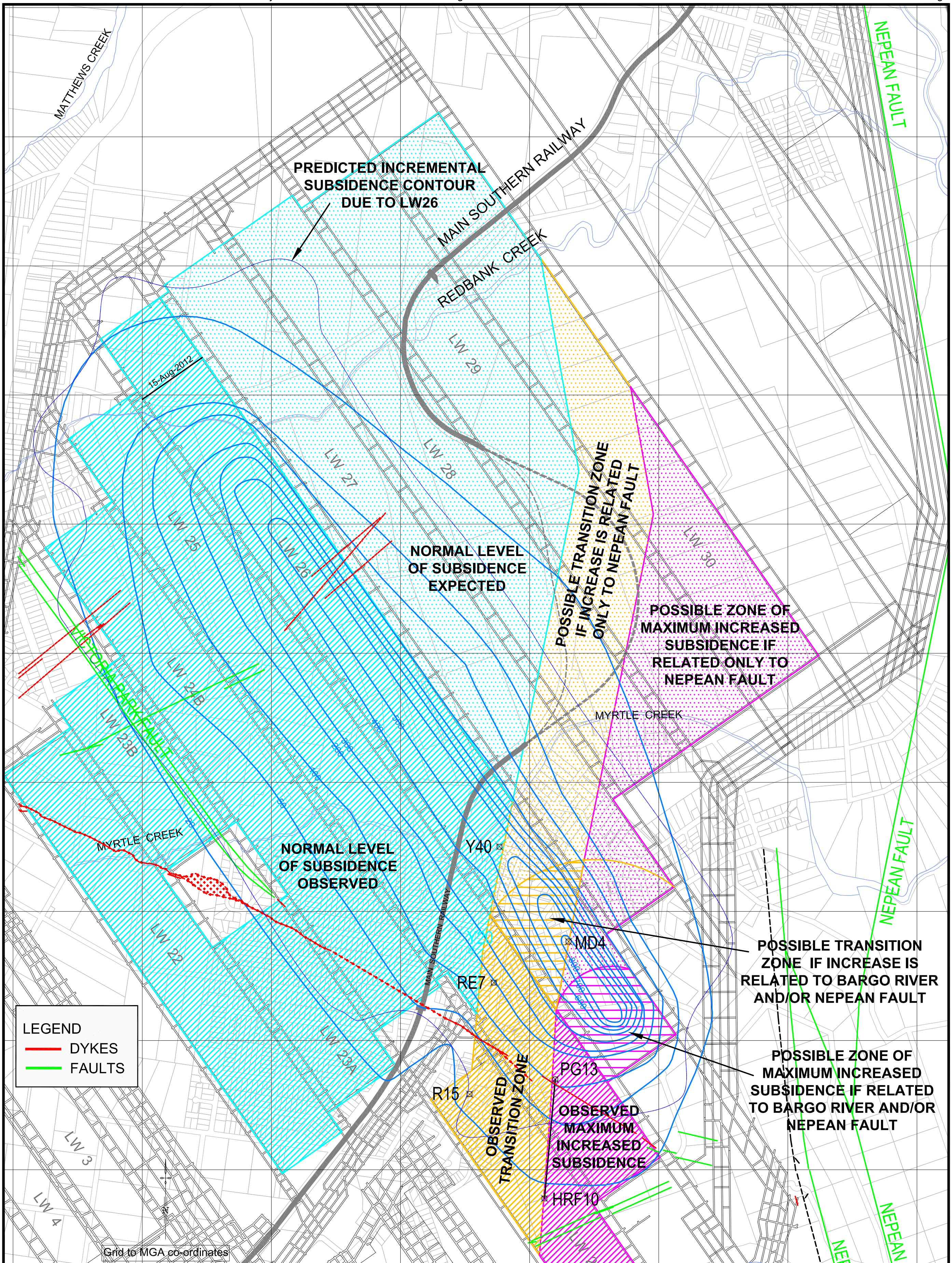

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xstrata coal

TAHMOOR COLLIERY

TAHMOOR NORTH - LONGWALL 27
OBSERVED INCREMENTAL SUBSIDENCE
DUE TO LW26 AS AT 15-AUG-2012

DATE:	SCALE:	DRAWING No:	Rev No
