SIMEC Mining:

Tahmoor Coal – Modification 3 - Longwall S7A

The effects of the proposed addition of LW S7A
on previous subsidence predictions and impact assessments

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
A	Draft	DJK		Nov-23
B	Final	DJK	AH/CW	Mar-24

Report produced to:- Support an application to extract Tahmoor LW S7A to be submitted to the Department of Planning and Environment.

Previous reports:- MSEC1192 (Revision A) – Tahmoor South Project – Extraction Plan for Longwalls S1A to S6A - Subsidence ground movement predictions and subsidence impact assessments for natural features and surface infrastructure (May 2022)

Background reports available at *www.minesubsidence.com*:

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

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Drawings

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

Drawing No.	***Description***	***Revision***
MSEC1348-01	General layout	A
MSEC1348-02	Surface level contours	A
MSEC1348-03	Bulli Seam roof contours	A
MSEC1348-04	Bulli Seam depth of cover contours	A
MSEC1348-05	Extraction height	A
MSEC1348-06	Geological structures at Bulli Seam level	A
MSEC1348-07	Natural features	A
MSEC1348-08	Main Southern Railway	A
MSEC1348-09	Surface infrastructure	A
MSEC1348-10	Archaeological and Heritage sites	A
MSEC1348-11	Built features	A
MSEC1348-12	Predicted incremental subsidence due to LW S7A	A
MSEC1348-13	Predicted total subsidence due to LW S1A to LW S7A	A
MSEC1348-14	Predicted total subsidence due to LW S1A to LW S6B	A
MSEC1348-15	Proposed Subsidence Monitoring Plan	A

1.0 INTRODUCTION

1.1. Background

Tahmoor Coal owns and operates Tahmoor Mine, an existing underground coal mine that is located approximately 80 km south-west of Sydney in the Southern Coalfield of NSW. Tahmoor Coal is a wholly owned entity within the SIMEC Mining Division of the GFG Alliance group.

Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by Tahmoor Coal to undertake subsidence predictions and impact assessments for the proposed Longwalls 101A to 106B in the Tahmoor South Domain area at Tahmoor Mine (Tahmoor South Project). Report No. MSEC1123 was issued in support of the EIS for these longwalls. The Department of Planning, Industry and Environment, granted Tahmoor Coal development consent for the Tahmoor South Project on 23 April 2021. This consent has subsequently been modified twice (Mod 1 and Mod 2).

On 20 May 2022, Tahmoor Coal lodged an Extraction Plan Application for the extraction of LWs S1A to S6A. Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by Tahmoor Coal to undertake subsidence predictions and impact assessments for the proposed Longwalls S1A to S6A in the Tahmoor South Domain area at Tahmoor Mine. Report No. MSEC1192 (Revision A) was issued during May 2022 in support of the Extraction Plan Application for these longwalls. The Department of Planning, Industry and Environment, granted Tahmoor Coal approval for extraction of LW S1A to S6A on 20 September 2022.

The longwall layout adopted in Report No. MSEC1192 is referred to as the *Approved Layout* in this report.

Tahmoor Coal is currently extracting LW S2A and proposes to extract an additional longwall panel, Longwall S7A (LW S7A) to the A series compared to *Approved Layout* adopted in Report No. MSEC1192. The proposed LW S7A represents the third modification to the development consent (Modification 3) and the proposed longwall layout including LW S7A is referred to as the *Modified Layout* in this report.

LW S7A has been included following a revision of the geological interpretation of the location of the Central Fault, which is located to the south west of the Tahmoor South Project. The commencing end of LW S7A has been shortened compared to LW S6A for the purposes of reducing the potential for subsidence effects on the urban area of Bargo township.

This subsidence report will support the Modification 3 application for the addition of LW S7A, which will be submitted to the Department of Planning and Environment. The location of LW S7A has been overlaid on an aerial photograph, as shown in Fig. 1.1.

1.2. Mining geometry

The locations of the longwalls in the Tahmoor South Domain are shown in Drawing No. MSEC1348-01, in Appendix B. The location of LW S7A based on the Modified Layout is shown in orange in this drawing.

A summary of the dimensions of LW S7A is provided in Table 1.1.

Table 1.1 Dimensions of LW S7A based on the Modified Layout

Layout (Report No.)	Longwall	Overall void length including installation heading (m)	Overall void width including first workings (m)	Overall tailgate chain pillar width (m)
Modified Layout (MSEC1348)	LW S7A	1,918	285	36

1.3. Surface and seam

The Tahmoor South Domain area at Tahmoor Mine is located between Tahmoor's surface facilities to the north and the township of Bargo to the south. The terrain directly above LW S7A is relatively flat such that the surface level above LW S7A varies between approximately 320 metres above Australian Height Datum (m AHD) and 350 m AHD. The surface level contours are shown in Drawing No. MSEC1348-02.

The seam roof contours are shown in Drawing No. MSEC1348-03. The Bulli Seam generally dips from the south-west towards the north-east with an average gradient of 5 % (i.e. 1 in 20) across the mining area.

The depth of cover contours are shown in Drawing No. MSEC1348-04. The depth of cover directly above LW S7A varies between approximately 375 m and 385 m.

The A series longwalls are approved to extract coal from the Bulli Seam. Tahmoor Coal has revised its forecast extraction heights since the previous predictions were provided in Report No. MSEC1192. The changes are generally minor for the A series longwall panels, in the range of 50 to 100 mm greater than previously forecast. Tahmoor Coal proposes to extract a minimum height of 2.1 metres and maximum extraction height of 2.6 metres within LW S7A, as shown in Drawing No. MSEC1348-05. The surface and seam levels across LW S1A to LW S7A are shown in Fig. 1.2.

Fig. 1.1 Location of LW S7A overlaid on aerial photograph

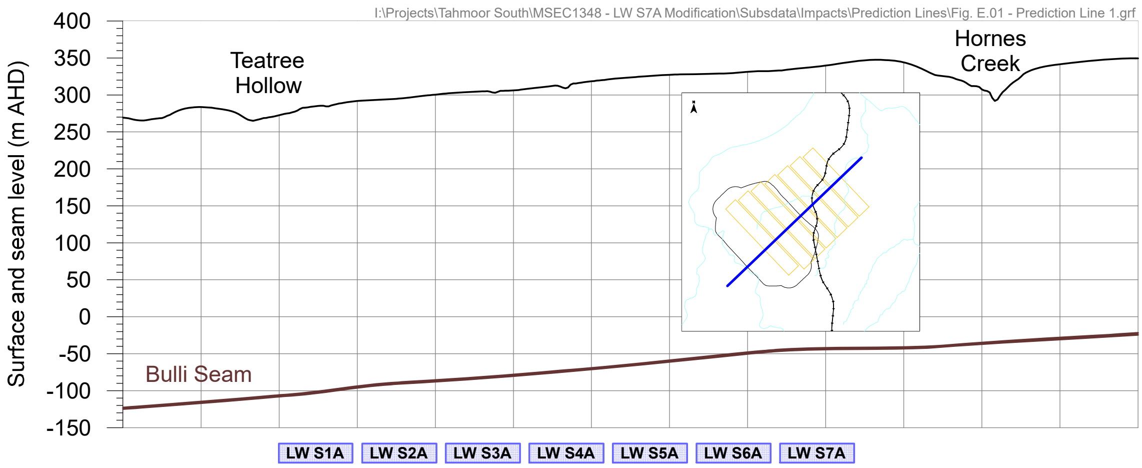


Fig. 1.2 Surface and seam levels along the Prediction Line across LWs S1A to S7A

2.1. Maximum predicted conventional subsidence effects

The Incremental Profile Method (IPM) was previously used to predict the conventional subsidence parameters resulting from the extraction of the approved LW S1A to S6A at Tahmoor, which were provided in Report No. MSEC1192.

The Incremental Profile Method has also been used to predict the conventional subsidence parameters resulting from the extraction of LW S7A, based on the *Modified Layout.*

The predicted incremental subsidence contours due to the extraction of LW S7A, based on the *Modified Layout*, are shown in Drawing No. MSEC1348-12. The predicted total subsidence contours after the extraction of LW S7A, based on the *Modified Layout*, are shown in Drawing No. MSEC1348-13.

The predicted 20 mm incremental and total subsidence contour lines are shown in Drawing No. MSEC1348-01. The predicted total 20 mm subsidence contour line, based on the *Approved Layout*, is also shown in the drawing for comparison. Predicted profiles across LWs S1A to S7A are shown in Fig. A.01, which is included in Appendix A at the back of this report.

The predicted total subsidence contours for the Tahmoor South Project after the extraction of LW S6B, based on the *Modified Layout* is shown in Drawing No. MSEC1348-14. It is noted, however, that Tahmoor Coal has not finalised its mine design for the B series longwall panels. The layout for the B series longwall panels differ from the layout presented in the EIS (Report N. MSEC1123) because some panels have been shortened due to the realignment of the central mains.

The predictions for LWs S1A to S6B have been provided to illustrate the effect of Modification 3 on the whole Tahmoor South Project but the mine layout may change in future when the design for the B series panels is finalised.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature, due to the extraction of LWs S1A to S6A under the *Approved Layout* and LW S7A, based on the *Modified Layout*, is provided in Table 2.1. The predicted tilts provided in this table are the maxima after the completion of each longwall. The predicted curvatures are the maxima at any time during or after the extraction of each longwall.

Table 2.1 Maximum predicted incremental conventional subsidence, tilt and curvature resulting from the extraction of LWs S1A to S7A

Longwall	Maximum predicted incremental conventional subsidence (mm)	Maximum predicted incremental conventional tilt (mm/m)	Maximum predicted incremental conventional hogging curvature (km^{-1})	Maximum predicted incremental conventional sagging curvature (km^{-1})
Approved Layout				
LW S1A	800	7.0	0.08	0.22
LW S2A	950	7.5	0.08	0.22
LW S3A	950	8.0	0.09	0.22
LW S4A	950	8.0	0.09	0.22
LW S5A	950	8.0	0.10	0.22
LW S6A	975	8.3	0.09	0.23
Modified Layout				
LW S7A	1,050	8.9	0.10	0.24

It can be seen from the above table, that the predicted maxima, based on the *Modified Layout*, are similar to those based on the *Approved Layout*. The differences in the predicted maximum parameters due to the proposed modification are not considered to be significant.

As shown in Drawing No. MSEC1348-12, the maximum predicted incremental subsidence due to the proposed extraction of LW S7A is located above the commencing end of the panel. This is because planned extraction heights are greatest in this location. As shown in Fig. 1.1, the commencing end of LW S7A is located directly beneath open farmland.

A summary of the maximum predicted total conventional subsidence, tilt and curvature, based on the *Approved and Modified* Layout are provided in Table 2.2. The values in this table are the maxima anywhere above the longwalls, and at any time during or after extraction of the longwalls.

Table 2.2 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature resulting from the extraction of LWs S1A to S7A

Layout	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
Approved Layout				
After LW S6A	1,350	9.5	0.14	0.24
After LW S6B	1,600	10.5	0.18	0.28
Modified Layout				
After LW S7A	1,400	10.0	0.14	0.25
After LW S6B	1,600	10.5	0.18	0.28

When comparing maximum predicted total subsidence parameters for the A series longwalls, it can be seen that the addition of LW S7A is predicted to result in a small increase in maximum total subsidence but negligible change in predicted maximum tilt and curvature.

When comparing maximum predicted total subsidence parameters for the A and B series longwalls, it can be seen that there is negligible change to the predictions. This is because predicted maximum subsidence due to the extraction of the B series longwalls is greater than the A series.

2.2. Effect of revision of planned extraction heights

Tahmoor Coal has revised its forecast extraction heights since the previous predictions were provided in Report No. MSEC1192. The changes are generally minor for the A series longwall panels, in the range of 50 to 100 mm greater than previously forecast.

It is noted, however, that forecast extraction heights at the commencing end of LW S7A are greater than previously planned for LWs S1A to S6A, such that predicted maximum incremental subsidence due to the extraction of LW S7A is greater in this area. The planned extraction heights for the rest of the longwall panel are similar in magnitude compared to the rest of the A series longwalls and predicted incremental subsidence due to the mining of LW S7A is similar to the predictions for the rest of the A series longwalls, as demonstrated in Fig. A.01.

A comparison of predicted conventional subsidence due to the extraction of LWs S1A to S6A between the predictions that were previously provided in Report No. MSEC1192 and predictions based on revised extraction heights is shown in Fig. 2.1 and Table 2.3.

Table 2.3 Comparison of Maximum Predicted Total Conventional Subsidence, Tilt and Curvature resulting from the extraction of LWs S1A to S6A due to revision of extraction heights

Layout	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
Approved Layout (MSEC1192)				
After LW S6A	1,350	9.5	0.14	0.24
Modified Layout with revised extraction heights				
After LW S6A	1,400	10.0	0.14	0.25

As shown in Fig. 2.1 and Table 2.3, the predicted increases in subsidence, tilt and curvature due to the revision in extraction height is relatively minor. The predictions do not materially change the assessment of potential impacts on natural and built features, nor our recommendations for managing potential impacts to natural and built features as previously provided in Report Nos. MSEC1123 (EIS) and MSEC1192 (Extraction Plan for LWs S1A to S6A).

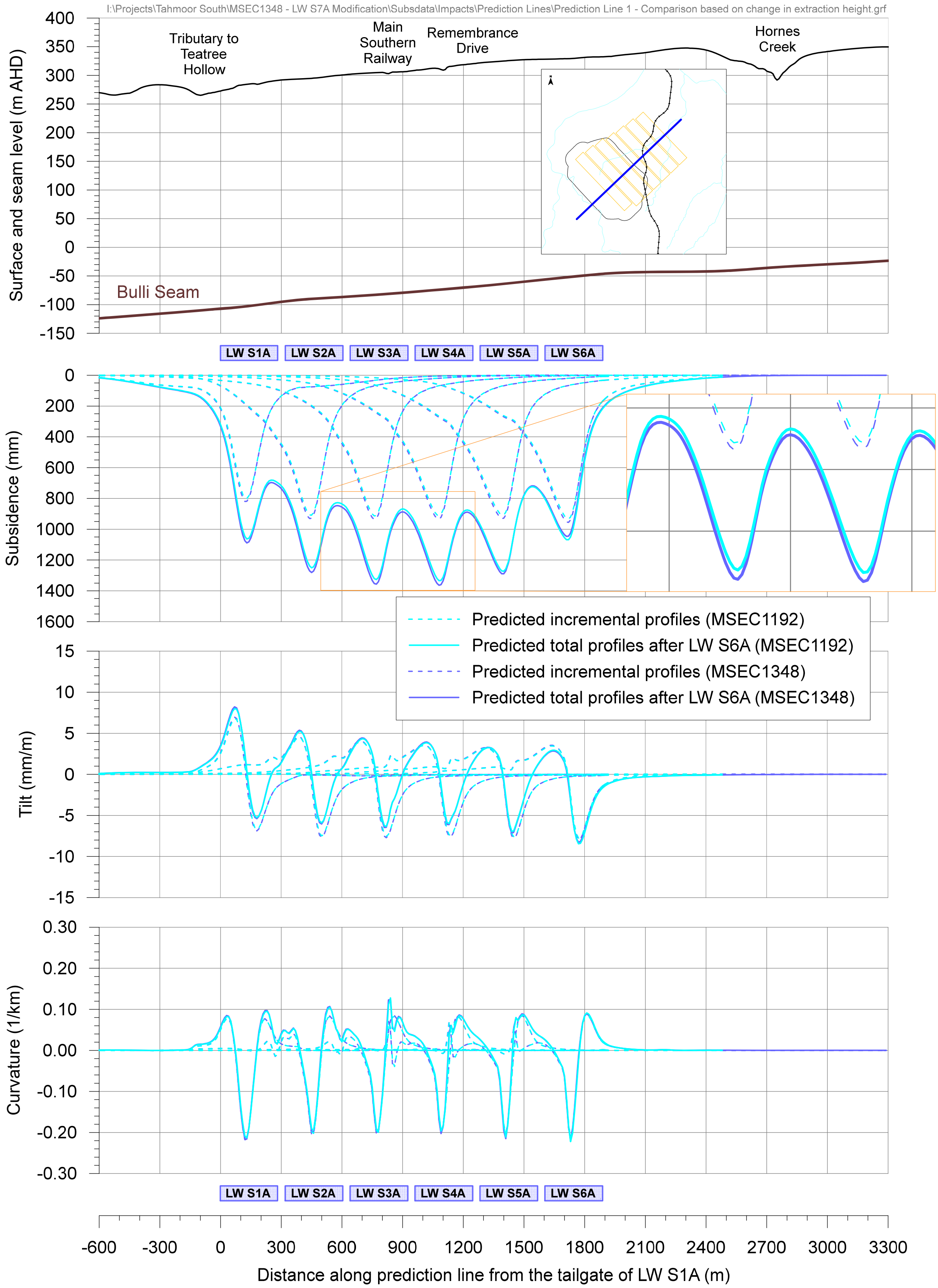


Fig. 2.1 Predicted subsidence, tilt and curvature across LWs S1A to S7A

For the purposes of providing clarity, this report will focus on predicted subsidence movements and potential impacts on natural and built features due to the addition of LW S7A only, rather than comment on the very minor changes in predicted movements due to the revised forecast of extraction heights within the broader mining domain of LW S1A to S6A.

2.3. Comparison between Observed and Predicted Subsidence during the mining of LWs S1A and S2A

Extensive monitoring has been undertaken by Tahmoor Coal during the mining of LWs S1A and S2A. Observed incremental subsidence due to the extraction of LWs S1A and LW S2A has correlated reasonably well with predictions, as shown in Fig. 2.2, Fig. 2.4 and Fig. 2.5.

Subsidence was observed to vary in magnitude along the centreline of LW S1A. Maximum subsidence was measured at Peg V51 on the V-Line, which is located between Teatree Hollow and the Tributary to Teatree Hollow. Observed subsidence was reduced in magnitude on the northern half of the longwall panel at the Main Southern Railway and Tahmoor Mine Site (Pier 2).

As shown in Fig. 2.2, observed subsidence at Peg V51 was slightly greater than predicted but within the accuracy of the prediction model of ± 15% (Reports Nos. MSEC1123 and MSEC1192). Observed subsidence at other locations above LW S1A was less than predicted.

As at January 2024, monitoring during the mining of LW S2A has measured subsidence movements developing within predictions, as shown in Fig. 2.3.

As recommended in Report No. MSEC1192, monitoring will be conducted during mining to compare observations with predictions. TC has extensive experience in successfully managing potential subsidence impacts on surface features, even when actual subsidence is substantially greater than the magnitudes that have been predicted above LW S7A. It is recommended that subsidence management plans be developed to manage potential impacts that could occur if greater than predicted subsidence occurs.

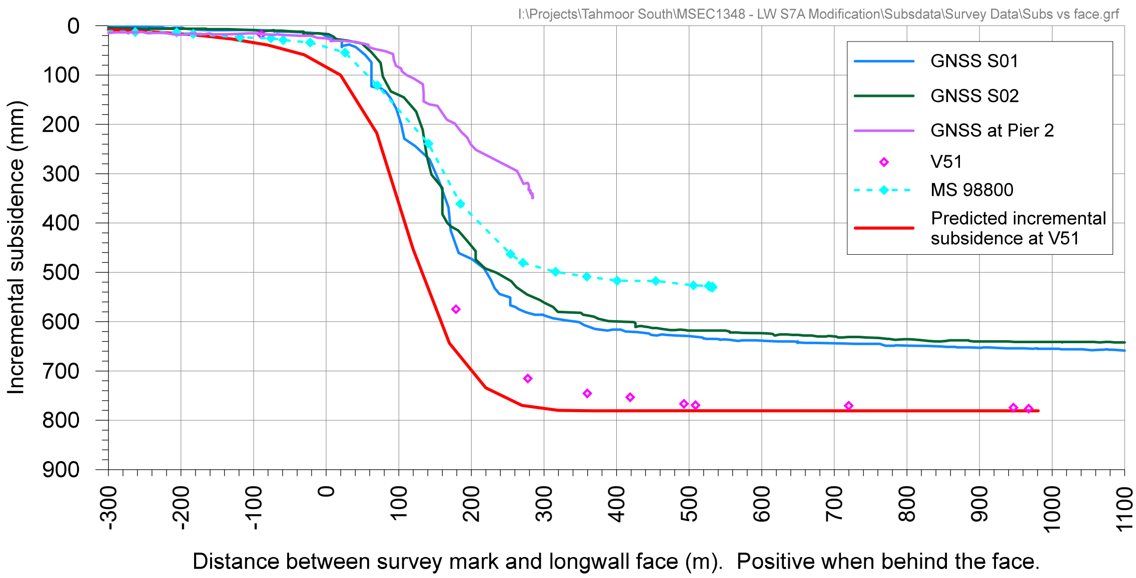


Fig. 2.2 Comparison between predicted and observed subsidence above centreline of LW S1A

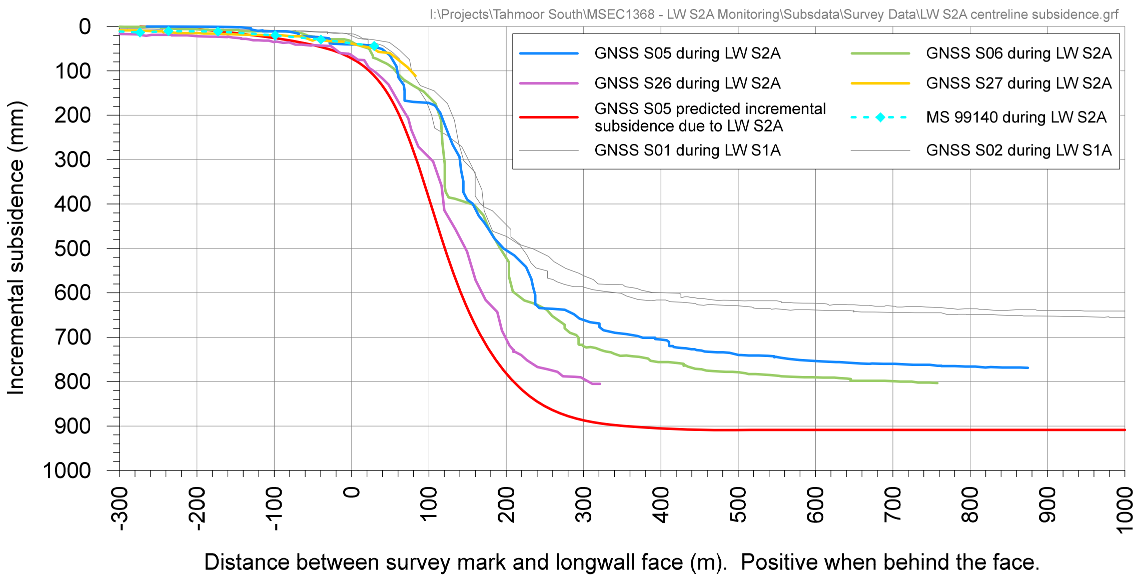


Fig. 2.3 Comparison between predicted and observed subsidence above centreline of LW S2A

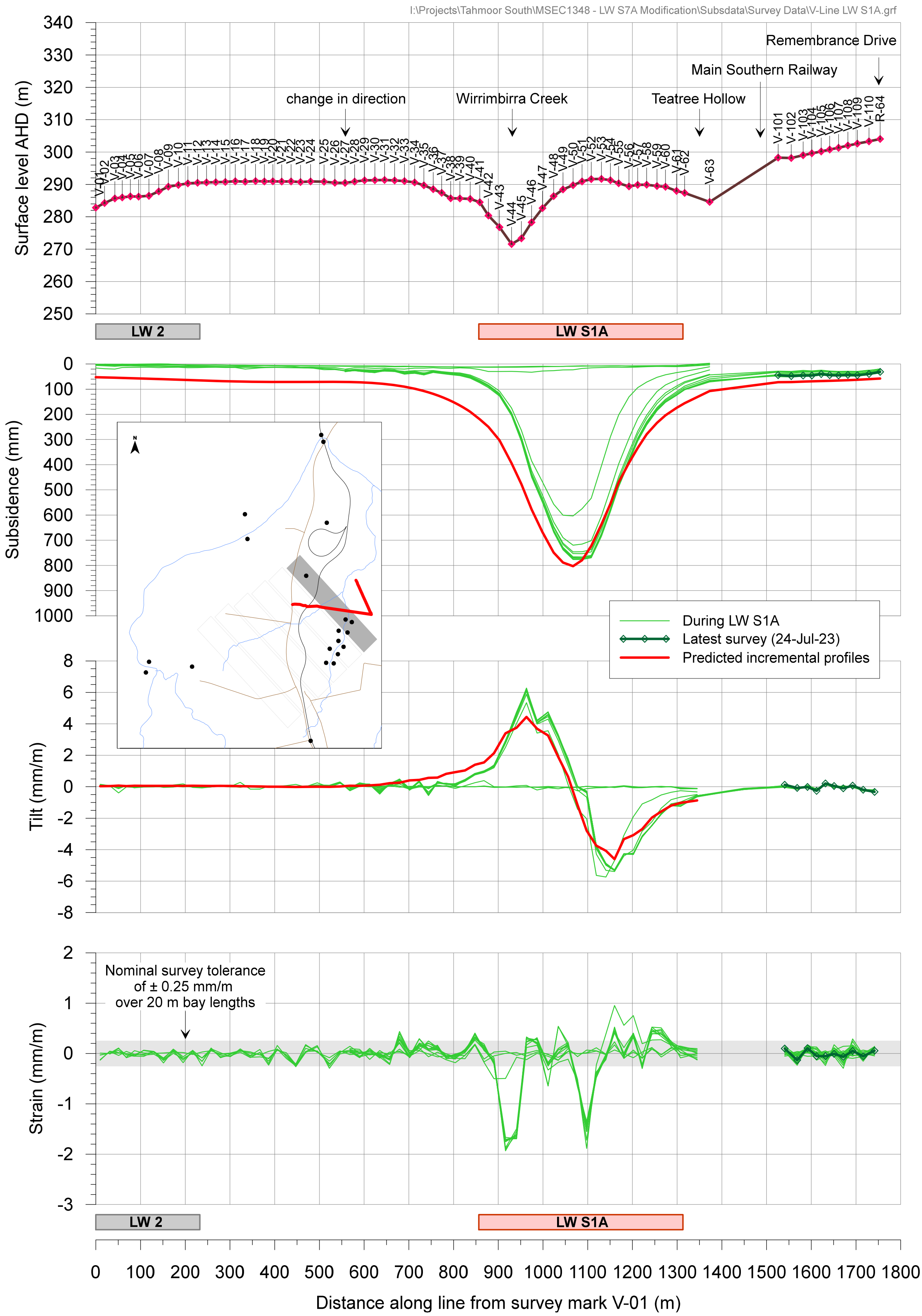


Fig. 2.4 Observed subsidence along V Line during the mining of LW S1A

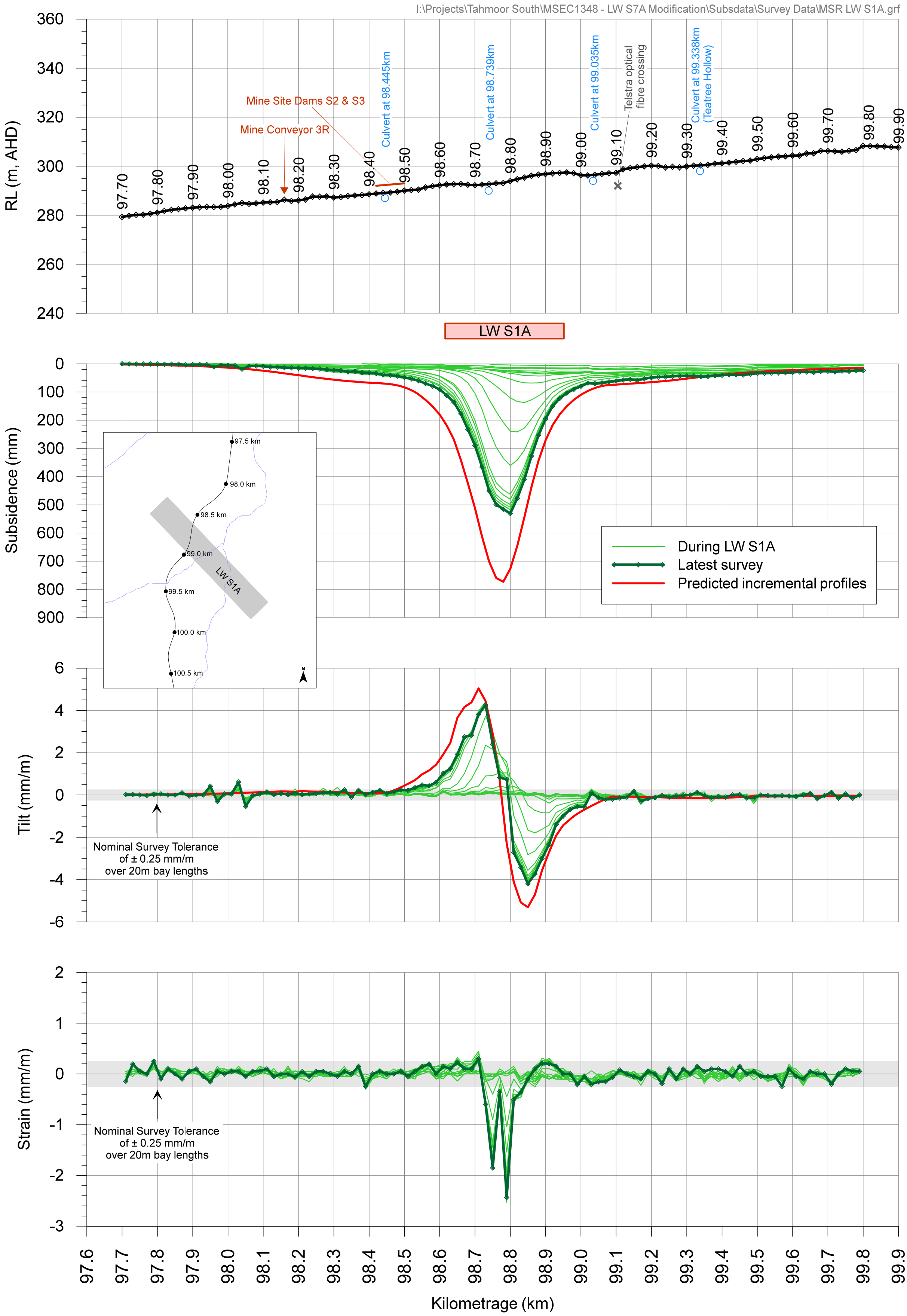


Fig. 2.5 Observed subsidence along Main Southern Railway during the mining of LW S1A

2.4. Potential for increased subsidence

As discussed in Report No. MSEC1123 (EIS), increased subsidence was observed above several previously extracted Longwalls, i.e. Longwall 8, Longwall 13, Longwall 24A and above the commencing ends of Longwalls 24A to 27 and above the commencing end of Longwall 32. Increased subsidence was also observed above the commencing end of LW W4.

The cause for the increased subsidence over Longwall 24A and above the commencing end of Longwall 25 was investigated by Strata Control Technology on behalf of Tahmoor Coal, (Gale and Sheppard, 2011). The investigations concluded that the increased subsidence is consistent with localised weathering of joint and bedding planes above a depressed water table adjacent to an incised gorge. The continued monitoring of the increased subsidence over Longwalls 26 and 27 confirmed that the extent of the increased subsidence reduced with increasing distance from the Bargo River Gorge and the northern end of a mapped fault echelon structure.

The observation above the commencing end of Longwall 32 and the commencing end of LW W4 has shown that increased subsidence has developed where mining has occurred close to other mapped first order fault echelon structures associated with the Nepean Fault.

It is worthwhile noting that Longwalls 10A, 10B, and 12 are also located near the Nepean Fault and the Bargo River and there was a reasonable correlation between observed and predicted subsidence along the available monitoring lines. Similarly, many longwalls have been extracted close to major river valleys and gorges and there were reasonable correlations between observed and predicted subsidence along all the available monitoring lines. Accordingly, it appears that the location of the zones of increased subsidence is linked to both the;

- close proximity to and the alignment of the Nepean Fault, and
- close proximity to the Bargo River Gorge, which is approximately 100 metres deep, which permitted groundwater flows to weather the joint and bedding plane properties of the surrounding strata.

The proposed LW S7A runs adjacent and approximately parallel to the Central Fault complex, which is located on the western side of the mining area. The Central Fault zone lies to the west and south of the proposed LW S7A, was described by MBGS (2013) as a normal fault trending northwest with vertical displacement up to 20 metres, east side up. This fault was identified in the 2D seismic lines and was also intercepted in one drill hole (JB06) where the Wongawilli Seam has been displaced. The Gordon Geotechniques (2013) report advised that this Central Fault zone was associated with a number of features including a change in Bulli Seam fluidity and thinning of the Balgownie to Bulli Seam interburden. The downstream part of Hornes Creek follows the surface expression of the Central Fault. Further analyses of exploration data has improved confidence in defining the location of the Central Fault, which has allowed Tahmoor Coal to propose extraction of LW S7A. Since the Extraction Plan of LW S1A to S6A was approved, Tahmoor Coal has also drilled boreholes on both ends of the Picton Weir. The fault was not observed by PSM (2023) during the geological field mapping and the boreholes did not intercept it.

It is possible that increased subsidence may develop above LW S7A but this is not certain for the following reasons:

- The Central Fault is less defined in the Tahmoor South area compared to the Nepean Fault in the Tahmoor North area, and
- The measured groundwater gradients in the Tahmoor South area are less than those measured near Longwalls 24A to 26.

If greater than predicted subsidence was to occur above the proposed longwalls, it is unlikely that the magnitude of this increased subsidence will be much greater than the predictions for the following reasons:

- Predicted maximum incremental subsidence is 1,150 mm, which represents approximately 45 % to 52 % of the proposed extraction height. Maximum observed incremental subsidence above Longwalls 24A to 27 was approximately 55 % of the extraction height.
- Predicted maximum total subsidence is 1,650 mm, which represents approximately 63 % of the proposed extraction height. Maximum observed total subsidence above Longwalls 24A to 27 was approximately 62 % of the extraction height.
- The higher levels of predicted subsidence at Tahmoor South are due to a combination of greater extraction heights and slightly shallower depths of cover. They are comparable to or just less than the observed increased subsidence above Longwalls 24A to 27 when expressed as a proportion of extraction height.
- In the cases of Longwalls 24A and 25, the observed maximum subsidence was greater than predictions by between 2 to 2.3 times. This was partly because the panels were the first and second in a series of longwalls where reduced subsidence would normally have been expected to develop. Increasing the predicted levels of subsidence by factors of 2 to 2.3 would result in subsidence much greater than the proposed extraction height, which is extremely unlikely to occur.

While the potential exists for increased subsidence to occur above LW S7A adjacent to the Central Fault, it is important to note that the potential impacts on surface infrastructure from this extra subsidence can be managed, as it was managed over Longwalls 24A to 27, Longwall 32 and Longwall W4, so that they remain safe and serviceable during and after the mining period with the implementation of effective management measures. When required, these measures would include;

- A detailed pre-mining assessment of the potential impacts on surface infrastructure in the event that increased subsidence occurs.
- Monitoring of subsidence movements above and beyond the proposed mining footprint, including across the projected location of the Central Fault on the surface.
- Monitoring of the condition of surface infrastructure during and after the mining period.
- Implementation of planned early intervention measures to further protect the safety and serviceability of surface infrastructure based on pre-determined trigger levels based on monitoring data.
- If increased subsidence were to occur during the mining of a proposed longwall, consideration of whether to continue mining future longwalls at the same commencing and/or finishing ends as proposed or make amendments to avoid future increased subsidence.

2.5. Predicted Strain

It is important to appreciate that the extraction of coal not only results in subsidence, but, it also induces horizontal ground movements and ground strains, and, unlike subsidence, which is measured vertically, it is important to appreciate that these parameters have both a magnitude and a direction. The magnitude of the measured ground strains can be sensitive to the ground distances over which they were measured, and, both the measured ground strains and horizontal movements are very sensitive to the direction in which they were measured. Hence, strain and horizontal movements are more complex, and they are more difficult to predict than subsidence, tilt and curvature.

The profiles of observed strain along monitoring lines, therefore, were often irregular in shape even when the profiles of observed subsidence, tilt and curvature were relatively smooth.

Early researchers noticed the similarity between the observed curvature and strain profiles and the similarity between the observed tilt and horizontal movement profiles. Hence, it was logical that the early strain prediction methods were based on linear relationships with predicted conventional curvature and the early horizontal ground movement prediction methods were based on linear relationships with predicted conventional tilt.

The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and the locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones and adopting a linear relationship between curvature and strain provided a reasonable prediction for the maximum conventional tensile and compressive strains.

In the Southern Coalfield, it was found that a curvature to conventional strain conversion factor of 15 provided a reasonable relationship between the maximum predicted curvatures and the maximum predicted conventional strains. Similarly, a tilt to conventional horizontal movement conversion factor of 15 was found to provide a reasonable relationship between the maximum predicted tilt and the maximum predicted conventional horizontal movement.

However, it was noticed that, whilst these correlations were reasonable for the maximum values of these parameters over some areas of the mined panels, they were not as reliable in many other areas, particularly in those locations that were beyond the edges of the mined panels that were near changes in geological conditions. It was also noted that survey tolerance and valley related movements can represent a high proportion of measured ground strains and horizontal displacements.

The limited accuracy of strain and horizontal movement predictions at locations away from the point of maximum strain and horizontal movement was discussed in later subsidence prediction reports where it was stated that the measured strains and horizontal ground movements at a point can vary considerably from the predicted conventional values. It was noted that the locations that were predicted to experience hogging or convex curvature experienced net tensile strain zones and the locations that were predicted to experience sagging or concave curvature experienced net compressive strain zones, but, it was highlighted that the observed strain and horizontal movement profiles along monitoring lines were irregular in shape, with an occasional spike, compared to the observed subsidence, tilt and curvature profiles which were relatively smooth. Hence, it was concluded that, whilst the prediction of vertical subsidence and tilt at a point could be carried out with reasonable accuracy and reliability, the prediction of mining-induced ground strains and horizontal movements at a point was far less accurate, especially when those predictions used linear conversion factors that were based on predicted conventional curvature and tilt.

Furthermore, the horizontal movement predictions at a point were rarely provided and the predictions of ground strains are usually provided based on statistical basis, as is detailed in Section 2.5.1.

However, strain is one of the most important parameters for assessing the likelihood of mine subsidence damage to natural features and built features on the surface. Recent research has resulted in some improved understanding and methods for predicting ground strains and relative horizontal movements in zones across mined panels at the surface, (Barbato, 2016, 2017). These new methods for predicting strain have been developed dependent on the mining geometry, surface topography, surface geology and the likelihood of irregular anomalous movements.

The predicted distribution of strains using this new method also provides guidance on the magnitudes of localised spikes and the likelihoods of exceeding strain thresholds based on previously measured ground monitoring data (Barbato et al., 2016 and 2017).

The reasons why ground strains and horizontal movements are more complex and difficult to predict than subsidence, tilt and curvature are partly associated with the observation that, while the strata has only one direction to move,(i.e. vertically downwards), it can be moved in two directions horizontally and it has been observed that the ground will move wherever it is easiest to go. Additionally, studies have noted that ground strains and horizontal movements are influenced/affected by many multiple factors and a complex interaction of many mechanisms, including the:

- magnitude of the vertical subsidence, tilt and the depth of cover;
- steepness and direction of the surface topography;
- steepness and direction of the seam dip;
- direction of mining in relation to both the surface and seam slope;
- geology, geomechanical properties and thicknesses of the near surface strata, as well as, all the overburden strata layers, the seam and the strata layers immediately under the seam;
- presence of geological faults, pre-existing natural joints and igneous intrusions;
- magnitude and principal direction of the in situ horizontal compressive stresses in the strata layers around the mined goaf and the surface strata layers;
- presence and proximity of previously extracted panels in the currently mined seam and previously extracted panels in other seams;
- behaviour of blocky sandstone environments where initial ground movements occur predominantly along pre-existing natural joints, the location of which would not be known;
- limited ability of opened joints to close fully during the following compression phases after the initial shearing and tensile movements;
- reversing component that seems to initially move surveyed surface pegs towards the longwall face as the face approaches and, then, after the face extracts under and away from this peg, the surface is moved back towards its initial position and often it is moved further past that position as it follows the mining face; and
- other contributing factors such as the degree of surface roughness and frictional resistance along the bedding planes, survey accuracy or survey tolerance (especially where the strains are of a low order of magnitude), the presence of groundwater flows along the bedding planes and its influence on the slippage along bedding planes, etc.

Nevertheless, it has been concluded that the curvature to conventional strain conversion factor and the tilt to horizontal movement conversion factor can be used to provide a reasonable indication of the maximum conventional strains and horizontal movements over extracted panels.

Using the maximum predicted conventional curvatures of 0.14 km^{-1} hogging and 0.25 km^{-1} sagging curvature and the conventional strain conversion factor of 15, the maximum predicted conventional strains for the proposed LWs S1A to S6A, are approximately 2.1 mm/m tensile and 3.8 mm/m compressive.

At specific points around the mined panels, however, there can be considerable variation from this linear curvature to conventional strain relationship, resulting from non-conventional movements and a wide range of scatter is observed between the predicted and observed 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, MSEC has provided a statistical approach to predict observed strain and hence account for this variability, instead of just providing a single predicted conventional strain.

The range of potential strains above the proposed longwalls has been determined using monitoring data from the previously extracted longwalls at Tahmoor Mine, as well as from other nearby collieries, including Appin and West Cliff, where the regional geology and mining geometries are reasonably similar to that for the proposed longwalls. A summary of the monitoring lines that were used in the strain analysis is provided in Table 2.4 and Table 2.5 shows the mining geometry for the proposed longwalls.

Table 2.4 Monitoring lines used in the strain analysis

Location	Monitoring Lines	Longwall Widths (m)	Depths of Cover (m)	Width-to-Depth Ratios	Extraction Heights (m)
Early longwall areas at Tahmoor Mine	100-Line	190	410	0.47	2.0
	200-Line	190	410	0.46	1.9
	300-Line	190 ~ 240	430	0.47	2.2
	800-Line	235	420	0.56	2.1
	900-Line	235	420	0.56	2.0
	1000-Line	190 ~ 240	400	0.57	1.8
Northern areas over Tahmoor	40 monitoring lines located outside the area of '*increased subsidence*'	285	425 ~ 470 *(440 average)*	0.60 ~ 0.67 *(0.64 average)*	1.7 ~ 2.3 *(2.1 average)*
Appin Area 3	M-Line	260	480 ~ 520 *(500 average)*	0.50 ~ 0.54 *(0.52 average)*	2.6 ~ 3.0 *(2.8 average)*
Appin Area 7	HW2 East, HW2 West, ARTC and Moreton Park Road	305	500 ~ 560 *(530 average)*	0.54 ~ 0.61 *(0.58 average)*	2.8 ~ 3.2 *(3.0 average)*
West Cliff Area 5	B-Line	305	490 ~ 530 *(510 average)*	0.58 ~ 0.62 *(0.60 average)*	2.4 ~ 3.0 *(2.6 average)*

Table 2.5 Mining geometry for the proposed LWs S1A to S7A

Location	Longwall Widths (m)	Depths of Cover (m)	Width-to-Depth Ratios	Extraction Heights (m)
LW S1A to LW S7A	283-285	375 ~ 410 *(390 average)*	0.69 ~ 0.76 *(0.73 average)*	2.1 ~ 2.6 *(2.2 average)*

It can be seen from the above tables, that the extraction heights for the LWs S1A and S6A and the proposed LW S7A vary between 2.1 metres and 2.6 metres, which are similar to those for the previously extracted longwalls at Tahmoor Mine, which varied between 1.7 metres and 2.3 metres, but is less on average than those for the previously extracted longwalls at Appin and West Cliff Collieries, which varied between 2.4 metres and 3.2 metres. That is, the extraction heights for the proposed longwalls are within the ranges of those for the previously extracted longwalls at Tahmoor, Appin and West Cliff Collieries.

The width-to-depth ratios for the proposed longwalls varies between 0.69 and 0.76, which are slightly greater than those for the previously extracted longwalls at Tahmoor, Appin and West Cliff Collieries, which varied between 0.46 and 0.67. Unfortunately, there is limited available ground monitoring data from previously extracted longwalls in the Southern Coalfield where the width-to-depth ratios are exactly similar to the proposed longwalls.

There is, however, extensive ground monitoring data available from previously extracted longwalls in the Newcastle, Hunter and Western Coalfields where the width-to-depth ratios were similar and much greater than those for the proposed longwalls. This data was not included in the strain analyses, since the overburden geology is different to that in the Southern Coalfield and since the width-to-depth ratios for the proposed longwalls are only slightly higher than the available Southern Coalfields data that has similar overburden geology.

A review of the available data from the Newcastle, Hunter and Western Coalfields indicates that the observed strains for previously extracted longwalls having width-to-depth ratios between 0.70 and 0.85, i.e. slightly greater when compared to the proposed amended longwalls, were on average, around 20 % to 40 % greater than the observed strains for previously extracted longwalls in the Newcastle, Hunter and Western Coalfields having width-to-depth ratios between 0.50 and 0.70, i.e. similar to Tahmoor North, Appin and West Cliff Collieries.

It could be expected, therefore, that the observed strains resulting from the extraction of the proposed longwalls would be, on average, around 20 % to 40 % greater than those previously experienced at Tahmoor, Appin and West Cliff Collieries and, hence, the predicted strains for the proposed longwalls have been determined from the analyses of strain from the previously extracted longwalls at Tahmoor, Appin and West Cliff Collieries, with the magnitudes increased by 20 % to 40 % to account for the higher width-to-depth ratios based on the observations from the Newcastle, Hunter and Western Coalfields.

The data used in the 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 monitored strain data. It was found that a *Generalised Pareto Distribution (GPD)* provided a good fit to the raw strain data. Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

2.5.1. Analysis of strains measured in survey bays

For features that are in discrete locations, such as building structures, farm dams and archaeological sites, it is appropriate to assess the frequency of the observed maximum strains for individual survey bays.

Predictions of strain above goaf

The survey database has been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of the previous longwalls at Tahmoor, Appin and West Cliff Collieries, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls, which has been referred to as "*above goaf*".

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf, for monitoring lines at Tahmoor, Appin Area and West Cliff Collieries, is provided in Fig. 2.6. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

The 95 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.9 mm/m tensile and 1.6 mm/m compressive. The strains for the proposed longwalls are predicted to be 20 % to 40 % greater than those previously observed at these collieries and, therefore, it is expected that 95 % of the strains measured *above goaf* would be less than 1.3 mm/m tensile and 2.2 mm/m compressive.

The 99 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 1.4 mm/m tensile and 3.1 mm/m compressive. Similarly, it is expected that 99 % of the strains measured *above goaf* for the proposed longwalls would be less than 2.0 mm/m tensile and 4.3 mm/m compressive.

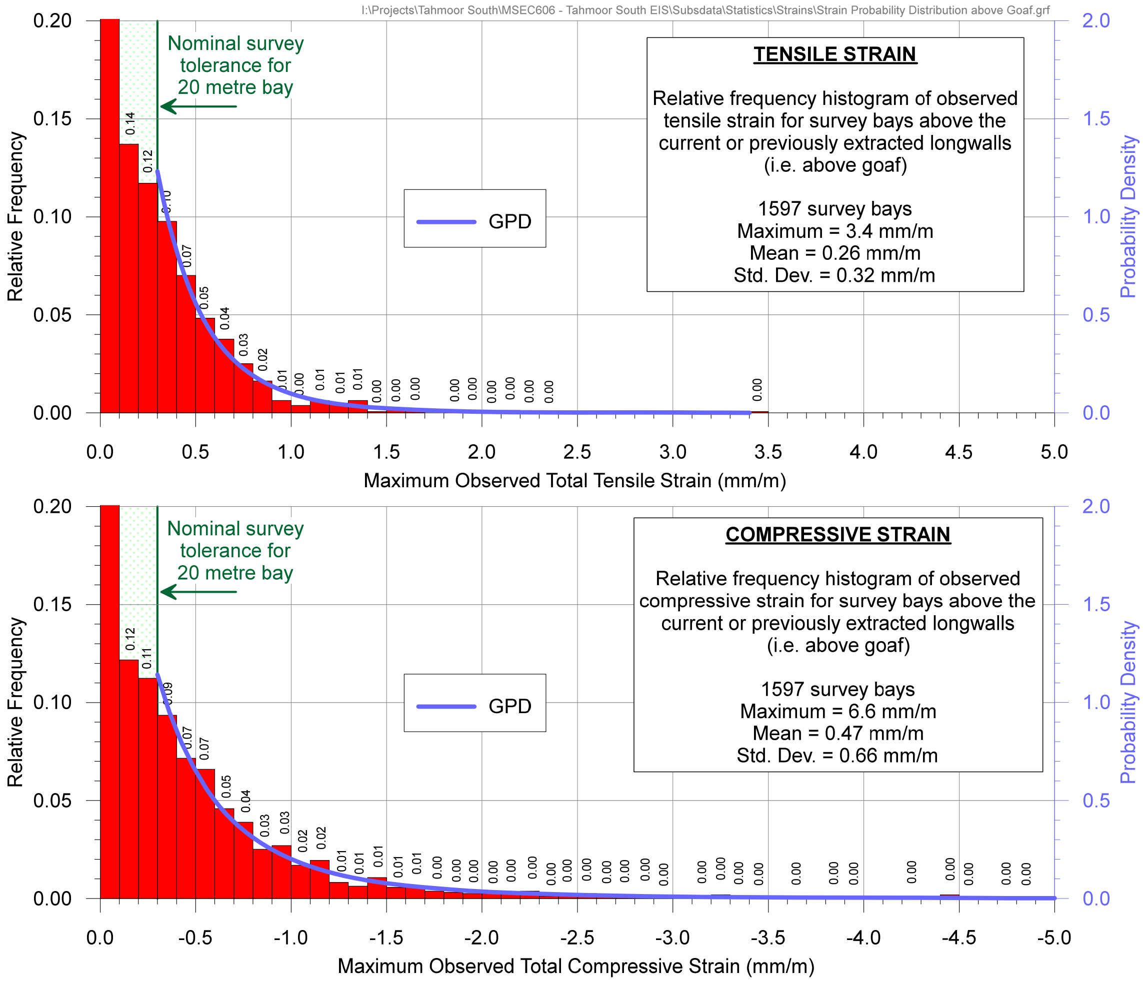


Fig. 2.6 Distributions of the measured maximum tensile and compressive strains for surveys bays located *above goaf* at Tahmoor, Appin and West Cliff Collieries

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf, for monitoring lines at Tahmoor, Appin Area and West Cliff Collieries, is provided in Fig. 2.7. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure, along with the probability distribution function shown in Fig. 2.6 for comparison.

It can be seen that the observed strains above LW S1A have generally been less than previously observed at Tahmoor, Appin and West Cliff Collieries. LW S1A is, however, the first panel in the series and ground strains were predicted to be smaller above LW S1A than above future longwalls.

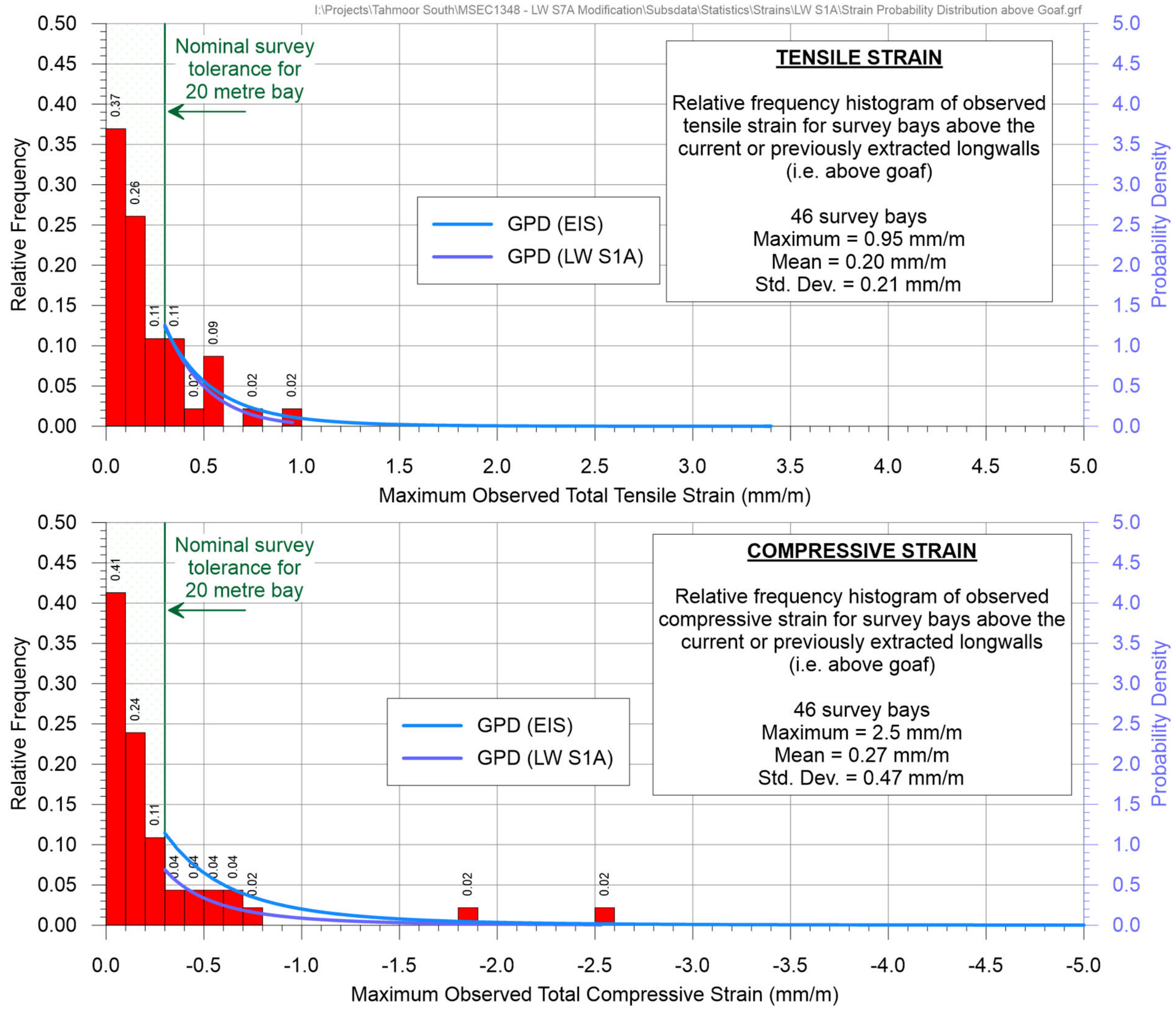


Fig. 2.7 Distributions of the measured maximum tensile and compressive strains for surveys bays located *above goaf* at Tahmoor LW S1A

Predictions of strain above solid coal

The survey database has also been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of the previous longwalls at Tahmoor, Appin and West Cliff Collieries, for survey bays that were located beyond the goaf edges of the mined panels and positioned on unmined areas of coal, i.e. outside panels but within 200 metres of the nearest longwall goaf edge, which has been referred to as "*above solid coal*".

The histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal, for monitoring lines at Tahmoor, Appin and West Cliff Collieries, is provided in Fig. 2.8. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

The 95 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.6 mm/m tensile and 0.5 mm/m compressive. The strains for the proposed longwalls are predicted to be 20 % to 40 % greater than those previously observed at these collieries and, therefore, it is expected that 95 % of the strains measured *above solid coal* would be less than 1.0 mm/m tensile and compressive.

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

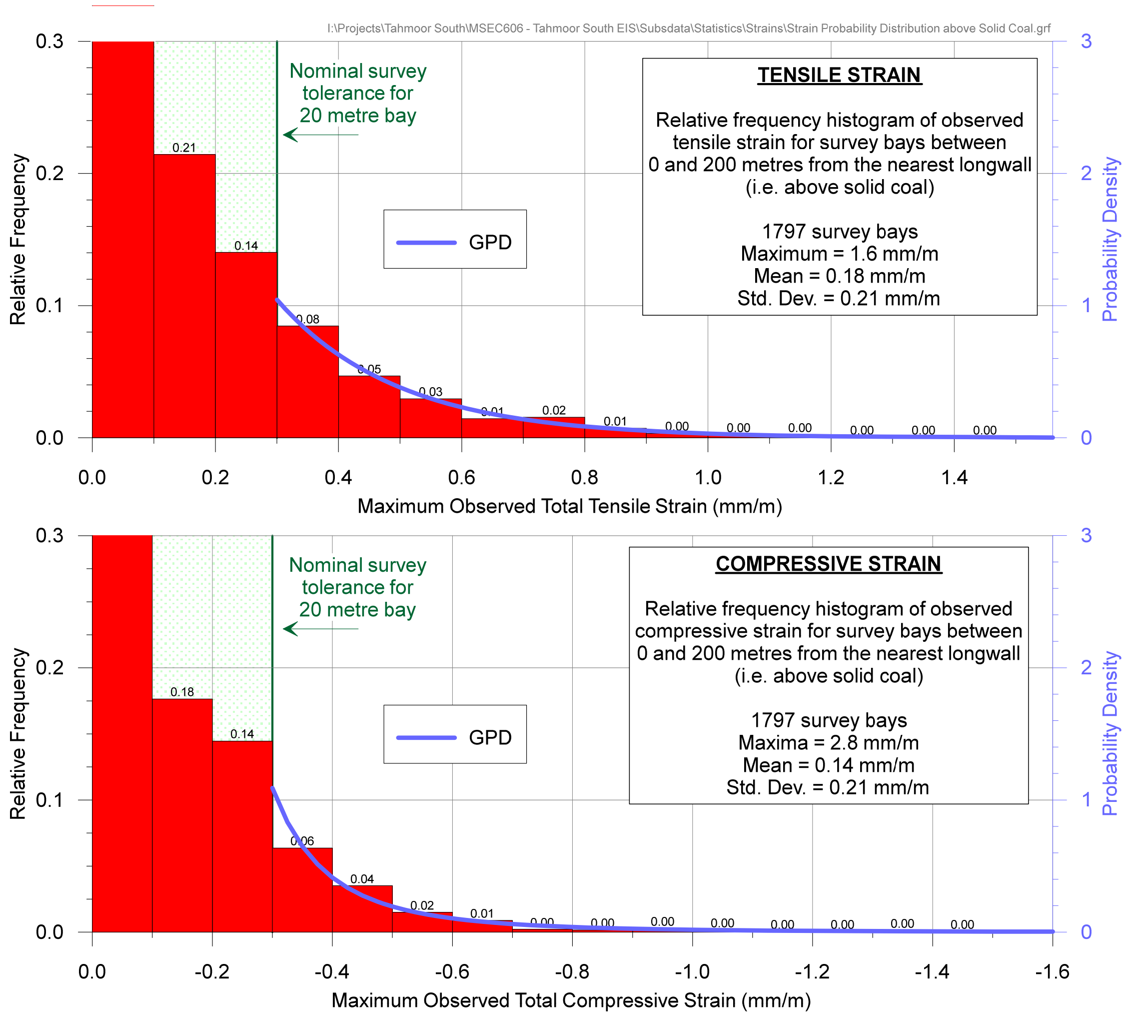


Fig. 2.8 Distributions of the measured maximum tensile and compressive strains for survey bays located *above solid Coal* at Tahmoor, Appin and West Cliff Collieries

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf, for monitoring lines at Tahmoor, Appin Area and West Cliff Collieries, is provided in Fig. 2.9. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure, along with the probability distribution function shown in Fig. 2.8 for comparison.

The results include the observed non-conventional compressive ground strain of 2.0 mm/m that was observed between Pegs R47 and R48 to the side of LW S1A.

It can be seen that the observed strains adjacent to LW S1A have generally been less than previously observed at Tahmoor, Appin and West Cliff Collieries. The distribution in LW S1A is, however, the first panel in the series and ground strains were predicted to be smaller above LW S1A than above future longwalls.

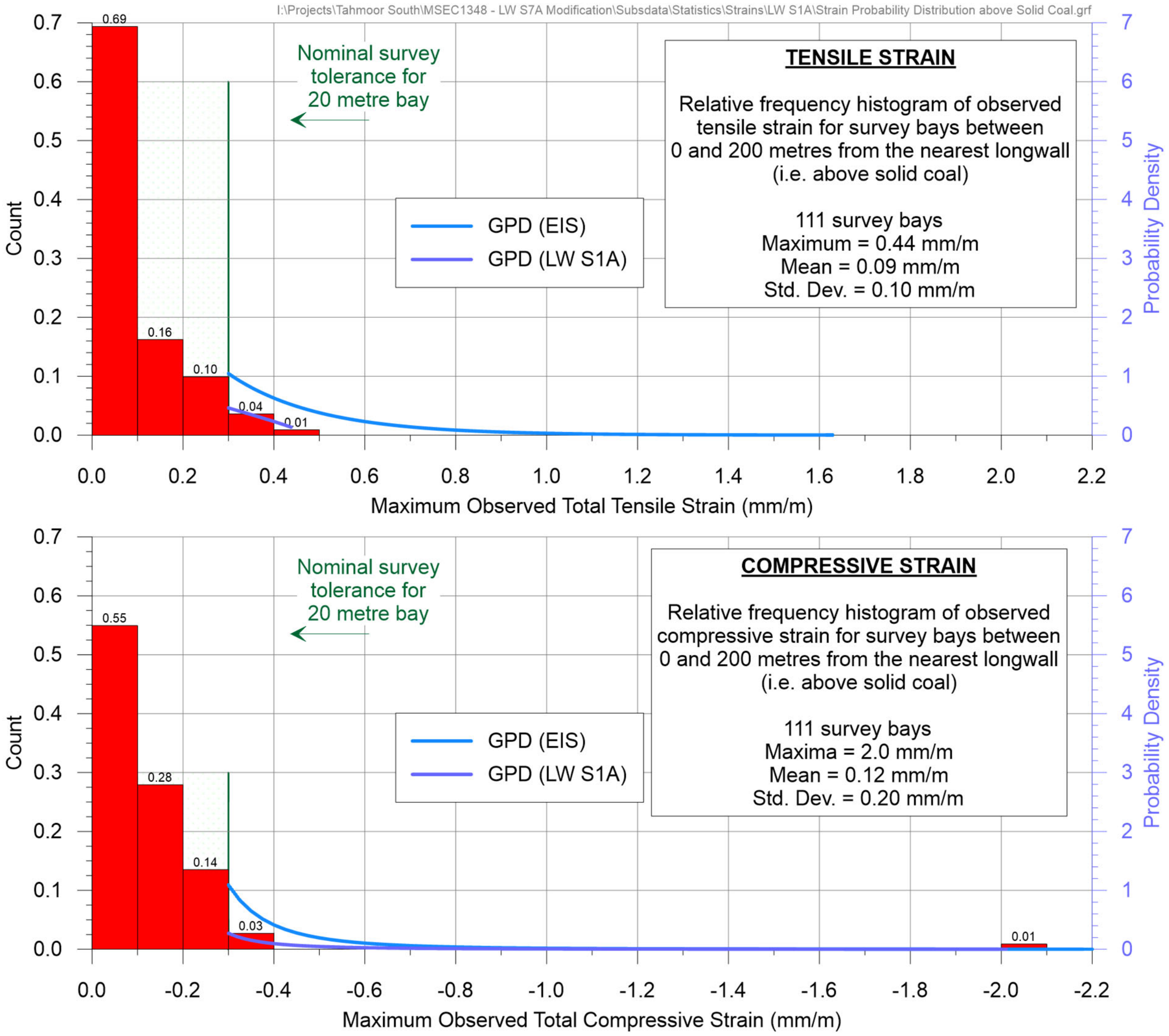


Fig. 2.9 Distributions of the measured maximum tensile and compressive strains for surveys bays located *above solid coal* at Tahmoor LW S1A

2.5.2. Analysis of strains measured along whole monitoring lines

For linear features such as roads, cables and pipelines, it is more appropriate to assess the frequency of the maximum observed strains along whole monitoring lines, rather than for individual survey bays. That is, an analysis of the maximum strains measured anywhere along the monitoring lines, regardless of where the strain actually occurs.

The histogram of maximum observed total tensile and compressive strains measured anywhere along the monitoring lines, at any time during or after the extraction of the previous longwalls at Tahmoor, Appin and West Cliff Collieries, is provided in Fig. 2.10.

It can be seen from Fig. 2.10, that 42 of the 52 monitoring lines (i.e. 92 % of the total) at Tahmoor, Appin and West Cliff Collieries had recorded maximum total tensile strains of 2.0 mm/m, or less. The strains for the proposed longwalls are predicted to be 20 % to 40 % greater than those previously observed at these collieries and, therefore, it is expected that 92 % of the monitoring lines above the proposed longwalls would experience maximum tensile strains of 3.0 mm/m, or less.

It can also be seen, that 45 of the 52 monitoring lines (i.e. 87 % of the total) at Tahmoor, Appin and West Cliff Collieries had recorded maximum total compressive strains of 4.0 mm/m, or less. The strains for the proposed longwalls are predicted to be 20 % to 40 % greater than those previously observed at these collieries and, therefore, it is expected that 87 % of the monitoring lines above the proposed longwalls would experience maximum compressive strains of 5.5 mm/m, or less.

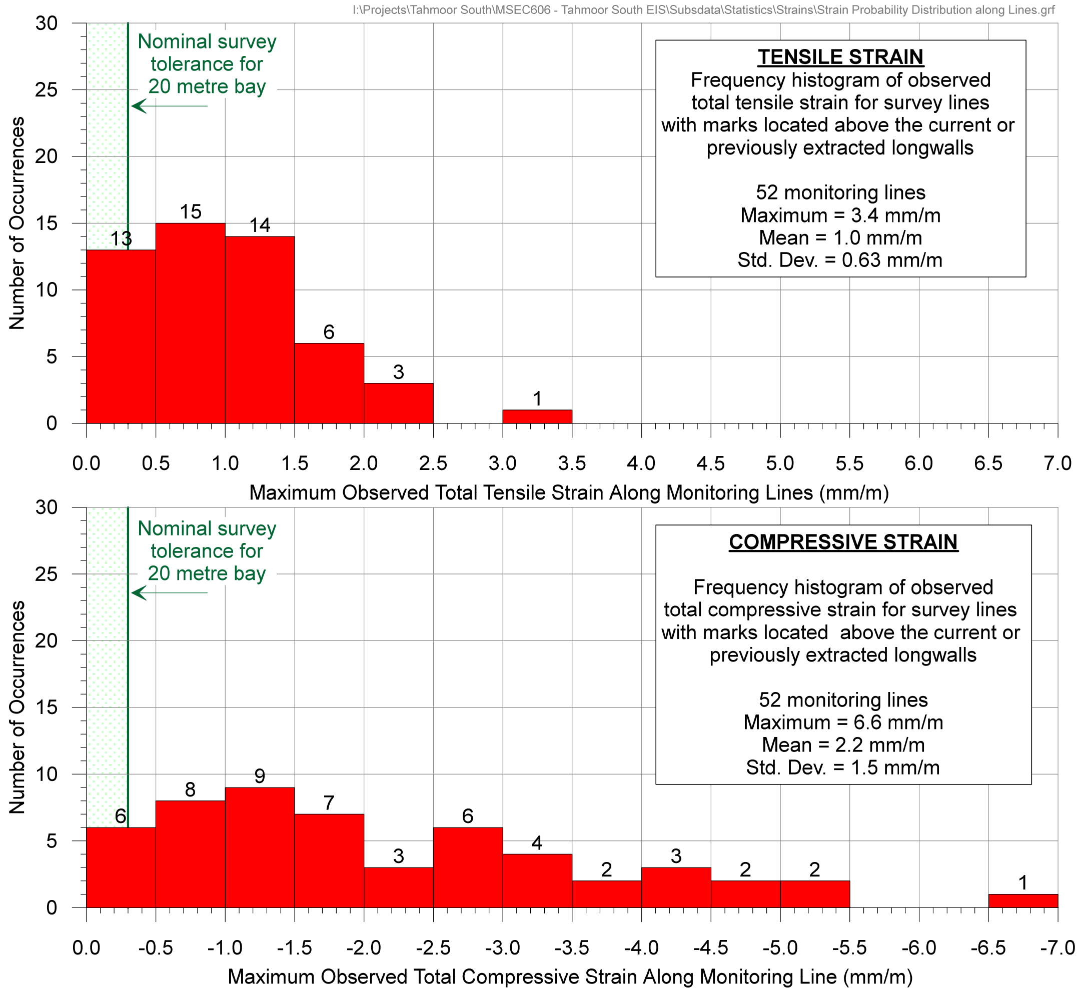


Fig. 2.10 Distributions of measured maximum tensile and compressive strains anywhere along the monitoring lines at Tahmoor, Appin and West Cliff Collieries

A statistical comparison of observed maximum strains along monitoring lines above LW S1A has not been conducted due to limited data. Two monitoring lines, the Main Southern Railway and Remembrance Drive recorded a maximum compressive strain of 2.5 mm/m and 2 mm/m, respectively.

2.5.3. Analysis of shear strains

Ground strain comprises two components, being normal strain and shear strain, which can be interrelated using a Mohr's Circle analysis. The magnitudes of the normal strain and shear strain components are, therefore, dependent on the orientation in which they are measured. The maximum normal strains (i.e. principal strains) are those in the direction where the corresponding shear strain is zero.

Normal strains along monitoring lines can be measured using 2D and 3D techniques, by taking the change in horizontal distance between two points on the ground and dividing by the original horizontal distance between them. This provides the magnitude of normal strain along the orientation of the monitoring line but, this strain may not necessarily be the maximum (i.e. principal) strain.

Shear deformations are more difficult to measure, as they are the relative horizontal movements perpendicular to the direction of measurement. However, 3D monitoring techniques provide data on the direction and the absolute displacement of survey marks and, therefore, the shear deformations perpendicular to the monitoring line can be determined. It is possible to gain an understanding of the shear strain along a monitoring line with repeat measurements, but, in accordance with rigorous definitions and the principles of continuum mechanics, (e.g. Jaeger, 1969), it is not possible to accurately determine horizontal shear strains in any direction relative to the monitoring line using 3D monitoring data from a straight line of survey marks.

Shear deformations perpendicular to monitoring lines can be described using various parameters, including horizontal tilt, horizontal curvature, horizontal mid-ordinate deviation, angular distortion and shear index. In this report, horizontal mid-ordinate deviation has been used as the measure for shear deformation, which is defined as the differential horizontal movement of each survey mark, perpendicular to a line drawn between two adjacent survey marks.

The frequency distribution of the maximum total horizontal mid-ordinate deviations measured at survey marks above goaf, for previously extracted longwalls in the Southern Coalfield, is provided in Fig. 2.11. As the typical survey bay length was 20 metres, the calculated mid-ordinate deviations were over a chord length of 40 metres. The probability distribution function, based on the fitted GPD, has also been shown in this figure.

