REPORT: SEWER SUBSIDENCE MANAGEMENT PLAN

GLENCORE:

Tahmoor Colliery - Longwalls 28 to 30

Management Plan for Potential Impacts to Sydney Water Sewer Infrastructure

AUTHORISATION OF MANAGEMENT PLAN

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DOCUMENT REGISTER

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Mar-06	MSEC286-0404	A	Draft for Submission to Sydney Water
May-06	MSEC286-0404	B	Agreed plan
Aug-06	MSEC286-0404	C	Chapter 1 amended
May-08	MSEC286-0404	C(1)	Amended risk control procedures to for Longwall 24A
May-08	MSEC286-0404	D	Amended management plan for Longwall 24A
Aug-08	MSEC286-0404	E	Amended procedures for Longwall 25
Sep-08	MSEC286-0404	F	Amended procedures for Longwall 25
Dec-10	MSEC446-04	A	Updated for Longwall 26
Jan-11	MSEC446-04	B	Updated after initial discussions with Sydney Water
Feb-11	MSEC446-04	C	Final plan following review with Sydney Water
Sep-12	MSEC567-04	A	Updated for Longwall 27
Oct-12	MSEC567-04	B	Updated after consultation with Sydney Water
Feb-14	MSEC646-04	A	Updated for Longwalls 28 to 30

References:-

MSEC, (2009). *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.* Mine Subsidence Engineering Consultants, Report No. MSEC355, Revision B, July 2009.

Sydney Water Work-As-Executed Plan – Project No. 371653 for Wollondilly Sewerage, Tahmoor

Sydney Water Risk Criteria, 6 July 2010

Wollondilly Sewerage Sewer Main Replacement Drawings SEG100-066 – DW-PL-CSP-001 to 006, Kellogg Brown & Root for Sydney Water, Issued for Construction, Rev 0, dated 28 August 2012.

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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 Glencore. 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 sewer 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. Objectives

The objectives of this Management Plan are to establish procedures to measure, control, mitigate and repair potential impacts that might occur on sewer infrastructure owned by Sydney Water.

The objectives of the Management Plan have been developed to:-

- Ensure the safe and serviceable operation of sewer infrastructure. Public and workplace safety is paramount. Disruption and inconvenience should be kept to minimal levels.
- Monitor ground movements and the condition of surface and sub-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, 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:-

- Sewer Pumping Stations
- Gravity Sewer Systems
- Sewage Pumping Station SP1045

The Management Plan describes measures that will be undertaken as a result of mining Longwalls 28 to 30 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 30 and for sufficient time thereafter to allow for completion of subsidence effects. The current schedule of mining is shown in Table 1.2.

Table 1.2 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

1.5. 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. Sydney Water Risk Criteria

Risks identified in this Management Plan have been assessed by Sydney Water, Tahmoor Colliery, and MSEC in accordance with Sydney Water's Risk Criteria, Issue C, dated 6 July 2010. The Risk Criteria document is attached as an appendix to this Management Plan.

2.2. Description of Sewerage System

Sydney Water has an extensive sewage disposal network in the urban areas of Tahmoor and Thirlmere and some of this network will experience subsidence movements during the mining of Longwalls 28 to 30. The Picton Regional Sewerage Scheme collects sewage from the urban areas of Tahmoor and Thirlmere and transports it by gravity to the Picton Sewage Treatment Plant. The sewer pipes were installed in 2000.

The sewerage system consists of the following components:

- Self-cleansing gravity sewer mains
- Pressured rising mains
- Pumping stations
- Sewage Treatment Plant in Picton (will not be affected by the mining of Longwalls 28 to 30)

With the exception of the rising mains, all of the sewer pipes are designed at self-cleansing grades. The average grade of the sewer pipes in the area is approximately 32 mm/m (i.e. 3.2%).

The design for the gravity sewer system was approved by the Mine Subsidence Board, on the condition that the sewers were installed at least 3 mm/m greater than the minimum grade required for the pipes to be self-cleansing. It has been found, on examination of information provided by Sydney Water, that some of the pipes may have been installed at grades less than self-cleansing, or installed at grades less than the Mine Subsidence Board requirements.

The design for the rising mains were certified in accordance with the requirement of the Mine Subsidence Board, which specified maximum vertical subsidence of 750 mm, maximum tensile strain of 1.5 mm/m, maximum compressive strain of 2.5 mm/m and minimum radius of curvature of 8 kilometres.

The sewer pipes are constructed from PVC and have extra length sockets and rubber ring joints, which will allow them to accommodate tensile and compressive ground strains and curvature. The pipe sections are typically 3 metres long. The majority of the sewer mains are laid on sand and buried in trenches.

Sydney Water advises that the existing pipework is in fair to good condition, based on CCTV investigations and fault history. Minor ponding has been observed at some locations due to minor undulations that occurred during installation. Occasional sections of pipe work were damaged or partially compressed. A blocked junction was also observed. A number of sections were observed to be unusually dirty. Sydney Water indicated that the issues that have been found during the investigations are of a minor maintenance nature or due to the sewer not being cleaned correctly after the installation of the pipe work.

The sewer pipelines in the vicinity of Longwalls 28 to 30 are shown according to their pipe sizes in Drawing No. MSEC646-04-01. It can be seen from this drawing that the sewer mains range in diameter between 100 mm and 450 mm. The larger sewer mains in Tahmoor are located adjacent to the Main Southern Railway, along York Street and between Remembrance Drive and Myrtle Creek. Larger sewer mains in Thirlmere are located along Bridge Street.

A summary of the total lengths of each diameter of sewer pipe is provided in Table 2.1. The lengths of pipes included in the totals consist of pipes within the greater extent of either a 35 degree angle of draw of Longwalls 28 to 30, or the predicted limit of subsidence for Longwalls 28 to 30, as shown in Drawing No. MSEC646-04-01.

Table 2.1 Distribution of Sewer Pipes by Pipe Diameter

Pipe Diameter (mm)	Total Length in vicinity of Longwalls 28 to 30 (m)	%
100	2779	26.9
150	3721	36.0
225	29	0.3
375	3744	36.2
400	74	0.7
Total	**10347**	**100.0**

The pipes are shown according to their type in Drawing No. MSEC646-04-02. The majority of pipes are sideline and reticulation pipes that transport sewage to the rising mains and carrier pipes.

A summary of the total lengths of each type of sewer pipe is provided in Table 2.2. The pipes included in the totals consist of pipes within the greater extent of either a 35 degree angle of draw of Longwalls 28 to 30, or the predicted limit of subsidence for Longwalls 28 to 30, as shown in Drawing No. MSEC646-04-02.

Table 2.2 Distribution of Sewer Pipes by Pipe Type

Pipe Type (mm)	Total Length in vicinity of Longwalls 28 to 30 (m)	%
Sideline	1065	10.3
Reticulation	5464	52.8
Carrier	3803	36.8
Overflow	14	0.1
Total	**10347**	**100.0**

The most significant pipes directly above Longwalls 28 to 30 are the Carrier pipes. The Tahmoor carrier pipe is located between Remembrance Drive and Myrtle Creek, and the Thirlmere Carrier pipe is located along Bridge Street.

2.3. Maximum Predicted Systematic Parameters

Predicted mining-induced systematic subsidence movements were provided in Report No. MSEC355, which was prepared in support of Tahmoor Colliery's SMP Application for Longwalls 27 to 30. 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 2.3. A summary of the maximum predicted cumulative systematic subsidence parameters, after the extraction of each of the proposed longwalls, is provided in Table 2.4.

Table 2.3 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Each of the Proposed 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)
After LW28	730	5.8	0.06	0.13
After LW29	720	5.8	0.06	0.12
After LW30	720	5.7	0.06	0.12

Table 2.4 Maximum Predicted Cumulative Systematic Subsidence Parameters after the Extraction of Each of the Proposed 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)
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 cumulative systematic subsidence parameters which occur within the general longwall mining area, including the predicted movements resulting from the extraction of Longwalls 22 to 30.

2.4. 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. 2.1, which shows observed subsidence at survey pegs located along the centreline of Longwall 24A.

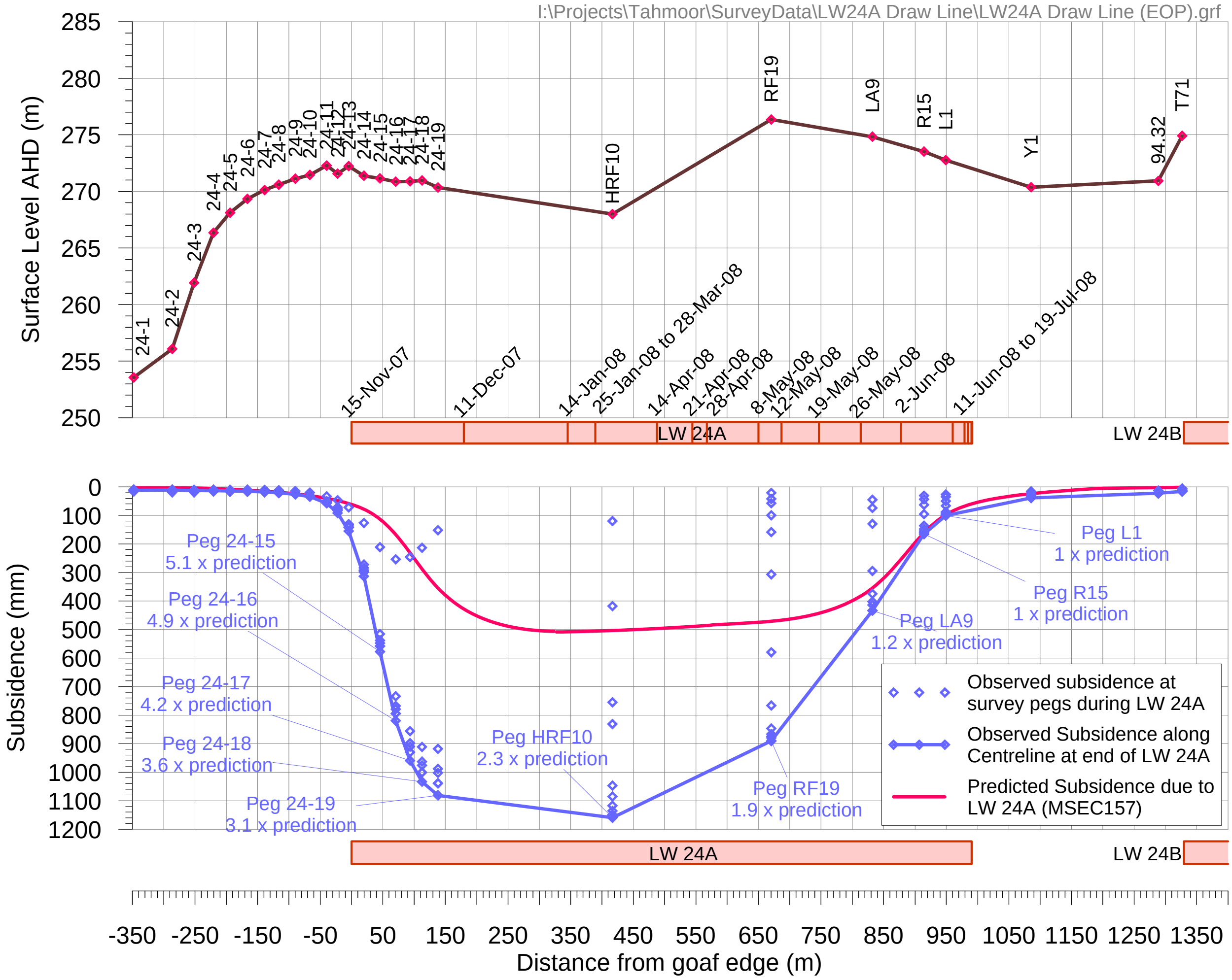


Fig. 2.1 Observed Subsidence along Centreline of Longwall 24A

It can be seen from Fig. 2.1 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. 2.2, which shows observed subsidence at survey pegs located along the centreline of Longwall 25.

It can be seen from Fig. 2.2 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.

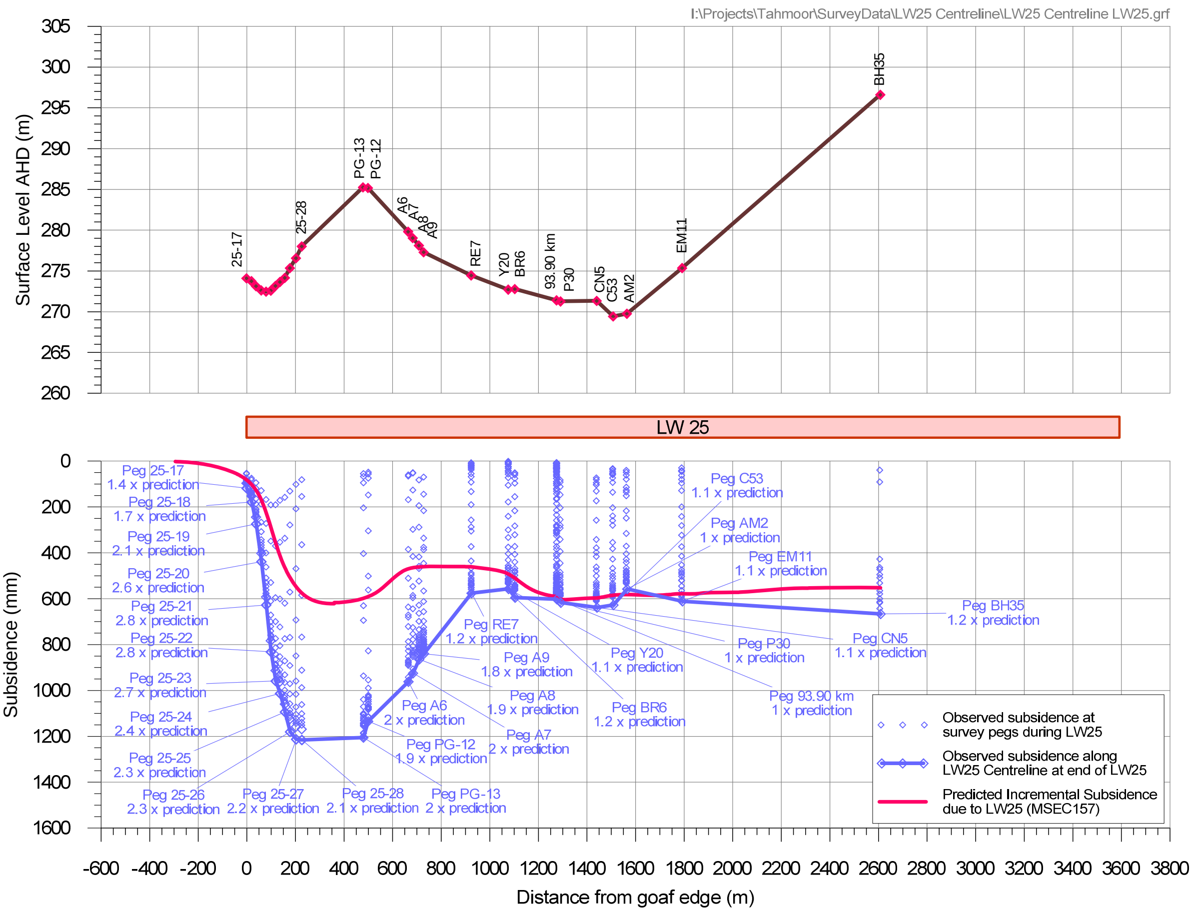


Fig. 2.2 Observed Subsidence along Centreline of Longwall 25

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

It can be seen from Fig. 2.3 that observed subsidence was approximately 1.3 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.

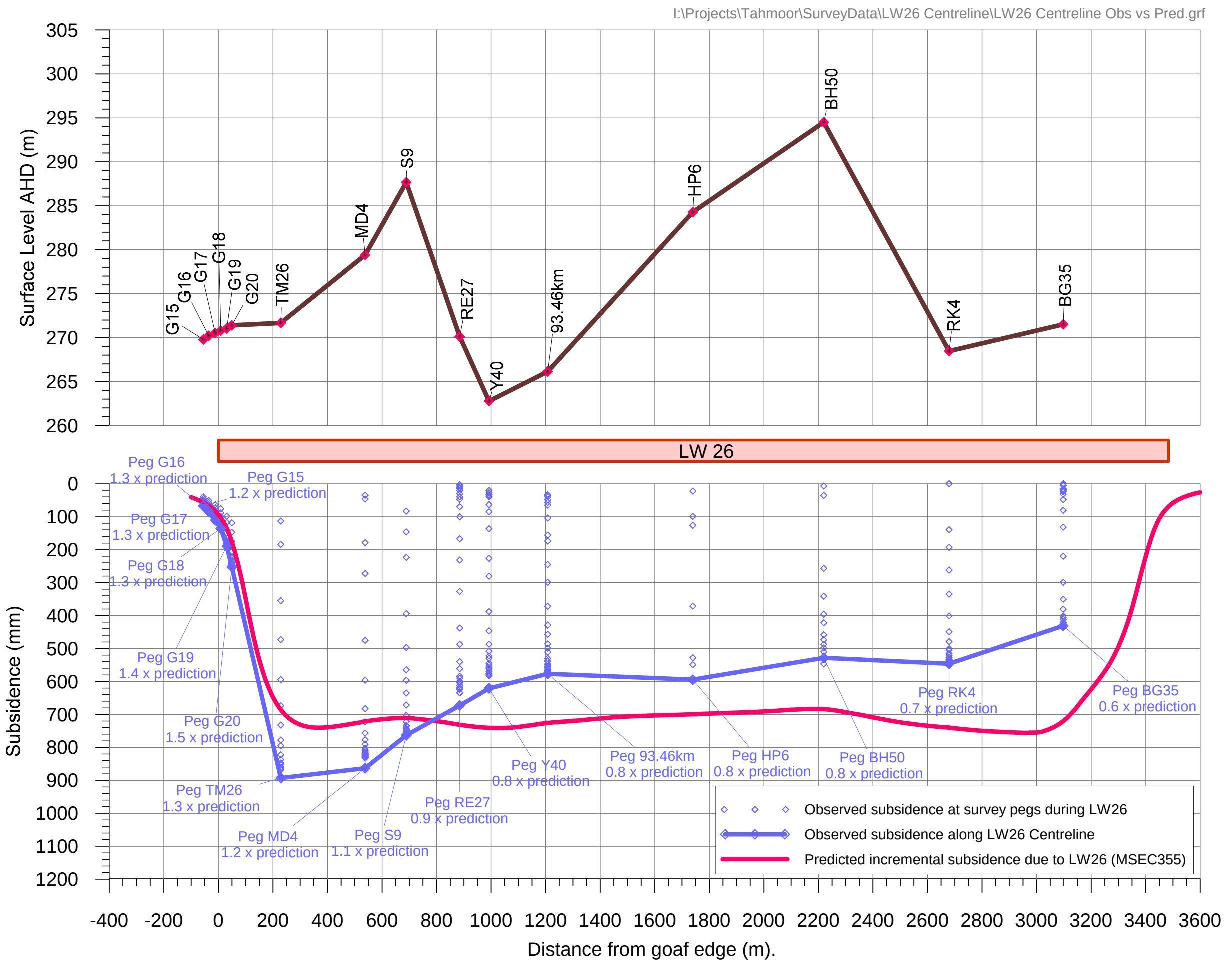


Fig. 2.3 Observed Subsidence along Centreline of Longwall 26

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 is shown graphically in Fig. 2.4. 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. 2.4 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.

