REPORT: SEWER SUBSIDENCE MANAGEMENT PLAN

mine subsidence ENGINEERING CONSULTANTS

TAHMOOR UNDERGROUND

GLENCORE

GLENCORE:

Tahmoor Colliery – Longwall 31

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
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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
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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
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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
Mar-17	MSEC862-04	A	Updated for Longwall 31
Mar-17	MSEC862-04	B	Updated following consultation with Sydney Water

References:-

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

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

Sydney Water Risk Criteria, 6 July 2010

CONTENTS

LIST OF TABLES, FIGURES AND DRAWINGS

Tables

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

Figures

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

Drawings

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

1.0 INTRODUCTION

1.1. Background

Tahmoor Colliery is located approximately 80 km south-west of Sydney in the township of Tahmoor NSW. It is managed and operated by Glencore. Tahmoor Colliery has previously mined 29 longwalls to the north and west of the mine's current location. It is currently mining Longwall 30.

Longwall 31 is a continuation of a series of longwalls that extend into the Tahmoor North Lease area, which began with Longwall 22. The longwall panels are located between the Bargo River in the south-east, the township of Thirlmere in the west and Picton in the north. Longwall 31 is located beneath the rural area of Tahmoor and part of the South Picton industrial area, and sewer infrastructure owned by Sydney Water is located within this area.

A summary of the dimensions of Longwall 31 is provided in Table 1.1.

Table 1.1 Longwall dimensions

Longwall	Overall void length including the installation heading (m)	Overall void width including the first workings (m)	Overall tailgate chain pillar width (m)
Longwall 31	2448	283	39

This Management Plan provides detailed information about how the risks associated with mining beneath the 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 to roads, bridges and culverts.

The objectives of the Plan have been developed to:

- Ensure the safe and serviceable operation of all surface infrastructure. Public and workplace safety is paramount. Disruption and inconvenience should be kept to minimal levels;
- Monitor ground movements and the condition of surface infrastructure during mining;
- Initiate action to mitigate or remedy potential significant impacts that are expected to occur on the surface;
- Provide a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted;
- Provide a forum to report, discuss and record impacts to the surface. This will involve Tahmoor Colliery, Sydney Water, relevant government agencies and consultants as required; and
- 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 Sydney Water sewer infrastructure identified to be at risk due to mine subsidence.

The Management Plan only covers the sewer infrastructure that is located within the limit of subsidence, which defines the extent of land that may be affected by mine subsidence as a result of mining Longwall 31 only. The management plan does not include other infrastructure owned by Sydney Water that lie outside the extent of this area.

This Management Plan does not include the Sydney Water Picton Water Recycling Plant (PWRP) as it is managed by a different section of Sydney Water. A separate management plan has been prepared for the PWRP. The operation of the Plant is, however, critical to the operation of the sewerage system and both sections of Sydney Water will be kept informed of observations from monitoring both the sewerage system and the PWRP.

This Management Plan does not include the Sydney Water potable water infrastructure. That infrastructure is included in a separate management plan

1.5. Description of the sewer infrastructure

Sydney Water has an extensive sewage disposal network in the urban areas of Tahmoor and Thirlmere. 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 sewer pipelines are shown in Drawing No. MSEC862-03-01 grouped by pipe size and in Drawing No. MSEC862-03-02 grouped by pipe type. This infrastructure located above and adjacent to Longwall 31 comprise the Thirlmere Carrier pipeline along Bridge Street (375 mm diameter) and the associated reticulation and sideline pipelines along Redbank Place, Bridge Street and Henry Street (100 to 225 mm diameter).

The rising main to the Picton Water Recycling Plant is located outside the extents of Longwall 31 at a minimum distance of 420 m. The rising main and associated pumping stations are located outside the predicted limit of vertical subsidence for Longwall 31.

The design for the gravity sewer system was approved by the Mine Subsidence Board (now Subsidence Advisory NSW), 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.

1.6. Proposed Mining Schedule

It is planned that Longwall 31 will extract coal working north-west from the south-eastern end. This Management Plan covers longwall mining until completion of mining in Longwall 31 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 31	July 2017	July 2018

The above schedule is subject to change due to unforeseen impacts on mining progress. Tahmoor Colliery will keep Sydney Water informed of changes.

1.7. 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 a distance of 150 m in front of the longwall face to a distance of 450 m 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 m in front and 450 m behind the active longwall face, as shown by Fig. 1.1.

Fig. 1.1 Diagrammatic representation of the active subsidence zone

1.8. Compensation

The Mine Subsidence Compensation Act 1961 (MSC Act) is administered by Subsidence Advisory NSW (Mine Subsidence Board). Currently, under the Mine Subsidence Compensation Act 1961, any claim for mine subsidence damage needs to be lodged with Subsidence Advisory NSW. Subsidence Advisory NSW staff will then assess the damage to determine the cause. If the damage is determined to be attributable to mine subsidence, a scope will be prepared and compensation will be assessed.

2.1. Maximum predicted conventional parameters

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

A summary of the maximum predicted incremental conventional subsidence parameters, due to the extraction of Longwall 31 only, is provided in Table 2.1. A summary of the maximum predicted total conventional subsidence parameters, after the extraction of Longwall 31, is provided in Table 2.2.

Table 2.1 Maximum predicted incremental conventional subsidence parameters due to the extraction of Longwall 31

Longwall	Maximum predicted incremental subsidence (mm)	maximum predicted incremental tilt (mm/m)	Maximum predicted incremental hogging curvature (1/km)	Maximum predicted incremental sagging curvature (1/km)
Due to LW31	725	5.5	0.06	0.12

Table 2.2 Maximum predicted total conventional subsidence parameters after the extraction of Longwall 31

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (1/km)	Maximum predicted total sagging curvature (1/km)
After LW31	1225	6.0	0.09	0.13

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

2.2. Observed subsidence during the mining of Longwalls 22 to 30

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

However, observed subsidence was greater than the predicted values over Longwalls 24A and the southern parts of Longwalls 25 to 27. Monitoring during the mining of Longwalls 28 to 30 has found that subsidence behaviour has returned to normal levels.

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

2.3. 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).

2.3.1. 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 Longwalls 22 to 28 at Tahmoor Colliery, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls, which has been referred to as "*above goaf*".

