mine subsidence ENGINEERING CONSULTANTS

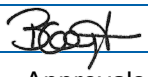
TAHMOOR UNDERGROUND GLENCORE

GLENCORE:

# Tahmoor Colliery - Longwall 31

Subsidence Monitoring Programme – Revision A

## AUTHORISATION OF MANAGEMENT PLAN

| **Authorised on behalf of Tahmoor Colliery:** | |
|---|---|
| Name: | Belinda Treverrow |
| Signature: |  |
| Position: | Approvals and Community Coordinator |
| Date: | 27/06/2017 |

## 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. |
| Mar-14 | MSEC646-00 | A | Draft for Longwall 28 |
| Mar-14 | MSEC646-00 | B | Final for Longwall 28 |
| Sep-14 | MSEC646-00 | C | Updated for Longwall 28 to include Redbank Creek Culvert and Bridge Street Overbridge |
| Nov-14 | MSEC646-00 | D | Updated for Longwall 28 following feedback from DTIRIS |
| Mar-15 | MSEC746-00 | A | Updated for Longwall 29 |
| May-15 | MSEC746-00 | B | Updated re Stilton Dams |
| Sep-15 | MSEC746-00 | C | Updated for Longwall 29 to include Redbank Creek Culvert and Bridge Street Overbridge |
| Sep-15 | MSEC746-00 | D | Updated for Redbank Creek surveys |
| May-16 | MSEC815-00 | A | Updated for Longwall 30 |
| Sep-16 | MSEC815-00 | B | Updated following review of Redbank Creek Culvert and Bridge Street Overbridge |
| Dec-16 | MSEC815-00 | C | Updated following completion of PSMPs for Picton Industrial Area |

| Date | Report No. | Rev | Comments |
|---|---|---|---|
| Apr-17 | MSEC815-00 | D | Updated following consultation with QVMH |
| Apr-17 | MSEC815-00 | E | Updated following consultation with DRE |
| Apr-17 | MSEC815-00 | F | Updated following consultation with DRE |
| Apr-17 | MSEC815-00 | G | Updated following consultation with DRE |
| Jun-17 | MSEC862-00 | A | Updated for Longwall 31 |

References:-


AS/NZS 4360:1999 Risk Management

MSEC (2014) Tahmoor Colliery Longwalls 31 to 37 - Subsidence Predictions and Impact Assessments for Natural and Built Features in support of the SMP Application. (Report MSEC647, Revision A, December 2014), prepared by Mine Subsidence Engineering Consultants.

CONTENTS

## LIST OF TABLES, FIGURES AND DRAWINGS

### Tables

Tables are prefaced by the number of the chapter in which they are presented.



### Figures

Figures are prefaced by the number of the chapter or the letter of the appendix in which they are presented.

**Drawings**

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

| *Drawing No.* | *Description* | *Revision* |
|---|---|---|
| MSEC862-00-01 | Monitoring over LW30 | B |
| MSEC863-03 | Main Southern Railway Monitoring Plan for LW31 | A |
| MSEC863-05 | Deviation Embankment Monitoring Plan for LW31 | A |
| MSEC863-06 | MSR Rail Cutting Monitoring Plan for LW31 | A |
| MSEC863-07 | Redbank Creek Culvert and Embankment Monitoring Plan for LW31 | A |
| MSEC863-08 | Bridge Street Cutting and Overbridge Monitoring Plan for LW31 | A |
| MSEC863-09 | Culvert and Embankment at 90.676 km Monitoring Plan for LW31 | A |
| MSEC863-10 | Culvert and Embankment at 90.252 km Monitoring Plan for LW31 | A |
| MSEC863-11 | Culvert and Embankment at 89.800 km Monitoring Plan for LW31 | A |
| MSEC862-15-02 | Stilton Dams Monitoring | A |
| MSEC862-18 | Picton WRP Monitoring Plan | B |
| MSEC815-17-01 | Queen Victoria Memorial Home – Ground survey locations within QVMH complex | E |
| MSEC815-17-02 | Queen Victoria Memorial Home – Ground survey locations | B |
| MSEC815-17-03 | Queen Victoria Memorial Home – Asbestos Air Monitoring | C |

## 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 Glencore. Tahmoor Colliery has previously mined 30 longwalls to the north and west of the mine's current location.

Longwall 31 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.

Longwall 31 is approximately 283 metres wide (rib-to-rib) and approximately 2.5 kilometres long. The width of the chain pillar between Longwalls 30 and 31 is 39 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 31 – Environmental Management Plan* (Revision 0), June 2017.
- *Tahmoor Colliery Longwall 31 Wollondilly Shire Council Management Plan* (Revision C), Report No. MSEC862-02, June 2017.
- *Tahmoor Colliery Management Plan for Potential Impacts to Potable Water Infrastructure due to the mining of Longwall 31* (Revision B), Report No. MSEC862-03, March 2017.
- *Tahmoor Colliery Management Plan for Potential Impacts to Sydney Water Sewer Infrastructure due to the mining of Longwall 31* (Revision B), Report No. MSEC862-04, March 2017.
- *Tahmoor Colliery Management Plan for Potential Impacts to Gas Infrastructure due to the mining of Longwall 31* (Revision B), Report No. MSEC862-05, April 2017.
- *Tahmoor Colliery Management Plan for Potential Impacts to Endeavour Energy Infrastructure due to the mining of Longwall 31* (Revision A), Report No. MSEC862-06, June 2017.
- *Management Plan Longwall Mining (LW 31) beneath Telstra Plant @ Tahmoor and Thirlmere NSW*, Colin Dove, March 2017.
- *Tahmoor Colliery Management Plan for Potential Impacts to LPI Survey Control Marks due to the mining of Longwall 31* (Revision A), Report No. MSEC862-11, June 2017.
- *Tahmoor Colliery Management Plan for Potential Impacts to Built Structures due to the mining of Longwall 31* (Revision A), Report No. MSEC862-12, June 2017.
- *Tahmoor Colliery Management Plan for Potential Impacts to Koorana Homestead Complex due to the mining of Longwall 31* (Revision A), Report No. MSEC862-13-01, May 2017.
- *Tahmoor Colliery Management Plan for Potential Impacts to 155 Stilton Lane due to the mining of Longwall 31* (Revision A), Report No. MSEC862-15, June 2017.
- *Tahmoor Colliery Management Plan for longwall mining beneath the Main Southern Railway, Revision A (Longwall 31)*, Report No. MSEC863, April 2017.

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 conventional subsidence movements were provided in Report No. MSEC647, which was prepared in support of Tahmoor Colliery's SMP Application for Longwalls 31 to 37, and includes predictions due to the extraction of Longwall 31.

A summary of the maximum predicted incremental conventional subsidence parameters after the extraction of Longwall 31, is provided in Table 1.1. A summary of the maximum predicted total conventional subsidence parameters after the extraction of Longwalls 22 to 31, is provided in Table 1.2.

**Table 1.1 Maximum Predicted Incremental Conventional Subsidence Parameters due to the Extraction of Longwall 31**

| 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) |
|---|---|---|---|---|
| Due to LW31 | 725 | 5.5 | 0.06 | 0.12 |

**Table 1.2 Maximum Predicted Total Conventional Subsidence Parameters after the Extraction of Longwall 31**

| Longwall | Maximum Predicted Total Subsidence (mm) | Maximum Predicted Total Tilt (mm/m) | Maximum Predicted Total Hogging Curvature (1/km) | Maximum Predicted Total Sagging Curvature (1/km) |
|---|---|---|---|---|
| After LW31 | 1225 | 6.0 | 0.09 | 0.13 |

The values provided in the above table are the maximum predicted total conventional subsidence parameters which occur within the general longwall mining area, including the predicted movements resulting from the extraction of Longwalls 22 to 31.

## 1.4. Observed Subsidence during the mining of Longwalls 22 to 30

The extraction of longwalls at Tahmoor Colliery has generally resulted in mine subsidence movements that were typical of those observed above other collieries in the Southern Coalfield of NSW at comparable depths of cover.

However, observed subsidence was greater than the predicted values over Longwalls 24A and the southern parts of Longwalls 25 to 27. Please refer to details provided in the LW29 Subsidence Monitoring Programme (Report No. MSEC746-00, Revision D).

Monitoring during the mining of Longwalls 28, 29 and 30 have found that subsidence behaviour has returned to normal levels.

Ground surveys will continue to be undertaken above Longwall 31. The survey results will be checked against predictions to confirm whether subsidence continues to develop in a normal manner during the mining of Longwall 31.

## 2.1. Layout of Monitoring Points

The layout of monitoring points is provided in Drawing No. MSEC862-00-01, which is included in Appendix A. Due to the density of survey marks, detailed layouts of monitoring points for key items of railway infrastructure are also included in Appendix A.

## 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 31*, by SMEC. 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 LW31* by Southern Rail Surveys. This specification is appended to this Subsidence Monitoring Programme.

Occasionally survey pegs become disturbed or lost. Tahmoor Colliery will replace the lost pegs unless approval for not replacing the pegs is provided by the NSW Department of Planning and Environment, Resources Regulator, Mine Safety Operations (MSO).

With respect to specialist monitoring undertaken within the railway corridor, including automated monitoring of rail stress, rail temperature and switch displacement, and automated total station monitoring in the vicinity of the geological fault at 92.850 km, please refer to details provided in the Railway Management Plan (Report No. MSEC863).

## 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 31*, by SMEC and *Main Southern Rail Line- Survey Monitoring Plan for LW31*, by Southern Rail Surveys. These specifications are appended to this Subsidence Monitoring Programme.

Survey results will be issued to MSO within 2 business days 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 31. This is described in Section 4.3 of the Railway Management Plan (Report No. MSEC863) and summarised as follows:

- Stage 1 – Early subsidence period
  - Monthly ground surveys are undertaken at survey marks nominally when the longwall face approaches to within 400 metres of each section of railway track.
- Stage 2 – Active subsidence period
  - Weekly ground surveys are undertaken at survey marks nominally when the longwall face approaches to within 200 metres of each section of railway track.
- Stage 3 – Post active subsidence period
  - Progressive reduction in monitoring and inspection frequencies and extents for the railway track, embankments, culverts and cuttings, in accordance with the Railway Management Plan
  - Progressive reduction does not commence until the longwall face has passed each section of track by more than 400 metres, and subject to a review of actual monitoring data and approval by ARTC via the governance meeting.

As mining progresses, monitoring measures for each section of track or associated rail infrastructure will progressively migrate from Stage 1 to Stage 2 and, subject to approval by ARTC, Stage 3. An example of the staged monitoring process is provided in Fig. 2.1.

In the case of the Main Southern Railway, when Stage 3 is reached for each section of track or item of infrastructure, Tahmoor Colliery will not reduce monitoring frequencies or stop monitoring until agreed by ARTC (via recommendation by the Rail Management Group). ARTC can agree to the proposed reduction during an ARTC / Tahmoor Colliery governance meeting as recorded by minutes of the meeting and reconfirmed separately in writing or email. MSO and the Office of the National Rail Safety Regulator (ONRSR) will be informed of the change separately in writing.

In the case of other infrastructure, survey and inspection frequencies will not be reduced until agreed by MSO and relevant stakeholders, unless stated in the attached Table 2.1 of this Monitoring Programme.

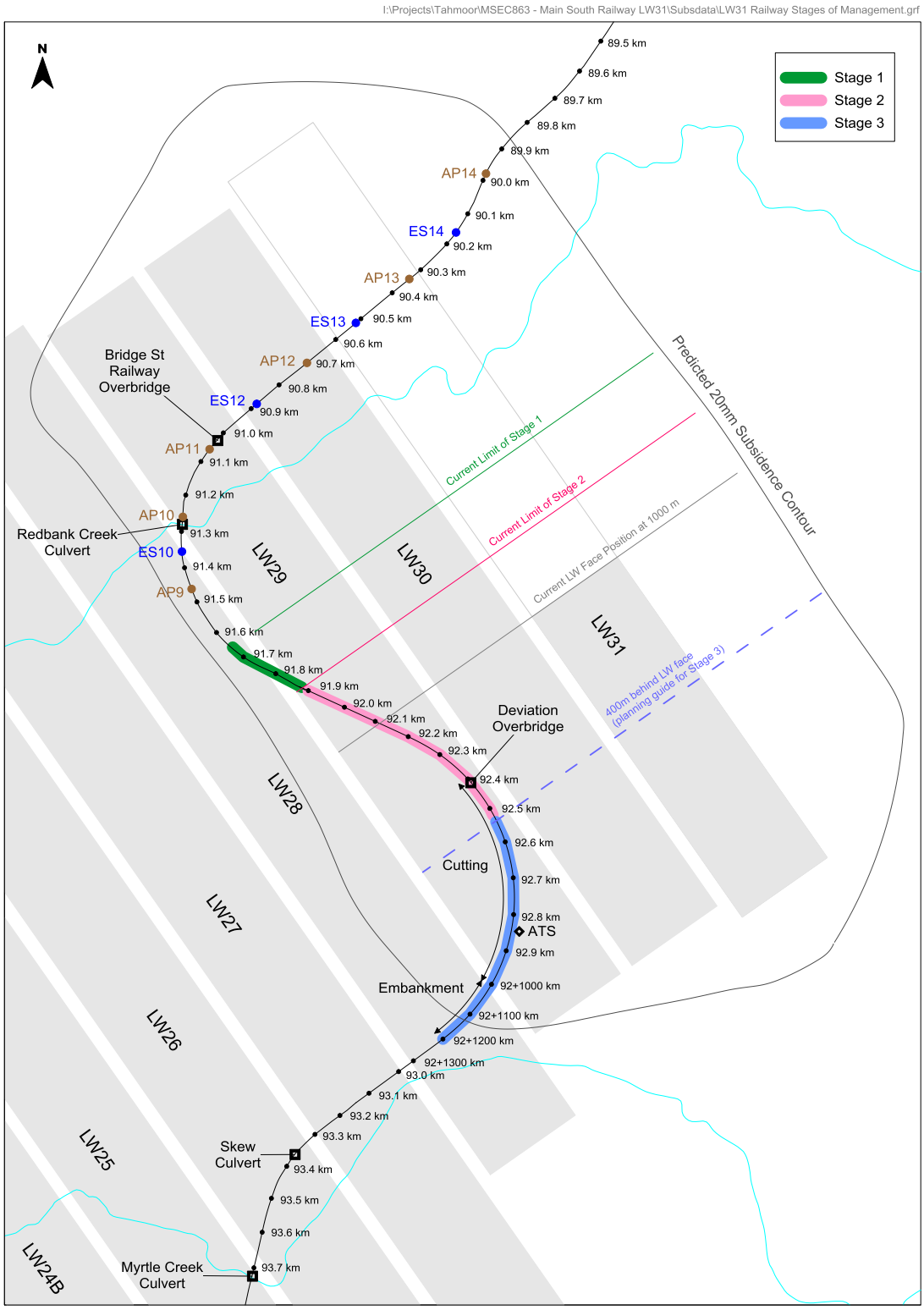



**Fig. 2.1 Conceptual diagram showing stages of management during mining of Longwall 31 at 1000 metres of extraction**

## 2.5. Surveys at Redbank Creek

Monitoring of valley closure over long bay lengths is conducted using absolute and relative 3D survey techniques. The RK 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.