23-Aug-2012	1:20000	MSEC567-00-01	A

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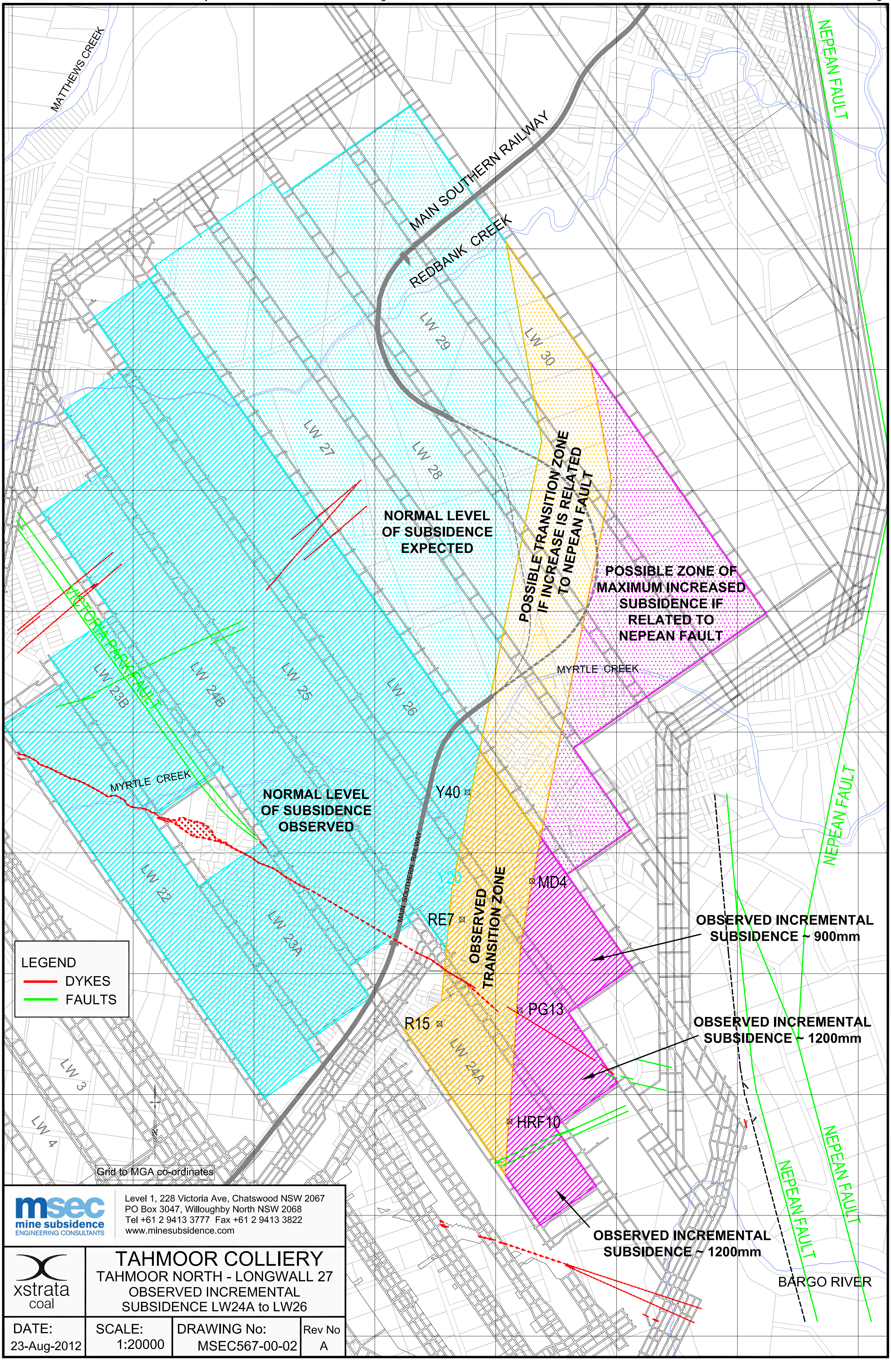

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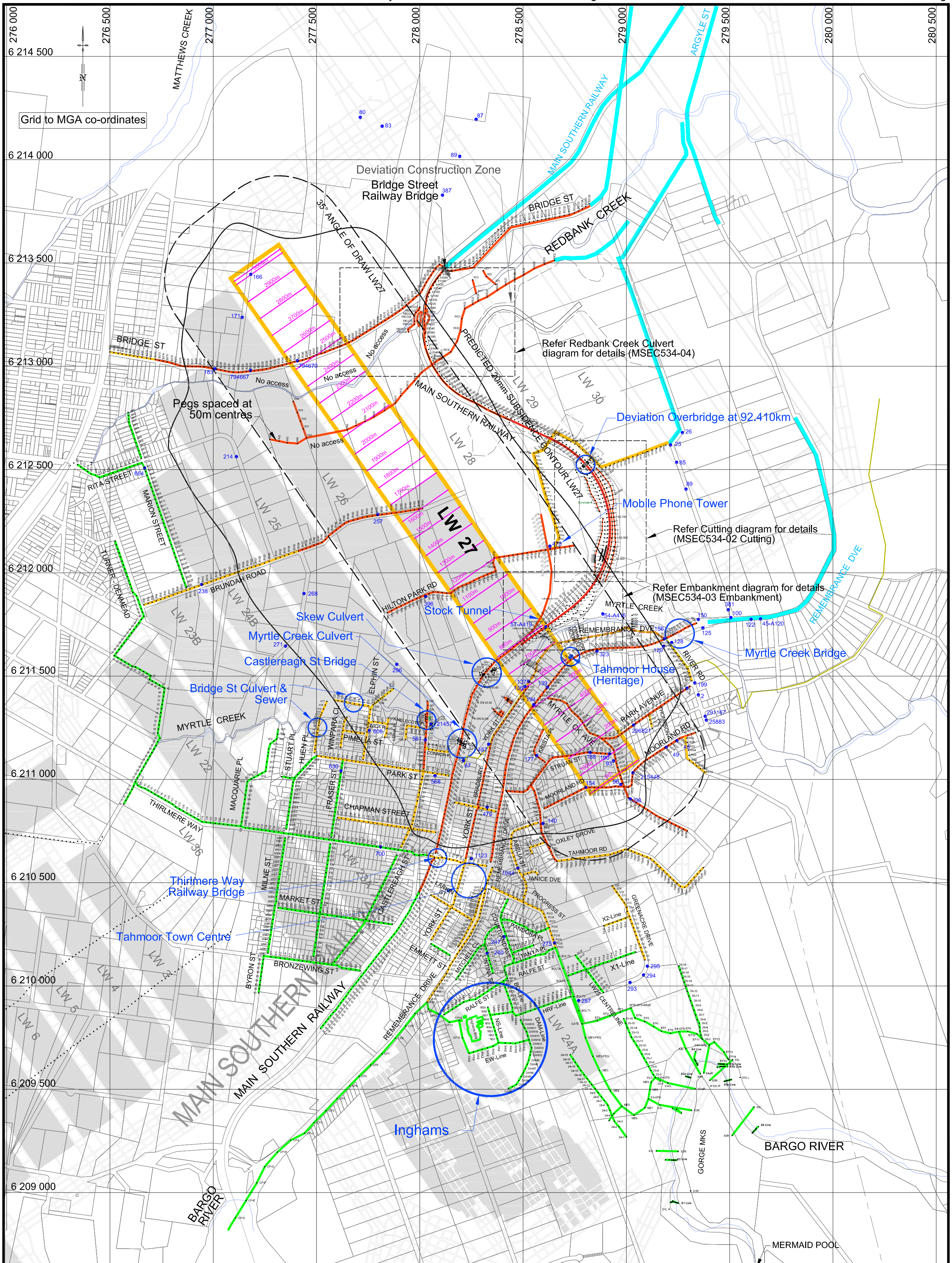

