Tahmoor Colliery
Longwalls 25 to 26

TAHMOOR TOWN CENTRE

SURFACE SAFETY AND SERVICEABILITY MANAGEMENT PLAN

REVISION E

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GENERAL

AUTHORISATION OF SURFACE SAFETY AND SERVICEABILITY MANAGEMENT PLAN

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REVIEW

Date	Rev	Comments
06-Mar-06	A	Initial Draft
10-Mar-06	B	Draft for submission to Tahmoor Town Centre
06-Jun-06	C	Agreed plan
07-Aug-06	D	Chapter 1 amended, as agreed in Plan Review Meeting, 7 August 2006
15-Spe-08	E	Updated for Longwalls 25 and 26

REFERENCES

AS4360, 1999. *AS/NZS 4360:1999 Risk Management.*

MSEC, 2006. *Tahmoor Colliery Longwalls 24 to 26 - The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Surface and Sub-Surface Features due to mining Longwalls 24 to 26 at Tahmoor Colliery in support of an SMP Application.* (Report MSEC157), prepared by Mine Subsidence Engineering Consultants, Revision C, March 2006.

JMA, 2005. *Structural Investigation Report for the Tahmoor Marketplace Building subject to PGMs Caused by Predicted Mines Subsidence.* John Matheson and Associates, 2005.

JMA, 2008a. *Report on column cracking at base of concrete columns in basement car park.* John Matheson and Associates, 2008.

JMA, 2008b. *Tahmoor Town Centre: Structural Investigation Report.* John Matheson and Associates, Revision B, 2008.

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CHAPTER 1. INTRODUCTION

1.1. Background

Tahmoor Colliery is located approximately 80 kilometres south west of Sydney in the township of Tahmoor NSW. It is managed and operated by Xstrata Coal. Tahmoor Colliery has previously mined 24 longwalls to the north and west of the mine's current location.

Longwalls 25 to 26 are a continuation of a series of longwalls that extend into the Tahmoor North Lease area, which began with Longwall 22. The longwall panels are located between the Bargo River in the south-east, the township of Thirlmere in the west and Picton in the north. A portion of each longwall is located beneath the urban area of Tahmoor.

This Management Plan provides detailed information about how the risks associated with the mining beneath the surface infrastructure will be managed by Tahmoor Colliery and Tahmoor Town Centre.

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 Tahmoor Town Centre.

1.2. Location

The Tahmoor Town Centre is located on the corner of Remembrance Drive and Thirlmere Way. The shopping centre (MSEC Structure Ref. Y02a to Y02f) contains a supermarket, a number of retail shops, a restaurant and a petrol station.

Tahmoor Town Centre is located between Longwalls 24A and 24B and to the side of Longwall 25, as shown in Fig. 1.1 and Dwg No. MSEC286-070101. Longwall mining will not mine directly beneath it.

Fig. 1.1 Aerial photograph of Tahmoor Town Centre overlaid with Mine Plan

The closest distance between Tahmoor Town Centre and the edge of the extracted Longwall 24A was 60 metres. The closest distance between Tahmoor Town Centre and the edge of Longwall 25 is 25 metres.

1.3. Predicted Subsidence Movements in general

Specific predictions of subsidence, tilt and strain are provided in Table D.1. A summary of the predicted maximum incremental parameters over the whole subsided area, due to the extraction of each longwall, is shown in Table 1.1.

Table 1.1 Maximum Predicted Incremental Subsidence Parameters

Subsidence Parameter	LW 22	LW 23	LW 24	LW 25	LW 26
Vertical Subsidence (mm)	503	613	596	631	636
Transverse Tilt (mm/m)	3.5	4.9	4.7	5.0	5.1
Longitudinal Tilt (mm/m)	3.0	3.8	3.5	3.7	3.7
Transverse Tensile Strain (mm/m)	0.4	0.7	0.7	0.8	0.8
Longitudinal Tensile Strain (mm/m)	0.6	0.7	0.8	0.8	0.8
Transverse Compressive Strain (mm/m)	0.9	1.6	1.5	1.7	1.7
Longitudinal Compressive Strain (mm/m)	0.6	0.8	0.6	0.6	0.8
Transverse Hogging Curvature (km^{-1})	0.03	0.05	0.05	0.05	0.05
Longitudinal Hogging Curvature (km^{-1})	0.04	0.05	0.05	0.05	0.05
Transverse Sagging Curvature (km^{-1})	0.06	0.11	0.10	0.11	0.11
Longitudinal Sagging Curvature (km^{-1})	0.04	0.05	0.04	0.04	0.05

The maximum predicted cumulative subsidence parameters, after the extraction of each longwall, are shown in Table 1.2.

Table 1.2 Maximum Predicted Cumulative Subsidence Parameters

Subsidence Parameter	LW 22	LW 23	LW 24	LW 25	LW 26
Vertical Subsidence (mm)	503	756	850	892	934
Transverse Tilt (mm/m)	3.5	5.0	4.8	5.2	5.2
Longitudinal Tilt (mm/m)	3.0	4.4	4.9	5.1	5.2
Transverse Tensile Strain (mm/m)	0.4	0.7	0.7	1.0	1.3
Longitudinal Tensile Strain (mm/m)	0.6	0.7	0.8	0.9	0.9
Transverse Compressive Strain (mm/m)	0.9	1.6	1.7	1.7	1.8
Longitudinal Compressive Strain (mm/m)	0.6	0.8	0.8	0.8	0.8
Transverse Hogging Curvature (km^{-1})	0.03	0.05	0.05	0.07	0.09
Longitudinal Hogging Curvature (km^{-1})	0.04	0.05	0.05	0.06	0.06
Transverse Sagging Curvature (km^{-1})	0.06	0.11	0.11	0.11	0.12
Longitudinal Sagging Curvature (km^{-1})	0.04	0.05	0.05	0.05	0.05

1.4. Limitations

This Management Plan is based on the predictions of the effects of mining on surface infrastructure as provided in Report No. MSEC157 by Mine Subsidence Engineering Consultants. Predictions are based on the planned configuration of longwalls at Tahmoor Colliery (as shown in Drawing No. MSEC286-070101), along with available geological information and data from numerous subsidence studies for longwalls previously mined in the area.

Infrastructure considered in this Plan has been identified from site visits, aerial photographs, regional maps and from discussions between Tahmoor Colliery representatives and Tahmoor Town Centre personnel.

The impacts of mining on surface and sub-surface features have been assessed in detail. However, it is recognised that the prediction and assessment of subsidence can be relied upon only to a certain extent. The limitations of the prediction and assessment of mine subsidence are discussed in report MSEC157 by Mine Subsidence Engineering Consultants.

As discussed in the report, there is a low probability that ground movements and their impacts could exceed the predictions and assessments. However, if these potentially higher impacts are considered prior to mining, they can be managed. This Surface Safety and Serviceability Management Plan will not necessarily prevent impacts from longwall mining, but will limit the impacts by establishing appropriate procedures that can be followed should evidence of increased impacts emerge.

1.5. Objectives

The objectives of this Surface Safety and Serviceability Management Plan (SSSMP) are to establish procedures to measure, control, mitigate and repair potential impacts that might occur on surface infrastructure owned by Tahmoor Town Centre.

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

- Ensure the safe and serviceable operation of all surface infrastructure. Public and workplace safety is paramount. Disruption and inconvenience should be kept to minimal levels.
- Monitor ground movements and the condition of surface infrastructure during mining.
- Initiate action to mitigate or remedy potential significant impacts that are expected to occur on the surface.
- Provide a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted.
- Provide a forum to report, discuss and record impacts to the surface. This will involve Tahmoor Colliery, Tahmoor Town Centre, Mine Subsidence Board, Department of Mineral Resources, and consultants as required.
- Establish lines of communication and emergency contacts.

1.6. Scope

The Management Plan is to be used to protect and monitor the condition of the items of infrastructure identified to be at risk due to mine subsidence. The major items at risk are:-

- Structures
- Petrol station
- Services
- Access and mobility
- Finishes
- Food Preparation Areas
- Carpark

The Plan applies to both common areas and tenancies in the Centre.

1.7. Proposed Mining Schedule

It is planned that each longwall will extract coal working northwest from the southeastern ends. This Management Plan covers longwall mining until completion of mining in Longwall 26 and for sufficient time thereafter to allow for completion of subsidence effects.

The current schedule of mining is shown in Table 1.3.

Table 1.3 Schedule of Mining

Longwall	Start Date	Completion Date
Longwall 25	August 2008	August 2009
Longwall 26	October 2009	October 2010

1.8. Definition of Active Subsidence Zone

As a longwall progresses, subsidence begins to develop at a point in front of the longwall face and continues to develop after the longwall passes. The majority of subsidence movement typically occurs within an area 150 metres in front of the longwall face to an area 450 metres behind the longwall face.

This is termed the "active subsidence zone" for the purposes of this Management Plan, where surface monitoring is generally conducted. The active subsidence zone for each longwall is defined by the area bounded by the predicted 20 mm subsidence contour for the active longwall and a distance of 150 metres in front and 450 metres behind the active longwall face, as shown by Fig. 1.2.

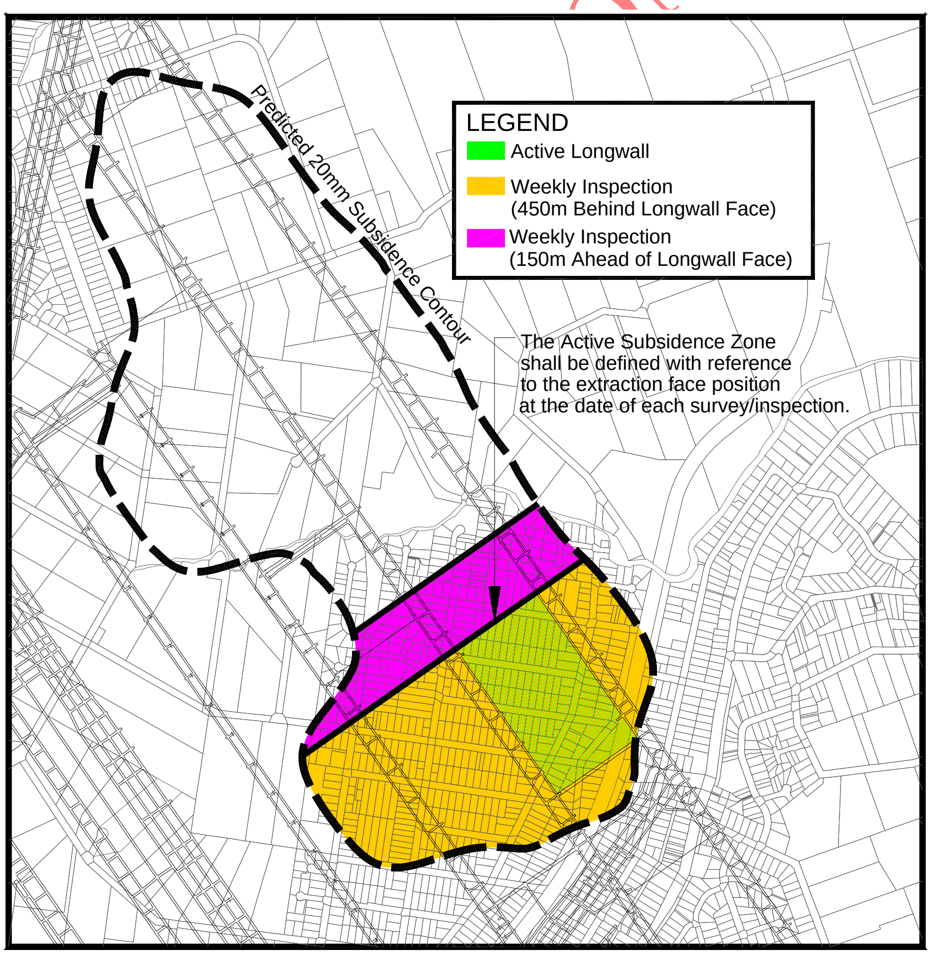


Fig. 1.2 Diagrammatic Representation of Active Subsidence Zone

CHAPTER 2. RISK MANAGEMENT METHOD

2.1. General

The Australian/New Zealand standard for Risk Management defines the terms used in the risk management process, which includes the identification, analysis, assessment, treatment and monitoring of risk. In this context:-

2.1.1. Consequence

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

2.1.2. Likelihood

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

2.1.3. Hazard

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

2.1.4. Risk

'The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.'[4] The risk combines the likelihood of an impact occurring with the consequence of the impact occurring. The risk is rated from very low to extreme. In this study, the likelihood and consequence are combined via the qualitative risk analysis matrix shown in Table 2.1, to determine an estimated level of risk for particular events or situations.