The RK Line ends at Henry Street, after which the survey line along Henry Street will be used to calculate valley closure.

A partial cross line has been installed above previously extracted 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 two other locations downstream of the railway crossing. These cross lines will provide information on the distribution of valley closure across Redbank Creek plus enable the surveyors to connect between the two main monitoring lines.

Following a review of valley closure data after the mining of Longwalls 29 and 30, it is proposed to maintain the survey methodology adopted for Longwalls 28 to 30, which is to focus weekly surveys for the section of Redbank Creek above Longwalls 30 to 32, with monthly survey above Longwall 29 to the extent of monitoring at the corner of Henry Street and Argyle Street. The following surveys are proposed on either side of Redbank Creek:

- Prior to 1300m of extraction, baseline absolute 3D survey new pegs along Henry Street, new pegs extended along Bridge Street northeast of Peg BG126, and new pegs along the THC Line between Redbank Place and Remembrance Drive (Argyle Street).
- Monthly relative 3D surveys from Pegs RK18 to RK40, ST48 to ST70 and from Pegs BG78 to BG144 after 1300 metres of extraction
- Weekly relative 3D surveys from Pegs RK24 to RK40, ST48 to ST61 and from Pegs BG95 to BG144 after 1500 metres of extraction.
- Absolute 3D survey at completion of Longwall 31.

## 2.6. Surveys at the Railway Cutting

Ground survey marks have been installed in the Railway Cutting in the new Deviation.

Pegs have been installed in the cutting at the locations shown in Drawing No. MSEC863-06, and will be surveyed during the mining of Longwall 31. The surveys will be undertaken by traditional ground survey across the full monitoring site by Southern Rail Surveys.

In addition to the above, automated total station monitoring of track geometry will be undertaken in the vicinity of the fault at 92.850 km. Prisms are spaced every fourth sleeper (nominally 2.4 metres apart) as shown in Fig. 2.2.

The total stations also measure selected prisms on the cutting faces and benches at the locations shown in Fig. 2.2.

The monitoring system consists of the following features:

- Two automated total stations (TS1 and TS2). The total stations are located across the track from each other. TS1 is located on top of the bench at the Downside cutting, at the same position that manual total station surveys are undertaken by Southern Rail Surveys, and as such, it can monitor positions of survey prisms on the cutting faces and benches. TS2 is located on top of the bench at the Upside cutting and monitors survey prisms on the Down track.
- Associated loggers, cabling and other electrical and IT support systems.
- An automated weather station at TS1 to record rainfall and atmospheric pressure.
- Readings will be undertaken every 2 hours.

Further details are provided in the Railway Management Plan (Report No. MSEC863).

Photographs of the automated total station system are provided in Fig. 2.3 to Fig. 2.6.

The purposes of the automated total stations are:

- to detect potential differential subsidence movements across the identified fault near 92.850 km on the railway track and on the cutting faces
- to detect ground movements on the cutting face on the Up side in the vicinity of the fault plane, which has been stabilised by reshaping of the batter profile.

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

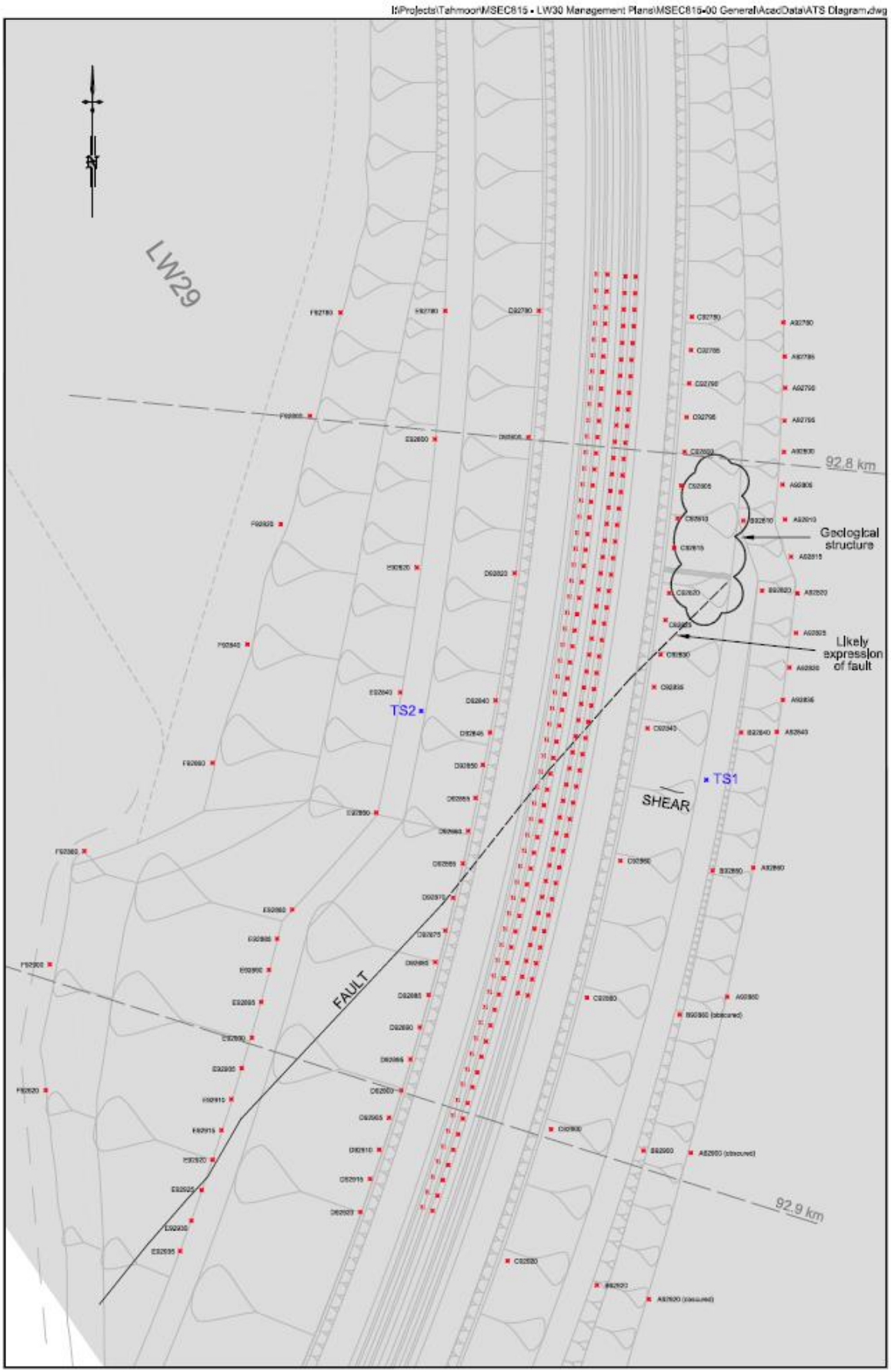



**Fig. 2.2 Location of survey prisms that will be continuously monitored by Automated Total Stations in the Cutting about the geological fault at 92.850 km**

**Fig. 2.3 Total Station 1 with weather station**

**Fig. 2.4 Prisms on Up track looking south facing Total Station 1**

**Fig. 2.5 Typical survey prism on railway sleeper**

**Fig. 2.6 Total Station 1 and 2 across the railway track**

## 2.7. Surveys at the Railway Embankment in the new Deviation

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 on areas to focus on during visual inspections for signs of distress in the embankment.

The locations of the survey marks are shown in Drawing No. MSEC863-05. The marks were installed during the early stages of mining Longwall 27. Due to bulk earthworks to reshape the southern end of the cutting during Longwall 28, new prisms were installed and a baseline survey completed prior to the commencement of Longwall 29.

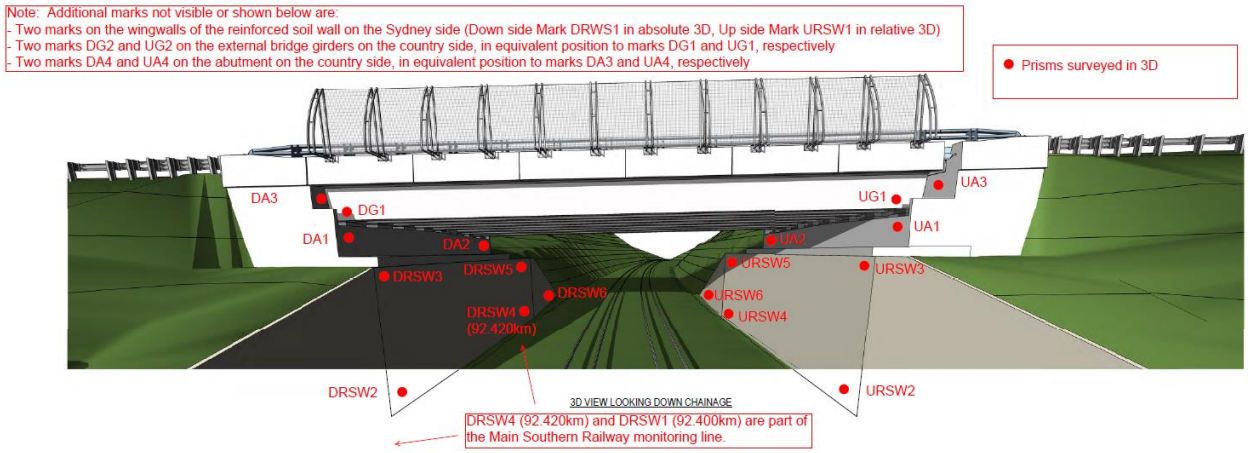
The ground surveys within the railway corridor are undertaken by Southern Rail Surveys.

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 surveyed at the Deviation Overbridge at 92.400 km. A diagram showing the location of survey marks on the Deviation Overbridge is provided in Fig. 2.7. The layout of marks in plan view is shown in Drawing No. MSEC863-06. A photograph showing survey prisms is provided in Fig. 2.8.

The purpose of the surveys is to detect potential 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. 2.7 Location of monitoring points on Deviation Overbridge at 92.400 km**

**Fig. 2.8 Survey prisms located on abutment and bridge deck of Deviation Overbridge at 92.400 km**

## 2.9. Monitoring and inspections at Redbank Creek Culvert and Embankment (RBCC)

A network of pegs has been installed and surveyed at the Redbank Creek Culvert and Embankment during the mining of Longwall 31. The layout of marks in plan view is shown in Drawing No. MSEC863-07.

### 2.9.1. Ground Monitoring

The following ground surveys will be undertaken by Tahmoor Colliery during mining.

- Absolute and relative 3D surveys of the RBCC and the embankment
- Absolute and relative 3D surveys of survey marks within the RBCC.
- Absolute and relative 3D surveys of the RBCC wingwalls and headwalls

Track monitoring will also be undertaken in the vicinity of the RBCC, and this is discussed in the Railway Management Plan.

### 2.9.2. Monitoring of the RBCC and embankment

The following monitoring will be undertaken during the mining of Longwall 31:

- Tape extensometer monitoring within the barrel of the RBCC and across the wingwalls, as per the network installed and monitored during the mining of Longwalls 27 to 30. The layout of the tape extensometer marks is shown in Fig. 2.9.
- Vertical inclinometer monitoring at boreholes RBCC01 to RBCC04 as undertaken during the mining of Longwalls 27 to 30. The locations are shown in Fig. 2.11.
- Horizontal extensometers across the crest of the embankment at three locations shown in Fig. 2.11. Details of the crest extensometers are shown in Fig. 2.10.
- Piezometer monitoring in the open standpipe and at the culvert inlet at the locations shown in Fig. 2.11.
- Visual inspections of the RBCC including the secondary culvert and the embankment during mining by the Track Certifier and geotechnical engineer. The geotechnical engineer will provide guidance for daily inspections by the Track Certifier.