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TAHMOOR COLLIERY

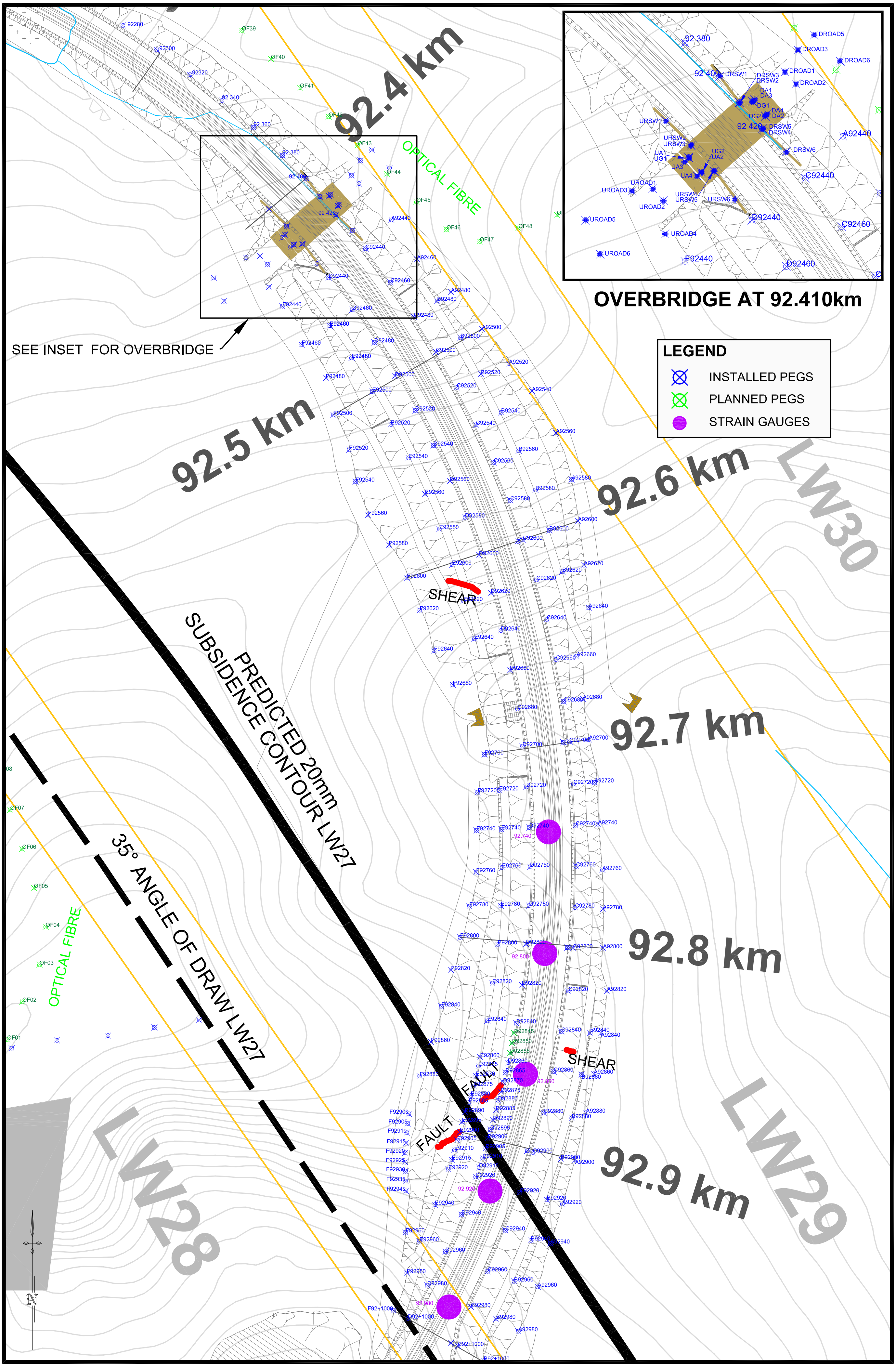
TAHMOOR NORTH - LONGWALL 27 MONITORING OVER LW27

DATE:	SCALE:	DRAWING No:	Rev No
15-Aug-2013	1:25000	MSEC567-00-03	I