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf at Tahmoor Colliery is provided in Fig. 2.1. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

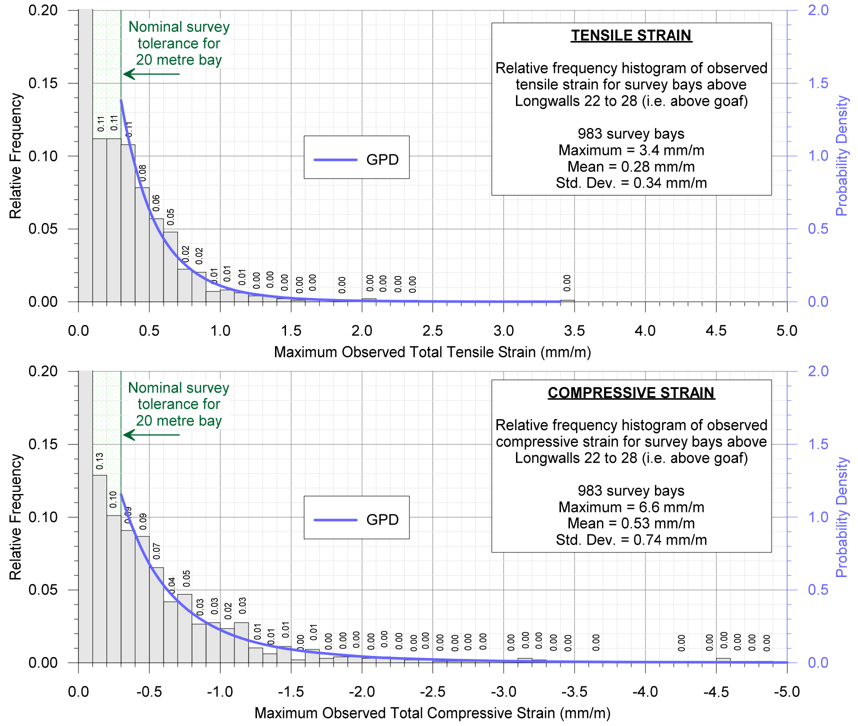

Fig. 2.1 Distributions of the measured maximum tensile and compressive strains for surveys bays located above goaf

The 95 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining are 0.9 mm/m tensile and 1.8 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining are 1.5 mm/m tensile and 3.5 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 Longwalls 22 to 28 at Tahmoor Colliery, 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 at Tahmoor Colliery is provided in Fig. 2.2. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

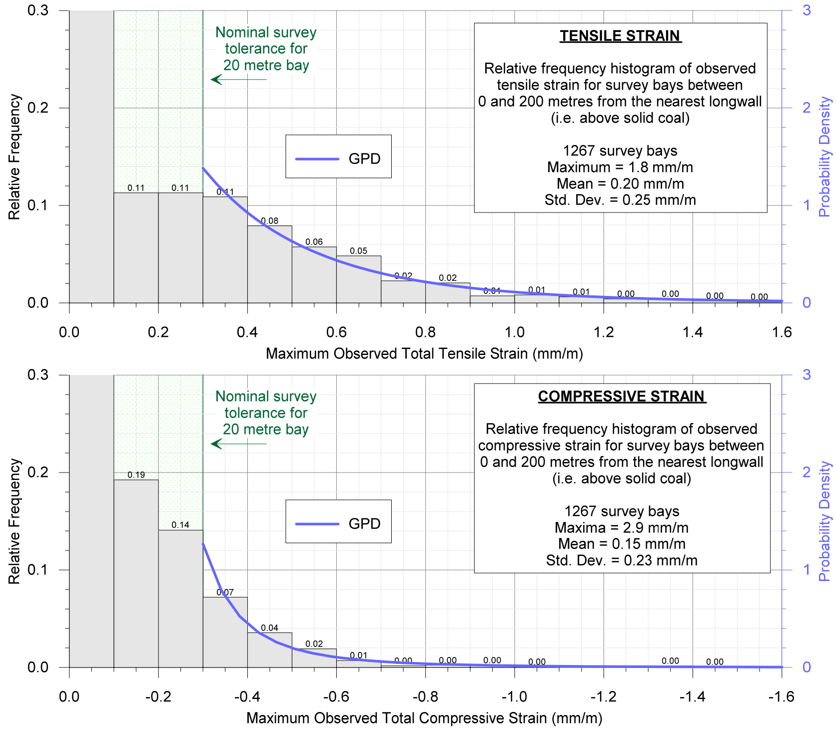

Fig. 2.2 Distributions of the measured maximum tensile and compressive strains for survey bays located above solid coal

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

2.3.2. 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 Longwalls 22 to 28 at Tahmoor Colliery, is provided in Fig. 2.3.

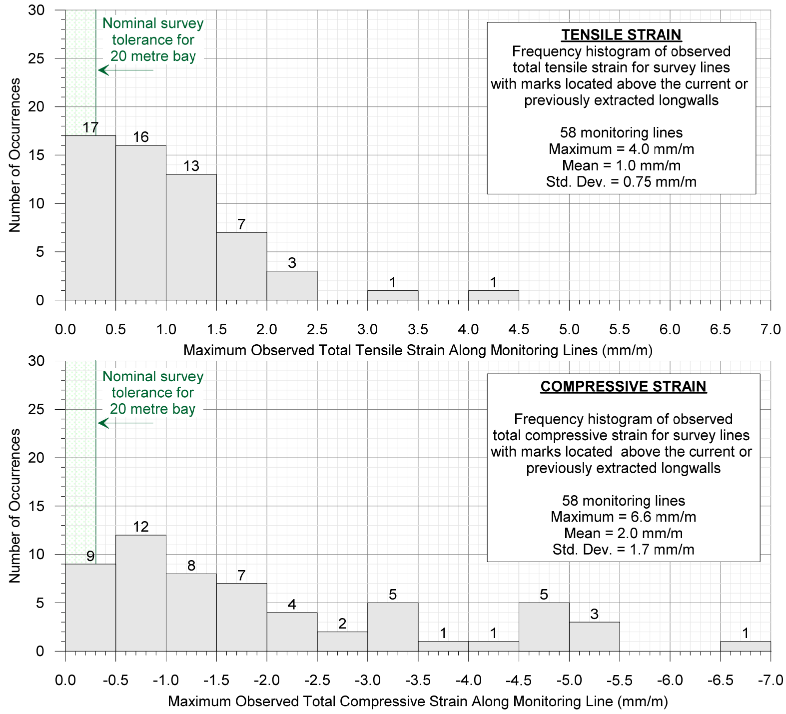

Fig. 2.3 Distributions of measured maximum tensile and compressive strains anywhere along the monitoring lines

It can be seen from Fig. 2.3, that 33 of the 58 monitoring lines (i.e. 57 %) had recorded maximum total tensile strains of 1.0 mm/m, or less, and that 53 monitoring lines (i.e. 91 %) had recorded maximum total tensile strains of 2.0 mm/m, or less. It can also be seen from this figure, that 36 of the 58 monitoring lines (i.e. 62 %) had recorded maximum compressive strains of 2.0 mm/m, or less, and that 48 of the monitoring lines (i.e. 83 %) had recorded maximum compressive strains of 4.0 mm/m, or less.

2.4. Predicted and observed valley closure across creeks

The Thirlmere Carrier pipeline along Bridge Street crosses a 'hidden creek' outside and adjacent to the maingate of Longwall 31. The predicted valley related effects in this location are provided later in this Management Plan. There are no other locations identified where the sewer pipelines cross creeks within the predicted limit of vertical subsidence.

3.1. NSW Work Health & Safety Legislation

All persons conducting a business or undertaking (PCBUs), including mine operators and contractors, have a primary duty of care to ensure the health and safety of workers they engage, or whose work activities they influence or direct. The responsibilities are legislated in *Work Health and Safety Act 2011* and the *Work Health and Safety (Mines) Act 2013* and associated Regulations (collectively referred to as the 'WHS laws').

