mine subsidence ENGINEERING CONSULTANTS

TAHMOOR UNDERGROUND GLENCORE

GLENCORE:

Tahmoor Colliery – Longwall 31

Management Plan for Potential Impacts to Wollondilly Shire Council Infrastructure

AUTHORISATION OF MANAGEMENT PLAN

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Nov-08	MSEC286-04	C	Updated for Castlereagh Street Bridge
Sep-12	MSEC567-02	A	Updated for Longwall 27
Oct-12	MSEC567-02	B	Updated following consultation with WSC
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Mar-14	MSEC646-02	A	Updated for Longwalls 28 to 30
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Mar-17	MSEC862-02	A	Draft for Longwall 31
Mar-17	MSEC862-02	B	Updated following consultation with WSC
Jun-17	MSEC862-02	C	Updated following consultation with WSC

REFERENCES

AS/NZS 4360:1999 Risk Management

MSEC (2014) 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.

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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 infrastructure owned by Wollondilly Shire Council 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 infrastructure will be managed by Tahmoor Colliery and Wollondilly Shire Council.

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 Wollondilly Shire Council.

1.2. Consultation

Tahmoor Colliery regularly consults with Wollondilly Shire Council in relation to mine subsidence effects from mining. This includes consultation during the development of Subsidence Management Plans for previous Longwalls 22 to 30, and regular reporting of subsidence movements and impacts.

A meeting was attended by Rebecca Cassidy (Wollondilly Shire Council), Belinda Treverrow (Tahmoor Colliery), Matthew Montgomery (Subsidence Advisory NSW) and James Barbato (MSEC) to discuss the draft Subsidence Management Plan for Longwall 31.

Feedback was provided by Wollondilly Shire Council in relation to identification of Council owned buildings and preparation of a traffic management plan for Thirlmere Way, which will be submitted to Council prior to the installation of survey marks and prior to influence of Longwall 31.

Tahmoor Colliery will continue to consult regularly with Wollondilly Shire Council during the extraction of Longwall 31 in relation to mine subsidence effects from mining.

1.3. 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. Ensure that the health and safety of people who may be present on public property or Wollondilly Shire Council property are not put at risk due to mine subsidence.
- 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, Wollondilly Shire Council, relevant government agencies and consultants as required; and
- Establish lines of communication and emergency contacts.

1.4. Scope

The Management Plan is to be used to protect and monitor the condition of the Wollondilly Shire Council infrastructure identified to be at risk due to mine subsidence and to ensure that the health and safety of people who may be present on public property or Wollondilly Shire Council property are not put at risk due to mine subsidence. The major items at risk are:

- Local roads;
- Bridges; and
- Culverts.

The Management Plan only covers 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 roads, bridges and culverts owned by Wollondilly Shire Council which lie outside the extent of this area.

This Management Plan does not include the Bridge Street and Deviation Overbridges, nor the building structures and infrastructure associated with the Wollondilly State Emergency Services Control Centre and the NSW Rural Fire Service. This infrastructure is included in separate management plans. A copy of those management plans can be provided to the Wollondilly Shire Council upon request.

1.5. 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 the Wollondilly Shire Council informed of changes.

1.6. Definition of the 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.

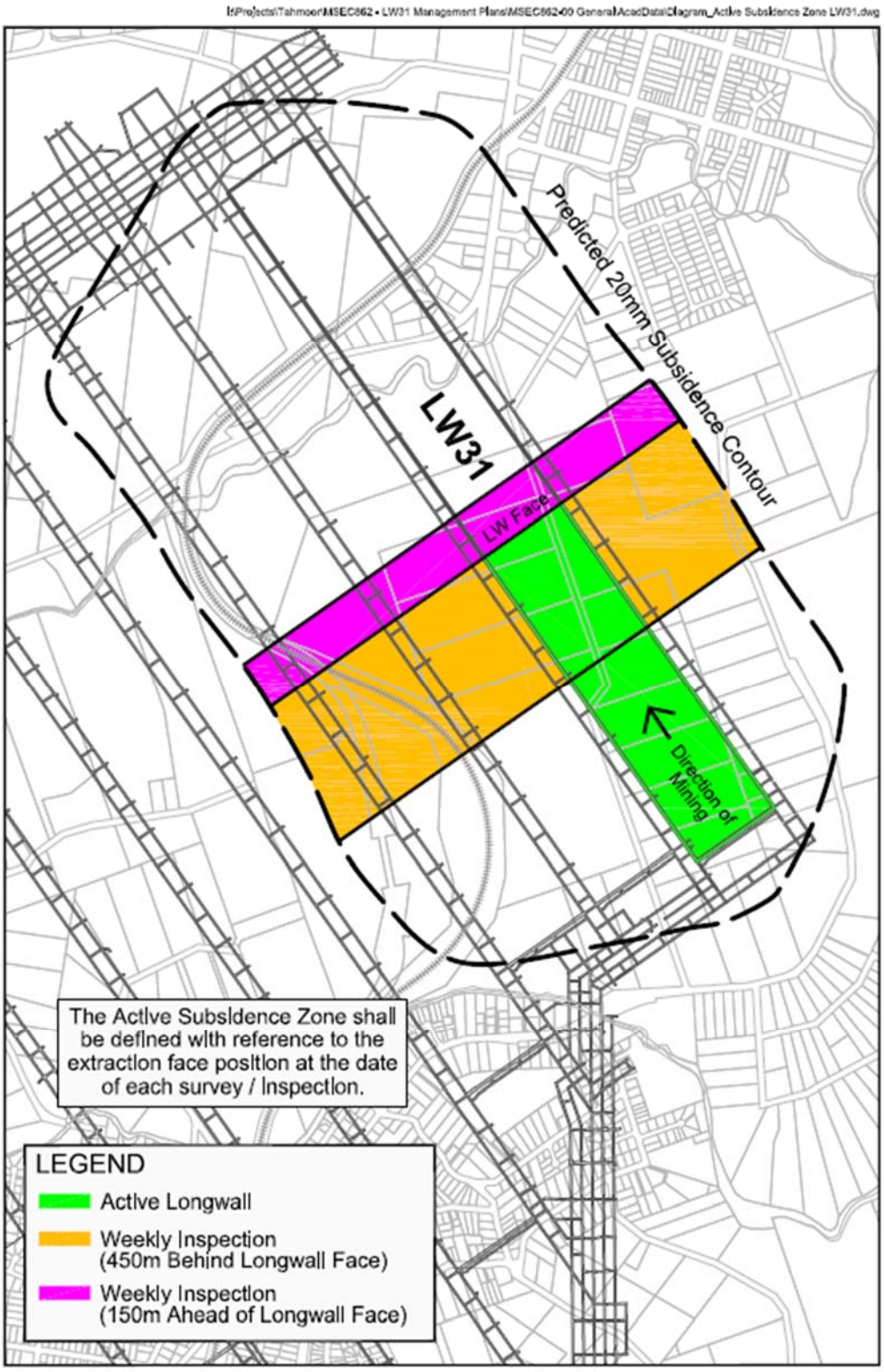


Fig. 1.1 Diagrammatic representation of the active subsidence zone

1.7. 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.