The Risk Analysis Matrix is similar to the example provided in AS/NZS 4360:1995, Appendix D, p.25.

Table 2.1 Qualitative Risk Analysis Matrix

LIKELIHOOD	CONSEQUENCES				
	Very Slight	**Slight**	**Moderate**	**Severe**	**Very Severe**
Almost Certain	Low	Moderate	High	Extreme	Extreme
Likely	Low	Moderate	High	Very High	Extreme
Moderate	Low	Low	Moderate	High	Very High
Unlikely	Very Low	Low	Moderate	High	High
Rare	Very Low	Very Low	Low	Moderate	High
Very Rare	Very Low	Very Low	Low	Moderate	Moderate

This SSSMP adopts a common system of nomenclature to summarise each risk analysis, which is **"LIKELIHOOD / CONSEQUENCE → LEVEL OF RISK".**

For example, if the likelihood of a risk is assessed as "**UNLIKELY**", and the consequence of a risk is assessed as "**SEVERE**", the risk analysis would be summarised as **"UNLIKELY / SEVERE → HIGH"**.

[1] AS/NZS 4360:1999 – Risk Management pp2
[2] AS/NZS 4360:1999 – Risk Management pp2
[3] AS/NZS 4360:1999 – Risk Management pp2
[4] AS/NZS 4360:1999 – Risk Management pp3

CHAPTER 3. RISK ASSESSMENT

3.1. Experience from previous mining

3.1.1. Survey results at Tahmoor Town Centre

Survey marks were placed around the perimeter of the Tahmoor Town Centre and for all columns located along three grid lines within the below-ground carpark. The survey marks were initially surveyed in October 2006, prior to the commencement of Longwall 24B.

The survey results show that subsidence of 30 to 47 mm has developed as a result of the mining of Longwalls 24B and 24A. Maximum predicted subsidence at Tahmoor Town Centre following the mining of Longwalls 24B and 24A was 39 mm, which compares well with the measured movements. The majority of the predicted movements developed during the mining of Longwall 24A, as expected.

Observed tilts have been small, with maximum observed tilts of 0.2 mm/m for bay lengths of 10 metres or greater. The building complex is currently tilting to the south, in a direction towards Longwall 24A, as expected. Observed differential horizontal movements have been small, with maximum observed differential horizontal movements of 8 mm over a bay length of 11 metres. It is noted that the final survey was conducted in July (winter), while the initial surveys were conducted during the warmer month of October. It is considered that differential temperature may be contributing to the observation of differential horizontal movements between some survey marks.

3.1.2. Survey results along surrounding streets

Survey marks were placed along Remembrance Drive, York Street and Thirlmere Way. These marks measure ground movements in the vicinity of the Tahmoor Town Centre.

The survey results show that small amounts of subsidence have developed along these streets accompanied by small tilts and strains, which are small and generally within survey tolerance. There is currently no evidence of irregular non-systematic movement along these monitoring lines in the vicinity of the Tahmoor Town Centre.

3.1.3. Observed impacts at Tahmoor Town Centre

Some minor cracking to carpark columns has been observed during the mining of Longwalls 24B and 24A. A report on investigations conducted in August 2008 has been provided by structural engineer John Matheson & Associates (JMA, 2008a), using observational data provided by an inspector from Sunrise Building and Property Services.

A total of 16 columns were identified with cracks prior to the commencement of Longwall 24B. The crack widths were all less than 1 mm (Category 1). A steady increase in the number of cracked columns has been observed during the mining of Longwalls 24B to 24A. An inspection in August 2008 has identified 18 columns with cracks less than 1 mm in width (Category 1) and 2 columns with cracks between 1 mm and 5 mm (Category 2).

Importantly, the cracks are considered by JMA to be spalling cracks and not seriously detrimental to the overall strength of the structure, though the cracks should be treated in the long term.

JMA concludes that the cause of the increased cracking is likely to have been contributed by mining given the coincidence in timing of cracking and mining. It is noted by MSEC, however, that there was no baseline monitoring prior to the commencement of Longwall 24B to measure the rate of development of column cracking since completion of building construction. JMA notes that the concrete shrinkage and construction practice may have contributed to the incidence of cracking.

Further detailed monitoring is recommended, including measurement of crack widths for all columns with observed cracks. This will be undertaken by Tahmoor Colliery.

3.1.4. Observed impacts along streets in vicinity of Tahmoor Town Centre

No impacts have been observed near the Tahmoor Town Centre. The closest known impact has been observed on Remembrance Drive near the corner of Larkin Street, which is located approximately 160 metres from the Centre and directly above the extracted Longwall 24A. The impacts are related to pavement damage, where it is considered that the combination of observed compressive ground strains have caused concrete footpaths to buckle. The impacts did not immediately develop during the mining of Longwall 24A but during the mining of Longwall 25 after a period increased ambient temperature.

3.1.5. Observed increased subsidence above Longwalls 24A and 25

While there has been a reasonable correlation between observed and predicted subsidence above Longwalls 22 to 24B, increased subsidence has been observed above Longwall 24A. Observed subsidence was greatest above the southern half of Longwall 24A, and gradually reducing in magnitude towards the northern half of the longwall, which was directly beneath the urban area of Tahmoor. These observations are shown graphically in Fig. 3.1, which shows observed subsidence at survey pegs located along the centreline of Longwall 24A.

It can be seen from Fig. 3.1 that while observed subsidence was substantially greater than predicted above the commencing end of the longwalls, observed subsidence compared reasonably well with predictions towards the finishing end of Longwall 24A. It is noted that the Tahmoor Town Centre is located further north along Remembrance Drive (Peg R15).

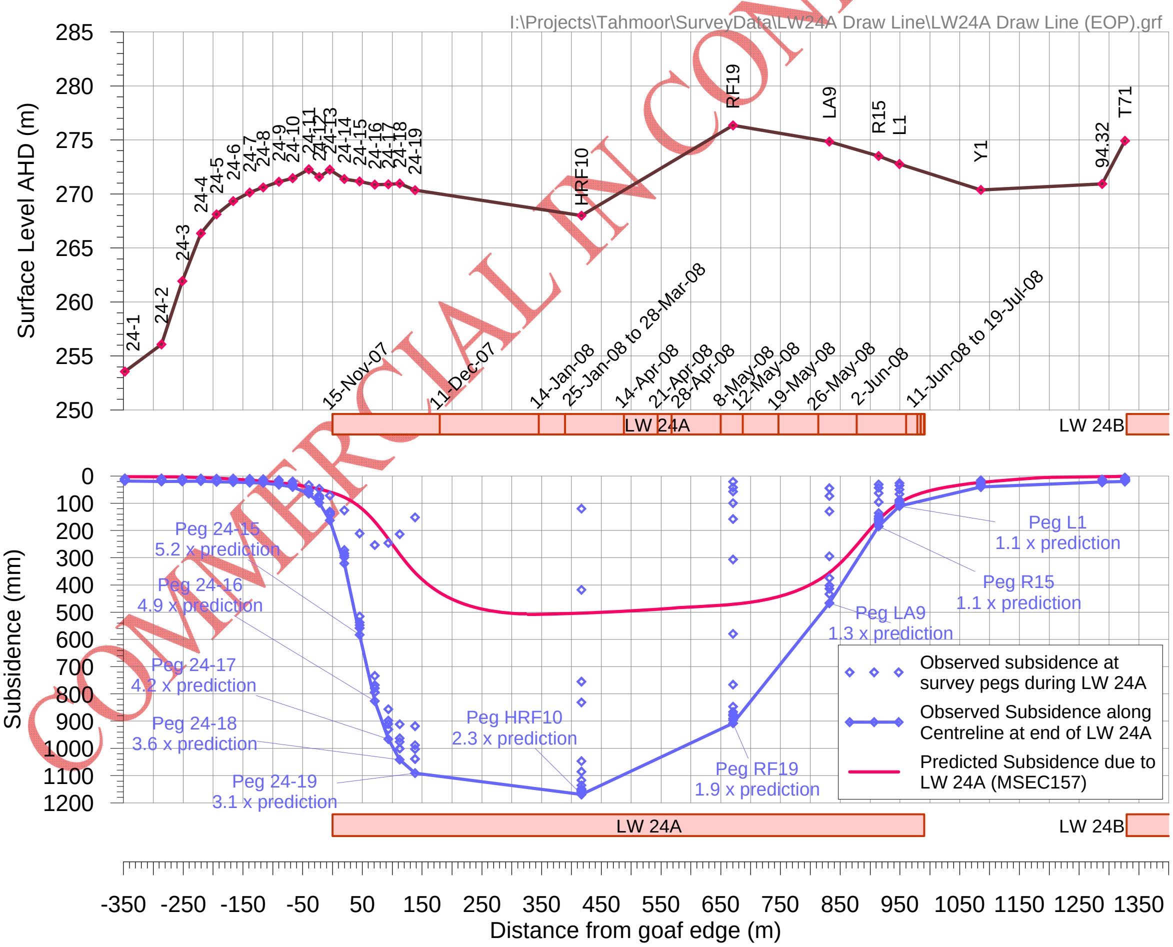


Fig. 3.1 Observed Subsidence along Centreline of Longwall 24A

3.1.6. Potential Increased Subsidence during the mining of Longwall 25

Recent subsidence monitoring after 372 metres of extraction has confirmed that increased subsidence is developing above the commencing end of Longwall 25. This is best illustrated by Fig. 3.2, which compares maximum observed subsidence during the mining of Longwalls 24B, 24A and 25, as well as maximum predicted subsidence during the mining of Longwall 25.

It can be seen from Fig. 3.2 that the observed subsidence behaviour during the mining of Longwall 25 is similar to but slightly less than the behaviour observed during the mining of Longwall 24A. This is substantially more subsidence compared to observations during the mining of Longwall 24B, which closely matches the subsidence predictions.

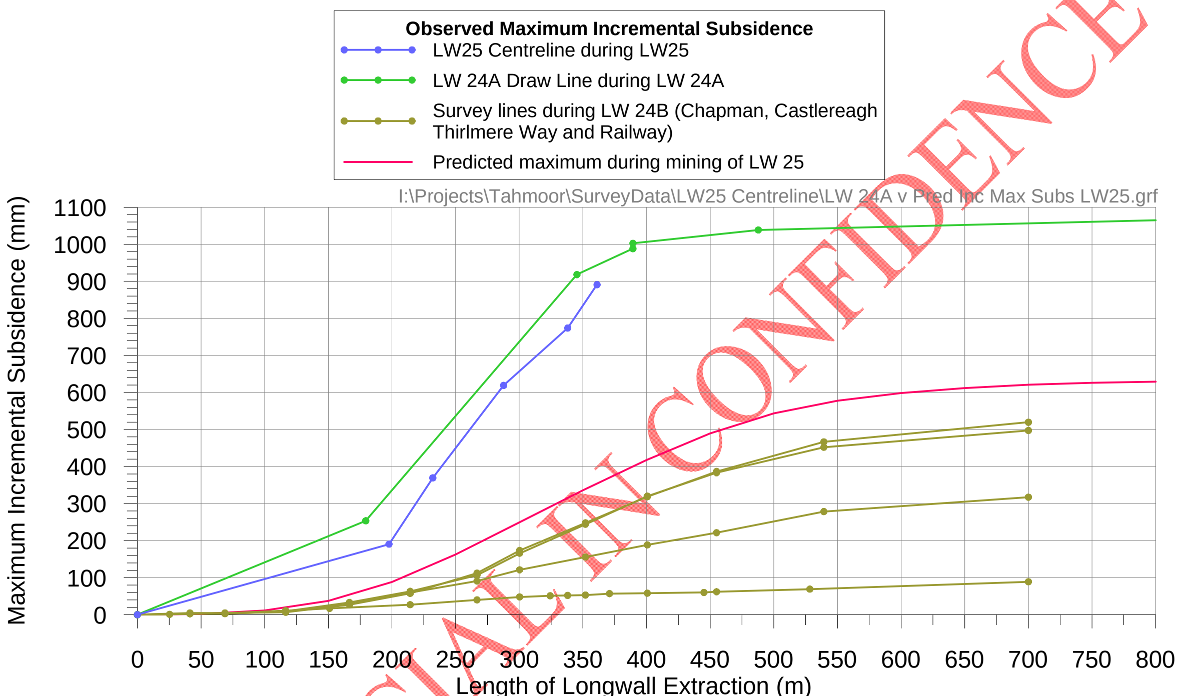


Fig. 3.2 Observed Maximum Incremental Subsidence during the mining of LWs 24B, 24A and 25

In light of the above data, it is considered likely that increased subsidence will be observed along the southern-most streets of Tahmoor, such as Courtland Avenue, Tanya Place, Pandora Place and Progress Street. It is possible that increased subsidence may also be observed at the Tahmoor Town Centre. However, the probability is considered low because subsidence movements were observed to gradually return to normal levels towards the finishing (northern) end of Longwall 24A.