The Work Health and Safety (Mines) Regulation 2014 commenced on 1 February 2015 and contains specific regulations in relation to mine subsidence.

As outlined in the Guide by the NSW Department of Trade & Investment Mine Safety:

"a PCBU must manage risks to health and safety associated with mining operations at the mine by:

- *complying with any specific requirements under the WHS laws*
- *identifying reasonably foreseeable hazards that could give rise to health and safety risks*
- *ensuring that a competent person assesses the risk*
- *eliminating risks to health and safety so far as is reasonably practicable*
- *minimising risks so far as is reasonably practicable by applying the hierarchy of control measures, any risks that it is are not reasonably practical to eliminate*
- *maintaining control measures*
- *reviewing control measures.*

The mine operator's responsibilities include developing and implementing a safety management system that is used as the primary means of ensuring, so far as is reasonably practicable:

- *the health and safety of workers at the mine, and*
- *that the health and safety of other people is not put at risk from the mine or work carried out as part of mining operations."*

This Management Plan documents the risk control measures that are planned to manage risks to health and safety associated with the mining of Longwall 31 in accordance with the WHS laws.

3.2. General

The method of assessing potential mine subsidence impacts in the Management Plan is consistent with the Australian/New Zealand Standard for Risk Management. The Standard defines the terms used in the risk management process, which includes the identification, analysis, assessment, treatment and monitoring of potential mine subsidence impacts. In this context:

3.2.1. Consequence

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

3.2.2. Likelihood

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

3.2.3. Hazard

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

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

3.2.4. Method of assessment of potential mine subsidence impacts

The method of assessing potential mine subsidence impacts combines the likelihood of an impact occurring with the consequence of the impact occurring. In this Management Plan, the likelihood and consequence are combined via Sydney Water's Risk Criteria, Issue C, dated 6 July 2010. The Risk Criteria document is attached as an appendix to this Management Plan.

The sewer pipelines located above and adjacent to Longwall 31 generally follow the alignments of the local roads. The maximum predicted subsidence parameters for these pipelines, therefore, are similar to those predicted for the roads.

A summary of the maximum predicted conventional subsidence, tilt and curvature for the sewer pipelines, after the extraction of Longwall 31, is provided in Table 4.1. The values are the maximum predicted parameters anywhere along the sections of pipelines located within the predicted limit of vertical subsidence for Longwall 31.

Table 4.1 Maximum predicted total conventional subsidence, tilt and curvature for the pipelines

Pipeline located adjacent to road	Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (1/km)	Maximum predicted total sagging curvature (1/km)
Thirlmere Carrier along Bridge Street	After LW31	1225	5.5	0.09	0.13
Reticulation and sideline along Redbank Place	After LW31	225	2.0	0.03	0.01
Reticulation and sideline along Bridge and Henry Streets	After LW31	60	< 0.5	0.01	< 0.01

The rising main to the Picton Water Recycling Plant (PWRP) is located outside the 35° angle of draw line and the predicted 20 mm vertical subsidence contour. This pipeline, therefore, is predicted to experience less than 20 mm vertical subsidence due to the extraction of Longwall 31. Whilst the Rising Main could experience very low levels of vertical subsidence, it is not expected to experience measurable tilts, curvatures or strains. Sydney Water advises that the rising main Tahmoor, Buxton and Bargo has been permanently elevated above ground for the last few hundred metres at the connection to the PWRP as part of the PWRP upgrade works. The rising main from Picton and Thirlmere is an older asbestos lined pipe.

Survey lines have been installed within PWRP land to track potential mine subsidence impacts on the PWRP. The survey lines cross over the rising mains and the results will be provided to the Sydney Water – Systems Delivery Officer for Area Team West. The locations of the survey line is provided in Drawing No. MSEC862-00-01, which is included in the Appendix of this Management Plan. The northernmost survey along the dam wall crosses a small tributary and results from this survey will be relevant to the Picton Rising Main, which crosses the same tributary immediately downstream of the survey line. Visual inspections will also be undertaken on PWRP land to detect leaks during the extraction of Longwall 31.

The predicted profiles of conventional subsidence and change in grade for the Thirlmere Carrier pipeline are shown in Fig. 4.1. The predicted total profiles after the completion of Longwall 30 are shown as the solid cyan lines. The predicted incremental profiles due to the extraction of Longwall 31 only are shown by the black dashed lines. The predicted total profiles after the completion of Longwall 31 are shown as the solid blue lines.

The pre-mining grade (green line) and the predicted post-mining grades after the completion of Longwall 30 (cyan line) and Longwall 31 (blue line) for the Thirlmere Carrier pipeline are shown in the bottom graph in Fig. 4.1. The predicted post-mining grades for the pipeline are greater than the self-cleansing grade after the completion of Longwall 31. The grade of the pipeline in one location above Longwall 30 is slightly less than the self-cleansing grade after the completion of that longwall, however, it increases above the self-cleansing grade after the completion of 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. Sydney Water reports that no odour issues have been reported for the section of the Carrier pipe directly above Longwalls 29 to 31.

The maximum predicted tilts for the reticulation and sideline pipelines are 2 mm/m along Redbank Place and less than 0.5 mm/m along Bridge and Henry Streets. The design grades of the sewer pipes are greater than 13 mm/m, which are much greater than the maximum predicted tilts.