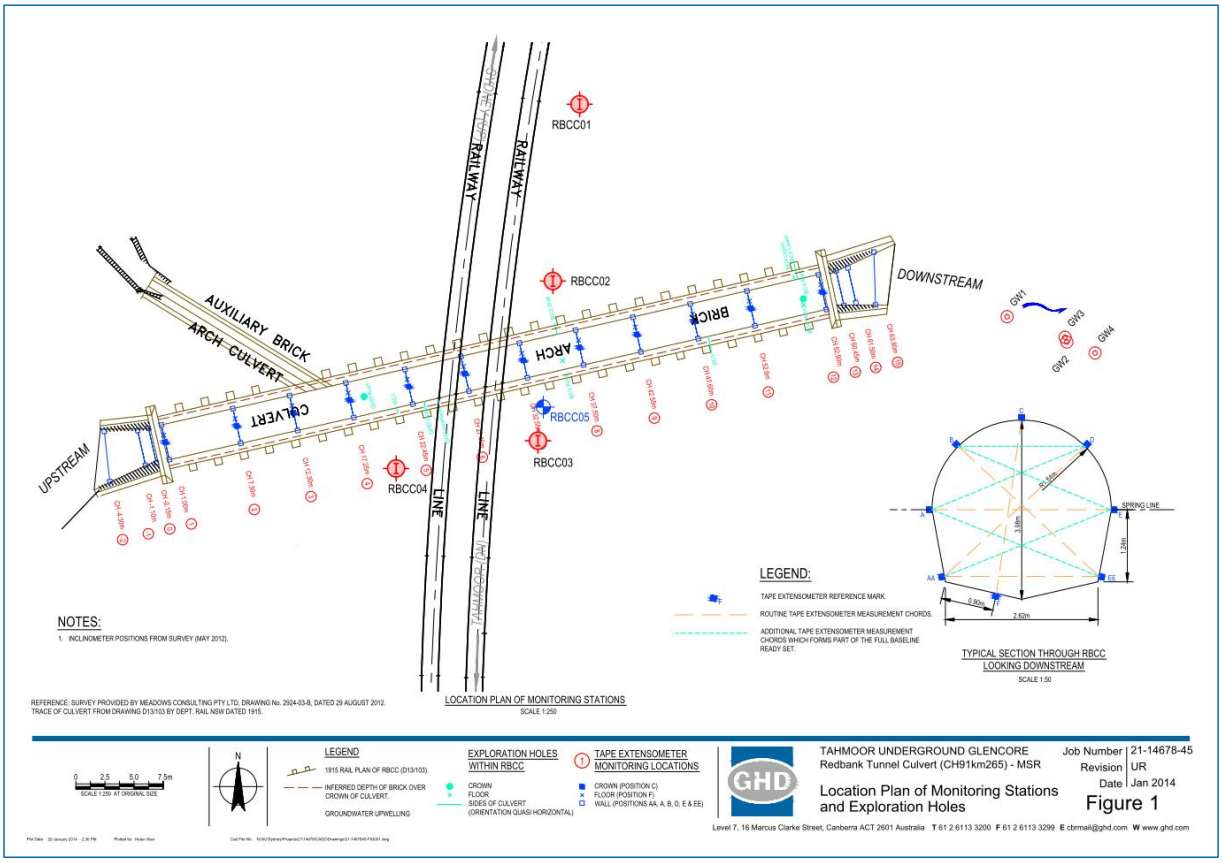



**Fig. 2.9 Location of tape extensometer points within RBCC**

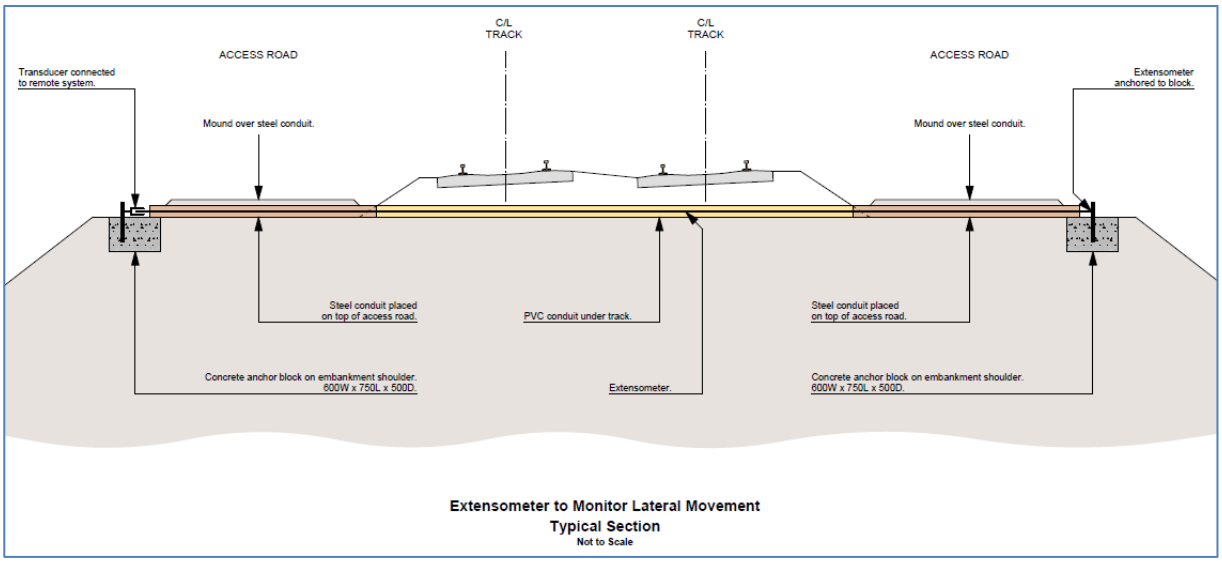



**Fig. 2.10 Details of extensometers installed across the crest of the RBCC embankment**

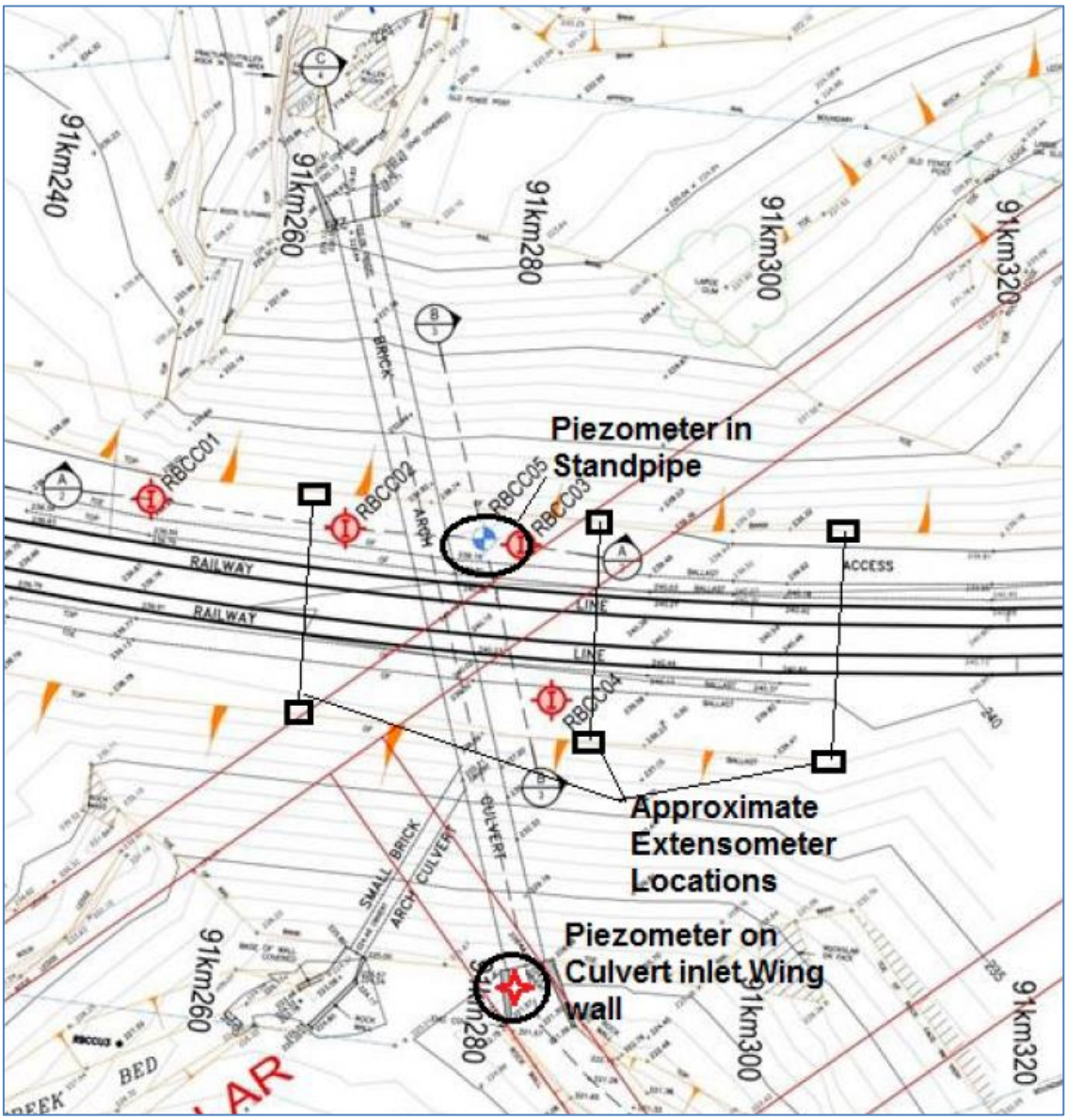



**Fig. 2.11 Locations of crest extensometers and piezometers at RBCC embankment**

## 2.10. Monitoring and inspections of Bridge Street Overbridge

The following monitoring will be undertaken during the mining of Longwall 31:

- Surveys of Overbridge and surrounding ground marks in the cutting.
  The layout of marks in plan view are shown in Drawing No. MSEC863-08. A photograph showing some of the survey prisms is provided in Fig. 2.12.
- The surveys will be undertaken in absolute 3D on a monthly basis during the most active period of subsidence.
- Measurement of gap in expansion joint and vertical distance between bearing and underside of bridge deck.
- Visual inspections of the Overbridge, including bridge bearings.
- Absolute 3D and 2D surveys along a monitoring line along the railway.

**Fig. 2.12 Survey prisms located on abutment and bridge deck of Bridge Street Overbridge at 91.030 km**

## 2.11. Railway Culverts and Embankments at 90.676 km, 90.252 km and 89.785 km

The following monitoring will be undertaken during the mining of Longwall 31, in addition to standard surveys and inspections along the track.

***Culvert and Embankment at 90.676 km***

- Absolute 3D surveys and relative 3D surveys of the culvert and embankment at 90.676 km along monitoring lines at crest and toe of embankment on both sides, as shown in Drawing No. MSEC863-09.
- Absolute 3D and relative 3D surveys along the brick arch culvert, with survey marks located at the spring point on both sides at the outlet, midpoint and inlet of the culvert (six survey marks in total).
- Horizontal extensometer across the crest of the embankment at 90.680 km
- Visual inspection by Track Certifier and geotechnical engineer

***Culvert and Embankment at 90.252 km***

- Absolute 3D surveys and relative 3D surveys of the culvert and embankment at 90.252 km along monitoring lines at crest of embankment on both sides, and along the toe of the embankment on the Down side, as shown in Drawing No. MSEC863-10.
- Visual inspection by Track Certifier and geotechnical engineer

***Culvert and Embankment at 89.785 km***

- Absolute 3D surveys and relative 3D surveys of the culvert and embankment at 89.785 km along monitoring lines at crest of embankment on both sides, and along the toe of the embankment on the Down side, as shown in Drawing No. MSEC863-11.
- Visual inspection by Track Certifier and geotechnical engineer

## 2.12. Bridge Street Industrial, Commercial and Business Precinct

Longwall 31 will extract directly beneath properties within the Bridge Street Industrial, Commercial and Business Precinct. Tahmoor Colliery will develop Property Safety Management Plans (PSMPs) in consultation with landowners for properties that are located within a distance equivalent to the 35 angle of draw of Longwall 31, or predicted limit of subsidence, whichever is greater.

The properties have already been or will be inspected by a structural engineer prior to the development of PSMPs. While the PSMPs will be developed on a case by case basis, they will include regular surveys and visual inspections, similar to the monitoring strategy that was implemented for Longwall 30. Details relating to proposed monitoring of each property will be provided in the PSMPs.

As shown in Drawing No. MSEC862-00-01, ground survey pegs have already been installed on either side of the closest section of the Precinct directly above Longwall 31, and the survey lines will be extended to the east prior to the longwall face approaching within 400 metres of the Precinct, including along Bollard Place. Survey lines have also been installed along Redbank Place and Henry Street.

Ground surveys will be undertaken along Bridge Street up to Peg BG144 on a weekly basis when the section of Bridge Street above Longwall 31 is within the active subsidence zone. Weekly 2D surveys will be undertaken up to 89.740 km when this section of the Railway is within the active subsidence zone.

## 2.13. Surveys of Telstra Mobile Phone Tower and Optical Fibre Cable

As described in the Telstra Management Plan, the following surveys are undertaken with respect to the Telstra Mobile Phone Tower and Optical Fibre Cable. A map of survey marks in the vicinity of the Tower is shown in Drawing No. MSEC862-00-01 and Fig. 2.13.

- Survey marks OF1 to OF53 along the alignment of the Telstra optical fibre cable which runs from the Telstra mobile phone tower to Stilton Lane
- 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.

It is understood from Telstra that the operating tolerances of the antennae are approximately 1 degree change in tilt. The predicted maximum change in tilt due to the mining of Longwalls 28 to 30 is approximately 0.3 degrees, which is well within the operating tolerances of the antennae.

No impacts have been observed during the mining of Longwalls 28 to 30, with maximum mining-induced tilts slightly less than 0.3 degrees. No impacts have been observed at the Towers. The tiltmeters previously deployed at the Tower during the mining of Longwalls 28 to 30 can now be removed.

The locations of the survey marks in the vicinity of the mobile phone tower are shown in Drawing No. MSEC862-00-01 and Fig. 2.13.

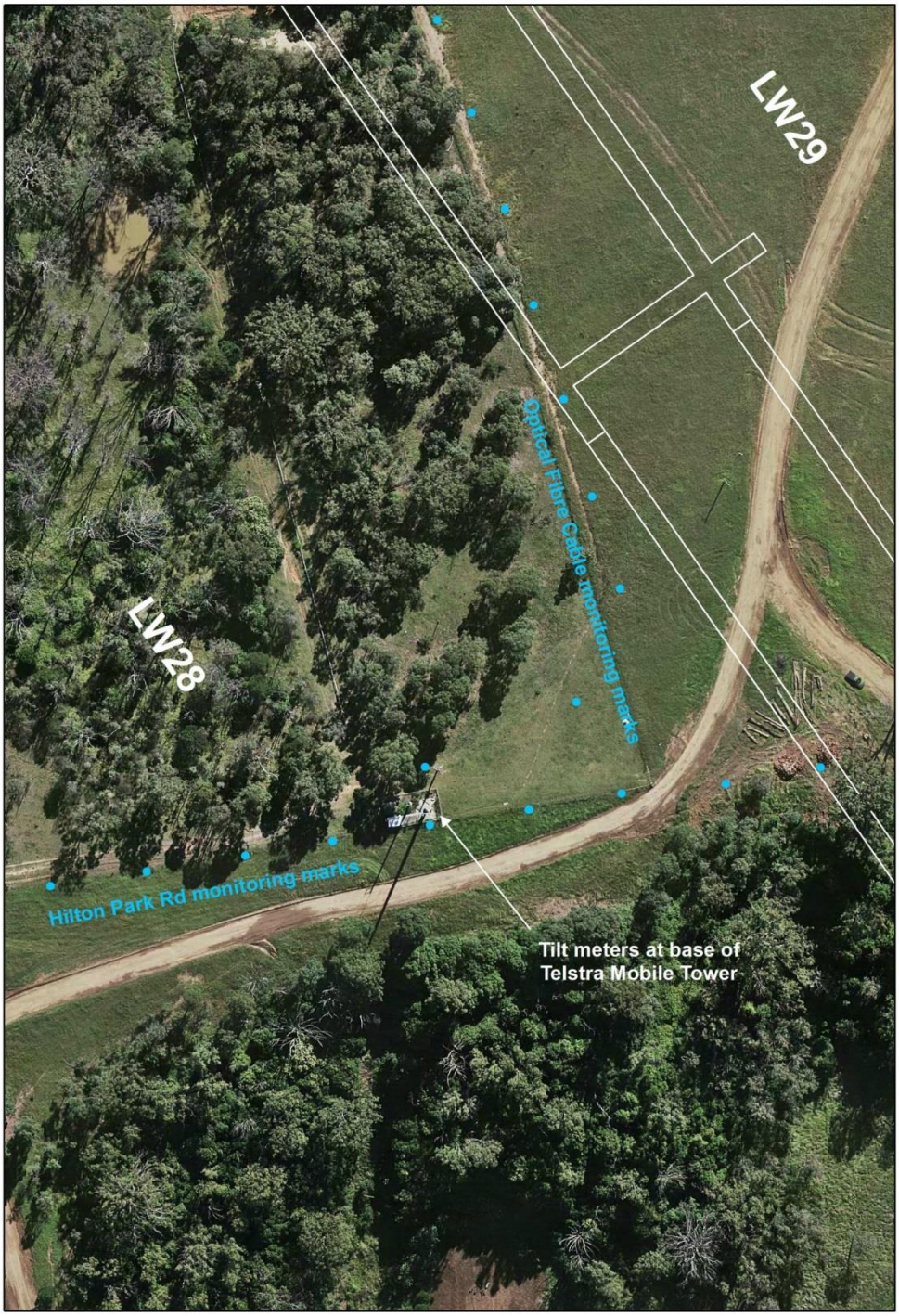



**Fig. 2.13 Location of monitoring marks in vicinity of Telstra Mobile Tower**

## 2.14. Monitoring and Inspections at No. 155 Stilton Lane

A PSMP has been developed in consultation, co-operation and co-ordination with the owners of No. 155 Stilton Lane.

The PSMP includes the following monitoring and management measures in relation to the dam and structures at No. 155 Stilton Lane:

- Monthly surveys along the top of the dam wall and along the base of the dam wall on the southern side from the commencement of Longwall 30, as shown in Drawing No. MSEC862-15-02.
- Monthly ground surveys at the corners of each of the eight greenhouses on the property, as shown in Drawing No. MSEC862-15-02.
- Weekly visual inspections of the dam and structures. The frequency may be increased following a review of actual survey data.