However, given the observation of increased subsidence, additional risk control procedures will be undertaken to manage the potential development of increased impacts within the urban areas above Longwall 25. The management measures are the same as those that were implemented during the mining of Longwall 24A. The Mine Subsidence Board has demonstrated its capacity to quickly respond to any claims for damage where they affect the safety or serviceability of structures. Building inspectors and structural engineers are available to inspect any affected structures within 24 hours on behalf of Tahmoor Colliery. If an impact occurs to a structure that represents a risk to public safety, the Mine Subsidence Board and Tahmoor Colliery are able to repair the impacts at short notice.

3.2. Predicted Subsidence Parameters

3.2.1. Predicted Normal Systematic Subsidence Predictions

Tahmoor Town Centre comprises six structures (Ref. Y02a to Y02f). Structures Y02a, Y02b and Y02c are the largest of these structures, with a maximum plan dimension of approximately 78 metres.

The predicted subsidence parameters for each structure, after the completion of each longwall, are provided in Table D.1.

A summary of the maximum predicted parameters is provided in Table 3.1. The maximum predicted tilts and strains are the maximum predicted tilts and strains that occur during or following the completion of each longwall.

Table 3.1 Predicted Systematic Subsidence Parameters for Tahmoor Town Centre

Structure	Maximum Predicted Subsidence (mm)	Maximum Predicted Systematic Tilt (mm/m)	Maximum Predicted Systematic Tension (mm/m)	Maximum Predicted Systematic Compression (mm/m)
Y02a	200	2.3	0.9	0.3
Y02b	122	1.0	0.6	0.2
Y02c	171	1.7	0.8	0.3
Y02d	230	2.7	0.8	0.3
Y02e	208	2.4	0.8	0.3
Y02f	291	3.3	0.8	0.3

The structures are anticipated to experience subsidence movements greater than 20 mm during the extraction of Longwalls 25 to 26, with the majority of the movements (over 70%) expected to occur during the extraction of Longwall 25.

3.2.2. Potential for Increased Subsidence based on observations above Longwall 24A

Alternative subsidence predictions have been developed in the unlikely event that increased subsidence develops at the Tahmoor Town Centre as has been observed above the south-eastern end of Longwall 24A. The alternative predictions relate to subsidence and tilt only as increased ground strains have generally not been observed.

The predictions relate to the addition of observed subsidence movements during the mining of Longwalls 24A and 24B and predicted movements if increased subsidence is observed during the mining of Longwall 25.

If increased subsidence occurs, maximum subsidence is predicted to increase to 235 mm following the mining of Longwall 25, with maximum ground tilts of 2.7 mm/m.

The alternative predictions were provided to JMA for the purposes of conducting additional structural analyses and the results are described in a separate report (JMA, 2008b).

3.2.3. Potential for Increased Subsidence based on Influence of Coal Barrier

There is a barrier of coal left between Longwalls 22 to 24B (on the northern side) and the 200 Panels and Longwall 24A (on the southern side). This coal has not been extracted, except for development headings.

Longwall 25 will excavate coal directly across this barrier, effectively blocking "the corridor". The Tahmoor Town Centre is located directly above the coal barrier.

The mining geometry in the vicinity of the coal barrier is rare in the Southern Coalfield. A similar mining geometry was present between Tower Longwalls 6 to 14, but unfortunately, limited subsidence monitoring was undertaken, most of which was influenced heavily by the presence of the nearby deeply incised Cataract Gorge. However, there is some empirical data measured around and directly above other coal barriers that provide some indication of possible deviations from the predictive model.

It is possible that increased vertical subsidence will be observed at the Tahmoor Town Centre where it crosses directly above the coal barrier. There have been a number of examples, including locations above Tahmoor Colliery, where subsidence monitoring has shown increased vertical subsidence of the surface in areas that are located directly above an isolated coal barrier. The magnitude of settlement has typically been between 50 and 150 mm above what would be predicted using the Standard Incremental Profile Method. The cause of the additional subsidence has not been proven, but it is thought that it is a result of a general relaxation of in-situ stresses in the strata within the coal barrier.

While observed subsidence may exceed predictions for the section of railway above the coal barrier, subsidence monitoring has shown that it is usually accompanied by relatively low systematic tilts, curvature and strains. This observation is understandable as the subsidence profile exiting the subsidence trough would be flatter compared to normal mining layouts as the subsidence beyond the edge of the panel extends for a greater distance.

3.2.4. Potential for Non-Systematic Movement at Tahmoor Town Centre

It is possible that non-systematic movement could develop at Tahmoor Town Centre as a result of mining movement. Non-systematic movements typically result in elevated ground strains and localised upsidence or heaving of the ground. The likelihood of substantial non-systematic movement at Tahmoor Town Centre is considered low for the following reasons:

- Longwalls will not mine directly beneath the Tahmoor Town Centre. Substantial non-systematic movements typically develop at sites located directly above extracted areas.
- No evidence of non-systematic movement has been observed to date during the mining of Longwalls 24A and 24B along nearby ground monitoring lines.

Further information on the probability of ground strains is provided in Section 3.2.5.

An igneous dyke mapped a seam level is projected to pass directly beneath the northern end of the Centre. This dyke has been mapped over Longwalls 22 to 24B but it is not known whether the dyke extends to the surface. It is possible that non-systematic movements observed at a road pavement and house located directly above the dyke above Longwall 22 may have been caused by irregular movements at the dyke. However, it is noted that no evidence of non-systematic movement has been observed above many monitoring lines that intersect the dyke above Longwalls 23A and 24B, even where extraction has occurred directly beneath the point of intersection on the surface. While the probability of non-systematic movement is considered low, the knowledge that a geological structure intersects with the Tahmoor Town Centre, albeit at seam level, provides a timely reminder that non-systematic may occur.

Non-systematic movements have historically been localised in nature and often follow a straight or curved line along the surface. If non-systematic movement develops at the Centre, it is considered that the movements will not be transferred over the entire building footprint but rather potentially affect one or two rows of columns in the carpark, following a line through the building footprint.

This Management Plan provides for early detection by monitoring and triggered responses in the event that non-systematic movement develops at the Centre.

3.2.5. Frequency Analysis of Ground Strains beyond goaf edge at Tahmoor Colliery

Given that the Tahmoor Town Centre is located between 25 and 160 metres from the closest edge of Longwall 25 and above solid coal, an analysis was conducted of observed strains measured between survey pegs that were between 0 and 200 metres from the side of all previous active longwalls, where pegs were located above solid coal and had not been directly extracted beneath. The dataset included observed strains between survey pegs from goaf edge as a conservative measure.

A plan showing all of the survey pegs included within the analysis is provided in Fig. 3.3. In each case, the survey pegs were only used when the active longwall was between 0 and 200 metres from the nearest side, and only when the pegs were located over solid coal.

Fig. 3.3 Locations of Survey Pegs used for Frequency Analysis of Observed "Solid Coal" Ground Strains at Tahmoor Colliery

A frequency analysis was conducted to estimate the frequency of observed "solid coal" ground strains at Tahmoor Colliery that were measured during the mining of each previous longwall. If multiple surveys were undertaken during the mining of a longwall, the maximum tension or compression was recorded and used for the analysis. The results of frequency analysis are shown graphically in Fig. 3.4.

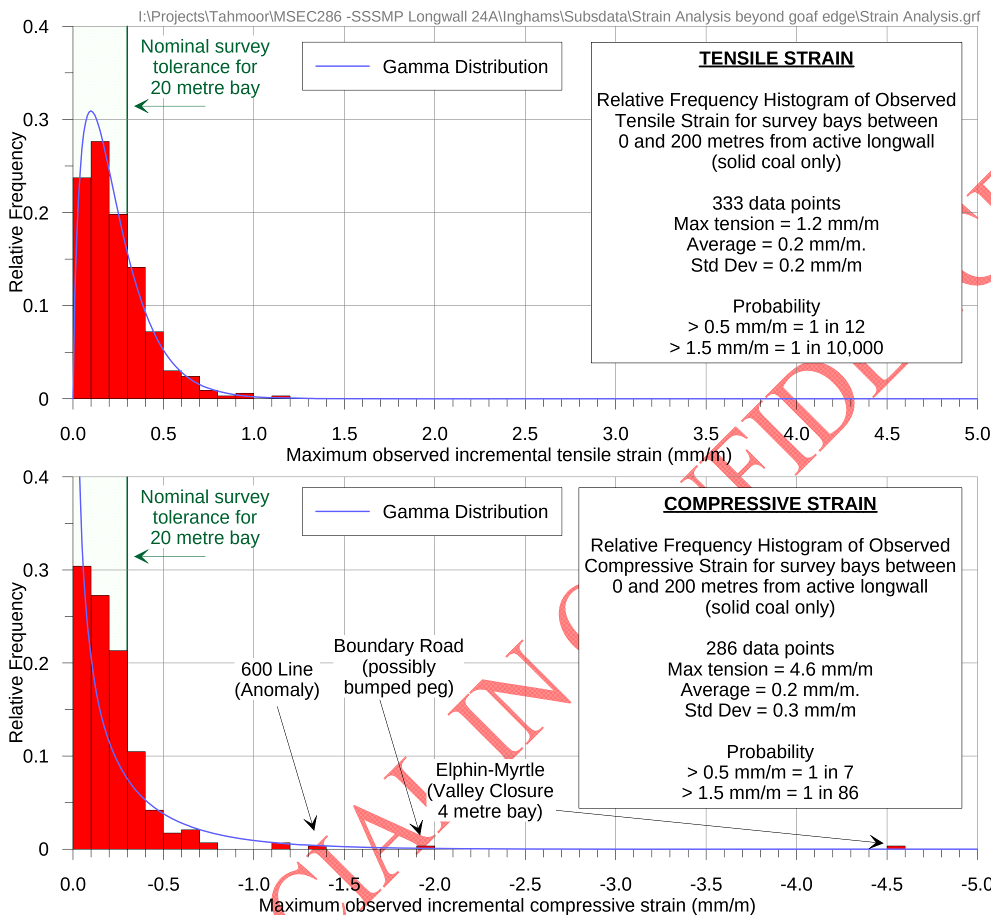


Fig. 3.4 Results of Frequency Analysis of Observed "Solid Coal" Strains at Tahmoor Colliery

It can be seen from the results that the average observed tensile or compressive "solid coal" strains at Tahmoor Colliery for this dataset is 0.2 mm/m, which are within survey tolerance. With respect to observed tensile strains, very few ground strains have exceeded 0.5 mm/m and none have exceeded 1.2 mm/m. Based on a conservatively selected dataset, the probability that tensile strains will exceed 0.5 mm/m is 1 in 12 and the probability that tensile strains will exceed 1.5 mm/m is 1 in 10,000 based on nominal 20 metre bays. The 1 in 1000 tensile strain is calculated to be 1.18 mm/m.