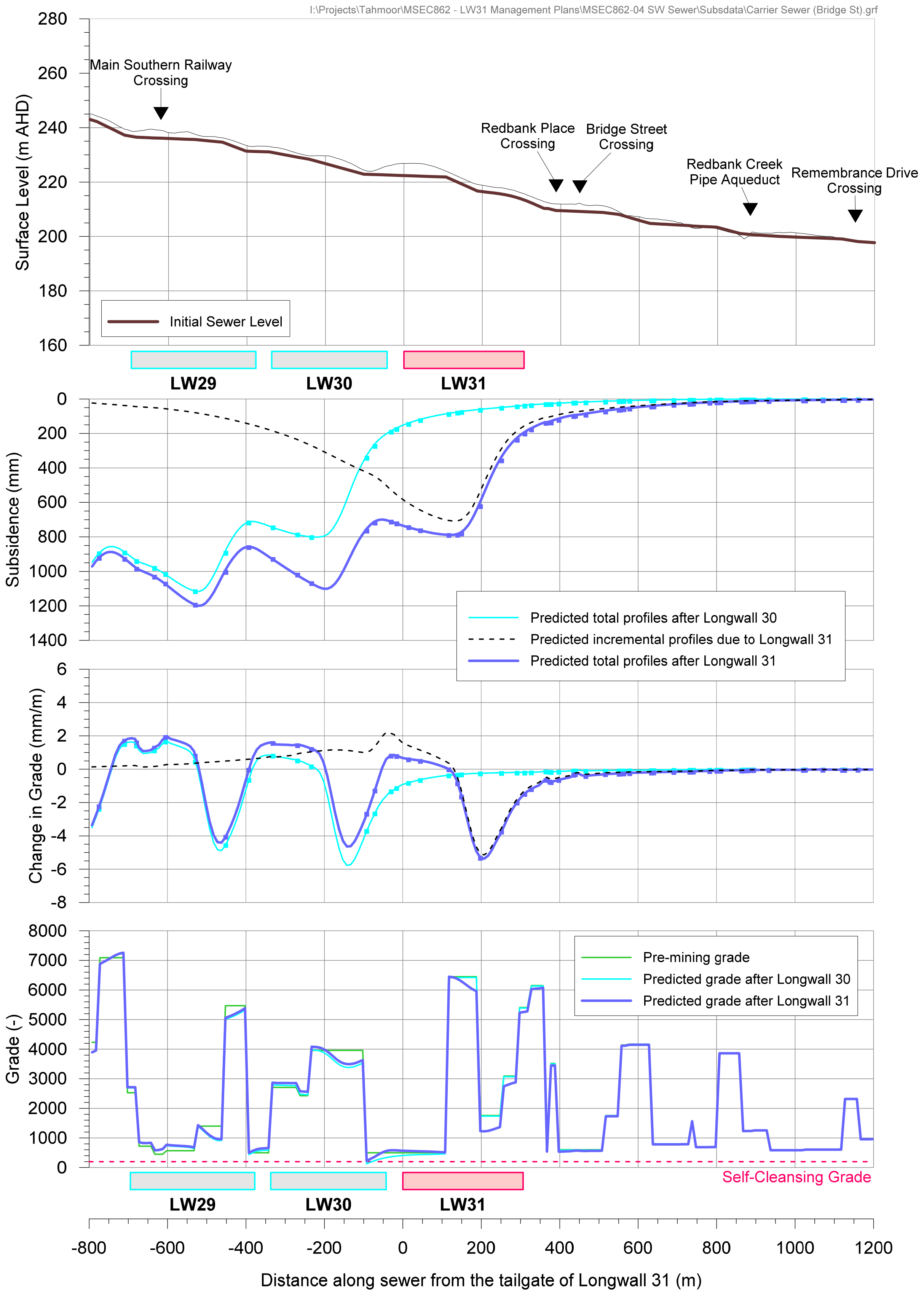

Fig. 4.1 Predicted profiles of total subsidence and change in grade for the Thirlmere Carrier pipeline along Bridge Street due to the mining of Longwalls 22 to 31

The maximum predicted subsidence parameters for the sewer pipelines are similar to the maxima predicted for the pipelines above the previously extracted longwalls at Tahmoor Colliery. Longwalls 22 to 30 have directly mined beneath approximately 29 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 29 where specific ground surveys were undertaken to confirm that mining-induced tilts reduced but do not reverse pre-mining grades. This includes the Thirlmere Carrier pipe along Bridge Street, which is currently experiencing active subsidence from the extraction of Longwall 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 m 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 m 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. 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.

- *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 on the sewer pipelines, to date, have been within expectations.

It is possible, but unlikely, that minor adverse impacts could occur to the sewer pipelines that are located directly above or immediately adjacent to Longwall 31, similar to those observed above the previously extracted longwalls. It is expected that the impacts would comprise relatively minor leaks and that these could be readily repaired.

The Thirlmere Carrier pipeline crosses a 'hidden creek' near Redbank Place, outside and adjacent to the maingate of Longwall 31, as shown in Drawing No. MSEC862-04-01. This pipeline could experience valley related effects in this location. The predicted closure at the creek crossing after the completion of Longwall 31 is 160 mm.

Additional studies have been undertaken to assess the likelihood of valley closure developing at this location.

- A statistical analysis of observed valley closure across creeks that are located within 100 metres of the sides of previously extracted longwalls at similar depths of cover in the Southern Coalfield.
- A study of observed valley closure of tributaries to Redbank Creek during the extraction of previous longwalls.

A statistical analysis has been undertaken of observed valley closure across creeks that have similar valley heights and locations relative to longwalls as for the hidden creek. The analysis includes creeks with valley heights up to 40 m located at distances between 50 and 150 m from the active longwall maingate. The creeks are located adjacent to the previously extracted longwalls at Tahmoor Colliery, as well as at the nearby Appin, Metropolitan, Tower and West Cliff Collieries.

The distribution of the maximum measured closure for the creeks is provided in Fig. 4.2. There is a total of 26 cases in this analysis. The maximum measured valley closure is 168 mm, which was measured across a tributary to Redbank Creek adjacent to the maingate of Tahmoor Longwall 28. The next greatest valley closure is 81 mm, which was measured at Appin Colliery.

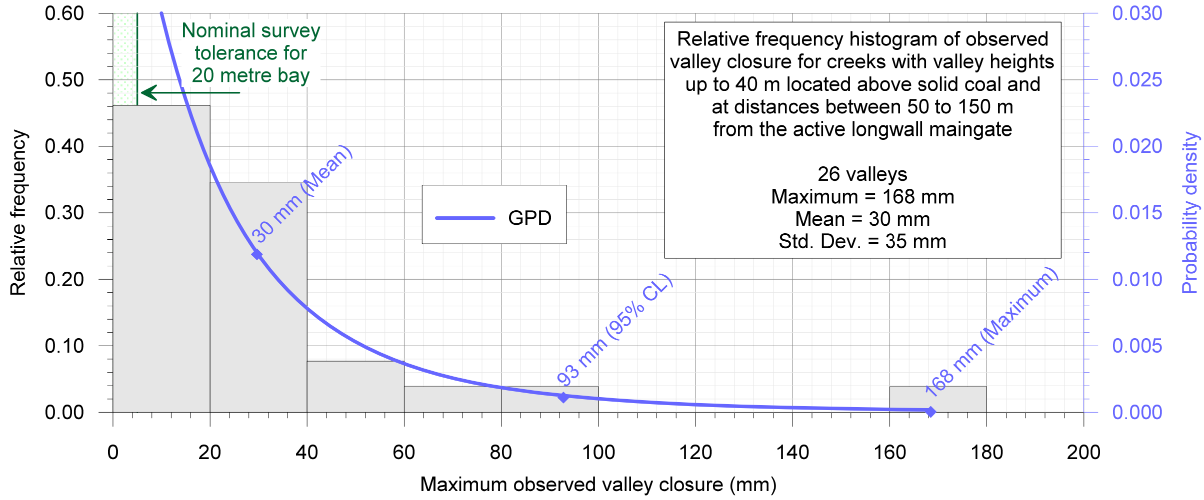

Fig. 4.2 Maximum measured valley closure for streams with valley heights up to 40 m located at distances between 50 and 150 m from the active longwall maingate

The Generalised Pareto Distribution (GPD) fitted to the raw data is shown as the blue line in Fig. 4.2. The predicted valley closure derived using the fitted GPD is 93 mm based on the 95 % confidence level and is 168 mm based on the 99 % confidence level.

The analysis indicates that the valley closure for the hidden creek due to the extraction of Longwall 31 is expected to be less than 100 mm, as measured by 25 of the 26 cases. However, valley closure similar to or greater than the predicted closure of 160 mm could occur, as for the tributary to Redbank Creek located adjacent to Tahmoor Longwall 28.