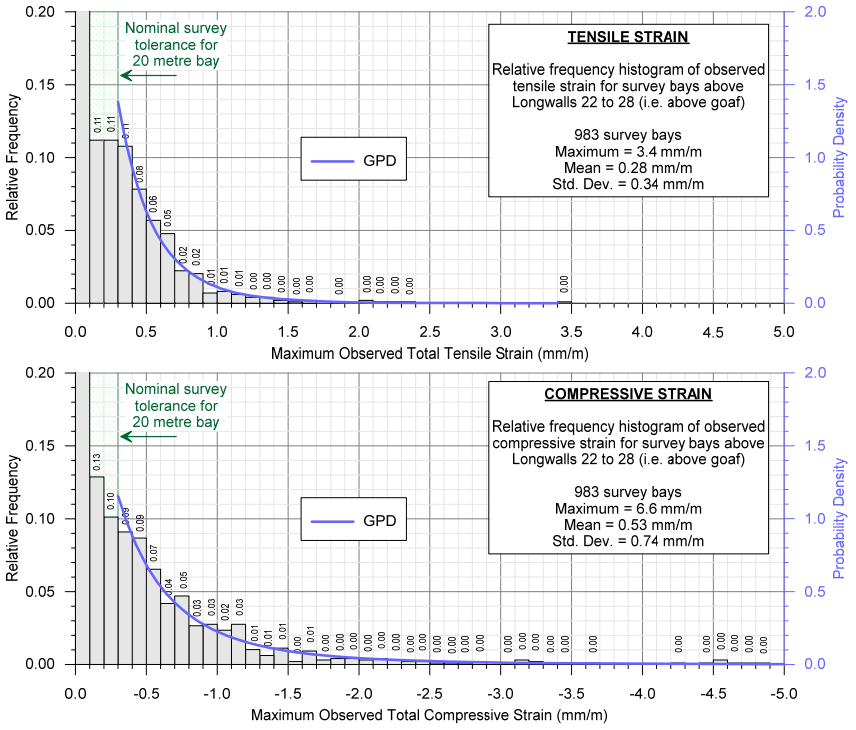


Fig. 2.1 Distributions of the measured maximum tensile and compressive strains for surveys bays located above goaf

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.

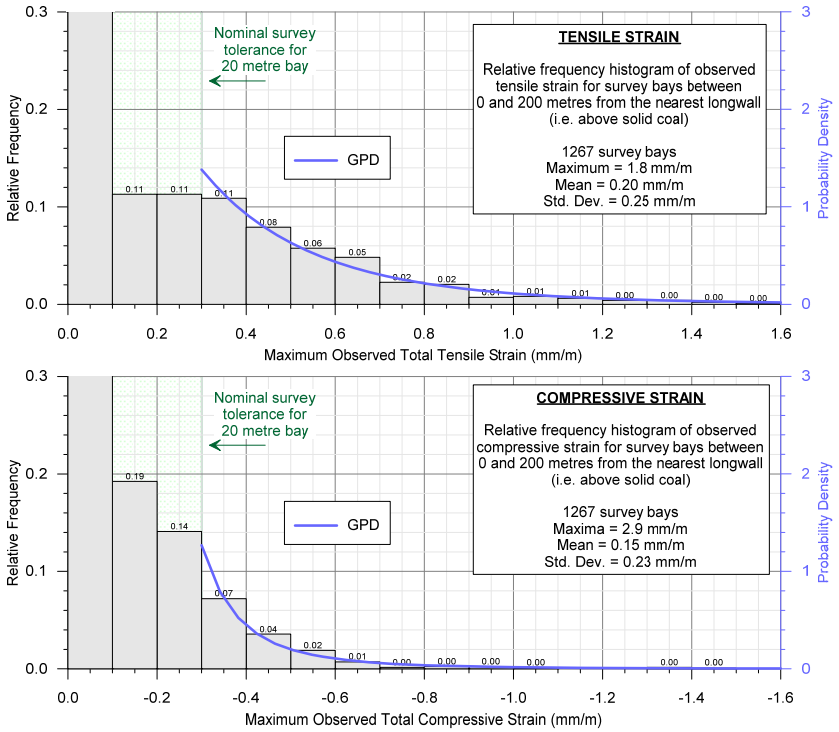


Fig. 2.2 Distributions of the measured maximum tensile and compressive strains for survey bays located above solid coal

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.

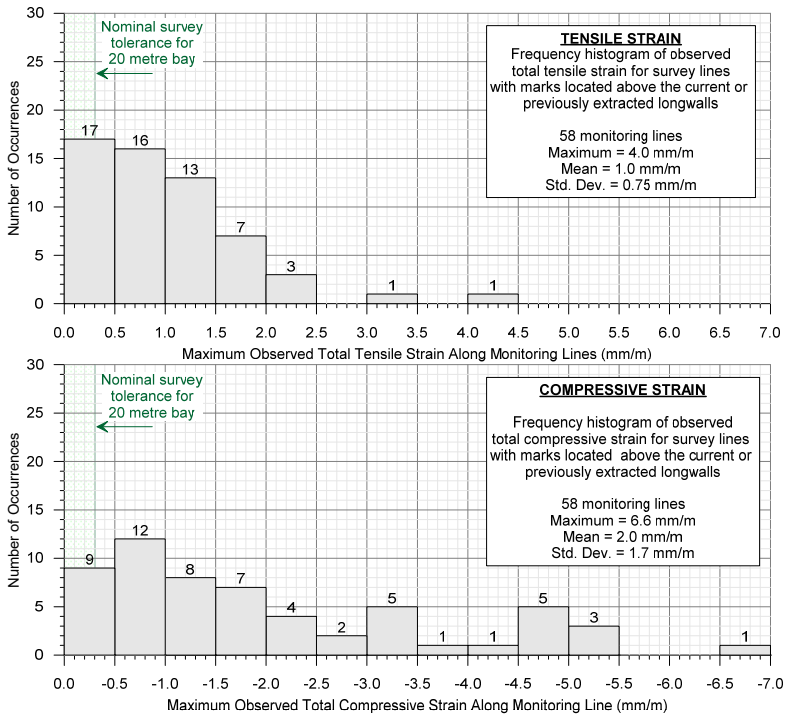


Fig. 2.3 Distributions of measured maximum tensile and compressive strains anywhere along the monitoring lines

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

A number of bridges and culverts above and adjacent to Longwall 31 carry road transport over small creeks. The predictions of valley closure and upsidence at each of these features are provided later in this Management Plan.