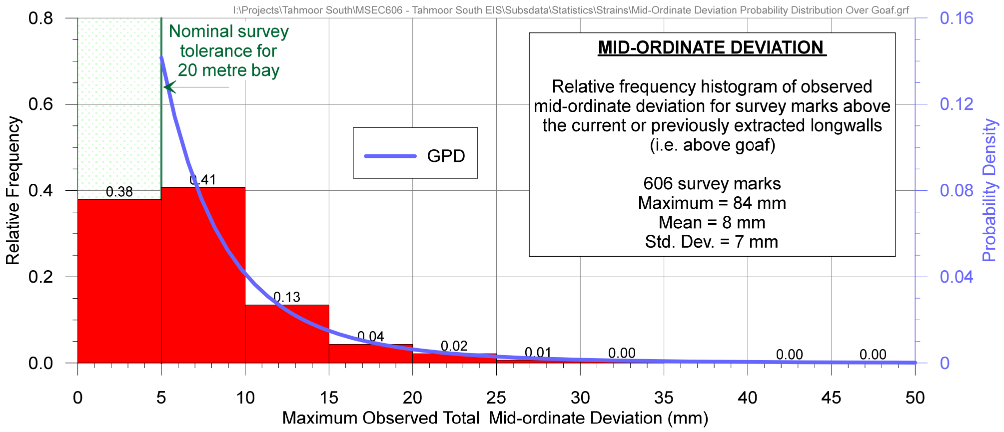


Fig. 2.11 Distribution of measured maximum mid-ordinate deviation during the extraction of previous longwalls in the Southern Coalfield for marks located above goaf

The 95 % and 99 % confidence levels for the maximum total horizontal mid-ordinate deviation that the individual survey marks located above goaf experienced at any time during mining were 20 mm and 35 mm, respectively. The shear deformations for the proposed longwalls are estimated to be 20 % to 40 % greater than those previously observed at Tahmoor, Appin and West Cliff Collieries and, therefore, it is expected that 95 % and 99 % of the horizontal mid-ordinate deviations measured above the proposed longwalls would be less than 30 mm and 50 mm, respectively.

A statistical comparison of observed maximum strains along monitoring lines above LW S1A has not been conducted due to limited data.

2.6. Predicted far-field horizontal movements

In addition to the conventional subsidence movements that have been predicted above and adjacent to the proposed LW S7A, far-field horizontal movements will also be experienced during the extraction of the proposed longwall.

The observed incremental far-field horizontal movements resulting from the extraction of incremental longwall panels, in any location above goaf, i.e. above the currently mined or previously mined panels, or above solid coal, i.e. unmined areas of coal, are provided in Fig. 2.12. The observed incremental far-field horizontal movements above solid coal only, i.e. outside the extents of extracted longwalls, are provided Fig. 2.13. The confidence levels, based on fitted *Generalised Pareto Distributions* (GPDs), have also been shown in these figures to illustrate the spread of the data. It can be seen from Fig. 2.12 and Fig. 2.13 that the magnitude of the observed far-field horizontal movements over solid unmined areas of coal are lower and more consistent than the observed far-field horizontal movements over previously extracted panels.

As successive longwalls within a series of longwalls are mined, the magnitudes of the incremental far-field horizontal movements decrease. This is possibly due to the fact that once the in-situ stresses within the strata have been redistributed around the collapsed zones above the first few extracted longwalls, the potential for further movement is reduced. The total far-field horizontal movement may be less, therefore, than the sum of the incremental far-field horizontal movements for the individual longwalls.

The predicted far-field horizontal movements resulting from the extraction of the proposed LW S7A are very small and could only be detected by precise surveys. Such movements tend to be bodily movements towards the extracted goaf area, and are accompanied by very low levels of strain, which are generally less than the order of survey tolerance (i.e. less than 0.3 mm/m). The potential impacts of differential far-field horizontal movements on the natural and built features within the vicinity of the proposed longwalls are not expected to be measurable, with possibly the exception of the road and railway bridges and the Picton Weir, which are discussed in the impact assessments for these features in the following chapter.

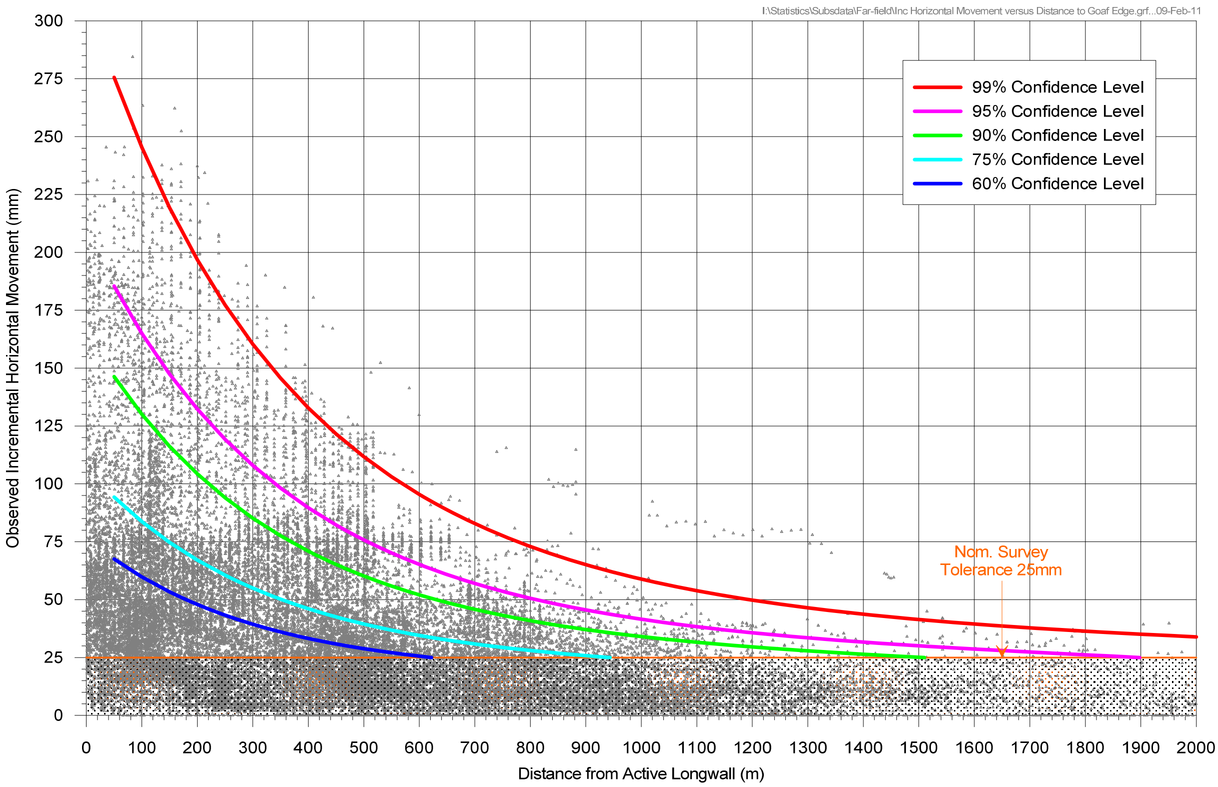


Fig. 2.12 Observed incremental far-field horizontal movements above goaf or solid coal

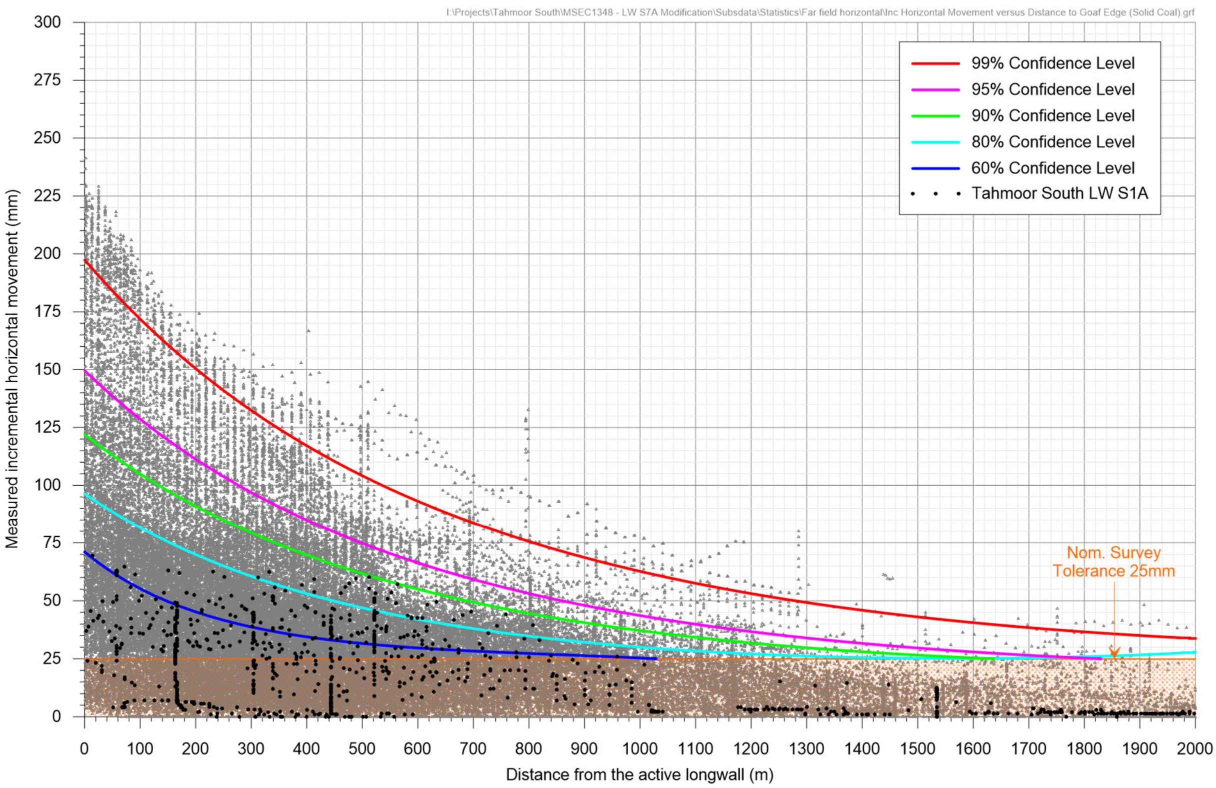


Fig. 2.13 Observed incremental far-field horizontal movements above solid coal only

A far field monitoring program was conducted by Tahmoor Coal during the extraction of LW S1A at key civil structures and along the Bargo River and Hornes Creek. The observed horizontal movements during the mining of LW S1A were within the normal range, as shown in Fig. 2.13.

3.1. The Study Area

The Study Area has been defined as the zone where the predicted subsidence effects, based on the *Modified Layout*, are different to those predicted based on the *Approved Layout*. The Study Area has been based on the following:

- 35° angle of draw line around LW S7A, based on the Modified Layout;
- The limit where the predicted incremental vertical subsidence due to the extraction of LW S7A on the tailgate (eastern side) of the panel is greater than 20 mm; and
- The limit where the predicted incremental total subsidence due to the extraction of LWs S1A to S7A on the maingate (western side) of the panel is greater than 20 mm.

The extent of the Study Area is shown in Drawing No. MSEC1348-01. Surface features that are located within 600 m of LW S7A, which will experience valley-related effects and could be sensitive to these effects, have also been included in the assessments provided in this report.

The natural and built features that are located within the Study Area are shown in Drawings Nos. MSEC1348-07 to MSEC1348-10. The surface features that have been included in the assessments provided in this report are:

- Bargo River at the confluence with Hornes Creek;
- Hornes Creek;
- Teatree Hollow and tributaries;
- Cliffs and steep slopes;
- Main Southern Railway;
- Local roads, specifically the whole of Yarran Road and parts of Caloola Road, Remembrance Drive and Wellers Road at Elvy Street;
- Powerlines, telecommunication infrastructure, gas pipelines, potable water pipelines and sewer pipelines;
- Picton Weir;
- Items of Heritage Significance;
- Farm dams;
- Commercial establishments; and
- Houses and other building structures.

The effects of the proposed LW S7A on the subsidence predictions and impact assessments for these features are provided in the following sections.

3.2. Bargo River

The location of the Bargo River is shown in Drawing No. MSEC1348-07. Descriptions, predictions and impact assessments for the river are provided in the following sections.

3.2.1. Description of the Bargo River

The Bargo River commences north of Colo Vale and near the townships of Hill Top and Yerrinbool and flows generally towards the north and to the west of the Bargo township. The Bargo River then flows to the west and north of the proposed Tahmoor South longwalls. The Bargo River ultimately drains into the Nepean River approximately 4.9 kilometres north-east of Longwall S1A.

While the Bargo River is located outside the Study Area, a short 200 metre long section of the Bargo River at the confluence with Hornes Creek is located within the 600m Study Area for Natural Features. The 200 metre long section commences from the Picton Weir and continues up to the confluence of Hornes Creek and slightly around the bend in the Bargo River. A photograph is shown in Fig. 3.1.

The 200 metre long section is located completely within the stored waters behind the Picton Weir. With exception of periods of prolonged drought, the bedrock is usually under water. The bedrock is covered with sediments that have been washed down the Bargo River and Hornes Creek.

The remainder of the Bargo River is outside the 600m Study Area for Natural Features. The closest distance between the Bargo River and LW S7A is approximately 520 metres.

A summary of the minimum distances between the river and the proposed longwalls is provided below in Table 3.1.

Table 3.1 Minimum distances of the proposed longwalls from the Bargo River

Longwall	Minimum distance from the centreline of Bargo River (m)
LW S1A	720
LW S2A	690
LW S3A	730
LW S4A	780
LW S5A	830
LW S6A	850
LW S7A	520

The section of Bargo River that is within the Study Area is a 5th order perennial stream as defined by the Strahler Stream Order Method.

The surface water flows in this section of the river are controlled by the Picton Weir (also called the Bargo Weir) with discharge regulated by a fixed discharge valve. The reservoir is emptied following extended dry periods, but it is quickly filled with the spillway overtopping following large storm events. The following article from the Picton Post, dated 1945, provides some background:

> *"The existing dam was built to T.W.L.912 in 1899, the lowest foundation being at R.L.887, which was a few feet below river bed level. In 1910 the wall was raised to T.W.L.920, giving a storage of 37 m.g."*
>
> *"During the recent drought the water level dropped considerably, and it was ascertained that the dam had silted up. It is understood that the silt level is approximately at R.L.904, which would leave an available storage, if this level were uniform, of 33 m.g. It is quite probable that the silt level in the upper reaches of storage is higher."*

The Weir was raised again in 1947 to its final height of RL1927 (Haigh, 1954). The water stored by the Picton Weir was initially used to supply the nearby communities. After pipes were laid from the much larger Nepean Dam, however, Bargo, Thirlmere, Picton and The Oaks were supplied water from the Nepean Dam (now through the Nepean Water Filtration Plant), and stored water from the Picton Weir was no longer used for town water supply.

Examples of fluctuations in water levels in the Bargo River are provided below:

- 13 November 2019 (Fig. 3.2) – Picton Weir was dry after an extended drought period, just prior to bushfires through the area in December 2019. It can be seen that water storage had receded such that very little surface water was visible upstream of the confluence with Hornes Creek. Alluvial sediments were visible in the aerial photograph, covering the bedrock.
- 18 February 2022 (Fig. 3.3) – Picton Weir was full and overtopping after substantial rain events. It can be seen that the whole section of Bargo River within the 600m Study Area for Natural Features was inundated with stored water.

The reports by Fluvial Systems (2013) and the Water Management Plan (Tahmoor Coal, 2023a) provide a detailed description of the river.

Image courtesy EMM on 24 May 2022

Fig. 3.1 View of Bargo River and Picton Weir downstream of confluence with Hornes Creek

Image courtesy Nearmap

Fig. 3.2 Aerial photo of section of Bargo River within 600m Study Area on 13 November 2019

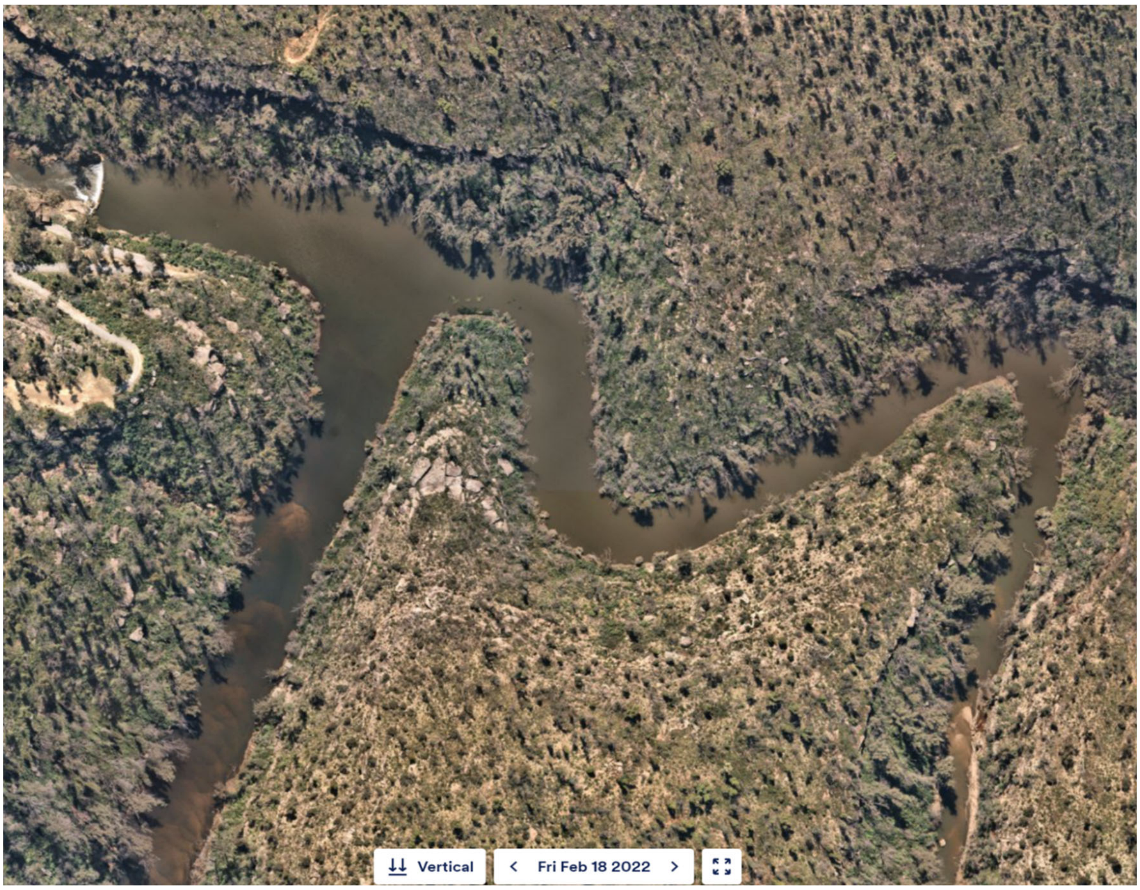


Image courtesy Nearmap

Fig. 3.3 Aerial photo of section of Bargo River within 600m Study Area on 18 February 2022

3.2.2. Predictions for the Bargo River

The predicted profiles of subsidence, upsidence and closure, using the IPM subsidence model and the 2002 ACARP valley closure prediction model, along the Bargo River and Hornes Creek are shown in Fig. A.02.

A summary of the maximum predicted values of incremental vertical subsidence, upsidence and closure for the Bargo River is provided Table 3.2 and the maximum predicted total values of vertical subsidence, upsidence and closure is provided in Table 3.3.

Table 3.2 Maximum predicted incremental vertical subsidence, upsidence and closure for Bargo River

Layout	Longwall	Maximum predicted incremental vertical subsidence (mm)	Maximum predicted incremental upsidence (mm)	Maximum predicted incremental closure (mm)
Modified Layout	LW S7A	< 20	20	20

Table 3.3 Maximum predicted total vertical subsidence, upsidence and closure for Bargo River

Layout	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Approved Layout	After LW S6A	< 20	< 20	< 20
Modified Layout	After LW S7A	< 20	30	20

It can be seen that the predictions for the *Modified Layout* are slightly increased when compared to the predictions based on the *Approved Layout*, which is expected given that LW S7A is closer to the River. Further statistical analysis and discussion on predicted closure movements are provided in the following Section 3.3 of this report for Hornes Creek.

3.2.3. Potential impacts on the Bargo River

The impact assessments for the Bargo River within the 600m Study Area are provided in the following sections. The assessments provided in this report should be read in conjunction with the Water Management Plan (Tahmoor Coal, 2023a) and the Biodiversity Management Plan (Tahmoor Coal, 2023c), which assess the consequences of the impacts on surface water flows and ecology.

Potential for increased levels of ponding, scouring or desiccation due to mining-induced tilt

Mining can potentially result in increased levels of ponding in locations where the mining-induced tilts oppose and are greater than the natural stream gradients that exist before mining. Mining can also potentially result in an increased likelihood of scouring of the stream beds in the locations where the mining-induced tilts considerably increase the natural stream gradients that exist before mining.

In this case, the predicted changes in grade along the Bargo River due to the proposed extraction of LW S7A are negligible. The potential for impacts due to mining-induced changes in stream gradients is also irrelevant given that the section of Bargo River within the 600m Study Area is usually inundated with stored water.

Potential for fracturing and surface water flow diversion in the stream

There has been a long history of mining directly beneath or near the Bargo River at Tahmoor Mine. While impacts have occurred when various previously extracted longwalls were mined directly beneath the river, impacts have not been observed when mining has been undertaken more than 500 metres away from the river.

- Longwalls 8, 10 to 13 were mined between 1991 and 1994 directly beneath a 2.0 kilometre section of the Bargo River and directly beneath a 1.0 kilometre section of Dog Trap Creek.

  These were the first series of longwalls to be mined directly beneath the Bargo River at Tahmoor Mine. Very little monitoring of the river occurred during this time, although extensive protective works were undertaken at the Rockford Road Bridge, which was located over Longwall 12.

  Surface fracturing of exposed bedrock was observed near to the supporting piers of the Bridge following the extraction of Longwalls 12 and 13. Fractures were also observed in flute holes downstream of the bridge over the goaf edge of Longwall 13, which were first observed during the extraction of Longwall 12 (Holla and Barclay, 2000). The fractures were localised and did not consistently run along the length of the river valley. They appeared to be the result of localised shearing and compressive buckling and some fractures were located where there was noticeable cross bedding within the river bed. There were no reports of impact to water flows along this section of river.

While surface fracturing is still visible in the flute holes that are located on a large, exposed rockbar, surface water diversion is not evident and large pools exist directly above the previously extracted longwalls, as Tahmoor Mine's licensed discharge has contributed a base flow to this section of the Bargo River.

Fig. 3.4 Large pool in the Bargo River, located upstream of Rockford Road Bridge, directly above previously extracted Longwall 12

Very little monitoring of the Dog Trap Creek occurred when Longwalls 12 and 13 mined directly beneath it, although extensive monitoring and works were undertaken at the small Road Bridge over Dog Trap Creek on Arina Road. No surface fractures are visible in the stream at the location, however, and pools are observed to exist. It is noted that this section of Dog Trap Creek contains plenty of sediment that could assist in the filling of fractures.

Fig. 3.5 Ponded water in Dog Trap Creek near bridge over Arina Road above previously extracted Longwall 13

- Longwalls 14 to 19 were mined between 1995 and 2002 directly beneath a 1.7 kilometre section of the Bargo River, downstream of Picton Weir. This section of river is located between 720 metres and 850 metres north-west of the proposed LWs S1A to S6A, as shown in Drawings No. MSEC1348-01 and MSEC1192-07.

  Limited monitoring indicated little impact on the River during the extraction of Longwalls 14 to 17. Fracturing was not observed on the surface, although many sections were concealed by alluvial and talus deposits.

  The first adverse impacts on the river were reported in January 2002, after the extraction of Longwall 18, when residents alerted Tahmoor Mine to reduced pool levels downstream of the mining area. At that time there was very little stored water in the Picton Weir due to low rainfalls and surface flows from the weir had reduced to a mere trickle. Inspections along the river indicated fracturing of rock shelves in the river bed and drainage of some shallow pools.

Fig. 3.6 Immediately upstream of Picton Weir during period of prolonged dry weather – January 2002

Detailed subsidence monitoring of survey pegs within the Bargo River over the centre of LW18 after LW18 was extracted, i.e. in October 2001 had indicated that total upsidence in the base of LW18 was 250 mm, the total valley closure was approximately 400 mm and the maximum measured valley closure strain was 15 mm/m.

The inspections in January 2002 found that the river had been drained directly above Longwall 18 and the length of drainage extended downstream for some distance beyond Longwall 14.

Shortly after this time a large rainfall event occurred, which filled the Weir and restored surface water flows along the River. A dry period followed and by July 2002 the Picton Weir was empty again and the extraction of Longwall 19 was completed. Inspections showed that surface flows ceased again, with the furthest drained pool from the longwalls being located 125 metres upstream of LW19. This coincided with the completion of this longwall.

Detailed subsidence monitoring of survey pegs within the Bargo River over the centre of LW18 after LW19 was extracted indicated that total upsidence in the base of LW18 was 450 mm, the total valley closure was approximately 700 mm and the maximum measured valley closure strain was 18 mm/m.

A further period of heavy rainfall occurred in February 2003 which then refilled the upstream sections of Picton Weir which then overtopped (see Fig. 3.7 and Fig. 3.8).

After this large storm, it was then observed that the water flows along the surface above the longwalls were progressively restored even during the following drier periods. It is believed that the high sediment load in the river, that was retained by the Picton Weir except when it is overtopped, had been washed down the river and filled in the mining induced fractures in the bedrock reducing the loss of surface water flows.

The extraction of Longwalls 14 to 19 also mined directly beneath small tributaries to the Bargo River. Fluvial Systems (2013) reports fracturing and surface flow diversions in two unnamed tributaries, which are located above previously extracted Longwalls 15 and 19. The stream channel beds in these tributaries were exposed bedrock.

Fig. 3.7 Picton Weir 1st February 2003

Fig. 3.8 Picton Weir 24th February 2003

- Previously extracted Longwall 24A was approximately 340 metres from the river at its closest point and Longwall 25 was approximately 510 metres from the river. Ground surveys measured very little vertical subsidence (less than 20 mm) and closure (less than 10 mm) occurred even though at this section of the river the gorge was 80 metres deep. Impacts to the river were not observed during the extraction of these longwalls.

With respect to streams or sections of streams located away from the proposed longwalls, the likelihood of fracturing and surface flow diversions reduces substantially compared to stream sections located directly above the proposed longwalls. The furthest known rockbar impact site where fracturing resulted in the diversion of surface water was at Pool F in the Waratah Rivulet that was being affected by a previously extracted longwall on one side and by the end of another longwall, i.e. the rockbar was located over solid unmined coal, but it was located in the corner between two longwalls. This site was located 160 metres to the side of one longwall and 230 metres from the approaching face of the active longwall. Surface water diversions have also been observed at three sites from the sides of longwalls at distances between 125 metres and 100 metres at the Bargo River, Waratah Rivulet and Native Dog Creek. Surface water diversion has only been observed at one site at Pool G1 in the Waratah Rivulet beyond the ends of the longwalls and in this case the closest distance was approximately 75 metres.

Minor and isolated fracturing could also occur outside the extents of the proposed longwalls. The furthest distance of an observed fracture from longwall mining at Appin Colliery was at the base of Broughtons Pass Weir, which was located approximately 415 metres from Appin Colliery Longwall 401. Another minor fracture was also recorded in the upper Cataract River, approximately 375 metres from Appin Colliery Longwall 301. This fracture occurred in a large rockbar, which was formed in thinly bedded sandstone, which had experienced movements from nearby previously extracted longwalls.

More recently, visual inspections along the Tributary to Teatree Hollow have identified a minor fracture that is located approximately 500 metres from LW S1A. The fracture was identified within a surface boulder upstream of Pool TT2. The boulder is wedged between two larger rocks on either side of the creek.

The above observations represent the furthest-most recorded fractures from longwall mining in the NSW Coalfields.

In the present case, the proposed LW S7A is located approximately 520 metres from the Bargo River at its closest point. The section of Bargo River within the 600 m Study Area is located within the stored waters behind the Picton Weir. Based on the previous experiences at Tahmoor Mine, it is very unlikely that the extraction of the proposed longwalls would result in adverse impacts on surface water flows in the river.

In the very unlikely event that surface fractures develop in the Bargo River due to the extraction of LW S7A, the fractures would likely not be detected as the bedrock is covered by alluvial sediment and frequently by stored water. Even if the predictions and impact assessments were exceeded, the likelihood of impacts on surface flow is considered extremely low given that water levels are controlled by the Picton Weir. Previously observed experiences have found that mining-induced sub-surface fracturing in this section of the Bargo River has been filled by sediment that is stored behind the Picton Weir, reducing the potential for impacts on surface water flows.

Further detailed discussions on the impacts and consequences of changes in the surface water flows are provided in the Water Management Plan (Tahmoor Coal, 2023a).

Potential for Gas Emissions and Changes to Water Quality

Gas emissions from the sandstone strata have been previously observed above and adjacent to mining areas in the Southern Coalfield, and some gas emissions have also been observed in water bores. Analyses of gas compositions indicate that the Bulli seam is not the direct and major source of the gas and that the most likely source is the Hawkesbury Sandstone (APCRC, 1997).

Gas emissions may occur and become visible in the stored water behind the Picton Weir as a result of the proposed extraction of the longwalls. Where these gas releases occur into the water column there is insufficient time for any substantial amount of gas to dissolve into the water. The majority of the gas is released into the atmosphere and is unlikely to have an adverse impact on water quality.

A description of potential water quality impacts and environmental consequences is presented in the Water Management Plan (Tahmoor Coal, 2023a) and the Biodiversity Management Plan (Tahmoor Coal, 2023c).

3.2.4. Management of potential impacts on the Bargo River

Tahmoor Coal has developed a Water Management Plan for LWs S1A to S6A to manage potential impacts on streams during the mining of longwalls, including the Bargo River. The management plan includes monitoring and triggered response plans. It includes monitoring of the required pre-mining conditions and data collection during mining. Monitoring typically continues for a period following mining.

The Water Management Plan will be updated to include LW S7A (Tahmoor Coal, 2023a).

Tahmoor Coal is currently monitoring ground movements at the Bargo River during the mining of LW S2A according to the Subsidence Monitoring Plan.

- Two GNSS have been installed near the tops of the Bargo River valley across the Picton Weir. The GNSS units have continuously monitored changes during mining since the commencement of LW S1A. While the GNSS units have measured minor horizontal movements, changes in horizontal distances between the units are less than 5 mm and within survey tolerance.
- Prior to the commencement of LW S2A, additional GNSS units have been installed along Hornes Creek, which will also provide relevant monitoring information for monitoring changes and potential impacts along the Bargo River.
- Two GNSS units have been installed across the Bargo River valley, directly above previously extracted LW 16. The GNSS units have continuously monitored changes during mining since the commencement of LW S1A. While the GNSS units have measured minor horizontal movements, changes in horizontal distances between the units are less than 5 mm and within survey tolerance.
- Tahmoor Coal installed ground surveys pegs across the Bargo River above previously extracted LWs 14B to 19. A re-survey after the completion of LW S1A on 6 November 2023 measured changes of ± 7 mm, which is considered to be within survey tolerance given the environment within which the pegs have been installed.

Tahmoor Coal will continue to monitor changes in the Bargo River during the extraction of proposed Tahmoor South longwalls, in accordance with the Subsidence Monitoring Plan and Water Management Plan.

3.3. Hornes Creek

The location of Hornes Creek is shown in Drawing No. MSEC1348-07. Descriptions, predictions and impact assessments for the creek are provided in the following sections.

3.3.1. Description of Hornes Creek

Hornes Creek commences west of the township of Bargo and flows generally towards the north-west before draining into the Bargo River. Hornes Creek catchment is located to the south-southwest of LW S1A-S6A. The catchment area of Hornes Creek is approximately 19.3 km^2 which comprises predominantly bushland, rural-residential area and residential area associated with the Bargo township (Tahmoor Coal, 2023a). Hornes Creek is a fourth order stream within the Study Area (Fluvial Systems, 2013).

The downstream section of Hornes Creek meanders inside and outside the Study Area and the majority of the downstream section is located inside the 600m Study Area for Natural Features, as shown in Drawing No. MSEC1348-07.

The closest distance between Hornes Creek and LW S7A is approximately 330 metres at a sharp bend and a photograph of the bend is shown in Fig. 3.9. Upstream of the bend, the distance between Hornes Creek and LW S7A is between 470 metres and 620 metres.

Image courtesy EMM

Fig. 3.9 View of Hornes Creek at bend located closest to LW S7A

Water levels in the downstream section of Hornes Creek are controlled by the Picton Weir. As discussed for the Bargo River in Section 3.2.1, Hornes Creek is generally inundated with stored water but the extent of stored water recedes during periods of prolonged dry weather.

Examples of fluctuations in water levels in Hornes Creek are provided below:

- 13 November 2019 (Fig. 3.2 and Fig. 3.10) – Picton Weir was dry after an extended drought period, just prior bushfires through the area in December 2019. It can be seen that water storage had receded such that very little surface water was visible upstream of the confluence with the Bargo River. Alluvial sediments were visible in the aerial photograph, covering the bedrock up to the upstream end of the storage area at Pool HC-16. Isolated pools were visible along the stream.
- 18 February 2022 (Fig. 3.3 and Fig. 3.11) – Picton Weir was full and overtopping after substantial rain events. It can be seen that the whole section of Bargo River within the 600m Study Area for Natural Features was inundated with stored water up to Pool HC-16.

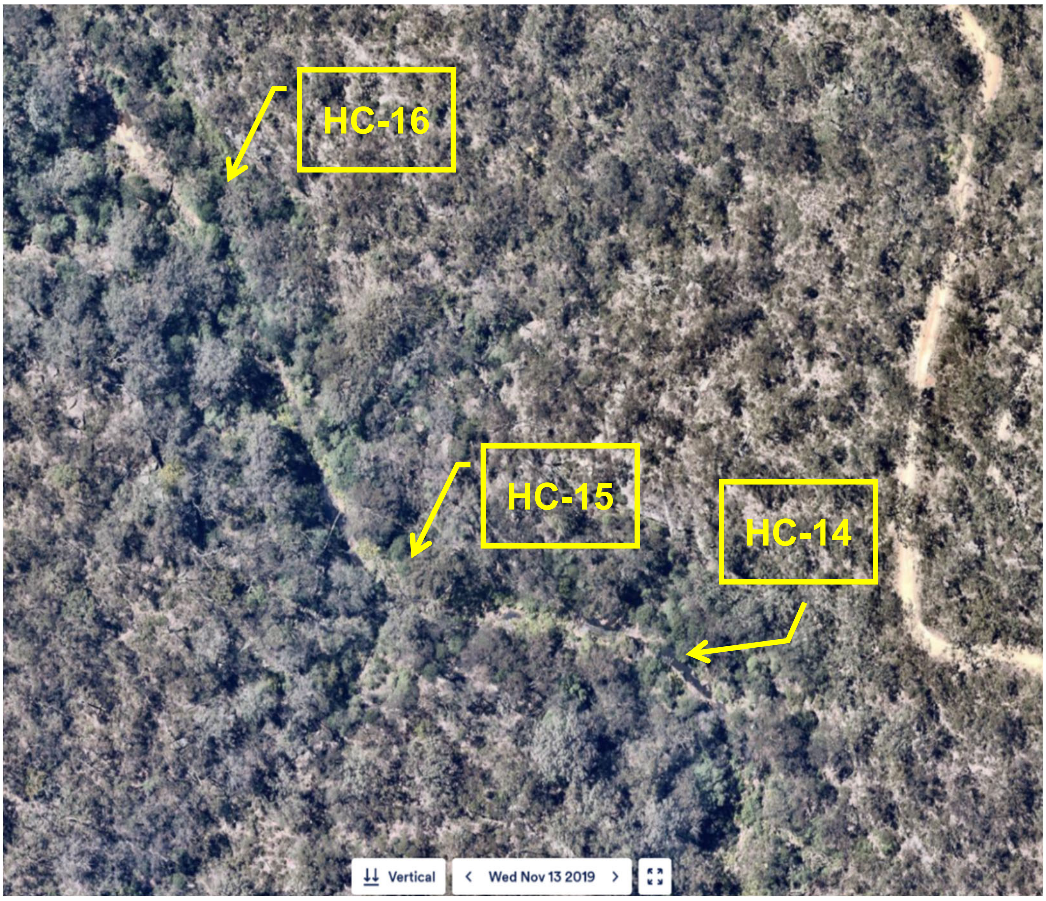


Image courtesy Nearmap

Fig. 3.10 Aerial of photo of Hornes Creek near Pools HC-P14 to HC-P16 on 13 November 2019

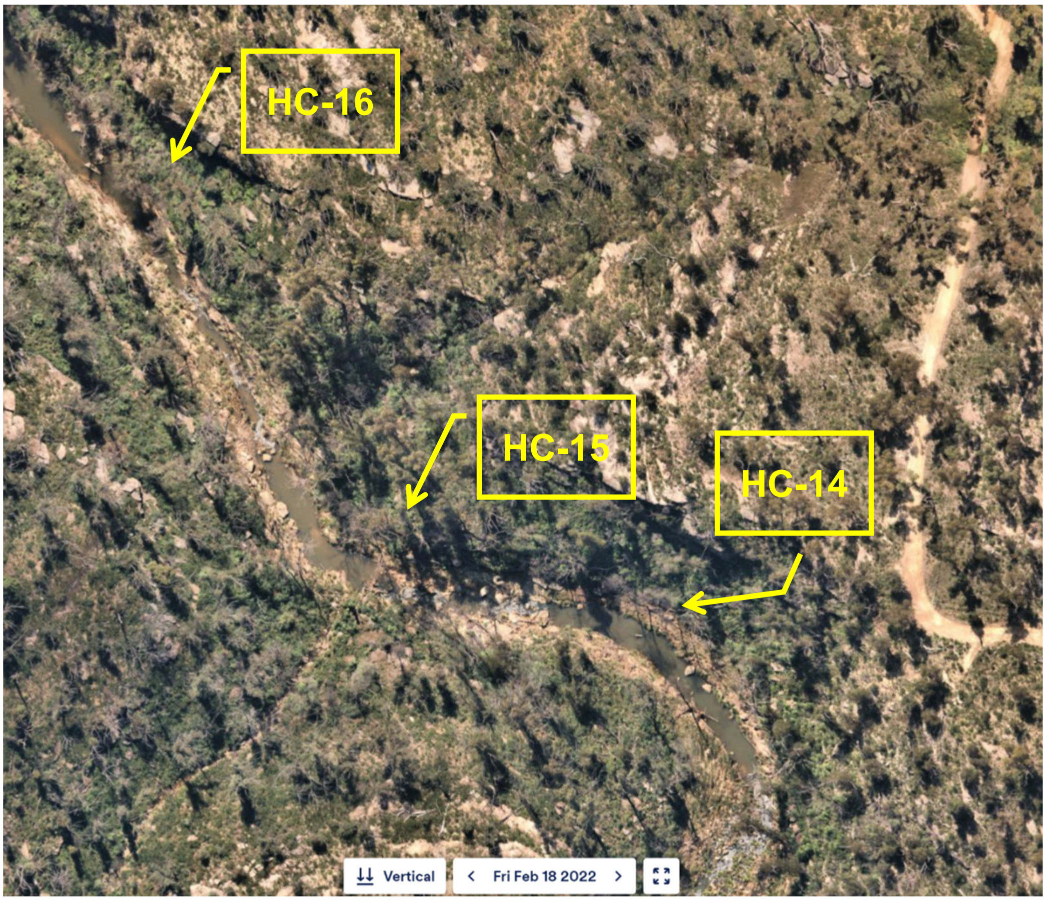


Image courtesy Nearmap

Fig. 3.11 Aerial of photo of Hornes Creek near Pools HC-P14 to HC-P16 on 18 February 2022

Upstream of Pool HC-16, Hornes Creek is comprised of a series of pools that are controlled by rockbars and boulders. Water flows are intermittent, with flowing water recorded on at least 81% of sampling occasions at all monitoring sites in Hornes Creek (Tahmoor Coal, 2023a). During periods of prolonged dry weather, however, the creek is dry with localised pools. A total of 9 pools (HC-08 to HC-16) are located within the 600m Study Area.

A photograph of Pool HC-09, which is closest to LW S7A is shown in Fig. 3.12.

Image courtesy MNC consulting

Fig. 3.12 Hornes Creek Pool HC-P09 on 23 September 2023

The reports by Fluvial Systems (2013) and the Water Management Plan (Tahmoor Coal, 2023a) provide a detailed description of Hornes Creek.

3.3.2. Predictions for Hornes Creek

The predicted profiles of subsidence, upsidence and closure, using the IPM subsidence model and the 2002 ACARP valley closure prediction model, along the Bargo River and Hornes Creek are shown in Fig. A.02.

A summary of the maximum predicted values of incremental vertical subsidence, upsidence and closure for Hornes Creek is provided in Table 3.4 and a summary of the maximum predicted values of total vertical subsidence, upsidence and closure for Hornes Creek is provided in Table 3.5.

Table 3.4 Maximum predicted incremental vertical subsidence, upsidence and closure for Hornes Creek

Layout	Longwall	Maximum predicted incremental vertical subsidence (mm)	Maximum predicted incremental upsidence (mm)	Maximum predicted incremental closure (mm)
Modified Layout	LW S7A			
Section with water levels controlled by Picton Weir downstream from Pool HC-16 to confluence with Bargo River		30	50	130
Section with water levels controlled by rockbars and boulders upstream from Pool HC-16		20	30	60

Table 3.5 Maximum predicted total vertical subsidence, upsidence and closure for Hornes Creek

Layout	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Approved Layout	After LW S6A	< 20	30	< 20
Modified Layout	After LW S7A			
Section with water levels controlled by Picton Weir downstream from Pool HC-16 to confluence with Bargo River		40	80	150
Section with water levels controlled by rockbars and boulders upstream from Pool HC-16		25	45	70

It can be seen that the predictions based on the *Modified Layout* are increased when compared to the predictions based on the *Approved Layout*, which is expected given that LW S7A is closer to Hornes Creek.

Maximum subsidence, closure and upsidence is located at the sharp bend in Hornes Creek, which is located closest to LW S7A. As shown in Fig. A.02, predicted movements reduce further upstream and downstream of the bend.

3.3.3. Statistical analyses of valley closure movements

Statistical analyses of previously measured valley closure in the Southern Coalfield have been conducted based on monitoring data from Tahmoor Colliery and nearby Appin and West Cliff Collieries, where depths of cover and extraction heights are similar to those proposed for LW S7A. The results are relevant for the proposed extraction of LW S7A adjacent to Hornes Creek and the Bargo River.

Observed incremental valley closure at sites located above solid, unmined coal, are shown relative to their distances from the maingate edges of previously extracted longwalls in Fig. 3.13. A total of 2390 measurements have been plotted, sorted into groups based on valley depths that are greater than or less than 40 metres. Where surveys were conducted on multiple occasions at a site during the extraction of a longwall, only the maximum measured incremental closure for each longwall has been plotted.

The confidence levels, based on fitted *Generalised Pareto Distributions* (GPDs), have also been shown in Fig. 3.13 to illustrate the spread of the data. The GPD and confidence levels have been calculated without filtering the data based on valley depths, nor the locations of the sites relative to the sides or ends of the longwalls.

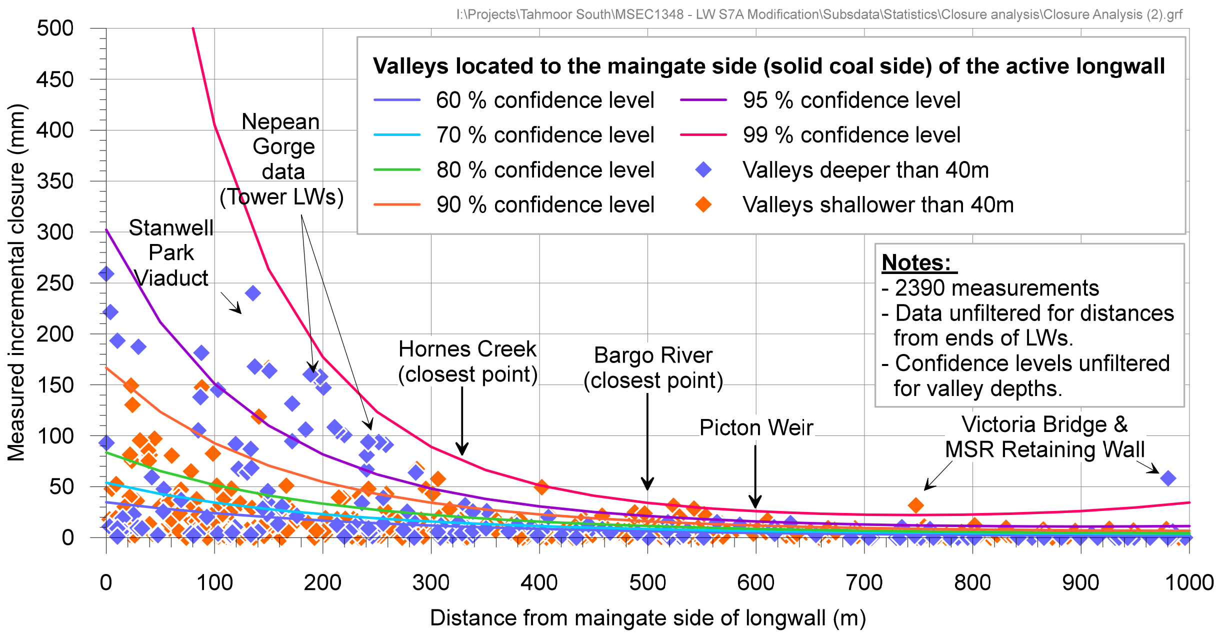


Fig. 3.13 Observed incremental valley closure against distance from the maingate edge of the active longwall over solid, unmined coal

It can be seen from Fig. 3.13 that observed valley closure increases as the distance of the sites to the extracted longwalls reduce, as expected. Given that predicted maximum incremental valley closure along Hornes Creek is 130 mm at a distance of 330 metres from the maingate edge of LW S7A, the statistical analyses also demonstrates that observed closure, when plotted against distance from the maingate edge, is generally less than predicted by the ACARP method.

The reason for the more conservative prediction by the ACARP method can be explained by the way in which the ACARP normalises the offset distances by dividing them by the sum of the longwall panel width and chain pillar width. The ACARP method of predicting valley closure relative to the transverse distance to the active longwall is shown in Fig. 3.14, with the latest available empirical data overlaid on the graph. It can be seen that upper bound prediction curves are conservative, though some outliers can be seen.

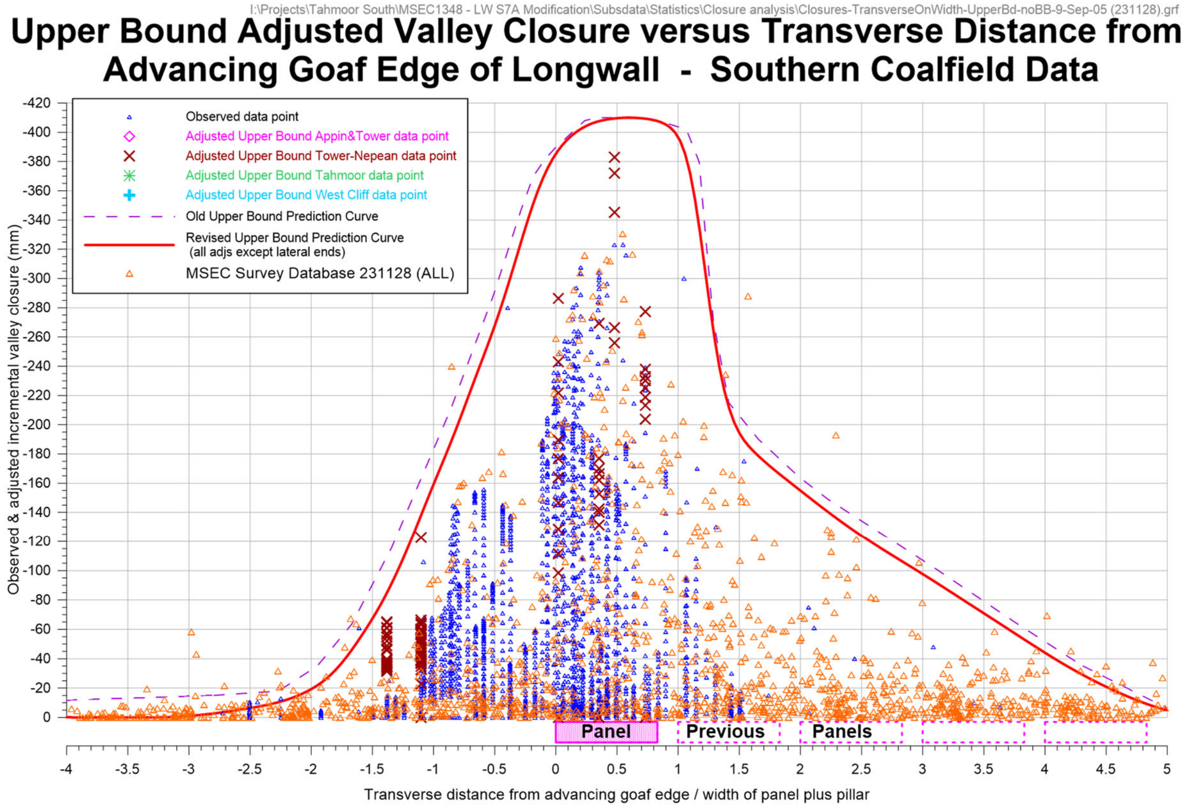


Fig. 3.14 Observed incremental valley closure against normalised transverse distance from maingate edge of longwalls and ACARP prediction model

The closest distance between Hornes Creek and LW S7A is approximately 330 metres at a sharp bend. The distance equates to an normalised distance of -1.03 in Fig. 3.14. The empirical data that influenced the shape of the prediction curve in the ACARP model was primarily based on surveys conducted across the Nepean Gorge during the extraction of longwalls at Tower Colliery, where the longwall panels were approximately 210 metres wide. When the data is plotted against distance only, as shown in Fig. 3.13, the Nepean Gorge data is located around 200 to 250 metres from the maingate edge. When the data is plotted against normalised distance, as shown in Fig. 3.14 and also in Fig. 3.15 below, the Nepean Gorge data is more applicable to the predictions at the closest point of Hornes Creek to LW S7A.

Similarly, measured incremental valley closure across the Stanwell Park Viaduct during mining at CoalCliff Colliery fits within the confidence level curves when plotted against distance in Fig. 3.13, but becomes an outlier when the distance is normalised due to the narrowness of the extracted panel.

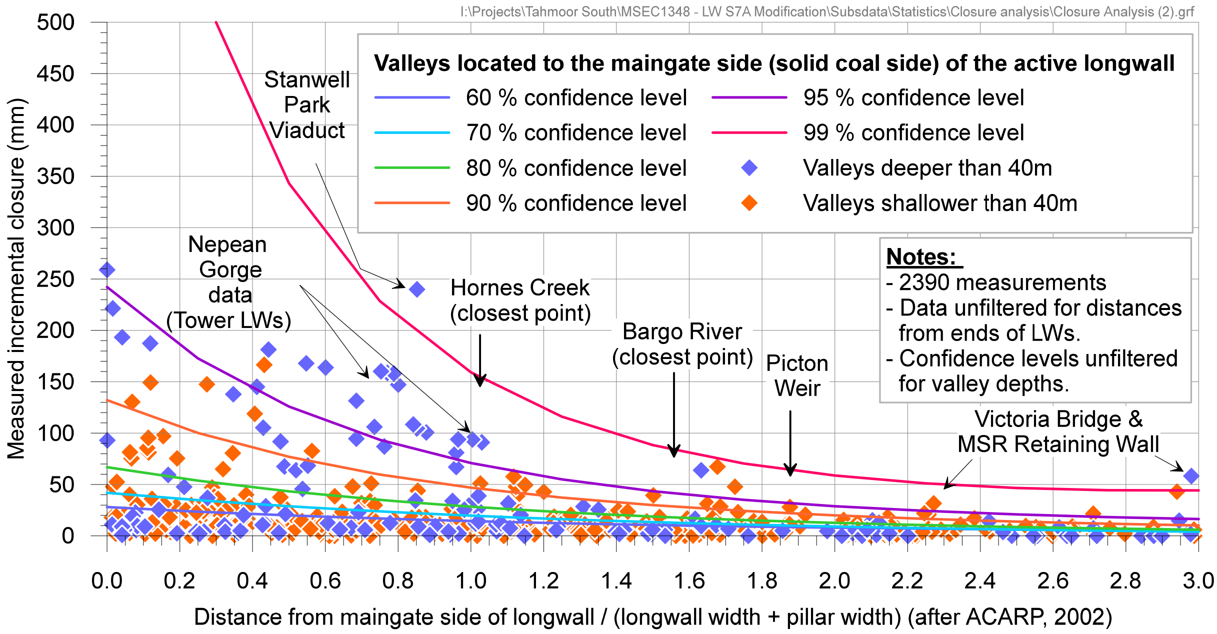


Fig. 3.15 Observed incremental valley closure against normalised distance from the maingate edge of longwalls / (longwall width + pillar width)

The closest distance between Hornes Creek and LW S7A is approximately 330 metres at a sharp bend. The statistical analyses indicates that the ACARP prediction of maximum incremental closure of 130 mm at the closest point to Hornes Creek is reasonably conservative:

- When compared against the empirical database based on the offset distance of 330 metres, it can be seen from Fig. 3.13 that the likelihood of exceedance is less than 1 in 100 (i.e. above the 99% confidence level curve).
- When compared against the empirical dataset based on a normalised offset distance of 1.03, it can be seen from Fig. 3.15 that the likelihood of exceedance is between 1 in 20 and 1 in 100 (i.e. between the 95% and 99% confidence level curves).

Upstream of the bend, the distance between Hornes Creek and LW S7A is between 470 metres and 620 metres. The statistical analyses indicates that the ACARP prediction of maximum incremental closure of 60 mm at the closest point to Hornes Creek is reasonably conservative:

- When compared against the empirical database based on the offset distance of 470 to 600 metres, it can be seen from Fig. 3.13 that the likelihood of exceedance is considerably less than 1 in 100 (i.e. above the 99% confidence level curve).
- When compared against the empirical dataset based on a normalised offset distance of 1.5 to 1.9, it can be seen from Fig. 3.15 that the likelihood of exceedance is between 1 in 20 and 1 in 100 (i.e. between the 95% and 99% confidence level curves).

While the statistical analyses show that the valley closure prediction is likely to be conservative, the empirical data presented in Fig. 3.13 and Fig. 3.15 shows there are two outliers at distances greater than 600 metres from previously extracted longwalls. These relate to recently observed closure during the mining of Tahmoor LW W3 and LW W4 across Stonequarry Creek at the Victoria Bridge and a Retaining Wall at 84.687 km on the Main Southern Railway. LW W4 was relatively short in length and incremental valley closure would likely have been greater if LW W4 was longer. LW W4 was also the last longwall to be extracted in this mining domain. Valley closure would likely have continued to develop at a greater magnitude if additional longwalls had been extracted closer to the monitoring sites. The observed closure, however, only developed along one arm of Stonequarry Creek, where less than 10 mm of valley closure was observed where the Picton Viaduct crosses Stonequarry Creek, 300 metres upstream of Victoria Bridge. The observations are discussed in Section 3.10.5.

The case study is relevant to the extraction of LW S7A to the side of Hornes Creek and the Bargo River as both sites involve a regionally significant valley (Stonequarry Creek compared to Bargo River) and both are located near a major geological fault system (Nepean Fault compared to the Central Fault). The case study is a reminder that greater valley closure movements can sometimes occur. The potential for greater than predicted movements has been considered when conducting impact assessments for Hornes Creek and the Bargo River.

3.3.4. Potential impacts on Hornes Creek

The impact assessments for Hornes Creek within the 600m Study Area are provided in the following sections. The assessments provided in this report should be read in conjunction with the Water Management Plan (Tahmoor Coal, 2023a) and the Biodiversity Management Plan (Tahmoor Coal, 2023c), which assess the consequences of the impacts on surface water flows and ecology.

Potential for increased levels of ponding, scouring or desiccation due to mining-induced tilt

Mining can potentially result in increased levels of ponding in locations where the mining-induced tilts oppose and are greater than the natural stream gradients that exist before mining. Mining can also potentially result in an increased likelihood of scouring of the stream beds in the locations where the mining-induced tilts considerably increase the natural stream gradients that exist before mining.

In this case, the predicted changes in grade along Hornes Creek due to the proposed extraction of LW S7A are negligible. The potential for impacts due to mining-induced changes in stream gradients is also irrelevant for the section downstream of Pool HC-16, given that this section is usually inundated with stored water.

Potential for fracturing and surface water flow diversion in the stream

A summary of observed experiences of impacts due to previous longwall mining adjacent but not directly beneath streams was discussed in Section 3.2.3.

The section of Hornes Creek downstream of Pool HC-16 is located approximately 330 metres from the proposed LW S7A at its closest point at the sharp bend in the stream. This section of Hornes Creek is located within the stored waters behind the Picton Weir. Based on the previous experiences at Tahmoor Mine, it is unlikely that the extraction of the proposed longwalls would result in adverse impacts on this section of the stream.

Minor fractures in bedrock have previously been observed in isolated locations at offset distances between 330 metres and 500 metres in the Southern Coalfield. In the event that minor, isolated surface fractures develop within the stored water areas of Hornes Creek due to the extraction of LW S7A, the fractures would likely not be detected as the bedrock is covered by alluvial sediment and frequently by stored water.

Even if the predictions and impact assessments were exceeded, the likelihood of impacts on surface flow is considered extremely low given that water levels are controlled by the Picton Weir. Previously observed experiences have found that mining-induced sub-surface fracturing in this section of the Bargo River have been filled by sediment that is stored behind the Picton Weir reducing the potential for impacts on surface water flows.

The section of Hornes Creek upstream of Pool HC-16 is located between 470 metres and 620 metres from the proposed LW S7A. The likelihood of fracturing occurring in this section of the creek is considered to be low. In the unlikely event that fracturing occurs, the fractures are expected to be minor and isolated.

The likelihood of fracturing resulting in surface flow diversion is considered to be very low given the offset distance of LW S7A to this section of stream.

Further detailed discussions on the impacts and consequences of changes in the surface water flows are provided in the Water Management Plan (Tahmoor Coal, 2023a).

Potential for Gas Emissions and Changes to Water Quality

Gas emissions from the sandstone strata have been previously observed above and adjacent to mining areas in the Southern Coalfield, and some gas emissions have also been observed in water bores. Analyses of gas compositions indicate that the Bulli seam is not the direct and major source of the gas and that the most likely source is the Hawkesbury Sandstone (APCRC, 1997).

Gas emissions may occur and become visible in the stored water behind the Picton Weir as a result of the proposed extraction of the longwalls. Where these gas releases occur into the water column there is insufficient time for any substantial amount of gas to dissolve into the water. The majority of the gas is released into the atmosphere and is unlikely to have an adverse impact on water quality.

A description of potential water quality impacts and environmental consequences is presented in the Water Management Plan (Tahmoor Coal, 2023a) and the Biodiversity Management Plan (Tahmoor Coal, 2023c).

3.3.5. Management of potential impacts on Hornes Creek

Tahmoor Coal has developed a Water Management Plan for LWs S1A to S6A to manage potential impacts on streams during the mining of longwalls, including Hornes Creek. The management plan includes monitoring and triggered response plans. It includes monitoring of the required pre-mining conditions and data collection during mining. Monitoring typically continues for a period following mining.

The Water Management Plan will be updated to include LW S7A (Tahmoor Coal, 2023a).

Tahmoor Coal is currently monitoring ground movements at Hornes Creek during the mining of LW S2A according to the Subsidence Monitoring Plan.

- Six GNSS units have been installed along the tops of Hornes Creek in pairs across the valley. The GNSS units have continuously monitored changes during mining since the commencement of LW S2A. While the GNSS units have measured minor horizontal movements, changes in horizontal distances between the units are less than 5 mm and within survey tolerance.

Tahmoor Coal will continue to monitor changes along Hornes Creek during the extraction of proposed Tahmoor South longwalls, in accordance with the Subsidence Monitoring Plan and Water Management Plan.

3.4. Teatree Hollow and tributaries

The locations of Teatree Hollow and its tributaries are shown in Drawing No. MSEC1348-07. The sections of Teatree Hollow and its tributaries within the Study Area are ephemeral first or second order drainage lines having shallow incisions into the natural surface soils.

The catchment area is located above LW S7A in predominantly grazing land, with stream flow captured by a number of farm dams.

3.4.1. Predictions for Teatree Hollow and tributaries

The predicted profiles of subsidence, upsidence and closure, using the IPM subsidence model and the 2002 ACARP valley closure prediction model, along the Teatree Hollow and the Tributary to Teatree Hollow are shown in Fig. A.03 and Fig. A.04, respectively.

A summary of the maximum predicted values of incremental vertical subsidence, upsidence and closure for Teatree Hollow and the Tributary to Teatree Hollow is provided in Table 3.6. A summary of the maximum predicted values of total vertical subsidence, upsidence and closure for Teatree Hollow and the Tributary to Teatree Hollow is provided in Table 3.7.

Table 3.6 Maximum predicted incremental vertical subsidence, upsidence and closure for Teatree Hollow and the Tributary to Teatree Hollow

Modified Layout	Longwall	Maximum predicted incremental vertical subsidence (mm)	Maximum predicted incremental upsidence (mm)	Maximum predicted incremental closure (mm)
Teatree Hollow	LW S7A	925	90	50
Tributary to Teatree Hollow	LW S7A	< 20	< 20	< 20

Table 3.7 Maximum predicted total vertical subsidence, upsidence and closure for Teatree Hollow and the Tributary to Teatree Hollow

Layout	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Teatree Hollow				
Approved Layout	After LW S6A	1400*	400*	275*
Modified Layout	After LW S7A	1400*	400*	275*
Tributary to Teatree Hollow				
Approved Layout	After LW S6A	1350	450	375
Modified Layout	After LW S7A	1350	450	375

* *Note: downstream sections of Teatree Hollow have been previously mined beneath by LW1 and LW2 at Tahmoor Mine. The maximum predicted parameters provided in the above table include those resulting from the extraction of these earlier longwalls.*

The proposed LW S7A is located directly beneath the upstream end of Teatree Hollow and it can be seen from Fig. A.03 that the predictions are increased at the upstream end of Teatree Hollow under the *Modified Layout* when compared to the predictions based on the *Approved Layout*.

The Tributary to Teatree Hollow is located to the east of the proposed LW S7A. It can be seen from Fig. A.04 that there is very little change between the predictions under the *Modified Layout* when compared to the predictions based on the *Approved Layout*.

It can be seen from Drawing No. MSEC1348-07 that another first order tributary to Teatree Hollow will be directly mined beneath by LW S7A. This tributary would experience increased subsidence movements under the *Modified Layout* when compared to the predictions based on the *Approved Layout.*

3.4.2. Observed subsidence movements during the mining of LWs S1A and S2A directly beneath Teatree Hollow and tributaries

LWs S1A and S2A have mined directly beneath Teatree Hollow and the Tributary to Teatree Hollow.

Tributary to Teatree Hollow

Ten GNSS units have been installed along the tops of the Tributary to Teatree Hollow in pairs across the valley, as shown in Drawing No. MSEC1348-15. The GNSS units have measured the development of subsidence and valley closure during the extraction of LWs S1A and S2A.

Observed subsidence during the extraction of LWs S1A and S2A are discussed in Section 2.3, where it can be seen that observed subsidence has been less than predicted.

Changes in horizontal distances can be calculated between GNSS units that are stationed close together and results are shown in Fig. 3.16.

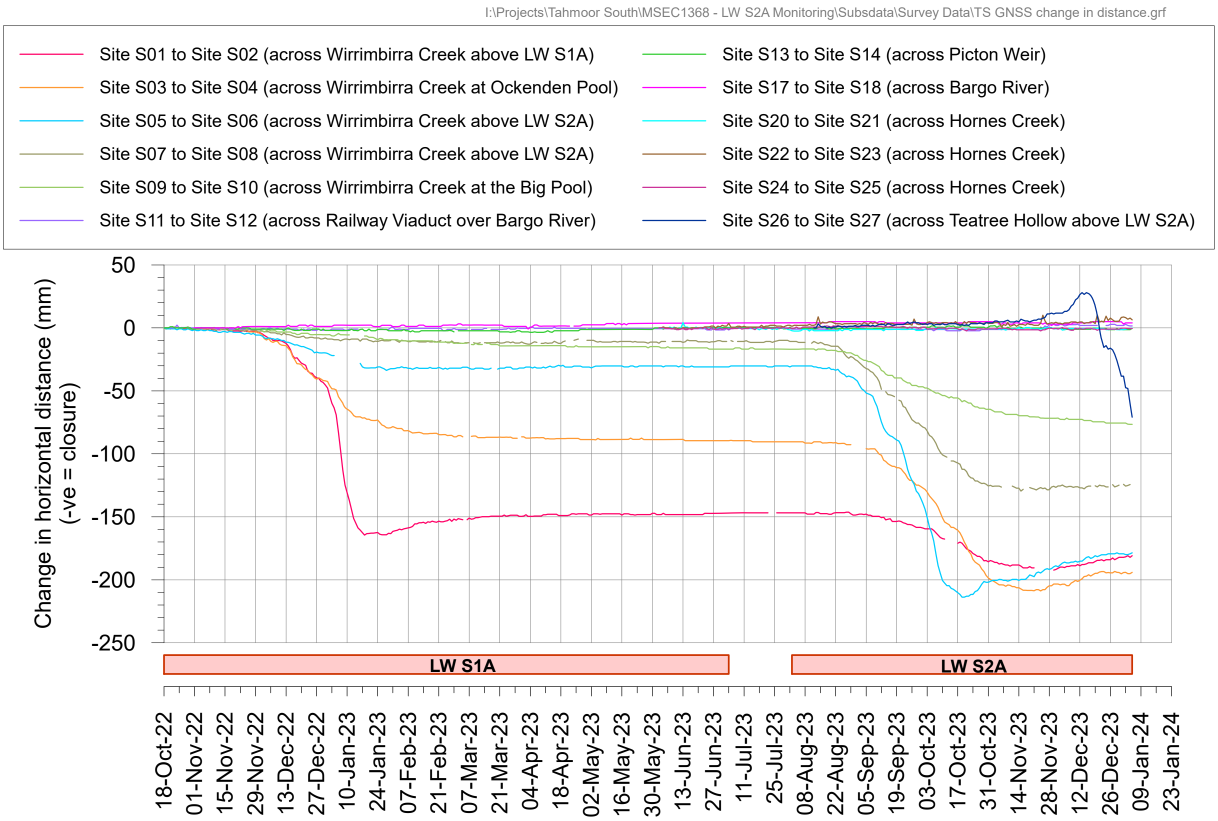


Fig. 3.16 Observed changes in horizontal distances between GNSS units across the Tributary to Teatree Hollow and Teatree Hollow

It can be seen from Fig. 3.16 that observed valley closure is less than the predicted maximum closure of 275 mm due to the extraction of LWs S1A and S2A.

In addition to the GNSS units, survey marks have been installed at four locations across valley floor of the Tributary to Teatree Hollow (Wirrimbirra Creek), as shown in Drawing No. MSEC1348-15. The observed development of valley closure at the ground survey lines across the Tributary to Teatree Hollow is shown in Fig. 3.17. The results correlate reasonably well with the observations from GNSS units, taking into account the shorter lengths of the survey lines, which are based within the floor of the creek valley, compared to the distances between the GNSS units, which are mounted at the tops of the valleys.

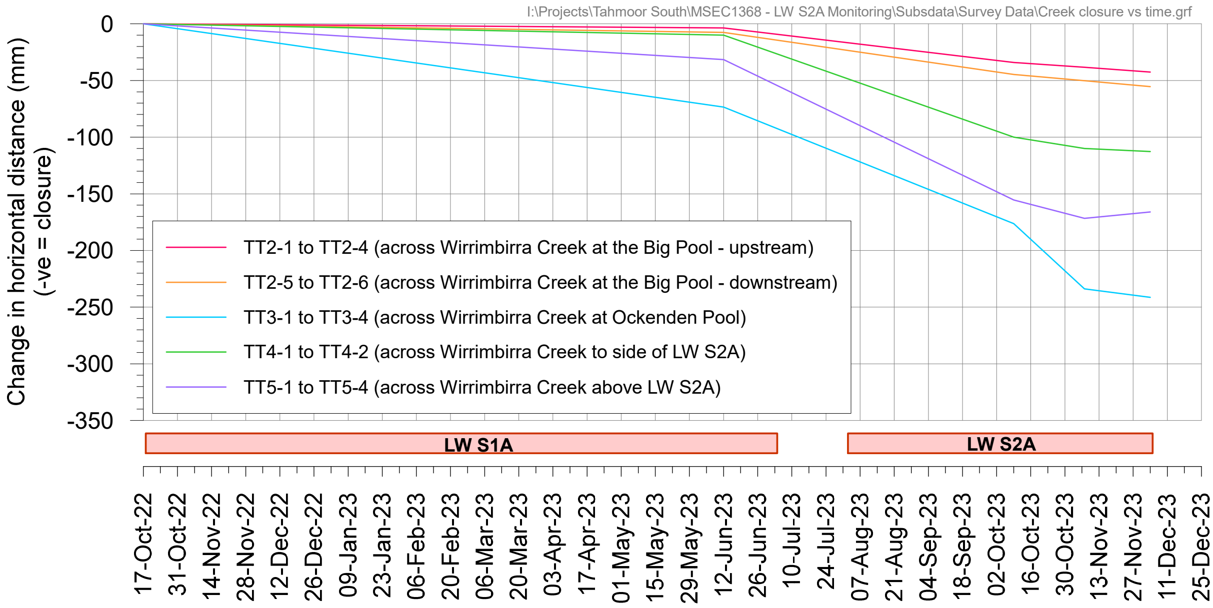


Fig. 3.17 Observed development of closure across Tributary to Teatree Hollow from ground surveys

The results from the ground surveys across lines TT2, TT3 and TT5 are shown in Fig. 3.18, Fig. 3.19 and Fig. 3.20, respectively. The survey lines are restricted to the base of the valley floor due to the remoteness of the sites and presence of thick vegetation and do not measure absolute vertical subsidence (this is measured by the GNSS units along the tops of the valley). The ground surveys measure changes in height relative to the first survey peg in the survey lines.

The results show that upsidence and closure has developed within the valley floor, concentrating either in the centre of the valley floor or to one side of the valley floor.