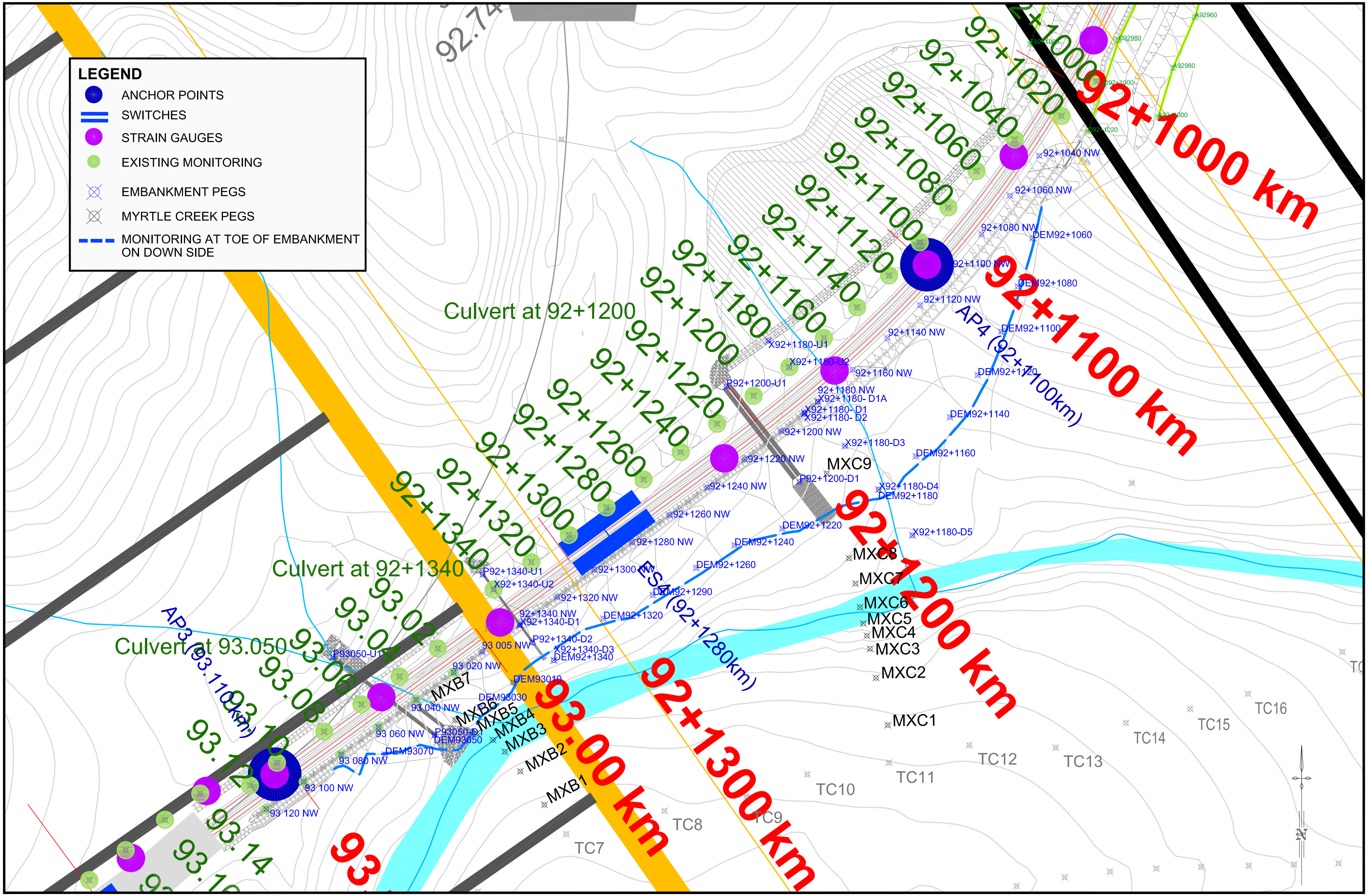
LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW27
- Monitoring Lines Before & End of LW27
- Surveys During LW27
- Critical Power Poles
- Specific Structure Inspections