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 and Petroleum Sites) Act 2013* and associated Regulations (collectively referred to as the 'WHS laws').

The *Work Health and Safety (Mines and Petroleum Sites) 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 the Glencore Coal Assets Australia Risk Matrix to determine an estimated level of risk for particular events or situations. A copy of the Risk Matrix is included in the Appendix of this Management Plan.

4.1. Local roads

There are a number of local roads that are located directly above or adjacent to Longwall 31, as shown in Drawing No. MSEC862-02-01.

The main road within the vicinity of Longwall 31 is Bridge Street, which connects Thirlmere with Picton to the north-east. Bridge Street crosses directly over Longwall 31, and it has previously been directly mined beneath by Longwalls 26 to 29 and is currently experiencing active subsidence due to the extraction of Longwall 30.

Stilton Lane, which connects Tahmoor with Picton to the north-east, also crosses directly over Longwall 31. A section of this road has previously experienced subsidence due to the extraction of Longwall 30.

Thirlmere Way is located to the north of Longwall 31 and is at a minimum distance of approximately 80 m from this longwall. Longwall 31 will be mined towards Thirlmere Way, but it will not mine directly beneath this road.

The section of Thirlmere Way in the vicinity of Longwall 31 runs along the top of a ridge, with steep slopes located on either side of the road. The road narrows in this section, with no shoulders on either side of the pavement. Small but deeply incised valleys are located adjacent to the road on the southern side.

A north-south orientated section through Thirlmere Way and the north-western end of Longwall 31, where the road is located closest to the longwall, is provided in Fig. 4.1. The natural surface gradients on the side of the ridgeline are approximately 1 in 3 (i.e. 33 %, or 18°).

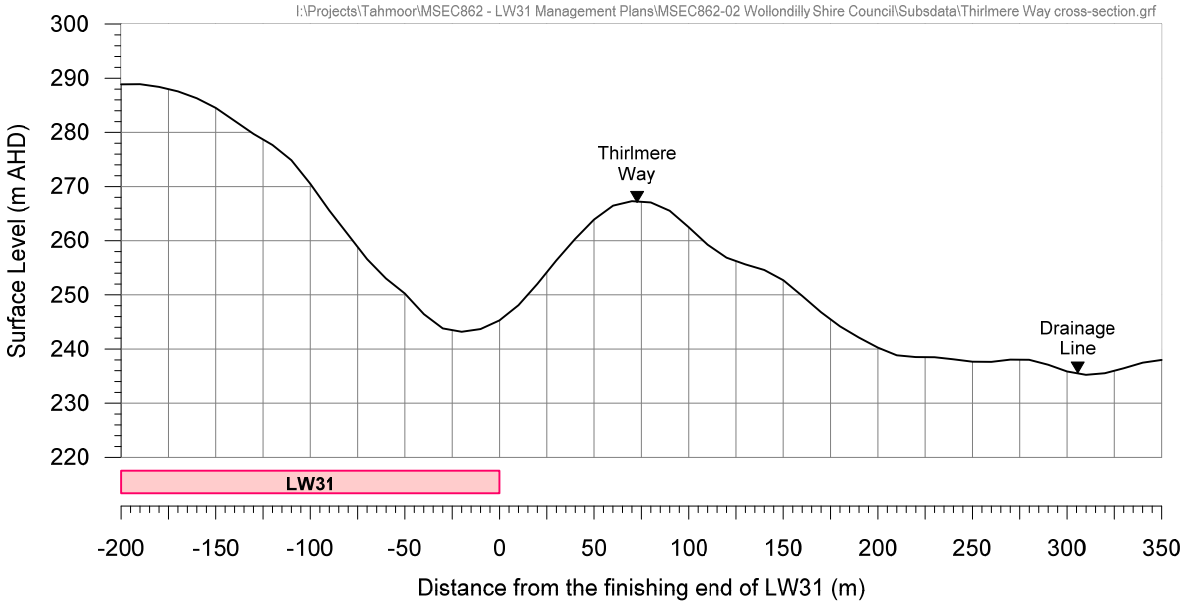


Fig. 4.1 North-south section through the finishing end of Longwall 31 and Thirlmere Way

The other important road within the vicinity of Longwall 31 is Remembrance Drive (formerly the Hume Highway), which connects Tahmoor with Picton to the north and Bargo to the south. This road is located to the north and to the east of Longwall 31 and is at a minimum distance of approximately 200 m from this longwall. Some main services are located along Remembrance Drive that include gas mains, water mains and optical fibre cables. Remembrance Drive crosses over Longwalls 24A to 28.

The local roads are spread across Longwall 31 and, therefore, they will collectively experience the full range of predicted subsidence movements, as described in Section 2.1. A discussion on the expected range of tensile and compressive strains during the mining of Longwall 31 is provided in Section 2.3.

The predicted profiles of conventional subsidence, tilt and curvature along Bridge Street are shown in Fig. 4.2. 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.