Two survey lines traverse across tributaries to Redbank Creek. A survey line along Bridge Street runs along the northern side of Redbank Creek directly above Longwalls 26 to 30 and future Longwall 31, and the results of regular surveys are shown in Fig. 4.3. The RK Line runs along the southern side of Redbank Creek directly above Longwalls 27 to 30 and future Longwall 31, and the results of regular surveys are shown in Fig. 4.4.

It can be seen that the experiences along Bridge Street have been very different from those experienced along the RK Line. Substantial compressive strains have been measured at isolated locations along the RK Line where the survey line crosses tributaries to Redbank Creek. On the other side of Redbank Creek, considerably smaller ground strains have been measured along Bridge Street where it crosses the tributaries.

Whilst the experiences along Bridge Street have been encouraging to date, it cannot be assumed that the same trend will continue above Longwall 31. The management strategies for the pipeline across the hidden creek, therefore, have been based on the potential for valley closure of 160 mm or greater.

Regular ground surveys and visual inspections will be undertaken during the extraction of Longwall 31 within the period of active subsidence. This will provide Sydney Water with prior warning of a potential water leak, upon which it may be decided to undertake additional CCTV inspections and/or pre-emptively excavate the pipe to relieve pipe stresses. If the sewer pipe becomes damaged, it can be readily repaired using established methods.

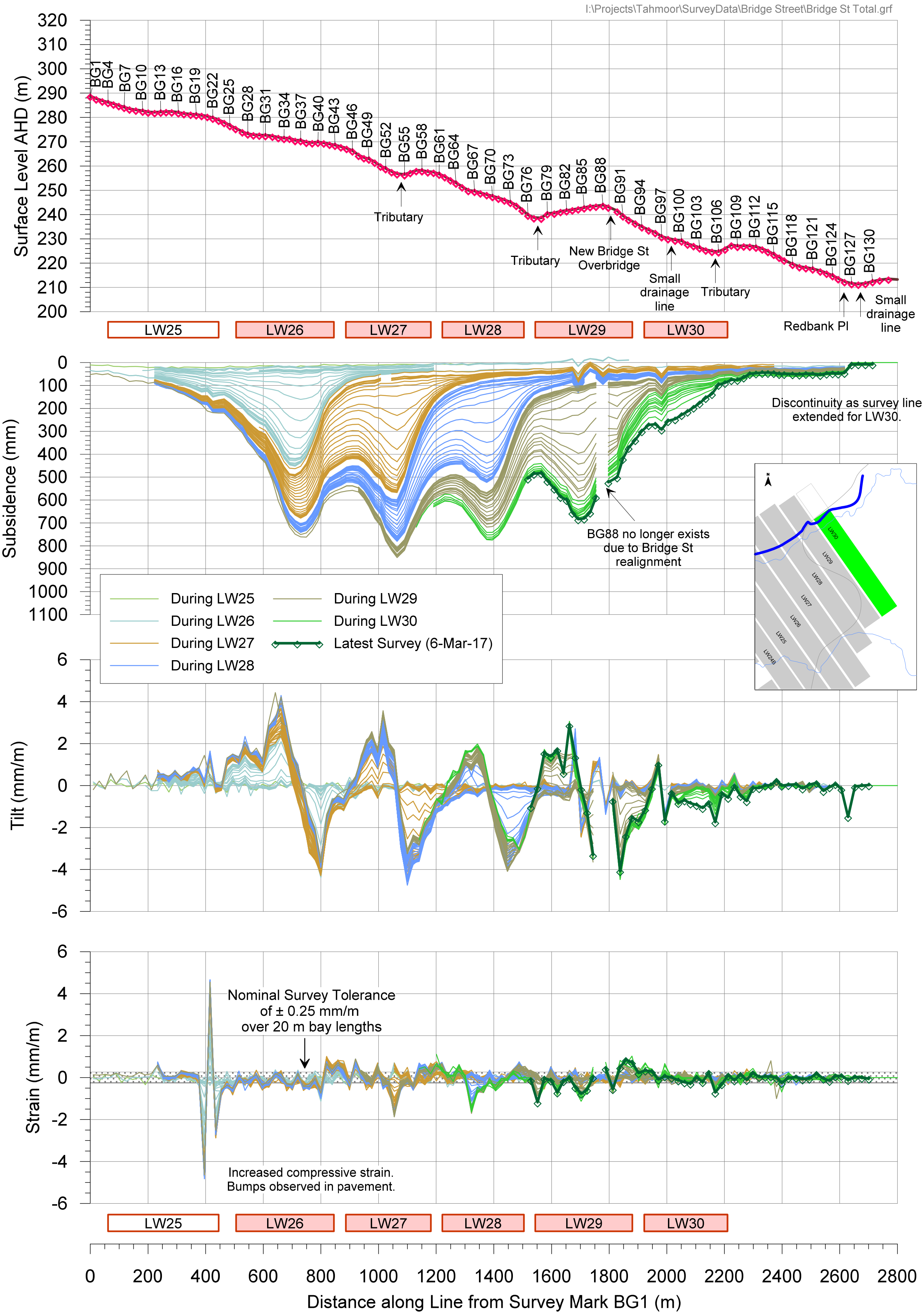

Fig. 4.3 Observed total subsidence, tilt and ground strain along Bridge Street during the mining of Longwalls 25 to 30 up to 6 March 2017