With respect to observed compressive strains, some strains have been observed that are greater than 1.5 mm/m. The maximum observed strain of 4.6 mm/m was measured during the mining of Longwall 24B in the base of Myrtle Creek, where such movements are expected. The rest of the observed ground strains are less than 2.0 mm/m, where one location is considered to be possibly survey error but has been included in the analysis as a conservative measure. Based on a conservatively selected dataset, the probability that compressive strains will exceed 0.5 mm/m is 1 in 7 and the probability that compressive strains will exceed 1.5 mm/m is 1 in 86 based on nominal 20 metre bays.

3.3. Structures

The shopping centre is constructed on bored piers and ground slabs with a steel frame and tilt-up concrete walls and a metal roof. The main building (Y02a and Y02b) is comprised of two double storey structures, with a below-ground carpark and service rooms on one storey, and retail areas on the second storey. The other buildings are single-storey structures. The open-air carpark is constructed with a combination of concrete and asphaltic pavements, some of which is suspended above the below-ground carpark.

3.3.1. Main structures (Y02a – House and Y02b – Woolworths)

Given the complex nature of the structures and the knowledge that they have been constructed with structural steel and precast wall elements, it was considered that the most appropriate method of impact assessment would be to conduct a conventional structural analysis, based on the predicted ground movements. While the empirical method of impact assessment could be used, this method is considered to be less appropriate because it is based upon observed impacts on houses that were constructed with masonry walls.

A structural analysis and impact assessment was conducted by John Matheson and Associates (2005), based upon structural drawings that were provided by the owner of the Tahmoor Town Centre. The analysis was revisited in 2008 (JMA, 2008) to consider the potential impacts if increased subsidence developed at the Centre, and propose trigger levels and possible responses to observed movements and impacts. The JMA (2008) report is included in APPENDIX C.

The analysis found that differential horizontal ground movements (ground strains) have an order of magnitude greater effect on structure stresses than subsidence, tilt and curvature movements. Given that the structures are supported by concrete columns, JMA advises that the columns will respond similarly to tensile or compressive ground strains, except that the columns will move and bend in the opposite direction relative to each other.

A sensitivity analysis was conducted for ground strains. JMA report that approximately 6 columns may experience Category 0 and Category 1 cracking if the building experiences a uniform ground strain of 0.5 mm/m orientated in a direction 45 degrees to the building. If the ground strain is increased to 1.18 mm/m, the analysis showed that approximately 22 columns may experience Category 1 and Category 2 cracking and some spalling on the compression face of the columns is possible.

JMA further advised that if localised elevated ground strains developed within a section of the building footprint, the building deformations are likely to be reflected by a concentrated pattern of cracked columns, which may be responded to in terms of crack treatment or, in the worst case, localised propping.

As discussed in Section 3.2.5, the frequency analysis of ground strains indicates that the probability of tensile strains exceeding 0.5 mm/m is 1 in 12 and the probability of exceeding compressive strains exceeding 0.5 mm/m is 1 in 7. The probability of tensile strains exceeding 1.18 mm/m is 1 in 1000 and the probability of compressive strains exceeding 1.18 mm/m is 1 in 40. The calculated probabilities relate to ground strain measurements over bay lengths of 20 metres. The probability of a uniform strain of 1.18 mm/m across the entire building footprint of the Tahmoor Town Centre is therefore considered to be substantially less than 1 in 1000.

Based on the advice by JMA, frequency analysis of ground strains and observation of cracking in the carpark columns, likelihood of cracking occurring at the Tahmoor Town Centre is considered **MODERATE**. The likelihood of an element of the structure becoming unstable is considered **RARE**.

Cracking to columns are generally considered repairable, provided that the column remains structurally sound. The consequence of cracking is therefore considered **MODERATE**. The level of risk is therefore considered **MODERATE / MODERATE → MODERATE.**

In the event that some structural members become potentially unstable, temporary strengthening works (such as propping) would need to be introduced. On completion of mining, the structural members would be replaced or strengthened. The consequence of instability occurring at some structural members is considered **MODERATE**.

The level of risk of structural instability occurring is therefore considered **RARE / MODERATE → LOW**.

3.3.2. Other Structures

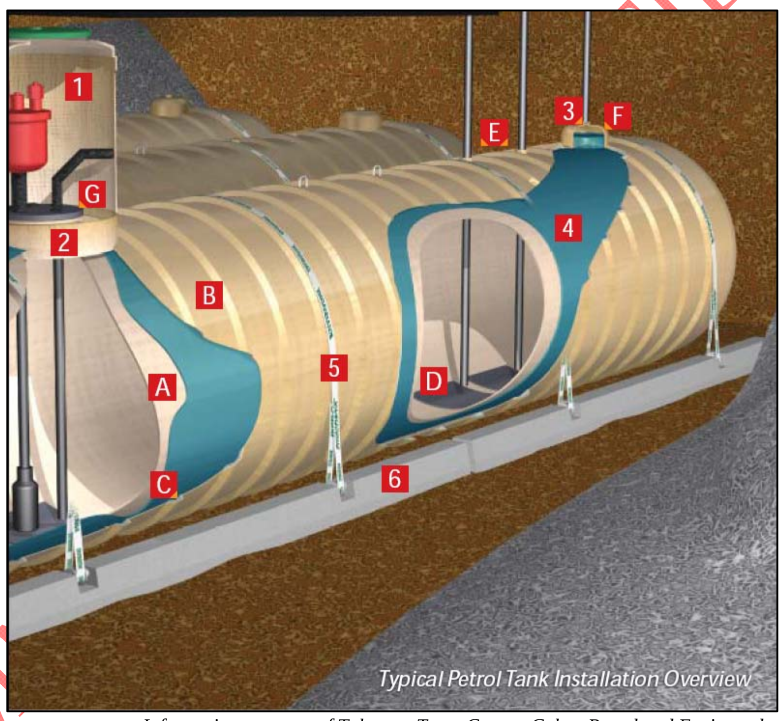
Impact assessments for the other structures on the property have been conducted using an empirical method, which is described in Report No. MSEC157. The structures are generally light-weight in construction and designed in accordance with MSB requirements.

There is an extensive experience of mining beneath over 900 structures during the mining of Longwalls 22 to 24. While impacts have been observed to some structures, at no stage have any impacts resulted in the development of an immediate safety hazard.

The risk to public safety for these structures is considered to be **LOW**.

3.4. Petrol Station

The petrol station contains a buried petrol tank that could present an environmental concern if it leaks. The petrol tank is an Envirotank Double-Wall Tank, which comprises an inner primary tank and an outer tank wall as illustrated in Fig. 3.5. Both walls are structurally designed to contain the fuel. The tank is fitted with an automated monitoring system that monitors for fuel leaks on a daily basis.



Information courtesy of Tahmoor Town Centre, Caltex Petrol and Envirotank

Fig. 3.5 Illustration of Double-Walled Envirotank

There is limited history of longwall mining under petrol stations in the Southern Coalfield. Appin Longwall 1 mined directly beneath a petrol station in the 1970's and no information on impacts is known.

West Cliff Longwall 5A3 mined directly beneath a petrol station at Appin. A monitoring line (B Line) was installed directly outside the petrol station. Substantial and rare non-systematic movements were observed in the vicinity of the petrol station, including a bulge in the road directly outside it. Survey records measured total subsidence of 140 mm to 290 mm during the mining of Longwalls 5A1 to 5A4, with observed compressive ground strain of 3.7 mm/m, which is substantial.

The MSB report that no impacts were observed to the petrol tank, though some impacts were observed to anti-flood valve and some lines connecting the petrol tank to the bowsers and fill points. There were also some impacts to the shop and concrete pavement. The impacts did not present an immediate public safety hazard.

By comparison, the petrol station at the Tahmoor Town Centre is located at Structure Y02e, and is predicted to subside approximately 208 mm, with maximum tilts during mining of 2.4 mm/m and strains of 0.8 mm/m, tensile, and 0.3 mm/m, compressive.

The tank was designed and constructed in accordance with the requirements of the Mine Subsidence Board, which specified that the structure must be designed to withstand subsidence of 800 mm, tilt of 5.0 mm/m and ground strain of 2.0 mm/m.

The double walled petrol tank is therefore unlikely to be adversely impacted by mine subsidence, though some impacts may be experienced to the pavements and connecting lines, valves and cover plates.

The likelihood of leakage of the petrol is therefore assessed as **RARE**. The consequence of leakage is assessed as **MODERATE**, as the tank would need to be repaired and any contaminated soils would need to be remediated.

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

3.5. Services

3.5.1. General Services

There are many services within the Tahmoor Town Centre. These services include potable water pipes, wastewater pipes, stormwater pipes, gas pipes, air-conditioning ductwork, electrical services and communications services.

Pipes and ducts are generally flexible and will be able to withstand the small movements that are predicted to occur. Water, wastewater, stormwater and gas pipes have been directly mined beneath in many locations in Tahmoor and other locations within the Southern Coalfield and very few impacts have been observed, all of which have been minor. Given the small movements that are expected to occur, the likelihood of an adverse impact occurring to pipes or ducts as a result of mine subsidence is considered **RARE**.

Cables are extremely flexible and will be able to withstand the small movements that are predicted to occur. Very few impacts have been observed to cables as a result of previous mining. Given the small movements that are expected to occur, the likelihood of an adverse impact occurring to cables as a result of mine subsidence is considered **VERY RARE**.

Any impacts to pipes and ducts will generally be easy to repair. Buried pipes are slightly more difficult to repair if they are found to be leaking. The consequence of impacts to pipes is therefore considered **SLIGHT**. The level of risk can therefore be considered **RARE / SLIGHT→ VERY LOW.**

Any impacts to cables will generally be easy to repair. The consequence of impacts to cables is therefore considered **SLIGHT**. The level of risk can therefore be considered **VERY RARE / SLIGHT→ VERY LOW.**

3.5.2. Fire Protection Services

Tahmoor Town Centre is fitted with a number of fire protection measures. These include fire sprinkler systems (permanently charged), heat detection systems, fire egress lighting, fire alarms, fire hydrants, fire hoses and fire egress doors. There is a fire control panel and the entire system is tested weekly by Automatic Fire Protection (02) 9831 2255. There are 6 monthly checks of all extinguishers and all fire hoses and fire doors are checked annually.

In the event of an alarm, there is an automated call out to the Picton Fire Control Centre, who will respond. There is also a call out to the Tahmoor Rural Fire Service, which is located across the railway line to Tahmoor Town Centre. This system is managed by Romteck Grid (02) 9666 1555. The automated system works by detecting a drop of water line pressure.

The likelihood of impacts occurring to pipes and cabling is similar to the likelihood of impacts occurring to general services pipes and cabling, which were discussed in the previous section. The likelihood of impacts occurring is therefore considered **VERY RARE to RARE**.

The likelihood of impacts occurring to fire egress doors is considered **RARE** as the predicted movements are very small.

The consequence of impacts occurring is understandably greater than other services within the Centre. The consequence of impacts is therefore considered **MODERATE / SEVERE.** The level of risk can therefore be considered **RARE / MODERATE / SEVERE→ MODERATE/LOW**

3.5.3. Security Services

Tahmoor Town Centre is fitted with a number of security measures. These include entry and exit doors and electronic monitoring systems.

The likelihood of impacts occurring to security doors is considered **RARE** as the predicted movements are very small. The likelihood of impacts occurring to electronic monitoring systems is considered **VERY RARE**.

The consequence of impacts to security measures is considered **MODERATE**. The level of risk can therefore be considered **RARE / MODERATE→ LOW.**

3.6. Access and Mobility

Tahmoor Town Centre must comply with Australian standards for access and mobility and Tahmoor Town Centre engaged a consultant to ensure that it met these standards. Australian Standard AS1428.1-2001 requires that all circulation spaces shall not exceed gradients and crossfalls of 1 in 40, all walkways shall not exceed gradients of 1 in 20, and all ramps shall not exceed gradients of 1 in 14. These gradients are an order of magnitude greater than the change in gradients due to mining, which are predicted to be less than 1 in 200. The likelihood of gradients substantially exceeding Australian standards is therefore considered **VERY RARE**.

It is also possible that cracks or steps might form in ramps and floors that might provide access to the Centre. Given the small movements that are expected to occur, the likelihood of cracking or stepping occurring is considered **VERY RARE**.

