REPORT: END OF PANEL SUBSIDENCE MONITORING REPORT

TAHMOOR UNDERGROUND

GLENCORE

GLENCORE:

Tahmoor Colliery - Longwall 29

End of Panel Subsidence Monitoring Report for Tahmoor Longwall 29

DOCUMENT REGISTER

Revision	Description	Author	Date
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Associated reports:-

MSEC, (2009). *Report on the Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Items of Surface Infrastructure due to mining Longwalls 27 to 30 at Tahmoor Colliery in support of an SMP Application*. Mine Engineering Consultants, Report No. MSEC355, Revision B, July 2009.

MSEC778-R01 to MSEC778-R37 – Subsidence Monitoring Reports, issued during the extraction of Longwall 29 between June 2015 and March 2016.

MSEC779-R01 to MSEC779-R49 – Main Southern Railway Monitoring Reports, issued during the extraction of Longwall 29 between May 2015 and April 2016.

GeoTerra (2016a). Longwall 29 Surface Water, Dams & Groundwater End of Panel Monitoring Report, Tahmoor, NSW. Report No. TA29-R1B, August 2016.

GeoTerra (2016b). Tahmoor Colliery – Myrtle Creek End of Undermining Status Report. Report No. TA28-R2, August 2016.

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1.0 INTRODUCTION

This report has been prepared by Mine Subsidence Engineering Consultants (MSEC) for Glencore Tahmoor Colliery to comply with conditions of the SMP Approval set by the NSW Department of Industry, Skills and Regional Development – Division of Resources and Energy (DRE).

This report includes:-

- A summary of the subsidence and environmental monitoring results for Longwall 29,
- An analysis of these results against the relevant impact assessment criteria, monitoring results from previous panels and predictions provided in the SMP application,
- The identification of any trends in the monitoring results, and
- A description of actions that were taken to ensure adequate management of any potential subsidence impacts.

The location of Longwall 29 is shown in Drawing No. MSEC834-01, which together with all other drawings, is attached in Appendix B at the back of this report.

This report also includes many of the movements and impacts observed during the extraction of Longwalls 22 to 28. Note that Longwall 24B was extracted prior to Longwall 24A. The dates of extraction for all longwalls are provided in Table 1.1.

Table 1.1 Start and Finish Dates for Longwalls 22 to 29

Longwall	Start Date	Completion Date
Longwall 22	31 May 2004	27 July 2005
Longwall 23A	13 September 2005	21 February 2006
Longwall 23B	22 March 2006	26 August 2006
Longwall 24B	14 October 2006	2 October 2007
Longwall 24A	15 November 2007	19 July 2008
Longwall 25	22 August 2008	21 February 2011
Longwall 26	30 March 2011	15 October 2012
Longwall 27	8 November 2012	10 April 2014
Longwall 28	24 April 2014	1 May 2015
Longwall 29	29 May 2015	18 April 2016

The predicted movements and impacts resulting from the extraction of Longwalls 27 to 30 were provided in Report No. MSEC355 (2009, Revision B). The comparisons provided here are based on the subsidence predictions provided in this report.

Longwall 29 was approximately 2,320 metres long and 283 metres wide, rib to rib. The pillar width was approximately 39 metres, rib to rib. The depth of cover over the panel varied from 430 metres to 500 metres. The seam thickness over the panel was approximately 2.1 metres.

Chapter 2 of this report describes the locations of the ground monitoring lines and points which were surveyed during the extraction of Longwall 29. This chapter also provides comparisons between the observed and predicted movements resulting from the extraction of Longwall 29.

Chapter 3 of this report summarises the surveys and inspections undertaken during the mining of Longwall 29.

Chapter 4 of this report describes the reported impacts on surface features resulting from the extraction of Longwall 29, and compares these with the MSEC assessed impacts. The reported impacts on surface water are provided in other reports.

Appendices A and B include all of the figures and drawings associated with this report.

2.1.1. Comparison between Observed and Predicted Maximum Subsidence Parameters

Maximum observed incremental and total subsidence parameters during or after the mining of Longwall 29 are shown in Table 2.1. The maximum values do not include parameters observed in creeks, which are discussed separately in this report.

Table 2.1 Summary of Maximum Incremental and Total Subsidence Parameters due to the mining of Longwall 29 (beyond creeks)

Monitoring Line	Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Comp. Strain (mm/m)
Incremental due to LW29 only	737	5.9	2.8	-3.9
Total after LW29	1124	6.3	2.1	-7.7

Maximum observed incremental and total subsidence parameters for monitoring lines surveyed during Longwall 29 are summarised in Table 2.2. The maximum value for each parameter (not including creeks) is highlighted in yellow.

Table 2.2 Summary of Maximum Subsidence Parameters along Monitoring Lines

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
Bridge St	LW 29 Inc	505	3.4	0.7	-1.2
	Total	852	4.4	0.9	-1.7
Hilton Park Rd	LW 29 Inc	520	2.0	0.6	-0.3
	Total	1124	4.5	1.0	-4.4
Main Southern Railway (2D) (incl. creek)	LW 29 Inc	737	5.3	1.2	-3.5
	Total	1008	5.5	2.1	-7.7
Optical Fibre Line	LW 29 Inc	692	5.9	0.6	-3.9
	Total	948	6.3	1.3	-3.9
Remembrance Driveway	LW 29 Inc	56	1.5	2.8	-1.0
	Total	982	4.1	1.9	-2.1
Stilton Lane	LW 29 Inc	18	0.8	0.4	-0.3
Tahmoor Carrier	LW 29 Inc	84	0.6	0.3	-0.4
	Total	764	5.6	0.9	-2.7
Thirlmere Carrier	LW 29 Inc	474	4.1	0.6	-1.1
	Total	493	3.7	0.5	-1.0

2.1.2. Observed Subsidence during the extraction of Longwall 29

Extensive ground monitoring within the urban areas of Tahmoor has allowed detailed comparisons to be made between predicted and observed subsidence, tilt, strain and curvature during the mining of Longwalls 22 to 29.

In summary, there is generally a reasonable correlation between observed and predicted subsidence, tilt and curvature over the majority of the mining area. Observed subsidence was, however, slightly greater than predicted in some locations, including along the Main Southern Railway.

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

However, observed subsidence was greater than the predicted values over Longwalls 24A and the southern parts of Longwalls 25 to 27. Monitoring during the mining of Longwalls 28 and 29 has found that subsidence behaviour has returned to normal levels.

2.1.3. Analysis of Measured Strain

A distribution of the observed incremental tensile and compressive strains along monitoring lines from the extraction of Longwall 29, for survey bays located directly above goaf, is shown in Fig. 2.1. In the cases where the survey bays were measured a number of times during mining, the maximum tensile strain and the maximum compressive strain for each survey bay were used in these distributions.

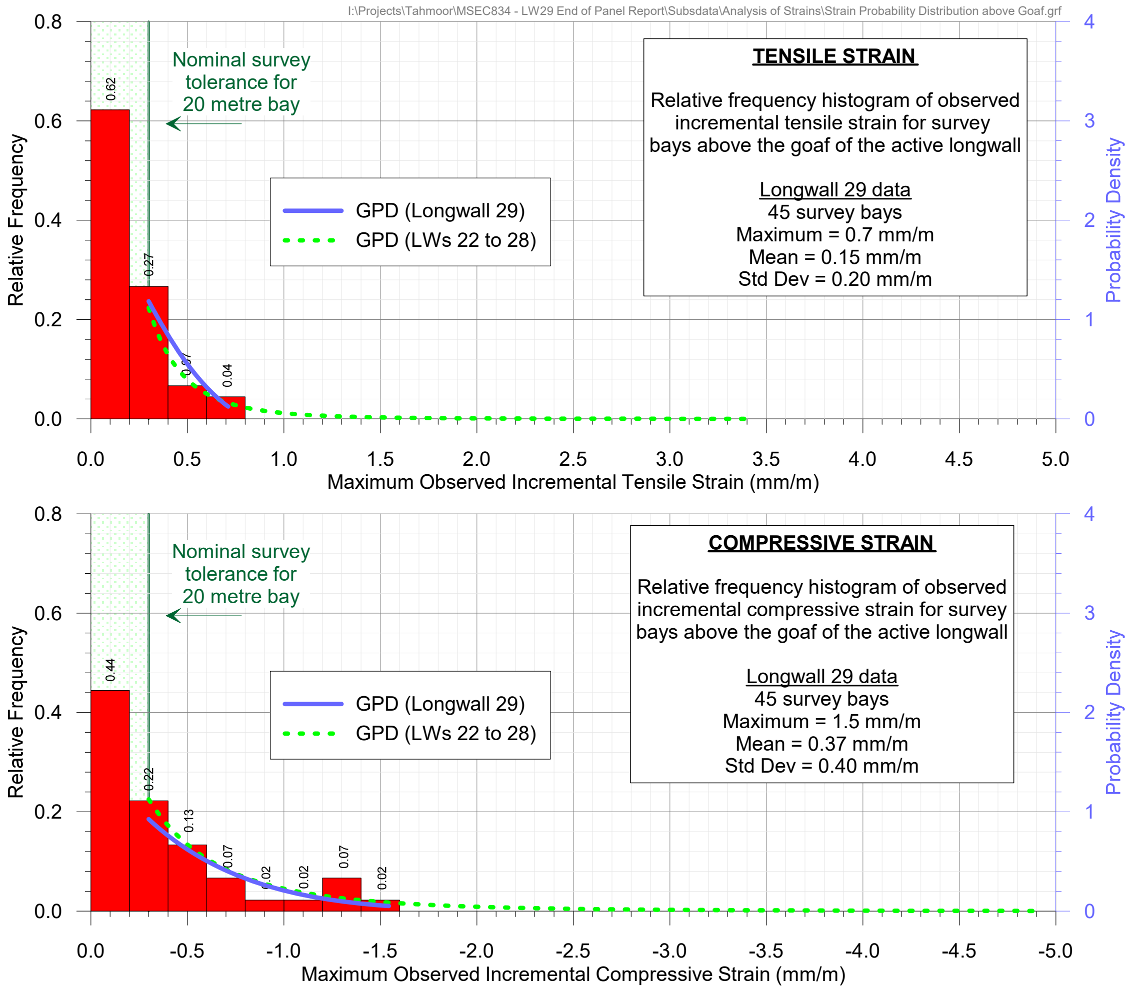

Fig. 2.1 Observed Incremental Strain for Survey Bays above Goaf resulting from the Extraction of Longwall 29

A *Generalised Pareto Distribution (GPD)* has been fitted to the raw strain data for Longwall 29, as shown in the blue lines.

The probability distribution functions for previous monitoring during the mining of Longwalls 22 to 28 are also shown in this figure, as the dashed green lines. It can be seen from these comparisons, that the overall distribution of tensile and compressive strain resulting from the extraction of Longwall 29 was similar to or less than the magnitude of that observed during the mining of Longwalls 22 to 28.

2.2. Identification of Non-Systematic Subsidence Movements

A plan showing the locations of observed non-systematic movements at Tahmoor is shown in Fig. 2.2. The locations were selected based on ground monitoring results or observed impacts that appear to have been caused by non-systematic movement. A total of approximately 51 locations (not including valleys) have been identified over the extracted Longwalls 22 to 28, of which 2 new locations were observed during the mining of Longwall 29.

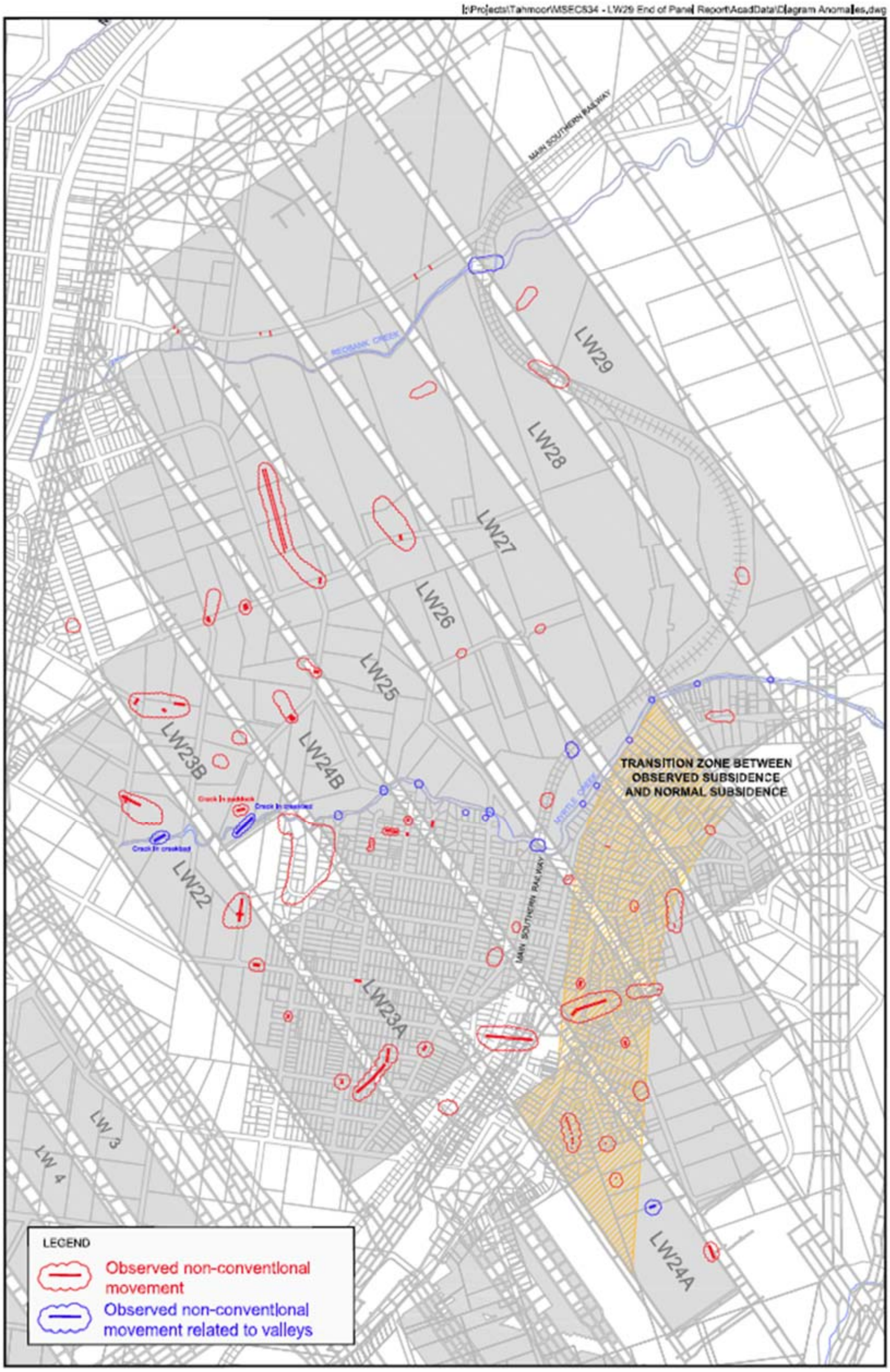

Fig. 2.2 Map of Locations of Potential Non-Systematic Movements

Monitoring lines were surveyed where non-systematic movement was identified. A summary of non-systematic movements at these locations is provided below in Table 2.3.

Table 2.3 Locations of New Identified Non-Systematic Movements during Longwall 29

Monitoring Line or Location	Maximum Change in Vertical Alignment during LW29 (mm)	Maximum Incremental Strain during LW29 (mm/m)	Type	Impacts on Surface Features
Main Southern Railway at 92.740 km to 92.840 km	32 mm over 40 metres	-1.7	Geological fault	Change in horizontal and vertical alignment of track in fault zone, with local adjustment undertaken regularly
Main Southern Railway at 92.660km	66 mm over 40 metres	-0.5	Anomaly	Change in horizontal and vertical alignment of track, within deep railway cutting.
Main Southern Railway 92.060km to 92.080km	27 mm over 40 metres	-3.9	Valley closure	Change in horizontal and vertical alignment of track.
Main Southern Railway at 91.280km	41 mm over 40 metres	-3.1	Valley closure	Substantial valley closure of 178 mm across Redbank Creek. Change in horizontal alignment of track. Minor changes in track geometry detected visually in the track. Impacts on brick arch culvert, which remained safe and serviceable.

Valley closure movements were also observed across Myrtle and Redbank Creeks, and the results of these surveys are discussed in following sections of this report.

Changes in vertical alignment have been calculated by measuring the difference in subsidence between each peg and average subsidence of the adjacent two pegs. The calculations quantify the small 'bumps' that are observed in the subsidence profiles.

2.3. Myrtle Creek and tributaries

A map of monitoring lines across Myrtle Creek and the creek at the Skew Culvert is shown in Fig. 2.3.

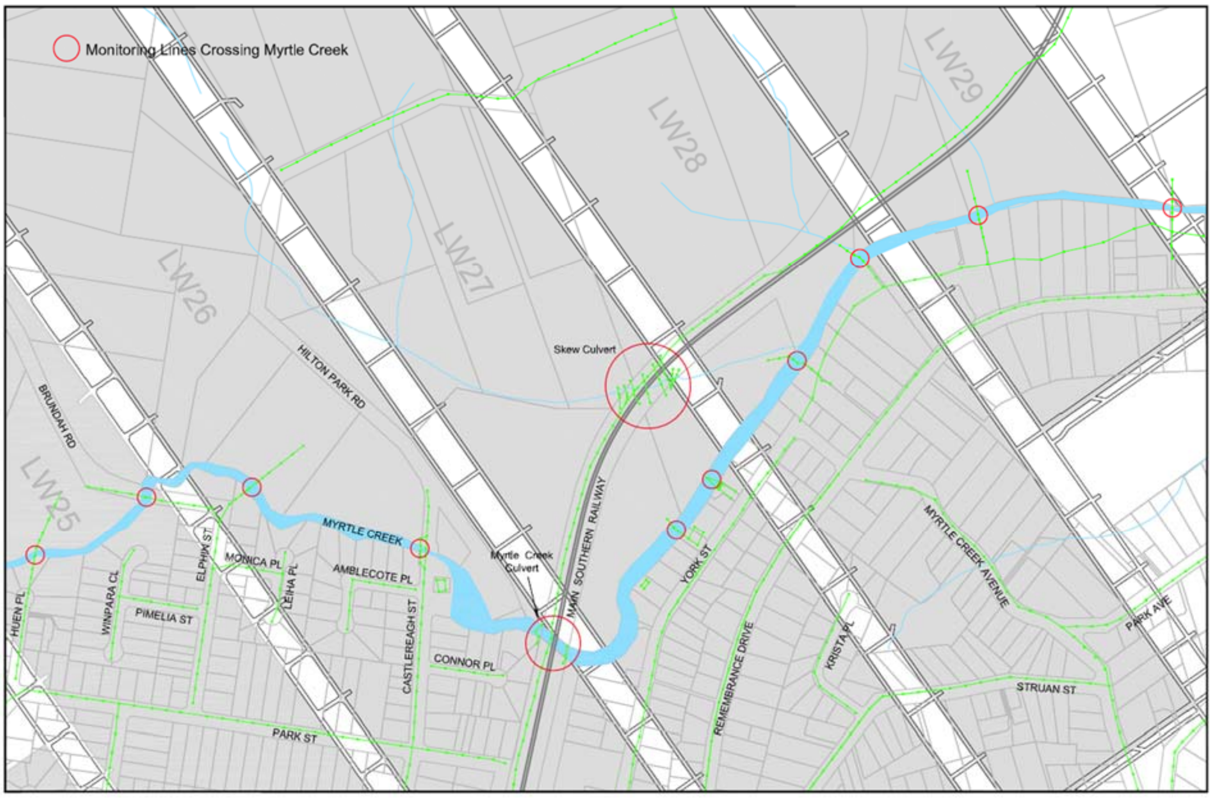

Fig. 2.3 Monitoring lines across Myrtle Creek and Skew Culvert

A summary graph showing the development of valley closure across Myrtle Creek at each monitoring line is shown in Fig. 2.4. It can be seen that very little additional, incremental valley closure was experienced during the mining of Longwall 29. The maximum measured incremental closure was 10 mm across the MXD Line due to the extraction of Longwall 29, with an additional 5 mm and 7 mm measured across the MXB Line and MXC Line, respectively.

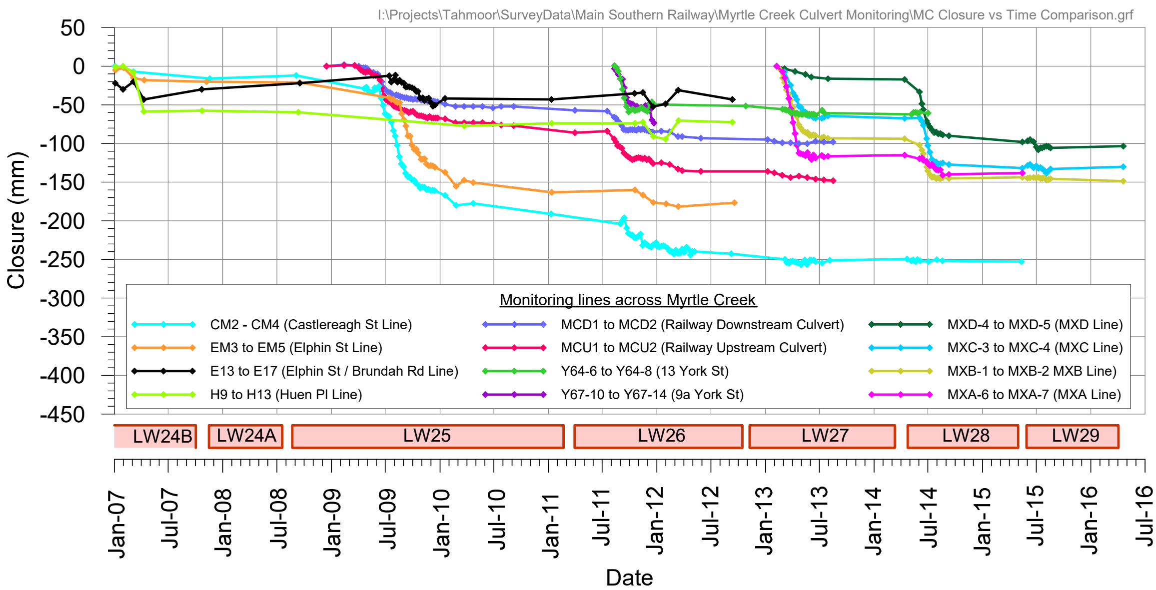

Fig. 2.4 Development of closure across Myrtle Creek during the mining of Longwalls 24B to 29

2.4. Redbank Creek

The ability to survey valley closure across the creek has been constrained by refusal by landowners to provide access. There is no access on the northern bank and limited access on the southern bank.

In light of the access constraints, ground surveys were undertaken in relative 3D from Bridge Street to a monitoring line that is located in cleared pasture land along the top of the valley, as shown in Fig. 2.5. This has provided measurements of total valley closure. Some survey pegs have been installed along a fence line on the southern side to a point where surveyors can sight a survey peg on Bridge Street. Despite the best efforts of the survey team, the accuracy of the survey is challenged by the lack of cross lines across Redbank Creek. Baseline monitoring indicates that the valley closure measurements were accurate to approximately 20 to 30 mm.

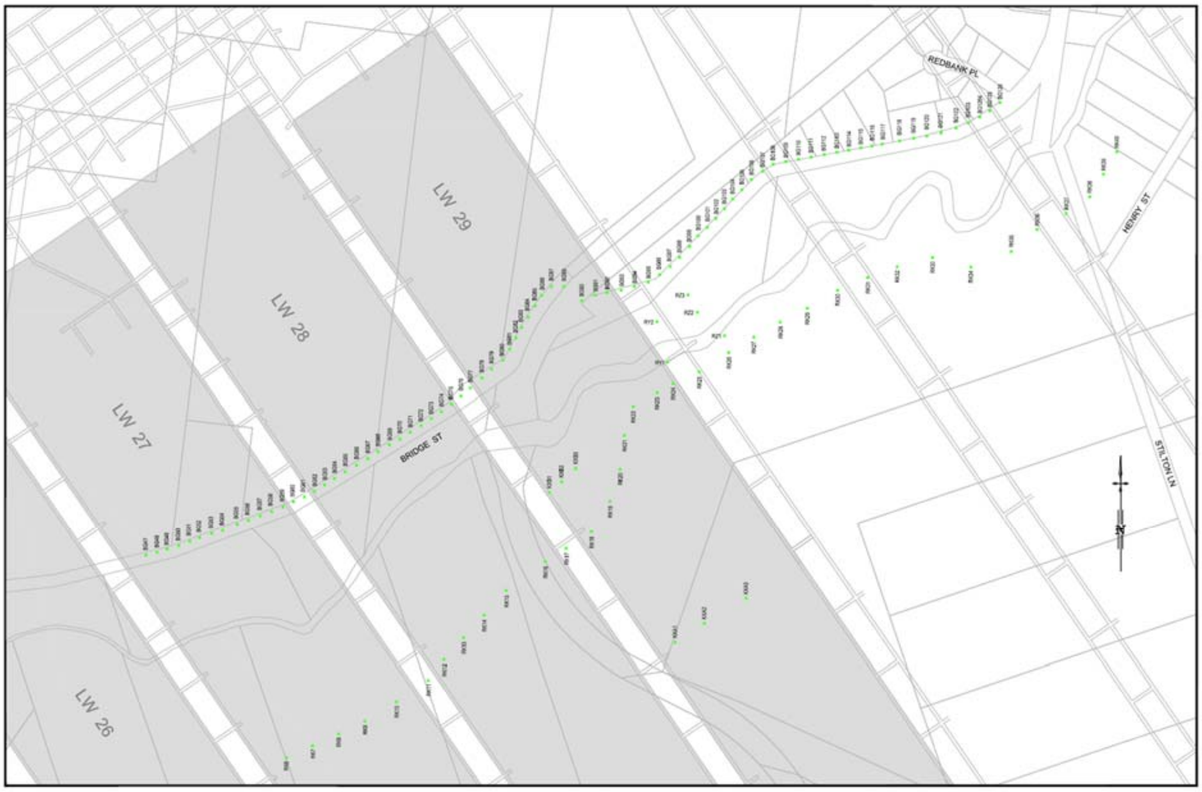

Fig. 2.5 Location of survey marks across Redbank Creek

Graphs showing observed subsidence, tilt and strain along each of the monitoring lines are provided in Figs. A.16 to A.21 and drawings showing incremental subsidence and relative horizontal movements are shown in Drawings Nos. MSEC834-02 and MSEC834-03.

The development of valley closure across Redbank Creek and its tributaries during the mining of Longwall 29 against time is shown in Fig. 2.6.

The closures are based on calculating changes in horizontal distance between pegs located across the valley in an orientation that is approximately parallel to the longwall panel. This orientation was chosen as Redbank Creek flows approximately at right angles across the panel.

Different results can be derived if the calculations were based on different pairs of pegs, though it is considered that if different pairs were chosen, such calculations would include an additional component of conventional and non-conventional ground shortening that occurs across the panel in both plateau areas or valleys. This is particularly the case if the pegs are located across the width of the longwall panel from each other. When comparing the results against predictions of valley closure, it was considered simpler to choose pegs that are approximately aligned with longwall direction so as not to make allowances for the additional effects of conventional lateral ground closure movements.

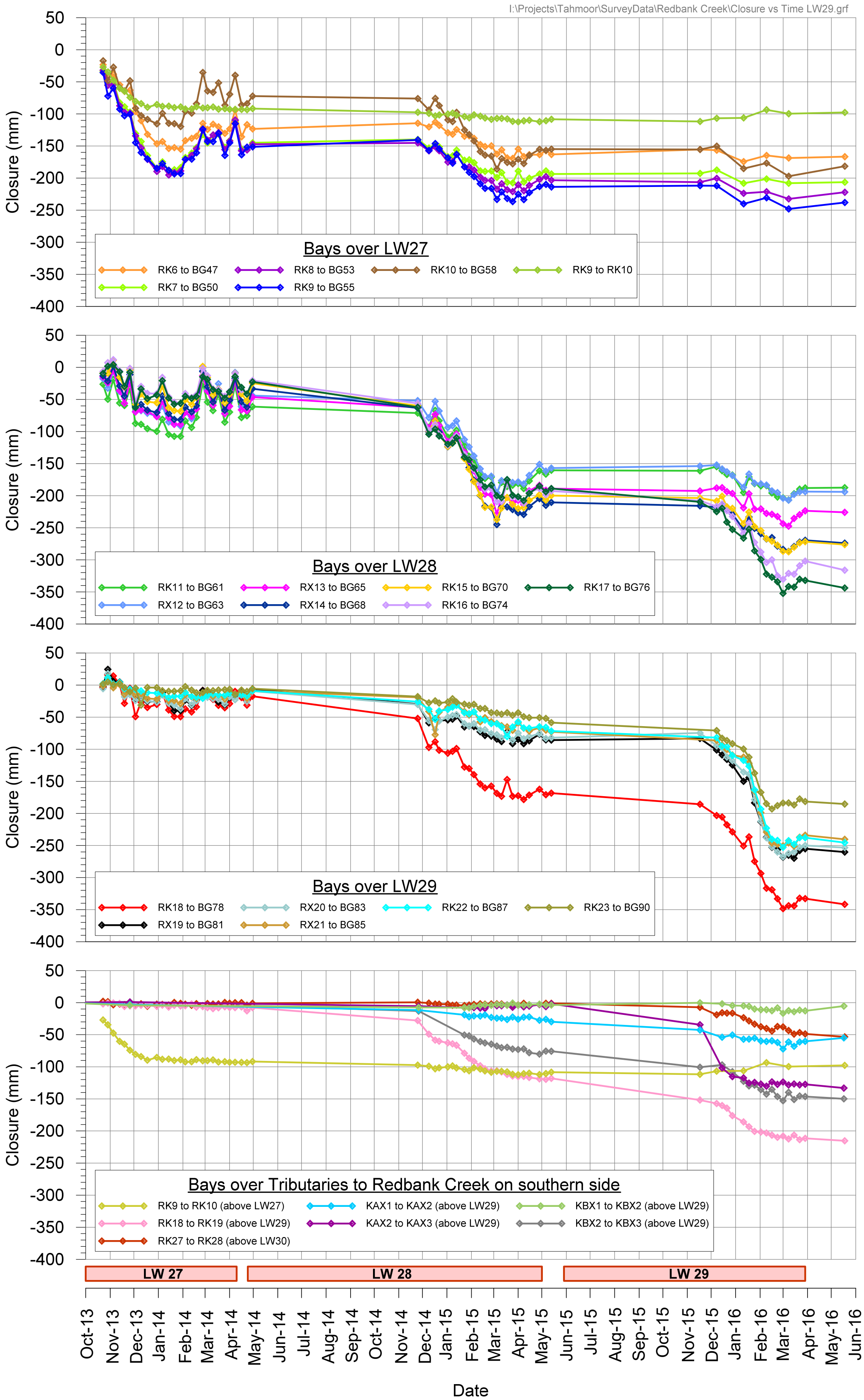

Fig. 2.6 Observed development of closure across tributaries to Redbank Creek over time

A number of observations are made from the monitoring data.

- It can be seen from Fig. 2.6 that valley closure was slightly greater for a temporary period of time, when the transient effects of the subsidence travelling wave passed through the valley.
- Maximum observed closure above Longwall 29 was greater than above Longwalls 27 and 28. This was predicted as the valley is deeper and more incised above Longwall 29.

A comparison between observed and predicted valley closure along Redbank Creek is shown in Fig. 2.7. A number of observations are made from the monitoring data.

- There has been a reasonable correlation between predicted and observed closure at the completion of Longwall 29.
- Observed total closure from the mining of Longwalls 26, 27, 28 and 29 is less than predicted.

Maximum predicted valley closure due to extraction of Longwall 29 was 200 mm. As shown in the bottom graph of Fig. 2.7, observed maximum incremental valley closure at the completion of Longwall 29 was 179 mm. It can also be seen, from the top graph of Fig. 2.7 that observed total closure from the mining of Longwalls 26 to 29 is less than predicted.

Observed total closure is also less than the predicted total closure of 450 mm due to the mining of Longwalls 22 to 29, as reported in Report No. MSEC355.

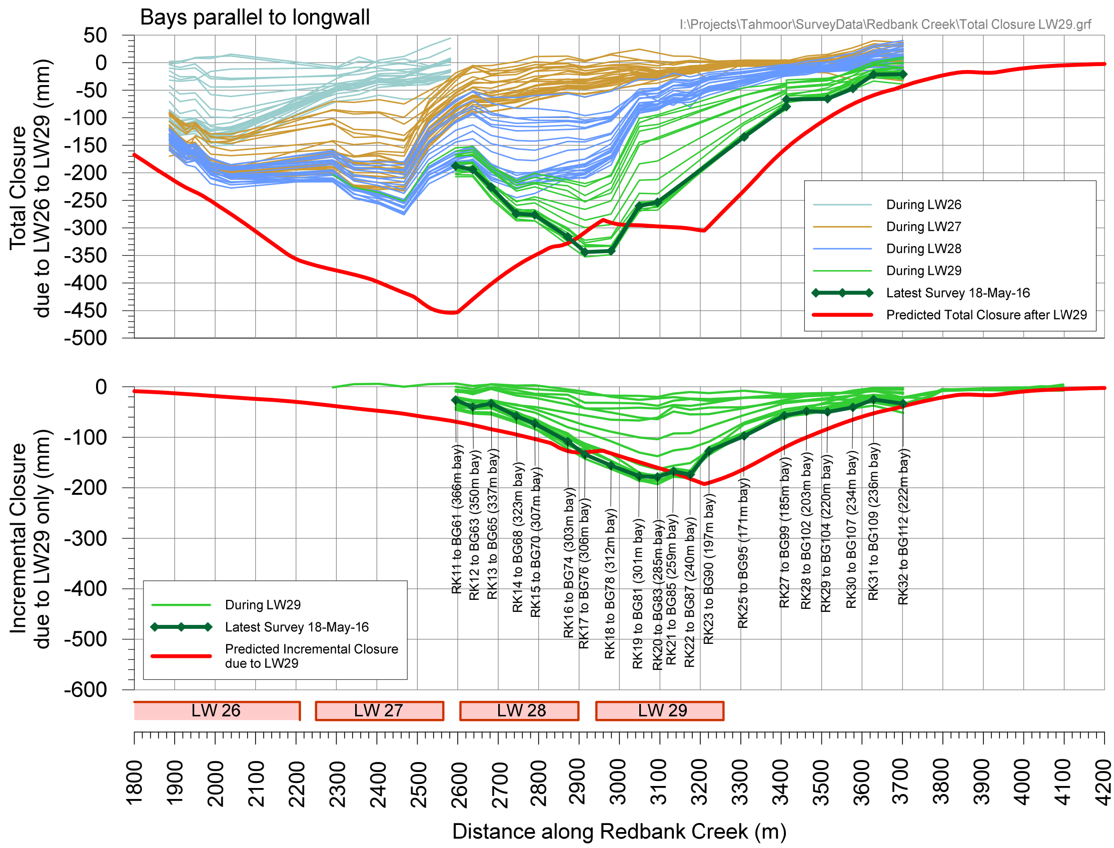

Fig. 2.7 Comparison between observed and predicted valley closure along Redbank Creek

2.5. Main Southern Railway

The Main Southern Railway was surveyed in either 2D or 3D for a total of 48 times on a weekly basis during the extraction of Longwall 29. Details of the monitoring undertaken are provided in the monitoring reports prepared by MSEC on behalf of Tahmoor Colliery and these reports have been provided to ARTC throughout the mining period.

The Main Southern Railway experienced a maximum of 737 mm of subsidence during the mining of Longwall 29.

When comparing predicted and observed subsidence, the following comments are provided:

- Observed maximum subsidence is slightly greater than predicted maximum subsidence at the southern half of the panel. Observed maximum subsidence is less than predicted at the northern half of the panel.

- The survey line was re-established along the new alignment after the completion of the Deviation works. As the survey line was installed after the construction of the Deviation, it missed subsidence movements that developed during the mining of Longwalls 25 and 26. Actual total subsidence along the railway above previously extracted Longwall 27 is therefore more than shown in Fig. A.29, bringing the results closer to prediction.
- There is a reasonable correlation between the shapes of the predicted and observed subsidence profiles. There is, therefore, a reasonable correlation between predicted and observed maximum tilt.
- Pronounced changes in vertical alignment were observed in the subsidence profile where a geological fault intersects with the railway between 92.740 km and 92.840 km. A similarly pronounced change in vertical alignment was observed in the subsidence at 92.660 km at the base of the Deviation Cutting.
- Increased ground strain was observed between 92.060 km and 92.080 km where the railway crosses a small tributary. A pronounced change in horizontal and vertical alignment was also observed at this location. The observed changes may have been influenced by the infilling of a farm dam at this location.
- Substantial valley closure was observed across Redbank Creek Culvert at 91.280 km. Upsidence was also observed in the floor of the creek at this location, though the change in vertical alignment at track level was reduced, being buffered by the presence of the earth embankment.
- Observed ground strains along the railway corridor have generally been relatively small in magnitude, with increased ground strains observed at a number of isolated locations. Increased ground strains were observed across the geological fault in the Deviation cutting between 92.820 km and 92.840 km, at the culvert at 92.060 km, and across Redbank Creek as expected (refer Section 2.4).

2.5.1. Automated Track Monitoring

Rail Stress Transducers

Rail stress transducers are located along all four rails of the railway track, spaced every 25 to 60 metres. They measured changes in rail strain every 5 minutes during the mining of Longwall 29. Rail stresses exceeded triggers during the mining of Longwall 29 due to ground shortening within an anchor point, which was corrected on site.

Expansion switch displacement sensors

Displacement sensors have been installed at each expansion switch. Measurements were recorded every 5 minutes during the mining of Longwall 29. Mining-induced changes were observed, though larger temperature-induced changes were observed. Some low level (Blue) alarms were triggered as a result of subsidence in combination with low or high rail temperatures. The alarms were responded to in accordance with the Management Plan. Some of the responses had already been planned in anticipation of the alarm.

2.5.2. Redbank Creek Culvert and Embankment at 91.265 km

A total of 27 ground surveys, 28 extensometer surveys and 26 detailed visual inspections were undertaken for the Redbank Creek Culvert and Embankment on a weekly to monthly basis in accordance with the agreed management plans with ARTC, as amended in agreement with DRE.

The Culvert has subsided between approximately 290 mm and 460 mm in total during the mining of Longwalls 27, 28 and 29.

Observed absolute horizontal movements along the Main Southern Railway are shown in Fig. 2.8. It can be seen that the rockmass on the Sydney side of the Culvert has moved substantially relative to the Country side. When observed in conjunction with the relative 3D surveys, as shown in Drawing No. MSEC834-03, it is clear that the boundaries of the rockmass are approximately Redbank Creek and the tributary, with ground strains relatively small in the plateau areas.

Observed incremental subsidence and horizontal movement of survey marks in the immediate of the culvert and embankment are shown in Fig. 2.9. The results show that boundaries of the rockmass in the south-western quadrant intersect with the country side of the culvert. The corner of the rockmass is approximately aligned with midpoint of the culvert, which correlates well with observed detailed closure measurements inside the culvert itself.

The observed gradual development with time of differential horizontal movements between selected pegs at the culvert and embankment are shown in Fig. 2.10. Maximum observed closure was measured between the long bay survey pegs on the track at 91.220 km and 91.360 km, though a similar result was observed between Pegs RBCCU4 and RBCCU6, which are located in the base of the embankment across the upstream inlet. This suggests that closure across the valley of Redbank Creek and its tributary, were focussed at the culvert. This was confirmed at greater detail from additional detailed surveys in the culvert, which are discussed later.

Whilst the ends of the wingwall on the upstream end closed by 213 mm, the culvert barrel at the inlet opened by 14 mm. Very little closure was observed across the culvert barrel or wingwalls at the downstream inlet.

Fig. 2.8 Observed total horizontal movement along Main Southern Railway during the mining of Longwalls 27 to 29 as at 24 May 2016

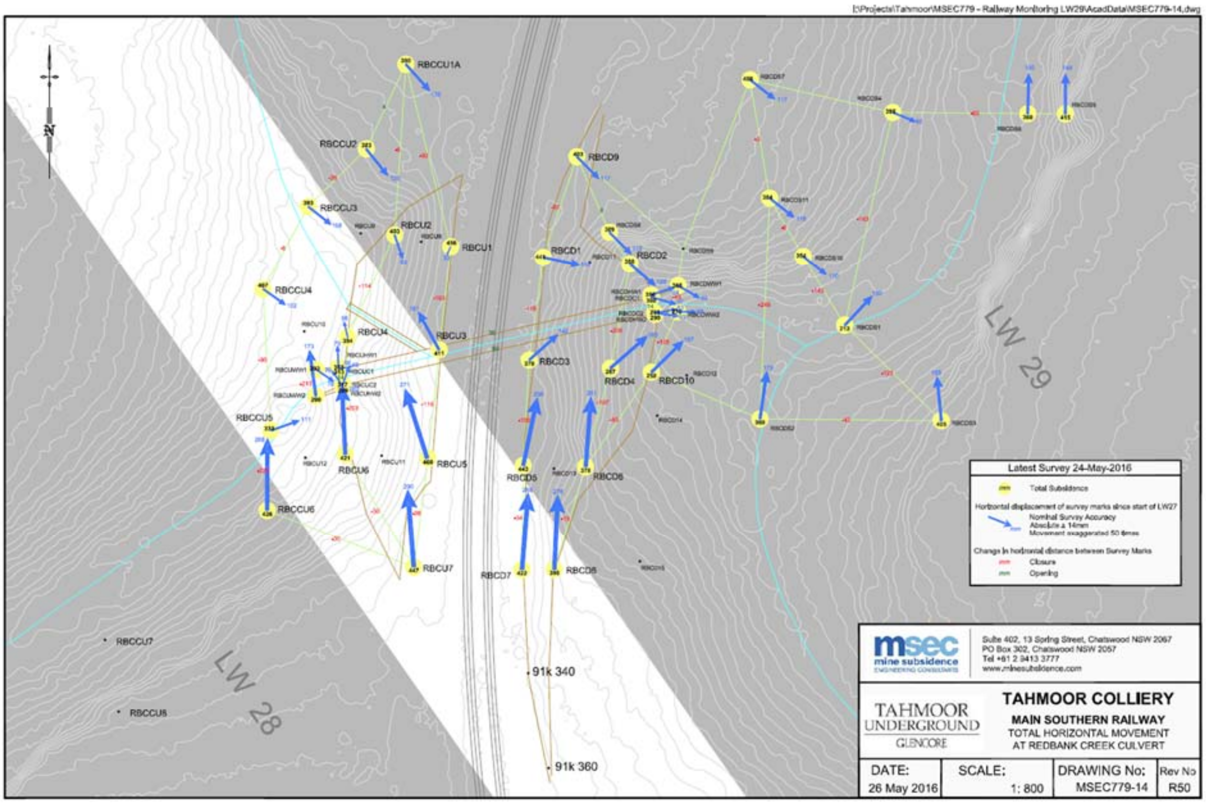

Fig. 2.9 **Observed total horizontal movement at Redbank Creek Culvert and embankment during the mining of Longwalls 27, 28 and 29**

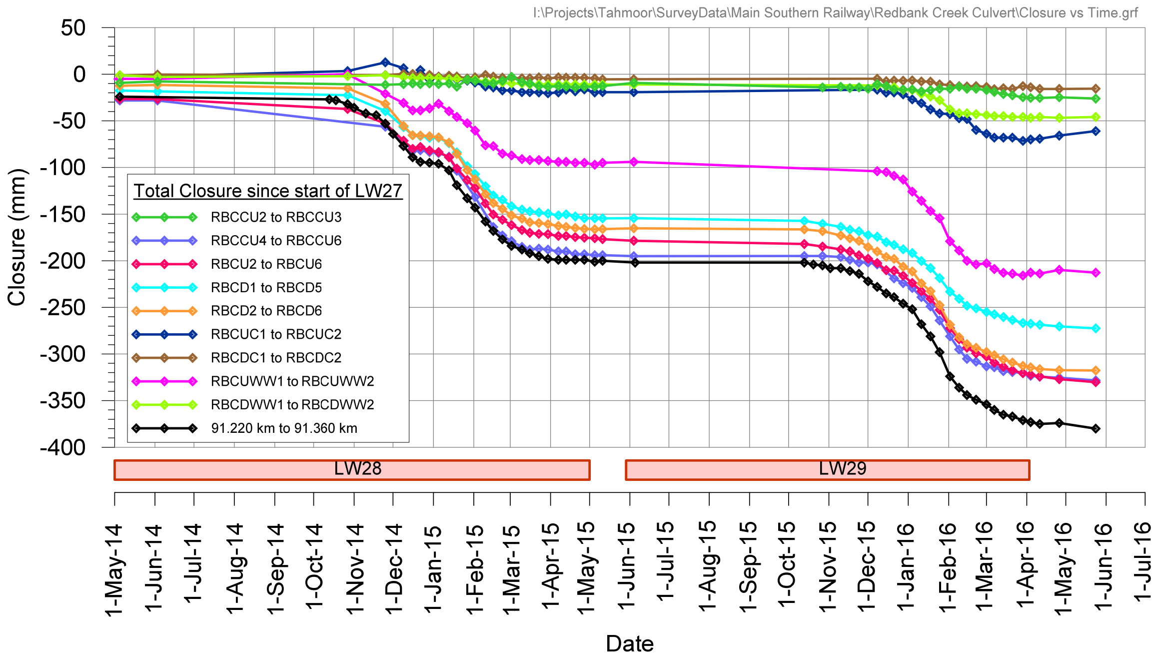

Fig. 2.10 **Observed Total Valley Closure over time across Redbank Creek Culvert at Main Southern Railway during the mining of Longwall 29 (includes closure from Longwalls 27 and 28)**

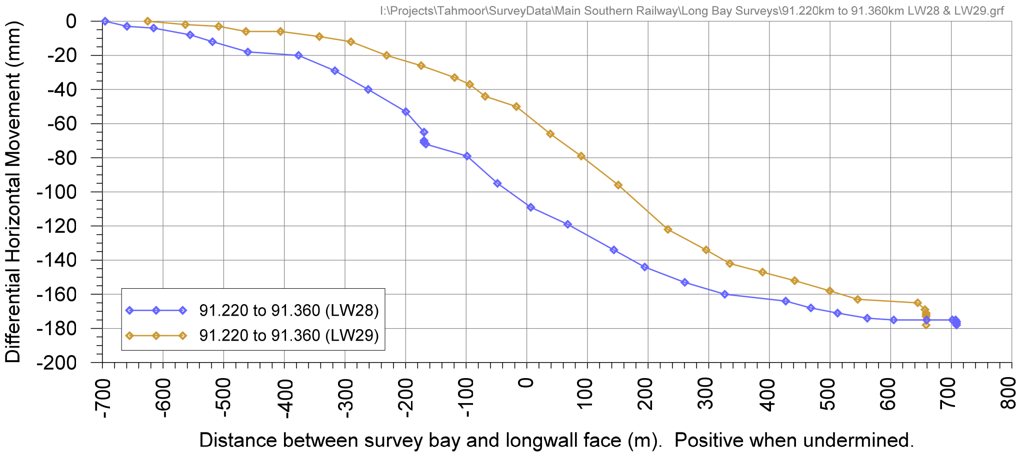

Fig. 2.11 Observed Incremental Valley Closure as measured by long bay survey, relative to face distance across Redbank Creek Culvert at Main Southern Railway during the mining of Longwall 29 (includes incremental closure from Longwall 28)

It can be seen from Fig. 2.11 that the majority of valley closure movements occurred from when the longwall face had approached within 300 metres of the culvert, until the longwall face had passed the culvert by approximately 300 metres.

When compared to the development of valley closure during the mining of Longwall 28, it can be seen that valley closure developed by a reduced amount as the longwall face approached the culvert but then accelerated at a faster rate once the culvert was directly mined beneath. By the end, the increment of valley closure due to the extraction of Longwall 29 was almost identical to the increment due to the extraction of Longwall 28.

Observed subsidence along the base of the embankment on the upstream side is shown in Fig. 2.12. The results show valley closure focussing between Pegs RBCCU4 and RBCCU6, with upsidence observed at Peg RBCCU4.

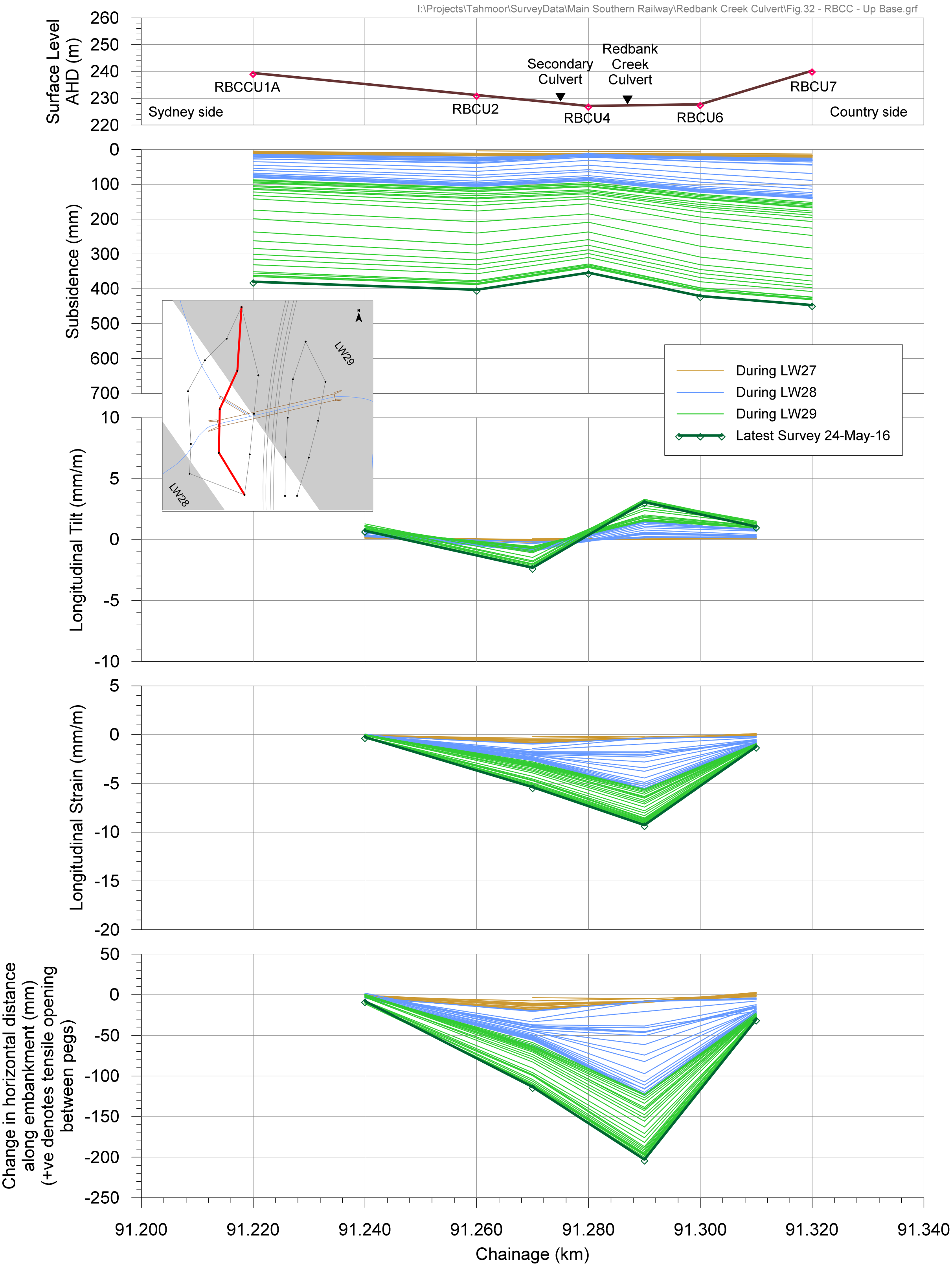

Fig. 2.12 **Observed total subsidence, tilt and strain across the upstream base of Redbank Creek Culvert due to the mining of Longwalls 27 to 29 as at 24 May 2016**

2.6. Sewer Infrastructure

2.6.1. Sewer grades

Subsidence monitoring was undertaken along the streets and along the Tahmoor Carrier and Thirlmere Carrier pipes during the mining of Longwall 29.

