TAHMOOR UNDERGROUND
GLENCORE

GLENCORE:

# Tahmoor Colliery - Longwall 30

Management Plan for Potential Impacts to Jemena Gas Infrastructure

## AUTHORISATION OF MANAGEMENT PLAN

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| Date: | 5/5/16 |

## DOCUMENT REGISTER

| Date | Report No. | Rev | Comments |
|---|---|---|---|
| Mar-06 | MSEC286-0405 | A | Draft for Submission to Jemena |
| Jul-06 | MSEC286-0405 | B | Agreed management plan |
| Aug-06 | MSEC286-0405 | C | Chapter 1 amended |
| Mar-08 | MSEC286-0405 | D | Draft update to mine plan and risk control procedures |
| May-08 | MSEC286-0405 | E | Agreed amended plan for Longwalls 24A to 26 |
| Sep-08 | MSEC286-0405 | F | Updated for Longwalls 25 to 26 and Jemena name change |
| Apr-10 | MSEC446-05 | A | Updated for Longwall 26 |
| Jun-10 | MSEC446-05 | B | Minor revisions |
| Sep-12 | MSEC567-05 | A | Updated for Longwall 27 |
| Oct-12 | MSEC567-05 | B | Updated after consultation with Jemena |
| Mar-14 | MSEC646-05 | A | Updated for Longwalls 28 to 30 |
| Mar-14 | MSEC646-05 | B | Updated following Jemena feedback |
| Apr-14 | MSEC646-05 | C | Final plan for Longwall 28 |
| Mar-15 | MSEC746-05 | A | Updated for Longwalls 29 to 30 |
| Apr-15 | MSEC746-05 | B | Updated following Jemena feedback |
| Apr-15 | MSEC746-05 | C | Final plan for Longwall 29 only |
| Feb-16 | MSEC815-05 | A | Updated for Longwall 30 |

References:-


AS/NZS 4360:1999 Risk Management

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

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

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 A at the end of this report.

| *Drawing No.* | *Description* | *Revision* |
|---|---|---|
| MSEC815-05-01 | Jemena Infrastructure and Predicted Incremental Subsidence due to Longwall 30 | A |

## 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 28 longwalls to the north and west of the mine's current location. It is currently mining Longwall 29.

Longwall 30 is a continuation of a series of longwalls that extend into the Tahmoor North Lease area, which began with Longwall 22. The longwall panel is located between the Bargo River in the south-east, the township of Thirlmere in the west and Picton in the north.

Longwall 30 is approximately 283 metres wide (rib-to-rib) and approximately 2.3 kilometres long. The width of the chain pillar between Longwalls 29 and 30 is 40 metres.

Longwall 30 is located beneath the rural area of Tahmoor. No infrastructure owned by Jemena is located directly above Longwall 30.

Tahmoor Colliery's mine plan has changed, in that Longwall 30 has been shortened by approximately 250 metres, when compared to the mine plan submitted with the SMP Application for Longwalls 27 to 30. This represents a significant change because the potential for impacts on the steel gas pipe crossing over Myrtle Creek on the Remembrance Drive Road Bridge has been substantially reduced.

The closest distance of Longwall 30 to the main PE gas pipe along Remembrance Drive is 260 metres. The location of Longwall 30 relative to Jemena assets is shown in Drawing No. MSEC815-05-01.

This Management Plan provides detailed information about how the risks associated with mining in the vicinity of gas infrastructure will be managed by Tahmoor Colliery and Jemena.

The Management Plan is a live document that can be amended at any stage of mining, to meet the changing needs of Tahmoor Colliery and Jemena.

## 1.2. Objectives

The objectives of this Management Plan are to establish procedures to measure, control, mitigate and repair potential impacts that might occur on surface infrastructure owned by Jemena. The objectives of the Management Plan have been developed to:-

- Ensure the safe and serviceable operation of all surface infrastructure. Public and workplace safety is paramount. Disruption and inconvenience should be kept to minimal levels.
- Monitor ground movements and the condition of surface infrastructure during mining.
- Establish procedures to measure, monitor, control, mitigate and repair gas infrastructure.
- Initiate action to mitigate or remedy potential significant impacts that are expected to occur on the surface.
- Provide a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted.
- Provide a forum to report, discuss and record impacts to the surface. This will involve Tahmoor Colliery, Jemena, Mine Subsidence Board, and the NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS), and consultants as required.
- Establish lines of communication and emergency contacts.

## 1.3. Scope

The Management Plan is to be used to protect and monitor the condition of the items of infrastructure identified to be at risk due to mine subsidence. The major items at risk are:-

- The main PE gas pipeline
- The local gas pipelines
- Gas mains at creek crossings

The Management Plan describes measures that will be undertaken as a result of mining Longwall 30 only.

## 1.4. Proposed Mining Schedule

It is planned that Longwall 30 will extract coal working northwest from the southeastern end. This Management Plan covers longwall mining until completion of mining in Longwall 30 and for sufficient time thereafter to allow for completion of subsidence effects. The current schedule of mining is shown in Table 1.1.

**Table 1.1 Schedule of Mining**

| Longwall | Start Date | Completion Date |
|---|---|---|
| Longwall 30 | May 2016 | March 2017 |

## 1.5. 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 and 450 metres behind the active longwall face, as shown by Fig. 1.1.

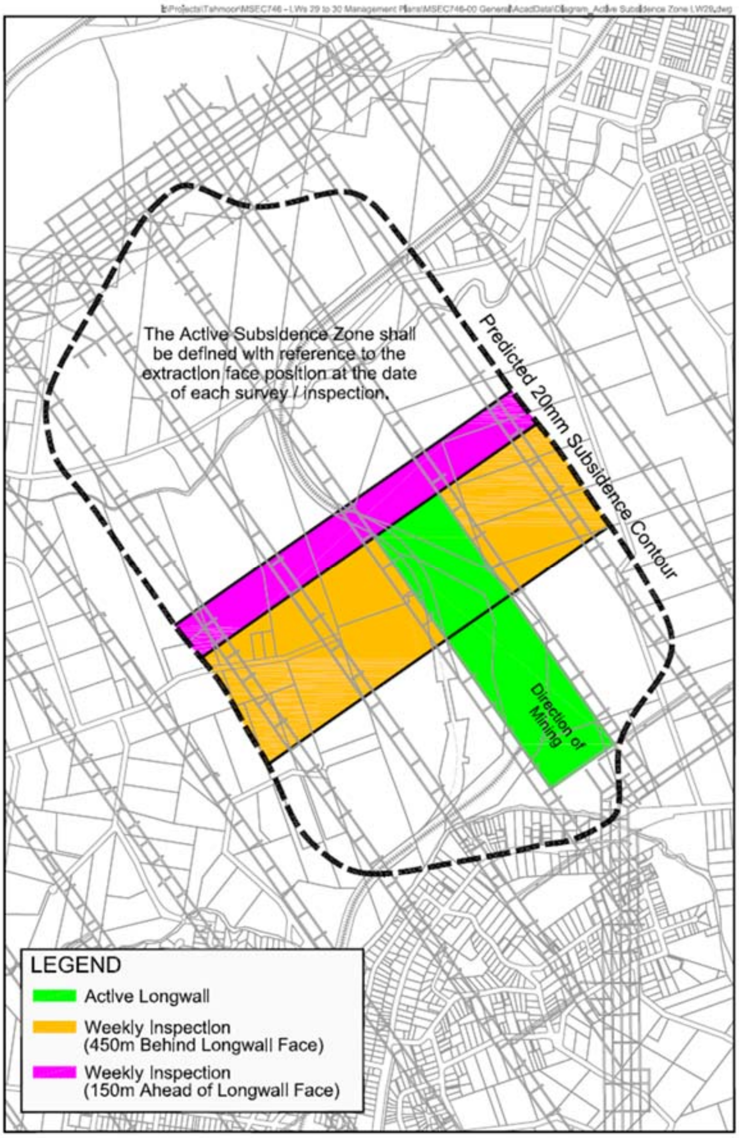



**Fig. 1.1 Diagrammatic Representation of Active Subsidence Zone**

## 2.1. General

The Australian/New Zealand standard for Risk Management defines the terms used in the risk management process, which includes the identification, analysis, assessment, treatment and monitoring of risk. In this context:-

### 2.1.1. Consequence

'The outcome of an event expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. There may be a range of possible outcomes associated with an event.'[1] The consequences of a hazard are rated from very slight to very severe.

### 2.1.2. Likelihood

'Used as a qualitative description of probability or frequency.'[2] The likelihood can range from very rare to almost certain.

### 2.1.3. Hazard

'A source of potential harm or a situation with a potential to cause loss.'[3]

### 2.1.4. Risk

'The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.'[4] The risk combines the likelihood of an impact occurring with the consequence of the impact occurring. The risk is rated from very low to extreme. In this study, the likelihood and consequence are combined via the qualitative risk analysis matrix shown in Table 2.1, to determine an estimated level of risk for particular events or situations.

The Risk Analysis Matrix is similar to the example provided in AS/NZS 4360:1995, Appendix D, p.25.

**Table 2.1 Qualitative Risk Analysis Matrix**

| Likelihood | CONSEQUENCES | | | | |
|---|---|---|---|---|---|
| | Very Slight | Slight | Moderate | Severe | Very Severe |
| Almost Certain | Low | Moderate | High | Extreme | Extreme |
| Likely | Low | Moderate | High | Very High | Extreme |
| Moderate | Low | Low | Moderate | High | Very High |
| Unlikely | Very Low | Low | Moderate | High | High |
| Rare | Very Low | Very Low | Low | Moderate | High |
| Very Rare | Very Low | Very Low | Low | Moderate | Moderate |

This Management Plan adopts a common system of nomenclature to summarise each risk analysis, which is **"LIKELIHOOD / CONSEQUENCE → LEVEL OF RISK".**

For example, if the likelihood of a risk is assessed as "**UNLIKELY**", and the consequence of a risk is assessed as "**SEVERE**", the risk analysis would be summarised as **"UNLIKELY / SEVERE → HIGH"**.

[1] AS/NZS 4360:1999 – Risk Management pp2
[2] AS/NZS 4360:1999 – Risk Management pp2
[3] AS/NZS 4360:1999 – Risk Management pp2
[4] AS/NZS 4360:1999 – Risk Management pp3

## 3.1. Maximum Predicted Systematic Parameters

Predicted mining-induced systematic subsidence movements were provided in Report No. MSEC355, which was prepared in support of Tahmoor Colliery's SMP Application for Longwalls 27 to 30. Tahmoor Colliery has submitted an application to modify the SMP mine layout to shorten the commencing end of Longwall 30 by approximately 250 metres. The predictions and impact assessments included in this document are based on the shortened longwall.