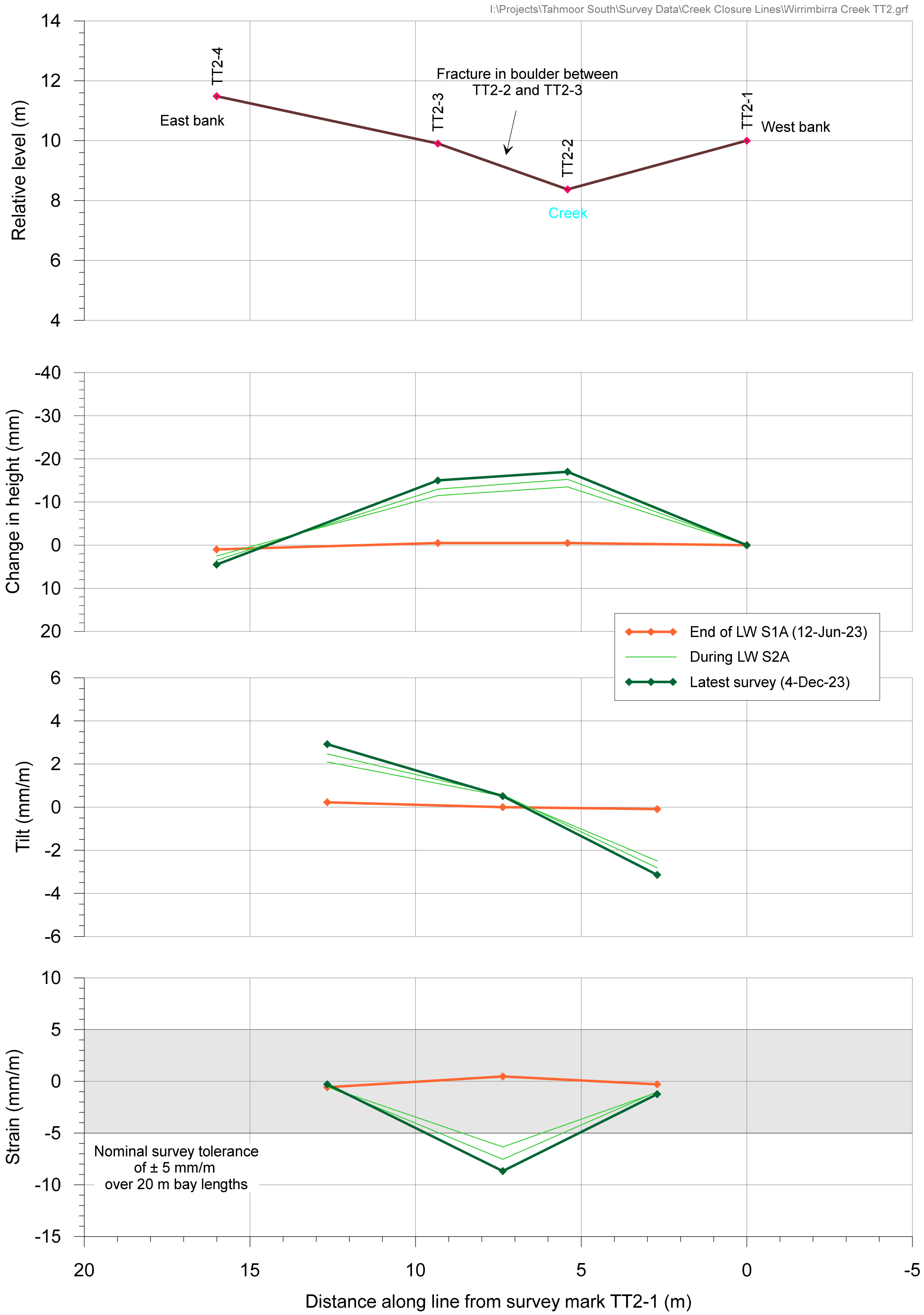


Fig. 3.18 Observed total changes in height, tilt and strain along survey line TT2 across the Tributary to Teatree Hollow during the mining of LWs S1A and S2A

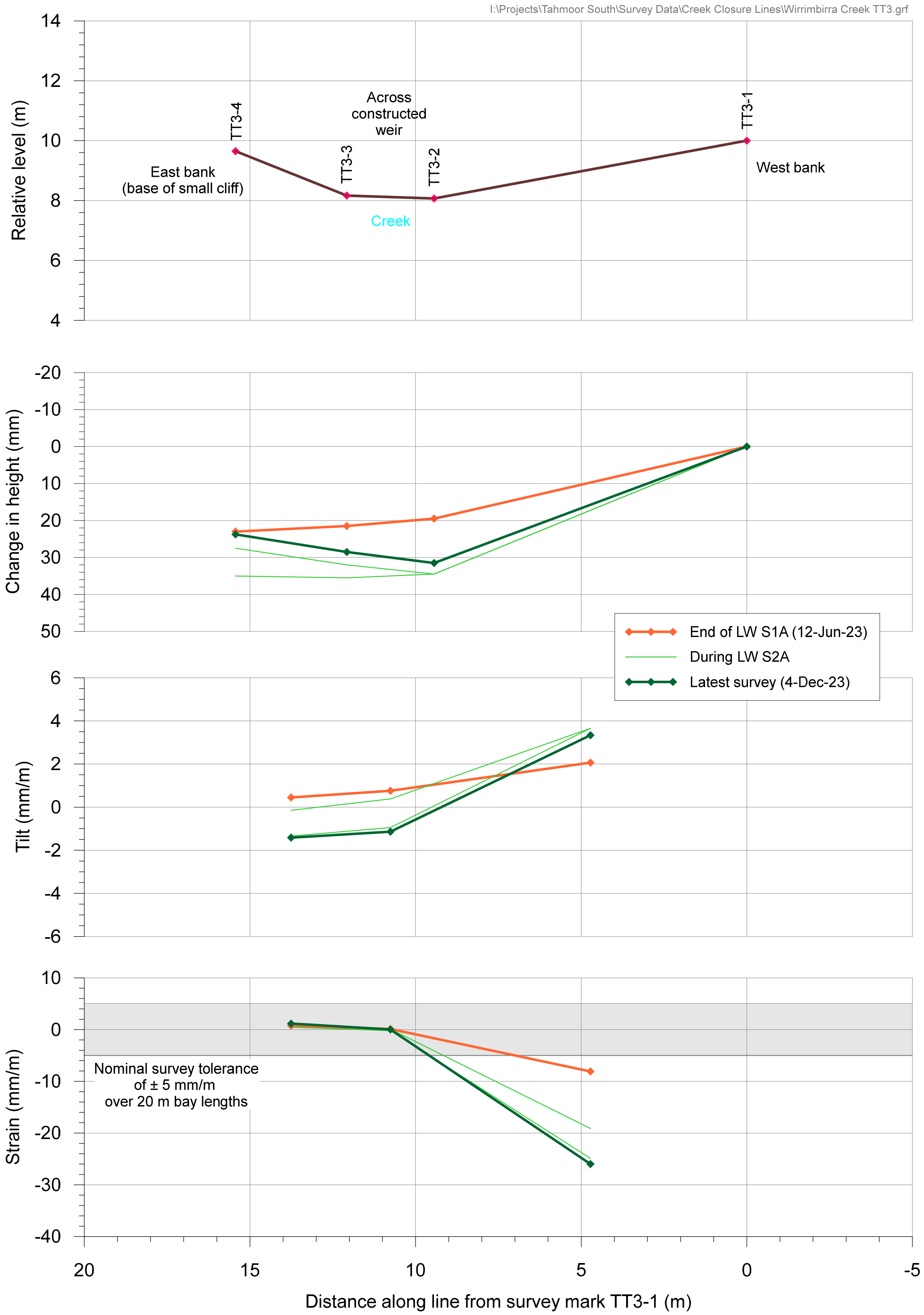


Fig. 3.19 Observed total changes in height, tilt and strain along survey line TT3 across the Tributary to Teatree Hollow during the mining of LWs S1A and S2A

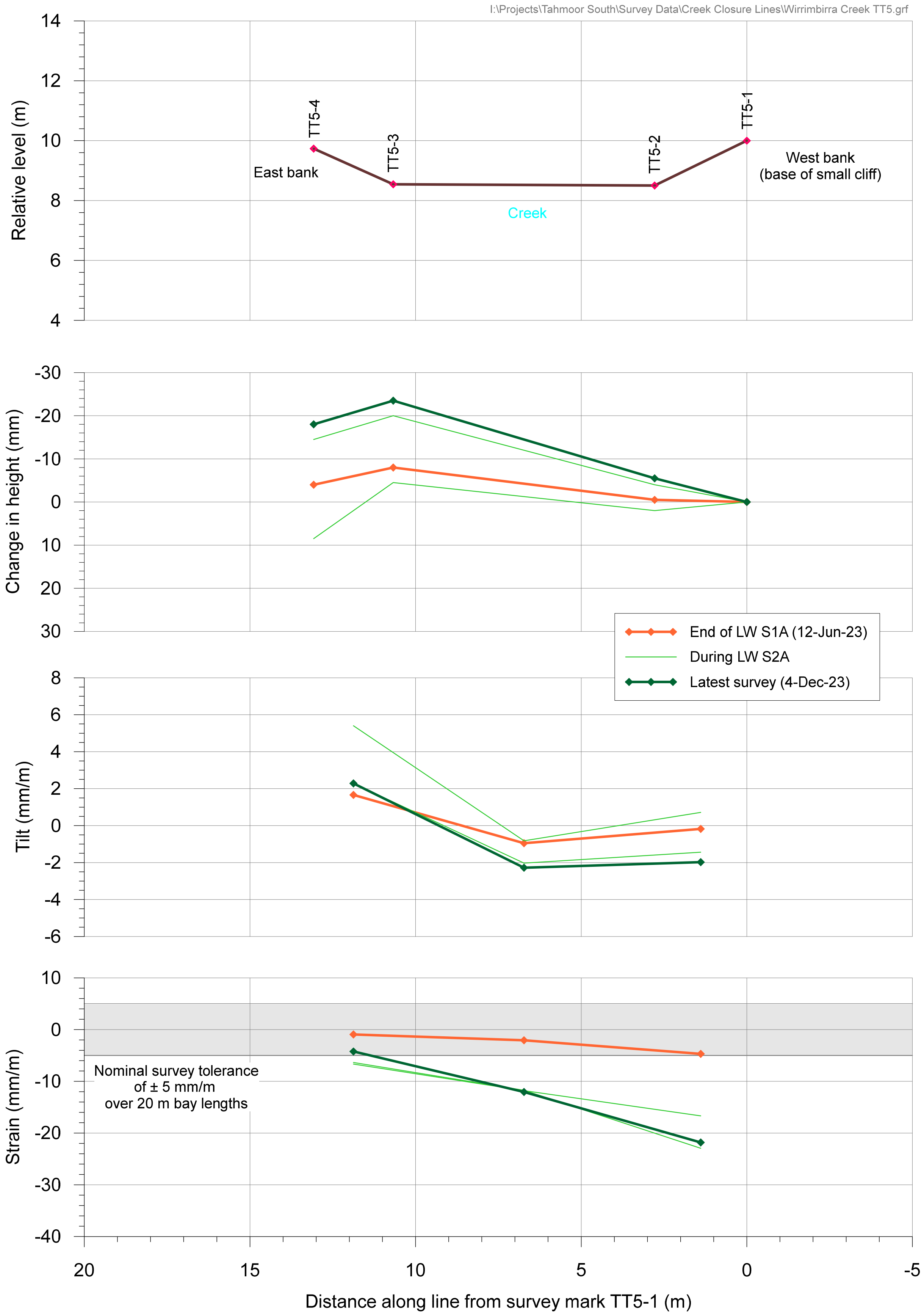


Fig. 3.20 Observed total changes in height, tilt and strain along survey line TT5 across the Tributary to Teatree Hollow during the mining of LWs S1A and S2A

3.4.3. Potential impacts on Teatree Hollow and tributaries

The impact assessments for Teatree Hollow and its tributaries within the Study Area are provided in the following sections. The assessments provided in this report should be read in conjunction with the Water Management Plan (Tahmoor Coal, 2023a) and the Biodiversity Management Plan (Tahmoor Coal, 2023c), which assess the consequences of the impacts on surface water flows and ecology.

Potential for increased levels of ponding, scouring or desiccation due to mining-induced tilt

Mining can potentially result in increased levels of ponding in locations where the mining-induced tilts oppose and are greater than the natural stream gradients that exist before mining. Mining can also potentially result in an increased likelihood of scouring of the stream beds in the locations where the mining-induced tilts considerably increase the natural stream gradients that exist before mining.

A flood study has been completed by ATC Williams on the potential changes to flood levels due to the extraction of LWs S1A to S7A (ATC, 2024). Minor increases to flood levels are predicted in areas subject to flooding under existing conditions above LW S3A at Caloola Road and LW S5A at Yaran Road. The addition of LW S7A does not materially change the results of the flood study and the results are generally consistent with the findings of the EIS.

It is further noted that the predicted 1% AEP flood levels do not extend to surface areas located directly above LW S7A prior to mining or after the extraction of LW S7A.

Potential for fracturing and surface water flow diversion in the stream

Teatree Hollow and its tributaries will be directly mined beneath by the *Approved Layout*. It was assessed that fracturing and surface flow diversions will occur in the sandstone bedrock along both streams due to the extraction of the longwalls in the *Approved Layout*. In some of these locations, the fracturing could impact the holding capacity of the standing pools, particularly those located directly above the proposed longwalls. It is unlikely, however, that there would be any net loss of water from the catchment. Mining-induced fractures and impacts on surface water flow and pool water levels have been observed during the extraction of LW S1A and LW S2A.

The addition of LW S7A does not materially change this assessment, though the extent of impacts increases further upstream to the include the headwaters of two first order sections in the catchment.

While the extent of impacts is increased, Tahmoor Coal will continue to develop and implement measures to manage the potential for impacts on Teatree Hollow and its tributaries during the extraction of LWs S1A to S7A.

Potential for Gas Emissions and Changes to Water Quality

Gas emissions from the sandstone strata have been previously observed above and adjacent to mining areas in the Southern Coalfield, and some gas emissions have also been observed in water bores. Analyses of gas compositions indicate that the Bulli seam is not the direct and major source of the gas and that the most likely source is the Hawkesbury Sandstone (APCRC, 1997).

As LW S7A is proposed to extract directly beneath the headwaters of first order tributaries, any gas emissions that occur will release into the atmosphere and is unlikely to have an adverse impact on water quality.

A description of potential water quality impacts and environmental consequences is presented in the Water Management Plan (Tahmoor Coal, 2023a) and the Biodiversity Management Plan (Tahmoor Coal, 2023c).

3.4.4. Management of potential impacts on Teatree Hollow and tributaries

Tahmoor Coal has developed a Water Management Plan for LWs S1A to S6A to manage potential impacts on streams during the mining of longwalls, including Teatree Hollow and its tributaries. The management plan includes monitoring and triggered response plans. It includes monitoring of the required pre-mining conditions and data collection during mining. Monitoring typically continues for a period following mining.

The Water Management Plan will be updated to include LW S7A (Tahmoor Coal, 2023a).

3.5. Cliffs

3.5.1. Descriptions of the cliffs

The locations of cliffs within the Study Area are shown in Drawing No. MSEC1348-07. A total of 19 cliffs are located within the 600m Study Area for Natural Features, of which 5 cliffs are located within the Study Area.

The cliffs are located within the Hawkesbury Sandstone along the Bargo River and Hornes Creek, at distances of between 275 metres and 600 metres from LW S7A. Photographs of the cliff lines are shown in Fig. 3.1, Fig. 3.9 and Fig. 3.28. There is no direct vehicle access to the cliffs within the Study Area though some cliffs can be reached on foot via walking trails. The Picton Weir is located beneath Cliff C_0800, which is located approximately 575 metres from LW S7A and setback approximately 50 metres from the dam wall (refer Fig. 3.32). A photograph of the cliff above Picton Weir is provided in Fig. 3.21.

Fig. 3.21 Cliff C_00800 above the Picton Weir

For the purposes of this report, a cliff has been defined as a continuous rockface having a maximum height greater than 10 metres, a minimum length of 20 metres and a minimum slope of 2 in 1, i.e. having a minimum angle to the horizontal of 63°. The definition is consistent with the definition provided in the Project Approval of the EIS. The locations and heights of cliffs within the Study Area were determined by Fluvial Systems based on the results of an airborne laser scan, refer to Fluvial Systems (2013).

The closest cliff (MSEC ID C_00130, DP ID BC1) is located approximately 275 metres from LW S7A. The cliff has been surveyed by aerial photogrammetry by MNC Consulting. The result of the survey is shown in Fig. 3.22.

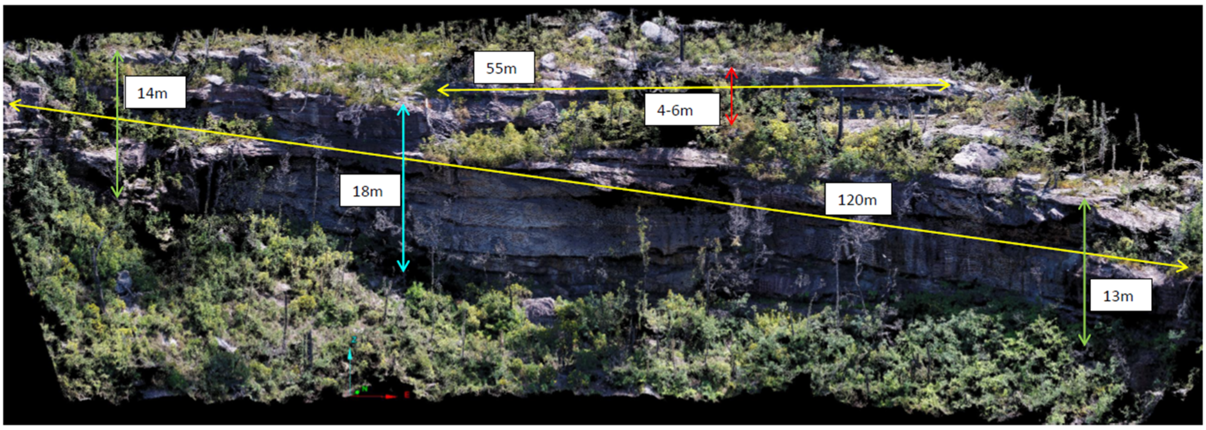


Image courtesy MNC Consulting

Fig. 3.22 Digital reconstruction of aerial photogrammetry survey of Cliff C_00130

The cliff is measured to be approximately 120 metres long with a maximum height of 18 metres, when the smaller upper section of the cliff is included in the height calculation with the main cliff. The cliff includes an overhang of approximately 4 to 5 metres in depth which is 50 metres long. The total face area has been calculated to be 2,685 m^2.

The second closest cliff (MSEC ID C_02060) is located approximately 360 metres from LW S7A. The cliff has been surveyed using aerial photogrammetry by MNC Consulting. The result of the survey is shown in Fig. 3.23.

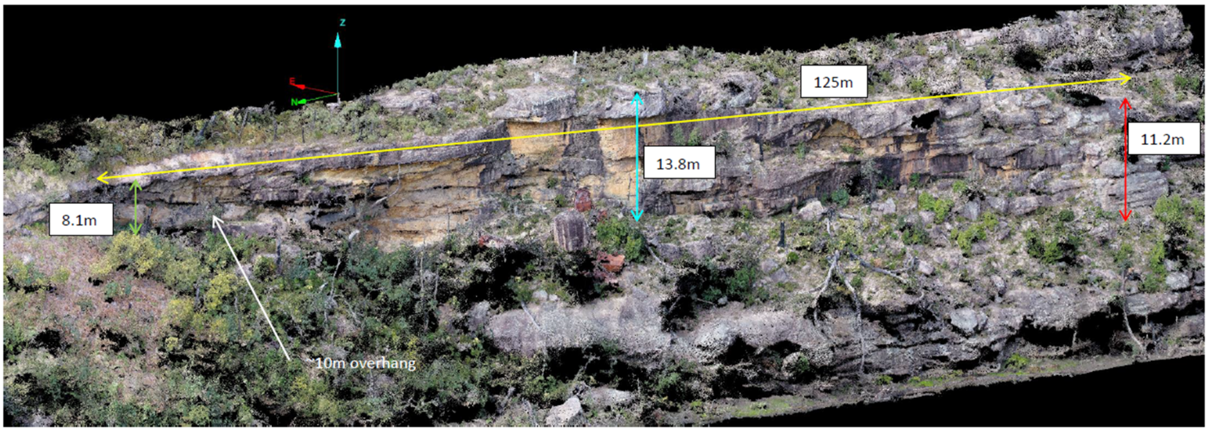


Image courtesy MNC Consulting

Fig. 3.23 Digital reconstruction of aerial photogrammetry survey of Cliff C_02060

The cliff is measured to be approximately 125 metres long with a maximum height of 14 metres. The cliff includes an overhang of approximately 10 metres at the northern end. The total face area has been calculated to be 1,583 m^2.

3.5.2. Predictions for the cliffs

A summary of the maximum predicted values of total vertical subsidence, tilt and the maximum predicted total hogging curvature and sagging curvature at the 19 identified cliffs is provided in Table 3.8. Because of the distance between the cliffs and the *Approved Layout* LWs S1A to S6A, the predicted subsidence movements due to the extraction of these longwalls are negligible, and hence the predicted total subsidence movements shown in Table 3.8 are essentially the incremental subsidence movements due to LW S7A.

Table 3.8 Maximum predicted total vertical subsidence, tilt and curvature for cliffs due to the extraction of LWs S1A to S7A

Modified Layout After LW S7A	**Maximum Predicted Total Conventional Subsidence (mm)**	**Maximum Predicted Total Conventional Tilt (mm/m)**	**Maximum Predicted Total Hogging Curvature (km^{-1})**	**Maximum Predicted Total Sagging Curvature (km^{-1})**
C_00130	60	< 0.5	< 0.01	< 0.01
C_00710	25	< 0.5	< 0.01	< 0.01
C_00800	< 20	< 0.5	< 0.01	< 0.01
C_00830	< 20	< 0.5	< 0.01	< 0.01
C_00920	< 20	< 0.5	< 0.01	< 0.01
C_01160	< 20	< 0.5	< 0.01	< 0.01
C_01280	< 20	< 0.5	< 0.01	< 0.01
C_01610	30	< 0.5	< 0.01	< 0.01
C_02020	< 20	< 0.5	< 0.01	< 0.01
C_02060	40	< 0.5	< 0.01	< 0.01
C_02170	< 20	< 0.5	< 0.01	< 0.01
C_02240	25	< 0.5	< 0.01	< 0.01
C_02670	< 20	< 0.5	< 0.01	< 0.01
C_02920	< 20	< 0.5	< 0.01	< 0.01
C_03370	< 20	< 0.5	< 0.01	< 0.01
C_05140	20	< 0.5	< 0.01	< 0.01
C_07220	30	< 0.5	< 0.01	< 0.01
C_11150	20	< 0.5	< 0.01	< 0.01
C_11590	< 20	< 0.5	< 0.01	< 0.01

3.5.3. Impact assessments for cliffs located above solid coal

The cliffs are located more than 275 metres from the proposed LW S7A and will not be directly mined beneath.

It is extremely difficult to assess the likelihood of cliff instabilities based upon predicted ground movements. The likelihood of a cliff becoming unstable is dependent on a number of factors which are difficult to fully quantify. These factors include jointing, inclusions, weaknesses within the rock mass, groundwater pressure and seepage flow behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors influence the stability of a cliff naturally or when it is exposed to mine subsidence movements. It is possible, therefore, that cliff instabilities may occur during mining that may be attributable to either natural causes, mine subsidence, or both.

The likelihood of cliff instabilities can be assessed using case studies where previous longwall mining has occurred close to but not directly beneath cliffs. Although very minor rock falls have been observed over solid coal outside the extracted goaf areas of longwall mining in the Southern Coalfield, there have been no recorded large cliff instabilities outside the extracted goaf areas of longwall mining in the Southern Coalfield. This statement is based on the following observations:-

- ***Tahmoor Longwalls 24A to 26***

  Tahmoor Longwalls 24A to 26 were mined near and adjacent to the cliff lines along the Bargo River valley between November 2007 and July 2011. The cliff lines are continuous on both sides of the valley along this section of the river. The cliffs are located at a minimum distance of 300 metres east of Longwall 24A, at their closest point to these longwalls. Whilst the overall valley depths, within one depth of cover of this gorge, were over 100 metres, the heights of the cliffs are around 60 metres and are formed within the Hawkesbury Sandstone.

  Tahmoor Longwalls 24A to 26 have void widths of 285 metres, solid chain pillar widths of 35 metres to 40 metres and were extracted from the Bulli seam at a depth of cover of 350 metres at the base of the gorge and 450 metres around the plateau areas. There were no impacts observed on the cliffs along the Bargo River Valley as a result of the extraction of Tahmoor Longwalls 24A to 26.

- ***Appin Longwalls 301 and 302 near the Cataract River***

  Appin Longwalls 301 and 302 were mined adjacent to a number of cliff lines located along the Cataract River valley between October 2006 and September 2007. A total of 68 cliffs were identified within a 35 degree angle of draw from these longwalls. These cliffs had continuous lengths ranging between 5 metres and 230 metres, overall cliff heights ranging between 10 metres and 37 metres, overall valley depths, within one depth of cover of the river, ranging from 50 to 75 metres, and had been formed within the Hawkesbury Sandstone.

  Appin Longwalls 301 and 302 have void widths of 260 metres, solid chain pillar widths of 40 metres and were extracted from the Bulli seam at a depth of cover of 420 metres at the base of the gorge and 490 metres around the plateau areas. These longwalls mined to within 50 metres of the identified locations of the cliffs along the Cataract River valley.

  There were no large cliff instabilities observed as a result of the extraction of Appin Longwalls 301 and 302. There were, however, five minor rock falls or disturbances which occurred during the mining period, of which, three were considered likely to have occurred due to a substantial rainfall event and one was probably a natural instability of the cliff overhang. Nevertheless, the length of cliff line disturbed as a result of the extraction of Appin Longwalls 301 and 302 was, therefore, estimated to be less than 0.5 % of the total face area of the cliff lines within the mining domain.

- ***Tower Longwalls 18 to 20 and Appin Longwalls 701 to 704 near the Nepean River***

  Tower Longwalls 18 to 20 and Appin Longwalls 701 to 704 mined adjacent to a number of cliff lines located along the Nepean River valley. A total of approximately 50 cliffs were identified within a 35 degree angle of draw from these longwalls. The cliffs had continuous lengths ranging between 5 metres and 225 metres, overall heights ranging between 10 metres and 40 metres, overall valley depths, within one depth of cover of the river, ranging from 60 to 80 metres and had been formed within the Hawkesbury Sandstone.

  Tower Longwalls 18 to 20 have void widths of 235 metres, solid chain pillar widths of 40 metres and were extracted from the Bulli seam at a depth of cover of 460 metres at the base of the gorge and 510 metres around the plateau areas. Appin Longwalls 701 to 704 have void widths of 320 metres, solid chain pillar widths of 40 metres and were extracted from the Bulli seam at a depth of cover of 460 metres at the base of the gorge and 510 metres around the plateau areas.

  Tower Longwall 20 was mined directly beneath some cliffs located at the confluence of Elladale Creek and the Nepean River. Appin Longwalls 701 to 704 mined to within 75 metres of the identified locations of the cliffs along the Nepean River valley.

  There were no cliff instabilities observed as a result of the extraction of Tower Longwalls 18 to 20 and Appin Longwalls 701 to 704.

Based on this previous experience of mining at Tahmoor, Appin and Tower Collieries, it is unlikely that cliffs beyond the extent of the longwall panels will experience large instabilities. It is possible that isolated rock falls could occur during the mining period due to natural weathering processes. Any impacts are expected to represent less than 0.5 % of the total face area of the cliffs.

The cliffs are located in area that is very difficult to access publicly. In the very unlikely event that an isolated rock fall occurs, the likelihood of a rock fall affecting public safety is assessed to be extremely low.

3.5.4. Impact assessments for the cliffs based on increased predictions

If the actual mine subsidence movements exceeded those predicted values by a factor of 2 times, the likelihood of impacts for the cliffs that are located well outside the proposed LW S7A would still be expected to be very low.

While the predicted ground movements are important parameters when assessing the potential impacts on the cliffs, it is noted that the impact assessments for cliff instabilities have primarily been based on historical observations from previous longwall mining in the Southern Coalfield.

3.5.5. Management of potential impacts on cliffs

Tahmoor Coal has developed a Land Management Plan for managing potential impacts on cliffs during the mining of LWs S1A to S6A. The management plan includes:

- Identification of all structures, dams and roads that are in close proximity to cliffs;
- Site investigation of cliffs by a qualified geotechnical engineer;
- Baseline mapping of cliffs to measure face area;
- Monitoring, including ground survey and visual inspections; and
- Erection of warning signs and consultation with landowners if impacts are observed.

It is recommended that Tahmoor Coal continue to develop management plans to manage potential impacts on cliffs during the mining of the proposed LW S7A. The Land Management Plan will be extended to include management of potential impacts due to the extraction of LW S7A.

3.6. Steep Slopes

The locations of the steep slopes are shown in Drawing No. MSEC1348-07.

The purpose of identifying steep slopes for this assessment is to highlight areas in which existing ground slopes may be marginally stable. As a conservative first pass, a steep slope has been defined as an area of land having a gradient greater than 1 in 3 (33 % or 18.3°). The definition is consistent with the definition provided in the Project Approval of the EIS layout. The minimum slope of 1 to 3 represents a slope that would generally be considered stable for slopes consisting of rocky soils or loose rock fragments. Clearly the stability of natural slopes varies depending on their soil or rock types, and in many cases, natural slopes are stable at much higher gradients than 1 to 3 (for example, talus slopes in Hawkesbury Sandstone).

The steep slopes were identified by Fluvial Systems from an airborne laser scan supplied by Tahmoor Coal. The steep slopes within the Study Area can be broadly categorised as:

a) Steep slopes on the sides of valleys;
b) Batters of road and railway embankments and cuttings;
c) Slopes on farm dams.

Types (b) and (c) are addressed later in this report.

The steep slopes on the sides of valleys are predominantly found in Hawkesbury Sandstone and consist of a mixture of cliffs and rock outcrops, which are stable at vertical to overhanging, and screed slopes with rocky soils and loose rock fragments. The majority of slopes are stabilised, to some extent, by natural vegetation.

The ranges of predicted subsidence parameters for the steep slopes are similar to those predicted along the streams, which are provided in Section 3.2.2.

There has been extensive experience of mining beneath steep slopes in the Southern Coalfield. These include steep slopes along the Cataract, Nepean, Bargo and Georges Rivers and streams such as Myrtle Creek and Redbank Creek above Tahmoor Mine Longwalls 22 to 32, slopes on Redback Range above Tahmoor Mine Longwalls 26 and 27 and slopes along ridges and valleys above Tahmoor LWs W1-W4. No large-scale slope failures have been observed along these slopes, even where longwalls have been mined directly beneath them. Surface cracking and minor rock falls along clifflines or rock outcrops have been observed, for example, during the mining of Appin Longwalls 301 and 302 adjacent to the Cataract River, however, no large-scale slope failures have been observed.

Potential impacts on steep slopes would generally result from the movement of soils, causing tension cracks to appear at the tops of the slopes and compression ridges to form at the bottoms of the slopes. These movements are consistent with observations of upsidence and closure of creek valleys where compression is developed at the bottoms of the valleys and tension is developed at the tops of the valleys. If tension cracks were left untreated it is possible that soil erosion could occur.

It is possible, therefore, that some remediation might be required to ensure that mining-induced surface cracking does not result in the formation of soil erosion channels. In some cases, erosion protection measures may be needed, such as the planting of additional vegetation in order to stabilise the slopes in the longer term.

While in most cases impacts to slopes are likely to consist of surface cracking, there remains a low probability of large-scale slope slippage. The probability is assessed to be very low for slopes that will not be directly mined beneath by the longwalls. Experience indicates that the probability of mining induced large-scale slippages is extremely low due to the substantial depths of cover within the Study Area. While the risk is extremely low, some risk remains and attention must therefore be paid to any structures or roads that may be located in the vicinity of steep slopes.

There are no structures or roads located along natural steep slopes within the Study Area.

3.6.1. Management of potential impacts on steep slopes

Tahmoor Coal has developed a Land Management Plan for managing potential impacts on steep slopes during the mining of LWs S1A to S6A. The management plan includes:

- Identification of all structures, dams and roads that are in close proximity to steep slopes;
- Site investigation and landslide risk assessment of structures near slopes by a qualified geotechnical engineer;
- Site investigation and structural assessment of structures where recommended by the geotechnical engineer. This may include recommendations to mitigate against potential impacts;
- Monitoring, including ground survey and visual inspections; and
- Remediation if cracking or slippage occurs.

It is recommended that Tahmoor Coal continue to develop management plans to manage potential impacts on slopes during the mining of the proposed LW S7A. The Land Management Plan will be extended to include management of potential impacts due to the extraction of LW S7A.

3.7. Main Southern Railway

The location of the Main Southern Railway is shown in Drawing No. MSEC1348-08. It can be seen that a section of the Main Southern Railway and associated infrastructure are located within the Study Area, however the proposed LW S7A is not located directly beneath the Main Southern Railway. The closest distance between the Railway and the proposed LW S7A is approximately 400 metres.

3.7.1. Description of the Main Southern Railway

The Main Southern Railway is a key national transport route that carries substantial freight and passenger services between Sydney and Melbourne. The Main Southern Railway is leased by Australian Rail Track Corporation (ARTC), who is responsible for maintaining the track.

Approximately 500 metres of track is located within the Study Area between kilometrages 100.1 km and 100.6 km.

The railway line is a dual track consisting of 60 kg rail on concrete sleepers with a mix of straight and curved track sections within the Study Area. The maximum speed limits on both tracks are 95 km/h for normal services and 105 km/h for XPT services. A photograph of a section of the railway at 99.400 km directly above proposed LW S4A is provided in Fig. 3.24.

Photograph courtesy Newcastle Geotech

Fig. 3.24 Main Southern Railway at 100.121 km

Two railway culverts are located within the Study Area at 100.121 km and 100.425 km, as shown in Drawing No. MSEC1348-08. A summary is provided in Table 3.9.

Table 3.9 Rail culverts potentially affected by LW S1A-S6A

Kilometrage (km)	Diameter (mm)	Description	Location relative to Proposed Longwalls
100.121 km	1500 dia	Skewed brick arch culvert with 1500 mm dia concrete extension on both sides. Separation observed between brick arch culvert and concrete extension on Down side.	Above LW S4A
100.425 km	1500 dia	Skewed brick arch culvert with brick wingwalls on both sides (no concrete extensions)	Above LW S5A

Based on boreholes drilled by Newcastle Geotech, the culverts appear to be either founded on natural soils or on the rock surface with no evidence of the culverts being constructed against rock. The culverts are located within rail embankments that are up to 6 metres in height.

A small cutting is located at 100.310 km, which up to 2 metres high in competent sandstone rock. Wellers Road Overbridge is located approximately 540 metres from LW S7A.

Photograph courtesy Robinson Rail

Fig. 3.25 Culvert with concrete extension on Up side at 100.121 km

Photograph courtesy Robinson Rail

Fig. 3.26 Culvert with concrete extension on Up side at 100.425 km

3.7.2. Predictions for the Main Southern Railway

The predicted profiles of total subsidence, tilt and change in track grade along the alignment of the Main Southern Railway are shown in Fig. A.05, which is included in Appendix A. Predicted profiles of cross tilt, change in track cant and long twist along the railway are shown in Fig. A.06 while predicted profiles of horizontal movement along the track, changes in 100 m long bays and change in Rail SFT are shown in Fig. A.07.

A summary of the maximum predicted incremental subsidence parameters due to the extraction of LW S7A is provided in Table 3.10.

Table 3.10 Maximum predicted incremental subsidence parameters along the alignment of the Main Southern Railway due to the extraction of LW S7A

Modified Layout	Maximum predicted incremental subsidence (mm)	Maximum predicted change in Grade (%)	Maximum predicted incremental hogging curvature along alignment (km^{-1})	Maximum predicted incremental sagging curvature along alignment (km^{-1})
LW S7A	40	< 0.05	< 0.01	< 0.01

A summary of the maximum predicted total subsidence parameters after the extraction of LW S7A is provided in Table 3.11.

Table 3.11 Maximum predicted total conventional subsidence parameters along the alignment of the Main Southern Railway due to the extraction of LWs S1A to S7A

Layout	Maximum predicted total subsidence (mm)	Maximum predicted change in Grade (%)	Maximum predicted total hogging curvature along alignment (km^{-1})	Maximum predicted total sagging curvature along alignment (km^{-1})
Approved Layout After LW S6A	1350	0.85	0.10	0.20
Modified Layout After LW S7A	1400	0.85	0.10	0.20

It can be seen from Fig. A.05, A.06 and A.07 and the preceding two tables that predicted subsidence movements along the Railway for the *Modified Layout* are similar or only slightly higher than the corresponding predicted conventional subsidence movements for the *Approved Layout*. The locations of the predicted maxima for subsidence, tilt along the Railway and curvature remain the same.

3.7.3. Impact assessments for the Main Southern Railway

The Railway will be directly mined beneath by the *Approved Layout*. There is extensive experience of mining directly beneath railways in the Southern Coalfield which demonstrates that impacts can be managed with the implementation of suitable management strategies.

The Railway is located approximately 400 metres from the proposed LW S7A at its closest point. The Railway is predicted to experience minor additional subsidence movements due to the proposed extraction of LW S7A.

The addition of LW S7A under the *Modified Layout* does not materially change the impact assessment, though the potential for impacts increases slightly within the Study Area.

Track geometry

The predicted differential subsidence movements are expected to result in negligible changes to track geometry, as they are an order of magnitude less than the maximum allowable deviations specified in Australian Rail Track Corporation's National Code of Practice. Non-conventional subsidence movements could result in impacts on track geometry, however, and potential impacts can be managed with the implementation of an effective subsidence management plan, which is discussed later in this report.

Track grades

The predicted changes in track gradient along the Main Southern Railway due to the extraction of LW S7A are an order of magnitude less than the existing gradients, as shown in Fig. A.05.

While non-conventional movements could result in localised changes in track grades, it should be noted, however, that they occur over short lengths, which is of less concern as freight trains are many hundreds of metres long. It is expected, however, that track resurfacing would be required to reduce the magnitude of the mining-induced undulations in the track.

Rail stress

The predicted mining-induced ground strains are predicted to result in changes in rail stress less than 10 degrees, which is not expected to be sufficient to warrant immediate preventative action on a track with concrete sleepers.

Non-conventional subsidence movements could result in impacts on rail stress, however, and potential impacts can be managed with the implementation of an effective subsidence management plan, which is discussed later in this report.

Wellers Road Overbridge

The Wellers Road Overbridge is located at Bargo at 101.162 km outside the Study Area. The Overbridge is 370 metres from the commencing end of LW S6A and 540 metres from LW S7A.

The bridge is predicted to experience less than 20 mm of conventional subsidence, with negligible tilt, curvature and strain due to the extraction of LWs S1A to S7A.

The bridge is expected to experience far field horizontal movements, as discussed in Report No. MSEC1192 for LWs S1A to S6A. With the implementation of an effective subsidence management plan, the development of ground movements and impacts can be detected early with time to implement intervention measures before the bridge becomes unserviceable.

Railway Culverts and Embankments

The culverts at 100.121 km and 100.425 km are predicted to experience less than 40 mm additional subsidence and 20 mm additional valley closure due to the extraction of proposed LW S7A.

Potential impacts from the additional subsidence and valley closure on the culverts and embankments can be managed with the implementation of an effective subsidence management plan, which is discussed later in this report.

Railway Cuttings

The cutting at 100.310 km is predicted to experience 40 mm of additional subsidence due to the extraction of proposed LW S7A.

Tahmoor Mine has successfully mined directly beneath railway cuttings during the extraction of Longwalls 25 to 32, with only minor impacts observed on cuttings. It is extremely unlikely that the cutting will experience adverse impacts due to the extraction of LW S7A.

Signalling and communications systems

The potential for impacts on cabling and wiring along the track is considered to be very low. Mine subsidence impacts on electrical and telecommunications cabling is historically very low in the Southern Coalfield. It is extremely unlikely that the signalling and communications will experience adverse impacts due to the extraction of LW S7A.

3.7.4. Management of potential impacts on the Main Southern Railway

Tahmoor Coal and the Australian Rail Track Corporation (ARTC) have developed a detailed risk management plan for managing potential mine subsidence impacts on the Main Southern Railway due to the extraction of LWs S1A to S6A. The Railway Management Plan will be updated to include LW S7A (Tahmoor Coal, 2023a).

The management measures described in this plan are similar to those that have been developed in consultation with ARTC and successfully implemented at Tahmoor Mine and Appin Colliery, as described in a paper by Pidgeon, et al. (2011).

A Rail Management Group has been coordinated to develop the risk management strategies. The Rail Management Group includes representatives from ARTC, Tahmoor Coal and specialist consultants in the fields of railway track engineering, geotechnical engineering, structural engineering, track signalling, mine subsidence, risk assessment and project management. The Technical Committee consults with the Resources Regulator and the Office of the National Rail Safety Regulator.

Works by the Rail Management Group include:-

- Identification of potential impacts on the railway;
- Undertaking a risk management approach, where identified risks are assessed and risk control measures are implemented; and
- Development of management measures that include mitigation and preventive works, monitoring plans, triggered response plans and communication plans; and
- Supervision and oversight of railway track and infrastructure mitigation, monitoring and maintenance of affected rail track and infrastructure.

With an appropriate management plan in place, it is considered that the Main Southern Railway will remain safe and serviceable at all times during and after the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.8. Roads

The locations of the local roads are shown in Drawing No. MSEC1348-09 in Appendix B, where there are sections of four roads located within the Study Area. The entire length of Yarran Road and sections of Caloola Road, Remembrance Drive, and Wellers Road at Elvy Street are all located within the Study Area. These local roads are maintained by Wollondilly Shire Council.

There are three road drainage culverts located within the Study Area, one under Caloola Road and two under Remembrance Drive in the vicinity of Yarran Road, although none of these are located directly over LW S7A. The culverts are reinforced concrete pipes (RCP).

Remembrance Drive is supported by two road embankments located within the Study Area, one north of Yarran Road (identified as RE3) and one south of Yarran Road (RE2). Both of these are located directly over LW S5A and will not be mined beneath during extraction of LW S7A.

Remembrance Drive passes through a rock cutting between Caloola Road and Yarran Road, which is located within the Study Area directly above LW S4A and not directly over LW S7A.

3.8.1. Predictions for the roads

Yarran Road

Yarran Road is a sealed no-through road that connects to Remembrance Drive from the west. It is located directly above LW S7A and also crosses LWs S5A and S6A, and therefore could experience the full range of predicted subsidence movements due to the extraction of LW S7A. The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Yarran Road, resulting from the extraction of the proposed longwalls, is shown in Fig. A.08, which is included in Appendix A.

A summary of the maximum predicted incremental conventional subsidence parameters for Yarran Road, due to the extraction of S7A, is provided in Table 3.12.

Table 3.12 Maximum predicted incremental conventional subsidence parameters for Yarran Road due to the extraction of LW S7A

Longwall	Maximum predicted incremental subsidence (mm)	Maximum predicted incremental tilt along alignment (mm/m)	Maximum predicted incremental tilt across alignment (mm/m)	Maximum predicted incremental hogging curvature in any direction (km^{-1})	Maximum predicted incremental sagging curvature in any direction (km^{-1})
<u>Modified Layout</u>					
LW S7A	950	3.5	7.0	0.04	0.05

A summary of the maximum predicted total conventional subsidence parameters for Yarran Road, after the extraction of each longwall, is provided in Table 3.13.

The predicted tilts are the maxima along and across the alignment of the road after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Table 3.13 Maximum predicted total conventional subsidence parameters for Yarran Road due to the extraction of LWs S1A to S7A

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt along alignment (mm/m)	Maximum predicted total tilt across alignment (mm/m)	Maximum predicted total hogging curvature in any direction (km^{-1})	Maximum predicted total sagging curvature in any direction (km^{-1})
Approved Layout					
LW S1A	< 20	< 0.5	< 0.5	< 0.01	< 0.01
LW S2A	< 20	< 0.5	< 0.5	< 0.01	< 0.01
LW S3A	20	< 0.5	< 0.5	< 0.01	< 0.01
LW S4A	100	< 0.5	< 0.5	< 0.01	< 0.01
LW S5A	1050	8.0	2.0	0.09	0.20
LW S6A	1300	7.0	4.0	0.09	0.20
Modified Layout					
After LW S7A	1350	6.5	7.5	0.10	0.20

It can be seen from Fig. A.08 and the preceding two tables that predicted subsidence, tilt along Yarran Road and curvatures for the *Modified Layout* are similar or only slightly higher than the corresponding predicted conventional subsidence movements for the *Approved Layout*. The locations of the predicted maxima for subsidence, tilt and curvature along Yarran Road remain the same.

Caloola Road

Caloola Road is a sealed no-through road that connects to Remembrance Drive from the west, via entry and exit ramps along the base of an embankment at Remembrance Drive.

Caloola Road is not located directly above LW S7A but crosses LWs S3A to S5A at the northern end of the Study Area. Caloola Road therefore would be expected to experience only small additional subsidence movements due to extraction of LW S7A. The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Caloola Road, resulting from the extraction of the proposed longwalls, is shown in Fig. A.09, which is included in Appendix A.

A summary of the maximum predicted incremental conventional subsidence parameters for Caloola Road, due to the extraction of S7A, is provided in Table 3.14.

Table 3.14 Maximum predicted incremental conventional subsidence parameters for Caloola Road due to the extraction of LW S7A

Longwall	Maximum predicted incremental subsidence (mm)	Maximum predicted incremental tilt along alignment (mm/m)	Maximum predicted incremental tilt across alignment (mm/m)	Maximum predicted incremental hogging curvature in any direction (km^{-1})	Maximum predicted incremental sagging curvature in any direction (km^{-1})
Modified Layout					
LW S7A	60	< 0.5	< 0.5	< 0.01	< 0.01

A summary of the maximum predicted total conventional subsidence parameters for Caloola Road, after the extraction of each longwall, is provided in Table 3.15.

The predicted tilts are the maxima along and across the alignment of the road after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Table 3.15 Maximum predicted total conventional subsidence parameters for Caloola Road due to the extraction of LWs S1A to S7A

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt along alignment (mm/m)	Maximum predicted total tilt across alignment (mm/m)	Maximum predicted total hogging curvature in any direction (km^{-1})	Maximum predicted total sagging curvature in any direction (km^{-1})
Approved Layout					
LW S1A	20	< 0.5	< 0.5	< 0.01	< 0.01
LW S2A	80	< 0.5	< 0.5	< 0.01	< 0.01
LW S3A	875	5.5	6.0	0.09	0.09
LW S4A	1150	5.0	6.5	0.11	0.20
LW S5A	1300	6.0	5.5	0.11	0.20
LW S6A	1350	6.5	6.0	0.12	0.20
Modified Layout					
After LW S7A	1400	6.5	6.5	0.12	0.20

The predicted conventional subsidence movements along Caloola Road for the *Modified Layout* are similar or only slightly higher than the corresponding predicted conventional subsidence movements for the *Approved Layout*. The locations of the predicted maxima for the conventional subsidence movements, tilt and curvature remain the same.

Remembrance Drive

Remembrance Drive is the main road linking the M31 Hume Motorway with the townships of Bargo and Tahmoor and traverses generally flat terrain along the western side of the Main Southern Railway. It crosses LWs S1A to S5A but does not cross directly above LW S7A. Remembrance Drive therefore would be expected to experience only small additional subsidence movements due to LW S7A following extraction of LWs S1A to S6A. The predicted profiles of conventional subsidence and tilt along the alignment of Remembrance Drive, resulting from the extraction of the proposed longwalls, are shown in Fig. A.10, which is included in Appendix A.

A summary of the maximum predicted incremental conventional subsidence parameters for Remembrance Drive, due to the extraction of S7A, is provided in Table 3.16.

Table 3.16 Maximum predicted incremental conventional subsidence parameters for Remembrance Drive due to the extraction of LW S7A

Longwall	Maximum predicted incremental subsidence (mm)	Maximum predicted incremental tilt along alignment (mm/m)	Maximum predicted incremental tilt across alignment (mm/m)	Maximum predicted incremental hogging curvature in any direction (km^{-1})	Maximum predicted incremental sagging curvature in any direction (km^{-1})
Modified Layout					
LW S7A	60	< 0.5	< 0.5	< 0.01	< 0.01

A summary of the maximum predicted total conventional subsidence parameters for Remembrance Drive, after the extraction of each longwall, is provided in Table 3.17.

The predicted tilts are the maxima along the alignment of the road after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Table 3.17 Maximum predicted total conventional subsidence parameters for Remembrance Drive due to the extraction of LWs S1A to S7A

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt along alignment (mm/m)	Maximum predicted total tilt across alignment (mm/m)	Maximum predicted total hogging curvature in any direction (km^{-1})	Maximum predicted total sagging curvature in any direction (km^{-1})
<u>Approved Layout</u>					
LW S1A	200	1.5	4.0	0.06	0.03
LW S2A	975	5.0	5.5	0.08	0.20
LW S3A	1150	7.0	4.5	0.10	0.20
LW S4A	1300	6.0	5.5	0.12	0.20
LW S5A	1350	5.5	6.0	0.13	0.20
LW S6A	1350	6.5	5.5	0.13	0.25
<u>Modified Layout</u>					
After LW S7A	1400	7.0	5.0	0.13	0.25

It can be seen that the predicted conventional subsidence movements for Remembrance Drive for the *Modified Layout* are similar or only slightly higher than the corresponding predicted conventional subsidence movements for the *Approved Layout*. The locations of the predicted maxima for subsidence, tilt and curvature along Remembrance Drive remain the same.

Wellers Road

Wellers Road is predicted to experience maximum total vertical subsidence of 20 mm of due to the extraction of LWs S1A to S7A, with tilts less than 0.5 mm/m and hogging and sagging curvature less than 0.01 km^{-1}.

3.8.2. Impact assessments for the roads

The local roads will be directly mined beneath by the *Approved Layout*. There is extensive experience of mining directly beneath local roads in the Southern Coalfield which demonstrates that impacts can be managed with the implementation of suitable management strategies. In all cases the local roads have remained in safe and serviceable condition and have been remediated using normal road maintenance techniques.

Longwalls 22 to 32 and LW W1-W3 at Tahmoor Mine have mined directly beneath 28 kilometres of local roads and a total of 54 impact sites have been observed. The observed rate of impact on the local roads equates to an average of one impact for every 520 metres of pavement. In most cases, the impacts were relatively minor and were remediated by locally resurfacing the pavements.

The most severe impacts were located where substantial non-conventional movements had developed. These impact sites were identified using visual and ground monitoring and remediation was undertaken during active subsidence to maintain these roads in safe and serviceable conditions.

The addition of LW S7A under the *Modified Layout* does not materially change this assessment, though the extent of impacts increases further west along Yarran Road.

While the extent of impacts is increased, Tahmoor Coal will continue to develop and implement measures to manage the potential for impacts on local roads during the extraction of LWs S1A to S7A.

3.8.3. Management of potential impacts on the roads

Tahmoor Coal and Wollondilly Shire Council have implemented extensive measures to manage potential impacts on local roads and the associated structures due to the extraction of LWs S1A to S6A, in accordance with a Subsidence Management Plan. This plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that the local roads will remain safe and serviceable at all times during and after the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.9. Services Infrastructure

The locations of electrical services and telecommunications infrastructure, gas, potable water and sewer pipelines is shown in Drawing No. MSEC1348-09. It can be seen that there are elements of each of these all located within the Study Area, as described in the following sections.

3.9.1. Electrical services infrastructure

Electrical infrastructure located within the Study Area comprises 11 kV and low voltage powerlines which are located across the area, generally following the alignment of Yarran Road, Caloola Road and Remembrance Drive, or the Main Southern Railway. There are no transmission lines or higher voltage powerlines located within the Study Area.

The power lines generally comprise aerial copper cables supported on timber poles, but there are also some sections of direct buried cables. The power lines are owned and operated by Endeavour Energy.

Because there are powerlines located directly above LW S7A, these therefore could experience the full range of predicted subsidence movements due to extraction of the longwalls under the *Modified Layout*.

The predicted profiles of conventional subsidence, tilt and curvature along the powerlines following the alignment of local roads are as predicted for these roads themselves (see Section 3.8). The profiles are shown in Figs. A.08 to A.10 in Appendix A, while maximum predicted incremental subsidence movements due to LW S7A are summarised in Table 3.12 for Yarran Road, Table 3.14 for Caloola Road and Table 3.16 for Remembrance Drive. Maximum predicted total conventional subsidence movements after extraction of LW S7A are summarised in Table 3.13 for Yarran Road, Table 3.15 for Caloola Road and Table 3.17 for Remembrance Drive.

As discussed in relation to the local roads, any additional subsidence movements due to extraction of LW S7A under the *Modified Layout* are slight when compared to the *Approved Layout*, and the locations of the predicted maxima do not change along these powerline alignments.

The electrical infrastructure will be directly mined beneath by the *Approved Layout*. There is extensive experience of mining directly beneath electrical infrastructure in the Southern Coalfield which demonstrates that impacts can be managed with the implementation of suitable management strategies. In all cases the electrical infrastructure have remained in safe and serviceable condition and have been remediated using normal maintenance techniques.

The addition of LW S7A under the *Modified Layout* does not materially change this assessment, though the extent of impacts increases further west along Yarran Road.

Tahmoor Coal and Endeavour Energy have implemented extensive measures to manage potential impacts on electrical infrastructure due to the extraction of LWs S1A to S6A under the *Approved Layout*, in accordance with a Subsidence Management Plan. This plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that the electrical infrastructure will remain safe and serviceable at all times during and after the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.9.2. Telecommunications infrastructure

Telecommunications infrastructure within the Study Area comprises optical fibre cables and copper cables which are owned by Telstra, the National Broadband Network (NBN) and TPG. The optical fibre cables are direct buried or buried in conduit. There is an NBN telecommunications tower and adjacent shed located at No. 3166 Remembrance Drive, with access from Yarran Road. The tower and shed are located directly above LW S6A, as shown in Drawing No. MSEC1348-09.

- The **Telstra** optical fibre cable follows the alignment of the Main Southern Railway and crosses directly above the proposed LWs S1A to S5A but does not cross directly above LW S7A. Telstra copper cables are generally direct buried and follow the alignments of local roads across the Study Area.
- The **NBN** optical fibre cable follows the alignment of Remembrance Drive but does not cross directly above LW S7A. NBN copper service cables follow the alignments of local roads across the Study Area.
- The **TPG** optical fibre cable follows the alignment of Remembrance Drive from the Wollondilly Anglican College to the Bargo Exchange, following the same route as the NBN optical fibre cable.

The predicted profiles of conventional subsidence, tilt and curvature along the optical fibre cables and copper cables following the alignment of the Main Southern Railway and the local roads are as predicted for the railway and these roads themselves (see Section 3.7 and Section 3.8). The profiles are shown in Fig. A.05 for the Telstra optical fibre cable alongside the Main Southern Railway, and Figs. A.08 to A.10 for the optical fibre and copper cables along the local roads.

The corresponding maximum predicted incremental subsidence movements due to LW S7A are summarised in Table 3.12 for Yarran Road, Table 3.14 for Caloola Road and Table 3.16 for Remembrance Drive. Maximum predicted total conventional subsidence movements after extraction of LW S7A are summarised in Table 3.13 for Yarran Road, Table 3.15 for Caloola Road and Table 3.17 for Remembrance Drive.

As discussed in relation to the local roads, any additional subsidence movements due to extraction of LW S7A under the *Modified Layout* are slight when compared to the *Approved Layout*, and the locations of the predicted maxima do not change along the alignments of these telecommunications cables.

The NBN telecommunications tower and shed located at No. 3166 Remembrance Drive (access from Yarran Road) will not be directly mined beneath during extraction of LW S7A, however they will experience some additional subsidence movements under the *Modified Layout* when compared to the *Approved Layout*. The maximum predicted incremental subsidence movements due to LW S7A are summarised in Table 3.18

Table 3.18 Maximum predicted incremental conventional subsidence parameters for the NBN telecommunications tower at No. 3166 Remembrance Drive due to the extraction of LW S7A

Longwall	Maximum predicted incremental subsidence (mm)	Maximum predicted incremental tilt (mm/m)	Maximum predicted incremental hogging curvature in any direction (km^{-1})	Maximum predicted incremental sagging curvature in any direction (km^{-1})
Modified Layout				
LW S7A				
Shed	175	1.0	0.01	< 0.01
Tower	175	1.0	0.01	< 0.01

A summary of the maximum predicted total conventional subsidence parameters for the NBN tower and shed for the *Approved Layout* and for the *Modified Layout*, is provided in Table 3.19. Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of the tower and the shed, as well as at points located at a distance of 20 metres from the perimeter of each structure. The predicted tilts are the maxima along and across the structures after the completion of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Table 3.19 Maximum predicted total conventional subsidence parameters for the NBN telecommunications tower at No. 3166 Remembrance Drive

Structure	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted hogging curvature in any direction (km^{-1})	Maximum predicted sagging curvature in any direction (km^{-1})
Approved Layout				
(after LW S6A)				
Shed	900	3.0	0.05	0.04
Tower	850	2.5	0.04	0.04
Modified Layout				
(after LW S7A)				
Shed	1050	3.5	0.05	0.21
Tower	1050	3.5	0.05	0.22

The NBN telecommunications tower is expected to experience some additional subsidence movements during the extraction of proposed LWs S7A. These are not likely to affect the structural integrity of the tower, although predicted tilts of 3.5 mm/m, while small, may affect the operation of the antennae on top of the structure. The tilts can be readily adjusted by either re-levelling the pole or the individual antennae, if required.

Tahmoor Coal has developed Subsidence Management Plans in consultation with Telstra, NBN and TPG to manage potential impacts on the telecommunications infrastructure due to the extraction of LWs S1A to S6A under the *Approved Layout*. This plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With appropriate management plans in place, it is considered that the telecommunications infrastructure will remain safe and serviceable at all times during and after the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.9.3. Gas infrastructure

Gas infrastructure located within the Study Area is owned by Jemena and comprises a 150 mm diameter steel main which generally follows the alignment of Remembrance Drive, and a short section of 50 mm nylon pipeline alongside Wellers Road, on the southern boundary of the Study Area. The gas main along Remembrance Drive crosses LWs S1A to S5A but does not cross directly above LW S7A. The nylon gas pipeline alongside Wellers Road also does not cross directly above LW S7A.

The steel gas main along Remembrance Drive therefore would be expected to experience only small additional subsidence movements due to LW S7A following extraction of LWs S1A to S6A. The predicted profiles of conventional subsidence and tilt along the steel gas main beside Remembrance Drive, resulting from the extraction of the proposed longwalls, are shown in Fig. A.11, which is included in Appendix A.

A summary of the maximum predicted incremental conventional subsidence parameters for the Jemena gas main along Remembrance Drive, due to the extraction of S7A, is provided in Table 3.20.

Table 3.20 Maximum predicted incremental conventional subsidence parameters for Jemena Gas Main along Remembrance Drive due to the extraction of LW S7A

Longwall	Maximum predicted incremental subsidence (mm)	Maximum predicted incremental tilt along alignment (mm/m)	Maximum predicted incremental hogging curvature in any direction (km^{-1})	Maximum predicted incremental sagging curvature in any direction (km^{-1})
Modified Layout				
LW S7A	50	< 0.5	< 0.01	< 0.01

A summary of the maximum predicted total conventional subsidence parameters for the Jemena gas main along Remembrance Drive, after the extraction of each longwall, is provided in Table 3.21. The predicted additional subsidence movements due to the extraction of LW S7A are very slight and these are not expected to result in any additional impacts on the gas infrastructure under the *Modified Layout*.

The predicted tilts are the maxima along the alignment of the road after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Table 3.21 Maximum predicted total conventional subsidence parameters for Jemena Gas Main along Remembrance Drive due to the extraction of LWs S1A to S7A

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt along alignment (mm/m)	Maximum predicted total hogging curvature in any direction (km^{-1})	Maximum predicted total sagging curvature in any direction (km^{-1})
Approved Layout				
LW S1A	325	2.5	0.06	0.06
LW S2A	1000	5.0	0.08	0.20
LW S3A	1200	6.5	0.10	0.21
LW S4A	1300	6.0	0.12	0.21
LW S5A	1350	6.5	0.12	0.21
LW S6A	1375	7.5	0.12	0.21
Modified Layout				
After LW S7A	1400	7.5	0.12	0.21

The nylon gas pipeline alongside Wellers Road also does not cross directly above LW S7A and is predicted to experience less than 20 mm of subsidence. There is extensive experience of mining directly beneath nylon gas pipelines above Tahmoor LWs 22 to 32 where no impacts were experienced. Based on the subsidence predictions and past experiences observed, it is extremely unlikely that the nylon gas pipeline along Wellers Road will experience adverse impacts due to the extraction of the proposed LW S7A.

Tahmoor Coal has developed a Subsidence Management Plan in consultation with Jemena to manage potential impacts on local gas infrastructure due to the extraction of LWs S1A to S2A under the *Approved Layout*. Tahmoor Coal and Jemena are currently developing an updated Subsidence Management Plan to manage potential impacts on local gas infrastructure due to the extraction of LWs S3A to S6A under the *Approved Layout*. This plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that the gas infrastructure will remain safe and serviceable at all times during and after the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.9.4. Potable Water infrastructure

The water pipelines within the Study Area are owned and operated by Sydney Water. The potable water infrastructure includes a Cast Iron Cement Lined (CICL) 450 mm diameter watermain which follows the alignment of Remembrance Drive, before crossing beneath the Main Southern Railway just north of Yarran Road and following Great Southern Road. 100 mm and 200 mm diameter Ductile Iron Cement Lined (DICL) water pipelines are located along Caloola Road, Yarran Road and along a short section Remembrance Drive to the south of the railway crossing. The types of pipeline within the Study Area are mainly DICL and CICL, with short sections of Steel Cement Lined (SCL) beneath road crossings.

The predicted profiles of conventional subsidence, tilt and curvature along the water pipelines following the alignment of local roads are as predicted for these roads themselves (see Section 3.8). The profiles are shown in Figs. A.08 to A.10 in Appendix A, while maximum predicted incremental subsidence movements due to LW S7A are summarised in Table 3.12 for Yarran Road, Table 3.14 for Caloola Road and Table 3.16 for Remembrance Drive. Maximum predicted total conventional subsidence movements after extraction of LW S7A are summarised in Table 3.13 for Yarran Road, Table 3.15 for Caloola Road and Table 3.17 for Remembrance Drive.

As discussed in relation to the local roads, any additional subsidence movements due to extraction of LW S7A under the *Modified Layout* are slight when compared to the *Approved Layout*, and the locations of the predicted maxima do not change along the pipelines.

Tahmoor Coal and Sydney Water have implemented extensive measures to manage potential impacts on potable water infrastructure due to the extraction of LWs S1A to S6A under the *Approved Layout*, in accordance with a Subsidence Management Plan. This plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that the potable water infrastructure will remain safe and serviceable at all times during and after the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.9.5. Sewer infrastructure

The sewer infrastructure within the Study Area is owned and operated by Sydney Water, and comprises a 180 mm diameter pressure main along Remembrance Drive. The sewer pressure main crosses LWs S1A to S5A but does not cross directly above LW S7A. There is no further sewer reticulation network along the local roads within the Study Area for the *Modified Layout.* The sewerage system was designed to accommodate mine subsidence movements and consists of polyethylene (PE) pipelines.

The predicted profiles of conventional subsidence, tilt and curvature along the sewer pressure main following the alignment of Remembrance Drive are as predicted for Remembrance Drive (see Section 3.8). The profiles are shown in Fig. A.10 in Appendix A. The maximum predicted incremental subsidence movements along Remembrance Drive due to LW S7A are summarised in Table 3.16 and the maximum predicted total conventional subsidence movements after extraction of LW S7A are summarised in Table 3.17.

As discussed in relation to Remembrance Drive, any additional subsidence movements due to extraction of LW S7A under the *Modified Layout* are slight when compared to the *Approved Layout*, and the locations of the predicted maxima do not change along the pipelines.

Tahmoor Coal and Sydney Water have implemented extensive measures to manage potential impacts on the sewer infrastructure due to the extraction of LWs S1A to S6A under the *Approved Layout*, in accordance with a Subsidence Management Plan. This plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that the sewer infrastructure will remain safe and serviceable at all times during and after the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.10. Picton Weir

3.10.1. Description and location

The Picton Weir is located on the Bargo River just downstream of the confluence with Hornes Creek. The weir was constructed in the late 19th century and it was built to provide water to the surrounding townships. It is now heavily silted and is no longer used for water supply. Water retained by the weir is released at its base through a seized open valve and outlet pipe. Photographs of the Weir, taken in September 2023, are shown in Fig. 3.27.

Photograph courtesy MNC Consulting

Fig. 3.27 Close up view of Picton Weir

Photograph courtesy MNC Consulting

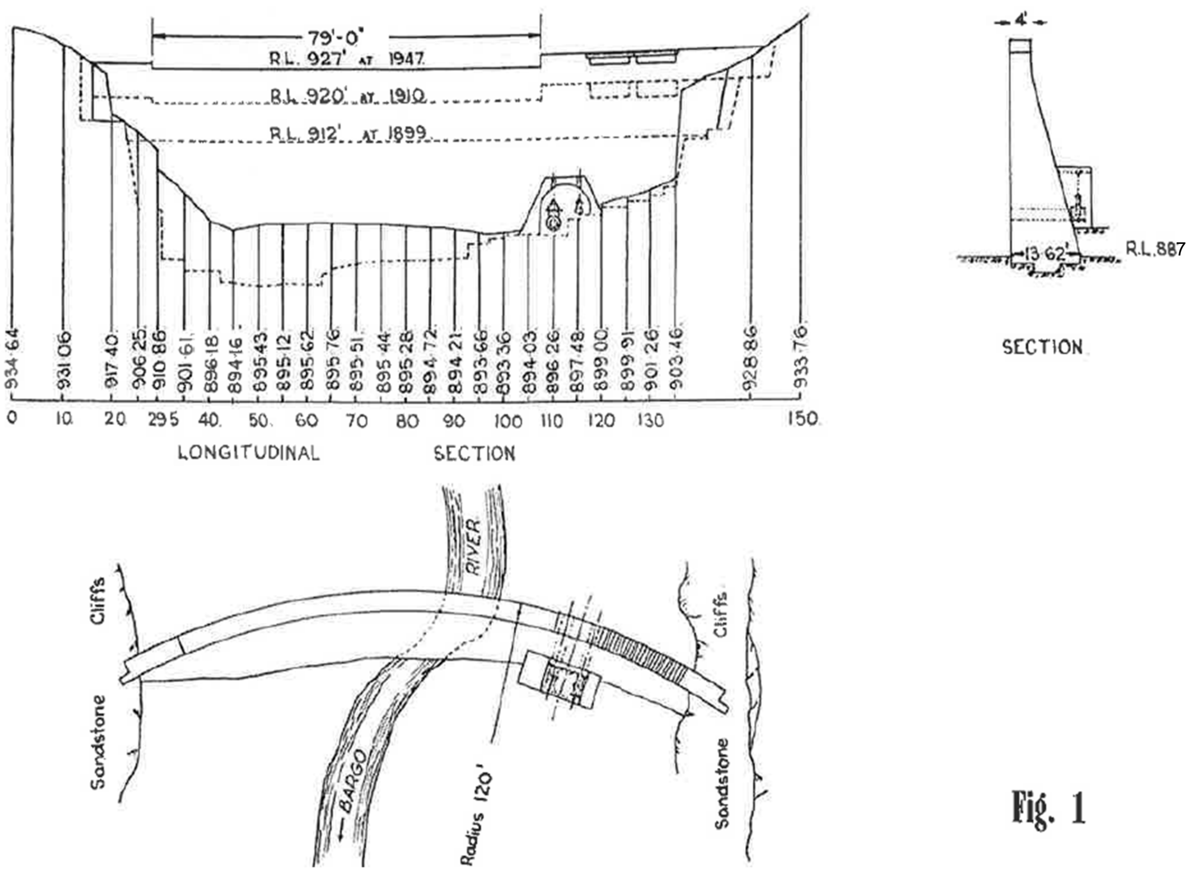
Fig. 3.28 Wide angle view of Picton Weir

The Picton Weir is located approximately 605 metres from LW S7A at its closest point. As shown in Fig. 3.29, LW S7A is proposed to approach the Weir from the southeast but stops approximately 75 metres before it is directly square with the Weir. No impacts were reported on the Picton Weir during the mining of previously extracted Longwalls 14 to 19, the closest of which was approximately 1.5 kilometres from the Weir (Longwall 19).

Fig. 3.29 Location of Picton Weir relative to LW S7A

The Picton Weir was constructed in 1899 at RL 912 (Imperial units) (Haigh, 1954). The level was raised by 8 ft to RL 920 in 1910 and raised a further 7 ft in 1947 to RL 927. Drawings describing the weir's dimensions were provided by Haigh (1954) and are produced in Fig. 3.30. The lowest foundation level at RL 887 was reported by the Picton Post (1945) to be a few feet below the river bed level.

Worley Consulting have found a reasonable correlation between the elevations shown in Fig. 3.30 and a photogrammetry survey of the Weir by MNC Consulting, allowing for the fact that the foundation level of RL 887 is below the river bed and water that is pooling at the downstream base of the Weir.



Source: Haigh (1954) from Sydney Water Board Journal

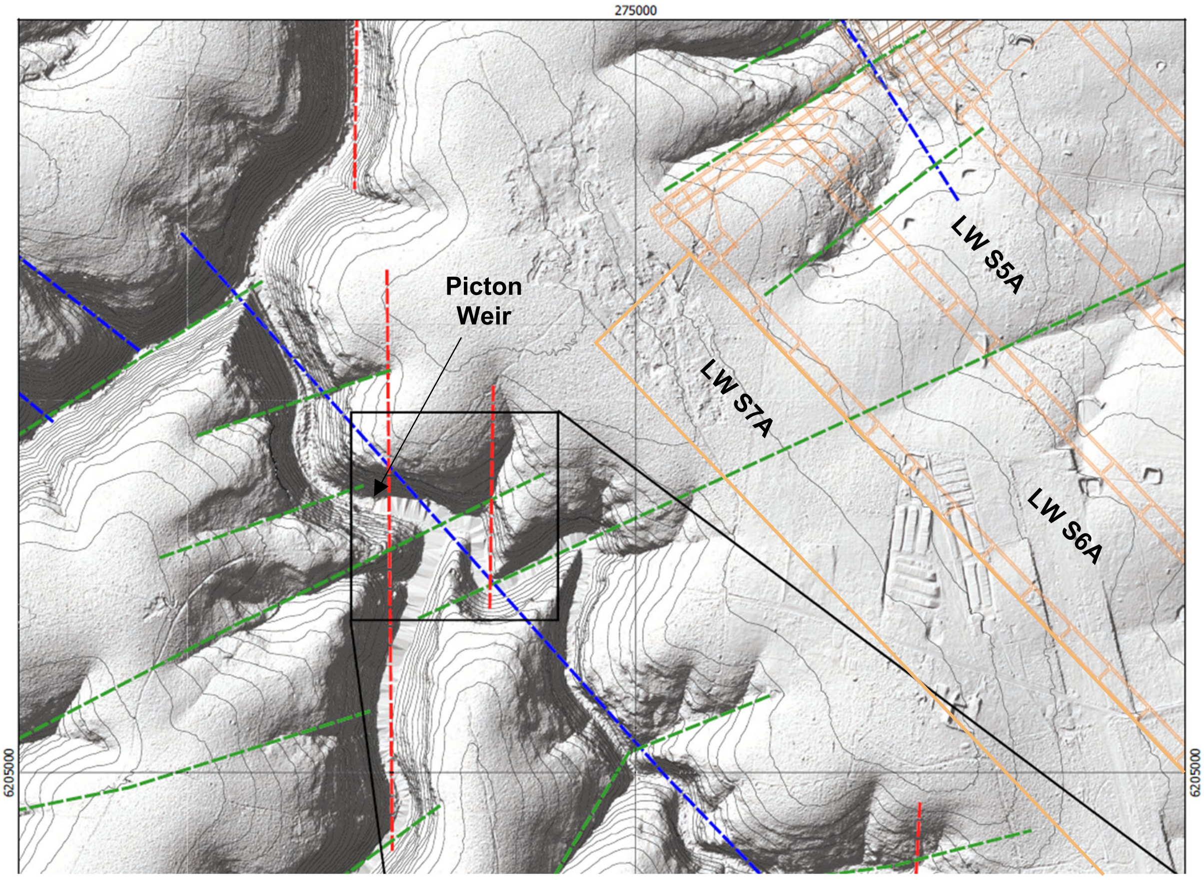
Fig. 3.30 Construction drawings of Picton Weir

3.10.2. Geotechnical assessment

Tahmoor Coal has engaged geotechnical engineer PSM (2023) to conduct a geotechnical investigation and assessment of the rock mass surrounding the Picton Weir. The investigation includes a review of available geological, geomorphological and mining reports, identification of potential geological structures, site inspections and logging and interpretation of two vertical boreholes that have been drilled by Tahmoor Coal on either side of Picton Weir.

Picton Weir near the Central Fault complex, which lies to the south and west of the proposed LW S7A. The fault was described by MBGS (2013) and PSM (2023) as a normal fault trending northwest with vertical displacement up to 20 metres, east side up (laying over the west side). The fault was identified in the 2D seismic lines and was also intercepted in one drill hole (JB06) where the Wongawilli Seam has been displaced. The fault was not observed by PSM during the geological field mapping and the boreholes did not intercept it.