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

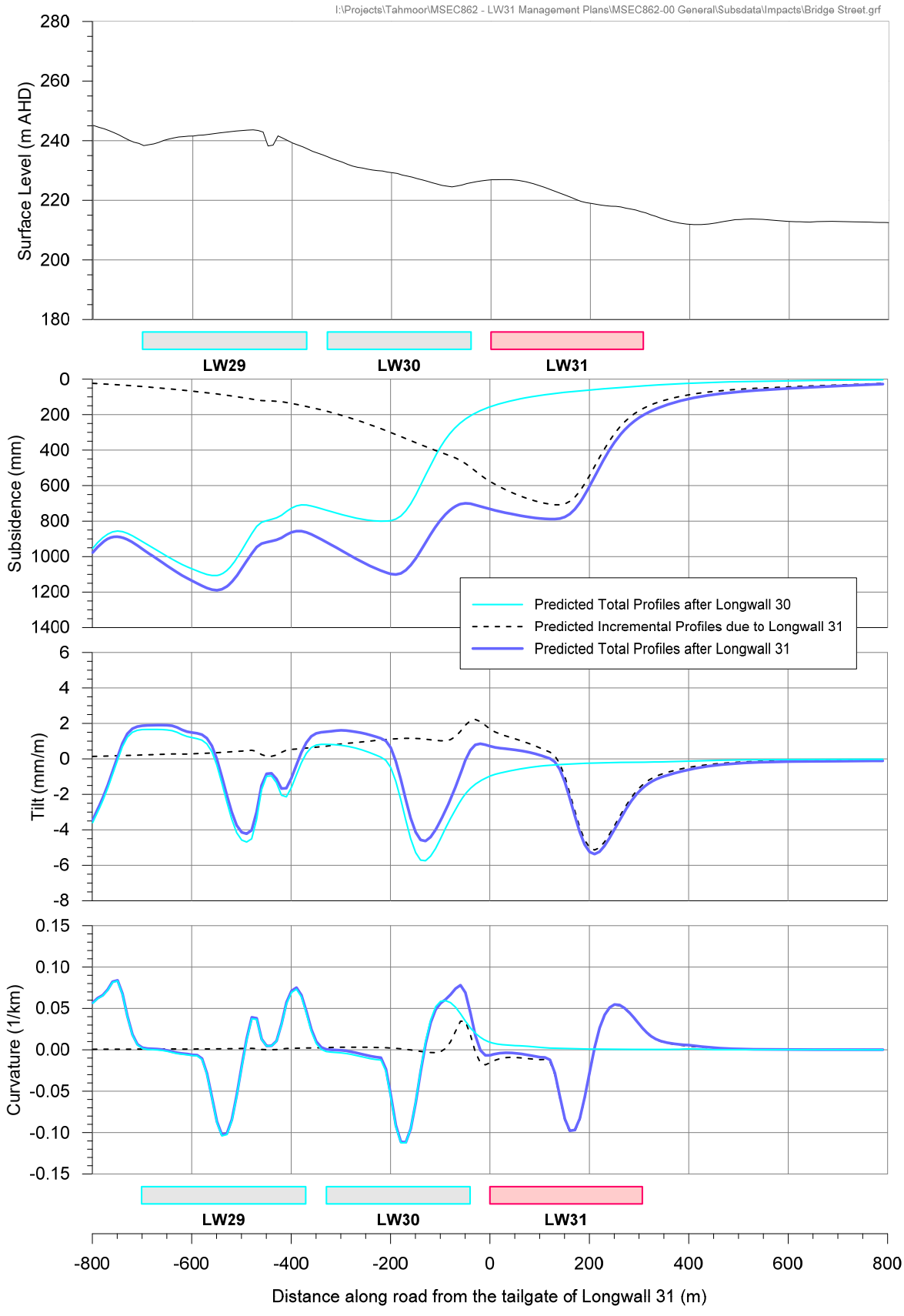


Fig. 4.2 Predicted profiles of total subsidence, tilt and curvature along Bridge Street due to the mining of Longwalls 22 to 31

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

Location	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)
Bridge Street	After LW31	1225	5.5	0.09	0.13
Remembrance Drive (between Wonga and Koorana Roads)	After LW31	50	< 0.5	0.01	< 0.01
Thirlmere Way (at South Picton)	After LW31	80	0.5	0.01	< 0.01

Bridge Street will also experience transient tilts and curvatures as the extraction face of Longwall 31 mines directly beneath it. The maximum predicted transient movements orientated across the alignment of this road are 3.5 mm/m tilt, 0.06 km^{-1} hogging curvature and 0.08 km^{-1} hogging curvature.

Monitoring of road pavements has been undertaken during the extraction of Longwalls 22 to 30 at Tahmoor Colliery. This includes a network of ground monitoring lines and weekly visual inspections in areas that are experiencing active subsidence. Approximately 27 km of asphaltic pavement lie directly above the extracted longwalls and a total of 51 impact sites have been reported. The observed rate of impact equates to an average of one impact for every 530 m of pavement. The impacts were minor and did not present a public safety risk.

One of these impact sites, located on Lintina Street above Longwall 24A, was substantially greater than at other impact sites. A selection of photographs is provided in Fig. 4.3. The impacts on Lintina Street were repaired twice by the Mine Subsidence Board as the longwall progressed.

A hump was observed on Abelia Street during the mining of Longwall 25 and this has been repaired by the Mine Subsidence Board. A hump was also observed on Remembrance Drive at the roundabout intersection with Thirlmere Way, as shown in Fig. 4.3.

While impacts have been observed to local roads at a number of locations during the mining of Longwalls 26 to 30, they have not been as severe as those observed on Lintina Street and Abelia Street, though some have required urgent repairs. Only very minor impacts have been observed on the local roads during the mining of Longwall 30.

More frequent impacts have been observed to concrete kerbs and gutters. The impacts are most commonly focussed around driveway laybacks and involve cracking, spalling or buckling. A typical buckling impact is shown in Fig. 4.3. A total of five drainage pits have been damaged during the mining of Longwalls 24A and 25 in Janice and Abelia Streets.

Traffic signs and other road infrastructure have not previously experienced impacts due to mine subsidence.

It is expected that minor impacts will occur to the local roads during the extraction of Longwall 31, similar in frequency and severity to those experienced during the mining of Longwalls 22 to 30.

The section of Thirlmere Way in the vicinity of Longwall 31 runs along the top of a ridge, with steep slopes located on either side of the road. Longwall 31 mines beneath the toe of the steep slope and, therefore, could result in increased horizontal movements in the downslope direction. The horizontal movements could result in tensile cracking on the side and at the top of the ridge, including along Thirlmere Way.

Thirlmere Way narrows in this section, with no shoulders on either side of the pavement, limiting the access for monitoring and undertaking repairs. The traffic along this section of road, therefore, will need to be managed to allow the required monitoring and any required remediation works.

Tahmoor Colliery has engaged a geotechnical engineer to undertake a geotechnical assessment of the steep slopes along Thirlmere Way. The recommendations from that report will be incorporated into this Management Plan as they become available.

The proposed locations of survey marks along Thirlmere Way will be submitted for approval by WSC prior to installation. A traffic management plan will also be developed and incorporated into this Management Plan for approval by WSC prior to the installation of surveys on Thirlmere Way. The traffic management plan will incorporate any work on Thirlmere Way, including the installation and monitoring of survey marks, visual inspections, any repair work if required, and emergency temporary road closures if a mine subsidence induced hazard has been identified that involves potential serious injury or illness to a person or persons.

Lintina Street (most severe to date)

Remembrance Drive (hump at roundabout)

Brundah Road (typical impact to pavement)

Patterson Street (typical impact to kerb)

Struan Street

Moorland Rd

Photographs courtesy of Tahmoor Colliery and Colin Dove

Fig. 4.3 Photographs of impacts to road pavements and kerbs during the mining of LWs 22 to 30

4.2. Bridges

The Bridge Street and Deviation Overbridges are addressed in a separate management plan for the Main Southern Railway. A copy of that management plan can be provided to Wollondilly Shire Council upon request. There are no other road bridges located within the active subsidence zone.