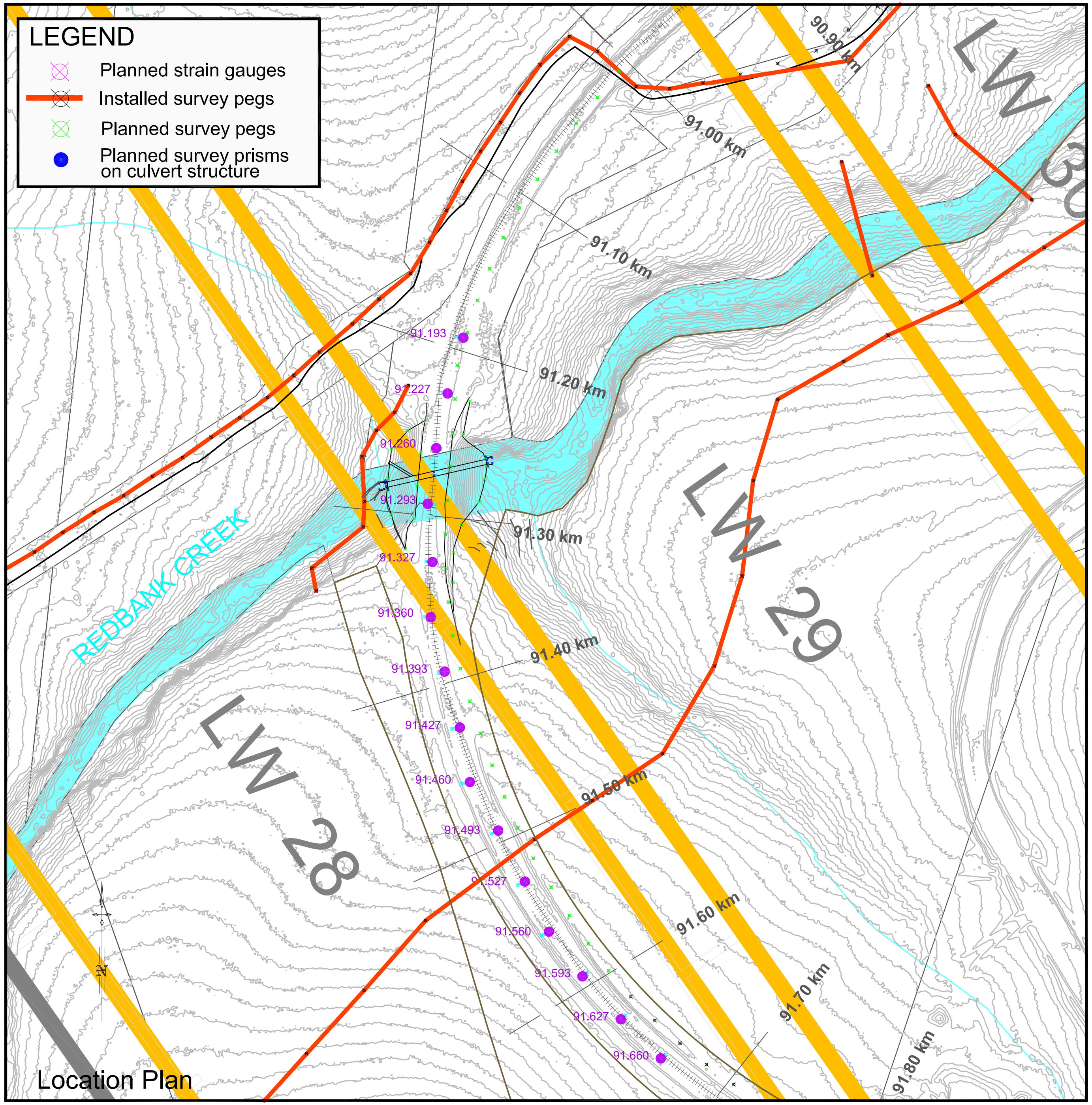
Refer to Management Plans for Timing & Frequencies