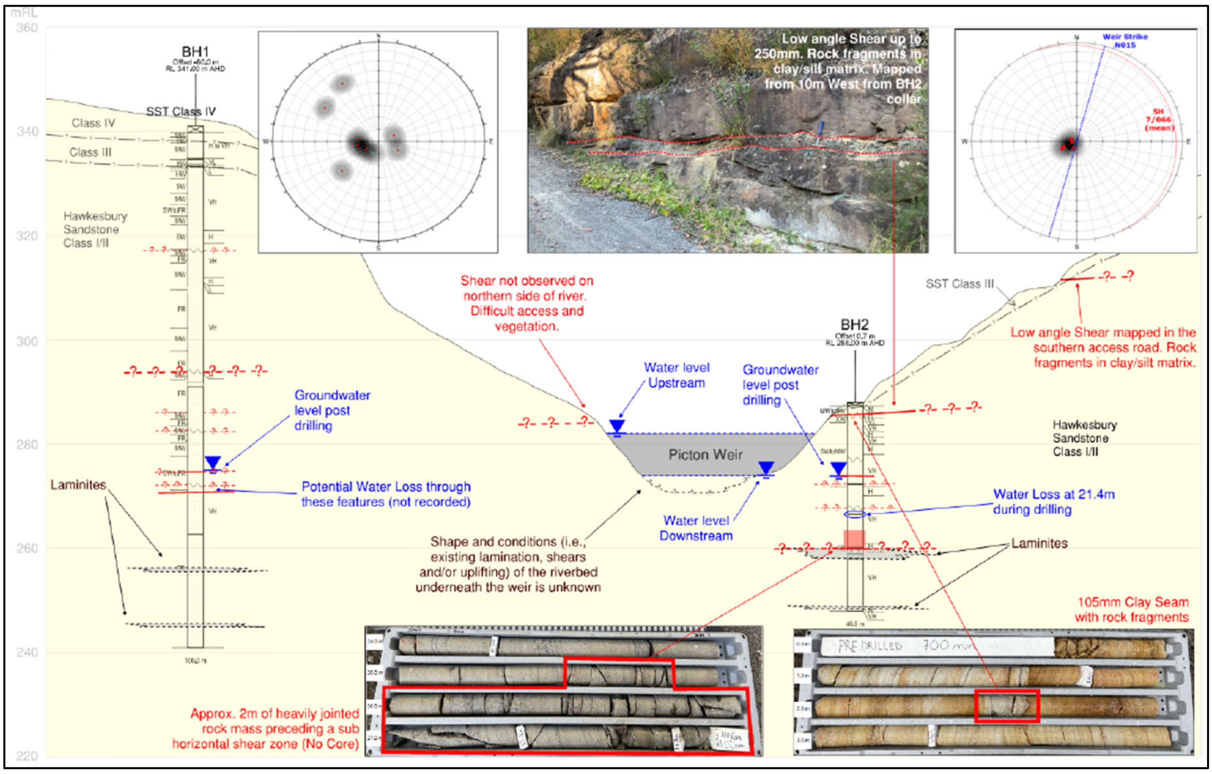
The Gordon Geotechniques (2013) report advised that the Central Fault zone was associated with a number of features including a change in Bulli Seam fluidity and thinning of the Balgownie to Bulli Seam interburden. The downstream part of Hornes Creek follows the surface expression of the Central Fault. PSM (2023) advised that the double kink in Hornes Creek, upstream of the Picton Weir could be attributable to conjugated lineaments sub-perpendicular to the Central Fault complex, as shown in Fig. 3.31.



Source: Marked up extract from Figure 3 of PSM (2023) to include LW S7A

Fig. 3.31 PSM Lineament Assessment (PSM, 2023)

PSM (2023) has developed a conceptual geological model based on the results of field investigations and borehole mapping. A cross-section through the Weir structure is reproduced in Fig. 3.32.



Source: Figure 5 of PSM (2023)

Fig. 3.32 PSM Conceptual Geological Model – Cross Section through Picton Weir (PSM, 2023)

The key findings of the assessment by PSM (2023) are summarised below.

- The ground conditions encountered are consistent with those associated with natural valley bulging;
- Low angle shears were observed in both boreholes and mapped from field investigations. There does not appear to be persistence of any single structure that is continuous beneath the entire width of the Weir;
- Initial groundwater readings suggest that current levels are lower than expected in a valley of this depth, which suggests that there is a network of interconnected structures that cause water levels to drain rapidly towards the valley;
- There is, therefore, a potential for movement along sub-horizontal bedding and, in particular, along low angle shears in response to mining-induced valley closure and upsidence. Concentrated movements along a single defect, however, appears unlikely.
- There is also a potential for movement along sub-vertical joints and/or cross begging in response to mining-induced valley closure and upsidence. The movements are likely to be limited due to the low persistence of sub-vertical joints that generally terminate against bedding partings and shears. Movements along cross bedding is possible but likely where defects are already showing some dilation, such as those observed at the base of the abutments.

3.10.3. Subsidence predictions

The Picton Weir is located approximately 605 metres from LW S7A at its closest point. The Weir is located outside the predicted limit of subsidence and is, therefore, predicted to experience negligible conventional subsidence movements.

Predictions of non-conventional valley closure and upsidence movements along the Bargo River were provided in Section 3.2. As shown in Fig. A.02, the Bargo River is predicted to experience less than 20 mm of incremental valley closure and upsidence at the Picton Weir due to the proposed extraction of LW S7A.

A summary of the predicted values of incremental vertical subsidence, upsidence and closure at the Picton Weir on the Bargo River is provided in Table 3.22 and the predicted total values of vertical subsidence, upsidence and closure at the Picton Weir is provided in Table 3.23.

Table 3.22 Predicted incremental vertical subsidence, upsidence and closure at Picton Weir

Layout	Longwall	Predicted incremental vertical subsidence (mm)	Predicted incremental upsidence (mm)	Predicted incremental closure (mm)
Modified Layout	LW S7A	< 20	< 20	< 20

Table 3.23 Predicted total vertical subsidence, upsidence and closure at Picton Weir

Layout	Longwall	Predicted total vertical subsidence (mm)	Predicted total upsidence (mm)	Predicted total closure (mm)
Approved Layout	After LW S6A	< 20	< 20	< 20
Modified Layout	After LW S7A	< 20	20	< 20

3.10.4. Statistical analyses of valley closure movements at Picton Weir

Statistical analyses of previously measured valley closure in the Southern Coalfield have been conducted based on monitoring data from Tahmoor Colliery and nearby Appin and West Cliff Collieries, where depths of cover and extraction heights are similar to those proposed for LW S7A. The results of the statistical analyses are described in Section 3.3 of this report and can be applied to the Picton Weir.

It is noted, however, that LW S7A is proposed to be extracted up to but stop short of the Weir, while the analyses includes sites where previously extracted longwalls had mined past them. The analyses, therefore, are expected to provide a conservative assessment.

Observed incremental valley closure at sites located above solid, unmined coal, are shown relative to their distances from the maingate edges of previously extracted longwalls in Fig. 3.13. A total of 2390 measurements have been plotted, sorted into groups based on valley depths that are greater than or less than 40 metres. Where surveys were conducted on multiple occasions during the extraction of a longwall, only the maximum measured incremental closure for each longwall has been plotted.

The confidence levels, based on fitted *Generalised Pareto Distributions* (GPDs), have also been shown in Fig. 3.13 to illustrate the spread of the data. The GPD and confidence levels have been calculated without filtering the data based on valley depths, nor the locations of the sites relative to the sides or ends of the longwalls.

A summary of the probabilities of exceedance for valley closure for survey bays at distance that is relevant to the distance between the Picton Weir and LW S7A, based on the fitted General Pareto Distribution function, is provided in Table 3.24.

Table 3.24 Probabilities of exceedance for valley closure for survey bays located at distance of 600 m from the nearest goaf edge in the Southern Coalfield

Statistical parameter	Probability of Exceedance	Incremental valley closure (mm)
Offset distance from maingate of active LW of 600 m	1 in 2.5 (0.4)	5
	1 in 3.3 (0.3)	7
	1 in 5 (0.20)	9
	1 in 10 (0.10)	12
	1 in 20 (0.05)	16
	1 in 100 (0.01)	26

When compared against the ACARP prediction of maximum incremental closure of <20 mm, it can be seen that the prediction of valley closure is reasonably conservative.

An alternative statistical approach was conducted to check the fitted confidence level curves that are shown in Fig. 3.13. A histogram showing the distribution of observed valley closure for a subset of sites that were located between 450 metres and 750 metres from the maingate side of previously extracted longwalls is shown in Fig. 3.33.

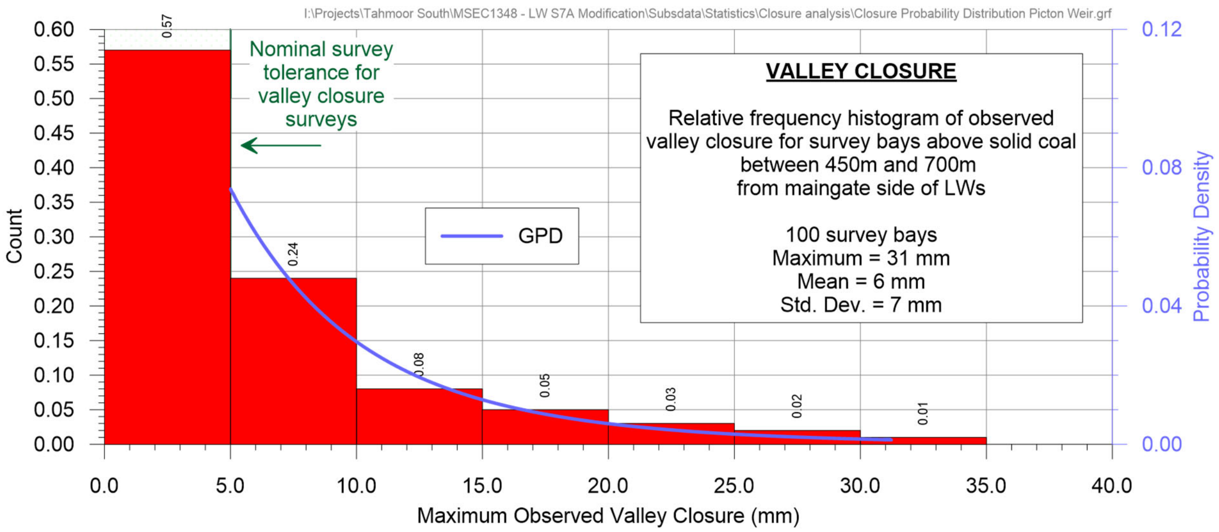


Fig. 3.33 Frequency distribution of observed valley closure for survey bays between 450m and 750m from maingate side of previously extraction LWs in Southern Coalfield

The average measured closure within the dataset was 6 mm and maximum observed closure was 31 mm, with 95 % of sites recording less 21 mm of closure and 99 % of sites recording less than 29 mm of closure. The results compare reasonably well with the values in Table 3.24.

As discussed in Section 3.3 of this report, the reason for the more conservative prediction by the ACARP method can be explained by the way in which the ACARP normalises the offset distances by dividing them by the sum of the longwall panel width and chain pillar width.

Observed incremental valley closure at sites located above solid, unmined coal, are shown relative to their normalised distances from the maingate edges of previously extracted longwalls in Fig. 3.15.

A summary of the probabilities of exceedance for valley closure for survey bays at a normalised distance that is relevant to the normalised distance between the Picton Weir and LW S7A, based on the fitted General Pareto Distribution function, is provided in Table 3.25.

Table 3.25 Probabilities of exceedance for valley closure for survey bays located at normalised distance of 1.875 from the nearest goaf edge in the Southern Coalfield

Statistical parameter	Probability of Exceedance	Incremental valley closure (mm)
Normalised Offset distance from maingate of active LW / (LW width + pillar width) of 600/(283+37) = 1.875	1 in 2.5 (0.4)	2.5
	1 in 3.3 (0.3)	10
	1 in 5 (0.20)	14
	1 in 10 (0.10)	22
	1 in 20 (0.05)	32
	1 in 100 (0.01)	64

When compared against the ACARP prediction of maximum incremental closure of <20 mm, it can be seen that the prediction of valley closure is conservative but less when compared to statistical analyses based on distances that are not normalised.

Closer examination of the statistical analyses found that the calculated confidence levels based on normalised distances were influenced by two outliers, which relate to recently observed closure during the mining of Tahmoor LW W3 and LW W4 across Stonequarry Creek at the Victoria Bridge and a Retaining Wall at 84.687 km on the Main Southern Railway. The observations are discussed in the following section.

3.10.5. Case study of observed valley closure movements during the mining of LW W1-W4

While the statistical analyses show that the valley closure prediction at Picton Weir is likely to be conservative, the empirical data presented in Fig. 3.13 and Fig. 3.15 shows that there are two outliers at distances greater than 600 metres from previously extracted longwalls. These relate to recently observed closure during the mining of Tahmoor LW W3 and LW W4 across Stonequarry Creek at the Victoria Bridge and a Retaining Wall at 84.687 km on the Main Southern Railway.

The case study is relevant to the extraction of LW S7A to the side of the Picton Weir as both sites involve a regionally significant valley (Stonequarry Creek compared to Bargo River) and both are located near a major geological fault system (Nepean Fault compared to the Central Fault).

Tahmoor Coal extracted LW W1-W4 in the Western Domain, which is located to the west of the township of Picton. LW W1-W4 were extracted between November 2019 and September 2022.

LW W1-W4 were bounded by Stonequarry Creek to the north, Matthews and Cedar Creek to the west, previously extracted LWs 22 to 32 to the south, and the Main Southern Railway, Stonequarry Creek and the Nepean Fault complex to the east. A map showing the location of LW W1-W4 relative to these features is provided in Fig. 3.34. The longwall panels were extracted from north to south.

Valley closure was observed to gradually develop across Stonequarry Creek between the bridge abutments and piers at Victoria Bridge and across Stonequarry Creek at the Retaining Wall at 84.867 km during the mining of LW W3 and LW W4. The closure commenced when the western abutment, closest to the longwalls, no longer moved in concert with the eastern abutment towards the longwalls and started to move northeast into the valley. The observed valley closure coincided with:

- Observed absolute horizontal movement of Thirlmere Way Underbridge and Connellan Crescent Overbridge in a north-easterly direction away from LWs W1-W4 and LW32 (refer Fig. 3.34 and Fig. 3.35);
- Observed absolute horizontal movement in a north-easterly direction at survey pegs spaced every 20 metres along the Main Southern Railway from 89.5 km (south of Thirlmere Way Underbridge) to the north beyond Connellan Crescent Overbridge, away from LWs W1-W4 and LW32. The magnitude of horizontal movements diminished along the railway corridor to the north, transitioning gradually between approximately 88.6 km and 88.8 km, such that measured ground strains and changes over long bay lengths did not result in measurable changes in rail stress on the track, with minor lateral shearing across the railway corridor at 88.750 km.

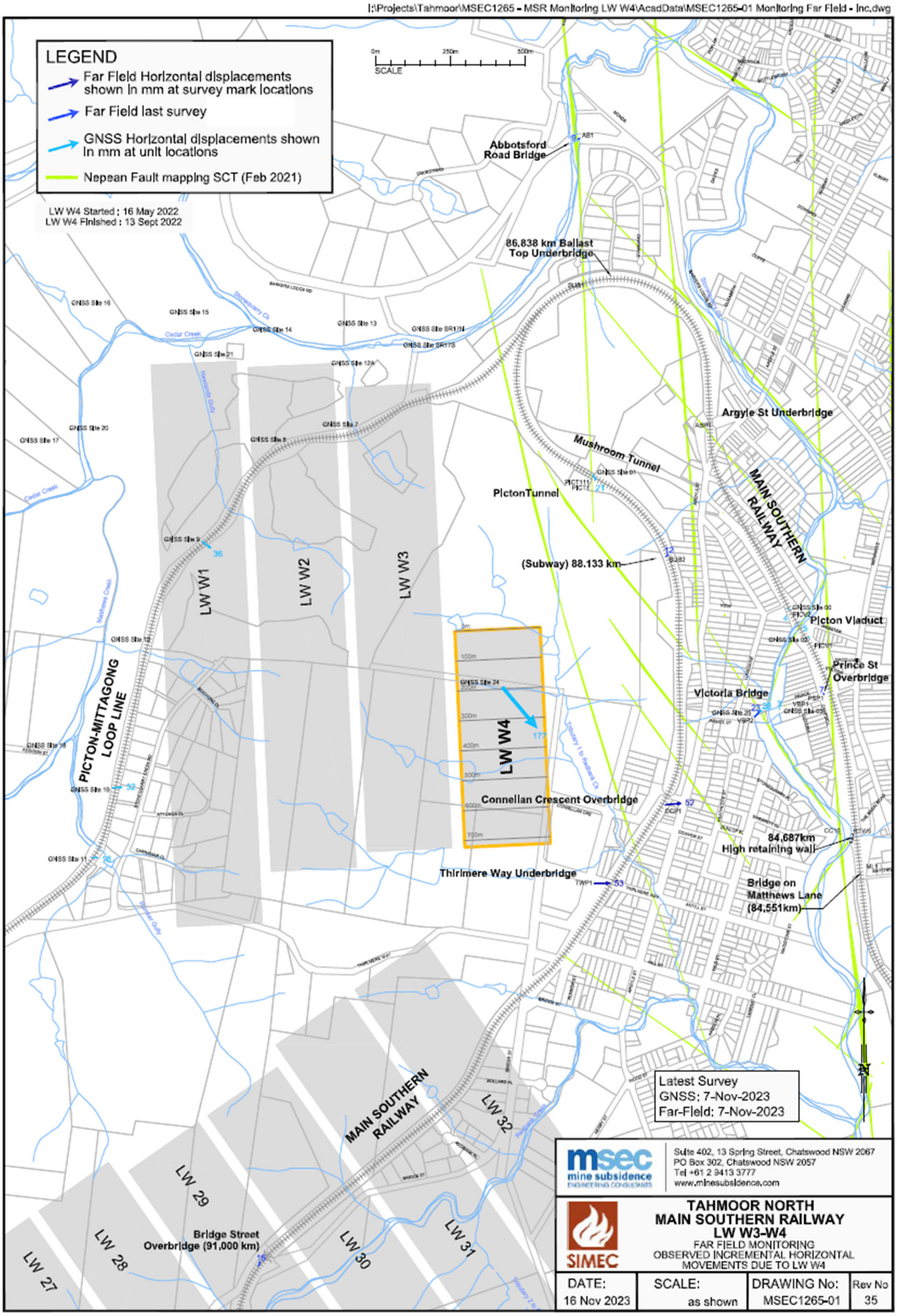


Fig. 3.34 Observed incremental horizontal movements during the mining of LW W4

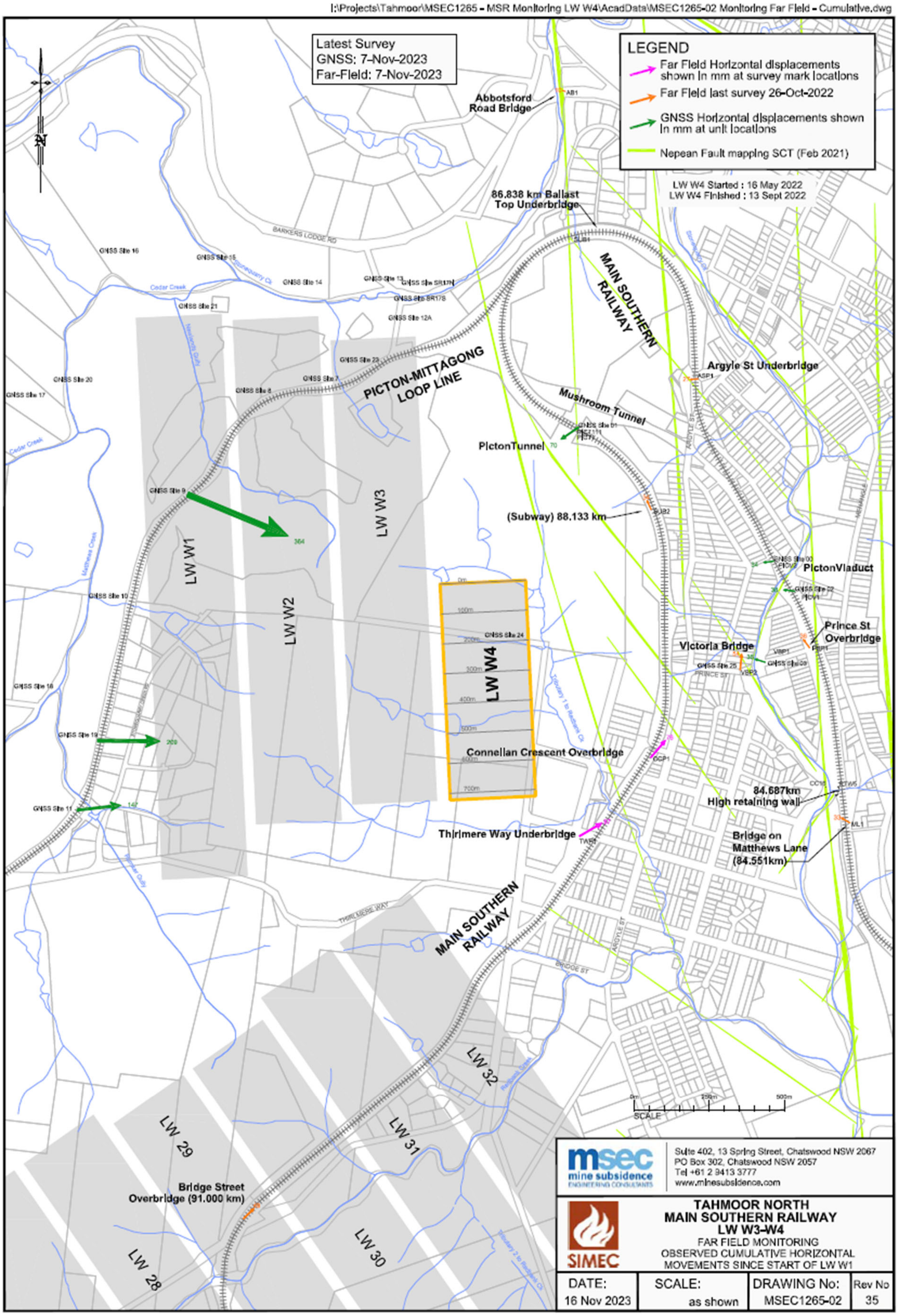


Fig. 3.35 Observed total horizontal movements during the mining of LW W1-W4

The observed development of valley closure across Stonequarry Creek at Victoria Bridge is shown in Fig. 3.36. The distances between Victoria Bridge from the maingate edges of each longwall are annotated on the graph.

The Retaining Wall at 84.867 km was monitored by Tahmoor Coal at the request of the Australian Rail Track Corporation during the mining of LW W1-W4. The main purpose of the surveys was to confirm that the wall was not deforming in response to differential far field movements. The survey consisted of a series of survey marks mounted on the wall, which were surveyed from the opposite side of Stonequarry Creek. The survey was measured in relative 3D coordinates and did not measure changes in the absolute 3D position of the survey marks.

While no measurable differential movements were observed between the marks on the wall, the measured distances between the wall and a survey mark on the opposite side of Stonequarry Creek gradually closed.

The observed development of valley closure across Stonequarry Creek at Retaining Wall at 84.867 km is shown in Fig. 3.37. The distances between the Retaining Wall from the maingate edges of each longwall are annotated on the graph.

Approximately 300 metres upstream (northeast) of Victoria Bridge, Tahmoor Coal extensively monitored changes at the Picton Viaduct during the mining of LWs 31, 32 and LW W1-W4. No measurable differential movements were observed across or along the Viaduct. A summary graph showing the observed changes in horizontal distances between two GNSS units on either side end of the Viaduct across Stonequarry Creek is shown in Fig. 3.38. Less than 10 mm of valley closure was observed, which is close to survey tolerance, taking into account that the GNSS units were installed in 2018. While the installed units were the best available at the time, GNSS technology has improved with later models.

The key lessons from the case study are provided below.

- Valley closure developed at the Victoria Bridge and Retaining Wall at a considerable distance away from LW W3 and LW W4. The represent outliers within the Southern Coafield empirical database.
- LW W4 was relatively short in length and incremental valley closure would likely have been greater if LW W4 had been longer, particularly at the Retaining Wall as the longwall panels were not extraction south of them.
- LW W4 was also the last longwall to be extracted in this mining domain. Valley closure would likely have continued to develop at a greater magnitude if additional longwalls had been extracted closer to the monitoring sites.
- The observed closure, however, only developed along one arm of Stonequarry Creek, where less than 10 mm of valley closure was observed where the Picton Viaduct crosses Stonequarry Creek, 300 metres upstream of Victoria Bridge.
- The observed valley closure movements coincided with an observation of horizontal movements towards Stonequarry Creek, away from the longwall mining area.
- The observed horizontal movements and valley closure developed gradually during mining.

The case study is a reminder that while the prediction model for valley closure is generally conservative, actual valley closure movements can sometimes exceed predictions. The movements can, however, be detected early as each successive longwall approaches Picton Weir. The potential for greater than predicted movements is considered when conducting impact assessments for the Picton Weir.

Tahmoor Coal is currently monitoring ground movements at Picton Weir and along Hornes Creek according to the Subsidence Monitoring Plan. The monitoring locations are shown in Drawing No. MSEC1348-15.

- A pair of GNSS units have been installed at the tops of the Bargo River at each end of the Picton Weir. The GNSS units have continuously monitored changes during mining since the commencement of LW S1A. While the GNSS units have measured minor horizontal movements towards the active mining area, changes in horizontal distances between the units are less than 5 mm and within survey tolerance.
- Six GNSS units have been installed along the tops of Hornes Creek in pairs across the valley. The GNSS units have continuously monitored changes during mining since the commencement of LW S2A. While the GNSS units have measured minor horizontal movements towards the active mining area, changes in horizontal distances between the units are less than 5 mm and within survey tolerance.

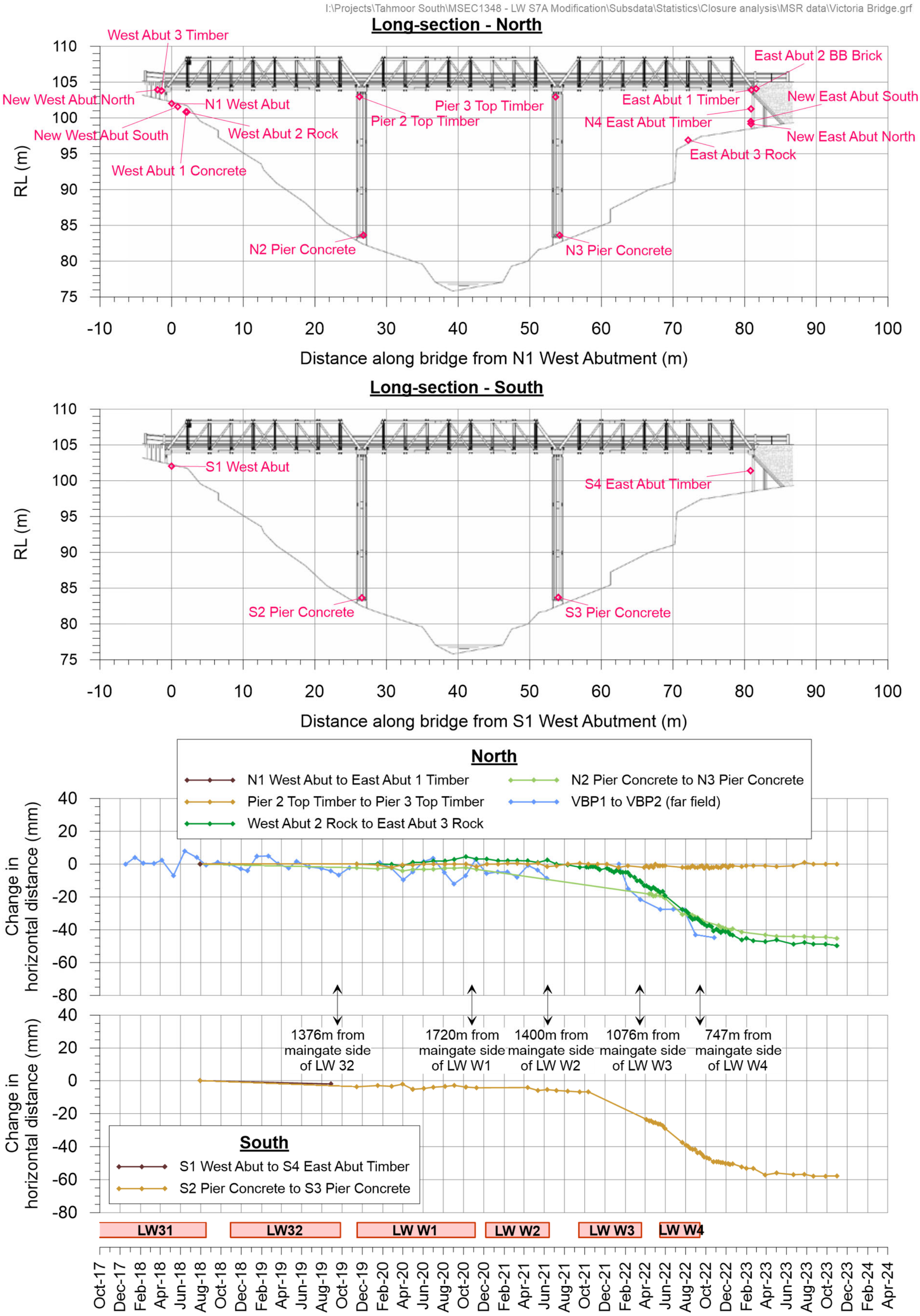


Fig. 3.36 Observed development of closure across Stonequarry Creek at Victoria Bridge during the mining of LWs 31, 32 and LW W1-W4

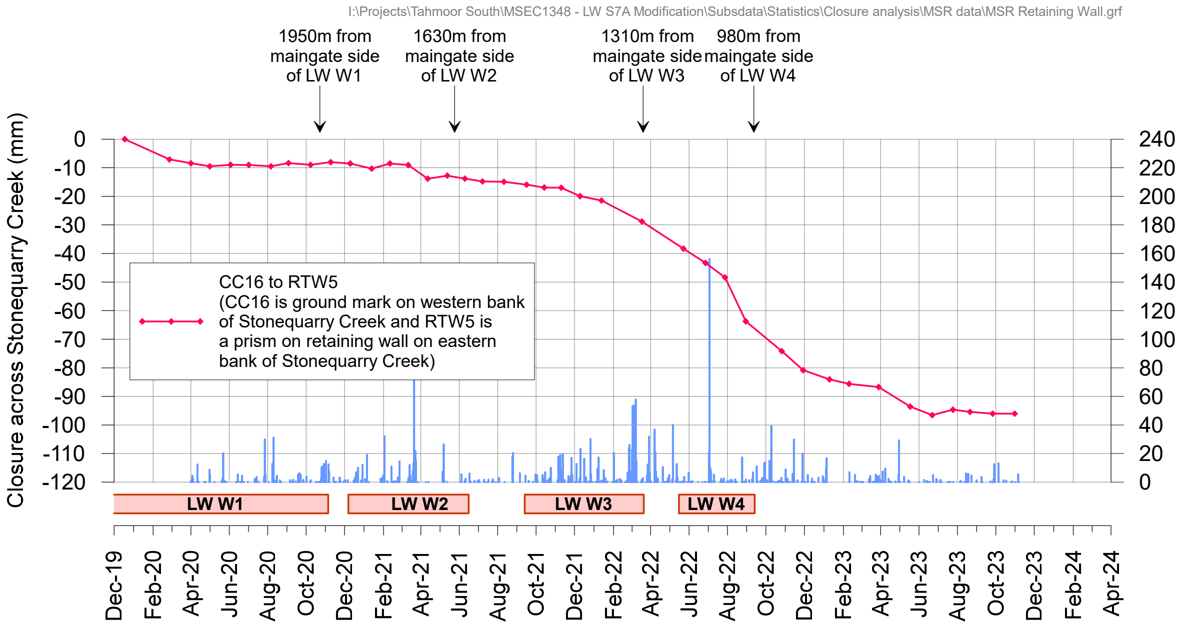


Fig. 3.37 Observed development of closure across Stonequarry Creek at Retaining Wall at 84.687 km on the Main Southern Railway during the mining of LW W1-W4

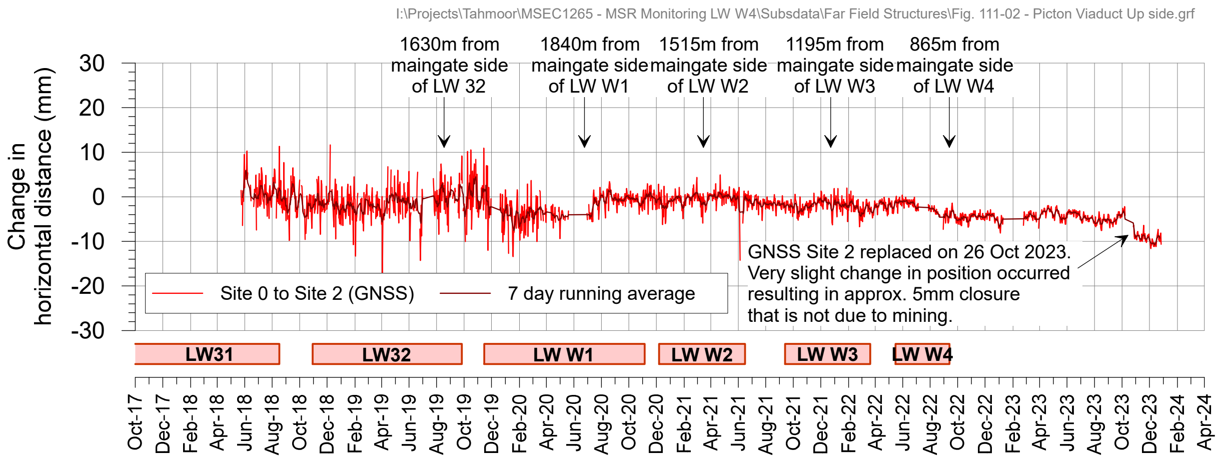


Fig. 3.38 Observed changes in horizontal distance across Stonequarry Creek at Picton Viaduct on the Main Southern Railway during the mining of LWs 31, 32 and LW W1-W4

3.10.6. Managing potential far field impacts on the Picton Weir

Tahmoor Coal has engaged Worley Consulting to develop a 3D structural model of the Weir, to assess its existing condition and assess potential structural impacts from potential mine subsidence movements. The assessment includes a sensitivity analysis that incrementally assesses the effects of valley closure at values up to and greater than predictions.

Tahmoor Coal is currently consulting with Wollondilly Shire Council to develop a Subsidence Management Plan to manage the potential for impacts to the Picton Weir due to the extraction of LWs S1A to S6A under the *Approved Layout*. This plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

Tahmoor Coal is currently developing management measures to ensure that it remains safe throughout the mining period and that impacts on the Picton Weir do not result in environmental consequences on the Bargo River due to the extraction of LWs S3A to S7A. The study requires input from structural, geotechnical and subsidence engineers. The management measures may include a combination of:

- Mitigation or strengthening measures prior to mining;
- Installation of a monitoring system, which includes, among other things:
    - GNSS monitoring at both ends of the Picton Weir (Sites S13 and S14, both installed),
    - GNSS monitoring at a location between LWs S1A to S7A and the Picton Weir (Site S19, installed);
    - GNSS monitoring at three pairs across Hornes Creek (Sites S20 to S25, installed);
    - Survey marks on rockfaces on both sides of the Picton Weir (installed);
    - Survey marks on the Picton Weir (to be installed prior to start of LW S3A);
    - Photogrammetric survey of shape of dam wall and surrounding rockfaces on both sides of the Picton Weir (baseline survey completed);
    - Vertical inclinometers in boreholes at mine side of the Picton Weir (boreholes drilled, inclinometer tubing to be installed prior to start of LW S3A);
    - Groundwater level monitoring in vertical inclinometers at mine side of the Picton Weir (to be installed prior to start of LW S3A);
    - Water level monitoring upstream of Picton Weir (to be installed prior to start of LW S3A);
    - Detailed visual inspection of Picton Weir and surrounding rockfaces by UAV (baseline inspection completed); and
    - Visual inspections during mining.
    - Install crack monitoring of existing gauges
- Conduct regular visual inspections of the Picton Weir; and
- Implement planned responses if triggered by monitoring and inspections.

As Tahmoor Mine will progressively approach the Picton Weir, it will be possible to review observations during the mining of each longwall and adjust the mine plan, if necessary to reduce the potential for impacts on Picton Weir. Picton Weir is also located beyond the finishing ends of the longwalls and it will be possible to stop the longwall face early, if necessary based on actual monitoring observations.

With an appropriate management plan in place, it is considered that the Picton Weir will remain safe and serviceable at all times due to the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.11. Rural structures

3.11.1. Descriptions of the rural structures

The locations of the rural structures (Structure Type R) within the Study Area are shown in Drawing No. MSEC 1348-11.

There are 276 rural structures which have been identified on private properties within Study Area, of which 48 structures (17 % of the total number of rural structures) will be mined directly beneath by the proposed LW S7A. There are a further 145 rural structures within the Study Area which will be mined directly beneath by longwalls S1A to S6A under the *Approved Layout*. The rural structures include sheds, garages, carports, gazebos, pergolas, greenhouses, shade structures and other non-residential structures. The locations and sizes of the rural structures were determined from aerial photographs of the area.

3.11.2. Predictions for rural structures

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at the vertices of each rural structure, as well as at eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature for each of the rural structures within the Study Area due to extraction of LW S7A is provided in Table C.04, in Appendix C. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for each of the rural structures within the Study Area after extraction of LWs S1A to S7A is also provided in Table C.04. The predicted tilts provided in this table are the maxima in any direction after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Distributions of the maximum predicted incremental conventional subsidence and tilt for the rural structures due to extraction of LW S7A are illustrated in Fig. 3.39, while Fig. 3.40 shows the corresponding distributions of maximum predicted total conventional subsidence and final tilt after extraction of LWs S1A to S7A under the *Modified Layout*.

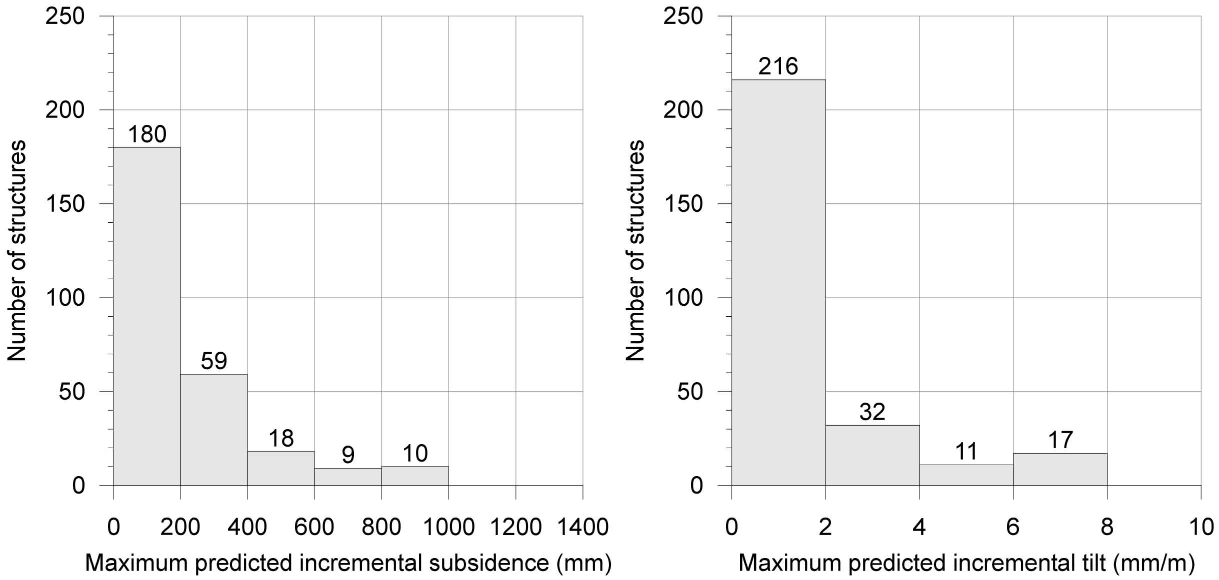


Fig. 3.39 Maximum predicted incremental conventional subsidence and tilt for the rural structures within the Study Area due to extraction of LW S7A

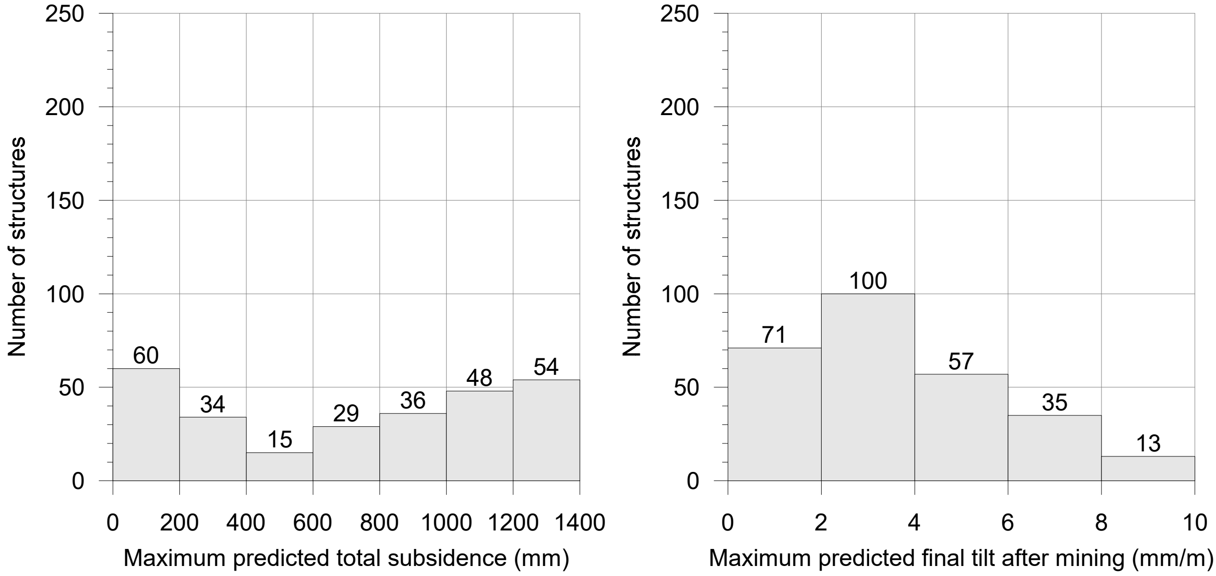


Fig. 3.40 Maximum predicted total conventional subsidence and tilt for the rural structures within the Study Area after extraction of LWs S1A to S7A

These distributions indicate that for a large number of the rural structures in the Study Area (180 out of 276 structures, or 65% of the total), the maximum predicted incremental subsidence due to LW S7A is less than 200 mm and thus a relatively small proportion of the maximum predicted total subsidence after extraction of LWs S1A to S7A. Similarly, the maximum predicted incremental tilt due to LW S7A is relatively small (< 2 mm/m) for most structures in the Study Area (216 out of 276 structures, or 78% of the total).

Distributions of the maximum predicted incremental conventional hogging and sagging curvatures for the structures due to extraction of LW S7A are illustrated in Fig. 3.41, while Fig. 3.42 shows the corresponding distributions of maximum predicted total conventional hogging and sagging curvatures after extraction of LWs S1A to S7A under the *Modified Layout*.

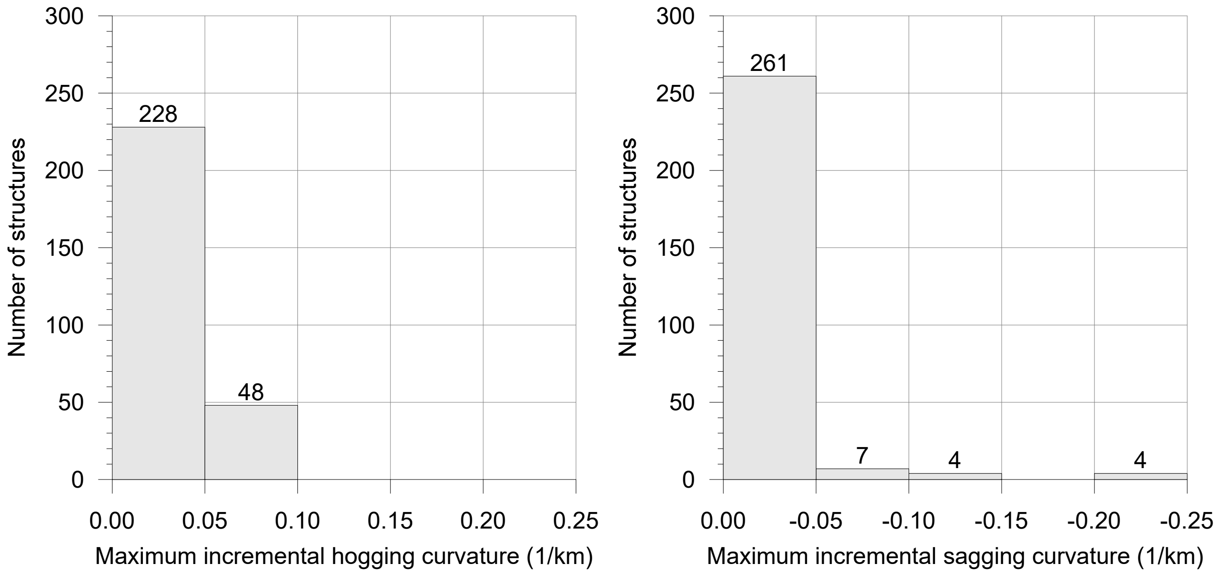


Fig. 3.41 Maximum predicted incremental conventional hogging curvature (left) and sagging curvature (right) for the farm dams within the Study Area due to extraction of LW S7A

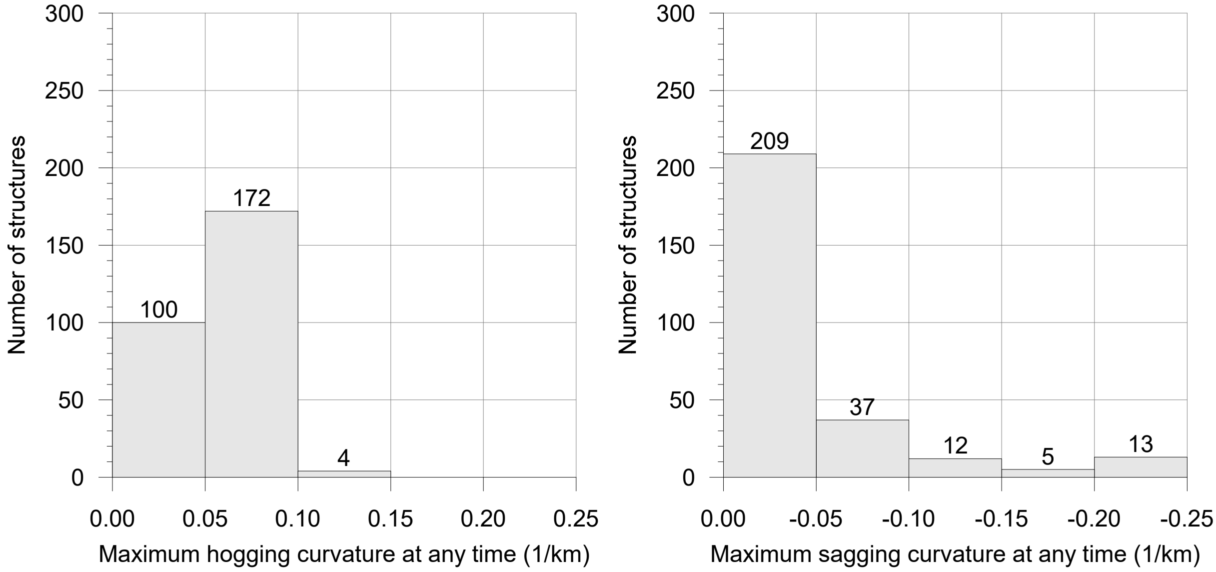


Fig. 3.42 Maximum predicted conventional hogging curvature (left) and sagging curvature (right) for tanks within the Study Area due to extraction of LW S7A

These distributions show that the maximum predicted incremental curvatures due to LW S7A are relatively small for most of the rural structures in the Study Area (of the 276 structures there are a total of 228 structures or 83% with hogging curvature < 0.05 km^{-1} and 261 structures or 95% with sagging curvature < 0.05 km^{-1}).

The maximum predicted conventional curvatures for the rural structures are 0.12 km^{-1} hogging and 0.23 km^{-1} sagging, which equate to minimum radii of curvature of 8.3 kilometres and 4.3 kilometres, respectively. The maximum predicted conventional strains for the rural structures, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.8 mm/m tensile and 3.5 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Section 2.5 includes those resulting from both conventional and non-conventional anomalous movements.

The rural structures are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 2.5. The results for survey bays located above goaf are provided in Fig. 2.6 and the results for survey bays located above solid coal are provided in Fig. 2.8.

3.11.3. Impact assessments for rural structures

The maximum predicted tilt for the rural structures is 8.5 mm/m (i.e. 0.85 %), which represents a change in grade of 1 in 118. The majority of the rural structures within the Study Area are of lightweight construction and able to tolerate mining-induced tilt. It has been found from past longwall mining experience that tilts of the magnitudes predicted within the Study Area generally do not result in adverse impacts on rural structures. Some minor serviceability impacts could occur at the higher levels of predicted tilt, including door swings and issues with roof and pavement drainage, all of which can be remediated using normal building maintenance techniques.

There is extensive experience of mining directly beneath rural structures in the Southern Coalfield which indicates that the incidence of impacts on these structures is very low and the structures have remained in safe and serviceable conditions. This is not surprising as rural structures are generally small in size and of light-weight construction, which makes them less susceptible to impact than houses which are typically more rigid.

Tahmoor Mine has mined directly beneath more than 2000 rural structures of similar construction during the mining of LWs 22 to 32 and LW W1-W3. It has managed the mining induced impacts with the implementation of suitable management strategies. The structures have remained safe and serviceable during mining.

Whilst the predicted subsidence parameters for the proposed longwalls are greater than those at Tahmoor North, it would still be expected that the rates of impact would be low and could be managed with the implementation of suitable management strategies. Impacts on rural structures have been successfully managed elsewhere in the NSW Coalfields, where the predicted subsidence parameters were similar to or greater than those predicted for the proposed longwalls.

Based on previous experiences, it is expected that the rural structures within the Study Area would remain safe and serviceable during the mining period, provided that they are in sound existing condition. The risk of impact is clearly greater if the structures are in poor existing condition, though the chances of there being a public safety risk remains very low. A number of rural structures which were in poor existing condition have been directly mined beneath and these structures have not experienced impacts during mining.

Impacts on the rural structures that occur as the result of the extraction of the proposed longwalls are expected to be remediated using well established building techniques. With these remediation measures available, it is unlikely that there would be long term impacts on rural structures resulting from the extraction of the proposed longwalls.

3.11.4. Impact assessments for rural structures based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the rural structures would be 17 mm/m (i.e. 1.7 %), or a change in grade of 1 in 59. In this case, the incidence of serviceability impacts, such as door swings and issues with gutter and pavement drainage, would increase in the locations of greatest tilt, such as adjacent to the active longwall maingate and adjacent to the ends of the proposed longwalls. It would still be unlikely that stabilities of these rural structures would be affected by tilts of these magnitudes.

If the actual curvatures exceeded those predicted by a factor of 2 times, the incidence of impacts would increase for the rural structures located directly above the proposed longwalls. Since rural structures are generally small in size and of light-weight construction, they would still be expected to remain safe, serviceable and repairable using normal building maintenance techniques. With the implementation of any necessary remediation measures, it is unlikely that there would be any substantial long-term impacts on the rural structures.

While the predicted ground movements are important parameters when assessing the potential impacts on the rural structures, it is noted that the impact assessments were primarily based on historical observations from previous longwall mining in the Southern Coalfield. The overall levels of impact on the rural structures, resulting from the extraction of the proposed longwalls, are expected to be similar to those observed where longwalls have previously mined directly beneath rural structures in the Southern Coalfield.

3.11.5. Management of potential impacts on rural structures

Tahmoor Coal has developed a Subsidence Management Plan to manage potential impacts to farm buildings during the mining of LWs S1A to S6A under the *Approved Layout*. The management plan provides for identification of buildings in poor pre-mining condition that are hazardous or may become hazardous due to mining, and monitoring of structures during active subsidence. If impacts occur, the structure will be repaired in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

The Subsidence Management Plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that rural structures can be maintained at all times due to the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.12. Tanks

3.12.1. Descriptions of the tanks

The locations of the tanks (Structure Type T) within the Study Area are shown in Drawing No. MSEC1348-11. These include both septic tanks and potable water storage tanks, and which comprise in-ground and above ground tanks of concrete or steel or polyethylene construction.

There are 67 tanks which have been identified within the Study Area, of which 16 are located directly above LW S7A. A further 27 tanks are located directly above longwalls S1A to S6A under the *Approved Layout* and 24 tanks will not be directly mined beneath by the planned longwalls. The locations and sizes of the tanks were determined from aerial photographs of the area and kerb side inspections. There are also a number of smaller rainwater tanks associated with the houses which are not shown in these drawings.

3.12.2. Predictions for the tanks

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of each tank, as well as at points located at a distance of 20 metres from the perimeter of each tank.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature for each tank within the Study Area due to extraction of LW S7A is provided in Table C.05, in Appendix C. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for each tank within the Study Area after extraction of LWs S1A to S7A is also provided in Table C.07. The predicted tilts provided in this table are the maxima in any direction after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Distributions of the maximum predicted incremental conventional subsidence and tilt for the tanks due to extraction of LW S7A are illustrated in Fig. 3.43, while Fig. 3.44 shows the corresponding distributions of maximum predicted total conventional subsidence and final tilt after extraction of LWs S1A to S7A under the *Modified Layout*.

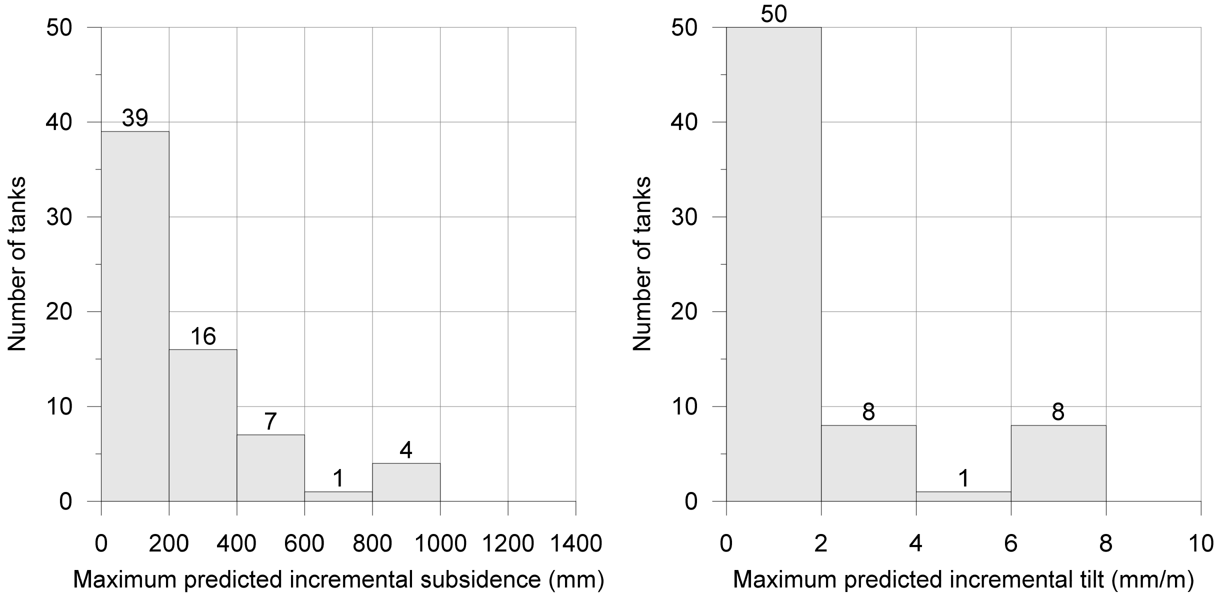


Fig. 3.43 Maximum predicted incremental conventional subsidence and tilt for the tanks within the Study Area due to extraction of LW S7A

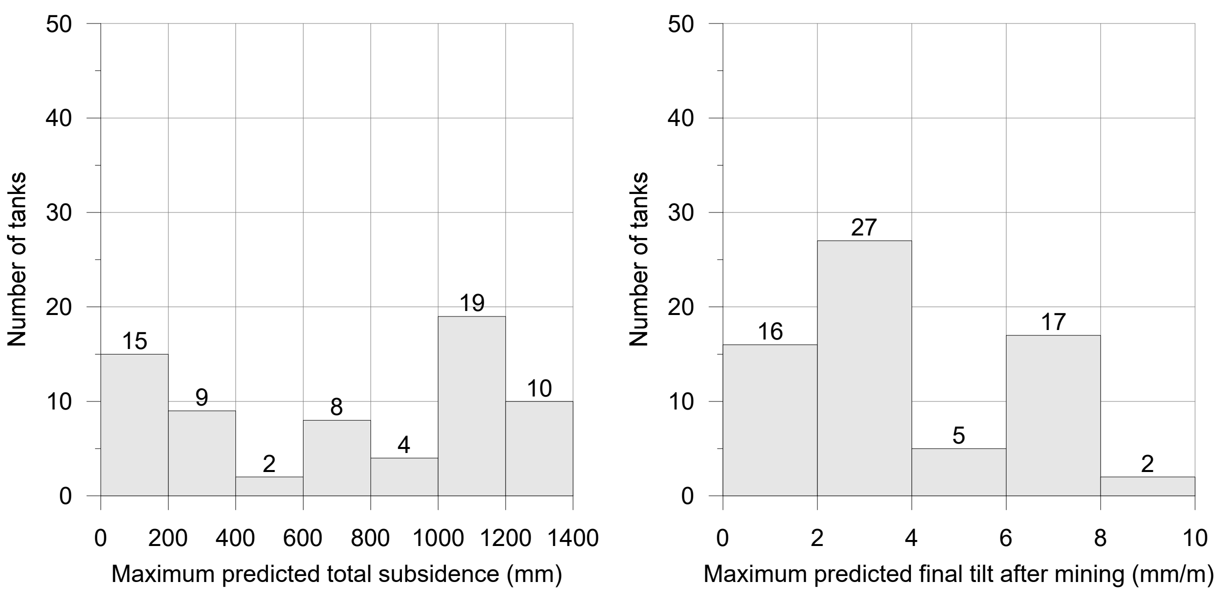


Fig. 3.44 Maximum predicted total conventional subsidence and tilt for the tanks within the Study Area after extraction of LWs S1A to S7A

These distributions indicate that for most tanks in the Study Area (55 out of 67 tanks, or 82% of the total), the maximum predicted incremental subsidence due to LW S7A is a relatively small proportion of the maximum predicted total subsidence after extraction of LWs S1A to S7A. Similarly, the maximum predicted incremental tilt due to LW S7A is relatively small (< 2 mm/m) for most tanks in the Study Area (50 out of 67 tanks, or 75% of the total).

Distributions of the maximum predicted incremental conventional hogging and sagging curvatures for the tanks due to extraction of LW S7A are illustrated in Fig. 3.45, while Fig. 3.46 shows the corresponding distributions of maximum predicted total conventional hogging and sagging curvatures after extraction of LWs S1A to S7A under the *Modified Layout*.

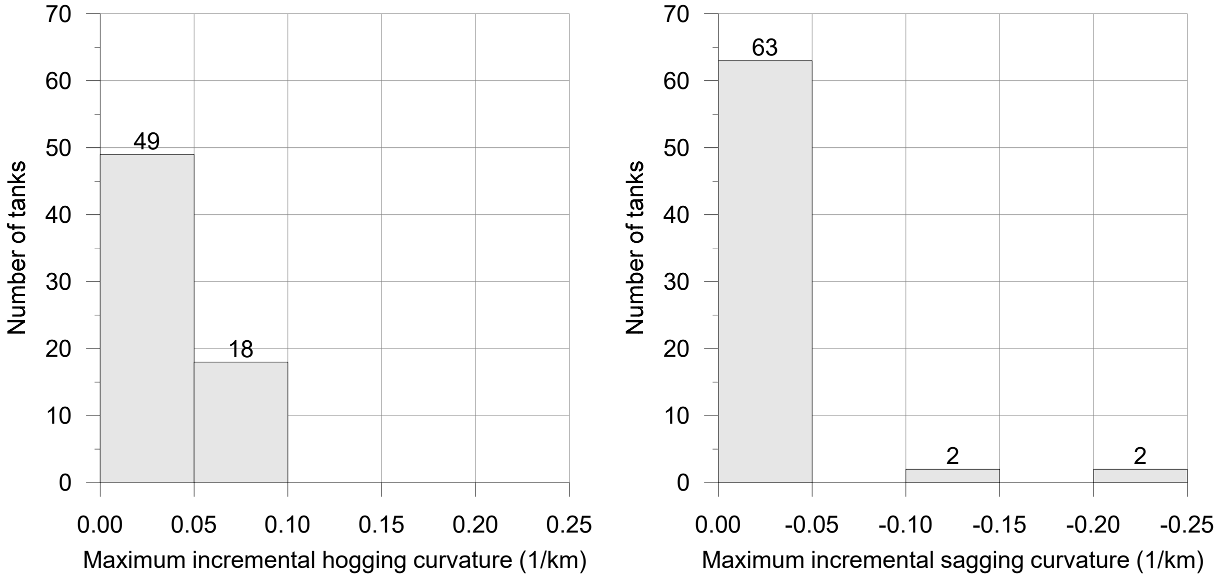


Fig. 3.45 Maximum predicted incremental conventional hogging curvature (left) and sagging curvature (right) for the farm dams within the Study Area due to extraction of LW S7A

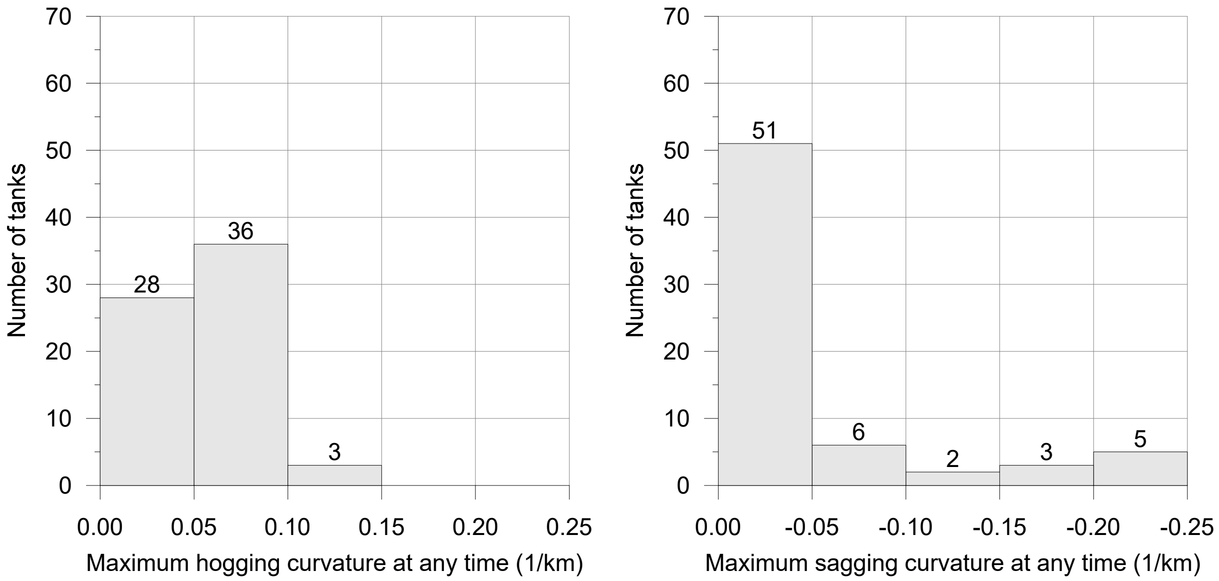


Fig. 3.46 Maximum predicted conventional hogging curvature (left) and sagging curvature (right) for tanks within the Study Area due to extraction of LW S7A

These distributions show that the maximum predicted incremental hogging curvature due to LW S7A is < 0.10 km^{-1} for almost all of the tanks in the Study Area (64 out of 67 pools, or 96% of the total), and the maximum predicted incremental sagging curvature due to LW S7A is < 0.05 km^{-1} for 51 out of 67 tanks (or 76 %).

The maximum predicted conventional strains for the tanks, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.8 mm/m tensile and 3.5 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Section 2.5 includes those resulting from both conventional and non-conventional anomalous movements.

The tanks are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 2.5. The results for survey bays located above goaf are provided in Fig. 2.6 and the results for survey bays located above solid coal are provided in Fig. 2.8.

3.12.3. Impact assessments for the tanks

Tilt can potentially affect the serviceability of tanks by altering the water levels in the tanks, which can in turn affect the minimum level of water which can be released from the outlets. The maximum predicted conventional tilt for the tanks within the Study Area is 8.5 mm/m (i.e. 0.85 %), which represents a change in grade of 1 in 118. The predicted changes in grade are small and unlikely, therefore, to result in any adverse impacts on the serviceability of the tanks.

The tanks are typically constructed above ground level and, therefore, are unlikely to experience the curvatures and ground strains resulting from the extraction of the proposed longwalls. It is possible that any buried water pipelines associated with the tanks within the Study Area could be impacted by the ground strains, if they are anchored by the tanks, or by other structures in the ground.

Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be easily repaired. With these remedial measures in place, it would be unlikely that there would be any adverse impacts on the pipelines associated with the tanks.

3.12.4. Impact assessments for the tanks based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the tanks would be 17 mm/m (i.e. 1.7 %), or a change in grade of 1 in 59. In this case, the incidence of serviceability impacts, such as changes in the minimum water levels which can be released from the outlets, could increase in the locations of greatest tilt, such as adjacent to the active longwall maingate and adjacent to the ends of the proposed longwalls. Impacts would be expected to be remediated by relevelling the tanks.

If the actual curvatures exceeded those predicted by a factor of 2 times, the incidence of impacts on the tank structures would not be expected to change substantially, as they are not expected to experience these ground movements. The incidence of impacts on the buried pipelines would, however, be expected to increase in the locations directly above the proposed longwalls. Impacts would still be expected to be of a minor nature which could be easily repaired. With these remediation measures in place, it would be unlikely that there would be long term impacts on the pipelines associated with the tanks.

3.12.5. Management of potential impacts on the tanks

Tahmoor Coal has developed a Subsidence Management Plan to manage potential impacts to tanks during the mining of LWs S1A to S6A under the *Approved Layout*. The management plan provides for identification of tanks in poor pre-mining condition that are hazardous or may become hazardous due to mining, and monitoring of structures during active subsidence. If impacts occur, the structure will be repaired in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

The Subsidence Management Plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that tanks can be maintained at all times due to the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.13. Farm dams

There are 20 farm dams (Structure Type D) which have been identified within the Study Area and their locations are shown in Drawing No. MSEC1348-11. The maximum plan dimensions and plan areas for these dams are provided in Table C.07, in Appendix C.

The locations and sizes of the farm dams were determined from aerial photographs of the area. The distributions of the longest lengths and surface areas of the farm dams within the Study Area are shown in Fig. 3.47.

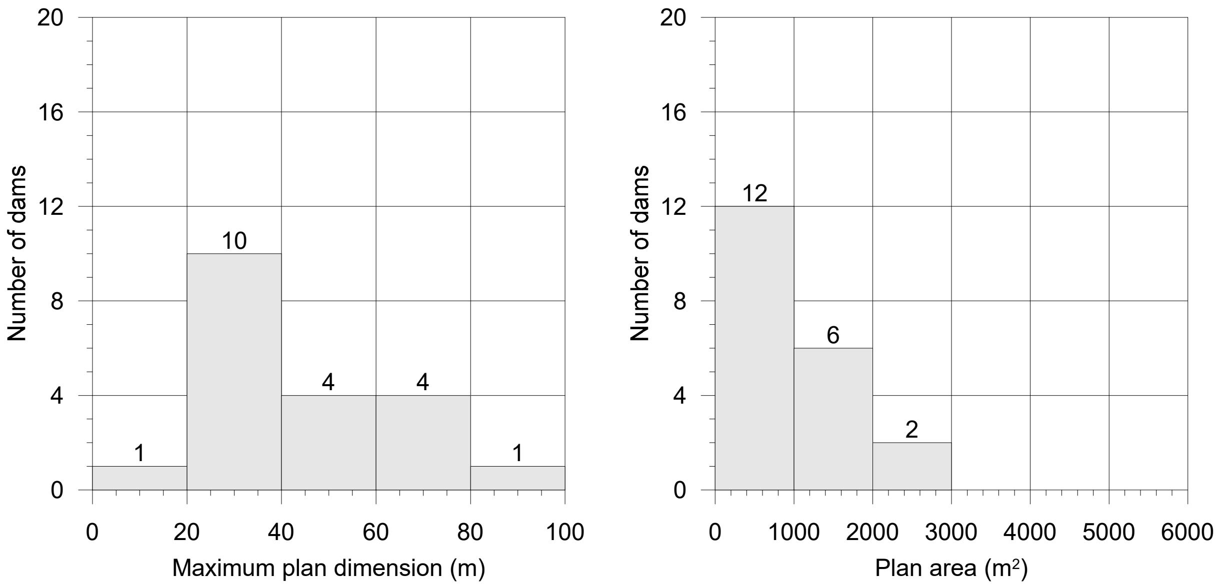


Fig. 3.47 Distributions of longest lengths and surface areas of the farm dams

The longest lengths of the farm dams within the Study Area vary between 16 metres and 99 metres and the plan areas vary between 170 m^2 and 2,925 m^2.

The dams are typically of earthen construction and have been established by localised cut and fill operations within the natural streams. The farm dams are generally shallow, with the dam wall heights generally being less than 3 metres.

Only one of these dams is located directly above the proposed LW S7A under the *Modified Layout*. This dam is identified as BYR_095_d01, with a maximum plan dimension of 43 m and a plan area 1,003 m^2. All of the remaining 19 dams located within the current Study Area were predicted to experience some subsidence movements due to extraction of LWs S1A to S6A under the *Approved Layout.*

3.13.1. Predictions for the farm dams

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and around the perimeters of each farm dam, as well as at points located at a distance of 20 metres from the perimeter of each dam.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature for each farm dam within the Study Area due to extraction of LW S7A is provided in Table C.07, in Appendix C. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for each farm dam within the Study Area after extraction of LWs S1A to S7A is also provided in Table C.07. The predicted tilts provided in this table are the maxima in any direction after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Distributions of the maximum predicted incremental conventional subsidence and tilt for the farm dams due to extraction of LW S7A are illustrated in and Fig. 3.51, while Fig. 3.49 shows the corresponding distributions of maximum predicted total conventional subsidence and final tilt after extraction of LWs S1A to S7A under the *Modified Layout*.