The purpose of the ground surveys on the property is to provide information to the owner, Tahmoor Colliery and Subsidence Advisory NSW (Mine Subsidence Board) in the unlikely event that impacts are visually observed to the dam and/or structures.

The surveys and inspections will be undertaken from the commencement of mining of Longwall 31 until 800 metres of extraction, unless adverse changes are observed at this time.

Additional surveys may be undertaken during the mining of Longwall 31 if impacts are reported at the site or substantial differential movements are observed from the results of the ground surveys.

## 2.15. Queen Victoria Memorial Gardens

A PSMP for Longwall 30 has been developed and agreed with the operators of the Queen Victoria Memorial Home, which is managed by TSA Management. The identified risks from subsidence movements are predominantly damage to the buildings and structures themselves, and an associated health and safety risk from potential additional hazardous material, subsequent to subsidence damage to buildings and structures.

In consultation with Tahmoor Colliery, QVMH engaged surveyors to undertake ground surveys in accordance with the PSMP. The surveyors have installed the pegs and completed a baseline survey. The purpose of the ground surveys is to provide information to the operator, Tahmoor Colliery and Subsidence Advisory NSW (Mine Subsidence Board) in the unlikely event that impacts are visually observed to built structures on the property, or to trigger additional inspections or additional management actions if required within the property, or to trigger a CCTV inspection of QVMH's sewer pipe.

The ground survey network is shown in Drawing No. MSEC815-17-01 and MSEC815-17-02. The prisms have been initially surveyed. Weekly surveys will commence of all survey pegs after 2200 metres of extraction until the completion of Longwall 31 and for a sufficient thereafter until measured changes are negligible.

No impacts were observed to QVMH structures during and after the extraction of Longwall 30. No analytical concerns have been recorded from asbestos air monitoring at any location during the extraction of Longwall 30.

A revised PSMP will be developed in consultation, co-operation and co-ordination with the operators of QVMH for Longwall 31, prior to the influence of Longwall 31.

Whilst the likelihood of impacts to the building structures is very rare, mine subsidence could result in new or existing cracks or joints opening up in building elements, potentially allowing existing hazardous materials, such as asbestos dust, to enter occupied spaces or be released externally. The hazard is greatest in ceiling spaces where dust containing asbestos or lead has been identified in ceiling spaces if a mining-induced crack was large enough for material to pass through.

Tahmoor Colliery has developed and implemented a monitoring and inspection program for mining-induced asbestos air dust in consultation, co-operation and co-ordination with the operators of QVMH for Longwall 30. A similar program will be developed and implemented for Longwall 31. The program includes the following monitoring measures:

- Weekly ground surveys
- Baseline asbestos air monitoring
- Visual inspections for properties where more than 20 mm of subsidence has been measured.

Tahmoor Colliery has engaged ADE Consulting Group to design and implement a monitoring program for the detection of mining-induced asbestos air dust, including associated baseline monitoring, in consultation, co-operation and co-ordination with QVMH and Tahmoor Colliery.

ADE Consulting Group undertook the original Hazardous Materials Survey for QVMH in 2013 and 2015, and selected locations based on where asbestos was previously identified. Air monitoring locations were

selected where asbestos containing dust is known to be present, and where asbestos linings are present within accessible spaces inside QVMH buildings.

A map showing the locations of asbestos air monitors is provided in Drawing No. MSEC815-17-03, which is attached to this report.

Air monitors collect airborne particles in a filter over a period of time (typically half a day). The filters are collected and analysed within a NATA accredited laboratory, with results provided the following day.

Air monitoring will commence after 2200 metres of extraction of Longwall 31. The monitoring program will be designed based on the expected completion of Longwall 31. Monitoring will continue until ground surveys confirm that the rates of change in subsidence have reduced to negligible levels. The frequency, duration and extent of monitoring may increase based on findings during baseline monitoring program, ground surveys, visual inspections, or if extraction of Longwall 31 continues for longer than planned.

The results of the asbestos air monitoring will be summarised in weekly reports, unless adverse readings are found.

## 2.16. Sydney Water Picton Water Recycling Plant

A PSMP has been developed in consultation, co-operation and co-ordination with Sydney Water. Whilst the locations of the survey points have been agreed, Sydney Water have not yet permitted access to the site, until its environmental department is satisfied that the installation survey pegs will have negligible impacts on the local environment on the site.

The Picton WRP is located on Remembrance Drive. The site treats sewage from the townships of Tahmoor, Thirlmere, Bargo, Buxton and Picton.

The plant includes a number of structures, skimmers and tanks, and a number of treated water storage dams, which are connected by a network of pipes. The design of the Picton WRP was approved by the Mine Subsidence Board (now Subsidence Advisory NSW).

The Picton WRP is being upgraded with new infrastructure, plant and services being developed on the site. The infrastructure has been designed for mine subsidence and was approved by the Mine Subsidence Board. Mine Subsidence Engineering Consultants also reviewed and provided recommendations on the detailing of the new infrastructure to accommodate mine subsidence movements.

Sewage is treated wholly within the plant. Recycled water is transported from the plant to holding dams, which is then released under licence to adjoining farmland.

Subject to approval by Sydney Water's environmental department, the monitoring measures for the Picton WRP will include: ground monitoring, visual monitoring, water level monitoring and water quality monitoring.

### 2.16.1. Continuous GNSS monitoring

Three continuous GNSS monitoring points will also be established across the Picton WRP site, as indicated by the magenta triangles in Fig. 2.14. These points measure the absolute horizontal movements and will be used to monitor the global or macro movements across the site. The monitoring points will be measured in real time and the data will be reviewed weekly during active subsidence. A more regular review of the data will be considered if a trigger is reached, in accordance with the PSMP.

### 2.16.2. 3D Ground surveys

Tahmoor Colliery will conduct 3D ground surveys on the Picton WRP site, which forms an integral part of the PSMP. The monitoring results will be reviewed by MSEC.

The locations of the ground monitoring lines and points are shown in Drawing No. MSEC862-18-02 and in Fig. 2.14. The 3D positions of survey pegs on the Picton WRP site will be measured based on control points provided by the GNSS units. The purpose of the surveys is to identify irregular or unusual ground movements associated with the Nepean Fault and provide baseline monitoring data prior to the extraction of planned future Longwall 32.

Ground monitoring lines will be established on the Picton WRP site, with approximate east-west alignments, as indicated by the magenta lines in Fig. 2.14. The locations of these lines have been developed to avoid environmentally sensitive areas. The monitoring lines will each comprise a series of survey marks spaced at approximately 20 m and will be used to identify localised irregular ground strains.

Base surveys of the ground monitoring lines will be carried out immediately after they have been approved by Sydney Water's environmental department. Subsequent surveys will be carried out after 600 m extraction, 1200 m of extraction and at the completion of the longwall. Additional surveys will be carried out if a trigger is reached, in accordance with the PSMP.

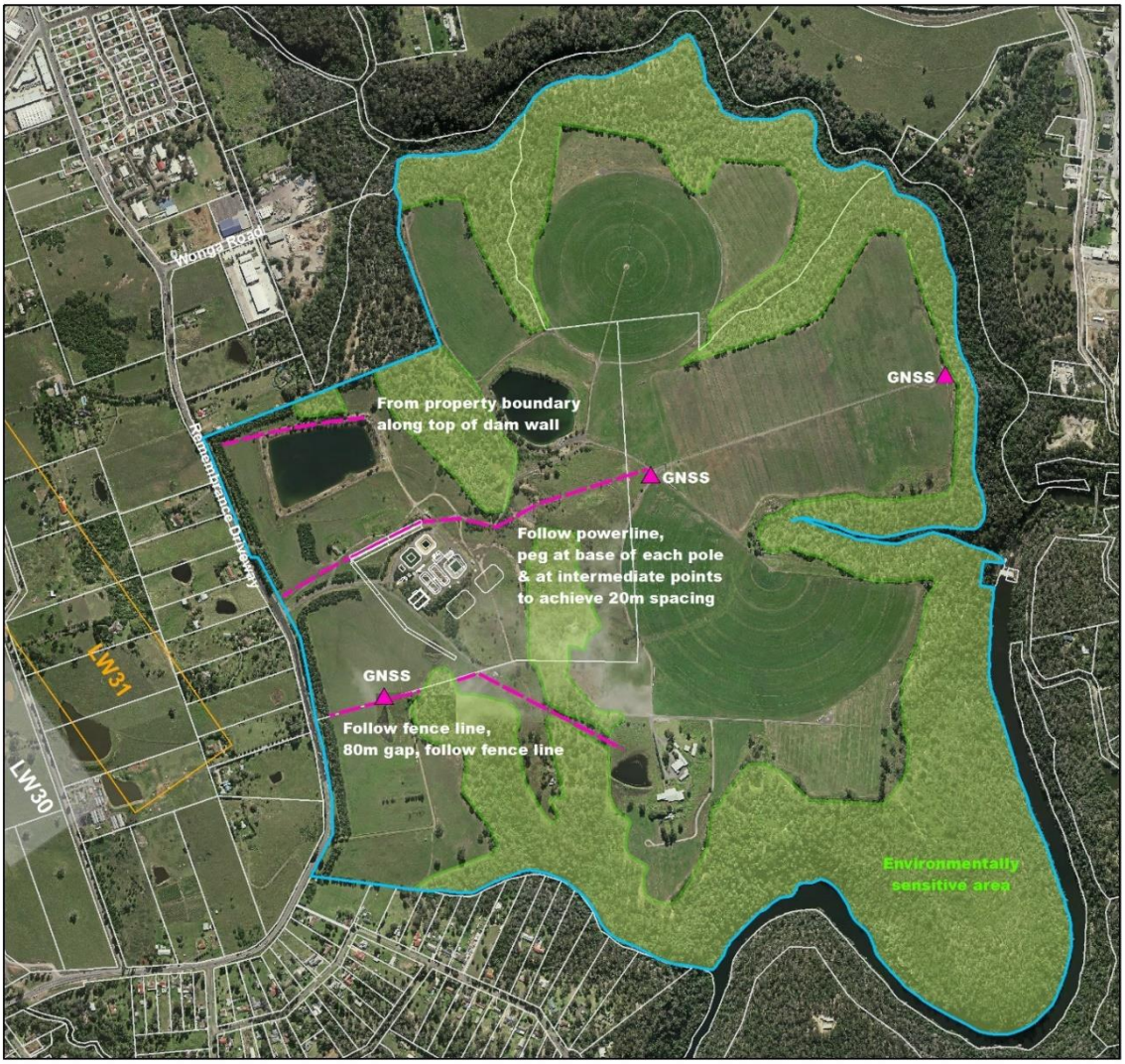



**Fig. 2.14 Ground monitoring lines and points**

A subsidence monitoring review report will be provided after the surveys of the ground monitoring lines have been carried out. An intermediate monitoring review report will be issued if a trigger is reached, in accordance with the PSMP.

### 2.16.3. Visual monitoring

Visual monitoring will be undertaken to identify surface cracking, irregular ground movements, impacts on surface infrastructure and water leaks. The visual inspections will be jointly carried out by Tahmoor Colliery and Sydney Water.

The visual inspections by Tahmoor Colliery will be undertaken weekly from the start of Longwall 31 until 800 metres of extraction, unless adverse changes are observed. The visual inspections by Sydney Water will be undertaken as part of the routine inspections in accordance with the Picton WRP management procedures.

Additional visual inspections will be carried out if a trigger is reached, in accordance with the PSMP.

### 2.16.4. Water level monitoring

Water level monitoring of the storage dams is undertaken by Sydney Water in accordance with the Picton WRP management procedures. The locations of the monitoring points at the western and eastern storage dams are shown in Drawing No. MSEC862-18-02.

The water levels are measured in real time and the data is recorded by the Supervisory Control and Data Acquisition (SCADA) control system and are available online. The data are reviewed daily (on weekdays) in

accordance with the Picton WRP management procedures. The loss of water is interpreted from the data based on the current inflow, outflow and rainfall conditions.

Sydney Water will notify Tahmoor Colliery if the water level in a storage dam or holding tank is less than expected based on the current conditions. Sydney Water will enact any relevant emergency response procedures in accordance with the Picton WRP Pollution Incident Response Management Plan (PIRMP). Further actions will be undertaken in accordance with the PSMP.

### 2.16.5. Water quality monitoring

Water quality testing is undertaken by Sydney Water in accordance with the Picton WRP Environmental Management Plan. Sampling is undertaken at the discharge point at Stonequarry Creek and at the irrigation locations.

Tahmoor Colliery will carry out additional water quality testing (at its own cost) during the active subsidence period and until cessation is agreed by the IMG. The testing would be undertaken weekly, unless a trigger is reached, in accordance with the PSMP.

The water quality data will be provided to Sydney Water, which will review the results and advise Tahmoor Colliery whether they are within the allowable measures, as outlined in the Sydney Water Environmental Management Plan. Sydney Water will enact any relevant emergency response procedures in accordance with the Picton WRP Pollution Incident Response Management Plan (PIRMP). Additional actions will also be undertaken in accordance with the PSMP.