The Tahmoor Carrier is the main branch servicing the majority of Tahmoor township. One survey was undertaken along the Tahmoor Carrier at the completion of Longwall 29. One area of focus was changes in grade between Pegs TC5 and TC6, where pipe grades were predicted and observed to reduce during the mining of Longwall 27. As expected, the mining of Longwall 29 increased the predicted grade in this area almost returning it to the pre-mining grade, as shown in Fig. 2.13.

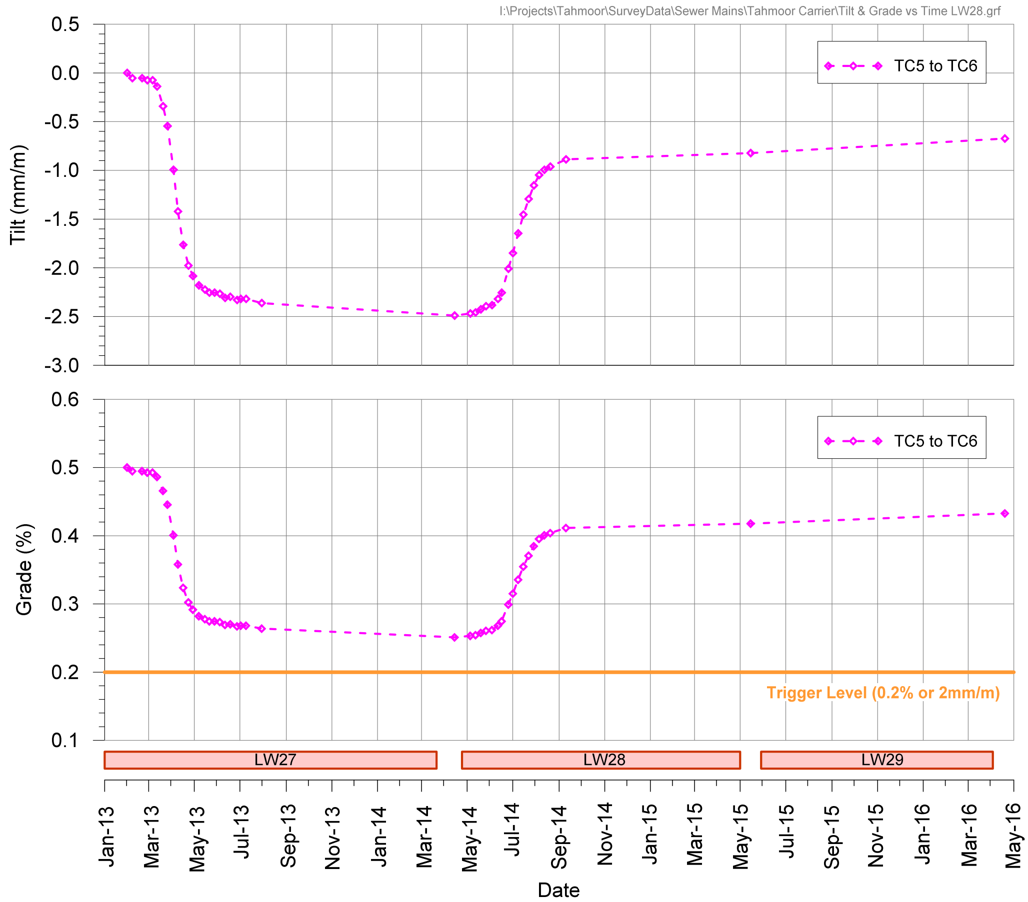

Fig. 2.13 Observed changes in mining-induced tilt and sewer grade at Tahmoor Carrier between Pegs TC5 and TC6

As shown in Fig. A.25, a small change in compressive ground strain was observed between Pegs TC15 and TC16 during Longwall 29, and observed changes are shown in Fig. 2.14.

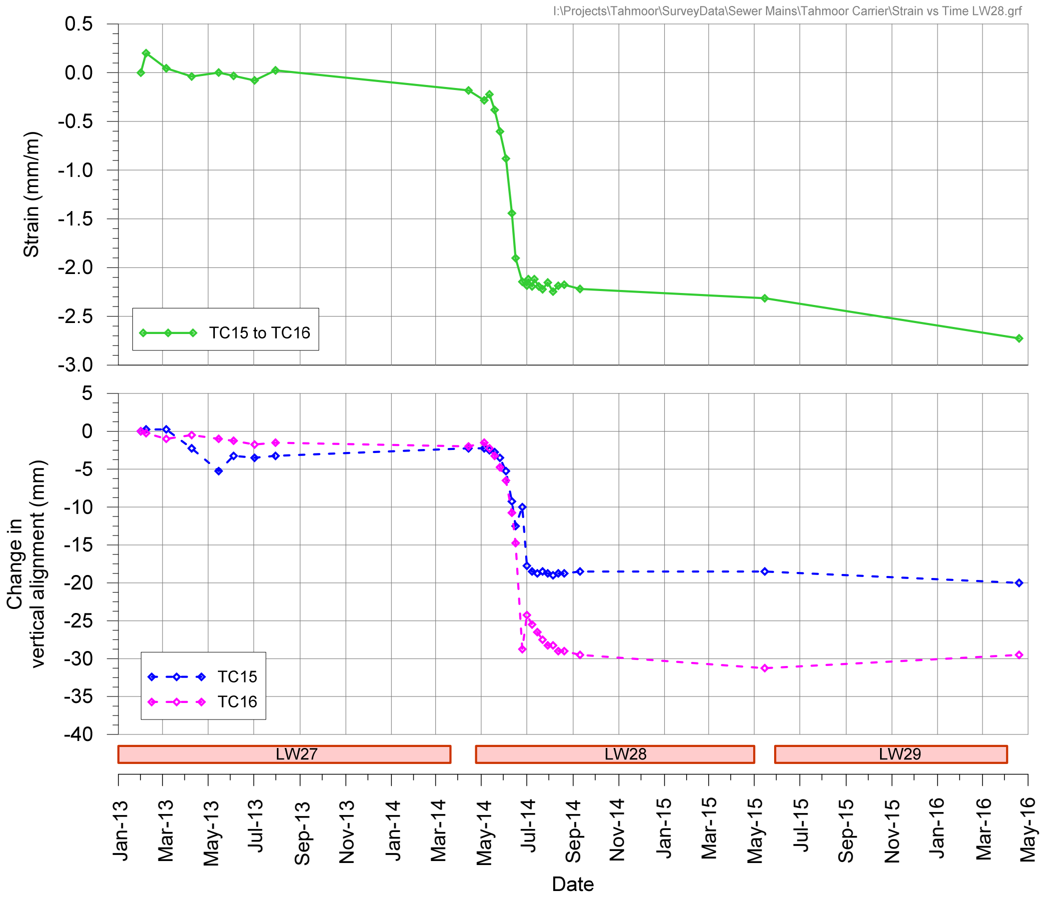

Fig. 2.14 Observed changes in strain and vertical alignment at Tahmoor Carrier between Pegs TC15 and TC16

The Thirlmere Carrier is the main branch servicing the majority of Thirlmere township. A total of 15 surveys were undertaken along the Thirlmere Carrier during the mining of Longwall 29. One area of focus was changes in grade between Pegs BG54 and BG57, where pipe grades were predicted and observed to reduce during the mining of Longwall 27. As expected, the mining of Longwall 29 increased the grade in this area, as shown in Fig. 2.15. Grades over one short 20 metre bay between Pegs BG55 and BG56 may not recover above 0.2 %. No impacts have been observed to the sewer.

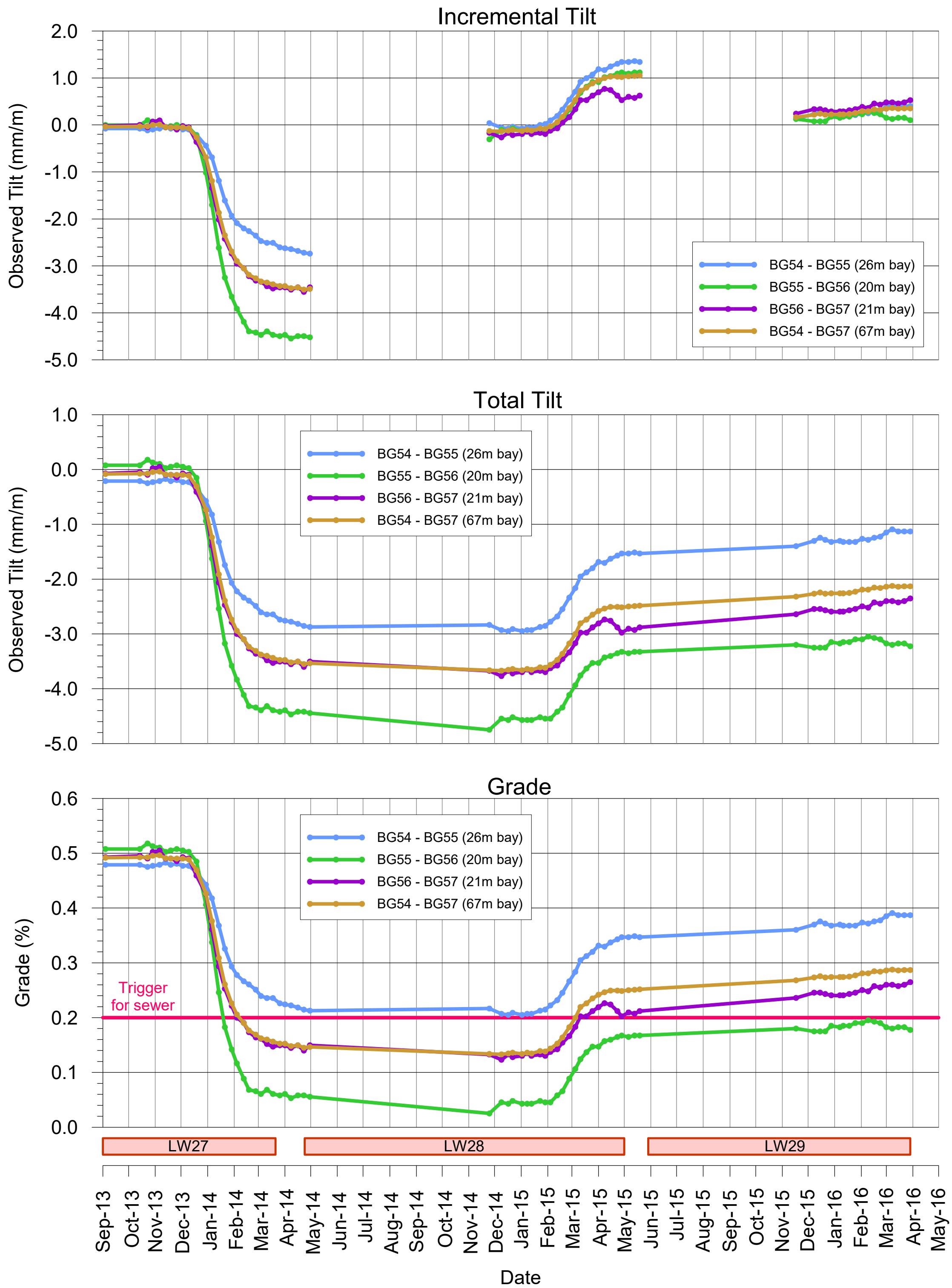

Fig. 2.15 Development of tilt on Bridge Street between pegs BG54 and BG57

2.7. Power Pole Surveys

A total of 61 surveys of selected power poles were conducted in accordance with the agreed management plan with Endeavour Energy. No impacts were observed to any power pole or cables during the mining of Longwall 29, as expected.

Of the poles that were surveyed, maximum subsidence of 365 mm was observed at Pole 478 located above the former Redbank Tunnel.

2.8. Wollondilly Shire Council

2.8.1. Remembrance Drive Bridge

Survey marks were installed on the Remembrance Drive Road Bridge prior to the extraction of Longwall 24A. While the Bridge has experienced approximately 40 mm of subsidence, measured changes in horizontal distances between the abutments are small. Minor closure has been measured, as shown in Fig. 2.16. This includes the measured changes in horizontal distances across the gas pipe supports. Vertical subsidence is relatively consistent across all survey marks, indicating that no measureable upsidence has occurred to date.

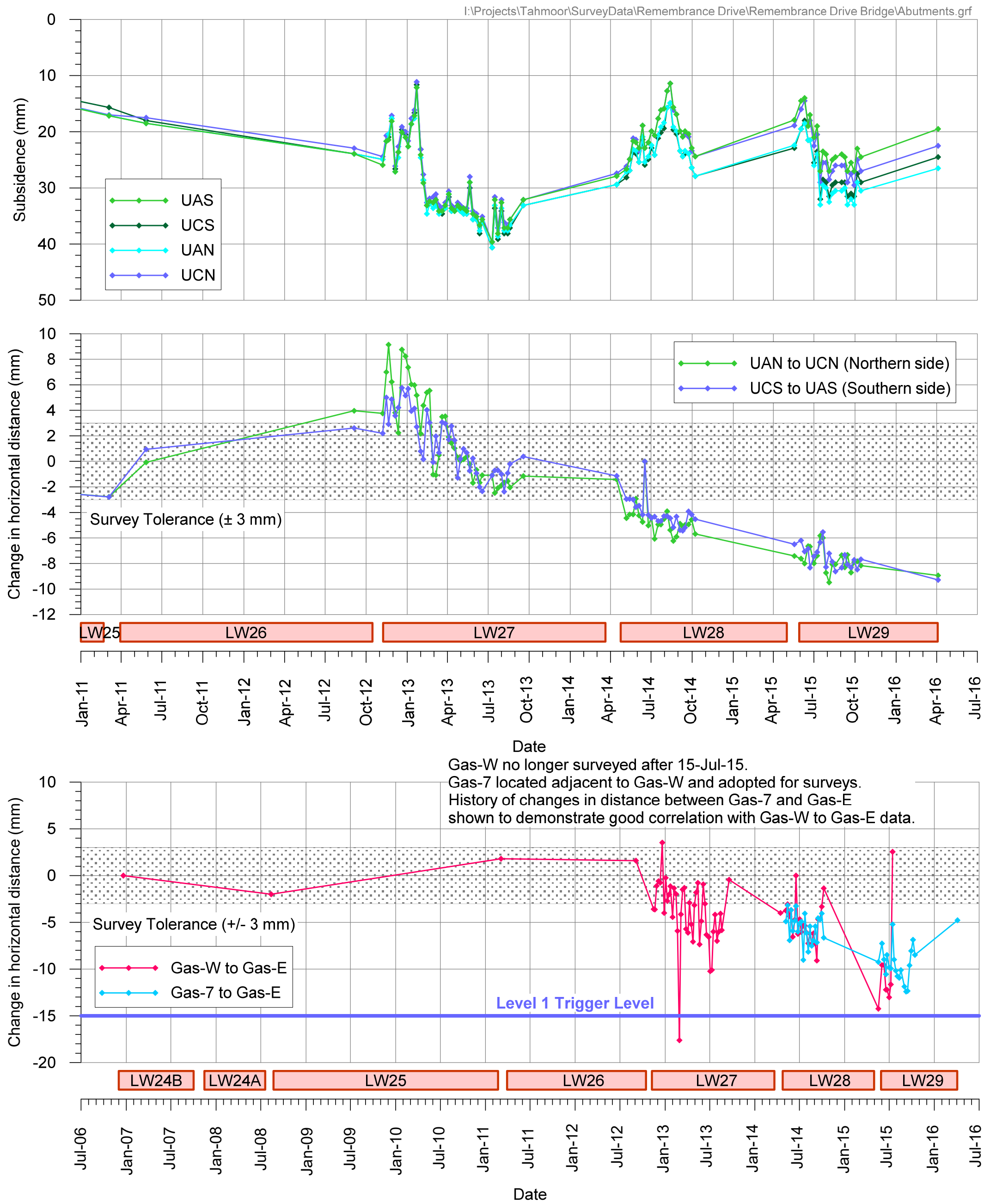

Fig. 2.16 Observed subsidence and changes in horizontal distances across the abutment and gas pipe supports at Remembrance Drive (Myrtle Creek) Road Bridge

Many surveys and inspections were conducted to meet the requirements of the Surface, Safety and Serviceability Management Plans. A timeline showing when each type of survey and inspection was conducted is shown in Fig. 3.1 below.

Fig. 3.1 Timeline of Surveys and Inspections during Longwall 29

A count of the total numbers of surveys and inspections is provided in Table 3.1

Table 3.1 Number of Surveys and Inspections conducted during Longwall 29

Inspection / Survey	Responsibility	Number of Inspections / Surveys
Ground Monitoring Surveys		
	SMEC	55
Sub-Total		**55**
Natural Features		
Myrtle Creek Crossings Surveys	SMEC	12
Myrtle Creek Visual Inspections	GeoTerra	5
Redbank Creek Survey Lines	SMEC	18
Redbank Creek Visual inspections	GeoTerra	9
Sub-Total		**44**
Main Southern Railway		
Ground Surveys	Southern Rail Surveys	48
Rail Creep Surveys	Southern Rail Surveys	48
Long Bay Surveys	Southern Rail Surveys	48
Track Geometry Surveys	BloorRail	59
Track Inspections	BloorRail	74
Cutting Surveys	Southern Rail Surveys	10
Embankment Surveys	Southern Rail Surveys	19
Noise Wall Surveys	Southern Rail Surveys	15
Deviation Overbridge Surveys	Southern Rail Surveys	29
Bridge St Overbridge Surveys	Southern Rail Surveys	18
Redbank Creek Culvert Surveys	Southern Rail Surveys	27
Redbank Creek Culvert Extensometer Surveys	GHD	28
Redbank Creek Culvert Visual Inspections	GHD	26
Sub-Total		**449**
Jemena - Gas		
Remembrance Drive Bridge Surveys	SMEC	20
Sub-Total		**20**
Sydney Water - Sewer		
Tahmoor Carrier Pipe Surveys	SMEC	1
Thirlmere Carrier Pipe Surveys	SMEC	16
Sub-Total		**17**
Endeavour Energy - Electrical		
Power Pole Surveys	SMEC	61
Sub-Total		**61**
Telstra - Telecommunications		
Optical Fibre Line Surveys	SMEC	9
Sub-Total		**9**
Wollondilly Shire Council		
Remembrance Drive Footbridge Surveys	SMEC	20
Remembrance Drive Bridges Visual Inspections	Colin Dove	12
Sub-Total		**32**
Total		**687**

4.1. Summary of Impacts to Surface Features

A comparison between assessed and observed impacts to surface features is summarised in Table 4.1 below. The assessed and observed impacts to surface features compare reasonably well.

Table 4.1 Summary of Predicted and Observed Impacts during Longwall 29

Surface Feature	Predicted Impacts	Observed Impacts
Natural Features		
Myrtle Creek and Redbank Creek	Potential cracking in creek bed. Potential surface flow diversion. Potential reduction in water quality during times of low flow. Potential increase in ponding.	Stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over LW's 25 to 30. Increased ferruginous and salinity levels have been observed in Redbank Creek over LW's 29 and 30. Increased salinity has been observed downstream of Redbank Creek subsidence zone, along with elevated nickel, zinc, iron and manganese. Refer report by GeoTerra and Section 4.2.
Aquifers or known groundwater resources	Temporary lowering of piezometric surface by up to 10m which may stay at that level until maximum subsidence develops. Groundwater levels should recover with no permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops Potential impacts to privately owned groundwater bores. Please refer report by GeoTerra.	Depressurisation of two groundwater monitoring boreholes observed, with partial depressurisation in the Bulgo Sandstone at 5 other boreholes. No indication of any adverse interconnection between aquifers and aquitards within 20m of the surface. No impacts on privately owned bores in yield, serviceability or quality. Please refer report by GeoTerra.
Steep slopes and cliffs	Potential soil slippage and cracking to slopes. Large scale slope failures or cliff instabilities unlikely.	No impacts observed during Longwall 29.
Natural vegetation	No impacts anticipated.	No impacts observed during Longwall 29.
Public Utilities		
Railway	Railway will remain safe and serviceable with management plans in place.	Railway maintained in safe and serviceable condition during mining. The railway infrastructure has experienced some impacts during mining. Refer to Section 4.3 for further details.
Roads and Bridges (all types)	Minor cracking and buckling may occur in isolated locations. Bridges will remain safe and serviceable with management plans in place.	Minor impacts to pavement and kerbs in isolated locations directly above the longwall. Minor cracking and compression bumps on Bridge Street. Refer Section 4.4 for further details.

Surface Feature	Predicted Impacts	Observed Impacts
Water pipelines	Minor impacts possible to pipelines, particularly older cast iron pipes with lead joints.	No impacts observed during Longwall 29. Refer Section 4.5 for further details.
Gas pipelines	Ground movements unlikely to adversely impact pipelines if systematic movement occurs.	No impacts observed during Longwall 29. Refer Section 4.6 for further details.
Sewer pipelines	Mining induced tilt unlikely to reduce grade less than that required for self-cleansing. Cracking to pipes and joints is unlikely if systematic movement occurs. Potential impacts where non-systematic movement occurs.	No impacts during Longwall 29. Refer Section 4.7 for further details.
Electricity transmission lines or associated plants	Ground movements unlikely to adversely impact electrical infrastructure if systematic movement occurs.	No impacts observed during Longwall 29. Refer Section 4.8 for further details.
Telecommunication lines or associated plants	Ground movements unlikely to adversely impact telecommunications infrastructure if systematic movement occurs. Most vulnerable cables are older cables such as air pressurised lead sheathed cables. Strains may be higher where cables connect to support structures or where affected by tree roots.	No impacts observed during Longwall 29. Refer Section 4.9 for further details.
Public Amenities	No public amenities affected by Longwall 29.	No public amenities affected by Longwall 29
Farmland and Facilities		
Farm buildings or sheds	Negligible to slight impacts predicted for all farm buildings and sheds if systematic movement occurs.	No impacts observed during Longwall 29.
Fences	Potential for impacts to fences and gates.	No impacts reported to fences on farm properties during Longwall 29.
Farm dams	Potential adverse effects on dam walls and storage capacity. Please refer report by GeoTerra.	No dam wall cracking and no adverse effects on dam wall integrity or dam water storage reduction have been observed from field investigations. No claims reported during Longwall 29. Please refer report by GeoTerra.
Wells or bores	Potential impact on one NOW registered bore. Please refer report by GeoTerra.	No impacts observed during Longwall 29. Please refer report by GeoTerra
Industrial, Commercial or Business Establishments	No business and commercial establishments affected by Longwall 29.	No business and commercial establishments affected by Longwall 29.
Areas of Archaeological Significance	Potential fracturing, rock falls or water seepage affecting artwork on rock shelter on Myrtle Creek. Low potential for impacts on rock shelter with art and isolated artefact site, both of which are located directly above future Longwall 29.	No impacts on archaeological sites observed during Longwall 29.
Areas of Heritage Significance	No items of heritage significance affected by Longwall 29	No items of heritage significance affected by Longwall 29
Permanent Survey Control Marks	Ground movement predicted at identified survey marks.	Ground movement occurred.

Surface Feature	Predicted Impacts	Observed Impacts
Residential Establishments		
Houses, flats or units	All houses expected to remain safe, serviceable and repairable provided that they are in sound condition prior to mining. Impacts predicted to some houses. Refer Section 4.10 for details.	While impacts occurred, houses were safe, serviceable and repairable during Longwall 29. Refer Section 4.10 for details.
Swimming pools	While predicted tilts are not expected to cause a loss in capacity, tilts are more readily noticeable in pools as the height of the freeboard will vary along the length of the pool. While predicted strain impacts are low, many of the pools are inground, which are more susceptible.	Impact to 32 pools during the mining of Longwalls 22 to 29, with impact to 1 pool reported during the mining of Longwall 29.
Associated structures such as workshops, garages, on-site wastewater systems, water or gas tanks or tennis courts	Potential impact to pipes connected to inground septic tanks. Negligible impacts predicted for non-residential domestic structures, including sheds and tanks.	Impact to 1 retaining wall was reported during Longwall 29.
External residential pavements	Cracking and buckling likely to occur, though majority minor.	Impacts to external pavements were reported by 4 properties during Longwall 29.
Fences in urban areas	Some fences and gates could be slightly damaged. Most vulnerable are Colorbond fences.	No impacts to fences reported during Longwall 29.

4.2. Creeks

4.2.1. Myrtle Creek

Longwall 29 did not mine directly beneath Myrtle Creek. GeoTerra undertook bi-monthly inspections of Myrtle Creek during the extraction of Longwall 29 (GeoTerra, 2016a). No new subsidence impacts were observed, and no trigger levels were exceeded.

A large storm occurred on 5 and 6 June 2016 after the completion of Longwall 29, resulting in significant water flows in Myrtle Creek. Many of the previously cracked, lifted or delaminated rock slabs in the stream bed were washed downstream.

A summary report on the history of mine subsidence impacts along Myrtle Creek, and its current status has been prepared by Geoterra (2016b), and included in this End of Panel Report.

4.2.2. Redbank Creek

GeoTerra undertook an investigation into the effects of Longwall 29 on surface and ground waters in the area (GeoTerra, 2016a).

During the mining of Longwall 29, new or additional subsidence effects were observed at Sites RB6 to RR11 tailgate section of future Longwall 30 (upstream half of Longwall 30). Re-emergence of the stream “through-flow” has been observed downstream of Longwall 29, at site RR11 that is approximately above the mid reach section of future Longwall 30 (refer to report by GeoTerra for locations of sites).

Increased salinity has been observed downstream of the subsidence zone. Elevated levels of iron, manganese, zinc and nickel were observed during the mining of Longwall 29. No observable trend or change in levels of aluminium or copper was observed during the mining of Longwall 29.

A number of seeps were identified in Redbank Creek prior to mining. No new springs have been generated, or reduced, due to subsidence due to the mining of Longwalls 22 to 29, though increased ferruginous and salinity levels have been observed over Longwalls 29 and 30.

A large storm occurred on 5 and 6 June 2016 after the completion of Longwall 29, resulting in significant water flows in Redbank Creek. Many of the previously cracked, lifted or delaminated rock slabs in the stream bed were washed downstream.

4.2.3. Comparison against Triggers in Natural Features Management Plan

The observed impacts have been compared against the triggers stated in Section 3.1.1 of the *Natural Features Surface Safety and Serviceability Management Plan for Longwalls 27 to 30*, (Rev. I, November 2012).

Table 4.2 Comparison against Triggers for Myrtle and Redbank Creeks during Longwall 29

Trigger	Myrtle Creek	Redbank Creek
Redirection of surface water flows and pool level / flow decline of >20% during mining compared to baseline for > 2 months, considering rainfall / runoff variability	No new triggers exceeded	Trigger exceeded during mining of LW29 at Sites 26A and RC2/37 above LWs 28 and 29, Sites RR2 and RB5 above LW29, and Site RR9 above LW30.
Significant reduction compared to baseline, predicted impacts last over 2 months and exceed 2 standard deviations compared to baseline	No new triggers exceeded.	Trigger exceeded at Site RC2/37 over LW29.

4.3. Main Southern Railway

4.3.1. Railway Track

While changes were observed, the Main Southern Railway remained serviceable at all times during the mining of Longwall 29. The track condition deteriorated slightly in isolated locations as a result of mining and the track was resurfaced.

During the mining of Longwall 29 some of the triggers associated with the *Tahmoor Colliery Longwalls 29 to 30 Management Plan for Longwall Mining beneath the Main Southern Railway (Rev B, March 2015)* were exceeded.

Rail stresses exceeded triggers on one occasion during the mining of Longwall 29 due to ground shortening within an anchor point, which was corrected on site.

With respect to switch displacement triggers, some low level (Blue) alarms were triggered as a result of subsidence in combination with low or high rail temperatures. The alarms were responded to in accordance with the Management Plan. Some of the responses had already been planned in anticipation of the alarm.

4.3.2. Redbank Creek Culvert and Embankment

Tahmoor Colliery has successfully extracted Longwall 29 beneath the Redbank Creek Culvert. Substantial ground shortening of approximately 380 mm was observed along the length of the embankment, and ground extension of approximately 165 mm was observed in the transverse direction.

A detailed Subsidence Management Plan was developed to manage potential impacts on the Redbank Creek Culvert and Embankment during the mining of Longwall 29.

The Monitoring Review Point Trigger of closure across the Culvert barrel was exceeded during the mining of Longwall 28. The culvert experienced cracking and spalling of brickwork but remained safe and serviceable during and after mining during the mining of Longwall 29. Additional measures are being installed in the Culvert in preparation for the influence of Longwall 30.

The Redbank Creek Culvert and Embankment has remained safe and serviceable during the mining of Longwall 29. The Monitoring Review Point trigger level for extension of the embankment was exceeded during mining. The Rail Management Group reviewed the monitoring data and the results of the visual inspections and agreed to incrementally increase the Monitoring Review Point from 125 mm to 150 mm, and then 200 mm. The decisions were based mainly on observations of no signs of distress by the geotechnical engineer.

4.4. Roads and Bridges

4.4.1. Roads

Approximately 25.5 kilometres of asphaltic pavement lie directly above the extracted longwalls and a total of 49 impact sites have been observed. The observed rate of impact equates to an average of one impact for every 520 metres of pavement. The impacts were minor and did not present a public safety risk. A collection of photographs of impacts is provided in Fig. 4.1.

Remembrance Drive

Bridge Street

Bridge Street

Photographs courtesy of Colin Dove

Fig. 4.1 Photographs of Impacts to Road Pavements and Kerbs during Longwall 29

4.5. Potable Water Infrastructure

Longwalls 22 to 29 have directly mined beneath approximately 4.8 kilometres of ductile iron concrete lined (DICL) pipe and 19 kilometres of cast iron concrete lined (CICL) pipe, with only minor impacts recorded. No impacts were observed during the mining of Longwall 29.

4.6. Gas Infrastructure

Longwalls 22 to 29 have directly mined beneath approximately 17.9 kilometres of gas pipes and no impacts have been recorded so far. The local nylon and 160 mm polyethylene main along Remembrance Drive are very flexible and have demonstrated that they are able to withstand the full range of subsidence experienced at Tahmoor to date.

4.7. Sewer Infrastructure

Longwalls 22 to 29 have directly mined beneath approximately 29.1 kilometres of sewer pipes. No impacts were observed during the mining of Longwall 29. The following observations have been made:

- *Changes to grades of self-cleansing gravity sewers*
  While changes in sewer grades have occurred as a result of mine subsidence, no blockages or reversals of grade have been observed. This includes observations at locations above Longwalls 24A to 28 where specific ground surveys were undertaken to confirm that mining-induced tilts did not exceed pre-mining grades.

- *Physical damage to pipes*
  There were no observations of damage during the mining of Longwalls 22 to 24 and Longwalls 27 to 29. Physical damage was observed at three locations during the mining of Longwall 25. In each case the pipes remained serviceable, though repairs were required at each location.

  - Crushing and vertical bending of 150 mm diameter pipe at Abelia Street. The impacts coincide with a large measured ground strain of 4.6 mm/m (over a 22 metre bay length) between Pegs A12 and A13, a measured vertical bump in the subsidence profile and an observed hump in the road pavement. The pipe was repaired prior to the influence of Longwall 26 and no impacts were observed to the repaired pipe during the mining of this longwall.
  - Crushing and vertical bending of 150 mm diameter pipe at Remembrance Drive. The impacts coincide with a large measured ground strain of 2.8 mm/m (over a 37 metre bay length) between Pegs R1 and RE1, a measured vertical bump in the subsidence profile and an observed hump in the road pavement and roundabout. The pipe was repaired prior to the influence of Longwall 26 and no impacts were observed to the repaired pipe during the mining of this longwall.
  - Crushing and vertical bending of the 225 mm diameter horizontal bore between Amblecote Place and Myrtle Creek. There is no monitoring line above this bore.

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

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

The observed impacts to date have been within expectations.

4.8. Electrical Infrastructure

Longwalls 22 to 29 have directly mined beneath approximately 36.5 kilometres of electrical cables and 973 power poles and no significant impacts have been recorded so far. However, tension adjustments have been made by Endeavour Energy to some aerial services connections to houses. This is understandable as the overhead cables are typically pulled tight between each house and power pole.

4.9. Telecommunications Infrastructure

Longwalls 22 to 29 have directly mined beneath approximately 43.1 kilometres of buried copper cable and 1.9 kilometres of buried optical fibre cable and 4.5 kilometres of aerial cable and no impacts have been recorded to telecommunications services so far.

Adjustments to tension of aerial telecommunications cables were required during the mining of Longwall 26 on Tahmoor Road and Krista Place. Damage was also observed to a conduit on the north-western abutment of the Castlereagh St Bridge. No issues were detected during the mining of Longwalls 27, 28 and 29.

No impacts were observed to the Telstra Tower, which is located directly above Longwall 28. Continuously operating tiltmeters recorded changes within expectations.

4.10. Residential Establishments

All structures remained safe and serviceable during the mining of Longwall 29.

A register of observed impacts is based on claims received from the MSB. Information on the nature of the impacts was provided by the MSB. The register was updated on a weekly basis and the statistics provided in this report are based on impacts recorded up to the week ending 14 April 2016, at the completion of Longwall 29.

A summary of reported impacts following the completion of Longwall 29 is provided in Table 4.3. The count of residential structures and public amenities includes only those structures that were predicted to experience more than 20 mm of subsidence due to the extraction of Longwalls 22 to 29.

Table 4.3 Summary of Observed Impacts to Structures

	Total after LWs 22 to 29	Increment during Longwall 29
Number of structures within zone of influence (predicted subsidence > 20 mm)	1870	46
Number of properties with reported impacts (not including refused claims)	521	9
Number of properties with reported impacts that relate to main structures (e.g. house or shop)	464	9
Number of properties with reported impacts that only relate to associated structures	57	0

The above information can be misleading as all of the claims received during the mining of Longwall 29 were associated with the mining of previous Longwalls 22 to 28. This is due to time lag between the actual impact and the claim of an impact by residents to the Mine Subsidence Board.

This is illustrated by a spatial plot of locations of impacts reported during the mining of Longwall 29 in Fig. 4.2.

Fig. 4.2 Locations of Impacts Reported during the Mining of Longwall 29

4.10.1. Discussion of Results

Prior to the mining of Longwall 27, the probabilities of impacts for each house within the SMP Area for Longwalls 27 to 30 were assessed using the method developed as part of ACARP Research Project C12015, based on observations of impacts during the mining of Longwalls 22 to 25. The method of assessment uses the primary parameters of ground curvature and type of construction. A summary of the predicted movements and the assessed impacts for each house within the SMP Area is described in Report No. MSEC355.

The overall distribution of the assessed impacts for the houses within the SMP Area is provided in Table 4.4.

Table 4.4 Assessed Impacts for the Houses within the *SMP Area* for Longwalls 27 to 30

Group	Repair Category		
	No Claim or R0	R1 or R2	R3 to R5
All Houses (total of 806)	657 **(82 %)**	102 **(13 %)**	47 **(6 %)**

Information on reported impacts has been provided by the Mine Subsidence Board during the mining of Longwalls 22 to 29. A summary of the observed distribution of impacts for all houses that are predicted to have experienced more than 20 mm of subsidence during the mining of Longwalls 22 to 29 is provided in Table 4.5.

Table 4.5 Observed Frequency of Impacts for Building Structures Resulting from the Extraction of Tahmoor Longwalls 22 to 29

Group	Repair Category		
	No Claim or R0 (Nil or Cat 0)	R1 or R2 (Cat 1 or 2)	R3 to R5 (Cat 3 to 5)
All houses, public amenities, commercial buildings (total of 1870)	1684 **(90 %)**	145 **(8 %)**	41 **(2 %)**

It is noted that a comparison cannot easily be made based on the total number of affected houses. It is very difficult to separate effects on houses due to the mining of Longwall 29 only due to the time lag effect discussed previously. All properties that reported impacts during the mining of Longwall 29 were associated with the mining of previous Longwalls 22 to 28.

It is recommended, therefore, that comparisons be made based on total percentages of claims, where a reasonable correlation can be seen.

The primary risk associated with mining beneath houses is public safety. Residents have not been exposed to immediate and sudden safety hazards during the mining of Longwall 29.

4.10.2. Swimming Pools

Minor cracking has been observed in one fibreglass swimming pool during the mining of Longwall 29.

4.10.3. Associated Structures

A minor impact has been observed to one retaining wall during the mining of Longwall 29.

4.10.4. Fences

The potential for impacts to fences was raised in the SMP Report, however, no properties have claimed impacts to gates and fences during the mining of Longwall 29.

5.0 SUMMARY OF RESULTS

In summary, there is generally a reasonable correlation between observed and predicted subsidence, tilt and curvature over the majority of the mining area.

As anticipated prior to mining, little to no increased subsidence was observed during the first stages of mining Longwall 29. The maximum observed incremental subsidence due to the mining of Longwall 29 was 737 mm, which only slightly exceeded the maximum predicted incremental subsidence for Longwall 29, with the difference being within the accuracy of the subsidence prediction methods.

There is a reasonable correlation between observed and predicted impacts, particularly in relation to public infrastructure such as the Main Southern Railway, sewer mains, water mains, gas mains, and electrical and telecommunications infrastructure. Fewer impacts to road pavements were observed compared to those observed during the mining of previous longwalls.

All structures remained safe and serviceable during the mining of Longwall 29.

In relation to Myrtle Creek and Redbank Creek, there was a reasonable correlation between predicted and observed incremental valley closure movements due to the mining of Longwall 29.

Cracking was observed in both creeks and pools were observed to drain at times of low flow, with sub-surface flow diversion observed to re-emerge downstream of Longwall 29. Some adverse changes in water quality were observed at times of low flow. The observed impacts are within predictions.

APPENDIX A. FIGURES

Tahmoor Colliery - Incremental Subsidence Profiles along Bridge Street

I:\Projects\Tahmoor\MSEC834 - LW29 End of Panel Report\Subsdata\Survey Data\Fig. A.01 - Bridge St Inc.grf