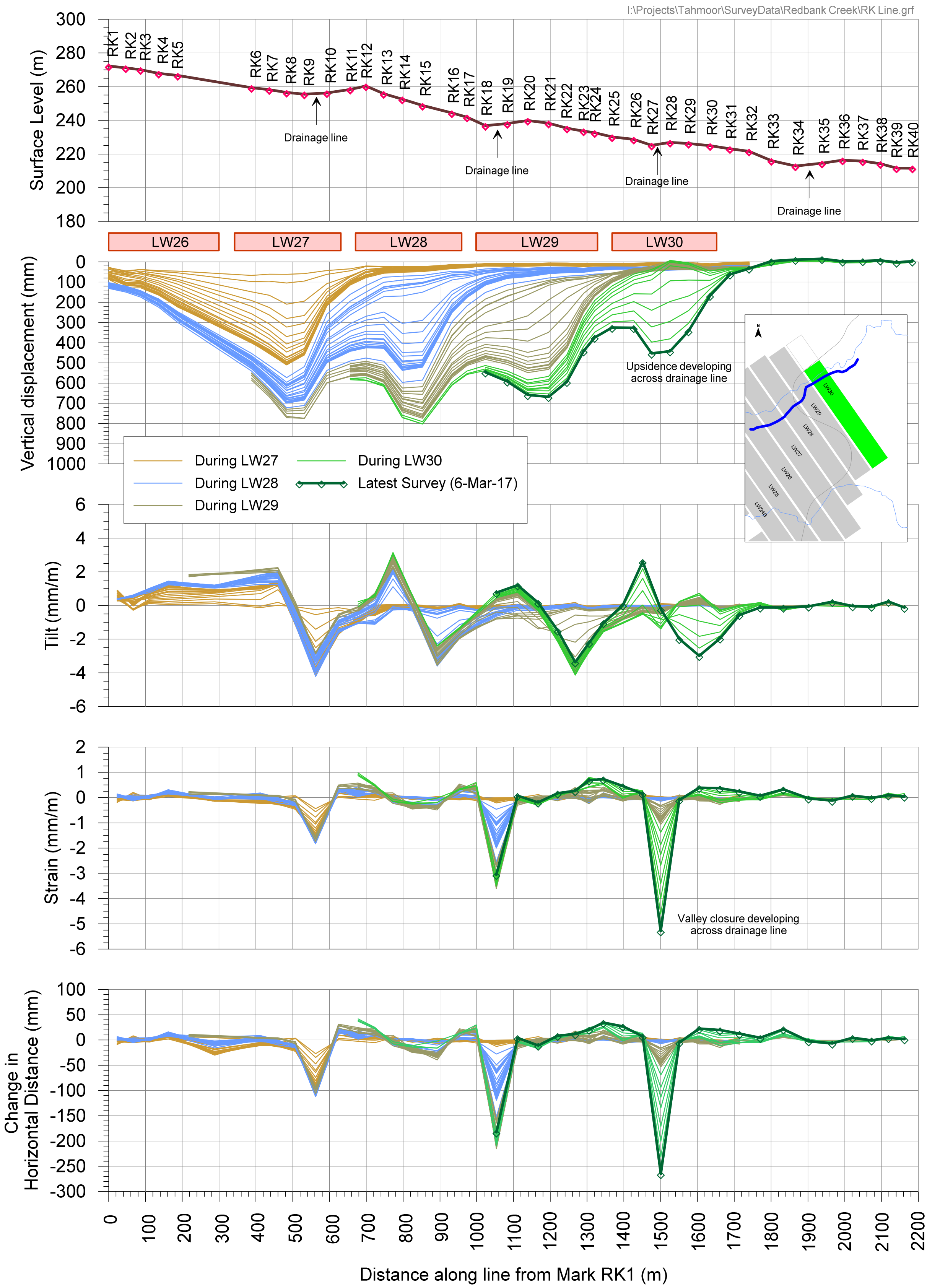

Fig. 4.4 Observed total subsidence, tilt, ground strain and changes in horizontal distances along the RK Line during the mining of Longwalls 27 to 30 up to 6 March 2017

5.1. 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.

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. 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.

5.2. Risk assessment

The risks to the sewer pipelines due to mine subsidence are the reduction of grade below the minimum required for self-cleansing and the damage or blocking of the pipelines. The potential for impacts are greater where the pipelines are located directly above Longwall 31 and at the creek crossings.

The risks have been assessed for the Thirlmere Carrier pipeline where it is located directly above Longwall 31 and where it crosses the hidden creek outside and adjacent to the maingate of this longwall. This risks have also been assessed for the reticulation and sideline pipelines located outside the extents of Longwall 31. The rising main has not been included in this risk assessment, as it is located outside the 35° angle of draw line and the predicted 20 mm subsidence contour due to Longwall 31.

A summary of the assessed levels of potential impacts on the Sydney Water sewer infrastructure is provided in Table 5.1.

Table 5.1 Summary of the risk assessment

Risk	Likelihood	Consequence	Level of potential impact
Thirlmere Carrier (above LW31)			
Reduction of grade below self-cleansing	Very Unlikely	Severe	Medium
Damage to pipeline	Unlikely	Moderate	Medium
Thirlmere Carrier (at hidden creek)			
Reduction of grade below self-cleansing	Very Unlikely	Severe	Medium
Damage to pipeline	Unlikely	Moderate	Medium
Other pipelines outside of LW31			
Reduction of grade below self-cleansing	Very Unlikely	Minor to Severe (depending on number of customers affected for each sewer pipe)	Low to Medium
Damage to pipeline	Very Unlikely	Moderate	Medium

6.0 RISK CONTROL PROCEDURES

6.1. Sewer Management Group (SMG)

The Sewer Management Group (SMG) is responsible for taking the necessary actions required to manage the risks that are identified from monitoring the infrastructure. The SMG's key members are Tahmoor Colliery, Sydney Water and Mine Subsidence Engineering Consultants. Subsidence Advisory NSW (Mine Subsidence Board) acts as an observer.

6.2. 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; and
- 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 30, 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.

6.3. Monitoring Plan

A number of monitoring measures will be undertaken during mining.

6.3.1. Ground monitoring lines

Monitoring lines have been installed along streets within the urban area above and adjacent to Longwall 31, as shown in Drawing No. MSEC862-00-01. 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 active subsidence for Longwall 31:

- Bridge Street, above the Thirlmere Carrier pipe; and
- THC Line, a monitoring line along the route of the section of the Thirlmere Carrier that does not follow Bridge Street above Longwalls 29 and 30 and to the side of Longwall 31.

Other streets located directly above Longwall 31 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 subsidence higher than predicted develops, or if substantial non-conventional movement is observed.

6.3.2. 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.

CCTV inspections have been progressively undertaken at the Thirlmere Carrier pipes from west to east up to an inspection manhole located just east of the Longwall 30 panel. A pre-mining CCTV inspection will be undertaken from this point up to the Redbank Creek viaduct crossing. 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.

6.4. Risk control procedures

The risk control procedures are provided in Table 6.1. The procedures include responses if triggered by the monitoring results.

Table 6.1 Risk Control Procedures for Sewer Infrastructure

Infrastructure	Hazard / Impact	Risk	Trigger	Control procedure/s	Frequency	By whom?
Sewer infrastructure	Impacts to Sydney Water sewer infrastructure	Low / Medium	None	Conduct surveys along the Bridge Street and THC monitoring lines	Weekly when longwall face is within the active subsidence zone	Tahmoor Colliery (SMEC / MSEC)
				Conduct surveys along the other monitoring lines to provide some early warning for potentially damaging subsidence events.	Every 200 metres of longwall face movement within the active subsidence zone	Tahmoor Colliery (SMEC / MSEC)
				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
				Conduct CCTV inspection for the Thirlmere Carrier pipeline	LW31 approaching within 200m of sewer and at the completion of LW31	Sydney Water
				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 of mining in area and possible issues.	Completed	Sydney Water
				Notify residents of potential mine subsidence impacts and contact numbers.	Prior to active subsidence	Tahmoor Colliery
			Ground survey indicates grade is less than 0.2 % (2 mm/m) for the Thirlmere Carrier pipe or less than 0.4 % (4 mm/m) for the other pipes.	Notify Sydney Water and convene an SMG meeting. Consider additional monitoring and mitigation measures based on observed monitoring results, which may include: - increase frequency of ground 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 Sewer Management Group	Sewer Management Group
			Non-conventional ground movement detected	Notify Sydney Water and convene an SMG meeting. Consider additional monitoring and mitigation measures based on observed monitoring results, which may include: - increase frequency of ground surveys at affected site - increase frequency of visual inspections - undertake additional CCTV inspections of 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 - installation of containment lines and signage - increase frequency of SMG meetings - any other additional management actions	As required by Sewer Management Group	Sewer Management Group
			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, Subsidence Advisory NSW and DRE	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 - installation of containment lines and signage - increase frequency of SMG meetings - any other additional management actions	As required by Sewer Management Group	Sewer Management Group

7.0 MANAGEMENT PLAN REVIEW MEETINGS

The monitoring of Sydney Water sewer infrastructure which forms an integral part of this Management Plan will be carried out by Tahmoor Colliery. SMG 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 meetings shall be as agreed by the parties.