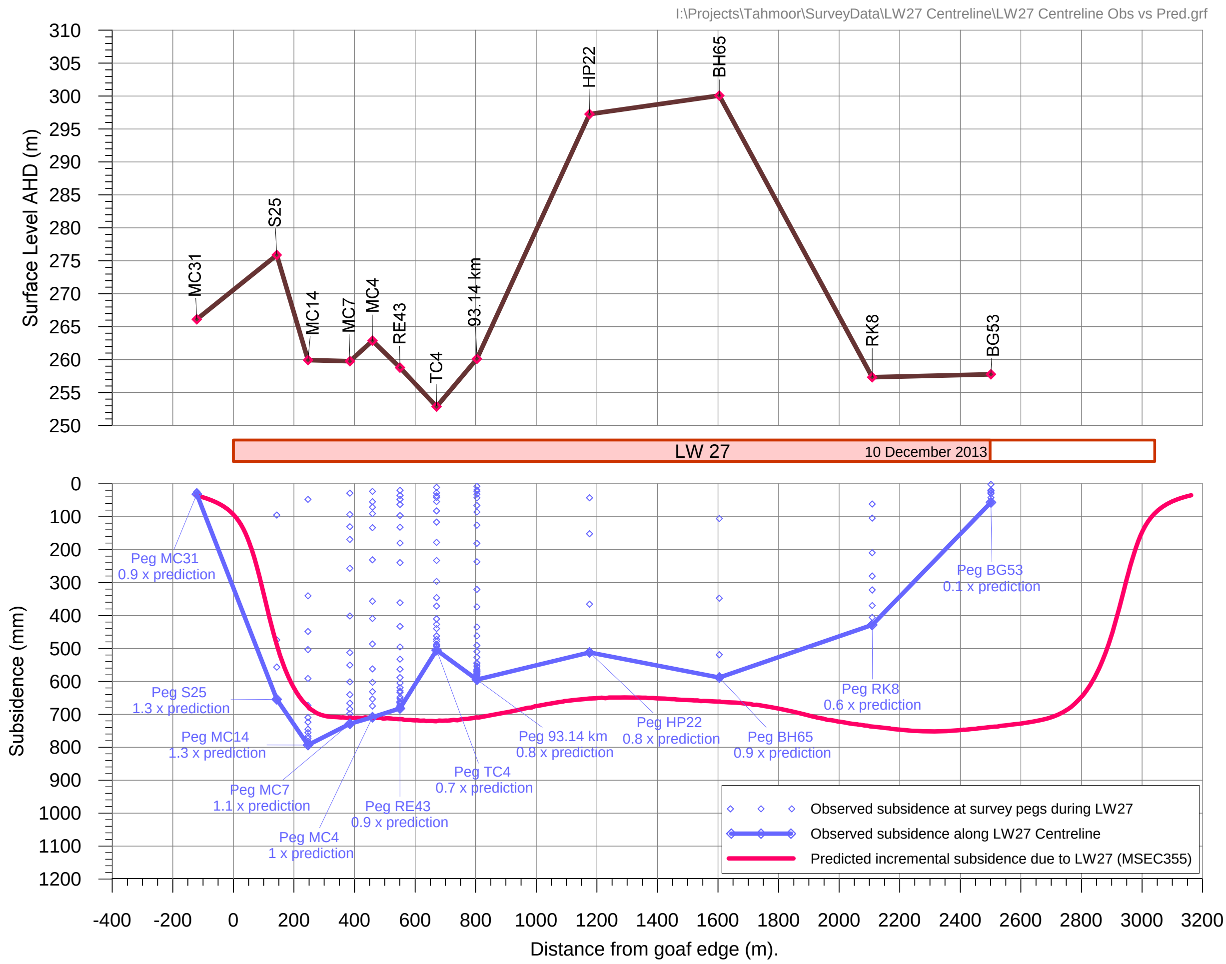


Fig. 2.4 Observed Subsidence along Centreline of Longwall 27

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 sewer infrastructure, sewer mains are located directly within a potential zone of increased subsidence above Longwall 28 only.

2.5. 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).

2.5.1. 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. 2.5. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

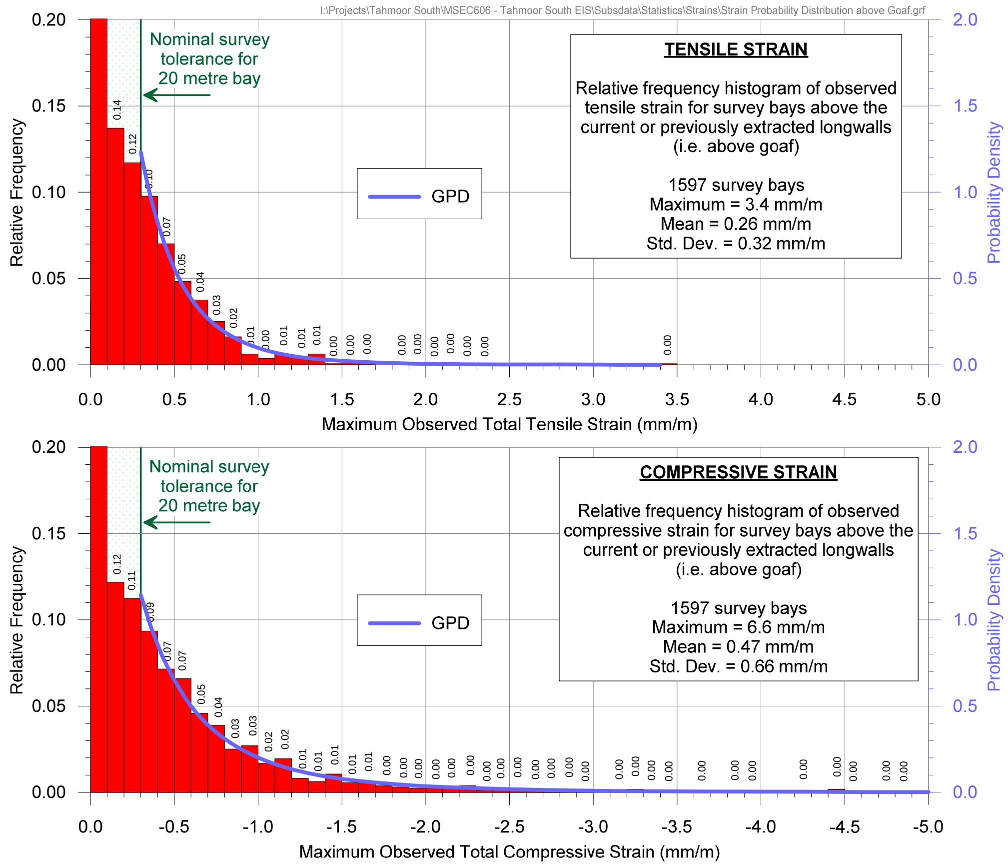


Fig. 2.5 Distributions of the Measured Maximum Tensile and Compressive Strains for Surveys Bays Located Above Goaf at Tahmoor, Appin and West Cliff Collieries

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. 2.6. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

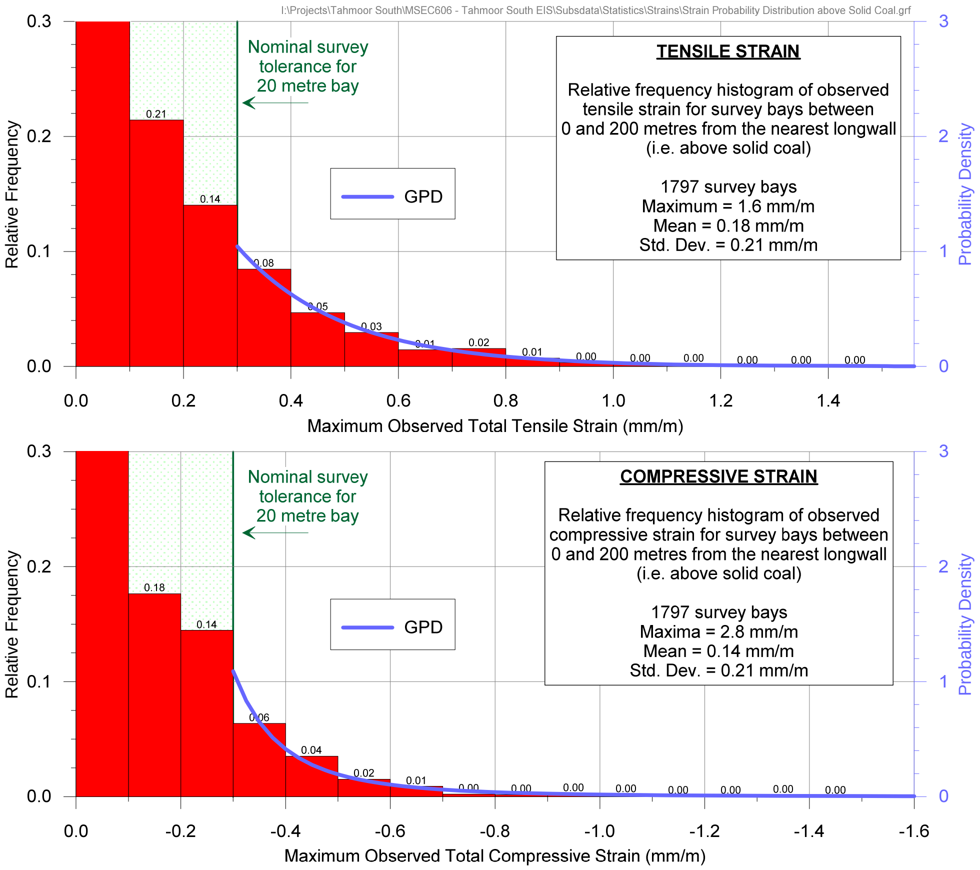


Fig. 2.6 Distributions of the Measured Maximum Tensile and Compressive Strains for Survey Bays Located Above Solid Coal at Tahmoor, Appin and West Cliff Collieries

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.

2.5.2. 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. 2.7.

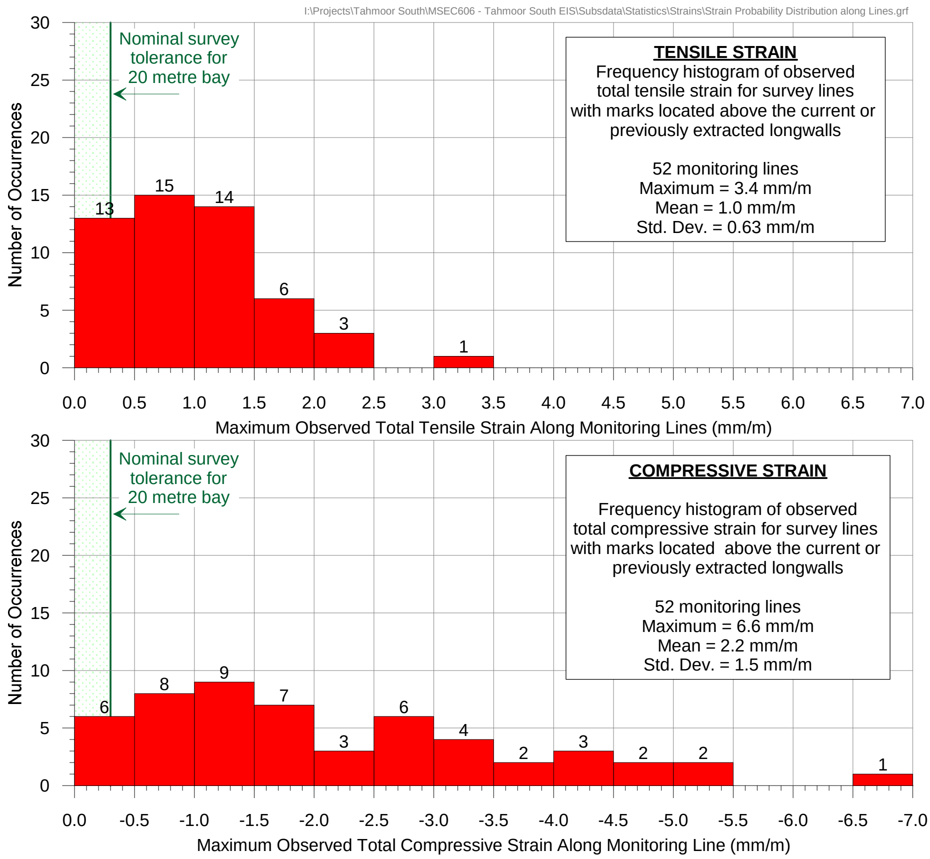


Fig. 2.7 Distributions of Measured Maximum Tensile and Compressive Strains Anywhere along the Monitoring Lines at Tahmoor, Appin and West Cliff Collieries

It can be seen from Fig. 2.7, 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.

2.6. Predicted and Observed Valley Closure across creeks

A number of bridges and culverts above Longwalls 28 to 30 carry road transport over Myrtle Creek, Redbank Creek and other watercourses. Predictions of valley closure and upsidence at each of these features are provided later in this Management Plan.

A comparison between predicted and observed valley closure movements is provided 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. 2.8.

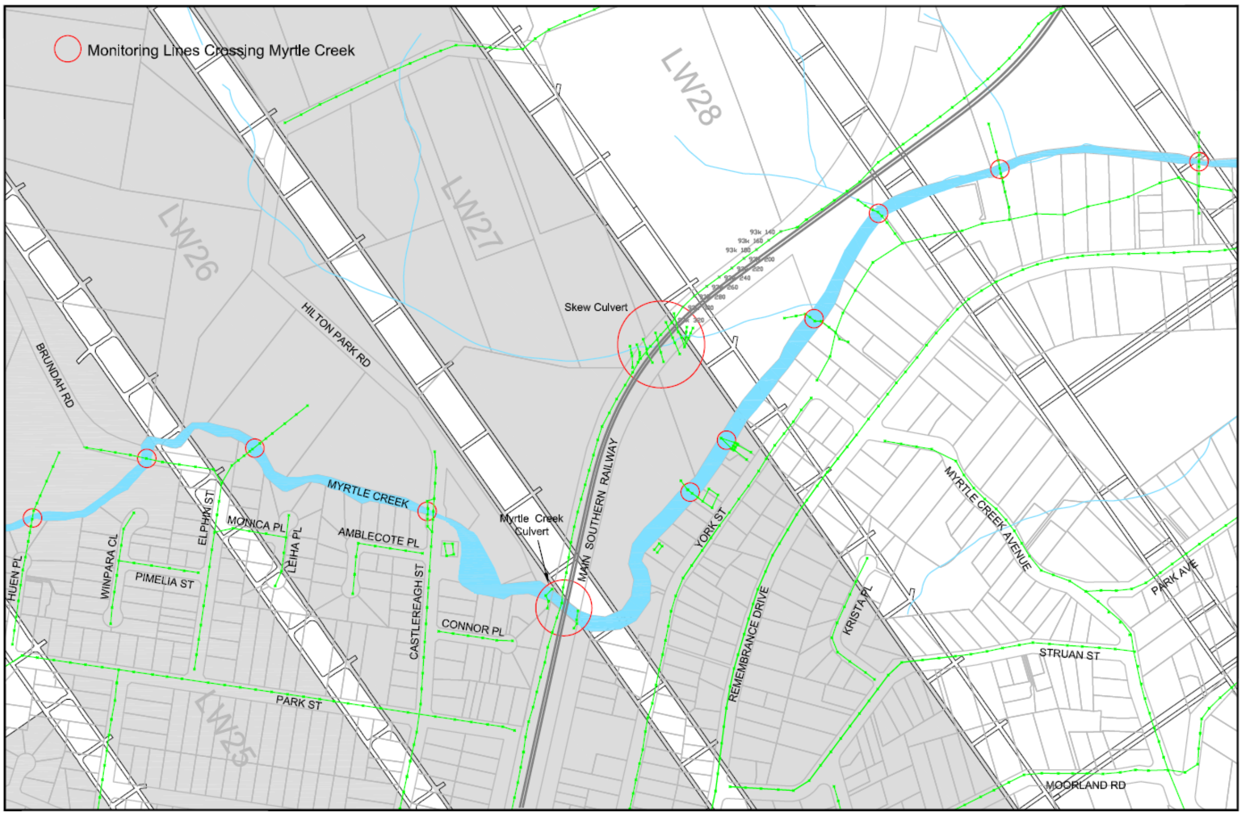


Fig. 2.8 Monitoring lines across Myrtle Creek and Skew Culvert

A summary graph showing the development of valley closure across the Myrtle Creek at each monitoring line is shown in Fig. 2.9.

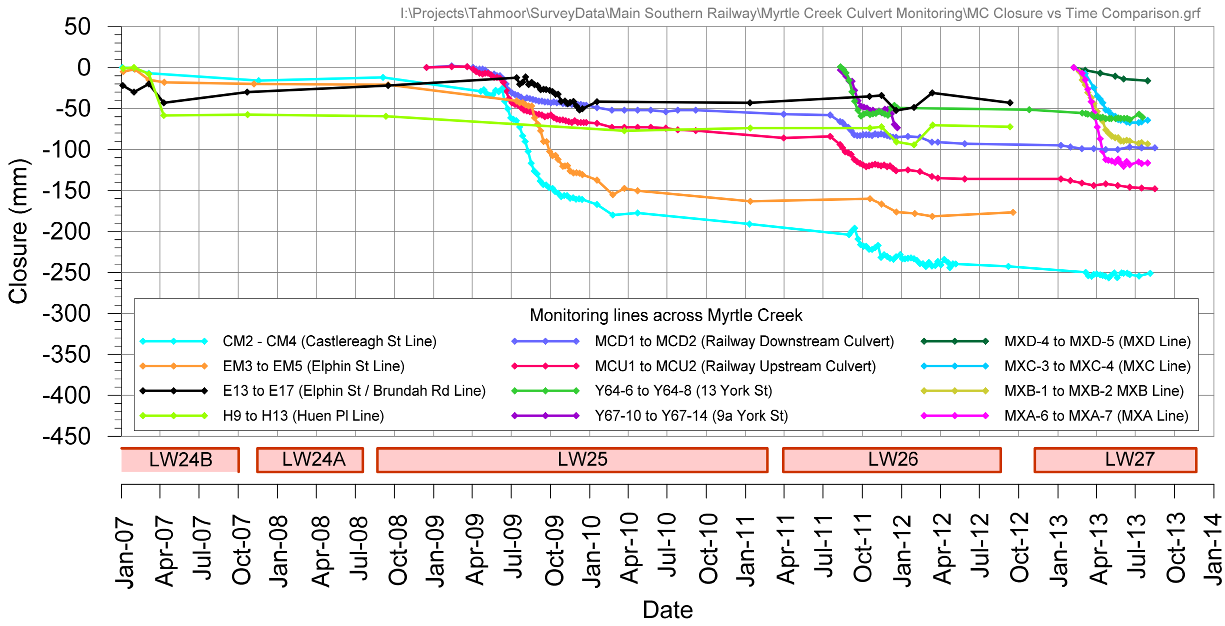


Fig. 2.9 Development of closure across Myrtle Creek during the mining of Longwalls 24B to 27

The development of valley closure across the creek at the Skew Culvert is shown in Fig. 2.10.

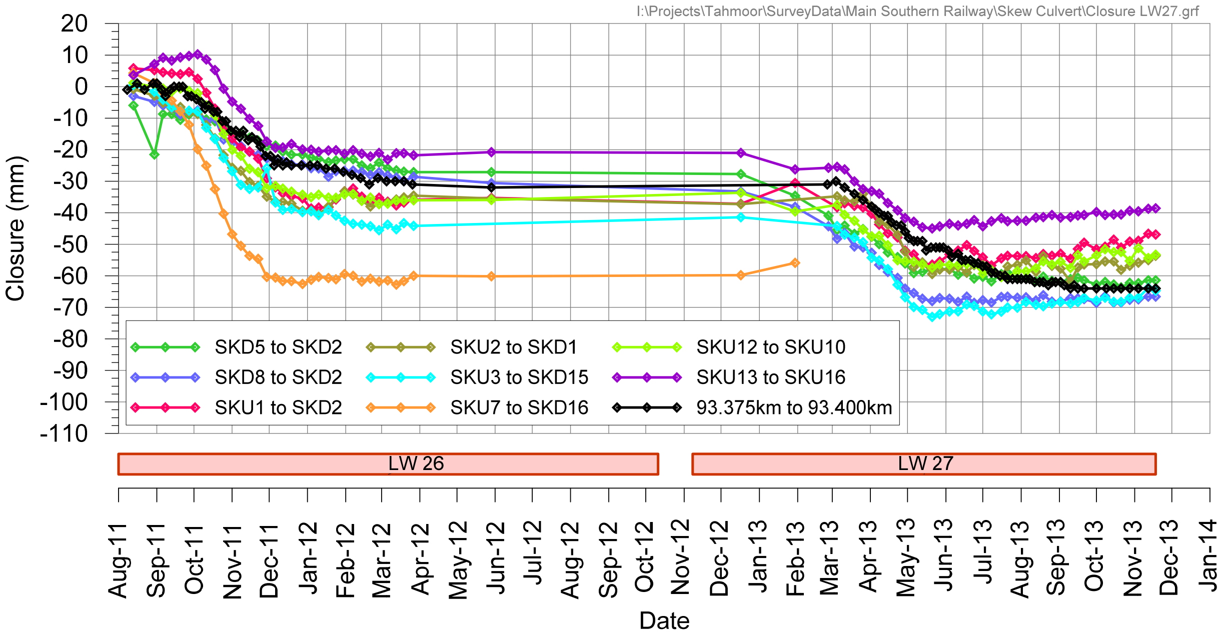


Fig. 2.10 Development of closure across Skew Culvert during the mining of Longwalls 26 and 27

A summary of predicted and observed valley closure across Myrtle Creek is provided in Table 2.5. The predictions are consistent with those provided in Report No. MSEC355, in support of Tahmoor Colliery's SMP application to extract longwalls 27 to 30.

