XSTRATA COAL:

# Tahmoor Colliery - Longwall 27

Management Plan for Potential Impacts to Jemena Gas Infrastructure

## AUTHORISATION OF MANAGEMENT PLAN

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## 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 |

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

[illegible] *Subsidence above Longwall Panels at Tahmoor Colliery.* Mine Subsidence Technological Society, Proceedings of the 8th Triennial Conference on Mine Subsidence, May 2011.

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



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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.

# 1.0 INTRODUCTION

## 1.1. Background

Tahmoor Colliery is located approximately 80 kilometres south west of Sydney in the township of Tahmoor NSW. It is managed and operated by Xstrata Coal. Tahmoor Colliery has previously mined 25 longwalls to the north and west of the mine's current location. It is currently mining Longwall 26.

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

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

This Management Plan provides detailed information about how the risks associated with mining beneath 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 major natural gas pipeline
- The main gas pipeline
- The local gas pipeline
- Gas mains at creek crossings

The Management Plan describes measures that will be undertaken as a result of mining Longwall 27 only.

## 1.4. Proposed Mining Schedule

It is planned that each longwall will extract coal working northwest from the southeastern ends. This Management Plan covers longwall mining until completion of mining in Longwall 27 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 27 | November 2012 | November 2013 |

## 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.

A summary of the maximum predicted incremental systematic subsidence parameters, due to the extraction of each of the proposed longwalls, is provided in Table 3.1. A summary of the maximum predicted cumulative systematic subsidence parameters, after the extraction of each of the proposed longwalls, is provided in Table 3.2. A summary of the maximum predicted travelling parameters, during the extraction of each of the proposed longwalls, is provided in Table 3.3.

**Table 3.1 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Each of the Proposed Longwalls 27 to 30**

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

**Table 3.2 Maximum Predicted Cumulative Systematic Subsidence Parameters after the Extraction of Each of the Proposed Longwalls 27 to 30**

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

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

**Table 3.3 Maximum Predicted Travelling Subsidence Parameters during the Extraction of Each of the Proposed Longwalls 27 to 30**

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

## 3.2. Observed Subsidence during the mining of Longwalls 22 to 26

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

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

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

*Observed Increased Subsidence during the mining of Longwall 24A*

Observed subsidence was greatest above the southern half of Longwall 24A, and gradually reducing in magnitude towards the northern half of the longwall, which was directly beneath the urban area of Tahmoor. These observations are shown graphically in Fig. 3.1, which shows observed subsidence at survey pegs located along the centreline of Longwall 24A.

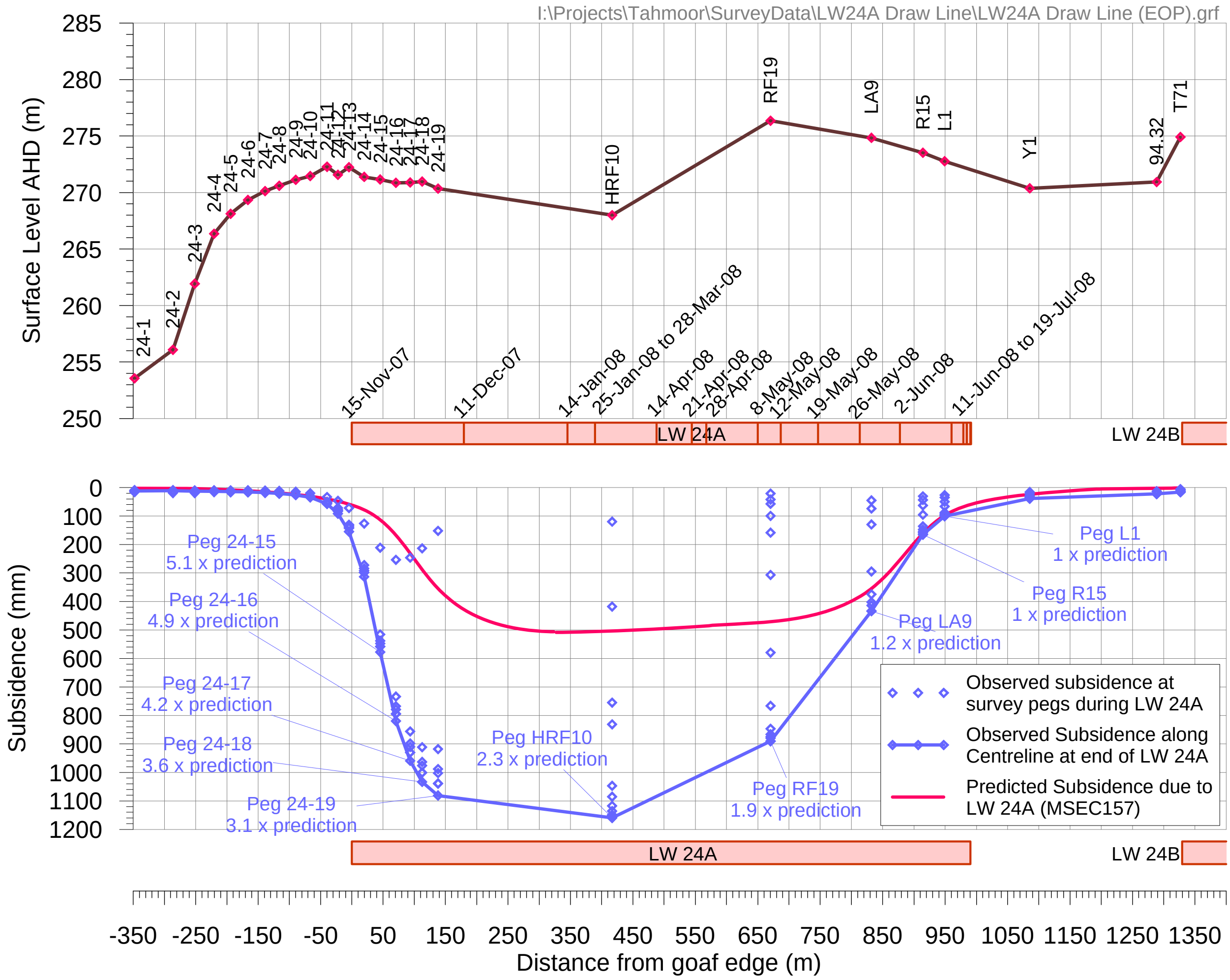



**Fig. 3.1 Observed Subsidence along Centreline of Longwall 24A**

It can be seen from Fig. 3.1 that observed subsidence was more than twice the predicted maximum value, reaching to a maximum of 1169 mm at Peg HRF10. It is possible that actual maximum subsidence developed somewhere between Pegs HRF10 and RF19, though this was not measured. Observed subsidence was similar to prediction near Peg R15 on Remembrance Drive. Survey pegs RF19 and LA9 are located within a transition zone where subsidence gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

*Observed Increased Subsidence during the mining of Longwall 25*

Increased subsidence was observed during the first stages of mining Longwall 25. These observations are shown graphically in Fig. 3.2, which shows observed subsidence at survey pegs located along the centreline of Longwall 25.

It can be seen from Fig. 3.2 that observed subsidence was approximately twice the predicted maximum value, with maximum subsidence of 1216 mm at Peg 25-28.