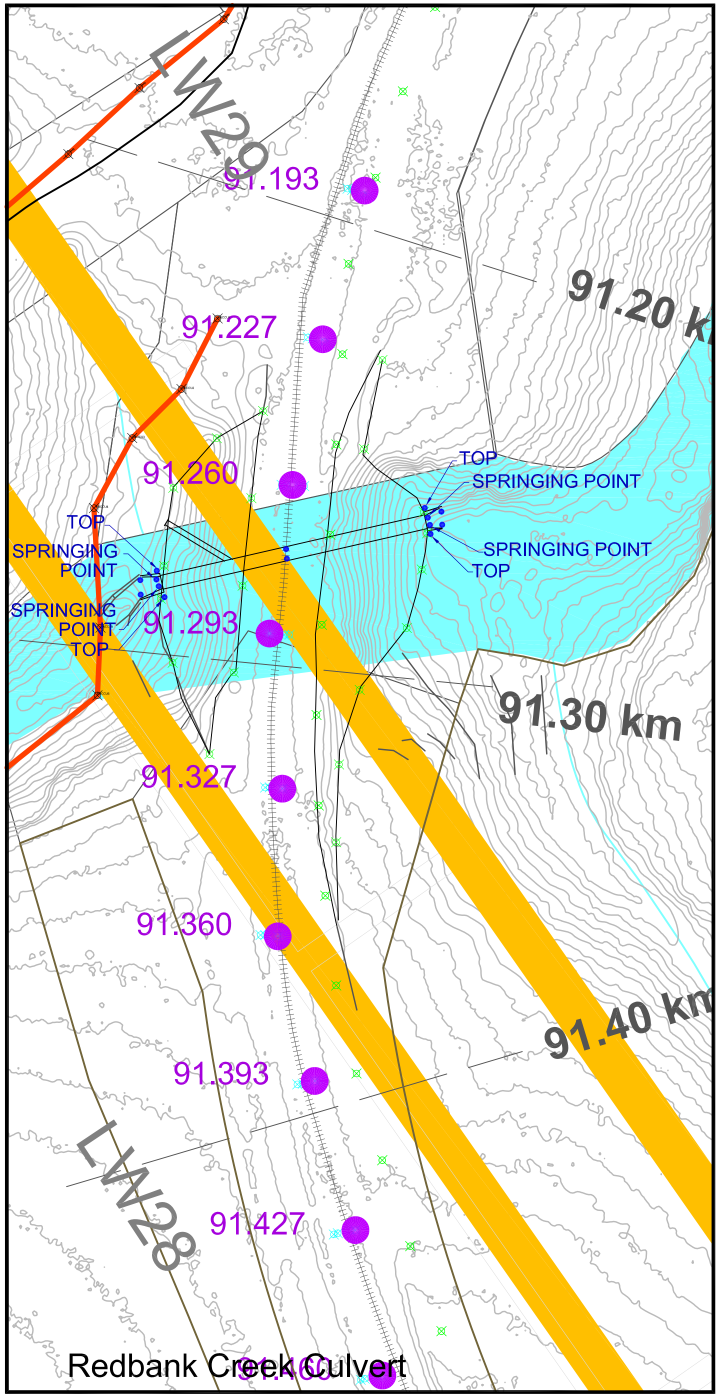


MSEC534-02 LW27 RAILWAY MANAGEMENT PLAN - CUTTING - REVISION D



MSEC534-03 LW27 RAILWAY MANAGEMENT PLAN - EMBANKMENT - REVISION B





MSEC534-04 LW27 RAILWAY MANAGEMENT PLAN - REDBANK CREEK CULVERT - REVISION C

APPENDIX B.
SURVEY SPECIFICATION BY SMEC URBAN

SPECIFICATIONS FOR SUBSIDENCE MONITORING LINES FOR LONGWALL 27

1. General Requirements

1.1. All surveys will be provided to the Tahmoor Colliery Mining Survey as digital Excel file/s.
1.2. *Survey and Drafting Directions for Mine Surveyors 2007(NSW Coal)* In particular *Section 3. (Survey Procedures)* will be complied with (see. www.dpi.nsw.gov.au/minerals and use search).

2. Required Surveys

2.1. Levels to Australian Height datum (AHD) on each station of the subsidence line. (In order to obtain subsidence.)
2.2. Measured distance between each station of the subsidence line. (In order to obtain strains.)
2.3. MGA Co-ordinates of each station of subsidence lines where possible. (In order to obtain horizontal movement).
2.4. Valley closure stations at (or substitute stations placed in 'open-sky' positions) close to the top of the northern side of Bargo River Gorge shall be MGA coordinated. (In order to obtain horizontal movement before & after mining.)

3. Establishment

3.1. Each line will be established and initial readings taken prior to the influence of mine subsidence affecting the subsidence line; a minimum distance of 1000m from longwall extraction may be used as a guide. This timeframe will be nominated by Tahmoor Colliery and installation time frames agreed.
3.2. Care is to be taken that bench marks and control stations (GPS base stations) will be unaffected by ground movement (subsidence & horizontal movement) from future mining or current Longwall extraction. The location of these bench marks and control stations should be confirmed with Tahmoor Colliery before use.
3.3. In addition to 3.2. Control stations (GPS base stations) used for measurement of upsidence and valley closure at the top and bottom of Bargo River Gorge shall be minimum 1km from Bargo River Gorge.

4. Surveying Methods

4.1. ICSM SP1 refers to The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 "Standards and Practices for Control Surveys".
(see http://www.icsm.gov.au/icsm/publications/sp1/sp1v1-7.pdf)

4.2. One, or a combination of, the following survey methods may be used and target accuracy must be achieved. Primarily EDM survey methods will be used where possible. Other survey methods are included herein in the event that they are required in specific circumstances. Conventional subsidence method is currently only planned to be used around Ingham's plant buildings due to access limitations.

4.3. EDM Methods ~ For both Subsidence & Strain and Three Dimensional Survey Traversing

4.3.1. Conventional Theodolite/EDM levelling traverse for measuring subsidence & strain.
4.3.2. Additional survey for three dimensional location of subsidence marks by conventional Theodolite/EDM traverse adjusted between GPS Baseline(s).
4.3.3. Height Datum to be carried through traverse by height traversing.
4.3.4. Maximum traverse line length 150 metres.
4.3.5. Maximum intermediate line length 80 metres.

4.3.6. Target at each subsidence station to generally be either a handheld miniprism or prism & fixed pole with dual-support for stability.

4.4. Conventional Subsidence Method.

4.4.1. Distances between stations (In order to obtain strains.) measured by a standardised steel band with corrections made for sag and temperature.
4.4.2. Alternatively, particularly in steep terrain or where there are objects on ground between stations that prevent steel band measurement. Distances between stations (In order to obtain strains.) measured by EDM.
4.4.3. Subsidence will be measured to the target accuracy and will start and finish on datum unaffected by ground movement (subsidence).
4.4.4. Levels will be measured with a digital level, lengths of back sights and foresights are to be equal and no more than 50m.
4.4.5. The digital level will be tested to prove it is in adjustment immediately prior to use.
4.4.6. This method is currently only planned to be used around Ingham's plant buildings due to access limitations.

4.5. GPS Survey Control for Three Dimensional Survey of Subsidence Lines:

4.5.1. Establishment of Site GPS Base Stations. Site Base Stations located not closer than 2 kilometres from active subsidence.
4.5.2. Site GPS Base Stations are to be monitored periodically (typically start and end of Long Walls) by connection to an established stable 'outer' network of GPS Stations.
4.5.3. GPS Baselines are to be surveyed relative to a Site GPS Base Station. Baselines are then used for the adjustment of Theodlite/EDM traverse lines locating subsidence marks in three dimensions (MGA~AHD).

