TAHMOOR UNDERGROUND

GLENCORE

GLENCORE:

Tahmoor Colliery - Longwalls 28 to 30

Management Plan for Potential Impacts to Sydney Water Potable Water Infrastructure

AUTHORISATION OF MANAGEMENT PLAN

Authorised on behalf of Tahmoor Colliery:	
Name:	Ian Sheppard
Signature:	Ian Sheppard
Position:	Manager, Environment and Community
Date:	31 March 2014

Authorised on behalf of Sydney Water:	
Name:	S. ZNAUTAS
Signature:	S. Zn
Position:	NETWORKS AREA MANAGER WEST
Date:	13/2/14

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Sep-12	MSEC567-06	A	Updated for Longwall 27
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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

Tahmoor Colliery Longwalls 29 and 30 - *The Effects of the Proposed Modified Commencing Ends of Longwalls 29 and 30 at Tahmoor Colliery on the Subsidence Predictions and Impact Assessments* (Report MSEC645, Revision A, December 2013), prepared by Mine Subsidence Engineering Consultants

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

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Drawings

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

1.1. Background

Tahmoor Colliery is located approximately 80 kilometres south west of Sydney in the township of Tahmoor NSW. It is managed and operated by Xstrata Coal. Tahmoor Colliery has previously mined 26 longwalls to the north and west of the mine's current location. It is currently mining Longwall 27.

Longwalls 28 to 30 are 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 Longwall 28 is located beneath the urban area of Tahmoor. Infrastructure owned by Sydney Water is located within these areas. A summary of the dimensions of these longwalls is provided in Table 1.1.

Table 1.1 Longwall Dimensions

Longwall	Overall Void Length Including Installation Heading (m)	Overall Void Width Including First Workings (m)	Overall Tailgate Chain Pillar Width (m)
Longwall 28	2630	283	39
Longwall 29	2321	283	39
Longwall 30	2321	283	39

This Management Plan provides detailed information about how the risks associated with the mining beneath potable water infrastructure will be managed by Tahmoor Colliery and Sydney Water.

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 Sydney Water.

1.2. 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. Revised predictions have been provided in Report No. MSEC645, which was prepared in support of Tahmoor Colliery's modification to the commencing ends of Longwalls 29 and 30.

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

Table 1.2 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Longwalls 28 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)
Due to LW28	730	5.8	0.06	0.13
Due to LW29	720	5.8	0.06	0.12
Due to LW30	720	5.7	0.06	0.12

Table 1.3 Maximum Predicted Total Systematic Subsidence Parameters after the Extraction of Longwalls 28 to 30

Longwall	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt (mm/m)	Maximum Predicted Total Hogging Curvature (1/km)	Maximum Predicted Total Sagging Curvature (1/km)
After LW28	1250	6.0	0.11	0.14
After LW29	1250	6.0	0.11	0.14
After LW30	1250	6.0	0.11	0.14

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

1.3. Observed Subsidence during the mining of Longwalls 22 to 27

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 27.

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

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

Observed Increased Subsidence during the mining of Longwall 24A

Observed subsidence was greatest above the southern half of Longwall 24A, and gradually reducing in magnitude towards the northern half of the longwall, which was directly beneath the urban area of Tahmoor. These observations are shown graphically in Fig. 1.1, which shows observed subsidence at survey pegs located along the centreline of Longwall 24A.

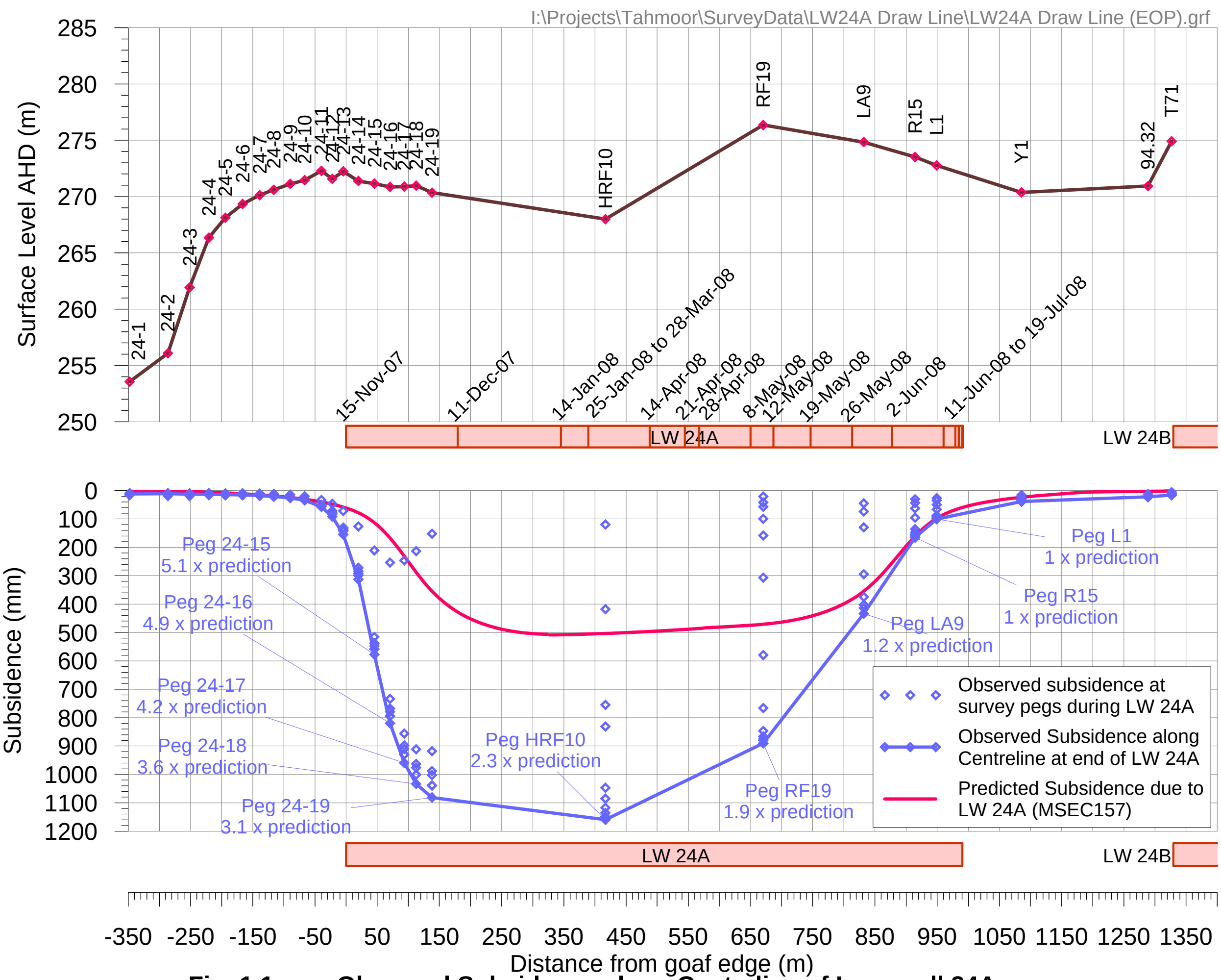


Fig. 1.1 Observed Subsidence along Centreline of Longwall 24A

It can be seen from Fig. 1.1 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. 1.2, which shows observed subsidence at survey pegs located along the centreline of Longwall 25.

It can be seen from Fig. 1.2 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.

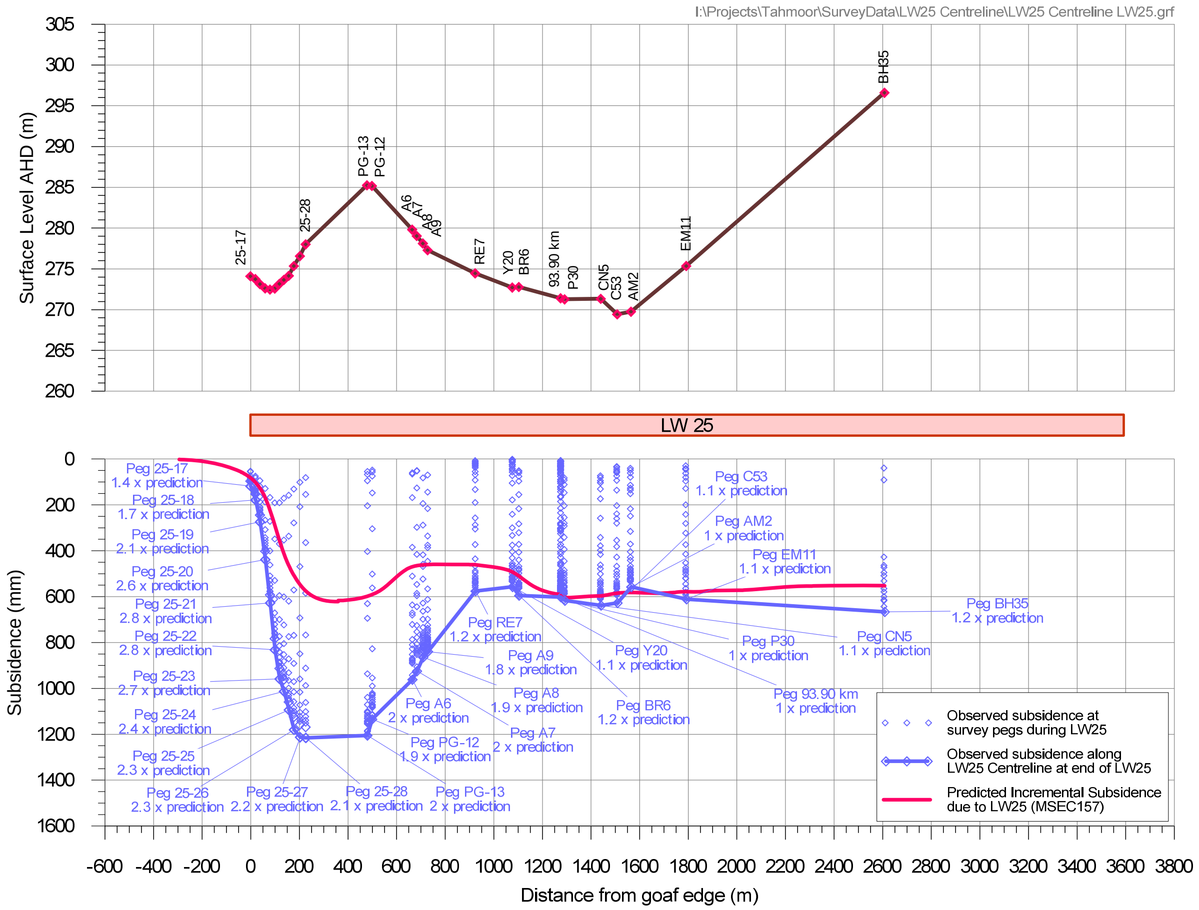


Fig. 1.2 Observed Subsidence along Centreline of Longwall 25

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. 1.3, which shows observed subsidence at survey pegs located along the centreline of Longwall 26.