**Table 2.1 Subsidence Monitoring Programme for Longwall 31**

| Feature | Survey or Inspection Regime | Parameters to be Measured | Timing and Frequency<br>(may be increased if triggered by monitoring results) |
|---|---|---|---|
| **Natural Features** | | | |
| Redbank Creek | Absolute and relative 3D survey | Absolute and Local easting, northing and level to calculate valley closure<br>(refer Section 2.5) | Baseline absolute 3D survey of new pegs along the THC Line between Redbank Place and Remembrance Drive (Argyle Street), and Henry Street prior to 1300m of extraction<br>Monthly Pegs RK18 to RK40, ST48 to ST70 and from Pegs BG78 to BG144, commencing after 1300m of extraction<br>Weekly Pegs RK24 to RK40, ST48 to ST61 and from Pegs BG95 to BG144 when within active subsidence zone, commencing after 1500m of extraction<br>Absolute 3D at end of LW31 for all lines |
| | Visual inspection of Redbank Creek | - | Weekly, commencing after 1500m of extraction within active subsidence zone |
| **Wollondilly Council Infrastructure** | | | |
| Local roads | Ground surveys along streets | 2D subsidence and distance | Please refer Dwg. No. MSEC862-00-01<br>*For street surveys with lines coloured red and labelled as "Surveys during LW31":*<br>Monthly surveys along Remembrance Drive for pegs located within 35 degree angle of draw of LW31, commencing after 200m of extraction until 800m of extraction unless adverse changes are observed.<br>Weekly surveys along Bridge Street and Redbank Place within the active subsidence zone.<br>For other street survey lines, including Stilton Lane: Conduct surveys every 200m of extraction for survey pegs located within the active subsidence zone, commencing after 200m of extraction.<br>*For street surveys with lines coloured yellow and labelled as "Monitoring Lines Before & End of LW31":*<br>Before and end of LW31 |
| | Visual inspections of streets | - | Detailed inspection once a week within the active subsidence zone, commencing from start of LW.<br>Vehicle based inspection once a week within the active subsidence zone (on alternate day to detailed inspection), commencing after 200m 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 |
| **No. 155 Stilton Lane** | | | |
| No. 155 Stilton Lane | Ground survey of pegs around top and base of dam wall at No. 155 Stilton Lane. | Local 3D survey, incl RL | Monthly surveys of survey pegs after start of LW31 until 800 metres of extraction, unless by exception, based on actual monitoring data.<br>Survey at end of LW31. |
| | Ground survey of pegs around perimeters of greenhouses at No. 155 Stilton Lane. | Local 3D survey, incl RL | Monthly surveys of survey pegs after start of LW31 until 800 metres of extraction, unless by exception, based on actual monitoring data.<br>Survey at end of LW31. |
| | Visual inspections of dam and greenhouses | - | Weekly visual inspections of dam wall and greenhouses after start of LW31 until 800 metres of extraction, unless by exception, based on actual monitoring data. Additional inspections during high intensity rain events. |
| **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 marks along THC Line, which follows sections of the Thirlmere Carrier Pipe where it deviates away from Bridge Street | 2D subsidence and distance | Install new pegs between Redbank Place and Remembrance Drive (Argyle Street) prior to 1300 m of extraction.<br>Weekly surveys when THC Line is within the active subsidence zone<br>Survey at end of LW31. |
| | CCTV inspection of Thirlmere Carrier pipe | - | Thirlmere Carrier (Bridge St for pipe section directly above LW31 to the Redbank Creek viaduct crossing) – prior to 1300m of extraction, and end of LW31 |

| Feature | Survey or Inspection Regime | Parameters to be Measured | Timing and Frequency<br>(may be increased if triggered by monitoring results) |
|---|---|---|---|
| **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 |
| **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. MSEC862-00-01. | Subsidence at base and vertical offset (or tilt) | Monthly for each pole within active subsidence zone, and for following three months thereafter<br>End of LW31 for all poles within limit of subsidence for panel |
| **Telecommunications Infrastructure** | | | |
| Telstra infrastructure | Ground surveys along streets | 2D subsidence and distance | As described for Wollondilly Council<br>Conduct surveys every 200m of extraction of OF and Stilton Lane survey lines where within active subsidence zone |
| | Visual inspections of streets | - | As described for Wollondilly Council |
| | Detailed visual inspections of pits and streets | - | Weekly when within active subsidence zone, and monthly at other times |
| | Ground survey at base of mobile phone tower above former Redbank Railway Tunnel | Subsidence and tilt of the tower | Prior to start of LW31<br>End of LW31 |
| | 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 | Weekly when within active subsidence zone<br>End of LW31 |
| **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<br>(Weekly when within active subsidence zone or as required by geotechnical or structural engineer) |
| **Bridge Street Industrial, Commercial and Business Precinct** | | | |
| Industrial, Commercial and Business Precinct | Ground surveys along Bridge Street | 2D subsidence and distance | As described for Wollondilly Council |
| | Ground surveys along Redbank Place | 2D subsidence and distance | As described for Wollondilly Council |
| | Ground surveys along Main Southern Railway up to 89.740 km | 3D, 2D and distance | As described for Main Southern Railway |
| | Surveys of properties within active subsidence zone | Local 3D survey, incl RL | To be developed and agreed with landowners prior to 1600m of extraction as part of PSMPs. |
| | Visual inspections of properties within active subsidence zone | - | To be developed and agreed with landowners prior to 1600m of extraction as part of PSMPs. |
| | Visual inspections of streets | - | As described for Wollondilly Council |

| Feature | Survey or Inspection Regime | Parameters to be Measured | Timing and Frequency<br>(may be increased if triggered by monitoring results) |
|---|---|---|---|
| **Main Southern Railway** | | | |
| Railway Track | 3D ground survey along rail corridor<br>*Full length start and end of LW = 89.74 km to 93.73 km*<br>*Initial extent for monthly survey = 92.38 km to 92+1200 km and then extend to the north to include pegs that are at least 400 metres in front of the longwall face, up to 89.74km.* | Subsidence, changes in easting and northing (MGA coordinates) | Monthly from start of LW<br>Full length at end of LW |
| | 2D ground survey along rail corridor<br>*Full length start and end of LW = 89.74 km to 93.73 km*<br>*Extent for Stage 2 Weekly survey = 89.74 km to 91.46 km.* | 2D subsidence and distance | Focussed weekly after 1700 m of extraction.<br>Full length at start and end of LW |
| | 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. MSEC863-06 for peg locations). | Subsidence, changes in easting and northing (MGA coordinates) | Monthly from start of LW31<br>End of LW |
| | Long bay length ground surveys<br>*Initial extent for monthly survey = 92.38 km to 92+1320 km and then extend to the north to include long bays that are at least 400 metres in front of the longwall face, up to 91.46 km.*<br>*Extent for Focussed Weekly survey = 89.74 km to 91.46 km and then extend to the north to include long bays that are at least 200 metres in front of the longwall face, up to 89.74 km.* | 2D distance | Monthly at start of LW31<br>Focussed weekly after 1700 m of extraction<br>For 92.26 km to 91.36 km only across Redbank Creek, commence weekly surveys after 1050 m |
| | Continuously monitor rail stress, rail temperature and switch displacement<br>*Full extent = 89.74 km to 92+1100 km*<br>*Initial active subsidence monitoring extent = 92.38 km to 92+1100 km (alarmed at LW start)*<br>*Activate alarms during Stage 2 only to include gauges that are at least 200 metres in front of the longwall face, up to 89.74 km* | Rail stress, rail temperature and switch displacement | Gauges installed from 90.100 km to 92+1100 km<br>Install and commission new gauges from 89.74 km to 90.010 km prior to LW approaching within 400 m<br>Readings every 5 minutes<br>Alarmed at start of LW31 (Stage 2) |
| | Continuously monitor rail stress, rail temperature and switch displacement<br>*Residual subsidence monitoring = at least one working gauge every 100 m along each rail from 92+1160 km to 93.05 km (southern end may be shortened based on future assessment)* | Rail stress and rail temperature | Every 5 minutes |
| | Track geometry surveys using Amber track mounted device or equivalent<br>*Full length start and end of LW = 89.74 km to 93.73 km*<br>*Initial extent for monthly and weekly survey = 92.38 km to 92+1200 km and then extend to the north to include track that is at least 200 metres in front of the longwall face, up to 89.740 km* | Superelevation (cant), twist, gauge | Weekly at start of LW31 (Stage 2) |
| | Continuously monitor track geometry by Automated Total Station in Deviation Cutting for track located near fault at 92.850 km (refer Fig. 2.2 for locations of prisms) | Local 3D survey: Changes in easting, northing and height relative to total stations | Every 2 hours<br>ATS not alarmed. |
| | Track inspection by qualified track certifier<br>*The extent of visual inspections is the same as the extent of track geometry surveys.* | 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 | Daily from start of LW10 (Stage 2) |

| Feature | Survey or Inspection Regime | Parameters to be Measured | Timing and Frequency<br>(may be increased if triggered by monitoring results) |
|---|---|---|---|
| Culverts and embankments | Conduct 3D ground survey of embankment monitoring lines at 92+1340 km and 92+1180 km, monitoring line along the toe of the embankment on the Down side, and monitoring line along the noise wall (Refer Drawing No. MSEC863-05 for peg locations) | Subsidence, changes in easting and northing (MGA coordinates) | Absolute 3D monthly at start of LW |
| | 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 | Start of LW<br>End of LW |
| | Measure gaps between the pipe joints of the new Deviation concrete pipes after installation | Steel tape or calliper | Baseline survey complete |
| | Absolute 3D surveys along monitoring lines along crest and toe of embankment at 90.676 km on both sides of track, and inside brick arch culvert at outlet, midpoint and inlet | Subsidence, changes in easting and northing (MGA coordinates) | Absolute 3D monthly after 1500m<br>Relative 3D weekly after 1700m |
| | Absolute 3D surveys along monitoring lines along crests and Downside toe of embankment at 90.252 km on both sides of track | Subsidence, changes in easting and northing (MGA coordinates) | Absolute 3D monthly after 1500m<br>Relative 3D weekly after 1700m |
| | Absolute 3D surveys along monitoring lines along crest and toe of embankment at 89.785 km on both sides of track | Subsidence, changes in easting and northing (MGA coordinates) | Absolute 3D monthly after 1500m |
| | Install continuously recording extensometer or laser distancemeter across crest of embankment at 90.676 km above culvert. | - | Every 15 minutes<br>Operating and alarmed after 1700m |
| | Visual inspection of Embankment at 90.676 km, 90.252 km and 89.785 km by geotechnical engineer | - | Monthly after 1450m<br>Weekly for Embankments at 90.676 km and 90.252 km after 1650m |
| Deviation Overbridge at 92.400 km | 3D survey of abutment and bridge deck at locations shown in Fig. 2.7.<br>*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.* | 3D survey: subsidence, changes in easting and northing (MGA coordinates) | Absolute 3D monthly at start of LW |
| | Visual inspection of bridge, including bearings | - | Monthly at start of LW |
| Redbank Creek Culvert and Embankment | Absolute 3D survey of prisms on culvert, wingwalls and embankment | Subsidence, changes in easting and northing (MGA coordinates) | Monthly after 1050m |
| | Local 3D survey of prisms on culvert and embankment | Local 3D survey: Changes in easting, northing and height relative to total stations | Weekly after 1350m |
| | Tape extensometer monitoring across width and height of culvert | Changes in distance | Monthly after 1050m<br>Weekly after 1350m |
| | Vertical inclinometer monitoring at boreholes RBCC01 to RBCC04 | Change in vertical tilt (and therefore horizontal shear of inclinometers) | Monthly after 1050m<br>Weekly after 1350m |
| | Extensometer monitoring across crest of Embankment | Change in distance | Every 15 minutes<br>Operating after 1050m (Stage 1)<br>Alarmed after 1350m (Stage 2) |
| | Monitoring of piezometers at open standpipe and culvert inlet | Change in water level | Every 15 minutes<br>Operating after 1050m (Stage 1)<br>Alarmed after 1350m (Stage 2) |
| | Track inspection by qualified track certifier. 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 | - | As per Railway Management Plan No. MSEC863 |

| Feature | Survey or Inspection Regime | Parameters to be Measured | Timing and Frequency<br>(may be increased if triggered by monitoring results) |
|---|---|---|---|
| | *The extent of visual inspections is the same as the extent of track geometry surveys as defined in the Railway Management Plan No. MSEC863* | | |
| | Visual inspection of Embankment by geotechnical engineer | - | Monthly after 1050m<br>Weekly after 1350m |
| Bridge Street Railway Overbridge at 91.03 km | Absolute and relative 3D surveys of the Overbridge and adjacent cutting | 3D survey: subsidence, changes in easting and northing (MGA coordinates) | Absolute 3D monthly after 1500m |
| | Track inspection by qualified track certifier. 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<br>*The extent of visual inspections is the same as the extent of track geometry surveys as defined in the Railway Management Plan No.* MSEC863 | - | As per Railway Management Plan No. MSEC863 |
| **Sydney Water Picton Water Recycling Plant** | | | |
| Sydney Water Picton Water Recycling Plant | Continuous GNSS monitoring at three locations | Easting, Northing, Height | Install and operate immediately, as soon as Sydney Water provide access.<br>Continuous readings. |
| | Absolute 3D survey along monitoring lines, as shown in Drawing No. MSEC862-18-02 | Easting, Northing, Height | Install and baseline survey immediately, as soon as Sydney Water provide access.<br>After 600m and 1200m and at completion of LW31, unless adverse changes are observed. |
| | Visual inspection of PWRP infrastructure and ground surface | - | Weekly from start of LW30 until 800m, unless adverse changes are observed. |
| | Water balance monitoring by Sydney Water | Water levels, inflows, outflows and rainfall | Weekly (routine monitoring by Picton WRP) |
| | Water quality testing at Stonequarry Creek by Sydney Water (routine) and Tahmoor Colliery | - | Weekly by Picton WRP (routine)<br>Weekly from start of LW30 until 800m, unless adverse changes are observed. |
| **Queen Victoria Memorial Home** | | | |
| Queen Victoria Memorial Home | Local 3D ground survey of all pegs won QVMH land, as shown in Drawings Nos.MSEC815-17-01 and MSEC815-17-02 | Local 3D survey, Height | Weekly after 2200 m of extraction until end of LW31 and continue until negligible changes observed |
| | Visual inspections by structural engineer to identify whether there has been any additional risk to the structure or whether there has been new or existing cracks or joints opening up in building elements, with increased risk of potentially allowing existing hazardous materials, such as asbestos dust, to enter occupied spaces or be released externally | - | Weekly after 2200 m of extraction for structures measured to have experienced more than 20 mm of incremental subsidence during extraction of Longwall 31<br>(target first inspection within 48 hours of receiving survey results that have measured more than 20 mm of subsidence at one or more structures.) |
| | Asbestos air monitoring devices at locations shown in Drawing No. MSEC815-17-03 | Asbestos fibres | Monitoring program, to be determined by asbestos monitoring contractor, commencing after 2200 m. Continue until end of LW31 and negligible changes observed from ground survey results. |

# APPENDIX A. DRAWINGS

I:\Projects\Tahmoor\MSEC862 - LW31 Management Plans\MSEC862-00 General\AcadData\MSEC862-00-01 Monitoring LW31 Rev B.dwg

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# TAHMOOR COLLIERY

TAHMOOR UNDERGROUND GLENCORE

**TAHMOOR NORTH - LW31**

MONITORING OVER LW31

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 26 June 2017 | as shown | MSEC862-00-01 | B |

277 500 278 000 278 500 279 000

6 214 500 6 214 000 6 213 500 6 213 000 6 212 500 6 212 000 6 211 500 6 211 000

Grid to MGA co-ordinates

Refer Queen Victoria Memorial Home for details (MSEC815-17)

Refer Embankment 89.80km diagram for details (MSEC863-11)

Refer Embankment 90.252km diagram for details (MSEC863-10)

Refer individual diagrams for details of Commercial area (MSEC862-19)

Refer Embankment 90.676km diagram for details (MSEC863-09)

Refer Bridge St Cutting & Overbridge 91.00km diagram for details (MSEC863-08)

Refer Redbank Creek Culvert diagram for details (MSEC863-07)

Refer Railway diagram for details (MSEC863-03)

Refer ATS diagram for details (MSEC863, Fig. 4.6)

Refer Embankment diagram for details (MSEC863-05)

Refer Picton Water Recycling diagram for details (MSEC862-18)

Refer Deviation Overbridge 92.41km diagram for details (MSEC863-06)

Refer Deviation Cutting diagram for details (MSEC863-06)

Refer No155 Stilton Lane diagram for details (MSEC862-15-02)

Dam removed 2016

Myrtle Creek Bridge

THIRLMERE WAY

RUMKER ST

ARGYLE ST

BRIDGE ST

REDBANK CREEK

HENRY ST

STILTON LN

REMEMBRANCE DRIVEWAY

MAIN SOUTHERN RAILWAY

MYRTLE CREEK

LW 28 LW 29 LW 30 LW 31 LW 27 LW 26

35° ANGLE OF DRAW LW31

PREDICTED 20mm SUBSIDENCE CONTOUR DUE TO LW31

628338 628565 623346 628632 628573 805777 805778 798027 628623 628624 628485

LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW31
- Monitoring Lines Before & End of LW30
- Surveys During LW31
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-01 General Layout LW31.dwg