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

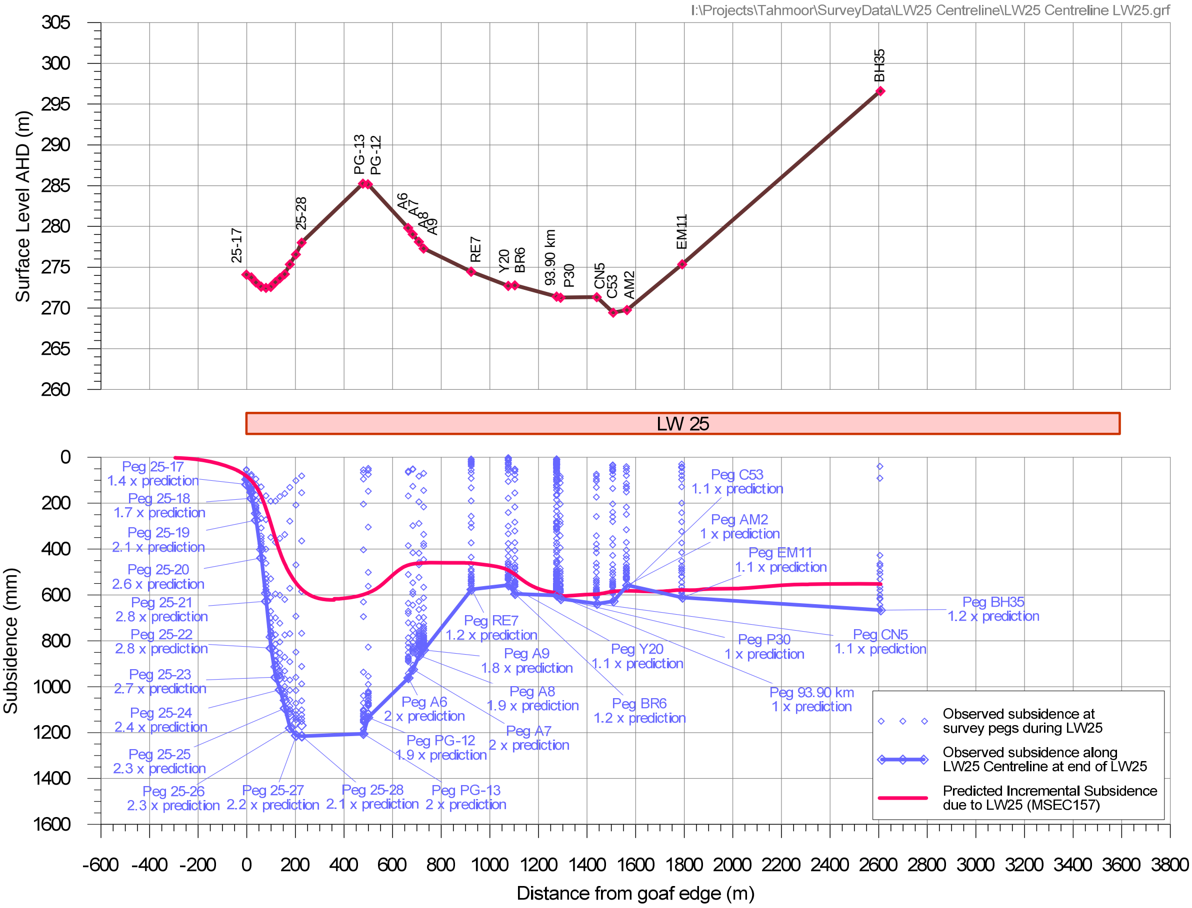



**Fig. 3.2 Observed Subsidence along Centreline of Longwall 25**

*Observed Increased Subsidence during the mining of Longwall 26*

Increased subsidence was observed during the first stages of mining Longwall 26, but at a reduced magnitude compared to the subsidence observed above Longwalls 24A and 25. These observations are shown graphically in Fig. 3.3, which shows observed subsidence at survey pegs located along the centreline of Longwall 26. The graph shows the latest survey results for each monitoring line as at August 2012. It is likely that further small increases in subsidence will be observed at these pegs when they are surveyed at the completion of Longwall 26.

It can be seen from Fig. 3.3 that observed subsidence was approximately 1.3 times the predicted maximum value, with maximum subsidence of 867 mm at Peg TM26.

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

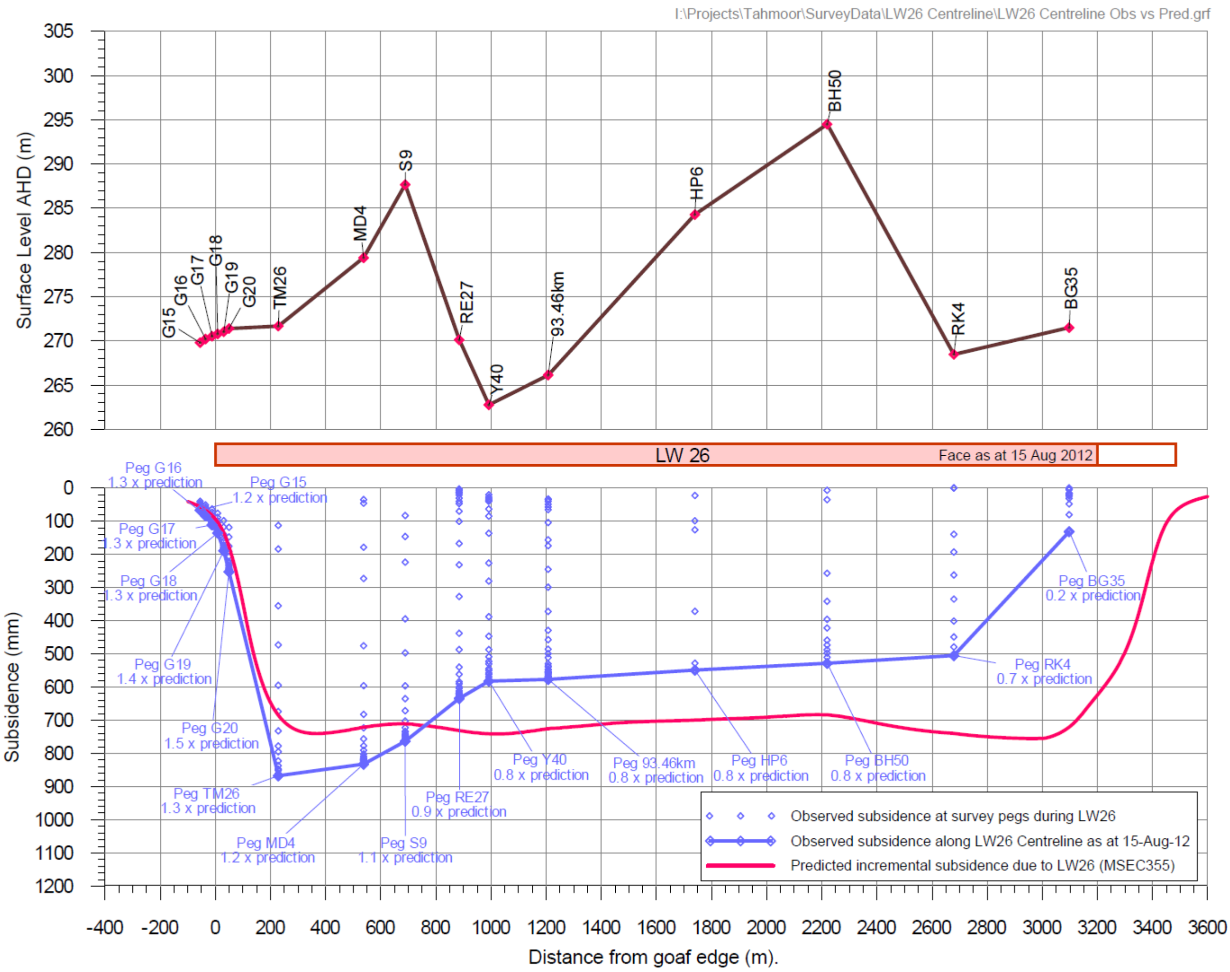



**Fig. 3.3 Observed Subsidence along Centreline of Longwall 26 as at August 2012**

*Analysis and commentary*

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

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

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

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

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

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

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

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

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

Given that Longwall 27 is located further away from the Bargo River than Longwall 26, it is expected that the magnitude of maximum subsidence at the commencing end of Longwall 27 will be less than 900 mm. The amount of reduction in maximum subsidence is difficult to predict. The difference in maximum subsidence between Longwalls 24A and 25 and Longwall 26 is approximately 300 mm. If maximum subsidence at the commencing end of Longwall 27 reduces a further 300 mm, the magnitude of subsidence at the commencing end will return to normal levels.

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

## 3.3. Predicted Strain

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reasons for this are that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near surface geology, the locations of joints at bedrock, and the depth of bedrock. The measurements are also affected by survey tolerance. The profiles of observed strain can, therefore, be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

The relative frequency distribution of maximum observed tensile strains and compressive strains for survey bays located directly above goaf is provided in Fig. 3.4.