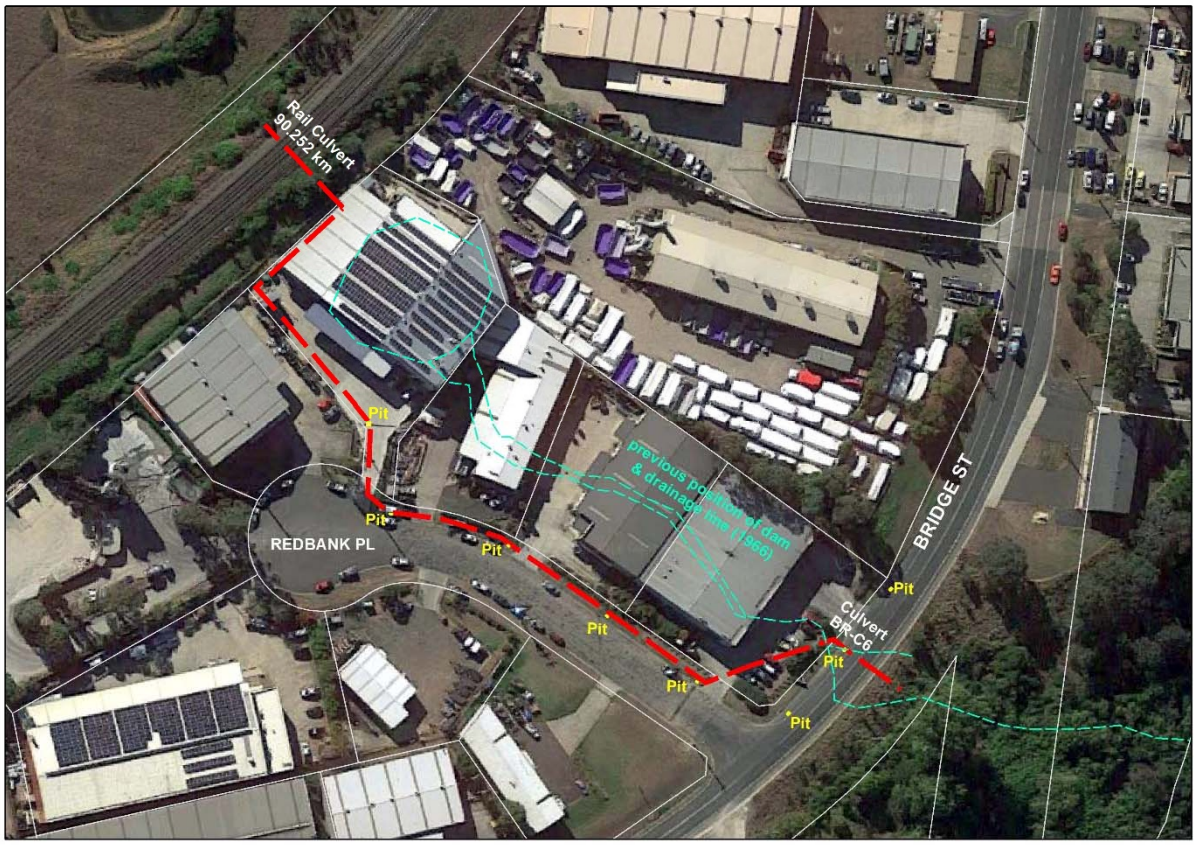
Victoria Road Bridge is owned by the Roads and Maritime Services (RMS) and is located approximately 1.7 km away from Longwall 31. Whilst it is extremely unlikely that the Bridge will experience mining-induced movements, it is located over a section of Stonequarry Creek that runs along the alignment of the Nepean Fault.

As part of a regional study, Tahmoor Colliery proposes to monitor ground movements at items of infrastructure along the Nepean Fault, including the Victoria Road Bridge. The proposed monitoring consists of deployment of a continuously operating GNSS unit, which measures the absolute position of the bridge, and two survey marks, one on either side of the Bridge to measure differential movements.

4.3. Road drainage culverts

There are a number of road drainage culverts located above and in the vicinity of Longwall 31. The culverts generally comprise either concrete or wrought iron pipes with diameters ranging between 300 and 600 mm. A 1500 mm box culvert (Ref. SL-C1) is located on Stilton Lane to the south of Longwall 31.

A previous drainage line located outside and adjacent to the maingate of Longwall 31 has been diverted using a stormwater drain that runs between the Main Southern Railway and culvert BR-C6 on Bridge Street. The alignment of this stormwater drain has been determined from information obtained from the Wollondilly Shire Council and site investigations and is shown as the red dashed line in Fig. 4.4. This stormwater drain is located beneath the pavements (i.e. not beneath the building structures) and, therefore, is more readily accessible if repairs are required.



Photograph courtesy Google

Fig. 4.4 Aerial photograph in 2016 with infilled drainage and stormwater diversion overlaid

The extraction of Longwall 31 could result in cracking in the drainage culverts located directly above or adjacent to this longwall. It is unlikely, however, that these movements would adversely impact on the stability or structural integrity of the culverts. There have been no reported adverse impacts on the road drainage culverts due to the mining of Longwalls 22 to 30.

The risk to the local roads is the deformation of the pavement or unsealed surface comprising cracking, heaving or stepping. The deformations have been categorised as either minor (crack widths less than 10 mm and bumps less than 20 mm) and major (crack widths more than 10 mm or bump heights more than 20 mm).

The risk to the drainage culverts and stormwater drain are cracking or spalling of the concrete pipes or headwalls. The deformations have been categorised as either minor (crack widths less than 3 mm) and major (crack widths more than 3 mm).

A summary of the assessed levels of potential impacts on the Wollondilly Shire Council infrastructure is provided in Table 5.1. The risk assessment has been undertaken in accordance with the Glencore Coal Assets Australia Risk Management Matrix (Glencore, 2017), which is included in the Appendix A.

Table 5.1 Summary of the risk assessment

Risk	Likelihood	Consequence	Level of potential impact
Bridge Street and Stilton Lane			
Minor cracking or heaving of pavement, kerbs and gutters	Likely	Negligible	Medium
Major cracking or heaving of pavement, kerbs and gutters	Possible	Minor	Medium
Thirlmere Way			
Minor cracking of pavement	Possible	Minor	Medium
Major cracking of pavement due to downslope movement	Unlikely	Moderate	Medium
Remembrance Drive			
Minor or major cracking of pavement, kerbs and gutters	Rare	Minor	Low
Culverts and stormwater drain			
Minor cracking or spalling	Unlikely	Negligible	Low
Major cracking or spalling	Rare	Minor	Low
Railway overbridges			
Refer to the separate risk assessment in the Main Southern Railway Management Plan			
Building structures			
Refer to the separate risk assessments in the Property Subsidence Management Plans			

6.1. Infrastructure Management Group

The Infrastructure Management Group (IMG) is responsible for taking the necessary actions required to manage the risks that are identified from monitoring the infrastructure and to ensure that the health and safety of people who may be present on public property or Wollondilly Shire Council property are not put at risk due to mine subsidence. The IMG's key members are Tahmoor Colliery, Wollondilly Shire Council and Mine Subsidence Engineering Consultants. Subsidence Advisory NSW (Mine Subsidence Board) acts as an observer.