It can be seen from Fig. 1.3 that observed subsidence was approximately 1.5 times the predicted maximum value, with maximum subsidence of 893 mm at Peg TM26.

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

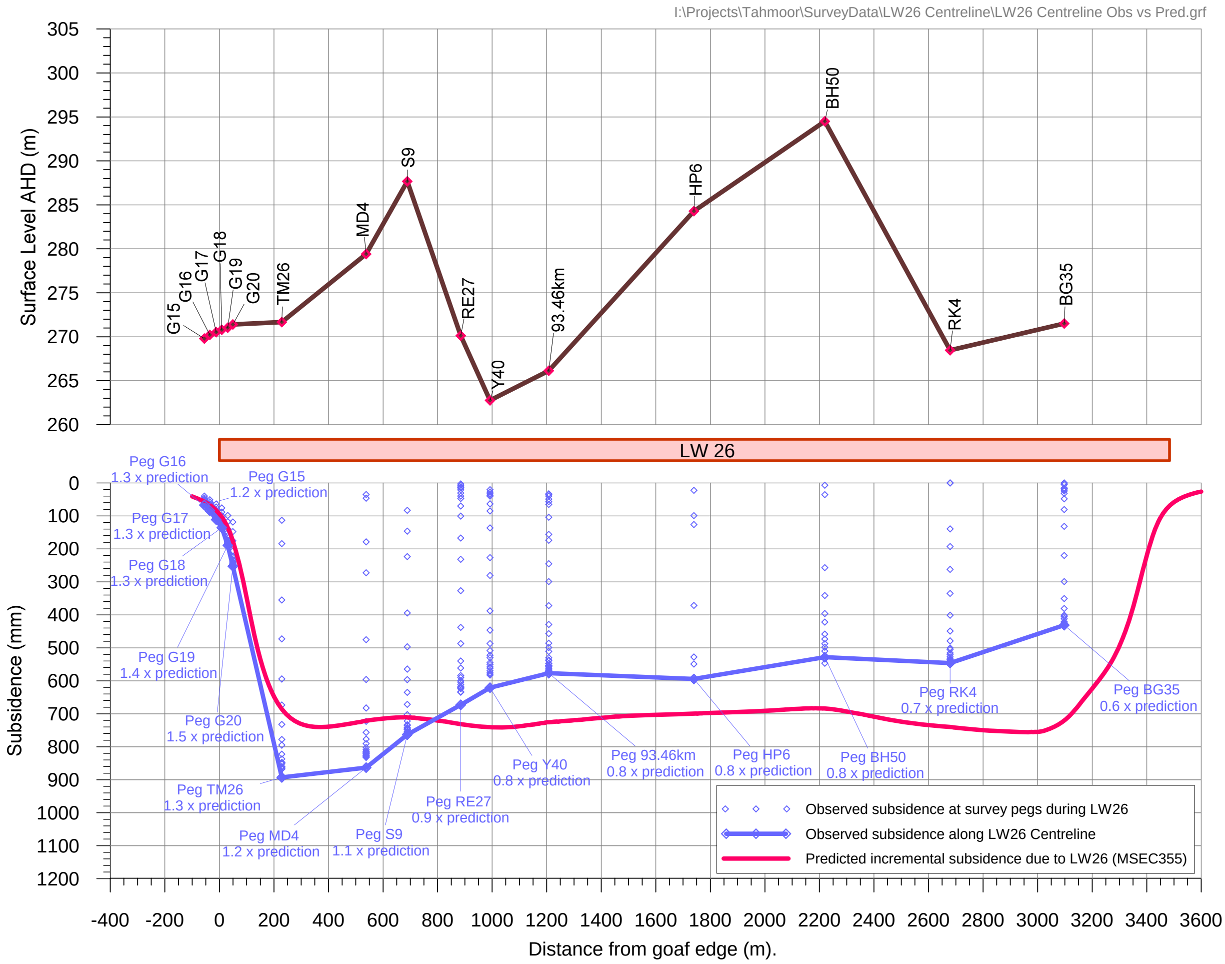


Fig. 1.3 Observed Subsidence along Centreline of Longwall 26

Observed Increased Subsidence during the mining of Longwall 27

The extraction of Longwall 27 is currently underway and is scheduled to finish in early 2014. Monitoring above the commencing end has shown that the magnitude of maximum subsidence is approximately 800 mm, which is slightly less than the measured maximum subsidence of approximately 900 mm above the commencing end of Longwall 26. Observed subsidence at survey pegs located along the centreline of Longwall 27 are shown graphically in Fig. 1.4. The graph shows the latest survey results for each monitoring line as at December 2013, with approximately 540 metres of extraction remaining. It is likely that further small increases in subsidence will be observed at these pegs when they are surveyed at the completion of Longwall 27.

It can be seen from Fig. 1.4 that observed subsidence is approximately 1.3 times the predicted maximum value, with current maximum subsidence of 793 mm at Peg MC14.

Observed subsidence reduced along the panel from Peg MC14 until Peg TC4, which is located between Remembrance Drive and Myrtle Creek. Observed subsidence along the centreline returned to normal levels as mining progressed beyond Peg TC4.

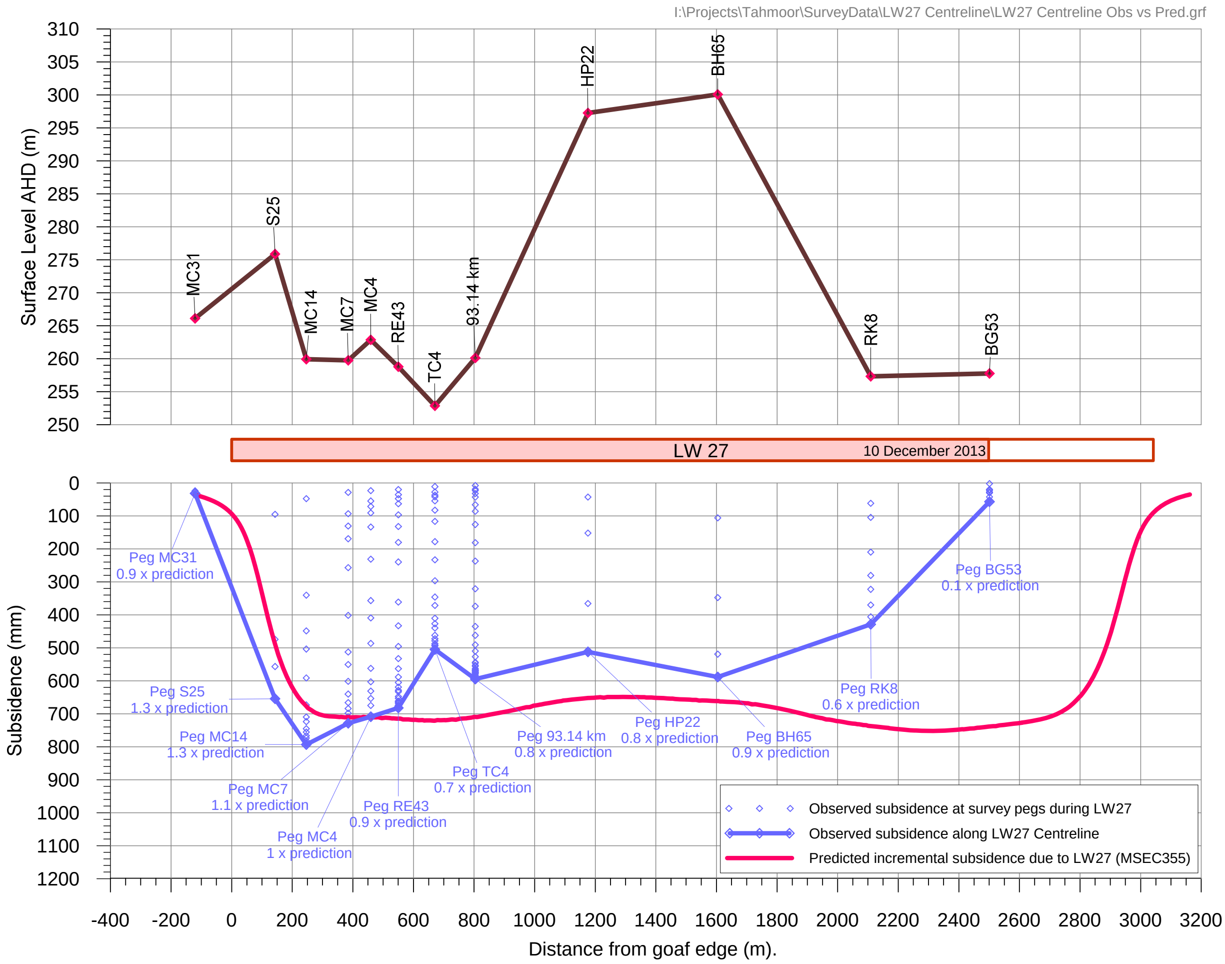


Fig. 1.4 Observed Subsidence along Centreline of Longwall 27

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, 900 mm above Longwall 26 and 800 mm above Longwall 27.