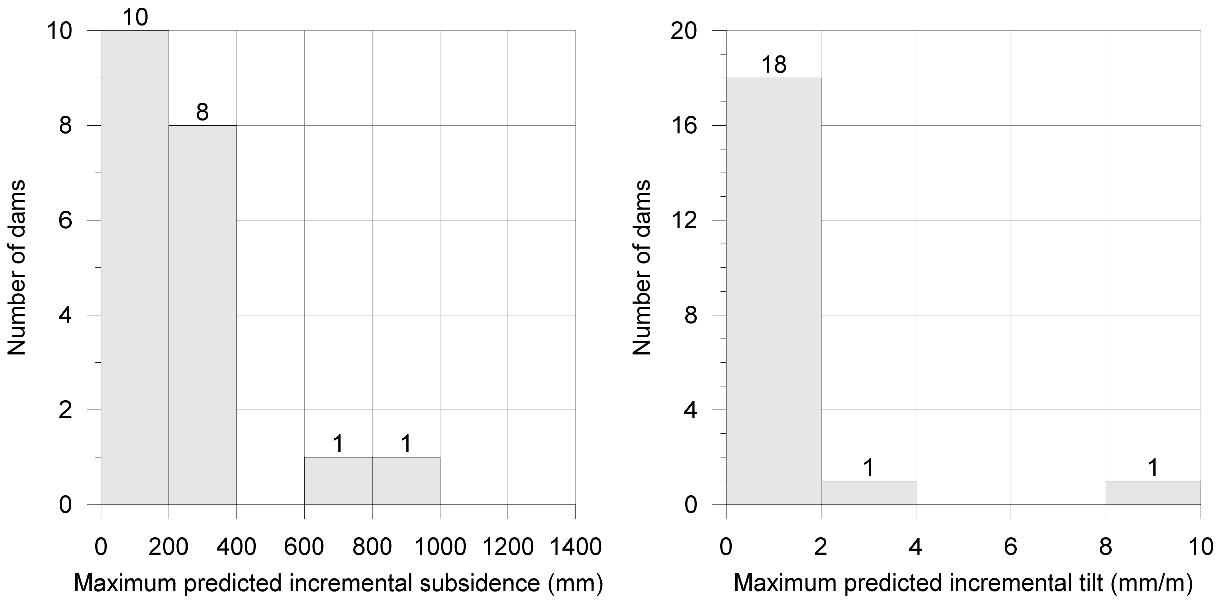


Fig. 3.48 Maximum predicted incremental conventional subsidence and tilt for the farm dams within the Study Area due to extraction of LW S7A

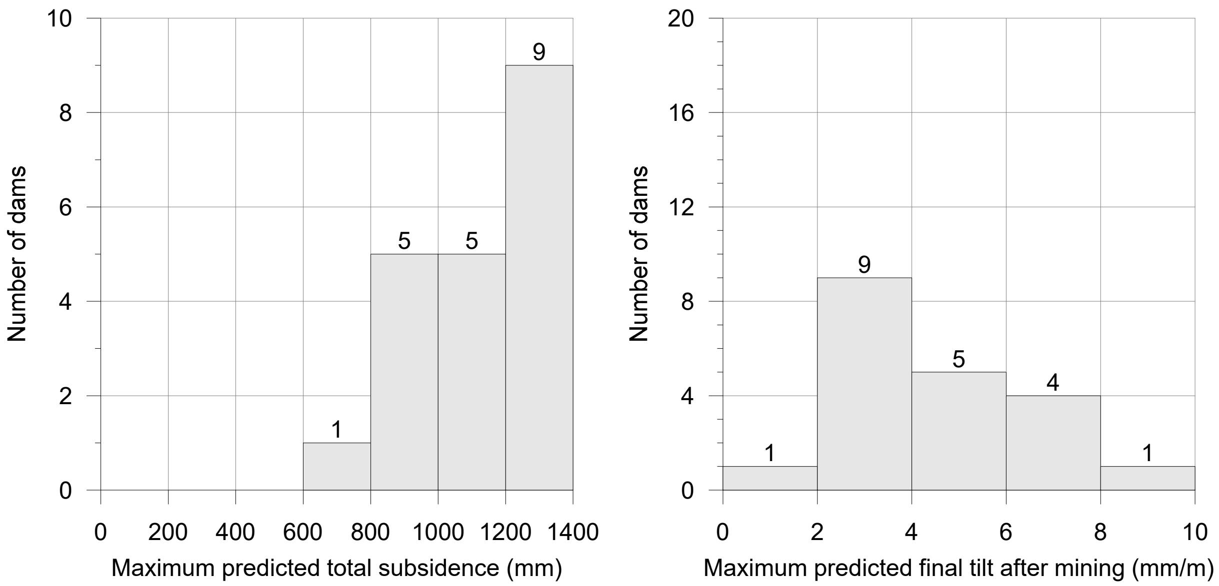


Fig. 3.49 Maximum predicted total conventional subsidence and tilt for the farm dams within the Study Area after extraction of LWs S1A to S7A

These distributions indicate that for most dams in the Study Area (18 out of 20 dams, or 90% of the total), the maximum predicted incremental subsidence due to LW S7A is a relatively small proportion of the maximum predicted total subsidence after extraction of LWs S1A to S7A. Similarly, the maximum predicted incremental tilt due to LW S7A is relatively small (< 2 mm/m) for most dams in the Study Area (18 out of 20 dams, or 90% of the total).

Distributions of the maximum predicted incremental conventional hogging and sagging curvatures for the farm dams due to extraction of LW S7A are illustrated in Fig. 3.50, while Fig. 3.51 shows the corresponding distributions of maximum predicted total conventional hogging and sagging curvatures after the extraction of LWs S1A to S7A under the *Modified Layout*.

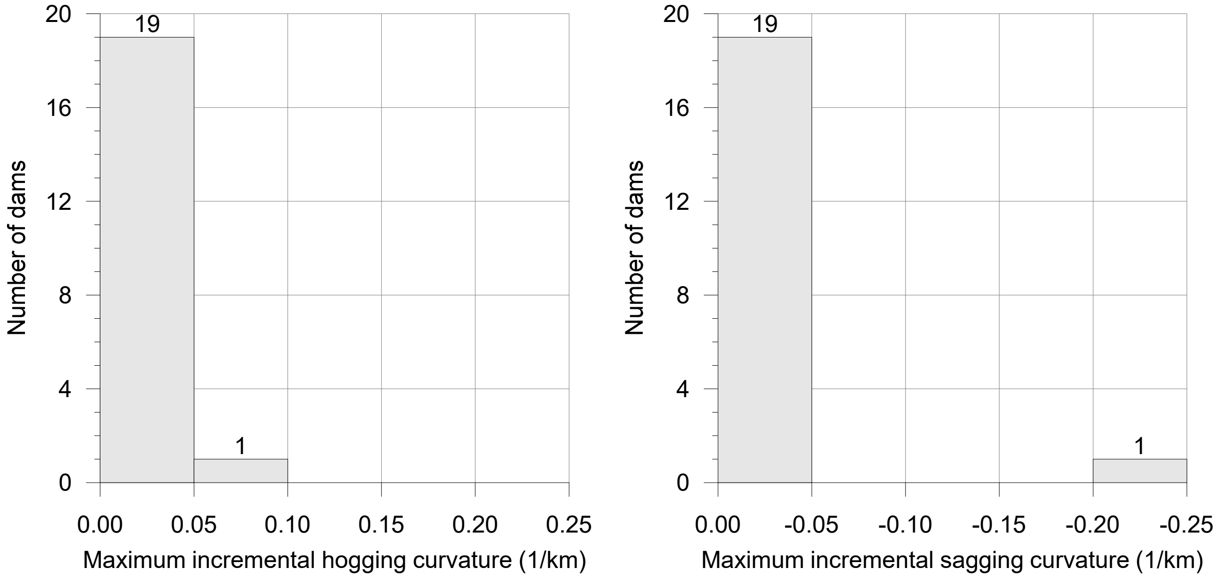


Fig. 3.50 Maximum predicted incremental conventional hogging curvature (left) and sagging curvature (right) for the farm dams within the Study Area due to extraction of LW S7A

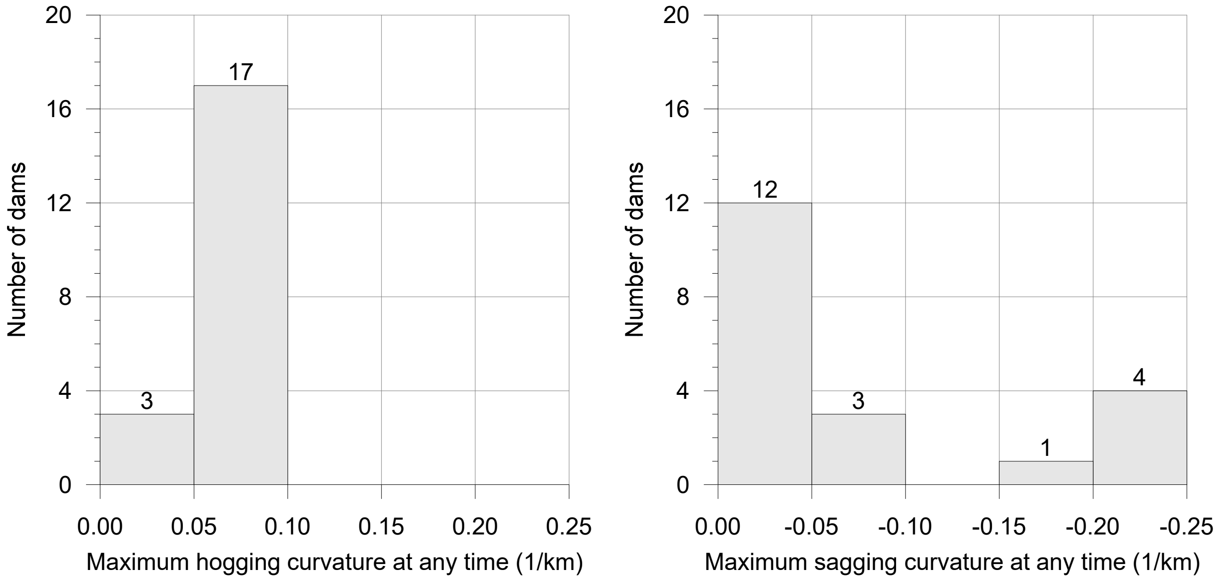


Fig. 3.51 Maximum predicted total conventional hogging curvature (left) and sagging curvature (right) for the farm dams after extraction of LWs S1A to S7A

These distributions show that for most dams in the Study Area (19 out of 20 dams, or 95% of the total), the maximum predicted incremental curvatures due to LW S7A are relatively small (< 0.05 km^{-1}) for both hogging and sagging curvatures. It is only the dam located directly above LW S7A where predicted incremental curvature exceeds 0.05 km^{-1}.

The maximum predicted conventional strains for the farm dams, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.5 mm/m tensile and 3.3 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Section 2.5 includes those resulting from both conventional and non-conventional anomalous movements.

The farm dams are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 2.5. The results for survey bays located above goaf are provided in Fig. 2.6 and the results for survey bays located above solid coal are provided in Fig. 2.8.

The farm dams have typically been constructed within the streams and, therefore, may be subjected to valley related movements resulting from the extraction of the proposed longwalls. The equivalent valley heights at the dams are very small and it is expected, therefore, that the predicted valley related upsidence and closure movements at the dam walls would be much less than the predicted conventional subsidence movements and would not be substantial.

3.13.2. Impact Assessments for the farm dams

The maximum predicted final tilt for the farm dams is 8.5 mm/m (i.e. 0.85 %), which represents a change in grade of 1 in 118. Mining induced tilts can affect the water levels around the perimeters of farm dams, with the freeboard increasing on one side, and decreasing on the other. Tilt can potentially reduce the storage capacity of farm dams, by causing them to overflow, or can affect the stability of the dam walls.

The predicted changes in freeboard at the farm dams within the Study Area were determined by taking the difference between the maximum predicted subsidence and the minimum predicted subsidence anywhere around the perimeter of each farm dam. The predicted maximum changes in freeboard at the farm dams within the Study Area after the completion of longwalls S1A to S7A under the *Modified Layout*, are provided in Table C.07, in Appendix C, and are illustrated in Fig. 3.52.

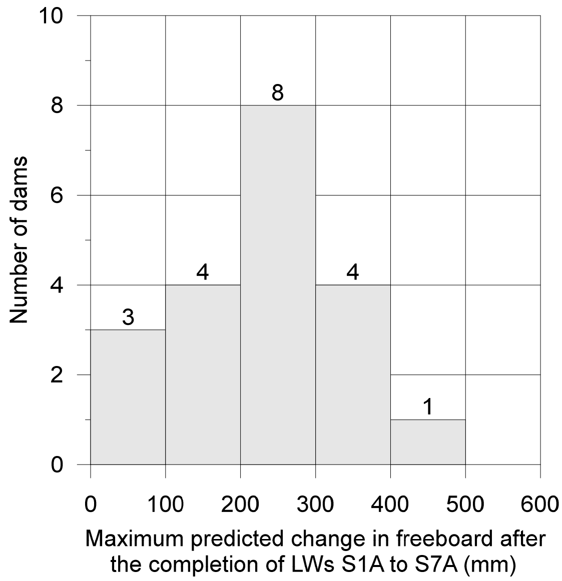


Fig. 3.52 Predicted changes in freeboards for the farm dams within the Study Area

It can be seen from the above figure, that the predicted changes in freeboard are less than 300 mm at 15 of 20 dams (i.e. 75 % of the total), and less than 500 mm at all 20 dams located within the Study Area, including the dam located directly above LW S7A. It is unlikely that the majority of the farm dams within the Study Area would experience adverse impacts on the storage capacities due to these small changes in freeboard. However, any reduced storage levels could be remediated by increasing the height of the affected dam wall.

The maximum predicted conventional curvatures for farm dams under the *Modified Layout* are 0.10 km^{-1} hogging and 0.23 km^{-1} sagging, which represent minimum radii of curvature of 10.0 kilometres and 4.3 kilometres, respectively. These are similar to the maximum predicted curvatures (0.14 km^{-1} hogging and 0.22 km^{-1}) and minimum radii of curvature (7.1 kilometres and 4.5 kilometres, respectively) under the *Approved Layout*. The predicted curvatures and strains could be sufficient to result in cracking in the bases and walls of some farm dams within the Study Area.

There is extensive experience of mining directly beneath farm dams in the Southern Coalfield, which indicates that the incidence of impacts on these features is very low. Farm dams are commonly constructed with cohesive materials in the bases and walls which can absorb the conventional subsidence movements typically experienced in the Southern Coalfield without the development of substantial cracking. Non-conventional movements can result in localised cracking and deformations at the surface and, where coincident with farm dams, could result in adverse impacts.

Tahmoor Coal has mined LW22 to LW32 and LW W1-W3 beneath approximately 110 dams. While a small number of landowners have advised of impacts, there has been one claim to SA NSW for impacts on farm dams at the time of the report.

Similarly, South32 Illawarra Coal has mined directly beneath more than 200 farm dams in Appin Area 3, Appin Area 4, Appin Area 7, Appin Area 9 and West Cliff Area 5. Loss of water was reported for one dam in Appin Area 7, however, it was noted that this dam was of poor, shallow construction and seepage was observed at the base of the dam wall prior to mining.

Whilst the predicted subsidence parameters for the proposed longwalls are greater than those at Tahmoor North and at Appin and West Cliff Collieries, it would still be expected that the rates of impact on the farm dams would be very low and could be managed with the implementation of suitable management strategies.

Any substantial cracking in the dam bases or walls could be repaired by reinstating with cohesive materials. If any farm dams were to lose water as a result of mining, the mine would provide an alternative water source until the completion of repairs in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

3.13.3. Impact assessments for the farm dams based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the farm dams, at the completion of mining, would be 17 mm/m (i.e. 1.7 %), or a change in grade of 1 in 59. In this case, there would be 9 dams within the *Study Area* (i.e. 45 % of the total) where the predicted change in freeboard was greater than 500 mm. In some cases, the tilts could be sufficient to reduce the capacities of the farm dams below acceptable levels, however, these could be remediated by increasing the heights of the affected dam walls.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, the likelihood and extent of cracking would increase for the farm dams located directly above the proposed longwalls. Any surface cracking would still be expected to be of a minor nature and could be readily repaired by reinstating with cohesive materials. If any farm dams were to lose water as a result of mining, the mine would provide an alternative water source until the completion of repairs in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

3.13.4. Management of potential impacts on the farm dams

Tahmoor Coal has developed a Subsidence Management Plan to manage potential impacts to farm dams during the mining of LWs S1A to S6A under the *Approved Layout*. The management plan includes an assessment of potential environmental or safety consequences as a result of dam breach. The management plan provides for visual monitoring of dams immediately prior to and after active subsidence at each dam.

If impacts occur to the dams, Tahmoor Coal will supply water to the landowner on a temporary basis until the dam is repaired in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

The Subsidence Management Plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that dams can be maintained at all times due to the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.14. Commercial and business establishments

A total of 29 structures are located within the Study Area that are used for commercial or business purposes by three different establishments. These are Bargo Valley Produce, Ingham Turkey Farm and the Canine Country Club and Cattery. These establishments were included within the Study Area for LWs S1A to S6A under the *Approved Layout.*

As shown in Drawing No. MSEC1348-11, the structures are all located on properties along Yarran Road and 26 of the 29 structures (90 %) will be directly mined beneath by LW S7A under the *Modified Layout*.

3.14.1. Predictions for the commercial and business establishments

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of each structure, as well as at points located at a distance of 20 metres from the perimeter of each structure.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature for each of the commercial structures within the Study Area due to extraction of LW S7A is provided in Table C.09, in Appendix C. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for each of the commercial structures within the Study Area after extraction of LWs S1A to S7A is also provided in Table C.09. The predicted tilts provided in this table are the maxima in any direction after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Distributions of the maximum predicted incremental conventional subsidence and tilt for the commercial structures due to extraction of LW S7A are illustrated in Fig. 3.53, while Fig. 3.54 shows the corresponding distributions of maximum predicted total conventional subsidence and final tilt after extraction of LWs S1A to S7A under the *Modified Layout*.

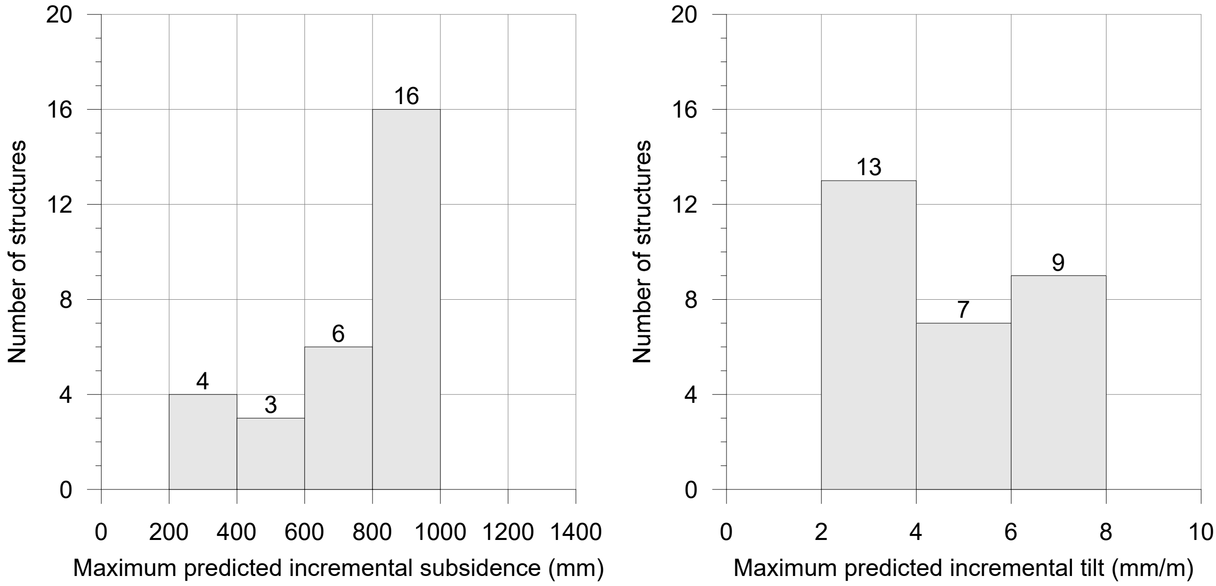


Fig. 3.53 Maximum predicted incremental conventional subsidence and tilt for the commercial structures within the Study Area due to extraction of LW S7A

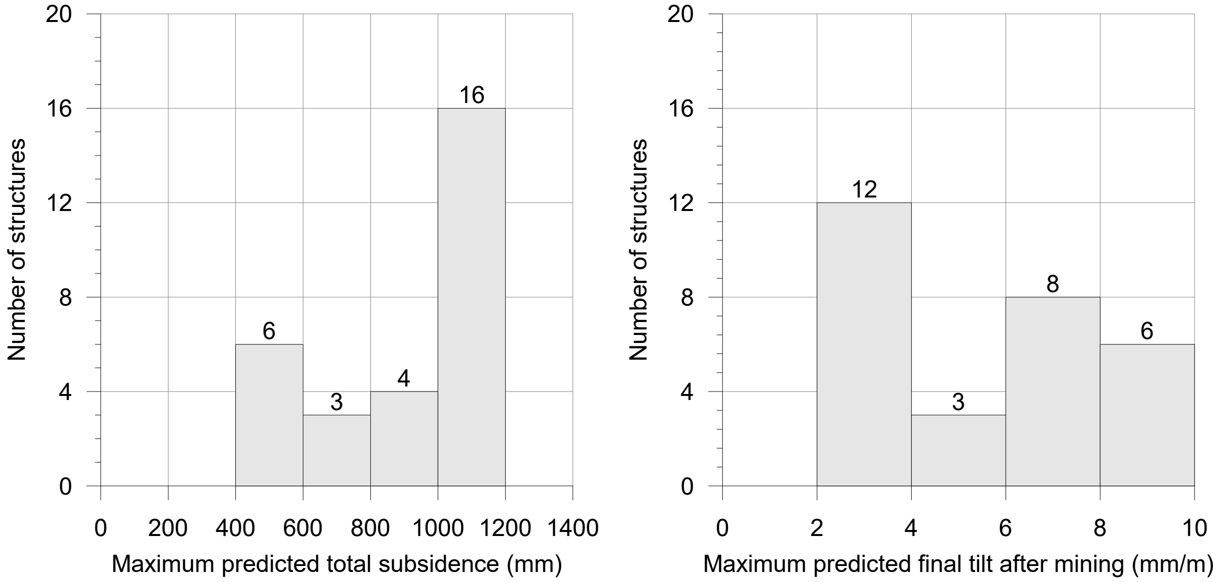


Fig. 3.54 Maximum predicted total conventional subsidence and tilt for the commercial structures within the Study Area after extraction of LWs S1A to S7A

These distributions indicate that, for the commercial structures in the Study Area the maximum predicted incremental subsidence due to LW S7A is a relatively large proportion of the maximum predicted total subsidence after extraction of LWs S1A to S7A. This is to be expected, as the commercial establishments are located along Yarran Road and most will be directly mined beneath by the proposed LW S7A. Similarly, the distribution of the maximum predicted incremental tilt due to LW S7A is similar to the distribution of the maximum predicted final tilt after extraction of all LWs S1A to S7A under the *Modified Layout.*

Distributions of the maximum predicted incremental conventional hogging and sagging curvatures for the commercial structures due to extraction of LW S7A are illustrated in Fig. 3.55, while Fig. 3.56 shows the corresponding distributions of maximum predicted total conventional hogging and sagging curvatures after extraction of LWs S1A to S7A under the *Modified Layout*.

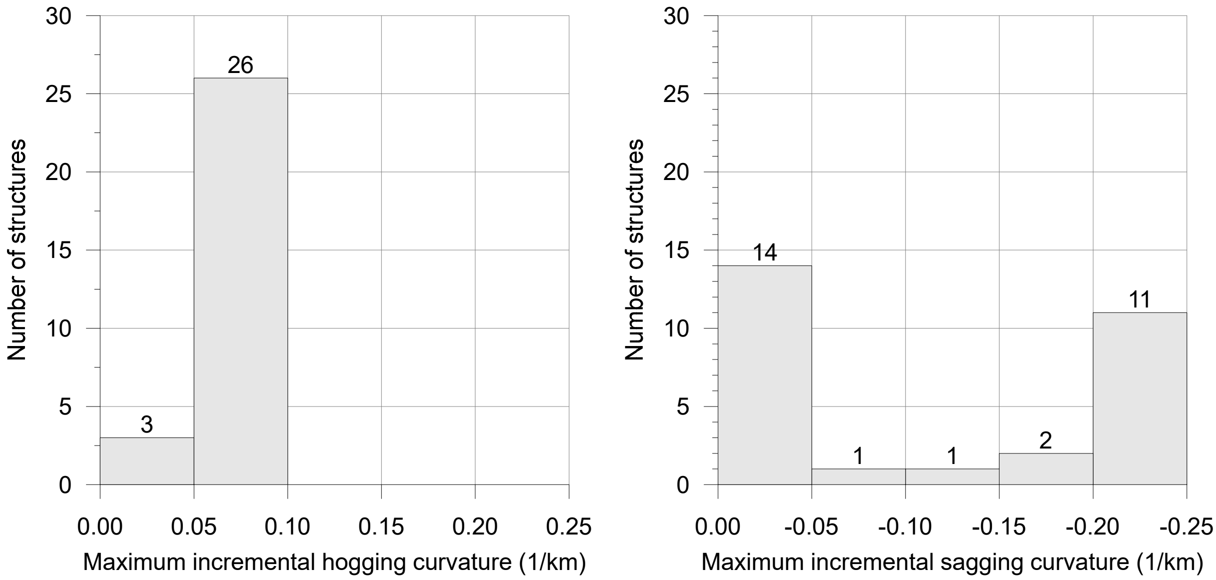


Fig. 3.55 Maximum predicted incremental conventional hogging (left) and sagging (right) curvatures for commercial structures within the Study Area due to extraction of LW S7A

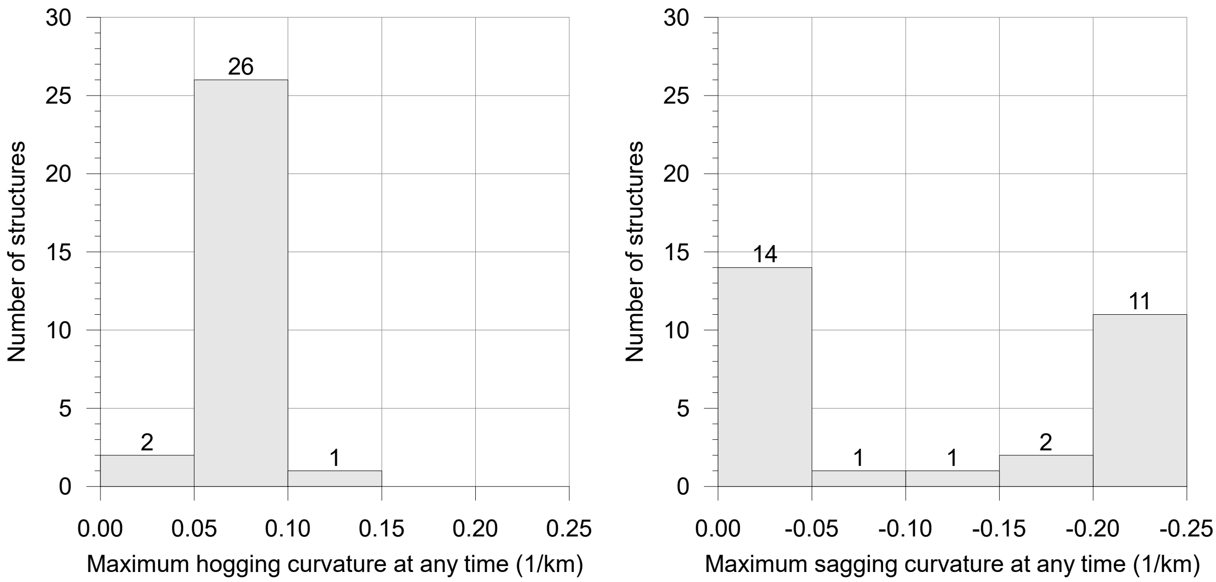


Fig. 3.56 Maximum predicted total conventional hogging curvature (left) and sagging curvature (right) for the commercial structures after extraction of LWs S1A to S7A

As expected, these distributions are almost identical for the maximum predicted incremental and total conventional hogging curvatures. The distributions are in fact identical for the maximum predicted incremental and total conventional sagging curvatures.

The maximum predicted conventional strains for the commercial and business establishments, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.8 mm/m tensile and 3.3 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Section 2.5 includes those resulting from both conventional and non-conventional anomalous movements.

The structures are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 2.5. The results for survey bays located above goaf are provided in Fig. 2.6 and the results for survey bays located above solid coal are provided in Fig. 2.8.

Tahmoor Coal has previously developed and acted in accordance with risk management plans to successfully manage potential impacts to industrial, commercial and business establishments during the mining of LWs 22 to 32, including a turkey processing plant, a large shopping centre, horticultural businesses, industrial and commercial establishments and a variety of shops.

Each business is unique in terms of the structures on the property and the activities that are conducted on each property. For this reason, Tahmoor Coal has committed to developing individual subsidence management plans in consultation with the owners of each business that are predicted to experience more than 20 mm of subsidence due to the extraction of LWs S5A and S6A under the *Approved Layout*. The subsidence management plans will be extended to include the extraction of the proposed LW S7A.

The management strategy for each business would include:

- Consultation with the owner of each business
- Pre-mining hazard identification inspection of each structure by structural engineer
- Identification and assessment of potential impacts to the operation of each business and safety of workers and the general public
- Consideration of mitigation measures to reduce risk prior to the commencement of subsidence movements
- Consideration of appropriate monitoring measures
- Consideration of appropriate triggered responses during mining
- Development of an agreed detailed subsidence management plan between Tahmoor Coal and the owners of each business

Each management plan would be reviewed periodically by Tahmoor Coal and the owners of each business. With an appropriate management plan in place, it is considered that commercial and business establishments can be maintained at all times due to the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

3.15. Swimming pools

The locations of the swimming pools (Structure Type P) within the Study Area are shown in Drawing No. MSEC1348-11. There are 13 swimming pools have been identified within the Study Area, of which 3 are located directly above LW S7A. A further 8 pools are located directly above longwalls S1A to S6A under the *Approved Layout*. Two pools will not be directly mined beneath by the planned longwalls. The locations and sizes of the pools were determined from orthophotographs of the area.

All of the swimming pools located within the current Study Area were predicted to experience some subsidence movements due to extraction of LWs S1A to S6A under the *Approved Layout*.

One above-ground pool previously identified above the proposed LW S7A has been removed since the structures were previously identified in Report No. MSEC1192 (BYR_055-p01).

3.15.1. Predictions for the swimming pools

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of each pool, as well as at points located at a distance of 20 metres from the perimeter of each pool.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature for each swimming pool within the Study Area due to extraction of LW S7A is provided in Table C.06, in Appendix C. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for each swimming pool within the Study Area after extraction of LWs S1A to S7A is also provided in Table C.06. The predicted tilts provided in this table are the maxima in any direction after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Distributions of the maximum predicted incremental conventional subsidence and tilt for the swimming pools due to extraction of LW S7A are illustrated in Fig. 3.57, while Fig. 3.58 shows the corresponding distributions of maximum predicted total conventional subsidence and final tilt after extraction of LWs S1A to S7A under the *Modified Layout*.

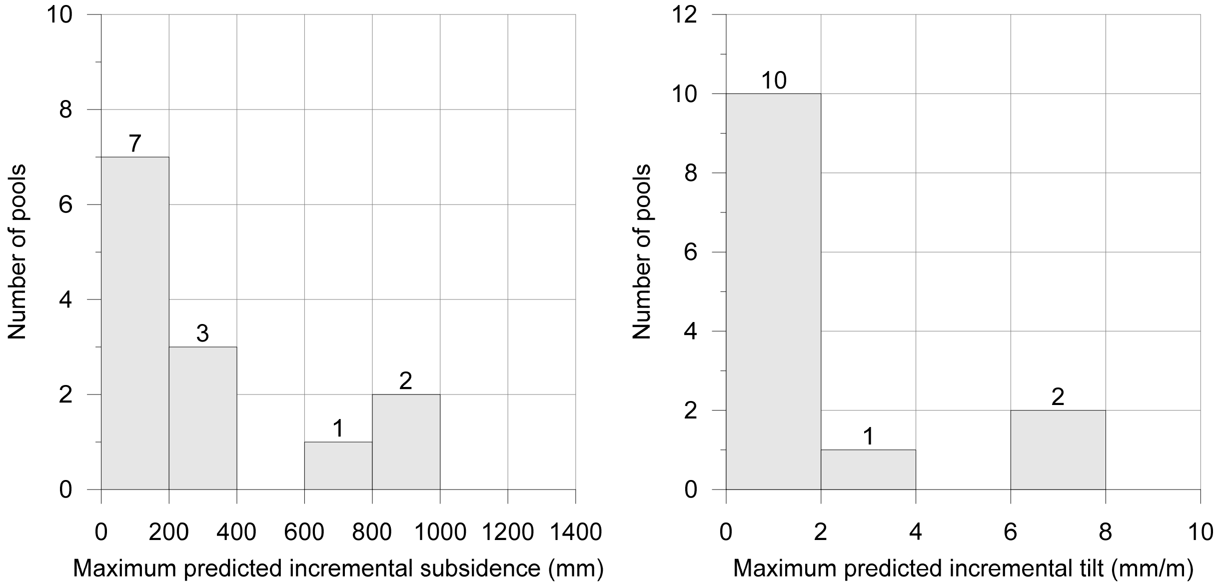


Fig. 3.57 Maximum predicted incremental conventional subsidence and tilt for the swimming pools within the Study Area due to extraction of LW S7A

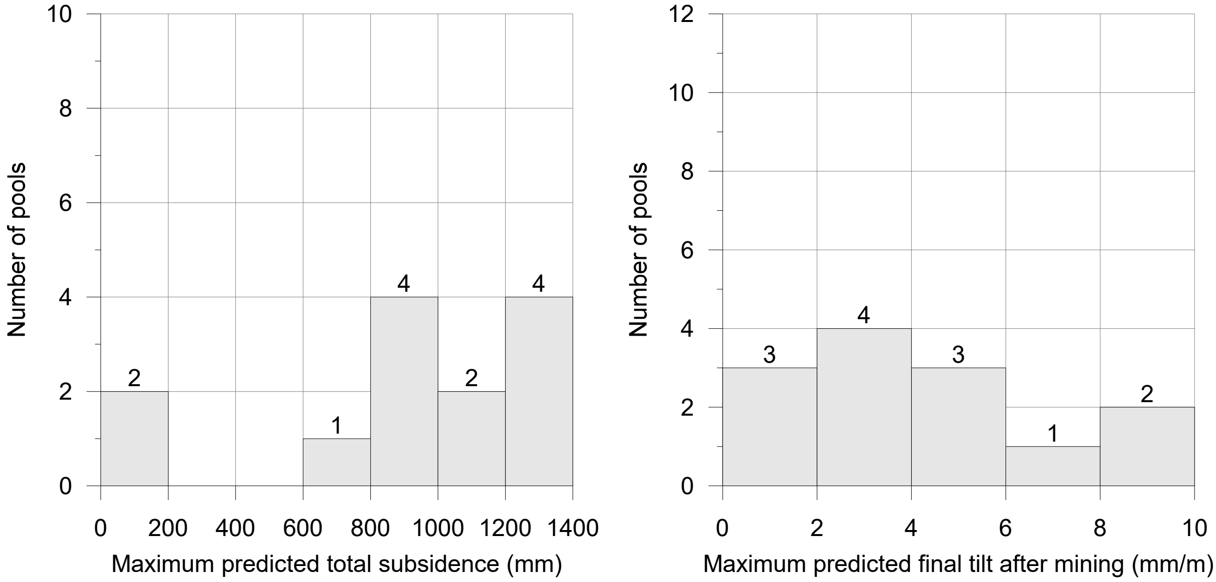


Fig. 3.58 Maximum predicted total conventional subsidence and tilt for the swimming pools within the Study Area after extraction of LWs S1A to S7A

These distributions indicate that for most swimming pools in the Study Area (10 out of 13 pools, or 77% of the total), the maximum predicted incremental subsidence due to LW S7A is a relatively small proportion of the maximum predicted total subsidence after extraction of LWs S1A to S7A. Similarly, the maximum predicted incremental tilt due to LW S7A is relatively small (< 2 mm/m) for most swimming pools in the Study Area (10 out of 13 pools, or 77% of the total).

Distributions of the maximum predicted incremental conventional hogging and sagging curvatures for the swimming pools due to extraction of LW S7A are illustrated in Fig. 3.59, while Fig. 3.60 shows the corresponding distributions of maximum predicted total conventional hogging and sagging curvatures after extraction of LWs S1A to S7A under the *Modified Layout*.

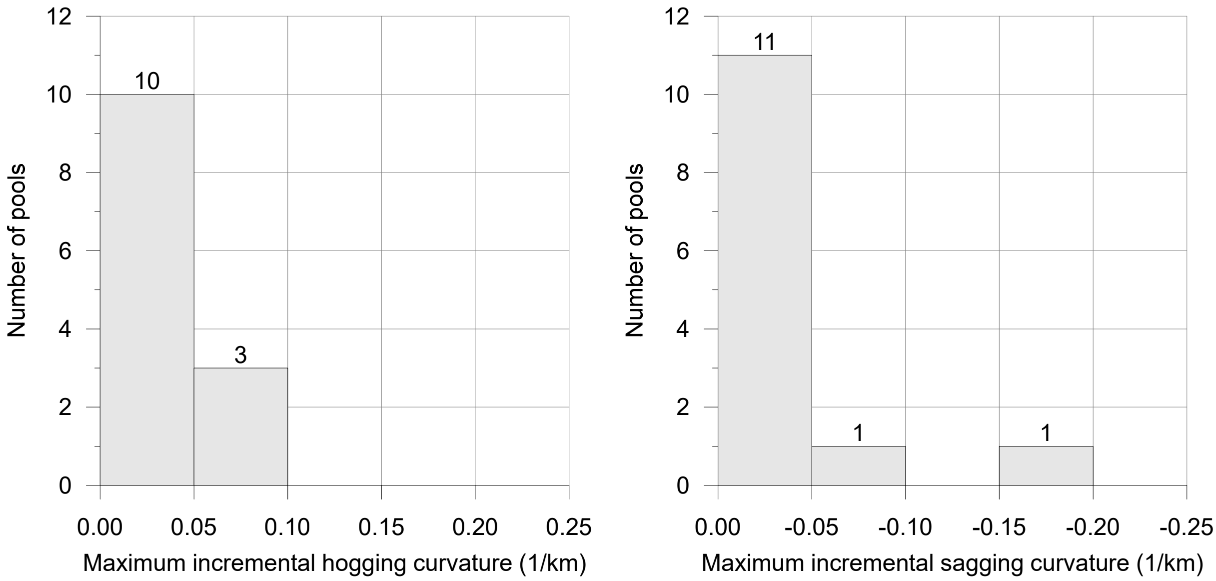


Fig. 3.59 Maximum predicted incremental conventional hogging curvature (left) and sagging curvature (right) for the swimming pools within the Study Area due to extraction of LW S7A

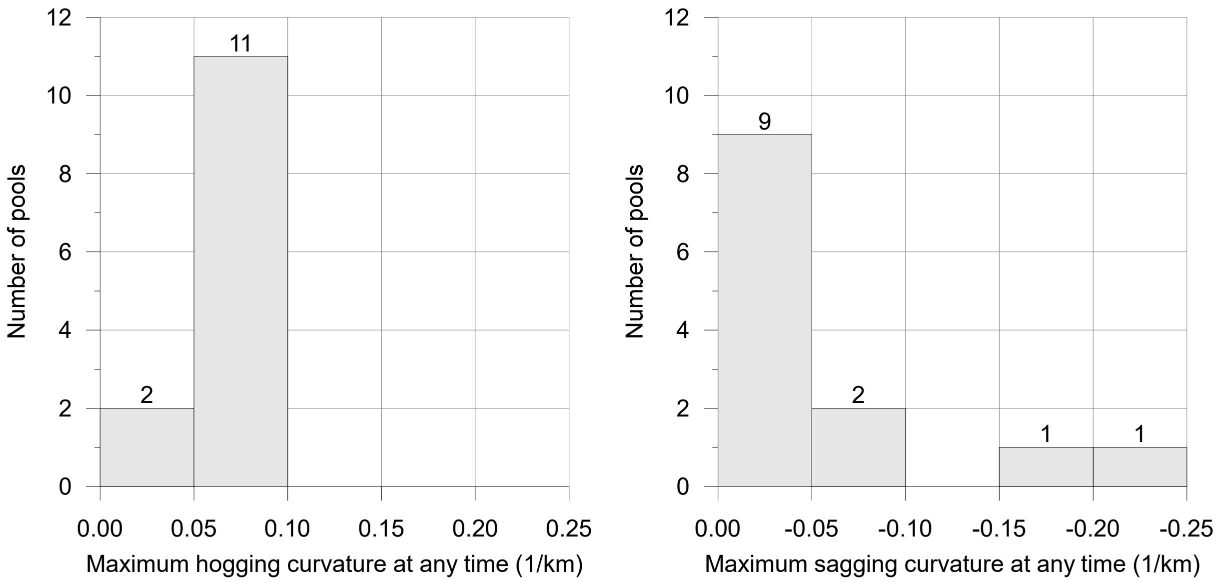


Fig. 3.60 Maximum predicted total conventional hogging curvature (left) and sagging curvature (right) for the swimming pools after extraction of LWs S1A to S7A

These distributions show that for most swimming pools in the Study Area, the maximum predicted incremental hogging curvature due to LW S7A is relatively small (< 0.05 km^{-1} for 10 out of 13 pools, or 77% of the total), and the maximum predicted incremental sagging curvature due to LW S7A is also relatively small (< 0.05 km^{-1} for 11 out of 13 pools, or 85 %).

The maximum predicted conventional strains for the pools, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.4 mm/m tensile and 3.5 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Section 2.5 includes those resulting from both conventional and non-conventional anomalous movements.

The pools are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 2.5. The results for survey bays located above goaf are provided in Fig. 2.6 and the results for survey bays located above solid coal are provided in Fig. 2.8.

3.15.2. Impact assessments for the swimming pools

Mining-induced tilts are more noticeable in pools than other structures due to the presence of the water line and the small gap to the edge coping, particularly when the pool lining has been tiled. Skimmer boxes are also susceptible of being lifted above the water line due to mining tilt.

The Australian Standard AS2783-1992 (Use of reinforced concrete for small swimming pools) requires that pools be constructed level ± 15 mm from one end to the other. This represents a tilt of approximately 3 mm/m for pools that are 10 metres in length. Australian Standard AS/NZS 1839:1994 (Swimming pools – Pre-moulded fibre-reinforced plastics – Installation) also requires that pools be constructed with a tilt of 3 mm/m or less.

There are 3 pools within the *Study Area* (i.e. 23 % of the total) which are predicted to experience final tilts of 3 mm/m or less, at the completion of the proposed longwalls, which is similar to or less than the Australian Standard.

There are 7 pools (i.e. 54 % of the total) predicted to experience final tilts between 3 mm/m and 7 mm/m and 3 pools (i.e. 23 % of the total) predicted to experience final tilts greater than 7 mm/m. The maximum predicted final tilt for the pools is 8.5 mm/m (i.e. 0.85 %), which represents a change in grade of 1 in 118. It is likely that a number of these pools would require some remediation of the pool copings.

The maximum predicted conventional curvatures for the pools are 0.09 km^{-1} hogging and 0.23 km^{-1} sagging, which equate to minimum radii of curvature of 10.8 kilometres and 4.3 kilometres, respectively. Whilst the predicted subsidence parameters for the proposed longwalls are greater than those at Tahmoor North, it would still be expected that the rates of impact on pools at Tahmoor North would provide a reasonable guide to the likely levels of impact.

Observations during the mining of Tahmoor Mine LWs 22 to 32 have shown that pools, particularly in-ground pools, are more susceptible to severe impacts than houses and other structures. Pools cannot be easily repaired and most of the impacted pools need to be replaced.

As of June 2017, a total of 157 pools have experienced mine subsidence movements during the mining of Tahmoor Mine Longwalls 22 to 30, of which 141 were located directly above the extracted longwalls. A total of 36 pools have reported impacts, all of which were located directly above the extracted longwalls. This represents an impact rate of approximately 23 %. A higher proportion of impacts have been observed for in-ground pools, particularly fibreglass pools. The majority of the impacts related to tilt or cracking, though in a small number of cases the impacts were limited to damage to skimmer boxes or the edge coping.

It is expected that the rate of impact on the pools within the Study Area would be similar, but, slightly greater than those previously experienced at Tahmoor North. Impacts to the pools would be repaired or, if required the pool would be replaced in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

3.15.3. Impact assessments for the swimming pools based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the final tilts would be 3 mm/m or less at 2 pools within the Study Area (i.e. 15 % of the total) at the completion of mining. In this case, there would be 3 pools (i.e. 23 % of the total) predicted to experience final tilts between 3 mm/m and 7 mm/m and 8 pools (i.e. 62 % of the total) predicted to experience final tilts greater than 7 mm/m. It is possible that most of the pools within the Study Area would require some remediation of the coping due to the mining induced tilt, if the actual tilts exceeded those predicted by a factor of 2 times.

If the actual curvatures exceeded those predicted by a factor of 2 times, the incidence of impacts would increase for the pools located directly above the proposed longwalls. While the predicted ground movements are important parameters when assessing the potential impacts on the pools, it is noted that the impact assessments were primarily based on observed rate of impact from Tahmoor North. The overall levels of impact on the pools, resulting from the extraction of the proposed longwalls, are expected to be similar to, but, slightly greater than those observed at Tahmoor North.

3.15.4. Management of potential impacts on the swimming pools

Tahmoor Coal has developed a Subsidence Management Plan to manage potential impacts to swimming pools during the mining of LWs S1A to S6A under the *Approved Layout*. This includes a pre-mining inspection of pools, pool fences and gates and measurement of levels around the pools.

While not strictly related to the pool structure, a number of pool gates have been impacted as the result of the previous extraction of longwalls beneath pools. While the gates can be easily repaired, the worst-case consequence of breaching pool fence integrity could be severe. As a result, Tahmoor Coal inspects the integrity of pool fences once a week for pools that are experiencing active subsidence during mining.

The Subsidence Management Plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

With an appropriate management plan in place, it is considered that pools and pool fences can be maintained at all times due to the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

3.16. Houses

3.16.1. Descriptions of the houses

There are 62 houses that have been identified within the Study Area under the *Modified Layout.* Of these, 49 houses are located directly above the proposed longwalls. The locations of the houses are shown in Drawing No. MSEC1348-11 and details are provided in Tables C.02 and C.03, in Appendix C.

The locations, sizes, and construction details of the houses were determined from orthophotographs of the area in 2017, 2021 and 2023, kerbside inspections in 2013 and *Google Street View®* in February 2021. In some cases, the houses were inspected at the request or consent of the landowners.

Given the medium-term nature of the proposed mining activity, it is likely that there will be a growth and renewal of houses over time. It is likely the total number of houses affected by the extraction of the proposed longwalls will be greater than currently identified. Two houses within the Study Area had been extended since the structures were previously identified in Report No. MSEC1192.

The following provides further discussions on the details of the houses within the Study Area.

Locations

Under the *Approved Layout* there were 65 houses located directly above the proposed LWs S1A to S6A, as shown in Table 3.26. An additional 11 houses are located directly above the proposed S7A under the *Modified Layout*. All of the houses located directly above the proposed LW S7A were already predicted to experience some subsidence movements due to extraction of LWs S1A to S6A under the *Approved Layout.*

Table 3.26 Number of houses located directly above each longwall

Layout	Longwall	Number of houses directly above each proposed longwall
Approved Layout LWs S1A to S6A	LW S1A	0
	LW S2A	1
	LW S3A	13
	LW S4A	20
	LW S5A	20
	LW S6A	11
	Total (LWs S1A to S6A)	**65**
Modified Layout LWs S1A to S7A	LW S7A	11
	Total (LWs S1A to S7A)	**76**

Maximum plan dimension, plan area and height

Distributions of the maximum plan dimensions and plan areas of the houses within the Study Area are provided in Fig. 3.61. The majority of the houses are between 10 metres and 30 metres in length, with an average of 21 metres. The majority of the houses have plan areas between 100 m^2 and 300 m^2, with an average of 240 m^2. These distributions of houses by maximum plan dimension and plan area are similar to the distributions of houses by plan dimension and plan area under the *Approved Layout*.

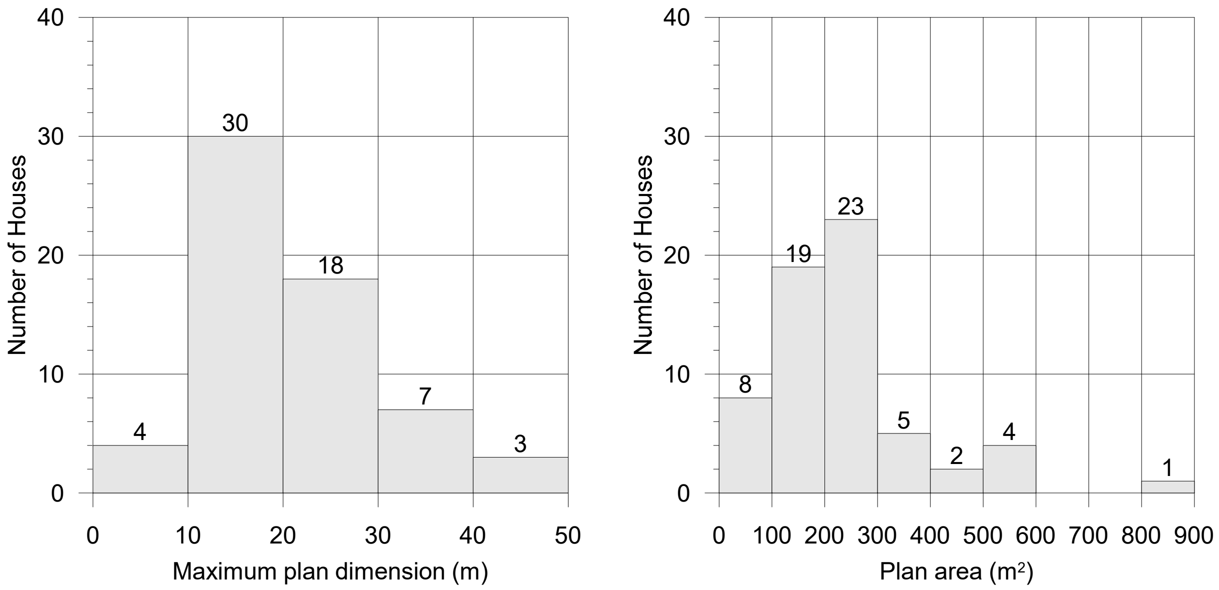


Fig. 3.61 Distribution of houses by maximum plan dimension and plan area

The houses have been categorised into four groups, on the basis of their maximum plan dimension and the number of stories. A summary of these house type categories is provided in Table 3.27 below. It is noted that two-storey houses include split-level houses.

Table 3.27 House type categories

House type	Description	Number	Percentage
H1	Single-storey with maximum plan dimension less than 30 metres	49	79 %
H2	Single-storey with maximum plan dimension of 30 metres or greater	9	15 %
H3	Two-storey with maximum plan dimension less than 30 metres	3	4.5 %
H4	Two-storey with maximum plan dimension of 30 metres or greater	1	1.5 %

It can be seen from the above table that the majority of houses within the Study Area are single-storey with a maximum plan dimension less than 30 metres (i.e. Type H1). There is one two-storey house with a maximum plan dimension greater than 30 metres (i.e. Type H4), which is located on Wellers Road and not directly above the proposed LWs S1A to S7A.

Type of construction

Distributions of the wall and footing construction of the houses within the Study Area are provided in Fig. 3.62. The most common construction method among the houses within the Study Area is brick or brick-veneer (38 houses, or approximately 60 %), followed by weatherboard (20 houses or approximately 32 %). Half of the houses within the Study Area are supported by slab on ground, while 17 of the remaining houses (27 %) have either brick piers or strip footings. The footing type for the remaining houses could not be determined at this point in time from street survey.

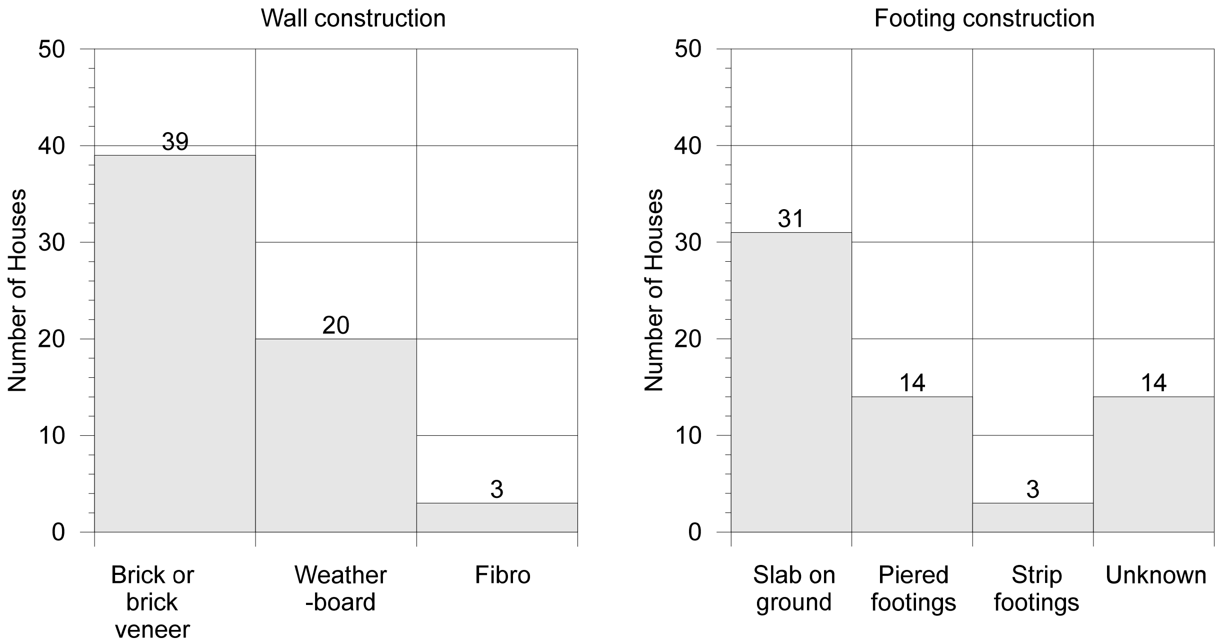


Fig. 3.62 Distributions of wall and footing construction for houses within the Study Area

Following a review of impacts to houses during the mining of Tahmoor Mine Longwalls 22 to 25, it was found that there was a noticeable difference in structural performance in response to mine subsidence movements between the following construction types:-

- Brick or brick-veneer houses constructed on a ground slab;
- Brick or brick-veneer houses constructed on strip footings or piers; and
- Weatherboard or fibro houses constructed on either ground slabs, strip footings or piers.

The distribution of houses construction type within the Study Area is provided in Table 3.28.

Table 3.28 Distribution of houses by construction type

Description	Number of houses	Percentage of houses
Brick or brick-veneer houses constructed on a ground slab	28	45%
Brick or brick-veneer houses constructed on strip footings or piers or foundation type is currently unknown	11	18 %
Weatherboard or fibro houses constructed on ground slabs, strip footings, piers	23	37 %

A map showing the spatial distribution of structures by construction type is provided in Fig. 3.63.

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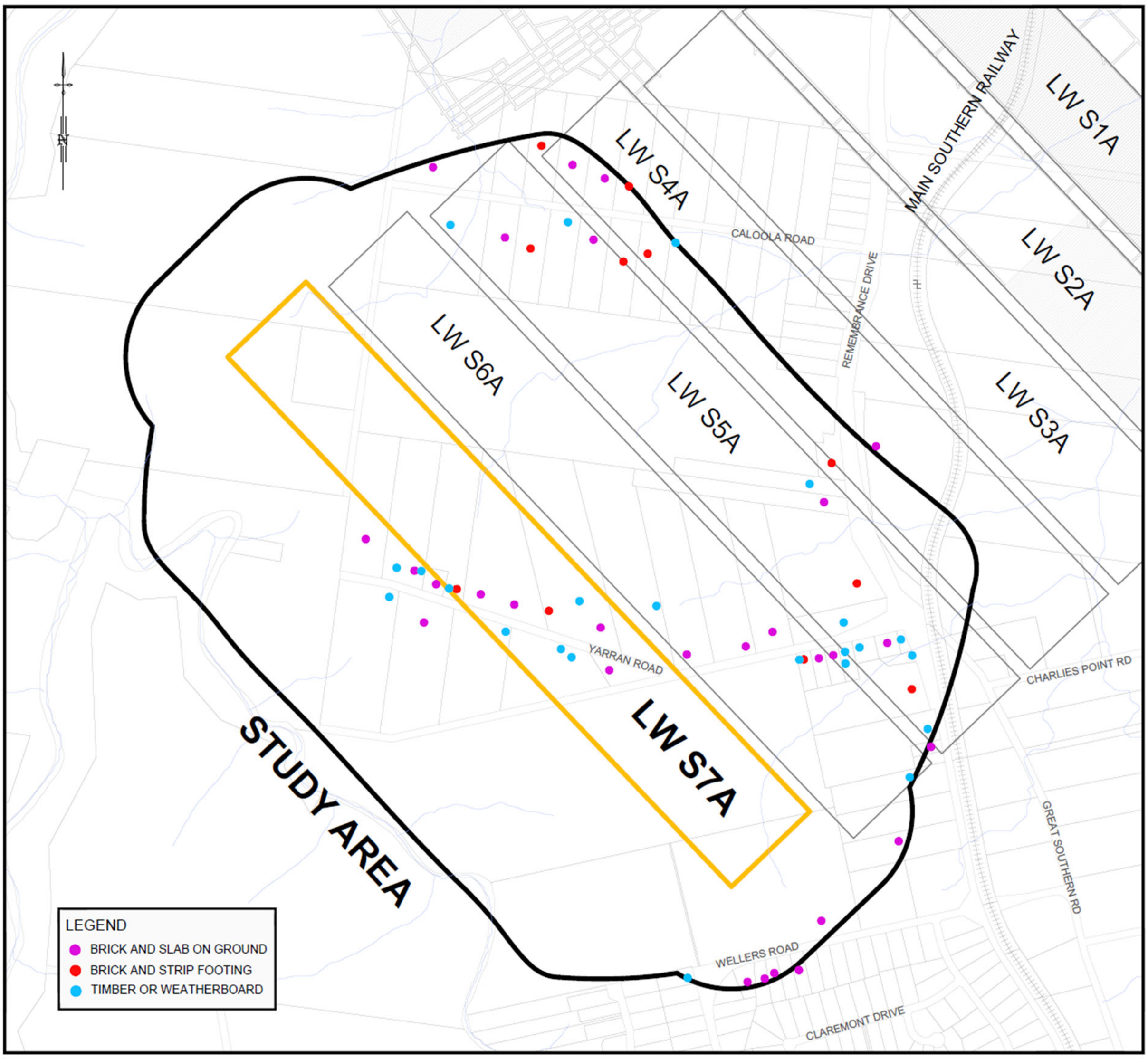


Fig. 3.63 Location of houses by construction type

The information on construction types has been undertaken using *Google Street View®* images and front of house inspections. It is possible that some houses will be renovated or rebuilt before the proposed longwalls are extracted.

As discussed in Section 3.16.3, construction type is an input parameter to the probabilistic method of assessment of impacts.

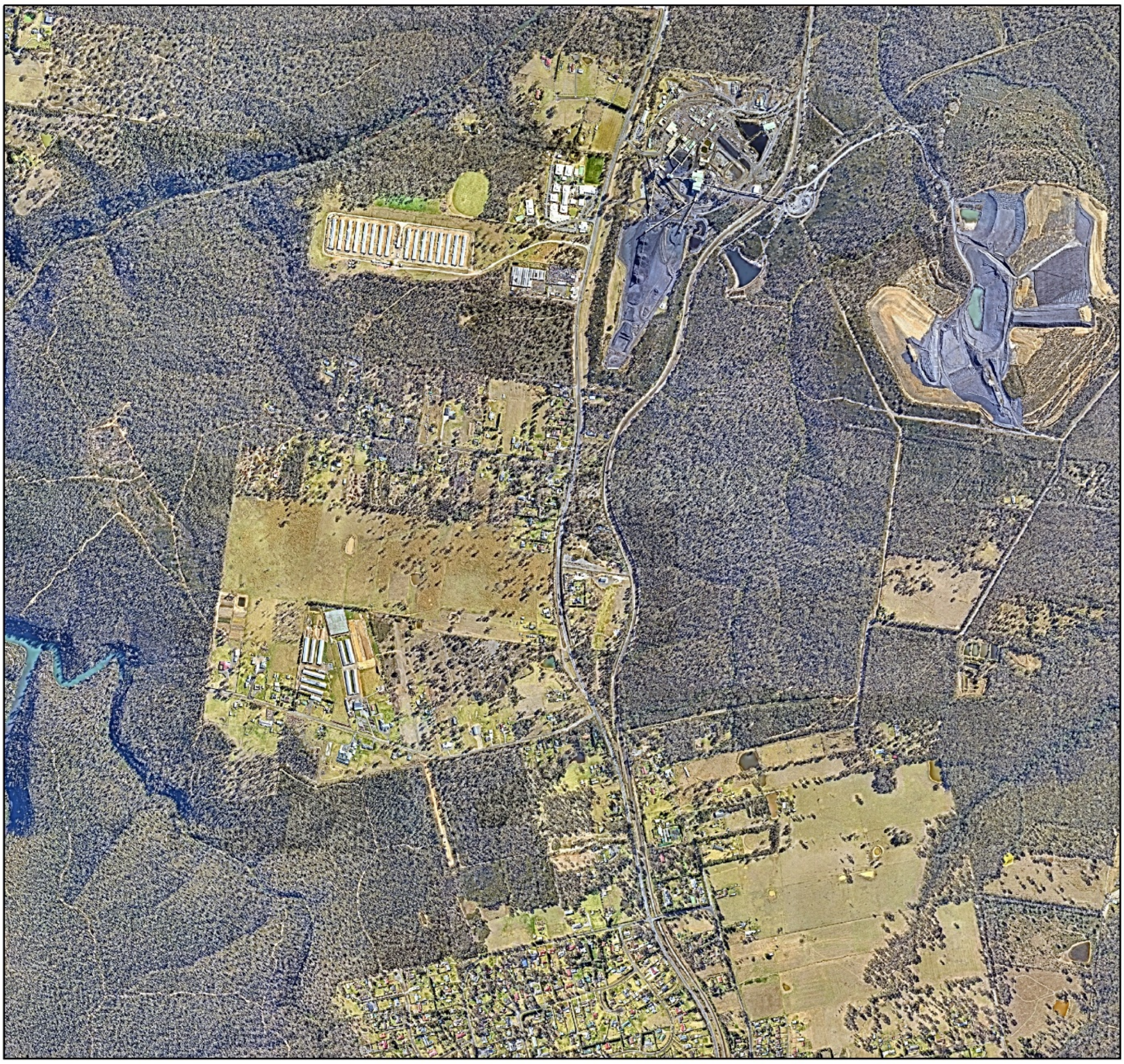
Age of houses

The Bargo area has expanded from a rural township to an urban village, as demonstrated by the following two images. An aerial photograph taken in 1975 is shown in Fig. 3.64. The most recent available aerial photograph in 2021 is shown in Fig. 3.65 for comparison. A large proportion of the houses in the Study Area (65 %) have been built since the Bargo Mine Subsidence District was declared in 1975.

House age has been determined by examination of a series of historical aerial photographs provided by Land and Property Information. The photographs that were available over the Study Area were taken in 1963, 1975, 1984, 1994, 2002 and Tahmoor Mine commissioned orthophotographs over the Study Area in 2013. A Nearmap image taken in 2017 was used to identify houses with the Study Area at the time MSEC's report in support of the original EIS was submitted. A Nearmap image taken in 2021 was used to identify new houses with the Study Area at the time of preparing the Extraction Plan. A Nearmap images taken in 2023 was used to identify new houses with the Study Area at the time of preparing this report.

Photograph courtesy Department of Lands (now Spatial Services NSW)

Fig. 3.64 Aerial photograph of Study Area in 1975 when Mine Subsidence District was declared



Photograph courtesy Nearmap

Fig. 3.65 Aerial photograph of Study Area in 2023

A map showing the spatial distribution of houses by age is provided in Fig. 3.67 and it can be seen that the older houses (tan and magenta coloured marks) are located throughout the Study Area. A histogram showing the distribution of houses by age is shown in Fig. 3.66.

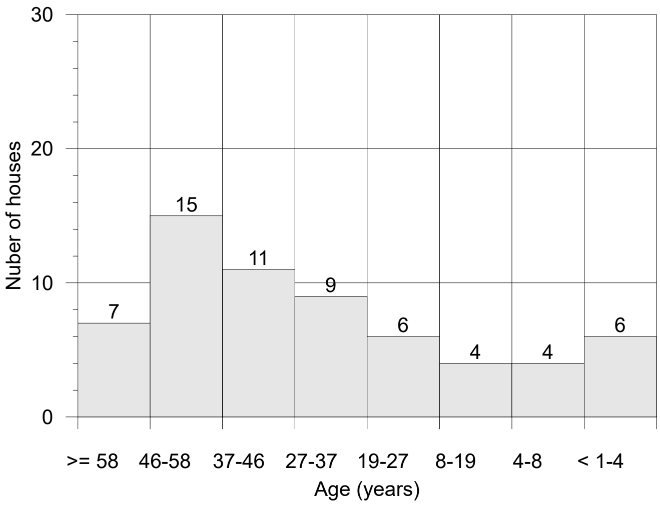


Fig. 3.66 Distribution of Houses by Age as at 2023

It can be seen from Fig. 3.66 that, as at 2021, a large proportion of houses were constructed between 27 and 58 years ago, that is between 1975 and 1994.

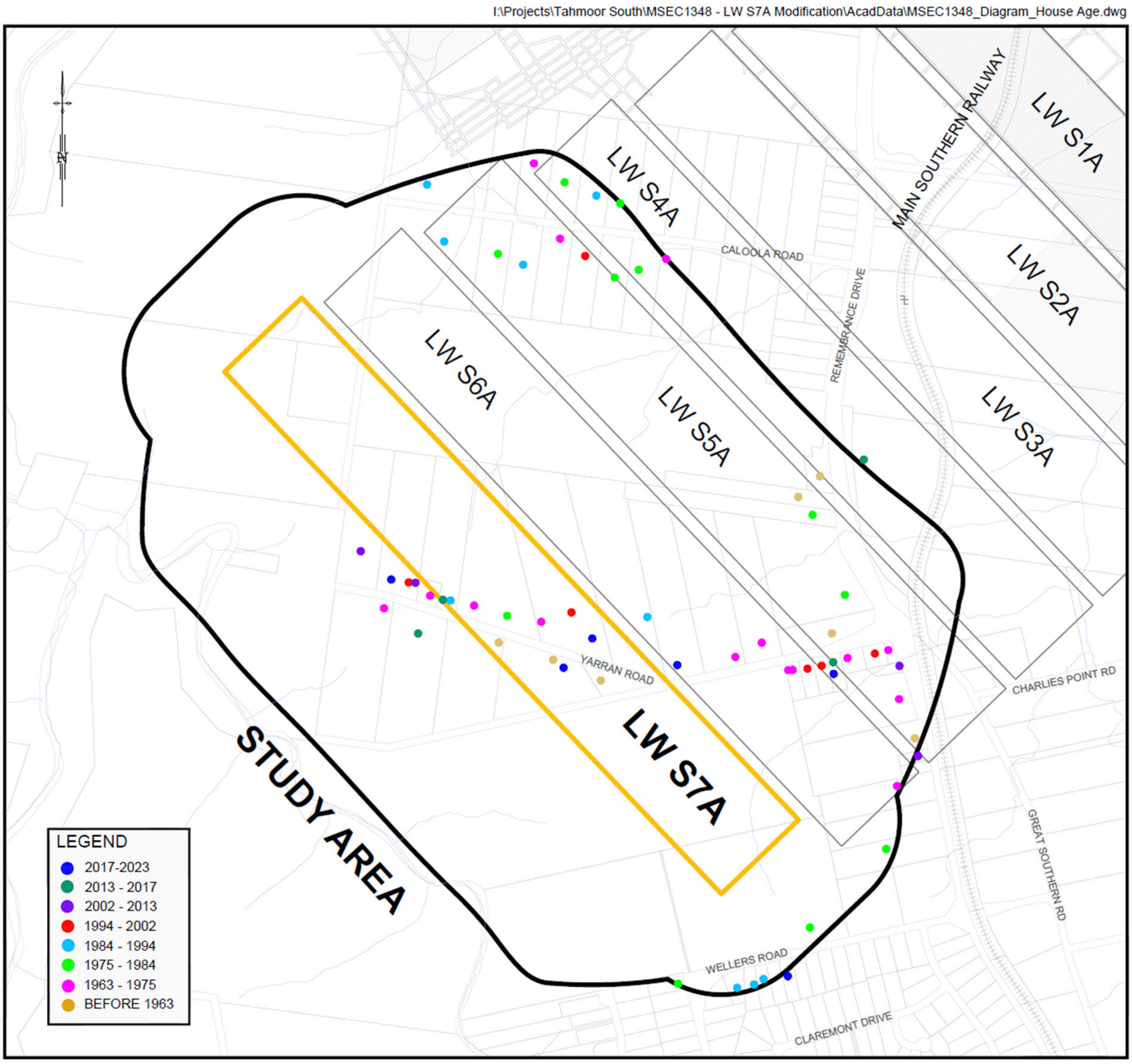


Fig. 3.67 Location of houses by age

3.16.2. Predictions for the houses

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at the vertices of each house, as well as eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for each house within the Study Area, resulting from the extraction of the proposed longwalls, is provided in Table C.03, in Appendix C. The predicted tilts provided in this table are the maxima in any direction after the completion of each longwall. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each longwall.

Distributions of the maximum predicted incremental conventional subsidence for the houses due to extraction of LW S7A are illustrated in Fig. 3.68, while Fig. 3.69 shows the corresponding distributions of maximum predicted total conventional subsidence after extraction of LWs S1A to S7A under the *Modified Layout*.

Distributions of the maximum predicted incremental conventional tilt for the houses due to extraction of LW S7A are illustrated in Fig. 3.70, while Fig. 3.71 shows the corresponding distributions of maximum predicted total conventional tilt during and after extraction of LWs S1A to S7A under the *Modified Layout*.