A summary of the maximum predicted incremental systematic subsidence parameters, due to the extraction of Longwall 30, is provided in Table 3.1. A summary of the maximum predicted total systematic subsidence parameters, after the extraction of Longwall 30, is provided in Table 3.2.

**Table 3.1 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Longwall 30**

| Longwall | Maximum Predicted Incremental Subsidence (mm) | Maximum Predicted Incremental Tilt (mm/m) | Maximum Predicted Incremental Hogging Curvature (1/km) | Maximum Predicted Incremental Sagging Curvature (1/km) |
|---|---|---|---|---|
| Due to LW30 | 725 | 6.0 | 0.06 | 0.15 |

**Table 3.2 Maximum Predicted Total Systematic Subsidence Parameters after the Extraction of Longwall 30**

| Longwall | Maximum Predicted Cumulative Subsidence (mm) | Maximum Predicted Cumulative Tilt (mm/m) | Maximum Predicted Cumulative Hogging Curvature (1/km) | Maximum Predicted Cumulative Sagging Curvature (1/km) |
|---|---|---|---|---|
| After LW30 | 1250 | 6.0 | 0.10 | 0.15 |

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

In this case, there is no Jemena infrastructure located directly above Longwall 30 and the small lengths of pipes near Longwall 30 will not experience the predicted maximum subsidence parameters above.

## 3.2. Predicted Strain

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock. Survey tolerance can also represent a substantial portion of the measured strain, in cases where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

In previous MSEC subsidence reports, predictions of conventional strain were provided based on the best estimate of the average relationship between curvature and strain. Similar relationships have been proposed by other authors. The reliability of the strain predictions was highlighted in these reports, where it was stated that measured strains can vary considerably from the predicted conventional values.

Adopting a linear relationship between curvature and strain provides a reasonable prediction for the conventional tensile and compressive strains. The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones. In the Southern Coalfield, it has been found that a factor of 15 provides a reasonable relationship between the maximum predicted curvatures and the maximum predicted conventional strains.

At a point, however, there can be considerable variation from the linear relationship, resulting from non-conventional movements or from the normal scatters which are observed in strain profiles. When expressed as a percentage, observed strains can be many times greater than the predicted conventional strain for low magnitudes of curvature. In this report, therefore, we have provided a statistical approach to account for the variability, instead of just providing a single predicted conventional strain.

The data used in an analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements, but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed survey marks have also been excluded.

### 3.2.1. Analysis of Strains Measured in Survey Bays

For features that are in discrete locations, such as building structures, farm dams and archaeological sites, it is appropriate to assess the frequency of the observed maximum strains for individual survey bays.

The survey database has been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of the previous longwalls at Tahmoor Colliery, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls, which has been referred to as "*above goaf*".

A histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf is provided in Fig. 3.1. A number of probability distribution functions were fitted to the empirical data. It was found that a *Generalised Pareto Distribution (GPD)* provided a good fit to the raw strain data, which have also been shown in this figure.

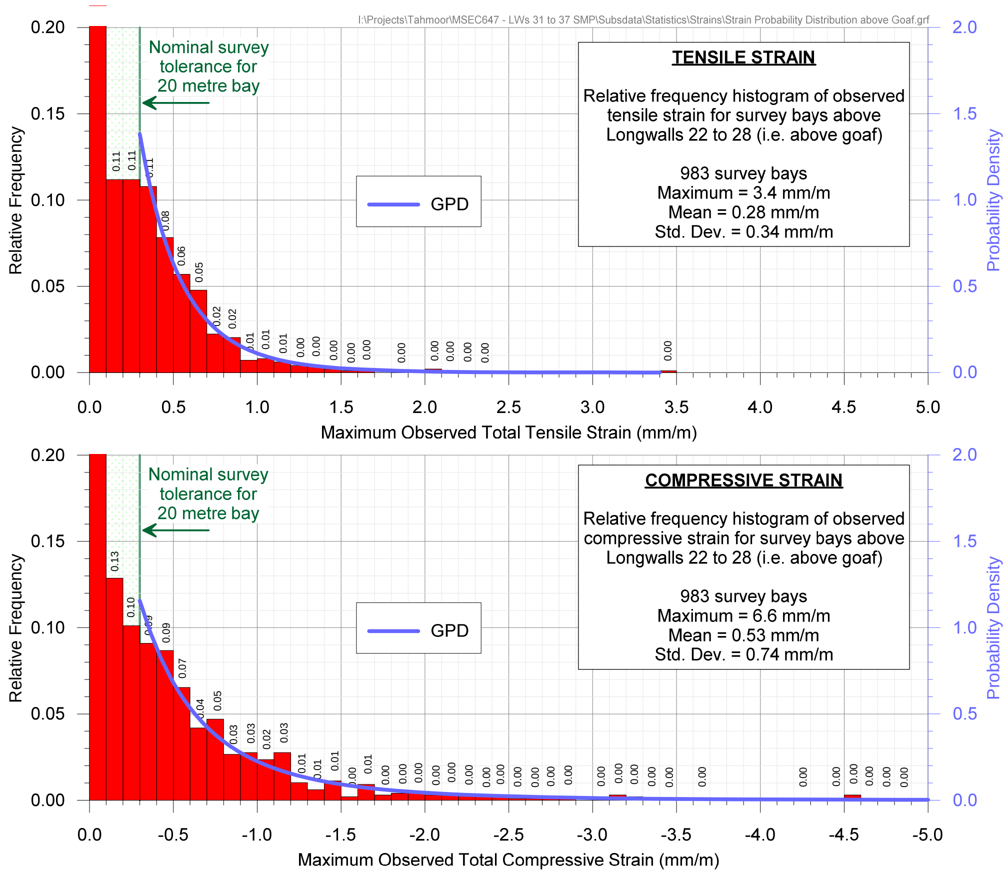



**Fig. 3.1 Distributions of the Measured Maximum Tensile and Compressive Strains during the Extraction of Previous Longwalls at Tahmoor Colliery for Bays Located Above Goaf**

Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

A summary of the probabilities of exceedance for tensile and compressive strains for survey bays located above goaf, based on the fitted GPDs, is provided in Table 3.3. The analysis does not include the strains resulting from valley related movements.

**Table 3.3 Probabilities of Exceedance for Strain for Survey Bays Located above Goaf**

| Strain (mm/m) | | Probability of Exceedance |
|---|---|---|
| Compression | -8.0 | 1 in 1,100 |
| | -6.0 | 1 in 450 |
| | -4.0 | 1 in 140 |
| | -2.0 | 1 in 25 |
| | -1.0 | 1 in 7 |
| | -0.5 | 1 in 3 |
| | -0.3 | 1 in 2 |
| Tension | +0.3 | 1 in 3 |
| | +0.5 | 1 in 5 |
| | +1.0 | 1 in 25 |
| | +2.0 | 1 in 330 |
| | +3.0 | 1 in 2,500 |

The 95 % confidence levels for the maximum total strains that the individual survey bays above goaf experienced at any time during mining were 0.9 mm/m tensile and 1.8 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above goaf experienced at any time during mining were 1.5 mm/m tensile and 3.5 mm/m compressive.

The probabilities for survey bays located above goaf are based on the strains measured anywhere above the previously extracted longwalls at Tahmoor Colliery. As described previously, tensile strains are more likely to develop in the locations of hogging curvature and compressive strains are more likely to develop in the locations of sagging curvature.

This is illustrated in Fig. 3.2, which shows the distribution of incremental strains measured above previously extracted longwalls in the Southern Coalfield. The distances have been normalised, so that the locations of the measured strains are shown relative to the longwall maingate and tailgate sides. The approximate confidence levels for the incremental tensile and compressive strains are also shown in this figure, to help illustrate the variation in the data.

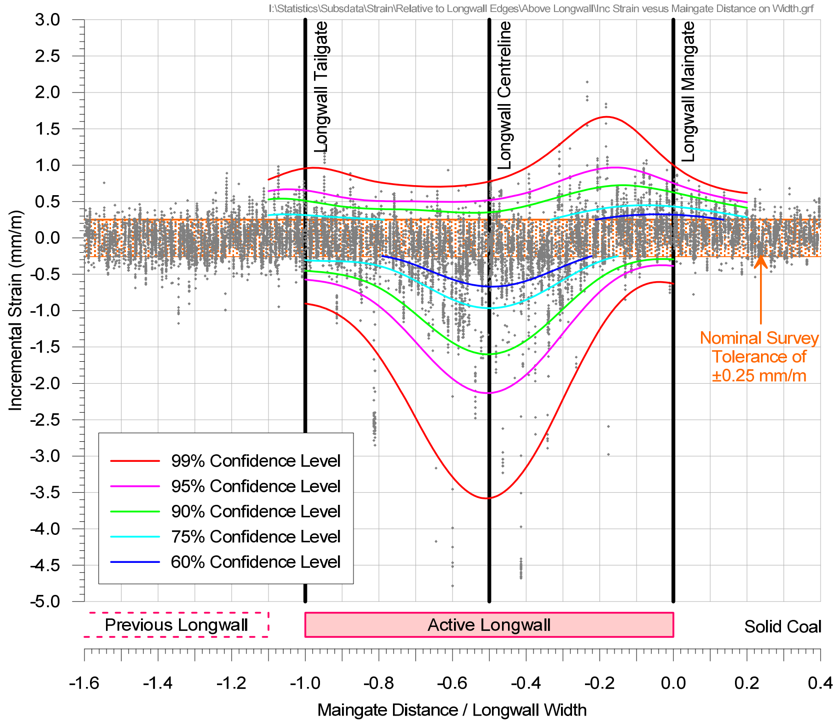



**Fig. 3.2 Observed Incremental Strains versus Normalised Distance from the Longwall Maingate for Previously Extracted Longwalls in the Southern Coalfield**

The survey database has also been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of the previous longwalls in the Southern Coalfield, for survey bays that were located outside and within 200 metres of the nearest longwall goaf edge, which has been referred to as "*above solid coal*".

A histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal is provided in Fig. 3.3. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

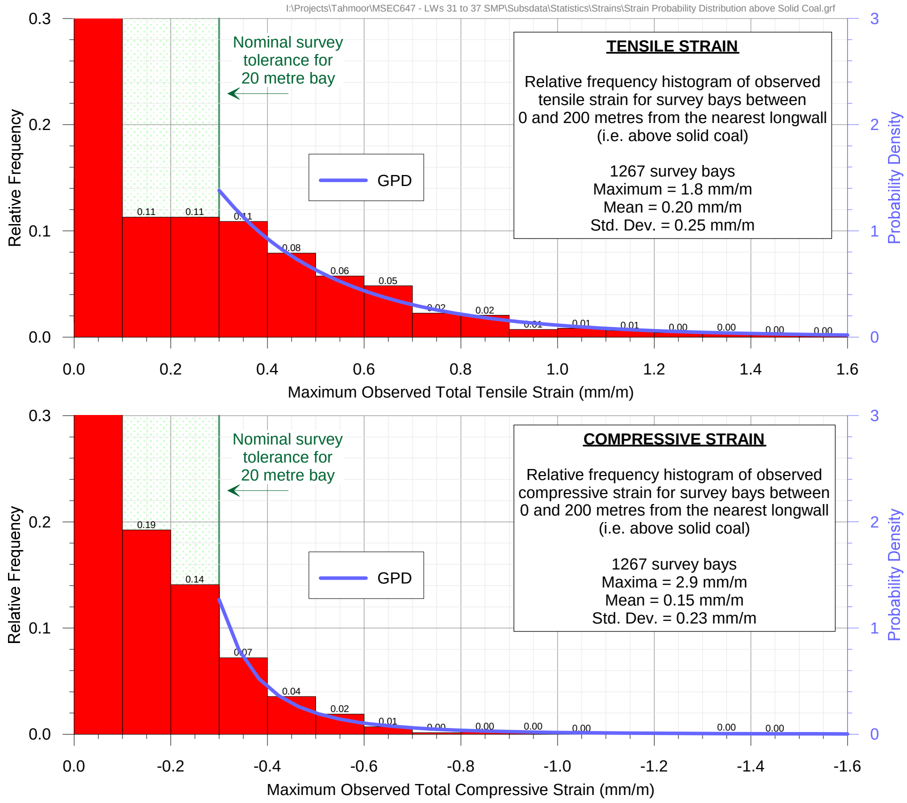



**Fig. 3.3 Distributions of the Measured Maximum Tensile and Compressive Strains during the Extraction of Previous Longwalls at Tahmoor Colliery for Bays Located Above Solid Coal**

Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

A summary of the probabilities of exceedance for tensile and compressive strains for survey bays located above solid coal, based on the fitted GPDs, is provided in Table 3.4. The analysis does not include the strains resulting from valley related movements.

**Table 3.4 Probabilities of Exceedance for Strain for Survey Bays Located above Solid Coal**

| Strain (mm/m) | | Probability of Exceedance |
|---|---|---|
| Compression | -3.0 | 1 in 2,200 |
| | -2.0 | 1 in 800 |
| | -1.5 | 1 in 400 |
| | -1.0 | 1 in 150 |
| | -0.5 | 1 in 25 |
| | -0.3 | 1 in 7 |
| Tension | +0.3 | 1 in 4 |
| | +0.5 | 1 in 10 |
| | +1.0 | 1 in 80 |
| | +1.5 | 1 in 400 |
| | +2.0 | 1 in 1,600 |

The 95 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining were 0.6 mm/m tensile and 0.5 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining were 1.1 mm/m tensile and 0.9 mm/m compressive.

### 3.2.2. Analysis of Strains Measured Along Whole Monitoring Lines

For linear features such as roads, cables and pipelines, it is more appropriate to assess the frequency of the maximum observed strains along whole monitoring lines, rather than for individual survey bays. That is, an analysis of the maximum strains measured anywhere along the monitoring lines, regardless of where the strain actually occurs.

A histogram of maximum observed total tensile and compressive strains measured anywhere along the monitoring lines, at any time during or after the extraction of the previous longwalls at Tahmoor Colliery, is provided in Fig. 3.4.

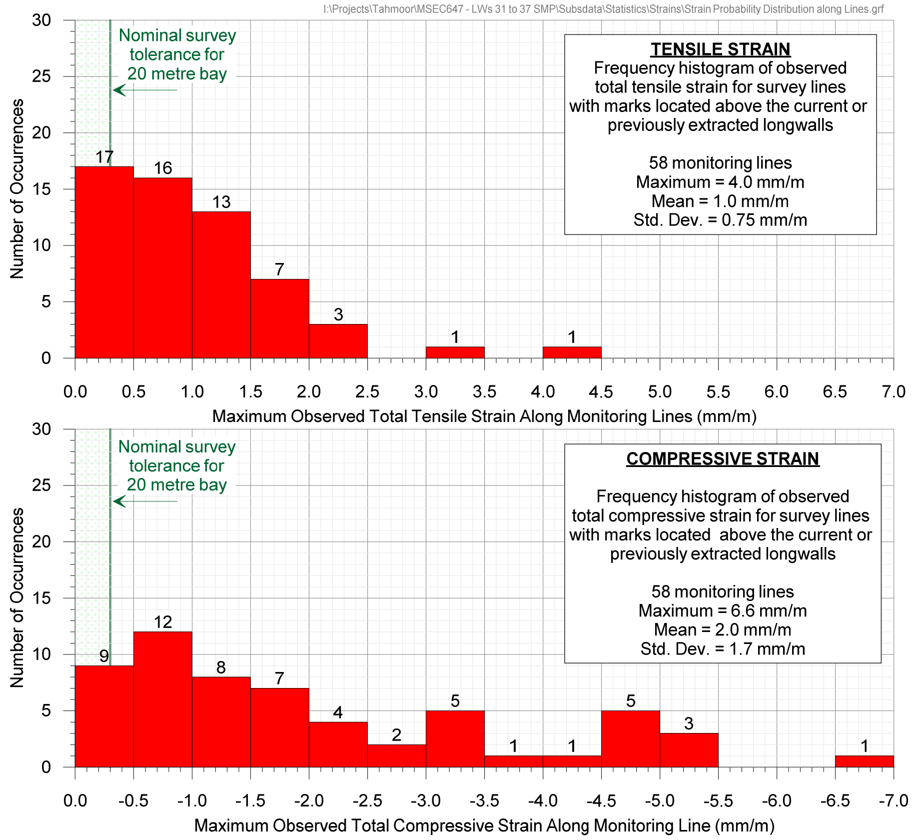



**Fig. 3.4 Distributions of Measured Maximum Tensile and Compressive Strains along the Monitoring Lines during the Extraction of Previous Longwalls at Tahmoor Colliery**

It can be seen from the above figure, that 33 of the 58 monitoring lines (i.e. 57 %) had recorded maximum total tensile strains of 1.0 mm/m, or less, and that 53 monitoring lines (i.e. 91 %) had recorded maximum total tensile strains of 2.0 mm/m, or less. It can also be seen, that 36 of the 58 monitoring lines (i.e. 62 %) had recorded maximum compressive strains of 2.0 mm/m, or less, and that 48 of the monitoring lines (i.e. 83 %) had recorded maximum compressive strains of 4.0 mm/m, or less.

## 3.3. Predicted and Observed Valley Closure across creeks

A number of bridges and culverts in the vicinity of Longwall 30 carry road transport over Myrtle Creek, Redbank Creek and other watercourses. Predictions of valley closure and upsidence at each of these features are provided later in this Management Plan.

A comparison between predicted and observed valley closure movements is provided in Table 3.5.

A map of monitoring lines across Myrtle Creek and a small creek that crosses the Main Southern Railway (called the Skew Culvert) is shown in Fig. 3.5.


**Fig. 3.5 Monitoring lines across Myrtle Creek and Skew Culvert**

A summary graph showing the development of valley closure across Myrtle Creek at each monitoring line is shown in Fig. 3.6.

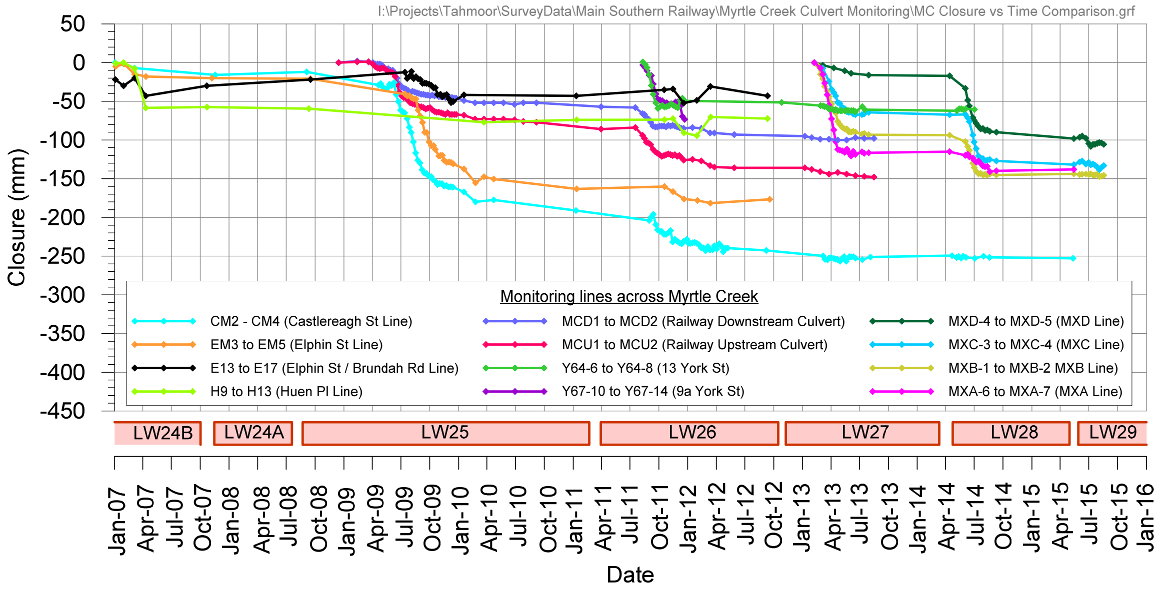



**Fig. 3.6 Development of closure across Myrtle Creek during the mining of Longwalls 24B to 29**

A summary of predicted and observed valley closure across Myrtle Creek is provided in Table 3.5. The predictions are consistent with those provided in Report No. MSEC355, in support of Tahmoor Colliery's SMP application to extract longwalls 27 to 30.