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. MSEC646-00-01 (refer Appendix), it can be seen that the transition zone is roughly consistent in width above Longwall 24A, Longwall 25 and Longwall 26. This orientation is roughly parallel to the Nepean Fault. The transition zone then appears to change direction above Longwall 27. This may suggest a relationship to the proximity of Longwall 27 to the Bargo River and a curved transition zone has been drawn to illustrate this. .

The observations above Longwalls 24A to 27 suggest that the location of the zone of increased subsidence is linked to both the alignment of the Nepean Fault and the proximity to the Bargo River. It correlates with 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.

The experiences of reduced maximum subsidence above Longwalls 26 and 27 suggest that the magnitude of maximum subsidence above the commencing ends of Longwalls 28 to 30 will be less than previously observed and may return close to normal levels of subsidence elsewhere at Tahmoor.

The zones of increased subsidence and transition to normal subsidence have been conservatively projected above Longwalls 28 to 30 in Drawing No. MSEC646-00-02 (refer Appendix). The projection is conservative as it is based on the orientation of the Nepean Fault rather than its proximity to the Bargo River. A curved dashed line is also shown in in Drawing No. MSEC646-00-02 above Longwall 28, which is an alternative projection based on the observations above Longwall 27 and its proximity to the Bargo River. This alternative projection appears reasonable based on the observations above Longwall 27.Despite the above observations and projections, it is recognised that substantially increased subsidence could develop above the commencing ends of Longwalls 28 to 30 and this Management Plan has been developed to manage potential impacts if substantial additional subsidence were to occur.

With respect to potable water infrastructure, water mains are located directly within the potential zone of increased subsidence above Longwall 28 only. There are no water mains located directly above Longwalls 29 and 30.

1.4. 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.

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. 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).

1.4.1. 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.

Predictions of Strain Above Goaf

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, Appin and West Cliff Collieries, 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*".

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf, for monitoring lines at Tahmoor, Appin Area and West Cliff Collieries, is provided in Fig. 1.5. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

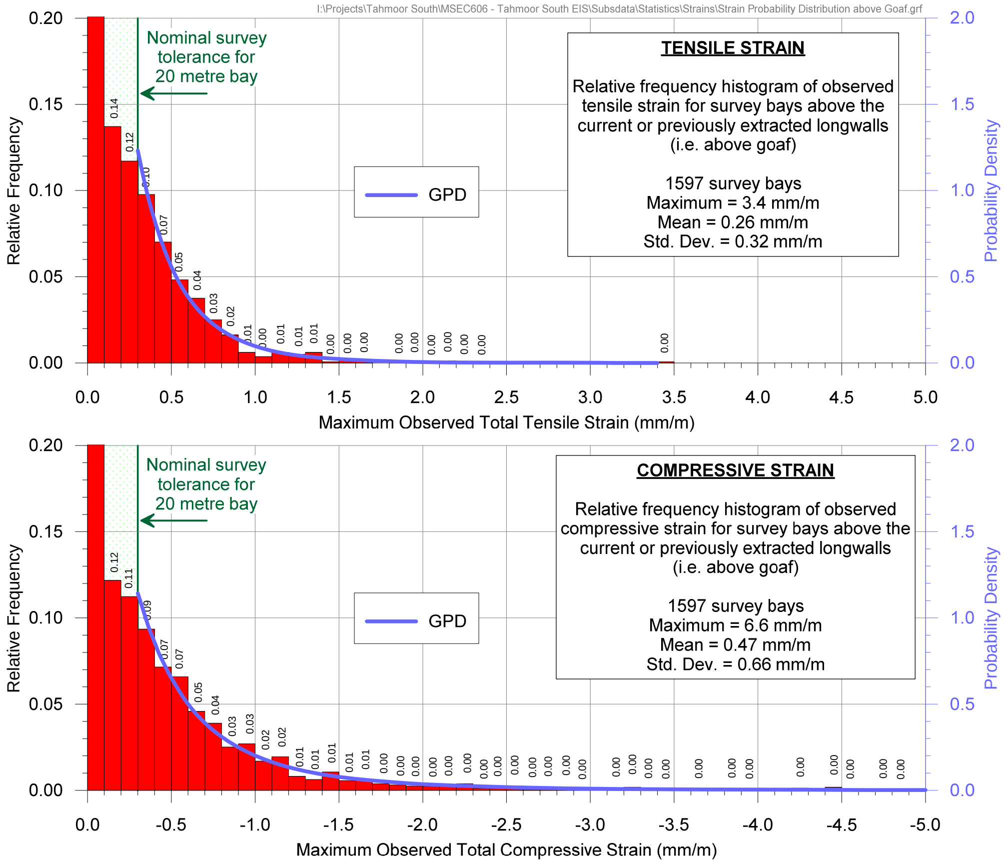


Fig. 1.5 Distributions of the Measured Maximum Tensile and Compressive Strains for Surveys Bays Located Above Goaf at Tahmoor, Appin and West Cliff Collieries

The 95 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.9 mm/m tensile and 1.6 mm/m compressive. The strains for the proposed longwalls are predicted to be 30 % to 50 % greater than those previously observed at these collieries and, therefore, it is expected that 95 % of the strains measured *above goaf* would be less than 1.5 mm/m tensile and 2.5 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 at Tahmoor, Appin and West Cliff Collieries were 1.4 mm/m tensile and 3.1 mm/m compressive. Similarly, it is expected that 99 % of the strains measured *above goaf* for the proposed longwalls would be less than 2.0 mm/m tensile and 4.5 mm/m compressive.

Predictions of Strain Above Solid Coal

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 at Tahmoor, Appin and West Cliff Collieries, 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*".

The histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal, for monitoring lines at Tahmoor, Appin and West Cliff Collieries, is provided in Fig. 1.6. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

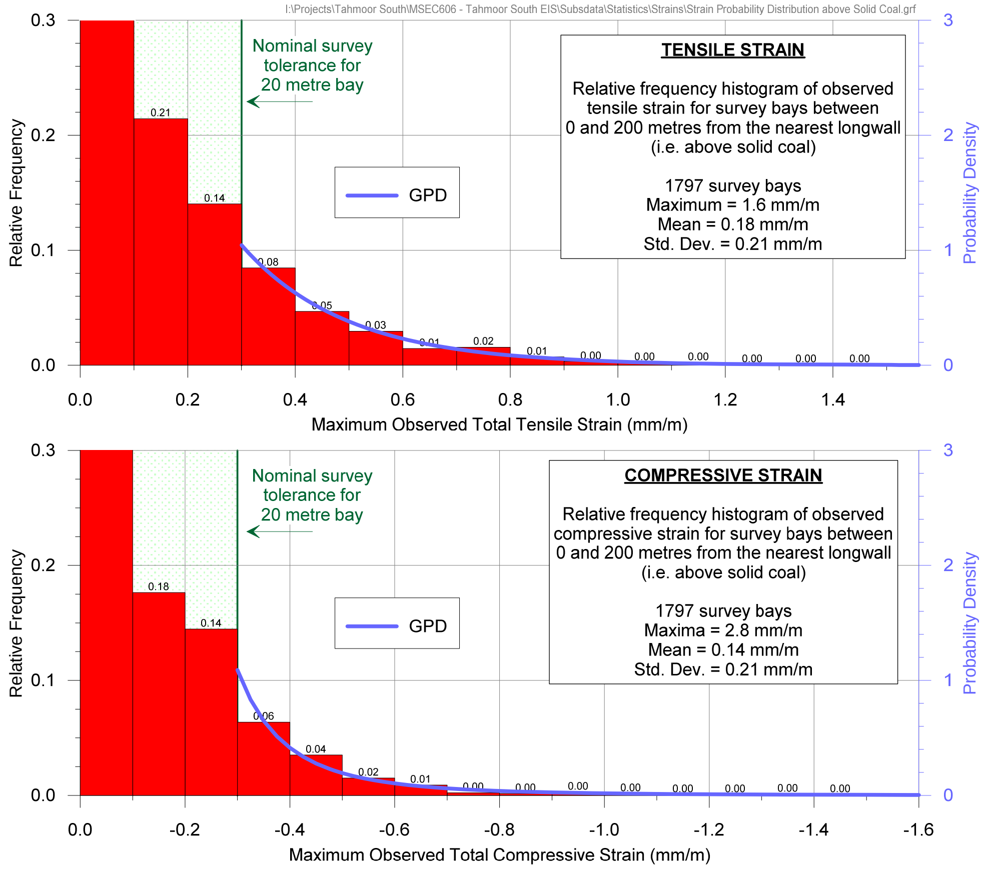


Fig. 1.6 Distributions of the Measured Maximum Tensile and Compressive Strains for Survey Bays Located Above Solid Coal at Tahmoor, Appin and West Cliff Collieries

The 95 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.6 mm/m tensile and 0.5 mm/m compressive. The strains for the proposed longwalls are predicted to be 30 % to 50 % greater than those previously observed at these collieries and, therefore, it is expected that 95 % of the strains measured *above solid coal* would be less than 1.0 mm/m tensile and compressive.