Table 2.5 Predicted and Observed Incremental Valley Closure at Monitoring Lines across Myrtle Creek and Skew Culvert

Location	Category	Predicted and Observed Valley Closure due to Mining of Each Longwall (mm)			
		Due to LW24	Due to LW25	Due to LW26	Due to LW27
Castlereagh St (Pegs CM2 to CM4)	Predicted	30	55	45	25
	Observed	12	179	52	8
Elphin-Myrtle (Pegs EM3 to EM5)	Predicted	60	70	40	-
	Observed	21	142	22	-
Elphin St / Brundah Rd (Pegs E13 to E17)	Predicted	75	75	30	-
	Observed	0	21	6	-
Huen Pl (Pegs H9 to H13)	Predicted	60	35	15	-
	Observed	58	15	20	-
Main Southern Railway Upstream (MCU1 to MCU4) Downstream (MCD1 to MCD4)	Predicted	15	30	30	15
	Observed	-	57 (d/s) to 86 (u/s)	36 (d/s) to 50 (u/s)	5 (d/s) to 12 (u/s)
Skew Culvert (8 cross-sections)	Predicted	< 5	10	25	25
	Observed	-	-	21 to 60 (average 36)	8 to 36 (average 21)
13 York St (Pegs Y64-6 to Y64-8)	Predicted	-	-	65	50
	Observed	-	-	51	9
9a York St (Pegs Y67-10 to Y67-14)	Predicted	-	-	85	85
	Observed	-	-	73	No access

Location	Category	Predicted and Observed Valley Closure due to Mining of Each Longwall (mm)			
		Due to LW24	Due to LW25	Due to LW26	Due to LW27
MXA Line (Pegs MXA-6 to MXA-7)	Predicted	-	-	-	150
	Observed	-	-	-	116
MXB Line (Pegs MXB-1 to MXB-2)	Predicted	-	-	-	170
	Observed	-	-	-	93
MXC Line (Pegs MXC-3 to MXC-4)	Predicted	-	-	-	150
	Observed	-	-	-	64
MXD Line (Pegs MXD-4 to MXD-5)	Predicted	-	-	-	50
	Observed	-	-	-	16

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

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.

Observed valley closure across Myrtle Creek above Longwall 27 has been less than predictions, but greater than previously observed. Predictions for this section of creek were greater than upstream sections because the valley is deeper.

2.7. Observations and Impacts on Sewers during Longwalls 22 to 27

Longwalls 22 to 27 have directly mined beneath approximately 27.3 kilometres of sewer pipes. The following observations have been made:

- *Changes to grades of self-cleansing gravity sewers*
  While changes in sewer grades have occurred as a result of mine subsidence, no blockages or reversals of grade have been observed. This includes observations at locations above Longwalls 24A to 27 where specific ground surveys were undertaken to confirm that mining-induced tilts did not exceed pre-mining grades.

  At the time of preparing this Management Plan, the Thirlmere Carrier pipe along Bridge Street is experiencing active subsidence from the extraction of Longwall 27, leading to a reduction in grade of a short section of pipe to 0.14% as at 29 January 2014. While there are signs that rates of change in grade are reducing, Sydney Water are ready to respond if required to ensure the sewer remains serviceable. Monitoring of this section of pipe continues. This section of pipe will experience an increase in grade during the extraction of Longwalls 28 to 30.

- *Physical damage to pipes*
  There were no observations of damage during the mining of Longwalls 22 to 24 and Longwall 27. Physical damage was observed at three locations during the mining of Longwall 25. In each case the pipes remained serviceable, though repairs were required at each location.

  - Crushing and vertical bending of 150 mm diameter pipe at Abelia Street. The impacts coincide with a large measured ground strain of 4.6 mm/m (over a 22 metre bay length) between Pegs A12 and A13, a measured vertical bump in the subsidence profile and an observed hump in the road pavement. The pipe was repaired prior to the influence of Longwall 26 and no impacts were observed to the repaired pipe during the mining of this longwall.

  - Crushing and vertical bending of 150 mm diameter pipe at Remembrance Drive. The impacts coincide with a large measured ground strain of 2.8 mm/m (over a 37 metre bay length) between Pegs R1 and RE1, a measured vertical bump in the subsidence profile and an observed hump in the road pavement and roundabout. The pipe was repaired prior to the influence of Longwall 26 and no impacts were observed to the repaired pipe during the mining of this longwall.

- Crushing and vertical bending of the 225 mm diameter horizontal bore between Amblecote Place and Myrtle Creek, as described in Section 2.10. There is no monitoring line above this bore.

Physical damage was observed at two new locations during the mining of Longwall 26. In each case the pipes remained serviceable, though repairs were required at each location.

- Deformation and cracking of 100 mm diameter pipe at Tahmoor Road. The pipe was repaired.
- Deformation of 150 mm diameter pipe between Abelia Street and Oxley Grove where non-systematic subsidence movements were observed (this may have occurred during the mining of Longwall 25). The pipe was repaired.
- Continued deformation of the 225 mm diameter horizontal bore between Amblecote Place and Myrtle Creek from Castlereagh Street to Brundah Road.

- *Rising mains*
  No impacts have been observed to rising mains. This includes the rising main that runs from the pumping station SP1045 at Castlereagh Street, which is located directly above previously extracted Longwall 25.
- *Sewer Pumping Station SP1045 at Castlereagh Street*
  Longwall 25 has mined directly beneath, and Longwalls 26 and 27 have mined adjacent to the pumping station. While the pumping station experienced differential movements, they were well below trigger levels. . No impacts have been observed, including during a visual inspection inside the chamber in September 2012 after the mining of Longwall 26.
- *Sewer Creek Crossings at Myrtle Creek*
  A 225 mm diameter sewer main crosses Myrtle Creek at two locations directly above Longwall 24B. While closure between the pit lids has been measured, no impacts have been observed from CCTV investigations of the pipes.

The observed impacts to date have been within expectations.

2.8. Changes to grades of self-cleansing gravity sewers

The pipes' ability to self-cleanse is dependent on their gradient, which varies according to the diameter of the pipe. The minimum grades for self-cleansing are provided in the Picton Regional Sewerage Scheme Design and Construction Plan (Issue A, Rev. 1), and are shown in Table 2.6. The design for the sewer system was approved by the Mine Subsidence Board, on the condition that the sewers were installed at least 3 mm/m (0.3%) greater than the minimum grade required for the pipes to be self-cleansing. These are also shown in Table 2.6.

Table 2.6 Minimum Grades for Self-Cleansing

Pipe Diameter	Minimum Grade for Self-Cleansing (%)	Minimum Grade to comply with MSB Requirements (%)
100	1.25	1.55
150	0.50	0.80
225	0.33	0.63
300	0.25	0.55
375	0.20	0.50
450	0.20	0.50

The grades of each section of pipe were provided in GIS format by Sydney Water, which divided the sewer network into pipe sections. An analysis of the GIS information shows that a small number of pipes have been laid with pre-mining grades that are less than the published minimum grades for self-cleansing. The locations of the pipes are shown in Drawing No. MSEC646-04-03. It can be seen that no sections are located directly above Longwalls 28 to 30.

The potential changes in sewer grades have been assessed based on the predicted subsidence during the mining of Longwalls 22 to 30. Some pipes are predicted to experience a reduction in grade and others are predicted to experience an increase in grade due to the mining of Longwalls 28 to 30. The locations of pipes predicted prior to mining to experience grades less minimum grades for self-cleansing grade after the extraction of Longwall 30 are shown in Drawing No. MSEC646-04-04. It can be seen that only one short section of Thirlmere Carrier pipe is location directly above Longwalls 28 to 30.

The assessment found that the grades on the majority of the pipes are expected to remain greater than the minimum grades required for self-cleansing following the mining of Longwalls 28 to 30, even if the predicted subsidence movements were doubled. Some exceptions are found in relation to short sections of the Tahmoor and Thirlmere Carrier pipes, which are discussed further below.

2.8.1. Tahmoor Carrier

The Tahmoor Carrier is the main branch servicing the majority of Tahmoor township. The predicted profiles of incremental and cumulative systematic subsidence and changes in grade along the alignment of the Tahmoor Carrier along York Street and Remembrance Drive are shown in Fig. 2.11.

Prior to the mining of Longwall 26, a 49 metre long section of 375 mm diameter pipe on York Street was identified as a pipe section that might experience a reversal of grade if it experienced mining-induced tilts greater than predicted. The pipe was laid with a pre-mining grade of 0.77% (7.7 mm/m), which is close to the minimum grade for self-cleansing of 0.2% (2 mm/m). The pipe was predicted to experience a reduction in grade to 0.4% (4 mm/m) following the mining of Longwall 26. Monitoring of subsidence and tilt along York Street during the mining of Longwall 26 found that mining-induced tilt was 4 mm/m or less along the identified section of pipe. No issues have been reported from residents or CCTV inspections during mining.

In the case of Longwall 27, an 84 metre long section of 375 mm diameter pipe was laid with a pre-mining grade of 0.5% (5.0 mm/m), which is close to the minimum grade for self-cleansing of 0.2% (2 mm/m). The pipe section is located at the rear of 3 private properties on Remembrance Drive, which back onto Myrtle Creek, as shown in Fig. 2.13. The pipe was predicted to experience a maximum reduction in grade of 5.7 mm/m, which would have resulted in a very slight reversal in grade of approximately 0.7 mm/m (0.07%). It was estimated that approximately 50 metres of this pipe was predicted to experience a very slight reversal of grade during the mining of Longwall 27. As seen in Fig. 2.12, the trigger level was not exceeded when this section of pipe was mined beneath by Longwall 27.

A water level sensor was installed in the upstream pit prior to the influence of Longwall 27 and no noticeable changes have been observed, as shown in Fig. 2.14.

The mining of Longwalls 28 to 30 will result in an increase in grade for this section of pipe. It can be seen from Fig. 2.11 that grades for pipes above Longwall 28 are well above self-cleansing prior to mining and predicted to remain so after mining.

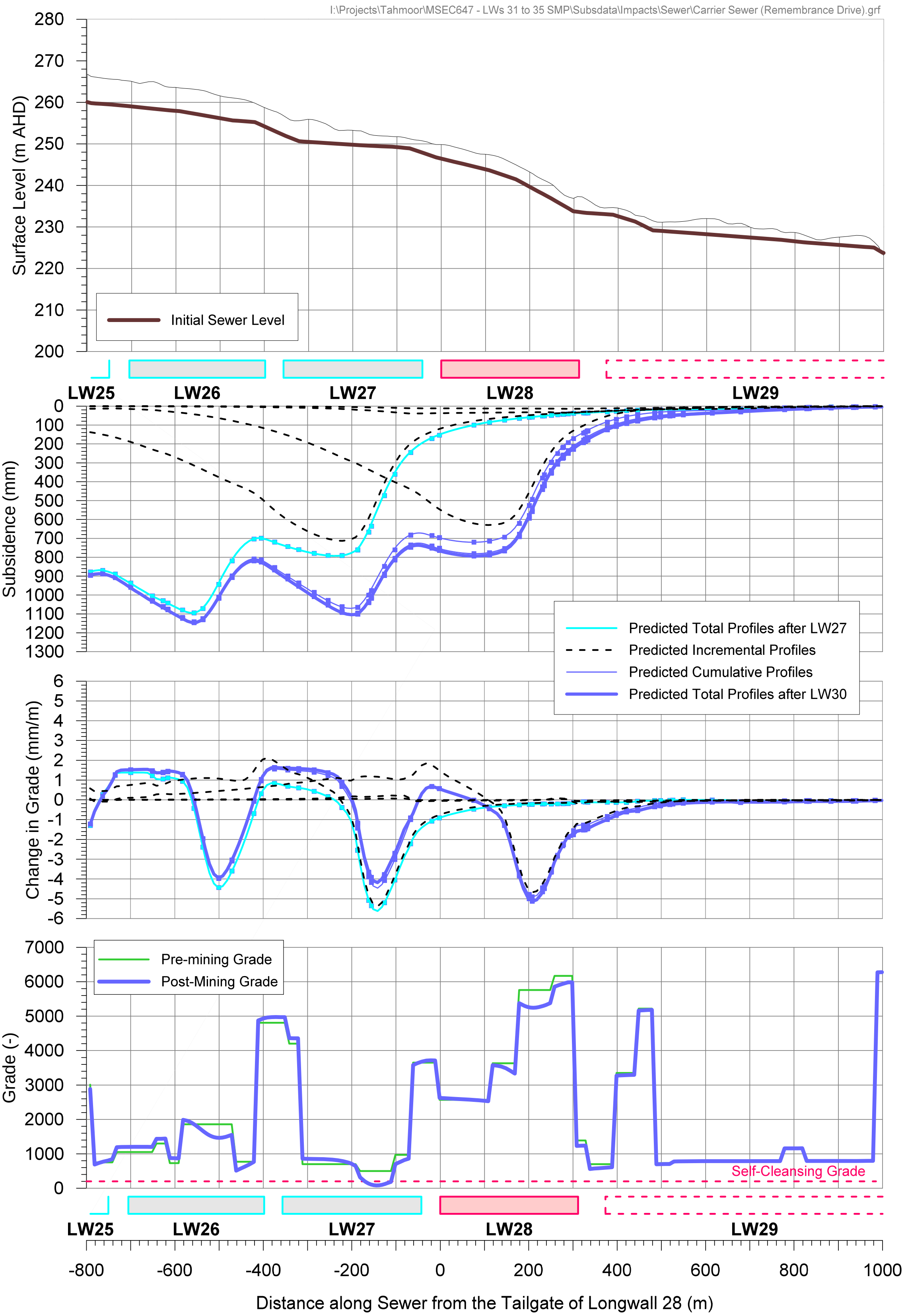


Fig. 2.11 Predicted Subsidence and Changes in Grade along Tahmoor Carrier

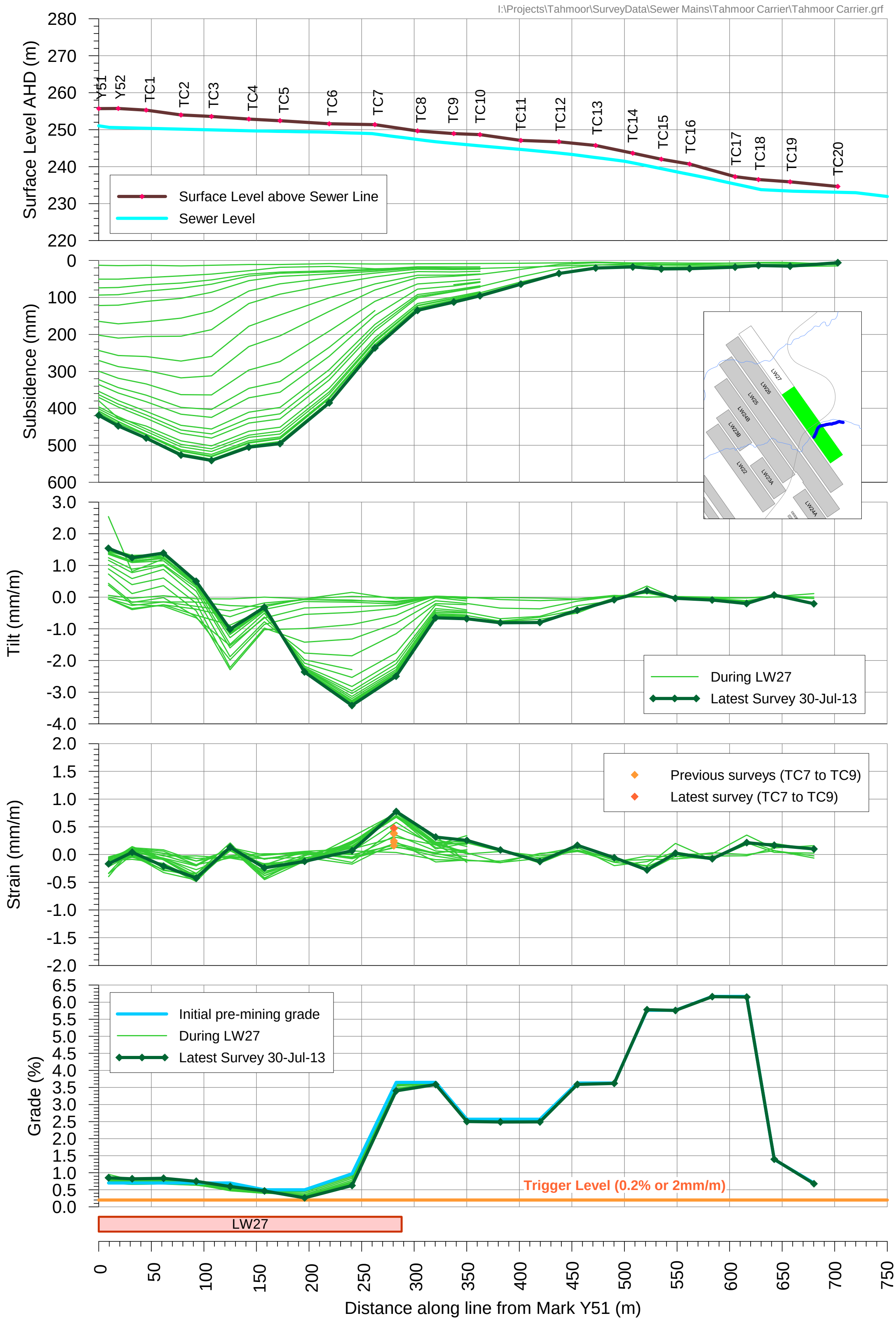


Fig. 2.12 Observed Subsidence, Tilt and Strain along the TC Line above the Tahmoor Carrier Pipe

Fig. 2.13 Location of Tahmoor Carrier Pipe behind properties on Remembrance Drive

The risk associated with sewers that have grades less than self-cleansing is that sewage may back up the pipe or a blockage may develop in the pipes over time. The likelihood of blockage depends on the flatness of the grade, the pipe diameter, the length of the affected section of pipe and sewerage flow. Sydney Water has undertaken a hydraulic modelling assessment of the Tahmoor Carrier pipe and found that sewage will not overflow during average dry weather flow conditions if the pipe is 90% blocked where a reversal of grade is predicted to occur.

In addition to the risk of blockage, there is also the possibility that odour issues may develop at the upstream manhole or manholes.

The following strategy has been developed to manage the potential impacts of reversal of grade of the Tahmoor Carrier.

Mitigation

- The Carrier pipe was flushed in April 2012 to minimise the chance of sludge build up in the line and development of odour issues.
- Arrangements have been made for contractors to remain on standby to tanker flush or high pressure jet the pipes to Sydney Water specifications. Similar arrangements were made during the mining of Longwalls 24A to 27.

Monitoring

- A baseline CCTV investigation was conducted in April 2012.
- Ground surveys during mining.

  Pegs have been installed along York Street along the route of the Tahmoor Carrier, and survey pegs have been installed at property boundaries along the route of the Tahmoor Carrier at the rear of private properties along Remembrance Drive. The surveys measure subsidence and ground strain.

- Water level sensor

  A water level sensor was installed in the manhole that is upstream of the location where the pipes may have experienced a reversal of grade during the mining of Longwall 27. The sensor was installed in February 2013 (during the initial mining of Longwall 27) to collect baseline readings. Readings from the sensor were taken every five minutes and transmitted to a monitoring website. As seen in Fig. 2.14, the water level has remained well below the top of the pipe.

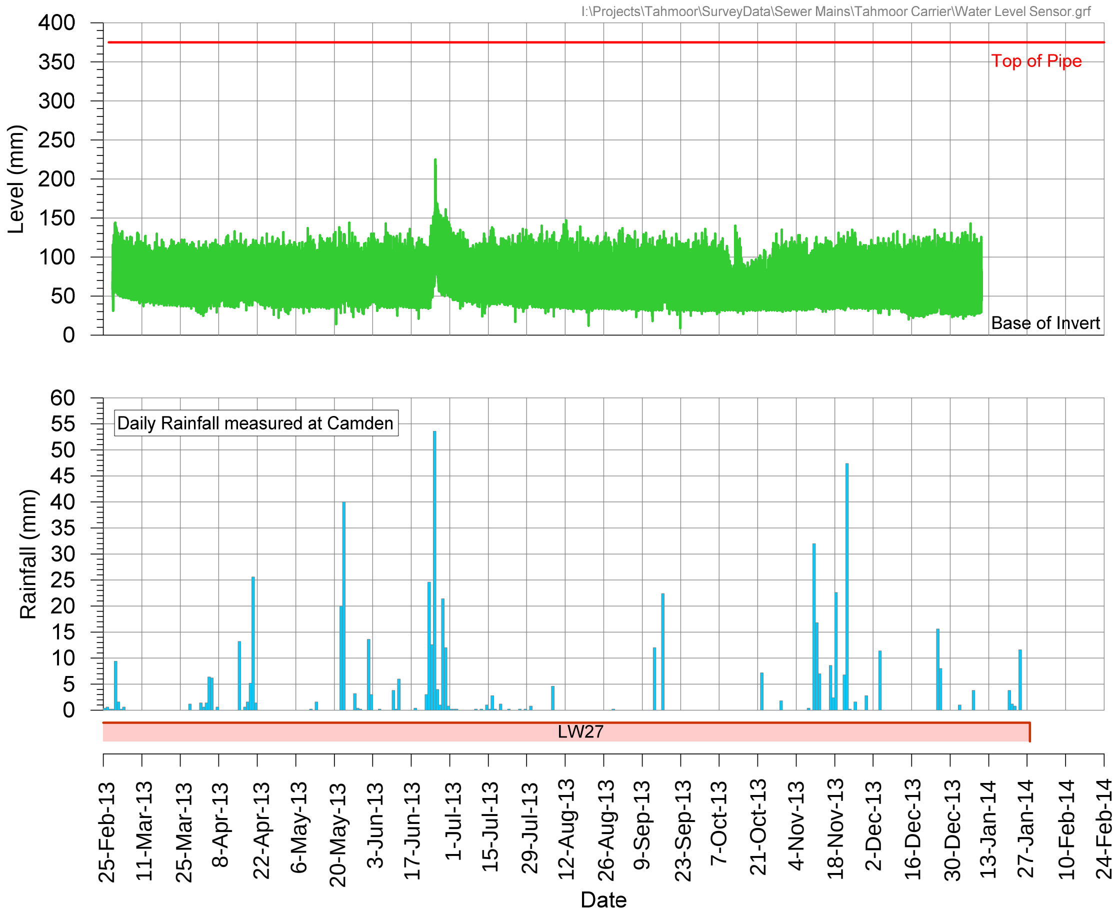


Fig. 2.14 Water level sensor observations during Longwall 27

Responses

- If subsidence surveys indicate that the pipe has reduced in grade to less than 0.2 % (2 mm/m), additional CCTV investigations will be undertaken. The frequency will be determined by Sydney Water in consultation with Tahmoor Colliery. For each CCTV investigation, the line may be flushed by high pressure jetting to minimise the chance of sludge build up in the line and development of odour issues.
- Based on the results of CCTV investigations and water level monitoring, the pipes may be periodically flushed by high pressure jetting.
- The pipes are predicted to experience an increase in grade during the mining of Longwall 28. If, however, long term ponding or odour issues develop it may be necessary to re-lay the pipes. This may require building up of the ground surface to provide minimum cover for the pipes. The likelihood of this response being required has been substantially reduced in light of the less than predicted reductions in grade experienced during the mining of Longwall 27.