**Table 3.5 Predicted and Observed Incremental Valley Closure across Myrtle Creek and Skew Culvert at monitoring lines**

| Location | Category | Predicted and Observed Valley Closure due to Mining of Each Longwall (mm) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Due to LW24 | Due to LW25 | Due to LW26 | Due to LW27 | Due to LW28 | Due to LW29 |
| Castlereagh St (Pegs CM2 to CM4) | Predicted | 30 | 55 | 45 | 25 | < 20 | - |
| | Observed | 12 | 179 | 52 | 8 | 1 | - |
| Elphin-Myrtle (Pegs EM3 to EM5) | Predicted | 60 | 70 | 40 | - | - | - |
| | Observed | 21 | 142 | 22 | - | - | - |
| Elphin St / Brundah Rd (Pegs E13 to E17) | Predicted | 75 | 75 | 30 | - | - | - |
| | Observed | 0 | 21 | 6 | - | - | - |
| Huen Pl (Pegs H9 to H13) | Predicted | 60 | 35 | 15 | - | - | - |
| | Observed | 58 | 15 | 20 | - | - | - |
| Main Southern Railway Upstream (MCU1 to MCU4) Downstream (MCD1 to MCD4) | Predicted | 15 | 30 | 30 | 15 | - | - |
| | Observed | - | 57 (d/s) to 86 (u/s) | 36 (d/s) to 50 (u/s) | 5 (d/s) to 12 (u/s) | - | - |
| Skew Culvert (8 cross-sections) | Predicted | < 5 | 10 | 25 | 25 | 10 | - |
| | Observed | - | - | 21 to 60 (average 36) | 8 to 36 (average 21) | +3 to -8 (average 3) | - |
| 13 York St (Pegs Y64-6 to Y64-8) | Predicted | - | - | 65 | 50 | < 20 | - |
| | Observed | - | - | 51 | 9 | 0 | - |
| 9a York St (Pegs Y67-10 to Y67-14) | Predicted | - | - | 85 | 85 | 25 | - |
| | Observed | - | - | 73 | No access | No access | - |
| MXA Line (Pegs MXA-6 to MXA-7) | Predicted | - | - | - | 150 | 75 | - |
| | Observed | - | - | - | 116 | 25 | - |
| MXB Line (Pegs MXB-1 to MXB-2) | Predicted | - | - | - | 170 | 150 | 60 |
| | Observed | - | - | - | 93 | 51 | 3 |
| MXC Line (Pegs MXC-4 to MXC-5) | Predicted | - | - | - | 150 | 170 | 100 |
| | Observed | - | - | - | 64 | 106 | 7 |
| MXD Line (Pegs MXD-4 to MXD-5) | Predicted | - | - | - | 50 | 70 | 80 |
| | Observed | - | - | - | 16 | 73 | 10 |
| Remembrance Drive (Pegs R77 to R80) | Predicted | - | - | < 5 | 10 | 15 | 20 |
| | Observed | - | - | 1 | 3 | 3 | 3 |

It can be seen that observed valley closure has substantially exceeded predictions at the Castlereagh Street crossing, at the crossing of the Elphin-Myrtle monitoring line and to a lesser extent the crossing of the Main Southern Railway during the mining of Longwall 25. It is considered that the reason for the differences in observations may be linked to the change in orientation of Myrtle Creek as the three above-mentioned monitoring lines are located along the same stretch of Myrtle Creek. It is noted, however, that less closure has developed at Castlereagh Street than predicted during the mining of Longwall 27.

Observed valley closure across Myrtle Creek during Longwalls 27 and 28 has been less than prediction, but greater than previously observed. Predictions for this section of creek were greater than upstream sections because the valley is deeper. Observed values during Longwall 29 are substantially less than predicted.

## 3.4. Gas Infrastructure

Jemena has an extensive gas infrastructure network at Tahmoor and Thirlmere. The gas pipelines are shown according to their pipe sizes in Drawing Nos. MSEC815-05-01. It can be seen that no part of the network is located directly above Longwall 30.

Longwalls 22 to 29 have directly mined beneath approximately 17.9 kilometres of gas pipes and no impacts have been recorded so far. The local nylon pipes and the 160 mm polyethylene main along Remembrance Drive are very flexible and have demonstrated that they are able to withstand the full range of subsidence experienced at Tahmoor to date. While no impacts have been experienced to date, the most vulnerable element of the system are rigid copper pipe connections between the gas mains and houses.

Drawing No. MSEC815-05-01 shows that one section of 32 mm diameter gas pipe along Bridge Street is predicted to experience between 20 mm and 50 mm additional vertical subsidence due to the extraction of Longwall 30. The 160 mm PE gas main along Remembrance Drive is predicted to experience additional vertical subsidence up to 20 mm due to the extraction of Longwall 30.

The main gas pipe, which is a 160 mm diameter polyethylene pipe with glued joints, is located along Remembrance Drive. Longwalls 24A, 25, 26, 27 and 28 have mined directly beneath this pipe and no impacts were observed. This gas main crosses over Myrtle Creek on the Remembrance Drive Road Bridge via a steel pipe with flanged ends. The creek crossing is not directly undermined by Longwall 30 but is expected to experience small upsidence and closure movements during the mining of this longwall.

## 3.5. Hazard Identification

The hazard associated with gas infrastructure is that it may be damaged as a result of mine subsidence impacts. This damage could involve rupturing of pipes and hence become a dangerous hazard to the public.

### 3.5.1. Local Gas Pipeline

Remaining gas pipes are generally 32 mm diameter nylon pipes, which are located along most of the urban streets of Tahmoor and Thirlmere. These smaller diameter local reticulation pipes should be sufficiently flexible to accommodate the predicted levels of strain. It is noted that no impacts were observed during the extraction of Longwalls 22 to 29. This includes no impacts at a site on Abelia Street, where a large measured ground strain of 6.5 mm/m (over a 22 metre bay length) was observed between Pegs A12 and A13, coinciding with a measured vertical bump in the subsidence profile and an observed hump in the road pavement.

It is noted that a ground survey line has already been installed and monitored along Bridge Street, extending to the intersection with Redbank Place. This survey line covers the upstream part of a 32 mm nylon pipe on Bridge Street, which lies within the area of predicted subsidence for Longwall 30.

The likelihood of damage occurring to these small pipes is therefore assessed as **VERY RARE**. The consequence of damage to these pipes is less than the main gas pipelines that run along Remembrance Drive and Thirlmere Way due to their size. The consequence of damage to these pipelines is therefore assessed as **MODERATE**.

The level of risk for this pipeline is therefore assessed as:- **VERY RARE / MODERATE → LOW**.

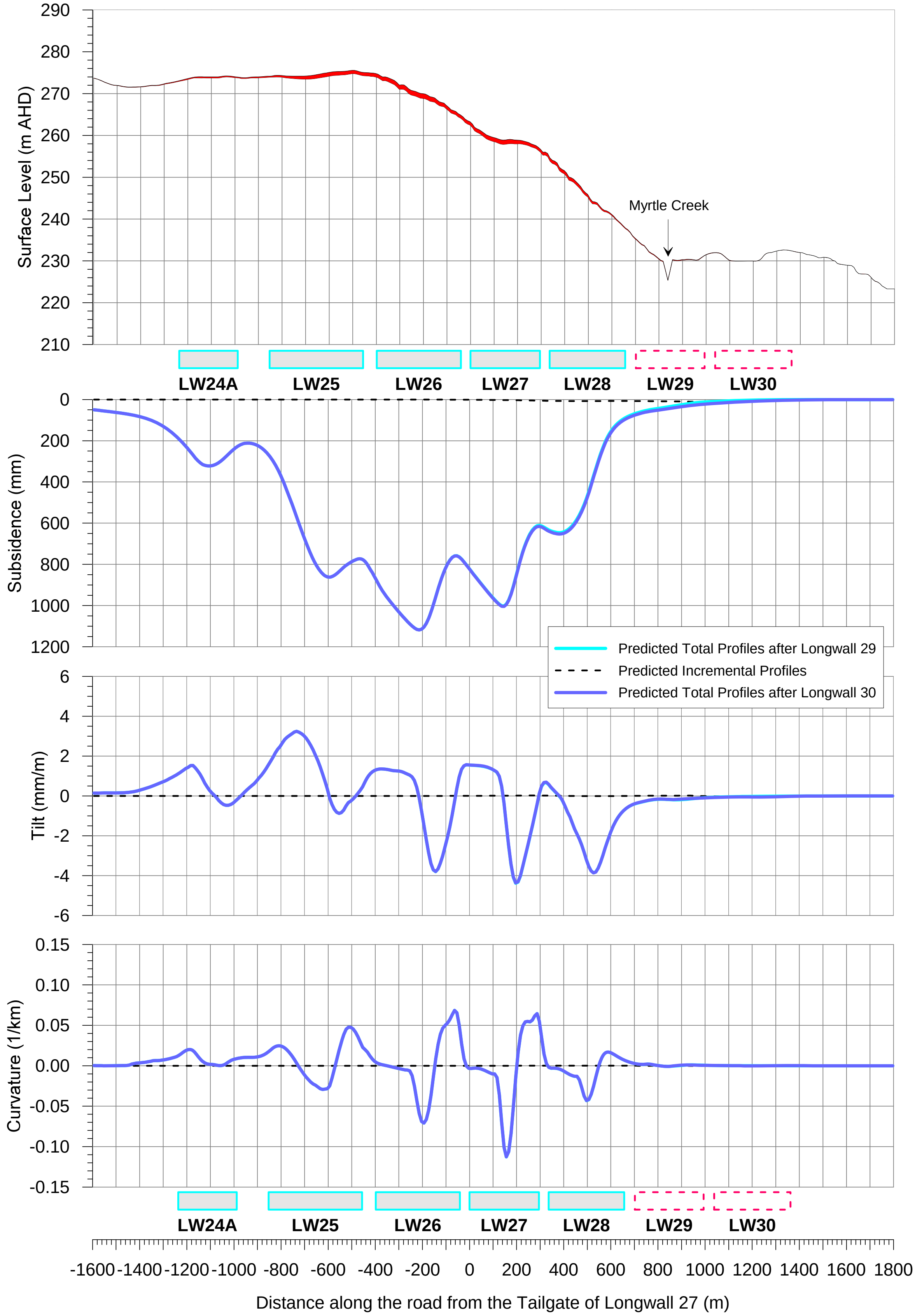



**Fig. 3.7 Predicted Subsidence, Tilt and Curvature along Remembrance Drive due to the mining of Longwalls 22 to 30**

### 3.5.2. Gas Mains at Remembrance Drive Creek Crossing

The gas main crosses over Myrtle Creek on the Remembrance Drive Road Bridge via a steel pipe with flanged ends, as shown in Fig. 3.8 and Fig. 3.9. The bridge is located approximately 310 metres south of the commencing end of Longwall 30 as shown in Drawing No. MSEC815-05-01.