The 99 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.9 mm/m tensile and compressive. Similarly, it is expected that 99 % of the strains measured *above solid coal* adjacent to the proposed longwalls would be less than 1.5 mm/m tensile and compressive.

1.4.2. 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.

The 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, Appin and West Cliff Collieries, is provided in Fig. 1.7.

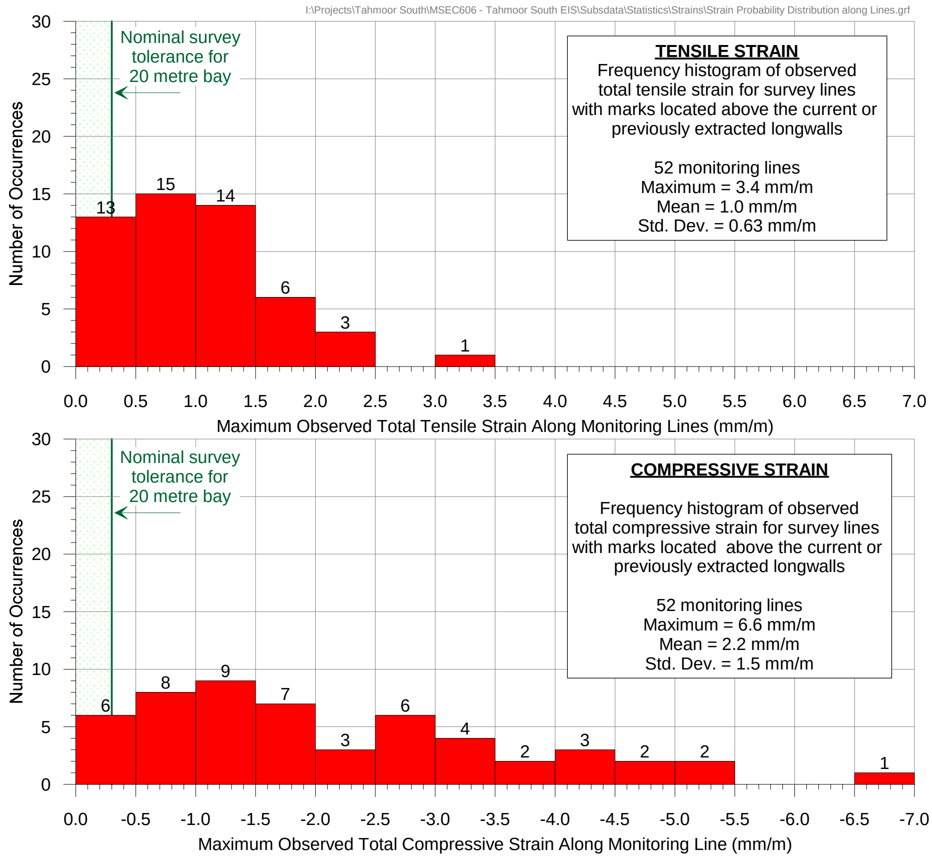


Fig. 1.7 Distributions of Measured Maximum Tensile and Compressive Strains Anywhere along the Monitoring Lines at Tahmoor, Appin and West Cliff Collieries

It can be seen from Fig. 1.7, that 42 of the 52 monitoring lines (i.e. 92 % of the total) at Tahmoor, Appin and West Cliff Collieries had recorded maximum total tensile strains of 2.0 mm/m, or less. The strains for the proposed longwalls are predicted to be 30 % to 50 % greater than those previously observed at these collieries and, therefore, it is expected that 92 % of the monitoring lines above the proposed longwalls would experience maximum tensile strains of 3.0 mm/m, or less.

It can also be seen, that 45 of the 52 monitoring lines (i.e. 87 % of the total) at Tahmoor, Appin and West Cliff Collieries had recorded maximum total compressive strains of 4.0 mm/m, or less. The strains for the proposed longwalls are predicted to be 30 % to 50 % greater than those previously observed at these collieries and, therefore, it is expected that 87 % of the monitoring lines above the proposed longwalls would experience maximum compressive strains of 6.0 mm/m, or less.

1.5. 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 Sydney Water.

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.
- 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, Sydney Water, Mine Subsidence Board, Industry and Investment, NSW, and consultants as required.
- Establish lines of communication and emergency contacts.

1.6. 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 water mains.

The Management Plan describes measures that will be undertaken as a result of mining Longwalls 28 to 30 only.

1.7. 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 30 and for sufficient time thereafter to allow for completion of subsidence effects. The current schedule of mining is shown in Table 1.4.

Table 1.4 Schedule of Mining

Longwall	Start Date	Completion Date
Longwall 28	April 2014	August 2015
Longwall 29	September 2015	October 2016
Longwall 30	November 2016	December 2017

1.8. 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. 1.8.

Fig. 1.8 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. Observations during Longwalls 22 to 27

Longwalls 22 to 27 have directly mined beneath approximately 4.8 kilometres of ductile iron concrete lined (DICL) pipe and 19.0 kilometres of cast iron concrete lined (CICL) pipe, with minimal impact to the distribution network reported. The reported impacts are listed below.

- There was a leak in a CICL water main on Glenanne Place in June 2007 during the mining of Longwall 24B. While there was no ground survey data to quantify the ground movements, the leak coincided with damage to the road pavement and damage to a fence. It is considered that non-systematic movements developed at this location.
- A water leak was observed in a CICL water main on York Street opposite the Tahmoor Town Centre during the mining of Longwall 25. While no impacts were reported to the road pavement and no elevated ground strain was observed at the leak, a bump was observed in the subsidence profile near the location of the leak.
- A CICL water main leaked on Moorland Road during Longwall 26, where increased ground strains and a small bump in the subsidence profile were observed. The pipe was repaired the same day.
- A CICL water leak was observed on York Street on two occasions during Longwall 26, at a site where increased strain and a bump in the subsidence profile were observed. The leak was repaired each time.
- A very small number of minor leaks have also been observed to consumer connection pipes on private properties. Remedial works were undertaken and the leaks repaired.
- There was a leak in a 100 mm diameter CICL water main on Myrtle Creek Avenue in January 2013 during the mining of Longwall 27, at a site where increased strain and a bump in the subsidence profile were observed. The leak was repaired the same day.

3.2. Water Supply Infrastructure

Sydney Water has an extensive water supply network that will experience subsidence movements during the mining of Longwalls 28 to 30. The water pipelines are shown according to their pipe size in Drawing No. MSEC646-03-01. The pipes are also shown according to their type in Drawing No. MSEC646-03-02.

It can be seen that there are water pipelines located directly above a portion of Longwall 28 but there are no water pipelines directly above Longwalls 29 to 30.

It can be seen from these drawings that the water mains that may experience subsidence during the mining of Longwalls 28 to 30 range in diameter between 100 and 300 mm. The larger water mains are located along Remembrance Drive. The majority of the pipes are either CICL or DICL, with some welded Steel Cement Lined directional bores.

There are also two pressure reducing valves that will experience additional subsidence movements during the mining of Longwall 28, with both located within 220 metres of the longwall, as shown in Drawing No. MSEC646-03-01. Longwall 27 extracted directly beneath the valves.

3.3. 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 27. The nature of the infrastructure that will experience subsidence during the mining of Longwalls 28 to 30 is similar to the infrastructure above Longwalls 22 to 27.

Sydney Water and Tahmoor Colliery have developed and acted in accordance with an agreed management plan during the mining of Longwalls 22 to 27.

Given that no significant impacts have been experienced to date, Sydney Water 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.

3.4. Hazard Identification

Four hazards have been identified that are associated with mine subsidence impacts on the water mains:-

1. The hazard that the joints are damaged as a result of mining induced ground strains.
2. The hazard that the pipes are damaged as a result of mining induced ground strains.
3. The hazard that valves, hydrants and chambers are damaged as a result of mining induced ground strains.
4. The hazard that there is damage to the water mains at creek crossings.

The likelihood and consequence of each hazard and the associated level of risk are discussed in the following sections.

3.5. Hazard 1 – Damaged Joints

Since the water mains are pressure mains, the predicted maximum subsidence should have very little effect on the capacity of the system, although the ground strains and curvatures could adversely affect the pipelines.

Experience during the mining of Longwalls 22 to 27 has shown that the pipes have typically not experienced impacts except when substantial localised compressive strain was observed, usually with a noticeable bump in the subsidence profile.

The pipe joints have accommodated the majority of the mining-induced ground strains, particularly the DICL pipes with rubber ring joints, whose locations are shown in Drawing No. MSEC646-03-02. Any ground movements along the pipes are likely to be transferred to the pipe joints. There have been no impacts reported in relation to DICL pipes or pipe joints to date.

As shown in Drawing No. MSEC646-03-02, there are a number of CICL pipes, which are typically older and may contain caulked lead joints. These pipes and joints are less flexible and more vulnerable to adverse impacts when compared to those with rubber ring joints. All impacts reported to date have been in relation to CICL pipes. The observed frequency of impacts to date from any mine subsidence movements has so far been 5 impacts in 19.0 kilometres of CICL water main, or 1 to 2 impact sites per longwall.