2.8.2. Thirlmere Carrier

The Thirlmere Carrier is the main branch servicing the majority of Thirlmere township. The predicted profiles of incremental and cumulative systematic subsidence and changes in grade along the alignment of the Thirlmere Carrier along Bridge Street are shown in Fig. 2.15.

In the case of Longwall 27, a 67 metre long section of 375 mm diameter pipe was laid with a pre-mining grade of 0.5% (5.0 mm/m), which is close to the minimum grade for self-cleansing of 0.2% (2 mm/m). The pipe section is located beneath the southern shoulder of Bridge Street directly above Longwall 27. As shown in Fig. 2.15, the pipe was predicted to experience a maximum reduction in grade of 5.9 mm/m, which would result in a very slight reversal in grade of approximately 0.9 mm/m (0.09%). It is estimated that approximately 50 metres of this pipe is predicted to experience a very slight reversal of grade during the mining of

Longwall 27. The section is located approximately between Pegs BG54 and BG57 on Bridge Street, as shown by the purple line in Fig. 2.16.

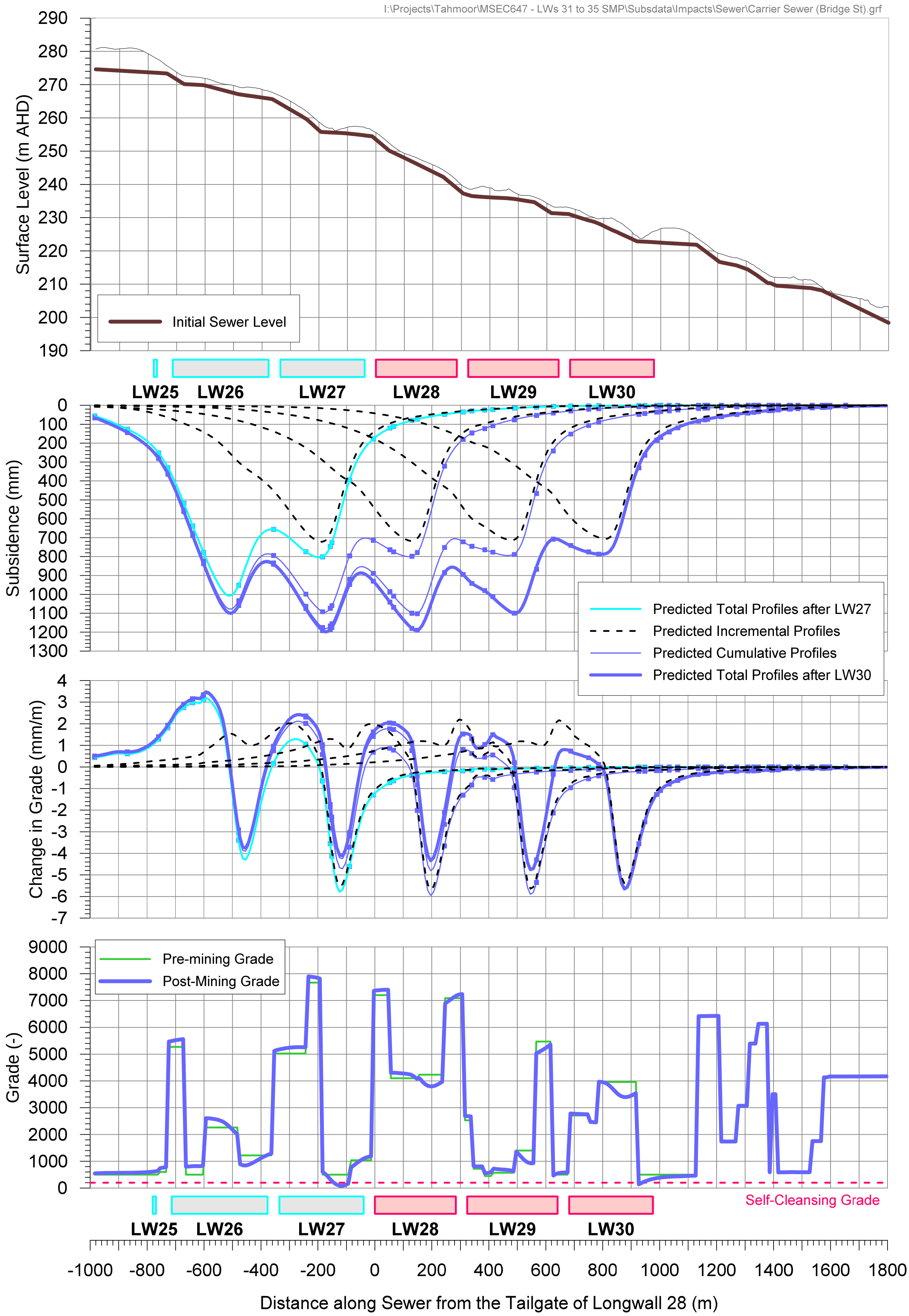


Fig. 2.15 Predicted Subsidence and Changes in Grade along Thirlmere Carrier

As at 29 January 2014, ground surveys have found that the grade for one 20 metre section (Peg BG55 to BG56) has reduced to 0.14%, below the early warning trigger level of 0.2%. When the survey results between Pegs BG54 and BG57 are used to estimate change over the 67 metre section, the average grade is approximately 0.23% from pit to pit.

The development of mining-induced ground tilts and changes in sewer grade relative to the position of longwall face relative to the survey pegs are shown in Fig. 2.17. It can be seen that changes in tilt are reducing, which is expected as the Longwall 27 face has passed the site by approximately 300 metres. Monitoring at this site continues.

Tahmoor Colliery has consulted directly with Sydney Water in accordance with the Sewer Management Plan to consider whether any additional management measures are required. It is agreed to continue monitoring at this stage but Sydney Water are ready to respond if required to ensure the sewer remains serviceable.

The mining of Longwalls 28 to 30 will result in an increase in grade for this section of pipe. It can be seen from Fig. 2.15 that grades for pipes above Longwalls 28 and 29 are well above self-cleansing prior to mining and predicted to remain so after mining. A very short section of pipe above Longwall 30 may experience a reduction in grade such that it becomes slightly less than self-cleansing. This section will experience an increase in grade during the extraction of future Longwall 31.

Sydney Water has undertaken a hydraulic modelling assessment of the Thirlmere Carrier pipe and found that sewage will not overflow during average dry weather flow conditions if the pipe is 90% blocked where a reversal of grade is predicted to occur.

The management strategy for the Thirlmere Carrier will be same as outlined for the Tahmoor Carrier, except that water level monitoring may not be undertaken as it is very difficult to access the manhole that is upstream of the location where the pipes may experience a reversal of grade during the mining of Longwall 27.

As shown in Fig. 2.18, it can be seen that the Thirlmere Carrier pipe does not follow the alignment of Bridge Street for a short section above Longwall 29. A new survey line, the THC line, will be installed along this section of the Thirlmere Carrier pipe prior to the influence of Longwall 28. Survey pegs have already been installed on Bridge Street, alongside the majority of the Carrier pipe above Longwalls 28 to 30.

Fig. 2.16 Location of Thirlmere Carrier Pipe on Bridge Street where a reversal of grade may occur during the mining of Longwall 27

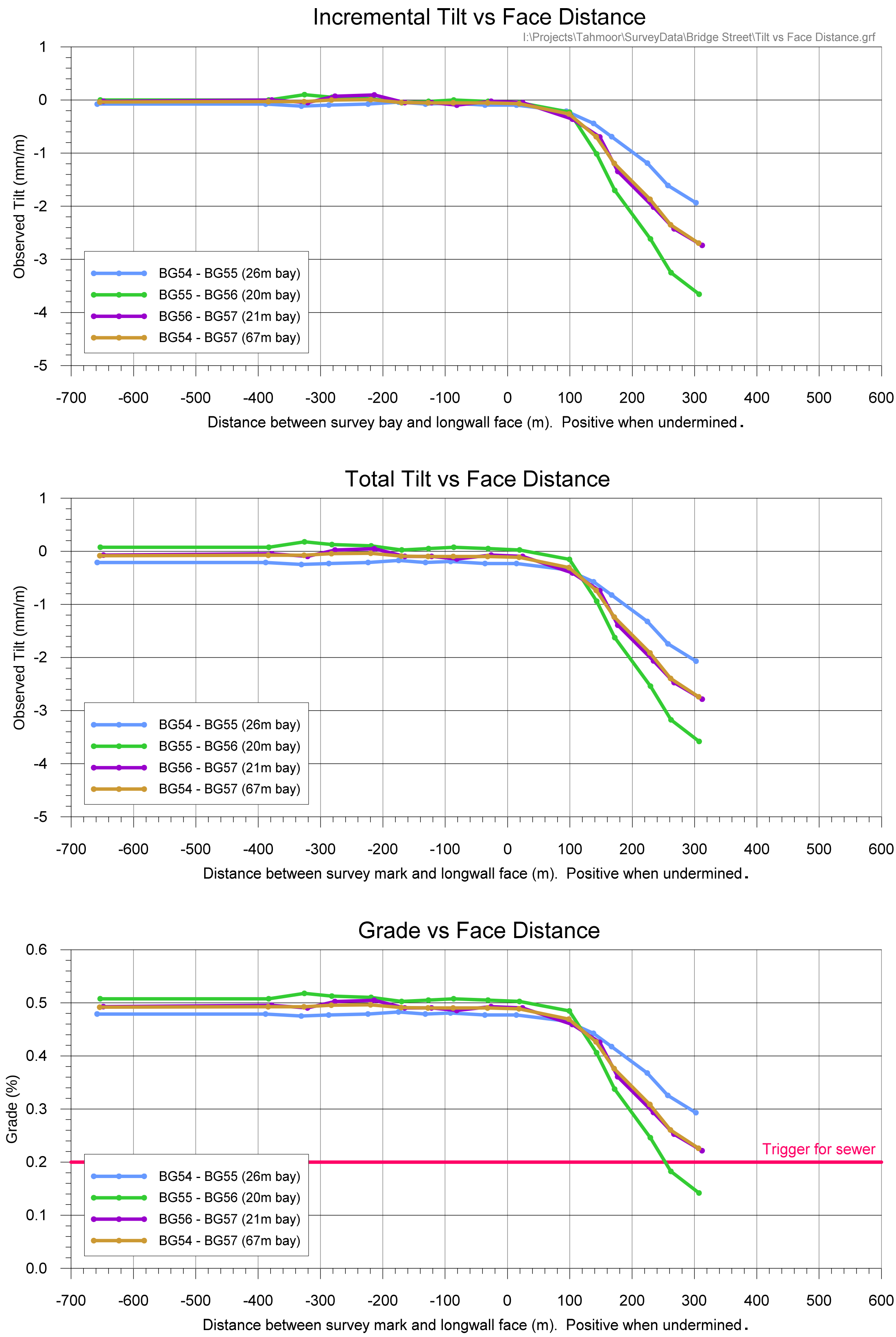


Fig. 2.17 Development of tilt on Bridge Street between pegs BG54 and BG57

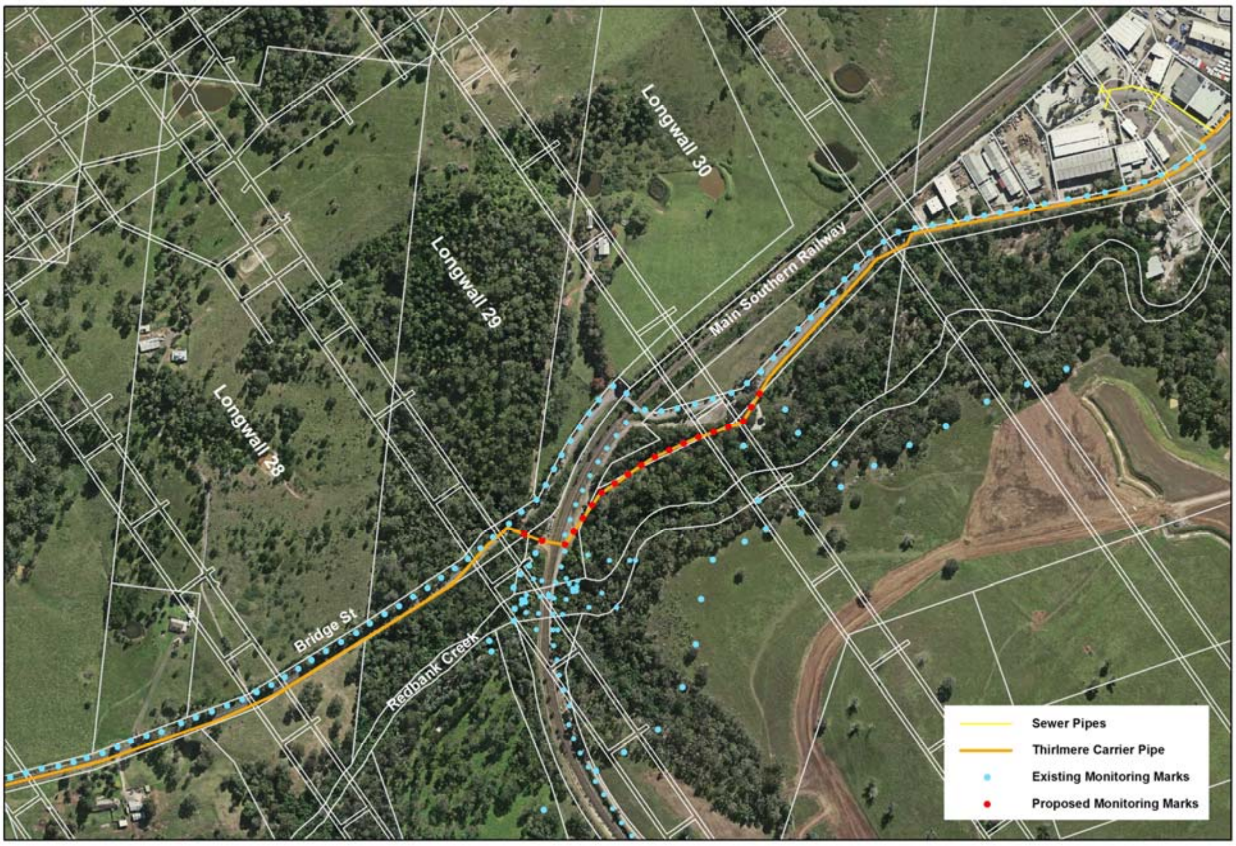


Fig. 2.18 Location of Thirlmere Carrier Pipe on Bridge Street

2.8.3. Risk Assessment

The consequence of a blockage is dependent on the number of properties that are affected, the cost to remove the blockage and, if required, the cost to repair the main. There are also additional environmental consequences if the blocked sewer is located near a watercourse or community concern over odour issues.

The consequence is therefore dependent on the size of sewer main and has been summarised in Table 2.7.

Table 2.7 Consequence of a Sewer Main Grade Being Less than the Minimum for Self-Cleansing

Pipe Diameter (mm)	Minimum Number of Properties Affected	Consequence	Consequence if near a watercourse
100	1 ~ 4	MINOR	MODERATE
150	65 ~ 135	MINOR	MODERATE
225	186 ~ 339	MINOR	MODERATE
300	389 ~ 648	MODERATE	SEVERE
375	Carrier Pipe – almost whole town	SEVERE	SEVERE

The likelihoods of blockages due to changes in grade have been assessed based on the following observations:

- Longwalls 22 to 27 have directly mined beneath approximately 27.3 kilometres of sewer pipes and no blockages or reversals of grade have been observed, including pipes within areas of increased subsidence.
- Detailed assessments of changes in grade for each pipe section based on predicted subsidence due to the mining of Longwalls 28, 29 and 30. The assessments were also repeated based on two times the prediction.

- The potential impacts due to changes in grade have been managed successfully during the mining of Longwalls 22 to 27. Sewer pipes at greater risk were intensively monitored by ground survey during the mining of these longwalls. This monitoring data confirmed that these pipes did not experience a reversal of grade. Tahmoor Colliery arranged for contractors to remain on standby to tanker flush or high pressure jet the pipes to Sydney Water specifications, though they were not required.
- Similar management measures will be undertaken during the mining of Longwalls 28 to 30, with contingency plans in the event that any pipe experiences a reversal of grade and is at risk of blockage.

With the above experience and management measures in place, and in light of the less than predicted reductions in grade observed along the Carrier pipes during the mining of Longwall 27, the likelihood of blockage of the sewer pipes above Longwalls 28 to 30 is considered to be **VERY UNLIKELY** within the limit of subsidence of Longwalls 28 to 30**.**

A summary of the assessed risks associated with blockage due to changes in grade of self-cleansing sewers as a result of the extraction of Longwall 28 is provided in Table 2.8.

Table 2.8 Risk analysis of blockage due to changes in grade due to the mining of Longwalls 28 to 30, with management measures in place

Pipe	Pipe Diameter (mm)	Level of Risk
All other sewer pipes within limit of subsidence of Longwall 27	100, 150 and 225	Likelihood = Very Unlikely Consequence = Minor **RISK → LOW (6)**
	300	Likelihood = Very Unlikely Consequence = Moderate **RISK → MEDIUM (5)**
	375	Likelihood = Very Unlikely Consequence = Severe **RISK → MEDIUM (4)**

The likelihood of any adverse impacts for sewer pipes located outside the limit of subsidence has been assessed as **LESS THAN VERY UNLIKELY**. A risk analysis has therefore not been made for these pipes.

2.9. Potential for further Physical Damage to Pipes at existing impact sites

Two sewer pipes were observed to experience physical damage during the mining of Longwall 26 and both sites were repaired. The impact sites were on Tahmoor Road and between Abelia Street and Oxley Grove.

Longwall 27 does not mine adjacent to these sites and given that the pipes have been repaired, it is considered extremely unlikely that they will experience impacts during the mining of Longwalls 28 to 30.

2.10. 225 mm diameter pipe behind Amblecote Place alongside Myrtle Creek

Sydney Water is currently in the process of replacing sections of a 225 mm diameter sewer pipe that was damaged from subsidence during the mining of Longwalls 25 and 26.

A map of this section of sewer is shown in Fig. 2.19.