**Fig. 3.8 Remembrance Drive Road Bridge over Myrtle Creek**

**Fig. 3.9 Termination of steel gas pipe at end of Remembrance Drive Road Bridge**

Roads and Maritime Services have provided a copy of the structural design drawings, which show that the dual-span bridge is constructed with a concrete deck on concrete abutments and central pier, as shown in Fig. 3.8. The span of the deck is approximately 18 metres and the heights of the abutments are approximately 7 metres.

The bridge units have been integrated with a reinforced concrete slab. The reinforced concrete abutments appear to rest on pad and strip footing foundations. The pre-tensioned bridge deck units are connected to the central pier with dowels. The drawings do not include the abutment connections, but it appears that the bridge units rest on a corbel at each end. It is likely that a concrete upstand has been constructed at the ends of the deck.

Predictions of systematic subsidence, tilt and strain movements have been made at the gas pipe crossing and bridge, and these are shown in Table 3.6.

**Table 3.6 Predicted Subsidence Parameters at the Gas Pipe Crossing at the Remembrance Drive Road Bridge**

| Stage of Mining | Maximum Predicted Subsidence (mm) | Maximum Predicted Tilt (mm/m) | Maximum Predicted Hogging Curvature (1/km) | Maximum Predicted Sagging Curvature (1/km) |
|---|---|---|---|---|
| Due to LW30 | < 20 | <0.1 | < 0.01 | < 0.01 |
| Total after LW29 | 30 | 0.2 | < 0.01 | < 0.01 |
| Total after LW30 | 40 | 0.2 | < 0.01 | < 0.01 |

The Bridge will also be subjected to upsidence and closure movements, and these are shown in Table 3.7.

**Table 3.7 Predicted Upsidence and Closure at the Gas Pipe Crossing and at the Remembrance Drive Road Bridge**

| Stage of Mining | Maximum Closure (mm) | Maximum Upsidence (mm) |
|---|---|---|
| Due to LW30 | < 20 | < 20 |
| Total after LW29 | 30 | 40 |
| Total after LW30 | 40 | 50 |

It can be seen from Table 3.7 that small additional valley closure and upsidence is predicted to occur during the mining of Longwall 30. It is noted that the predicted closure refers to closure across the whole valley. It is possible that the predicted closure will not concentrate entirely between the gas crossing and the bridge abutments.

Survey marks were installed on the Remembrance Drive Road Bridge prior to the extraction of Longwall 24A. The Bridge has experienced approximately 35 mm of subsidence after the mining of Longwalls 24A to 29.

The distance between the bridge abutments has closed approximately 10 mm, of which approximately 4 to 6 mm has developed during the mining of Longwall 29.

Measured changes in horizontal distances between termination points of the steel gas pipes have generally been small, as shown in Fig. 3.10. Vertical subsidence is relatively consistent across all survey marks, indicating that no measureable upsidence has occurred to date that might result in bending of the bridge deck and gas pipe, as shown in Fig. 3.11 and Fig. 3.12.

The pipes over Remembrance Drive Road Bridge were surveyed at multiple locations to track potential changes in the shape of the pipe during the mining of Longwall 29. It can be seen from Fig. 3.13 that only minor changes were observed to the pipe shape during mining, much of it in the form of rotation about the horizontal plane, recognising that changes in pipe position have been plotted to an exaggerated scale in Fig. 3.13.

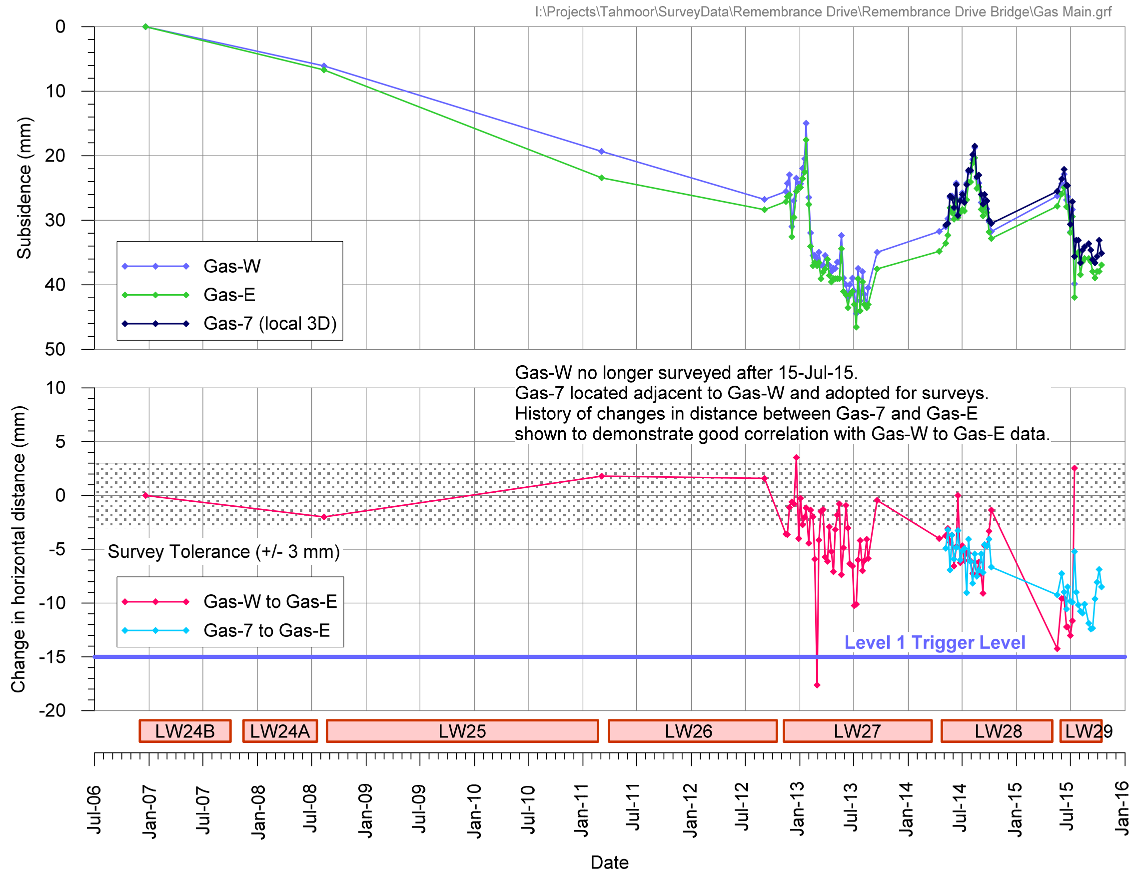



**Fig. 3.10 Observed subsidence and changes in horizontal distances across the abutment of Remembrance Drive (Myrtle Creek) Road Bridge**