The largest water mains that will experience the full range of subsidence movements during the mining of Longwalls 28 to 30 are the 300 mm DICL pipes that run along Remembrance Drive from Emmett Street towards Picton. The pipeline changes down in size to an older 200 mm diameter CICL pipe approximately 70 metres north of the intersection of Remembrance Drive and Myrtle Creek Avenue. This section of pipe is located directly above the previously mined Longwalls 22 to 27. No impacts were observed during the mining of Longwalls 24A to Longwall 27. Predictions of subsidence, tilt and strain along Remembrance Drive are provided in Fig. 3.1 and are summarised in Table 3.1.

Table 3.1 Maximum Predicted Systematic Subsidence, Tilt and Strain along Remembrance Drive due to the Extraction of Longwalls 28 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)
Longwall 28	1105	4.4	0.08	0.12
Longwall 29	1110	4.3	0.08	0.12
Longwall 30	1110	4.3	0.08	0.12

Based on the above experiences, it is concluded that it is unlikely that the pipe joints will be broken by systematic (normal) mine subsidence movements. Non-systematic localised ground strains and curvatures higher than predicted can occur where compressive ground strains cause the underlying strata to buckle.

On the basis of the above comments, the likelihood of the joints in the CICL pipes being damaged by systematic mining impacts can therefore be considered **MODERATE**. The likelihood rating is for Longwall 28 only. The likelihood of impacts occurring due to the extraction of Longwalls 29 and 30, which do not mine directly beneath the water pipelines, is considered **RARE**.

DICL pipes are more readily able to tolerate mine subsidence movements compared to CICL pipes by virtue of the rubber ringed joints. No DICL pipes have experienced impacts to date and no DICL will be directly mined beneath by Longwalls 28 to 30. The likelihood of the joints in the DICL pipes being damaged by systematic mining impacts can therefore be considered **RARE**.

The result of damaged joints is the leakage of water into the surrounding area and/or localised erosion. In the case of the smaller 100 and 150 mm diameter pipes, the damaged joints can be repaired at a relatively low financial cost and the inconvenience to Sydney Water customers is limited to a relatively small number of properties. The consequence can therefore be considered **SLIGHT**. In the case of the pipes that are larger than 150 mm in diameter, the inconvenience to customers is greater and the consequence can be considered **MODERATE**.

The level of risk can therefore be considered:-

For 100 and 150 mm dia pipes:- **MODERATE** (CICL) or **UNLIKELY** (DICL) / **SLIGHT → LOW**

For CICL pipes with dia > 150 mm (Remembrance Drive):- **MODERATE** / **MODERATE → MODERATE**

For DICL pipes with dia > 150 mm (Remembrance Drive):- **UNLIKELY** / **MODERATE → LOW**

3.6. Hazard 2 – Damaged Pipes

There are no watermains located over Longwall 29 or Longwall 30. The water mains located over Longwall 28 consist of 200 mm diameter CICL pipes, and 100 mm uPVC pipes.

Longwalls 22 to 27 have directly mined beneath approximately 4.8 kilometres of DICL pipe and 19.0 kilometres of CICL pipe, with only 5 impacts noted to CICL pipes as described in Section 3.1.

The likelihood of the pipes being damaged by systematic mining impacts can therefore be considered **RARE**. Non-systematic localised strains and curvatures higher than predicted can occur where compressive strains cause the underlying strata to buckle, however, the likelihood of this anomalous behaviour occurring can be considered **RARE**. The observed frequency of impacts to date from any mine subsidence movements has so far been 5 impacts in 19.0 kilometres of water mains.

The result of damaged water mains is the leakage of water into the surrounding area and localised erosion. In the case of the smaller 100 and 150 mm diameter pipes, the damaged joints can be repaired at a relatively low financial cost and the inconvenience to Sydney Water customers is limited to a relatively small number of properties. The consequence can therefore be considered **SLIGHT**. In the case of the pipes that are larger than 150 mm in diameter, the inconvenience to customers is greater and the consequence can be considered **MODERATE**.

The level of risk can therefore be considered:-

For 100 and 150 mm dia pipes:- **RARE** / **SLIGHT → VERY LOW**

For pipes with dia > 150 mm:- **RARE** / **MODERATE → LOW**

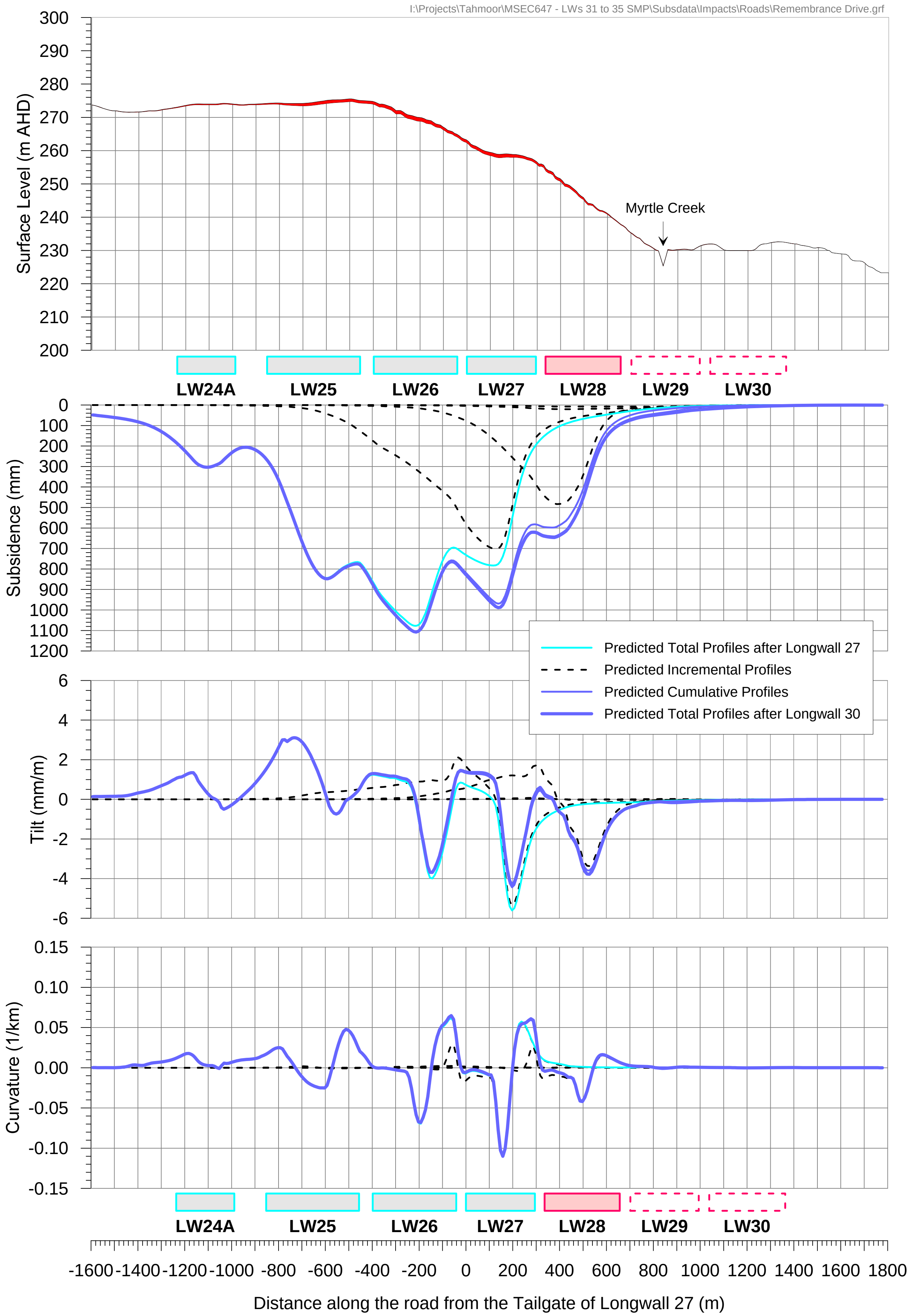


Fig. 3.1 Predicted Subsidence Parameters along Remembrance Drive

3.7. Hazard 3 – Damaged Valves, Hydrants and Chambers

Two pressure reducing valves on Remembrance Drive and Myrtle Creek Avenue may experience additional subsidence movements during the mining of Longwalls 28 to 30. They are located directly above the previously extracted Longwall 27 and no impacts on the valves were observed during the mining of this longwall.

Pipes around fixed valves and hydrants are more susceptible to mine subsidence movements as the valves and hydrants act as an anchor while the pipes slide as the ground moves beneath them. This creates greater movements at the first few pipe joints around valves and hydrants.

While these movements can usually be accommodated in the pipe joints it is noted that monitoring for leaks should be more vigilant around valves and hydrants during the mining period. If a large number of breakages are observed during mining, further breakages could be prevented by introducing more flexible joints around valves and hydrants.

Given that no impacts have been observed to the valves, hydrants and chambers to date, the likelihood of impacts occurring during the mining of Longwall 28 is considered **RARE**.

The valves and chamber are typically connected to large water mains and the consequence of impacts occurring is therefore considered **MODERATE**.

The level of risk can therefore be considered **RARE / MODERATE → LOW**

3.8. Hazard 4 – Damage to the Water Mains at Creek Crossings

The water mains cross Myrtle Creek near Castlereagh Street and at Remembrance Drive, as shown in Drawing No. MSEC646-03-01.

The Castlereagh Street crossing has experienced approximately 250 mm of valley closure movements during the mining of Longwalls 24B to 27, with no impacts observed to the SCL pipe or the joints at each end that connect to the CICL pipes. No additional valley closure movements were measured during the mining of Longwall 27. The additional amount of closure due to the extraction of Longwalls 28 to 30 is predicted to be extremely small and the likelihood of impacts is considered to be **RARE**.