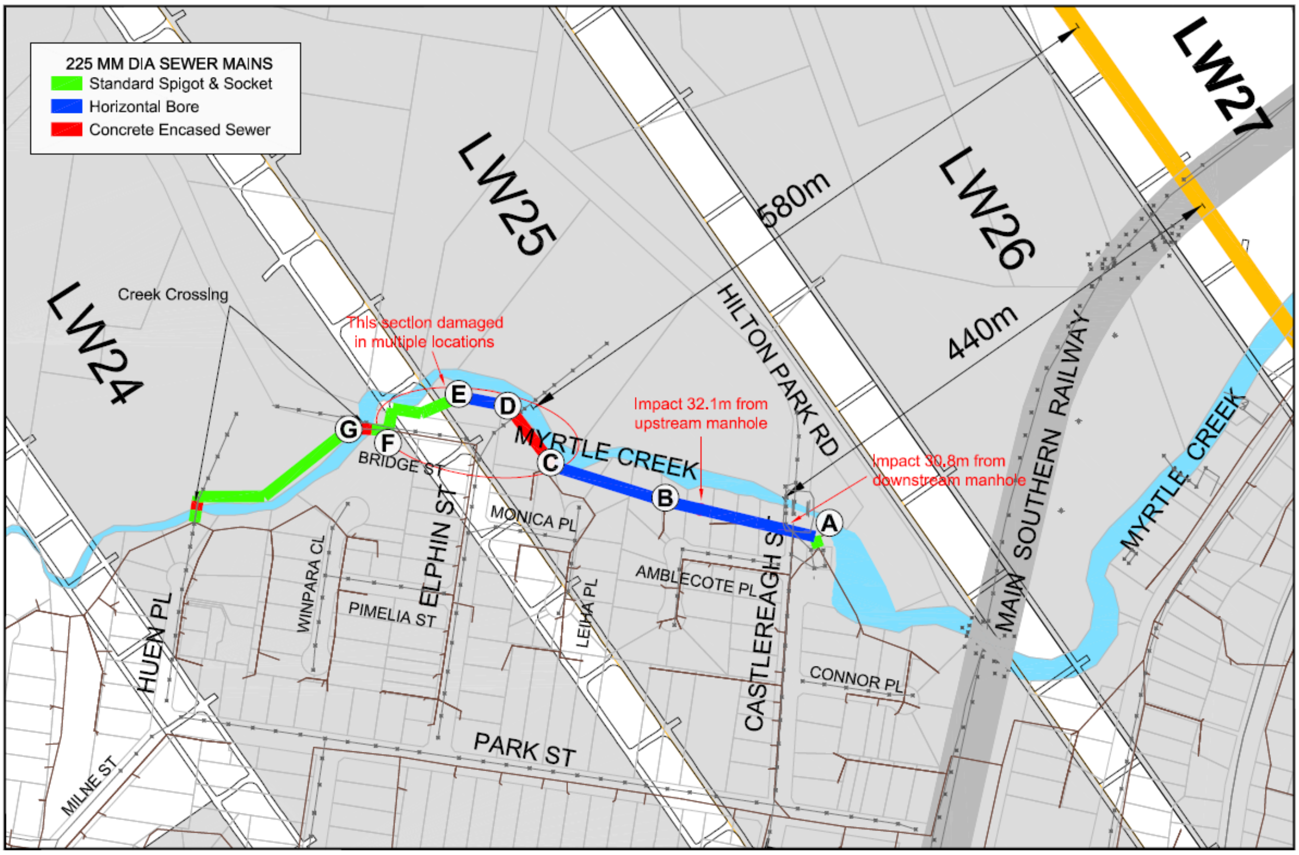


Fig. 2.19 Diagram showing the locations of subsidence impacted sewer pipes near Myrtle Creek

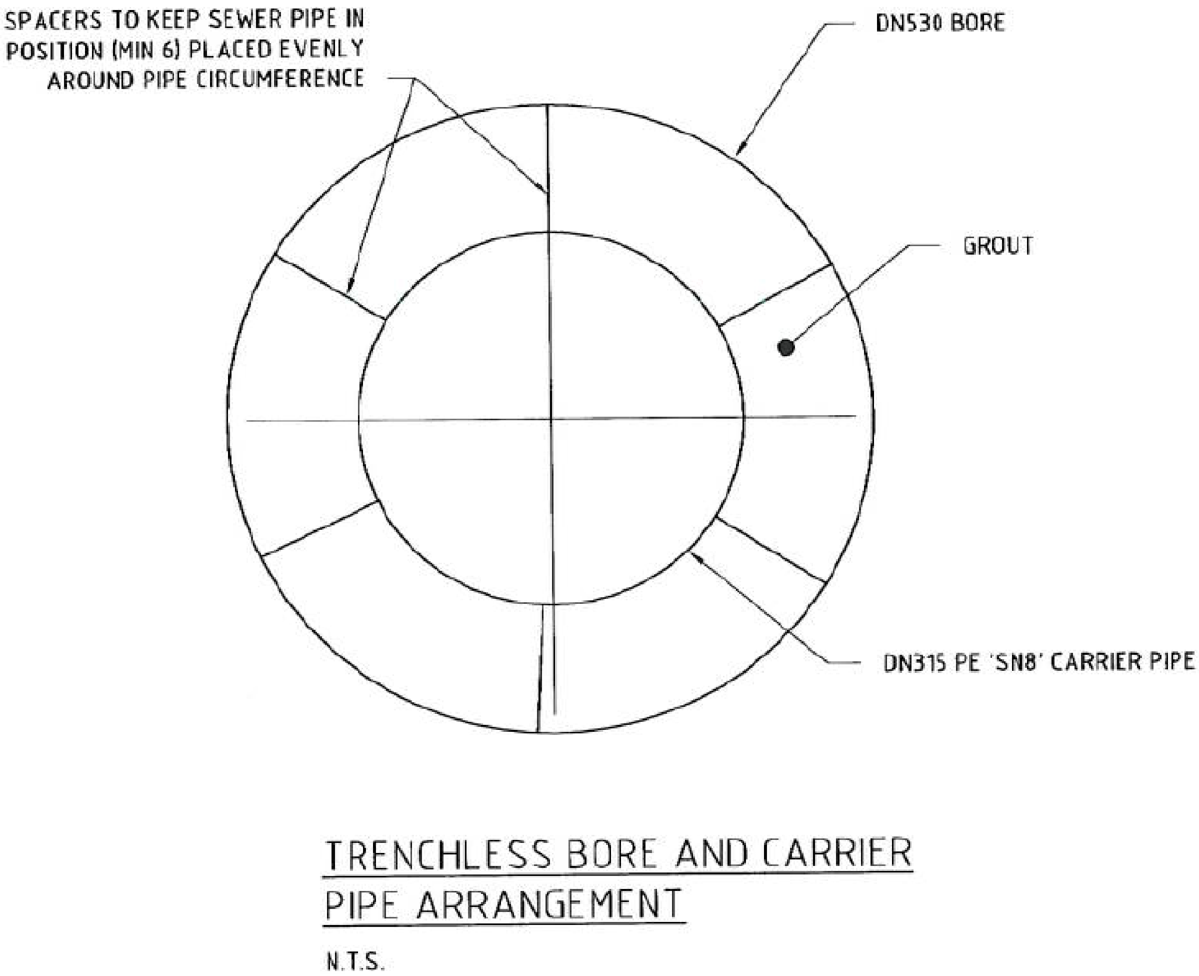
The design of the replacement bores has taken into account expected additional subsidence movements. The rectification work includes the following:

Replacement of horizontal bore from Sites A to C

A new horizontal bore will be installed along a new alignment that is closer to Myrtle Creek than the original, damaged bore, which will become disused and sand filled.

The new horizontal bore has been designed to accommodate additional movements in the following manner:

- The replacement sewer pipe is a polyethylene (PE) pipe, which is able to withstand greater deformation without cracking than a PVC pipe. The external diameter of the PE pipe is 315 mm, meaning that there is a gap of approximately 107 mm between the pipe and the 530 mm diameter bore.
- Spacers will be inserted at intervals of approximately 6 metres, which is sufficient for the pipe to span safely and maintain grade under full load. A diagram of the spacers within the oversized bore is shown in Fig. 2.20. The spacers can be replaced at different sizes and spacings at a later time if required due to future deformation of the bore.
- The 530 mm diameter bore will not be filled with grout along its entirety. Grout will be used as a plug only at the ends of the bore.
- The internal diameter of the PE pipe is approximately 277 mm, which is larger than the original 225 mm diameter PVC pipe. Some deformation reduction in cross-sectional area could be accommodated without impacting on the cross-section that is required by design.



Extract from KBR Drawing No. SEG100-066-DW-PL-CSP-004, Rev. 0

Fig. 2.20 Detail of Horizontal Bore and 315 mm diameter sewer pipe

Replacement of sewer pipes from Sites C to G

The sewer pipes in this section will be replaced with new 3 metre long 225 mm diameter PVC pipes, with deep entry spigot and socket joints.

The pipes in this section will be re-laid in trenches or encased in concrete on top of the ground surface at the base of an existing retaining wall. The damaged horizontal bore in this section will be disused and sand filled.

2.10.1. Risk Assessment

The impacts on the sewer pipe were related to the closure of Myrtle Creek. Less than 10 mm of valley closure was observed during the mining of Longwall 27.

Given the offset distance of Longwalls 28 to 30 from the 225 mm diameter pipes, the predicted additional valley closure movements and in recognition that the pipes have been replaced after to the influence of Longwall 27, it is considered **VERY UNLIKELY** that the replaced 225 mm diameter sewer will become unserviceable due to mine subsidence movements during the mining of Longwall 28 and **LESS THAN VERY UNLIKELY** due to the mining of Longwalls 29 and 30.

The consequence of blockage or leakage of the 225 mm diameter pipe would normally be considered MODERATE, as per Table 2.7, as the bore is near Myrtle Creek. In this case, however, the pipe is a horizontal bore, which services a substantial proportion of the Tahmoor township. The consequence of loss of service of this bore is therefore considered **SEVERE**. The overall risk assessment for these pipes is therefore **VERY UNLIKELY / SEVERE → MEDIUM (4).**

2.11. Potential for Physical Damage to Pipes at new sites

The sewer pipes are constructed from PVC and have extra length sockets and rubber ring joints, which will allow them to accommodate tensile and compressive ground strains and curvature. The majority of the sewer mains are laid on sand and buried in trenches.

The design for PVC pipes are certified in accordance with the requirement of the Mine Subsidence Board, which specified maximum vertical subsidence of 750 mm, maximum tensile strain of 1.5 mm/m, maximum compressive strain of 2.5 mm/m and minimum radius of curvature of 8 kilometres.

Longwalls 22 to 27 have directly mined beneath approximately 27.3 kilometres of sewer pipes. Physical damage to pipes and joints has occurred at two sites during the mining of Longwall 26, three sites during the mining of Longwall 25 and no reported impacts during the mining of Longwalls 22, 23, 24 and 27. Based on this experience, it is assessed that the likelihood of physical damage at one or more new sites somewhere within the sewerage network due to the mining of Longwalls 28 to 30 is **LIKELY**. The pipes above the longwalls are reticulation pipes of either 100 mm or 150 mm diameter. The consequence of damage to these pipes is considered to be **MINOR**, as per Table 2.7.

The overall risk for physical pipe damage to occur somewhere within the sewerage network is considered to be **LIKELY / MINOR → MEDIUM (4)**.

The likelihood of impacts on individual pipes is considered **VERY UNLIKELY**, as the longwalls have directly mined beneath approximately 27 kilometres of sewer pipes, with impacts observed at only 5 sites. The most significant pipes within the sewerage network are the two 375 mm diameter Carrier pipes above Longwalls 28 to 30.

The likelihood of these specific pipes experiencing physical damage is considered to be **VERY UNLIKELY**. The consequence of damage to the 375 mm diameter Carrier pipes is considered to be **SEVERE**, as per Table 2.7.

The overall risk assessment for the Carrier pipes is therefore **VERY UNLIKELY / SEVERE → MEDIUM (4)**.

2.12. Potential Impacts to Rising Mains

The mining of Longwall 27 has resulted in additional minor subsidence of the rising main that is located along part of Castlereagh Street between the Pumping Station SP1045 near Myrtle Creek and the intersection at Park Street. This rising main is located directly above the extracted Longwall 25. No impacts have been observed along this main during the mining of Longwalls 25 to 27.

Ground monitoring along Castlereagh Street in the vicinity of the rising main indicated very small differential movements during the mining of Longwalls 26 and 27, as shown in Fig. 2.21. As the rising main is located beyond the predicted limit of subsidence from the extraction of Longwalls 28 to 30, the likelihood of damage to the Castlereagh Street rising main during the mining of these longwalls is **LESS THAN VERY UNLIKELY**.

A risk analysis has therefore not been made for these pipes due to the extraction of Longwalls 28 to 30.

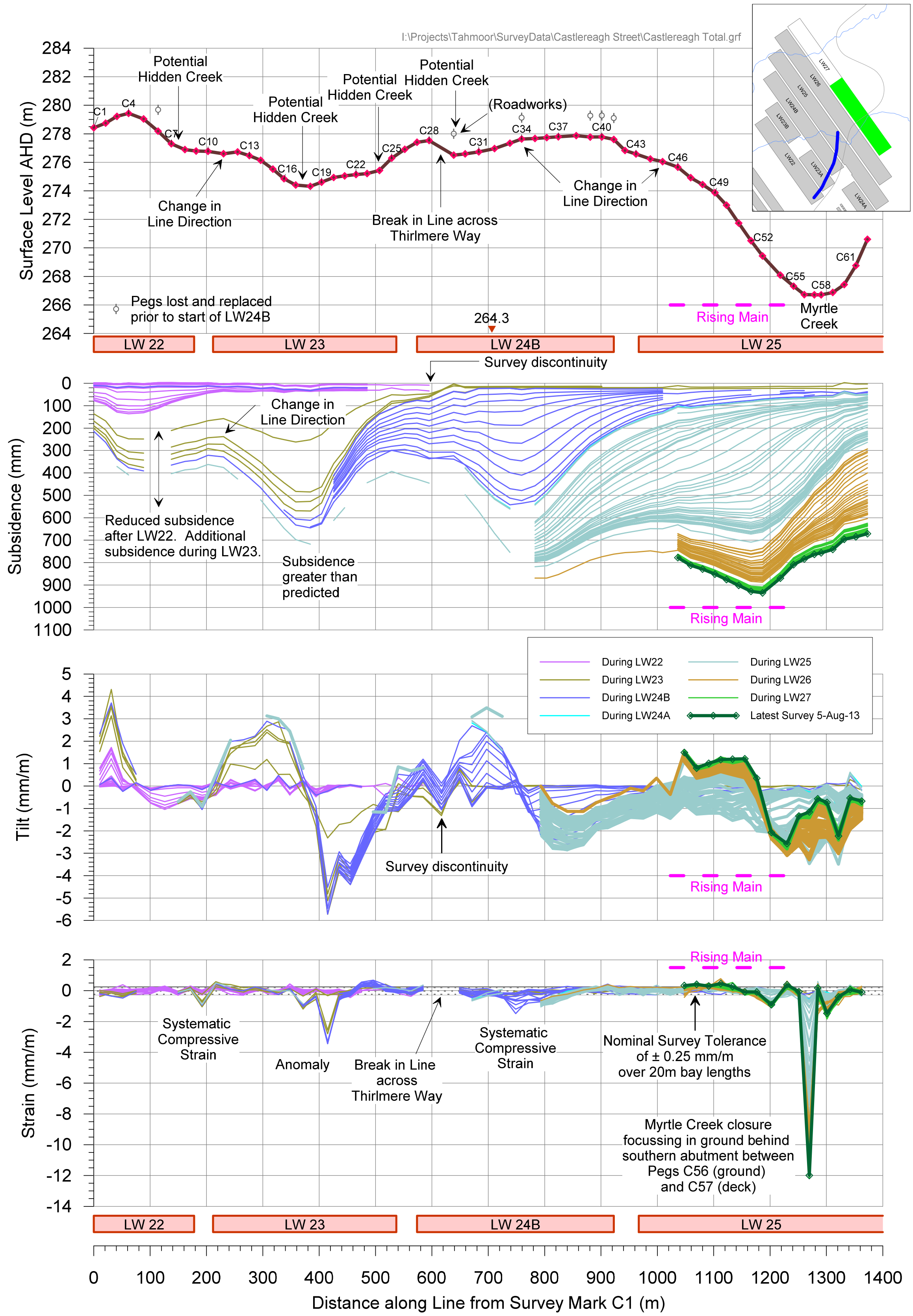


Fig. 2.21 Observed Subsidence, Tilt and Strain along Castlereagh Street above Rising Main

2.13. Sewage Pumping Station SP1045

The mining of Longwalls 28 to 30 will result in very little additional subsidence at Pumping Station SP1045, which is located on Castlereagh Street near Myrtle Creek. This pumping station is located directly above the extracted Longwall 25. No impacts have been observed to the Pumping Station to date, including during a visual inspection inside the chamber in September 2012 after the mining of Longwall 26.

Ground monitoring around the pumping station during the mining of Longwalls 25, 26 and 27 showed that the pumping station subsided approximately 740 mm, as shown in Fig. 2.22. Observed tilts were within expectations. The majority of ground strains around the pumping station were relatively small, with the exception of strain between Pegs PS2 and PS3 on the northern or downslope side. Compressive strain between the pegs reached a maximum of 3.4 mm/m in December 2009 during Longwall 25, but had reduced to 1.7 mm/m in August 2013 during Longwall 27.

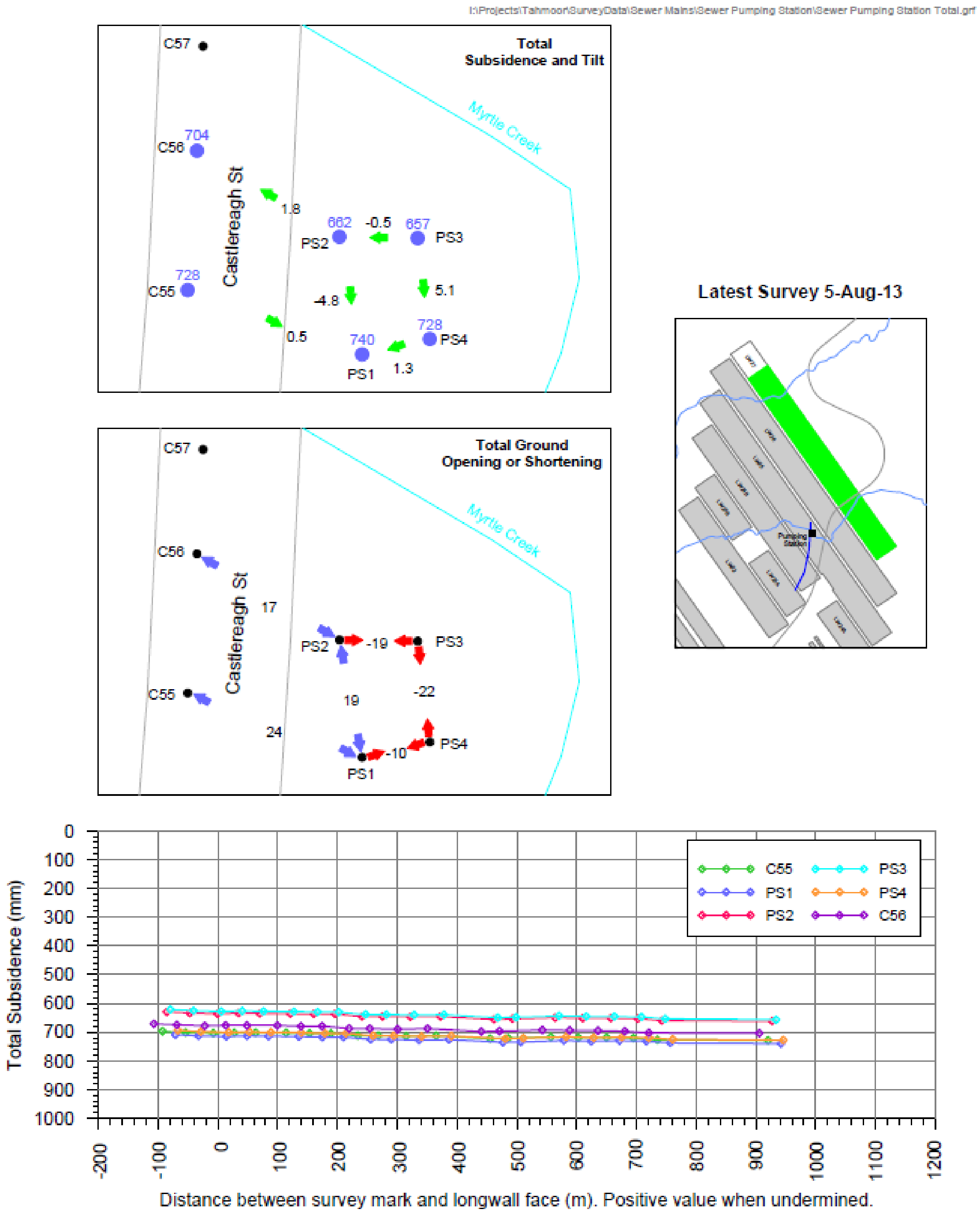


Fig. 2.22 Observed Total Subsidence, Tilt and Strain of Survey Pegs around SP1045 during the mining of Longwall 27

Automated continuous tiltmeters monitored changes in tilt in 3 vertical lines, placed at the top, base and mid-point on the internal face of the chamber wall. As shown in Fig. 2.23, observed curvatures are well within trigger levels as defined under the Management Plan. Very little change was observed during the mining of Longwall 27. It can be seen that after more than 5 years of operation, some sensors have recorded erratic readings at the 180 degrees position in December 2013. These sensors will not be replaced.