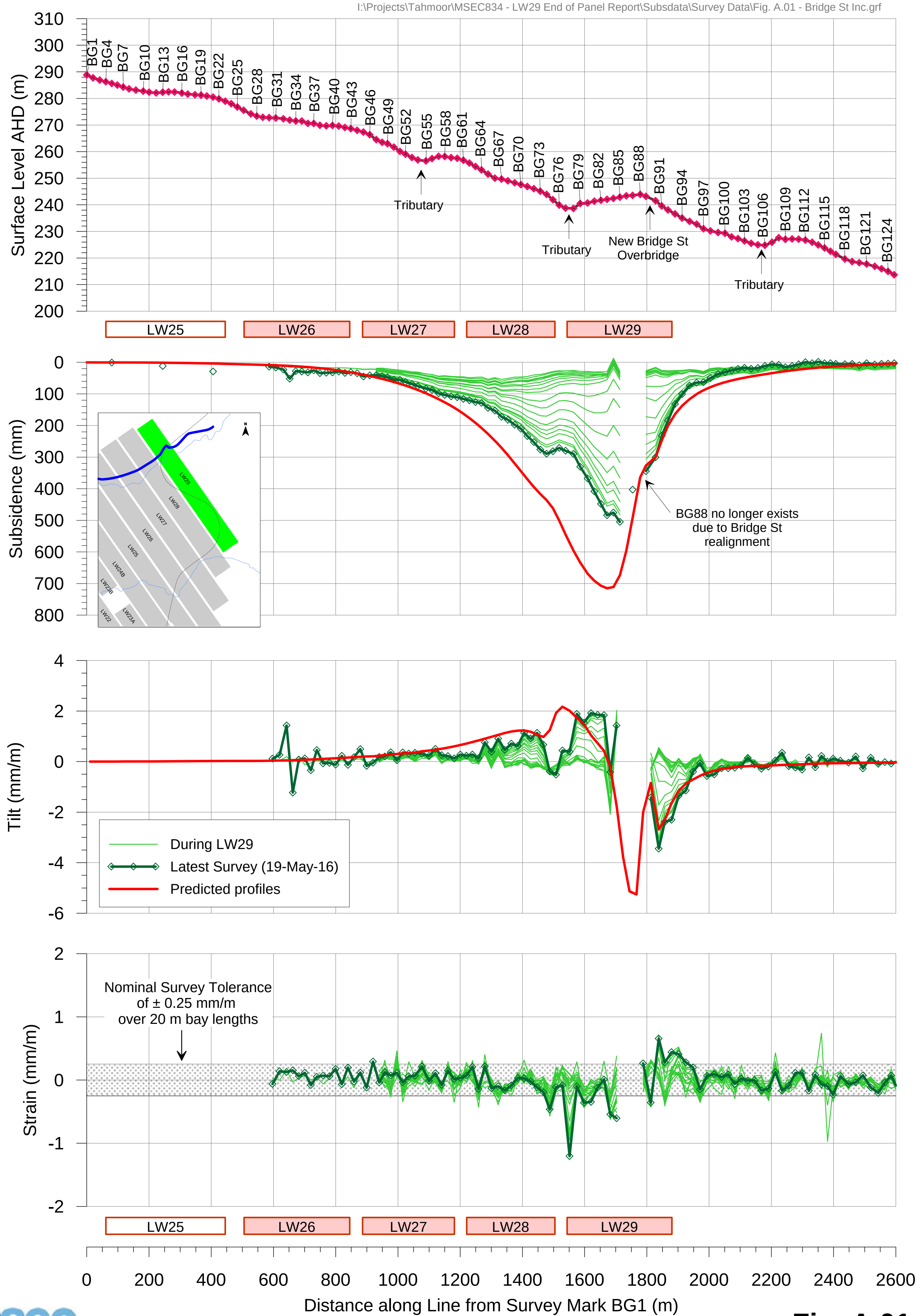

Fig. A.01

Tahmoor Colliery - Total Subsidence Profiles along Bridge Street

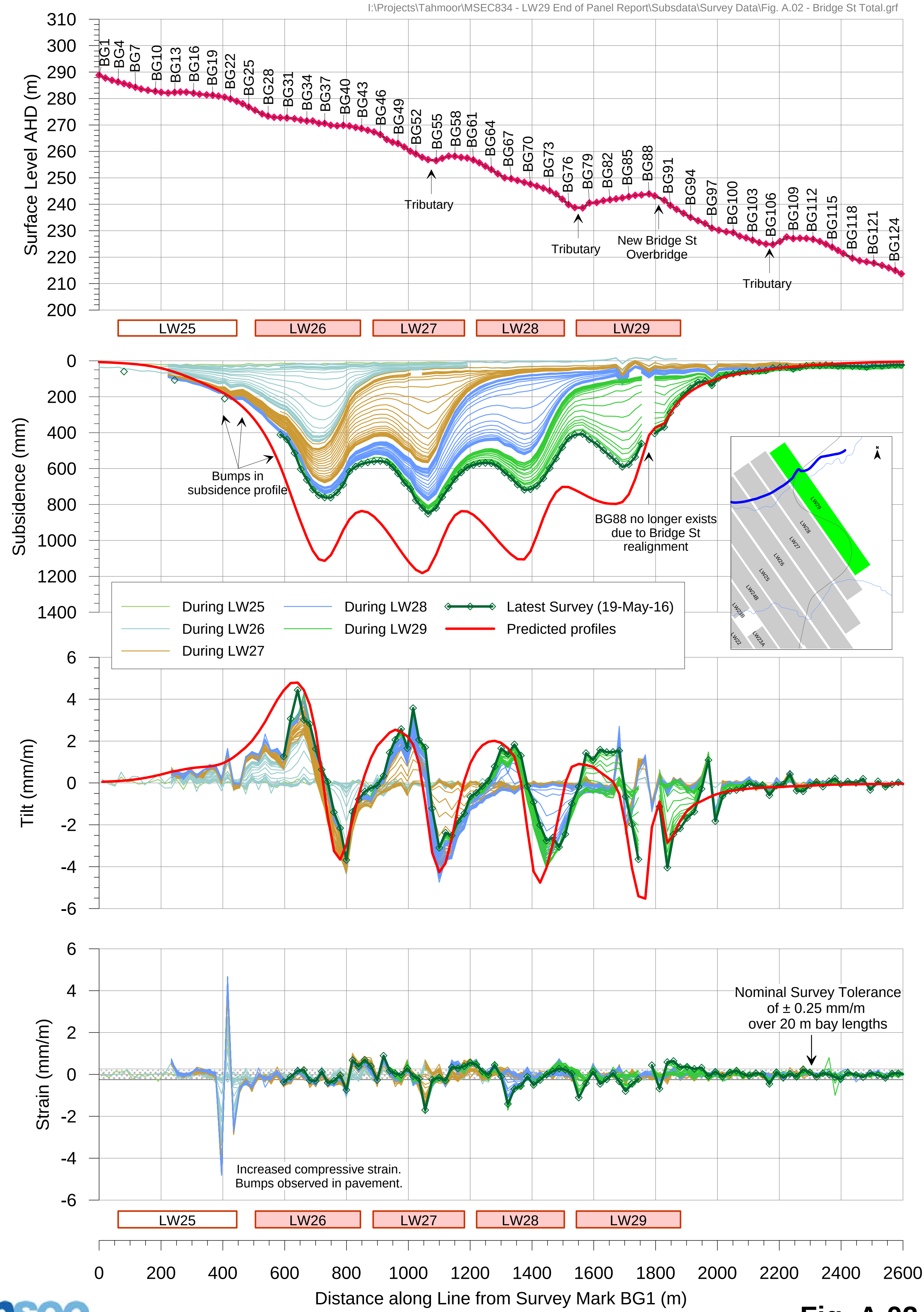

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Fig. A.02

Tahmoor Colliery - Total Subsidence Profiles along Hilton Park Road

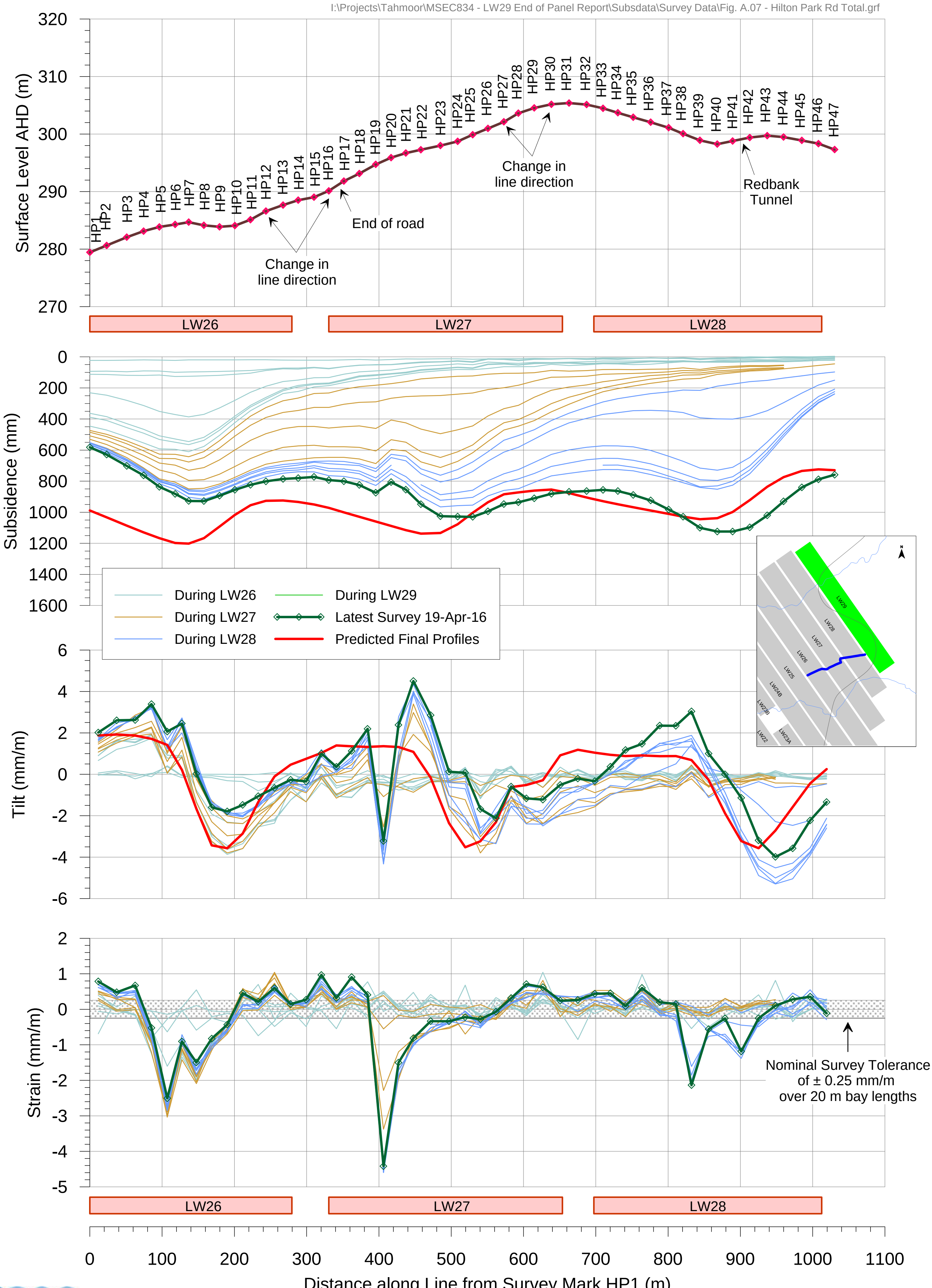

Fig. A.03

Tahmoor Colliery
Incremental Subsidence Profiles along KXA Line

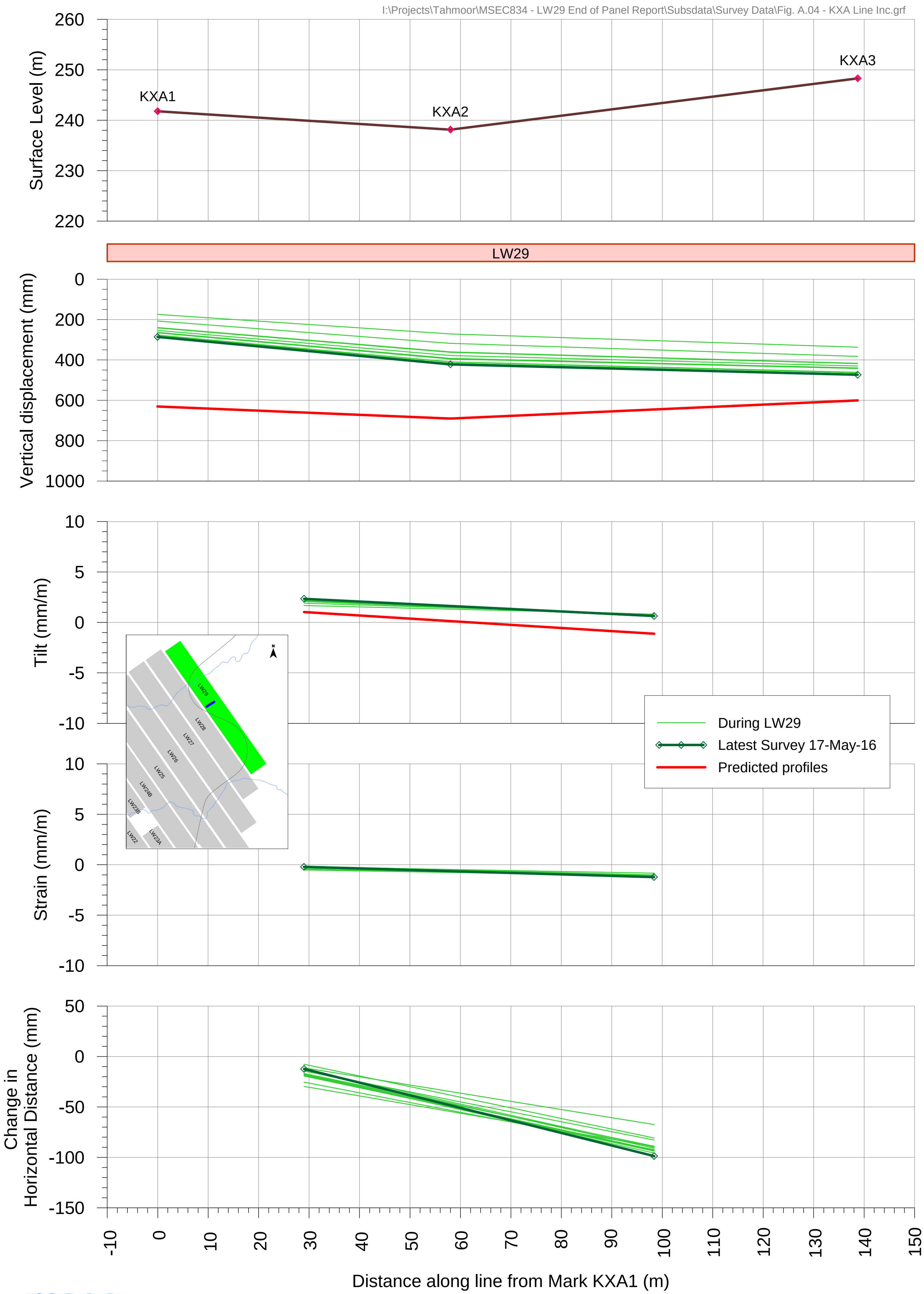

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Fig. A.04

Tahmoor Colliery
Total Subsidence Profiles along KXA Line

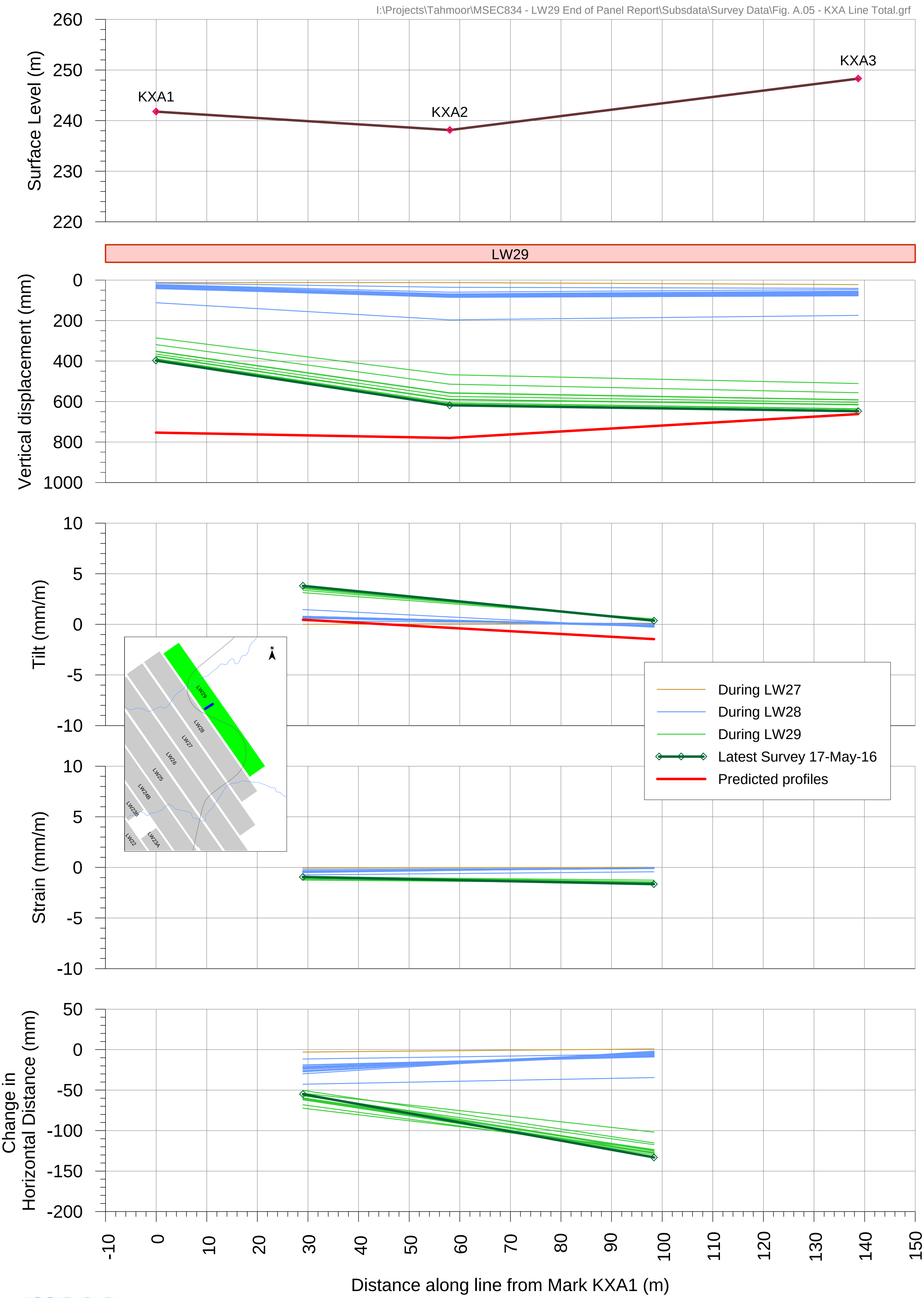

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Fig. A.05

Tahmoor Colliery
Incremental Subsidence Profiles along KXB Line

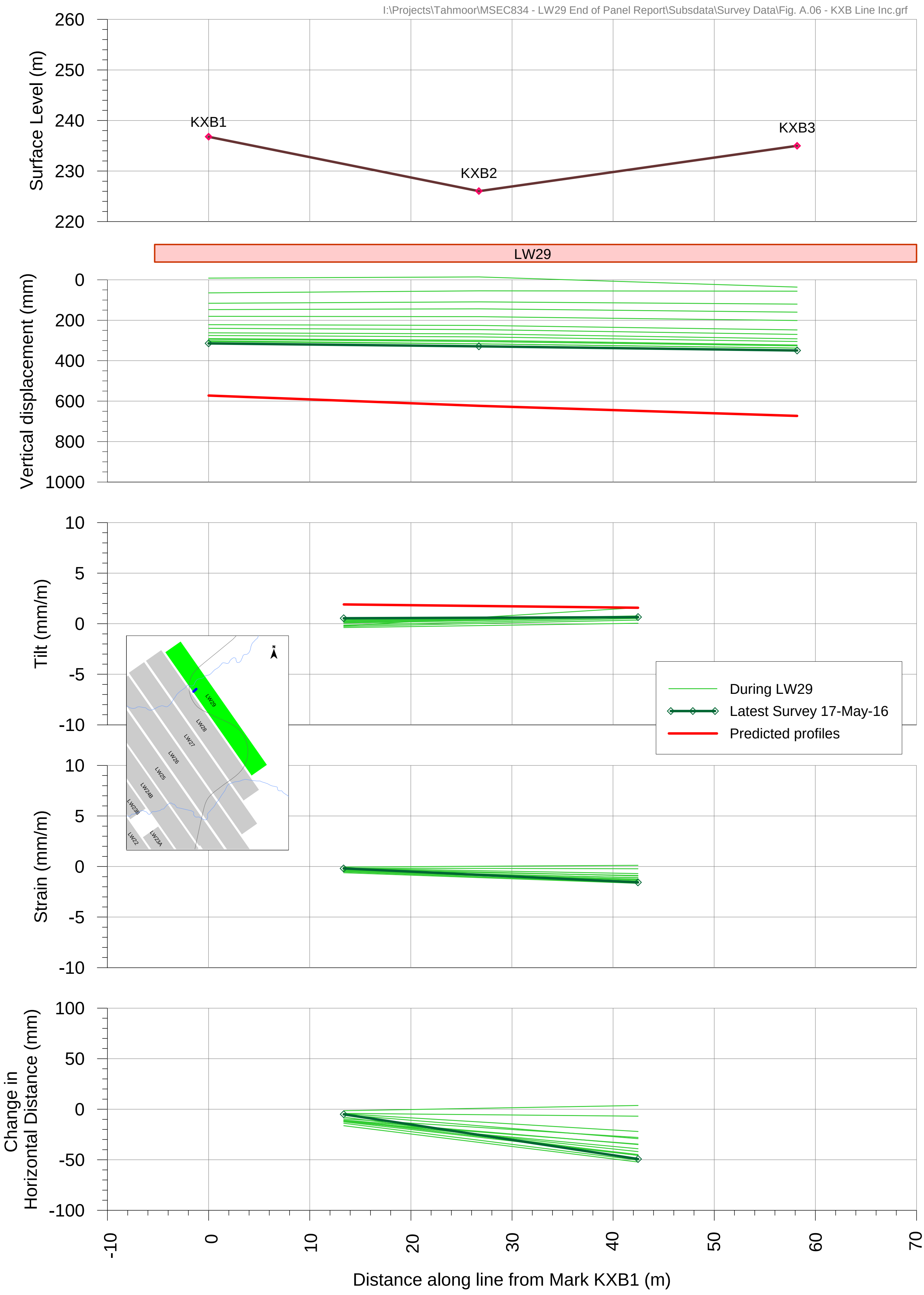

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Fig. A.06

Tahmoor Colliery
Total Subsidence Profiles along KXB Line

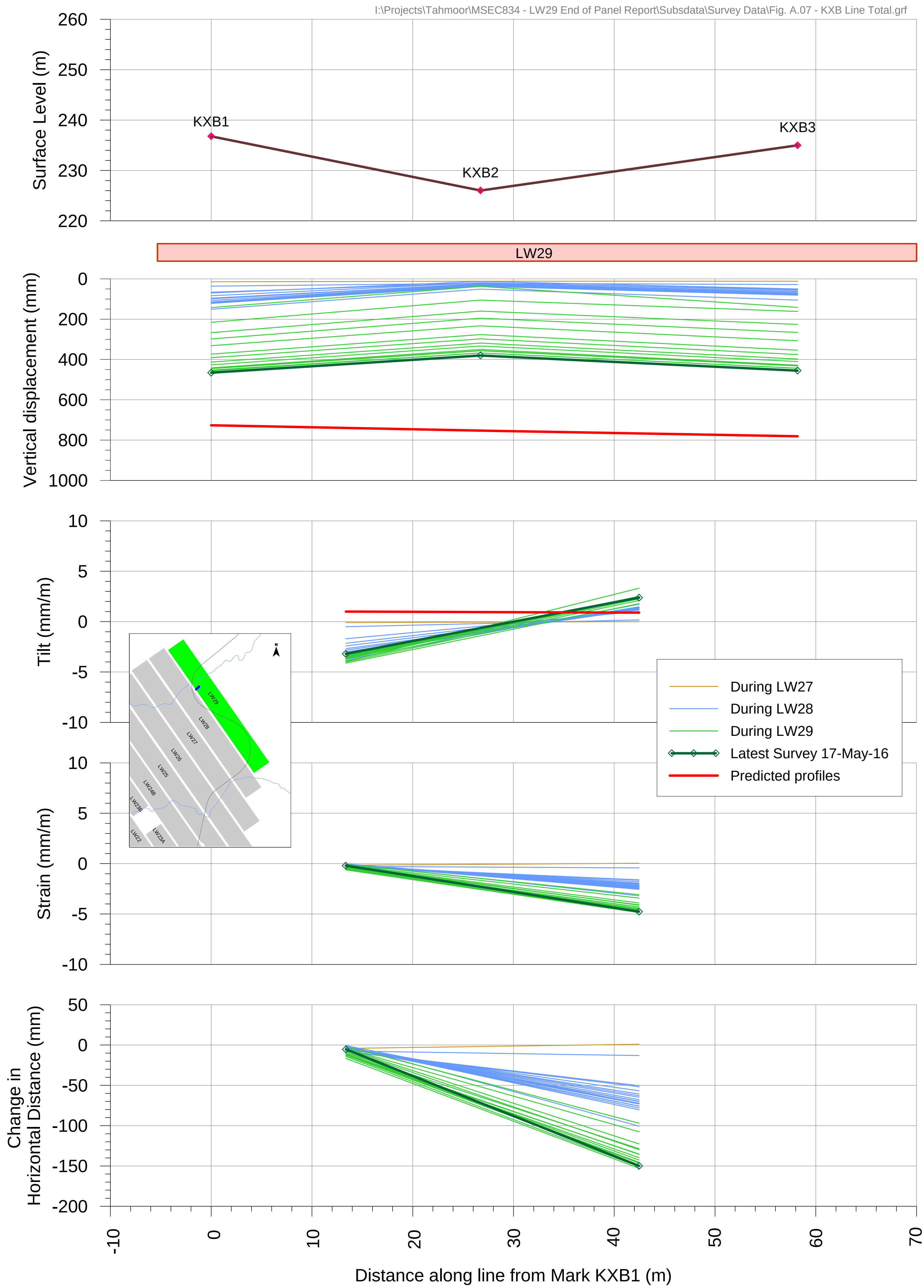

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Fig. A.07

Tahmoor Colliery
Incremental Subsidence Profiles along MXB Line

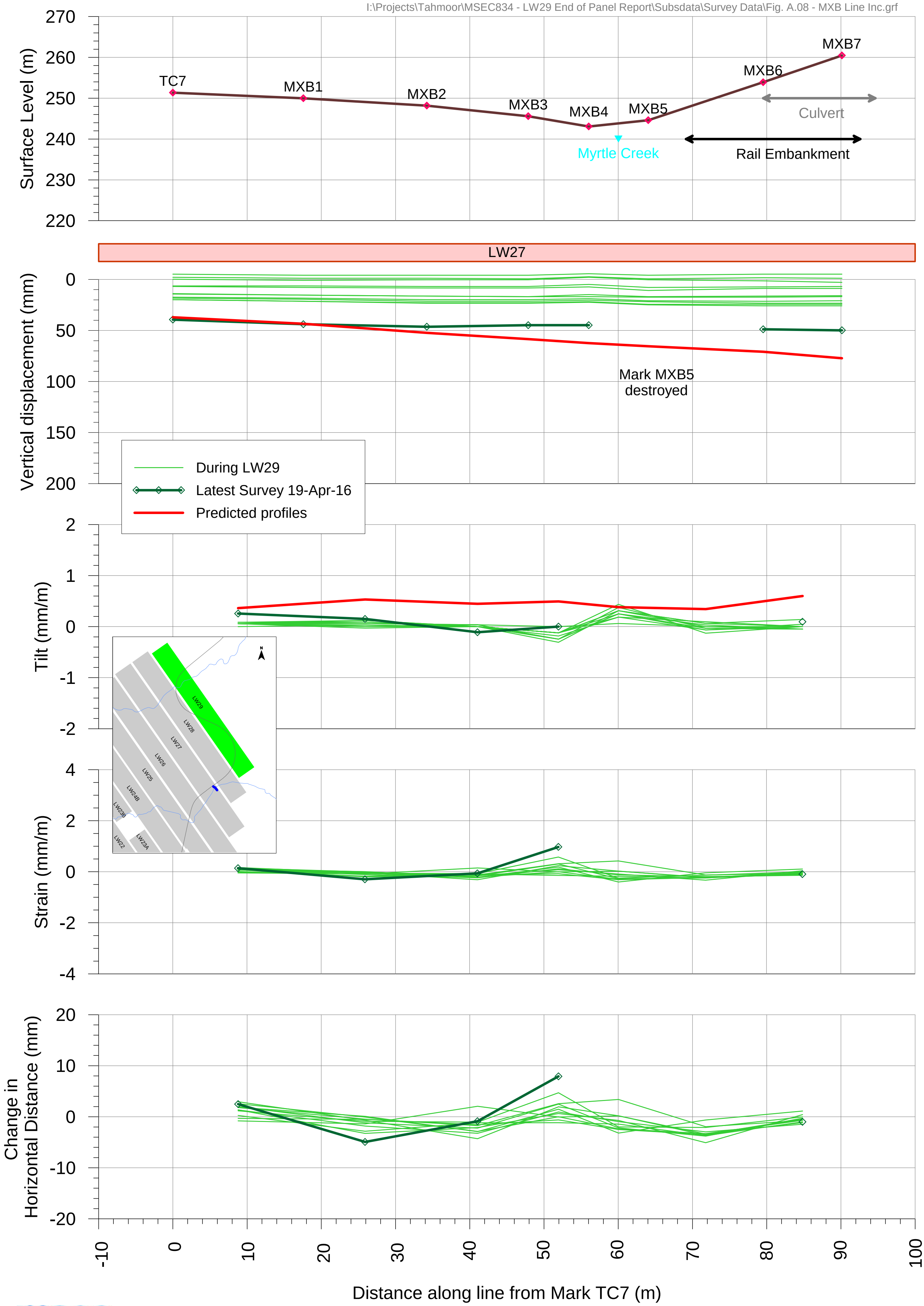

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Fig. A.08

Tahmoor Colliery
Total Subsidence Profiles along MXB Line

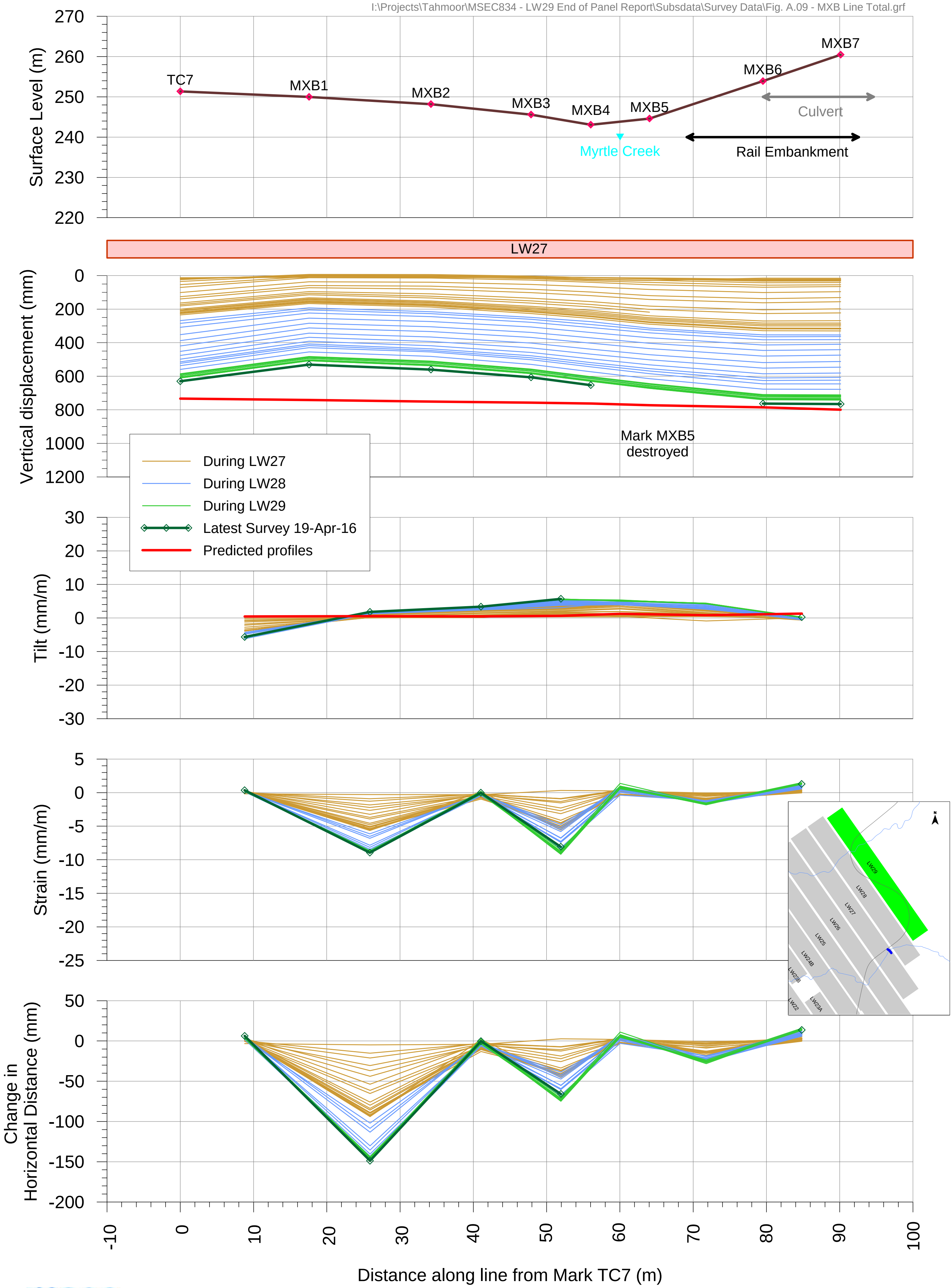

Fig. A.09

Tahmoor Colliery
Total Subsidence Profiles along MXC Line

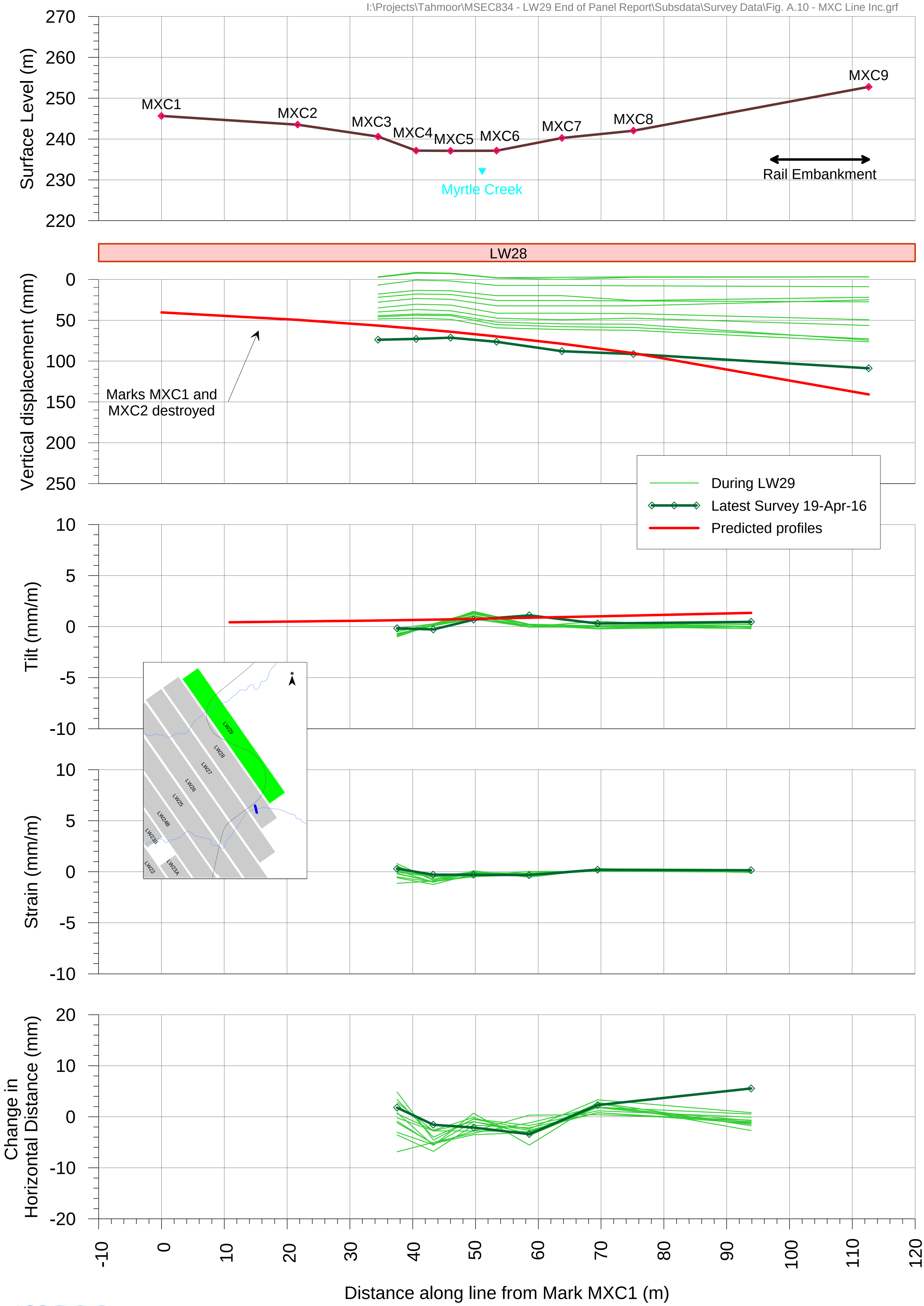

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Fig. A.10

Tahmoor Colliery
Total Subsidence Profiles along MXC Line

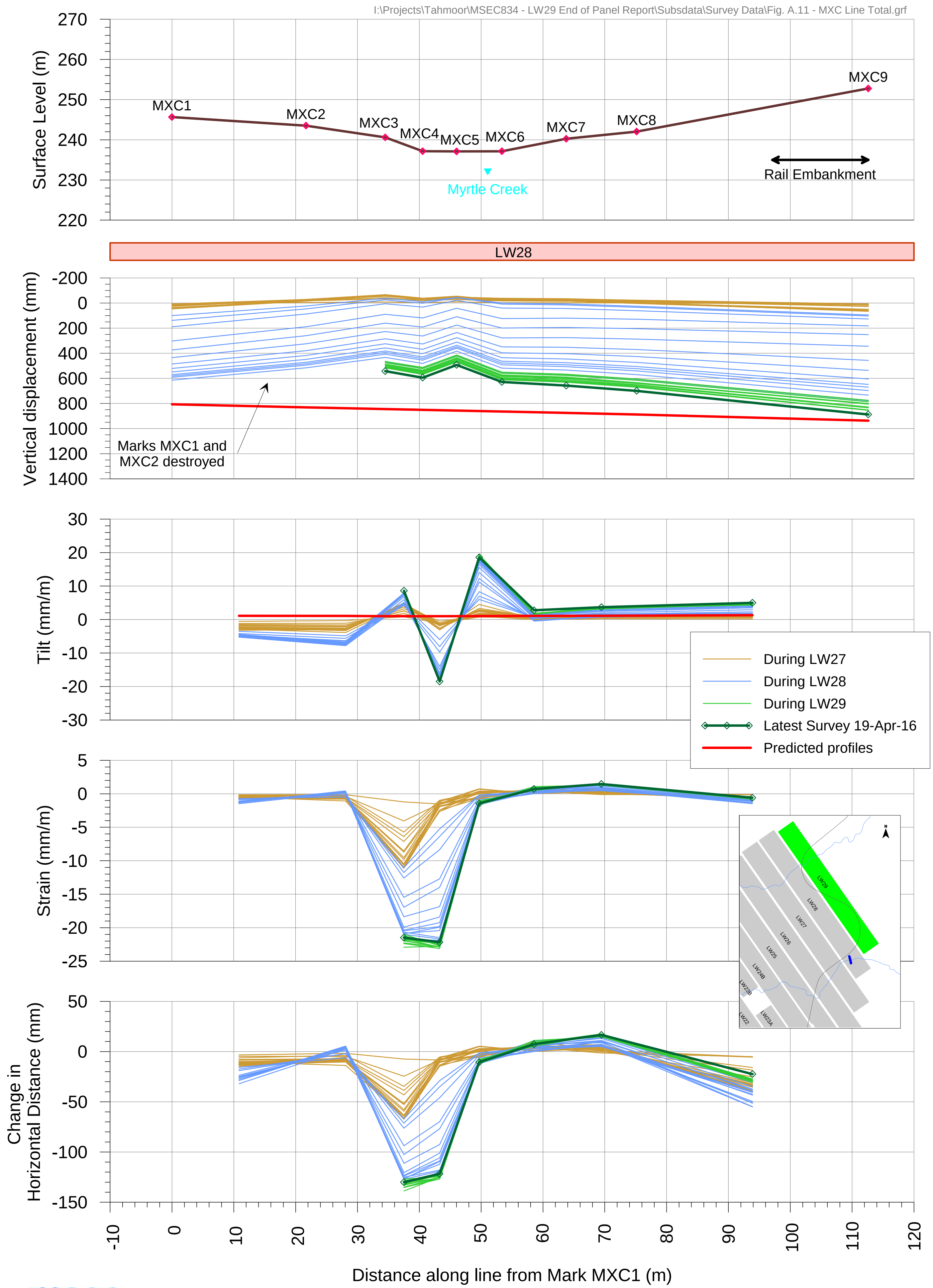

Fig. A.11

Tahmoor Colliery
Incremental Subsidence Profiles along MXD Line

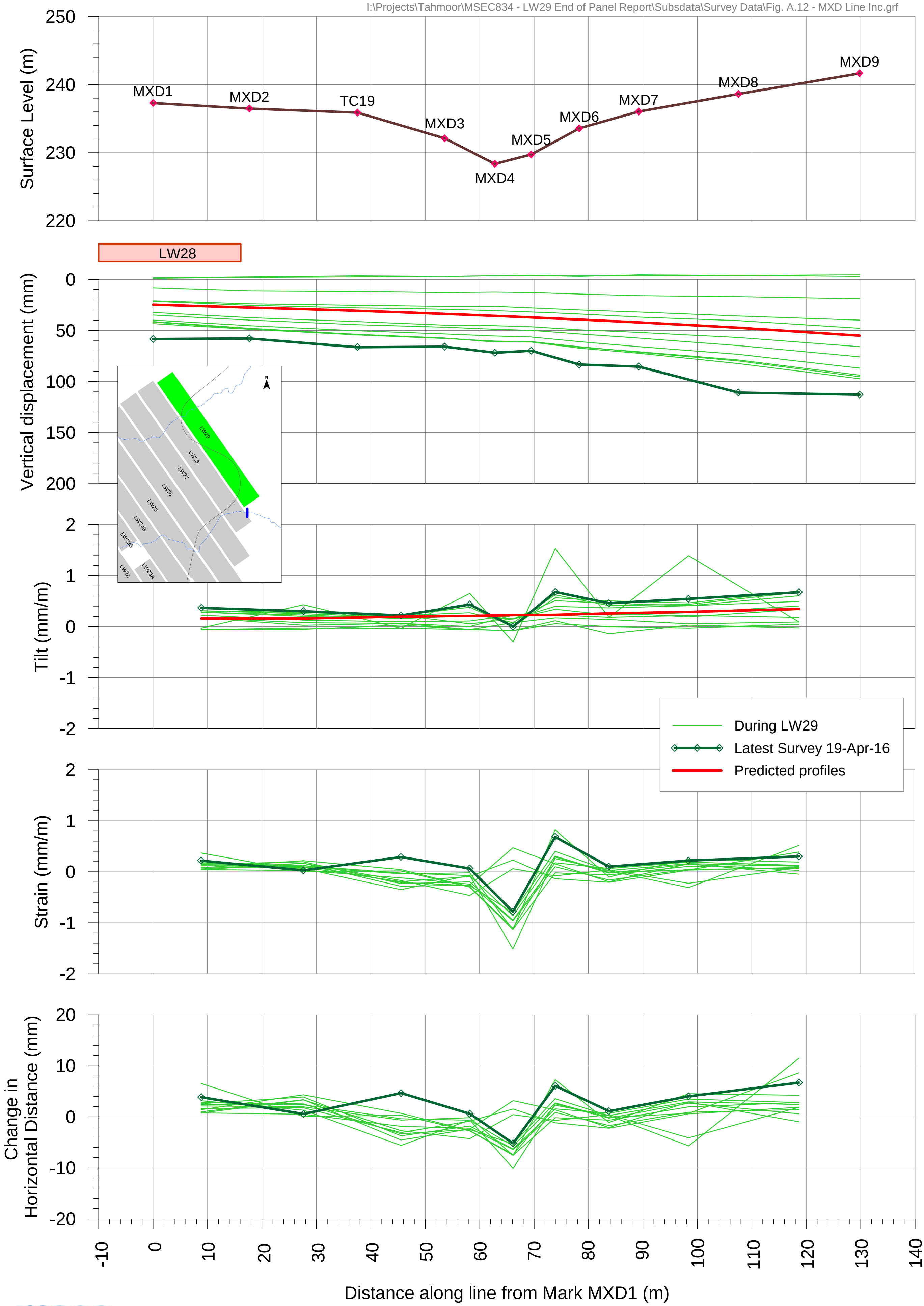

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Fig. A.12

Tahmoor Colliery
Total Subsidence Profiles along MXD Line

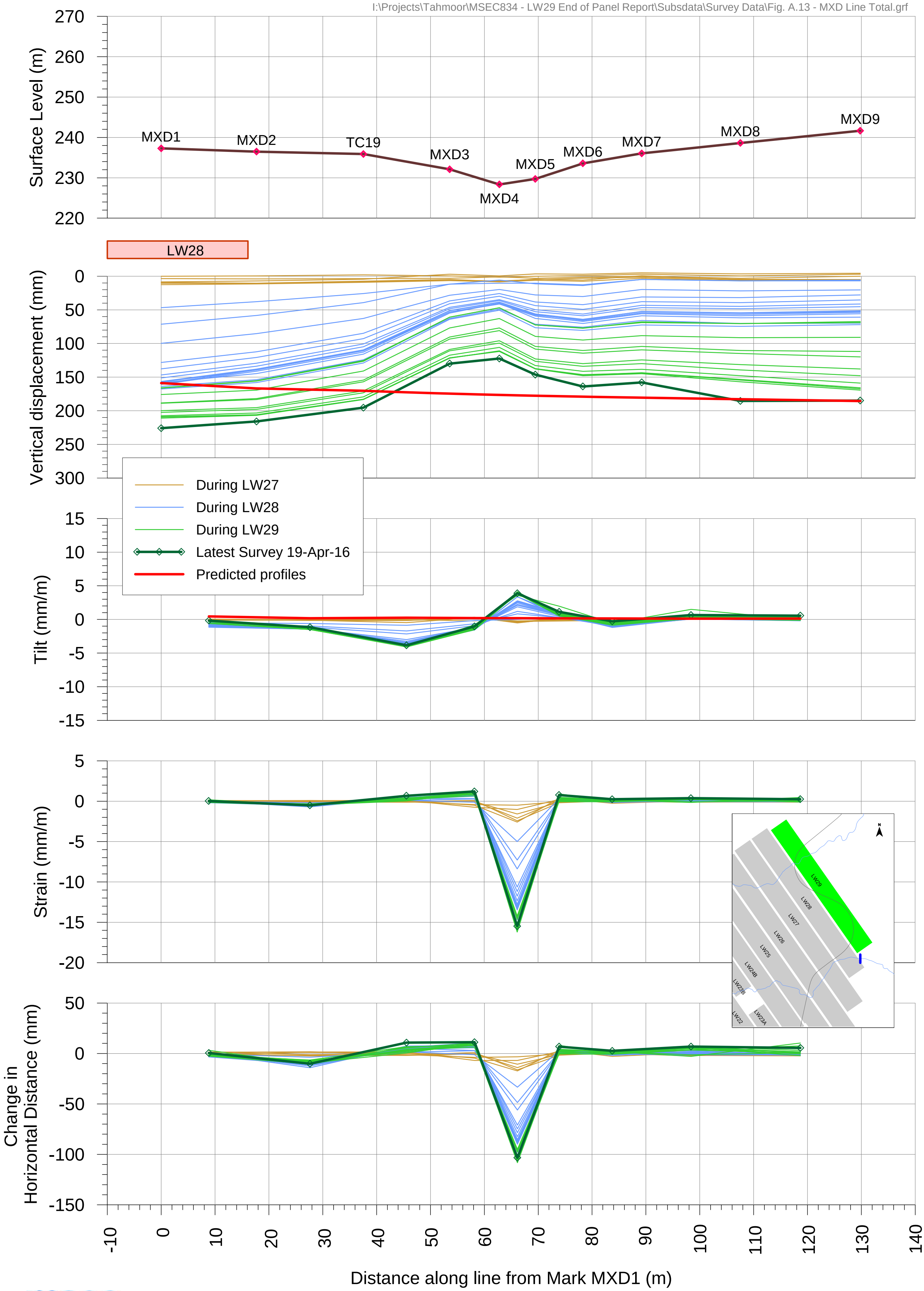

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Fig. A.12

Tahmoor Colliery - Incremental Subsidence Profiles along the Optical Fibre Line

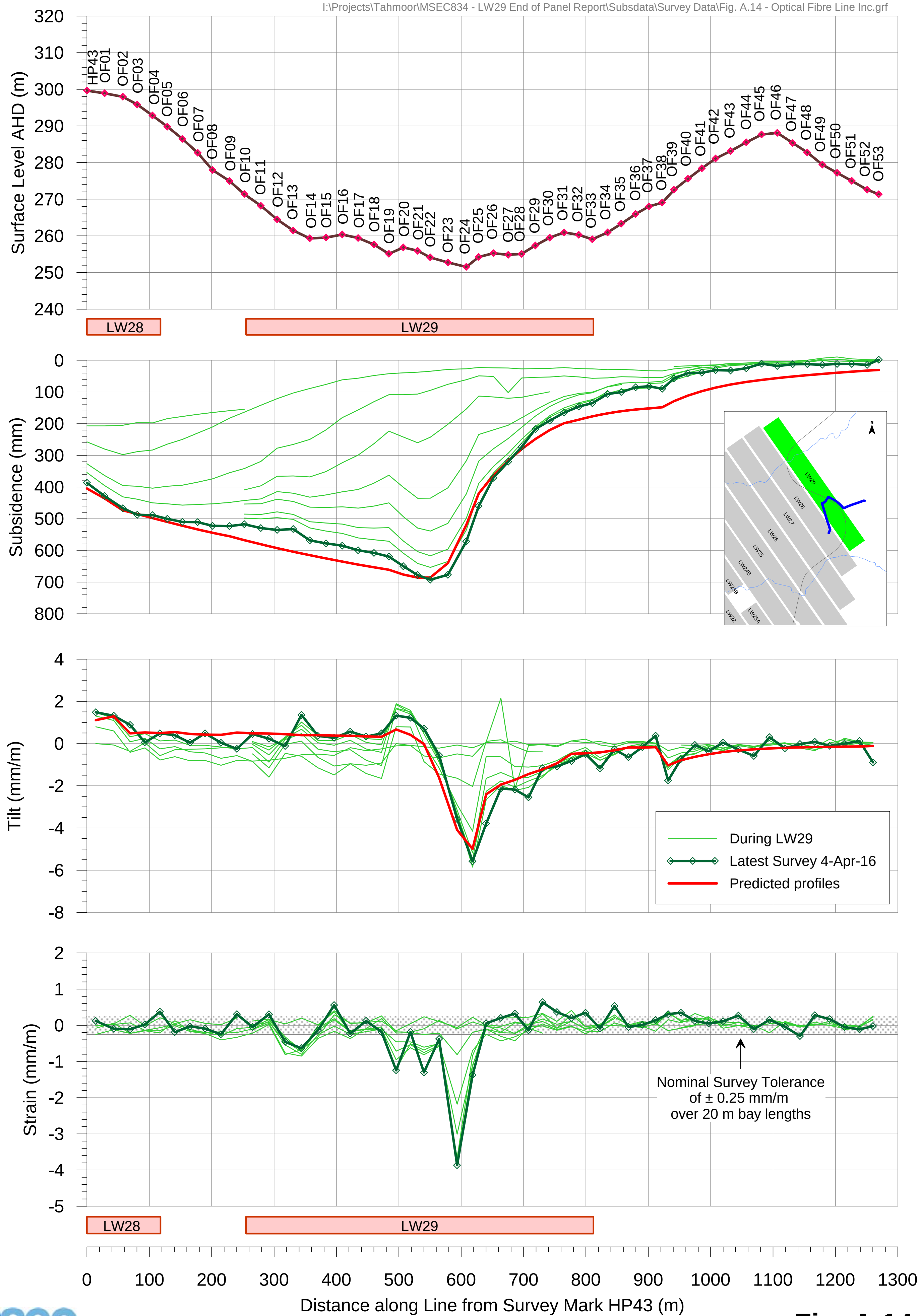

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Fig. A.14

Tahmoor Colliery - Total Subsidence Profiles along the Optical Fibre Line

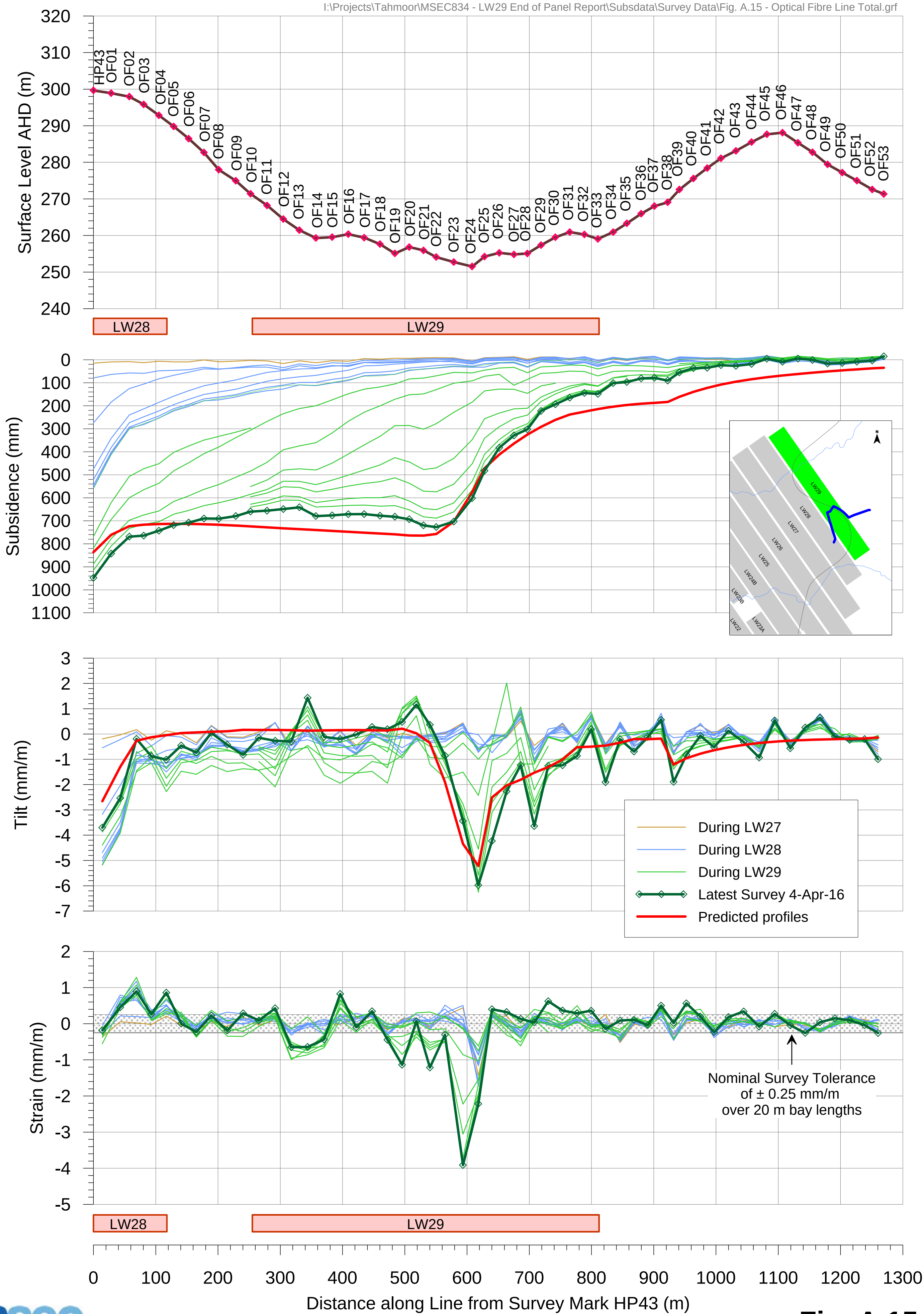

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Fig. A.15

Tahmoor Colliery
Incremental Profiles along Redbank Creek RK Line

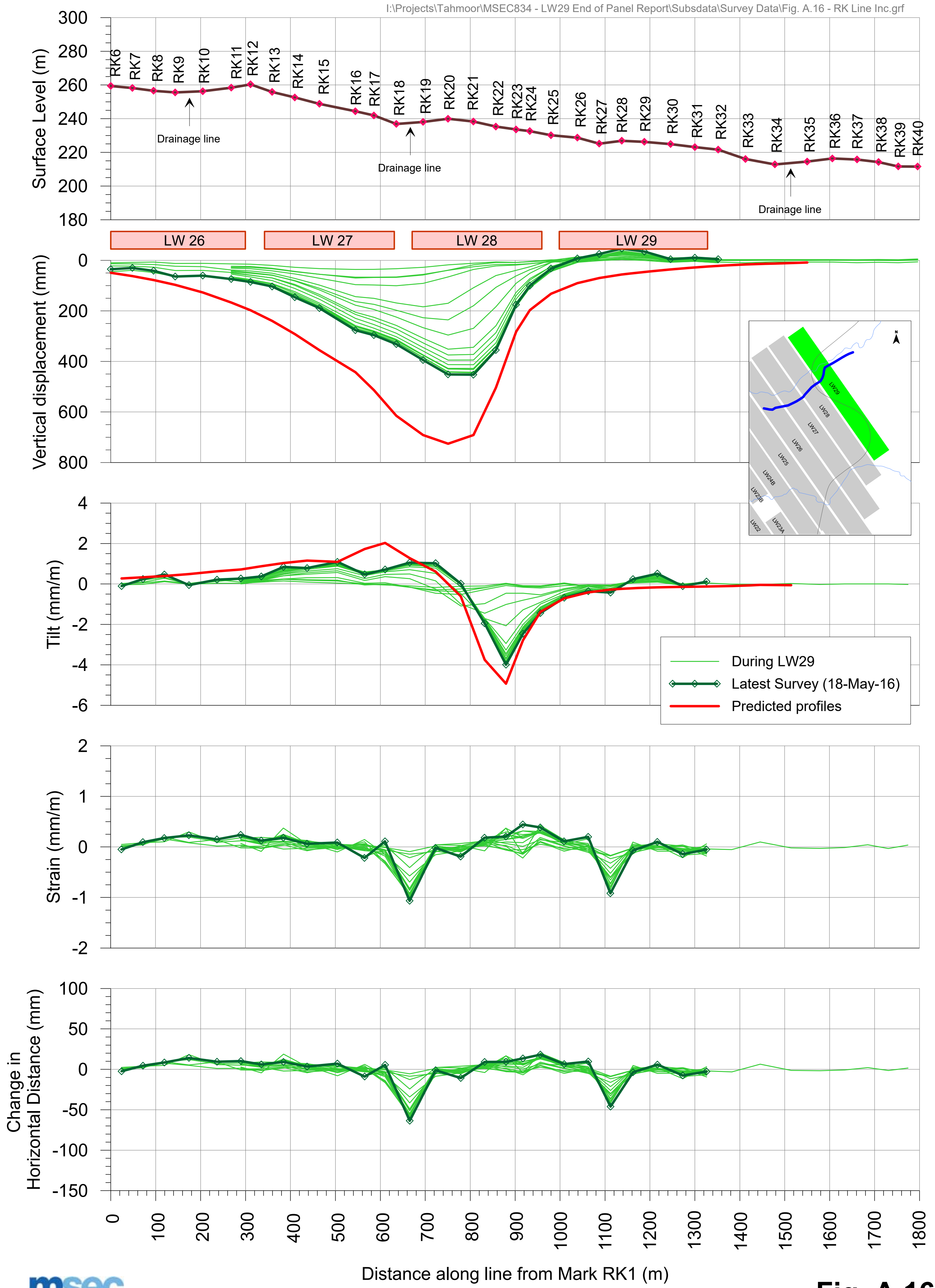

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Fig. A.16

Tahmoor Colliery
Total Profiles along Redbank Creek RK Line

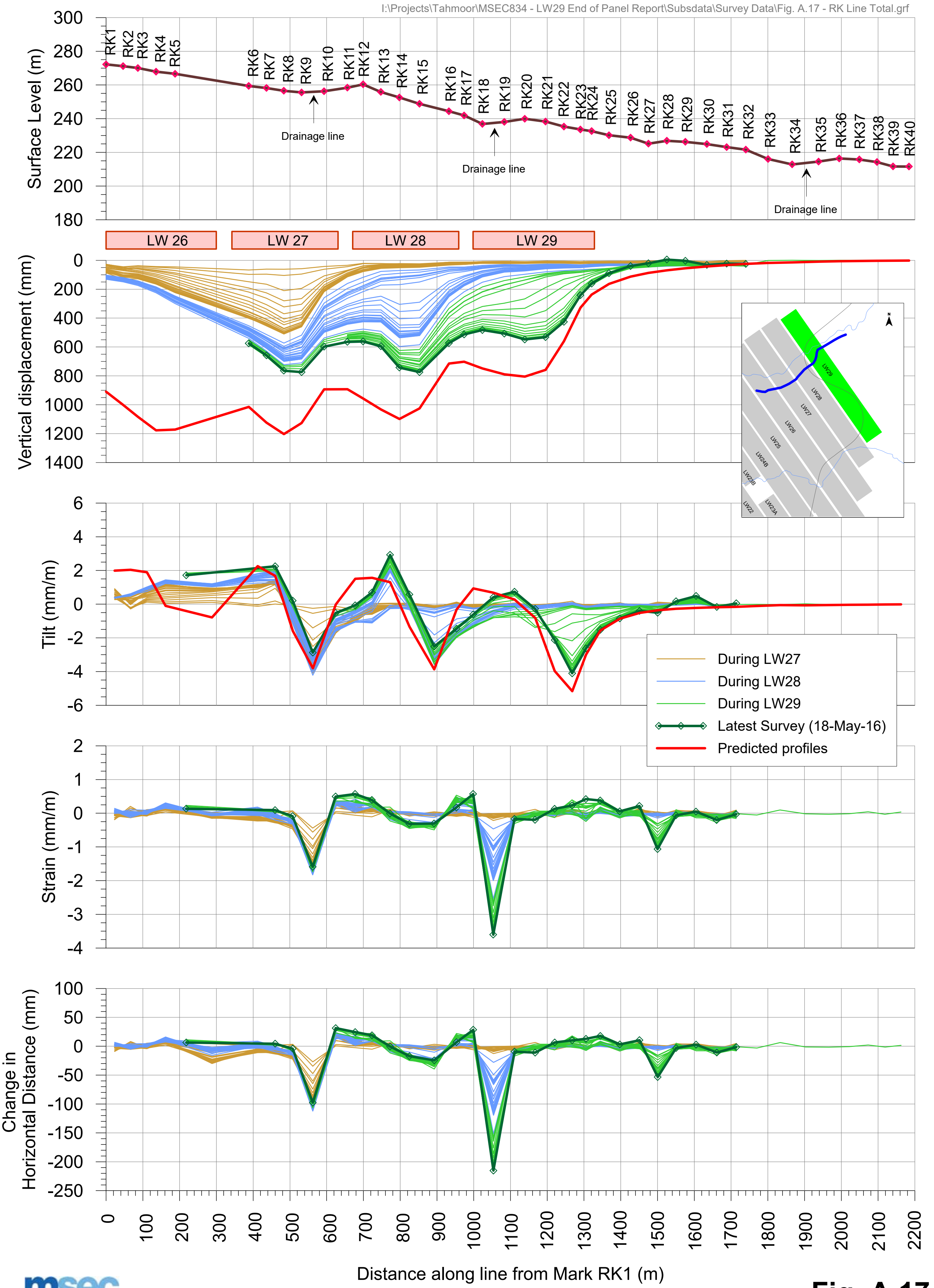

Fig. A.17

Tahmoor Colliery