A secretary will be appointed at the SMG Meeting. All documentation, distribution of meeting minutes and organising of meeting times will be undertaken by the secretary.

SMG 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 SMG 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.

8.0 AUDIT AND REVIEW

All Management Plans within this document have been agreed between parties. The Management Plan will be reviewed following extraction of the 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; and
- Observation of significant variation between observed and predicted subsidence.

9.0 RECORD KEEPING

The secretary will keep and distribute regular minutes of each Plan Review Meeting for each surface feature. The minutes will include reports on the condition of the relevant surface feature, the progress of mining, the degree of mine subsidence that has occurred, comparisons between observed and predicted ground movements, agreements reached between parties, and a log of incidents that have occurred on the surface feature.

10.0 CONTACT LIST

Organisation	Contact	Phone	Email / Mail	Fax
NSW Department of Industry – Division of Resources and Energy (DRE)	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
Subsidence Advisory NSW (Mine Subsidence Board)	Matthew Montgomery	(02) 4677 1967 0425 275 564	matthew.montgomery@finance.nsw.gov.au	(02) 4677 2040
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay*	(02) 9413 3777 0416 191 304	daryl@minesubsidence.com	(02) 8412 0222
Sydney Water	Emergency Line	13 20 90	-	-
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 0100	Ian.Sheppard@glencore.com.au	(02) 4640 0140
Glencore Tahmoor Coal – Approvals and Community Coordinator	Belinda Treverrow*	(02) 4640 0133 0458 627 752	Belinda.L.Treverrow@glencore.com.au	(02) 4640 0140
Tahmoor Colliery 24 hour contact	Tahmoor Colliery Control	1800 154 415	-	-

* denotes member of Sewer Management Group

APPENDIX A.

Please refer to the following documents:

- Drawing No. MSEC862-00-01 Monitoring over Longwall 31
- Drawing No. MSEC862-04-01 Sewer – Pipe Size
- Drawing No. MSEC862-04-02 Sewer – Pipe Type
- Sydney Water, (2010). *Risk Criteria*, Sydney Water, Issue 3, 6 July 2010.

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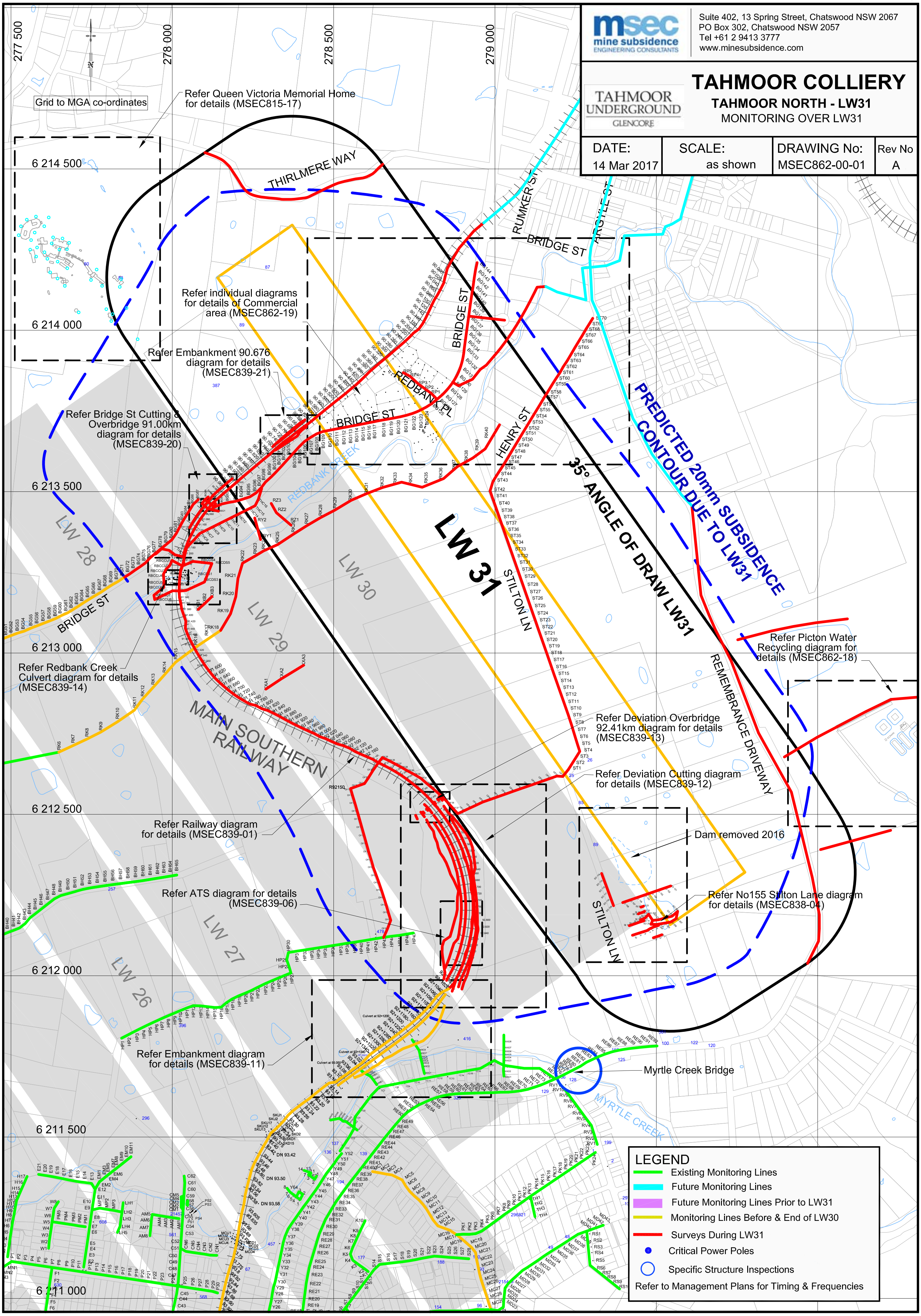