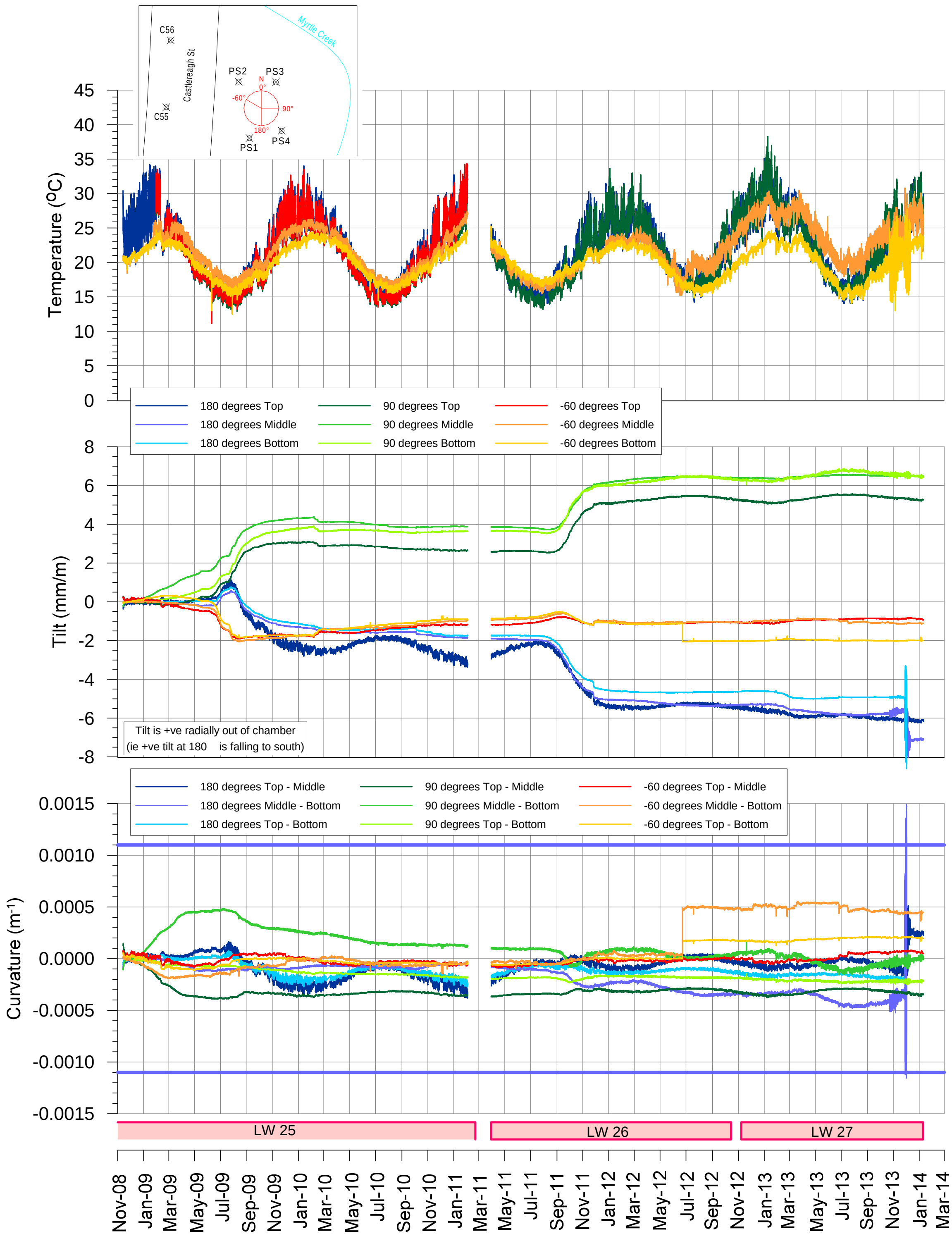


Fig. 2.23 Observed Tilts and Curvature of Walls of SP1045 measured by tiltmeters

Very little changes were observed during the mining of Longwall 27 and the pumping station is located approximately 700 metres from the side of Longwall 28. It is predicted to experience very little additional vertical subsidence during the mining of Longwalls 28 to 30.

The chamber has been constructed with reinforced concrete and occupies a small footprint of 3 metres in diameter. A structural analysis suggests that cracking to the chamber may develop if curvatures exceed 1.1 x 10^{-6} mm^{-1}, which equates to a radius of curvature of approximately 900 metres (JMA, 2008). This curvature is substantial compared to normal observed mining-induced curvatures. Furthermore, the tank is partially protected from ground curvature by 100 mm thick polystyrene foam, which has been placed between the external concrete faces and the excavated foundations.

The likelihood of impacts occurring to Pumping station SP1045 during the mining of Longwalls 28 to 30 is therefore considered **LESS THAN VERY UNLIKELY**.

A risk analysis has therefore not been made for these pipes due to the extraction of Longwalls 28 to 30.

The pumping station contains a number of automated alarms that immediately alert Sydney Water in the event of a mechanical or electrical fault occurring to the station. The pumping station has a four hour capacity to store sewage before any overflows into Myrtle Creek. If the length of time to repair the fault exceeds four hours, it is possible that sewage may pollute Myrtle Creek. Sydney Water has developed robust contingency plans to respond and address failure modes.

If cracking develops within the chamber, the consequence depends on the depth of the crack. Normal operating depth is the bottom 1 metre of the chamber. A possible failure point is the structural joint, which is located above the normal operating depth. If cracking occurs, the pumping rate can be increased to reduce the depth of sewage in the chamber. The cracks can also be repaired by patching. Horizontal struts can also be installed across the chamber if required (JMA, 2008).

Monitoring of ground survey marks will be undertaken after the mining of Longwall 28 to confirm that little change has occurred. As the tiltmeters are beginning to deteriorate after more than 5 years of operation, they will not be replaced as very little change was observed during the mining of Longwall 27 and results are well within trigger levels.

2.14. Concrete Encasements and Horizontal Bores

There are some sewer pipes within the mining area that have been concrete encased. These encasements are typically found across driveways and structures. Concrete encased sewers are more vulnerable to mine subsidence impacts when compared to normal sewers as the pipe joints are unable to slide in response to ground strains. If the encasements are long and subjected to large ground strains, there would be a risk of sewer breakage at the joint or within the pipe. In this case, the majority of concrete encasements do not appear to be very long and based on experience gained to date, the likelihood of impacts occurring to these short individual pipes is considered **VERY UNLIKELY**. The above assessment does not include the concrete encased pipes that cross Myrtle Creek, which are discussed in the next section.

There are some small horizontal bores that will experience subsidence movements during the mining of Longwall 27. These are typically found across roads and railways. Horizontal bores are more vulnerable to mine subsidence impacts when compared to normal sewers as there are fewer pipe joints to accommodate the mining-induced ground strains. In this case, the majority of horizontal bores do not appear to be very long and based on experience gained to date, the likelihood of impacts occurring to these short individual pipes is considered **VERY UNLIKELY**. It is therefore unlikely that horizontal bores will be adversely impacted by mine subsidence except for the long horizontal bore, which experienced impacts as described and risk assessed in Section 2.10.

The likelihood of a typical short length concrete encased pipe or horizontal bore being damaged by systematic mining impacts can therefore be considered **VERY UNLIKELY**.

If an impact occurs, the time taken to repair a leak is greater than for other pipes as access to the leakage point is more difficult. The consequence of an impact is therefore assessed as **MINOR** for small concrete encased sewer pipes (100 and 150 mm diameter) and **MODERATE** for larger horizontal bores, such as those under roads and the Main Southern Railway.

The level of risk associated with concrete encased pipes and horizontal bores can therefore be considered **VERY UNLIKELY / MINOR --> LOW (6)** for small pipes and **VERY UNLIKELY / MODERATE --> MEDIUM (5)** for large pipes.

2.15. Creek Crossings

The sewer mains do not cross any major streams above Longwalls 28 to 30.

The Thirlmere Carrier pipe does, however, cross two small tributaries to Redbank Creek. One tributary crossing is located above the chain pillar between Longwalls 28 and 29 and another is located directly above Longwall 30. Valley closure and Upsidence may develop at these locations and will be monitored by ground survey.

Intensive ground monitoring and visual inspections were undertaken at the Huen Place and Bridge Street creek crossings during the mining of Longwalls 24B, 25 and 26. CCTV investigations were also undertaken. The most recent investigations were in mid December 2011. While the horizontal distances between the sewer pits were observed to close, no impacts or changes at pipe joints were observed.

The results of ground surveys at the two creek crossings are shown in Fig. 2.24. It can be seen that very little change was observed across the Brundah Road crossing during the mining of Longwall 25 and an additional 10 mm closure developed across the Huen Place crossing.

While additional ground closure during the mining of Longwall 27 is possible, the increments are expected to be quite small. Comfort is drawn from CCTV observations of no changes at pipe joints to date.

A survey of the creek crossings is planned to be undertaken at the end of Longwall 27, in accordance with the management plan for this longwall. Additional management actions may be undertaken if adverse observations are made at this time.

As Longwalls 28 to 30 are located another panel width further away from the creek crossings, the likelihood of mining-induced leakage in Myrtle Creek at the sewer crossings is considered **LESS THAN VERY UNLIKELY.**

A risk analysis has therefore not been made for these pipes due to the extraction of Longwalls 28 to 30.

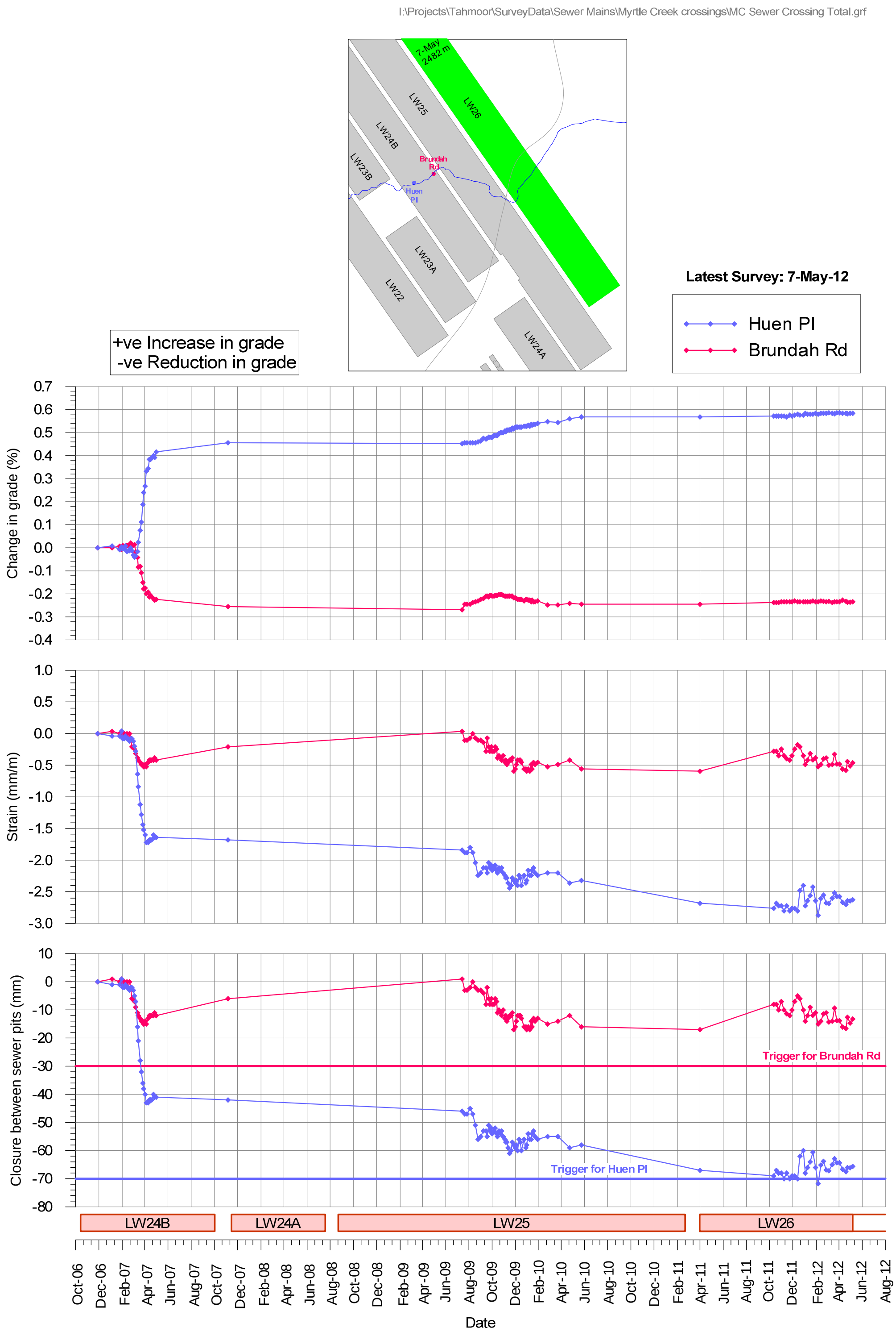


Fig. 2.24 Observed Changes in Grade and Horizontal Distance at Myrtle Creek Crossings during the mining of Longwalls 24B to 26

2.16. Summary of Risk Analysis for Sewerage System

A summary of the levels of risk for the sewer mains associated with damaged joints, damaged pipes and grades less than the minimum for self-cleansing are provided in Table 2.9.

Table 2.9 Summary of Risk Analysis for Sewer Mains

Risk	Likelihood	Consequence	Level of Risk
Blockage of other pipes due to change of grade	VERY UNLIKELY	MINOR to SEVERE	LOW (6) to MEDIUM (4)
Blockage or leakage of replaced 225 mm diameter horizontal bore behind Amblecote Place during mining of LW28 only	VERY UNLIKELY	SEVERE	MEDIUM (4)
Physical damage to reticulation pipes at one or more locations somewhere within the sewerage network	LIKELY	MINOR	MEDIUM (4)
Physical damage to Tahmoor or Thirlmere Carrier pipes	VERY UNLIKELY	SEVERE	MEDIUM (4)
Physical damage to typical concrete encased sewers or horizontal bores	VERY UNLIKELY	MINOR to MODERATE	LOW (6) to MEDIUM (5)

3.1. Sewer Management Group (SMG)

The Sewer Management Group (SMG) is responsible for providing advice on all technical issues relating to mine subsidence related impacts to sewer infrastructure due to the mining of Longwalls 28 to 30, on which decisions are made by Sydney Water and Tahmoor Colliery. The SMG develops and reviews this Management Plan, collects and analyses monitoring results, determines potential impacts and provides advice to Sydney Water and Tahmoor Colliery regarding appropriate actions. The members of the SMG are highlighted in Chapter 7.0 .

3.2. Avoidance, Mitigation and Response Measures

There are a number of temporary avoidance and mitigation measures available to minimise the consequence of blocked or back-flowing sewers during and after active subsidence:

- Tanker flush using equipment of sufficient volume and pumping capacity.
- High pressure jetting of sewer pipes
- Bypass pump sewage around a potentially affected section of pipe.
- Lining a pipe to seal pipe joints. This can be done for full length of pipe, or patch lining can be installed to seal a single pipe joint.

As undertaken during the mining of Longwalls 24A to 27, Tahmoor Colliery will engage a contractor with capacity to implement these measures as required by Sydney Water. The above measures are considered temporary measures that can be undertaken before an impact occurs. The sewerage system can return to normal operations if monitoring shows that no impact has occurred, or if impacts have occurred, after a section of pipe is repaired.

In the case of the horizontal bore behind Amblecote Place, a gap is left between the bore and PE pipe, with spacers installed every 6 metres. The spacers can be readjusted at different spacings if deformation is observed.

3.3. Monitoring Plan

A number of monitoring measures will be undertaken during mining.

3.3.1. Ground Monitoring Lines

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

Ground Survey along Streets

Monitoring lines have been installed along streets within the urban area above Longwalls 28 to 30.

The frequency of surveys along each street varies depending on the assessed risks to infrastructure in the vicinity of each monitoring line.

The following monitoring lines will be surveyed on a weekly basis during the mining of Longwalls 28 to 30:

- York Street, from Bradbury St intersection to the start of the TC Line above the Tahmoor Carrier pipe during the mining of Longwall 28 only
- TC Line along the route of the Tahmoor Carrier during the mining of Longwall 28 only.
- Remembrance Drive during the mining of Longwall 28 only
- Bridge Street, above the Thirlmere Carrier pipe
- THC Line, a new monitoring line along the route of Thirlmere Carrier that does not follow Bridge Street above Longwall 29

Other streets located directly above Longwalls 28 to 30 will be surveyed every 200 metres of longwall advance, when the streets are located in the active subsidence zone. The survey frequency may increase if increased subsidence is found to be developing, or if substantial non-systematic movement is observed.

3.3.2. Visual Inspections (including CCTV)

Visual inspections will be undertaken within the active subsidence zone during mining. Sydney Water personnel may also undertake inspections of the pits during mining. In the case of the pumping station, visual inspections can be conducted by people trained for working in confined spaces.

CCTV inspections have been undertaken at the Carrier pipes. More CCTV inspections can be undertaken if triggered by monitoring results to detect the condition of the sewer and whether any further movement can be accommodated by the pipe joints.

3.3.3. Automated Continuous Monitoring of Water Levels in Tahmoor Carrier pipe

A water level sensor was installed in the manhole that is upstream of the location where the pipes may have experienced a reversal of grade during the mining of Longwall 27. While the pipe is predicted to experience an increase in grade during the mining of Longwall 28, the water level sensor will continue during the mining of this longwall.

It is planned to decommission the sensor after the influence of Longwall 28, unless adverse observations are made.

3.3.4. Water Quality Monitoring of Myrtle Creek

The following water quality monitoring procedures have been implemented by Tahmoor Colliery:

- Testing points have been established in consultation and agreement with Sydney Water. They are located upstream and downstream of the two sewer crossings, horizontal bore and pumping station.
- Background FC (faecal coliform) & ENT (enterococci) levels were established prior to mining along Myrtle Creek.
- Testing points are sampled on a weekly basis and trends are monitored.
- Water is tested in dry weather only. If rainfall occurs, Tahmoor Colliery will wait 3 days after rain has ceased before continuing sampling.
- Tahmoor Colliery will provide monitoring results on a weekly basis to Sydney Water during mining.
- An emergency meeting will be held by the SMG if a spike of 10 times the background levels is observed in dry weather. The SMG will consider the water quality monitoring results in light of other monitoring and mining information to determine the appropriate course of action. It is recognised that standard procedure in a non-subsidence environment is to retest the following week and investigate further if high levels are still evident.

3.4. Triggers and Responses

Trigger levels have been developed by the SMG based on observed subsidence data. Trigger levels for each monitoring parameter are described in the risk control procedures, detailed in Table 3.1.