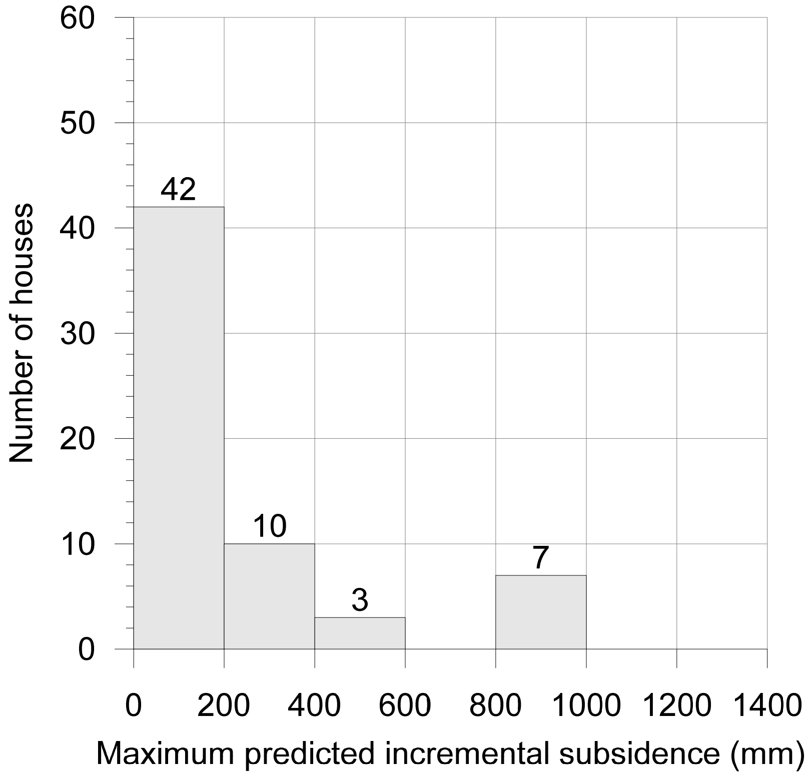


Fig. 3.68 Maximum predicted incremental conventional subsidence for the houses within the Study Area due to extraction of LW S7A

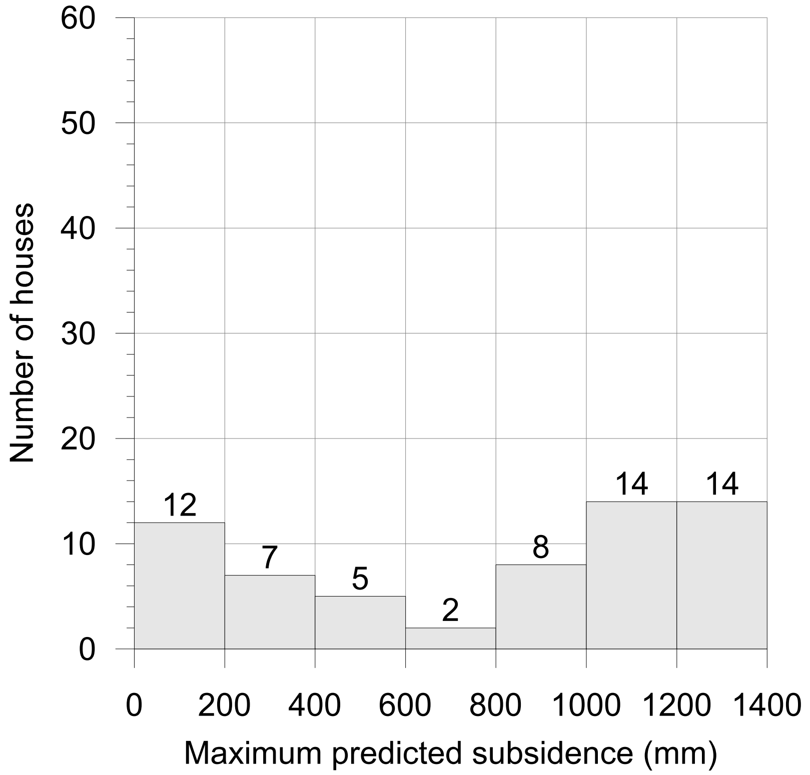


Fig. 3.69 Maximum predicted total conventional subsidence for the houses within the Study Area after extraction of LWs S1A to S7A

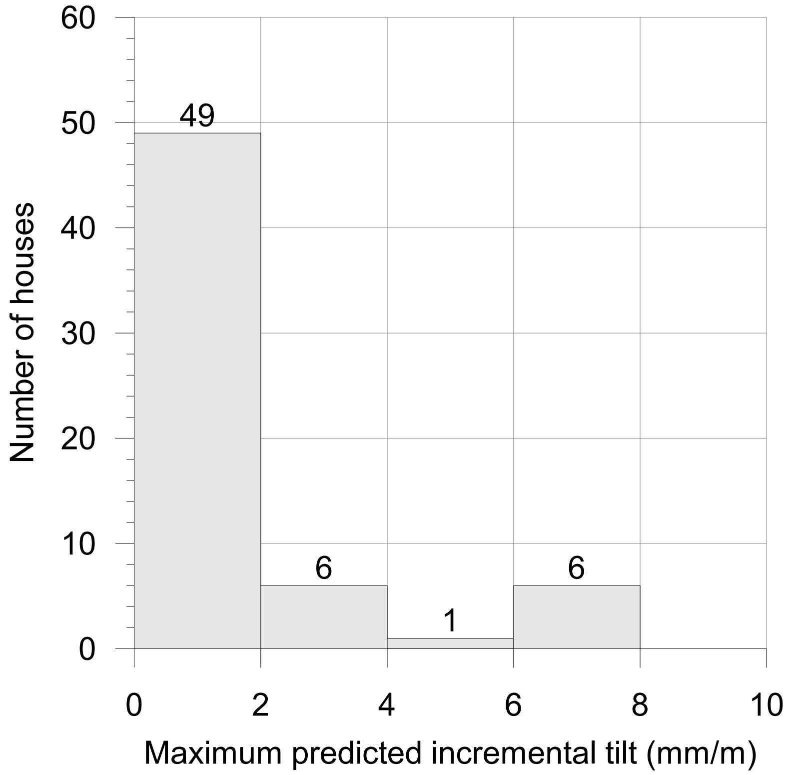


Fig. 3.70 Maximum predicted incremental conventional tilts for the houses within the Study Area due to extraction of LW S7A

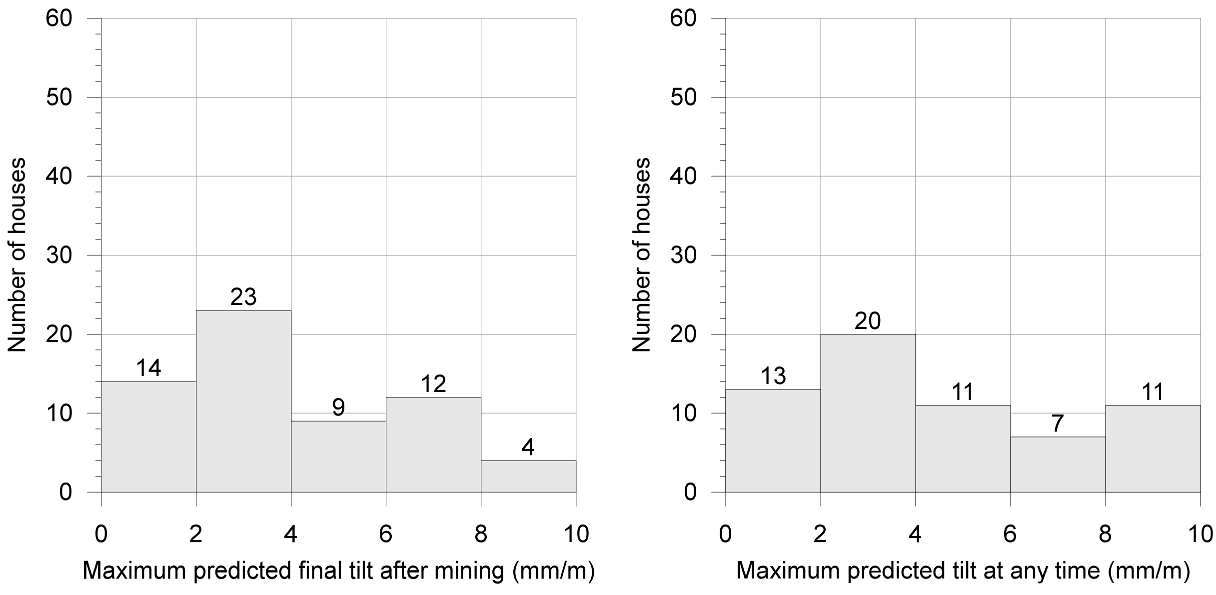


Fig. 3.71 Maximum predicted conventional tilts after the extraction of longwalls S1A to S7A (left) and maximum predicted conventional tilts after extraction of any longwall (right)

These distributions indicate that for most houses in the Study Area (52 out of 62 houses, or 84% of the total), the maximum predicted incremental subsidence due to LW S7A is a relatively small proportion of the maximum predicted total subsidence after extraction of LWs S1A to S7A. Similarly, the maximum predicted incremental tilt due to LW S7A is relatively small (< 2 mm/m) for most houses in the Study Area (49 out of 62 houses, or 79% of the total).

Distributions of the maximum predicted incremental conventional hogging and sagging curvatures for the houses due to extraction of LW S7A are illustrated in Fig. 3.72, while Fig. 3.73 shows the corresponding distributions of maximum predicted total conventional hogging and sagging curvatures after extraction of LWs S1A to S7A under the *Modified Layout*.

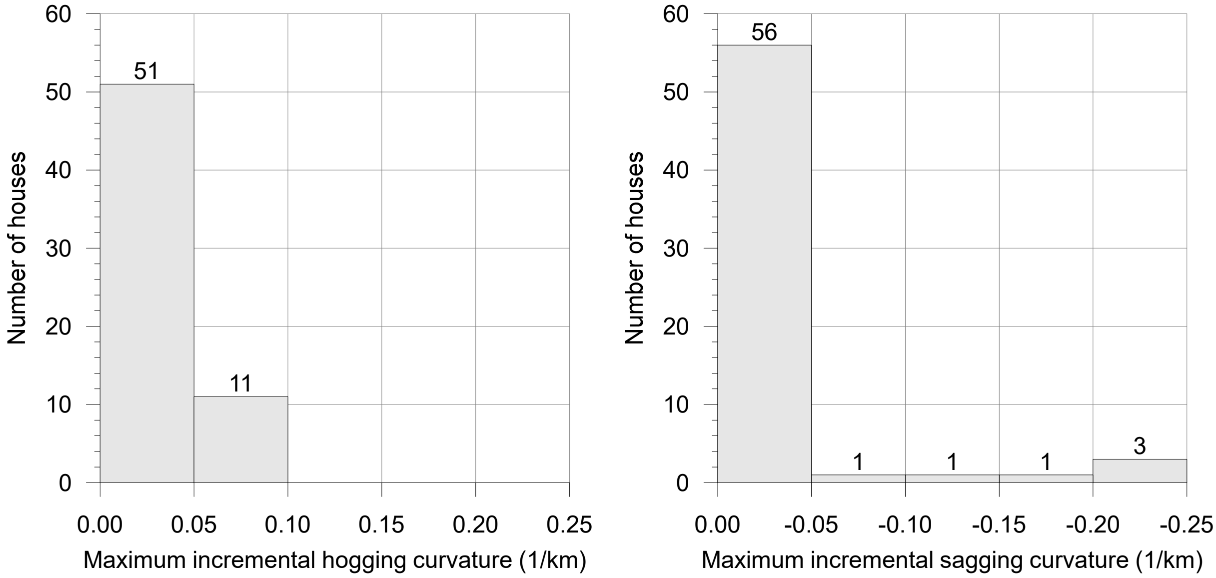


Fig. 3.72 Maximum predicted incremental conventional hogging curvature (left) and sagging curvature (right) for the houses within the Study Area due to extraction of LW S7A

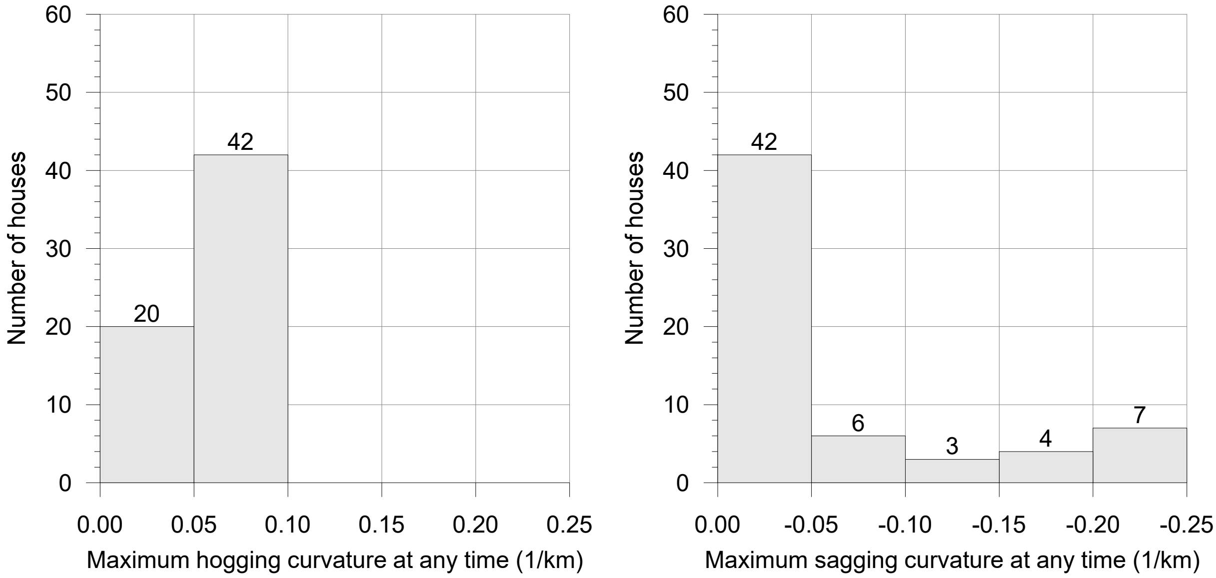


Fig. 3.73 Maximum predicted conventional hogging curvature (left) and sagging curvature (right) for the houses within the Study Area after extraction of LWs S1A to S7A

These distributions show that the maximum predicted incremental hogging curvature due to LW S7A is < 0.10 km^{-1} for all of the houses in the Study Area, and the maximum predicted incremental sagging curvature due to LW S7A is < 0.05 km^{-1} for 56 out of 62 tanks (or 84 %).

The maximum predicted conventional strains for the houses, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.4 mm/m tensile and 3.5 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Section 2.5 includes those resulting from both conventional and non-conventional anomalous movements.

The houses are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 2.5. The results for survey bays located above goaf are provided in Fig. 2.6 and the results for survey bays located above solid coal are provided in Fig. 2.8.

3.16.3. Impact assessments for the houses

The following sections provide the impact assessments for the houses within the Study Area.

Potential impacts resulting from vertical subsidence

Vertical subsidence does not directly affect the stability or serviceability of houses. The potential for impacts on houses is affected by differential subsidence, which includes tilt, curvature and strain, and the impact assessments based on these parameters are described in the following sections.

Vertical subsidence may affect the heights of some the houses above the flood level. The potential impacts on the houses resulting from the changes in flood level from the proposed mining has been assessed as part of the flood model, which is described in the Water Management Plan (Tahmoor Coal, 2023a).

Potential impacts resulting from tilt

It has been found from past longwall mining experience that tilts of less than 7 mm/m generally do not result in any substantial impacts on houses. Some minor serviceability impacts can occur at these levels of tilt, including door swings and issues with roof gutter and wet area drainage, all of which can be remediated using normal building maintenance techniques. Tilts greater than 7 mm/m can result in greater serviceability impacts which may require more substantial remediation measures, including the relevelling of wet areas or, in some cases, the relevelling of the building structure.

The predicted maximum tilts are less than 7 mm/m at 53 of the houses within the Study Area (i.e. 85 % of the total) at the completion of mining. It is expected that only minor serviceability impacts would occur at these houses, as the result of tilt, which could be remediated using normal building techniques.

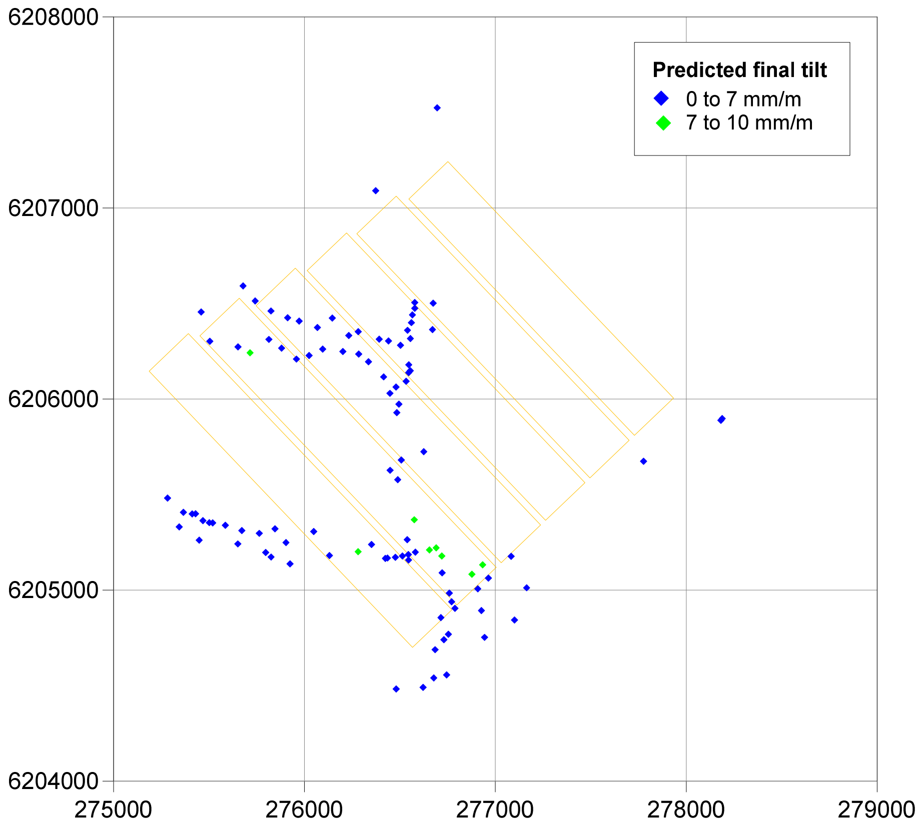
The maximum predicted tilt for the houses is 8.5 mm/m (i.e. 0.85 %, or 1 in 118). A total of 9 houses (i.e. 15 % of the total) are predicted to experience tilts greater than 7 mm/m. The potential for serviceability impacts is greater for these houses. In some cases, more substantial remediation measures may be required, such as relevelling of the building structure.

It should be noted that the effect of extracting LW S7A under the *Modified Layout* is predicted to result in a reduction of tilt for some houses when compared to be *Approved Layout*. This is because mining-induced tilts due to the extraction of LWs S1A to S6A is predicted to be reversed due to the extraction of LW S7A.

The distribution of predicted final tilts for the houses within the Study Area after the extraction of LW S6A is provided in Fig. 3.74 and LW S7A is provided in Fig. 3.75.

It can be seen that some houses that were predicted to experience more than 7 mm/m tilt after the extraction of LW S6A are predicted to experience a reduction in tilt after the extraction of LW S7A.

Houses located above previously extracted longwalls at Tahmoor have experienced mining-induced tilts within the predicted range for the *Amended Layout*. This includes tilts at magnitudes of 10 mm/m and greater, which were observed above Tahmoor Mine LW 24A and above the south-eastern ends of LWs 25 and 26, in the areas of increased subsidence. To date, there have been very few claims to SA NSW for impacts on houses as a result of mining induced tilt. Claims in these areas have mainly been based on impacts resulting from mining induced curvatures or strains.



Note: the image is reproduced from Report No. MSEC1192

Fig. 3.74 Distribution of predicted final tilts for the houses at the completion of LW S6A

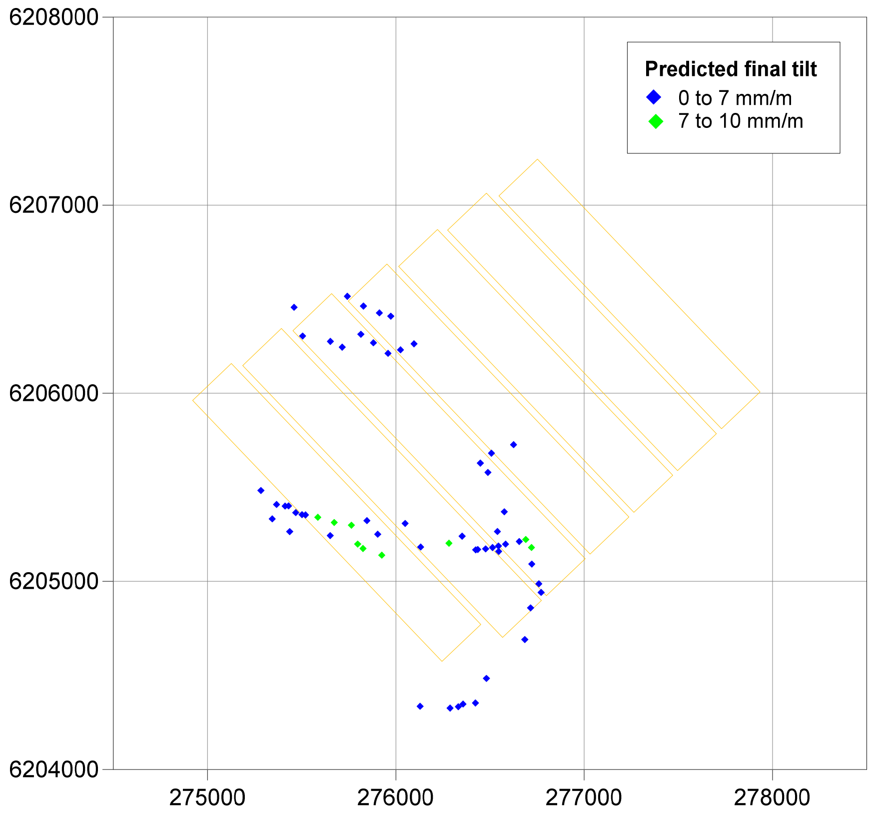


Fig. 3.75 Distribution of predicted final tilts for the houses at the completion of LW S7A

The distribution of measured tilts for the survey bays located in the area of increased subsidence above LWs 24B, 25 and 26, is provided in Fig. 3.76. A gamma function has also been fitted to the observed data which is shown by the blue curve.

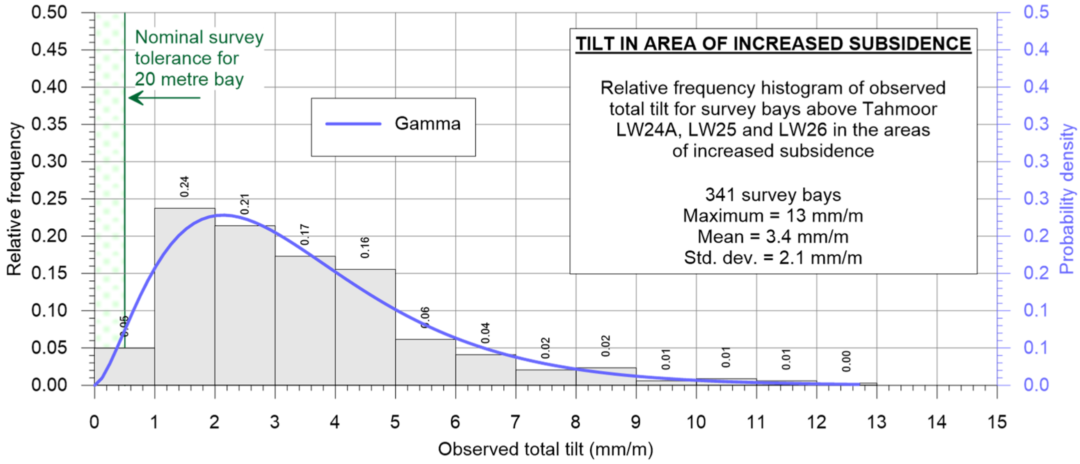


Fig. 3.76 Distribution of measured tilts for survey bays located in the areas of increased subsidence above Tahmoor Mine longwalls 24A, 25 and 26

It can be seen from the above figure, that the maximum observed total tilt for the survey bays in the areas of increased subsidence was 13 mm/m, which is greater than the maximum predicted tilt at the houses directly above the proposed longwalls, which is 9 mm/m.

The range of predicted tilts for the houses within the Study Area, therefore, is less than that observed above previously extracted longwalls at Tahmoor Mine, including LW 24A and above the south-eastern ends of LWs 25 and 26, in the areas of increased subsidence. It is expected that the incidence of claims for impacts resulting from the mining induced tilt would be low, due to the extraction of the proposed longwalls, as was previously experienced in the areas of increased subsidence.

It is expected that, in all cases, the houses within the Study Area will remain in safe and serviceable conditions as the result of the mining induced tilts as tilts by themselves rarely impact on the stability of building structures at the levels that are predicted to occur.

Potential impacts resulting from curvature and strain

It has been found from past longwall mining experience that the majority of mining-induced impacts on houses are a result of curvature and strain.

All 62 houses within the *Study Area* are predicted to experience hogging curvatures less than 0.10 km^{-1} and 48 houses (i.e. 77 % of the total) are predicted to experience sagging curvatures less than 0.10 km^{-1}, which represent minimum radii of curvature of 10 kilometres.

The maximum predicted curvatures for the houses within the *Study Area* are 0.10 km^{-1} hogging and 0.23 km^{-1} sagging, which represent minimum radii of curvature of 10.5 kilometres and 4.3 kilometres, respectively.

The distribution of predicted curvatures for the houses within the Study Area is provided in Fig. 3.77.

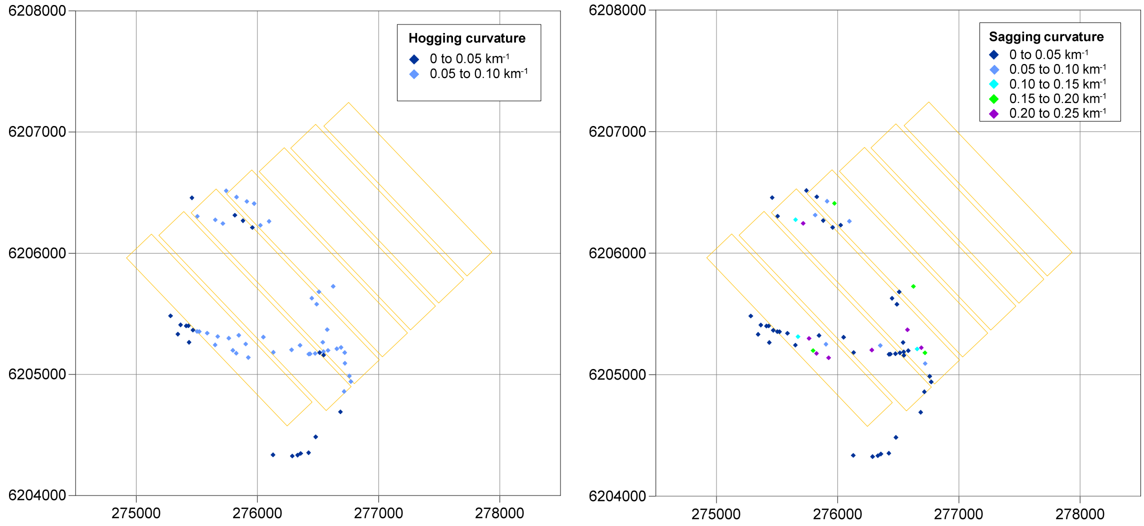


Fig. 3.77 Distribution of predicted hogging curvatures (left) and sagging curvatures (right) for houses at the completion of mining

The above figure shows that the greatest predicted curvatures occur directly above the proposed longwalls.

Houses located above previously extracted longwalls at Tahmoor have experienced mining-induced curvatures within the predicted range for the *Amended Layout*. This includes curvatures greater than 0.10 km^{-1}, which were observed above Tahmoor Mine LW 24A and above the south-eastern ends of LWs 25 and 26, in the areas of increased subsidence. The distributions of measured hogging and sagging curvatures for the survey bays located in the area of increased subsidence above LW 24A, LWs 25 and 26, is provided in Fig. 3.78. Generalised Pareto Distributions (GDPs) have also been fitted to the observed data which are shown by the blue curves.

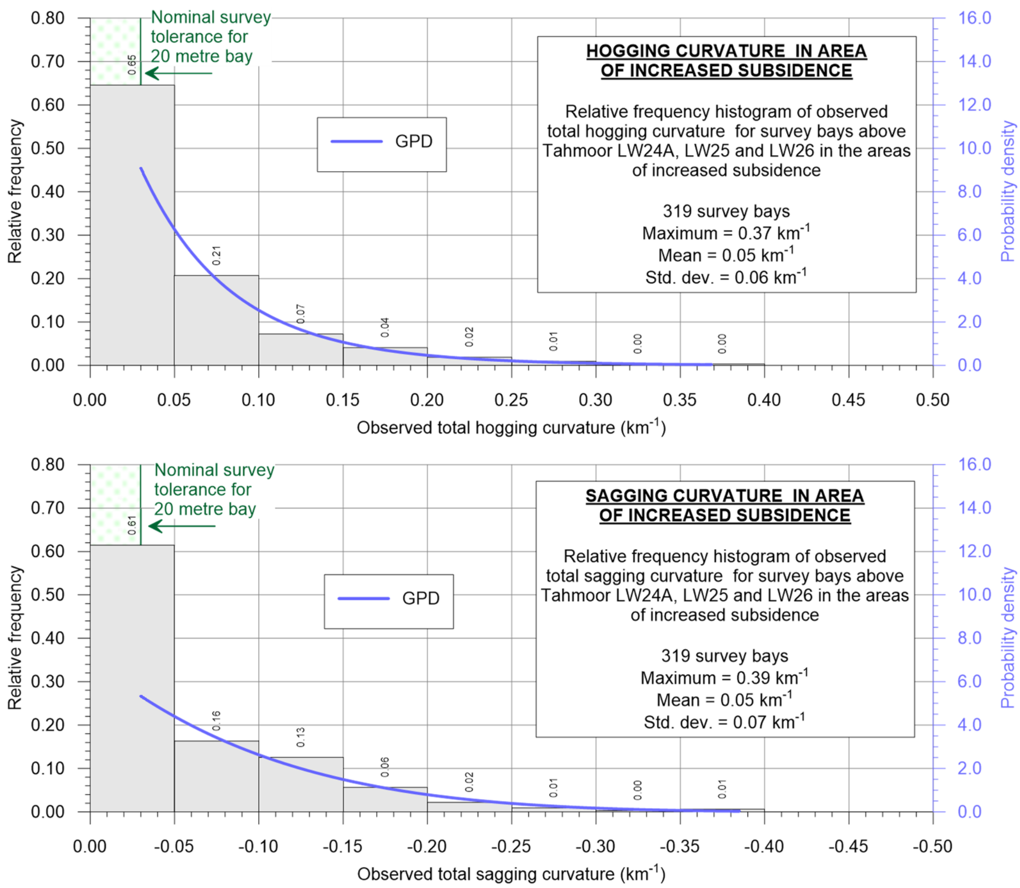


Fig. 3.78 Distributions of measured curvatures for survey bays located in the areas of increased subsidence above Tahmoor Mine LWs 24A, 25 and 26

It can be seen from the above figure, that the maximum observed total curvatures for the survey marks in the areas of increased subsidence were 0.37 km^{-1} hogging and 0.39 km^{-1} sagging, which are greater than the maximum predicted curvatures at the houses within the Study Area of 0.10 km^{-1} hogging and 0.23 km^{-1} sagging.

The range of predicted curvatures for the houses within the Study Area are, therefore, less than those observed above previously extracted longwalls at Tahmoor Mine, including LW 24A and above the eastern ends of LWs 25 and 26 in the areas of increased subsidence. It is expected, therefore, that the incidence of claims for impacts resulting from the mining induced curvature and strain for the proposed longwalls would be similar to but slightly less than those previously experienced in the areas of increased subsidence. The methods for predicting and assessing impacts on building structures have developed over time as knowledge and experience has grown. MSEC has provided predictions and impact assessments for the houses within the Study Area using the latest methods available at the time of writing.

Building structures have been directly mined beneath at a number of collieries throughout the NSW Coalfields. The experience gained has provided substantial information that has been used to continually develop the methods of impact assessment for houses. The assessments provided in this report are based on the latest research, which is summarised in Appendix C of Report No. MSEC1192.

Trend analyses were conducted following the mining of Tahmoor Mine LWs 22 to 29. The analyses indicated that the chance of impact is higher for the following houses:-

- Houses predicted to experience higher strains and curvatures,
- Houses with masonry walls,
- Masonry walled houses that are constructed on strip footings,
- Larger houses, and
- Houses with variable foundations, such as those with extensions added.

The probabilities of impacts for each house within the Study Area have been assessed using the method developed as part of ACARP Research Project C12015 (Waddington, 2009) and it has been updated based on observations of impacts at Tahmoor up to 2016 when the extraction of Longwall 29 was completed. This method uses the primary parameters of ground curvature and type of construction and is described in Appendix C of Report No. MSEC1192. The parameter of strain is indirectly used in this method due to its relationship with curvature. A summary of the predicted movements and the assessed impacts for each house within the Study Area is provided in Table C.03, in Appendix C.

The overall distribution of the assessed impacts for the houses within the Study Area is provided in Table 3.29. The assessed impacts have been determined based on the existing construction type of each house, as described in Section 3.16.1.

Table 3.29 Assessed impacts for houses within the Study Area

Group	Repair category			
	No Claim or R0	R1 or R2	R3 or R4	R5
All houses (total of 62)	41 (66 %)	14 (23 %)	6 (9 %)	1 (1 %)
Directly above proposed longwalls (total of 49)	30 (59 %)	13 (26 %)	5 (10 %)	1 (2 %)
Directly above solid coal (total of 13)	11 (83 %)	2 (13 %)	0 (4 %)	< 1 (< 0.5 %)

In comparison, extensive data has come from the extraction of Tahmoor Mine Longwalls 22 to 29, where approximately 1,900 houses have experienced mine subsidence movements. A summary of the observed distribution of impacts for all houses within a 35° angle of draw of previously extracted Longwalls 22 to 29 as at 2016 is provided in Table 3.30.

Table 3.30 Observed frequency of impacts for building structures resulting from the extraction of Tahmoor Mine longwalls 22 to 29

Group	Repair category			
	No Claim or R0	R1 or R2	R3 or R4	R5
All houses within 35 degree angle of draw of LWs 22 to 29 (total of 1890)	1430 (76 %)	329 (17 %)	111 (6 %)	20 (1 %)
All houses, located directly above LWs 24A to 27 in Zone of Increased Subsidence (total of 432)	235 (54 %)	128 (30 %)	55 (13 %)	14 (3 %)

As discussed previously, the range of predicted curvatures for the houses within the Study Area are less than but similar to those observed above Tahmoor Mine Longwalls 24A to 27 within the observed zone of increased subsidence.

When the assessed distribution of impacts for the houses located directly above the proposed longwalls (second row of Table 3.29) are compared with the observed distribution of impacts of houses and major civil structures located directly above Longwalls 24A to 27 within the zone of increased subsidence (bottom row of Table 3.30), it can be seen that these are reasonably similar.

As mentioned earlier, the assessed impacts have been undertaken based on the existing construction type of each house. It is recognised that houses may be rebuilt in the future before the proposed mining occurs. The proportion of houses impacted by mining would, for example, increase if a greater proportion of houses are constructed directly above the proposed longwalls, or if a greater proportion of houses are constructed with brick walls rather than timber-framed weatherboard style structures. The most vulnerable style of house affected by mine subsidence movements above Tahmoor Mine Longwalls 22 to 29 were constructed as brick or brick-veneer houses on strip footings.

Severe impacts have previously occurred as a result of substantial non-conventional movements and in plateau areas away from incised valleys, such as where the houses are located within the Study Area. The precise location of non-conventional movements cannot be predicted prior to mining. The impacts, however, develop gradually such that they can be detected early and repairs can be undertaken incrementally to ensure that the houses remain safe and serviceable during mining.

As noted in Appendix C of Report No. MSEC1192, at the time of writing ACARP Research Project C12015 (Waddington, 2009), the observed proportion of houses where the Mine Subsidence Board (MSB, now SA NSW) and affected landowners had agreed to rebuild rather than repair, i.e. Category R5 impacts was less than 0.5 %. Since the publication of the research report, the proportion of houses where a decision has been made to rebuild has increased to approximately 1.1 % overall and 3.2 % above Longwalls 24A to 27 within the observed zone of increased subsidence.

The observed proportion of houses with Category R1 to R4 impacts have also increased since the original ACARP study. This is partly due to the time lag effect between the mining impact, when damage is claimed by residents and when the nature and level of the damage requiring repairs is assessed in detail by SA NSW. The latest review includes observations up to the end of Longwall 29 in 2016, which was approximately two years after the completion of Longwall 27 and one year after the completion of Longwall 28, which was the last panel to directly mine beneath the urban areas of Tahmoor.

The primary risk associated with mining beneath houses is public safety. Residents have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mine subsidence movements in the NSW Coalfields, where the depths of cover were greater than 350 metres, such as the case above the proposed longwalls. This includes the recent experience at Tahmoor Mine, which has affected more than 1,950 houses, and the experiences at Appin, Teralba, West Cliff and West Wallsend Collieries, which have affected around 500 houses.

Emphasis is placed on the words “immediate and sudden” as in rare cases, some structures have experienced severe impacts, but the impacts did not present an immediate risk to public safety as they developed gradually with ample time to temporarily relocate residents.

All houses within the Study Area are expected to remain safe and repairable throughout the mining period, provided that effective management measures are adopted during mining and these are described in Section 3.16.4.

3.16.4. Management of potential impacts on the houses

Tahmoor Mine has extensive experience of mining beneath urban areas. It has developed and acted in accordance with a risk management process to manage potential impacts to residential structures during the mining of LWs 22 to 32, LWs W1-W4 and LWs S1A and S2A.

The Subsidence Management Process has been developed in consideration of the following facts and observations:

1. Australian standards have been available for use in the design of structures since 1948. The great majority of structures at Tahmoor and Thirlmere (approximately 80 %) have been constructed after the declaration of the Bargo Mine Subsidence District in November 1975.
2. There is sufficient redundancy in structural design such that ductile deformation will develop and be noticeable to residents before structural failure occurs.
3. Subsidence movements develop gradually over time at Tahmoor Mine as they have above other previously extracted longwalls at similar depths of cover.
4. Experiences during the mining of LWs 22 to 32 and LWs W1-W3 have found that the most effective method of managing potential impacts on the safety and serviceability of structures are by way of community consultation. Residents living within the active subsidence zone have often provided early feedback to Tahmoor Mine and/or SA NSW about impacts developing at their houses or along their local roads. Contact is made well before impacts develop to a level of severity sufficient to become a safety hazard.
5. On the basis of the above, there is sufficient time for residents to notify Tahmoor Mine or SA NSW of significant displacement or deflection well before structural failure will occur.
6. The conclusions are supported by the observation that residents have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mine subsidence movements at Tahmoor Mine and above other previously extracted longwalls at similar depths of cover. This includes the recent experience at Tahmoor Mine during the mining of LWs 22 to 32 and LWs W1-W4, which have affected more than 2000 houses and civil structures.

While severe impacts have developed during the mining of LWs 22 to 32, there is sufficient redundancy in structural design such that when structures have experienced severe impacts, they have developed gradually with ample time for residents to notify Tahmoor Mine or SA NSW to repair the structure and/or relocate residents before structural failure occurs.

While the three most important factors in managing risks to public safety are redundancy in structural design, gradual development of subsidence movements and an effective community consultation program, a number of additional management measures have been undertaken, including site specific investigations, regular surveys and inspections during mining and triggered response measures.

Tahmoor Coal has developed a Subsidence Management Plan to manage potential impacts to houses during the mining of LWs S1A to S6A under the *Approved Layout*. It is recommended that Tahmoor Coal continues its current practice of ensuring that built structures remain safe and serviceable at all times during mining. It is recommended that Tahmoor Coal, in consultation with landowners, study the potential for impacts on the structures and other infrastructure and develop management measures. The study would require input from structural and subsidence engineers. The risk management process includes the following processes:-

1. Regular consultation, cooperation and coordination with the community before, during and after mining. This includes letters and door knocking to all residents of structures that will soon be affected by subsidence. The letters offer a free pre-mining inspection and hazard identification inspection by a structural engineer;
2. Site-specific investigations, where they are necessary and appropriate, into the conditions of buildings and associated structures and their surrounding environment (where access is allowed). The site-specific investigations have been and will continue to be undertaken early so that there is adequate time, if required, to arrange additional inspections and/or surveys and implement any mitigation measures before mining-induced impacts are experienced;

   For properties located directly above the first 300 metres of the commencing end of a longwall, the investigations are targeted to be undertaken prior to extraction or at the latest, they will be undertaken prior to the first 200 metres of extraction of the longwall.

   The site-specific investigations include the following:

   a) Identification of structures from aerial photographs and kerbside inspections;
   b) Front of house risk and visual screening inspections by Tahmoor Coal in company with a structural engineer for all properties that are predicted to experience more than 20 mm of incremental vertical subsidence due to the extraction of each upcoming longwall. The purpose of the inspections is to identify hazards where access has not been granted by the landowner.

In some cases, particularly in semi-rural and rural areas, it is difficult to inspect a structure that is remote from the street front. Where these cases involve properties that are located directly above a longwall, Tahmoor Coal will request access to conduct a pre-mining inspection and hazard identification inspection by a structural engineer;

c) Tahmoor Coal will request access to conduct pre-mining geotechnical inspections of structures located on or immediately adjacent to steep slopes that are predicted to experience more than 20 mm of incremental vertical subsidence due to the extraction of each longwall;

d) Tahmoor Coal will request access to conduct pre-mining hazard identification inspections by a structural engineer (where access is allowed by the landowner) to properties with structures that have been specifically targeted on the basis that may be more sensitive to mine subsidence movements. These include:

   i) Commercial and business establishments, public amenities and public utilities;

   ii) Structures of heritage significance;

   iii) Structures that are located above hidden creeks (none identified within the *Study Area*);

   iv) Structures that are located above mapped geological structures (none identified within the *Study Area*);

   v) Structures that are located on or adjacent to steep slopes or that have been recommended for structural inspection by the geotechnical engineer;

   vi) Structures that have been identified as being potentially unstable or unsafe by landowners (Item 1), or from the front of house inspections (Item 2b);

   vii) Houses and units located outside the declared Mine Subsidence Districts; and

   viii) Houses and units estimated to have been constructed prior to the declaration of the Bargo Mine Subsidence District (in November 1975).

3. Implementation of pre-mining mitigation measures following inspections by the geotechnical engineer and the structural engineer, in consultation and agreement with the landowner.

4. Surveys and inspections during mining within the active subsidence area:

   a) detailed visual inspections and vehicle-based inspections along the streets;

   b) ground surveys along the streets;

   c) specific ground surveys for selected properties, where recommended by the geotechnical engineer or structural engineer due to their proximity to steep slopes or pre-existing condition;

   d) visual inspections of residential structures that are either: located on or adjacent to steep slopes, are in poor existing condition (based on the hazard identification inspections), have previously reported impacts, or where recommended by the Structures Response Group;

   e) visual inspections of pool fences and gates; and

   f) visual inspections of commercial, industrial and business establishments, public amenities and public utilities.

With appropriate management plans in place, it is considered that the houses will remain safe and serviceable at all times due to the extraction of the proposed LW S7A, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

The Subsidence Management Plan will be updated to include potential impacts due to the extraction of LW S7A under the *Modified Layout*.

3.17. Archaeological Sites

There are no lands within the Study Area declared as an Aboriginal Place under the *National Parks and Wildlife Act 1974*.

There are 9 archaeological sites which have been recently identified along Hornes Creek by heritage consultant EMM (2024) within the 600m Study Area for Natural Features. Their locations are shown in Drawing No. MSEC1348-10. The proposed LW S7A will not extract directly beneath the sites.

- 7 rockshelter sites were recorded, of which 6 sites contained potential archaeological deposits. No art was identified, although indeterminate charcoal markings were observed on the walls of two shelters.
- One grinding groove site was identified on a rockbar within Hornes Creek.
- One isolated find was identified on a fire track.

Detailed descriptions of the archaeological sites within the Study Area are provided in the Aboriginal Cultural Heritage Assessment.

3.17.1. Predictions for the archaeological sites

The predicted conventional subsidence, tilts and curvatures for the archaeological sites within the Study Area are provided in Table C.10, in Appendix D. A summary of the maximum predicted conventional subsidence parameters for the archaeological sites is provided in Table 3.31. The predicted tilts are the maxima after the completion of any or all of the proposed longwalls. The predicted curvatures are the maxima at any time during or after the extraction of the proposed longwalls.

Table 3.31 Maximum Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site Type	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
Rock Shelter Site (WP1258RS)	50	< 0.5	< 0.01	< 0.01
Grinding Grooves (WP1263GG)	20	< 0.5	< 0.01	< 0.01
Isolated Find (48-2-0275)	20	< 0.5	< 0.01	< 0.01

The maximum predicted conventional strains for the archaeological sites, based on applying a factor of 15 to the maximum predicted conventional curvatures, are less than 0.2 mm/m tensile and compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 2.0 includes those resulting from both conventional and non-conventional anomalous movements.

The archaeological sites are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 2.5.1. The results for survey bays above solid coal are provided in Fig. 2.8.

The grinding groove site is located on a rockbar within the valley and, therefore, could experience valley-related movements. A summary of the maximum predicted upsidence and closure movements for the stream at the location of this site is provided in Table 3.32.

Table 3.32 Maximum predicted total upsidence and closure for the archaeological sites

Site Type	Stream	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Grinding Grooves (WP1263GG)	Hornes Creek	45	65

3.17.2. Impact assessments for the rock shelter

There are 9 rock shelters identified within the 600m Study Area for Natural Features to the west of LW S7A on Hornes Creek. The closest site is located approximately 330 metres to the side of LW S7A.

The maximum predicted conventional tilts and curvatures for the rock shelters are negligible and unlikely to result in adverse impacts on the rock shelter sites.

It is extremely difficult to assess the likelihood of instabilities for the rock shelters based upon predicted ground movements. The likelihood of the shelters becoming unstable is dependent on a number of factors which are difficult to fully quantify. These factors include jointing, inclusions, weaknesses within the rockmass, groundwater pressure and seepage flow behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors may influence the stability of the shelter naturally or when it is exposed to mine subsidence movements.

In this case, the shelters are located away from the proposed LW S7A, with the closest distance of 330 metres. As discussed in the assessment for cliffs in Section 3.5, no cliff instabilities have previously been observed above solid, unmined coal, during previous longwall mining in the Southern Coalfield at similar depths of cover. It is, therefore, unlikely that cliffs beyond the extent of the longwall panels will experience large instabilities. It is possible that isolated rock falls could occur during the mining period due to natural weathering processes. Any impacts are expected to represent less than 0.5 % of the total face area of the cliffs. The identified aboriginal rock shelter sites are a small proportion of the overall total face area of the cliffs, and any impacts are, therefore, expected to be even less 0.5 %.

Based on the experience from the Southern Coalfield, the likelihood of substantial physical impacts on rock shelters within the Study Area is very low.

3.17.3. Impact assessments for the Grinding Groove site

The grinding groove site is located approximately 520 metres to the side of LW S7A.

The maximum predicted conventional tilts and curvatures for the grinding groove site are negligible and unlikely to result in adverse impacts on the grinding groove site.

Hornes Creek is predicted to experience valley closure, including at the rockbar that hosts the grinding grooves. As discussed in Section 3.3, given the offset distance of the grinding site relative to LW S7A, the likelihood of fracturing occurring is considered to be low and in the unlikely event that it occurs, the fractures are expected to be minor and isolated. The identified grooves are a small proportion of the rockbar and, therefore, the likelihood of a fracture intersecting the griding grooves is considered to be extremely low.

3.17.4. Impact assessments for the Isolated Find site

The isolated find site is located approximately 520 metres to the side of LW S7A.

The maximum predicted conventional tilts and curvatures for the isolated find site are negligible and unlikely to result in adverse impacts on the isolated find site.

Given the offset distance of the site relative to LW S7A, the potential for cracking of the surface soils as a result of mine subsidence movements is extremely low. It is unlikely, however, that the isolated finds themselves would be impacted by surface cracking.

3.17.5. Impact assessments for the archaeological sites based on increased predictions

If the actual mine subsidence movements exceeded those predicted values by a factor of 2 times, the likelihood of impacts would still be expected to be very low.

While the predicted ground movements are important parameters when assessing the potential impacts on the rock shelters on cliffs, it is noted that the impact assessments for cliff instabilities have primarily been based on historical observations from previous longwall mining in the Southern Coalfield.

Similarly, while the predicted conventional and non-conventional ground movements at the grinding groove site are very small, it is noted that the impact assessments for rockbars have primarily been based on historical observations from previous longwall mining in the Southern Coalfield.

3.17.6. Management of potential impacts on the archaeological sites

Tahmoor Coal has developed a Heritage Management Plan to manage potential impacts to Aboriginal heritage sites for LWs S1A to S6A. The management plan included consultation with the community, monitoring and reporting. Tahmoor Coal will develop a Heritage Management Plan as part of the Mod 3 application for LW S7A, in consultation with the community, to manage the potential impacts on Aboriginal heritage sites during the extraction of the proposed longwalls.

3.18. Heritage Sites

There are no heritage sites located within the Study Area, as shown in Drawing No. MSEC1348-10.

The Wellers Road Overbridge and Picton Weir are items of heritage significance and their locations relative to the Study Area are shown in Drawing No. MSEC1348-10.

As discussed in Section 3.7, Tahmoor Coal and ARTC have implemented extensive measures to manage potential impacts on the Main Southern Railway and the associated railway structures due to the extraction of LW S1A to S6A, in accordance with a Railway Management Plan. The Railway Management Plan includes measures to manage potential impacts on Wellers Road Overbridge.

As discussed in Section 3.7, while the Wellers Road Overbridge is predicted to experience additional absolute horizontal movements as a result of the extraction of LW S7A, the potential for impacts on Wellers Road Overbridge due to differential horizontal movements does not materially change.

While the potential for impacts due to the extraction of LW S7A under the *Modified Layout* does not materially change from the potential for impacts under the *Approved Layout*, Tahmoor Coal will continue to implement the planned measures to manage the potential for impacts on the Main Southern Railway, as is currently planned during the extraction of LW S1A to S6A. The Railway Management Plan will be extended to include management of potential impacts due to the extraction of LW S7A.

As discussed in Section 3.10, Tahmoor Coal and Wollondilly Shire Council are developing measures to manage potential impacts on the Picton Weir due to the extraction of LW S1A to S6A, in accordance with a Picton Weir Management Plan, which is required prior to the commencement of LW S3A.

While the potential for impacts on the Picton Weir due to the extraction of LW S7A is higher than the potential for impacts under the *Approved Layout*, the methods of managing potential impacts on the Weir does not materially change. The Picton Weir Management Plan will be extended to include management of potential impacts due to the extraction of LW S7A.

3.19. Summary

The maximum predicted subsidence parameters within the Study Area, based on the *Modified Layout*, are similar to those based on the *Approved Layout*.

The potential for impacts has been assessed based on the predicted subsidence movements, consultation with infrastructure owners and experiences gained during the extraction of previous longwalls at Tahmoor Mine and more broadly from experiences during the extraction of previous longwalls at similar depths of cover at nearby mines in the Southern Coalfield.

The overall findings of the assessments undertaken by MSEC are that the levels of impact and damage to all identified natural features and built infrastructure are manageable and can be controlled by the preparation and implementation of Subsidence Management Plans (or Extraction Plans), many of which have been successfully implemented during previous mining at Tahmoor Mine. These management plans are developed in consultation with the owners of infrastructure and are approved by relevant government agencies. The findings in this report should be read in conjunction with all other associated consultant reports.

Recommended management measures generally include monitoring of ground movements and the condition of surface features. Some mitigation measures are recommended to mitigate or avoid the risk of serious consequences should impacts occur to some critical surface features.

It is recommended that Tahmoor Coal continues to develop management plans to manage the potential impacts for the surface features due to the extraction of the proposed LW S7A.

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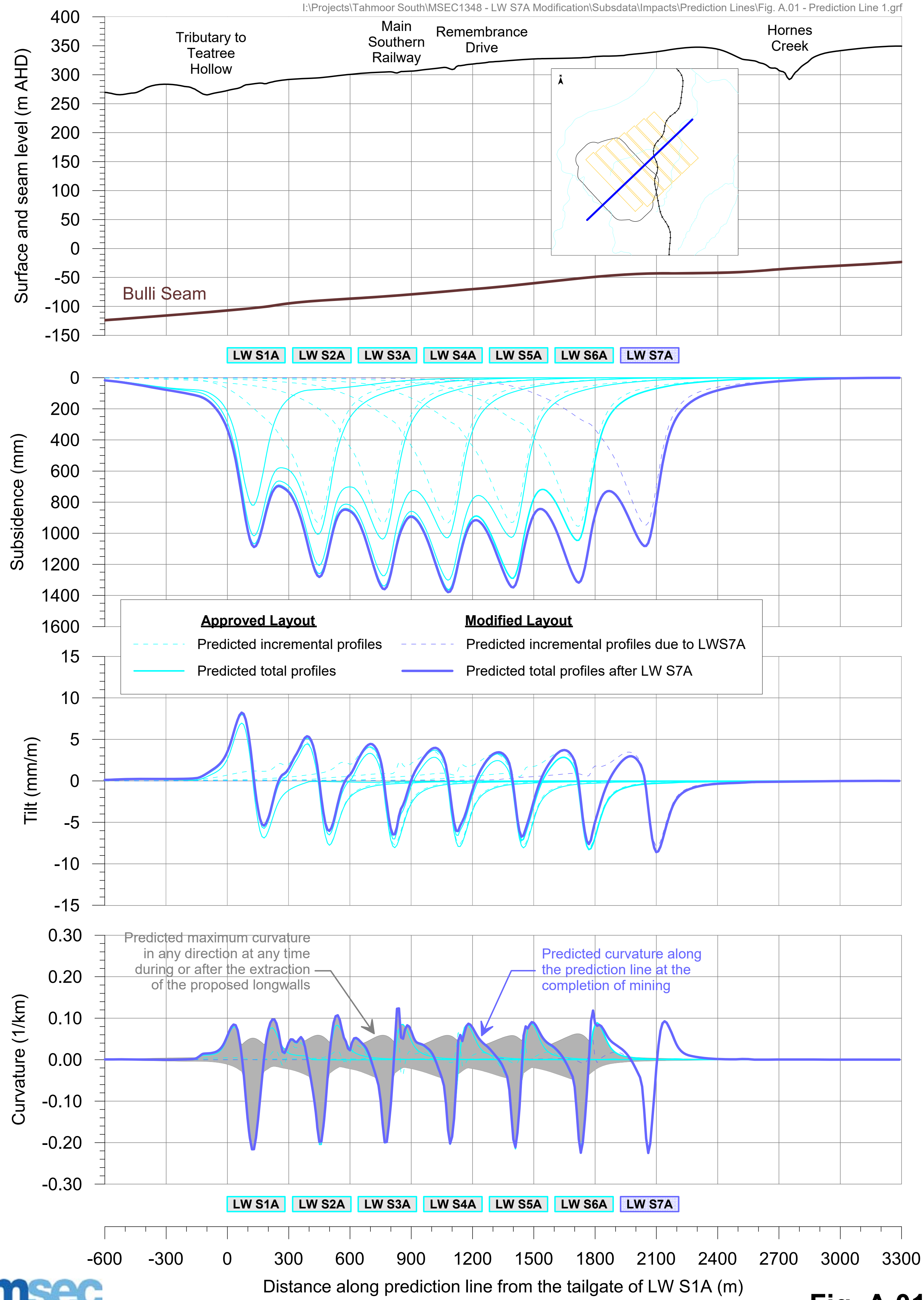
APPENDIX A. FIGURES

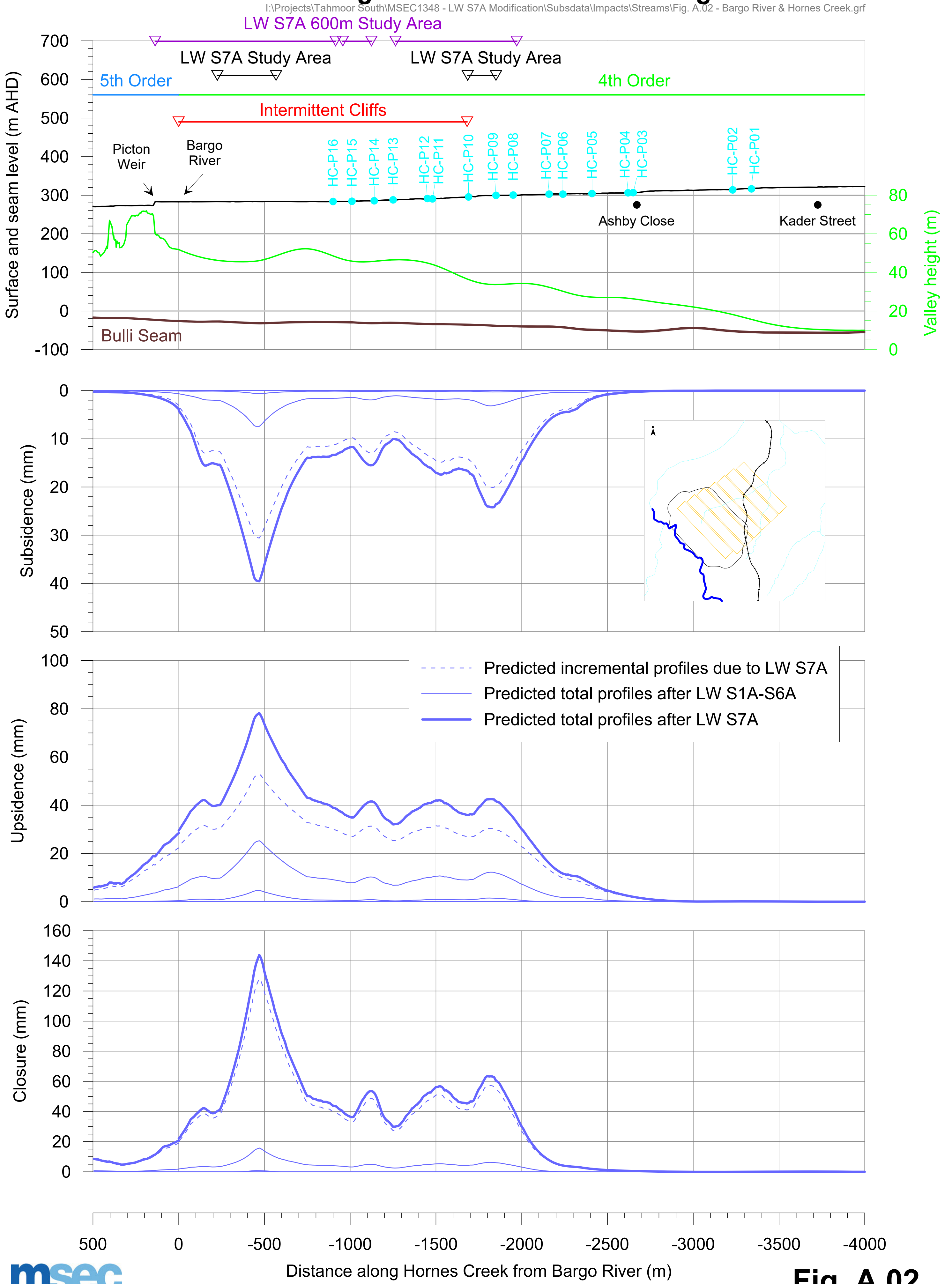
Predicted profiles of conventional subsidence, tilt and curvature along Prediction Line 1 resulting from the extraction of Longwalls S1A to S7A



msec

Fig. A.01

Predicted profiles of subsidence, upsidence and closure along Bargo River and Hornes Creek resulting from the extraction of Longwalls S1A to S7A



msec

Fig. A.02

Predicted profiles of subsidence, upsidence and closure along Teatree Hollow resulting from the extraction of Longwalls S1A to S7A

I:\Projects\Tahmoor South\MSEC1348 - LW S7A Modification\Subsdata\Impacts\Streams\Fig. A.03 - Teatree Hollow.grf

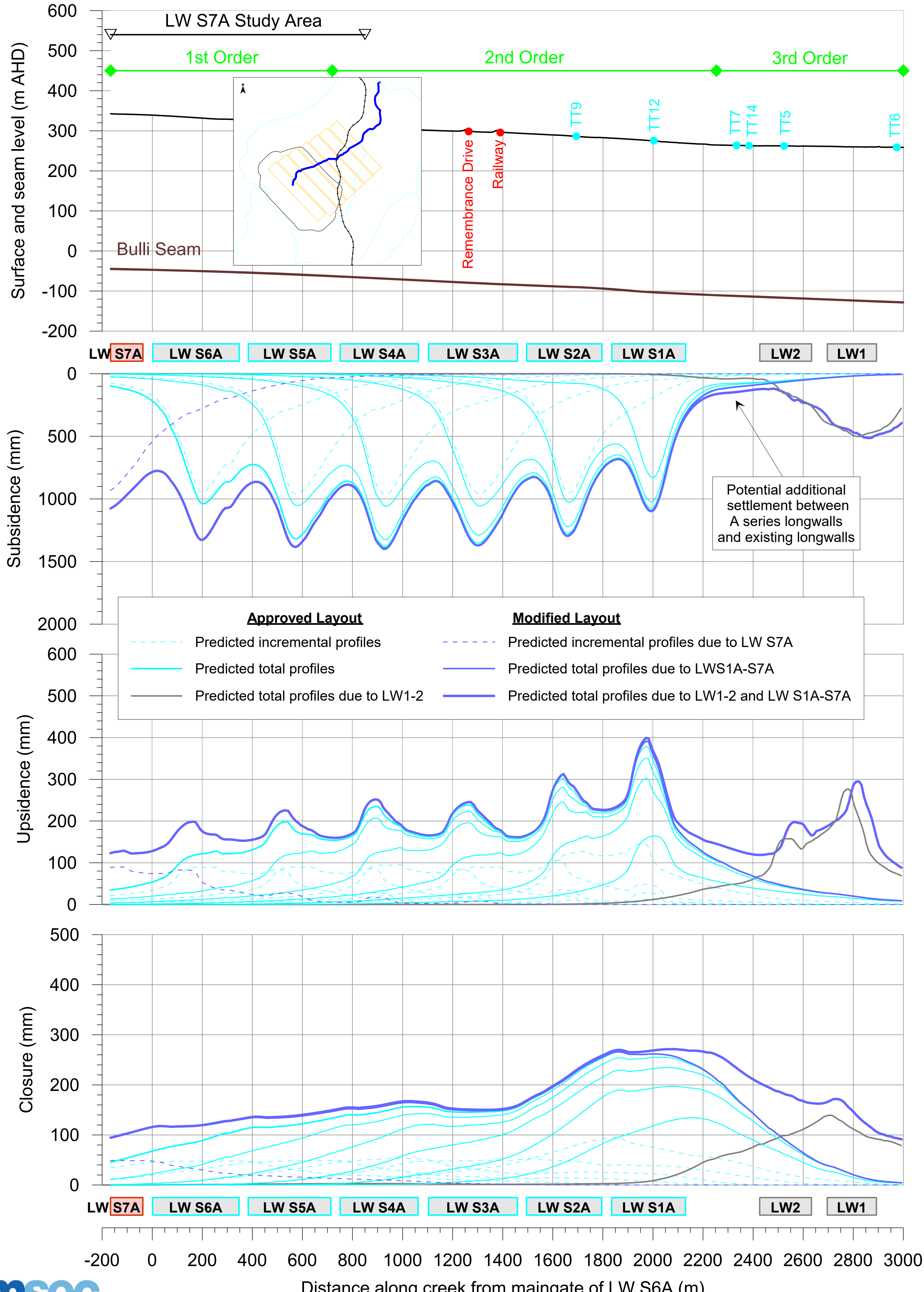
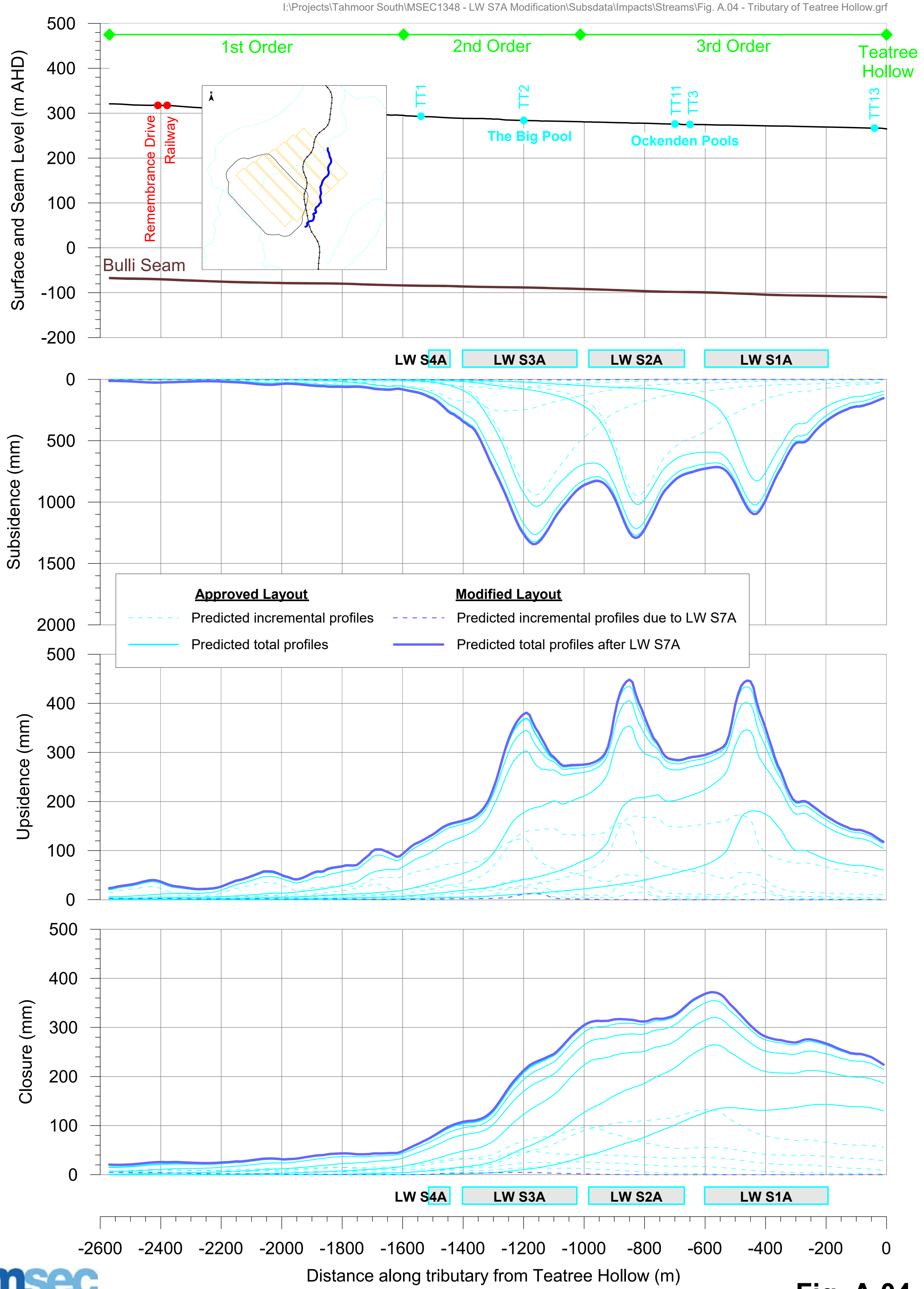


Fig. A.03

Predicted profiles of subsidence, upsidence and closure along Tributary of Teatree Hollow resulting from the extraction of Longwalls S1A to S7A

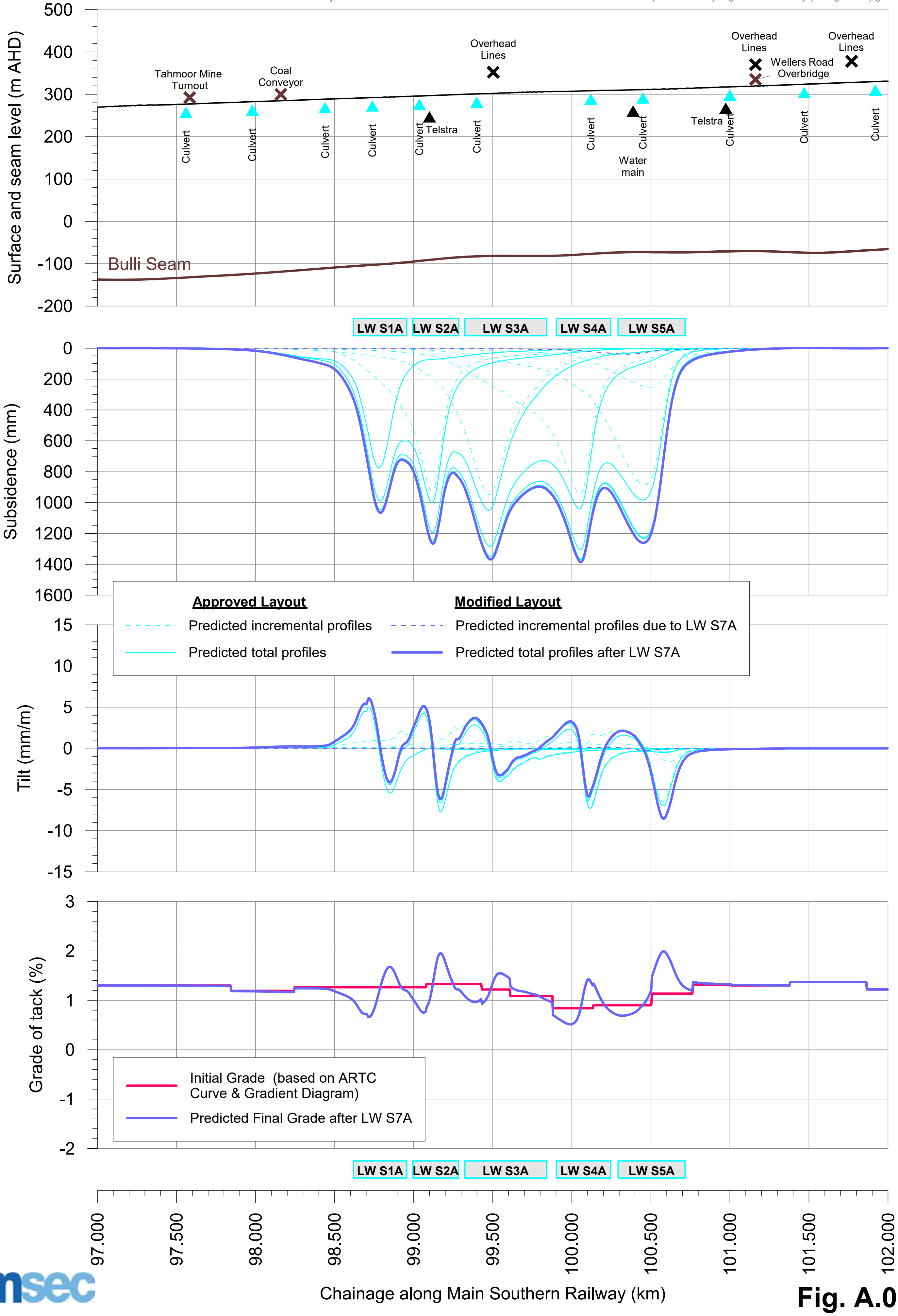


msec

Fig. A.04

Predicted profiles of conventional subsidence, tilt and change in grade along the Main Southern Railway due to the extraction of Longwalls S1A to S7A

I:\Projects\Tahmoor South\MSEC1348 - LW S7A Modification\Subsdata\Impacts\Railway\Fig. A.05 - Railway (Along Track).grf



msec

Fig. A.05

Predicted profiles of conventional cross tilt, change in track cant and long twist along the Main Southern Railway due to the extraction of Longwalls S1A to S7A