Incremental Profiles along Redbank Creek RY Line

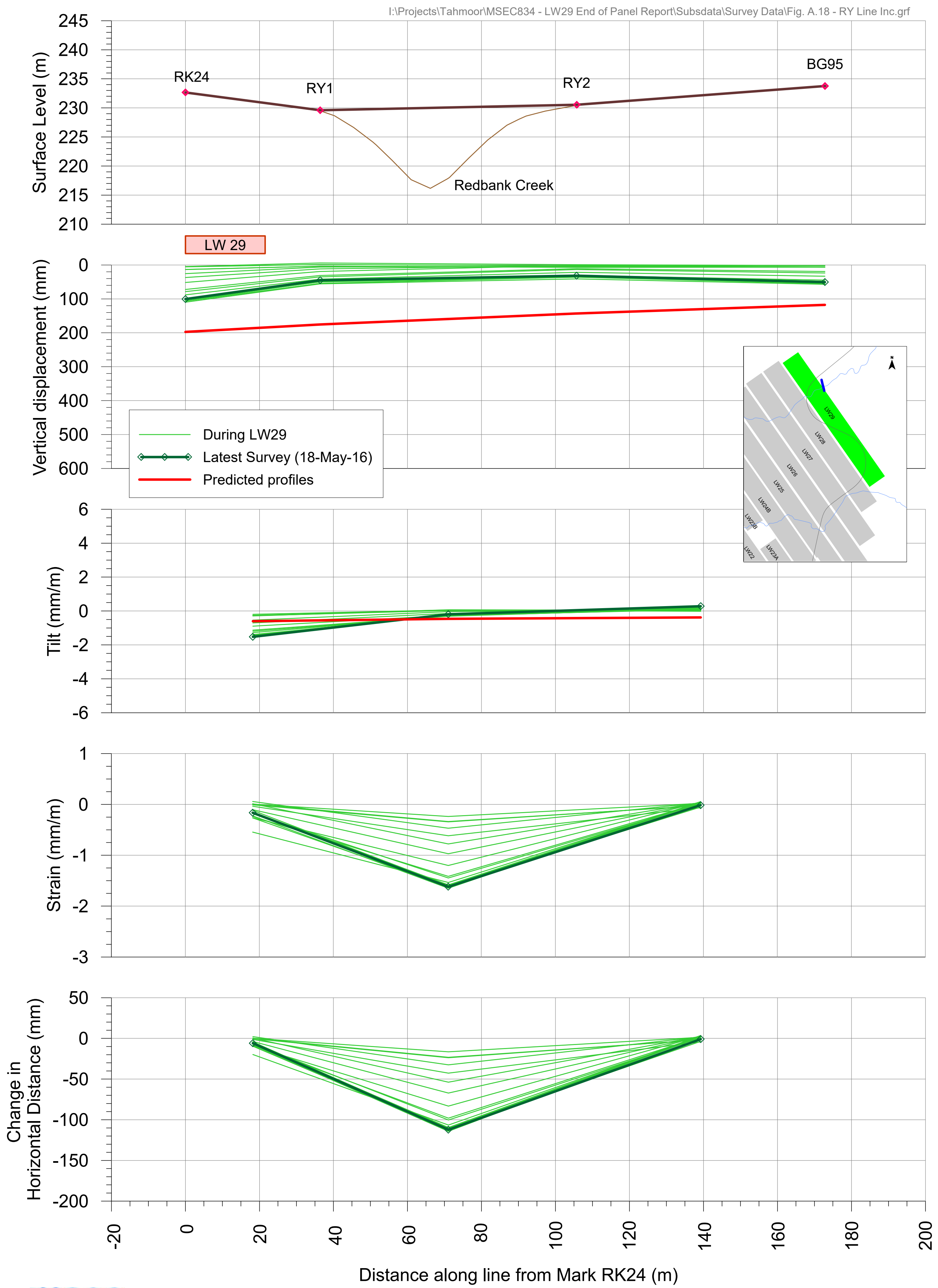

Fig. A.18

Tahmoor Colliery
Total Profiles along Redbank Creek RY Line

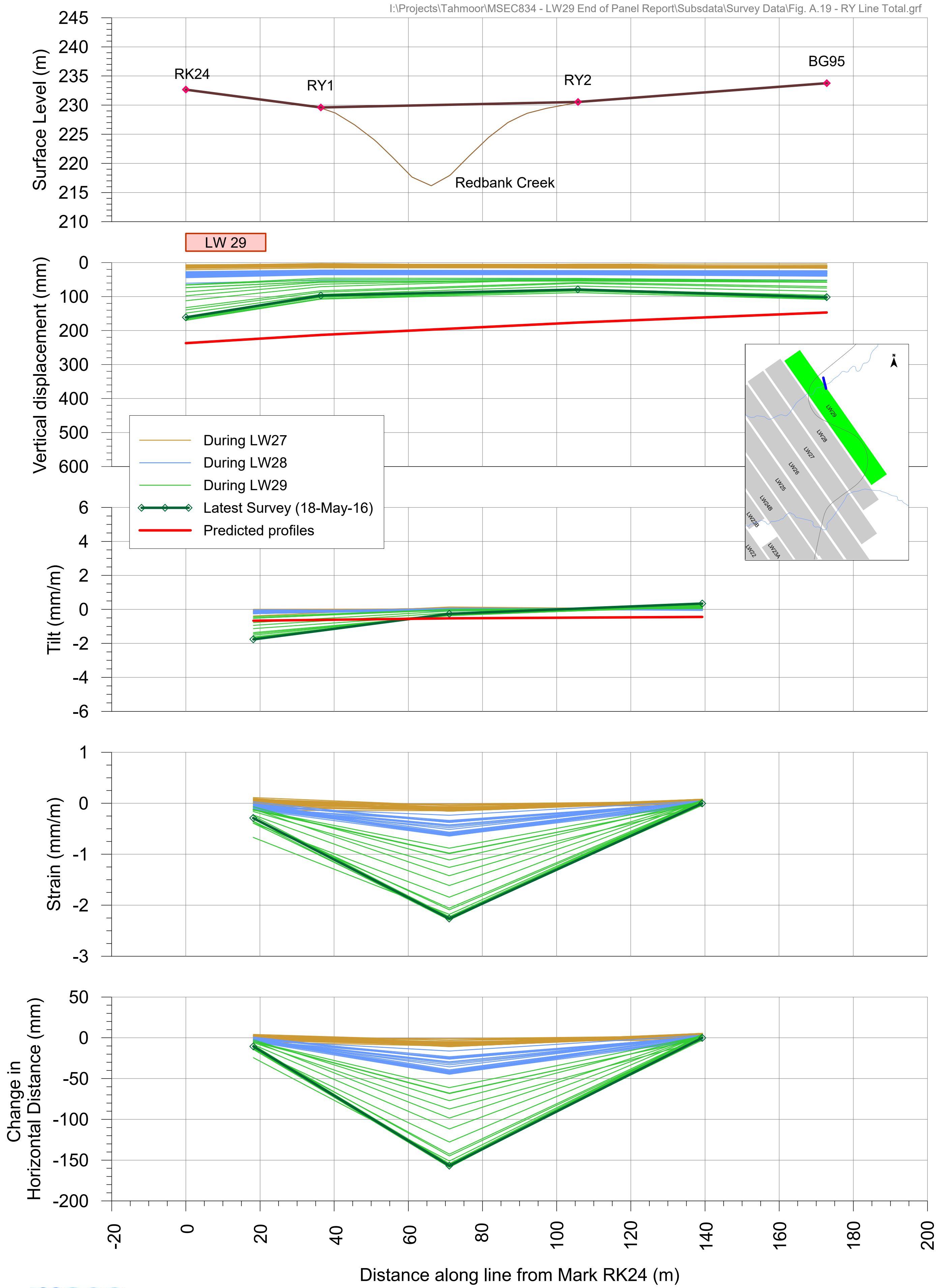

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Fig. A.19

Tahmoor Colliery
Incremental Profiles along Redbank Creek RZ Line

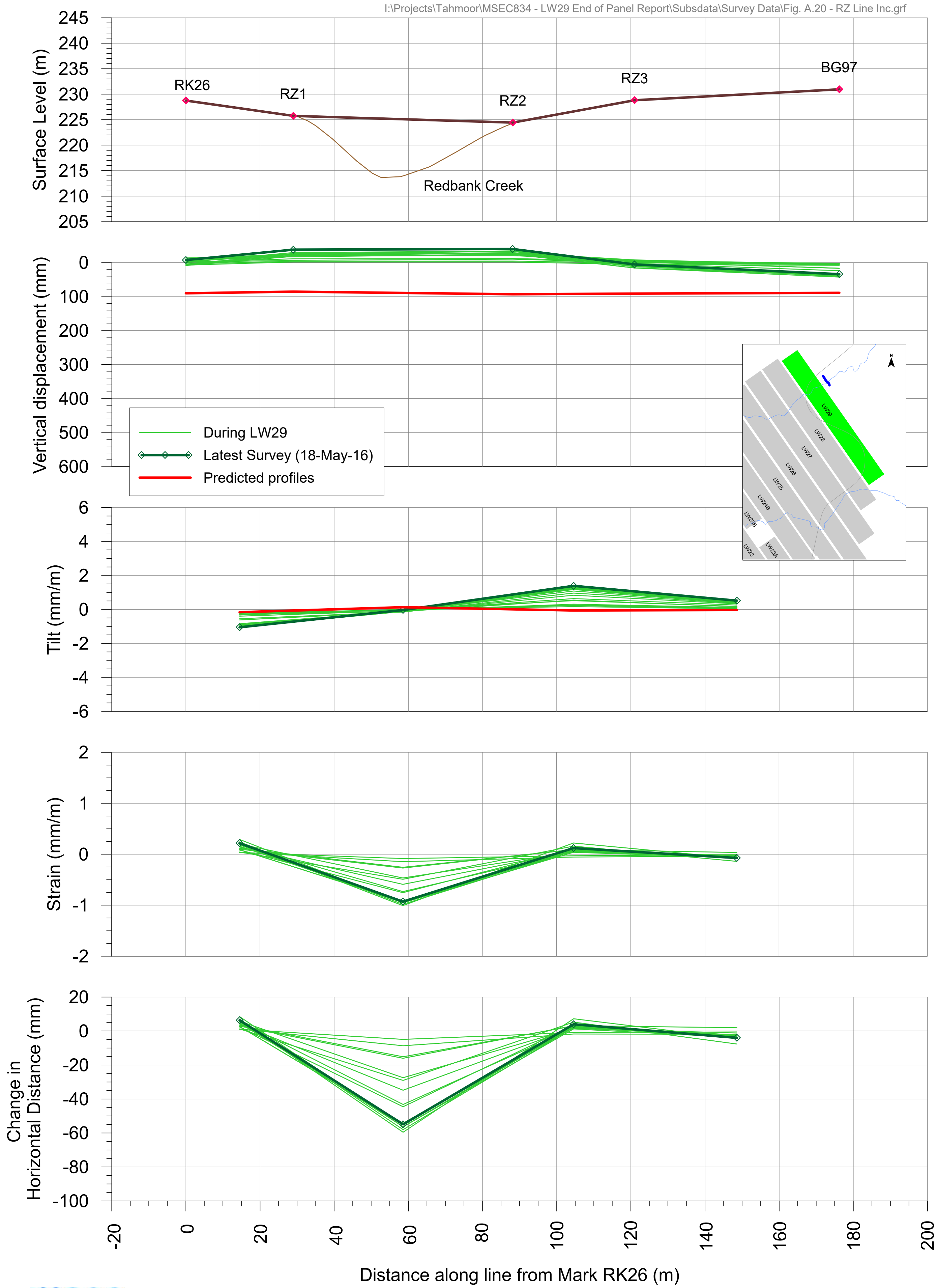

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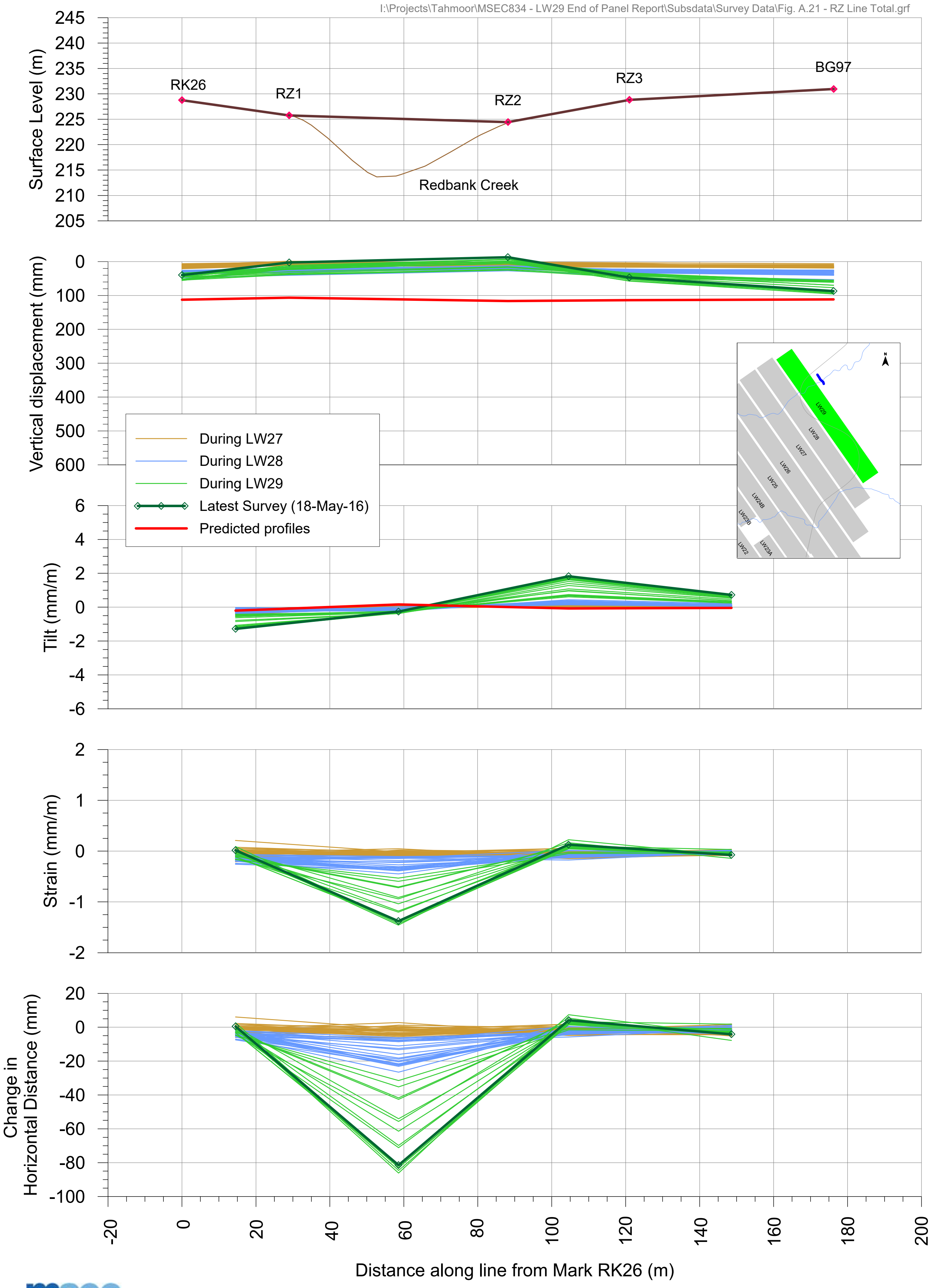
Fig. A.20

Tahmoor Colliery
Total Profiles along Redbank Creek RZ Line



Tahmoor Colliery
Incremental Subsidence Profiles along Remembrance Drive

msec

Fig. A.22

Tahmoor Colliery
Total Subsidence Profiles along Remembrance Drive

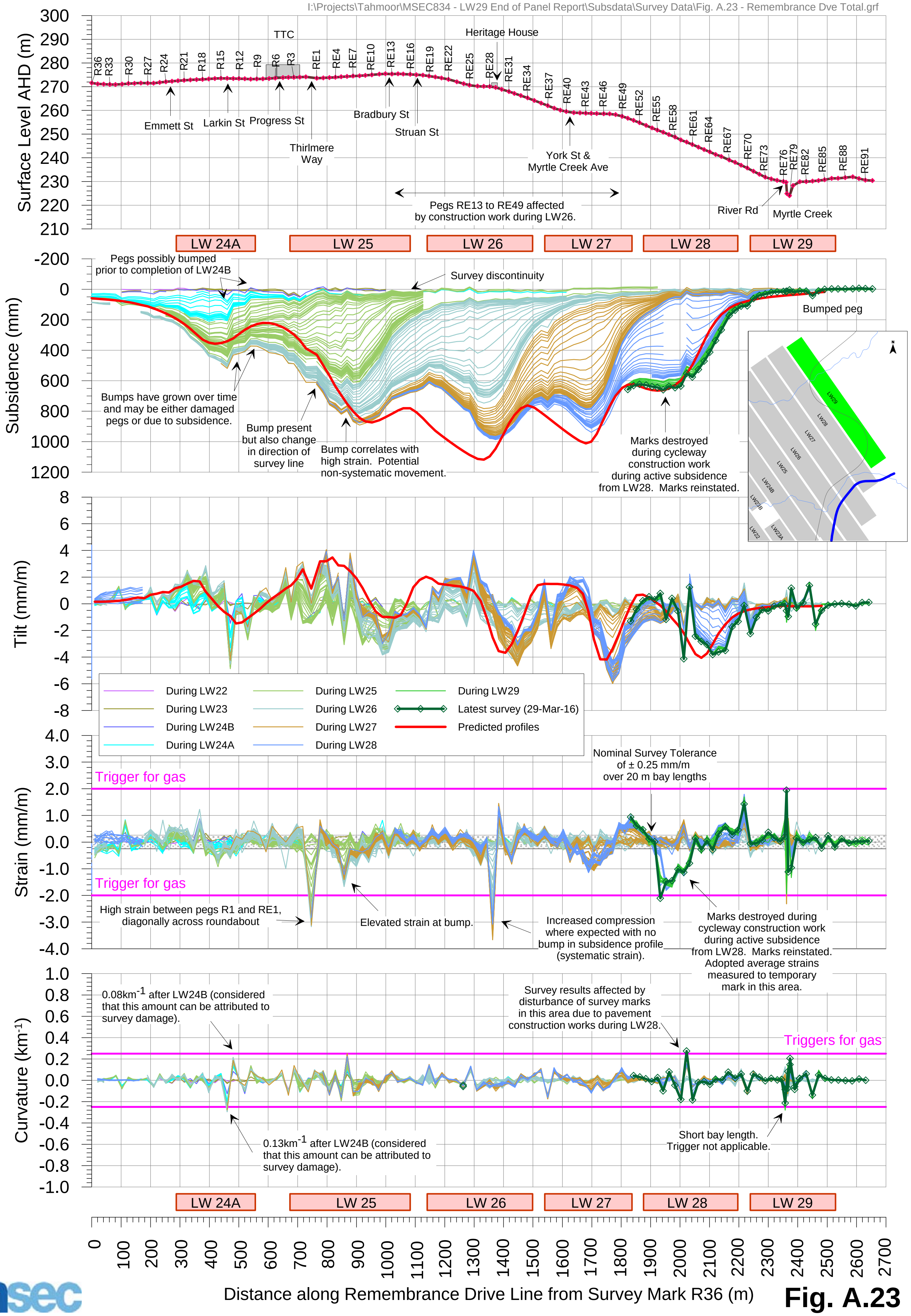


Fig. A.23

Tahmoor Colliery
Incremental Subsidence Profiles along Stilton Lane

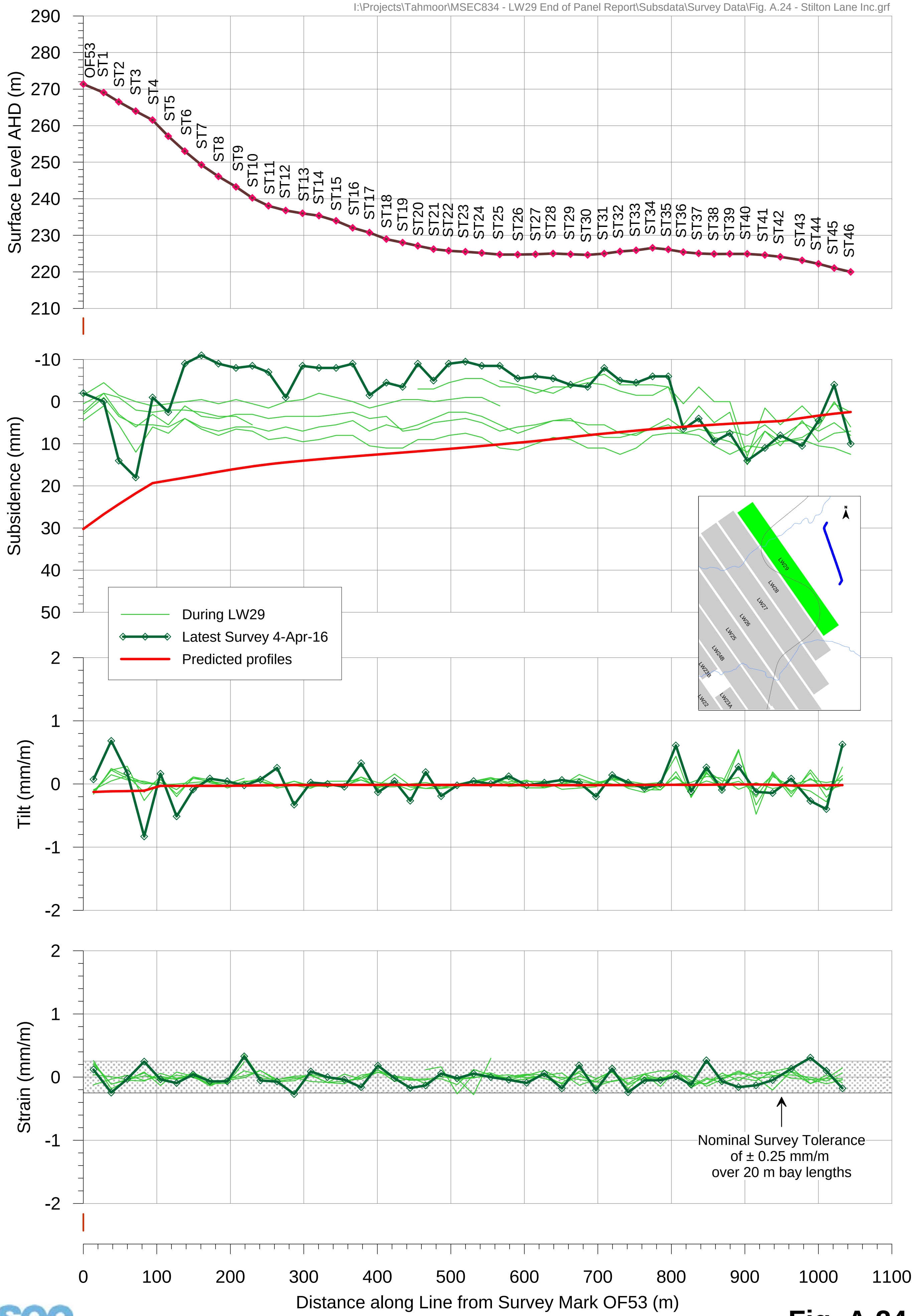


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Fig. A.24

Tahmoor Colliery
Total Subsidence Profiles along Tahmoor Carrier Pipe

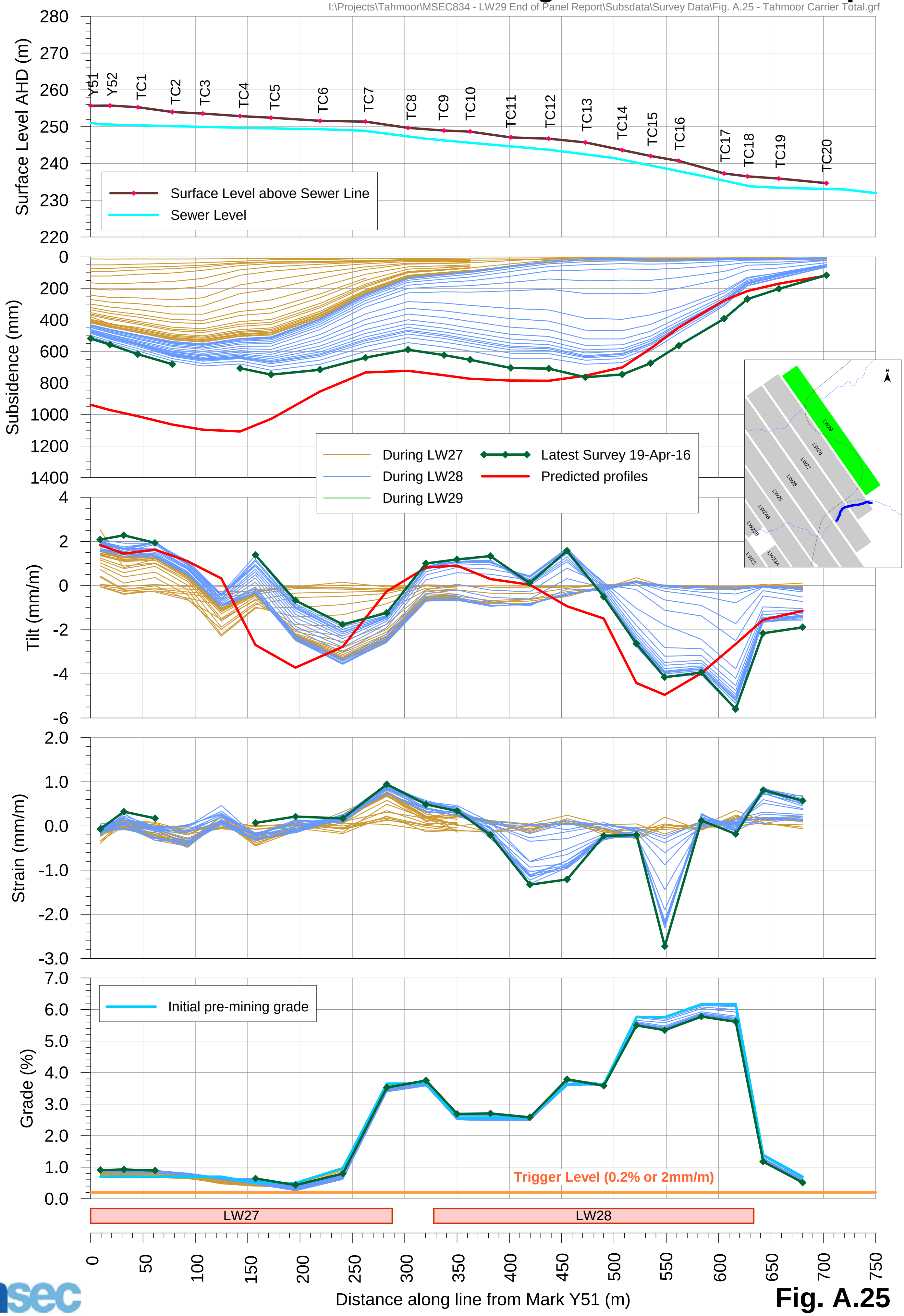

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Fig. A.25

Tahmoor Colliery
Incremental Subsidence Profiles along Thirlmere Carrier Pipe

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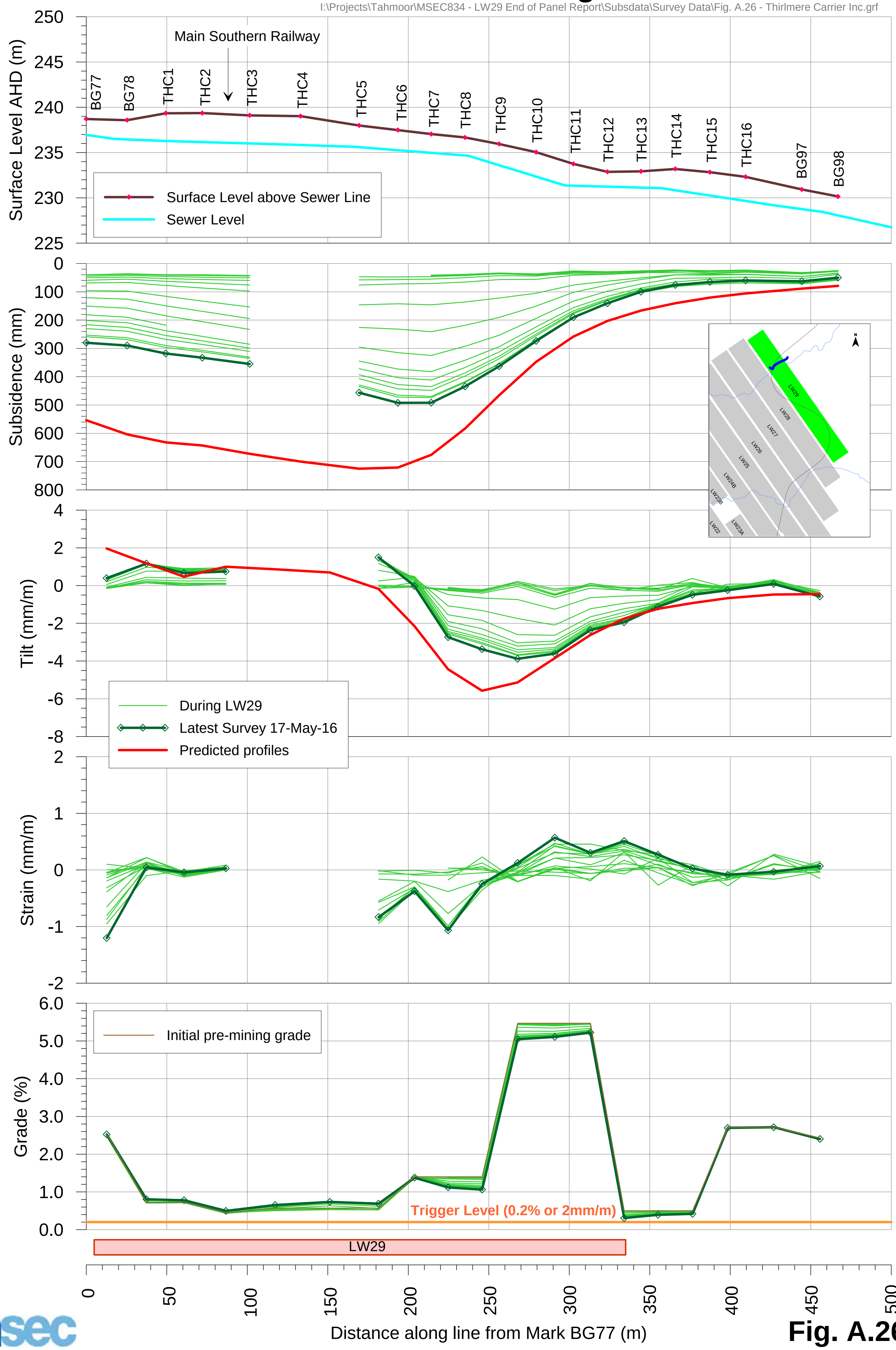

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Fig. A.26

Tahmoor Colliery
Total Subsidence Profiles along Thirlmere Carrier Pipe

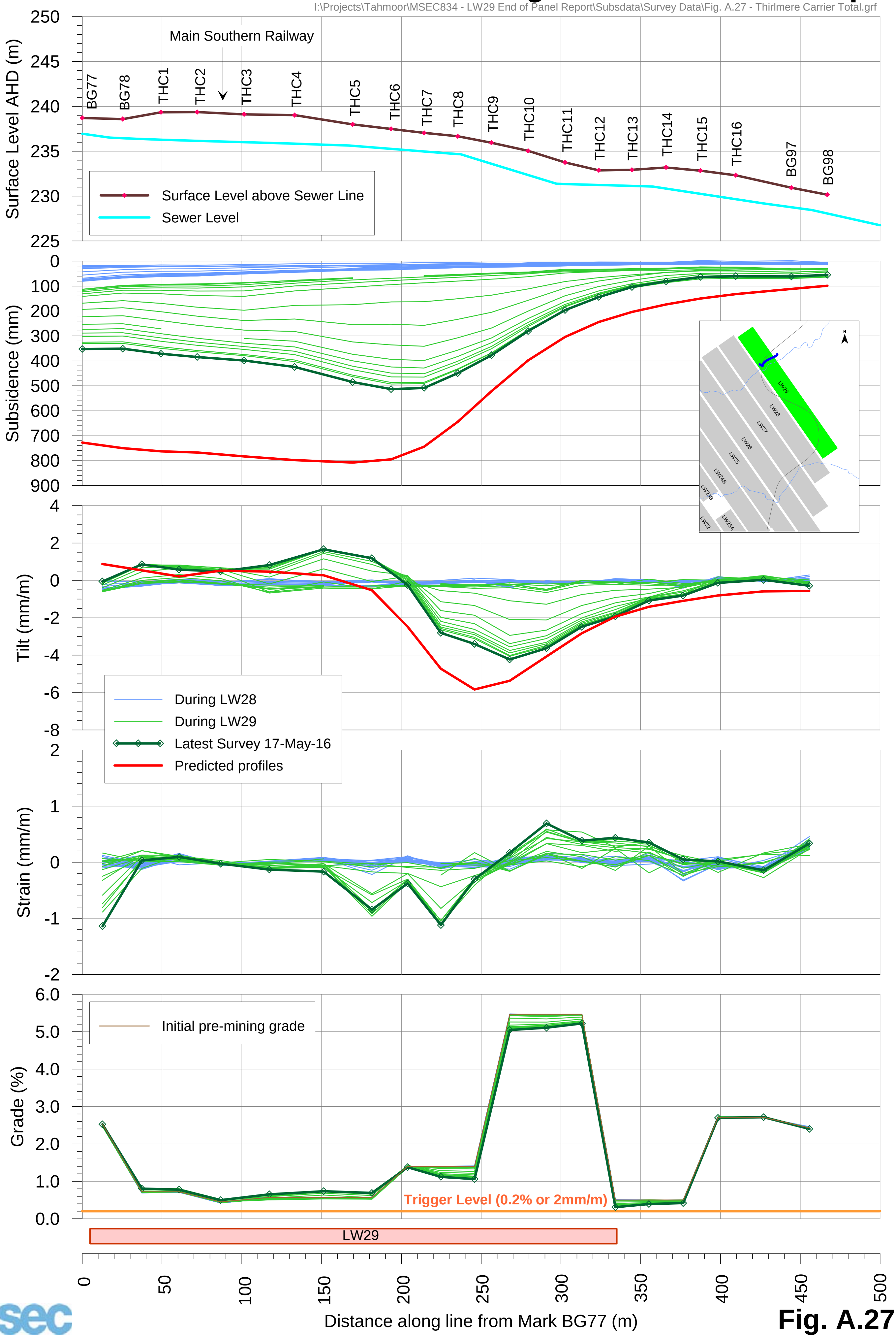

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Fig. A.27

Tahmoor Colliery
Incremental Subsidence Profiles
along the Main Southern Railway Corridor Line

I:\Projects\Tahmoor\MSEC834 - LW29 End of Panel Report\Subsdata\Survey Data\Fig. A.28 - Main Southern Railway Inc.grf

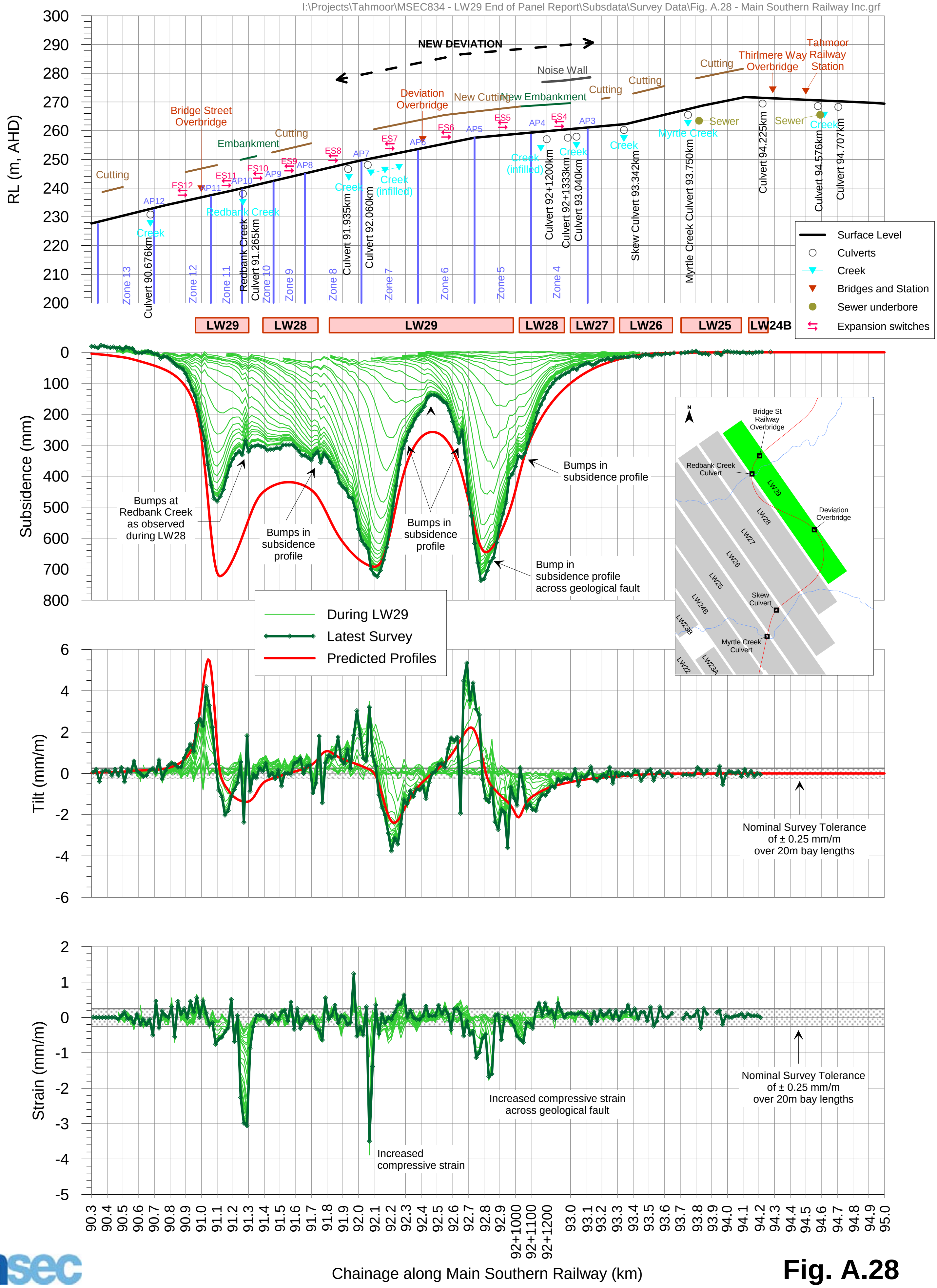

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Fig. A.28

Tahmoor Colliery
Total Subsidence Profiles
along the Main Southern Railway Corridor Line

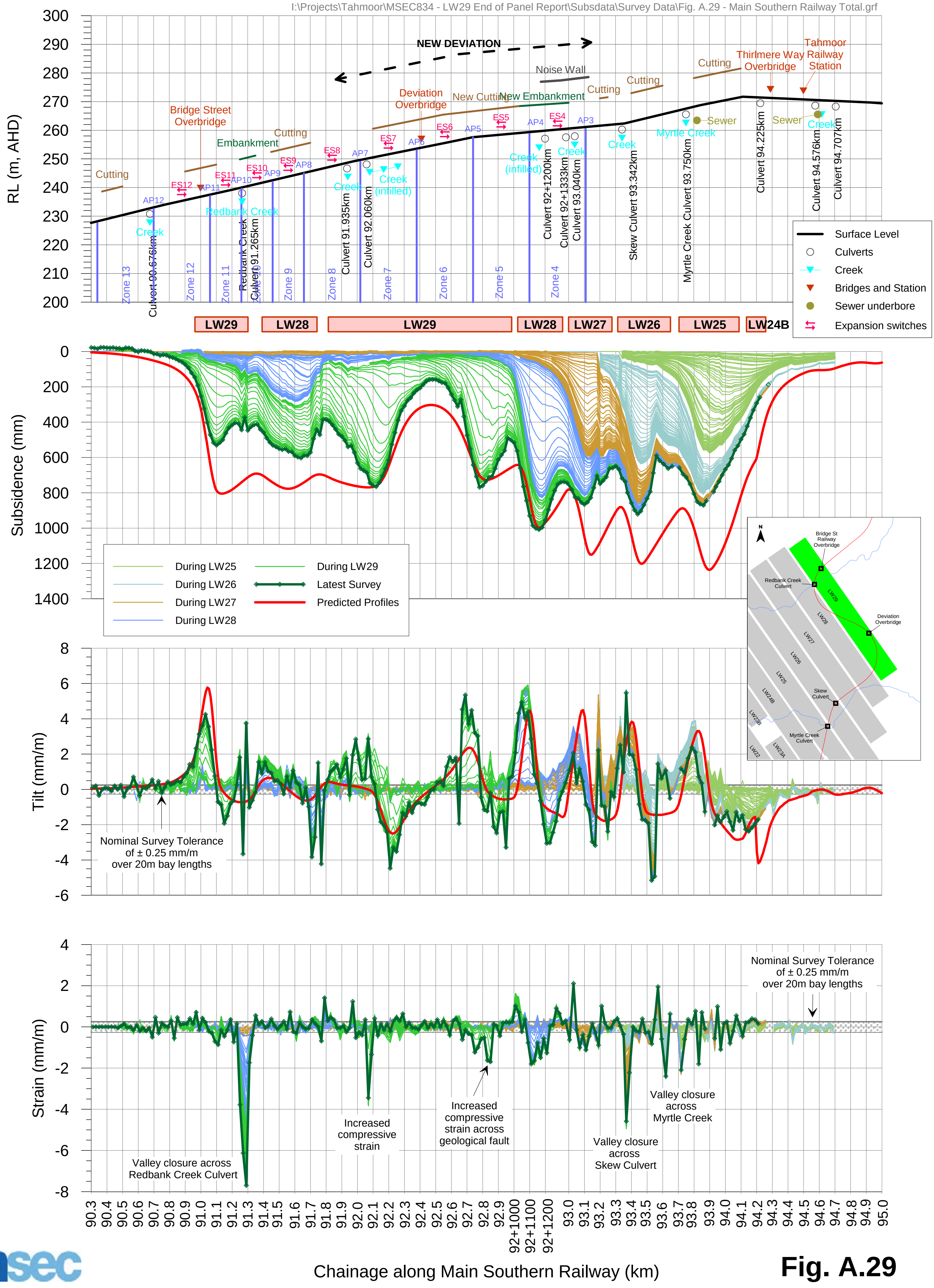

Fig. A.29

Tahmoor Colliery
Incremental Subsidence Profiles
along the Railway Corridor Southern Embankment Toe

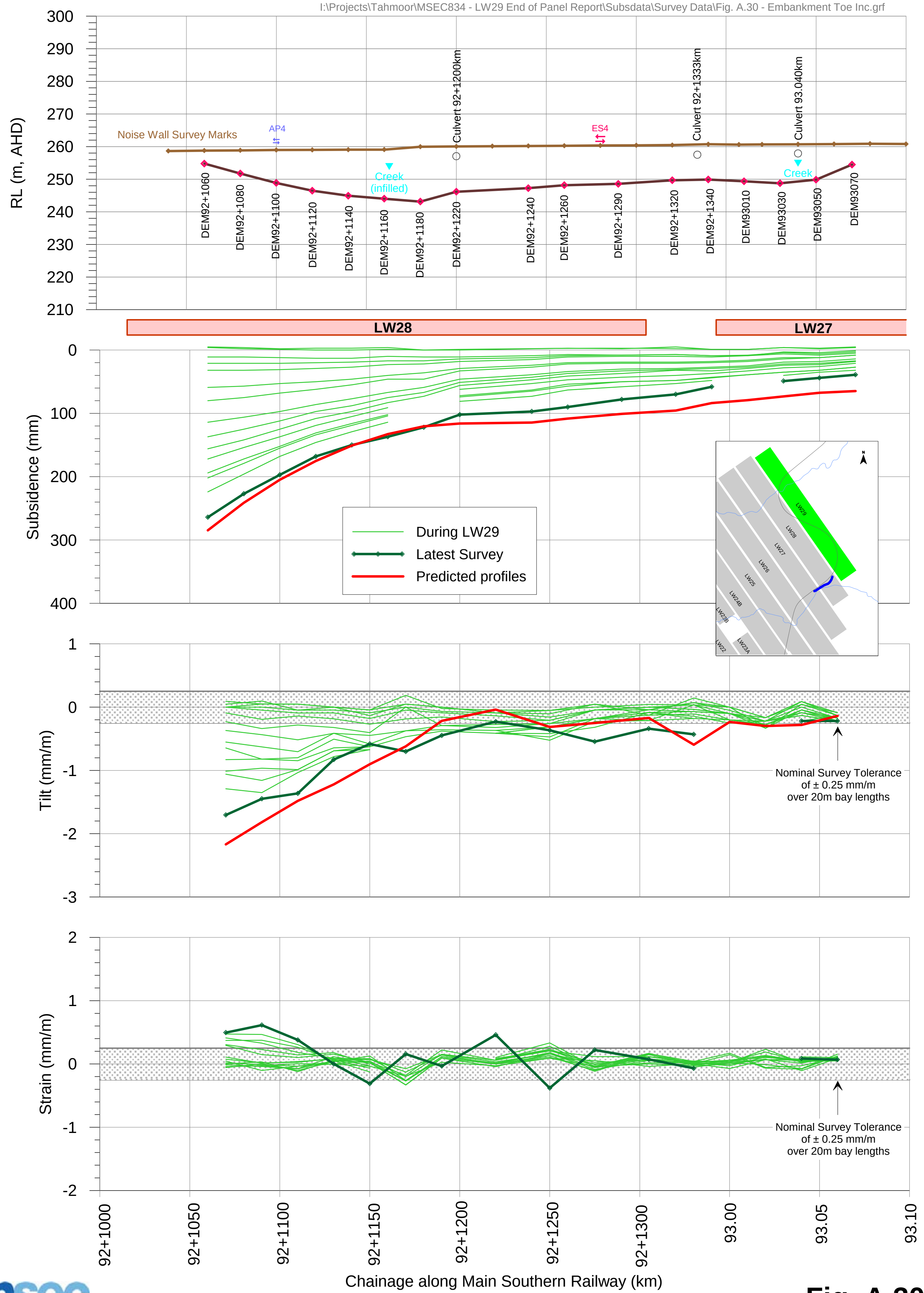

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Fig. A.30

Tahmoor Colliery
Total Subsidence Profiles
along the Railway Corridor Southern Embankment Toe

I:\Projects\Tahmoor\MSEC834 - LW29 End of Panel Report\Subsdata\Survey Data\Fig. A.31 - Embankment Toe Total.grf

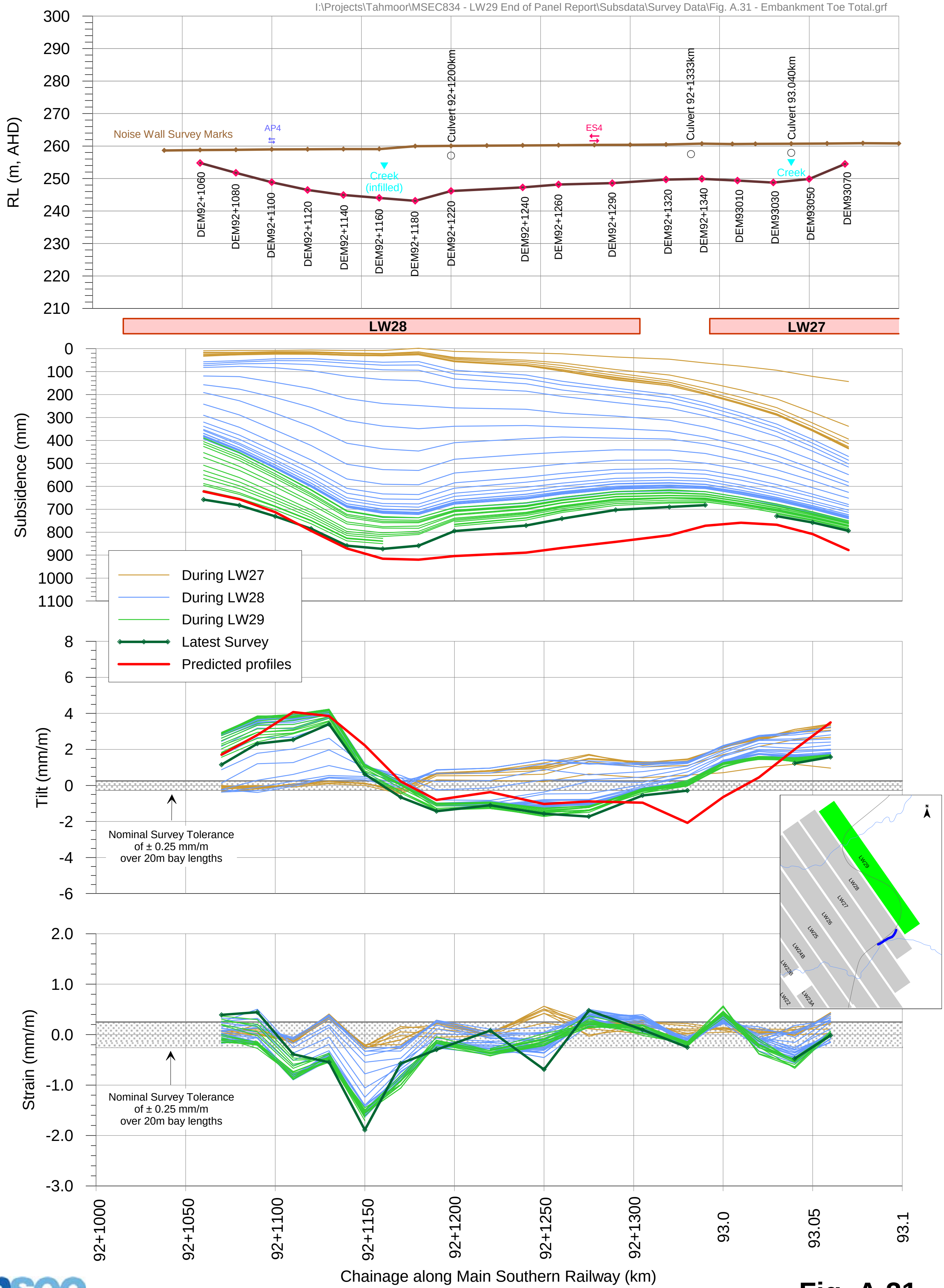

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Fig. A.31

Tahmoor Colliery
Incremental Subsidence Profiles
along the Railway Corridor Noise Wall