If ramps and floors are found to exceed Australian standards or cracks or steps occur as a result of mine subsidence, they can be repaired. However, these repairs are likely to result in some inconvenience to patrons of the Centre. The consequence of impacts to ramps and floors in the Centre is considered **MODERATE**.

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

3.7. Finishes

There is a risk that mine subsidence movements could result in cracking to floor and wall finishes. These finishes are typically more vulnerable to impacts than structures. Previous experiences of mining in the Southern Coalfields suggest that the likelihood of impacts to finishes at the Tahmoor Town Centre would be low, given the small amounts of movement that occur. For example, the majority of claims for impacts to finishes during the extraction of Longwalls 22 to 24 have occurred where houses have been directly mined beneath. By comparison, the Tahmoor Town Centre will not be directly mined beneath.

Given the small movements that are expected to occur, the likelihood of impacts to finishes as a result of mine subsidence is therefore considered **RARE**.

Impacts to finishes in residential properties would normally be considered slight as they are easy to repair. However, cracking to floor and wall finishes clearly detract from the aesthetic appearance of common areas and retail tenancies. Any repairs would represent an inconvenience to patrons and tenants. The consequence of impacts to finishes is therefore considered **MODERATE**.

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

3.8. Food Preparation Areas

Health regulations require that food is prepared in areas with appropriate standards of finishes. While any impacts on the structures are expected to be minor, some may cause food preparation areas to not comply with health regulations.

The likelihood of impacts to food preparation areas is considered similar to those that would occur to finishes, which were discussed in the previous section and considered **RARE**.

Impacts to finishes in residential properties would normally be considered slight as they are easy to repair. However, cracking to floor and wall finishes in food preparation areas may represent health concerns to patrons if they are not repaired quickly. Any repairs would represent an inconvenience to patrons and tenants. The consequence of impacts to food preparation areas is therefore considered **MODERATE**.

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

3.9. Asphaltic Carpark

The carpark may experience some impacts to the asphaltic surface as a result of mine subsidence. Experiences of mining directly beneath roads in Tahmoor suggest that such impacts are likely to be rare and minor in nature. For example, all of the impacts that have occurred to pavements during mining Longwalls 22 to 24 at Tahmoor Colliery are located directly above the extracted longwalls. By comparison, the Tahmoor Town Centre will not be directly mined beneath.

Given the small movements that are expected to occur, the likelihood of impacts occurring to the asphaltic pavement is considered **RARE**.

If impacts are observed in the pavement, they can be easily repaired. However, it is recognised that any repairs would represent an inconvenience to patrons. The consequence of impacts to the asphaltic pavement is considered **SLIGHT.**

The level of risk can therefore be considered **RARE / SLIGHT→ VERY LOW.**

3.10. Summary of Risk Identification and Assessment

A summary of the levels of risk for infrastructure at the Tahmoor Town Centre is provided in Table 3.2.

Table 3.2 Risk Analysis Matrix for Tahmoor Town Centre

Risk	Likelihood	Consequence	Level of Risk
Structures			
Cracking to Main Structures Y02a & Y02b	MODERATE	MODERATE	MODERATE
Local instability within Main Structures	RARE	MODERATE	LOW
Impacts to other structures			LOW or VERY LOW
Petrol Station			
Leakage of petrol	RARE	MODERATE	LOW
Services			
Impacts to general services – pipes	RARE	SLIGHT	VERY LOW
Impacts to general services – cables	VERY RARE	SLIGHT	VERY LOW
Impacts to Fire Protection Services	RARE	MODERATE	LOW
Impacts to Security Services	RARE	MODERATE	LOW
Impacts to Access and Mobility requirements	VERY RARE	MODERATE	LOW
Finishes			
Impacts to Finishes	RARE	MODERATE	LOW
Food Preparation Areas			
Impacts to Food Preparation Areas	RARE	MODERATE	LOW
Asphaltic Carpark			
Impacts to carpark	RARE	SLIGHT	VERY LOW

Notwithstanding the generally low levels of risk that have been identified, Risk Control Procedures will be established as described in Chapter 4.

CHAPTER 4. RISK CONTROL PROCEDURES

4.1. Structures Response Group (SMG)

The SMG is responsible for taking the necessary actions required to manage the risks that are identified from monitoring of structures. The SMG's key members are:

- Tahmoor Colliery
- John Matheson and Associates
- Mine Subsidence Engineering Consultants
- Mine Subsidence Board
- Sunrise Building and Property Services
- Tahmoor Town Centre

The Department of Primary Industries may attend SMG meetings from time to time.

4.2. Mitigation Measures

The Tahmoor Town Centre is a newly constructed building, designed accordance with the requirements of the Mine Subsidence Board, which specified that the structure must be designed to withstand subsidence of 800 mm, tilt of 5.0 mm/m and ground strain of 2.0 mm/m.

No mitigation measures have been undertaken to the structure, although some mitigation measures will be undertaken to reduce response times if impacts are observed. Tahmoor Colliery will engage contractors to remain on standby in readiness for structural repairs to basement columns or installation of precautionary structural propping around some columns in the unlikely event that such responses are required.

4.3. Monitoring Measures

4.3.1. Ground survey

Survey marks have been placed in the adjacent streets to measure ground movements around the Tahmoor Town Centre. These include York Street, Thirlmere Way and Remembrance Drive and are shown in Fig. 4.1.

The survey marks were placed prior to the commencement of Longwall 24B and have been surveyed in 2D (levels and distances between survey marks). The survey marks were recently surveyed in 3D (eastings, northings and levels) prior to the commencement of Longwall 25. 2D surveys will be conducted regularly during the mining of Longwall 25. 3D surveys can be conducted during mining if required.

A 2D monitoring line has also been installed along the pavement in front of the shops along Remembrance Drive. This is called the shopfront monitoring line. A baseline 2D initial survey has been conducted. Regular surveys during mining are not planned along this line as regular surveys will be undertaken along the Remembrance Drive line. However, surveys may be undertaken during mining if required.

Raw ground monitoring results will be sent to the Department of Primary Industries, MSEC and Tahmoor Colliery within 48 hours of survey.

4.3.2. Structure surveys

The following structure surveys will be conducted at Tahmoor Town Centre:

- 2D perimeter survey
  A total of 21 survey marks were placed around the perimeter of Tahmoor Town Centre prior to the commencement of Longwall 24B. The marks are placed in the superstructure, generally above the basement carpark level and their locations are shown in Fig. 4.1.
  Regular surveys during mining are not planned along this line as the structural analysis found that differential horizontal ground movements (ground strains) have an order of magnitude greater effect on structure stresses than subsidence, tilt and curvature movements. Monitoring of

subsidence will be undertaken along ground surveys along the adjacent streets. However, surveys of the building perimeter may be undertaken during mining if required.

- 2D basement column survey
  Survey marks were placed on the top of basement columns in Grids 09, 10 and 11, prior to the commencement of Longwall 24B and are shown in Fig. 4.2. The grids were selected by the structural engineer, JMA based on structural analyses. The marks have been used to measure levels and distances between adjacent marks in both grid directions. The marks have also been used to measure mining-induced column tilt, by measuring changes in the horizontal offset between the top of the column and the base.
  Regular surveys during mining are not planned along this line in preference for regular Basement Width and Length Surveys, which are discussed below. However, surveys of the columns may be undertaken during mining if required.

- Relative 3D baseline grid survey
  This is a new survey following a review of subsidence management practices. A survey mark will be placed in the base of all columns within the carpark and at the base of all perimeter walls where they intersect with grid lines, as shown in Fig. 4.2. The marks will be placed at the base of the columns as they will best measure differential ground movements. Marks placed at the tops of columns would be constrained by the suspended slab.
  The survey will be conducted in relative 3D, where the positions of all marks will be linked to a local coordinate system. The survey marks will be installed and initially surveyed before the Longwall 25 face approaches within 200 metres of the Tahmoor Town Centre.
  The survey is quite onerous as it involves over 120 points and must be conducted out of hours to avoid traffic and optimise lines of sight. Regular surveys during mining are not planned. The survey will be conducted as a baseline survey. However, regular relative 3D surveys may be undertaken to some or all of the survey marks if triggered by monitoring results.

- Basement Width and Length Surveys
  This is a new survey following a review of subsidence management practices. Long horizontal distance measurements will be undertaken across the full width and length of the basement carpark at each grid location. An additional four long distance surveys will be undertaken across the diagonal of both building structures, as shown in Fig. 4.2. The survey uses the same perimeter marks that will be installed as part of the Relative 3D basement grid survey.
  Regular surveys will be undertaken along the widths, lengths and diagonals during mining. The monitoring concept is to use the basement width and length surveys as a large net, where whole of structure movements are monitored. If differential horizontal movements are detected, the net will be tightened using the relative 3D survey of individual columns to identify whether the movements are focussed in a particular area.

4.3.3. Visual inspections

Visual inspections will be undertaken by a qualified building inspector familiar with mine subsidence impacts. The inspector will undertake the following:

- Check for any signs of impact within the building generally.
- Detailed inspection of all basement carpark columns for any cracking or spalling. A detailed inspection sheet is being developed with the structural engineer.
- Measurement of crack widths as requested by the structural engineers. This currently covers all cracks in carpark basement columns
- Check for proper operation of all fire egress door and any impacts to access ramps and steps.
- Check for any signs of impact to the petrol station, including daily check for impacts with the petrol station staff who operate the automated tank monitoring system.

The inspector will check the building on a daily basis during active subsidence and will report weekly.