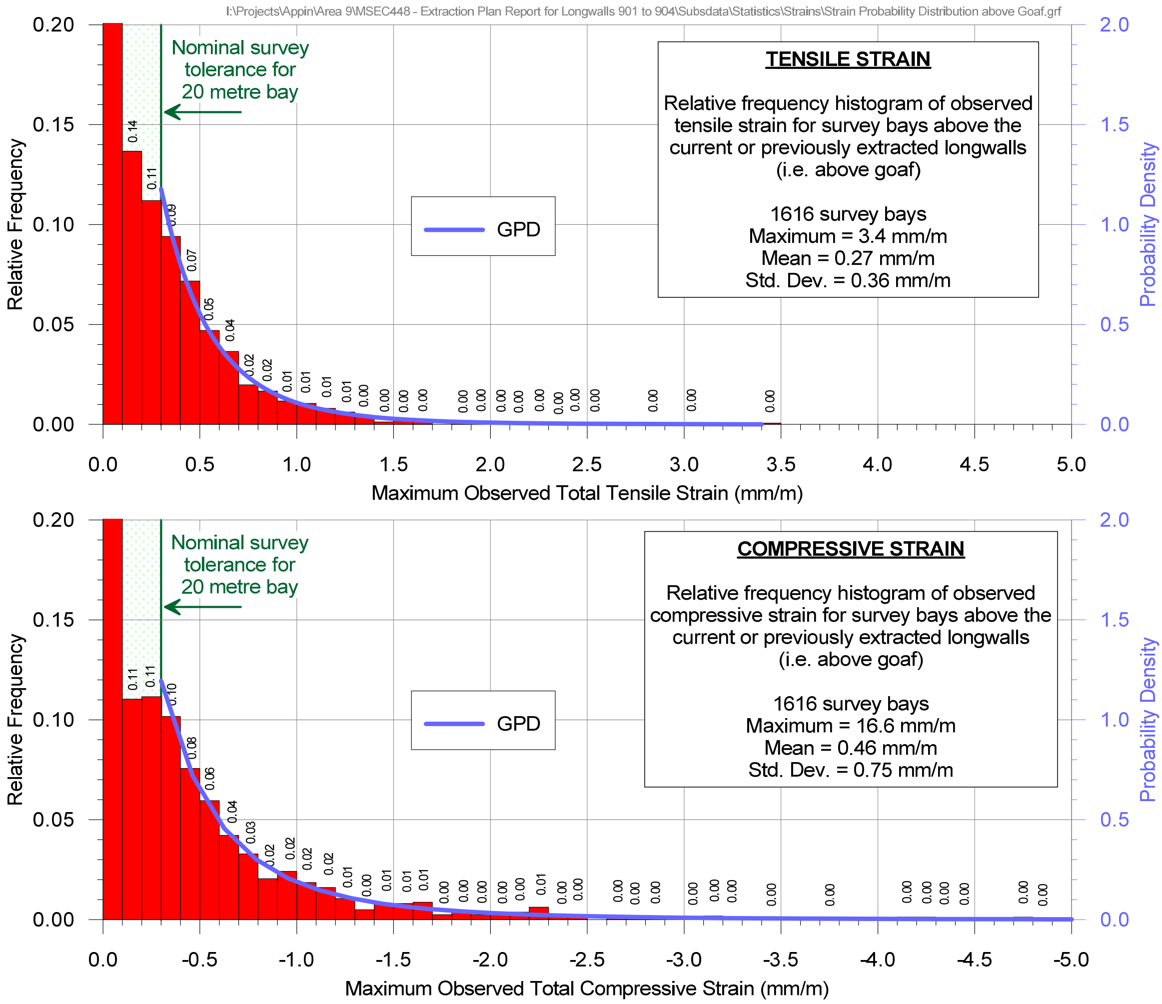



**Fig. 3.4 Distributions of Measured Maximum Tensile and Compressive Strains at Any Time for Pegs Located Above Goaf in the Southern Coalfield**

While not shown in Fig. 3.4, it is noted that the maximum observed compressive strain of 16.6 mm/m, which occurred along the T-Line above Appin Longwall 408, was the result of movements along a low angle thrust fault within the Cataract Tunnel. All remaining compressive strains in this dataset (which exclude valley related movements) were less than 5 mm/m.

The relative frequency distribution of maximum observed tensile strains and compressive strains above solid coal is provided in Fig. 3.5.

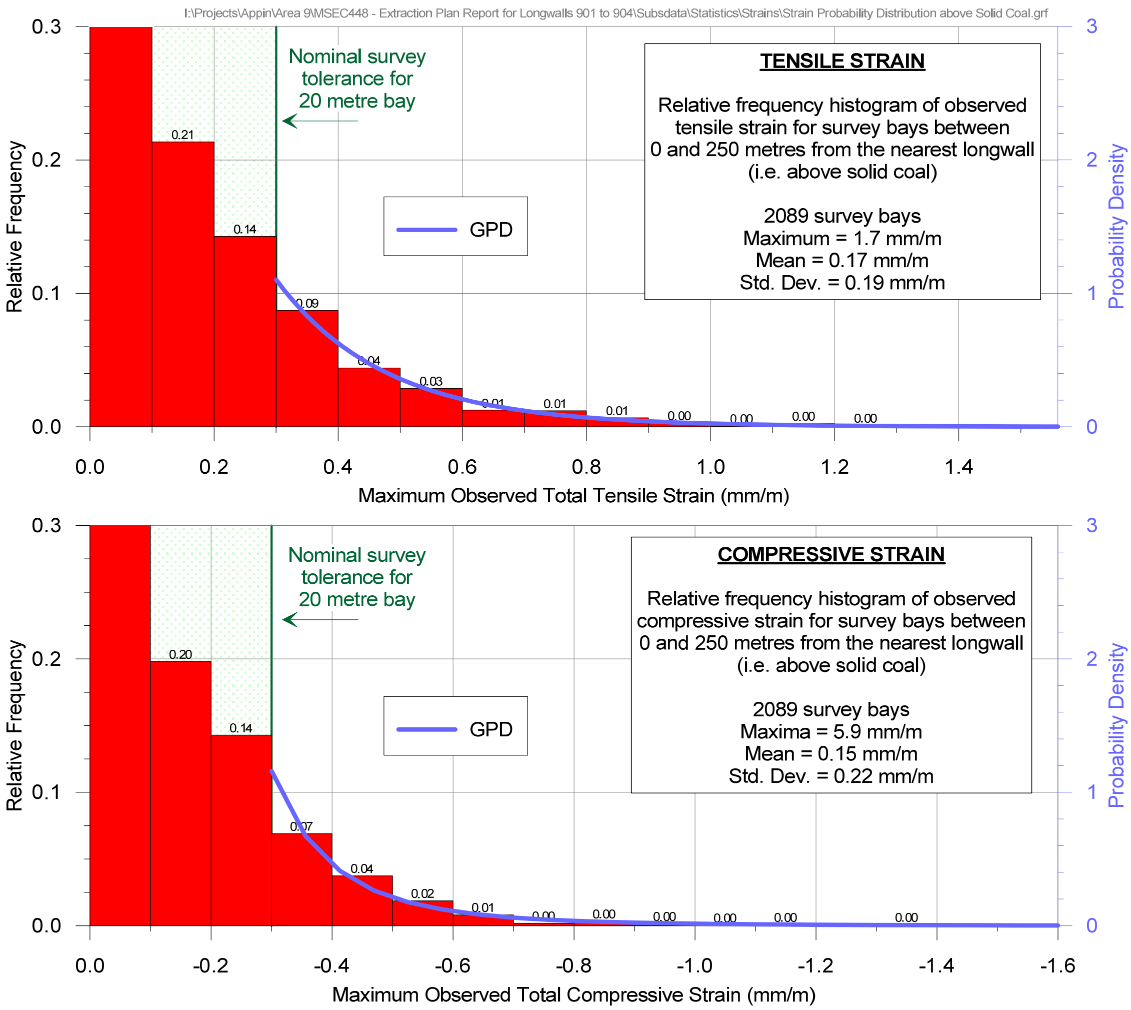



**Fig. 3.5 Distributions of Measured Maximum Tensile and Compressive Strains at Any Time for Pegs Located Above Solid Coal in the Southern Coalfield**

While not shown in Fig. 3.5, it is noted that the maximum observed compressive strain of 5.9 mm/m, which occurred along the T-Line above Appin Longwall 408, was the result of movements along a low angle thrust fault within the Cataract Tunnel as Longwall 408 approached the monitoring line. A maximum observed compressive strain of 3.1 mm/m was observed across the fault at the completion of Longwall 407. All remaining compressive strains in this dataset (which exclude valley related movements) were less than 5 mm/m.

## 3.4. Predicted and Observed Valley Closure across creeks

A number of bridges and culverts above Longwall 27 carry road transport over Myrtle 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 below.

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. 3.6.