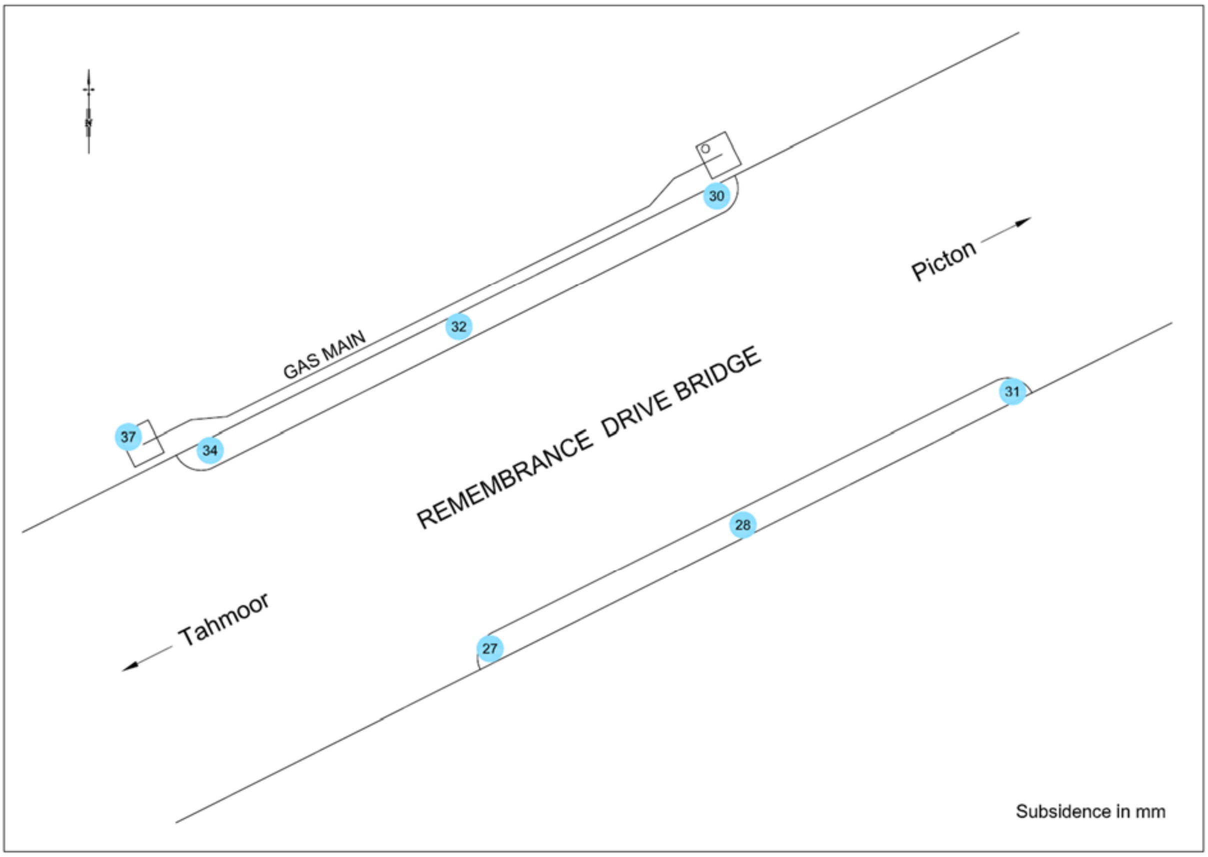



**Fig. 3.11 Observed subsidence along Remembrance Drive (Myrtle Creek) Road Bridge**

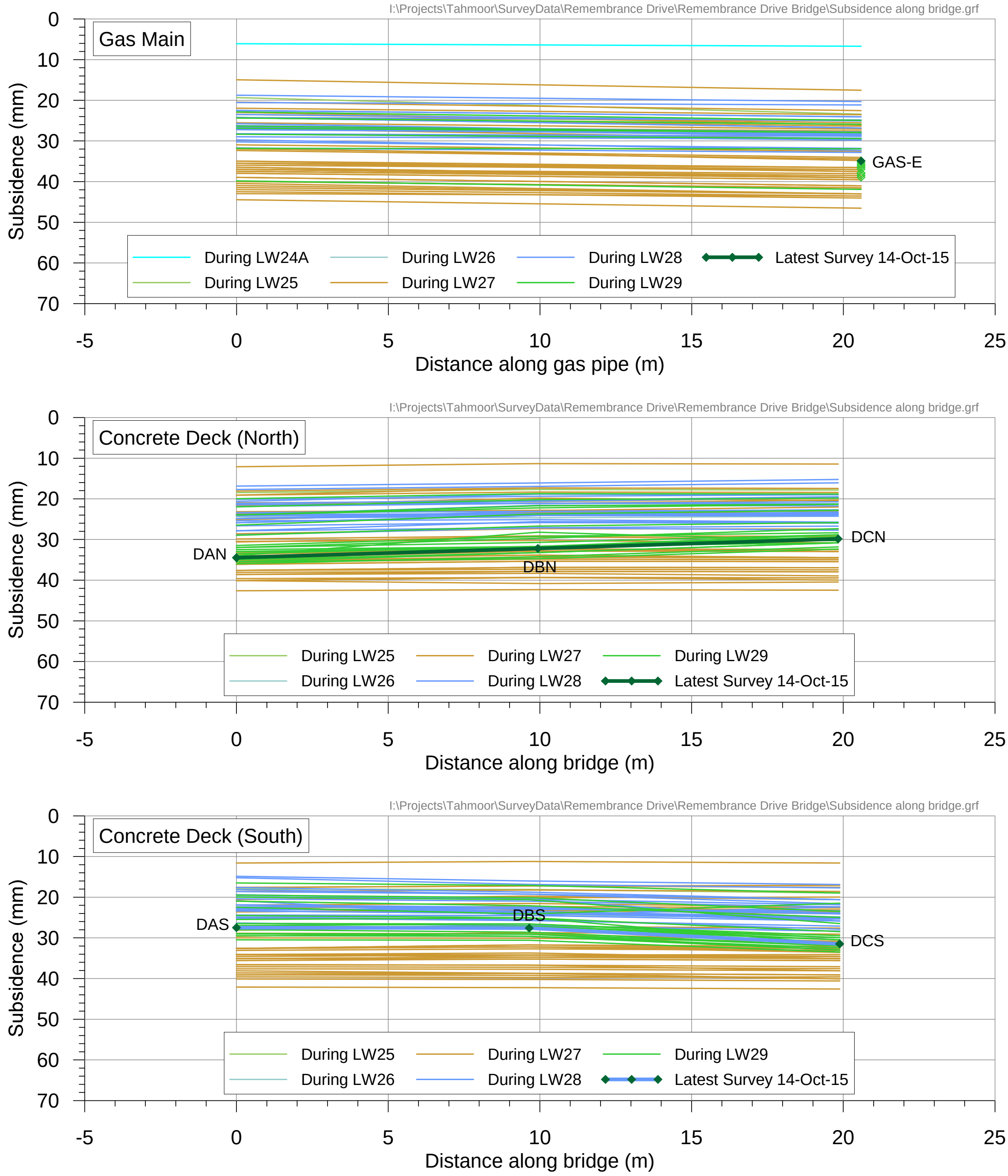



**Fig. 3.12 Observed subsidence along Remembrance Drive (Myrtle Creek) Road Bridge**

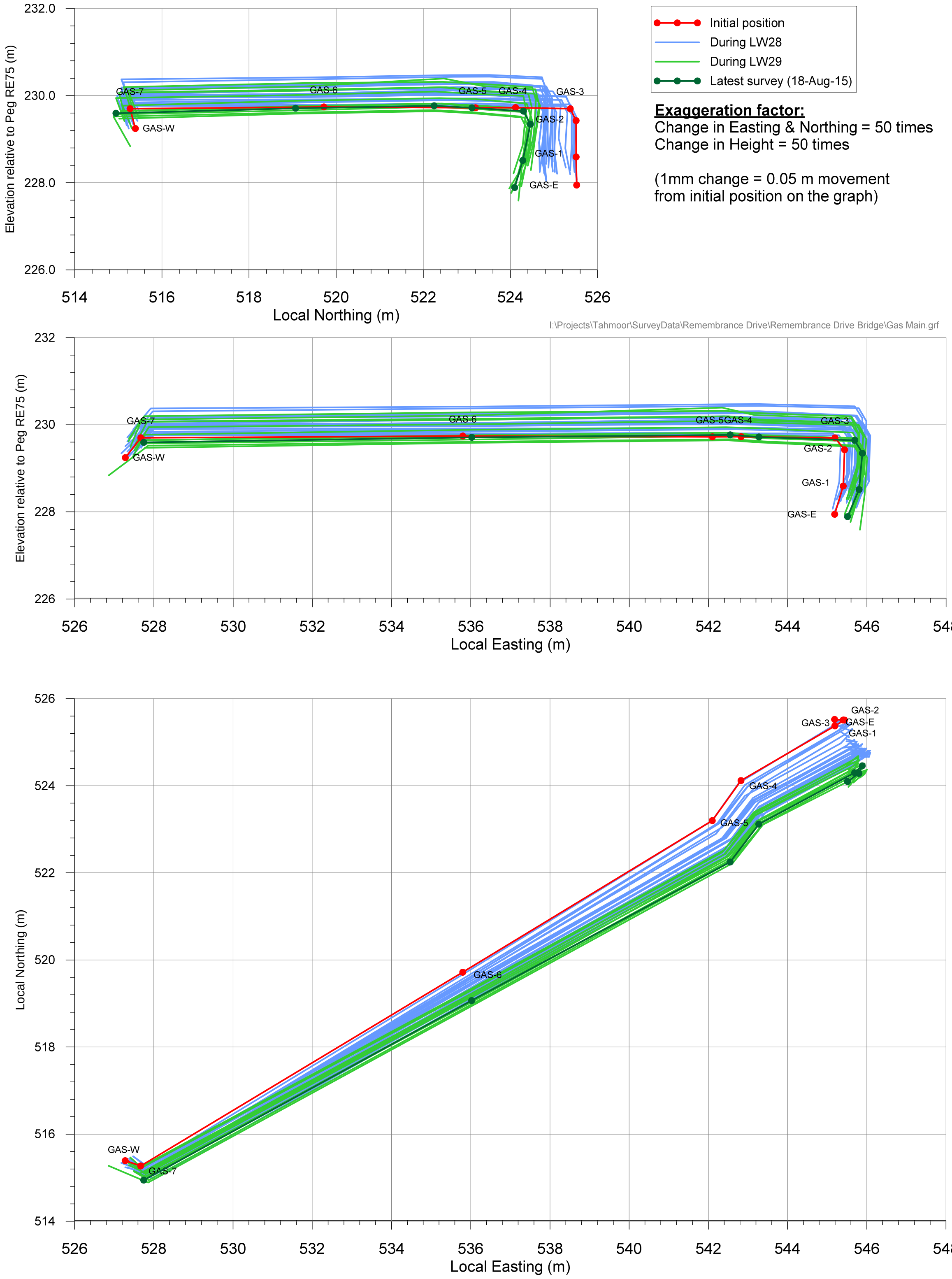



**Fig. 3.13 Observed displacement of survey marks on gas pipe along Remembrance Drive (Myrtle Creek) Road Bridge**

The Remembrance Drive survey line crosses Myrtle Creek between the Remembrance Drive Road Bridge and Pedestrian Bridge. Measured changes in horizontal distances between survey pegs within the Myrtle Creek valley are very small and within survey tolerance.

The steel gas pipe can tolerate some closure movements. The flanged ends of the gap pipe were included in the design to allow some flexibility in the pipework. If the ground on either side of the pipe crossing moves towards each other due to valley closure, the pipe is able to accommodate the compression through bending at the elbow. The most likely elbow to bend in response to differential horizontal movement is located at the northern end, as the vertical arm is high. The vertical arm below the elbow at the southern end is comparatively short. If actual ground closure exceeds the capacity of the pipe, the foundations at one end of the steel pipe can be excavated, to allow the foundations to slide and relieve pipe stresses.

This management strategy is possible because the ground movements will develop gradually, providing sufficient time to detect early the development of adverse movements and respond prior to impacts occurring on the Bridge or gas pipe.