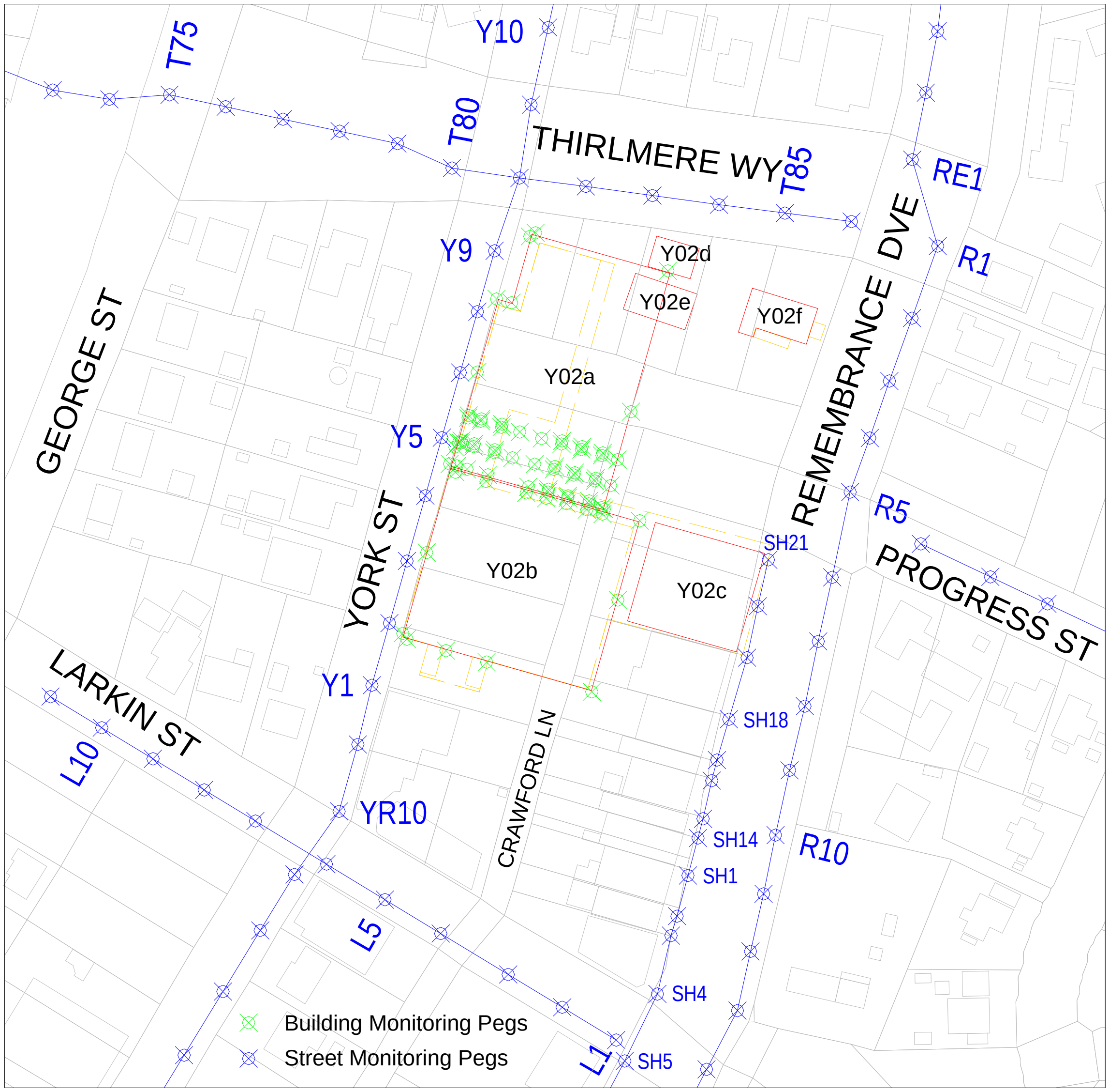
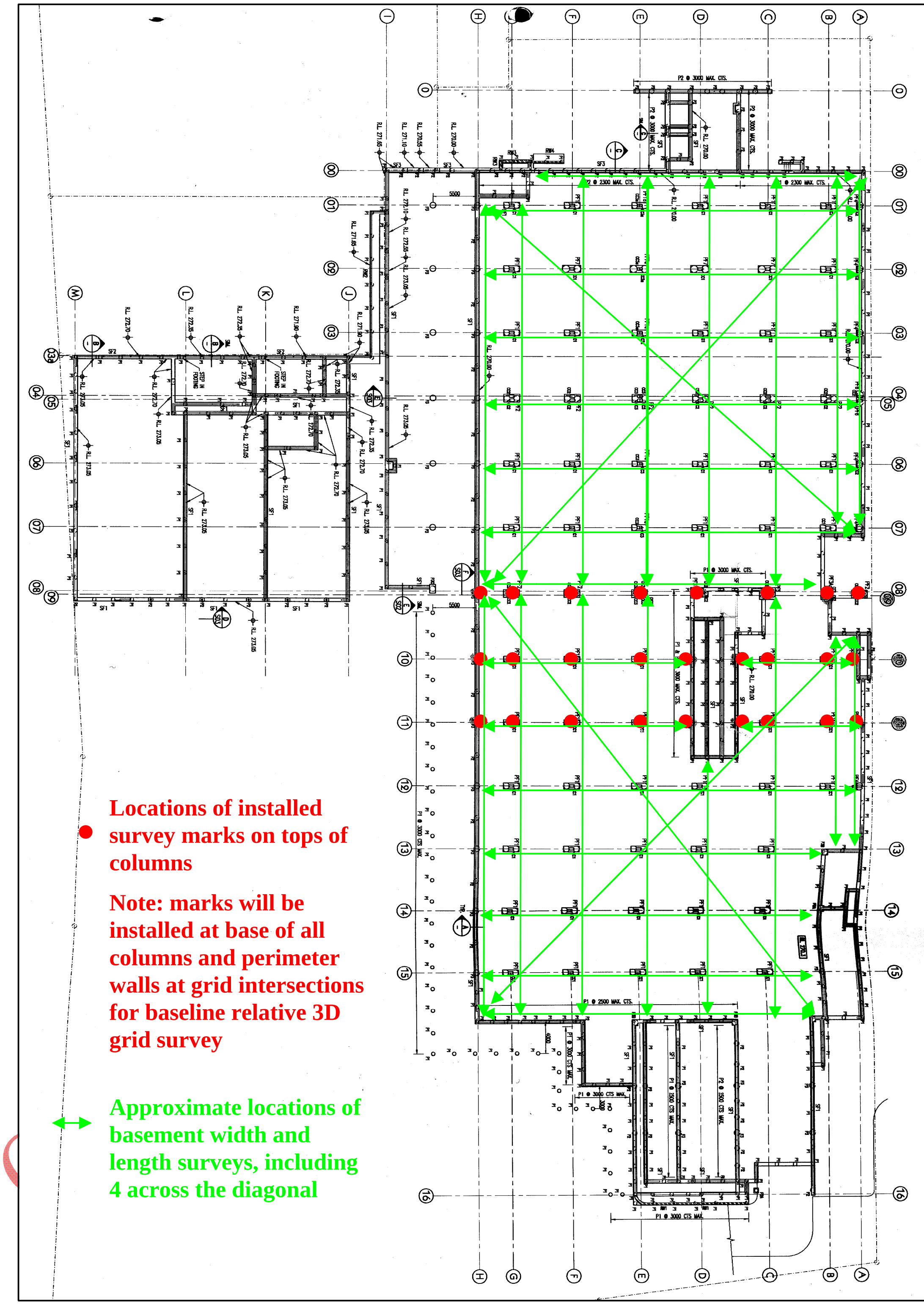


Fig. 4.1 Existing and Proposed Ground Monitoring at Tahmoor Town Centre



Base Footing Layout Plan courtesy Algorry Zappia & Associates Pty Ltd

Fig. 4.2 Proposed Survey Marks on Basement Columns

4.3.4. Structural inspections

Structural inspections will be undertaken by JMA as required by the SMG.

4.3.5. Changes to monitoring frequencies

Monitoring frequencies will continue until agreed to reduce following approval from the SMG, Tahmoor Town Centre and the DPI. As a general guide, monitoring is likely to continue until the longwall has moved away from the Tahmoor Town Centre by a distance of approximately 400 metres.

4.4. Trigger and Response Plan

Trigger levels have been developed by Tahmoor Colliery based on observed ground movements or impacts. The triggers are primarily related to column cracking in the basement columns, as recommended by JMA (2008b). Triggers are also recommended for wall tilts of the precast panels. Tilt monitoring will be primarily undertaken using the ground survey marks that surround the Tahmoor Town Centre. Actual wall tilts can be measured at any time by the surveyor if triggered by the monitoring results.

Trigger levels for each monitoring parameter are described in the risk control procedures in Table 4.1.

Tahmoor Colliery will engage contractors to remain on standby in readiness for structural repairs to basement columns or installation of precautionary structural propping around some columns in the unlikely event that such responses are required.

Tahmoor Colliery will also coordinate with the Mine Subsidence Board and ensure that building contractors are on standby for immediate call out and service in the event of other impacts occurring.

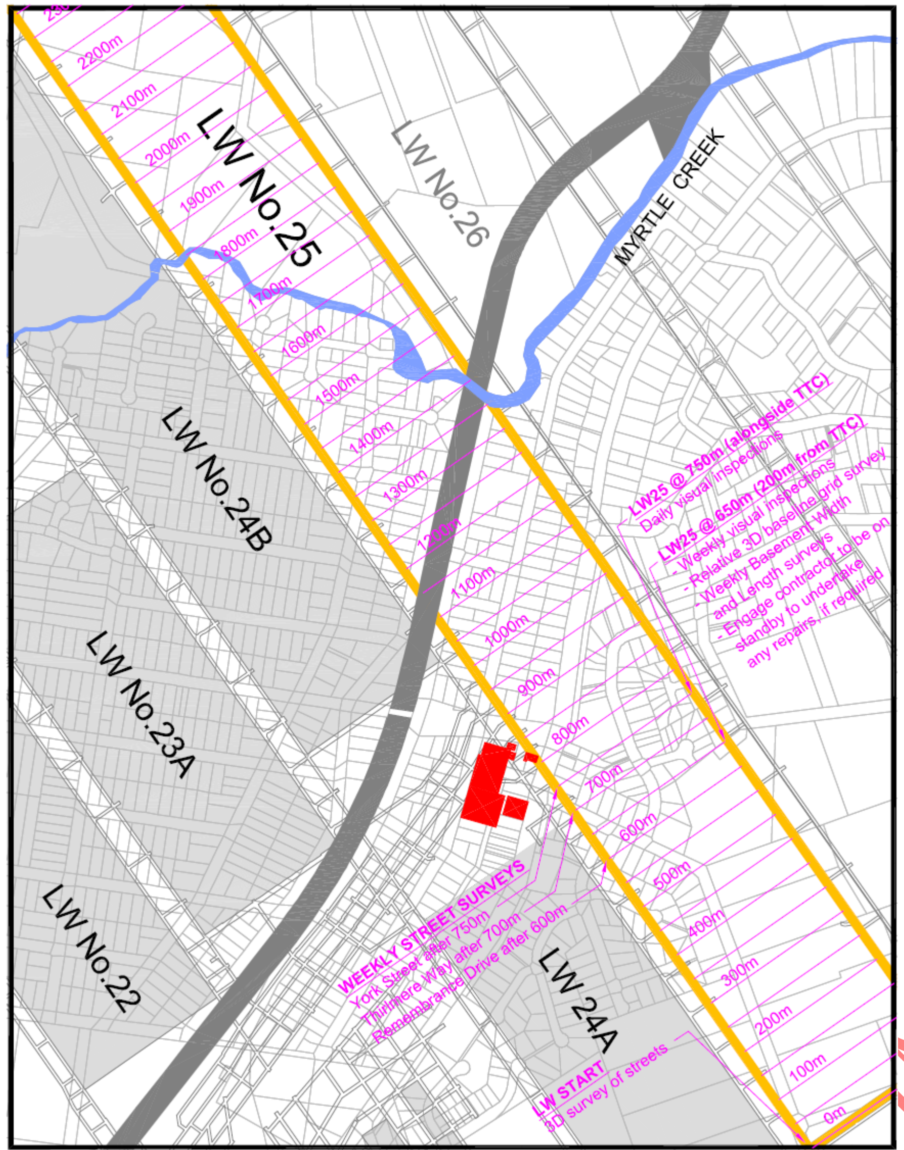
Immediate responses will be undertaken by Tahmoor Colliery or the Mine Subsidence Board if triggered by monitoring results:

- Increase in survey and inspection frequencies if required by the SMG.
- Additional surveys and inspections, such as regular of widths of any new cracks that might appear.
- Repair of impacts that create a serious public safety hazard
- Repair of impacts to all entry and exit doors, and all other doors that must remain operational for security and fire egress reasons, even if further impacts are anticipated.
- Repair of impacts that impair any essential services.
- Repair of impacts that impair access and mobility to the Centre, even if further impacts are anticipated.
- Repair of impacts to the aesthetic appearance of the Centre, even if further impacts are anticipated.
- Repair of impacts to food preparation areas that result in a potential breach of health regulations, even if further impacts are anticipated.
- Repair of impacts to sensitive equipment, even if further impacts are anticipated.

4.5. Risk Control Procedures

The risk control procedures for the management of potential impacts to the Tahmoor Town Centre are provided in Table 4.1.

Table 4.1 Risk Control Procedures for Tahmoor Town Centre

RISK ISSUE	TRIGGER	CONTROL PROCEDURES	TIMING & FREQ	BY WHOM?
General Procedures				
	**None**	Ground surveys of level and strain distance along adjacent streets	3D baseline prior to subsidence (complete) Weekly when TTC within active subsidence zone. For LW25: Remembrance Dr weekly after 600m Thirlmere Way weekly after 700m York Street weekly after 750m	L&H
		Relative 3D baseline grid survey	Prior to LW25 approaching within 200 m of TTC (after 650 m of extraction) After LWs 25 and 26 unless triggered	L&H
		Basement width and length surveys (including diagonal)	Prior to LW25 approaching within 200 m of TTC (after 650 m of extraction) Weekly during active subsidence. For LW25: after 650 m of extraction After LWs 25 and 26	L&H
		Building perimeter structure surveys	Prior to LW25 (complete) After LWs 25 and 26 unless triggered	L&H
		Basement top of column tilt and distance surveys	Prior to LW25 (complete) After LWs 25 and 26 unless triggered	L&H
		Conduct pre-mining building inspection of structures	Complete	Tahmoor Colliery (SBPS)
		Visual inspection of structures, including: • crack width monitoring • inspection of petrol station services, including confirmation of status with petrol station operator	For LW25: Weekly after 650 m of extraction (within 200 m) Daily after 750 m of extraction (LW alongside TTC) For LW26: Weekly when TTC within active subsidence zone	Tahmoor Colliery (SBPS)
		Arrange for contractors to remain standby for undertaking prompt structural repairs if required	Prior to LWs 25 & 26 approaching within 200 metres of TTC	Tahmoor Colliery
		Analyse and report monitoring and inspection results to SMG	Weekly within active subsidence zone For LW25: after 650 m of extraction	MSEC
		SMG discuss results and consider whether any additional management measures are required	As required by SMG	SMG

IMPACTS TO STRUCTURE

TRIGGER LEVELS

Trigger Level	Description
GREEN	No additional cracking to columns
BLUE	Any of the following: • Category 1 cracking to columns • Ground tilt > 3 mm/m • Differential horizontal movements along basement width and length surveys of ± 8 mm (equates to ground strain of 1 mm/m between 8 metre carpark column bays) • Ground strain > 1 mm/m along York Street, Thirlmere Way or Remembrance Drive where the pegs are located adjacent to Tahmoor Town Centre
YELLOW	Any of the following: • Category 2 cracking to columns Note: Additional triggers may be recommended by structural engineer following detailed inspections.
ORANGE	Any of the following: • Category 3 cracking to columns Note: Additional triggers may be recommended by structural engineer following detailed inspections.