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# TAHMOOR COLLIERY

TAHMOOR UNDERGROUND GLENCORE

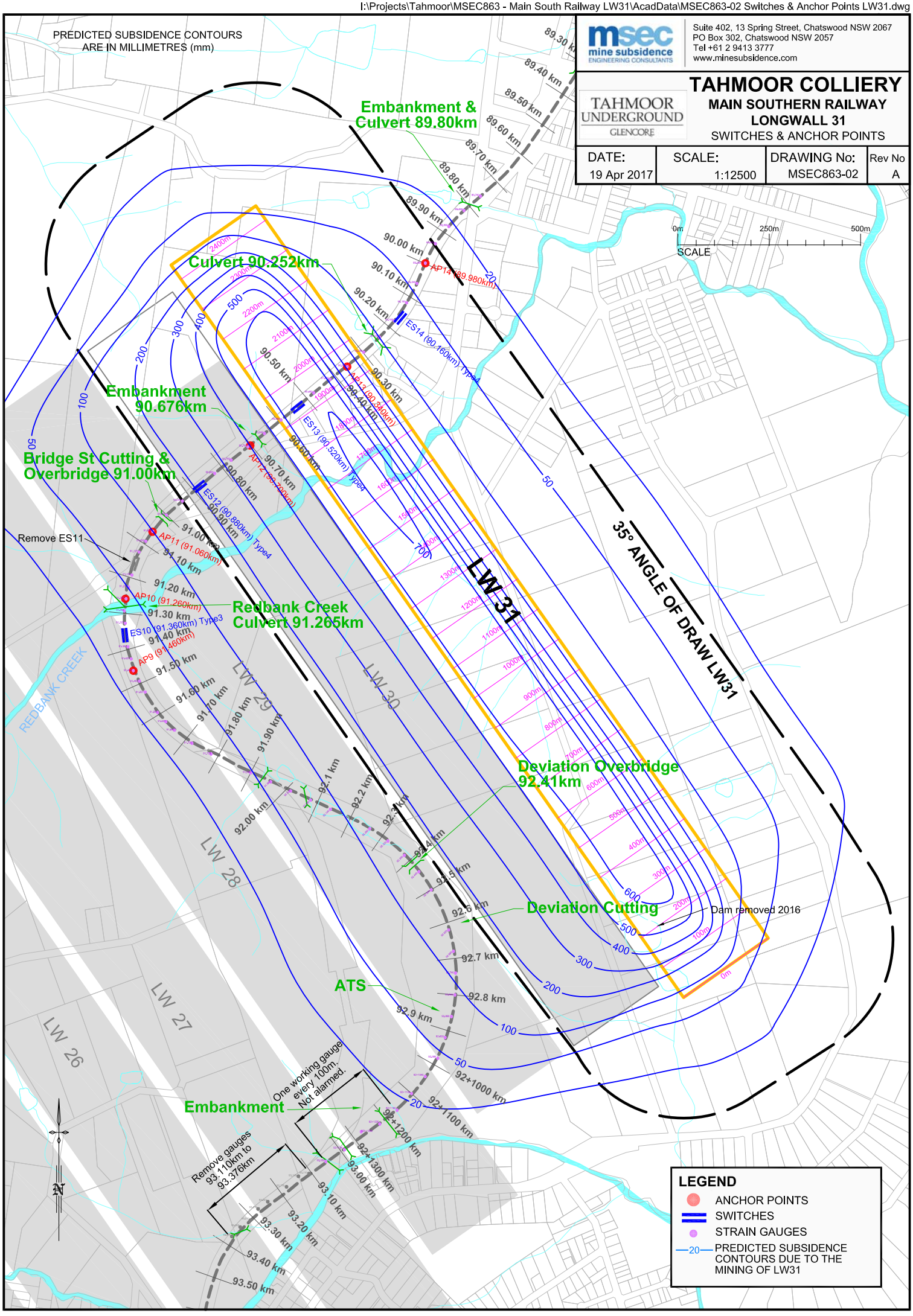
**MAIN SOUTHERN RAILWAY**
**LONGWALL 31**
GENERAL LAYOUT

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | 1:12500 | MSEC863-01 | A |

Embankment & Culvert 89.80km
Culvert 89.80 km
Culvert 90.252km
Culvert 90.252 km
Embankment 90.676km
Culvert 90.676 km
Bridge St Cutting & Overbridge 91.00km
RBCC 91.265 km
Redbank Creek Culvert 91.265km
R = 400m
R = 476m
Culvert 91.935 km
Culvert 91.910 km
Culvert 92.060 km
Deviation Overbridge 92.41km
Deviation Cutting
Dam removed 2016
ATS
Culvert 92+1205 km
Embankment
Culvert 92+1340 km
Culvert 93.045 km
Skew Culvert 93.342 km
LW 31
LW 30
LW 29
LW 28
LW 27
LW 26
35° ANGLE OF DRAW LW31
PREDICTED 20mm SUBSIDENCE CONTOUR DUE TO LW31
REDBANK CREEK
MYRTLE CREEK

LEGEND
CULVERTS
EMBANKMENTS
CUTTINGS

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-02 Switches & Anchor Points LW31.dwg



I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-03 Monitoring LW31.dwg

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# TAHMOOR COLLIERY

TAHMOOR UNDERGROUND GLENCORE

**MAIN SOUTHERN RAILWAY**
**LONGWALL 31**
MONITORING PLAN

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | 1:12500 | MSEC863-03 | A |

Embankment & Culvert 89.80km

Culvert 90.252km

Embankment 90.676km

Bridge St Cutting & Overbridge 91.00km

Redbank Creek Culvert 91.265km

Deviation Overbridge 92.41km

Deviation Cutting

ATS

Embankment

Dam removed 2016

REDBANK CREEK

MYRTLE CREEK

LW 31

LW 30

LW 29

LW 28

LW 27

LW 26

PREDICTED 20mm SUBSIDENCE CONTOUR DUE TO LW31

35° ANGLE OF DRAW LW31

LEGEND

- MONITORING PEGS
- EMBANKMENTS
- CUTTINGS

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-04 Timing LW31.dwg

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# TAHMOOR COLLIERY

TAHMOOR UNDERGROUND GLENCORE

**MAIN SOUTHERN RAILWAY**
**LONGWALL 31**
TIMING

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | 1:12500 | MSEC863-04 | 01 |

## LW31 @ 1700m
Start weekly surveys along Railway
Start weekly local 3D surveys at culvert and embankment at 90.676km and 90.252km
Start weekly surveys across base of Cutting at 90.5km
Start daily track inspections

## LW31 @ 1500m
Start monthly absolute 3D surveys at culvert and embankment at 90.676km, 90.252km and 89.8km.
Start monthly absolute 3D surveys at Bridge Street Overbridge

## LW31 @ 1050m
Start weekly long bay surveys ES10 to AP10 (Redbank Creek)
Start monthly absolute 3D surveys, tape extensometer and inclinometer surveys at Redbank Creek

## LW31 @ 1350m
Start weekly local 3D ground survey, tape extensometer and inclinometer surveys at Redbank Creek

## LW31 @ start
Start monthly 3D surveys along Railway
Start weekly track geometry trolley surveys
Start monthly Deviation embankment surveys
Start monthly 3D Deviation cutting surveys
Start monthly 3D Deviation Overbridge surveys
Start twice weekly track inspections

LW 31
LW 30
LW 29
LW 28
LW 27
LW 26
35° ANGLE OF DRAW LW31
REDBANK CREEK
MYRTLE CREEK
Culvert 89.80 km
Culvert 90.252 km
Culvert 90.676 km
Culvert 91.935 km
Culvert 92+1205 km
RBCC 91.265 km
Dam removed 2016

LEGEND
CULVERTS
EMBANKMENTS
CUTTINGS

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-05 Deviation Embankment LW31.dwg

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# TAHMOOR COLLIERY

TAHMOOR UNDERGROUND GLENCORE

TAHMOOR NORTH - LW31
MAIN SOUTHERN RAILWAY
DEVIATION EMBANKMENT FOR LW31

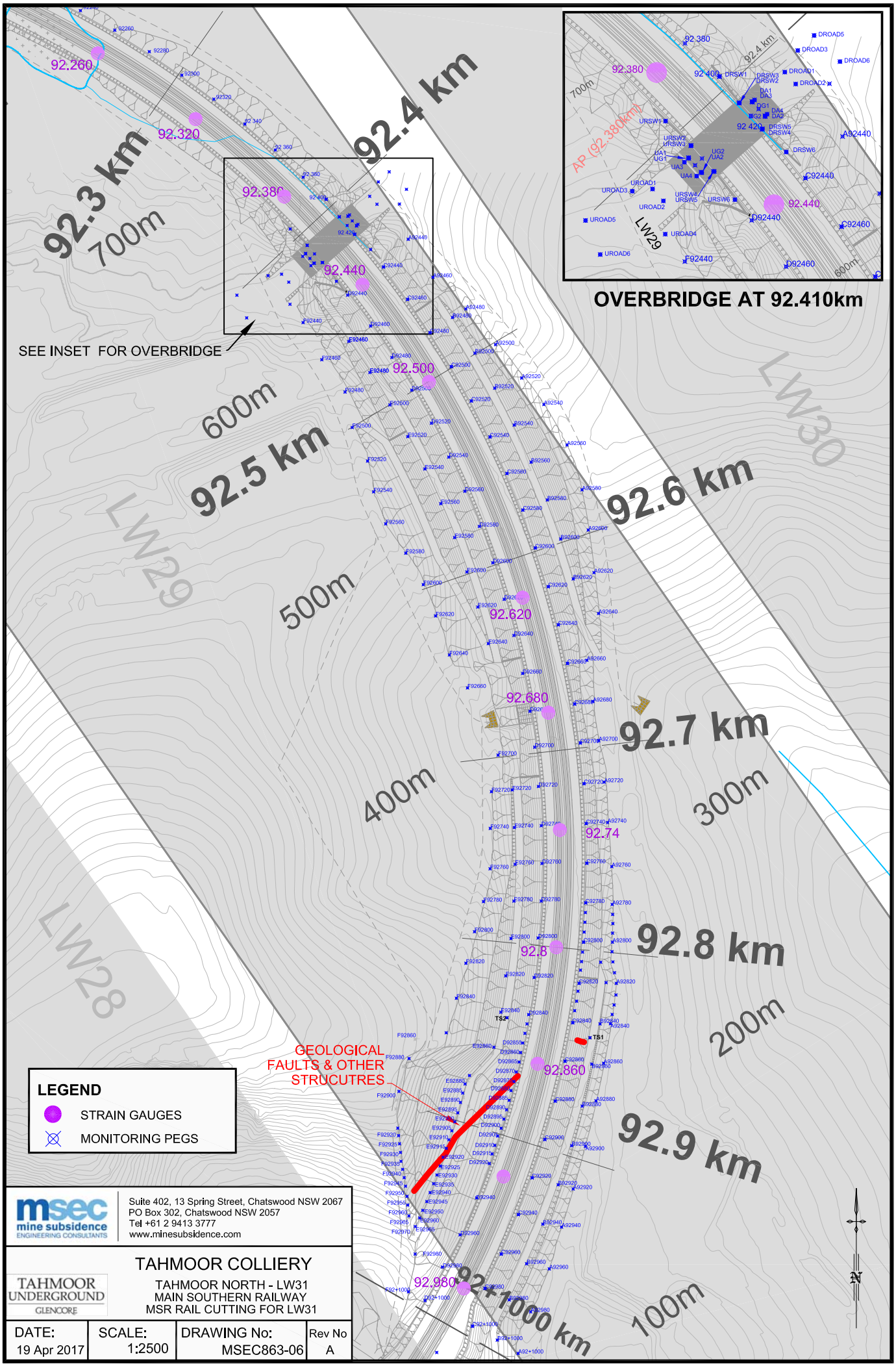
| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | 1:2000 | MSEC863-05 | A |

**LEGEND**

- STRAIN GAUGES
- DECOMISSIONED STRAIN GAUGES
- MONITORING PEGS

92+1100 km
92+1200 km
92+1000 km
93.10 km
93.00 km
92+1300 km
LW29
LW27
LW28
Myrtle Creek
92.980
92+1040
92+1100
92+1160
92+1220
92+1280
92+1340
93.050
93.110
93.145
93.179
N

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-06 MSR Rail Cutting LW31.dwg





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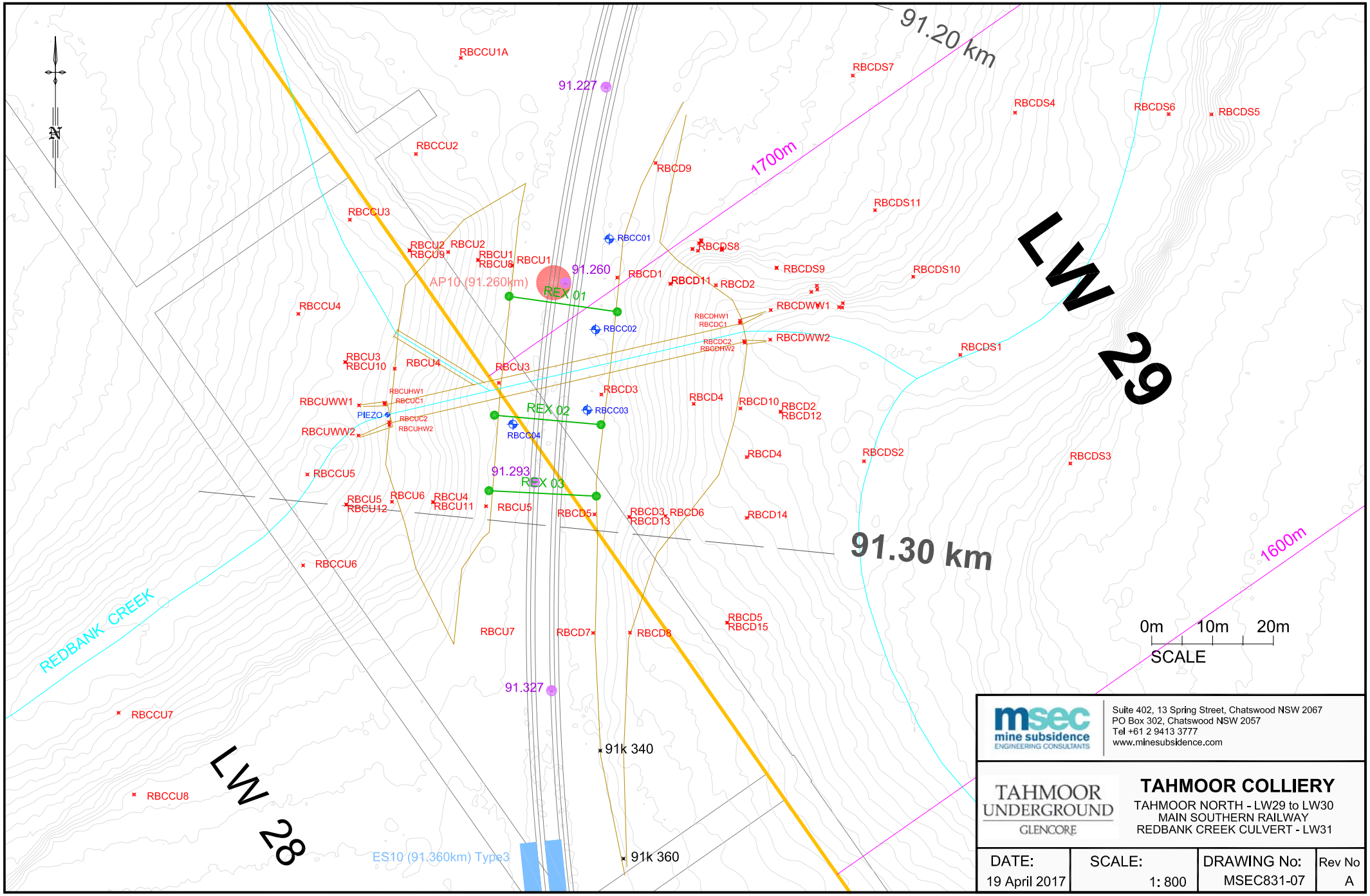
# TAHMOOR COLLIERY