4.6. Bargo River Gorge:-

4.6.1. Bargo river gorge is heavily vegetated. Relative survey is carried out both for Valley closure across the top of the gorge and also over selected rockbars within the gorge.
4.6.2. Relative movement of valley closure and upsidence is measured, where possible, by theodolite/EDM survey from stations placed at the top of the northern side of the Gorge.
4.6.3. Where relative survey from the top to the bottom of the gorge is impossible, due to terrain considerations, valley closure and rockbar surveys are carried out independently of each other.
4.6.4. Valley Closure is measured to fixed reflectors placed in rock on the southern side of the Gorge.
4.6.5. Relative survey, where possible, from the top to the bottom of the gorge is carried out by theodolite/EDM. Height differences and slope/horizontal distances are measured in both directions and in both theodolite faces.
4.6.6. Valley closure stations (or substitute stations placed in 'open-sky' positions) close to the top of the northern side of Bargo River Gorge shall be surveyed for MGA coordinates relative to Site GPS Base Station. (In order to obtain horizontal movement before & after mining.)

5. Target Accuracies

5.1. Target Accuracies for monitoring surveys shall be as follows:
Differential Levelling (Digital Level) - 1.5mm per kilometre of double run.
Differential Levelling (Theodolite) to an accuracy of ±5mm.
5.1.1. Strain distances measured to an accuracy of ±5mm (Strain 0.25mm/m over a 20 m bay) for measurement by EDM/theodolite traverse & to an accuracy of ±2.5mm (Strain 0.13mm/m over a 20 m bay) for measurement by steel band.
5.1.2. Traversing shall be minimum Class D or LC as prescribed in ICSM SP1 or better.
5.1.3. Co-ordinates derived from horizontal movement surveys (by traverse &/or GPS) shall have an absolute accuracy of ± 20mm or better (Relative two dimensional accuracy of ± 5mm).

5.1.4. The horizontal distance between the Bargo Gorge valley closure monitoring points will be surveyed to an accuracy of ± 5 mm. The relative vertical height between the points will be surveyed to an accuracy of ± 10 mm.

5.1.5. The surveys along the rockbar monitoring lines along the base of the Bargo gorge will be surveyed to an accuracy of ± 3 mm (horizontal or vertical) from the local datum. The datum will be connected to AHD where possible from survey marks at the tops of the Gorge to an accuracy of ± 10 mm. The survey marks at the tops of the Gorge are connected to AHD along monitoring lines that extend beyond the subsidence area, in accordance with Section 5.1.1.

6. Subsidence Station Placement

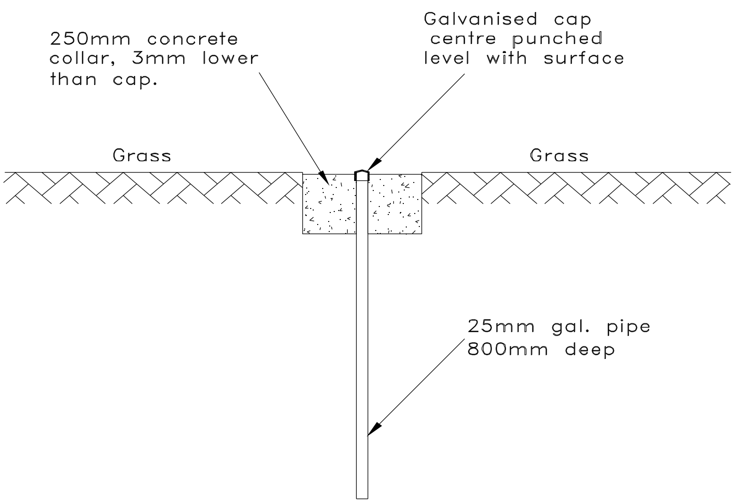
6.1. Installation. Subsidence stations are to be installed level or below the ground and in such a way so as not to become a danger or hazard (to the public, railway employees or other persons).

6.2. Location. Subsidence stations are to be installed in locations that will not be damaged or run over by vehicles. Where subsidence stations are located in a position near where vehicles or other equipment may access, the location of the subsidence station should be clearly indicated with an adjacent stake or other warning marker.

6.3. Spacing. All subsidence stations are to be placed at nominal 20 metre intervals and in a straight line where possible.

6.4. Line length. The subsidence line will cover the area affected by mining and shall be specified by Tahmoor Colliery.

6.5. Station type. The subsidence stations are generally to be 20mm diameter galvanised pipe, approximately 800mm length, driven into the ground, capped and centre punched (or rivet placed), together with a concrete collar (as shown below).
Where an area of bitumen or concrete needs to be crossed marks may be installed as a galvanized iron nail, ramset nail or drill hole.
Mini prisms or equivalent, attached permanently to rock, can be used for the Bargo River Gorge.



6.6. Placement in footpaths and locations of Utility/Service providers. Utilities and services are not to be damaged by the subsidence stations.

6.6.1. Railway Corridor. The location of utilities and services needs to be ascertained from the appropriate rail authority and confirmed prior to installation of the subsidence survey line.

7. Monitoring frequency

The lines will be established and surveyed initially before subsidence affects the line.

Various timing for resurvey frequency may be requested by the Tahmoor Colliery based on the requirements of the Subsidence Management Plans. The frequency may be 3 monthly, 1 monthly, bi-weekly, weekly or daily.

A final survey will be completed at the end of each longwall before the area is affected by extraction of the next adjacent longwall.

Please refer to Tahmoor Colliery Subsidence Management Plans for survey frequencies.