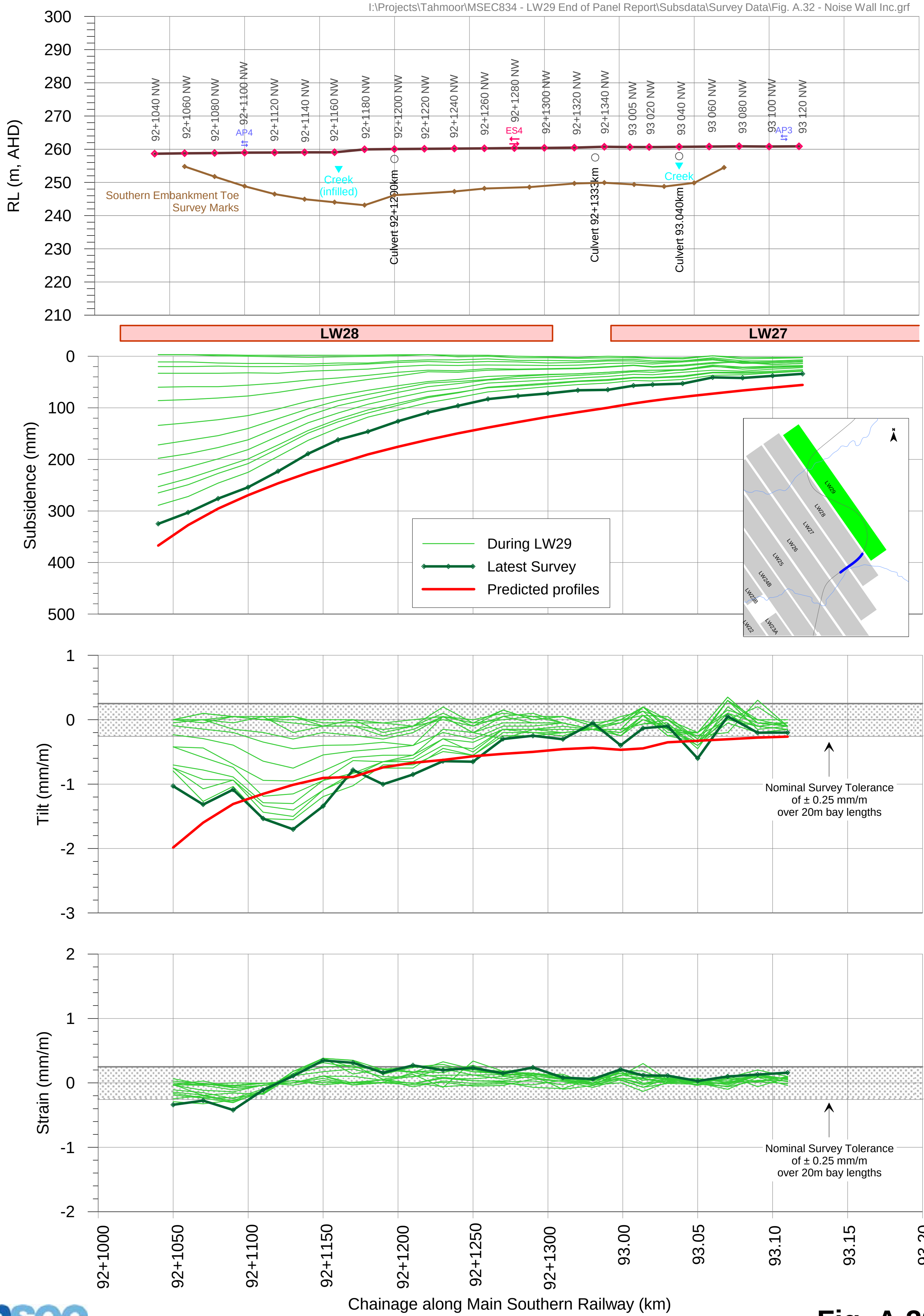

Fig. A.32

Tahmoor Colliery
Total Subsidence Profiles along the Railway Corridor Noise Wall

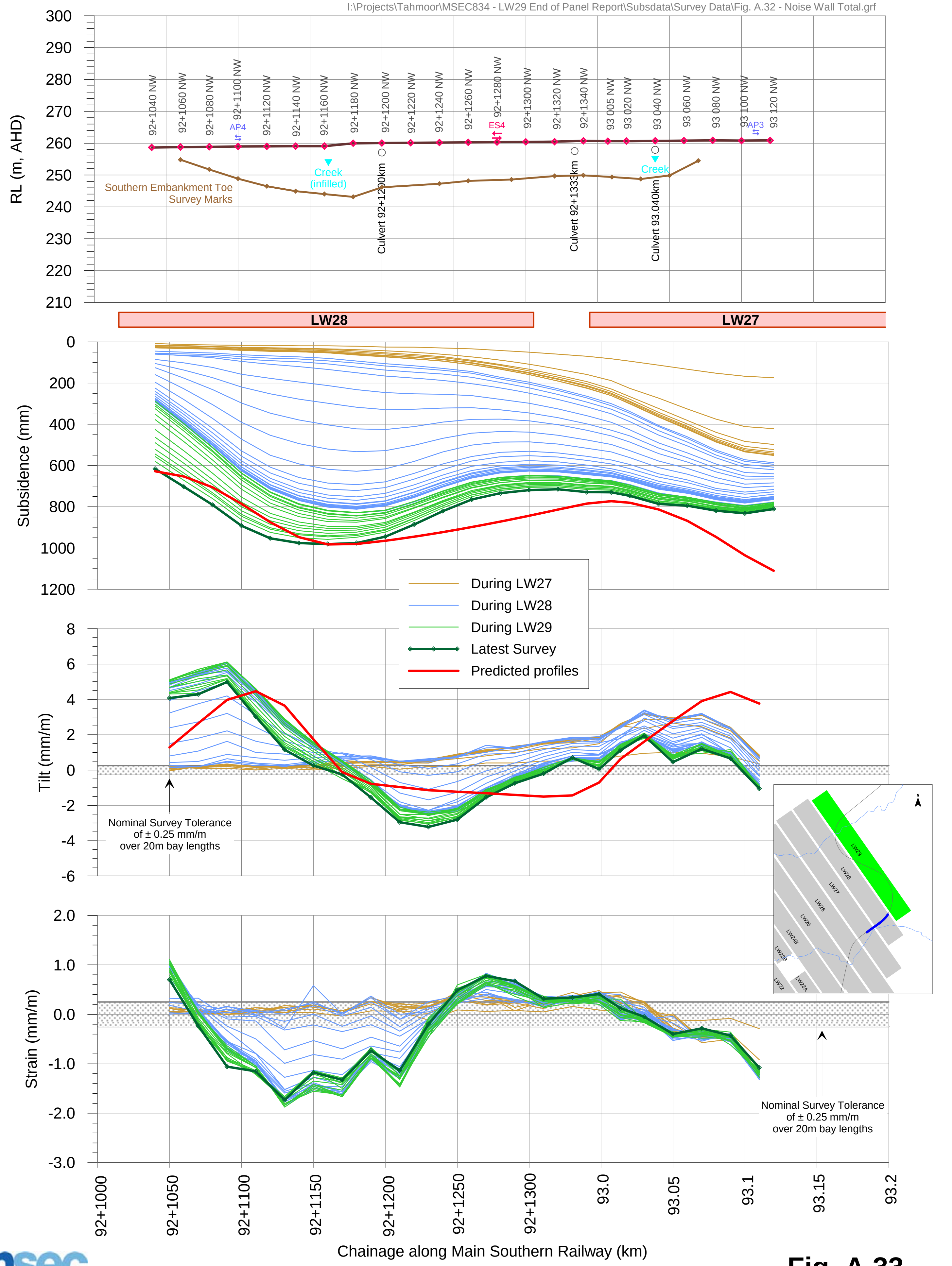

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Fig. A.33

Tahmoor Colliery
Incremental Subsidence Profiles along Crossline at 92+1180km

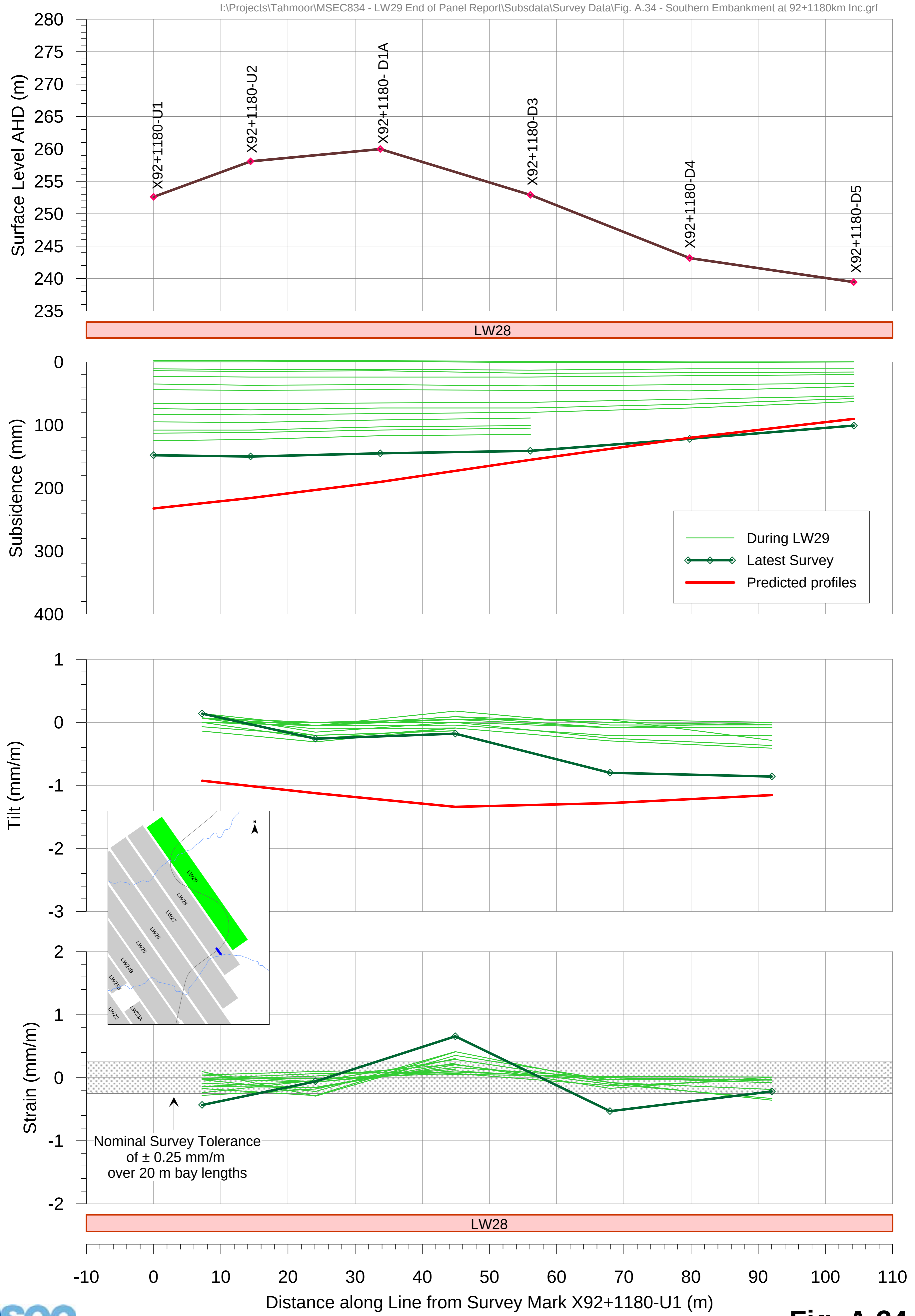

Fig. A.34

Tahmoor Colliery
Total Subsidence Profiles along Crossline at 92+1180km

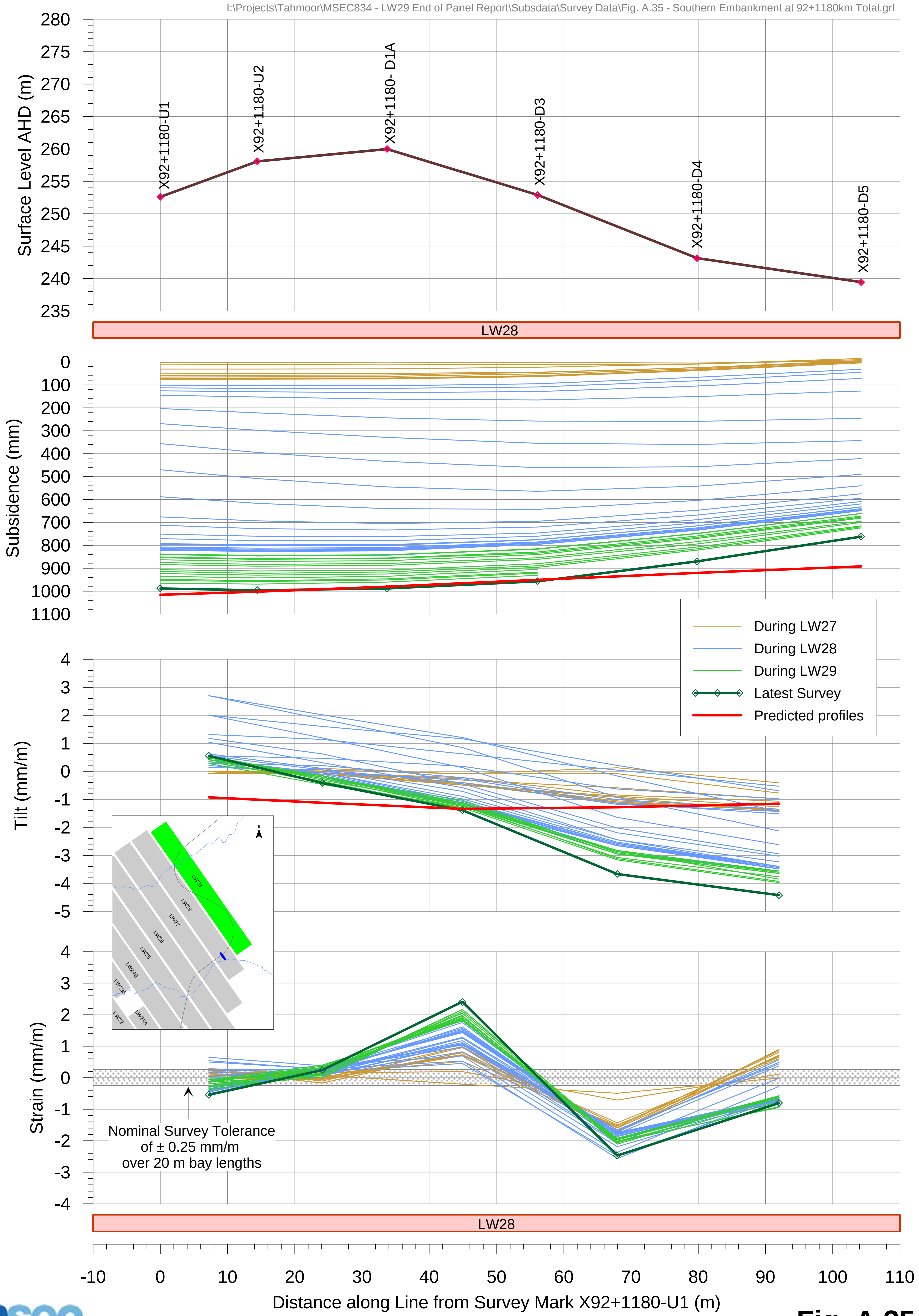

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Fig. A.35

Tahmoor Colliery
Incremental Subsidence Profiles along Crossline at 92+1340km

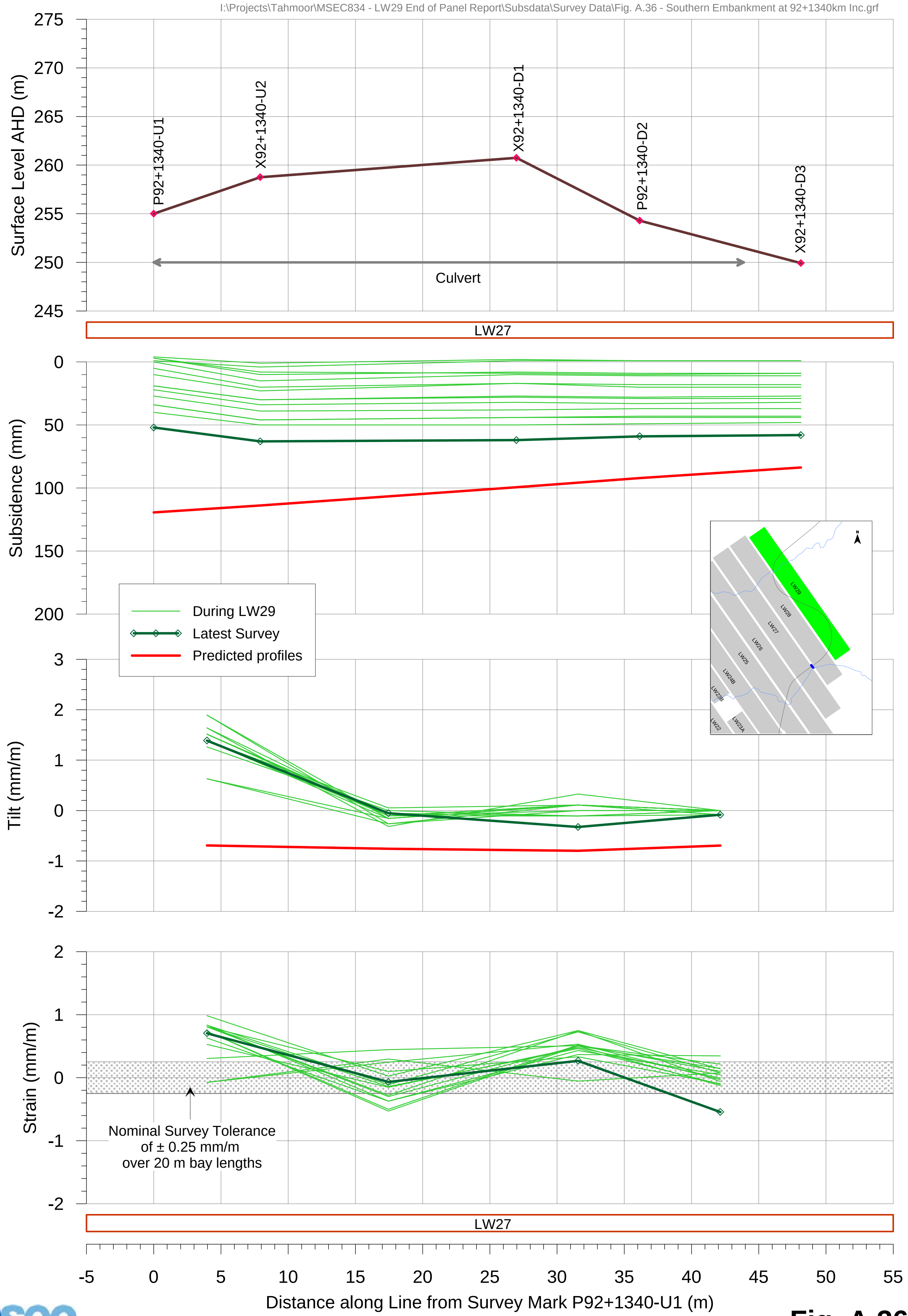

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Fig. A.36

Tahmoor Colliery
Total Subsidence Profiles along Crossline at 92+1340km

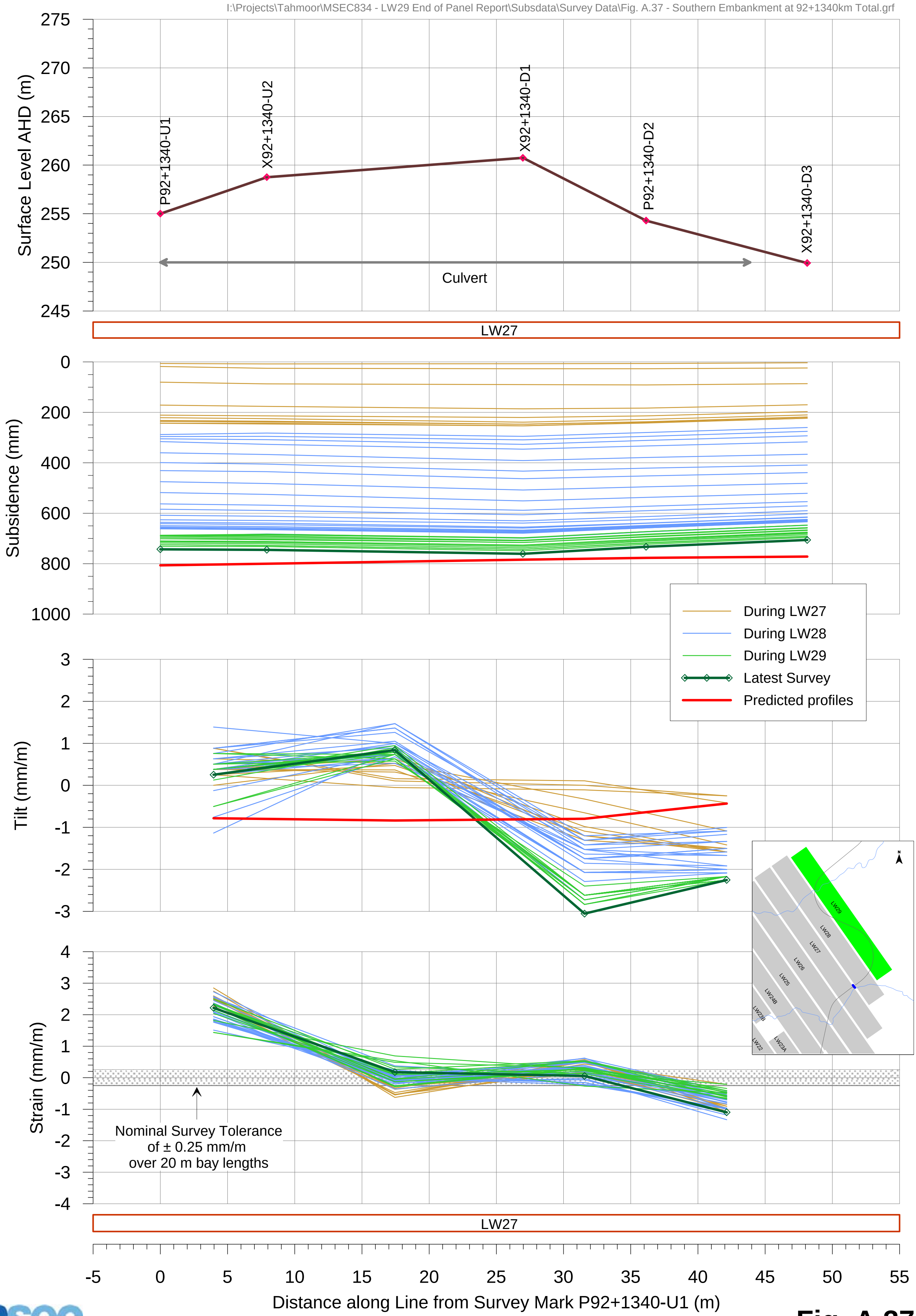

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Fig. A.37

APPENDIX B. DRAWINGS

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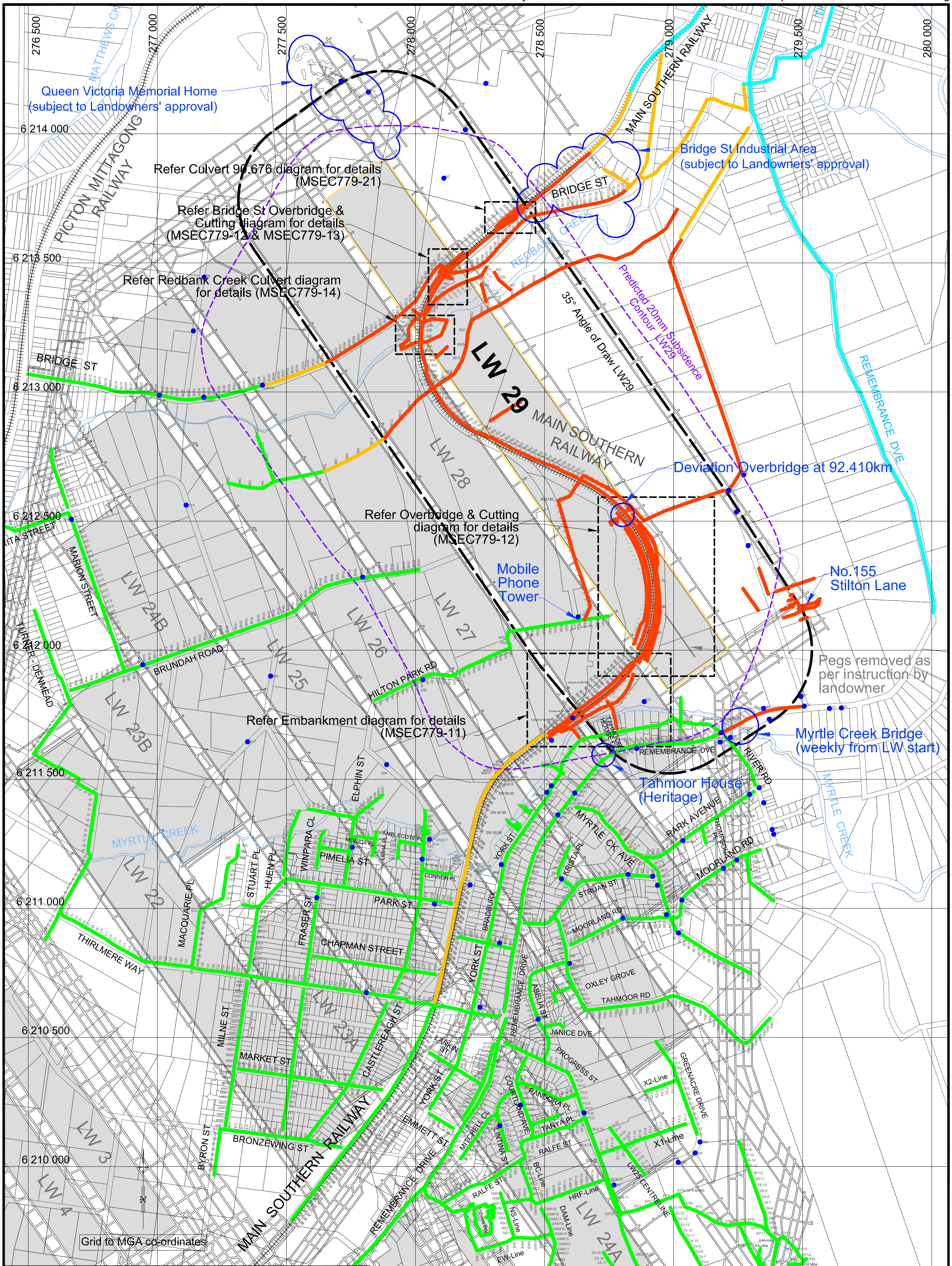

msec mine subsidence ENGINEERING CONSULTANTS	Suite 402, 13 Spring Street, Chatswood NSW 2067 PO Box 302, Chatswood NSW 2057 Tel +61 2 9413 3777 www.minesubsidence.com	
TAHMOOR UNDERGROUND GLENCORE	# TAHMOOR COLLIERY TAHMOOR NORTH MONITORING OVER LW29	

DATE:	SCALE:	DRAWING No:	Rev No
May 2016	1:20000	MSEC834-01	01

LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW29
- Monitoring Lines Before & End of LW29
- Surveys During LW29
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

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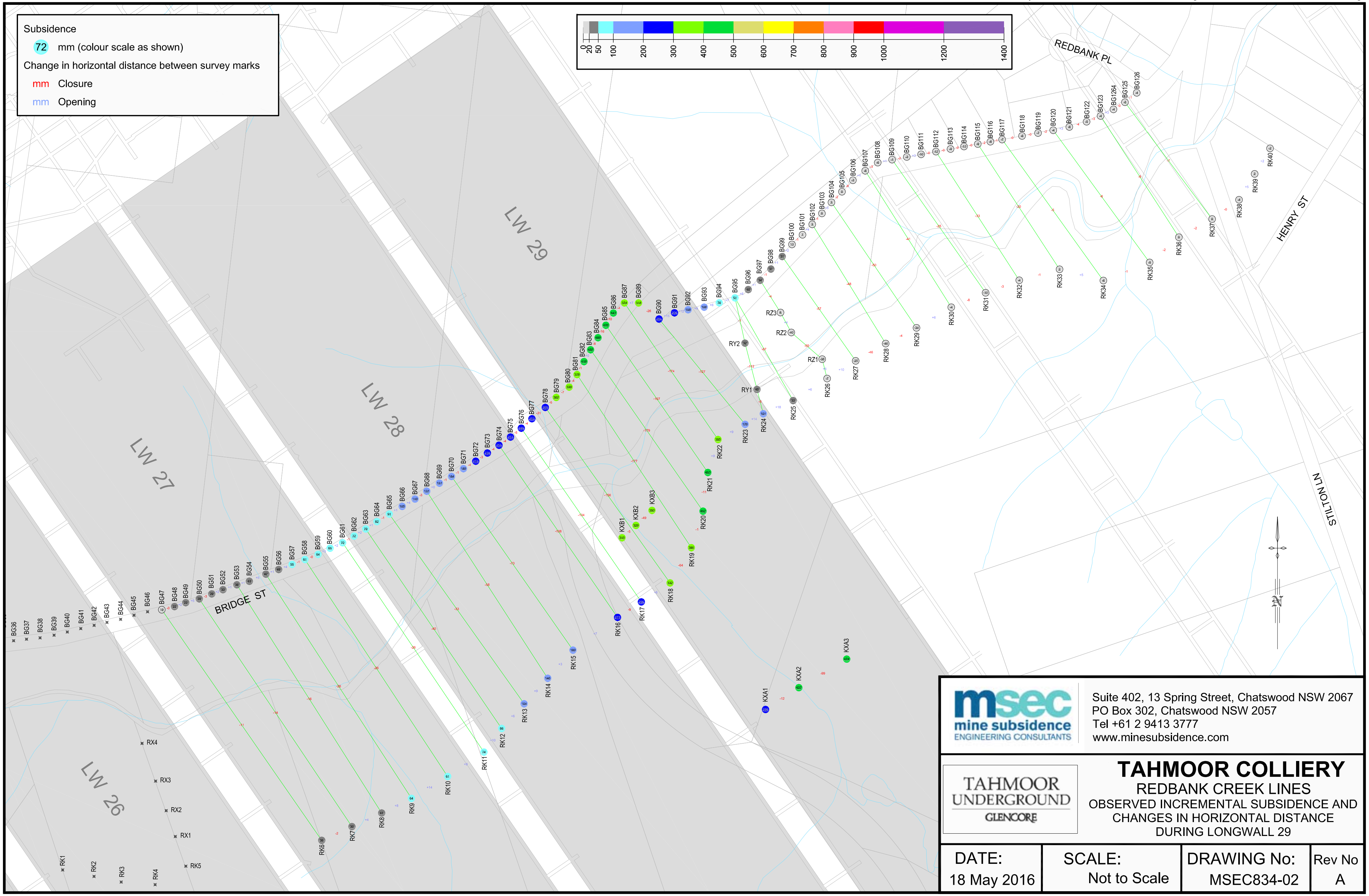

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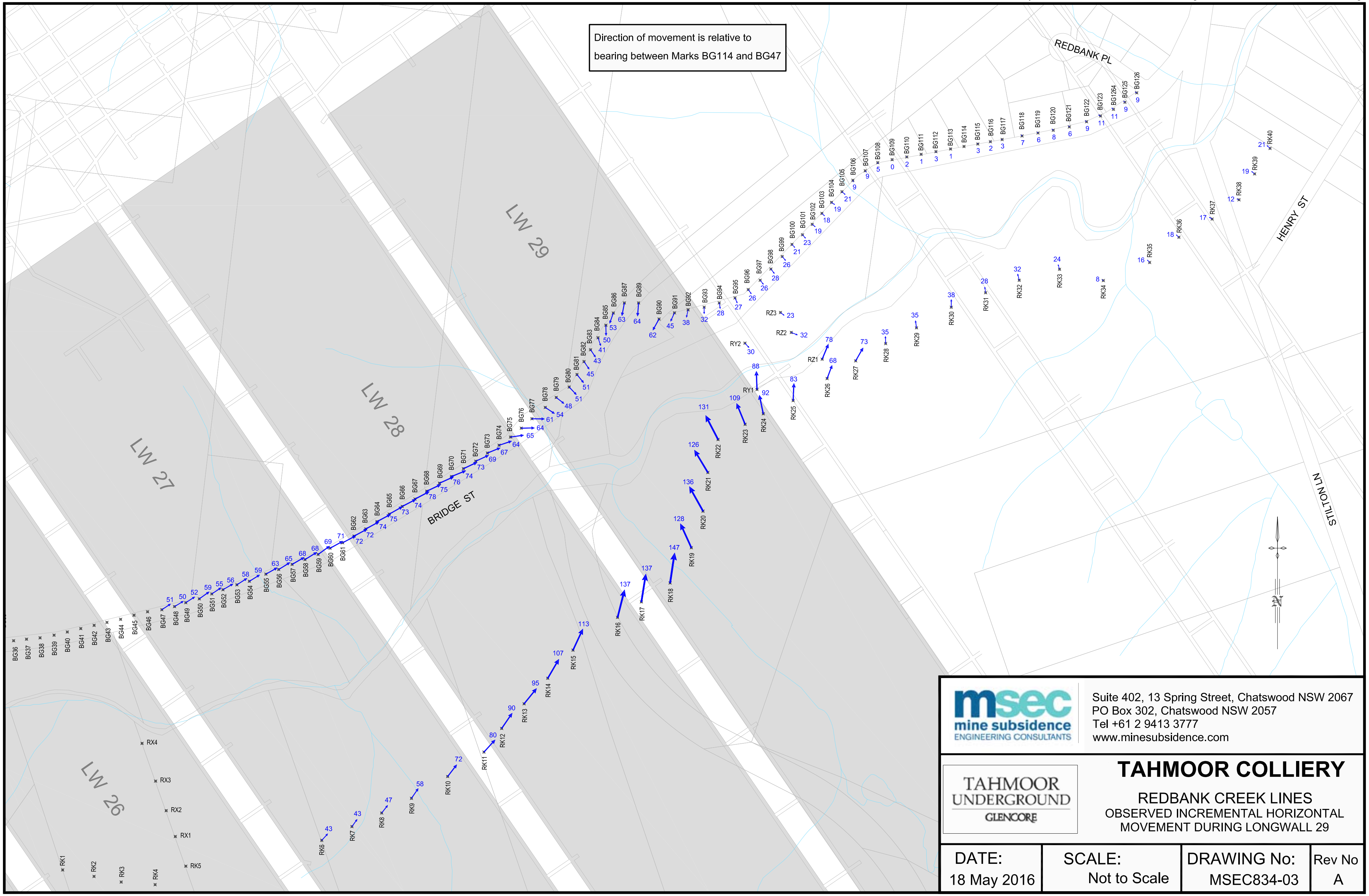

mine subsidence ENGINEERING CONSULTANTS

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TAHMOOR UNDERGROUND
GLENCORE

TAHMOOR COLLIERY

REDBANK CREEK LINES

OBSERVED INCREMENTAL HORIZONTAL MOVEMENT DURING LONGWALL 29

DATE:	SCALE:	DRAWING No:	Rev No
18 May 2016	Not to Scale	MSEC834-03	A

GeoTerra

Tahmoor Colliery

Longwall 29
Surface Water, Dams and Groundwater
End of Panel Monitoring Report

TA28-R1B
16 August, 2016

GeoTerra Pty Ltd ABN 82 117 674 941

PO Box 530 Newtown NSW 2042

Phone: 02 9519 2190 Mobile 0417 003 502 Email: geoterra@iinet.net.au

Tahmoor Coal Pty Ltd
Tahmoor Underground
PO Box 100
TAHMOOR NSW 2573

Attention: Belinda Treverrow

Belinda,

RE: Tahmoor Colliery End of Longwall 29 Surface Water, Dams and Groundwater Monitoring Report

Please find enclosed a copy of the above mentioned report.

Yours faithfully

GeoTerra Pty Ltd

Andrew Dawkins (AuSIMM CP-Env)

Managing Geoscientist

Distribution:	Original	GeoTerra Pty Ltd
	1 electronic copy	Tahmoor Colliery
	1 electronic copy	MSEC Pty Ltd

Authorised on behalf of GeoTerra Pty Ltd:	
Name	Andrew Dawkins
Signature	
Position	Principal Geoscientist

Date	Rev	Comments
02/08/2016		Initial draft
15/08/2016	A	Revision of report structure
16/08/2016	B	Incorporate reviewer comments

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Executive Summary

The following table summarises the potential and observed effects on the Redbank Creek stream bed as well as the Tahmoor North dams and groundwater systems within the Longwall 29, 20mm subsidence zone, and the observed effects due to subsidence related to extraction of the subject longwall and previous longwalls.

Potential Impacts	Observed Impacts Due to Extraction of Longwall 29
Surface Water	
Bedrock cracking and loss of plateau stream flow not anticipated in Redbank Creek or smaller gullies over Longwalls 22 to 29 due to mitigating effects of stream sediment cover	Stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over LW's 25 to 30
No adverse ecological changes to plateau streams due to subsidence	No adverse effect on plateau stream ecology has been reported
Possible localised ponding may occur in plateau streams	No localised stream ponding due to subsidence has been observed
No adverse effects on plateau stream water quality anticipated	Increased salinity has been observed downstream of Redbank Creek subsidence zone, along with elevated nickel, zinc iron and manganese
Plateau stream bed incision may occur	No plateau stream bed incision has been observed
Dams	
Subsidence, strain or tilting may cause adverse effects on dam walls or may affect dam storage capability	No dam wall cracking and no adverse effects on dam wall integrity or dam water storage reduction has been reported.
Groundwater	
Adverse interconnection of aquifers and aquitards is not anticipated within 20m of the surface	No adverse interconnection between aquifers and aquitards observed within 20m of the surface
Potential increased rate of recharge into the plateau	No increased rate of recharge into the plateau
Temporary lowering of regional phreatic water levels by up to 10m which may stay at that level until maximum subsidence develops	No additional lowering of open standpipe piezometer water levels due to Longwall 29
Groundwater levels should recover over a few months and no permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops	Previously depressurised open standpipe piezometers have gradually re-pressurised to similar, albeit lower pre-mining levels
The yield and serviceability in 1 NOW registered bore (P4) may be affected by subsidence	No private bores have been reportedly adversely affected by subsidence
Horizontal displacement may make the private bore inaccessible	No private bores reported to have been horizontally displaced in the Longwall 22 to 29 subsidence zone
Strata dilation and subsequent re-filling of secondary voids may temporarily lower standing water levels and increase the potential private bore yields	No private bore yields have been reportedly adversely affected

Potential Impacts	Observed Impacts Due to Extraction of Longwall 29
Private bore groundwater may experience increased iron / manganese hydroxide precipitation and / or lowering of pH	No private bores have been adversely affected by Fe / Mn precipitates
Interface drainage, ferruginous, brackish seeps may be generated in streams on the plateau	Increased ferruginous and salinity levels have been observed over Longwall 29 and 30 in Redbank Creek
Increased groundwater seepage inflow into the Bulli Seam workings should not occur	No notable increase in groundwater inflow to the mine
Strata gas discharge into private bores may occur	No strata gas discharge into private bores has occurred

TARP Trigger Exceedances

The "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for >2 months, considering rainfall / runoff variability*" TARP was triggered on;

- 18th February 2016 between Sites 26A and RC2 / 37 in Redbank Creek over Longwall 28 as well as the LW28/29 chain pillar and the tailgate section of Longwall 29;
- 18th February 2016 at Site RR9 over the tailgate section of Longwall 30, and;
- 29th March 2016 between Sites RR2 and RB5 in Redbank Creek over Longwall 29.

The "*significant reduction compared to baseline and predicted impacts last over more than 2 months or 2 standard deviation over 2 months reduction in water quality*" TARP was also triggered at Redbank Creek Site RC2 (aka Site 37) for zinc on 18/2/16.

1. INTRODUCTION

Tahmoor Colliery (Tahmoor Coal Pty Ltd) has extracted the Bulli Seam in Longwalls 22, 23A, 23B, 24A, 24B and 25 to 29 by retreat mining within the Tahmoor North Lease Area since June 2004.

The previous panels and the current panel (Longwall 30) are located underneath Tahmoor and Thirlmere villages, as well as surrounding urban and semi-rural areas as shown in **Drawing 1,** which are approximately 4 kilometres (km) south of Picton in the Southern Coalfield of NSW.

This report provides a compilation of physical and geochemical groundwater, as well as Redbank Creek streambed and catchment dam monitoring that has been conducted, and observation of any subsidence related changes that have occurred since August 2004, up to and including the extraction of Longwall 29.

This document does not discuss the observed subsidence effects on Myrtle Creek or its catchment, which was last undermined by Longwall 28, as these aspects are covered in a separate report (GeoTerra, 2016).

Surface water and groundwater features within the Longwall 29, 20mm subsidence zone include:

- The main channel and tributaries of Redbank Creek, which flows ENE into Stonequarry Creek and subsequently, the Nepean River;
- The southern tributary flanks of Matthews Creek, but not the main channel. Matthews Creek flows to the northeast and joins with Cedar Creek and Stonequarry Creek, then into Racecourse Creek and subsequently the Nepean River;
- 3 medium sized, predominantly earthen wall dams that directly overly Longwall 29, and;
- Two vibrating wire piezometer arrays in bores TNC28 and TNC29 that were installed by the colliery and six NOW licensed private bores (P3, P4, Pescud, McPhee, Boissery and Machin).

Redbank Creek is a Category 2 stream with a 3rd order or higher channel, whilst its tributaries are Category 1 streams, being 1st or 2nd order channels.

Monitoring has been conducted since June 2004 by assessing the;

- Ephemeral or perennial nature and flow in streams over the panels;
- Creek bed and bank erosion and channel bedload;
- Stream and dam water quality;
- Stream bed and bank vegetation;
- Nature of alluvial land along stream banks;
- Presence, size and integrity of dams and their water levels,
- Presence and use of groundwater bores, and;
- Assessment of standing water levels and water quality.

2. PREVIOUS STUDIES

An assessment of potential subsidence levels and impacts for Longwalls 27 to 30 was studied by MSEC (2009).

Assessment of the baseline characteristics and prediction of possible subsidence related effects on the surface water and groundwater system were assessed for Longwalls 27 to 30 in GeoTerra (2009).

Surface water and groundwater monitoring end of panel reports have been prepared for Longwalls 22, 23A, 23B, 24A, 24B and 25 to 28 by GeoTerra Pty Ltd (GeoTerra).

Ongoing monitoring of water levels, flows and water quality in the plateau streams, dams and groundwater bores is being conducted throughout extraction of Panel 29 by colliery staff, GeoTerra Pty Ltd and Hydrometric Consulting Systems Pty Ltd (HCS) in accordance with GeoTerra (2013).

3. GENERAL DESCRIPTION

3.1 Mine Layout and Progression

Tahmoor Colliery has extracted coal by longwall mining Panels 1 to 29 to the south, southwest and northwest of the current panel (Longwall 30).

Longwall 29 commenced on 31 May 2015 and was completed on 9th April, 2016 as outlined in **Table 1**, with Longwall 30 extraction continuing updip in the Bulli Seam from south to north.

Table 1 Panel Extraction Details

Panel	Start	Finish	Length (m)	Depth of Cover (mbgl)
22	02/06/04	11/07/05	1877	420 – 432
23A	07/09/05	20/02/06	776	430 – 450
23B	15/03/06	21/08/06	771	430 – 440
24B	15/10/06	26/08/07	2072	430 – 440
24A	15/11/07	190/7/08	983	420 - 448
25	22/08/08	27/02/11	3730	440 - 460
26	30/03/11	11/10/12	3480	440 - 470
27	10/11/12	22/03/14	3030	420 - 495
28	20/04/14	01/05/15	2629	420 - 500
29	29/05/15	03/04/16	2322	425 - 490
30	20/6/16	ongoing	2322	425 - 490

Extraction of Panel 29 occurred from 425 – 490m below surface.

Seam thickness varies from 1.8m at the finish end of Panel 24B / Panel 25 up to 2.15m in Longwall 29.

Longwalls 22 to 29 are 283m wide rib to rib, with 34.5m to 40m wide chain pillars and between 771m to 3,730m long as shown in **Drawing 1**.

3.2 Topography and Drainage

The plateau is generally flat to undulating and incised by the Bargo River gorge which is up to 104m deep in the Longwalls 22 to 29, 20mm subsidence area, with steep to vertical sandstone cliff faces and vegetated scree slopes, whilst the gorge and river bed comprise a series of exposed sandstone shelves interspersed with sandstone boulder fields and pools.

The Longwall 22 to 29 study area also contains the main channel and tributaries of Myrtle and Redbank Creeks, which flow both to the Nepean River, with the Bargo River being approximately 2,225m south, and the Nepean River at least 1,700m east of Longwall 29.

Both Myrtle and Redbank Creeks drain the residential areas of Tahmoor and Thirlmere, as well as semi-rural fallow, orchard and grazing areas outside of the villages.

3.2.1 Bargo River

The Bargo River is present in the south-eastern part of the Longwall 22 to 29 monitoring area, which covers approximately 1,130m of the river bed, with the closest panel (24A) being at least 289m from the edge of the gorge and 354m from the centre of the river.

The Bargo River over Longwalls 12 and 13 has previously sustained up to 550mm of subsidence, 2mm/m of tensile and 3mm/m of compressive strain in the “potholes” area and Rockford Road Bridge (GeoTerra, 2006) where the gorge was directly undermined.

The Bargo River and its associated gorge is outside the Longwall 29, 20mm subsidence zone, and is not discussed further in this report.

3.2.2 Myrtle Creek

Myrtle Creek flows directly into the Nepean River approximately 1.8km southeast of Longwall 29.

Its headwaters are located upstream of Panel 22 and generally consist of small grass covered channels that become larger and more incised downstream of Panels 23 to 29.

Myrtle Creek has been undermined by Longwalls 4, 22, 23B, 24B and 25 to 28, whilst Longwall 29 has not undermined the main channel of the creek

The riparian flanks have been significantly altered by residential development in Tahmoor, whilst the channel has not been significantly affected except where general rubbish or solid waste has been dumped in the creek or it is overgrown by invasive weeds. Some isolated weeding and stream bank regeneration works have been conducted, however many of the areas are re-infested with weeds.

The stream bed and banks are generally well vegetated, and do not show significant erosion or bank instability.

No NOW registered water extraction is listed within the creek, however an unlicensed pump was present over the middle of Longwall 25, off Castlereagh Street.

3.2.3 Redbank Creek

Redbank Creek drains into Stonequarry Creek, which subsequently flows to the Nepean River approximately 3km downstream of the monitoring area.

Redbank Creek has been undermined by Longwalls 25 to 29.

Within the monitoring area it has a reasonably incised, narrow (<5m wide) channel with a wetland upstream of the Longwall 23. The creek overlies the western end of Longwall 25 as a small channel with an incised bed 1m to 2m deep which evolves into a channel up to 3m deep and 10m wide downstream of Panel 26.

The Redbank Creek channel becomes sequentially deeper and wider over Longwall 27 compared to Longwall 26, and subsequently is additionally wider and deeper over Longwalls 28 and 29.

The headwaters of Redbank Creek, outside of the monitoring area, lie within the residential development area of Thirlmere, with housing and road development significantly affecting the banks of the creek.

In the vicinity of Longwalls 25 to 29, the creek flows out of the Thirlmere residential area, into the downstream urban fringe.

The local residents have previously undertaken bed and bank restoration works at isolated locations, such as a Landcare wetland restoration area located near the intersection of Turner Street and Thirlmere Way, whilst the local Council subsequently conducted weed eradication works between the wetlands and Windeyer Street. The Windeyer St works have been re-infested with weeds since the works were conducted.

The creek does not exhibit significant bed and bank erosion and is not significantly eroded due to the high vegetative and weed cover as well as exposed sandstone rock bars and shelves along the creek.

A section of Redbank Creek near Windeyer Street generally has an orange iron hydroxide precipitate on the stream surface after heavier rain periods in the vicinity of a leaking sewer pipe that crosses under the creek and is leaking into the stream. The iron hydroxide precipitate at water quality monitoring site RC1 can also be observed in the creek bed upstream of the sewer pipe following heavier rain events where leaking house sewer lines overflow into the stream.

Other areas of iron hydroxide precipitation that pre-existed mining related subsidence in Redbank Creek were observed in the reach between observation sites 24 and 25, as well as sites 30 to 37 (a.k.a. RC2 and R6) and downstream at site R9 over Longwall 31.

3.2.4 Dams

Surface runoff into the local streams and subsequently, the Bargo or Nepean Rivers is regulated by 3 dams that directly overly Longwall 29 as shown in **Drawing 1**.

The dams are constructed of earthen walls that collect and store surface runoff that would otherwise drain directly into Redbank Creek.

3.2.5 Geology

The Bargo River gorge is underlain by the fine to medium to coarse grained Hawkesbury Sandstone, with Wianamatta Shale outcrop present in the headwaters and mid-stream of Myrtle Creek and Redbank Creek, which transgresses to Hawkesbury Sandstone further downstream as shown in **Figure 1**.

Further details on the area's geology structure and stratigraphy are outlined in (GeoTerra, 2006).

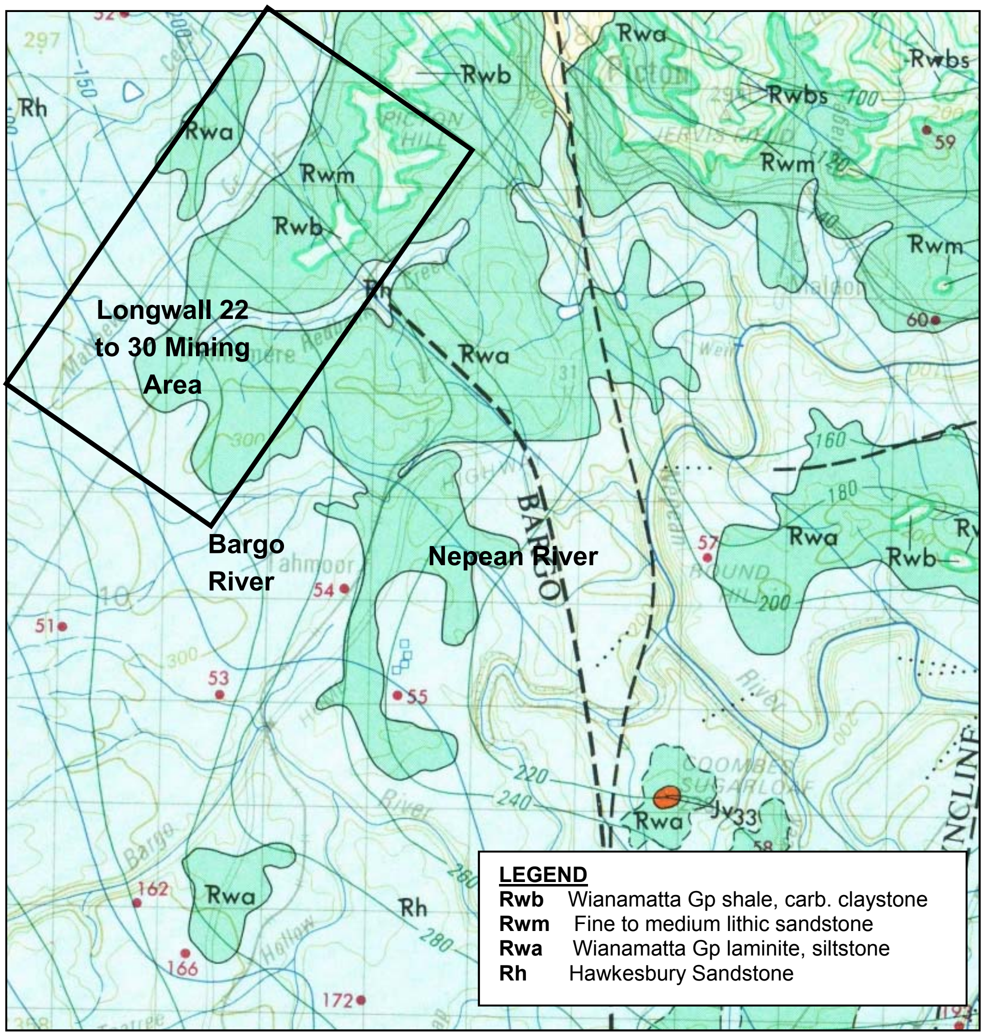

Figure 1 Surficial Geology

3.3 Hydrogeology

The Bargo River is a 'gaining' system, where groundwater flows from the plateau under a regional hydraulic gradient to the river, with groundwater flow being dominantly horizontal within confined flow along discrete layers that are underlain by fine grained or relatively impermeable strata.

The Hawkesbury Sandstone sequence exposed in the gorge is characteristic of sedimentary deposition and erosion in a braided stream with individual facies representing local sedimentary processes that generally do not persist across the area.

The Hawkesbury Sandstone within the Sydney Basin generally provides low yielding aquifers with low hydraulic conductivities.

Seven NOW registered bores, two uncased coal exploration bores and three Tahmoor Colliery (NOW registered) piezometers are located within the Longwall 22 to 29 monitoring area as shown in **Drawing 1** and **Table 2**.