6.2. Mitigation measures

There are no recommended mitigation measures for the Wollondilly Shire Council infrastructure prior to active subsidence.

6.3. Monitoring measures

Monitoring lines have been installed along all streets within the urban area above and adjacent to Longwall 31, as shown in Drawing No. MSEC862-00-01. The monitoring lines have been initially surveyed to provide a baseline reference. The proposed locations of survey marks along Thirlmere Way will be submitted for approval by WSC prior to installation.

Monitoring of street survey lines will be conducted for every 200 metres of longwall travel as a minimum for marks located within the active subsidence zone. Visual inspections of the roads located within the active subsidence zone will also be carried out.

A monitoring report will be provided after the surveys have been carried out.

As part of a regional study, Tahmoor Colliery proposes to monitor ground movements at items of infrastructure along the Nepean Fault, including the Victoria Road Bridge (owned by RMS). The proposed monitoring consists of deployment of a continuously operating GNSS unit, which measures the absolute position of the bridge, and two survey marks, one on either side of the Bridge to measure differential movements.

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

Infrastructure	Hazard / Impact	Risk	Trigger	Control procedure/s	Frequency	By whom?
Local roads	Cracking, heaving or stepping of the pavements or unsealed surfaces	Medium / Low	None	Conduct visual inspection for surface deformations along local roads.	Vehicle based inspection once a week within active subsidence zone	Tahmoor Colliery
				Conduct ground monitoring and visual inspection of Thirlmere Way, verges and the steep slope adjacent longwall finishing end	Location of survey pegs along Thirlmere Way to be approved by WSC prior to installation Review the findings of geotechnical assessment (likely to be once a week during the last 200 m of longwall extraction)	Tahmoor Colliery
				Prepare traffic management plan for any work on Thirlmere Way to satisfaction of WSC	Prior to installation of survey marks on Thirlmere Way	Tahmoor Colliery
				Conduct surveys along 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)
			Impacts occur	Notify all stakeholders, including Wollondilly Shire Council, Tahmoor Colliery, Subsidence Advisory NSW (Mine Subsidence Board) and DRE	Within one week	Tahmoor Colliery / WSC
				Repair road	As required	WSC
			A hazard has been identified that involves potential serious injury or illness to a person or persons on public property or, or WSC property and cannot be controlled	Tahmoor Colliery and WSC meet to decide whether any additional management measures are required, including: - emergency evacuation of hazardous area - demarcation to prevent people entering hazardous area, including diversion of traffic	Immediately	Tahmoor Colliery / WSC
				Notify SRG of trigger exceedence and any management decisions undertaken (incl Subsidence Advisory NSW (Mine Subsidence Board), DRE)	Within 24 hours of decision	Tahmoor Colliery
Drainage culverts	Cracking or spalling	Low	None	Conduct visual inspection for impacts	Visual inspection once a week of culverts within the active subsidence zone	Tahmoor Colliery
			Impacts occur	Notify all stakeholders, including Wollondilly Shire Council, Tahmoor Colliery, Subsidence Advisory NSW (Mine Subsidence Board) and DRE	Within one week	Tahmoor Colliery / WSC
				Repair culvert	As required	WSC
Stormwater drain between the Main Southern Railway and Culvert BR-C6	Cracking or spalling	Low	None	Conduct visual inspection of pavement above alignment of stormwater drain	Visual inspection once a week once a week when within the active subsidence zone	Tahmoor Colliery
			Impacts occur	Notify all stakeholders, including Wollondilly Shire Council, Tahmoor Colliery, Subsidence Advisory NSW (Mine Subsidence Board), DRE and property owners adjacent to stormwater drain	Within one week	Tahmoor Colliery / WSC
				Repair stormwater drain	As required	WSC

7.0 CONSULTATION, CO-OPERATION AND CO-ORDINATION

Substantial consultation, co-operation and co-ordination has taken place between Tahmoor Colliery and Wollondilly Shire Council prior to and during the development of this Management Plan, as detailed in Section 1.2.

The following procedures will be implemented during and after active subsidence of the property to ensure the continued effective consultation, co-operation and co-ordination of action with respect to subsidence between Tahmoor Colliery and Wollondilly Shire Council:

- Arrangements to facilitate surveys and inspections during active subsidence.
- Reporting observed impacts to Tahmoor Colliery either during the weekly visual inspection or at any time directly to Tahmoor Colliery.
- Distribution of monitoring reports, which will provide the following information whilst surveys are being conducted on local roads during active subsidence:
    - Position of longwall relative to the local area and Wollondilly Shire Council property;
    - Summary of management actions since last report;
    - Summary of consultation with Wollondilly Shire Council since last report;
    - Summary of observed or reported impacts, incidents, service difficulties, complaints;
    - Summary of subsidence development;
    - Summary of adequacy, quality and effectiveness of management process;
    - Any additional and/or outstanding management actions; and
    - Forecast whether there will be any subsidence impacts to the health and safety of people who may be present at the property due to the continued extraction of Longwall 31.
- Convening of meetings between Tahmoor Colliery and Wollondilly Shire Council at any time as required.
- Arrangements to facilitate timely repairs, if required, to avoid business interruption.

Immediate contact between Tahmoor Colliery and Wollondilly Shire Council if a mine subsidence induced hazard has been identified that involves potential serious injury or illness to a person or persons on public property or Wollondilly Shire Council property and may require emergency evacuation, entry restriction or suspension of work activities.

8.0 MANAGEMENT PLAN REVIEW MEETINGS

The monitoring of Wollondilly Shire Council infrastructure which forms an integral part of this Management Plan will be carried out by Tahmoor Colliery. IMG Meetings will be held between Tahmoor Colliery and Wollondilly Shire Council 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 IMG Meeting. All documentation, distribution of meeting minutes and organising of meeting times will be undertaken by the secretary.

IMG 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 IMG 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.

9.0 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.

10.0 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.

11.0 CONTACT LIST

Organisation	Contact	Phone	Email / Mail	Fax
NSW Department of Industry – Division of Resources and Energy (DRE)	Phil Steuart	(02) 4931 6648	phil.steuart@industry.nsw.gov.au	(02) 4931 6790
	Gang Li	(02) 4931 6644 0409 227 986	gang.li@industry.nsw.gov.au	(02) 4931 6790
	Ray Ramage	(02) 4931 6645 0402 477 620	ray.ramage@industry.nsw.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
Glencore Tahmoor Coal – Approvals and Community Coordinator	Belinda Treverrow*	(02) 4640 0133 0458 627 752	Belinda.L.Treverrow@glencore.com.au	(02) 4640 0140
Wollondilly Shire Council Manager - Works	Justin Nyholm*	(02) 4677 8247	justin.nyholm@wollondilly.nsw.gov.au	(02) 4677 2339
Wollondilly Shire Council Acting Manager – Infrastructure Planning	Michael Nelson*	(02) 4677 1180	michael.nelson@wollondilly.nsw.gov.au	(02) 4677 2339

* denotes member of Infrastructure Management Group

APPENDIX A.