TAHMOOR NORTH - LW31
MAIN SOUTHERN RAILWAY
MSR RAIL CUTTING FOR LW31

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | 1:2500 | MSEC863-06 | A |

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-07 RBCC & Embkmt LW31.dwg





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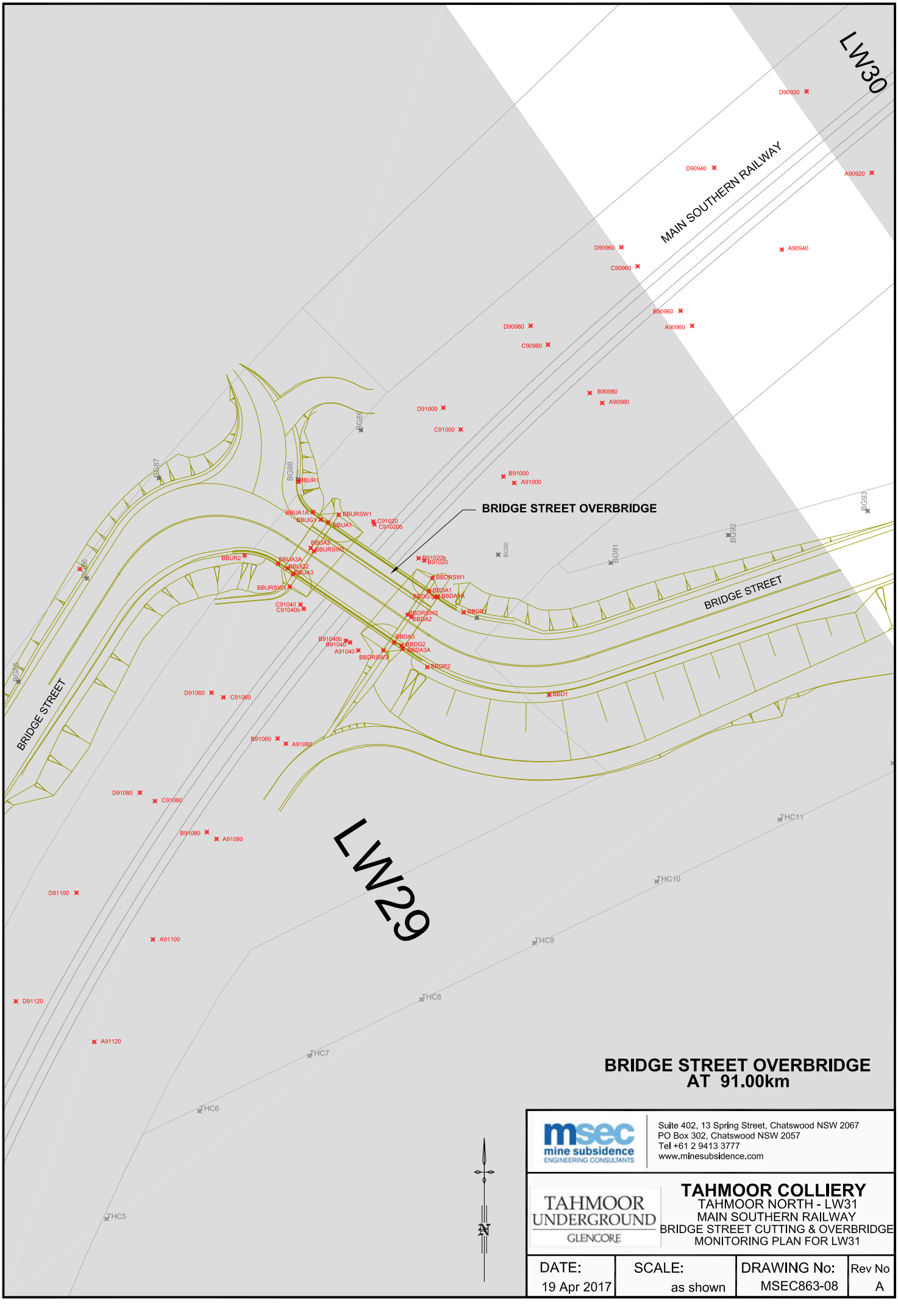
# TAHMOOR COLLIERY

TAHMOOR NORTH - LW29 to LW30
MAIN SOUTHERN RAILWAY
REDBANK CREEK CULVERT - LW31

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 April 2017 | 1: 800 | MSEC831-07 | A |

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-08 Bridge Street Cutting.dwg




## BRIDGE STREET OVERBRIDGE AT 91.00km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# TAHMOOR COLLIERY

TAHMOOR NORTH - LW31
MAIN SOUTHERN RAILWAY
BRIDGE STREET CUTTING & OVERBRIDGE
MONITORING PLAN FOR LW31

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | as shown | MSEC863-08 | A |

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-09 Culvert & Embkmt 90.676km.dwg

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TAHMOOR UNDERGROUND GLENCORE

# TAHMOOR COLLIERY

**MAIN SOUTHERN RAILWAY**
CULVERT & EMBANKMENT 90.676 km
MONITORING PLAN FOR LW31

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | 1: 2500 | MSEC863-09 | A |

**LEGEND**
- ANCHOR POINTS
- STRAIN GAUGES
- MONITORING PEGS
- EMBANKMENT MONITORING PEGS

N

90.580
LW 31
MAIN SOUTHERN RAILWAY
90.640
AP12 (90.700 km)
90.700
culvert
Bridge Street
90.70 km
LW 30
90.760
B90 630
C90 640
B90 640
C90 650
B90 650
C90 660
B90 660
C90 665
C90 670
B90 670
C90 675
C90 680
B90 680
C90 685
C90 690
B90 690
C90 695
C90 700
B90 700
C90 705
C90 710
B90 710
C90 720
B90 720
C90 730
B90 730
C90 740
B90 740
C90 750
C90 760
90 640
A90 640
A90 650
90 660
A90 660
E90 685
E90 690
90 680
A90 670
A90 675
F90 685
F90 690
A90 680
A90 685
90 700
A90 690
A90 695
A90 700
A90 705
90 720
A90 710
A90 720
A90 730
90 740
A90 740
A90 750
90 760
A90 760
D90 685
D90 690

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-10 Culvert & Embkmt 90.252km LW31.dwg

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TAHMOOR UNDERGROUND GLENCORE

# TAHMOOR COLLIERY

**MAIN SOUTHERN RAILWAY**
CULVERT & EMBANKMENT 90.252 km
MONITORING PLAN FOR LW31

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | 1: 500 | MSEC863-10 | A |

**LEGEND**
- ANCHOR POINTS
- SWITCHES
- STRAIN GAUGES
- MONITORING PEGS
- EMBANKMENT MONITORING PEGS

N

ES14 (90.160 km) Type4

90.160

90.160
90.180
90.200
90.220
90.240
90.260
90.280
90.300
90.320
90.340
90.360

90.220

90.280

90.340

culvert

MAIN SOUTHERN RAILWAY

LW31

AP13 (90.340 km)

90.20 km
90.30 km
90.40 km

I:\Projects\Tahmoor\MSEC863 - Main South Railway LW31\AcadData\MSEC863-11 Culvert & Embkmt 89.600km LW31.dwg

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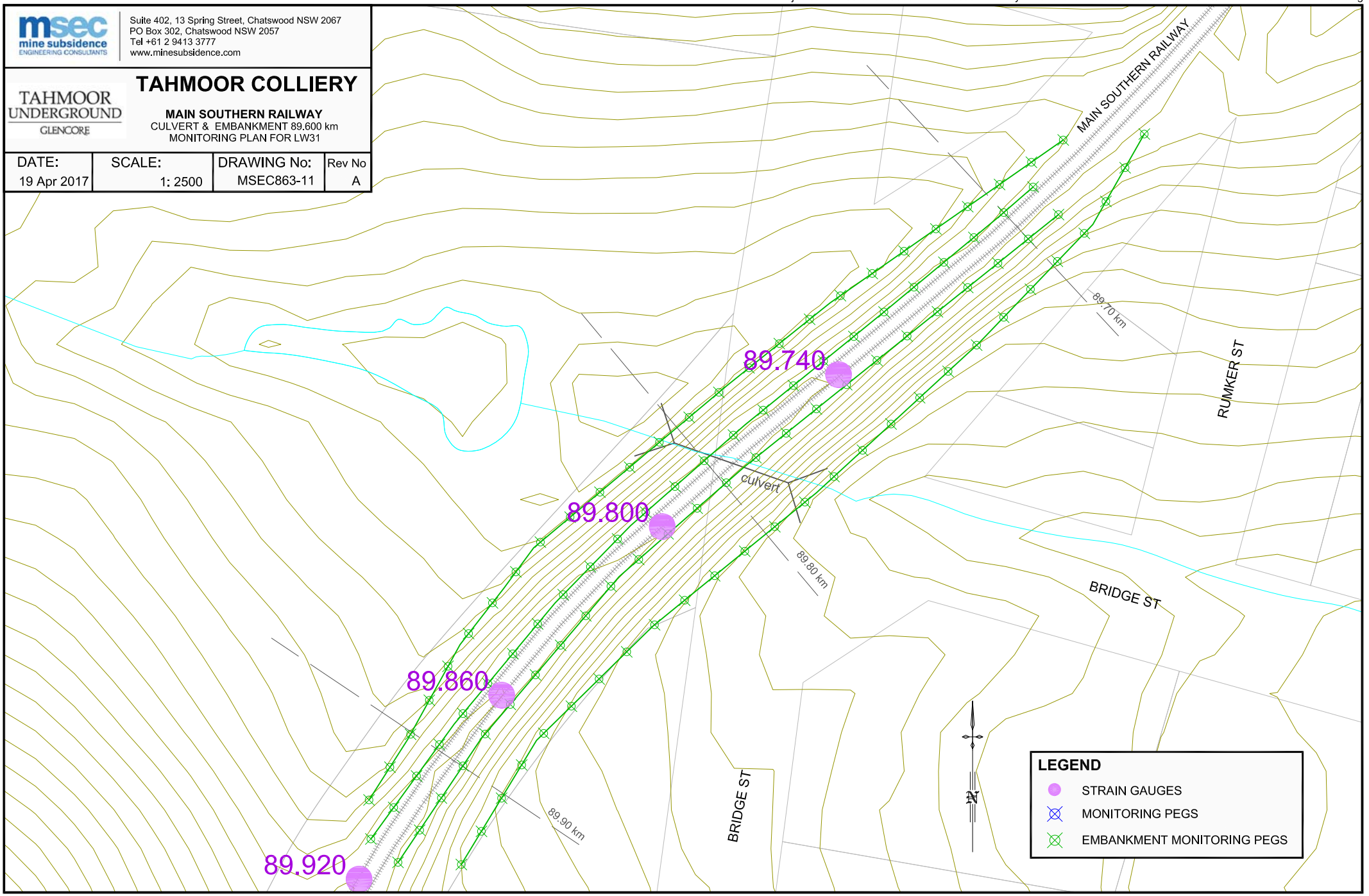
TAHMOOR UNDERGROUND GLENCORE

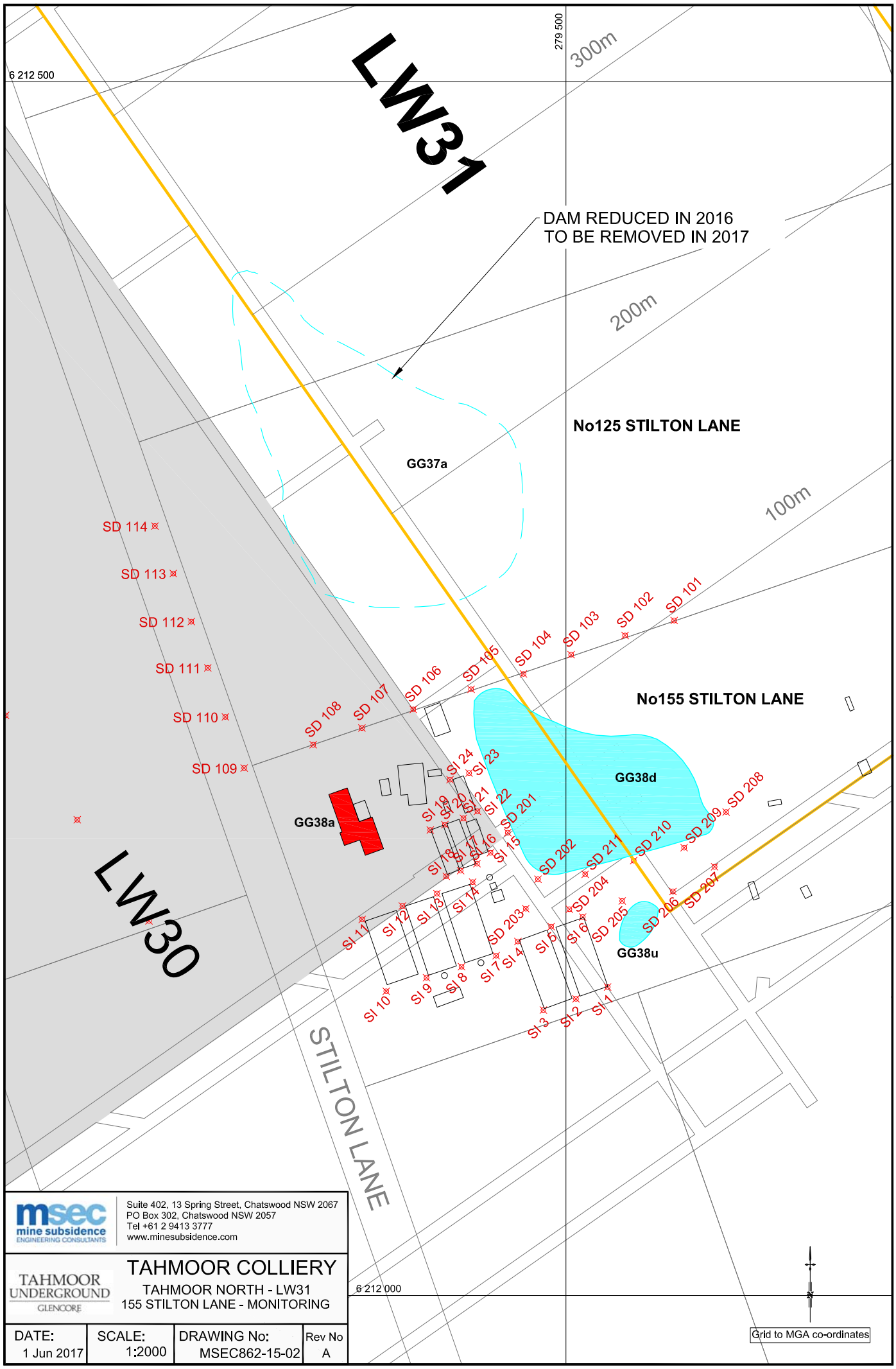
# TAHMOOR COLLIERY

**MAIN SOUTHERN RAILWAY**
CULVERT & EMBANKMENT 89.600 km
MONITORING PLAN FOR LW31

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 19 Apr 2017 | 1: 2500 | MSEC863-11 | A |