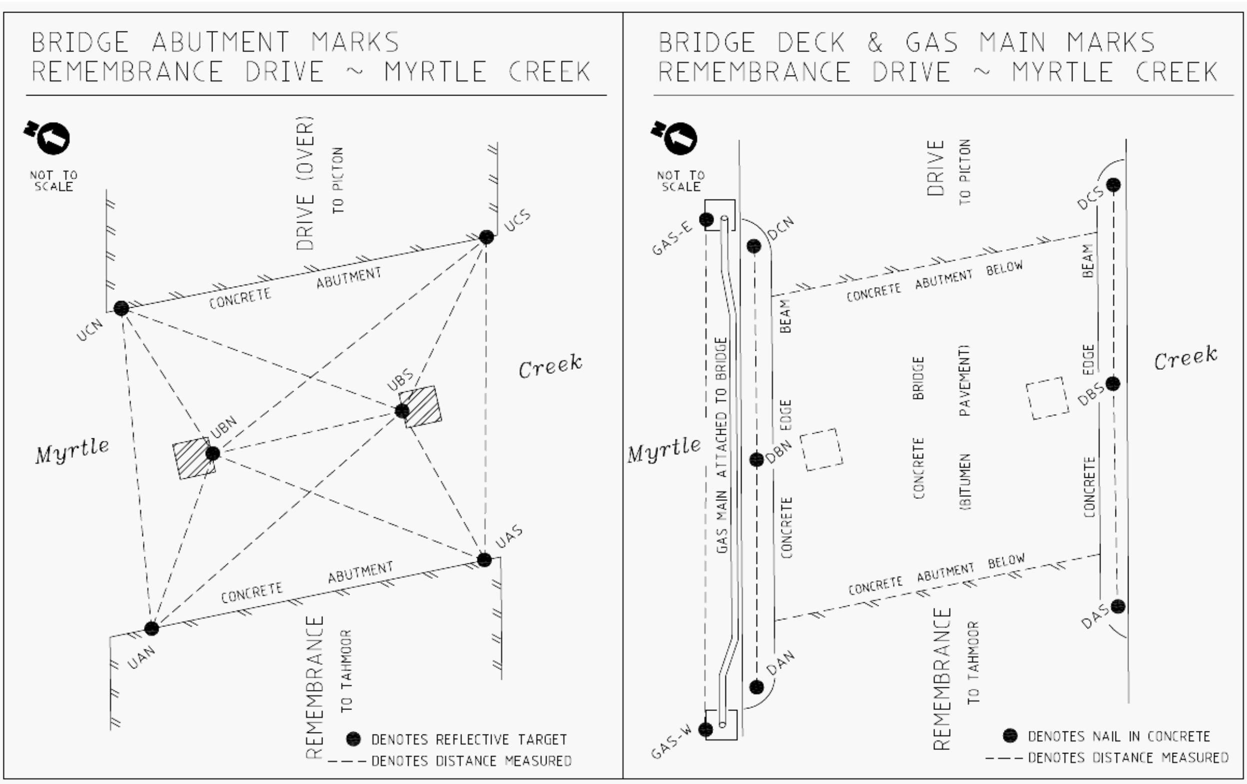
As the pipe is supported by the Remembrance Drive Road Bridge, it may potentially also experience impacts due to differential movements of the bridge in response to mine subsidence. Upsidence may cause the central pier to move upwards, relative to the abutments. This may result in vertical bending of the steel pipe. Closure of the bridge abutments are unlikely to result in impacts on the pipe as it is free to slide through the brackets. In addition to potential impacts due to movements, the pipe may also be exposed to damage if repairs are required to be carried out on the Bridge in response to mine subsidence movements. Despite the above-mentioned potential causes of impacts, the predicted movements are quite small.

Prior to the decision to shorten the commencing ends of Longwalls 29 and 30, it had been planned to undertake detailed investigations and potentially undertake mitigation works on the Bridge to reduce the potential for mine subsidence impacts on the Bridge. The shortening of Longwalls 29 and 30, however, substantially reduces the potential for impacts on the Bridge and the steel gas pipe. In light of the shortening, it is planned to manage potential impacts on the Bridge and the gas pipe through monitoring and, if necessary, response measures.

Given the offset distance of the pipe crossing and the Bridge from Longwall 30, and the anticipated small amount of movement that is expected to occur to the pipe and the Bridge, the likelihood of impact on the steel gas pipe, is assessed as **VERY RARE.** The consequence of impacts on the steel gas pipe is assessed as **VERY SEVERE**. The risk is therefore assessed as **VERY RARE / VERY SEVERE → MODERATE**.

The gas pipe crossing and the Bridge will be surveyed and visually inspected on a weekly basis from the start of extraction of Longwall 30 until the length of extraction is 800 metres unless adverse changes are being observed at this time. A survey will also be undertaken at the completion of Longwall 30. The surveys include monitoring of survey points on the Bridge and include survey marks on the concrete pads at each end of the gas pipe. A map of survey points is shown in Fig. 3.14.

Prior to the commencement of Longwall 29, Jemena undertook a gas detection survey of the bridge crossing pipework and the section of the 160 mm diameter PE pipe along Remembrance Drive from the intersection of Tahmoor House Court to the intersection of Koorana Road. No issues were detected.




*Sketch courtesy of SMEC (Urban)*

**Fig. 3.14 Survey marks on Remembrance Drive (Myrtle Creek) Road Bridge**

### 3.5.3. Summary of Risk Analysis for Gas Infrastructure

A summary of the levels of risk for the gas pipes are provided in Table 3.8.

**Table 3.8 Risk Analysis Matrix for Gas Infrastructure**

| Risk | Likelihood | Consequence | Level of Risk |
|---|---|---|---|
| Damage to main gas pipeline on Remembrance Drive (160 mm) | VERY RARE | VERY SEVERE | MODERATE |
| Damage to local reticulation pipes | VERY RARE | MODERATE | LOW |
| Castlereagh Street gas main crossing at Myrtle Creek | VERY RARE | MODERATE | LOW |
| Remembrance Drive gas main crossing at Myrtle Creek | VERY RARE | VERY SEVERE | MODERATE |

## 4.1. Gas Management Group (GMG)

The Gas Management Group (GMG) is responsible for providing advice on all technical issues relating to mine subsidence related impacts to gas infrastructure due to the mining of Longwall 30 on which decisions are made by Jemena and Tahmoor Colliery. The GMG develops and reviews this management plan, collects and analyses monitoring results, determines potential impacts and provides advice to Jemena and Tahmoor Colliery regarding appropriate actions. The members of the GMG are highlighted in Chapter 8.0

## 4.2. Avoidance and Mitigation Measures

Given the results of the risk assessment and nature of the gas infrastructure, which has been constructed with flexible materials and buried beneath the surface in urban areas, it is considered impractical and unnecessary to implement avoidance and mitigation measures to the gas infrastructure that will experience mine subsidence movements as a result of the mining of Longwall 30, as it does not mine directly beneath the infrastructure network.

Further confidence is drawn from the experience of mining Longwalls 22 to 29, where no impacts have been observed, even where predicted subsidence movements have been exceeded.

## 4.3. Monitoring Plan

A number of monitoring measures will be undertaken during mining.

### 4.3.1. Ground Monitoring Lines

Ground surveys of level and strain distance will be conducted during mining along monitoring lines that are generally located in streets.

***General Ground Monitoring along streets***

As a general guide, the frequency of ground monitoring within urban areas is every 200 metres of longwall extraction for all survey marks that are located within the active subsidence zone. This includes a survey line along Bridge Street, on which a small 32 mm nylon pipe is located. The timing of surveys within rural areas is determined by the location of street monitoring lines, where a survey has been scheduled to occur when the longwall face has passed each monitoring line by approximately 200 metres.

At the completion of each longwall, surveys will be undertaken along the full length of each monitoring line expected to have experienced some subsidence movements as a result of mining the longwall.

***Monitoring of Remembrance Drive Bridge over Myrtle Creek***

Weekly surveys of the Remembrance Drive Bridge over Myrtle Creek and the termination points of the steel gas pipe will be undertaken after the start of extraction of Longwall 30 until the length of extraction is 800 metres, unless adverse changes are being observed at this time. The survey will also include tilt measurements on both sides of the elbows at each end of the pipe crossing to measure potential bending at the elbow in response to subsidence. A survey will also be undertaken at the completion of Longwall 30.

## 4.4. Visual Inspections

Visual inspections will be undertaken within the active subsidence zone during mining.

## 4.5. Jemena Gas Patrols

Jemena pipeline officers conduct routine gas patrols in the Tahmoor area, which can be quickly increased in frequency in response to increased subsidence, curvature or strains. Prior to the start of Longwall 29, Jemena undertook a pre-mining gas detection survey of pipe crossing on Remembrance Drive Bridge over Myrtle Creek and section of 160 mm diameter PE pipe along Remembrance Drive from the Bridge to the intersection of Remembrance Drive and York Street, with no issues detected.

## 4.6. Triggers and Responses

Trigger levels have been developed by Jemena based on the capacity of the gas services to tolerate ground movements. Trigger levels for each monitoring parameter are described in Table 4.1.