The Remembrance Drive crossing will not be directly mined beneath by Longwalls 28 to 30. It is located approximately 160 metres to the side of Longwall 28 and 240 metres beyond the commencing end of Longwall 29. The predicted subsidence movements at this offset distance are very small and the likelihood of impacts occurring at the creek crossing is considered **RARE**.

Although the water has been treated, it is considered that the addition of potable water will not pose a significant environmental risk to the ecology of Myrtle Creek, in the event of pipe or joint leakage. It is therefore considered that the level of consequence for leakage of these joints and pipes is the same as those discussed previously in this management plan, which is **SLIGHT**.

The level of risk for the Myrtle Creek crossing at Castlereagh Street can therefore be considered **RARE / SLIGHT → LOW.** The level of risk for the Remembrance Drive crossing is also considered **LOW**.

3.9. Summary of Risk Analysis for Sydney Water Infrastructure

A summary of the level of risk for the water mains associated with damaged joints, damaged pipes and damage to associated items is provided in Table 3.2 below.

Table 3.2 Risk Analysis Matrix for Water Mains

Risk	Likelihood	Consequence	Level of Risk
Damaged Joints for 100 and 150 mm dia pipes	MODERATE (CICL) for LW28 RARE (CICL) for LWs 29 & 30 RARE (DICL)	SLIGHT	LOW
Damaged Joints for pipes with dia > 150 mm	MODERATE (CICL) for LW28	MODERATE	MODERATE
Damaged Joints for pipes with dia > 150 mm	RARE (CICL) for LWs 29 & 30 RARE (DICL)	MODERATE	LOW
Damaged Pipes for 100 and 150 mm dia pipes	RARE	SLIGHT	VERY LOW
Damaged Pipes for pipes with dia > 150 mm	RARE	MODERATE	LOW
Damaged Valves, Hydrants and Chambers	RARE	MODERATE	LOW
Myrtle Creek crossing at Castlereagh Street and Remembrance Drive	RARE	SLIGHT	LOW

4.0 RISK CONTROL PROCEDURES

Infrastructure	Hazard / Impact	Risk	Trigger	Control Procedure/s	Frequency	By Whom?
Potable Water Infrastructure	Impacts to Sydney Water infrastructure	**VERY LOW TO MODERATE**	None	Conduct surveys along survey lines, other than Remembrance Drive.	Every 200 metres of extraction for streets within active subsidence area ***OR*** Weekly surveys if increased subsidence observed	Tahmoor Colliery (SMEC Urban)
				Conduct surveys along Remembrance Drive (Struan Street to end of survey line - Peg RE85).	Weekly after start of LW28 until 800m of extraction, unless by exception, based on actual monitoring data End of LW28 One survey after 800m of extraction of LW29 and LW30 End of LW29 and LW30	Tahmoor Colliery (SMEC Urban)
				Conduct visual inspection for surface deformations along Remembrance Drive	Weekly after start of LW28 until 800m of extraction, unless by exception, based on actual monitoring data ***OR*** Daily during active subsidence if increased subsidence observed during LW28 One inspection after 800m of extraction of LW29 and LW30 End of LW29 and LW30	Tahmoor Colliery
				Monitor water main at Myrtle Creek crossing near Remembrance Drive.	Weekly after start of LW28 until 800m of extraction, unless by exception, based on actual monitoring data End of LW28 One inspection after 800m of extraction of LW29 and LW30 End of LW29 and LW30	Tahmoor Colliery
				Inform Sydney Water Call Centre of mining in area & possible issues.	Completed	Sydney Water
				Notify residents of potential mine subsidence impacts and contact numbers.	Prior to mine subsidence impacts	Tahmoor Colliery
			Non-systematic movement detected	Notify Sydney Water	Within 24 hours	Tahmoor Colliery
				Consider increasing the frequency of surveys and visual inspections in vicinity of the non-systematic movement.	As agreed between Tahmoor Colliery and Sydney Water	Tahmoor Colliery
				Consider investigating for potential of damage occurring to Sydney Water infrastructure.	Within one week	Tahmoor Colliery
			Leakage of water observed	Notify all stakeholders, including Sydney Water, Tahmoor Colliery, Mine Subsidence Board and DTIRIS	Within 24 hours	Sydney Water or Tahmoor Colliery
				Repair leak.	As per Sydney Water procedures	Sydney Water
				Consider increasing the frequency of surveys and visual inspections in vicinity of water leak, if appropriate.	As agreed between Tahmoor Colliery and Sydney Water	Tahmoor Colliery

5.0 MANAGEMENT PLAN REVIEW 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. Management Plan Review Meetings will be held between Tahmoor Colliery and Sydney Water for discussion and resolution of issues raised in the operation of the Management Plan. The frequency of the Plan Review Meetings will be once a longwall unless requested by any party.

Plan Review 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 Plan Review 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.

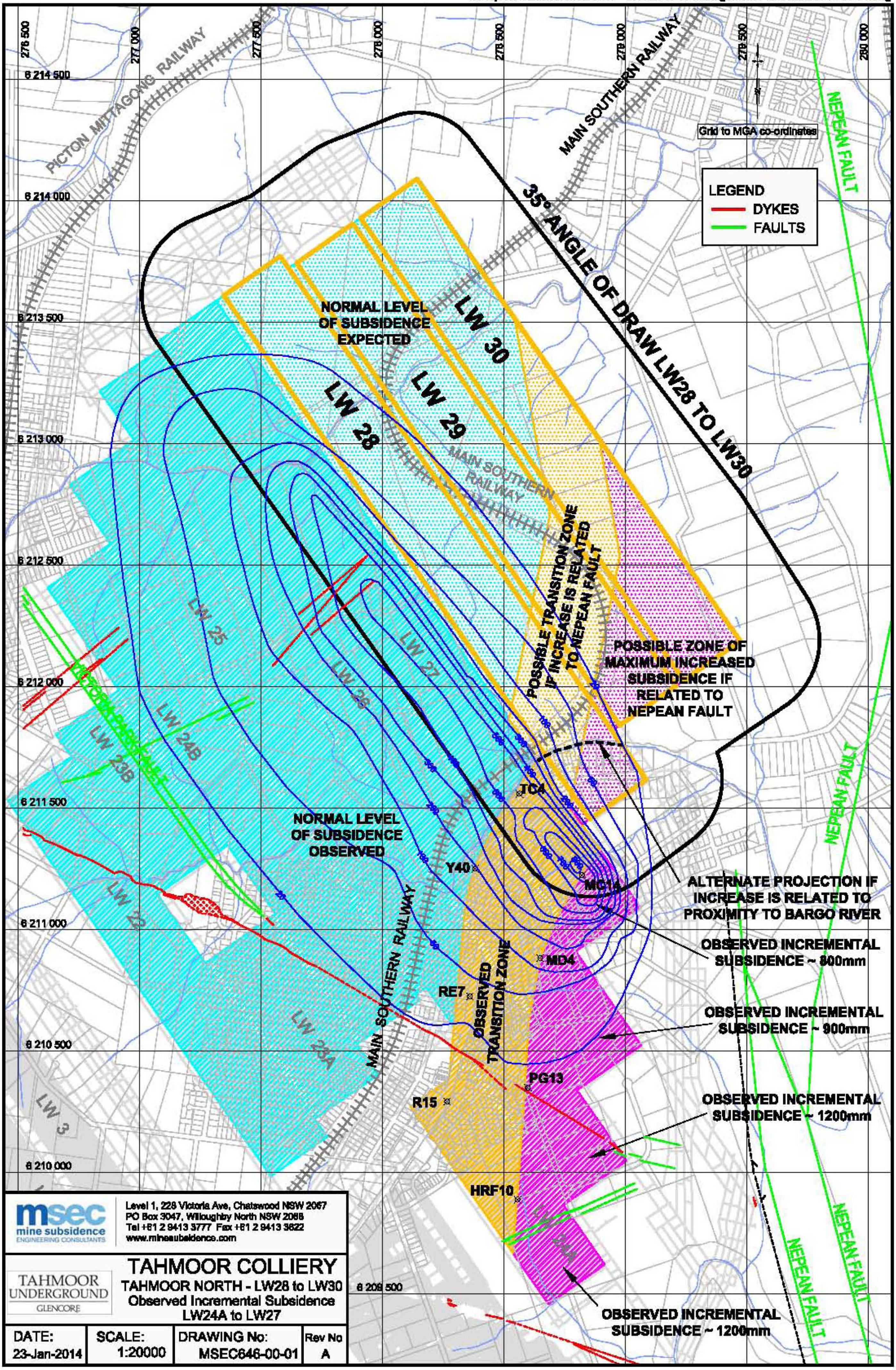
7.0 RECORD KEEPING

Tahmoor Colliery will keep and distribute minutes of any Management Plan Review Meeting.