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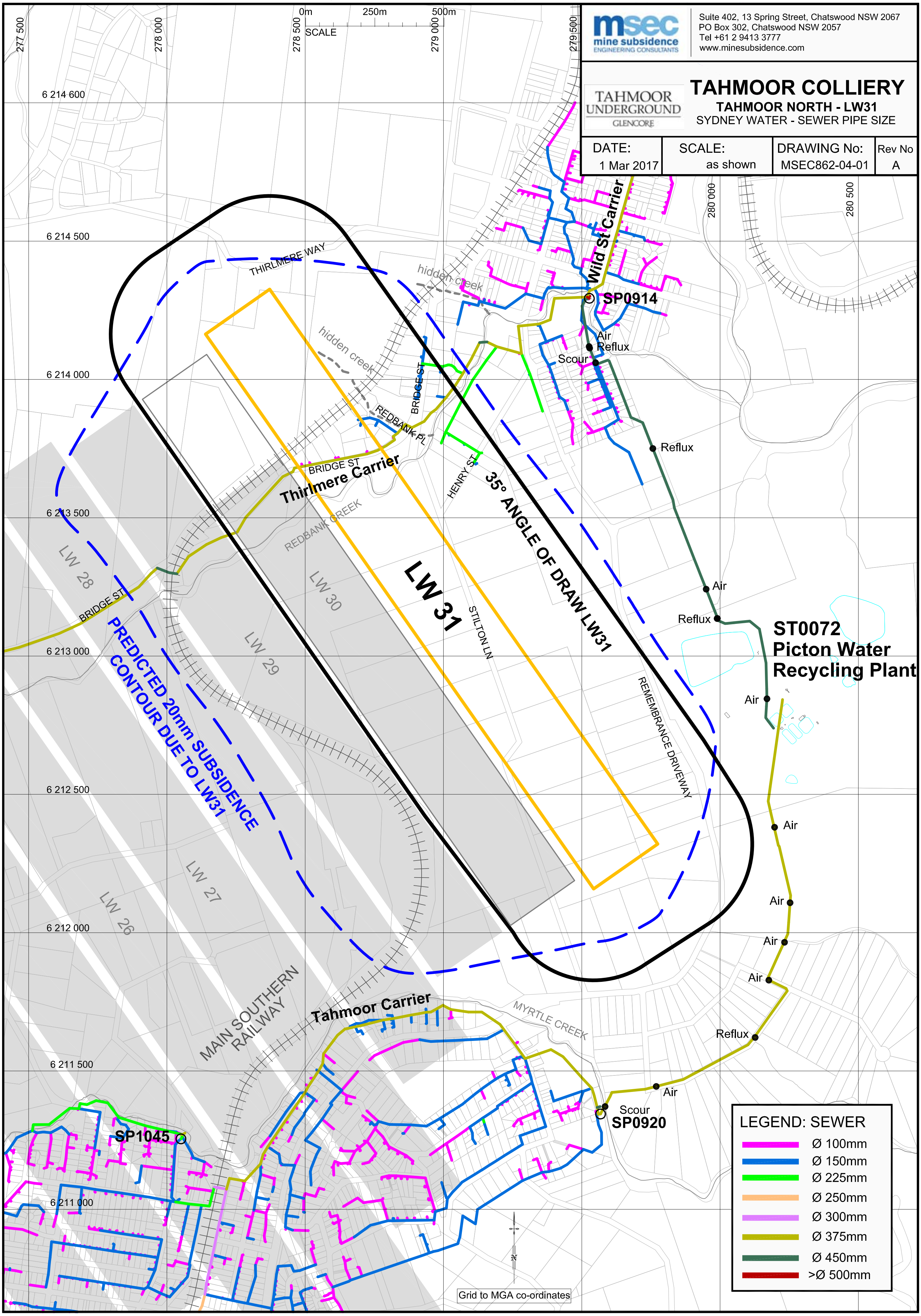

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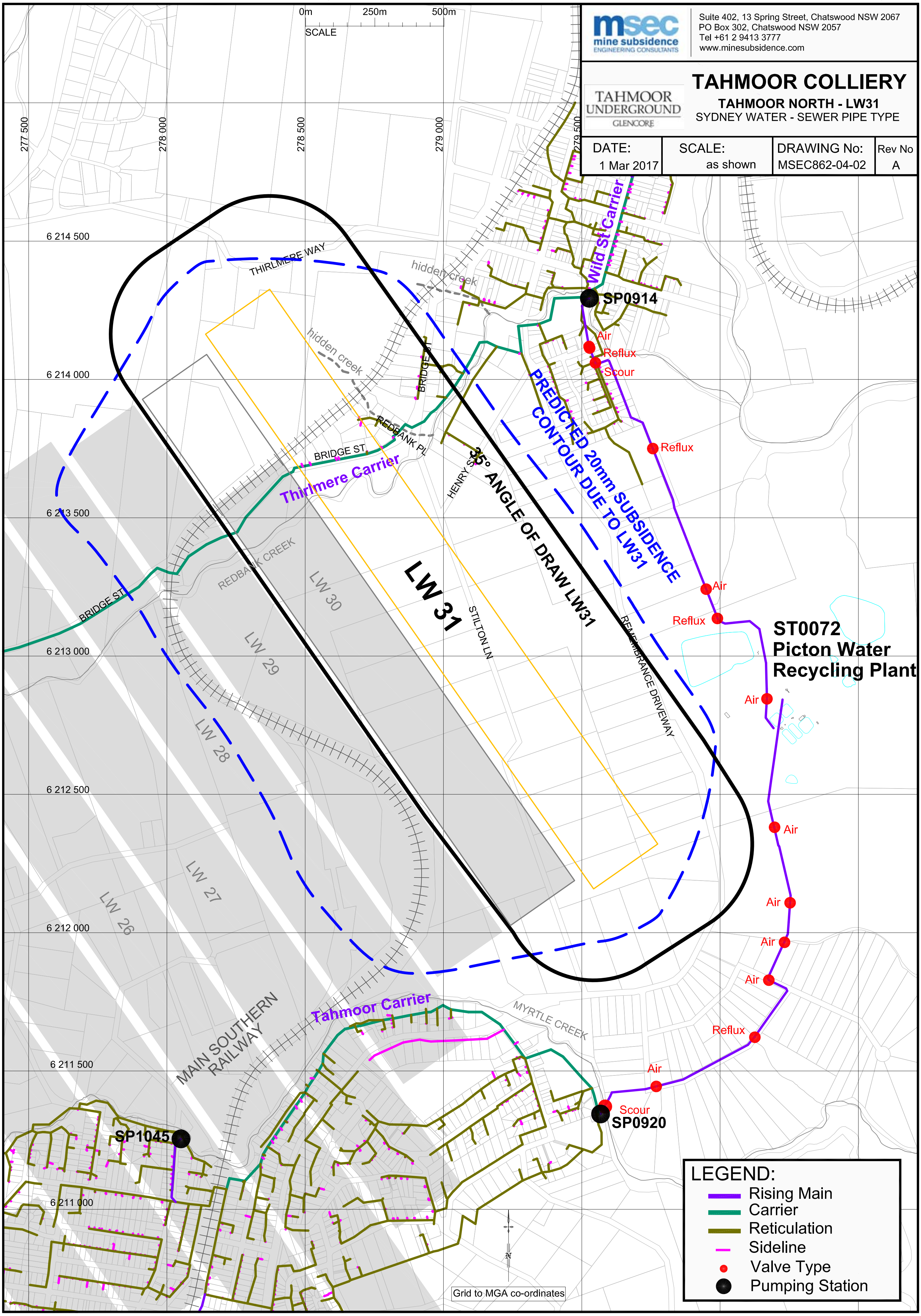

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www.minesubsidence.com

TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW31

SYDNEY WATER - SEWER PIPE TYPE

DATE:	SCALE:	DRAWING No:	Rev No
1 Mar 2017	as shown	MSEC862-04-02	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)	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