Please refer to the following documents:

- Drawing No. MSEC862-00-01 Monitoring over Longwall 31
- Drawing No. MSEC862-02-01 Wollondilly Shire Council – Local roads, culverts and bridges
- Glencore (2017) Glencore Coal Assets Australia Risk Management Matrix

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Tel +61 2 9413 3777
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TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW31

MONITORING OVER LW31

DATE:	SCALE:	DRAWING No:	Rev No
14 Mar 2017	as shown	MSEC862-00-01	A

277 500 278 000 278 500 279 000

6 214 500 6 214 000 6 213 500 6 213 000 6 212 500 6 212 000 6 211 500 6 211 000

Grid to MGA co-ordinates

Refer Queen Victoria Memorial Home for details (MSEC815-17)

Refer individual diagrams for details of Commercial area (MSEC862-19)

Refer Embankment 90.676 diagram for details (MSEC839-21)

Refer Bridge St Cutting & Overbridge 91.00km diagram for details (MSEC839-20)

Refer Redbank Creek Culvert diagram for details (MSEC839-14)

Refer Railway diagram for details (MSEC839-01)

Refer ATS diagram for details (MSEC839-06)

Refer Embankment diagram for details (MSEC839-11)

Refer Picton Water Recycling diagram for details (MSEC862-18)

Refer Deviation Overbridge 92.41km diagram for details (MSEC839-13)

Refer Deviation Cutting diagram for details (MSEC839-12)

Dam removed 2016

Refer No155 Stilton Lane diagram for details (MSEC838-04)

Myrtle Creek Bridge

THIRLMERE WAY
RUMKER ST
ARGYLE ST
BRIDGE ST
REDBANK PL
HENRY ST
STILTON LN
REMEMBRANCE DRIVEWAY
MYRTLE CREEK
REDBANK CREEK
MAIN SOUTHERN RAILWAY

LW 28 LW 30 LW 29 LW 31 LW 27 LW 26

35° ANGLE OF DRAW LW31

PREDICTED 20mm SUBSIDENCE CONTOUR DUE TO LW31

LEGEND
- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW31
- Monitoring Lines Before & End of LW30
- Surveys During LW31
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

I:\Projects\Tahmoor\MSEC862 - LW31 Management Plans\MSEC862-02 Wollondilly Shire Council\AcadData\MSEC862-02-01 WSC Local Roads.dwg

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TAHMOOR COLLIERY

TAHMOOR UNDERGROUND GLENCORE

TAHMOOR NORTH - LW31
WOLLONDILLY SHIRE COUNCIL
LOCAL ROADS, CULVERTS & BRIDGES

DATE:	SCALE:	DRAWING No:	Rev No
30 Mar 2017	as shown	MSEC862-02-01	B

Thirlmere Way Underbridge (89.326 km)

Bridge Street Overbridge (91.000 km)

Deviation Overbridge (92.410 km)

WOLLONDILLY STATE EMERGENCY SERVICES CONTROL CENTRE & NSW RURAL FIRE SERVICE

WOLLONDILLY COMMUNITY LEISURE CENTRE

COUNCIL ANIMAL SHELTER

WOLLONDILLY COMMUNITY NURSERY

REMONDIS PICTON DEPOT

Stormwater diversion pipes

PREDICTED 20mm SUBSIDENCE CONTOUR DUE TO LW31

35° ANGLE OF DRAW LW31

LW 31

LW 30

LW 29

LW 28

LW 27

LW 26

CR-C1
SC-C1
TH-C2
HL-C1
BR-C7
RE-B1
BR-C6
BR-C5
BR-C4
SL-C3
SL-C2
SL-C1
RE-C4
RE-C3
RE-C2
RE-C1
RE-B2

ATTUNGA CL
STONEQUARRY CL
CARRAMAR CL
THIRLMERE WAY
RUMKER ST
ARGYLE ST
HILL ST
HADDON PL
TARRANT CL
BRIDGE ST
WOOD ST
COACHWOOD CRS
BOLLARD PL
REDBANK PL
HENRY ST
WONGA RD
REDBANK CREEK
STILTON LN
REMEMBRANCE DRIVEWAY
TICKLE DV
HILTON PARK RD
MAIN SOUTHERN RAILWAY
TAHMOOR HOUSE CT
MYRTLE CREEK
KENT RD
KOORANA RD
PARK AVE
CHIVERS PL
SUFFOLK PL
MOORLAND RD
RIVER RD
WINDAH RD
WINPARA CL
ELPHIN ST
LEIHA PL
AMBLECOTE PL
CONNOR PL
PARK ST
YORK ST
CYCLEWAY
KRISTA PL
STRUAN ST
FORGE ST

278 000
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LEGEND
BRIDGES
CULVERTS
ROADS

Grid to MGA co-ordinates

Appendix A - Glencore Coal Assets Australia Risk management Matrix

GLENCORE COAL ASSETS AUSTRALIA RISK MATRIX

CONSEQUENCE [potential foreseeable outcome of the event]

	Health & Safety	Environment	Financial Impact	Image & Reputation / Community	Legal & Compliance
5 Catastrophic	• Multiple fatalities • Multiple cases of permanent total disability / health effects	• Environmental damage or effect (permanent; >10 years) • Requires major remediation	• >$600M investment return • >$100M operating profit • >$20M property damage	• Negative media coverage at international level • Loss of multiple major customers or large proportion of sales contracts • Loss of community support • Significant negative impact on the share price	• Major litigation / prosecution at Glencore corporate level • Nationalisation / loss of licence to operate
4 Major	• Fatality or permanent incapacity / health effects	• Long-term (2 to 10 years) impact • Requires significant remediation	• $60-600M investment return • $20-100M operating profit • $2-20M property damage	• Negative media coverage at national level • Scrutiny from government and NGOs • Complaints from multiple “final” customers • Loss of major customer • Loss of community support • Negative impact on share price	• Major litigation / prosecution at Division level
3 Moderate	• Lost time / disabling injury / occupational health effects / multiple medical treatments	• Medium-term (<2 years) impact • Requires moderate remediation	• $6-60M investment return • $2-20M operating profit • $200K-2M property damage	• Negative media coverage at local / regional level over more than one day • Complaint from a “final” customer • Off-spec product • Community complaint resulting in social issue	• Major litigation / prosecution at Operation level
2 Minor	• Medical Treatment Injury (MTI) / occupational health effects • Restricted Work Injury (RWI)	• Short-term impact • Requires minor remediation	• $600K-6M investment return • $200K-2M operating profit • $10-200K property damage	• Complaint received from stakeholder or community • Negative local media coverage	• Regulation breaches resulting in fine or litigation
1 Negligible	• First Aid Injury (FAI) / illness	• No lasting environmental damage or effect • Requires minor or no remediation	• <$600K investment return • <$200K operating profit • <$10K property damage	• Negligible media coverage	• Regulation breaches without fine or litigation