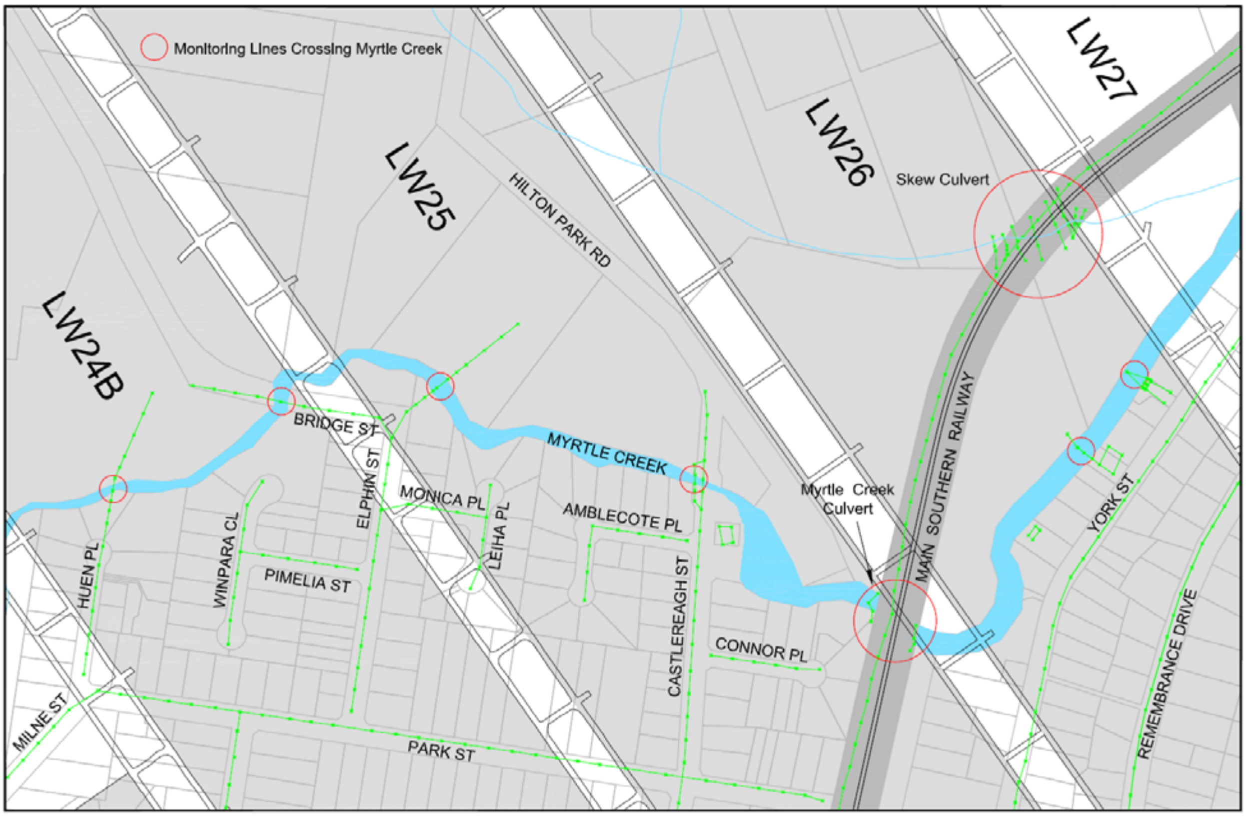



**Fig. 3.6 Monitoring lines across Myrtle Creek and Skew Culvert**

A summary graph showing the development of valley closure across the Myrtle Creek at each monitoring line is shown in Fig. 3.7.

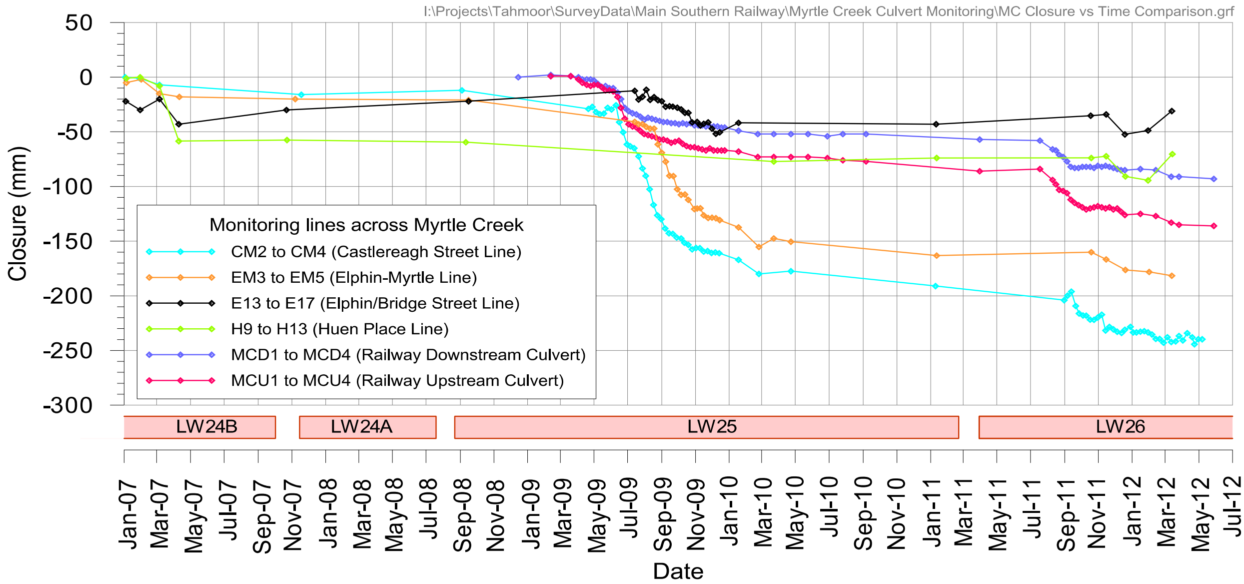



**Fig. 3.7 Development of closure across Myrtle Creek during the mining of Longwalls 24B to 26**

The development of valley closure across the creek at the Skew Culvert is shown in Fig. 3.8.

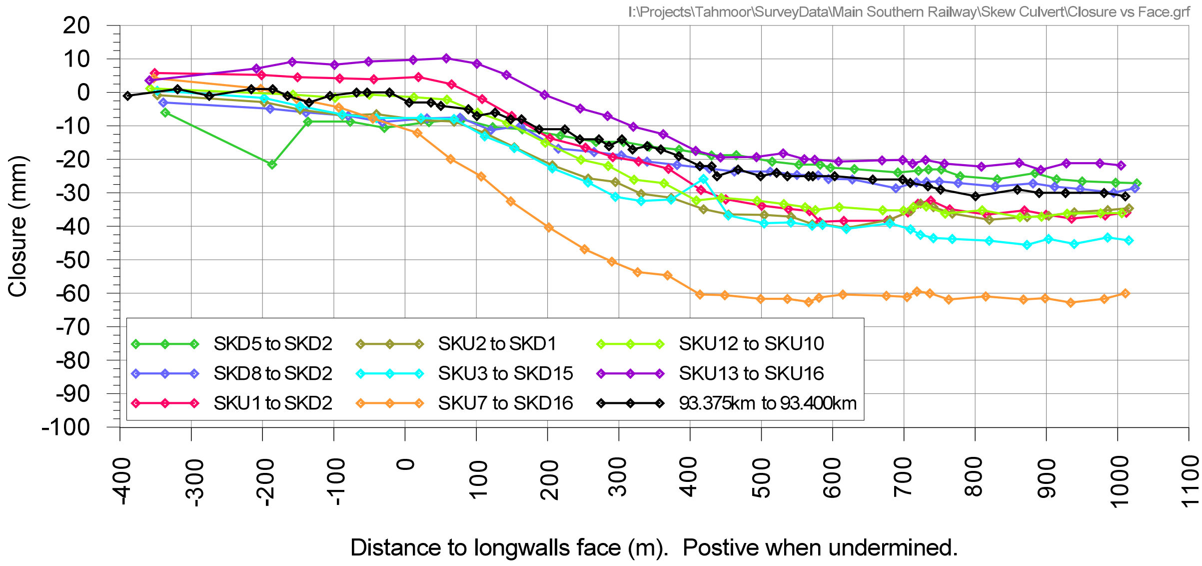



**Fig. 3.8 Development of closure across Skew Culvert during the mining of Longwall 26 as at 27 March 2012**

A summary of predicted and observed valley closure across Myrtle Creek is provided in Table 3.4. The predictions are consistent with those provided in Report No. MSEC355, in support of IC's SMP application to extract longwalls 27 to 30.

**Table 3.4 Predicted and Observed Incremental Valley Closure across Myrtle Creek and Skew Culvert at monitoring lines**

| | | Predicted and Observed Valley Closure due to mining of each longwall(s) | | |
|---|---|---|---|---|
| | | Due to LW24 (mm) | Due to LW25 (mm) | Due to LW26 (mm) |
| **Castlereagh Street** (Pegs C2 to C4) | Predicted | 30 | 55 | 45 |
| | Observed | 12 | 179 | 49 |
| **Elphin-Myrtle** (Pegs EM3 to EM5) | Predicted | 60 | 70 | 40 |
| | Observed | 21 | 142 | 22 |
| **Elphin Street / Bridge Street** (Pegs E13 to E17) | Predicted | 75 | 75 | 30 |
| | Observed | 0 | 21 | 6 |
| **Huen Place** (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 |
| | Observed | - | 57 (d/s) to 86 (u/s) | 36 (d/s) to 50 (u/s) |
| **Skew Culvert** (8 cross sections) | Predicted | < 5 | 10 | 25 |
| | Observed | - | - | 21 to 60 (avg 36) |
| **13 York Street** (Y64-6 to Y64-9) | Predicted | - | - | 65 |
| | Observed | - | - | 60 |
| **9a York Street** (Y67-10 to Y67-14) | Predicted | - | - | 85 |
| | Observed | - | - | 73 |

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.

Observed valley closure across the creek at the Skew Culvert has also slightly exceeded predictions, where the differences between predicted and observed closure are relatively small for most cross sections.

## 3.5. Observations during Longwalls 22 to 26

Longwalls 22 to 26 have directly mined beneath approximately 12.3 kilometres of gas pipes and no impacts have been recorded so far. The local nylon and 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.

## 3.6. Gas Infrastructure

The natural gas pipe lines in the area influenced by the longwall mining operation will be subjected to the full range of predicted subsidence parameters as the coal is extracted.

Jemena has an extensive gas infrastructure network at Tahmoor and Thirlmere. The gas pipelines are shown according to their pipe sizes in Drawing No. MSEC567-05-01.

It can be seen from this drawing that the gas pipes range in diameter between 32 mm and 160 mm.