Two piezometers, P3 and P4, are closest to Longwall 29, however they directly overlie or are close to Longwalls 26 and 27 respectively.

Piezometer P3 is an old, open, coal exploration bore that is being used by Tahmoor Coal as an open monitoring piezometer, which is located approximately 950m south west of Longwall 29, whilst P4 is an open private bore located approximately 500m west of the finishing, northern end, of Longwall 29.

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Table 2 Monitoring Bores and Piezometers

GW	Drilled	Depth (m)	SWL (m)	Aquifer (mbgl)	YIELD (L/s)	Purpose
SMP Area						
P1 (GW106281)	2004	48	Fig 11	18 - 20	0.75	monitoring
P2	-	150	Fig 11	-	-	coal exploration
P3	-	100	Fig 11	-	-	coal exploration
P4 (GW67570)	1988	85	Fig 11	-	0.22	domestic
P5 (GW63525)	1954 / 1990	76 / 91	Fig 11	60-66 & 70-91	1.0	stock domestic irrigation
P6 (GW42788)	1976	148	Fig 11	105 - 135	1.52	agriculture
P7 (GW110435)	2008	100	Fig 11	95 - 100	0.76	monitoring
P8 (GW110436)	2008	105	Fig 11	90 - 105	V low	monitoring
McPhee (GW105254)	2002	163	80.0	113-156	0.67	domestic
Kavanagh (GW105813)	2003	168	28	114 – 115 146 - 147 160 - 161	6.6	stock / domestic
Pescud (GW109010)	2008	169	89	n.a.	0.8	stock domestic
Boissery (GW109224)	2008	132	60	n.a.	1.0	domestic
Machin (GW107918)	2007	60	42.49	40 - 48	2.2	domestic

Note: All bore water supply is from Hawkesbury Sandstone.
redrill depth for bore replaced by Tahmoor Colliery
- no data available

Groundwater has been obtained from sandstone aquifers with yields ranging from 0.2L/sec to 5.0L/sec between 18m and 138m below surface.

NOW bore data indicates it is likely that significant aquifers are intersected below depths of approximately 18m to 60m, depending on whether the bore is spudded on top of a hill or in a valley. Shallower, low yielding groundwater may be present above that depth range as perched ephemeral aquifers.

Alluvial sediments within the plateau gullies and river bed are too shallow to be used as aquifers for groundwater supply.

3.3.1 Vibrating Wire Piezometer Arrays

Two cement / bentonite sealed exploration bores (TNC28 and TNC29) are installed with vibrating wire piezometer arrays over Longwall 29, with an additional three (TNC36, 40 and 43) located to the north as shown in **Drawing 1** and **Table 3**.

Due to potential monitoring equipment being a potential hazard to the underground workings, TNC29 was decommissioned on 10 August 2015, prior to the VWP being undermined.

Table 3 Tahmoor North Vibrating Wire Piezometer Installation

Piezometer	Intake Depth (mbgl)	Formation	Piezometer	Intake Depth (mbgl)	Formation
TNC28	95	Hawkesbury Sandstone	TNC29	70.96	Hawkesbury Sandstone
	195	Hawkesbury Sandstone		165.06	Hawkesbury Sandstone
	245	Bald Hill Claystone		182.06	Bald Hill Claystone
	270	Bulgo Sandstone (top)		215.06	Bulgo Sandstone (top)
	430	Scarborough Sandstone		382.56	Scarborough Sandstone
	490	Bulli Seam		441.56	Bulli Seam
TNC36	65	Hawkesbury Sandstone	TNC40	27	Wianamatta Shale
	97	Hawkesbury Sandstone		65	Hawkesbury Sandstone
	169	Colo Vale Sandstone		131	Hawkesbury Sandstone
	214	Colo Vale Sandstone		225	Hawkesbury Sandstone
	298.5	Colo Vale Sandstone		352	Bulgo Sandstone
	412.5	Colo Vale Sandstone		452	Bulgo Sandstone
	463.5	Bulli Seam		501.9	Bulli Seam
TNC43	65	Hawkesbury Sandstone			
	111.5	Hawkesbury Sandstone			
	213	Hawkesbury Sandstone			
	240	Bulgo Sandstone			
	332.6	Bulgo Sandstone			
	425.2	Bulgo Sandstone			
	476.3	Bulli Seam			

3.4 Subsidence

The maximum monitored subsidence, tilt and strain following the completion of extraction of Longwall 29 is shown in **Table 4**.

Table 4 Maximum Subsidence at the Completion of Longwall 29

Component	Observed Total Movement
Vertical subsidence	1124 mm
Tilt	6.3 mm/m
Tensile / Compressive Strain	2.1 / -7.7 mm/m

3.4.1 Redbank Creek

The ability to survey valley closure across the creek has been constrained due to refusal by landowners to provide access, with no available access on the northern bank and limited access on the southern bank (MSEC 2016), with the available survey data (accurate to approximately 20 – 30mm) shown in **Table 5**.

Table 5 Maximum Redbank Creek Valley Closure up to Completion of LW29 (mm)

Location	After LW26	After LW27	After LW28	After LW29
Between Bridge St and RK Line	151	233	276	350

Source (MSEC, 2016)

Valley closure was slightly greater for a temporary period of time when the transient effects of the subsidence travelling wave passed through the valley, with the maximum incremental valley closure of 179 mm.

3.5 Redbank Creek Monitoring

3.5.1 Water Level and Chemistry Monitoring Site Descriptions

Stream water level, and subsequently stream flow monitoring, as well as field chemistry and laboratory analysis of water samples has been conducted in Redbank Creek since April 2005 at the sites summarised in **Table 6** and shown in **Drawing 1**.

Table 6 Redbank Creek Water Level and / or Chemistry Monitoring Locations

Site	Description	Monitored Parameters
RC1	Off the end of Windeyer Street	Pool depth (discontinued), field and laboratory chem.
RC2	Downstream of Railway bridge	Pool depth (discontinued), field and laboratory chem.
RC3	Downstream of Remembrance Driveway culvert	Pool depth (discontinued), field and laboratory chem.
R1	Downstream of Turner Street bridge	Weir plate
R2	End of Windeya Street	Rock bar pool depth and flow
R3	350m downstream of R2	Rock bar pool depth and flow
R4	Upstream of railway culvert	Rock bar pool depth and flow
R5	Downstream of railway culvert	Rock bar pool depth and flow
R6	Downstream of R5 near RC2	Rock / gravel pool depth and flow
R7	Adjacent to Bridge Street	Rock bar pool depth and flow
R8	Downstream of R6	Rock bar pool depth and flow
R9	Access from old Highway thru Picton	Weir plate
R10	Between Nepean Conveyors and Site 9	Rock bar pool depth and flow
R11	Behind Nepean Conveyors	Rock bar pool depth and flow

Weekly monitoring of the Redbank Creek over Longwalls 28, 29 and 30 commenced on 19th November 2015 and continued until 24th February 2016 at the observation sites shown in **Tables 7** and **8**.

Redbank Creek was undermined by Longwall 29 between approximately the 2nd and 9th of January 2016.

Table 7 Redbank Creek Weekly Monitoring Sites

Site	Description	Additional Sites
19	sand based pool downstream of rock shelf	
19A	sandstone / sand based pool	
20	boulder based pool next to cliff	
21	rock bar pool with logger	R4
21A	rock bar pool	
22	boulder based reach	
22A	rock shelf pools	
23	rock shelf pools	
24	ferruginous seepage in boulder based pool	
25	ferruginous seepage in boulder based pool	
25A	rock shelf with limited shallow pools	
26	rock shelf pools	
26A	sandstone based pool	
27	sandstone based pool	
28	sandstone / boulder based pool	R5
29	extended rock shelf with limited shallow pools	
30	ferruginous seepage in boulder / sandstone based pool	
31	ferruginous seepage in boulder / sandstone based pool	
32	ferruginous seepage in boulder / sandstone based pool	
33	ferruginous seepage in boulder / sandstone based pool	
34	ferruginous seepage in boulder / sandstone based pool	
35	ferruginous seepage in boulder / sandstone based pool	

Table 8 Redbank Creek Weekly Observation Sites (continued)

Site	Description	Additional Sites
36	sand / rubble based ferruginous pool	
37	sand / sandstone ferruginous pool	RC2 / R6
RR2	sandstone race trending to series of ferruginous pools	
RB3	shallow boulder race becoming large ferruginous rock pool	
RB4	boulder constrained shallow ferruginous rock pool	
RB5	boulder constrained shallow ferruginous rock pool	
RB6	boulder constrained shallow ferruginous rock pools	
RR7	long sandstone race with ferruginous rock shelf pools	R7
RR8	shallow sandstone race with ferruginous rock shelf pools	
RR9	shallow sandstone race with ferruginous rock shelf pools	
RR10	shallow sandstone race with ferruginous rock shelf pools	
RR11	shallow sandstone race with ferruginous rock shelf pools	
RRS12	extended sandstone rock shelf with ferruginous overflow	
RW13	<0.5m high sandstone rock step / waterfall constrained pool	
RB14	boulder constrained shallow ferruginous rock pool	
RR15	shallow sandstone race with ferruginous rock shelf pools	
RR16	shallow sandstone race with ferruginous rock shelf pools	
RB17	boulder constrained shallow ferruginous rock pool	
RR18	shallow sandstone race with ferruginous rock shelf pools	
RR19	shallow sandstone race with ferruginous rock shelf pools	R8

NOTE: RR= Redbank Ck rock bar constrained pool RB = boulder pool RRS = rock shelf RW = waterfall

3.5.2 Pre Longwall 29 Creek Subsidence Observations

Subsidence effects observed due to extraction of Longwall 28 (i.e. prior to 29/5/15, when extraction of Longwall 29 commenced) at the following sites included;

Over Longwall 25

- 4 to 9 – pool desiccation in a clay incised section of the creek with cobbles and limited exposed sandstone rockbars.

Over Longwall 26

- 12 to 13 – sandstone stream bed cracking, with no obvious effect on pool holding capacity;
- 14 to 14a - pool desiccation in a cobble / sandstone based section;
- 15 to 17 - pool desiccation in sandstone based pools; and
- 17a to 19 - pool desiccation in cobble / sandstone based pools.

Over Longwall 27

- 21 to 21a - pool desiccation in sandstone based pools;
- 22 - pool desiccation in a cobble / sandstone based section;
- 22a to 23 – significant cracking and pool desiccation in sandstone based pools;
- 24 to 25 – pool desiccation with significant iron hydroxide in cobble / sandstone based pools;
- 25a to 26 - significant cracking and pool desiccation in sandstone based pools;

Over Longwall 28

- 26a to 28 - pool desiccation in sandstone based pools, and
- 29 – reduced flow over sandstone rock shelf.
- 30 to 34 – drying up of previously ferruginous pools in boulder and rock bar pools.

Over Longwall 29

- 35 to 37 and RB3 to RB5 – reduced pool level or drying up of previously ferruginous pools in boulder and rock bar pools.

3.5.3 Post Longwall 29 Creek Subsidence Observations

During undermining by Longwall 29, Redbank Creek was observed to have undergone subsidence effects as summarised in **Table 9**.

In addition to the sites over Longwall 29 that had previously been affected by Longwall 28 extraction, subsidence effects (or additional subsidence effects) were observed at:

- Sites RB6 to RR11 over the tailgate section of Longwall 30.

Photos of selected pools and stream reaches after the extraction of Longwall 29 are shown in **Appendix A**.

As shown in **Table 9**, the "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* TARP was triggered on;

- 18th February 2016 between Sites 26A and RC2 / 37 in Redbank Creek over Longwall 28 as well as the LW28/29 chain pillar and the tailgate section of Longwall 29;
- 18th February 2016 at Site RR9 over the tailgate section of Longwall 30, and;
- 29th March 2016 between Sites RR2 and RB5 in Redbank Creek over Longwall 29.

The "*significant reduction compared to baseline and predicted impacts last over more than 2 months or 2 standard deviation over 2 months reduction in water quality"* TARP was also triggered at Site RC2 (aka Site 37) for Zinc on 18/2/16.

Table 9 Redbank Creek Subsidence Effects During LW29 Extraction

Site	Relative Location	Effect	Date Initially Observed	TARP First Triggered
Over Longwall 28				
28	tailgate	pool dried up, no obvious cracking	17/12/13	_
29	tailgate	further cracks in rock shelf, pools very low	21/11/13	_
30	centre	ferruginous pool dried up, no obvious cracking	03/01/14	_
31	centre	new cracks, pool holding but increased iron	21/11/13	_
32	centre / maingate	ferruginous pool dried up, no obvious cracking	03/01/14	_
33	maingate	ferruginous pool dried up, no obvious cracking	03/01/14	_
34	LW28 / 29 chain pillar	cracked dried up ferruginous pool	23/12/14	_
Over Longwall 29				
35	tailgate	Very low ferruginous pool	since LW27 & 16/12/14	_
36	tailgate	reduced flow in ferruginous sand / rubble pool	since LW27 & 16/12/14	_
37	centre	significant depth reduction of ferruginous pool and exceedance of Zn trigger	depth (05/01/15) Zn (before LW25)	(Zn) 5/3/15
RR2	centre	sandstone based ferruginous pools without cracking or pool level reduction		_
RB3	centre	shallow boulder race and large ferruginous rock pool without cracking or pool level reduction		_
RB4	centre	series of shallow ferruginous rock pools without cracking or pool level reduction		_
RB5	centre - maingate	pool depth reduction and cracks in ferruginous pool	low flow (17/03/15), cracks (23/04/15)	_
RB6	maingate	series of shallow ferruginous rock pools without cracks or pool level reduction		_
RR7	maingate – chain pillar	long sandstone race with ferruginous rock shelf pools without cracks		_
Over Longwall 30				
RR8	tailgate	long shallow sandstone race with ferruginous rock shelf pools without cracks	cracks 30/12/15 pool dry 28/1/16	_
RR9	tailgate	rock shelf / race with ferruginous pools	cracks 17/12/15 pool dry 13/1/16	_
R7 / RR10	tailgate / centre	rock shelf / race with ferruginous pools	cracks 7/1/16 pool dry 28/1/16	_
RR11	centre	rock shelf / race with ferruginous pools	cracks 7/1/16 pool dry 28/1/16	_
RRS12	centre	extended rock shelf with overland ferruginous flow	_	_
RW13	centre	<0.5m high waterfall constraining upstream pool	_	_
RB14	centre - maingate	boulder constrained ferruginous pool	_	_

NOTE: RR= Redbank Ck rock bar constrained pool RB = boulder pool RRS = rock shelf RW = waterfall

3.5.4 Redbank Creek Pool Depth and Creek Flow Monitoring

GeoTerra commenced monitoring water levels in the creek in April 2005 (GeoTerra, 2011). HCS took over stream flow monitoring and decommissioned the original RC1-3 sites in January 2010.

Pool levels and creek flow at monitoring locations R1 – R3, as monitored by HCS, are shown in **Figure 3**.

HCS are endeavouring to convert all stream depths to flow as sufficient manual stream flow data is collected, however insufficient readings are currently available for the conversion at all sites.

Reversal of flow in the creek has not occurred due to subsidence as the creek gradient exceeds the subsidence tilt in the stream bed.

Site R1 is situated upstream of Longwall 24, whilst R2 is located at north eastern upstream corner of Longwall 25, and upstream of Longwall 26.

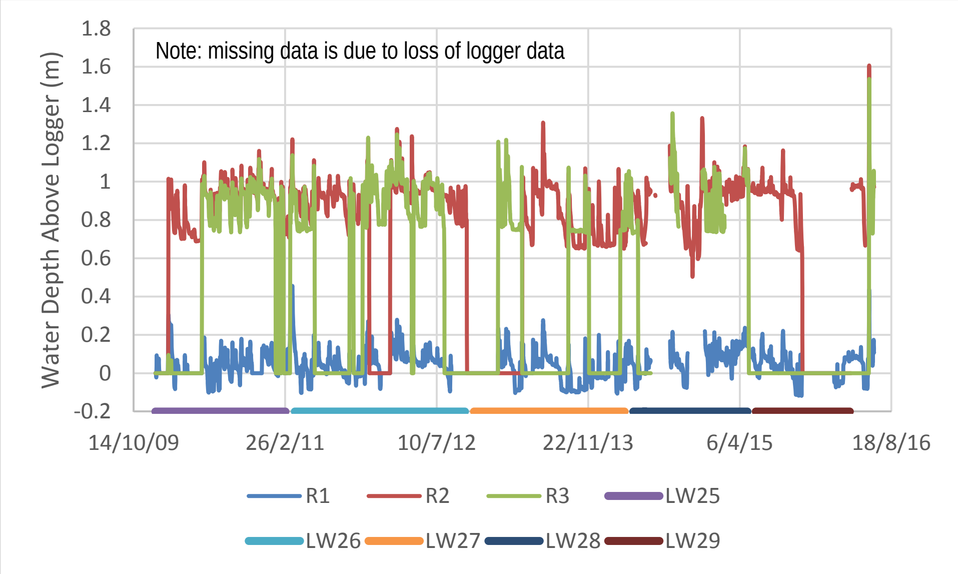
Pool R3 is located at the northern western end of Longwall 25 and upstream of Longwall 26 and R4 is located over Longwall 27 as shown in **Drawing 1**.

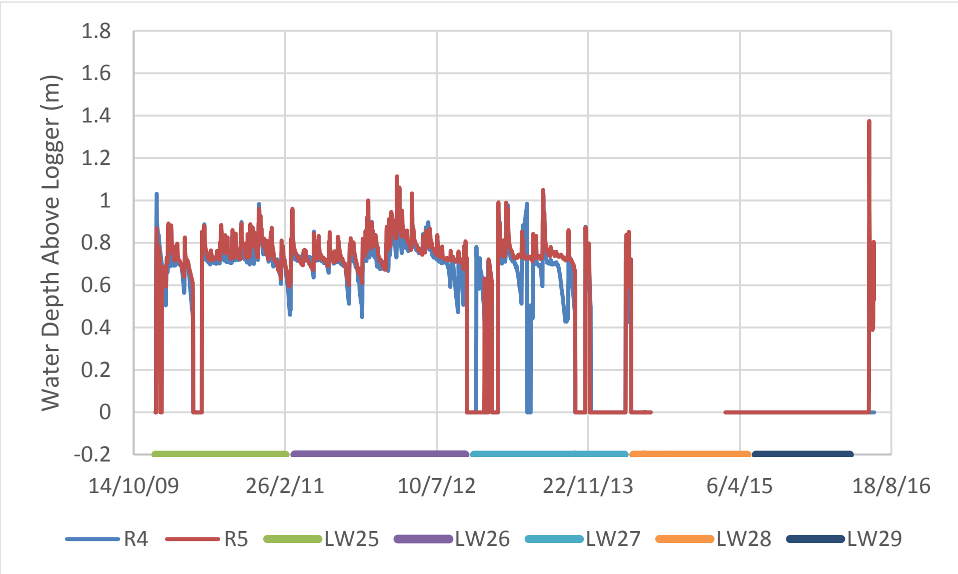
Pool R5 is located downstream of Longwall 27, whilst R6 is situated over the middle of Longwall 29 and contains the permanently ferruginous pool RC2.

Pool R7 is located over mid Longwall 30, R8 is over the tailgate side whilst R9 is located over the maingate side of Longwall 31. Pool R10 is situated over mid Longwall 32 and R11 is located over mid Longwall 32A as shown in **Drawing 1**.

Sites R2, 3, 4, 5, 6 and R7, which overlie Longwalls 25 to 29, show evidence of subsidence related pool holding capacity effects, whilst R8 to 11 do not, as shown in **Figure 2**.

Observation of weekly monitoring sites 19 to 37 and between RR2 to RR19 (over Longwalls 27 to 31) were monitored during extraction of Longwall 29 indicate that stream flow and pool depths have been significantly affected by subsidence associated with Longwalls 26 to 29 between Sites 19 – 37 and between RR2 to RR11, which overlie Longwalls 27 and 30 as shown in **Drawing 2**.





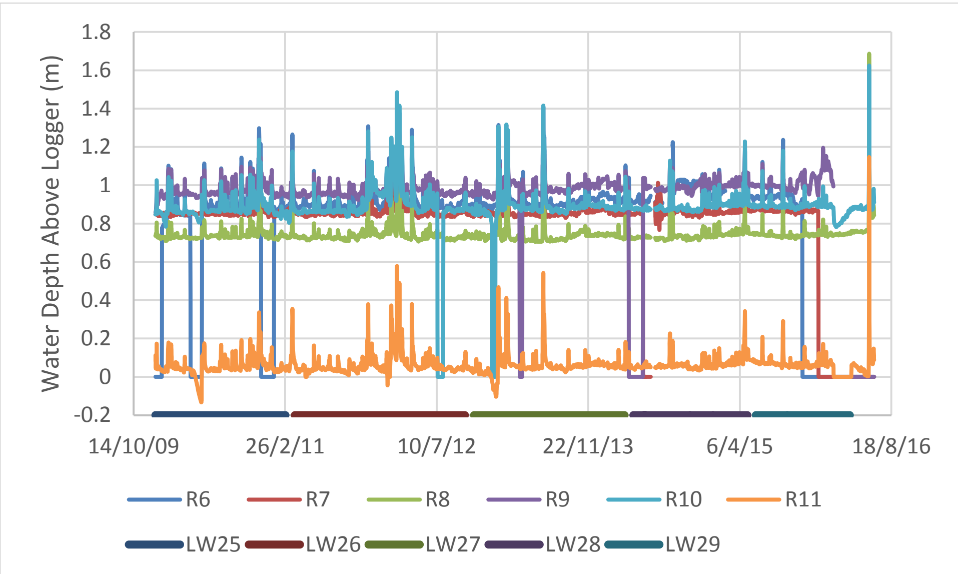


Figure 2 Redbank Creek Pool Depth

3.5.5 Redbank Creek Water Quality

Redbank Creek has an EC range from 22 - 3290uS/cm, and pH was between 3.10 and 7.50, with the creek generally being more acidic and saline at RC2 as shown in **Figure 3**.

During extraction of Longwall 29, pH in Redbank Creek distinctly acidified at all monitored sites, whilst salinity did not show a specific trend, except for higher salinity during low flow periods.

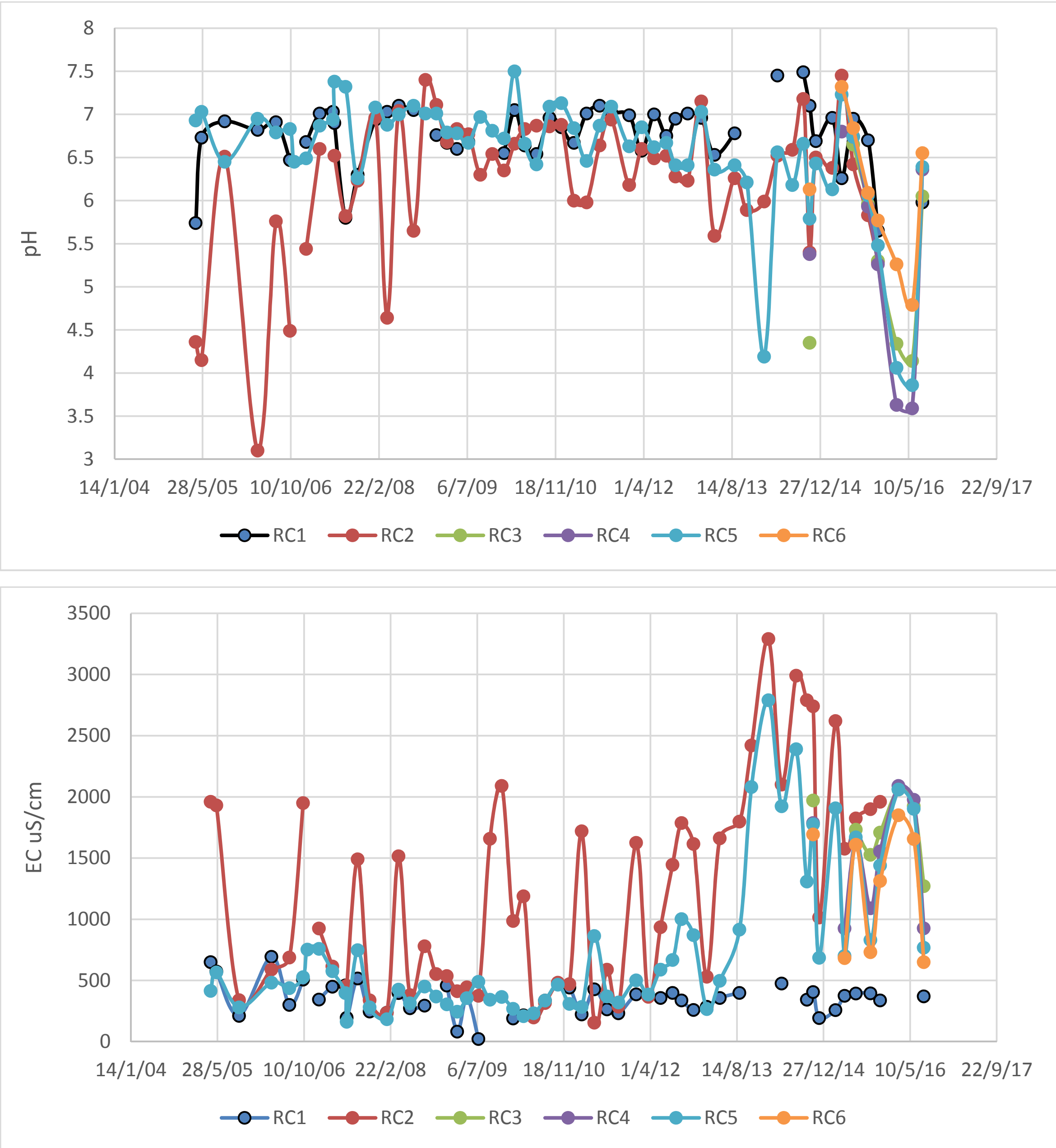


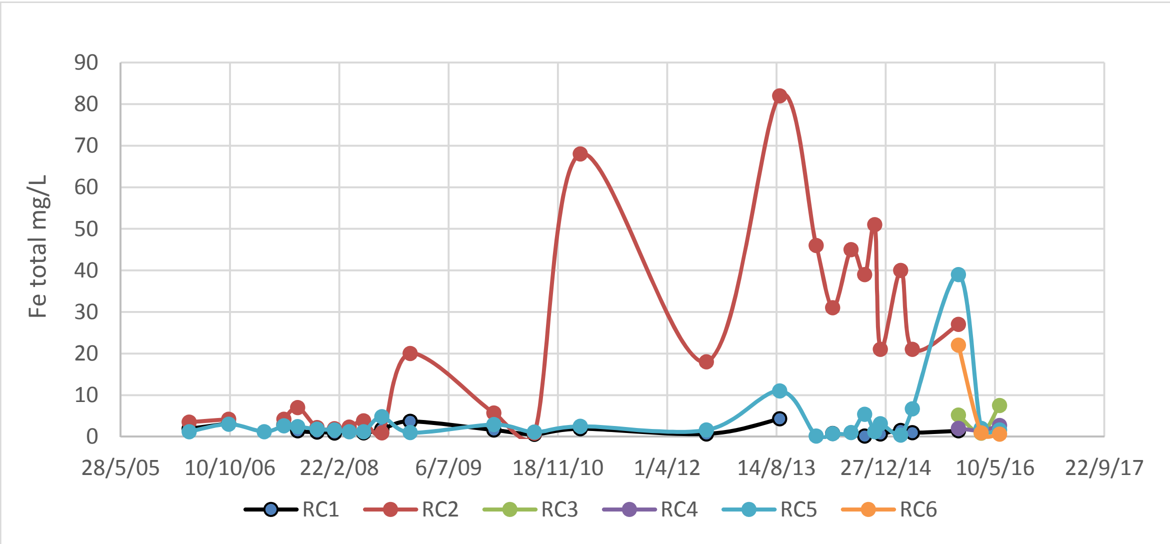
Figure 3 Redbank Creek Field Water Quality

Enhanced salinity and lower pH is predominantly associated with the more ferruginous seeps in the stream.

Redbank Creek generally contains elevated iron and, occasionally, above ANZECC 2000 Protection of 95% of Freshwater Aquatic Species trigger level manganese at RC2 in association with the upstream tributary seepage as shown in **Figure 4**.

The stream reach at RC2 (a.k.a. Site 37) has had a definitive ferruginous hydroxide precipitate in the standing pool since monitoring was started in early 2005 which is present due to upwelling and re-oxygenation of chemically reduced waters in the creek between sites 30 to 35, as well as a groundwater seep in a tributary entering Redbank Creek downstream of the railway tunnel at Site 36, as well as sites RC37, RR2, RB3-6, RR7-10, RRS12, RW13, RB14 and RR15 -19.

The iron and manganese levels vary with rainfall in the catchment, with lower concentrations after wetter periods, however a definitive rise in iron has been observed at RC2 and for manganese at RC2 and RC5 since Longwall 27 and Longwall 28 undermined Redbank Creek. Manganese also rose distinctly during extraction of Longwall 29 at Sites RC3-6 (at which time RC1 and RC2 were dry).



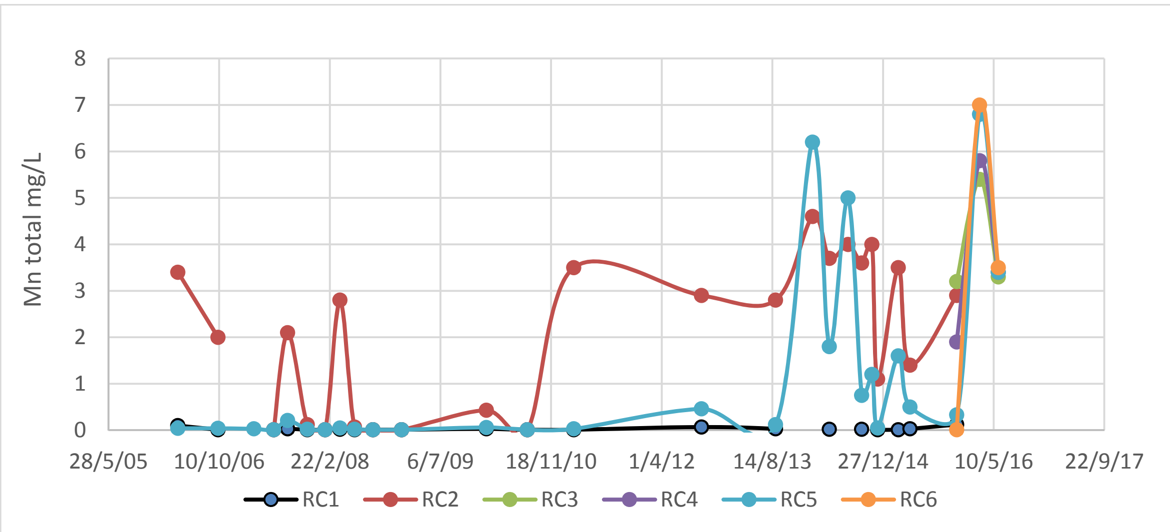


Figure 4 Redbank Creek Iron and Manganese

The creek can have total nitrogen up to 7.6mg/L and total phosphorous up to 0.23mg/L, which can be above the ANZECC 2000 SE Australian Upland Stream criteria at all monitored sites as shown in **Figure 5**.

The above criteria nutrients are present in the creek due to urban and rural / residential runoff in the catchment from house gardens, market gardens, as well as properties with poultry and stock, and are not related to mining influences.

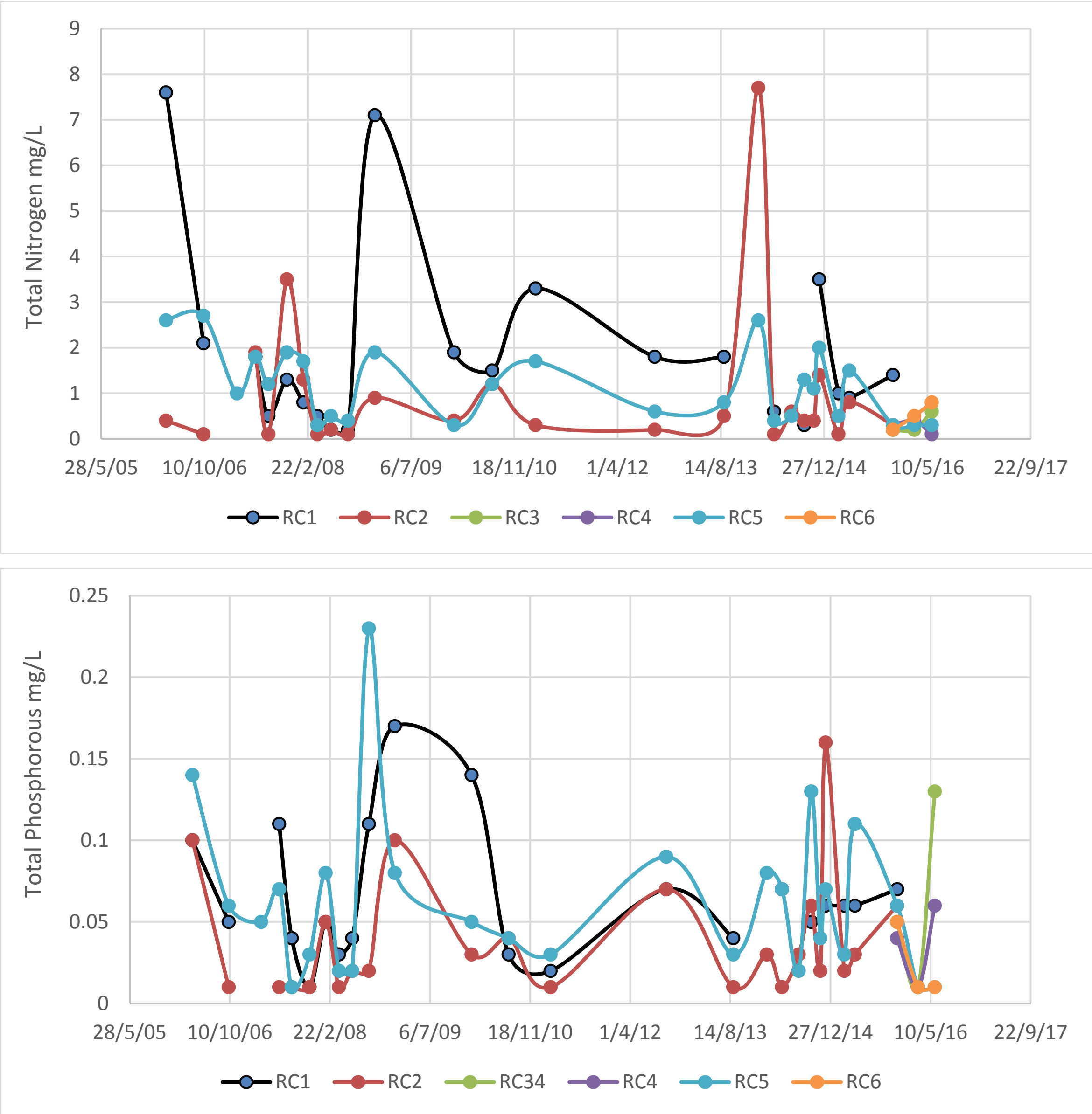


Figure 5 Redbank Creek Nutrients

Redbank Creek can also exceed the ANZECC 2000 trigger levels for filterable aluminium (<0.26mg/L), although the peak levels occurred during late 2007 and early 2008, with no observable increase above background levels during the Longwall 26 to 28 mining period.

Copper can reach up to 0.007mg/L at RC1 and RC2, however no sustained increase as a result of Longwall 28 or Longwall 29 is observed as shown in **Figure 6**.

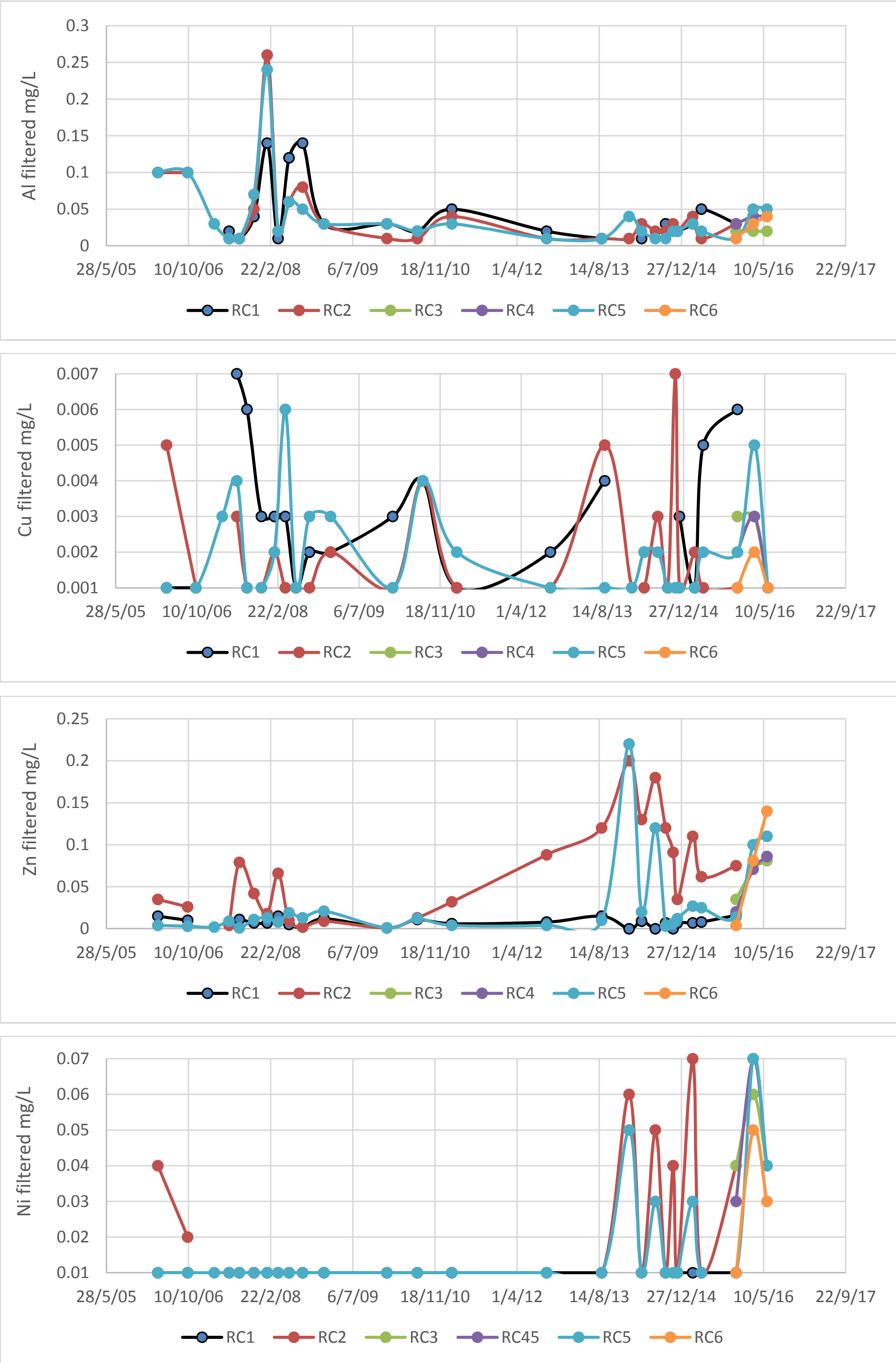


Figure 6 Redbank Creek Metals

Zinc can reach up to 0.22mg/L as shown in **Figure 6**, with its concentration being observed to rise at RC2 since late 2010, and since August 2013 at RC3 with an erratic, although generalised reduction since February 2014 and subsequent rise after extraction of Longwall 29.

Nickel has also significantly increased at RC2 and RC3 since August 2013, reaching up to 0.07mg/L.

Both the zinc and nickel concentration increases indicate a response in the Redbank Creek water quality due to undermining of Redbank Creek by Longwalls 27, 28 and 29.

3.6 Dams

Three dams directly overlie Longwall 29 as shown in **Drawing 1** and **Table 10**. All of the dams are located within rural residential properties.

The dams are constructed by excavation and downslope emplacement of an earthen bund wall within first order tributaries of Redbank Creek.

All dams have had variable water levels in response to rainfall recharge and / or water extraction rates.

No direct evidence of dam wall or floor cracking was reported by landowners, and the associated adverse water level, water storage or water quality effects due to subsidence associated with Longwall 29.

Table 10 Dams Over Longwall 29

Dam	Construction	Subsidence Effects
GG08a	Medium earth bank on slopes	None reported
GGo8b	Medium earth bank on slopes	None reported
GGo8c	Medium earth bank on slopes	None reported

3.7 Groundwater

3.7.1 Open Standpipe Piezometers and Private Bores

Regular manual and data logger based standing water level monitoring began in June 2004 in piezometers located as summarised below;

- P1 - 450m south west of Panel 22;
- P2 - within a remnant coal exploration bores over Panel 23B;
- P3 - within a remnant coal exploration bore over the chain pillar between Panels 25 and 26;
- P4 - within an undeveloped, unsecured block of land, 300m northeast of Panel 26;
- P5 - 950m north-west of Panel 26 that was used for general domestic / irrigation water. Monitoring ceased in P5 in August 2010 due to a request from the property tenant;
- P6 - 1.1km east of Panel 26 in the old Jay-R Stud; and
- P7 and P8 - within the Inghams Turkey property, between the eastern end of Panels 25 and 26 and the Bargo Gorge.

The actively used private bores GW105254 (McPhee), GW107918 (Machin), GW109010 (Pescud) and GW109224 (Boissery) and GW105813 (Kavanagh) are fully sealed with pump equipment and their water levels are not monitored.

The Pescud and McPhee private bores are located over Longwall 26. The Boissery and Machin bores are located to the south east of Longwalls 28 and 29 respectively, whilst the Kavanagh bore is located to the east of Longwall 31.

All piezometers and bores are located as shown in **Drawing 1** whilst the monitored groundwater levels are shown in **Figure 7**.

No open standpipe piezometer water level reduction in response to Longwall 29 has been observed, and no complaints of adverse effects on private bore water levels or yield were received by the Colliery during extraction of Longwall 29.

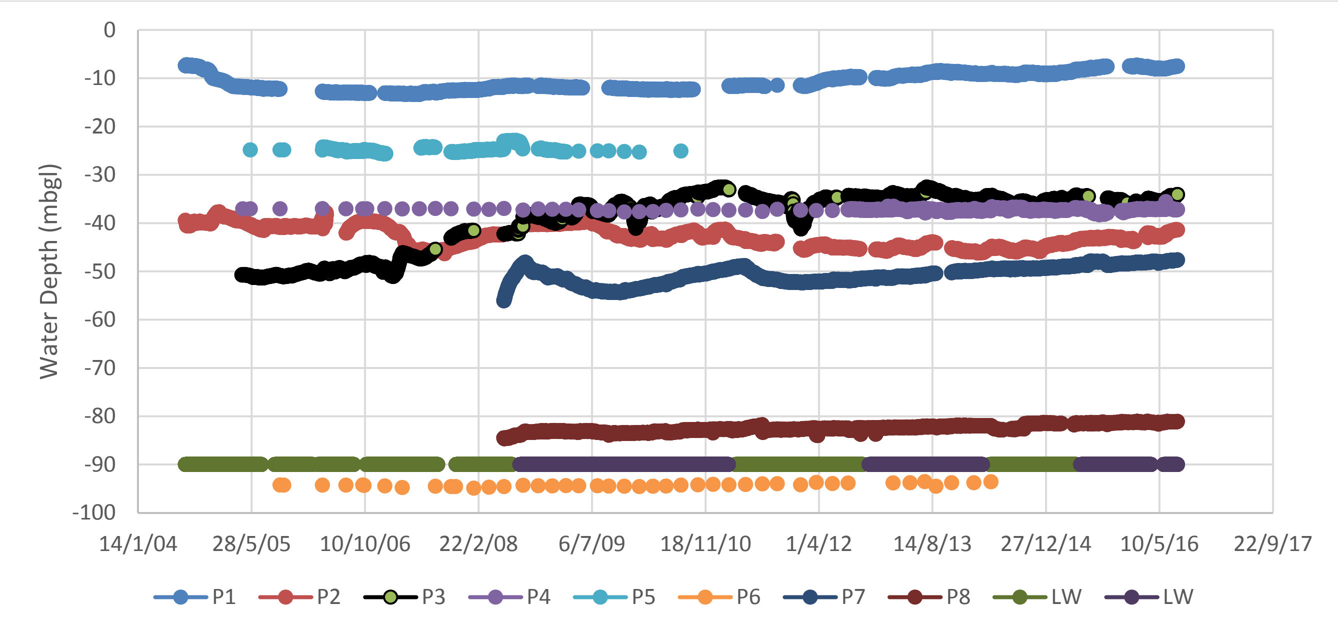


Figure 7 **Standing Water Levels and Panel Extraction**

3.7.2 Vibrating Wire Piezometers

Monitoring data from the vibrating wire piezometers (VWP) TNC28 and 29 are shown in **Figure 8**, whilst TNC36, 40 and 43 are shown in **Figure 9**.

The graphs indicate that the Bulli Seam has been dewatered in TNC28 and 29, whilst the Bulgo Sandstone has undergone partial depressurisation in TNC28 and TNC29, along with the Scarborough Sandstone in TNC29.

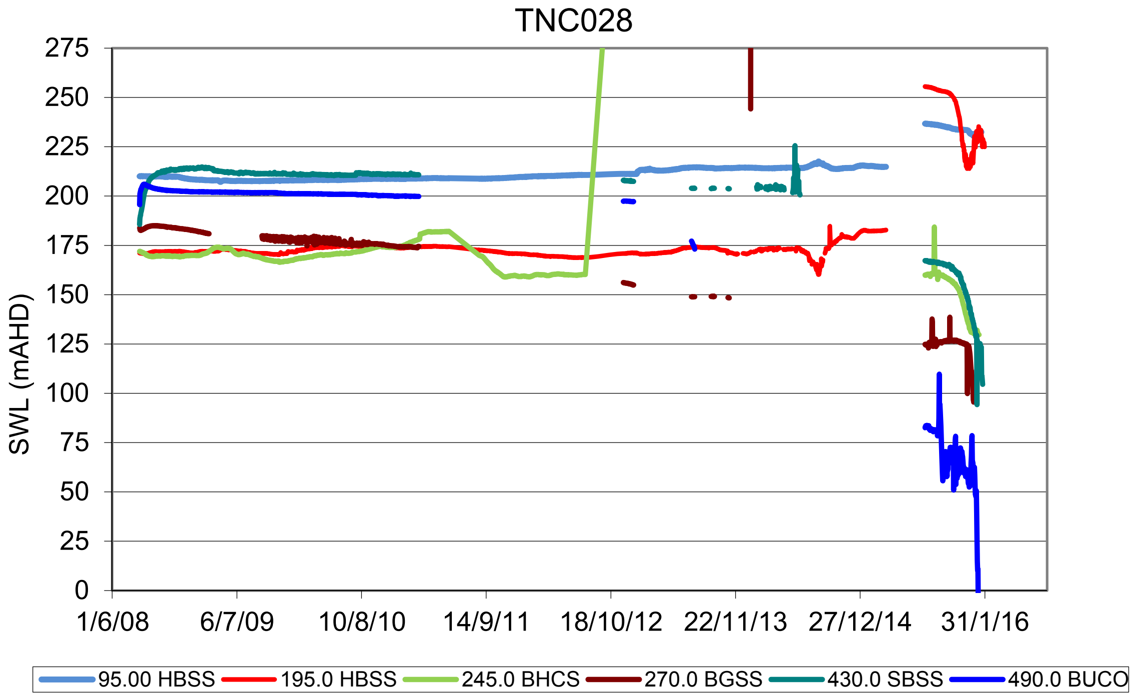
TNC28 overlies Longwall 29, whilst TNC29 overlies the chain pillar between Longwalls 29 and 30. TNC29 was decommissioned prior to it being undermined by the longwall.

Partial depressurisation is observed in the Hawkesbury Sandstone at 97mbgl as well as in the Bulgo Sandstone (at 169 / 214 / 299mbgl) and the Bulli Seam in TNC36.

The Hawkesbury Sandstone (225mbgl) in TNC40 is undergoing partial depressurisation, along with the Bulgo Sandstone (at 252 & 352mbgl) and the Bulli Seam.

Partial depressurisation is also observed in the Hawkesbury Sandstone (213mbgl) as well as in the Bulgo Sandstone (at 240 / 333 / 425mbgl) and Bulli Seam in TNC43.

TNC36 is located approximately 1600m north of Longwall 29, whilst TNC40 is located approximately 1300m north east and TNC43 is approximately 1050m north east of Longwall 29.