8. Reports

The following information shall be included in the report:

8.1. Date of survey.
8.2. Name, location and RL of bench mark and or GPS Base station used.
8.3. When requested a summary stating maximum values of subsidence, tensile(+ve) strain, compressive(-ve) strain and horizontal movement of the current survey. Reports can also state if any visual subsidence impacts were observed.
8.4. Excel table showing subsidence results of current survey. This is to be supplied as digitally.
8.5. Single graph showing subsidence of all resurveys. This is to be supplied as a digital Excel file.
8.6. Single graph showing strain of all resurveys. This is to be supplied as a digital Excel file.
8.7. Any other relevant information required by the Surveyor.

9. Additional Information

Tahmoor Colliery will provide an AutoCAD file of the Mine Workings if required.
Tahmoor Colliery will provide an Excel file to be used as a template.

Yours faithfully,

SMEC Urban
per .. **Gary Warren**
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APPENDIX C.
SURVEY SPECIFICATION BY MEADOWS CONSULTING

Meadows Consulting Pty Ltd
Suite A2 / 674 Princes Hwy
Sutherland 2232

04 June 2013

Main Southern Rail Line- Survey Monitoring Plan for LW27

This document defines the Survey Monitoring Plan for the Main Southern Rail Line at Tahmoor with regard to the mining of Longwall 27 for Tahmoor Coal Pty Ltd.

This plan has been developed in consultation with the rail monitoring sub-committee, taking into account the concurrent monitoring activities planned for the rail corridor (strain gauges, expansion switches, manual and mechanized track inspection etc.). The survey measurements are designed to supplement these tasks and support the overall monitoring regime.

Survey marks are a combination of galvanized pipe/star picket flush with the ground or raised star picket (driven at least 800 mm's into ground) with fixed prism or steel spigot. The noise wall survey marks are fixed prisms attached to steel supporting beams. The base and bench survey marks with cutting are steel rod, drilled and epoxy anchored with a fixed prism.

Proposed track kilometrage range and monitoring frequencies are defined in the Tahmoor LW27 Railway Subsidence Management Plan. Methodologies are defined in Table below.

SURVEY REPORTING

Survey results will nominally be reported within 24 hours of the completion of survey. Results will be forwarded electronically in Excel spreadsheets (.xls and .xml files) to relevant parties.

John Rolles
Surveyor

Location	Description	Targeted Accuracy / Survey Methodology
Main South Railway	Absolute 3D survey in MGA coordinates Survey Stations established at 20m nominal centres in rail corridor	Absolute 3D determined by static GPS Leica system 1200 receivers and TCRA 1102 traversing. Absolute 3D accuracy Position +/- 10mm Vertical +/- 10mm Relative 3D accuracy Position +/- 5mm Vertical +/- 5mm
	2D subsidence survey. Survey Stations established at 20m nominal centres in rail corridor	Vertical Accuracy: Class LC (SP1). Stains +/- 0.25mm/m (for 20m bays) Levels and strains determined by Leica TCRA1102 total station (2.0 second angular resolution, +/- 2mm and 2 ppm distance) or higher.
	Rail Creep. Survey longitudinal creep at anchor points. Survey switch bearer creep at each switch	Creep +/- 2mm using corridor marks
	Long Bays. Survey long bays from expansion switch to anchor points for each switch	Stains +/- 3 mm for long bays
Myrtle Creek and Skew Culvert	Absolute 3D monitoring of upstream, downstream, inside and outside marks in MGA coordinates	Absolute 3D determined by static GPS Leica system 1200 receivers and TCRA 1102 traversing.
	Local 3D monitoring of upstream, downstream, inside and outside marks	Local 3D with Leica TCRA1102 total station (2.0 second angular resolution, +/- 2mm and 2 ppm distance) or higher.
Redbank Creek Culvert	Absolute 3D monitoring of survey lines along top and base of embankment on both sides in MGA coordinates.	Absolute 3D determined by static GPS Leica system 1200 receivers and TCRA 1102 traversing.
Embankment Monitoring	Absolute 3D monitoring of embankment sections, along noise wall and along toe of embankment on Down side in MGA coordinates	Absolute 3D determined by static GPS Leica system 1200 receivers and TCRA 1102 traversing.

Location	Description	Targeted Accuracy / Survey Methodology
New Deviation Culvert Monitoring	Level and horizontal distance changes between inlet/outlets	Levels and distances determined by Leica TCRA1102 total station (2.0 second angular resolution, +/- 2mm and 2 ppm distance) or higher.
	Measure gaps at pipe joints	Caliper measurements
Deviation Cutting	Absolute 3D monitoring of survey lines along top, benches and bases of cutting on both sides in MGA coordinates.	Absolute 3D determined by static GPS Leica system 1200 receivers and TCRA 1102 traversing.
Deviation Overbridge	Absolute 3D monitoring of marks on abutments and bridge deck in MGA coordinates. *Note: Pegs DRSW1 and DRSW4 on base of reinforced soil wall on Down side will also be surveyed in absolute 3D as part of the Main Railway Corridor survey line.*	Absolute 3D determined by static GPS Leica system 1200 receivers and TCRA 1102 traversing.
	Relative 3D monitoring of marks on and around Overbridge, including abutments, bridge deck, reinforced soil walls, fill and natural ground behind approaches to Overbridge	Local 3D with Leica TCRA1102 total station (2.0 second angular resolution, +/- 2mm and 2 ppm distance) or higher.