The main gas pipe, which is a 160 mm diameter polyethylene pipe with glued joints, is located along Remembrance Drive. Longwalls 24A, 25 and 26 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 27 but is expected to experience upsidence and closure movements during the mining of future longwalls.

The majority of the gas pipes that are expected to experience subsidence movements during the mining of Longwall 27 are 32 mm diameter pipes which distribute gas to properties in the Tahmoor and Thirlmere urban areas.

The other main gas pipe is a 75 mm diameter nylon pipe, which is located along Thirlmere Way. This pipe has experienced the full range of subsidence movements due to the mining of Longwalls 22 to 26. The pipe will experience minor additional movements due to the mining of Longwall 27.

## 3.7. Review of Risk Assessment and Management Measures

The range of subsidence movements is predicted to be similar to those experienced during the mining of Longwalls 22 to 26. The nature of the infrastructure that will experience subsidence during the mining of Longwall 27 is similar to the infrastructure above Longwalls 22 to 26.

Jemena and Tahmoor Colliery have developed and acted in accordance with an agreed management plan during the mining of Longwalls 22 to 26.

Given that no impacts have been experienced to date, Jemena and Tahmoor Colliery consider that there is no need to amend the risk assessment or the management measures that have been developed in previously agreed management plans.

## 3.8. 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.

### 3.8.1. Major Gas Pipeline along Remembrance Drive

The main gas pipeline is a 160 mm diameter polyethylene pipe, which is laid along the eastern side of Remembrance Drive. The pipeline has experienced no impacts during the mining of Longwalls 24A to 26.

During this time, ground surveys have measured maximum subsidence of approximately 800 mm with two sites of increased compressive ground strains:

- A maximum compressive ground strain of approximately 2.5 mm/m over a 37 metre bay between Pegs R1 and RE1 along Remembrance Drive at the intersection with Thirlmere Way above Longwall 25. If all of the compressive strain is concentrated at one location, this would equate to a strain of approximately 4 mm/m over a 20 metre bay. A noticeable bump in the pavement and roundabout was also observed at this site. Regular gas patrols were undertaken in response to the observations though no impacts were observed.
- A maximum compressive ground strain of approximately 2.6 mm/m over a 20 metre bay along Remembrance Drive above Longwall 26 between Pegs RE28 and RE29. A bump was observed in

the road pavement and concrete footpath. Regular gas patrols were undertaken in response to the observations though no impacts were observed.

The pipeline is expected to experience additional subsidence movements during the mining of Longwall 27 and future longwalls. Predicted subsidence, tilt and curvature due to the mining of Longwalls 27 to 30 are shown in Fig. 3.9.

The experience of mining beneath Longwalls 24A to 26 provides confidence that the pipeline can accommodate typical mining-induced strains without adverse impacts, and protective works should not be necessary. While the pipelines are quite flexible, the 160 mm diameter pipes are connected with socket joints that are glued together. It is unlikely that these joints will be adversely affected by the proposed longwalls.

The likelihood of impacts occurring to the pipeline is therefore assessed as **VERY RARE**.

Given that this pipe is the main gas pipeline, any leakage of the pipeline would require emergency procedures, and since there is significant surface infrastructure in the vicinity of the pipeline, the consequence of damage to the pipeline is assessed as **VERY SEVERE**.

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

### 3.8.2. Main Gas Pipeline along Thirlmere Way

The other main gas pipe is a 75 mm diameter nylon pipe, which is located along Thirlmere Way. This pipe has experienced the full range of subsidence movements due to the mining of Longwalls 22 to 26 and no impacts have been observed. The pipe is predicted to experience less than 20 mm of additional movements due to the mining of Longwall 27.

The likelihood of impacts occurring to the pipeline is therefore assessed as **VERY RARE**.

The consequence of damage to the pipeline is similar to the main gas pipeline, except that the pipe is slightly smaller in diameter, and there is slightly less surface infrastructure in the vicinity of the pipeline. The consequence of damage to the pipeline is therefore assessed as **SEVERE**.

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

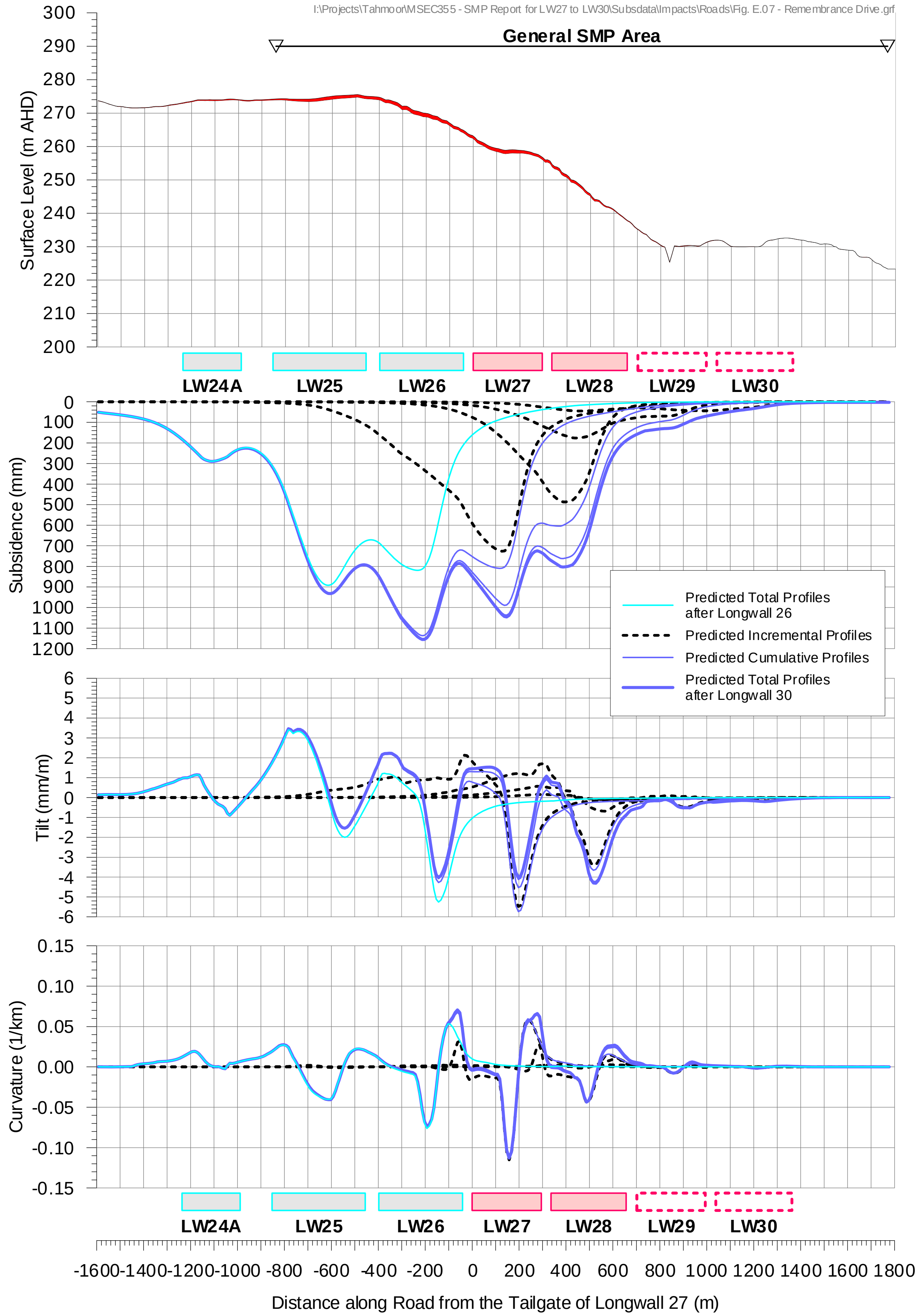



**Fig. 3.9 Predicted Subsidence, Tilt and Curvature along Remembrance Drive due to the mining of Longwalls 22 to 30 (Source: Report No. MSEC355).**

### 3.8.3. 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 26. This includes no impacts at a site on Abelia Street, where a large measured ground strain of 4.6 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.

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**.

### 3.8.4. Gas Mains at Castlereagh Street Creek Crossing

Longwall 25 mined directly beneath a 32 mm diameter nylon gas main that crosses Myrtle Creek at Castlereagh Street and no impacts were observed. The gas main also experienced additional movement during the mining of Longwall 26 with no impact. Ground surveys have measured valley closure of approximately 250 mm at this creek crossing.

While the gas main is expected to experience additional valley closure movements of approximately 25 mm during the mining of Longwall 27, the flexibility of the pipelines is expected to allow them to accommodate these values of strain without adverse impacts.

The level of risk is therefore assessed to be the same as for other local gas pipelines, which is:-

**VERY RARE / MODERATE → LOW**.

### 3.8.5. 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. 3.10 and Fig. 3.11. The bridge is located just beyond the commencing (southern) end of Longwall 29. The bridge is located approximately 500 metres to the side of Longwall 27.