RISK ISSUE	TRIGGER	CONTROL PROCEDURES	TIMING & FREQ	BY WHOM?
IMPACTS TO STRUCTURE	GREEN	Follow general procedures	-	-
IMPACTS TO STRUCTURE	BLUE	Notify SMG of trigger exceedence and any management decisions undertaken (incl TTC, DPI and MSB)	Within 24 hours	Tahmoor Colliery
IMPACTS TO STRUCTURE	BLUE	Structural inspection of cracks (in person or by photographic records) if triggered by observation of cracking	Within 1 week	JMA
IMPACTS TO STRUCTURE	BLUE	Measure precast panel wall tilts if triggered by ground tilt surveys	Within 1 week	L&H
IMPACTS TO STRUCTURE	BLUE	SMG meet and consider whether any additional management measures are required, including: - increase monitoring and reporting procedures including crack width monitoring and relative 3D survey - inspect precast panels and structural steel connections - consider whether any other triggers are applicable based on detailed inspections	Within 1 week	SMG
IMPACTS TO STRUCTURE	YELLOW	Notify SMG of trigger exceedence and any management decisions undertaken (incl TTC, DPI and MSB)	Within 24 hours	Tahmoor Colliery
IMPACTS TO STRUCTURE	YELLOW	Structural inspection of cracks (in person or by photographic records)	Within 3 days	JMA
IMPACTS TO STRUCTURE	YELLOW	SMG meet and consider whether any additional management measures are required, including: - increase monitoring and reporting procedures including crack width monitoring and relative 3D survey - strengthening columns or heavy duty propping - consider whether any other triggers are applicable based on detailed inspections	Within 3 days	SMG
IMPACTS TO STRUCTURE	ORANGE	Notify SMG of trigger exceedence and any management decisions undertaken (incl TTC, DPI and MSB)	Within 24 hours	Tahmoor Colliery
IMPACTS TO STRUCTURE	ORANGE	Structural inspection of cracks (in person or by photographic records)	Within 24 hours	JMA
IMPACTS TO STRUCTURE	ORANGE	SMG meet and consider whether any additional management measures are required, including: - increase monitoring and reporting procedures including crack width monitoring and relative 3D survey - strengthening columns or heavy duty propping	Within 3 days	SMG
IMPACTS TO PETROL TANK	None	Follow general procedures (including daily inspections and checking automated petrol tank monitoring status with petrol station staff, checking valves and cover plates)	-	-
IMPACTS TO PETROL TANK	None	Brief petrol station staff on potential for subsidence impacts	Prior to LW face approaching within 200 m of TTC	Tahmoor Colliery
IMPACTS TO PETROL TANK	Impact(s) observed to petrol station	Notify SMG of impact and any management decisions undertaken	Within 24 hours	Tahmoor Colliery
IMPACTS TO PETROL TANK	Impact(s) observed to petrol station	Repair impact(s)	As required	MSB
IMPACTS TO FIRE PROTECTION SERVICES	None	Follow general procedures (including daily inspections and checking of fire egress doors)	-	-
IMPACTS TO FIRE PROTECTION SERVICES	None	Test fire protection system	As per Tahmoor Town Centre fire protection management plan	TTC
IMPACTS TO FIRE PROTECTION SERVICES	Impact observed	Repair fire protection services	As required	MSB
IMPACTS TO ACCESS AND MOBILITY, FINISHES, FOOD PREPARATION AREAS AND CARPARK	None	Follow general procedures (including daily visual inspections)	-	-
IMPACTS TO ACCESS AND MOBILITY, FINISHES, FOOD PREPARATION AREAS AND CARPARK	Impacts observed	Repair impacts	As required	MSB

CHAPTER 5. SMG REVIEW MEETINGS

SMG meetings will be held between Tahmoor Town Centre, Tahmoor Colliery, the Mine Subsidence Board and / or the Department of Primary Industries for discussion and resolution of issues raised in the operation of the Management Plan. The frequency of the SMG meetings will be monthly unless agreed otherwise between representatives of each Plan Review Meeting.

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 member of the SMG 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.

CHAPTER 6. AUDIT AND REVIEW

This Management Plan has been agreed between parties. The Management Plan will be reviewed following extraction of each longwall.

Should an audit of the Management Plan be required during that period, an auditor shall be appointed by the Tahmoor Colliery to review the operation of the Management Plan and report at the next scheduled Plan Review Meeting.

Other factors that may require a review of the Management Plan are:-

- Observation of greater impacts on surface features due to mine subsidence than was previously expected.
- Observation of fewer impacts or no impacts on surface features due to mine subsidence than was previously expected.
- Observation of significant variation between observed and predicted subsidence.

CHAPTER 7. RECORD KEEPING

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

CHAPTER 8. CONTACT LIST

Organisation	Contact (* SMG Member)	Phone	Email / Mail	Fax
Automatic Fire Protection	-	(02) 9831 2255	-	-
Department Primary Industries (Mineral Resources Division)	Phil Steuart	(02) 4931 6648	phil.steuart@dpi.nsw.gov.au	(02) 4931 6790
Department Primary Industries (Mineral Resources Division)	Gang Li*	(02) 4931 6644 0409 227 986	gang.li@dpi.nsw.gov.au	(02) 4931 6790
Department Primary Industries (Mineral Resources Division)	Ray Ramage	(02) 4931 6645 0402 477 620	ray.ramage@dpi.nsw.gov.au	(02) 4931 6790
John Matheson & Associates (JMA)	John Matheson*	(02) 9979 6618	jma.eng@bigpond.net.au	(02) 9999 0121
Mine Subsidence Board	Darren Bullock*	(02) 4677 1967	d.bullock@minesub.nsw.gov.au	(02) 4677-2040
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay*	(02) 9413 3777	daryl@minesubsidence.com	(02) 9413 3822
Romteck Grid (automated fire alarm call out system)	-	(02) 9666 1555	-	-
Sunrise Building and Property Services (SBPS)	John Schwarz*	(02) 4883 9030 0400 390058	sunbuilding@westnet.com.au	(02) 4883 9738
Xstrata Coal Tahmoor Colliery – Environment and Community Manager	Ian Sheppard*	(02) 4640 0156 0408 444 257	isheppard@xstratacoal.com.au	(02) 4640 0140
Xstrata Coal Tahmoor Colliery – Community and SMP Coordinator	David Clarkson*	(02) 4640 0133 0428 114 614	dclarkson@xstratacoal.com.au	(02) 4640 0140
Tahmoor Town Centre	Diana Lang	(02) 4683 1386	milleni@bigpond.net.au	(02) 4683 1387

APPENDIX A. Glossary of Terms and Definitions

Glossary of Terms and Definitions

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections.
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Overlap adjustment factor	A factor that defines the ratio between the maximum incremental subsidence of a panel and the maximum incremental subsidence of that panel if it were the first panel in a series.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points.
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel.
Super-critical area	An area of panel greater than the critical area.
Tilt	The difference in subsidence between two points divided by the horizontal distance between the points.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	A reduction in the expected subsidence at a point, being the difference between the predicted subsidence and the subsidence actually measured.

APPENDIX B. Drawings and Illustrations

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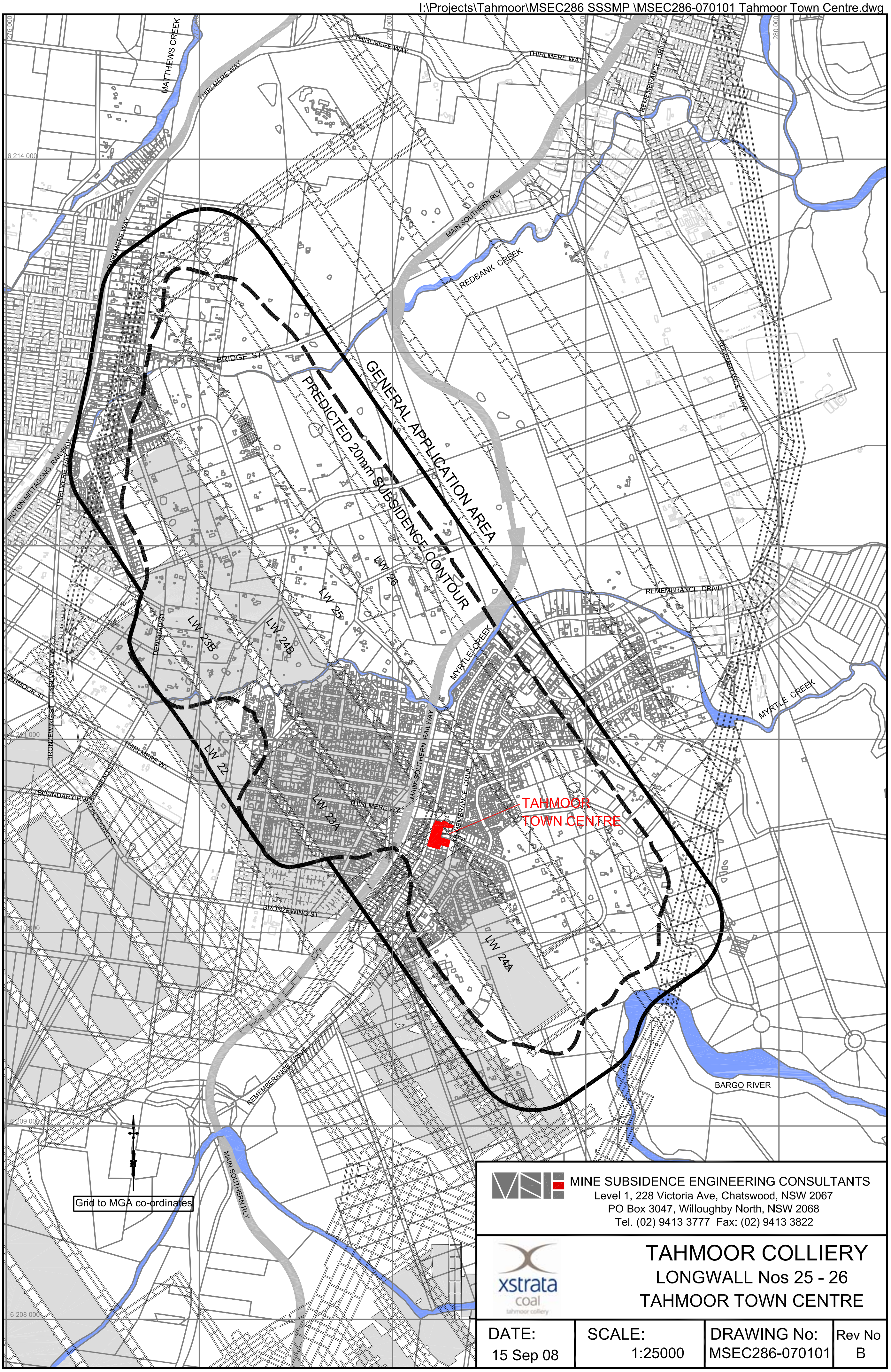

MINE SUBSIDENCE ENGINEERING CONSULTANTS
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xstrata coal
tahmoor colliery

TAHMOOR COLLIERY
LONGWALL Nos 25 - 26
TAHMOOR TOWN CENTRE

DATE:	SCALE:	DRAWING No:	Rev No
15 Sep 08	1:25000	MSEC286-070101	B

APPENDIX C. Structural Report by John Matheson & Associates

Report on column cracking at base of concrete columns in basement car park.