I:\Projects\Tahmoor\MSEC862 - LW31 Management Plans\MSEC862-15 Stilton Dams\AcadData\MSEC862-15-02 Monitoring.dwg





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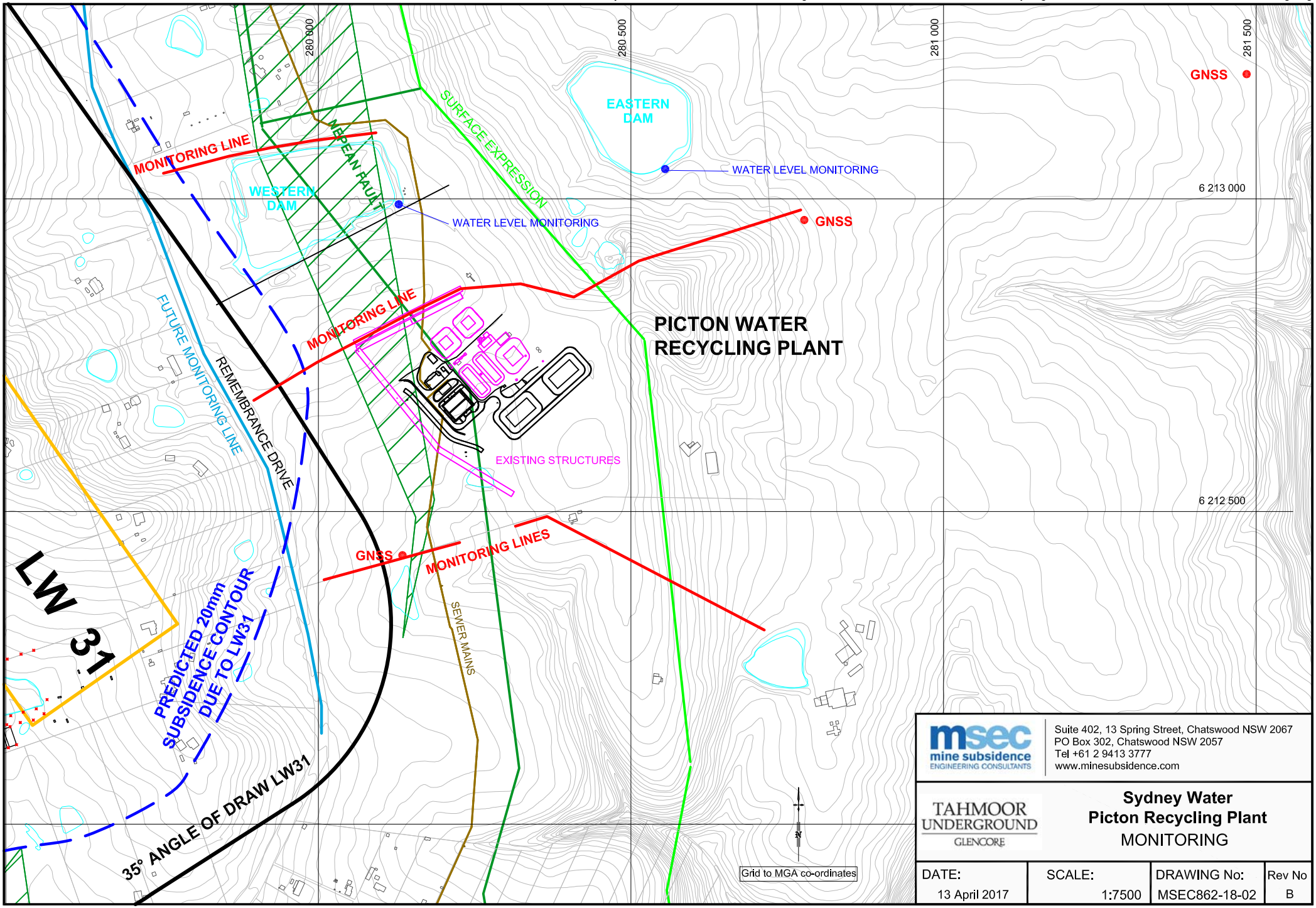
TAHMOOR UNDERGROUND GLENCORE

# TAHMOOR COLLIERY

TAHMOOR NORTH - LW31
155 STILTON LANE - MONITORING

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 1 Jun 2017 | 1:2000 | MSEC862-15-02 | A |

I:\Projects\Tahmoor\MSEC862 - LW31 Management Plans\MSEC862-18 Picton Water Recycling Plant\AcadData\MSEC862-18-02 PWRP Monitoring.dwg





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TAHMOOR UNDERGROUND GLENCORE

**Sydney Water**
**Picton Recycling Plant**
MONITORING

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 13 April 2017 | 1:7500 | MSEC862-18-02 | B |

I:\Projects\Tahmoor\MSEC815 - LW30 Management Plans\MSEC815-17 Queen Victoria Memorial Home\AcadData\MSEC815-17-01 QVMH.dwg

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TAHMOOR UNDERGROUND GLENCORE

# TAHMOOR COLLIERY

TAHMOOR NORTH - LW30
QUEEN VICTORIA MEMORIAL HOME

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 2 May 2017 | 1:2500 | MSEC815-17-01 | E |

**LEGEND**
- MONITORING PEGS

## QUEEN VICTORIA MEMORIAL HOME

T27 T28 T01 T02 T03 T04 T05 T06 T07 T08 T09 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T40 T41 T42 T43 T44 T45 T46 T47 T48

V04a V04b V04ba V04bd V04be V04bh V04bj V04bk V04c V04d V04e V04f V04g V04h V04i V04j V04k V04l V04m V04n V04o V04p V04s V04t V04u V04v V04w V04x V04y V04z V04aa V04ab V04ac V04ad V04ae V04af V04ag V04ah V04ai V04aj V04ak V04al V04am V04an V04ao V04ap V04aq V04ar V04as V04at V04au V04av V04aw V04ax V04ay V04az

505 m
400 m
150 m
140 m
LW 30

I:\Projects\Tahmoor\MSEC815 - LW30 Management Plans\MSEC815-17 Queen Victoria Memorial Home\AcadData\MSEC815-17-02 QVMH.dwg

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TAHMOOR UNDERGROUND GLENCORE

# TAHMOOR COLLIERY

TAHMOOR NORTH - LW30
QUEEN VICTORIA MEMORIAL HOME
MONITORING

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 21 Apr 2017 | 1:5000 | MSEC815-17-02 | B |

## QUEEN VICTORIA MEMORIAL HOME

**LEGEND**
- MONITORING PEGS

THIRLMERE WAY

V04be V04bd V04ba V04az V04ay V04ax V04bh V04a V04as V04d V04b V04bk V04ah V04ai V04aj V04ag V04ac V04ad V04ae V04af V04aa V04ab V04g V04c V04t V04u V04ar V04bj V04n V04h V04l V04ak V04j V04m V04v V04w V04y V04aw V04z V04x V04av V04af V04ad V04ap V04an V04k V04am V04p V04ao V04s V04l V04o

505 m
400 m
150 m
140 m

LW 28
LW 29
LW 30
MAIN SOUTHERN RAILWAY
BRIDGE ST

N

I:\Projects\Tahmoor\MSEC815 - LW30 Management Plans\MSEC815-17 Queen Victoria Memorial Home\AcadData\MSEC815-17-03 QVMH - Asbestos Air Monitoring.dwg

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TAHMOOR UNDERGROUND GLENCORE

# TAHMOOR COLLIERY

TAHMOOR NORTH - LW30
QUEEN VICTORIA MEMORIAL HOME
ASBESTOS AIR MONITORING

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 10 May 2017 | 1:2500 | MSEC815-17-03 | C |

THIRLMERE WAY

N

**LEGEND**

- ASBESTOS AIR MONITORS

## QUEEN VICTORIA MEMORIAL HOME

Goodlet House (access restricted)

Tuberculosis Huts

Site office (access restricted)

Nurses Quarters

Q Store (access restricted)

Polyclinic Building & RSL Sub Branch Office

Maintenance Building

Old barn and House and adjacent barns

Mayfair House & Laundry

V04d
V04e
V04f
V04g
V04h
V04i
V04j
V04k
V04l
V04n
V04o
V04aa
V04ab
V04ac
V04ad
V04ae
V04af
V04aj
V04ak
V04al
V04am
V04an
V04ap
V04aq
V04ar
V04au

LW 30

# APPENDIX B.
# SURVEY SPECIFICATION BY SMEC

TAHMOOR UNDERGROUND
GLENCORE

SMEC
Local People. Global Experience.

# ***SPECIFICATIONS FOR SUBSIDENCE MONITORING LINES FOR LONGWALL 31***

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. Relative co-ordinates of subsidence line stations where required. (In order to obtain relative horizontal movement).

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 GPS control 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.

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.

   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.

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Tahmoor NSW 2573 Australia
Telephone 02 4640 0100

SMEC Australia Pty Ltd
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Campbelltown NSW 2560
Telephone 02 4640 8222

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.

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

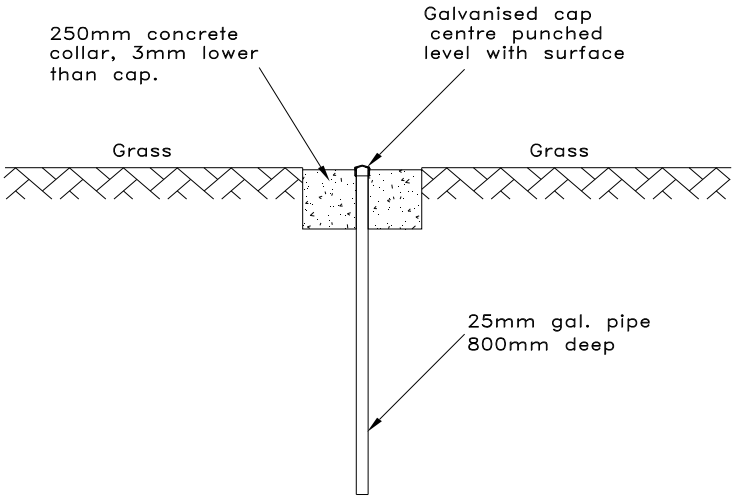
4.5.1. Establishment of Site GPS Base Stations. Site Base Stations located not closer than 2 kilometres from active subsidence.
4.5.2. Site GPS Base Stations are to be monitored periodically by connection to an established stable 'outer' network of GPS Stations.
4.5.3. GPS Baselines are to be surveyed 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).

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).

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.




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.

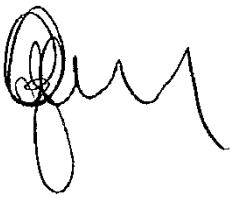
8. Reports

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 and XML file showing subsidence results of current survey. This is to be supplied electronically.
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 & XML files be used as a template.

Yours faithfully,
**SMEC Australia Pty Ltd**
per .. **Gary Warren**
**Senior Registered Surveyor**
PO Box 232
Campbelltown NSW 2560
Ph: 02 4640 8222
gus.warren@smec.com



**Tahmoor Colliery Contacts:**

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# APPENDIX C.
# SURVEY SPECIFICATION BY SOUTHERN RAIL SURVEYS

TAHMOOR UNDERGROUND
GLENCORE

*Southern Rail Surveys Pty Ltd*

*PO Box 3078*

*Exeter, NSW, 2579*

# ***Main Southern Rail Line- Survey Monitoring Plan for LW31***

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).

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.

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 Totalstation survey methods will be used where possible. Other survey methods are included herein in the event that they are required in specific circumstances.

   4.3. Totalstation 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 nominally 150 metres.
      4.3.5. Maximum intermediate line length nominally 80 metres.
      4.3.6. Target at each subsidence station to generally be a fixed miniprism.

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*Exeter, NSW, 2579*

4.4. GPS Survey Control for Three Dimensional Survey of Subsidence Lines (in conjunction with SMEC Urban):

4.4.1. Establishment of Site GPS Base Stations. Site Base Stations located not closer than 2 kilometres from active subsidence.
4.4.2. 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.
4.4.3. 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).

4.5. Culvert pipe joints:

4.5.1. Culvert pipe joints will be measured by calliper.

5. Target Accuracies

5.1. Target Accuracies for monitoring surveys by total station shall be as follows:
- 2.0 second angular resolution
- ±2mm and 2 ppm distance

5.2. Strain distances measured to an accuracy of ±5mm (Strain 0.25mm/m over a 20 m bay) for measurement by EDM/theodolite traverse.
5.3. Traversing shall be minimum Class D or LC as prescribed in ICSM SP1 or better.
5.4. Co-ordinates derived from horizontal movement surveys (by traverse &/or GPS) shall have an absolute accuracy of ± 10mm or better (Relative two dimensional accuracy of ± 5mm).
5.5. Rail creep surveys shall be measured to an accuracy of ±3mm
5.6. Long bay surveys shall be measured to an accuracy of ±3mm
5.7. 2D Bridge surveys across the arches shall be measured to an accuracy of ±3mm

6. Survey Instrument Calibration

6.1. In accordance with the Surveying and Spatial Information Regulation 2012 the survey instruments associated with this project will be calibrated annually.
6.2. A calibration certificate will be supplied to Tahmoor Colliery.

7. Subsidence Station Placement

7.1. Survey marks in the ground 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.
7.2. The noise wall survey marks are fixed prisms attached to steel supporting beams.
7.3. The Deviation Overbridge survey marks are fixed prisms attached to the concrete bridge elements.
7.4. 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 LW31 Railway Subsidence Management Plan.

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8. 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 LW31 Railway Subsidence Management Plan for survey frequencies.

9. Reports

The following information shall be included in the report:

9.1. Date of survey.
9.2. Name, location and RL of bench mark and or GPS Base station used.
9.3. 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.
9.4. Excel table and XML file showing subsidence results of current survey. This is to be supplied electronically.
9.5. Any other relevant information required by the Surveyor.

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.

10. Additional Information
Tahmoor Colliery will provide an AutoCAD file of the Mine Workings if required.
Tahmoor Colliery will provide an Excel & XML files be used as a template.

**John Rolles**
**Registered Surveyor**
**Southern Rail Surveys Pty Ltd**
**26 June 2017**

**Tahmoor Colliery Contacts:**

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