**Fig. 3.10 Remembrance Drive Road Bridge over Myrtle Creek**

**Fig. 3.11 Termination of steel gas pipe at end of Remembrance Drive Road Bridge**

The Roads and Traffic Authority 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. 3.10. 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.

The design of the bridge is not conducive to upsidence and closure movements because it is partly supported by a central pier. Upsidence may cause the central pier to move upwards, relative to the abutments. It is likely that the upstand at the ends of the bridge units will prevent the deck from sliding over the abutments as they close towards each other.

Predictions of systematic subsidence, tilt and strain movements have been made at the bridge, and these are shown in Table 3.5.

**Table 3.5 Predicted Subsidence Parameters at Remembrance Drive Road Bridge and Pedestrian Bridge**

| Stage of Mining | Maximum Predicted Subsidence (mm) | Maximum Predicted Tilt (mm/m) | Maximum Predicted Tension (mm/m) | Maximum Predicted Compression (mm/m) |
|---|---|---|---|---|
| After Longwall 27 | < 20 | < 0.2 | < 0.01 | < 0.01 |
| After Longwall 28 | 25 | < 0.2 | < 0.01 | < 0.01 |
| After Longwall 29 | 100 | 0.9 | 0.01 | 0.01 |
| After Longwall 30 | 145 | 1.3 | 0.02 | 0.01 |

The Bridge will also be subjected to upsidence and closure movements, and these are shown in Table 3.6.

**Table 3.6 Prediction of Upsidence and Closure at Castlereagh Street Road Bridge**

| Stage of Mining | Maximum Cumulative Closure (mm) | Maximum Cumulative Upsidence (mm) |
|---|---|---|
| Increment due to LW27 only | < 10 | <10 |
| Total due to LWs 22 to 27 | < 10 | 15 |
| Total due to LWs 22 to 28 | 20 | 25 |
| Total due to LWs 22 to 29 | 40 | 80 |
| Total due to LWs 22 to 30 | 55 | 125 |

It can be seen from Table 3.6 that very little valley closure and upsidence is predicted to occur during the mining of Longwall 27, as the Bridge is located approximately 500 metres from the side of Longwall 27.

Survey marks were installed on the Remembrance Drive Road Bridge prior to the extraction of Longwall 24A. While the Bridge has experienced approximately 25 mm of subsidence, measured changes in horizontal distances between termination points of the steel gas pipes have been very small and within survey tolerance. No closure has been detected and instead, a small opening has been measured. 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.

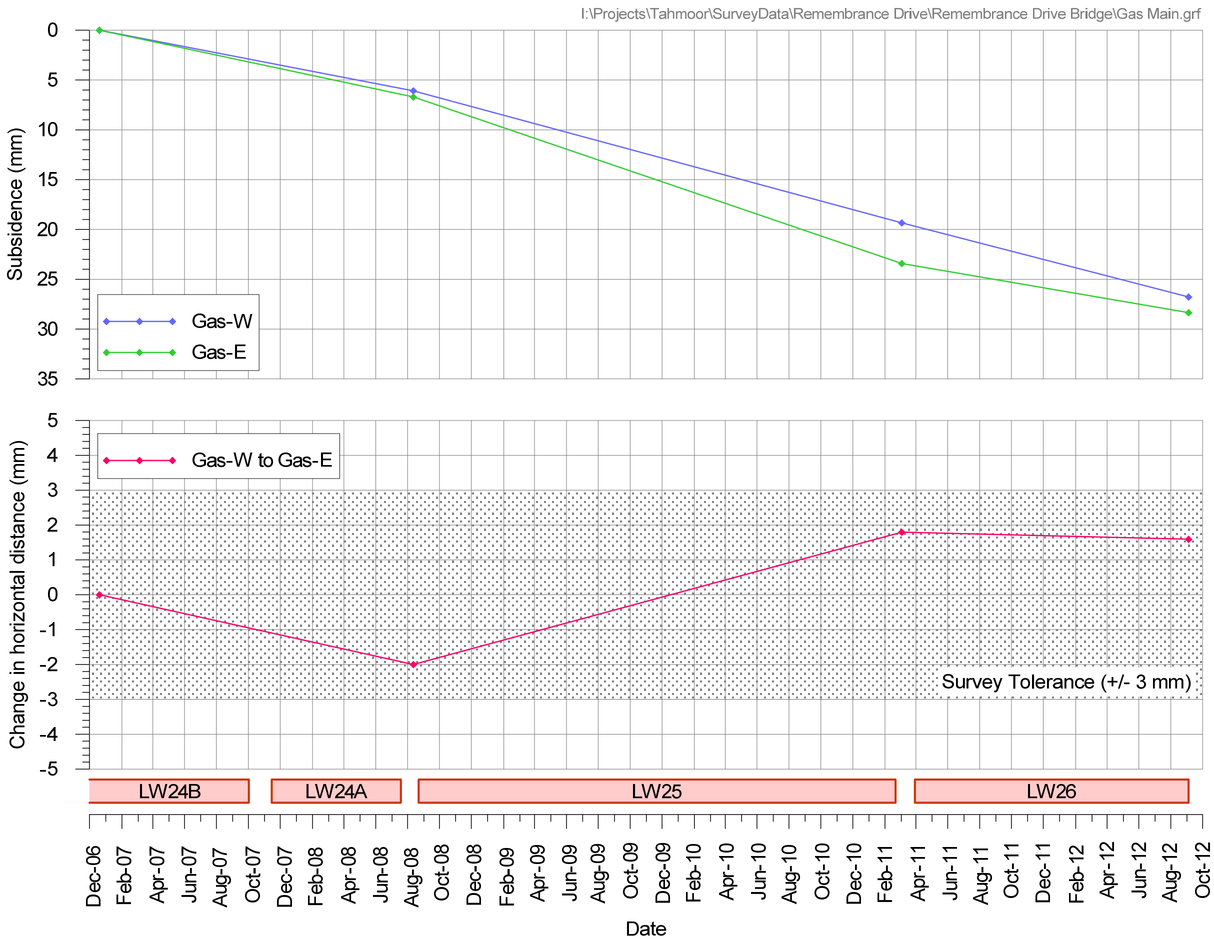



**Fig. 3.12 Observed subsidence and changes in horizontal distances across the abutment of Remembrance Drive (Myrtle Creek) Road Bridge**

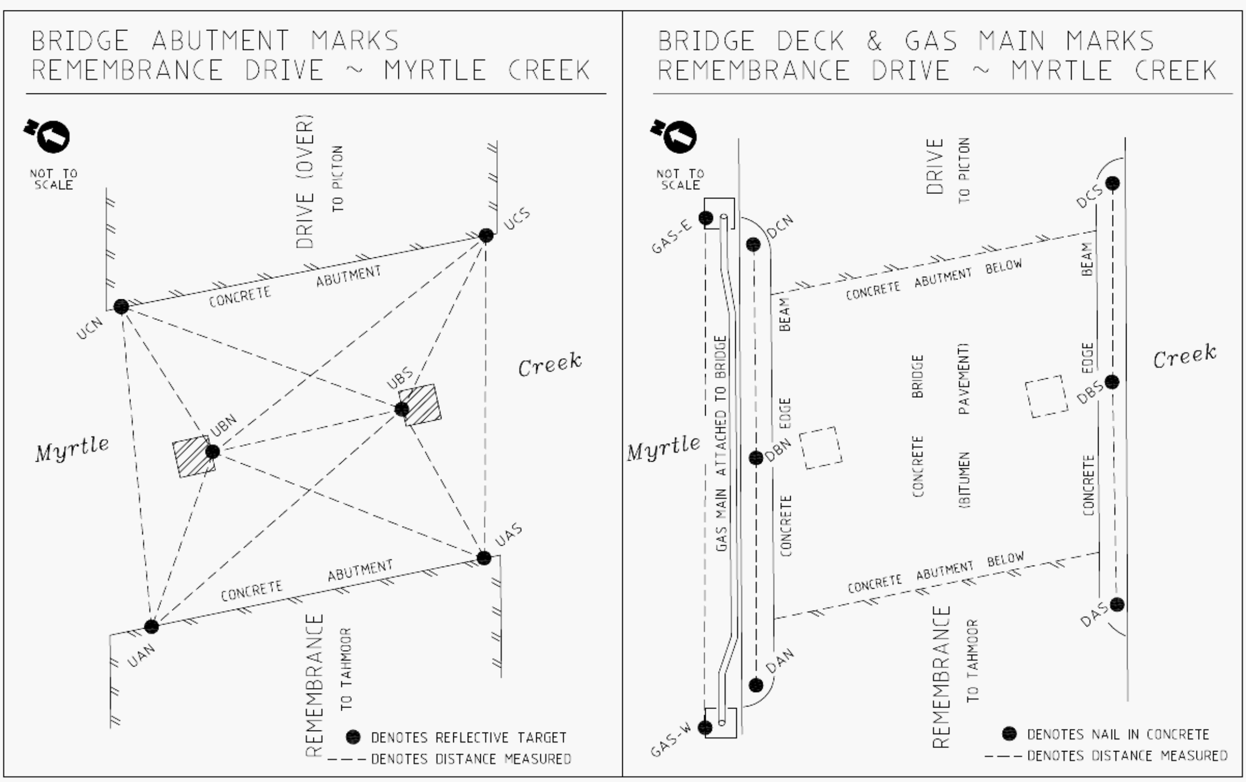
The Remembrance Drive survey line crosses Myrtle Creek between the Remembrance Drive Road Bridge and Pedestrian Bridge. Measured changes in horizontal distances between survey pegs within the Myrtle Creek valley are very small and within survey tolerance.