Prepared by John Matheson

Date: 25th August 2008.

John Matheson & Associates Pty Ltd

Consulting Civil & Structural Engineers

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Introduction

Mr. John Matheson from this office carried out a site inspection of the reported cracking at the base of some columns within the basement car park at the Tahmoor Town Centre development. The purpose of the inspection was to observe the cracks and to report on the history of the observed cracks and the likely causes. The pre-mining inspection report prepared by Mr. John Schwarz is referred to in this report with respect to the chronology and intensity of cracking evident before the commencement of active subsidence.

Observations

A number of columns have developed cracking around the column base, where the concrete has been poured so that it bears directly upon the ground floor slab. It is evident that the concrete ground slab was cast before the concrete column and that the ovoid recess had been incorrectly located so that when casting the column, the cover concrete was cast directly onto the ground slab rather than wholly upon the underlying footing without any provision for differential movement between the ground slab and overlying column concrete. The intimate bearing of the column cover concrete on the ground slab has meant that restraint forces have been developed sufficient to cause slab cracking and surface spalling cracks at the base of the columns.

The connections between the concrete columns and the suspended concrete slab above were inspected and these connections appeared to be unchanged from earlier inspections and there was no discernable change in the condition of the structure in these locations.

Possible Causes of Cracking

The observed cracking appears to have been caused by restraint forces developed between the concrete column and the basement slab on ground. The restraint forces develop where the slab moves away from the column due to concrete shrinkage, significant slab shortening during extended periods of low temperature and tensile ground strains caused by mine subsidence.

In order to determine the possible causes of the current level of cracking, a matrix has been prepared to record crack size versus time overlaid with ambient temperature conditions and the progress of LW24A/B in order to better understand the relationship of the observed cracks and crack growth with the conditions likely to cause cracking and these results are provided in Table 1.

Description	Number of Columns	Date
Number of columns with Cat 0/1 cracks before LW24B	16	August 2006
Number of columns with Cat 2 cracks before LW24B	0	August 2006
Number of columns with Cat 0/1 cracks before LW24A	17	July 2007
Number of columns with Cat 2 cracks before LW24A	1	July 2007
Number of columns with Cat 0/1 cracks at end of LW24A	18	23rd July 2008
Number of columns with Cat 2 cracks at end of LW24A	2	23rd July 2008
Number of Columns with Cat 0/1 cracks at end of July 2008	18	August 2008
Number of columns with Cat 2 cracks at end of July 2008	2	August 2008

Table 1

Conclusions & Recommendations

From the analysis of the above data, the following has been concluded:

1. Prior to mining LW24B, 16 columns had pre-existing category 0 or 1 cracking.
2. During or after mining LW24B and prior to mining LW24A, 2 additional columns developed category 0/1 cracking and one column developed category 2 cracking.
3. During or after mining LW24A and prior to the extended cold period during winter 2008, 2 additional columns developed category 0/1 cracking and one column developed category 2 cracking.

4. Additional cracking appears not to have developed during the recent very cold period of weather.

From the above chronology it has been concluded that subsidence is the most likely cause of the additional 4 cracked columns and the growth in 2 columns from category 0/1 to category 2 although pre-existing ground slab shrinkage strains and poor column/ground slab construction detail may be contributing to the additional observed cracking.

The observed cracking appears to be localised within the column concrete cover zone and does not appear to propagate into the core of the column within the confinement of the column ties and longitudinal reinforcement. From our conversations with the designing consultant at the time of preparing the original structural report, we were informed that the columns were effectively designed as pinned at the base and therefore minor spalling cracking, whilst it is undesirable, is therefore considered not to be seriously detrimental to the overall strength of the structure and that repairs may be carried out to control further cracking of category 1 cracking and epoxy concrete repairs to the small number of category 2 cracks observed.

Where the concrete cracking is hairline up to 1.0mm in width and the cover concrete has not become fully separated from the remainder of the columns concrete, it is recommended that the paint be stripped back to expose bare concrete and the bottom 400mm of the columns be externally reinforced with epoxy bonded carbon fibre reinforcement wrapped continuously around the column to confined the cover concrete and mitigate against further crack growth. Where the cracking is category 2 and the cover concrete has clearly spalled away from the parent concrete, it is recommended that the spalled concrete be carefully removed and the column section be reinstated to the intended dimensions and surface finish using a suitable epoxy concrete repair technique such as Parchem or equal. All of the repaired columns should then be painted to match the surrounding columns.

Tahmoor Town Centre: Structural Investigation Report.

Prepared by John Matheson

Date: 29th October 2008.

Revision B

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Introduction

This report has been prepared by Mr. John Matheson from this office at the request of MSEC on behalf of Tahmoor Colliery and is based upon documentation provided by the Structural Engineer, Algorry Zappia & Associates Pty Ltd and site inspections carried out on Monday June 27th 2005 and on subsequent dates.

An investigation into the effects of the subsidence, tilt and ground strain, predicted by MSEC, on the largest single part of the building structure was carried out in the preparation of the August 2005 report.

Recent subsidence monitoring of LW24A revealed subsidence exceeding the original predictions and this has caused a re-evaluation of the subsidence predictions for LW25 in the event that a similar experience develops at the Tahmoor Town Centre. Preparation of new subsidence, tilt and ground strain data has been carried out by MSEC and the new data has been input into the original Microstran model for re-analysis.

The original analysis included for factors applied to the subsidence, tilt and ground strain predictions of 1.25, 1.5 and 2.0, which were applied to cover the observed statistical variations in subsidence data. Since the original report, a significant amount of effort has been invested by MSEC into the statistical evaluation of the body of subsidence, tilt and ground strain data. Exceedence probabilities have been developed, which may be broadly comparable to the annual exceedence probabilities commonly applied to environmental loads such as wind and earthquake in the Australian Standards.

Design Limit State

The BCA and Australian Standards classify a building that is designed to contain a large number of people as importance level 3 therefore requiring the design of the structure for design events for safety of a 1:1000 annual exceedence probability (AEP) for wind load and 1:500 AEP for earthquake, where the wind and earthquake forces are calculated bases on statistical analysis of wind speed and seismic acceleration data from a historical perspective.

The statistical analysis of the historical subsidence, tilt and ground strain data is ongoing and useful correlations appear to be emerging that provide 1/1000 and 1/10,000 data for ground strains, where 1/1000 and 1/10,000 events are considered to occur on an annual basis. However, it is not yet clear whether the 1/1000 and 1/10,000 data are true AEP figures but it would not be unreasonable to use the MSEC 1/1000 ground strain data for the analysis of the impact of ground strain on the building structure particularly where there is significant structural continuity and basement shear walls to provide resistance to lateral loads. The MSEC tensile ground strains for 1/1,000 and 1/10,000 events are 1.18mm/m and 1.5mm/m respectively. Compressive ground strains will cause the columns to move in the opposite direction to tensile ground strain and are expected to result in equal magnitude but bending moments and shear forces in the opposing direction. For example if a 1.18mm/m tensile ground strain causes tension on the left hand face of a column then a - 1.18mm/m compressive ground strain will cause a tension on the right hand face of a column of equivalent magnitude.

The revised subsidence and tilt predictions were double the original values and were not defined in terms of exceedence probabilities in the same manner that the ground strains were and therefore a load factor of 1.2 was applied to the subsidence and tilt movements. The computer analysis of the concrete framed structure shows that the effects of ground curvature as expressed by the subsidence and tilt on the basement columns are secondary in order of magnitude by comparison with the computed impact of ground strain.

Possible Structural Impacts

The concrete columns supporting the "Homemakers" section of the shopping centre were reviewed based upon a pinned connection with the pier caps and a rigid connection with the suspended ground floor slab as they were in the original report.

A review of calculated column CC1 reactions shows that the calculated reactions are consistently lower than the compression load at balanced failure (P_{bal}), which is the point on the column axial force/bending moment interaction diagram where the steel reinforcement yields simultaneously with reaching the concrete compressive strength.

At reactions less than P_{bal} the limiting column capacity occurs when the longitudinal reinforcement yields after the concrete has cracked in tension and is termed tension failure in column design. The column cracking is expected to occur on the internal face of the columns under tensile ground strain and will result in a loss of stiffness of the column section as the tension crack propagates into the column section and the steel stress increases toward yield. The tendency for the CC1 columns to fail in tension indicates that the overload behaviour will be more ductile and observable due to the development of tension cracks.

The effects of concrete creep due to the effect of sustained tensile ground strain being imposed upon the structure, the above-mentioned tension cracking at the top of the concrete columns and possible cracking in the post-tensioned floor slab have been modeled in the analysis of the structure by using a reduced effective concrete modulus of elasticity of 50% of the initial concrete modulus of elasticity. The reduced column stiffness concept is an approach normally applied in the design of low-rise concrete framed structures and is reasonable provided the punching shear design is carried out assuming full column stiffness.

The frame analysis for 0.5mm tensile ground strain indicates that around 6 columns may develop cracking near the interface with the suspended ground floor slab and this is expected to increase to around 22 columns if tensile ground strain increases to 1.18mm/m or the 1/1,000 event used in the analysis for the strength limit state. The worst affected columns beneath the "Homemakers" section are generally along grids A, B, C, F & G with the largest calculated column moments occurring along grid10G and progressively reducing in severity from grid 9 to grid14 and from grids G to E and grids A to C, which is consistent with a reduction of impact toward the centre of the building as expected.

From the analysis of the column cross sections and the possible column rigid body tilt due to 1.18mm tensile ground strain, it is unlikely that a category 3 tension crack could eventuate on the inside face of the column (toward the centre of the structure) due to interaction of the column and ground floor slab as the columns are effectively spread apart under tensile ground strain and therefore category 2 cracking is considered to be the upper bound for potential column damage where the columns connect to the ground floor slab.

The 'Homemakers" section of the building has a large footprint and it is primarily for this reason that the predicted ground strains, if transmitted entirely to the building foundation and structure, may generate column bending moments of the magnitude calculated. If localized ground strains occur and assuming that they are transmitted to the structure, the building deformations are likely to be reflected by a concentrated pattern of cracked columns, which may be responded to in terms of the recommended triggers in this report with localized propping in the basement car park in the event that this occurs.

Structural Steel and Precast Wall Panels

Reservations concerning the structural capacity of the main roof beam midspan bolted connections were made in the 2006 report and these comments were based primarily upon a difference of opinion between engineers as to the most appropriate connection design model. However, the structural steelwork is generally expected to behave in a ductile manner and should not be adversely affected by the predicted subsidence.

The predicted ground tilts are expected to be in the order of 2.0mm/m and tilts of this magnitude are not expected to significantly increase the horizontal eave level loads due to wind or seismic load.

Conclusions & Recommendations

The analysis of the concrete framed basement structure for the revised subsidence, tilt and ground strain predictions indicates that a significant although fewer number of columns beneath the "Homemakers" section may be affected by the revised subsidence, tilt and tensile ground strains. At tensile ground strains less than 0.5mm/m, some 6 and possibly more columns may be affected by Category 0 and1 cracking. At tensile ground strains approaching 1.18mm/m, Category 1 and 2 may affect some 22 and possibly more columns and some spalling on the compression face of the columns is possible.

Trigger	Damage Category	Comment
	Category 0	Monitor the basement columns and walls weekly during active subsidence period. Monitor the main roof beam midpsan bolted connections weekly.
	Category 1 Precast wall panel tilt 3mm/m	Monitor weekly as above and install crack measurement gauges. Inspect precast concrete wall panels and structural steel to steel and steel to concrete connections and monitor for precast panel wall tilt.
	Category 2	Monitor daily and consider strengthening measures at the top of the basement columns such as carbon fibre confinement of the column to enhance column ductility. Consider installation of heavy duty propping.
	Category 3	Install heavy-duty mono-props or similar rated propping to resist the entire calculated column reaction.