### Table 4.1 Control Measures and Response for Tahmoor Colliery Longwall 30 on Jemena AGN Gas Facilities

| Level | Control Measures | Frequency | Analysis | Trigger Level | Action |
|---|---|---|---|---|---|
| 1 | <u>Ground Inspections:</u><br>- 2D survey<br>- ground inspection | <u>Ground surveys by Tahmoor Colliery:</u><br>Submit data within 24 hours duration<br>Baseline survey of pipe crossing on Remembrance Drive Bridge over Myrtle Creek prior to start of LW30 (complete)<br>Local 3D survey: weekly survey of Remembrance Drive Bridge over Myrtle Creek, including pipe crossings after start of LW30 until the length of extraction of LW30 is 800m, unless adverse changes are observed at this time. Survey at completion of Longwall 30.<br><u>Ground inspections by Tahmoor Colliery</u>:<br>Weekly inspections of Remembrance Drive Bridge over Myrtle Creek from start of LW30 until the length of extraction is 800m, unless adverse changes are observed at this time. | Tahmoor<br>surveys and provides Jemena with<br>- ground surveys<br>- ground movements / features reports | <u>Ground Movement Survey and Measurements</u>:<br>* Radius of ground curvature greater than 4 (km)<br>* Ground strain 0 to 2 (mm/m)<br>* Ground movements rate of change steady<br>* Closure or opening of pipe crossing 0 to 15 (mm)<br><br><u>Ground Conditions Monitoring:</u><br>- ground cracks reported<br>- ground subsidence reported<br>- impacts observed on Remembrance Drive Road Bridge | Go to LEVEL 2 if LEVEL 1 limit is exceeded:<br>* normal ground patrol by Jemena pipeline officer<br><br>Jemena actions following receipt of reported incidents: inspects site to confirm operation of gas facilities not affected<br><br>Assess potential for impacts on the pipe crossing due to valley closure. Consider trigger level for Level 2. |
| | <u>Ground Subsidence Validations:</u><br>- Observed against predictions | Weekly: verify and track results against predictions | MSEC<br>analyses and reports findings to stakeholders | - ground movements showing a <u>step change</u> indicating shear and / or <u>discontinuity</u> in humps near the gas services | * undertake additional inspection e.g. exposing and inspecting gas service as applicable to determine gas facilities integrity<br>*based on above findings, undertake corrective action per Level 3 activities where gas services integrity affected |
| | <u>Baseline Gas Detection Survey</u>:<br>Prior to the start of LW29, Jemena undertook a pre-mining gas detection survey of pipe crossing on Remembrance Drive Bridge over Myrtle Creek and section of 160 mm diameter PE pipe along Remembrance Drive from the Bridge to the intersection of Remembrance Drive and York Street | | Jemena reviews:<br>- 2D ground surveys report<br>- pipe integrity<br>- ground conditions report | | |
| 2 | <u>Ground Inspections:</u><br>- 2D survey<br>- ground inspection | Submit data within 24 hours duration<br>Twice weekly 2D survey | Tahmoor<br>surveys and provides Jemena with<br>- ground surveys<br>- ground movements / features reports | <u>Ground Movement Survey and Measurements</u>:<br>* Radius of ground curvature 2 to 4 (km)<br>* Ground strain 2 to 5 (mm/m)<br>* Ground movements rate of change increasing with increasing upward trend<br><br><u>Ground Conditions Monitoring:</u><br>- ground cracks reported<br>- ground subsidence reported<br>- minor emergency repairs required to Remembrance Drive Road Bridge (treatment of cracks) | Go to LEVEL 3 if LEVEL 21 limit is reached:<br>* weekly ground patrol by Jemena pipeline officer<br><br>Jemena actions following receipt of reported incidents: inspects site to confirm operation of gas facilities not affected<br><br>Jemena reviews planned minor emergency repair works on Remembrance Drive Road Bridge |
| | <u>Ground Subsidence Validations:</u><br>- Observed against predictions | Twice weekly: verify and track results against predictions | MSEC<br>analyses and reports findings to stakeholders | | |
| | | | Jemena reviews:<br>- 2D ground surveys report<br>- pipe integrity<br>- ground conditions report | - ground movements showing a <u>step change</u> indicating shear<br>and / or <u>discontinuity</u> in humps near the gas services | * undertake additional inspection e.g. exposing and inspecting gas service as applicable to determine gas facilities integrity, or adjust supports between steel gas pipe and Remembrance Drive Road Bridge<br>*based on above findings, undertake corrective action per Level 3 activities where gas services integrity affected<br>* if no immediate corrective actions required, Jemena may put field construction on standby |
| 3 | <u>Ground Inspections:</u><br>- 2D survey<br>- ground inspection | Submit data within 24 hours duration<br>Daily 2D survey | Tahmoor<br>surveys and provides Jemena with<br>- ground surveys<br>- ground movements / features reports | <u>Ground Movement Survey and Measurements</u>:<br>* Radius of ground curvature less than 2 (km)<br>* Ground strain greater than 5 (mm/m)<br>* ground movements showing a <u>step change</u> indicating shear and / or <u>discontinuity</u> in humps near the gas services<br>* ongoing severe impacts on Remembrance Drive Road Bridge, requiring extensive emergency repairs including jacking and relevelling the bridge deck. | Jemena's field corrective actions:<br>- mobilisation construction in the field<br>- excavate affected area<br>- inspect gas facilities to confirm integrity<br>- repair and / or replace gas services as applicable to maintain supply and safe operation<br>- adjust supports between steel gas pipe and Remembrance Drive Road Bridge<br>- undertake works to protect gas pipe from impacts caused by construction activities to repair Remembrance Drive Road Bridge |
| | <u>Ground Subsidence Validations:</u><br>- Observed against predictions | Daily: verify and track results against predictions | MSEC<br>analyses and reports findings to stakeholders | | |
| | | | Jemena reviews:<br>- 2D ground surveys report<br>- pipe integrity<br>- ground conditions report (as applicable) | | |

## 5.0 GMG MEETINGS

The monitoring of natural surface features and surface infrastructure which forms an integral part of this Management Plan will be carried out by Tahmoor Colliery. GMG Meetings will be held between Tahmoor Colliery and Jemena for discussion and resolution of issues raised in the operation of the Management Plan.

GMG Meetings will discuss any incidents reported in relation to the relevant surface feature, the progress of mining, the degree of mine subsidence that has occurred, and comparisons between observed and predicted ground movements.

It will be the responsibility of the meeting representatives to determine whether the incidents reported are due to the impacts of mine subsidence, and what action will be taken in response.

In the event that a significant risk is identified for a particular surface feature, any party may call an emergency GMG Meeting, with one day's notice, to discuss proposed actions and to keep other parties informed of developments in the monitoring of the surface feature.

## 6.0 AUDIT AND REVIEW

All Management Plans within this document have been agreed between parties. The Management Plan will be reviewed following extraction of each longwall.

Should an audit of the Management Plan be required during that period, an auditor shall be appointed by the Tahmoor Colliery to review the operation of the Management Plan and report at the next scheduled Plan Review Meeting.

Other factors that may require a review of the Management Plan are:-

- Observation of greater impacts on surface features due to mine subsidence than was previously expected.
- Observation of fewer impacts or no impacts on surface features due to mine subsidence than was previously expected.
- Observation of significant variation between observed and predicted subsidence.

## 7.0 RECORD KEEPING

Tahmoor Colliery will keep and distribute minutes of any GMG Meeting.

## 8.0 CONTACT LIST

| Organisation | Contact | Phone | Email / Mail | Fax |
|---|---|---|---|---|
| Jemena Control Centre | Emergency Contact | 131909 | | |
| Jemena<br>Asset Manager Pipelines | Mark Dragar* | (02) 9867 7112<br>0419 285 145 | mark.dragar@jemena.com.au | - |
| Jemena<br>Principal Pipeline Engineer<br>Asset Strategy Gas | Paul Grace* | (02) 9867 8347<br>0427 002 601 | paul.grace@jemena.com.au | - |
| NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS) | Phil Steuart | (02) 4931 6648 | phil.steuart@dpi.nsw.gov.au | (02) 4931 6790 |
| | Gang Li | (02) 4931 6644<br>0409 227 986 | gang.li@dpi.nsw.gov.au | (02) 4931 6790 |
| | Ray Ramage | (02) 4931 6645<br>0402 477 620 | ray.ramage@dpi.nsw.gov.au | (02) 4931 6790 |
| Mine Subsidence Board | John Rawes | (02) 4677 1967<br>0457 727 263 | j.rawes@minesub.nsw.gov.au | (02) 4677 2040 |
| Mine Subsidence Engineering Consultants (MSEC) | Daryl Kay* | (02) 9413 3777<br>0416 191 304 | daryl@minesubsidence.com | (02) 8412 0222 |
| Glencore Tahmoor Coal –<br>Environment and Community Manager | Ian Sheppard | (02) 4640 0156<br>0408 444 257 | Ian.Sheppard@glencore.com.au | (02) 4640 0140 |
| Glencore Tahmoor Coal –<br>Approvals and Community Coordinator | Belinda Treverrow* | (02) 4640 0100<br>0428 260 899 | Belinda.Treverrow@glencore.com.au | (02) 4640 0140 |

* denotes member of Gas Management Group

# APPENDIX A. DRAWINGS

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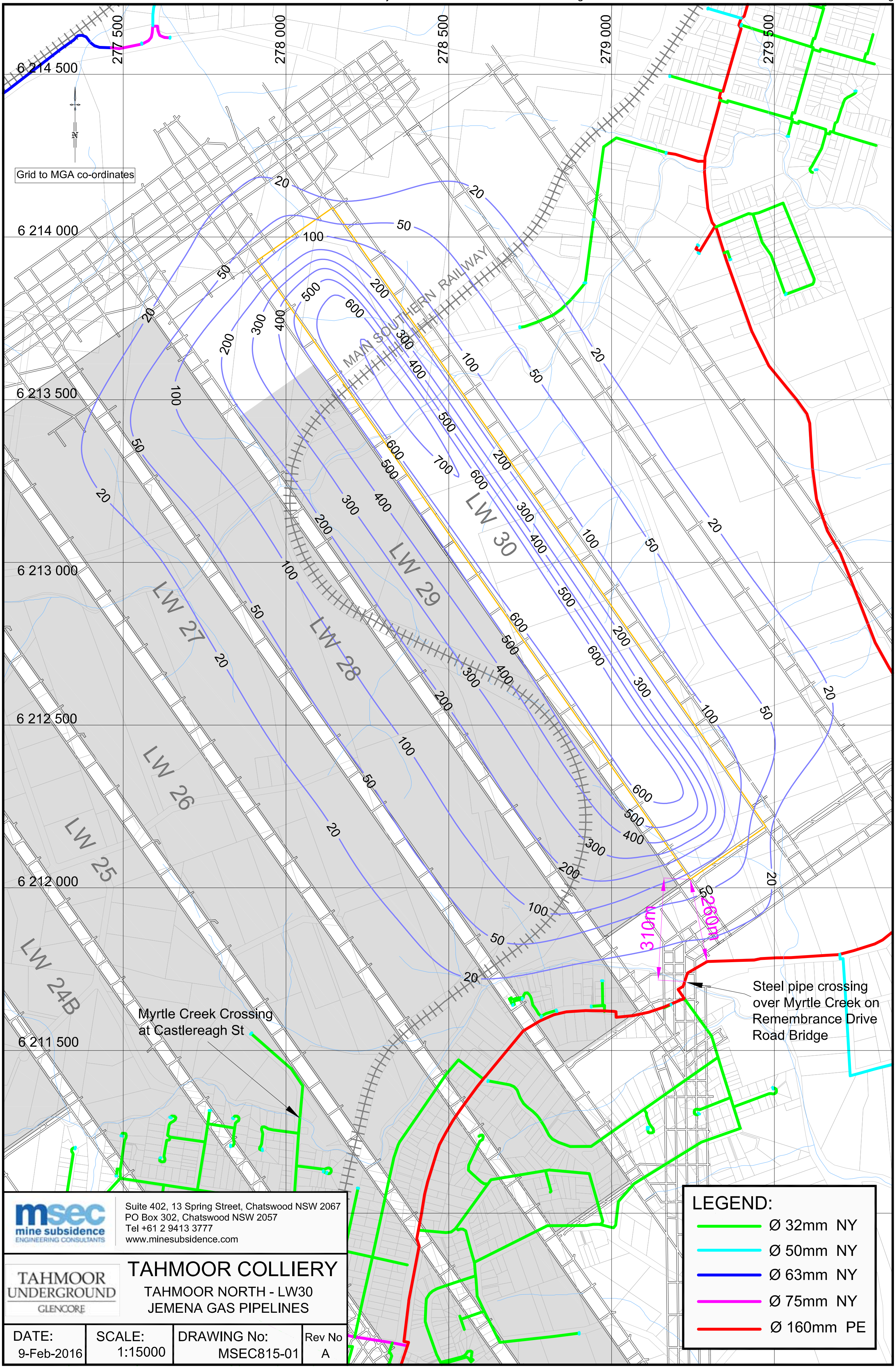



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TAHMOOR UNDERGROUND GLENCORE

# TAHMOOR COLLIERY

TAHMOOR NORTH - LW30
JEMENA GAS PIPELINES

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 9-Feb-2016 | 1:15000 | MSEC815-01 | A |