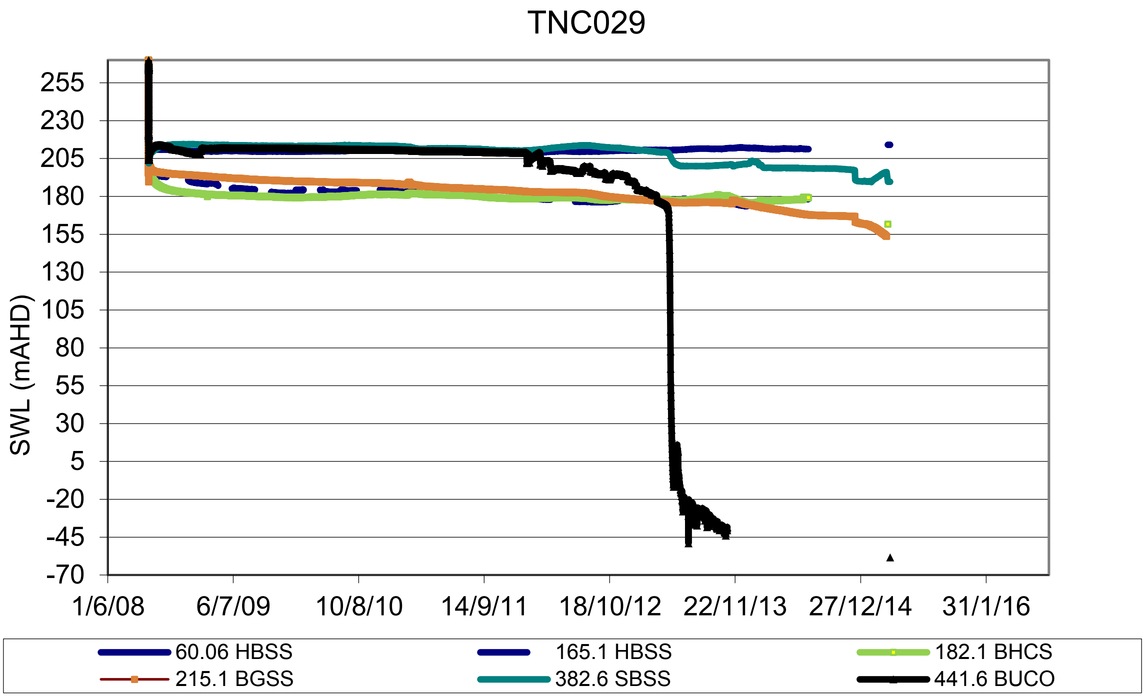
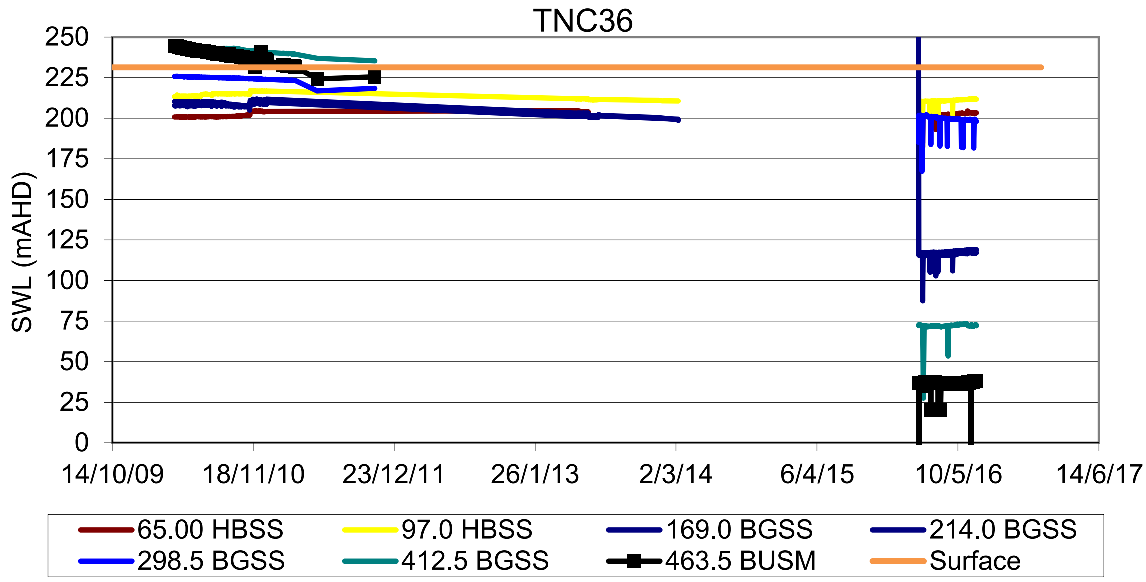
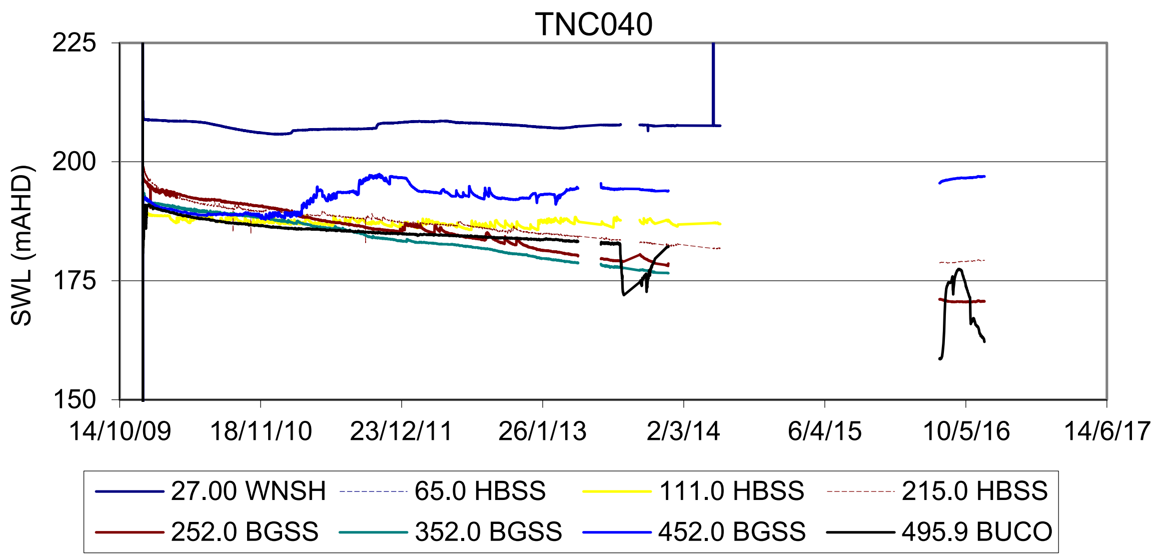


Figure 8 Vibrating Wire Piezometer TNC28 and 29 Groundwater Levels





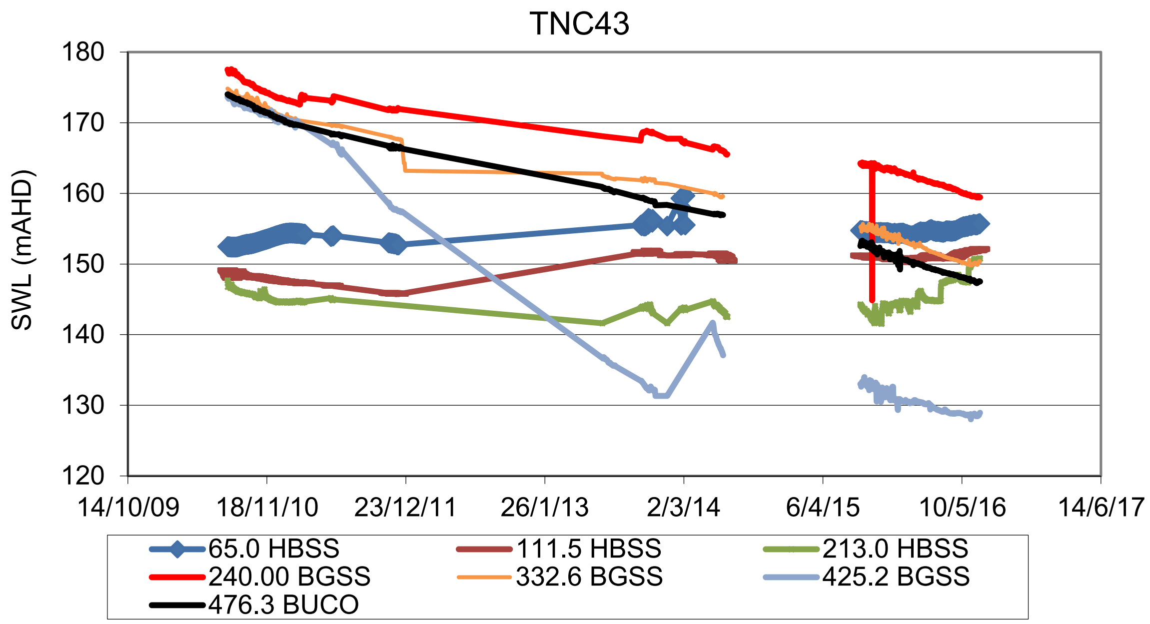


Figure 9 Vibrating Wire Piezometer TNC36, 40 and 43 Groundwater Levels

3.7.3 Aquifer / Aquitard Interconnection

The available data from the open standpipe piezometers, coal exploration and private bores, as well as the piezometric head monitoring in TNC28 and TNC29 have not indicated any adverse breaching or interconnection between the Hawkesbury Sandstone and Bulgo Sandstone, or through the Bald Hill Claystone.

Hydraulic connection has been instigated between the Bald Hill Claystone and Bulgo Sandstone in TNC28 as well as between the base of the Scarborough Sandstone and the Wombarra Shale in TNC29 during extraction of Longwalls 22 to 28 as shown in **Figure 10**.

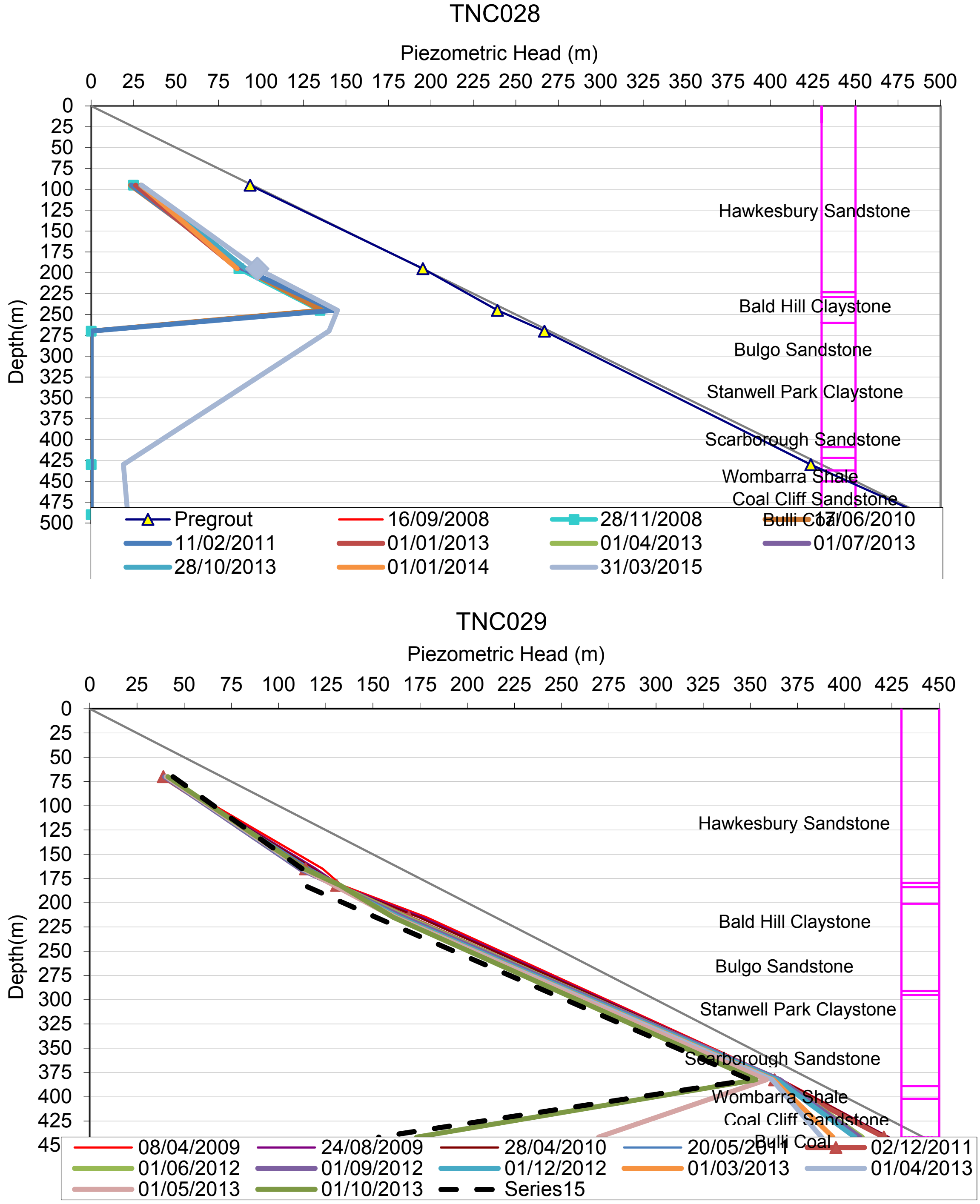


Figure 10 Vibrating Wire Piezometer Head vs Depth

3.7.4 Groundwater Seepage To or From Streams

To date, no loss of stream flow from Myrtle Creek or Redbank Creek into the Tahmoor workings has occurred.

Generation of a new seep was observed at Site 21A into Myrtle Creek over the mid-stream reach section of Longwall 28.

Reduction of groundwater seep / stream flow volumes into or within Myrtle or Redbank Creek has been observed over the extracted longwalls, with additional return seepage flowing back into the streams in the next longwall reach downstream of the extracted panels.

3.7.5 Groundwater Quality

Groundwater in the study area has generally brackish salinity (459µS/cm to 12,250µS/cm) with acid to circum-neutral pH (3.06 to 7.6) as shown in **Figure 11**.

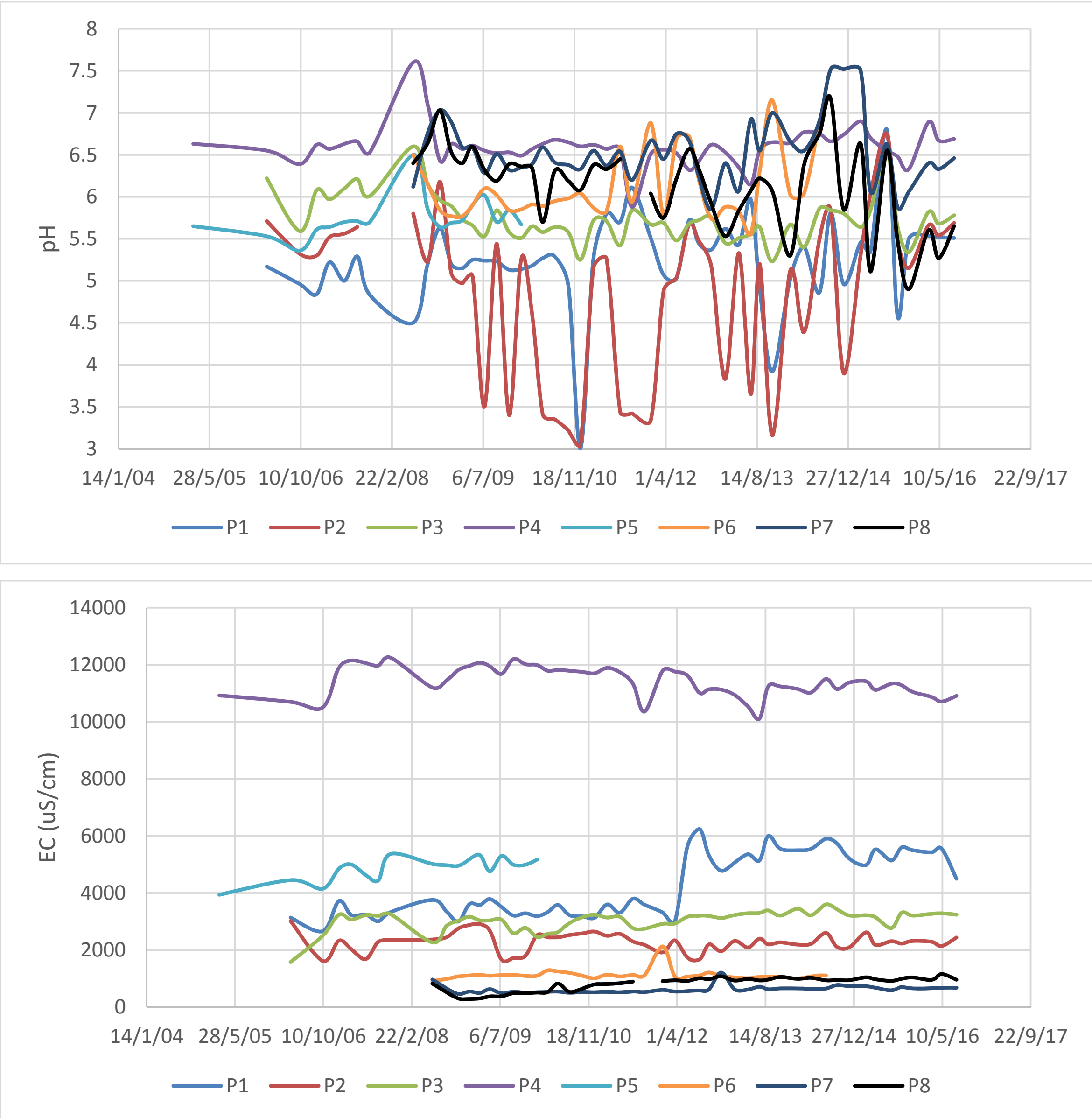


Figure 11 Field Groundwater Quality

Laboratory analyses obtained to date indicate that the bore water generally is outside ANZECC 2000 criteria (default trigger values for physical & chemical stressors in SE Aust upland rivers / 95% protection of freshwater species / livestock / irrigation) for:

- pH;
- Electrolytical conductivity;
- Sodium;
- Hardness;
- Total nitrogen, total phosphorous, as well as; and
- Filterable manganese, copper, zinc, nickel, aluminium and, to a small degree, lead.

The exceedance varies depending on the applicable guideline applied for the end use of the water.

Groundwater in the Longwall 22 to 29 subsidence area is suitable for selected livestock and limited irrigation use, but not for potable water.

No complaints regarding groundwater quality changes have been reported in the study area during the monitoring period.

No adverse change to groundwater quality in the subsided bores has been observed, along with no distinctive increase in salinity, iron or manganese.

4. CONCLUSIONS

Based on monitoring of streams, dams and groundwater conducted prior to, during and after extraction of Longwall 29, the following conclusions can be made:

- Significant stream bed cracking, associated with a reduction in stream flow and pool desiccation has been observed in Redbank Creek due to extraction of Longwall 29 (and preceding panels) downstream to Site RR11 over the mid reach section over Longwall 30;
- Re-emergence of the connected pool stream "through-flow" occurs over the centre of Longwall 30 at Site RRS12;
- A large east coast low storm that occurred in early June 2016 resulted in significant flows in Redbank Creek, which resulted in many of the previously cracked, lifted or delaminated rock slabs being broken up and washed downstream;
- The "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability*" TARP was triggered on;
  - ➢ 18th February 2016 between Sites 26A and RC2 / 37 in Redbank Creek over Longwall 28 as well as the LW28/29 chain pillar and the tailgate section of Longwall 29;
  - ➢ 18th February 2016 at Site RR9 over the tailgate section of Longwall 30, and;
  - ➢ 29th March 2016 between Sites RR2 and RB5 in Redbank Creek over Longwall 29.
- The "*significant reduction compared to baseline and predicted impacts last over more than 2 months or 2 standard deviation over 2 months reduction in water quality*" TARP was also triggered at Site RC2 (aka Site 37) for zinc on 18/2/16;
- Significant depressurisation of the Bulli Seam has been observed in the vibrating wire piezometer bore at TNC28 and 29 along with partial depressurisation in the Bulgo Sandstone in TNC28, 29, 36, 40 and 43, and;
- No adverse effects on private bore yield or water quality have been reported during or after the Longwall 29 extraction period.

5. REFERENCES

ANZECC 2000 Australian and New Zealand Guidelines For Fresh and Marine Water Quality

GeoTerra, 2004 Longwall Panels 22 and 23 Surface Water, Stream, Alluvial Land and Groundwater Subsidence Management and Monitoring

GeoTerra, 2006 Longwall Panels 24 to 26 Surface Water & Groundwater Subsidence Management Plan

GeoTerra, 2009 Longwall Panels 27 to 30 Surface Water & Groundwater Assessment

GeoTerra, 2011 End of Longwall 25 Streams Dam and Groundwater Monitoring Report

GeoTerra, 2013 Tahmoor Colliery Groundwater Management Plan

GeoTerra, 2013A End of Longwall 26 Surface Water, Dams and Groundwater Monitoring Report

GeoTerra, 2014 End of Longwall 27 Surface Water, Dams and Groundwater Monitoring Report

GeoTerra, 2015 End of Longwall 28 Surface Water, Dams and Groundwater Monitoring Report

GeoTerra, 2016 Myrtle Creek End of Undermining Status Report

Mine Subsidence Engineering Consultants Pty Ltd 2003 The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure (In support of a section 138 application)

Mine Subsidence Engineering Consultants Pty Ltd 2006A The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Surface and Sub Surface Features Due to Mining Longwalls 24 to 26 at Tahmoor Colliery in Support of and SMP Application

Mine Subsidence Engineering Consultants Pty Ltd 2006B End of Panel Monitoring report for Longwall 23B at Tahmoor Colliery

Mine Subsidence Engineering Consultants Pty Ltd 2008 End of Panel Subsidence Monitoring Report for Longwall 24B at Tahmoor Colliery

Mine Subsidence Engineering Consultants Pty Ltd 2008 Supplementary Information on the Potential Ground Movements and Impacts Along the Bargo River Due to Mining of Longwall 25

Mine Subsidence Engineering Consultants Pty Ltd 2008 Results of Monitoring of Inghams Infrastructure During Mining of Longwall 25

Mine Subsidence Engineering Consultants Pty Ltd 2009 Longwalls 27 to 30 Subsidence Predictions and Impact Assessment for Natural Features and Items of Surface Infrastructure

Mine Subsidence Engineering Consultants Pty Ltd 2014 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 27

Mine Subsidence Engineering Consultants Pty Ltd 2015 Tahmoor Colliery Longwall 28 Subsidence Monitoring Report R44

Mine Subsidence Engineering Consultants Pty Ltd 2015A End of Panel Subsidence Monitoring Report for Tahmoor Longwall 28

Mine Subsidence Engineering Consultants Pty Ltd 2016 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 29

NSW Dept Planning, 2008 Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield – Strategic Review

Strata Control Technologies, 2008 Packer Test Summary Hole P1 and P2 (now amended to P7 and P8)

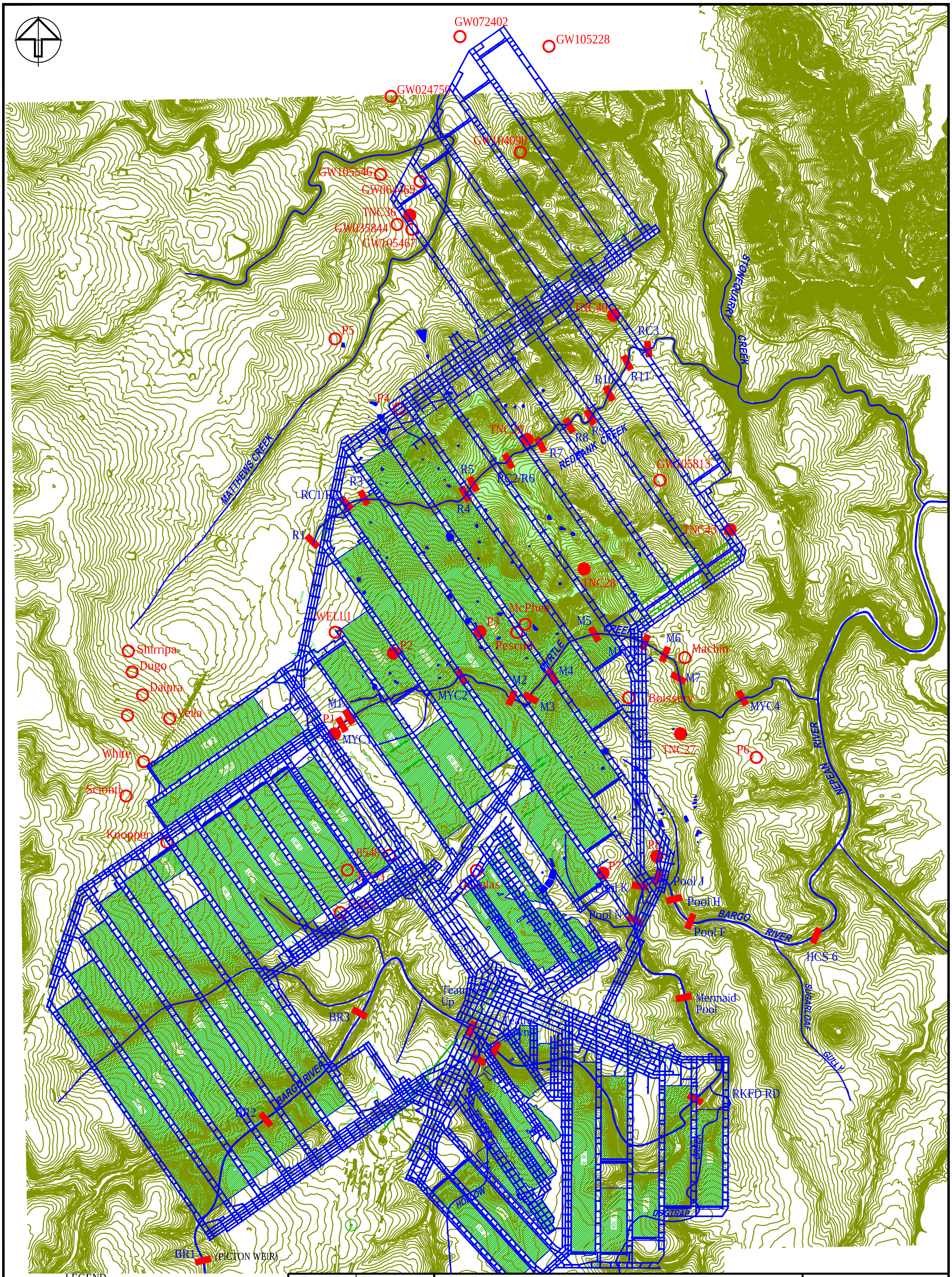
LIMITATIONS

This report was prepared in accordance with the scope of services set out in the contract between GeoTerra Pty Ltd (GeoTerra) and the client, or where no contract has been finalised, the proposal agreed to by the client. To the best of our knowledge the report presented herein accurately reflects the clients requirements when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

In preparing this report, GeoTerra has relied upon information and documentation provided by the client and / or third parties. GeoTerra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. GeoTerra assume the client will make their own enquiries in regard to conclusions and recommendations made in this document. GeoTerra accept no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to GeoTerra.

The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of GeoTerra is solely to its client and it is not intended that this report be relied upon by any third party. This report shall not be reproduced either wholly or in part without the prior written consent of GeoTerra.



LEGEND

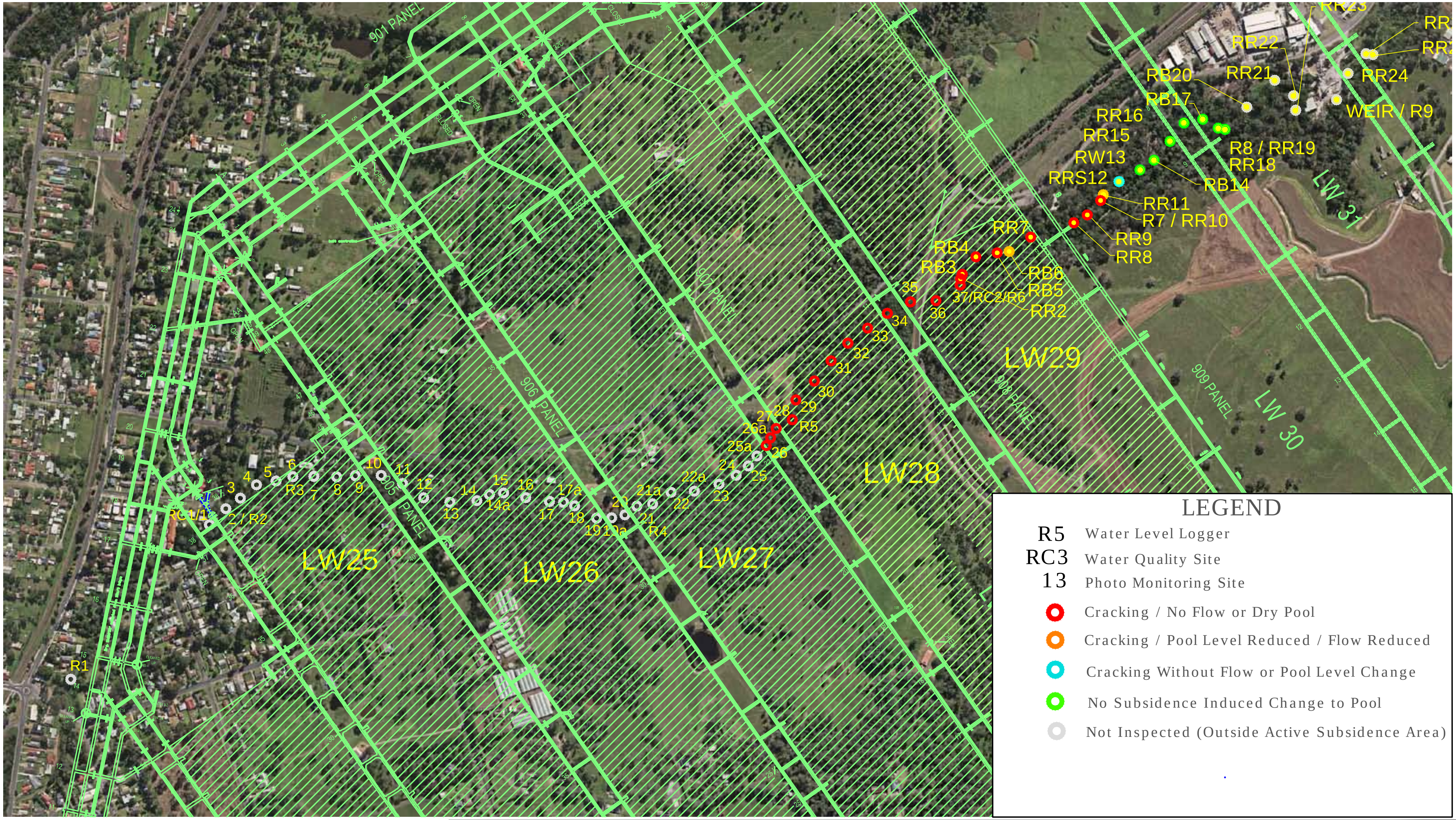
- PIEZOMETER
- STREAM MONITORING SITE
- NOW REGISTERED BORE / WELL

PROJECT:	TA28
DRAWN:	A. DAWKINS
DATE:	2 Aug 2016
SCALE:	1:30 000

TAHMOOR COAL PTY LTD
TAHMOOR COLLIERY
WATER MONITORING LOCATIONS

GeoTerra

DRAWING1



LEGEND

R5 Water Level Logger

RC3 Water Quality Site

13 Photo Monitoring Site

Cracking / No Flow or Dry Pool

Cracking / Pool Level Reduced / Flow Reduced

Cracking Without Flow or Pool Level Change

No Subsidence Induced Change to Pool

Not Inspected (Outside Active Subsidence Area)

100 0 100 300 500

Scale (metres)

PROJECT:	TA29
DRAWN:	A. DAWKINS
DATE:	18 MAR 2016
SCALE:	As Shown

TAHMOOR COAL PTY LTD
REDBANK CREEK

Creek Status (18 March 2016)

GeoTerra

DRAWING 2

APPENDIX A

REDBANK CREEK END OF LONGWALL 29
SELECTED PHOTOGRAPHS

Site 28 (flow Monitoring Site R5) dry pool

Site 36 (downstream of railway culvert tunnel) dry reach

Site 37 (chemistry monitoring Site RC2)

Site RR2 dry pool

Site RB3 dry pool

Site RB4 dry pool

Site RB5 dry pool

Site RB6 dry pool

Site RR7 dry pool

Site RR8 dry / cracked rock shelf

Site RR9 dry/ cracked rock shelf

Site RR10 dry / cracked rock shelf

Site RR11 highly ferruginous pool

Site RRS12 highly ferruginous flow over the rock shelf.

(All sites downstream of here contain full pools or overland flow)

GeoTerra

Tahmoor Colliery

Myrtle Creek
End of Undermining
Status Report

TA28-R2A
18 August, 2016

GeoTerra Pty Ltd ABN 82 117 674 941

PO Box 530 Newtown NSW 2042

Phone: 02 9519 2190 Mobile 0417 003 502 Email: geoterra@iinet.net.au

Tahmoor Coal Pty Ltd
Tahmoor Underground
PO Box 100
TAHMOOR NSW 2573

Attention: Belinda Treverrow

Belinda,

RE: Tahmoor Colliery Myrtle Creek End of Undermining Status Report

Please find enclosed a copy of the above mentioned report.

Yours faithfully

GeoTerra Pty Ltd

Andrew Dawkins (AuSIMM CP-Env)
Principal Geoscientist

Distribution:	Original	GeoTerra Pty Ltd
	1 electronic copy	Tahmoor Colliery
	1 electronic copy	MSEC Pty Ltd

Authorised on behalf of GeoTerra Pty Ltd:	
Name	Andrew Dawkins
Signature	
Position	Principal Geoscientist

Date	Rev	Comments
16/08/2016		Initial Draft
18/08/2016		Incorporate reviewer comments

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Tables

Figures

Drawings

1. INTRODUCTION

Tahmoor Colliery (Tahmoor Coal Pty Ltd) has extracted the Bulli Seam in Longwalls 22, 23A, 23B, 24A, 24B and 25 to 29 by retreat mining within the Tahmoor North Lease Area since June 2004.

The previous panels and the current panel (Longwall 30) are located underneath Tahmoor and Thirlmere villages, as well as surrounding urban and semi-rural areas as shown in **Drawing 1,** which are approximately 4 kilometres (km) south of Picton in the Southern Coalfield of NSW.

This report describes the undermining and associated subsidence effects which occurred due to extraction of Longwalls 22 to 28 under the main channel of Myrtle Creek, as well as the current status of the creek, after undermining, when Longwall 28 was completed.

Myrtle Creek is a Category 2 stream with 3rd order or higher channels, whilst its tributaries are Category 1 as they are 1st or 2nd order channels.

Monitoring has been conducted since June 2004 by assessing the;

- Ephemeral or perennial nature and flow in Myrtle Creek;
- Creek bed and bank erosion and channel bedload;
- Stream water quality;
- Stream bed and bank vegetation, and the;
- Nature of alluvial land along stream banks.

2. PREVIOUS STUDIES

Assessment of subsidence impacts relating to extraction of Longwalls 22 to 29 under Myrtle Creek has been reported on in end of panel reports by GeoTerra and Mine Subsidence Engineering Consultants (MSEC) since 2004 as shown in the references section.

Ongoing monitoring of water levels, flows and water quality in Myrtle Creek is being conducted throughout extraction of Longwall 30 by colliery staff, GeoTerra and Hydrometric Consulting Systems Pty Ltd (HCS) in accordance with GeoTerra (2013).

3. GENERAL DESCRIPTION OF MYRTLE CREEK

3.1 Mining Progression

Tahmoor Colliery extracted coal from the Bulli Seam between 420 – 500m below surface by longwall mining under Myrtle Creek with Longwalls 22 to 28.

As outlined in **Table 1**, Myrtle Creek was first undermined by Longwall 4 in early 1989, then by Longwall 22 around early March 2005, and was last undermined by Longwall 28 around mid May to early June 2014.

Longwalls 23A and 24A did not undermine the creek.

Although Longwall 29 did not undermine the creek, its 20mm subsidence zone intersected the creek, whilst Longwall 30, which also did not undermine the creek, is currently being extracted.

Seam thickness varies from 1.8m at the finish end of Panel 24B / Panel 25 up to 2.15m in Longwall 29.

Longwalls 22 to 29 are 283m wide rib to rib, with 34.5m to 40m wide chain pillars and between 771m to 3,730m long as shown in **Drawing 1**.

Table 1 Panel Extraction and Myrtle Creek Undermining Details

Longwall	Longwall Start	Longwall Finish	Period of Myrtle Creek Undermining	Depth of Cover (mbgl)
4	04/02/89	09/05/89	April 1989	approx. 400
22	02/06/04	11/07/05	early March 2005	420 – 432
23A	07/09/05	20/02/06	not undermined by creek	430 – 450
23B	15/03/06	21/08/06	early – mid September 2005	430 – 440
24B	15/10/06	26/08/07	mid February 2007	430 – 440
24A	15/11/07	190/7/08	not undermined by creek	420 - 448
25	22/08/08	27/02/11	early May – early September 2009	440 - 460
26	30/03/11	11/10/12	mid – end August 2011	440 - 470
27	10/11/12	22/03/14	early – late March 2013	420 - 495
28	20/04/14	01/05/15	mid May – early June 2014	420 - 500
29	29/05/15	03/04/16	not undermined by creek	425 - 490
30	20/6/16	ongoing	not undermined by creek	425 - 490

3.2 Myrtle Creek Stream Bed Topography, Drainage and Geology

Myrtle Creek flows directly into the Nepean River approximately 1.8km southeast of Longwall 29.

Its headwaters are located over Longwall 4 upstream of Panel 22 and generally consist of small grass covered channels that become larger and more incised downstream of Panels 23 to 29.

The riparian flanks have been significantly altered by residential development in Tahmoor, whilst the channel has not been significantly affected except where general rubbish or solid waste has been dumped in the creek or it is overgrown by invasive weeds. Some isolated weeding and stream bank regeneration works have been conducted, however many of the areas are re-infested with weeds.

The stream bed and banks are generally well vegetated, and do not show significant erosion or bank instability.

No NOW registered water extraction is listed within the creek, however an unlicensed pump was present over the middle of Longwall 25, off Castlereagh Street.

Its stream bed comprises either very shallow alluvial sediments (<1m thick), generally as sand or sandy clay, sandstone boulder fields, or, commonly, exposed Hawkesbury Sandstone.

In general, the area is developed for either residential use, with semi-rural residential development on the fringes of Tahmoor and Thirlmere villages, along with some agricultural land use for orchards, vegetable green houses, chicken and turkey farms as well as limited cattle grazing.

The creeks in the vicinity of the villages are generally in a poor state, with high content of various weeds, as well as rubbish dumped or washed down the catchment. The creeks are generally less weed and rubbish affected outside of the immediate developed areas.

Apart from the weeds and rubbish, the creek bed and banks are generally well vegetated, and do not show evidence of significant erosion or bank instability.

3.3 Regional Geological Structures

Mapped and inferred geological structures in the vicinity of Myrtle Creek include NW and NNW trending faults and a NW trending intrusive dyke with a subset of EW to ENE trending faults.

The dyke which caused mining problems in Panel 22 was mapped as a dilational zone within Panel 23, and extrapolated into Panel 24 along a south easterly strike.

No additional groundwater seepage inflows to the mine workings were encountered whilst mining through the dyke.

The NNW trending Victoria Park Fault Zone lies to the east of the longwalls and Myrtle Creek.

The Nepean Fault and Bargo Fault Zones are approximately 2 kilometres east of the longwalls and did not influence subsidence profiles or groundwater flows associated with the extracted longwalls.

3.4 Vegetation

The Lucas Heights soil landscape contains remnant low open eucalypt woodland with a schlerophyll shrub understorey in uncleared areas. Dominant trees species include turpentine, smooth barked apple, red bloodwood, silvertop ash, snappy gum and Sydney peppermint. Understorey species include black she-oak, Blue Mountains mallee ash and heath banksia. Cleared areas are dominated by grasses.

The Blacktown soil landscape has been almost completely cleared of its tall open wet schlerophyll, open forest and dry schlerophyll woodland forest and has been replaced with grassland. In uncleared sections, it is covered by tall open forest, including the remnant Sydney Blue Gum and blackbutt which grow in higher rainfall areas.

Pockets of original woodlands and open forests remain in drier areas in the west, including forest red gum, narrow leaved iron bark and grey box.

Creek beds are generally well vegetated, albeit with grass in the rural areas and weeds in the developed areas. Where wet, reeds, lilies and other water plants are present in the channel bed and ponds.

3.5 Myrtle Creek Subsidence Monitoring

The maximum monitored subsidence, tilt and strain over Longwalls 22 to 29, following the completion of Longwall 29 is shown in **Table 2**, whilst valley closure measured in Myrtle Creek is shown in **Table 3**.

Table 2 Maximum Subsidence Parameters at the Completion of Longwall 29

Component	Observed Total Movement
Vertical subsidence	1124 mm
Tilt	6.3 mm/m
Tensile / Compressive Strain	2.1 / -7.7 mm/m

Very little additional, incremental valley closure was experienced during Longwall 29 extraction with a maximum incremental closure of 10 mm across the MXD Line and 5 mm and 7 mm on the MXB and MXC lines, respectively.

Table 3 Myrtle Creek Valley Closure to the Completion of Longwall 29 (mm)

Line Location	LW22	LW23B	LW24B	LW25	LW26	LW27	LW28	LW29	Total
Turner - Denmead	-	-	18+	-	-	-	-	-	18+
Castlereagh St	-	-	12	179	52	8	3	-	254
Elphin – Myrtle Streets	-	-	21	142	22	-	-	-	185
Elphin – St Brundah Rd	-	-	0	21	6	-	-	-	27
Huen Place	-	-	58	15	20	-	-	-	93
Main Sthn Railway u/s	-	-	-	57	36	5	-	-	98
Main Sthn Railway d/s	-	-	-	86	50	12	-	-	148
13 York St	-	-	-	-	51	9	1	-	61
9A York St	-	-	-	-	73	n/a	n/a	n/a	73+
MXA Line	-	-	-	-	-	115	138	-	253
MXB Line	-	-	-	-	-	94	144	149	238
MXC Line	-	-	-	-	-	67	132	130	199
MXD Line	-	-	-	-	-	17	98	103	115
KXA Line	-	-	-	-	-	-	30	-	30
KXB Line	-	-	-	-	-	-	76	-	76

Source (MSEC, 2016) n/a no granted access to site - not measured

3.6 Stream Flow, Level, Chemistry and Subsidence Impact Monitoring Locations

Bi-monthly (unless otherwise specified in the relevant TARP) stream water level, and subsequently stream flow monitoring, as well as field chemistry and laboratory analysis of water samples has been conducted in Myrtle Creek since December 2004 at the water level and / or chemistry monitoring sites summarised in **Table 4** and shown in **Drawings 1** to **3**.

The “Myc” sites have been monitored by GeoTerra, whilst the “M” designated sites have been monitored by Hydrometric Consulting Services Pty Ltd (HCS).

Table 4 Myrtle Creek Water Level and / or Chemistry Monitoring Locations

Site	Description	Monitored Parameters
Myc1	Upstream of Thirlmere Way culvert	Pool depth (discontinued), field and laboratory chem.
Myc2	Downstream of Brundah Road culvert	Pool depth (discontinued), field and laboratory chem.
Myc3	At Remembrance Driveway bridge	Pool depth (discontinued), field and laboratory chem.
Myc4	Downstream of old Jay-R Stud	Pool depth (discontinued), field and laboratory chem.
M1	Thru park off Thirlmere Way	Dirt / vegetation pool depth and flow
M2	Access off railway culvert	Root / dirt pool depth and flow
M3	Downstream of York Park	Root growth pool depth and flow
M4	Downstream of M3	Rock bar pool depth and flow
M5	Access thru vacant block in Remembrance Driveway	Rock bar pool depth and flow
M6	Access opposite 12 River Road	Rock bar pool depth and flow
M7	Access thru Suffolk Street Lane near Sydney Water pump station	Concrete weir

Table 5 details monitoring sites that were designated for weekly monitoring in the relevant TARP before, during and after active undermining periods.

Table 5 Myrtle Creek Weekly Observation Sites (whilst being undermined)

Site	Description	Additional Site Name
1	pool upstream of culvert	
2	pool with culvert and willow constrained pool and M3 site	M3 (HCS)
3	pool behind log jam	
4	extended pool	
5	extended pool	
6	extended pool	
7	extended pool	
8	race over rock shelf / pool at creek bend	
9	extended pool with motorbike wheel	
10	extended pool with large fallen tree	
11	extended pool in landowner cleared area	M4 (HCS)
12 (12A)	extended pool	
13 (13A)	race over rock shelf and downstream pool with tractor tyre	
14	exposed rock shelf	
15	extended pool (with gas cylinder)	
16	small waterfall / rock race	
17	extended pool (with concrete cylinder)	
18	railway works outflow pool	
19	extended pool and race over exposed sandstone plus small rock spall	
20	race over exposed sandstone	
21	race over exposed sandstone, 2-3m waterfall and downstream pool	
22	race over exposed sandstone	
23	large rock bar constrained pool	M5 (HCS)
24	pool downstream of M5 site	
25	rock pool	
26	overgrown boulder race	
27	rock pool	
28	exposed sandstone race	
29	rock pool	
30	exposed sandstone race	
31	boulder pool	MYC3 (GeoTerra)

4. CREEK SUBSIDENCE EFFECT AND IMPACT MONITORING

4.1 Physical Impacts

4.1.1 Longwall 4

No impacts on the soil dominated creek bed or banks in the headwaters of Myrtle Creek have been observed or reported over Longwall 4 when the creek was undermined around April 1989.

4.1.2 Longwall 22

Myrtle Creek was undermined by Longwall 22 around early March 2005.

Valley closure and upsidence occurred in a tributary of Myrtle Creek near the centre of the panel, although no creek bed cracking or other subsidence effects were observed after LW22 undermined the creek.

The reduced subsidence observed on Macquarie Place is due to the presence of a dilational igneous intrusion in the Bulli Seam beneath Macquarie Place and Stuart Place, with an increased tilt into the subsidence bowl of approximately 9 mm/m. The observed strains are less than 2 mm/m.

Observed subsidence in Myrtle Creek was approximately 0.5m, with strains generally between -1.6 mm/m tensile and 0.6 mm/m compressive, although higher strains were observed near the intrusion which necessitated Longwall 23 to be subdivided into two sections.

4.1.3 Longwall 23A

Longwall 23A did not undermine or have any impact on Myrtle Creek.

4.1.4 Longwall 23B

Myrtle Creek was undermined by Longwall 23B from early to mid-September 2005.

The starting point of the subdivided northern section of the Longwall (23B) is close to Myrtle Creek and therefore the creek did not undergo significant additional subsidence associated with extraction of 23B, whilst tilts and strains at the southern starting point of the longwall, north of the dilational intrusion in the Bulli Seam, were likely to be high, although were not directly measured in the creek.

Cracking of the soil and bedrock over Panels 22 and 23B, probably due to non-systematic upsidence and valley closure movements occurred after LW23B undermined the creek bed at locations shown in **Drawing 2**.

Figure 1 shows sandstone pool base cracking that developed over Longwall 22 after Longwall 23 undermined the creek.

The cracking was up to 10mm wide and limited to the base of the creek within a small rock bar over Panel 22, whilst the soil cracking occurred at the southern end of Panel 23B, close to the barrier pillar between Panels 23A and 23B.

The bedrock crack in the creek bed over Panel 22 is within a small sandstone rock bar outcrop, with no observable adverse effect on stream flow, and therefore, no rehabilitation of the Panel 22 cracking was proposed.

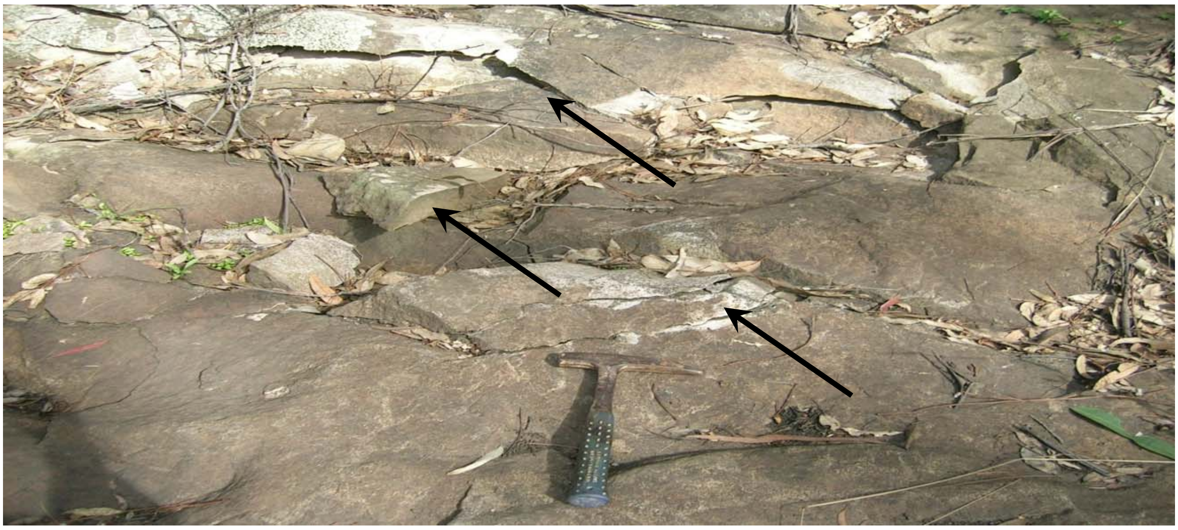


Figure 1 Cracking over Longwall 22

The soil crack over 23B was located close to the Longwall 23A and 23B barrier pillar. It was up to 65mm wide and extended into the soil to approximately 1.5m - 2.0m over an approximate length of 40m, however, it did not develop within the bed of Myrtle Creek, even though it was observed on both the upper banks and flank of the creek.

Even though soil cracking was noted in the creek over Longwall 23B, it did not instigate bed or bank instability and was not rehabilitated. No surface flow diversion, reduction in water quality or change to ponding or pool storage capacity was observed in the creek.

Figure 2 Cracking over Longwall 23B

4.1.5 Longwall 24B

Myrtle Creek was undermined by Longwall 24B around mid-February 2007.

No creek bed cracking was observed over the longwall, along with no observable adverse effects on stream bed or bank stability, flow or pool holding capacity.

Valley closure and upsidence was observed on monitoring lines across the creek near Huen Place and Elphin Street. Valley closure was first observed following the 900 metre survey and the observed peak compressive strains aligned with the base of the creek.

Upsidence movements are less evident than the valley closure related compressive strains.

No impacts were observed on the Castlereagh Street bridge over the creek, with a maximum subsidence of 58 mm along with negligible tilts and strains as summarised below;

- Elphin St 300mm subsid, 2mm tilt, +0.5 to -0.75mm/m strain (over 24B)
- Elphin / Myt Ck 75mm subsid, -1.5mm/m tilt, -4.5 to 0.5mm/m strain (over 24B)
- Huen Place 450mm subsid, 2mm /m tilt, -3.5 to 0.25mm/m strain (over 24B)
- Turner Denmead 275mm subsid, -2mm tilt, -5.0 to 0.5mm/m strain (over LW22)

4.1.6 Longwall 24A

Longwall 24A was mined after Longwall 24B.

It did not undermine, or have any effect on Myrtle Creek.

4.1.7 Longwall 25

Myrtle Creek was undermined by Longwall 25 between early May and early September 2009.

After Myrtle Creek was undermined by the longwall, subsidence within the creek was observed to have generated limited exposed sandstone stream bed cracking or isolated exposed sandstone through flow over Longwalls 22, 23B and 25, along with soil cracks in the upper bank and flanks over Panel 23B at locations shown in **Drawing 2**.

The available measured maximum subsidence parameters from the limited data relevant to the channel of Myrtle Creek (from seven monitoring sites) are

- Subsidence 200 - 660mm
- Upsidence 20 - 110mm
- Closure 25 - 181mm
- Strain -1.1 to -37mm

Three areas of isolated cracking of exposed sandstone in the base or sides of generally dry pools occurred after the completion of Longwall 25 as summarised in **Table 6** and shown in **Figure 3**.

Table 6 Myrtle Creek Cracking

Location	North	East	Comments
LW22	277000	6211200	small isolated cracking in exposed sandstone in ephemeral pool
LW23B	277300	6211285	up to 5cm wide cracking in soil on a first order tributary
LW25	278155	6211203	small isolated cracking in exposed sandstone in ephemeral pool
LW25	278100	6211198	small isolated cracking in exposed sandstone in ephemeral pool
LW25	277845	6211320	small isolated spalling of sandstone in ephemeral pool

Due to the low quantum of subsidence and high vegetative cover in the creek, no erosion from the creek bed or banks or sediment accumulation in subsidence troughs has been observed.

Reversal of flow in the creek did not occur as the creek gradient exceeds the subsidence tilt in the stream.

Figure 3 Cracking over Longwall 25

4.1.8 Longwall 26

Myrtle Creek was undermined by Longwall 26 between the mid to the end of August 2011.

As shown in **Drawing 2**, and summarised in **Table 7**, physical subsidence effects such as bedrock cracking and pool level reduction to full desiccation were observed in Myrtle Creek as a result of Longwall 26 extraction at sites 5 to 9, over the central to maingate section of Longwall 26, as well as at sites 12 to 16 over the central to maingate section of Longwall 27.

Table 7 Myrtle Creek Subsidence Effects after LW26 Extraction

Sites	Relative Location to Longwall	Effect	Effect Initially Observed
Over Longwall 26			
5	central / maingate	dry pool due to cracking	5/3/13
6	central / maingate	dry pool due to cracking	5/3/13
7	central / maingate	dry pool due to cracking	5/3/13
8	maingate	dry pool due to cracking	5/3/13
9	maingate	dry pool due to cracking	5/3/13
Over Longwall 27			
12	central / tailgate	pool level reduction and cracks in rock bar	5/3/13
13	central	cracking and dry pool continuation	5/3/13
14	central	dry pool due to cracking	5/3/13
15	central	cracking and dry pool	5/3/13
16	central / maingate	cracking and dry pool / race	5/3/13

Heavy rain and stream flow preceded the first survey over Longwall 26 on the 5th March 2013, during extraction of Longwall 27.

Overall, no observable adverse effects on stream flow, water quality and bed or bank stability were observed in the creek at the end of mining Longwall 26, whilst reversal of flow in the creek did not occur as the creek gradient exceeds the imposed subsidence tilt.

Photographs of sites adversely affected by Longwall 26 are shown on the following pages.