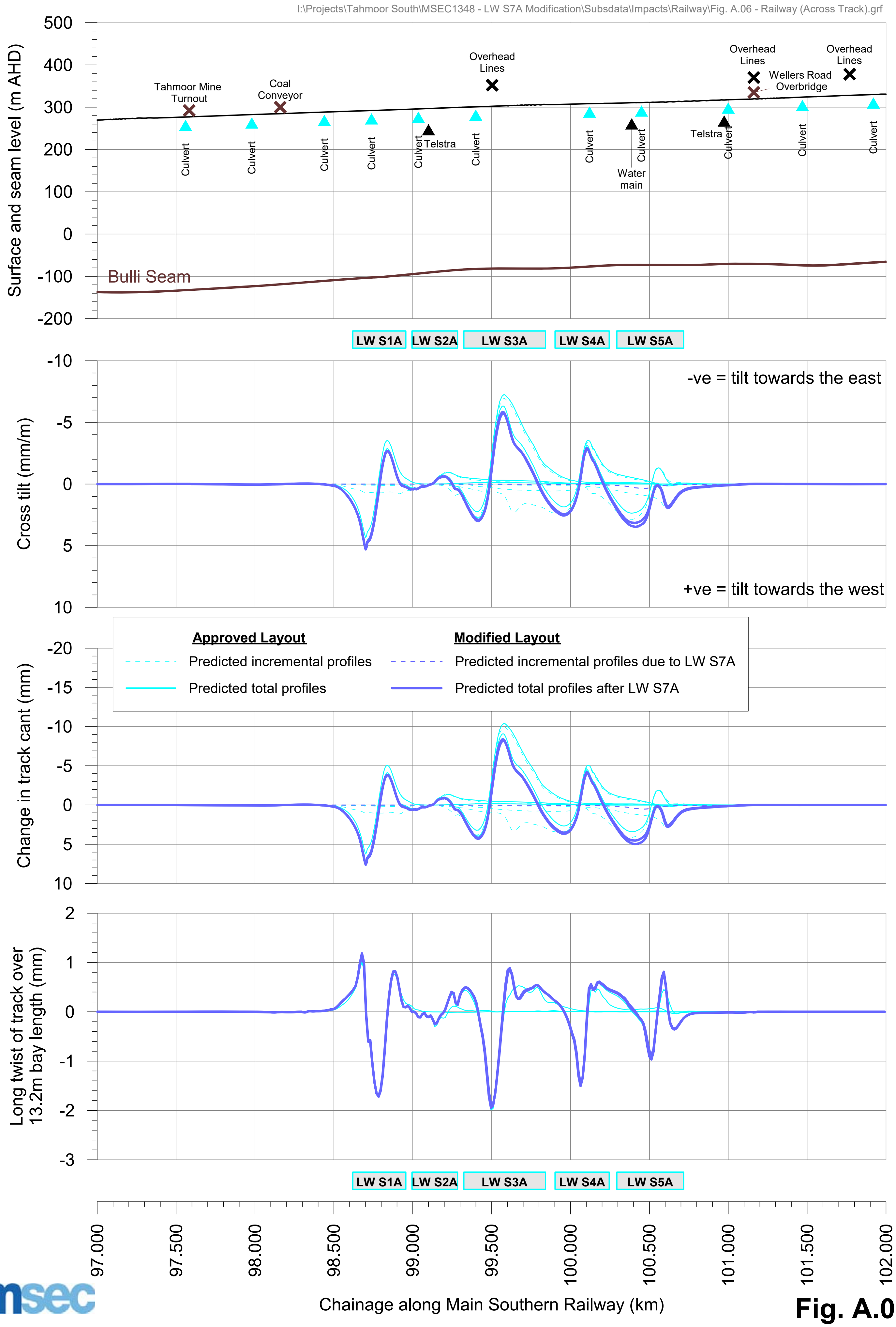


Fig. A.06

Predicted profiles of conventional horizontal movement along track, change in 100 metre long bay length and change in SFT for the Main Southern Railway due to the extraction of Longwalls S1A to S7A

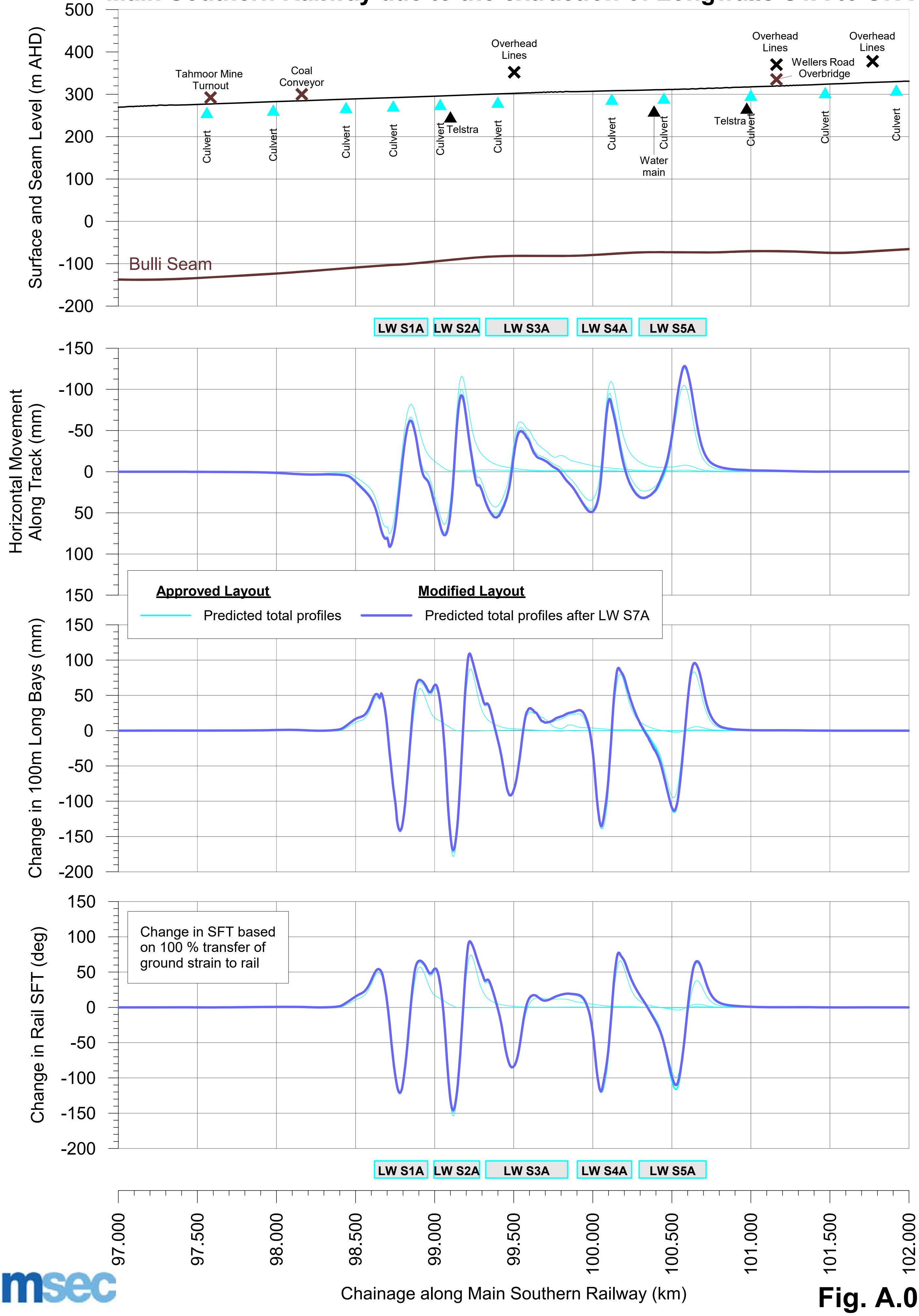
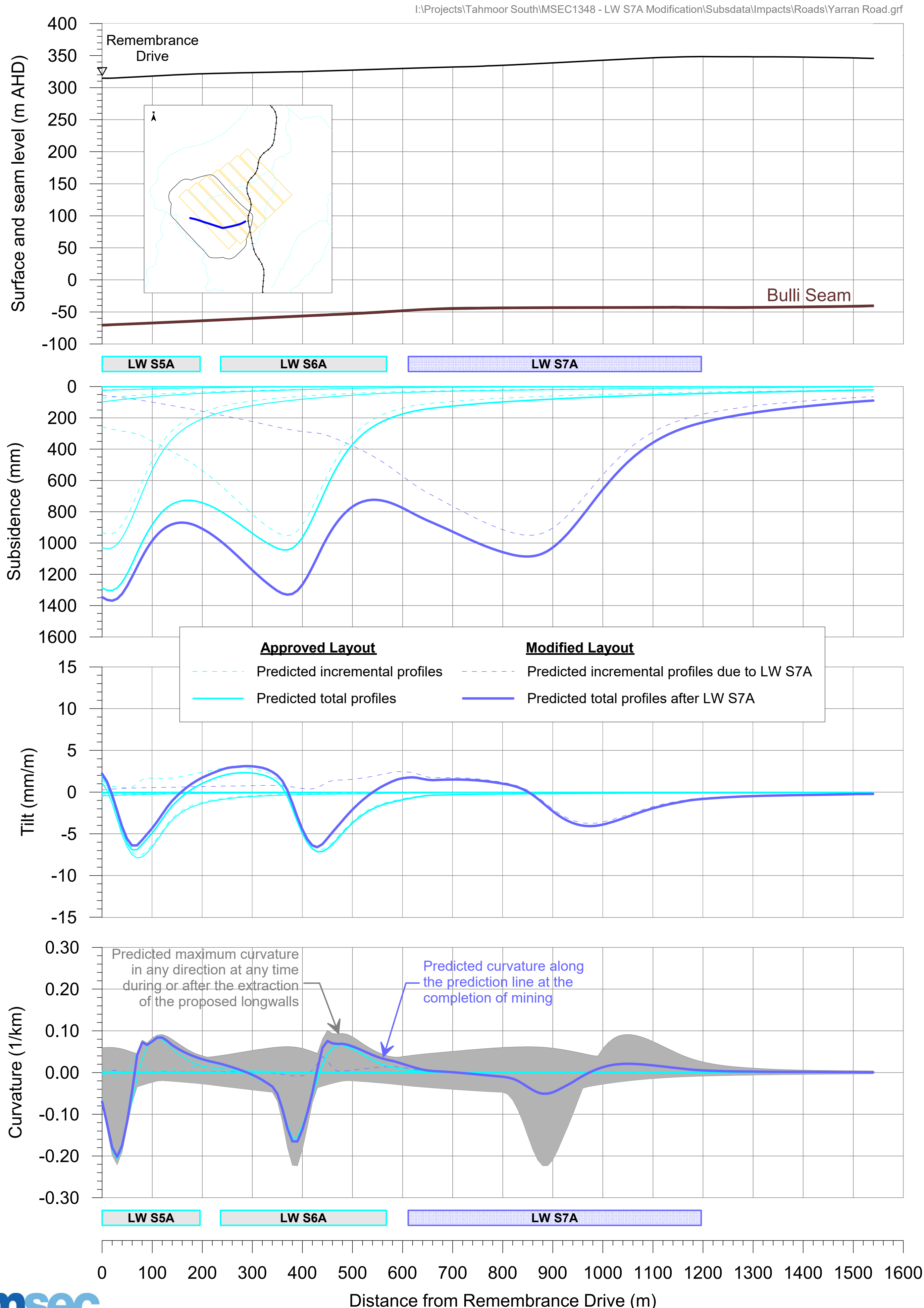


Fig. A.07

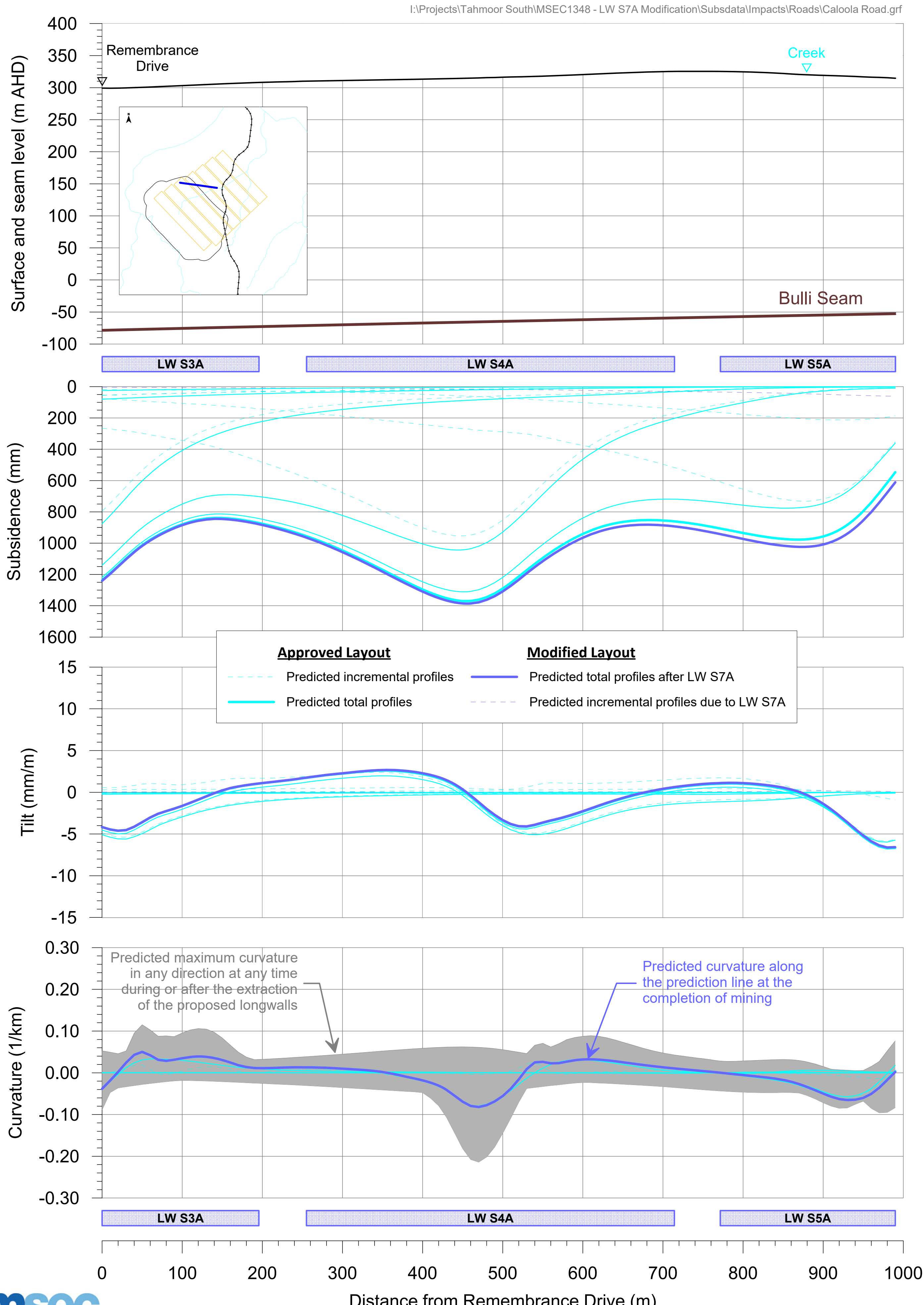
Predicted profiles of conventional subsidence, tilt and curvature along Yarran Road resulting from the extraction of Longwalls S1A to S7A



msec

Fig. A.08

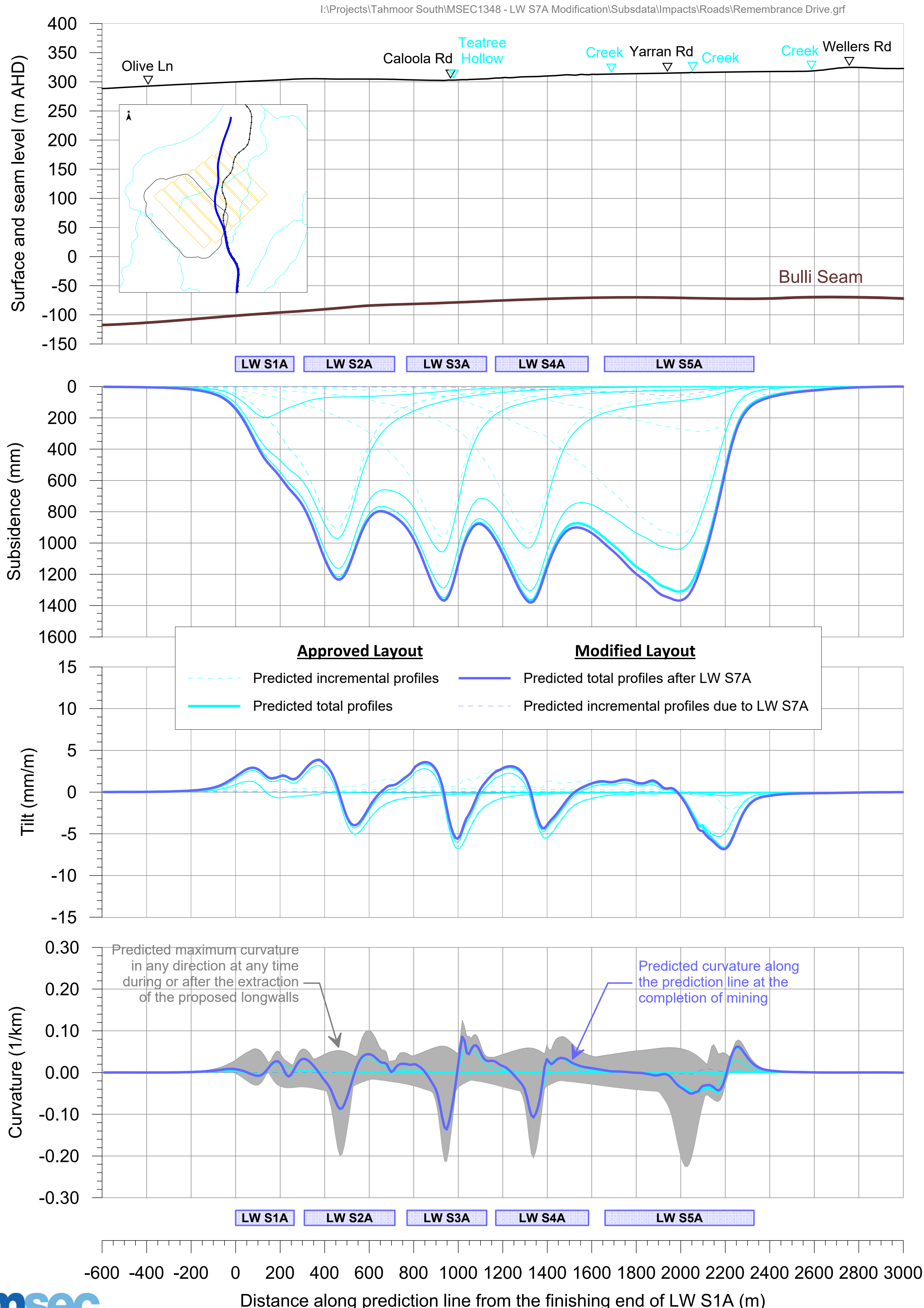
Predicted profiles of conventional subsidence, tilt and curvature along Caloola Road resulting from the extraction of Longwalls S1A to S7A



msec

Fig. A.09

Predicted profiles of conventional subsidence, tilt and curvature along Remembrance Drive resulting from the extraction of Longwalls S1A to S7A



msec

Fig. A.10

Predicted profiles of conventional subsidence, tilt and curvature along Remembrance Drive and the 150mm steel gas main resulting from the extraction of Longwalls S1A to S7A

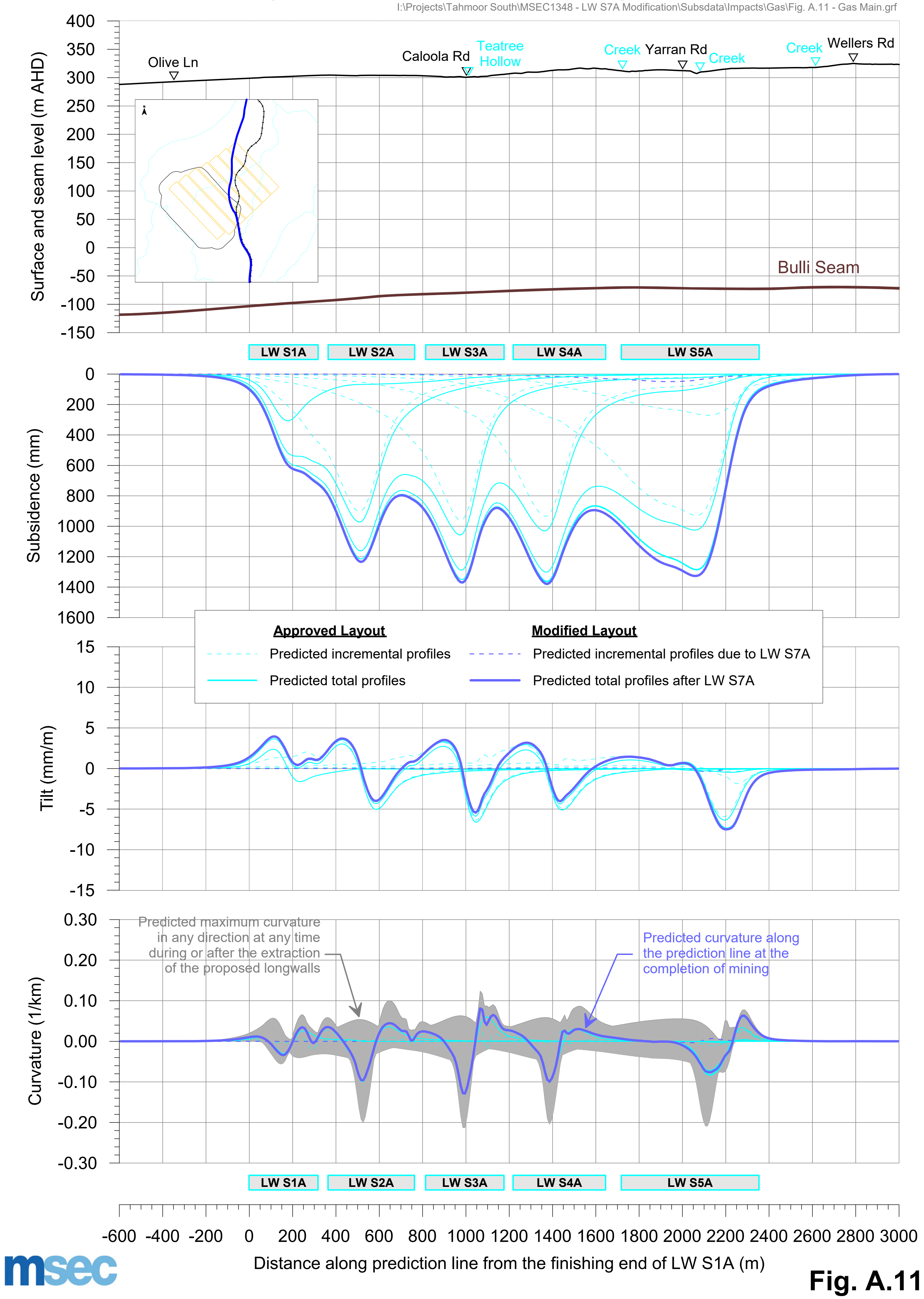


Fig. A.11

APPENDIX B. DRAWINGS

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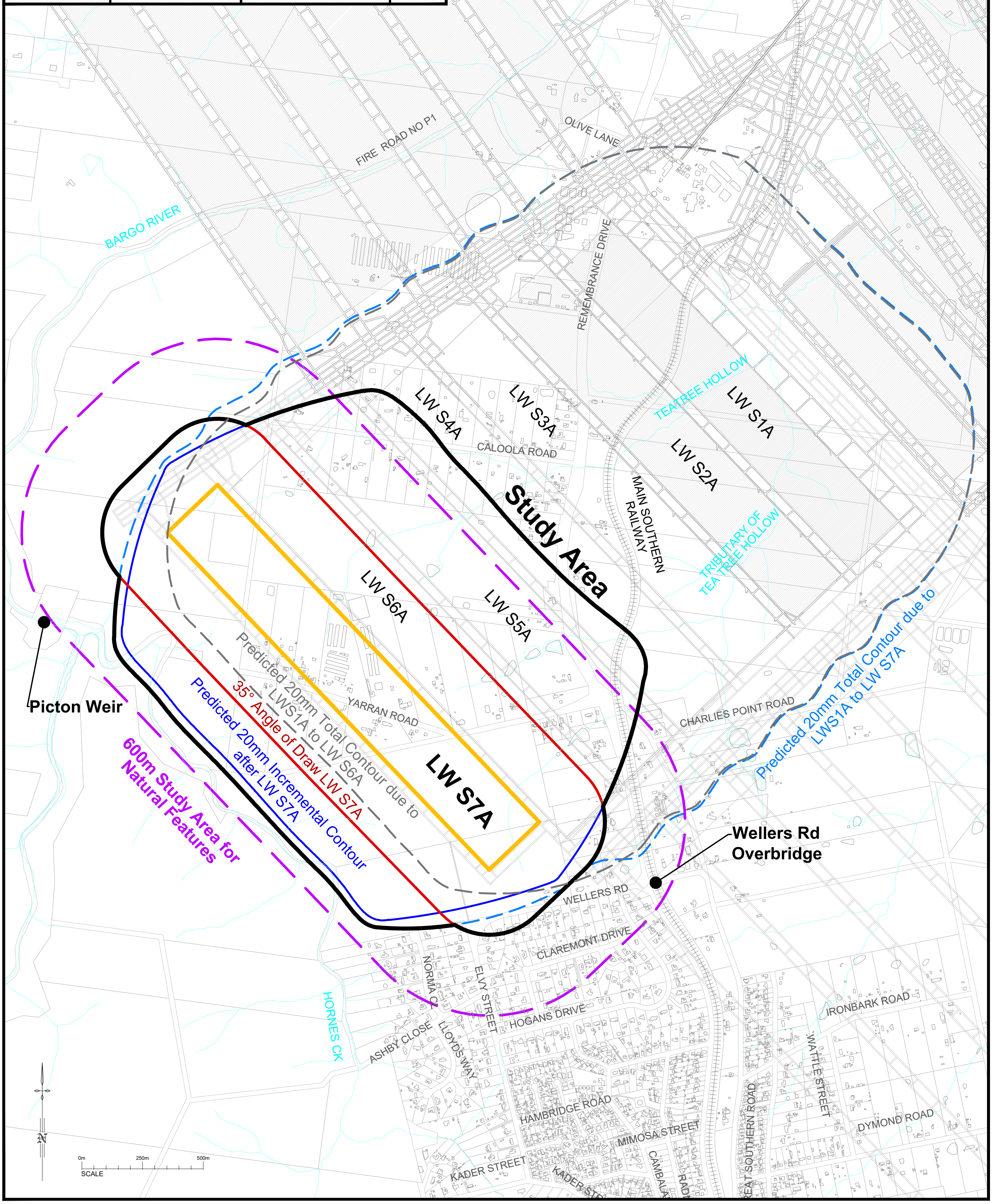
TAHMOOR SOUTH MODIFICATION 3 - LWS7A

GENERAL LAYOUT

DATE:	SCALE:	DRAWING No:	Rev No
27 Mar 2024	as shown	MSEC1348-01	A



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SURFACE LEVEL CONTOURS

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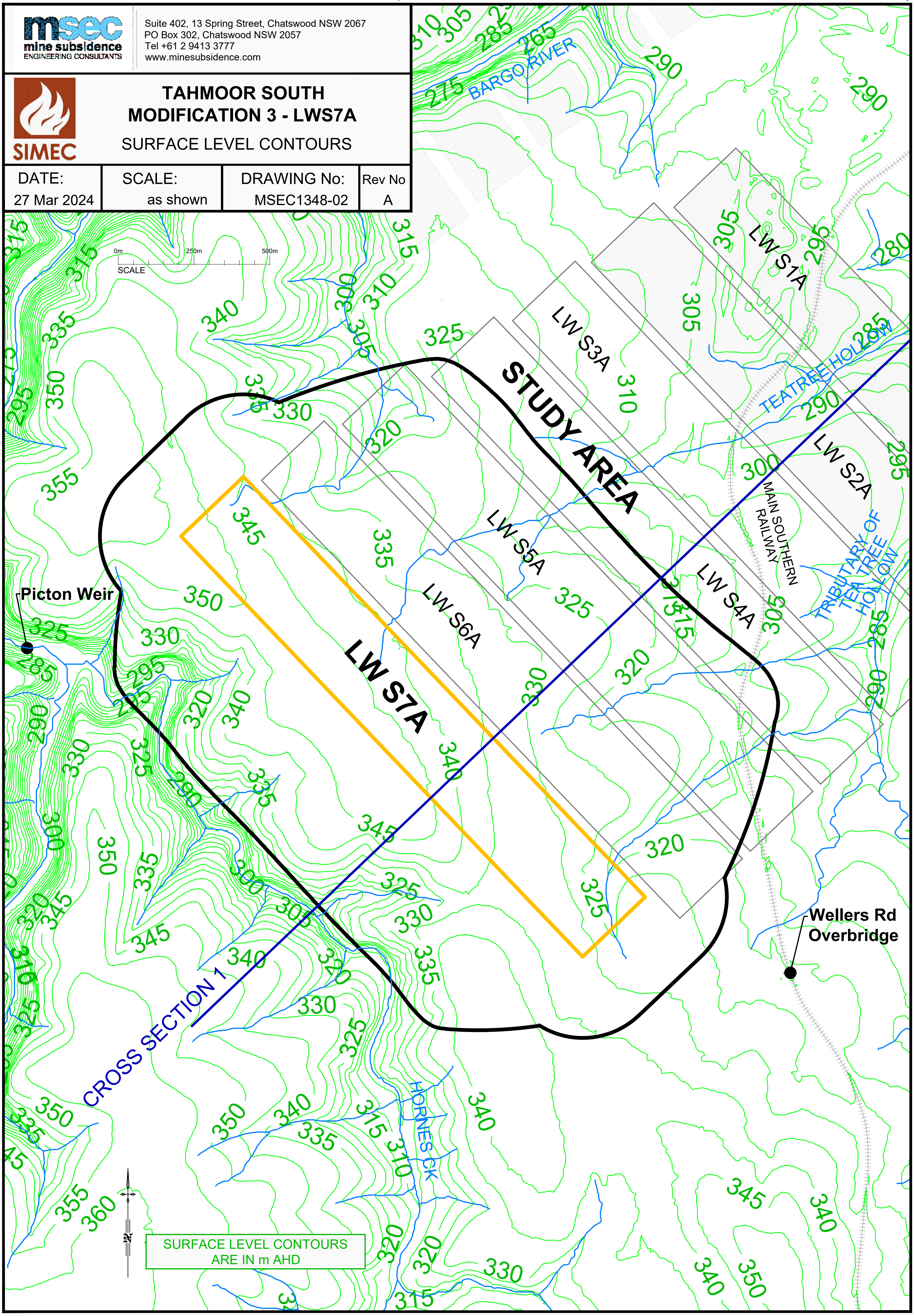

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BULLI SEAM ROOF CONTOURS

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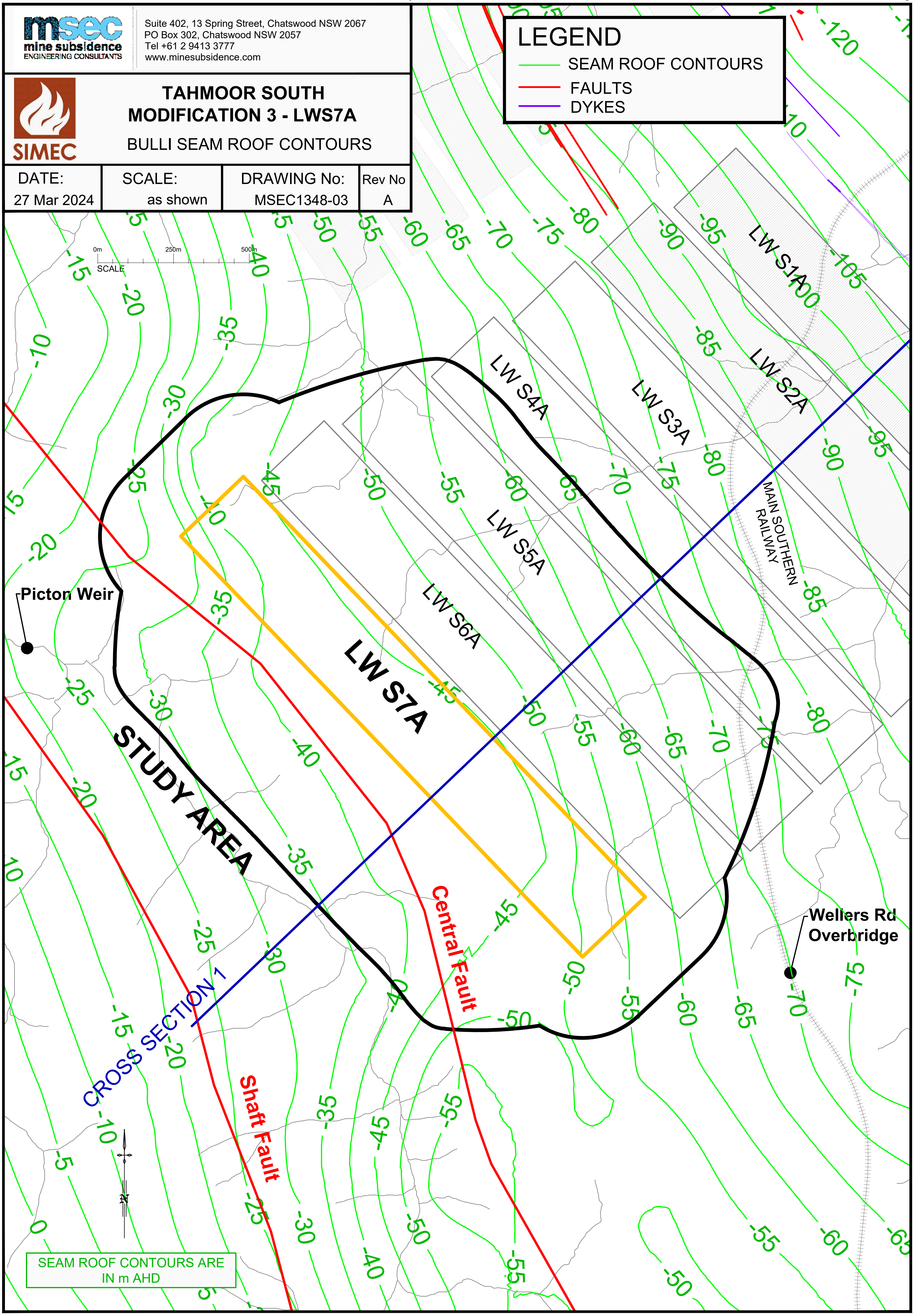

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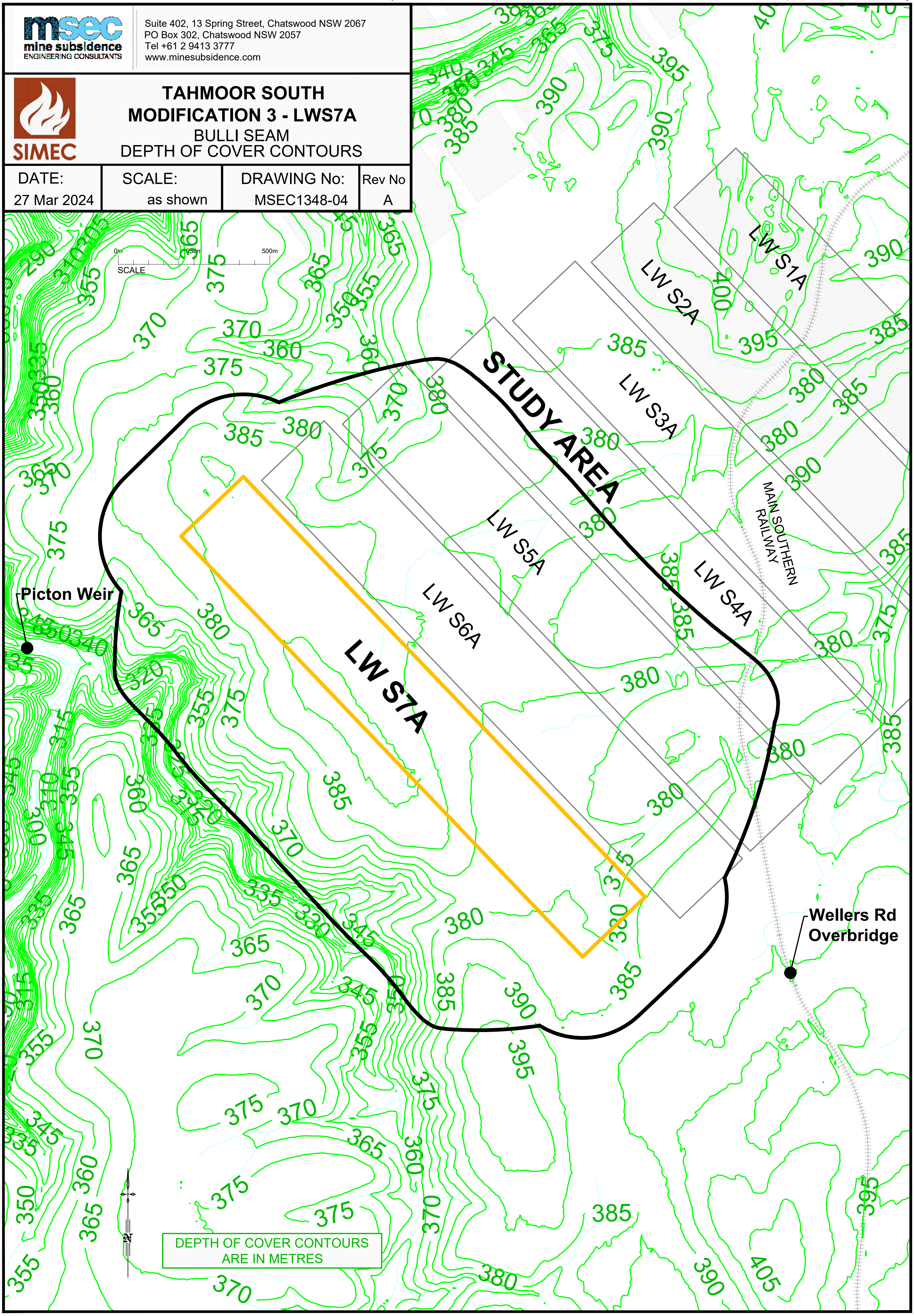
BULLI SEAM
DEPTH OF COVER CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
27 Mar 2024	as shown	MSEC1348-04	A



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MODIFICATION 3 - LWS7A

EXTRACTION HEIGHT

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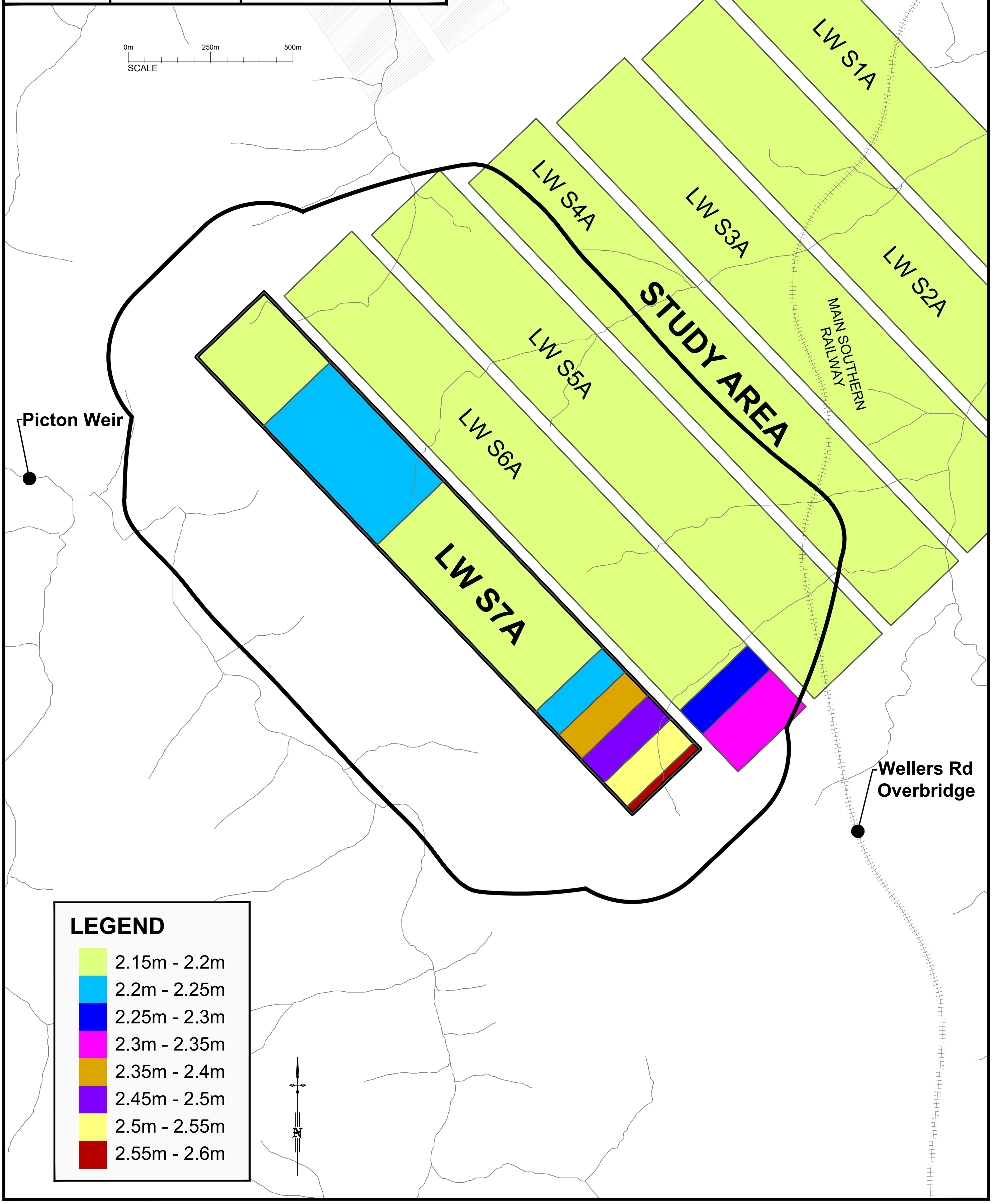
27 Mar 2024	as shown	MSEC1348-05	A



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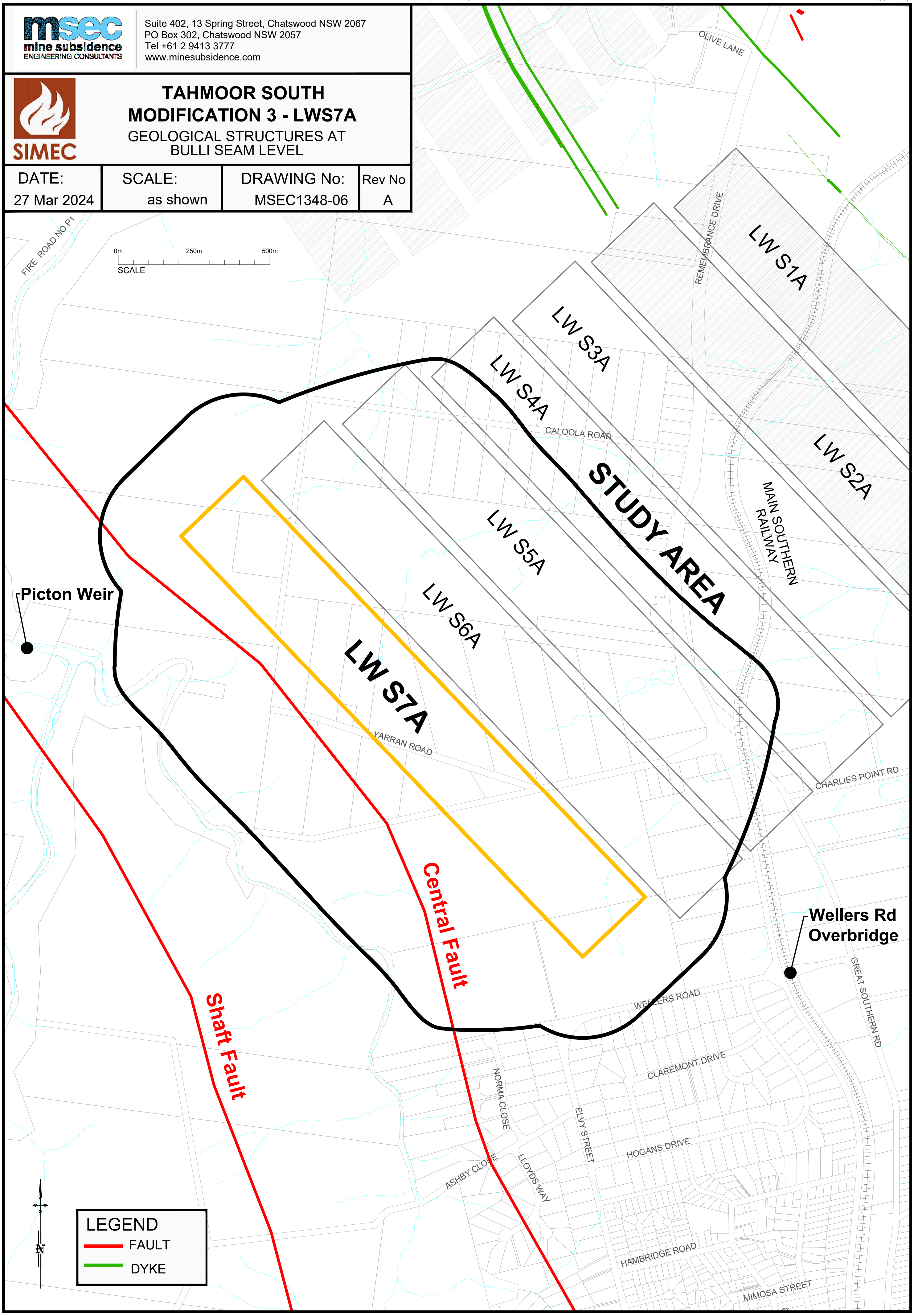
TAHMOOR SOUTH
MODIFICATION 3 - LWS7A
GEOLOGICAL STRUCTURES AT BULLI SEAM LEVEL

DATE:	SCALE:	DRAWING No:	Rev No
27 Mar 2024	as shown	MSEC1348-06	A



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NATURAL FEATURES

DATE:	SCALE:	DRAWING No:	Rev No
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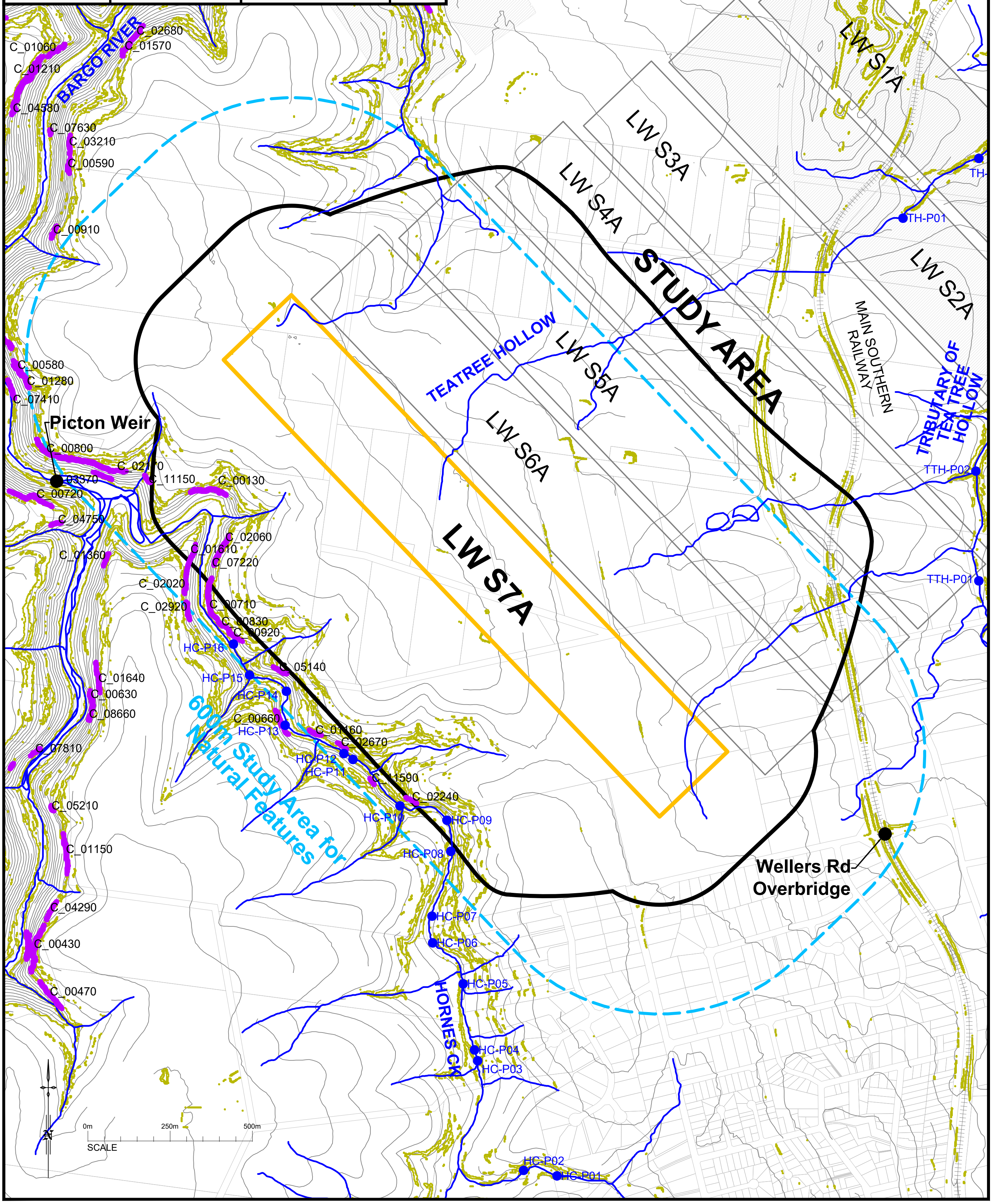

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MAIN SOUTHERN RAILWAY

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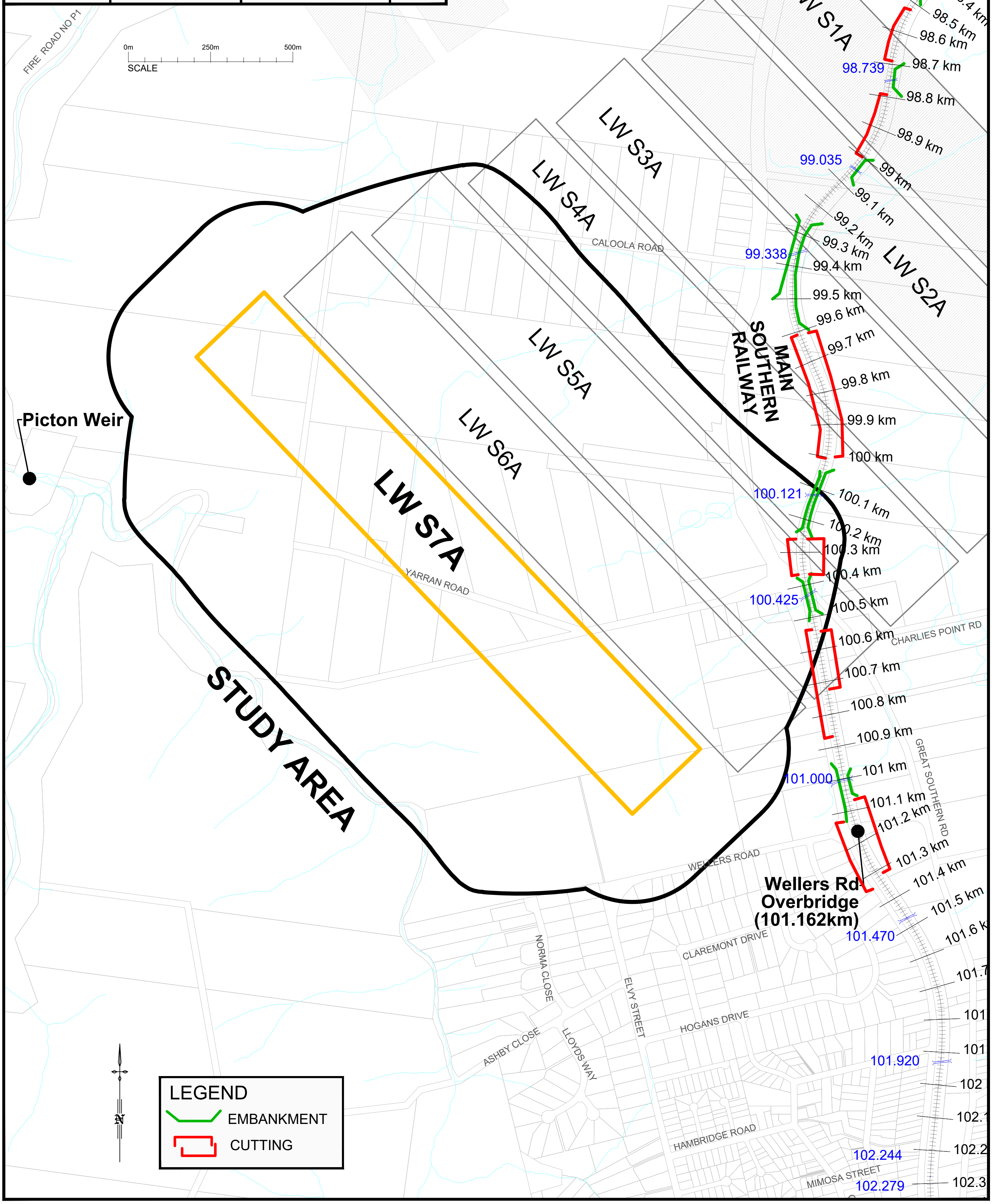

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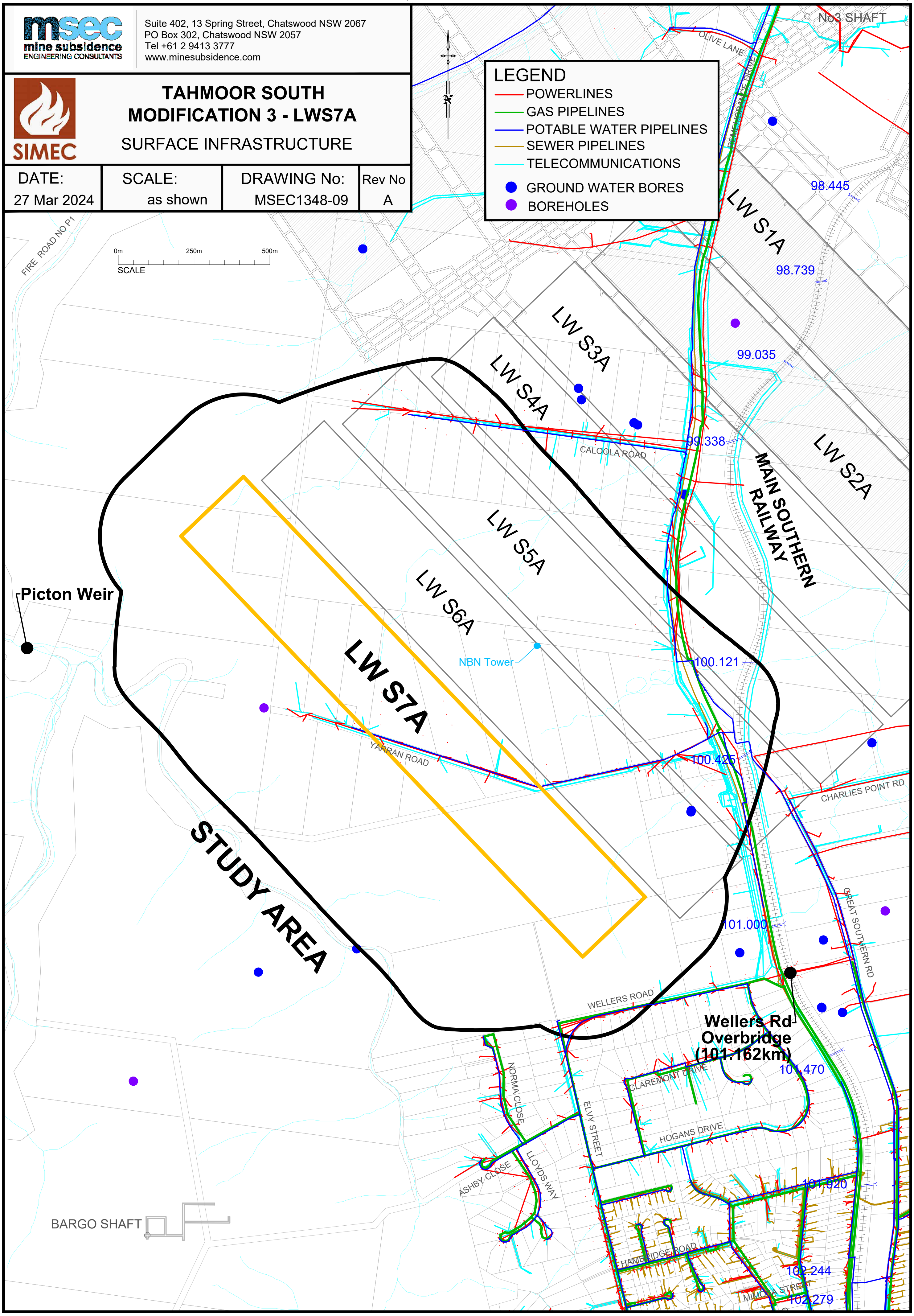
MODIFICATION 3 - LWS7A
SURFACE INFRASTRUCTURE

DATE:	SCALE:	DRAWING No:	Rev No
27 Mar 2024	as shown	MSEC1348-09	A



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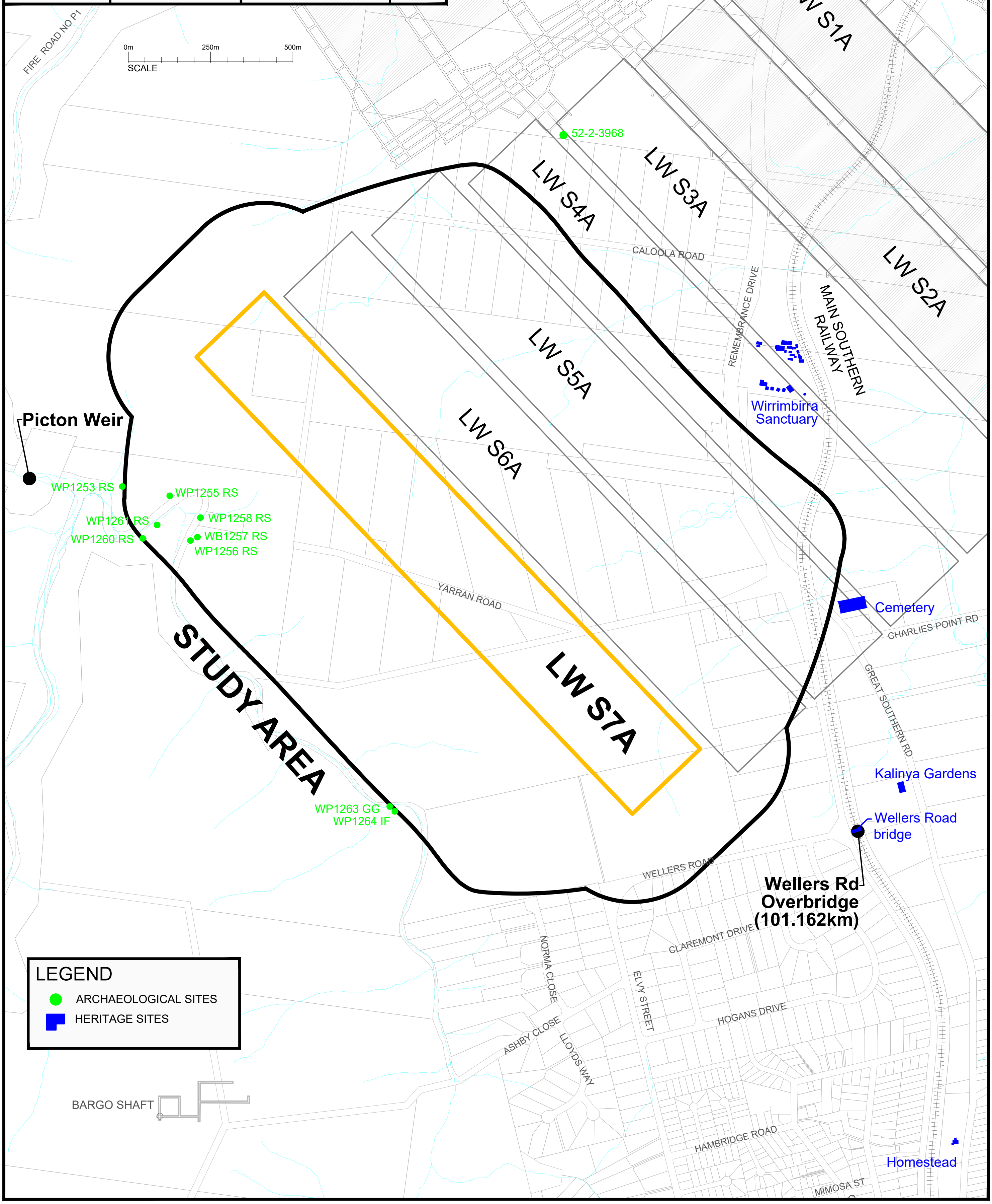
MODIFICATION 3 - LWS7A
ARCHAEOLOGICAL & HERITAGE SITES

DATE:	SCALE:	DRAWING No:	Rev No
27 Mar 2024	as shown	MSEC1348-10	A



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BUILT FEATURES

DATE:	SCALE:	DRAWING No:	Rev No
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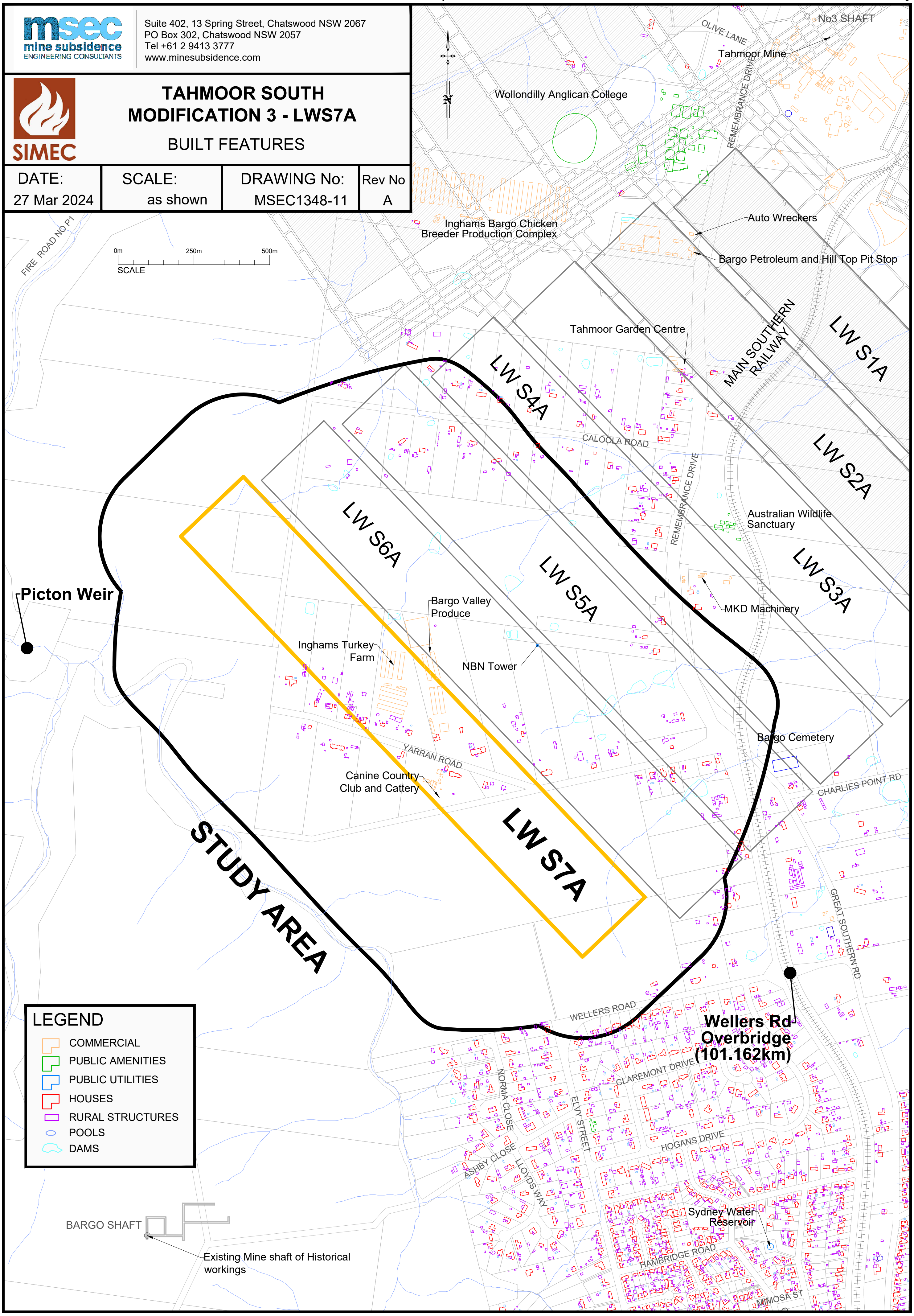

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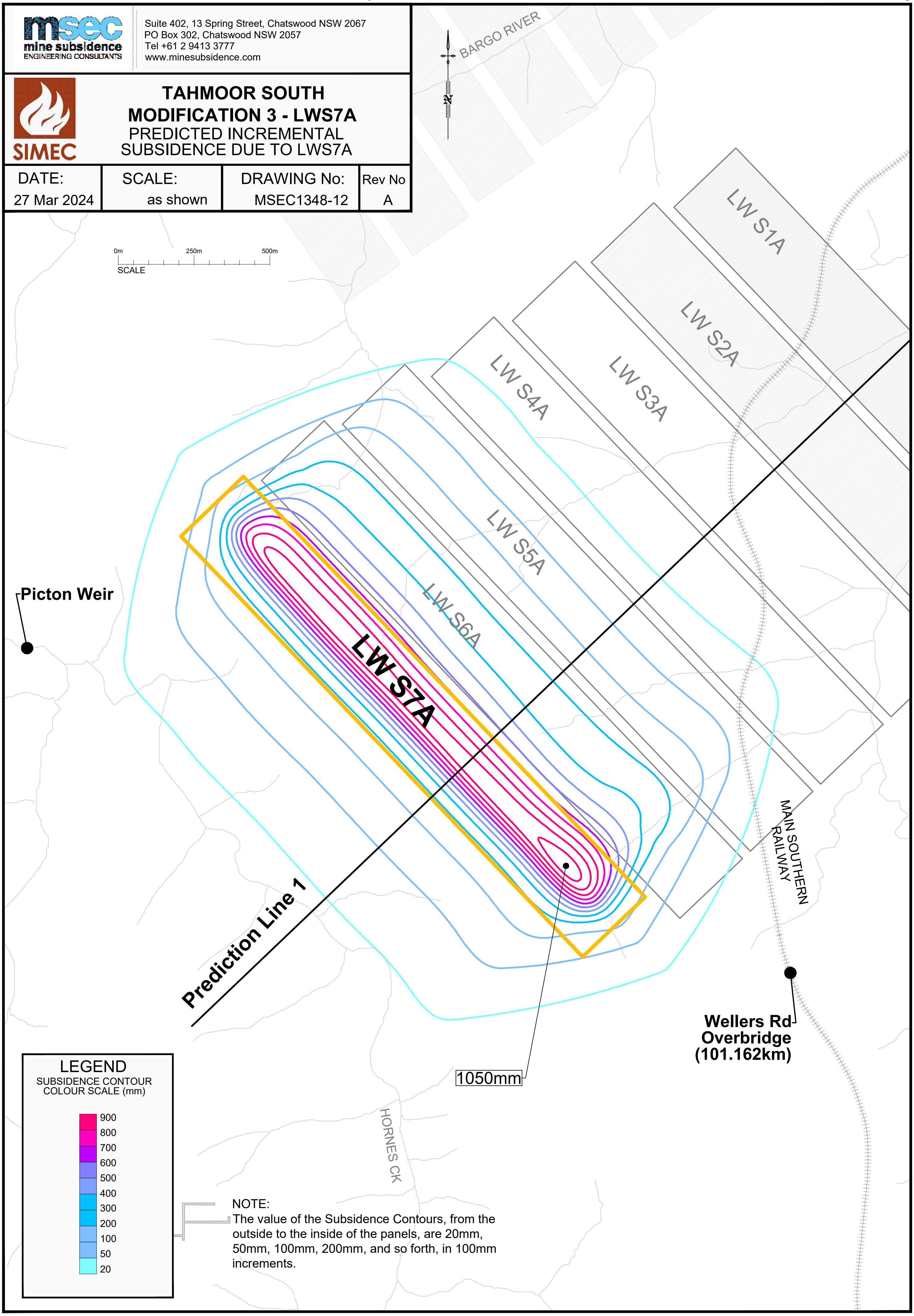
PREDICTED INCREMENTAL SUBSIDENCE DUE TO LWS7A

DATE:	SCALE:	DRAWING No:	Rev No
27 Mar 2024	as shown	MSEC1348-12	A



LEGEND
SUBSIDENCE CONTOUR COLOUR SCALE (mm)

900
800
700
600
500
400
300
200
100
50
20

NOTE:
The value of the Subsidence Contours, from the outside to the inside of the panels, are 20mm, 50mm, 100mm, 200mm, and so forth, in 100mm increments.