Table 3.1 Risk Control Procedures for Sewer Infrastructure

Hazard / Impact	Risk	Trigger	Control Procedure/s	Frequency	By Whom?
GENERAL PROCEDURES					
All sewer infrastructure	**LOW (6) to MEDIUM (4)**	None	Conduct CCTV inspections for Tahmoor and Thirlmere Carrier pipes	Tahmoor Carrier complete Thirlmere Carrier (Bridge St): Section above LWs 27 to 29 prior to LW28 approaching within 200m of sewer and end of LW28 Section above LWs 28 to 30 prior to LW29 approaching within 200m of sewer and end of LW29 Section above LWs 29 to 31 prior to LW30 approaching within 200m of sewer and end of LW30	Sydney Water
			Conduct surveys along street survey lines	Weekly surveys along Remembrance Drive from start of LW28 until 800m of extraction Weekly surveys along York Street from start of LW28 until 800m of extraction Weekly surveys along Bridge Street during mining of LWs 28 to 30 when the survey line is within the active subsidence zone For other street survey lines: Conduct surveys every 200m of extraction for survey pegs located within the active subsidence zone, commencing after 200m of extraction	Tahmoor Colliery (SMEC Urban)
			Surveys of marks along TC Line, which follows the route of the Tahmoor Carrier Pipe on private properties behind Remembrance Drive from York Street Peg Y52 to Remembrance Drive Peg RE74	Weekly from start of LW28 until 800m of extraction	Tahmoor Colliery (SMEC Urban)
			Surveys of marks along THC Line, which follows the route of the Thirlmere Carrier Pipe that deviates away from Bridge Street where it crosses the Main Southern Railway	Install and initial survey prior to LW28 approaching within 400m of sewer Weekly surveys during mining of LWs 28 to 30 when the survey line is within the active subsidence zone	Tahmoor Colliery (SMEC Urban)
			Continuously monitor water levels at manhole upstream of the Tahmoor Carrier, where reversal of grade was predicted to occur during LW27	Tahmoor Carrier (off Remembrance Drive) Monitor during LW28 Decommission after 800m of extraction of LW28 unless adverse observations are made	Tahmoor Colliery
			Conduct survey of ground pegs installed around the perimeter of Pumping Station SP1045 and valley closure survey across Myrtle Creek at Castlereagh Street	Start and End of LW28	Tahmoor Colliery (SMEC Urban)
			Automated continuous tilt monitoring of chamber wall (9 tiltmeters, consisting of 3 vertical lines in three radial locations, placed at top, base and mid-point)	Continue during mining of LW28	Tahmoor Colliery
			Automated monitoring for faults at pumping station	Ongoing, as per Sydney Water procedures	Sydney Water
			Conduct visual inspection of streets and rail corridor for sewage leaks.	Detailed inspection once a week within the active subsidence zone Vehicle based inspection once a week within the active subsidence zone (on alternate day to detailed inspection)	Tahmoor Colliery
			Assess monitoring results and report on observed trends, comparison between observed and predicted subsidence, and presence of any non-systematic movement	Weekly when surveys are undertaken	Tahmoor Colliery (MSEC)
			Conduct choke report to compare rate of incidents within zone of influence of longwalls with rate of incidents in other areas	As per standard Sydney Water requirements	Sydney Water
			Inform Sydney Water Call Centre employees of potential impacts in area. Establish contact protocol between Tahmoor Colliery and Sydney Water in the events of incidents occurring on site.	Complete	Sydney Water
			Notify residents of potential mine subsidence impacts and contact numbers.	Prior to mine subsidence impacts	Tahmoor Colliery

Hazard / Impact	Risk	Trigger	Control Procedure/s	Frequency	By Whom?
Blockage of pipes due to change of grade	**LOW (6) to MEDIUM (4)**	None	Follow general procedures	-	-
		Ground survey along Carrier pipes indicates grade of pipe is less than 0.2% (2 mm/m) or Ground survey indicates grade of pipe is less than 0.4% (4 mm/m) for all other pipes or Any member of SMG requests a meeting	Convene SMG meeting to consider additional monitoring and mitigation measures based on observed monitoring results, which may include: - increase frequency of surveys along streets - increase frequency of visual inspections - undertake additional CCTV inspections - increase frequency of reporting of results, including calculation of sewer grades - arrangement of equipment to be made available on call for daily tanker flush or high pressure jetting of sewer lines or bypass pump around affected pipe, as per Sydney Water advice for each site - gully pit inspections for any potentially affected property - increase frequency of SMG meetings - any other additional management actions	As required by SMG	SMG
		Blockage or Leakage of sewage observed	Contact Sydney Water as per contact protocol. Clear blockage as required.	As required by Sydney Water	Tahmoor Colliery / Sydney Water
			Investigate cause of sewage leak to ascertain whether leak might be due to subsidence	Within 24 hours	Sydney Water
			If blockage is subsidence related, notify all stakeholders, including Sydney Water, Tahmoor Colliery, Mine Subsidence Board and DTIRIS	Within 24 hours	Sydney Water or Tahmoor Colliery
			Convene SMG meeting to consider additional monitoring and mitigation measures based on observed monitoring results, which may include: - increase frequency of surveys along streets - increase frequency of visual inspections - undertake additional CCTV inspections - increase frequency of reporting of results, including calculation of sewer grades - arrangement of equipment to be made available on call for daily tanker flush or high pressure jetting of sewer lines or bypass pump around affected pipe, as per Sydney Water advice for each site - gully pit inspections for any potentially affected property - increase frequency of SMG meetings - any other additional management actions	As required by SMG	SMG
Physical damage to pipes at existing or new sites	**MEDIUM (4))**	None	Follow general procedures	-	-
		Non-systematic movement detected in ground surveys or Impacts detected from CCTV inspections or Any member of SMG requests a meeting	Convene SMG meeting to consider additional monitoring and mitigation measures based on observed monitoring results: - increase frequency of surveys and inspections at affected site - CCTV inspections of potentially affected pipes - excavate to expose pipe and reduce distortion or strain on pipe - arrange on standby temporary bypass pump sewage around affected area - installation of temporary internal full length or patch lining to pipes - increase frequency of SMG meetings - any other additional management actions	As required by SMG	SMG
		Leakage of sewage observed	Contact Sydney Water as per contact protocol. Clear blockage as required.	As required by Sydney Water	Tahmoor Colliery / Sydney Water
			Investigate cause of sewage leak to ascertain whether leak might be due to subsidence	Within 24 hours	Sydney Water
			If blockage is subsidence related, notify all stakeholders, including Sydney Water, Tahmoor Colliery, Mine Subsidence Board and DTIRIS	Within 24 hours	Sydney Water or Tahmoor Colliery
			Convene SMG meeting to consider additional monitoring and mitigation measures based on observed monitoring results, which may include: - increase frequency of surveys, inspections and reporting - arrangement of equipment to be made available on call for daily tanker flush or high pressure jetting of sewer lines or bypass pump around affected pipe, as per Sydney Water advice for each site - increase frequency of SMG meetings - any other additional management actions	As required by SMG	SMG

4.0 MANAGEMENT PLAN REVIEW MEETINGS

The monitoring of sewer 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 as 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.

5.0 AUDIT AND REVIEW

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.

6.0 RECORD KEEPING

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

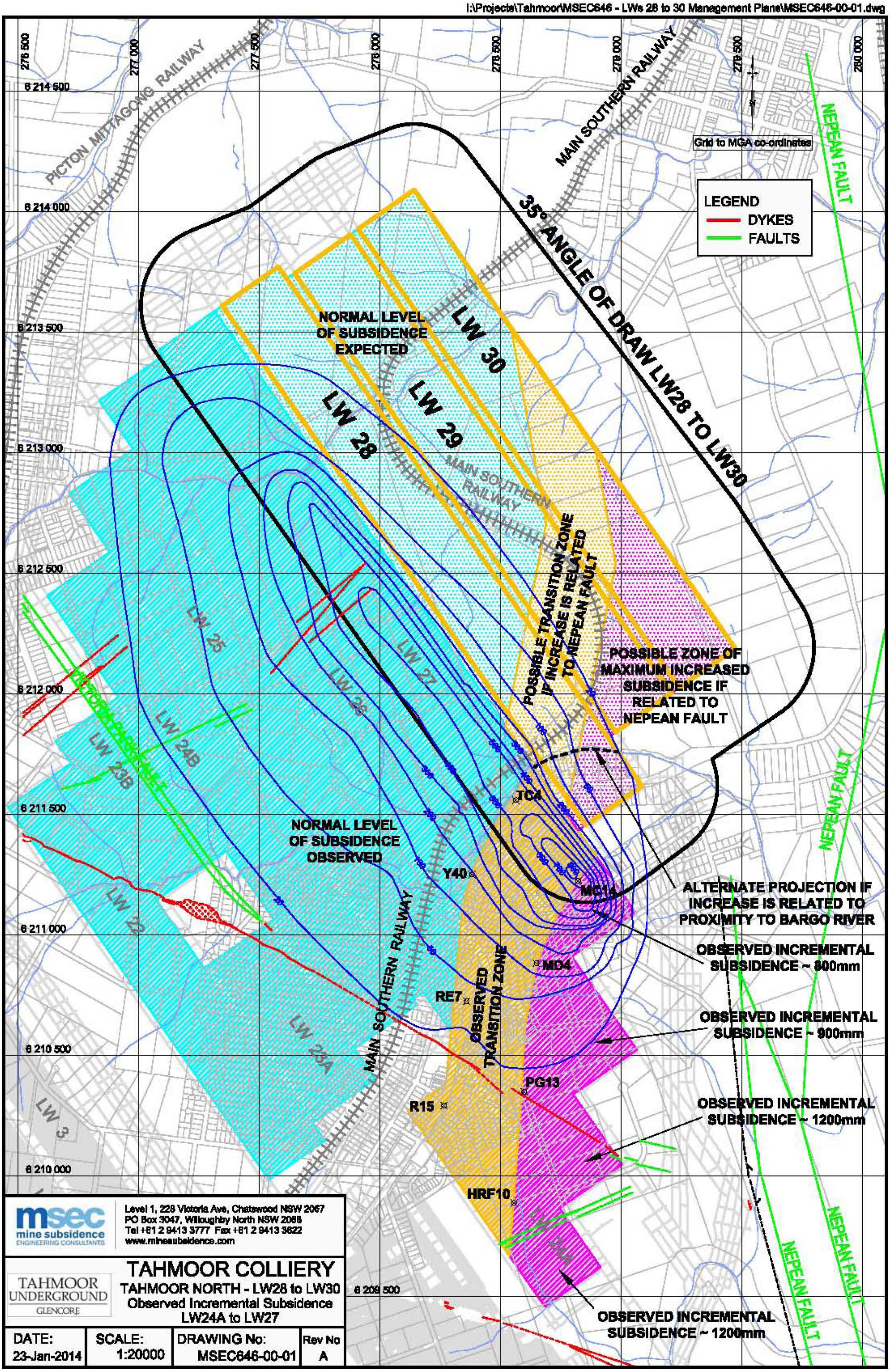
7.0 CONTACT LIST

Organisation	Contact (* SMG Member)	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 0425 275 567	d.bullock@minesub.nsw.gov.au	(02) 4677 2040
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay*	(02) 9413 3777 0416 191 304	daryl@minesubsidence.com	(02) 9413 3822
Sydney Water	Emergency Line	132090	-	-
Sydney Water – Systems Delivery Officer Area Team West	Charlie Kawtal*	(02) 8763 8616	charlie.kawtal@sydneywater.com.au	(02) 8763 8661
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	Belinda.Treverrow@glencore.com.au	(02) 4640 0140
Tahmoor Colliery 24 hour contact	Tahmoor Colliery Control	1800 154 415	-	-

APPENDIX A.

Please find the following report attached:

- Drawings
- Sydney Water, (2010). *Risk Criteria*, Sydney Water, Issue 3, 6 July 2010.



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MAIN SOUTHERN RAILWAY
Grid to MGA co-ordinates
NEPEAN FAULT
LEGEND
DYKES
FAULTS
35° ANGLE OF DRAW LW28 TO LW30
NORMAL LEVEL OF SUBSIDENCE EXPECTED
LW 30
LW 29
LW 28
LW 27
LW 26
LW 25
LW 24B
LW 23B
LW 22
LW 23A
LW 24A
LW 3
VICTORIA PARK FAULT
POSSIBLE TRANSITION ZONE IF INCREASE IS RELATED TO NEPEAN FAULT
POSSIBLE ZONE OF MAXIMUM INCREASED SUBSIDENCE IF RELATED TO NEPEAN FAULT
NORMAL LEVEL OF SUBSIDENCE OBSERVED
TC4
Y40
MC11
MD4
RE7
PG13
R15
HRF10
OBSERVED TRANSITION ZONE
ALTERNATE PROJECTION IF INCREASE IS RELATED TO PROXIMITY TO BARGO RIVER
OBSERVED INCREMENTAL SUBSIDENCE ~ 800mm
OBSERVED INCREMENTAL SUBSIDENCE ~ 900mm
OBSERVED INCREMENTAL SUBSIDENCE ~ 1200mm
OBSERVED INCREMENTAL SUBSIDENCE ~ 1200mm
msec
mine subsidence
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www.minesubsidence.com
TAHMOOR UNDERGROUND
GLENCORE
TAHMOOR COLLIERY
TAHMOOR NORTH - LW28 to LW30
Observed Incremental Subsidence
LW24A to LW27
DATE:
23-Jan-2014
SCALE:
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Rev No
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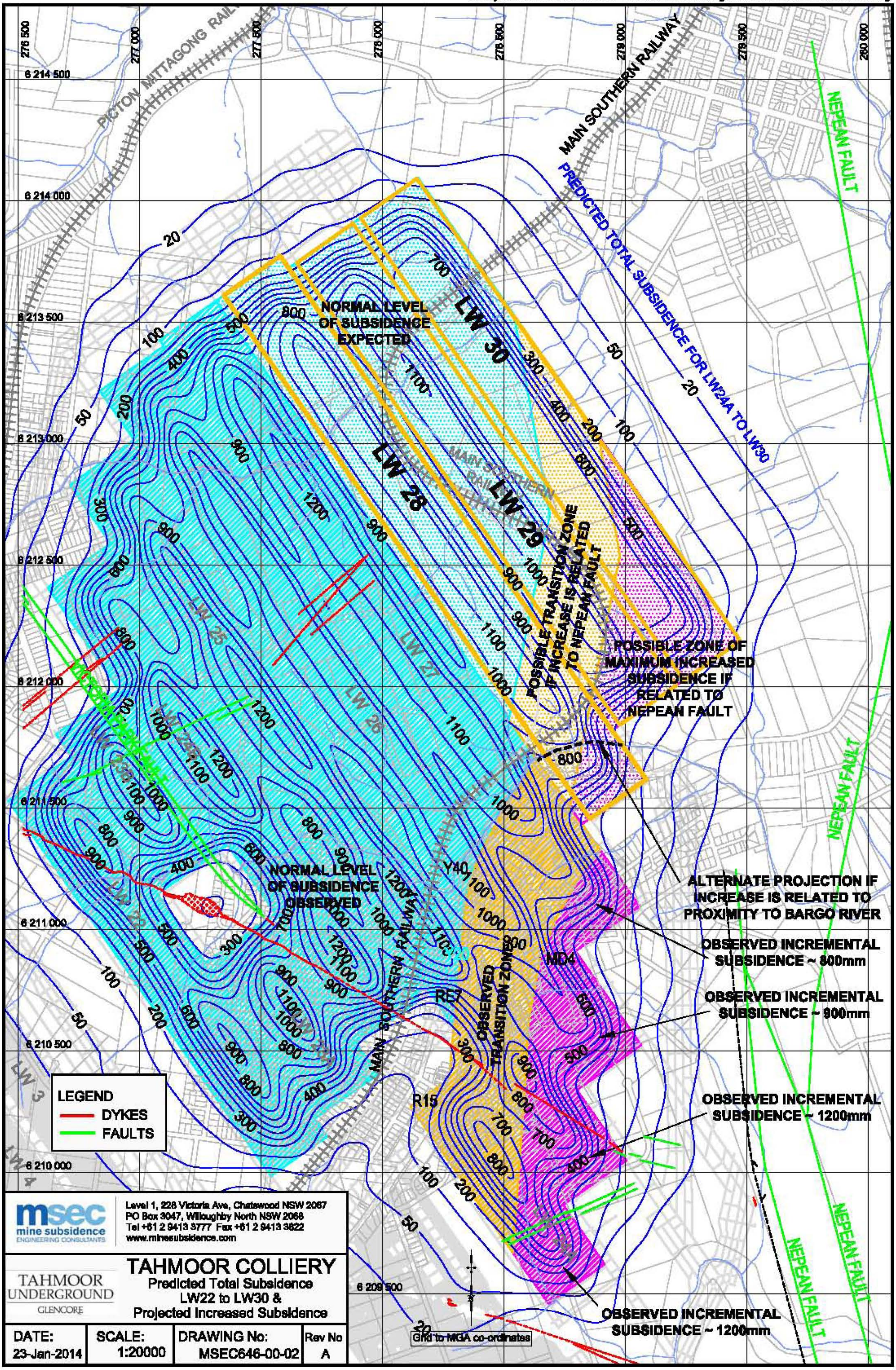

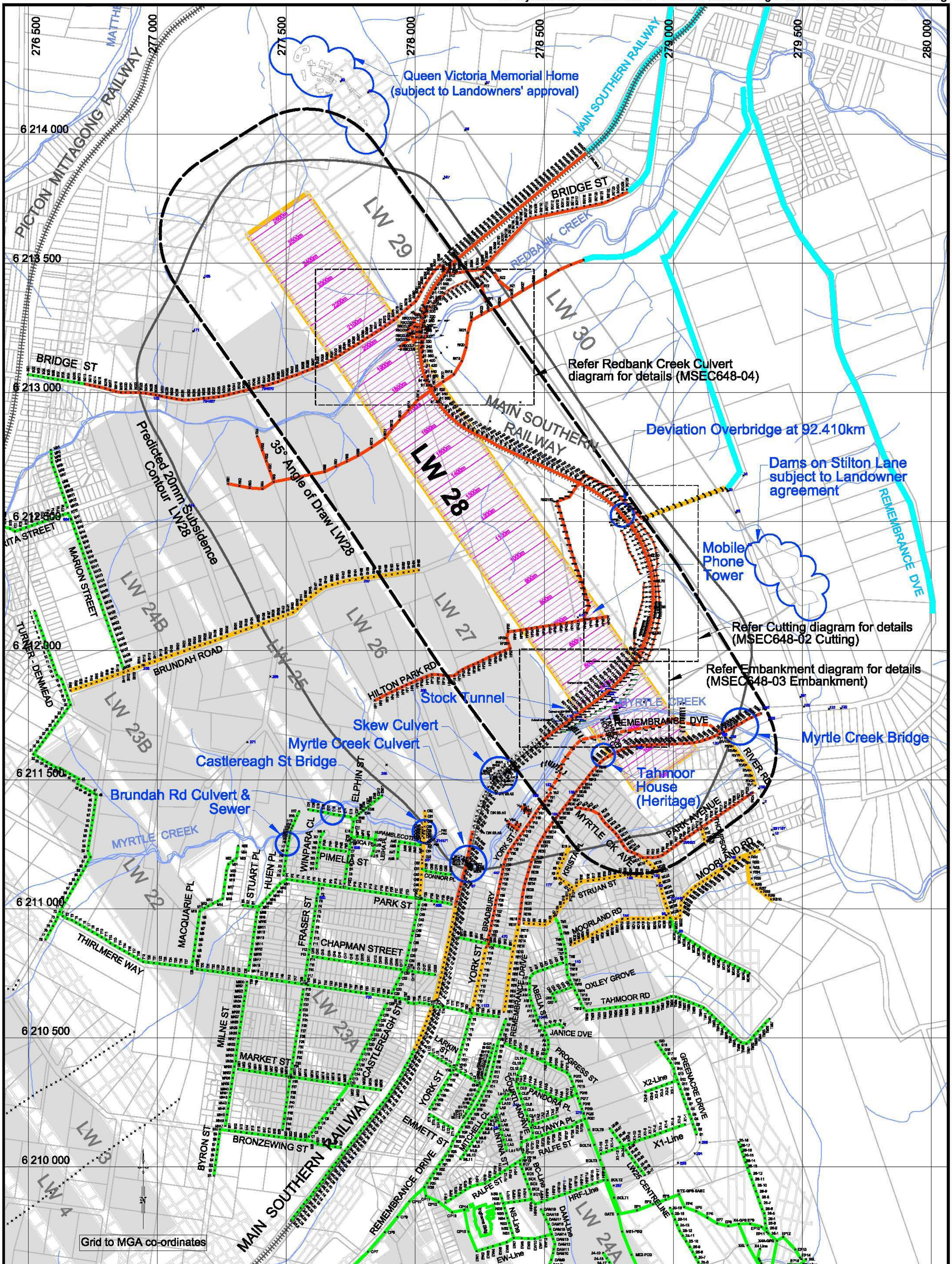

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TAHMOOR UNDERGROUND
GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30 MONITORING OVER LW28

DATE:	SCALE:	DRAWING No:	Rev No
5-Feb-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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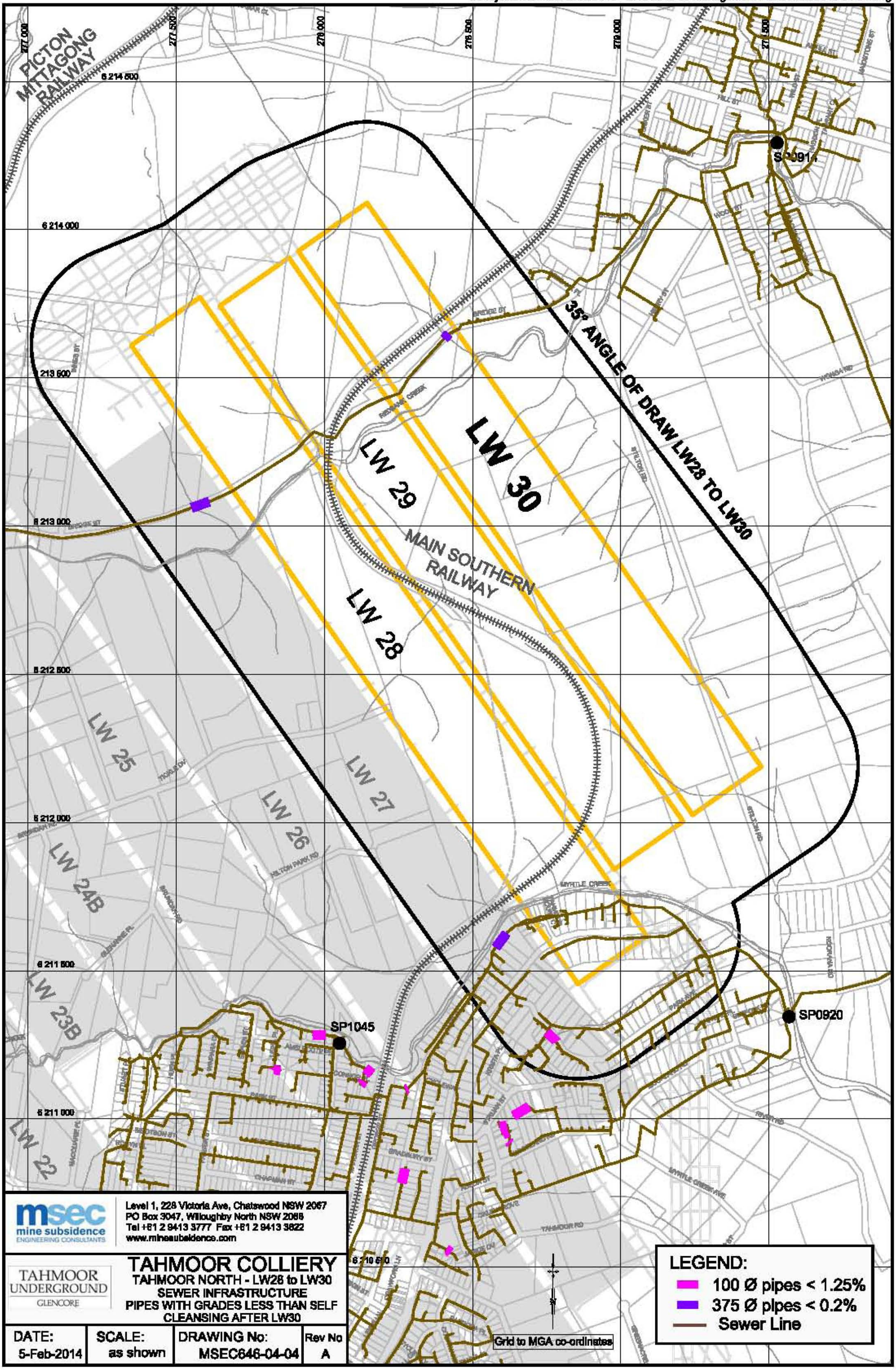