8.0 CONTACT LIST

Organisation	Contact	Phone	Email / Mail	Fax
NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS)	Gang Li	(02) 4931 6644 0409 227 986	gang.li@ industry.gov.au	(02) 4931 6790
	Phil Steuart	(02) 4931 6648	phil.steuart@industry.gov.au	(02) 4931 6790
	Ray Ramage	(02) 4931 6645 0402 477 620	ray.ramage@ industry.gov.au	(02) 4931 6790
Mine Subsidence Board	Darren Bullock	(02) 4677 1967	d.bullock@minesub.nsw.gov.au	(02) 4677 2040
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay	(02) 9413 3777	daryl@minesubsidence.com	(02) 9413 3822
Glencore Tahmoor Coal – Environment and Community Manager	Ian Sheppard	(02) 4640 0156 0408 444 257	Ian.Sheppard@glencore.com.au	(02) 4640 0140
Glencore Tahmoor Coal – Community Coordinator	Belinda Treverrow	(02) 4640 0133 0428 260 899	Belinda.Treverrow@glencore.com.au	(02) 4640 0140
Sydney Water	Emergency Line	132 090		
Sydney Water – Systems Delivery Officer Area Team West	Charlie Kawtal	(02) 8763 8616	charlie.kawtal@sydneywater.com.au	(02) 8763 8661

APPENDIX A. DRAWINGS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PICTON MITTAGONG RAILWAY
MAIN SOUTHERN RAILWAY
Grid to MGA co-ordinates
LEGEND
DYKES
FAULTS
NEPEAN FAULT
35° ANGLE OF DRAW LW28 TO LW30
NORMAL LEVEL OF SUBSIDENCE EXPECTED
LW 30
LW 29
LW 28
MAIN SOUTHERN RAILWAY
POSSIBLE TRANSITION ZONE IF INCREASE IS RELATED TO NEPEAN FAULT
POSSIBLE ZONE OF MAXIMUM INCREASED SUBSIDENCE IF RELATED TO NEPEAN FAULT
LW 25
LW 27
LW 26
VICTORIA PARK FAULT
LW 24B
LW 23B
TC4
NORMAL LEVEL OF SUBSIDENCE OBSERVED
Y40
MC14
ALTERNATE PROJECTION IF INCREASE IS RELATED TO PROXIMITY TO BARGO RIVER
LW 22
OBSERVED INCREMENTAL SUBSIDENCE ~ 800mm
MD4
RE7
OBSERVED TRANSITION ZONE
MAIN SOUTHERN RAILWAY
LW 23A
OBSERVED INCREMENTAL SUBSIDENCE ~ 900mm
PG13
R15
OBSERVED INCREMENTAL SUBSIDENCE ~ 1200mm
LW 3
HRF10
LW 24A
OBSERVED INCREMENTAL SUBSIDENCE ~ 1200mm
276 500
277 000
277 500
278 000
278 500
279 000
279 500
280 000
6 214 500
6 214 000
6 213 500
6 213 000
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msec mine subsidence ENGINEERING CONSULTANTS
Level 1, 228 Victoria Ave, Chatswood NSW 2067
PO Box 3047, Willoughby North NSW 2068
Tel +61 2 9413 3777 Fax +61 2 9413 3822
www.minesubsidence.com
TAHMOOR UNDERGROUND GLENCORE
TAHMOOR COLLIERY
TAHMOOR NORTH - LW28 to LW30
Observed Incremental Subsidence
LW24A to LW27
DATE: 23-Jan-2014
SCALE: 1:20000
DRAWING No: MSEC646-00-01
Rev No A

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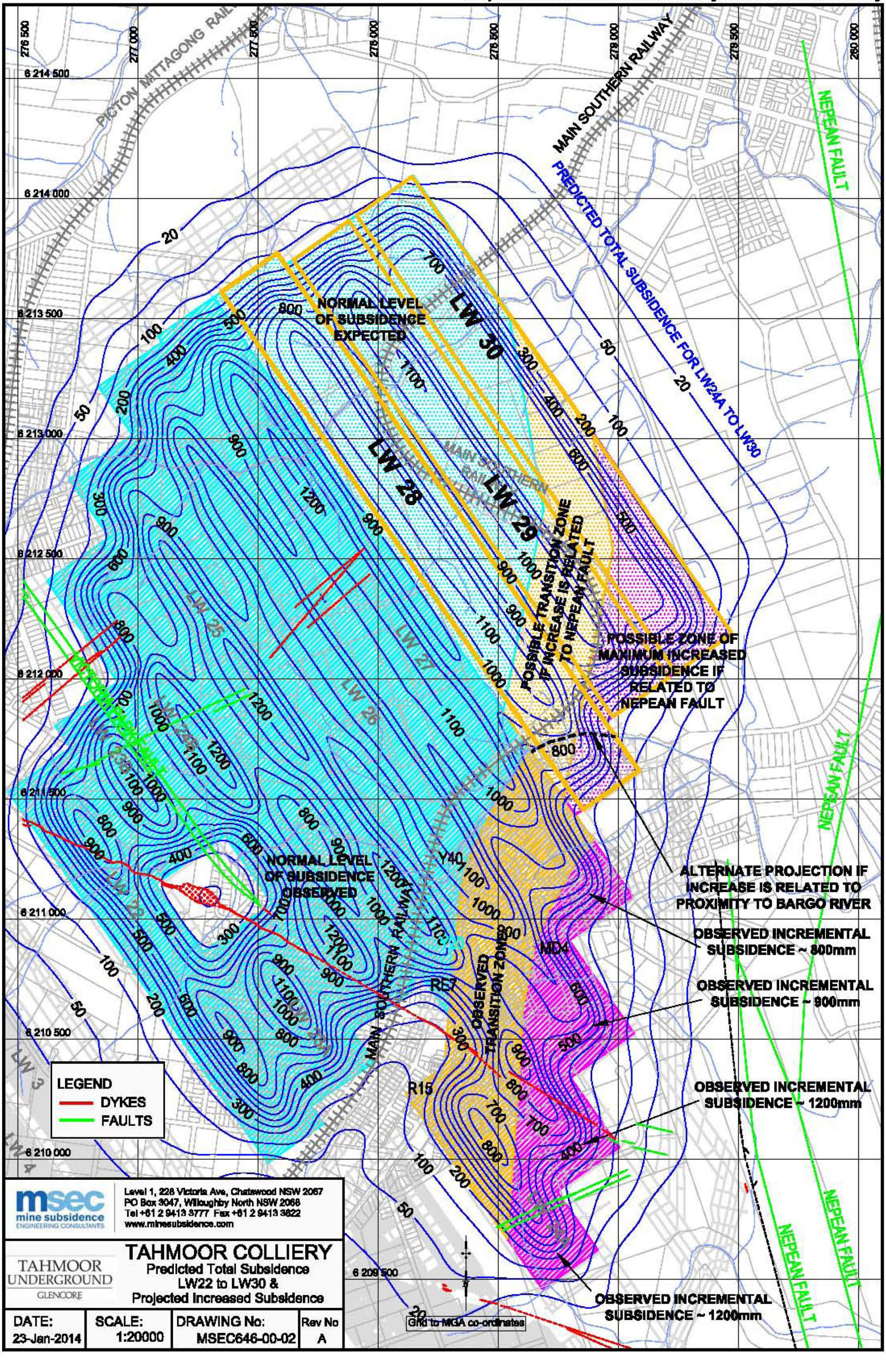

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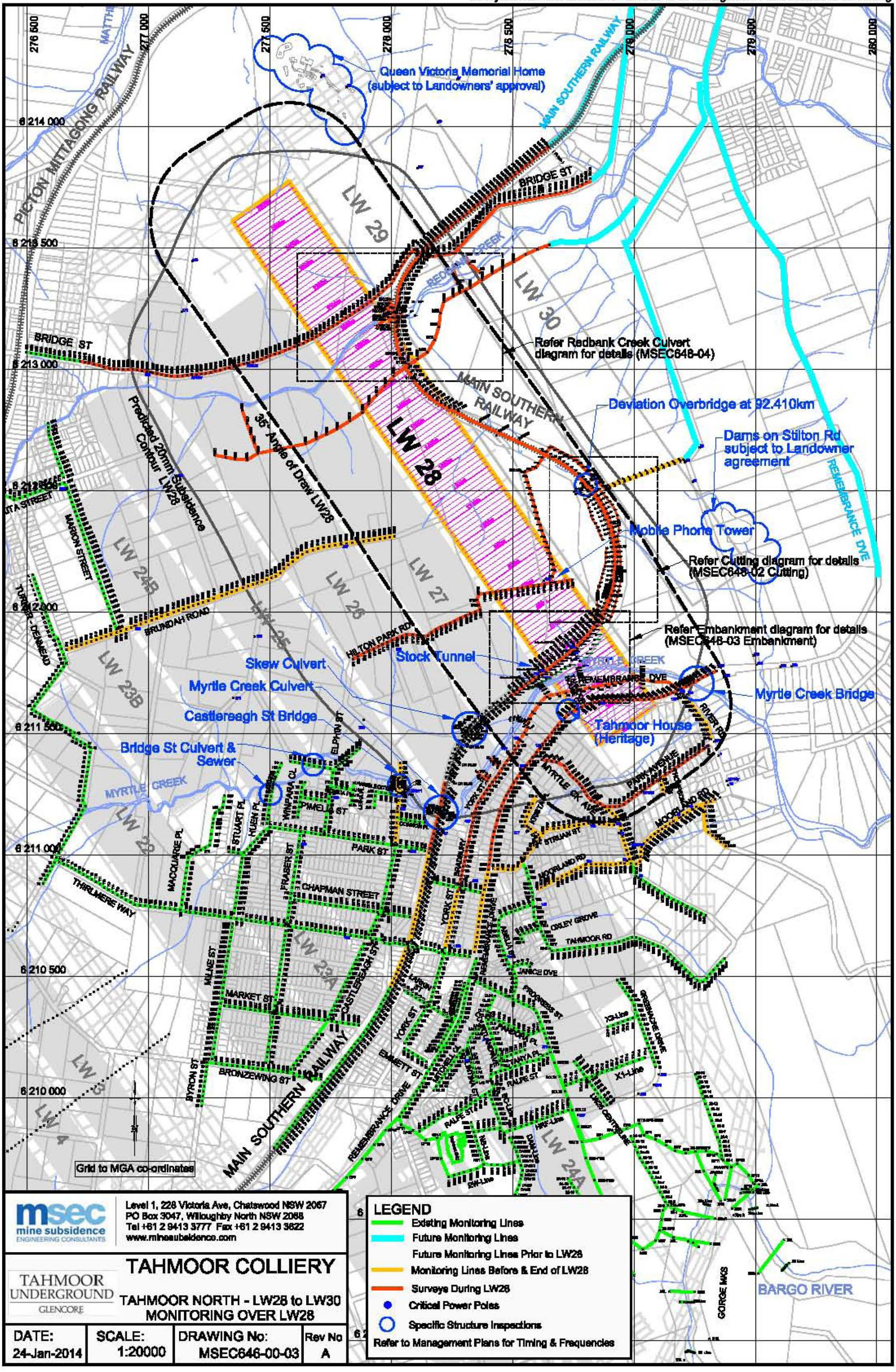

msec mine subsidence ENGINEERING CONSULTANTS

Level 1, 228 Victoria Ave, Chatswood NSW 2067
PO Box 3047, Willoughby North NSW 2068
Tel +61 2 9413 3777 Fax +61 2 9413 3822
www.minesubsidence.com

TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30
MONITORING OVER LW28

DATE:	SCALE:	DRAWING No:	Rev No
24-Jan-2014	1:20000	MSEC646-00-03	A

LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW28
- Monitoring Lines Before & End of LW28
- Surveys During LW28
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

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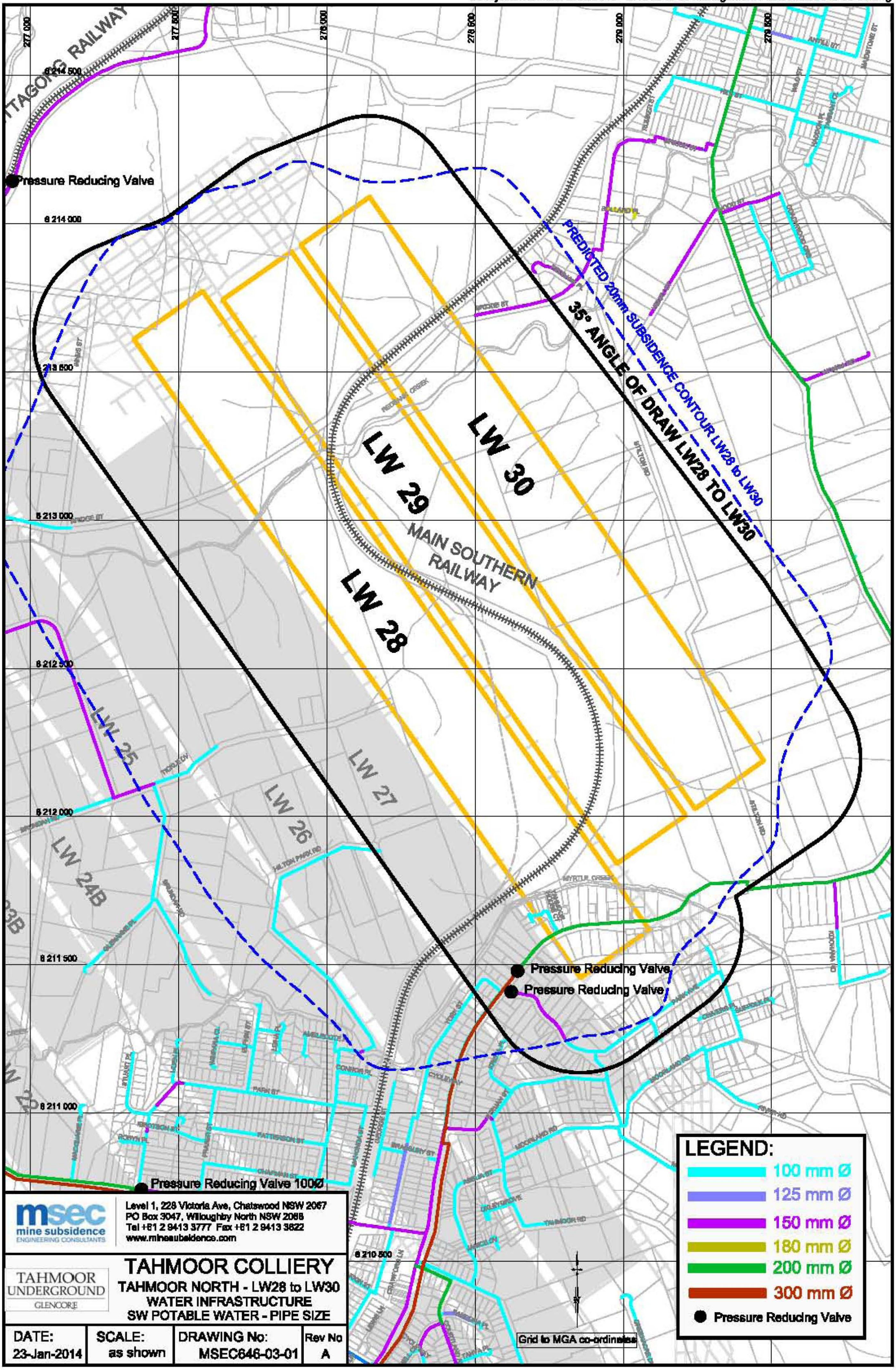

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www.minesubsidence.com

TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30
WATER INFRASTRUCTURE
SW POTABLE WATER - PIPE SIZE

DATE:	SCALE:	DRAWING No:	Rev No
23-Jan-2014	as shown	MSEC646-03-01	A

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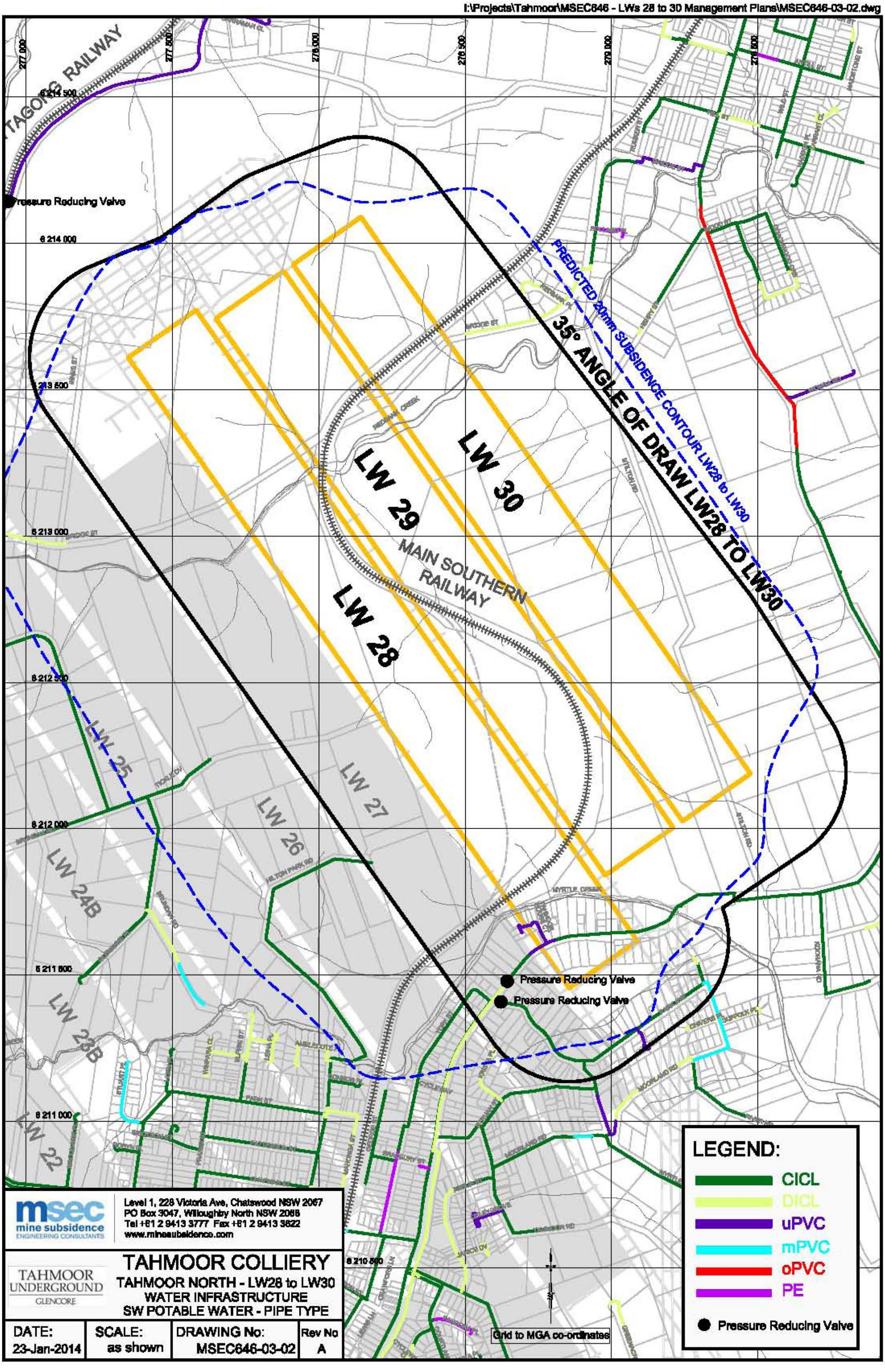

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PO Box 3047, Willoughby North NSW 2068
Tel +61 2 9413 3777 Fax +61 2 9413 3822
www.minesubsidence.com

TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30
WATER INFRASTRUCTURE
SW POTABLE WATER - PIPE TYPE

DATE:	SCALE:	DRAWING No:	Rev No
23-Jan-2014	as shown	MSEC646-03-02	A