LIKELIHOOD [of the event occurring <u>with that consequence</u>]

Basis of Rating	E - Rare	D - Unlikely	C - Possible	B - Likely	A – Almost Certain
LIFETIME OR PROJECT OR TRIAL OR FIXED TIME PERIOD OR NEW PROCESS / PLANT / R&D	Unlikely to occur during a lifetime OR Very unlikely to occur OR No known occurrences in broader worldwide industry	Could occur about once during a lifetime OR More likely <u>NOT</u> to occur than to occur OR Has occurred at least once in broader worldwide industry	Could occur more than once during a lifetime OR As likely to occur as not to occur OR Has occurred at least once in the mining / commodities trading industries	May occur about once per year OR More likely to occur than not occur OR Has occurred at least once within Glencore	May occur several times per year OR Expected to occur OR Has occurred several times within Glencore
5 Catastrophic	**15 (M)**	**19 (H)**	**22 (H)**	**24 (H)**	**25 (H)**
4 Major	**10 (M)**	**14 (M)**	**18 (H)**	**21 (H)**	**23 (H)**
3 Moderate	**6 (L)**	**9 (M)**	**13 (M)**	**17 (H)**	**20 (H)**
2 Minor	**3 (L)**	**5 (L)**	**8 (M)**	**12 (M)**	**16 (M)**
1 Negligible	**1 (L)**	**2 (L)**	**4 (L)**	**7 (M)**	**11 (M)**

Consequence Category	Consequence Type	Ownership	Action
Cat. 5	**Catastrophic Hazard**	Divisional / Functional / Operational / Asset Leadership	• Quantitative or semi-quantitative risk assessment required. • Capital expenditure will be justified to achieve ALARP ('As Low As Reasonably Practicable'). • Catastrophic Hazard Management Plans (CHMP) must be implemented where practical, Crisis Management Plans (CMP) tested and Catastrophic Event Recovery Plans (CERP) developed.
Cat. 4 (Health & Safety consequence)	**Fatal Hazard**	Divisional / Functional / Operational / Asset Leadership	• Glencore SafeWork Fatal Hazard Protocols or appropriate management plans must be applied. • Capital expenditure will be justified to achieve ALARP.
Risk Rank	**Risk Rating**	**Ownership**	**Action**
17 to 25	**High Risk**	Divisional / Functional / Operational / Asset Leadership	• Install additional HARD and SOFT controls to achieve ALARP. • Capital expenditure will be justified to achieve ALARP.
7 to 16	**Medium Risk**	Operational / Asset Leadership	• install additional HARD and SOFT controls if necessary to achieve ALARP. • Capital expenditure may be justified.
1 to 6	**Low Risk**	Operational / Asset Leadership	• Install additional controls if necessary to achieve ALARP. • Capital expenditure is not usually justified.

Table 3-3 - Risk Control Effectiveness (RCE)

RCE	Guide
Poor or no existing controls	• Significant control gaps or no credible control; • Either controls do not treat root causes, are non-existent or, if they exist, they are ineffective; • Management has no confidence that any degree of control is being achieved due to poor control design; • Very limited or no operational effectiveness.
Require improvement	• Most controls are designed correctly and are in place and effective; • Controls may only treat some of the root causes of the risk, and/or are not currently effective and/or there may be an over-reliance on “reactive” controls; • Management has doubts about operational effectiveness and reliability; • More work is required to improve operating effectiveness.
Satisfactory	• Controls are well designed and appropriate for the risk; • Controls are largely “preventative” and address the root causes; • Management believes that they are effective and reliable at all times; • Nothing more to be done except review and monitor the existing controls.

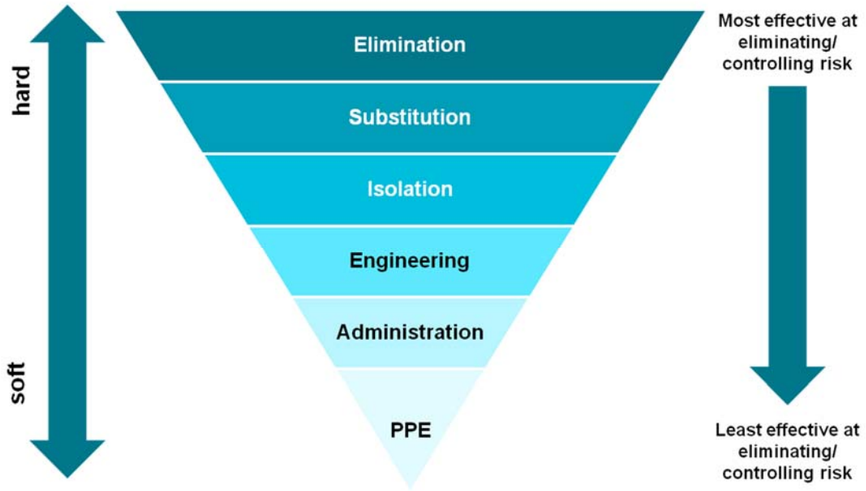

Figure 3-4 – Hierarchy of control

Table 3-4 - Priority for risk treatment authority for continued toleration of risk (applicable for risk assessment level 3 and 4)

Current risk rank	Action	Timing for authority	Authority for continued toleration of current level of risk
23 to 25	The activity must be stopped immediately until action to reduce the level of risk to less than 23 is undertaken or authority to continue is received.	Immediately to within 24 hours.	CE/COO Notification to CE prior to granting of authority to continue
17 to 22	The activity must be stopped immediately until action to reduce the level of risk to less than 17 is under taken or authority to continue is received.	The activity must be stopped immediately until action to reduce the level of risk to less than 17 is under taken or authority to continue is received.	Directors/COO Notification to COO prior to granting of authority to continue
10 to 16	Take action to reduce the level of risk to less than 10 or authority to continue is received.	Within 1 month.	General Managers / Operations Managers / Project Managers
7 to 9	Take action to reduce the level of risk to less than 7 or authority to continue is received.	Within 1 month.	Superintendents/ Managers / Project Team
1 to 6	Tolerable risk unless circumstances change	Ongoing control as part of a management system.	N/A