I:\Projects\Tahmoor South\MSEC1348 - LW S7A Modification\AcadData\MSEC1348-13 Pred Total Subs due to LW S7A.dwg

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PREDICTED TOTAL SUBSIDENCE DUE TO LW S1A TO LW S7A

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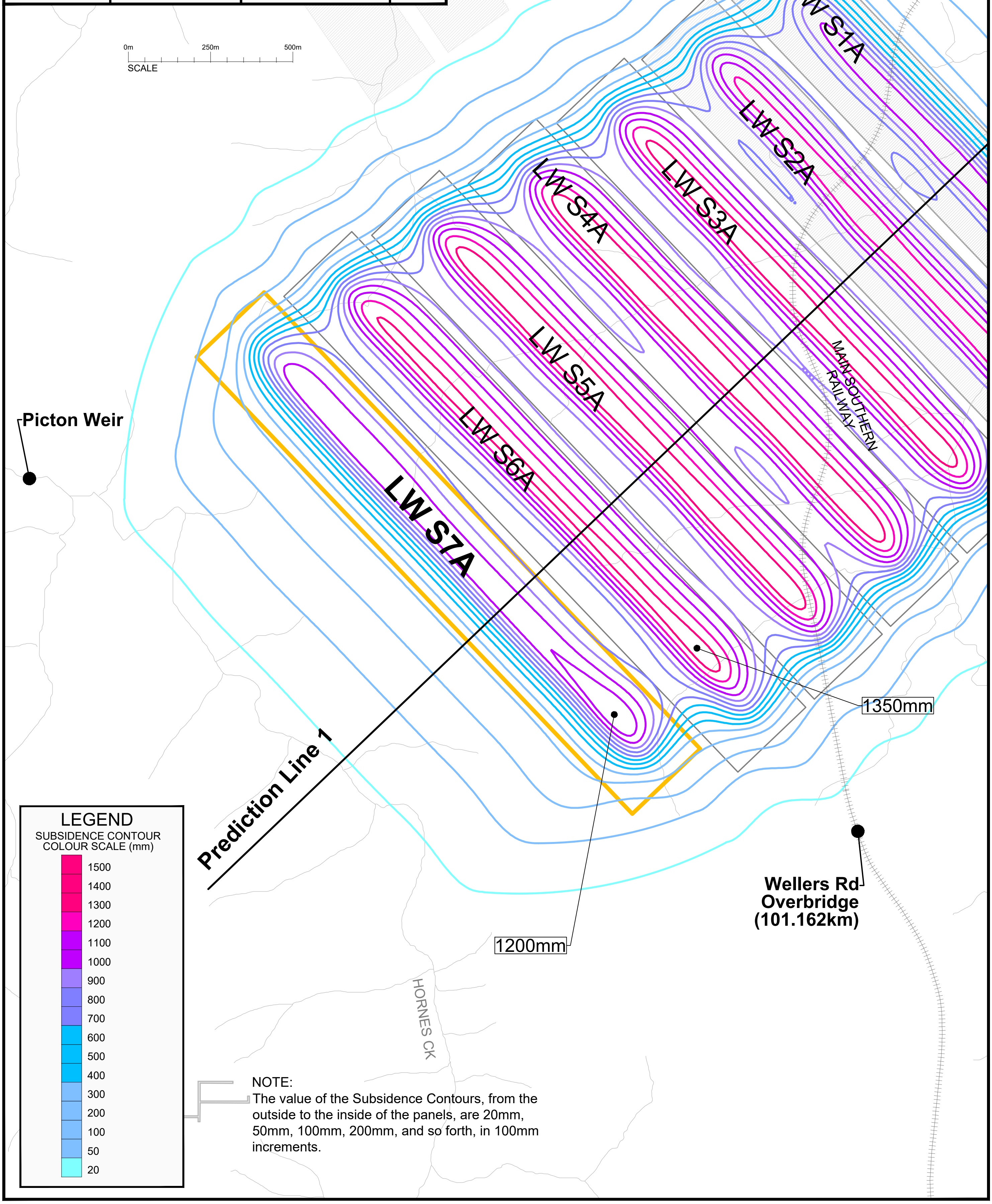

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MODIFICATION 3 - LWS7A
PREDICTED TOTAL SUBSIDENCE DUE TO LW S1A TO LW S6B

DATE:	SCALE:	DRAWING No:	Rev No
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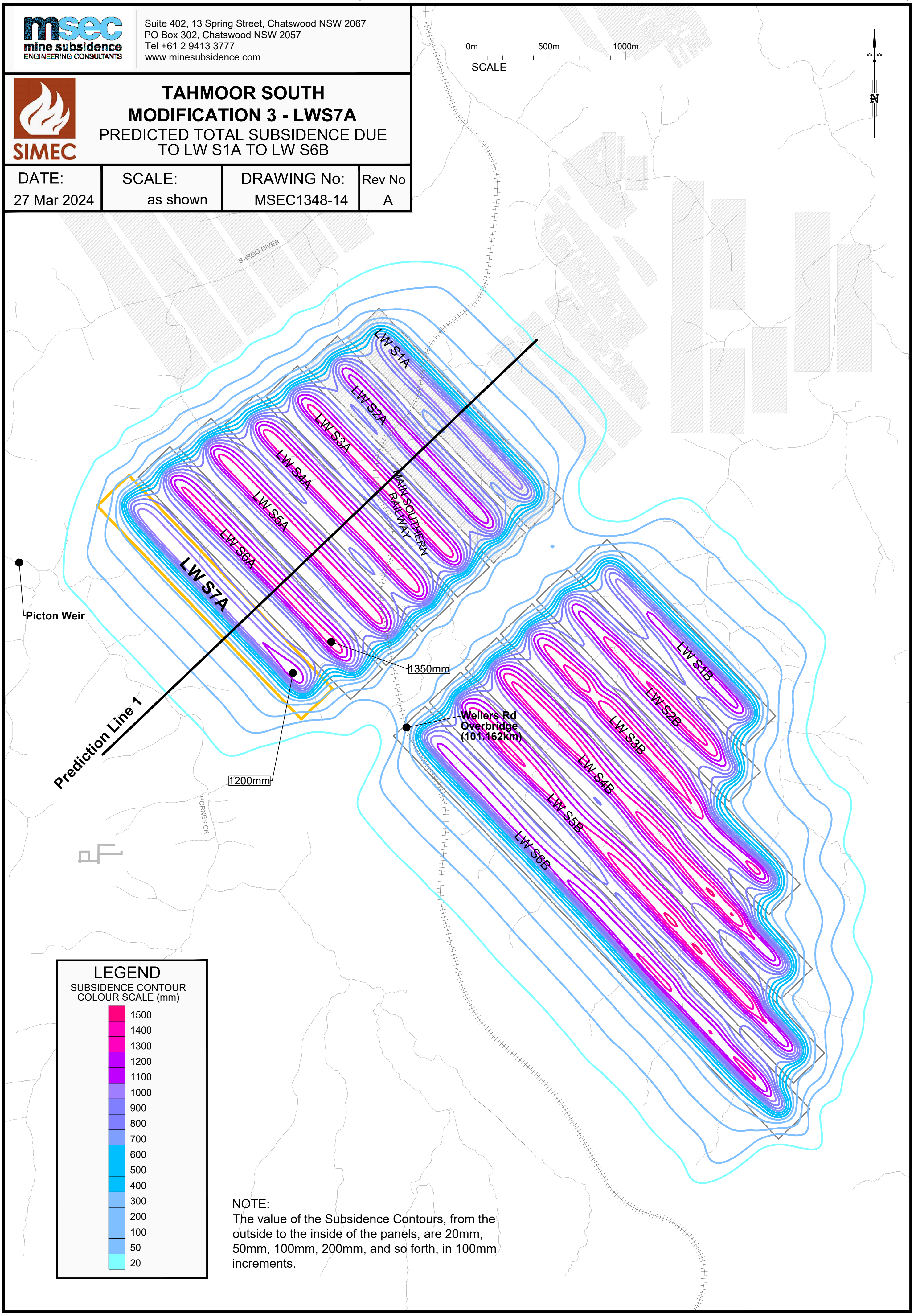

NOTE:
The value of the Subsidence Contours, from the outside to the inside of the panels, are 20mm, 50mm, 100mm, 200mm, and so forth, in 100mm increments.

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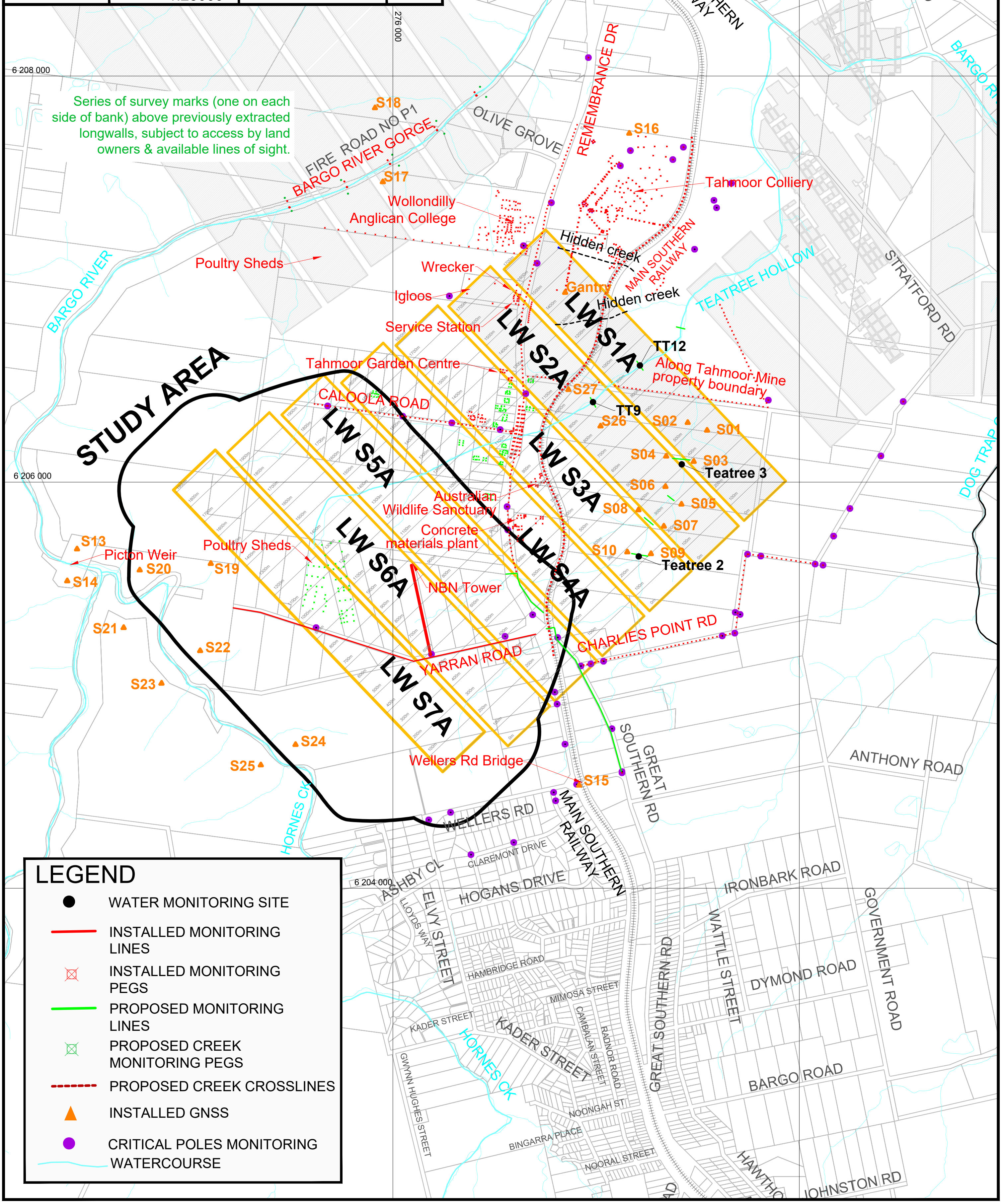
TAHMOOR SOUTH PROJECT EXTRACTION PLAN LW S1A TO LW S7A

SUBSIDENCE MONITORING

DATE:	SCALE:	DRAWING No:	Rev No
27 Mar 2024	1:25000	MSEC1348-15	A



APPENDIX C. TABLES

Table C.01 - Predictions for Stream Pools

Stream	Pool	Predicted Total Subsidence after all Longwalls (mm)	Predicted Total Upsidence after all Longwalls (mm)	Predicted Total Closure after all Longwalls (mm)
Hornes Creek	HC-P01	< 20	< 20	< 20
	HC-P02	< 20	< 20	< 20
	HC-P03	< 20	< 20	< 20
	HC-P04	< 20	< 20	< 20
	HC-P05	< 20	< 20	< 20
	HC-P06	< 20	< 20	< 20
	HC-P07	< 20	< 20	< 20
	HC-P08	< 20	40	50
	HC-P09	20	40	60
	HC-P10	< 20	40	50
	HC-P11	< 20	40	60
	HC-P12	< 20	40	50
	HC-P13	< 20	30	30
	HC-P14	< 20	40	50
	HC-P15	< 20	40	40
	HC-P16	< 20	40	50
Teatree Hollow	TT9	1300	275	225
	TT12	1100	400	250
	TT7	100	90	175
	TT14	100	80	150
	TT5	70	50	100
	TT6	< 20	< 20	< 20
	TT4	< 20	< 20	< 20
	TT8	< 20	< 20	< 20
Tributary of Teatree Hollow	TT1	125	125	70
	TT2	1300	375	225
	TT11	850	300	325
	TT3	800	300	350
	TT13	200	125	250

Table C.02 - Details of Houses

House Ref.	Maximum Plan Dimension (m)	Plan Area (m2)	Number of Stories	Wall Construction	Footing Construction	Wall and Footing Construction	Roof Construcftion	House Located Above Goaf	House Located Above Solid Coal
BCA_001_h01	21	234	1	Fibro	Slab on Ground	Timber Framed	Metal	1	
BCA_010_h01	24	252	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BCA_015_h01	18	227	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Metal	1	
BCA_020_h01	17	217	1	Weatherboard	N/A	Timber Framed	Metal	1	
BCA_025_h01	30	298	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BCA_030_h01	32	291	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BCA_035_h01	17	181	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BCA_040_h01	14	159	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BCA_095_h01	22	279	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BCA_100_h01	31	370	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BCA_105_h01	22	259	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BCA_110_h01	23	189	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Metal		1
BCA_120_h01	19	230	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BEL_001_h01	19	293	1	Fibro	Suspended on Piers	Timber Framed	Metal		1
BRE_140_h01	28	361	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Metal	1	
BRE_143_h01	17	176	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BRE_148_h01	20	303	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BRE_154_h01	19	174	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Tiled	1	
BRE_165_h01	9	63	1	Weatherboard	N/A	Timber Framed	Metal	1	
BRE_167_h01	19	160	2	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BRE_177_h01	14	158	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BRE_187_h01	29	396	2	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BRE_191_h01	15	134	1	Weatherboard	N/A	Timber Framed	Metal	1	
BRE_201_h01	22	272	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BRE_515_h02	26	401	2	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BWE_019_h02	35	519	2	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BWE_023_h01	26	296	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BWE_025_h01	18	225	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BWE_027_h01	18	208	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BWE_051_h01	22	201	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BYR_001_h01	10	95	1	Weatherboard	Suspended on Piers	Timber Framed	Tiled	1	
BYR_005_h01	22	165	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_015_h01	17	232	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_025_h01	35	538	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BYR_035_h01	17	119	1	Weatherboard	N/A	Timber Framed	Metal	1	
BYR_045_h01	18	152	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_045_h02	50	819	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BYR_055_h01	19	275	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BYR_065_h01	18	245	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_065_h02	15	131	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BYR_075_h01	21	264	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	

Table C.02 - Details of Houses

House Ref.	Maximum Plan Dimension (m)	Plan Area (m2)	Number of Stories	Wall Construction	Footing Construction	Wall and Footing Construction	Roof Constrúcftion	House Located Above Goaf	House Located Above Solid Coal
BYR_075_h02	10	80	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_084_h01	17	171	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BYR_085_h01	19	200	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BYR_085_h02	8	45	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BYR_085_h03	18	147	1	Weatherboard	Slab on Ground	Timber Framed	Metal		1
BYR_095_h01	37	591	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BYR_105_h01	11	87	1	Fibro	Suspended on Piers	Timber Framed	Metal		1
BYR_115_h02	48	592	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BYR_125_h01	18	156	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_135_h01	16	141	1	Weatherboard	Suspended on Piers	Timber Framed	Tiled	1	
BYR_135_h02	41	484	1	Weatherboard	Slab on Ground	Timber Framed	Metal	1	
BYR_145_h01	21	215	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_150_h01	12	102	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BYR_150_h02	7	39	1	Weatherboard	N/A	Timber Framed	Tiled	1	
BYR_152_h01	20	257	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_154_h01	27	327	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_156_h01	22	268	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_156_h02	12	95	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_158_h01	14	77	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_160_h01	30	285	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_162_h01	18	156	1	Weatherboard	N/A	Timber Framed	Metal	1	

Table C.03 - Predictions for Houses

House Ref.	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)	Predicted Probability of Nil or Category R0 Impact (%)	Predicted Probability of Category R1 or R2 Impact (%)	Predicted Probability of Category R3 or R4 Impact (%)	Predicted Probability of Category R5 Impact (%)
BCA_001_h01	125	1.0	< 0.01	0.01	550	5.5	5.5	0.05	0.03	71.6	19.4	8.6	0.4
BCA_010_h01	100	0.5	< 0.01	< 0.01	1200	6.5	8.0	0.09	0.14	49.5	35.8	13.6	1.0
BCA_015_h01	90	< 0.5	< 0.01	< 0.01	1350	7.0	8.0	0.09	0.22	42.2	35.2	15.7	6.9
BCA_020_h01	50	< 0.5	< 0.01	< 0.01	1200	4.0	4.0	0.05	0.05	71.3	19.6	8.7	0.4
BCA_025_h01	40	< 0.5	< 0.01	< 0.01	1150	4.0	4.0	0.05	0.04	66.3	26.3	7.0	0.5
BCA_030_h01	40	< 0.5	< 0.01	< 0.01	1100	3.5	3.5	0.05	0.04	54.7	28.2	13.5	3.7
BCA_035_h01	30	< 0.5	< 0.01	< 0.01	950	2.0	4.5	0.09	0.03	46.4	32.7	15.2	5.7
BCA_040_h01	20	< 0.5	< 0.01	< 0.01	1250	6.5	8.0	0.09	0.10	69.0	21.4	9.1	0.5
BCA_095_h01	20	< 0.5	< 0.01	< 0.01	1300	6.5	8.0	0.08	0.18	43.0	34.7	15.6	6.7
BCA_100_h01	30	< 0.5	< 0.01	< 0.01	1050	6.0	7.5	0.08	0.06	58.3	31.3	9.8	0.6
BCA_105_h01	30	< 0.5	< 0.01	< 0.01	700	4.0	4.0	0.05	0.03	65.4	26.9	7.2	0.5
BCA_110_h01	30	< 0.5	< 0.01	< 0.01	425	5.0	5.0	0.06	0.01	51.8	29.5	14.5	4.2
BCA_120_h01	30	< 0.5	0.01	< 0.01	100	1.5	1.5	0.02	< 0.01	77.2	18.3	4.2	0.3
BEL_001_h01	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	95.7	3.3	0.8	0.1
BRE_140_h01	30	< 0.5	< 0.01	< 0.01	1000	3.0	3.0	0.06	0.03	50.6	30.1	15.0	4.4
BRE_143_h01	50	< 0.5	< 0.01	< 0.01	1300	3.5	3.5	0.06	0.04	70.9	19.8	8.8	0.5
BRE_148_h01	50	< 0.5	< 0.01	< 0.01	1300	4.0	4.0	0.06	0.05	63.5	28.5	7.9	0.1
BRE_154_h01	80	< 0.5	< 0.01	< 0.01	1350	7.0	8.0	0.06	0.22	42.1	35.2	15.7	6.9
BRE_165_h01	70	1.0	< 0.01	< 0.01	1300	7.0	8.0	0.08	0.19	66.3	23.0	10.2	0.5
BRE_167_h01	50	1.0	0.02	< 0.01	850	5.0	6.0	0.09	0.05	46.5	32.6	15.2	5.7
BRE_177_h01	< 20	< 0.5	< 0.01	< 0.01	425	6.0	6.0	0.08	< 0.01	69.1	21.1	9.3	0.5
BRE_187_h01	< 20	< 0.5	< 0.01	< 0.01	275	5.0	5.0	0.08	< 0.01	58.6	31.2	9.7	0.6
BRE_191_h01	< 20	< 0.5	< 0.01	< 0.01	225	4.0	4.0	0.08	< 0.01	69.1	21.2	9.2	0.5
BRE_201_h01	< 20	< 0.5	< 0.01	< 0.01	60	0.5	0.5	< 0.01	< 0.01	91.5	7.4	1.0	0.2
BRE_515_h02	20	< 0.5	< 0.01	< 0.01	1300	6.5	8.0	0.09	0.17	47.2	36.4	15.2	1.2
BWE_019_h02	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	95.3	4.4	0.2	0.1
BWE_023_h01	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	95.4	4.3	0.2	0.1
BWE_025_h01	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	95.4	4.3	0.2	0.1
BWE_027_h01	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	95.4	4.3	0.2	0.1
BWE_051_h01	< 20	< 0.5	< 0.01	< 0.01	30	< 0.5	< 0.5	< 0.01	< 0.01	94.0	5.4	0.5	0.1
BYR_001_h01	150	0.5	< 0.01	< 0.01	950	3.5	6.0	0.09	0.02	69.0	21.3	9.2	0.5
BYR_005_h01	250	1.0	0.02	0.01	1300	4.0	4.0	0.06	0.08	59.4	30.8	9.3	0.5
BYR_015_h01	300	1.0	0.05	0.02	1350	7.5	8.5	0.08	0.23	43.6	37.1	17.3	2.0
BYR_025_h01	550	3.0	0.04	0.03	750	2.0	3.5	0.08	0.03	58.9	31.0	9.5	0.5
BYR_035_h01	450	2.0	0.03	0.02	800	3.5	5.5	0.09	0.02	69.0	21.3	9.2	0.5
BYR_045_h01	900	3.5	0.06	0.04	1050	3.0	3.0	0.06	0.04	70.9	19.8	8.8	0.5
BYR_045_h02	950	3.5	0.06	0.09	1100	3.0	3.0	0.06	0.09	57.1	32.0	10.3	0.6
BYR_055_h01	950	7.5	0.06	0.21	1100	8.0	8.0	0.06	0.22	42.2	35.2	15.7	6.9
BYR_065_h01	800	8.0	0.09	0.13	950	8.5	8.5	0.09	0.13	50.3	35.6	13.1	1.0
BYR_065_h02	450	6.5	0.09	0.02	550	7.0	7.0	0.09	0.02	56.6	32.3	10.5	0.7
BYR_075_h01	300	4.0	0.07	0.02	375	4.5	4.5	0.08	0.02	47.4	32.1	15.1	5.4
BYR_075_h02	225	2.5	0.05	0.01	300	3.0	3.0	0.05	0.01	71.2	19.7	8.7	0.4
BYR_084_h01	200	2.0	0.03	< 0.01	250	2.5	2.5	0.04	< 0.01	70.4	23.4	6.0	0.3
BYR_085_h01	175	1.5	0.02	< 0.01	225	2.0	2.0	0.03	< 0.01	75.6	19.5	4.6	0.3
BYR_085_h02	200	1.5	0.03	< 0.01	250	2.0	2.0	0.03	< 0.01	77.7	15.5	6.5	0.3
BYR_085_h03	150	1.0	0.01	< 0.01	200	1.5	1.5	0.01	< 0.01	87.4	8.9	3.6	0.1
BYR_095_h01	150	1.0	0.01	< 0.01	175	1.0	1.0	0.01	< 0.01	84.3	12.9	2.5	0.3
BYR_105_h01	90	< 0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01	93.2	5.0	1.7	0.1
BYR_115_h02	100	0.5	< 0.01	< 0.01	150	1.0	1.0	< 0.01	< 0.01	88.7	9.5	1.5	0.3
BYR_125_h01	350	5.0	0.08	0.02	425	5.5	5.5	0.09	0.02	69.0	21.3	9.2	0.5

Table C.03 - Predictions for Houses

House Ref.	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)	Predicted Probability of Nil or Category R0 Impact (%)	Predicted Probability of Category R1 or R2 Impact (%)	Predicted Probability of Category R3 or R4 Impact (%)	Predicted Probability of Category R5 Impact (%)
BYR_135_h01	850	8.0	0.08	0.16	1000	8.5	8.5	0.09	0.17	66.8	22.7	10.0	0.5
BYR_135_h02	900	8.0	0.09	0.21	1050	8.5	8.5	0.09	0.22	65.6	23.4	10.5	0.5
BYR_145_h01	950	6.5	0.06	0.22	1100	7.5	7.5	0.06	0.23	43.6	37.1	17.3	2.0
BYR_150_h01	250	1.0	0.02	0.01	1300	3.5	3.5	0.06	0.05	50.9	30.0	14.8	4.3
BYR_150_h02	275	1.0	0.02	0.01	1300	3.5	3.5	0.06	0.05	70.6	20.1	8.8	0.5
BYR_152_h01	225	1.0	0.02	0.01	1200	4.0	4.0	0.05	0.04	64.6	27.6	7.5	0.3
BYR_154_h01	200	1.0	0.01	0.01	1100	3.5	3.5	0.05	0.04	66.5	26.1	6.9	0.4
BYR_156_h01	175	1.0	0.01	< 0.01	1000	3.0	3.0	0.06	0.03	70.4	20.2	8.9	0.5
BYR_156_h02	200	1.0	0.01	< 0.01	1000	3.5	3.5	0.04	0.04	73.3	18.4	8.0	0.3
BYR_158_h01	150	0.5	< 0.01	< 0.01	900	2.0	4.5	0.09	0.03	69.0	21.3	9.2	0.5
BYR_160_h01	100	0.5	< 0.01	< 0.01	1250	7.0	8.5	0.10	0.10	54.4	33.4	11.4	0.8
BYR_162_h01	80	0.5	< 0.01	< 0.01	1350	7.0	8.5	0.08	0.23	65.5	23.5	10.5	0.5
Maxima:	**950**	**8.0**	**0.09**	**0.22**	**1350**	**8.5**	**8.5**	**0.10**	**0.23**				

Table C.04 - Predictions for Rural Structures

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BCA_001_r01	8	125	1.0	< 0.01	0.01	500	5.0	5.0	0.05	0.01
BCA_001_r02	17	225	1.0	0.01	0.01	1000	6.0	6.0	0.02	0.07
BCA_001_r03	7	225	1.0	0.01	0.01	1050	4.5	4.5	0.03	0.06
BCA_001_r04	6	250	1.0	0.01	0.01	1150	5.0	5.0	0.04	0.06
BCA_001_r05	15	250	1.5	0.01	0.02	1000	8.0	8.0	0.03	0.12
BCA_001_r07	4	150	1.0	< 0.01	0.01	600	6.0	6.0	0.04	0.04
BCA_001_r09	3	250	1.0	0.01	0.01	1150	5.0	5.0	0.04	0.06
BCA_001_r10	4	250	1.0	0.02	0.01	1200	5.0	5.0	0.04	0.06
BCA_010_r01	10	100	0.5	< 0.01	< 0.01	1100	6.5	8.0	0.09	0.05
BCA_010_r02	12	125	0.5	< 0.01	< 0.01	900	4.5	6.5	0.09	0.05
BCA_010_r03	7	125	0.5	< 0.01	< 0.01	950	5.0	7.0	0.09	0.04
BCA_010_r04	6	100	0.5	< 0.01	< 0.01	1100	6.5	8.0	0.09	0.04
BCA_010_r05	4	100	0.5	< 0.01	< 0.01	1150	6.5	8.0	0.09	0.05
BCA_010_r06	11	100	0.5	< 0.01	< 0.01	1150	6.5	8.0	0.09	0.05
BCA_010_r07	6	100	0.5	< 0.01	< 0.01	1100	6.5	8.0	0.09	0.05
BCA_010_r08	10	175	0.5	0.01	< 0.01	950	3.0	3.0	0.05	0.04
BCA_010_r09	6	125	0.5	< 0.01	< 0.01	900	4.5	6.5	0.09	0.04
BCA_015_r01	16	100	0.5	< 0.01	< 0.01	1250	7.0	8.0	0.09	0.13
BCA_015_r02	18	100	0.5	< 0.01	< 0.01	1300	7.0	8.0	0.09	0.13
BCA_015_r03	4	100	0.5	< 0.01	< 0.01	1150	6.5	8.0	0.09	0.05
BCA_020_r02	4	50	< 0.5	< 0.01	< 0.01	1200	4.0	4.0	0.05	0.05
BCA_020_r03	6	50	< 0.5	< 0.01	< 0.01	1250	4.0	4.0	0.05	0.05
BCA_020_r07	6	40	< 0.5	< 0.01	< 0.01	1150	4.0	4.0	0.04	0.05
BCA_020_r08	20	50	< 0.5	< 0.01	< 0.01	1250	4.0	4.0	0.05	0.05
BCA_020_r09	4	50	< 0.5	< 0.01	< 0.01	1250	4.0	4.0	0.05	0.05
BCA_020_r10	5	50	< 0.5	< 0.01	< 0.01	1300	4.0	4.0	0.05	0.05
BCA_020_r11	2	60	< 0.5	< 0.01	< 0.01	1300	4.5	4.5	0.05	0.06
BCA_020_r12	2	60	< 0.5	< 0.01	< 0.01	1300	4.0	4.0	0.05	0.06
BCA_020_r13	2	60	< 0.5	< 0.01	< 0.01	1300	4.0	4.0	0.05	0.08
BCA_020_r14	2	60	< 0.5	< 0.01	< 0.01	1350	4.0	4.0	0.05	0.11
BCA_020_r15	2	60	< 0.5	< 0.01	< 0.01	1350	4.0	4.0	0.05	0.14
BCA_020_r16	2	60	< 0.5	< 0.01	< 0.01	1350	4.0	4.0	0.05	0.18
BCA_020_r17	2	70	< 0.5	< 0.01	< 0.01	1350	3.5	3.5	0.05	0.20
BCA_020_r18	2	70	< 0.5	< 0.01	< 0.01	1350	3.5	3.5	0.06	0.22
BCA_025_r01	12	40	< 0.5	< 0.01	< 0.01	1150	4.0	4.0	0.05	0.04
BCA_025_r03	4	50	< 0.5	< 0.01	< 0.01	1250	4.0	4.0	0.05	0.04
BCA_025_r04	4	50	< 0.5	< 0.01	< 0.01	1250	4.0	4.0	0.05	0.05
BCA_025_r05	9	50	< 0.5	< 0.01	< 0.01	1300	4.0	4.0	0.06	0.05
BCA_025_r07	3	60	< 0.5	< 0.01	< 0.01	1300	4.0	4.0	0.06	0.05
BCA_025_r08	4	60	< 0.5	< 0.01	< 0.01	1350	4.0	4.0	0.06	0.05
BCA_025_r09	3	40	< 0.5	< 0.01	< 0.01	1200	4.0	4.0	0.05	0.04
BCA_030_r01	7	40	< 0.5	< 0.01	< 0.01	1050	3.5	3.5	0.04	0.03
BCA_030_r02	10	50	< 0.5	< 0.01	< 0.01	1300	4.0	4.0	0.06	0.05

Table C.04 - Predictions for Rural Structures

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BCA_030_r03	13	40	< 0.5	< 0.01	< 0.01	1150	3.5	3.5	0.05	0.04
BCA_030_r04	6	40	< 0.5	< 0.01	< 0.01	1150	4.0	4.0	0.05	0.04
BCA_035_r01	11	30	< 0.5	< 0.01	< 0.01	900	1.5	4.0	0.08	0.03
BCA_035_r02	13	40	< 0.5	< 0.01	< 0.01	1100	3.5	3.5	0.05	0.04
BCA_035_r03	3	40	< 0.5	< 0.01	< 0.01	1150	4.0	4.0	0.05	0.04
BCA_035_r04	3	30	< 0.5	< 0.01	< 0.01	950	2.0	3.0	0.07	0.03
BCA_040_r02	10	20	< 0.5	< 0.01	< 0.01	1150	6.0	8.0	0.09	0.03
BCA_040_r03	5	20	< 0.5	< 0.01	< 0.01	1100	5.5	8.0	0.09	0.03
BCA_040_r04	5	20	< 0.5	< 0.01	< 0.01	1050	5.0	7.5	0.09	0.03
BCA_040_r05	7	30	< 0.5	< 0.01	< 0.01	1050	5.0	7.5	0.09	0.03
BCA_040_r06	6	30	< 0.5	< 0.01	< 0.01	1000	4.0	6.0	0.09	0.02
BCA_095_r02	9	20	< 0.5	< 0.01	< 0.01	1200	6.0	7.5	0.07	0.14
BCA_095_r03	11	20	< 0.5	< 0.01	< 0.01	1250	6.5	8.0	0.07	0.16
BCA_100_r01	9	20	< 0.5	< 0.01	< 0.01	800	5.5	6.5	0.07	0.05
BCA_100_r02	7	20	< 0.5	< 0.01	< 0.01	800	6.0	6.5	0.06	0.05
BCA_100_r03	6	20	< 0.5	< 0.01	< 0.01	800	6.0	6.5	0.06	0.05
BCA_100_r04	3	30	< 0.5	< 0.01	< 0.01	800	4.5	5.5	0.07	0.05
BCA_100_r05	5	30	< 0.5	< 0.01	< 0.01	800	4.5	5.5	0.07	0.05
BCA_105_r01	11	30	< 0.5	< 0.01	< 0.01	850	4.5	4.5	0.03	0.04
BCA_105_r02	14	30	< 0.5	< 0.01	< 0.01	500	4.5	4.5	0.04	0.02
BCA_105_r03	16	30	< 0.5	< 0.01	< 0.01	750	4.5	4.5	0.03	0.04
BCA_105_r04	8	30	< 0.5	< 0.01	< 0.01	750	4.0	4.0	0.06	0.04
BCA_105_r05	3	30	< 0.5	< 0.01	< 0.01	700	4.5	4.5	0.06	0.03
BCA_110_r01	12	30	< 0.5	< 0.01	< 0.01	425	5.0	5.0	0.06	< 0.01
BCA_110_r02	7	20	< 0.5	< 0.01	< 0.01	400	4.5	4.5	0.04	0.01
BCA_110_r04	9	20	< 0.5	< 0.01	< 0.01	375	4.0	4.0	0.04	< 0.01
BCA_110_r07	11	40	< 0.5	< 0.01	< 0.01	850	5.0	5.0	0.03	0.04
BCA_120_r01	7	30	< 0.5	0.01	< 0.01	125	1.5	1.5	0.03	< 0.01
BCA_120_r02	5	30	0.5	0.01	< 0.01	125	1.5	1.5	0.03	< 0.01
BCA_120_r03	3	30	0.5	0.01	< 0.01	125	1.5	1.5	0.03	< 0.01
BCA_120_r04	5	< 20	< 0.5	< 0.01	< 0.01	70	0.5	0.5	< 0.01	< 0.01
BCA_120_r05	11	20	< 0.5	< 0.01	< 0.01	100	1.0	1.0	0.02	< 0.01
BCA_120_r06	7	20	< 0.5	< 0.01	< 0.01	90	1.0	1.0	0.02	< 0.01
BCA_120_r07	4	< 20	< 0.5	< 0.01	< 0.01	70	0.5	0.5	< 0.01	< 0.01
BCA_120_r09	3	< 20	< 0.5	< 0.01	< 0.01	90	1.0	1.0	0.01	< 0.01
BCA_120_r10	3	20	< 0.5	< 0.01	< 0.01	100	1.5	1.5	0.02	< 0.01
BEL_001_r01	17	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BEL_001_r02	11	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BEL_001_r04	4	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BEL_001_r05	8	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BEL_001_r06	3	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BNO_043_r04	9	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_090_r01	10	40	< 0.5	< 0.01	< 0.01	1250	3.5	3.5	0.06	0.04

Table C.04 - Predictions for Rural Structures

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BRE_140_r01	11	30	< 0.5	< 0.01	< 0.01	1000	3.0	3.0	0.05	0.03
BRE_140_r02	6	30	< 0.5	< 0.01	< 0.01	1050	3.0	3.0	0.04	0.03
BRE_143_r01	3	50	< 0.5	< 0.01	< 0.01	1300	3.5	3.5	0.06	0.04
BRE_143_r02	6	50	< 0.5	< 0.01	< 0.01	1300	3.5	3.5	0.06	0.05
BRE_143_r03	7	50	< 0.5	< 0.01	< 0.01	1300	3.5	3.5	0.06	0.05
BRE_148_r01	7	50	< 0.5	< 0.01	< 0.01	1300	3.5	3.5	0.06	0.06
BRE_148_r02	8	50	< 0.5	< 0.01	< 0.01	1350	3.5	3.5	0.06	0.08
BRE_148_r03	7	60	< 0.5	< 0.01	< 0.01	1350	3.0	3.0	0.06	0.22
BRE_148_r04	2	50	< 0.5	< 0.01	< 0.01	1350	3.5	3.5	0.06	0.06
BRE_148_r05	6	50	< 0.5	< 0.01	< 0.01	1350	3.5	3.5	0.06	0.12
BRE_154_r01	6	80	< 0.5	< 0.01	< 0.01	1350	7.0	8.0	0.07	0.22
BRE_154_r02	9	90	0.5	< 0.01	< 0.01	1350	7.0	8.0	0.08	0.20
BRE_154_r03	10	90	< 0.5	< 0.01	< 0.01	1350	7.0	8.0	0.08	0.22
BRE_154_r04	11	100	0.5	< 0.01	< 0.01	1300	7.0	8.0	0.09	0.15
BRE_154_r05	5	100	0.5	< 0.01	< 0.01	1200	7.0	8.0	0.09	0.05
BRE_154_r06	4	100	0.5	< 0.01	< 0.01	1150	7.0	8.0	0.09	0.04
BRE_154_r07	10	100	0.5	< 0.01	< 0.01	1200	7.0	8.0	0.09	0.06
BRE_167_r01	11	60	1.0	0.02	< 0.01	900	5.0	6.5	0.09	0.05
BRE_167_r02	9	70	1.0	0.02	< 0.01	850	4.0	5.5	0.09	0.04
BRE_167_r03	12	70	1.0	0.02	< 0.01	800	3.5	4.5	0.08	0.04
BRE_167_r04	12	80	1.0	0.02	< 0.01	800	3.0	4.0	0.08	0.04
BRE_167_r06	9	70	1.0	0.02	< 0.01	800	3.0	3.5	0.07	0.04
BRE_167_r07	7	70	1.0	0.02	< 0.01	800	3.0	3.0	0.07	0.05
BRE_167_r08	6	60	1.0	0.02	< 0.01	800	3.5	4.5	0.08	0.05
BRE_167_r09	6	50	1.0	0.02	< 0.01	750	3.5	3.5	0.07	0.05
BRE_167_r10	3	50	1.0	0.02	< 0.01	750	3.5	4.5	0.08	0.05
BRE_167_r12	3	50	1.0	0.02	< 0.01	750	3.5	3.5	0.06	0.05
BRE_167_r13	4	50	1.0	0.02	< 0.01	750	3.5	3.5	0.06	0.05
BRE_167_r14	3	60	1.0	0.02	< 0.01	750	3.5	3.5	0.06	0.05
BRE_167_r15	29	50	1.0	0.02	< 0.01	800	4.5	4.5	0.05	0.06
BRE_167_r16	19	60	1.0	0.02	< 0.01	800	4.0	4.0	0.05	0.05
BRE_167_r17	14	90	1.5	0.02	< 0.01	900	4.0	4.0	0.04	0.05
BRE_167_r18	3	60	1.0	0.02	< 0.01	800	3.5	4.5	0.08	0.05
BRE_167_r19	6	80	1.5	0.02	< 0.01	900	4.5	4.5	0.03	0.05
BRE_177_r01	6	< 20	< 0.5	< 0.01	< 0.01	450	6.0	6.0	0.08	0.01
BRE_187_r01	9	< 20	< 0.5	< 0.01	< 0.01	350	6.0	6.0	0.09	< 0.01
BRE_189_r01	12	< 20	< 0.5	< 0.01	< 0.01	200	3.5	3.5	0.08	< 0.01
BRE_191_r01	13	< 20	< 0.5	< 0.01	< 0.01	225	3.5	3.5	0.08	0.01
BRE_191_r02	4	< 20	< 0.5	< 0.01	< 0.01	275	4.5	4.5	0.10	0.02
BRE_195_r02	12	< 20	< 0.5	< 0.01	< 0.01	125	1.0	1.0	0.02	0.01
BRE_195_r03	8	< 20	< 0.5	< 0.01	< 0.01	125	1.5	1.5	0.03	0.02
BRE_195_r04	4	< 20	< 0.5	< 0.01	< 0.01	80	1.0	1.0	< 0.01	< 0.01
BRE_195_r06	8	< 20	< 0.5	< 0.01	< 0.01	150	2.0	2.0	0.03	0.02

Table C.04 - Predictions for Rural Structures

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BRE_195_r07	7	< 20	< 0.5	< 0.01	< 0.01	80	0.5	0.5	< 0.01	< 0.01
BRE_195_r08	6	< 20	< 0.5	< 0.01	< 0.01	70	0.5	0.5	< 0.01	< 0.01
BRE_195_r12	4	< 20	< 0.5	< 0.01	< 0.01	125	1.5	1.5	0.03	0.02
BRE_195_r13	2	< 20	< 0.5	< 0.01	< 0.01	100	1.0	1.0	0.01	0.01
BRE_195_r14	7	< 20	< 0.5	< 0.01	< 0.01	100	1.0	1.0	0.02	0.01
BRE_195_r15	4	< 20	< 0.5	< 0.01	< 0.01	100	1.0	1.0	0.01	0.01
BRE_201_r01	17	< 20	< 0.5	< 0.01	< 0.01	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_201_r02	5	< 20	< 0.5	< 0.01	< 0.01	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_201_r03	4	< 20	< 0.5	< 0.01	< 0.01	60	0.5	0.5	< 0.01	< 0.01
BRE_201_r04	2	< 20	< 0.5	< 0.01	< 0.01	60	0.5	0.5	< 0.01	< 0.01
BRE_201_r05	12	< 20	< 0.5	< 0.01	< 0.01	50	0.5	0.5	< 0.01	< 0.01
BWE_023_r01	10	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_025_r01	8	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_025_r02	10	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_027_r01	12	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_027_r08	9	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_027_r09	6	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_029_r03	4	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_029_r04	7	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_041_r04	30	< 20	< 0.5	< 0.01	< 0.01	30	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r01	18	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r02	5	< 20	< 0.5	< 0.01	< 0.01	20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r03	10	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r04	10	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r05	2	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r07	7	< 20	< 0.5	< 0.01	< 0.01	20	< 0.5	< 0.5	< 0.01	< 0.01
BYR_001_r02	19	150	0.5	< 0.01	< 0.01	950	4.0	6.0	0.09	0.02
BYR_001_r03	8	125	0.5	< 0.01	< 0.01	1000	5.0	7.0	0.09	0.03
BYR_001_r05	5	125	0.5	< 0.01	< 0.01	1050	5.0	7.5	0.09	0.03
BYR_005_r01	7	250	1.0	0.02	0.01	1300	3.5	3.5	0.06	0.09
BYR_005_r02	13	250	1.0	0.02	0.01	1300	4.0	4.0	0.06	0.07
BYR_005_r03	17	250	1.0	0.02	0.01	1300	4.0	4.0	0.06	0.06
BYR_005_r04	6	250	1.0	0.02	0.01	1300	3.5	3.5	0.06	0.10
BYR_005_r05	9	225	1.0	0.02	0.01	1200	4.0	4.0	0.06	0.04
BYR_005_r06	4	200	1.0	0.01	0.01	1150	4.0	4.0	0.05	0.04
BYR_015_r01	12	275	1.0	0.02	0.01	1350	6.0	6.5	0.06	0.23
BYR_015_r02	12	300	1.0	0.02	0.02	1350	7.5	8.0	0.06	0.23
BYR_015_r06	4	250	1.0	0.02	0.01	1300	3.5	3.5	0.06	0.15
BYR_015_r07	29	300	1.5	0.05	0.02	1350	8.0	8.5	0.11	0.23
BYR_025_r05	4	475	2.5	0.03	0.03	750	1.5	3.5	0.08	0.03
BYR_025_r08	6	550	3.0	0.04	0.03	750	2.0	2.5	0.05	0.03
BYR_025_r09	24	350	1.5	0.06	0.02	1150	8.0	8.5	0.12	0.05
BYR_035_r02	7	475	2.0	0.03	0.02	800	3.0	5.0	0.08	0.02

Table C.04 - Predictions for Rural Structures

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BYR_035_r03	7	450	2.0	0.03	0.02	800	3.0	5.0	0.08	0.02
BYR_035_r04	12	450	2.0	0.03	0.02	850	4.0	5.5	0.09	0.02
BYR_035_r05	7	400	2.0	0.03	0.02	900	5.0	7.0	0.09	0.03
BYR_035_r06	9	400	2.0	0.04	0.02	900	5.5	7.5	0.11	0.03
BYR_035_r07	7	375	2.0	0.06	0.02	1050	7.5	8.5	0.12	0.03
BYR_035_r08	12	425	2.0	0.03	0.02	900	5.0	7.0	0.09	0.02
BYR_035_r09	5	400	2.0	0.03	0.02	900	5.0	7.0	0.09	0.02
BYR_035_r10	2	400	2.0	0.03	0.02	900	5.0	7.0	0.09	0.03
BYR_035_r12	4	425	2.0	0.03	0.02	800	4.0	5.5	0.09	0.02
BYR_035_r13	11	500	2.5	0.03	0.03	750	1.5	3.5	0.07	0.03
BYR_045_r10	7	950	3.5	0.06	0.06	1050	3.0	3.0	0.06	0.06
BYR_045_r11	21	900	3.5	0.06	0.05	1050	3.0	3.0	0.06	0.05
BYR_065_r01	12	750	8.0	0.09	0.07	850	8.5	8.5	0.09	0.07
BYR_065_r02	9	800	8.0	0.08	0.11	900	8.5	8.5	0.09	0.11
BYR_065_r03	4	350	4.5	0.08	0.02	425	5.0	5.0	0.09	0.02
BYR_065_r04	3	425	6.0	0.09	0.02	500	6.5	6.5	0.09	0.02
BYR_065_r05	21	850	8.0	0.09	0.14	950	8.5	8.5	0.09	0.14
BYR_065_r06	18	750	8.0	0.09	0.08	900	8.5	8.5	0.09	0.08
BYR_065_r07	7	550	7.5	0.09	0.03	650	8.0	8.0	0.09	0.03
BYR_065_r08	4	350	5.0	0.08	0.02	425	5.5	5.5	0.09	0.02
BYR_065_r09	2	350	5.0	0.08	0.02	425	5.5	5.5	0.09	0.02
BYR_065_r10	4	750	8.0	0.09	0.07	850	8.5	8.5	0.09	0.07
BYR_065_r11	3	650	8.0	0.09	0.03	800	8.5	8.5	0.09	0.03
BYR_065_r12	6	600	7.5	0.09	0.03	700	8.5	8.5	0.09	0.03
BYR_075_r01	15	325	4.5	0.08	0.02	400	5.0	5.0	0.08	0.02
BYR_075_r02	11	350	5.0	0.08	0.02	425	5.5	5.5	0.09	0.02
BYR_075_r03	11	400	5.5	0.09	0.02	475	6.0	6.0	0.09	0.02
BYR_075_r04	11	650	8.0	0.09	0.03	750	8.5	8.5	0.09	0.03
BYR_075_r05	10	275	3.5	0.07	0.01	350	4.0	4.0	0.07	0.01
BYR_075_r06	3	250	3.0	0.06	0.01	325	3.5	3.5	0.06	0.01
BYR_075_r07	3	300	4.0	0.08	0.02	375	4.5	4.5	0.08	0.02
BYR_075_r08	14	250	3.0	0.06	0.01	325	3.0	3.0	0.06	0.01
BYR_075_r09	6	225	2.0	0.04	0.01	275	2.5	2.5	0.05	0.01
BYR_075_r10	2	250	3.0	0.06	0.01	325	3.0	3.0	0.06	0.01
BYR_075_r11	4	225	2.5	0.05	0.01	300	3.0	3.0	0.05	0.01
BYR_075_r12	3	300	4.0	0.07	0.01	375	4.5	4.5	0.08	0.01
BYR_075_r13	14	450	6.0	0.09	0.02	500	6.5	6.5	0.09	0.02
BYR_084_r01	8	200	2.0	0.04	0.01	275	2.5	2.5	0.04	0.01
BYR_084_r02	8	275	3.5	0.06	0.01	350	3.5	3.5	0.07	0.01
BYR_084_r03	8	250	3.0	0.06	0.01	325	3.5	3.5	0.06	0.01
BYR_084_r04	14	225	2.0	0.04	0.01	275	2.5	2.5	0.04	0.01
BYR_084_r05	9	250	3.0	0.06	0.01	325	3.5	3.5	0.06	0.01
BYR_084_r06	7	300	3.5	0.07	0.01	350	4.0	4.0	0.07	0.01

Table C.04 - Predictions for Rural Structures

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BYR_085_r01	16	175	1.5	0.02	< 0.01	225	1.5	1.5	0.02	< 0.01
BYR_085_r03	19	175	1.5	0.02	< 0.01	225	2.0	2.0	0.03	< 0.01
BYR_085_r04	4	250	3.0	0.06	0.01	325	3.5	3.5	0.06	0.01
BYR_085_r05	4	200	2.0	0.03	0.01	250	2.5	2.5	0.04	0.01
BYR_085_r06	17	400	5.5	0.09	0.02	500	6.0	6.0	0.09	0.02
BYR_085_r08	4	275	3.0	0.06	0.01	325	3.5	3.5	0.07	0.01
BYR_085_r09	6	150	1.0	0.01	< 0.01	200	1.5	1.5	0.02	< 0.01
BYR_085_r10	9	150	1.0	0.02	< 0.01	200	1.5	1.5	0.02	< 0.01
BYR_085_r11	5	200	2.0	0.03	< 0.01	250	2.0	2.0	0.03	< 0.01
BYR_085_r12	10	300	3.5	0.07	0.01	375	4.0	4.0	0.08	0.01
BYR_085_r13	5	350	5.0	0.08	0.02	425	5.5	5.5	0.09	0.02
BYR_085_r14	5	600	7.5	0.09	0.03	700	8.5	8.5	0.09	0.03
BYR_085_r15	6	225	2.0	0.04	0.01	275	2.5	2.5	0.04	0.01
BYR_085_r16	3	200	1.5	0.03	< 0.01	250	2.0	2.0	0.03	< 0.01
BYR_095_r02	12	200	1.5	0.03	< 0.01	250	2.0	2.0	0.03	< 0.01
BYR_095_r03	12	200	2.0	0.03	< 0.01	250	2.0	2.0	0.03	< 0.01
BYR_095_r04	19	225	2.5	0.05	0.01	300	3.0	3.0	0.05	0.01
BYR_095_r05	16	250	2.5	0.05	0.01	300	3.0	3.0	0.05	0.01
BYR_095_r06	4	125	0.5	< 0.01	< 0.01	150	1.0	1.0	< 0.01	< 0.01
BYR_105_r01	11	90	< 0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_105_r02	10	80	< 0.5	< 0.01	< 0.01	100	0.5	0.5	< 0.01	< 0.01
BYR_105_r03	15	70	< 0.5	< 0.01	< 0.01	100	< 0.5	< 0.5	< 0.01	< 0.01
BYR_105_r07	5	80	< 0.5	< 0.01	< 0.01	100	0.5	0.5	< 0.01	< 0.01
BYR_105_r09	3	80	< 0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_105_r10	2	80	< 0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_115_r01	18	125	1.0	0.01	< 0.01	175	1.0	1.0	0.01	< 0.01
BYR_115_r02	6	100	0.5	< 0.01	< 0.01	150	1.0	1.0	< 0.01	< 0.01
BYR_115_r04	5	100	0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_115_r08	14	100	0.5	< 0.01	< 0.01	150	1.0	1.0	< 0.01	< 0.01
BYR_115_r09	9	90	< 0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_115_r10	6	100	0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_115_r11	2	125	1.0	0.01	< 0.01	175	1.0	1.0	0.01	< 0.01
BYR_125_r04	9	275	3.5	0.06	0.01	350	3.5	3.5	0.07	0.01
BYR_135_r01	9	800	8.0	0.09	0.09	900	8.5	8.5	0.09	0.09
BYR_135_r02	9	800	8.0	0.09	0.11	900	8.5	8.5	0.09	0.11
BYR_135_r03	3	700	8.0	0.09	0.04	850	8.5	8.5	0.09	0.04
BYR_135_r04	7	500	7.0	0.09	0.03	600	8.0	8.0	0.09	0.03
BYR_145_r01	11	950	3.0	0.06	0.22	1100	3.0	3.0	0.06	0.23
BYR_145_r02	11	950	5.5	0.06	0.22	1100	6.5	6.5	0.06	0.23
BYR_145_r03	12	950	3.5	0.06	0.12	1100	3.0	3.0	0.06	0.13
BYR_145_r05	3	950	5.0	0.06	0.22	1100	5.5	5.5	0.06	0.23
BYR_145_r06	4	950	6.0	0.06	0.22	1100	7.0	7.0	0.06	0.23
BYR_145_r07	2	950	3.5	0.06	0.09	1100	3.0	3.0	0.06	0.09

Table C.04 - Predictions for Rural Structures

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BYR_150_r01	7	275	1.0	0.02	0.01	1300	3.5	3.5	0.06	0.05
BYR_150_r02	8	250	1.0	0.02	0.01	1300	3.5	3.5	0.06	0.05
BYR_150_r03	12	250	1.0	0.02	0.01	1300	3.5	3.5	0.06	0.05
BYR_150_r04	10	275	1.0	0.02	0.01	1350	3.5	3.5	0.06	0.09
BYR_152_r01	8	200	1.0	0.01	0.01	1100	3.5	3.5	0.05	0.04
BYR_152_r02	7	225	1.0	0.01	0.01	1150	4.0	4.0	0.05	0.04
BYR_152_r03	15	225	1.0	0.02	0.01	1200	4.0	4.0	0.05	0.04
BYR_152_r04	3	250	1.0	0.02	0.01	1250	4.0	4.0	0.06	0.05
BYR_152_r05	5	250	1.0	0.02	0.01	1300	4.0	4.0	0.06	0.05
BYR_152_r06	12	275	1.0	0.02	0.01	1300	4.0	4.0	0.06	0.05
BYR_152_r07	3	250	1.0	0.02	0.01	1250	4.0	4.0	0.06	0.04
BYR_154_r01	9	225	1.0	0.01	0.01	1150	4.0	4.0	0.05	0.04
BYR_156_r01	10	175	1.0	0.01	< 0.01	1000	3.0	3.0	0.05	0.03
BYR_158_r01	3	150	0.5	< 0.01	< 0.01	900	1.5	3.5	0.08	0.03
BYR_158_r02	14	150	0.5	< 0.01	< 0.01	900	1.5	4.0	0.09	0.03
BYR_160_r01	9	90	1.0	< 0.01	< 0.01	1200	7.0	8.5	0.10	0.07
BYR_160_r02	11	100	0.5	< 0.01	< 0.01	1150	7.0	8.5	0.10	0.04
BYR_162_r01	9	70	0.5	< 0.01	< 0.01	1350	7.0	8.0	0.06	0.23
	Maxima:	**950**	**8.0**	**0.09**	**0.22**	**1350**	**8.5**	**8.5**	**0.12**	**0.23**

Table C.05 - Predictions for Tanks

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BCA_001_t01	7	100	1.5	0.015	< 0.01	325	5.0	5.0	0.06	< 0.01
BCA_001_t02	2	125	1.0	< 0.01	< 0.01	550	5.0	5.0	0.04	0.03
BCA_010_t01	3	90	< 0.5	< 0.01	< 0.01	1250	6.5	8.0	0.09	0.18
BCA_010_t02	2	100	0.5	< 0.01	< 0.01	1150	6.5	8.0	0.09	0.06
BCA_010_t03	2	100	0.5	< 0.01	< 0.01	1100	6.5	8.0	0.09	0.04
BCA_010_t04	2	175	0.5	0.011	< 0.01	950	3.0	3.0	0.05	0.04
BCA_015_t01	4	80	< 0.5	< 0.01	< 0.01	1350	6.5	8.0	0.05	0.22
BCA_015_t02	3	100	0.5	< 0.01	< 0.01	1150	7.0	8.0	0.09	0.04
BCA_015_t03	3	100	0.5	< 0.01	< 0.01	1150	7.0	8.0	0.09	0.05
BCA_025_t01	1	40	< 0.5	< 0.01	< 0.01	1100	3.5	3.5	0.04	0.04
BCA_100_t01	4	20	< 0.5	< 0.01	< 0.01	1000	6.5	7.0	0.07	0.07
BCA_105_t01	2	30	< 0.5	< 0.01	< 0.01	650	4.0	4.0	0.04	0.02
BCA_105_t02	2	20	< 0.5	< 0.01	< 0.01	700	5.0	5.0	0.06	0.02
BCA_120_t01	3	20	< 0.5	< 0.01	< 0.01	90	1.0	1.0	0.02	< 0.01
BCA_120_t02	2	30	0.5	0.011	< 0.01	125	1.5	1.5	0.03	< 0.01
BRE_148_t01	2	60	< 0.5	< 0.01	< 0.01	1350	3.0	3.0	0.06	0.22
BRE_154_t01	4	80	< 0.5	< 0.01	< 0.01	1350	6.5	7.5	0.06	0.22
BWE_027_t01	2	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_027_t02	2	< 20	< 0.5	< 0.01	< 0.01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BYR_001_t01	1	125	0.5	< 0.01	< 0.01	900	3.0	5.5	0.09	0.02
BYR_001_t02	3	125	0.5	< 0.01	< 0.01	950	3.5	5.5	0.09	0.02
BYR_005_t01	3	250	1.0	0.017	0.013	1300	3.5	3.5	0.06	0.08
BYR_015_t01	8	325	1.5	0.052	0.017	1250	8.0	8.5	0.11	0.16
BYR_015_t02	3	250	1.0	0.017	0.014	1350	3.5	3.5	0.06	0.17
BYR_025_t01	3	325	1.5	0.054	0.018	1100	8.0	8.5	0.12	0.04
BYR_055_t03	6	400	2.0	0.076	0.022	1000	6.5	8.0	0.12	0.03
BYR_065_t01	9	500	7.0	0.086	0.025	600	7.5	7.5	0.09	0.03
BYR_065_t02	3	550	7.0	0.086	0.026	600	8.0	8.0	0.09	0.03
BYR_065_t03	2	450	6.5	0.086	0.022	550	7.0	7.0	0.09	0.02
BYR_075_t01	3	250	3.0	0.060	0.013	325	3.5	3.5	0.06	0.01
BYR_075_t02	2	225	2.5	0.049	0.012	300	3.0	3.0	0.05	0.01
BYR_075_t03	2	600	7.5	0.087	0.029	700	8.5	8.5	0.09	0.03
BYR_075_t04	2	650	8.0	0.087	0.031	750	8.5	8.5	0.09	0.03
BYR_075_t05	2	300	4.0	0.075	0.015	375	4.5	4.5	0.08	0.02
BYR_075_t06	2	300	4.0	0.075	0.015	375	4.5	4.5	0.08	0.02
BYR_084_t01	3	275	3.0	0.063	0.013	325	3.5	3.5	0.07	0.01
BYR_085_t01	3	500	7.0	0.088	0.025	600	8.0	8.0	0.09	0.03
BYR_085_t02	3	550	7.5	0.088	0.027	650	8.0	8.0	0.09	0.03
BYR_085_t03	3	150	1.0	0.013	< 0.01	200	1.5	1.5	0.02	< 0.01
BYR_085_t04	3	150	1.0	0.014	< 0.01	200	1.5	1.5	0.02	< 0.01
BYR_085_t05	2	125	1.0	< 0.01	< 0.01	175	1.0	1.0	< 0.01	< 0.01
BYR_085_t06	2	150	1.0	0.016	< 0.01	200	1.5	1.5	0.02	< 0.01
BYR_095_t01	3	200	2.0	0.028	< 0.01	250	2.0	2.0	0.03	< 0.01

Table C.05 - Predictions for Tanks

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BYR_095_t02	3	200	2.0	0.031	< 0.01	250	2.0	2.0	0.03	< 0.01
BYR_095_t03	2	100	0.5	< 0.01	< 0.01	150	1.0	1.0	< 0.01	< 0.01
BYR_105_t01	2	90	< 0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_115_t01	4	125	1.0	0.011	< 0.01	175	1.0	1.0	0.01	< 0.01
BYR_115_t02	4	125	1.0	0.011	< 0.01	175	1.0	1.0	0.01	< 0.01
BYR_115_t03	2	80	< 0.5	< 0.01	< 0.01	100	0.5	0.5	< 0.01	< 0.01
BYR_115_t04	2	80	< 0.5	< 0.01	< 0.01	100	0.5	0.5	< 0.01	< 0.01
BYR_115_t05	2	100	0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_115_t06	3	80	< 0.5	< 0.01	< 0.01	125	0.5	0.5	< 0.01	< 0.01
BYR_145_t01	2	950	6.5	0.063	0.222	1100	7.5	7.5	0.06	0.23
BYR_145_t02	2	950	2.5	0.064	0.220	1100	2.5	2.5	0.06	0.23
BYR_145_t03	2	950	3.5	0.064	0.132	1100	3.0	3.0	0.06	0.14
BYR_145_t04	2	950	3.5	0.064	0.119	1100	3.0	3.0	0.06	0.12
BYR_150_t01	2	275	1.0	0.018	0.014	1350	3.5	3.5	0.06	0.09
BYR_152_t01	2	275	1.0	0.017	0.014	1300	4.0	4.0	0.06	0.05
BYR_152_t02	2	275	1.0	0.017	0.014	1300	4.0	4.0	0.06	0.05
BYR_152_t03	2	225	1.0	0.015	0.012	1150	4.0	4.0	0.05	0.04
BYR_152_t04	2	225	1.0	0.015	0.012	1150	4.0	4.0	0.05	0.04
BYR_154_t01	2	200	1.0	0.014	0.011	1100	3.5	3.5	0.05	0.04
BYR_154_t02	2	200	1.0	0.013	0.010	1100	3.5	3.5	0.05	0.04
BYR_156_t01	2	175	1.0	0.012	< 0.01	1000	3.0	3.0	0.04	0.03
BYR_156_t02	2	175	1.0	0.012	< 0.01	1000	3.0	3.0	0.04	0.03
BYR_156_t03	2	175	1.0	0.012	< 0.01	1000	3.5	3.5	0.04	0.03
BYR_156_t04	2	175	1.0	0.012	< 0.01	1000	3.5	3.5	0.04	0.04
	Maxima:	**950**	**8.0**	**0.09**	**0.22**	**1350**	**8.5**	**8.5**	**0.12**	**0.23**

Table C.06 - Predictions for Pools

Structure Ref.	Maximum Plan Dimension (m)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BCA_035_p01	7	30	< 0.5	< 0.01	< 0.01	950	2.0	3.0	0.07	0.03
BCA_100_p01	10	20	< 0.5	< 0.01	< 0.01	1000	6.0	7.0	0.08	0.06
BCA_105_p01	9	30	< 0.5	< 0.01	< 0.01	700	4.0	4.5	0.05	0.03
BCA_120_p01	9	20	< 0.5	< 0.01	< 0.01	100	1.0	1.0	0.02	< 0.01
BRE_148_p01	9	50	< 0.5	< 0.01	< 0.01	1300	3.5	3.5	0.06	0.05
BRE_167_p01	8	60	1.0	0.02	< 0.01	850	4.0	5.5	0.09	0.04
BYR_005_p01	10	250	1.0	0.02	0.01	1300	4.0	4.0	0.06	0.05
BYR_015_p01	9	300	1.0	0.04	0.02	1300	8.0	8.5	0.06	0.23
BYR_045_p01	11	900	3.5	0.06	0.05	1050	3.0	3.0	0.06	0.05
BYR_065_p01	6	900	8.0	0.06	0.19	1000	8.5	8.5	0.06	0.20
BYR_095_p01	9	150	1.0	0.01	< 0.01	200	1.5	1.5	0.02	< 0.01
BYR_135_p01	10	750	8.0	0.09	0.06	850	8.5	8.5	0.09	0.06
BYR_152_p01	12	250	1.0	0.02	0.01	1250	4.0	4.0	0.06	0.04
	Maxima:	**900**	**8.0**	**0.09**	**0.19**	**1300**	**8.5**	**8.5**	**0.09**	**0.23**

Table C.07 - Predictions for Farm Dams

Dam Ref.	Maximum Length (m)	Plan Area (m2)	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)	Predicted Change in Freeboard (mm)
BCA_001_d01	25	345	250	1.0	0.02	0.01	1175	5.5	5.5	0.03	0.07	300
BCA_010_d01	21	251	150	0.5	< 0.01	< 0.01	875	3.5	5.5	0.09	0.04	100
BCA_015_d01	26	342	60	< 0.5	< 0.01	< 0.01	1250	5.0	5.0	0.04	0.08	250
BCA_110_d01	24	414	30	< 0.5	< 0.01	< 0.01	625	6.5	6.5	0.06	0.05	350
BRE_090_d01	52	1889	150	0.5	< 0.01	< 0.01	975	4.5	6.5	0.09	0.03	100
BRE_090_d02	24	310	30	< 0.5	< 0.01	< 0.01	975	2.5	3.0	0.07	0.03	100
BRE_090_d03	69	1849	225	1.0	0.01	0.01	1200	3.5	3.5	0.05	0.04	300
BRE_090_d04	36	508	300	1.0	0.04	0.01	1275	6.5	7.0	0.04	0.22	250
BRE_143_d01	29	534	125	0.5	< 0.01	< 0.01	925	3.5	5.5	0.09	0.03	50
BRE_148_d01	35	693	225	1.0	0.01	0.01	1200	3.5	3.5	0.06	0.04	250
BRE_148_d02	22	170	225	1.0	0.01	0.01	1225	3.5	3.5	0.06	0.04	200
BRE_154_d01	76	2658	70	< 0.5	< 0.01	< 0.01	1375	6.5	7.5	0.06	0.23	200
BRE_154_d02	64	1554	100	0.5	< 0.01	< 0.01	1325	7.0	8.5	0.10	0.20	500
BRE_167_d01	99	2924	175	1.5	0.01	0.02	1075	4.0	5.0	0.09	0.05	300
BRE_167_d02	16	180	225	2.0	0.01	0.02	1300	4.0	4.0	0.06	0.08	200
BYR_005_d01	28	404	250	1.0	0.02	0.01	1275	4.0	4.0	0.06	0.05	250
BYR_005_d02	73	1662	175	1.0	0.01	< 0.01	1050	3.5	3.5	0.08	0.04	200
BYR_015_d01	50	1415	250	1.0	0.02	0.01	1325	4.0	4.0	0.06	0.16	300
BYR_065_d01	44	790	650	3.0	0.04	0.03	825	2.0	3.5	0.07	0.03	50
BYR_095_d01	43	1003	950	8.0	0.06	0.21	1100	8.5	8.5	0.06	0.22	350
		Maxima:	**950**	**8.0**	**0.06**	**0.21**	**1375**	**8.5**	**8.5**	**0.10**	**0.23**	**500**

Table C.08 - Predictions for Public Utilities

Structure Ref.	Description	Structure Type	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BYR_200_pu01	Comms shed - NBN - 2574006	Shed	175	1.0	0.01	< 0.01	1050	3.5	3.5	0.05	0.21
BYR_200_pu02	Comms tower - NBN - 2574006	Tower	175	1.0	0.01	< 0.01	1050	3.5	3.5	0.05	0.22
		Maxima:	**175**	**1.0**	**0.01**	**0.00**	**1050**	**3.5**	**3.5**	**0.05**	**0.22**

Table C.09 - Predictions for Commercial and Business Establishments

Structure Ref.	Maximum Plan Dimension (m)	Description	Structure Type	Predicted Incremental Subsidence due to LW S7A (mm)	Predicted Incremental Tilt due to LW S7A (mm/m)	Predicted Incremental Hogging Curvature due to LW S7A (1/km)	Predicted Incremental Sagging Curvature due to LW S7A (1/km)	Predicted Total Subsidence after LW S1A to S7A (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature after LW S1A to S7A (1/km)	Predicted Total Sagging Curvature after LW S1A to S7A (1/km)
BYR_055_c01	29	Bargo Valley Produce	Shed	950	3.5	0.06	0.21	1050	3.0	3.0	0.06	0.21
BYR_055_c02	41	Bargo Valley Produce	Shed	950	6.0	0.06	0.21	1050	6.5	6.5	0.06	0.22
BYR_055_c03	89	Bargo Valley Produce	Poultry Shed	900	3.5	0.06	0.08	1050	3.0	3.0	0.06	0.08
BYR_055_c04	89	Bargo Valley Produce	Poultry Shed	900	3.5	0.06	0.04	1050	3.0	3.0	0.06	0.04
BYR_055_c05	89	Bargo Valley Produce	Poultry Shed	750	3.5	0.05	0.04	900	2.5	2.5	0.05	0.04
BYR_055_c06	89	Bargo Valley Produce	Poultry Shed	650	3.0	0.04	0.03	850	2.5	3.0	0.07	0.03
BYR_055_c07	91	Bargo Valley Produce	Greenhouse	650	3.0	0.07	0.03	1000	6.0	8.0	0.12	0.03
BYR_055_t01	8	Bargo Valley Produce	Tank	950	2.5	0.06	0.20	1050	2.5	2.5	0.06	0.21
BYR_055_t02	3	Bargo Valley Produce	Tank	750	3.5	0.05	0.04	950	2.5	2.5	0.05	0.04
BYR_065_c06	91	Ingham Turkey Farm	Poultry Shed	950	8.0	0.09	0.21	1050	8.5	8.5	0.09	0.22
BYR_065_c07	96	Ingham Turkey Farm	Poultry Shed	950	8.0	0.08	0.21	1050	8.5	8.5	0.09	0.22
BYR_065_c08	83	Ingham Turkey Farm	Poultry Shed	950	8.0	0.06	0.21	1050	8.5	8.5	0.06	0.22
BYR_065_c09	11	Ingham Turkey Farm	Poultry Shed	950	2.5	0.06	0.21	1050	2.5	2.5	0.06	0.21
BYR_065_c10	15	Ingham Turkey Farm	Poultry Shed	950	3.0	0.06	0.19	1050	2.5	2.5	0.06	0.19
BYR_065_c11	26	Ingham Turkey Farm	Poultry Shed	950	7.0	0.06	0.21	1100	7.5	7.5	0.06	0.22
BYR_065_c12	91	Ingham Turkey Farm	Poultry Shed	950	5.5	0.06	0.21	1100	6.0	6.0	0.06	0.22
BYR_065_c13	90	Ingham Turkey Farm	Poultry Shed	950	3.5	0.06	0.21	1100	3.0	3.0	0.06	0.22
BYR_065_c14	91	Ingham Turkey Farm	Poultry Shed	950	3.5	0.06	0.11	1050	2.5	2.5	0.06	0.12
BYR_065_t02	5	Ingham Turkey Farm	Tank	950	2.5	0.06	0.21	1100	3.0	3.0	0.06	0.22
BYR_065_t03	4	Ingham Turkey Farm	Tank	850	8.0	0.06	0.16	1000	8.5	8.5	0.07	0.17
BYR_135_c01	14	Canine Country Club and Cattery	Shed	700	8.0	0.09	0.03	800	8.5	8.5	0.09	0.03
BYR_135_c02	20	Canine Country Club and Cattery	Shed	350	4.5	0.08	0.02	425	5.0	5.0	0.09	0.02
BYR_135_c03	9	Canine Country Club and Cattery	Shed	650	8.0	0.09	0.03	750	8.5	8.5	0.09	0.03
BYR_135_c04	17	Canine Country Club and Cattery	Shed	400	5.5	0.09	0.02	475	6.0	6.0	0.09	0.02
BYR_135_c05	26	Canine Country Club and Cattery	Shed	400	5.5	0.09	0.02	475	6.0	6.0	0.09	0.02
BYR_135_c06	3	Canine Country Club and Cattery	Shed	400	5.5	0.09	0.02	475	6.0	6.0	0.09	0.02
BYR_135_c07	14	Canine Country Club and Cattery	Shed	500	7.0	0.09	0.03	600	7.5	7.5	0.09	0.03
BYR_135_c08	25	Canine Country Club and Cattery	Awning	400	5.5	0.09	0.02	500	6.5	6.5	0.09	0.02
BYR_135_c09	6	Canine Country Club and Cattery	Shed	350	4.5	0.08	0.02	425	5.0	5.0	0.09	0.02
			Maxima:	**950**	**8.0**	**0.09**	**0.21**	**1100**	**8.5**	**8.5**	**0.12**	**0.22**

Table C.10 - Tahmoor South - Predictions for Archaeological Sites

Site ID	Type	Predicted Total Subsidence after all Longwalls (mm)	Predicted Total Tilt after all Longwalls (mm/m)	Predicted Total Hogging Curvature after all Longwalls (1/km)	Predicted Total Sagging Curvature after all Longwalls (1/km)	Predicted Total Upsidence after all Longwalls (mm)	Predicted Total Closure after all Longwalls (mm)
WP1253 RS	Rock shelter	20	< 0.5	< 0.01	< 0.01	-	-
WP1255 RS	Rock shelter	40	< 0.5	< 0.01	< 0.01	-	-
WP1256 RS	Rock shelter	40	< 0.5	< 0.01	< 0.01	-	-
WB1257 RS	Rock shelter	40	< 0.5	< 0.01	< 0.01	-	-
WP1258 RS	Rock shelter	50	< 0.5	< 0.01	< 0.01	-	-
WP1260 RS	Rock shelter	20	< 0.5	< 0.01	< 0.01	-	-
WP1261 RS	Rock shelter	30	< 0.5	< 0.01	< 0.01	-	-
WP1263 GG	Grinding grooves	20	< 0.5	< 0.01	< 0.01	45	65
WP1264 IF	Isolated find	20	< 0.5	< 0.01	< 0.01	-	-
		50	**< 0.5**	**< 0.01**	**< 0.01**	**45**	**65**