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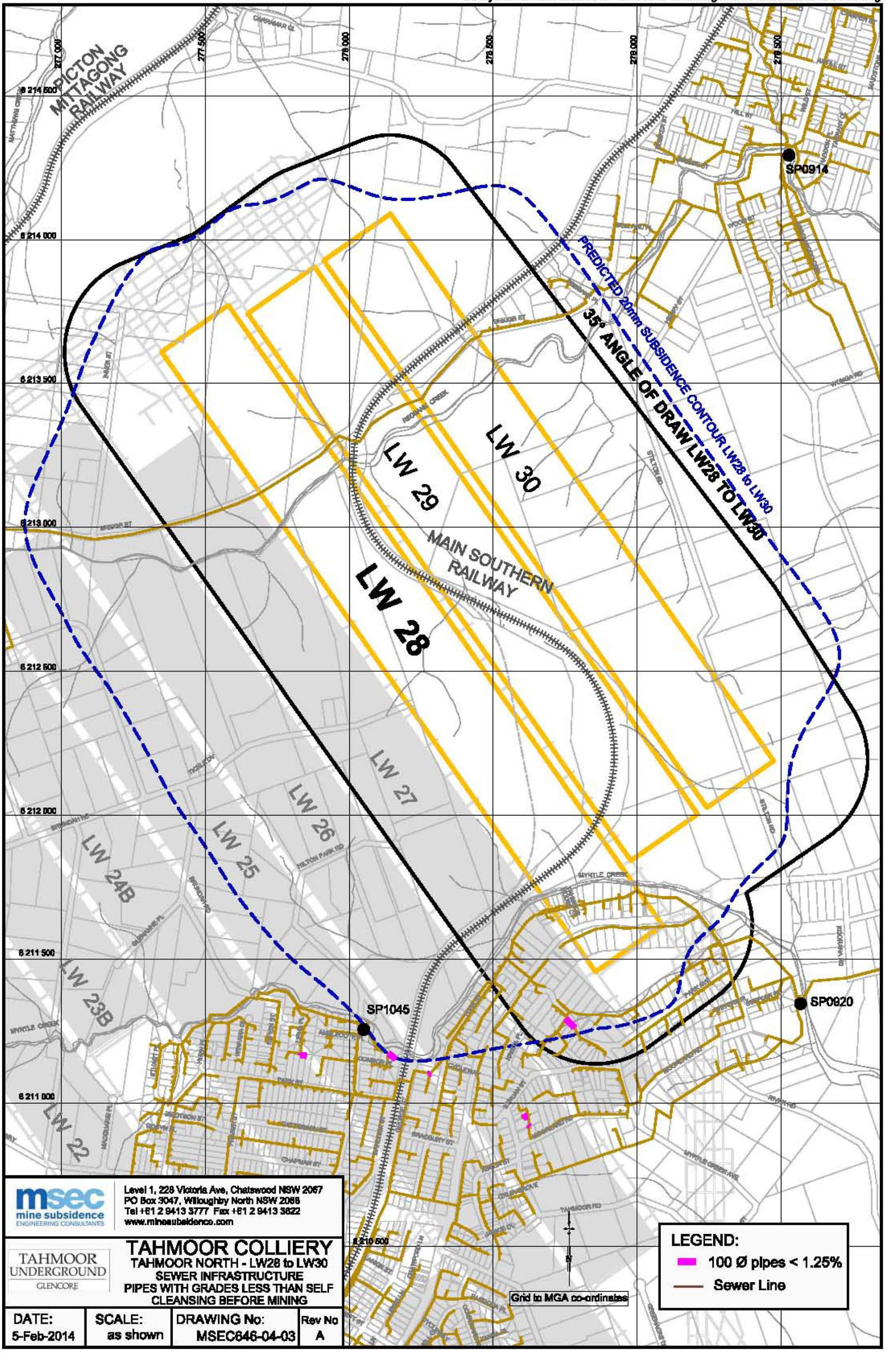

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TAHMOOR UNDERGROUND
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TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30
SEWER INFRASTRUCTURE
PIPES WITH GRADES LESS THAN SELF CLEANSING BEFORE MINING

DATE:	SCALE:	DRAWING No:	Rev No
5-Feb-2014	as shown	MSEC646-04-03	A

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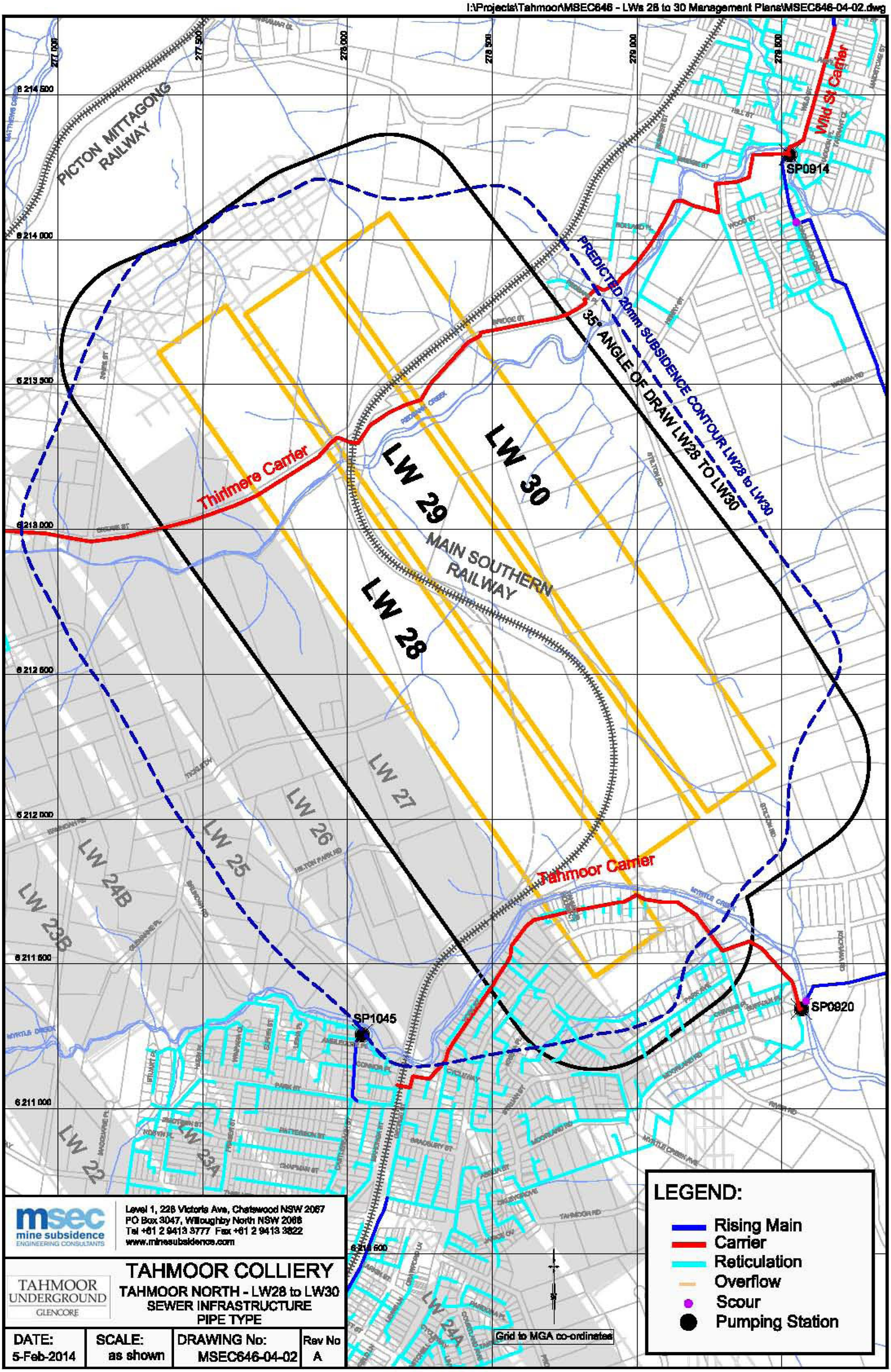

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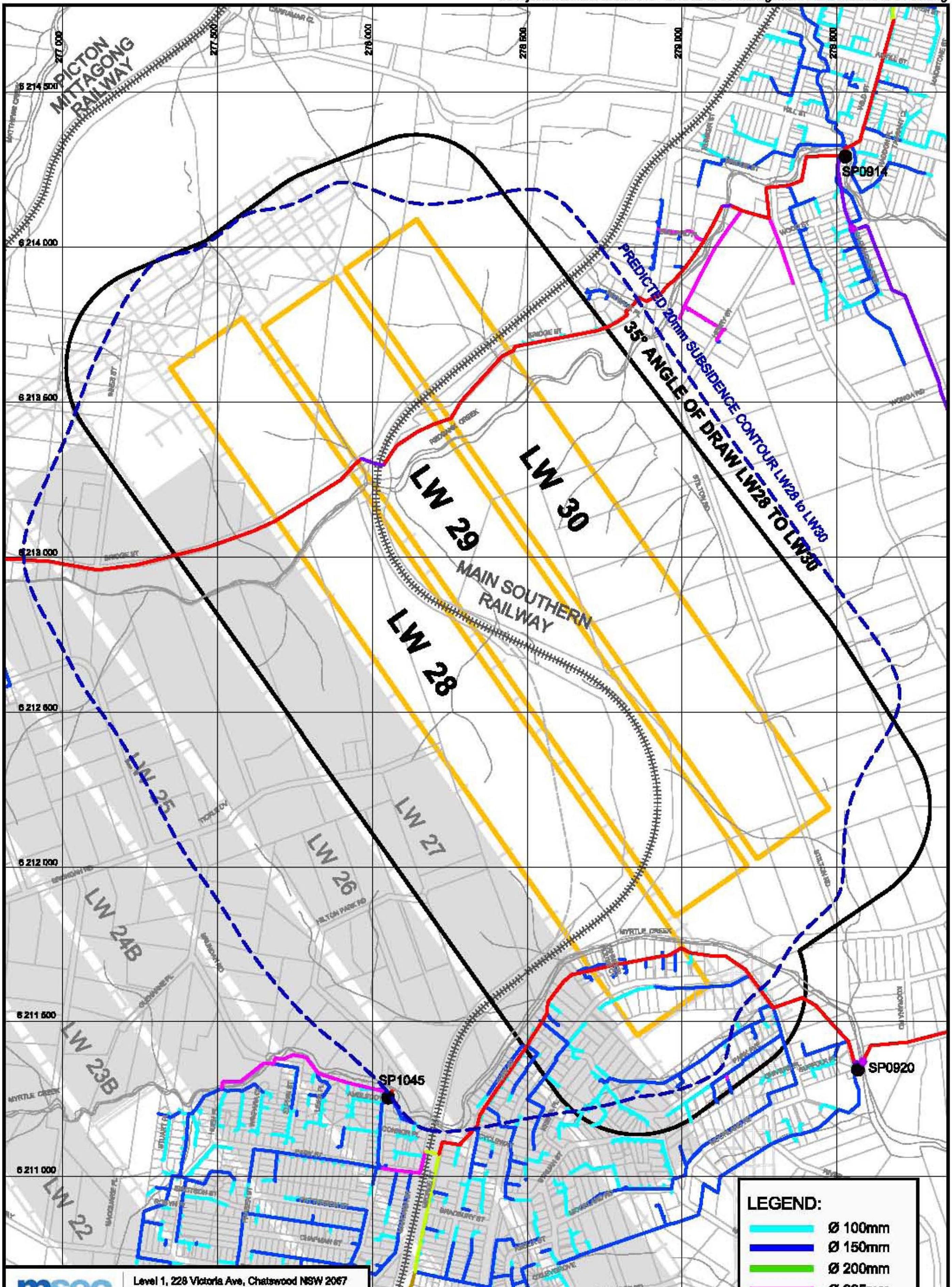

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TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30
SEWER INFRASTRUCTURE
PIPE SIZE

DATE:	SCALE:	DRAWING No:	Rev No
5-Feb-2014	as shown	MSEC646-04-01	A

Risk Criteria

Level of Risk Matrix

	Very Likely	Likely	Unlikely	Very Unlikely
Catastrophic	1	1	2	3
Severe	1	2	3	4
Moderate	2	3	4	5
Minor	3	4	5	6
Insignificant	4	5	6	6

Likelihood Descriptions

Levels	Description
Very Likely	The event could happen > 90% of the time within a 12-month period.
Likely	The event could happen 50% - 90% of the time within a 12-month period.
Unlikely	The event could happen 10% - 50% of the time within a 12-month period.
Very Unlikely	The event could happen < 10% of the time within a 12-month period.

Consequence Categories

Assessment	Financial [1]	Political / Reputation	Environment	Safety (Sydney Water & Public Safety)	Customers	Public Health	Performance [2]	Compliance
Catastrophic Very High impact with very significant consequences	Corporate: > $100m cost increase >$250m revenue loss Project: Cost overrun >= 50% of project budget	Widespread loss of confidence by Govt and community. Sustained key adverse media.	Large scale, irreversible, adverse impact to environment.Very significant impact on threatened species or critical habitat eg sustained dry weather overflow in protected bushland.	Fatality, amputation of limb, person on life support, other immediately life threatening incidents. Widespread serious injuries or illnesses.	Complete disruption to services > 1 week; Affects > 30% of SWC customers.	Widespread illness / fatalities.	Very significant and unmananagable disruption of critical processes. Majority of key objectives and/or KPIs cannot be achieved. Very significant impact on resource use and/or benefits not realised.	Significant compliance breach - may result in: Operating Licence sanction. High-impact prosecution eg Tier 1 POEO Act offence or Workcover criminal offence..
Severe High impact with major consequences	Corporate: > $50m - $100m cost increase >$100m - $250m revenue loss Project: Cost overrun > 20% and < 50% of project budget	Considerable Govt and community concern. Key adverse media.	Large scale, long-term (>2 years), adverse impact to environment.Significant impact on areas of high heritage or ecological value (aquatic or terrestrial) eg spillage of raw sewage or chemicals into a waterway resulting in a major aquatic life kill; Water quality impacts to Special or Protected waters.	A serious injury or long term illness, or lost time injury (minimum 1 day lost per injury).	Partial disruption > 2 days; Affects 10% to 30% of Customers; Widespread complaints.	Serious illness requiring hospitalisation.	Major disruption to critical processes. Key objectives and KPIs cannot be achieved. Significant impact on resource use and/or benefits not realised.	Compliance breach - may result in severe enforcement action, regulatory sanction or prosecution eg Tier 2 POEO Act offence or Workcover prosection..
Moderate Noticeable impact with clearly visible consequences	Corporate: > $10m - $50m cost increase > $50m - $100 revenue loss Project: Cost overrun > 10% and < 20% of project budget	Some public concern raised. Adverse local media.	Small scale, medium-term (1-2 years), impact to environment eg native vegetation that provides habitat for important species is cleared or damaged within a National Park; spillage of partially treated sewage into a waterway.	Significant near miss incident; Injury or illness requiring medical treatement.	Unreliable Services; Increase in number of Complaints; Multiple and repeat customer Complaints;. 5% to 10% of customers affected.	Deterioration in water quality parameters. Reportable event. Increase in illness.	Non-performance of critical processes. Objectives and KPIs cannot be achieved. Noticable impact on resource use and/or benefits not realised.	Compliance breach - may result in Ministerial requirement, enforceable undertaking or statutory fine eg POEO Act or Workcover Penalty Infringement Notice.
Minor Minor impact with some consequences	Corporate: > $5m - $10m cost increase > $25m - $50m revenue loss Project: Cost overrun > 5% and < 10% of project budget	Minor public concern.	Small scale, short-term (<1 year), reversible impact to environment that is contained & readily remediated eg minor damage to a heritage building.	Illness or injury requiring first aid eg minor burns, abrasions, sprains.	Some customer complaints.	Deterioration in water quality parameters. Reportable event. No increase in illness.	Limited non-performance of critical processes, objectives and KPIs. Limited impact on resource use and/or benefits not realised.	Compliance breach -may result in minor corrective action or business requirement.
Insignificant Very minor impact with unimportant consequences	Corporate: < $5m cost increase <$25m revenue loss Project: Cost overrun < 5% of project budget	Minimal public concern.	Temporary, reversible, environmental degradation, quickly contained & immediately restored eg no discernable change.	Near misses incidents.	Isolated customer complaints.	Non-reportable event.	Very minor non-performance of critical processes, objective and KPIs. Very minor impact on resource use and/or benefits not realised.	Technical compliance breach with limited material impact.

1 Financial limits for projects are a guide only. Actual amounts should be set at an appropriate level (based on business case value) for each individual project prior to conducting a risk assessment.
2 Performance category descriptions are a guide only and may be further enhanced by divisional procedures.

Required Management Actions

Risk Rating	Level	Report to	Level	Management Action	Timeframe: Corporate (strategic, divisional, non-project operational)	Timeframe: Project [1]
1	Very High	Division Head / appropriate level manager	Intolerable	Immediate action to eliminate risk or reduce to acceptable level.	Implementation: Immediate Review: Weekly	
2 & 3	High	Division Head / appropriate level manager	Conditionally tolerable	Conditionally tolerable if all reasonably practical measures to treat the level of risk are implemented. Where reasonably practical measures can be applied, additional action required to reduce level of residual risk.	Implementation: 6 months Review: Quarterly	Implementation: 3 months Review: Key Project Milestones
4 & 5	Medium	Senior Manager / appropriate level manager	Conditionally tolerable	Conditionally tolerable if all reasonably practical measures to treat the level of risk are implemented. Maintain watching brief, 6-monthly review by management. Where reasonably practical measures can be applied, longer term additional action required to reduce level of residual risk.	Implementation: 12 months Review: 6 monthly	Implementation: 6 months Review: Key Project Milestones
6	Low	Immediate Supervisor	Tolerable	All reasonably practical measures to reduce level of risk have been implemented – monitoring action required.	N/A	N/A

[1] Timeframes for management actions related to projects are a guide only and should be revised based on the length and complexity of the project.

Control Effectiveness Criteria

Definition of Control

“An existing process, policy, device, practice or other action that acts to minimize negative impacts or enhance positive opportunities” (AS/NZS 4360:2004)

Control Elements

For a control to be effective it must have the following elements:

- Relevance — Direct relationship to risk reduction, pertinent
- Independence — Not dependent upon other controls or a combination of controls to reduce risk
- Integrity — Soundness of operation, unimpaired, in perfect condition

Category	Indicative Risk Reduction	Safety Example	Business Example
Very Effective	Will reduce likelihood or consequence by 3 cells ie. Reduces risk by > 97 %	Elimination, Substitution and Engineering Controls	A full automated system directly addressing the risk
Effective	Will reduce likelihood or consequence by 2 cells ie. Reduces risk by 60 to 97 %		A well implemented system requiring considerable staff input
Partly Effective	Will reduce likelihood or consequence by 1 cell ie. Reduces risk by 40 to 60 %	Administrative controls: • Training • Documented procedures • Signs	A well implemented paper based process. Tailored training specific to reduce risk
Only effective in combination	A pair of controls will reduce likelihood or consequence by 1 cell ie. Reduces risk by 20 to 40 %		General training, infrequently used procedures and awareness programs
Minimal risk reduction	Only many controls will reduce likelihood or consequence by 1 cell ie. Reduces risk by < 20 %	Personal Protective Equipment	Interdependent, irrelevant or low integrity controls