The bridge has been inspected by structural engineer John Matheson & Associates (JMA) who advises that mitigation measures can be designed, if required, to reduce the potential of impacts to the bridge (JMA, 2009). JMA recommends a structural analysis be conducted on the bridge to assess its ability to withstand differential ground movements and we concur with this recommendation. If mitigation measures are required, it is recommended that they be installed prior to the mining of Longwall 29. The measures will be designed in consultation with Jemena.

The steel gas pipe can tolerate some closure movements and in the extremely unlikely event of significant closure developing, adjustments could be made to the pipe or the connections to the Bridge.

Given the offset distance of the Bridge from Longwall 27 and the anticipated very small amount of movement that is expected to occur, 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 Bridge will be surveyed and visually inspected on a weekly basis after 200 metres of extraction of Longwall 27. The surveys include monitoring of survey points on the Bridge, which were installed prior to the commencement of Longwall 24A and include survey marks on the concrete pads at each end of the gas pipe. A map of survey points is shown in Fig. 3.13.




*Sketch courtesy of SMEC (Urban)*

**Fig. 3.13 Survey marks on Remembrance Drive (Myrtle Creek) Road Bridge**

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

A summary of the levels of risk for the gas pipes are provided in Table 3.7.

**Table 3.7 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 gas pipeline on Thirlmere Way (75 mm) | VERY RARE | 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 27 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 27.

Further confidence is drawn from the experience of mining Longwalls 22 to 26, where no impacts have been experienced, even where predicted subsidence movements have been exceeded.

Mitigation measures will be considered to potentially reduce the risk of impact to the exposed steel gas main that runs along the Remembrance Drive Bridge over Myrtle Creek, but implementation is not required until the mining of Longwall 28.

## 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. 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.

***Ground Monitoring along Remembrance Drive***

Weekly surveys of level and strain distance will be undertaken along Remembrance Drive when this road is within the active subsidence zone, which is when the extraction length of Longwall 27 is approximately 350 metres.

***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 length of extraction of Longwall 27 has exceeded 200 metres.

## 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.

## 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 27 on Jemena AGN Gas Facilities

| Level | Control Measures | Frequency | Analysis | Trigger Level | Action |
|---|---|---|---|---|---|
| 1 | Ground Inspections:<br>- 2D survey<br>- ground inspection | Ground surveys by Tahmoor Colliery:<br>Submit data within 24 hours duration<br>2D survey: start LW, every 200m within urban area except Remembrance Drive, which is weekly after the length of extraction of LW27 is 350m<br>Weekly surveys of Remembrance Drive Bridge over Myrtle Creek and termination points of the steel gas pipe after the length of extraction of LW27 is 200m<br><br>Ground inspections by Tahmoor Colliery:<br>Detailed inspection once a week within active subsidence zone<br>Vehicle based inspection once a week within active subsidence zone<br>Weekly inspections of Remembrance Drive Bridge over Myrtle Creek after the length of extraction of LW27 is 200m | Tahmoor<br>surveys and provides Jemena with<br>- ground surveys<br>- ground movements / features reports | Ground Movement Survey and Measurements:<br>* Radius of ground curvature greater then 4 (km)<br>* Ground strain 0 to 2 (mm/m)<br>* Ground movements rate of change steady<br><br>Ground Conditions Monitoring:<br>- ground cracks reported<br>- ground subsidence reported | 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:<br>inspects site to confirm operation of gas facilities not affected |
| | Ground Subsidence Validations:<br>- Observed against predictions | Weekly: verify and track results against predictions | MSEC<br>analyses and reports findings to stakeholders | - ground movements showing a step change indicating shear and / or discontinuity in humps near the gas services | * undertake additional inspection eg 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 |
| | | | Jemena reviews:<br>- 2D ground surveys report<br>- pipe integrity<br>- ground conditions report | | |
| 2 | Ground Inspections:<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 | Ground Movement Survey and Measurements:<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>Ground Conditions Monitoring:<br>- ground cracks reported<br>- ground subsidence reported | 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:<br>inspects site to confirm operation of gas facilities not affected |
| | Ground Subsidence Validations:<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 step change indicating shear<br>and / or discontinuity in humps near the gas services | * undertake additional inspection eg 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<br>* if no immediate corrective actions required, Jemena may put field construction on standby |
| 3 | Ground Inspections:<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 | Ground Movement Survey and Measurements:<br>* Radius of ground curvature less than 2 (km)<br>* Ground strain greater than 5 (mm/m)<br>* ground movements showing a step change indicating shear and / or discontinuity in humps near the gas services | 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 |
| | Ground Subsidence Validations:<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 | Meng Cheng* | (02) 9397 9200<br>0408 469 091 | meng.cheng@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 | Darren Bullock | (02) 4577 1967<br>0425 275 567 | d.bullock@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) 9413 3822 |
| Xstrata Coal Tahmoor Colliery – Environment and Community Manager | Ian Sheppard | (02) 4640 0156<br>0408 444 257 | isheppard@xstratacoal.com.au | (02) 4640 0140 |
| Xstrata Coal Tahmoor Colliery – Community Coordinator | Belinda Clayton* | (02) 4640 0133<br>0428 260 899 | bclayton@xstratacoal.com.au | (02) 4640 0140 |

* denotes member of Gas Management Group

# APPENDIX A. DRAWINGS

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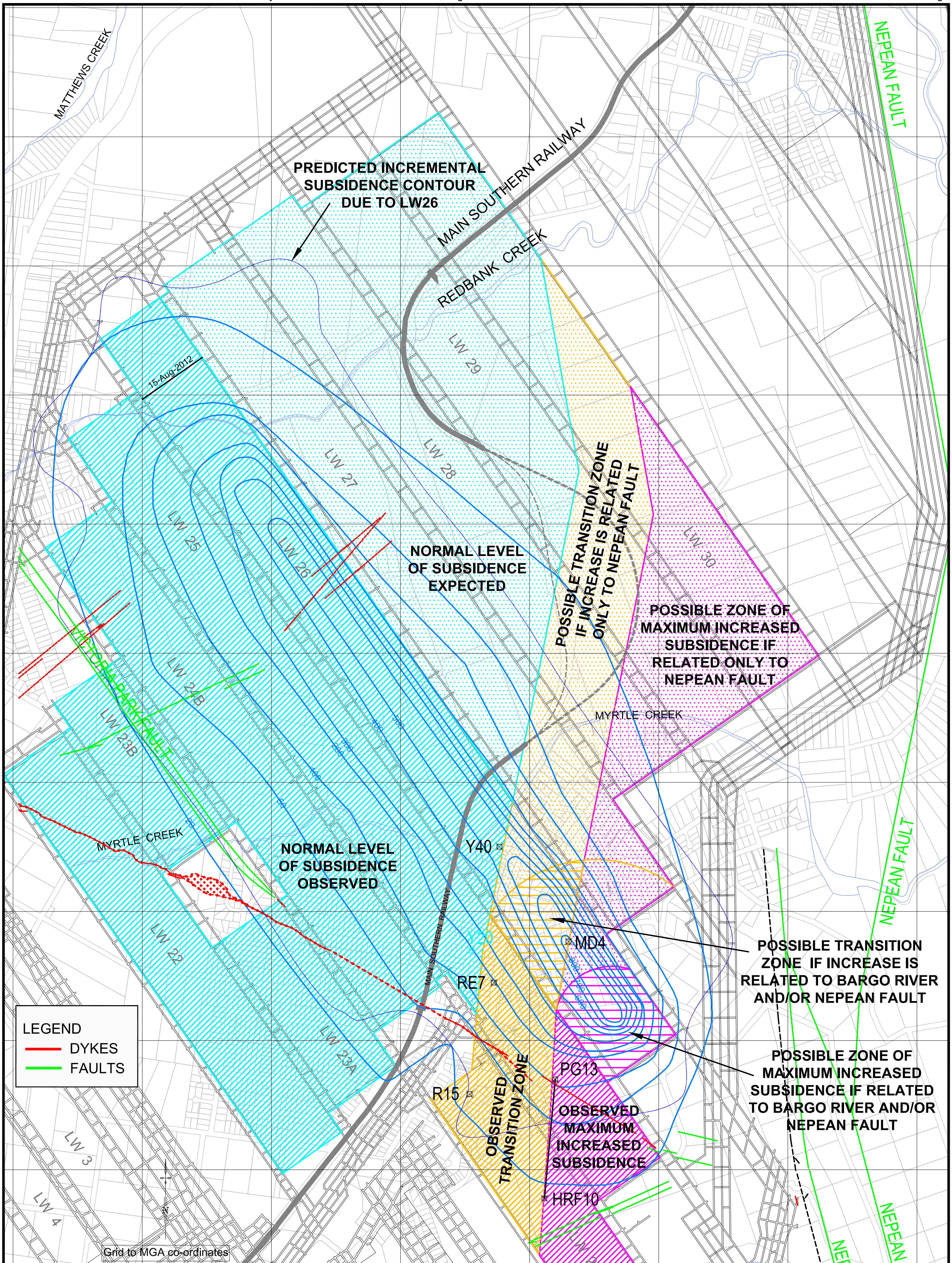


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xstrata coal

TAHMOOR COLLIERY

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

| DATE: | SCALE: | DRAWING No: | Rev No |
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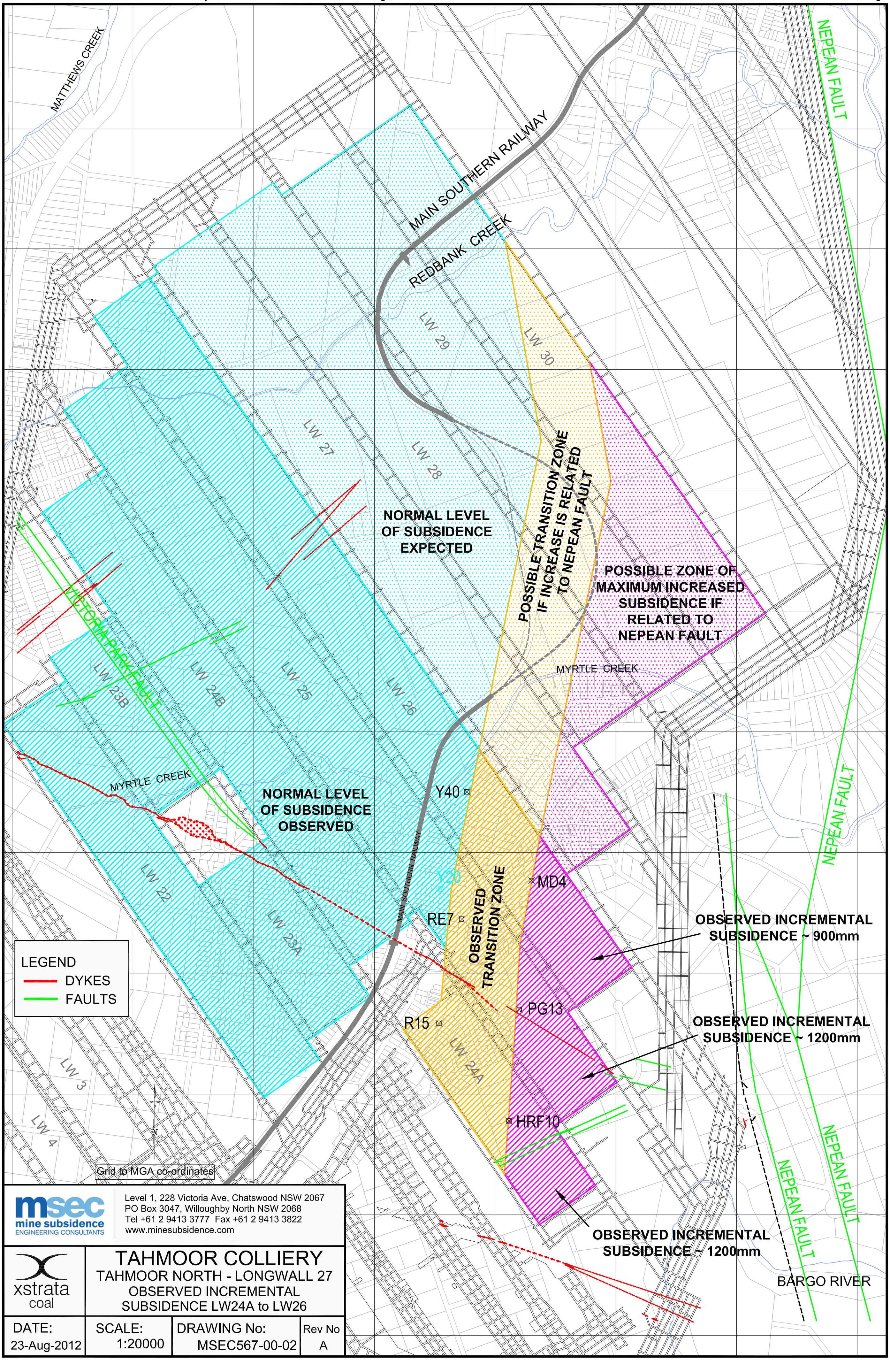

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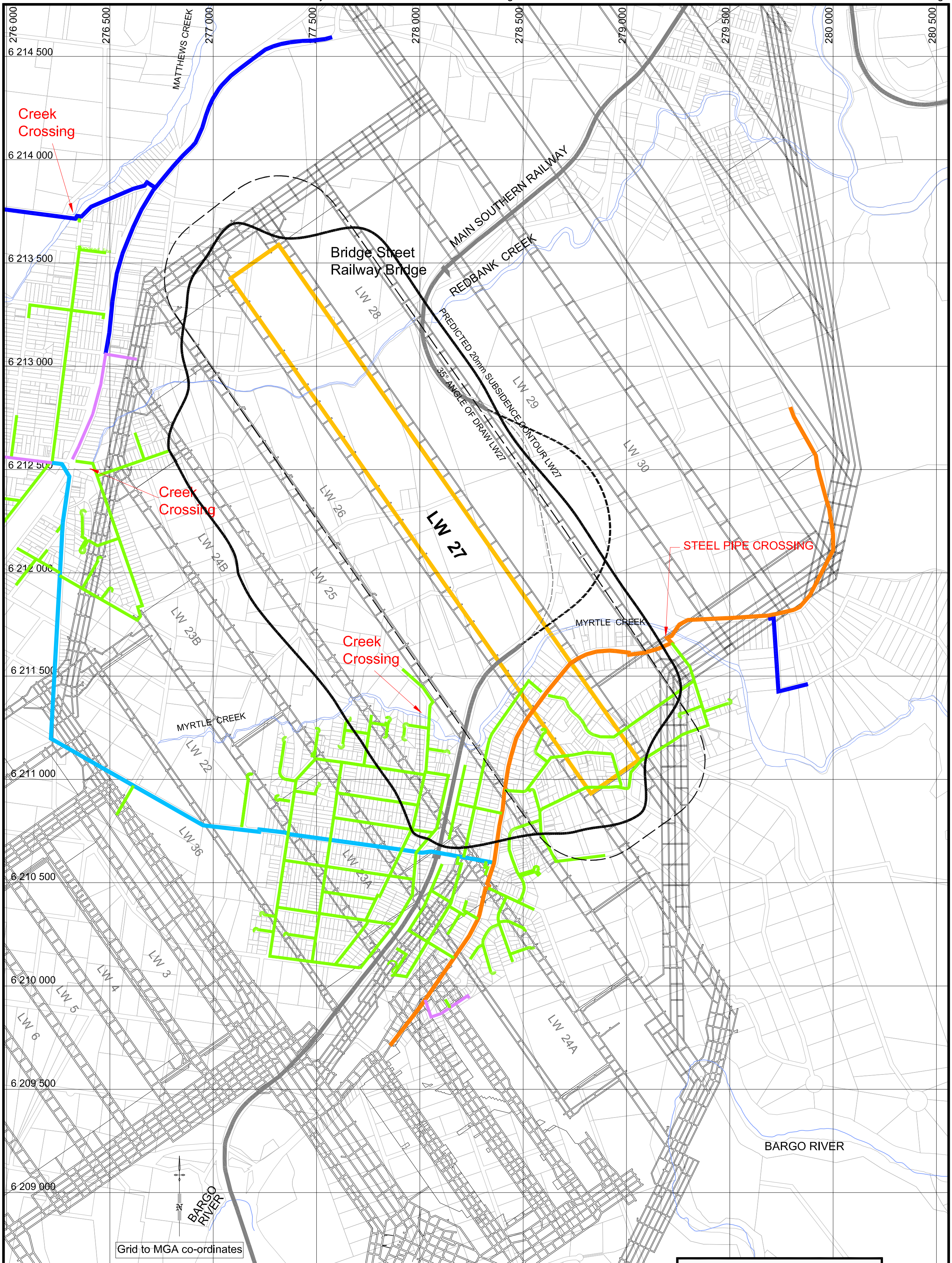


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# TAHMOOR COLLIERY

## TAHMOOR NORTH - LONGWALL 27 JEMENA INFRASTRUCTURE

| DATE: | SCALE: | DRAWING No: | Rev No |
|---|---|---|---|
| 13-Sep-2012 | 1:25000 | MSEC567-05-01 | A |