Figure 4 Site 5 and 6 Subsidence Effects after Longwall 26 Extraction

Figure 5 Site 7 and 8 Subsidence Effects after Longwall 26 Extraction

Figure 6 Site 9 and 12 Subsidence Effects after Longwall 26 Extraction

Figure 7 Site 13 and 14 Subsidence Effects after Longwall 26 Extraction

Figure 8 Site 15 and 16 Subsidence Effects after Longwall 26 Extraction

4.1.9 Longwall 27

Myrtle Creek was undermined by Longwall 27 around early to mid-March 2013, with the observed subsidence effects summarised in **Table 8** and shown in **Drawing 3**.

In addition to the sites over Longwall 26 that had previously been affected, additional subsidence effects were observed at:

- Sites 9, 10 and 11 over the chain pillar between Longwall 26 and 27;
- Sites 12 - 19 over Longwall 27, and, to a lesser degree, at;
- Sites 21 – 24 over Longwall 28

Table 8 Myrtle Creek Subsidence Effects after LW27 Extraction

Sites	Relative Location in the Panel	Effect	Effect Initially Observed	TARP First Triggered
Over Longwall 26				
4	central / tailgate	additional cracking and dry pool continuation	during LW26 & 22/3/13	10/5/13
5	central / maingate	continuation of dry pool due to cracking	during LW26	10/5/13
6	central / maingate	continuation of dry pool due to cracking	during LW26	10/5/13
7	central / maingate	continuation of dry pool due to cracking	during LW26	10/5/13
8	maingate	continuation of dry pool due to cracking	during LW26	10/5/13
9	maingate	additional cracking and dry pool continuation	during LW26 & 13/6/13	10/5/13
10	maingate	continuation of dry pool (no obvious cracking)	during LW26	10/5/13
11	LW26 / 27 chain pillar	continuation of dry pool (no obvious cracking)	during LW26	10/5/13
Over Longwall 27				
12	tailgate	additional cracking, dry pool and fallen tree	22/3/13	23/5/13
12A	central / tailgate	pool level reduction and cracks in rock bar	during LW26	no
13 – 13A	central	additional cracking and dry pool continuation	during LW26 & 5/4/13	10/5/13
14	central	continuation of dry pool due to cracking	during LW26	10/5/13
15	central	additional cracking and dry pool	during LW26 & 28/3/13	10/5/13
16	central / maingate	additional cracking and dry pool / race	during LW26 & 11/4/13	12/6/13
17	maingate	additional cracking and dry pool	during LW26 & 26/4/13	27/6/13
18	maingate	dry pool (no obvious cracking)	22/3/13	23/5/13
19	LW27 / 28 chain pillar	additional cracking of rock shelf, no overland flow	during LW26 & 26/4/13	27/6/13
Over Longwall 28				
21	tailgate / central	continuation of dry rock shelf due to cracking	during LW26	10/5/13
23	central - maingate	new cracks and pool dry	19/4/13	no
24	maingate	No flow, strong iron hydroxide developed	10/5/14	no

As shown in **Table 8**, the "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* TARP was triggered on 10 May 2013.

Where pools were cracked and drained, but the >20% pool level reduction did not last for longer than two months, the TARP trigger was not reached.

Photographs of new sites that were adversely affected by Longwall 27 are shown on the following pages.

Figure 9 Site 4 and 10 Subsidence Effects after Longwall 27 Extraction

Figure 10 Site 11 and 17 Subsidence Effects after Longwall 27 Extraction

Figure 11 Site 18 and 19 Subsidence Effects after Longwall 27 Extraction

Figure 12 Site 21, 23 and 24 Subsidence Effects after Longwall 27 Extraction

4.1.10 Longwall 28

Myrtle Creek was undermined by Longwall 28 between late May to mid-June 2014.

New subsidence effects due to Longwall 28 were observed at Sites 20 to 26 over the longwall.

During and after undermining by the longwall, Myrtle Creek was observed to undergo pool cracking and significant to total pool water holding capacity reduction at sites:

- 5 to 9, over the central to maingate section of Longwall 26;
- Sites 9, 10 and 11 over the chain pillar between Longwall 26 and 27;
- Sites 12 - 19 over all of Longwall 27, and at;
- Sites 20, 21 and 23, with less significant effects at Sites 21A to 28 over Longwall 28 as shown in **Drawing 2**.

As shown in **Table 9**, the "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* TARP was triggered on;

- 7th November 2014 between Sites 13A and 17, and;
- 14th August 2014 at Site 20.

Where pools were cracked and drained, but the >20% pool level reduction did not last for longer than two months, the TARP trigger was not reached, or if rainfall / runoff re-filled pools, the TARP trigger "clock" was re-set.

Reversal of flow in the creek was also not observed as the creek gradient exceeded the degree of imposed tilt in the stream bed.

Table 9 Myrtle Creek Subsidence Effects during LW28 Extraction

Sites	Relative Location in the Panel	Effect	Effect Initially Observed	TARP First Triggered
Over Longwall 27				
12	tailgate	additional cracking, dry pool and fallen tree	during LW27 & 02/07/14	_
12A	central / tailgate	pool level reduction and cracks in rock bar	during LW27 & 02/07/14	_
13 – 13A	central	additional cracking and dry pool continuation	during LW27 & 020/7/14	11/07/14
14	central	continuation of dry pool due to cracking	during LW27 & 07/05/14	11/07/14
15	central	additional cracking and dry pool	during LW27 & 07/05/14	11/07/14
16	central / maingate	additional cracking and dry pool / race	during LW27 & 07/05/14	11/07/14
17	maingate	additional cracking and dry pool	during LW27 & 07/05/14	11/07/14
18	maingate	dry pool (no obvious cracking)	during LW27 & 07/05/14	11/07/14
19	LW27 / 28 chain pillar	additional cracking of rock shelf, no overland flow	during LW27 & 06/08/14	_
Over Longwall 28				
20	tailgate	cracking and no flow or pool on sandstone shelf	during LW27 & 13/06/14	20/08/14
21	tailgate / central	dry rock shelf due to cracking	during LW27 & 06/08/14	_
21A	central	drying up of boulder pools in dense vegetation	during LW27 & 06/08/14	_
22	central	no subsidence induced change	_	_
23	central - maingate	cracking and drying up of pool	during LW27 & 02/07/14	_
24	maingate	no flow, strong iron hydroxide	during LW27 & 25/07/14	_
25	maingate	cracking and drying up of rock pool	during LW27 & 01/08/14	_
25A	maingate – pillar	cracking and drying up of pool	during LW27 & 01/08/14	_
26	LW28 pillar	drying up of overgrown boulder race	during LW27 & 02/07/14	_

Photographs of new sites that were adversely affected by Longwall 28 are shown on the following pages.

Figure 13 Site 20, 25 and 26 Subsidence Effects after Longwall 28 Extraction

4.1.11 Longwalls 29 and 30

Bi monthly monitoring of Myrtle Creek at sites shown in **Table 5** was conducted during Longwall 29 extraction as the longwall did not undermine the creek, however no significant change occurred at the affected sites during and after the longwall being completed.

Longwall 30 also did not undermine the creek, although bi-monthly monitoring of monitoring and observation sites over Longwalls 26, 27 and 28 is currently being conducted during the period of longwall extraction.

A summary of the observed subsidence effects during the period of Longwall 30 extraction is shown in **Figure 14**.

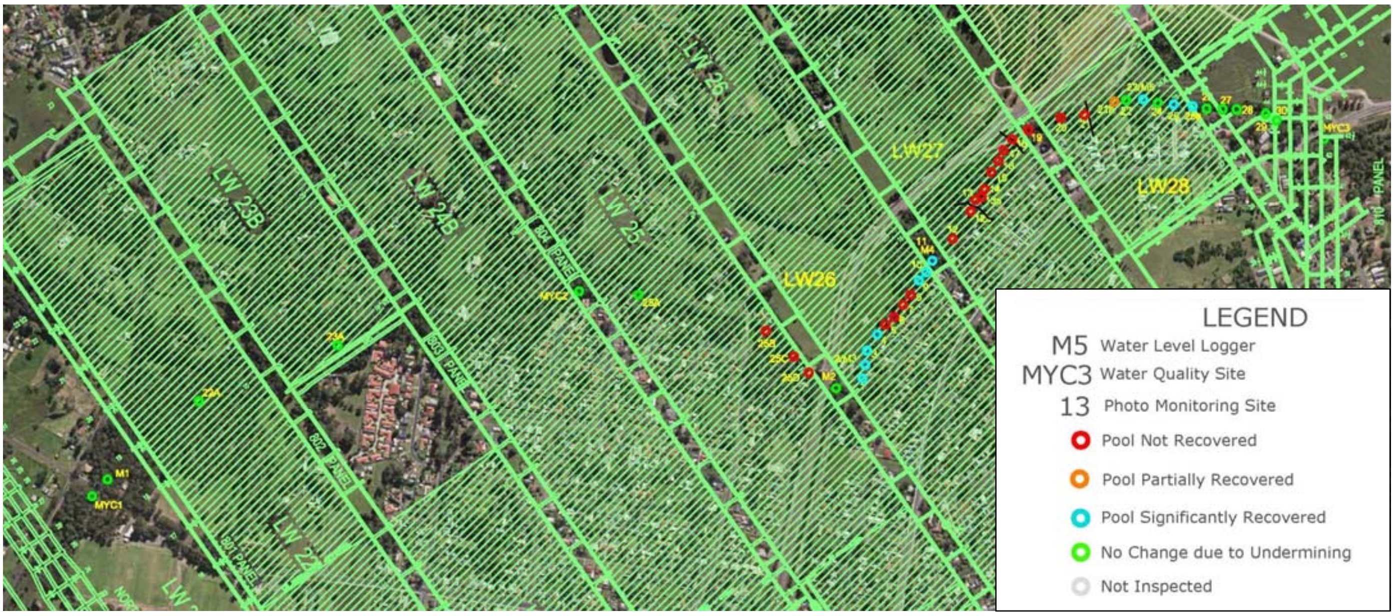


Figure 14 Subsidence Effects After Longwalls 29 and 30 (ongoing) Extraction

4.2 Myrtle Creek Pool Depth Monitoring

Stream depth monitoring using pressure transducers and loggers was instigated by GeoTerra in Myrtle Creek prior to extraction of Panel 22 and subsequently extended into lower Myrtle Creek and Redbank Creek in April 2005 (GeoTerra, 2011).

Hydrometric Consulting Services (HCS) took over the monitoring in March 2010, at an expanded (and different) suite of locations, with the original monitoring sites (MYC1-3) being decommissioned.

HCS are endeavouring to convert stream heights to flows when sufficient manual flow data is collected, however insufficient readings are currently available, whilst the flows in Myrtle Creek are very “flashy”.

Site M1 is located upstream of Longwall 22 and its water levels reflect its headwater position and lack of subsidence effects.

Site M2 was discontinued early in 2012 as it had not provided sufficiently reliable data and the control point was severely altered by a heavy flow in the creek.

M3 is located immediately downstream of the Longwall 25 / 26 chain pillar, whilst M4 is located over the chain pillar between Longwall 26 and 27.

M5 is located over the central to maingate section of Longwall 28, whilst M6 and M7 are located downstream of Longwall 28 as shown in **Drawing 1.**

Sites M1, M3, M4 and M5 show evidence of subsidence related pool holding capacity effects, whilst M6 and M7 show no subsidence effects on their pool holding capacity as shown in **Figure 15**.

Observation of weekly monitoring sites 1 to 30, which overlie Longwalls 26 to 28 and to 175m downstream of Longwall 28, indicate that stream flow and pool depths have been significantly affected by subsidence associated with Longwalls 26 to 28 between Sites 13 - 21.

No observable change in Myrtle Creek flow was observed during extraction of Panels 22 and 23A, with the main flow determinant in the monitoring period being the lack of rain.

The creek had an extend no-flow period up to completion of 24B due to lack of rain prior to the February 2007 rains, with interspersed short periods of flow followed by static pondage as the creek gradually dried up.

A new seep was generated at Site 21A during Longwall 28 extraction, which maintains flow in Site 22, however the water that flows into a large pool at Site 23 was generally insufficient to maintain above low levels and the pool often dried out after Longwall 28 extraction, although a recovery in pool holding capacity was observed after extraction of Longwall 29.

Seepage flow is generally observed in a downstream pool at Site 24, with pool levels often maintained, although they are now more responsive from Sites 25 to 31 after extraction of Longwalls 27 and 28.

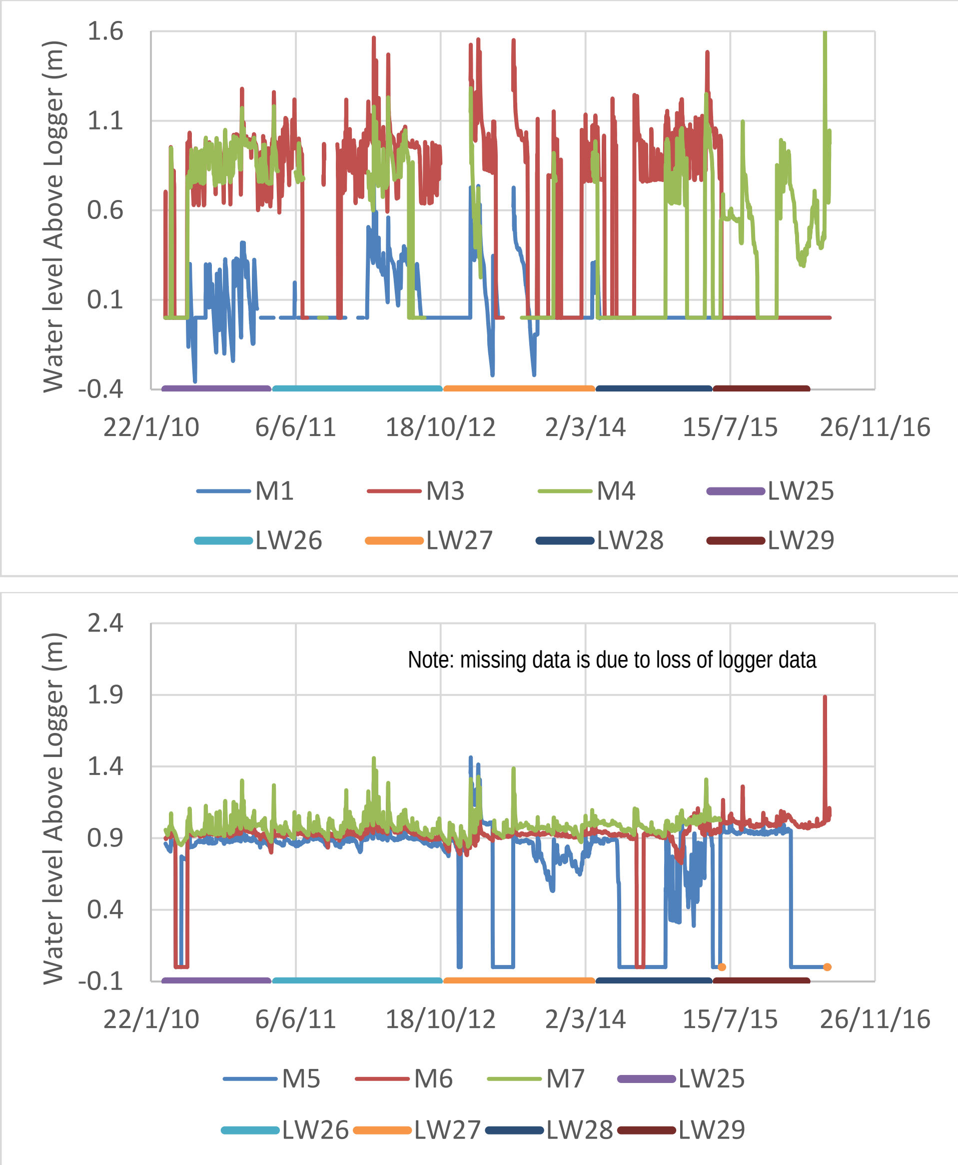


Figure 15 Myrtle Creek Pool Depth

4.3 Water Quality Monitoring

Myrtle Creek has been intermittently dry at MYC1 and MYC2 during extraction of Longwall 29, however MYC3 generally contains water. Site access to MYC4 in the old JR Horse Stud was discontinued during the LW29 period.

Myrtle Creek has an electrical conductivity (EC) range from 125 to 2630uS/cm, with pH between 5.31 and 8.34.

The creek became more acidic during LW29 extraction, with a pH reduction from around 8 to 5.75 at all 3 monitored sites as shown in **Figure 16**.

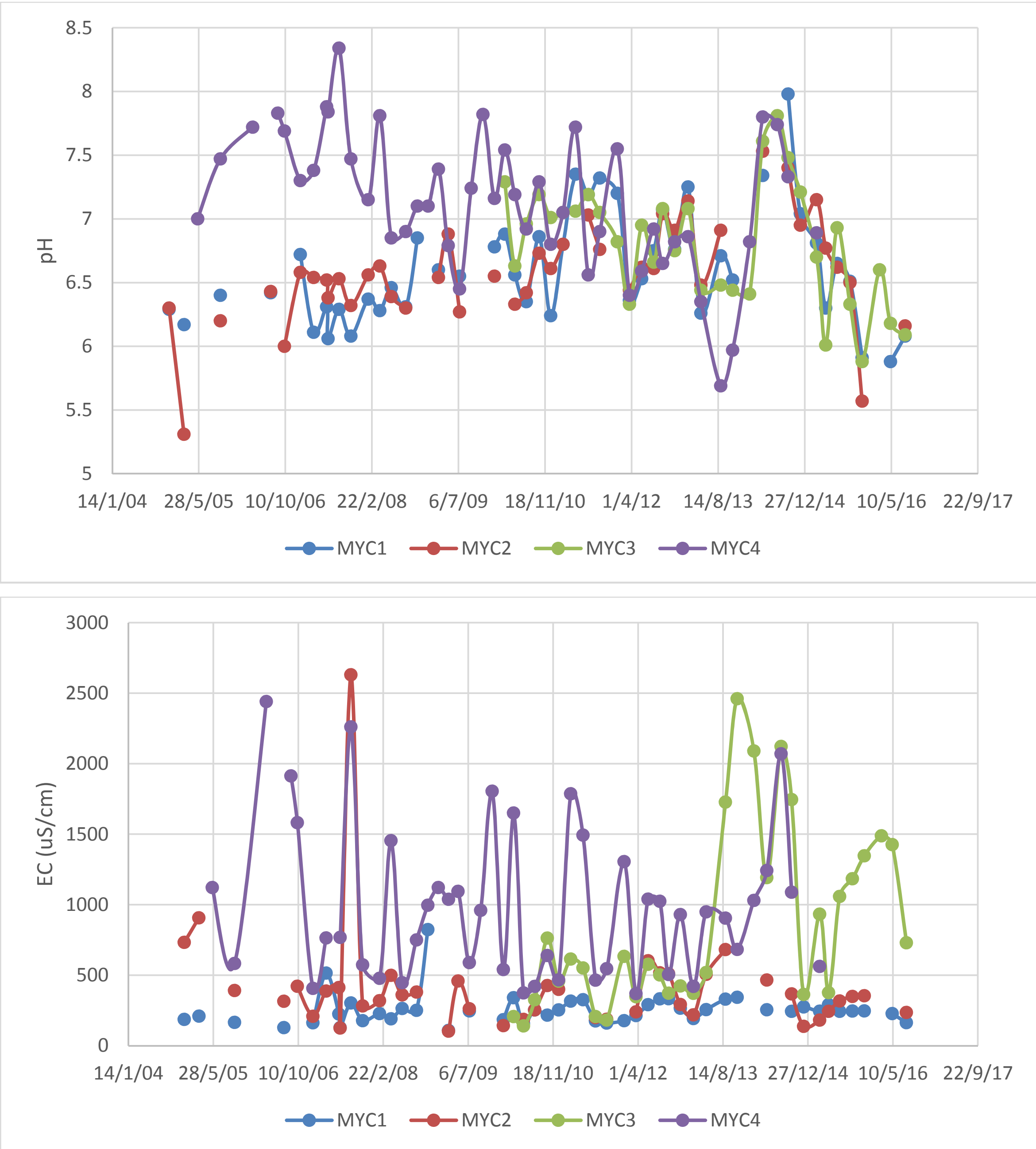


Figure 16 Myrtle Creek Field Water Quality

Sulfate and bicarbonate levels are generally not elevated in Myrtle Creek, with no long term trend or increase over subsided areas as shown in **Figure 17**.

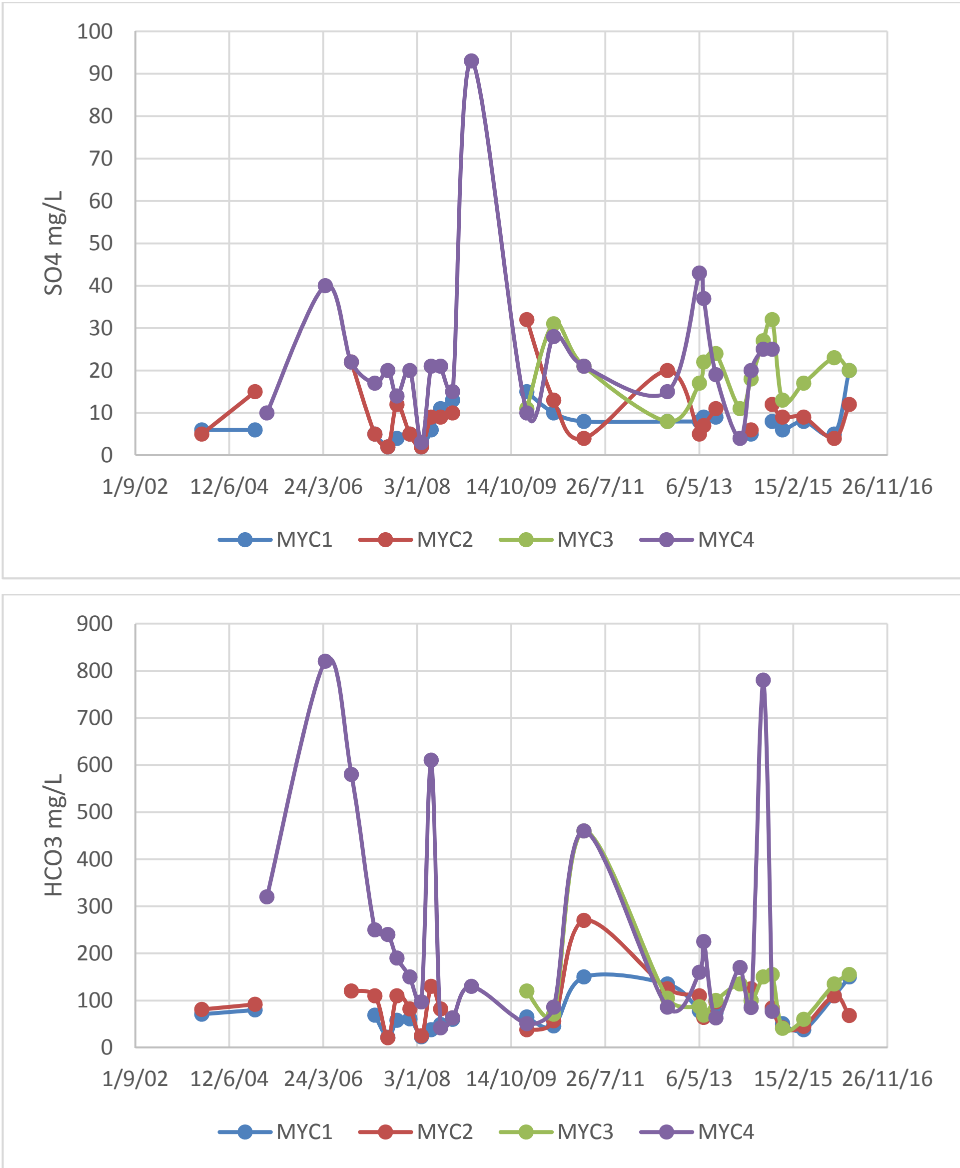


Figure 17 Myrtle Creek Sulfate and Bicarbonate

Iron and manganese levels are generally not elevated in Myrtle Creek, with no long term trend or increase over subsided areas as shown in **Figure 18**.

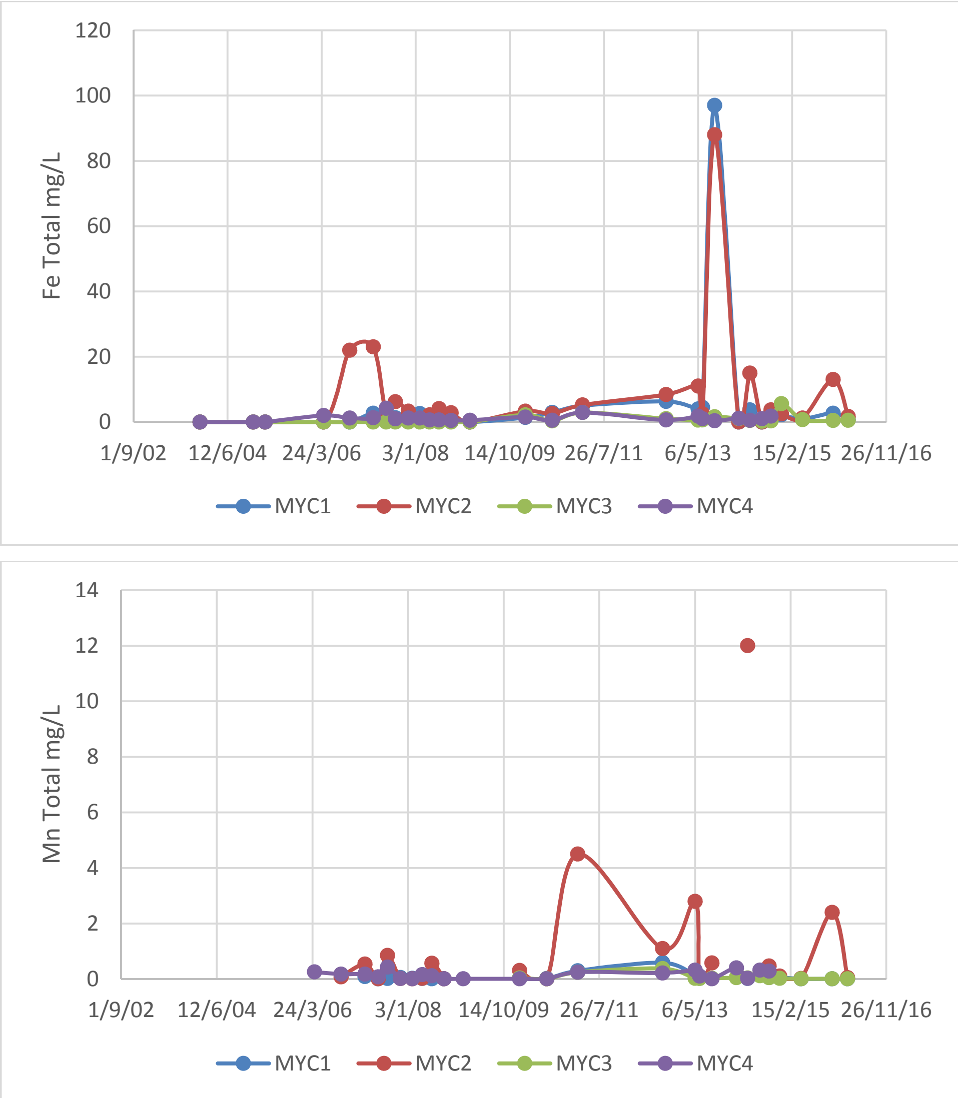


Figure 18 Myrtle Creek Iron and Manganese

Myrtle Creek can have total nitrogen up to 190mg/L and total phosphorous up to 30mg/L, which are above the ANZECC 2000 SE Australian Upland Stream criteria, generally at all water quality monitoring sites, but not at all times, as shown in **Figure 19.**

The high nutrient levels at Site MYC4 are present as the site is a watering hole for a mob of goats that live around the now decommissioned JR Horse Stud, and the site is also downstream of an abattoir and the industrial area of Thirlmere.

The other three sites show typical, variable, levels of nutrients for a residential / rural catchment area.

The above criteria nutrients are present in the creek due to urban and rural / residential runoff in the catchment from house gardens, market gardens, as well as properties with poultry and stock, and are not related to mining influences.

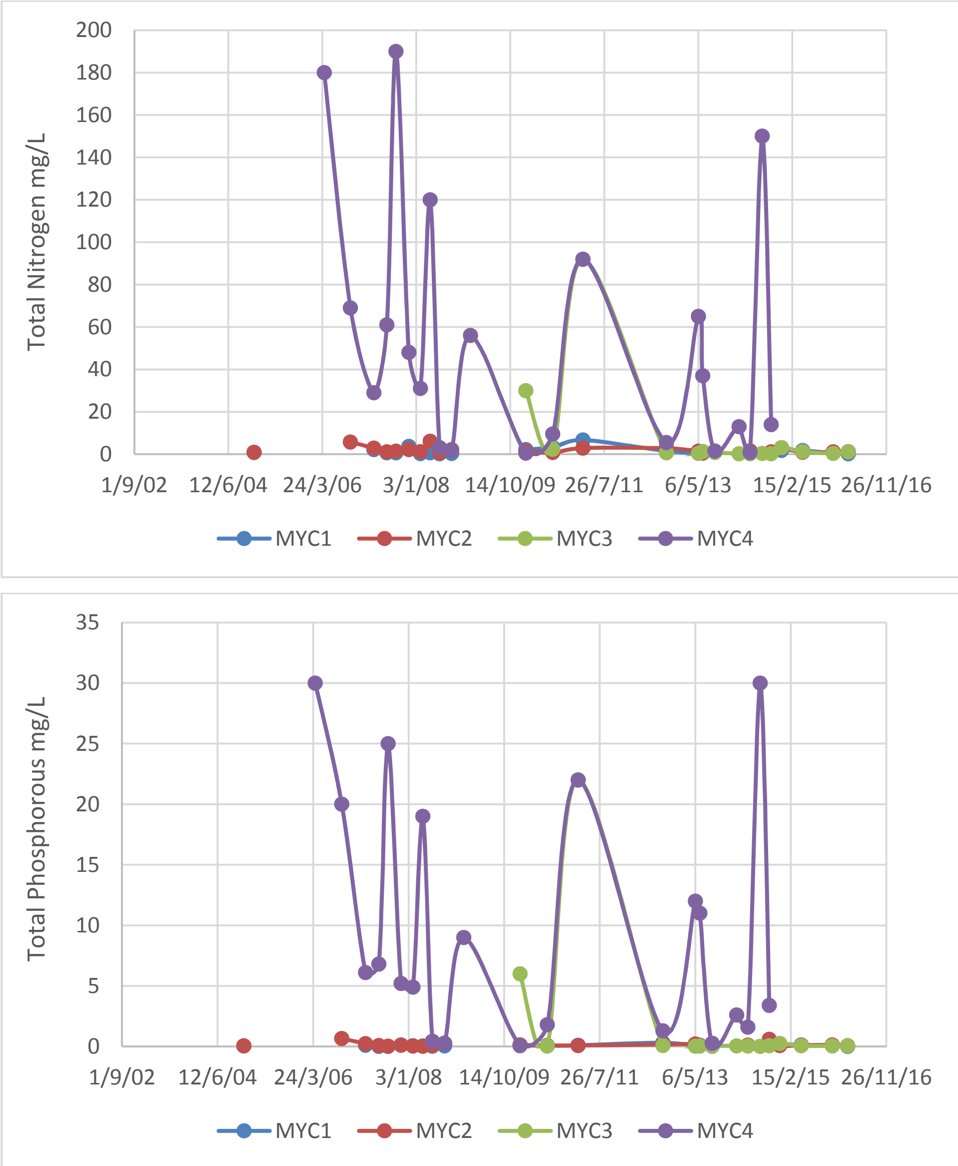
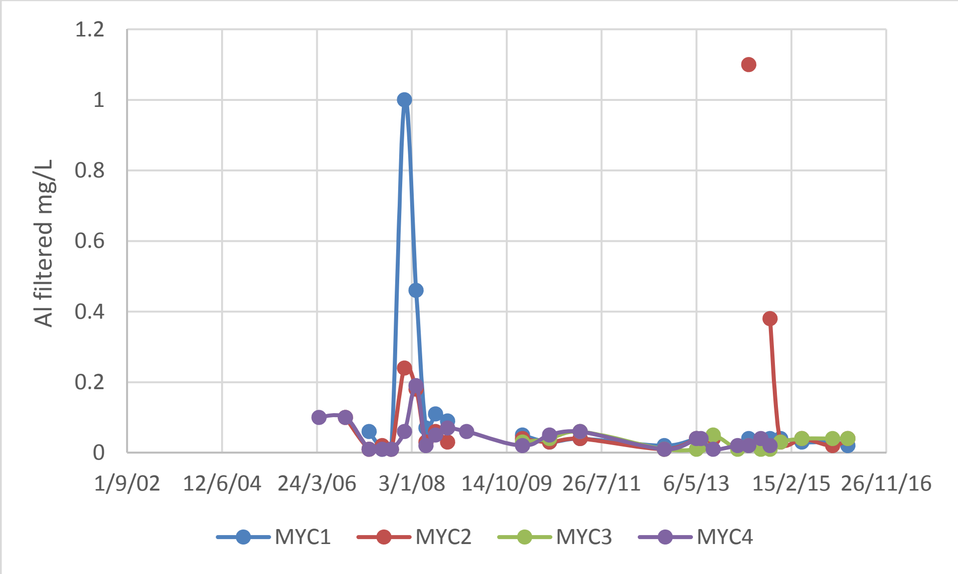
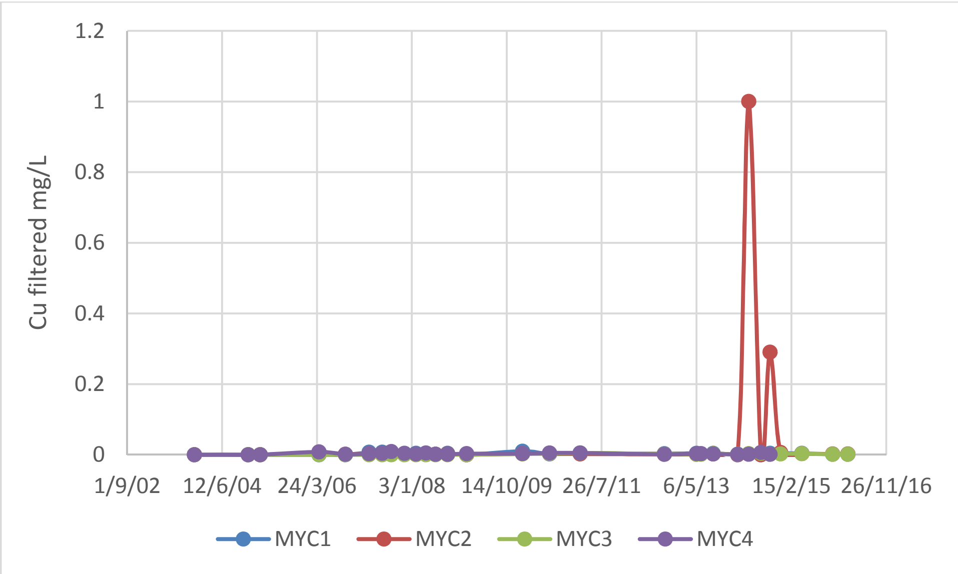


Figure 19 Myrtle Creek Nutrients

Myrtle Creek can also exceed the ANZECC 2000 trigger levels for filterable aluminium (<1.0mg/L), copper (<0.009mg/L) or zinc (0.027mg/L) at all sites, for variable times at each monitoring site.

A notable increase in copper occurred at MYC2 (over the chain pillar between longwalls 24B and 25) and for zinc at MYC2 and MYC4 (approximately 1.5km downstream of Longwall 28) during the extraction period of Longwall 28 as shown in **Figure 20**.





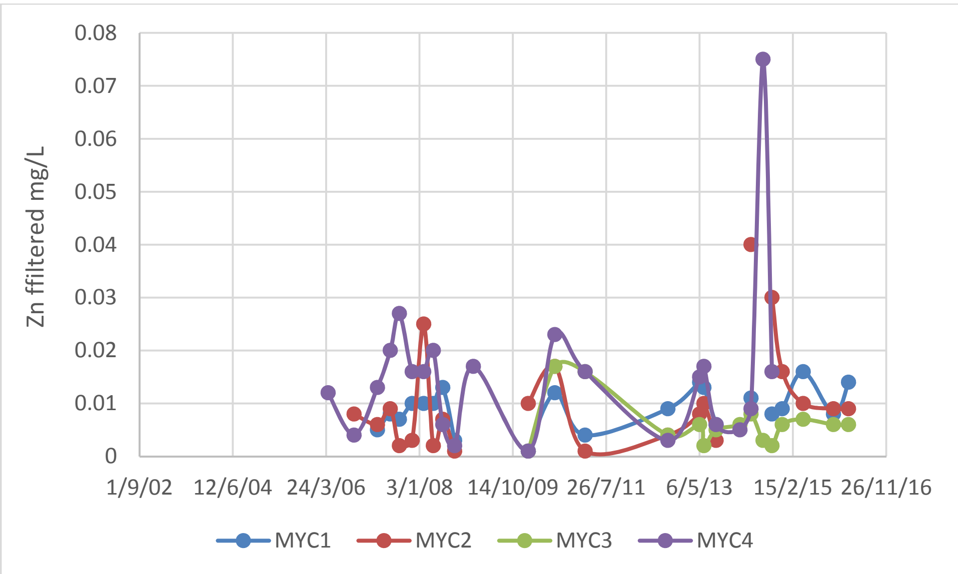


Figure 20 Myrtle Creek Metals

4.4 Groundwater Seepage To or From Streams

To date, no loss of stream flow from Myrtle Creek into the Tahmoor workings has occurred.

Generation of a new seep was observed at Site 21A into Myrtle Creek over the mid-stream reach section of Longwall 28.

Reduction of groundwater seep / stream flow volumes into or within Myrtle Creek has been observed over the extracted longwalls, with additional return seepage flowing back into the streams in the next longwall reach downstream of the extracted panels.

5. CREEK REHABILITATION

Myrtle Creek will not be affected by further subsidence associated with undermining, and based on the current creek status, as well as projection of the predicted pool and connected stream flow recovery, it is anticipated that creek rehabilitation may be required at sites outlined in **Tables 10** and **11** and shown in **Drawing 2**.

The Colliery intend to follow a process including;

- Continued monitoring to ascertain the ongoing pool, connected stream flow, water quality and ecological status of Myrtle Creek;
- Consultation with acknowledged experts in stream monitoring, ecological health and rehabilitation to generate any required creek rehabilitation plan/s which will outline the proposed rehabilitation techniques, monitoring processes and timeframes;
- Consultation with DRE during the development of any required rehabilitation plan;
- Consultation with DRE as appropriate regarding the proposed stream rehabilitation locations, techniques, processes and timeframes, then;
- Implementation of the rehabilitation plan.

Periodic monitoring of Myrtle Creek will continue to assess the extent and scope of the natural remediation observed to be occurring within the creek.

The level of remediation will be reviewed in consultation with DRE at the completion of the current longwall (Longwall 30) and an update provided in the Longwall 30 End of Panel Report.

Table 10 Myrtle Creek Subsidence Effects – Current Status

Sites	Location	Impact	Current Status (July – Aug 2016)
LW22	central	cracked dry pool	pool has not recovered
LW23	central	stream bank soil cracking	no significant initial impact on pool storage or through flow
LW25A	tailgate	cracked dry pool	no significant recovery
LW25B	central / maingate	cracked dry pool	pool has not recovered
LW25C	maingate	cracked dry pool	pool has not recovered
LW25D	maingate / chain pillar	cracked dry pool	pool has not recovered

Table 11 Myrtle Creek Subsidence Effects – Current Status (continued)

Sites	Location	Impact	Current Status (July – Aug 2016)
Over Longwall 26			
1	tailgate	cracked dry pool	pool shows significant recovery
2	tailgate	cracked dry pool	pool shows significant recovery
3	tailgate / central	cracked dry pool	pool shows significant recovery
4	central / tailgate	cracked dry pool	pool shows significant recovery
5	central / maingate	cracked dry pool	no recovery of flow over rock shelf
6	central / maingate	cracked dry pool	no recovery of flow over rock shelf
7	central / maingate	cracked dry pool	no recovery of flow over rock shelf
8	maingate	cracked dry pool	pool has not recovered
9	maingate	cracked dry pool	pool shows significant recovery
10	maingate	dry pool, no obvious cracks	pool shows significant recovery
Over Longwall 27			
11	LW26 / 27 pillar	dry pool, no obvious cracks	pool shows significant recovery
12 - 12A	tailgate	dry pool and fallen tree	pool not holding water, signif. vegetation and rock slab scouring
13 – 13A	central	cracked dry pool	pool not holding water, signif. vegetation and rock slab scouring
14	central	cracked dry pool	pool not holding water, signif. vegetation and rock slab scouring
15	central	cracked dry pool	pool not holding water
16	central / maingate	cracking and dry pool / race	pool not holding water
17	maingate	cracked dry pool	pool not holding water
18	maingate	dry pool, no obvious cracks	pool not holding water, signif. vegetation and rock slab scouring
Over Longwall 28			
19	LW27 / 28 pillar	cracked rock shelf, no flow	many sandstone slabs washed downstream, no overland flow
20	tailgate	cracked rock shelf pool	pool not holding water, significant rock slab scouring
21	tailgate / central	cracked rock shelf, no flow	some sandstone slabs washed downstream, no overland flow
21A	central	dried up boulder pools	pool not holding water, signif. vegetation and rock slab scouring
22	central	cracked shelf, but holds water	some cracking but pool still holding water
23	central - maingate	cracked dry pool	significant improvement, but pool not at perennial full capacity
24	maingate	low flow, strong iron hydroxide	unchanged flow, with improved FeOOH
25 - 25A	maingate	cracked dry pool	improved pool holding capacity, some tree / rock scouring
26	LW28 pillar	dried up boulder pool	pool partially holds water, vegetation and rock slab scouring

6. CONCLUSIONS

No subsidence effects were observed in the dominantly sediment covered reach in the headwaters of Myrtle Creek over Longwall 4.

A limited distribution and extent of observable cracking and delamination was observed over Longwalls 22 to 25, in the transitional sediment, gravel / boulder and limited exposed sandstone reach.

During the latest inspection on 11th August, 2016, following the high June 2016 storm runoff, it was observed that the pools over Longwall 25, upstream of the railway culvert, did not show signs of recovery.

However, downstream of the culvert and over the tailgate and maingate sections of Longwall 26, a number of pools had shown significant recovery as shown in **Figure 21**, even though there remains a significant reach of exposed sandstone shelf in the middle of Longwall 26 that has not recovered as shown in **Figure 22**.

Figure 21 Recovering Pools at Site 4 and 10 over Longwall 26

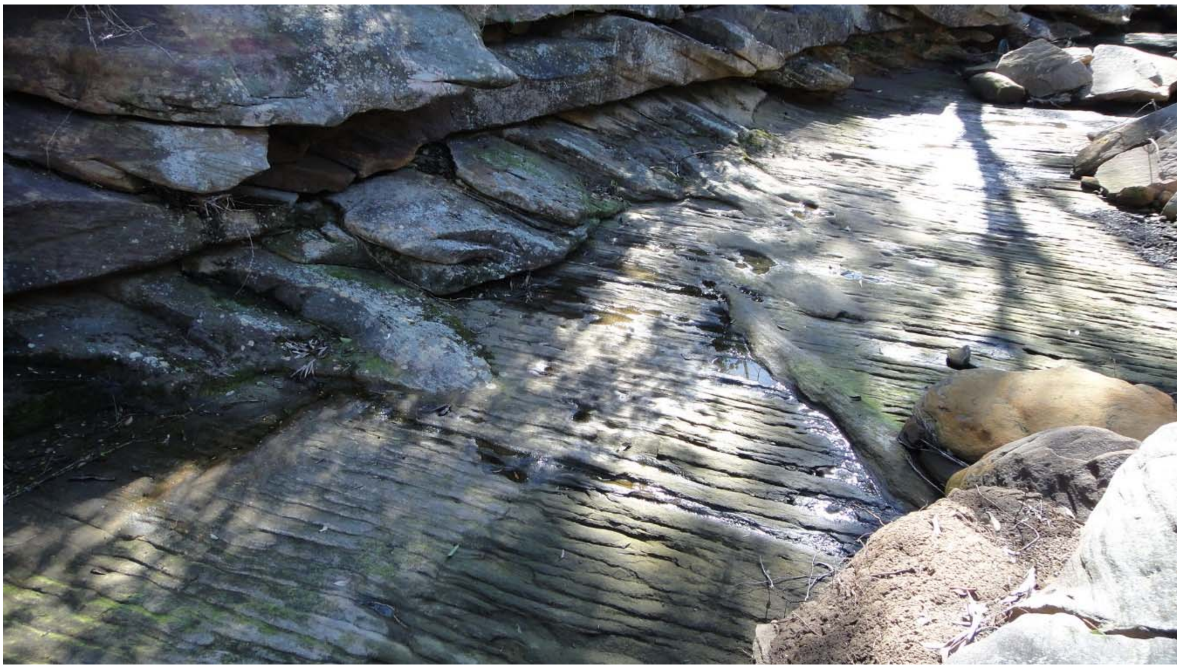


Figure 22 Sandstone Shelf at Site 7 and 8 over Longwall 26 with No Sign of Recovery

As the stream becomes wider, deeper and more incised, with exposed sandstone being more dominant, more cracking / delamination effects, along with long term drying up of pools or rock shelves were observed, which in some cases, such as at Site 19 (15/9/2015), was significantly affected, as shown in **Figure 23**.

Figure 23 Site 19 Subsidence Effects (15/09/15)

During the weekly observation periods during undermining of the creek by Longwalls 26 to 28, it was observed that the subsidence effects extended over the current longwall and over at least half the subsequent (downstream) longwall.

The subsidence affected pools were dry for a sufficiently long period that grasses, weeds and small shrubs grew in the old pool sites as shown below for Site 13 (03/03/2016).

Figure 24 Site 13 Subsidence Effects (03/03/16)

The affected pools occasionally held water after significant rain events, such as the significant runoff after the east coast low storms in April 2015 and June 2016, but the pool longevity was short lived, lasting for days to a week or so before drying up again.

During the storm of June 2016, where significant flooding occurred in the local area, the creek had sufficient force to flip over, break up and wash away the delaminated reach, such as at Site 19 (29/07/2016) with the broken blocks piled up further downstream.

Figure 25 Site 19 after June 2016 East Coast Low Storm

In the case of the large pool at Site 23, which had been essentially totally dry after mid-April 2013, and contained 2 old car bodies, the car bodies were washed downstream of Site 30 in early June 2016 and haven't yet been located. The two photos below (02/07/2014) and (29/07/2016) show the pool when it was totally dry, and after the June 2016 storm.

Figure 26 Site 23 (02/07/14 and 29/07/16)

At present, as shown in **Figure 27**, the;

- Significantly dried out pools or sandstone shelves are located at Sites 25B,C and 25D over Longwall 25, Sites 5 to 8 over Longwall 26 and Sites 12 to 21 over Longwalls 27 and 28;
- Pools showing signs of recovery or those that were not significantly adversely affected are located at Sites 2 to 4 11 over Longwall 26, as well as Sites 23 to 30 over and downstream of Longwall 28, whilst;
- The pool at Site 22 was not affected at all by subsidence.

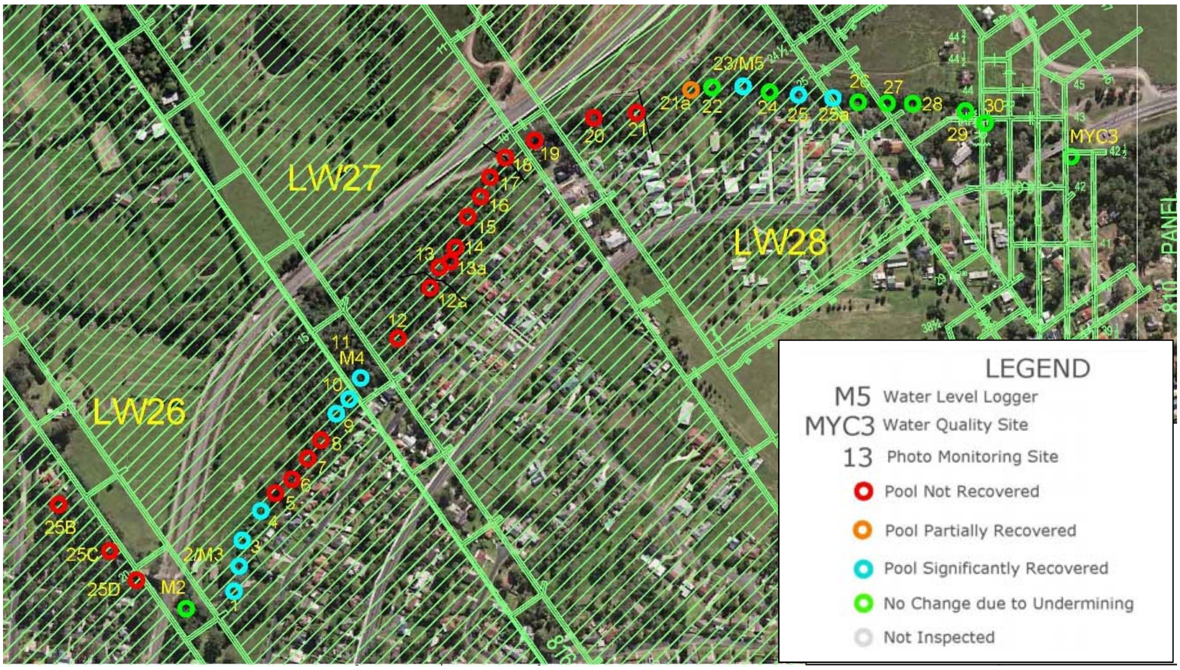


Figure 27 Status of Pools over and Downstream of Longwalls 25 to 28 as of August 2016

The creek was fully inspected between 29 July and 11 August 2016 to ascertain the current status of the undermined reach of Myrtle Creek over Longwalls 4 and 22 to 28, as summarised in **Tables 10** and **11**.

7. REFERENCES

ANZECC 2000 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

GeoTerra, 2002 Longwall Panels 20 to 22 Surface Water and Groundwater Baseline Survey and Preliminary Subsidence Management Strategy

GeoTerra, 2004 Longwall Panels 22 and 23 Surface Water, Stream, Alluvial Land and Groundwater Subsidence Management and Monitoring

GeoTerra, 2006 Longwall Panels 24 to 26 Surface Water & Groundwater Subsidence Management Plan

GeoTerra, 2008A End of Longwall 24B Surface Water, Dams and Groundwater Monitoring Report

GeoTerra, 2008B End of Longwall 24A Surface Water, Dams and Groundwater Monitoring Report

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GeoTerra, 2013A End of Longwall 26 Surface Water, Dams and Groundwater Monitoring Report

GeoTerra, 2014 End of Longwall 27 Surface Water, Dams and Groundwater Monitoring Report

GeoTerra, 2015 End of Longwall 28 Surface Water, Dams and Groundwater Monitoring Report

Mine Subsidence Engineering Consultants Pty Ltd 2005 End of Panel Monitoring Report for Longwall 22 at Tahmoor Colliery

Mine Subsidence Engineering Consultants Pty Ltd 2006 End of Panel Monitoring Report for Longwall 23B at Tahmoor Colliery

Mine Subsidence Engineering Consultants Pty Ltd 2008 End of Panel Subsidence Monitoring Report for Longwall 24B at Tahmoor Colliery

Mine Subsidence Engineering Consultants Pty Ltd 2011 End of Panel Subsidence Monitoring Report for Longwall 25 at Tahmoor Colliery

Mine Subsidence Engineering Consultants Pty Ltd 2013 End of Panel Subsidence Monitoring Report for Longwall 26 at Tahmoor Colliery

Mine Subsidence Engineering Consultants Pty Ltd 2014 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 27

Mine Subsidence Engineering Consultants Pty Ltd 2015A End of Panel Subsidence Monitoring Report for Tahmoor Longwall 28

Mine Subsidence Engineering Consultants Pty Ltd 2016 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 29

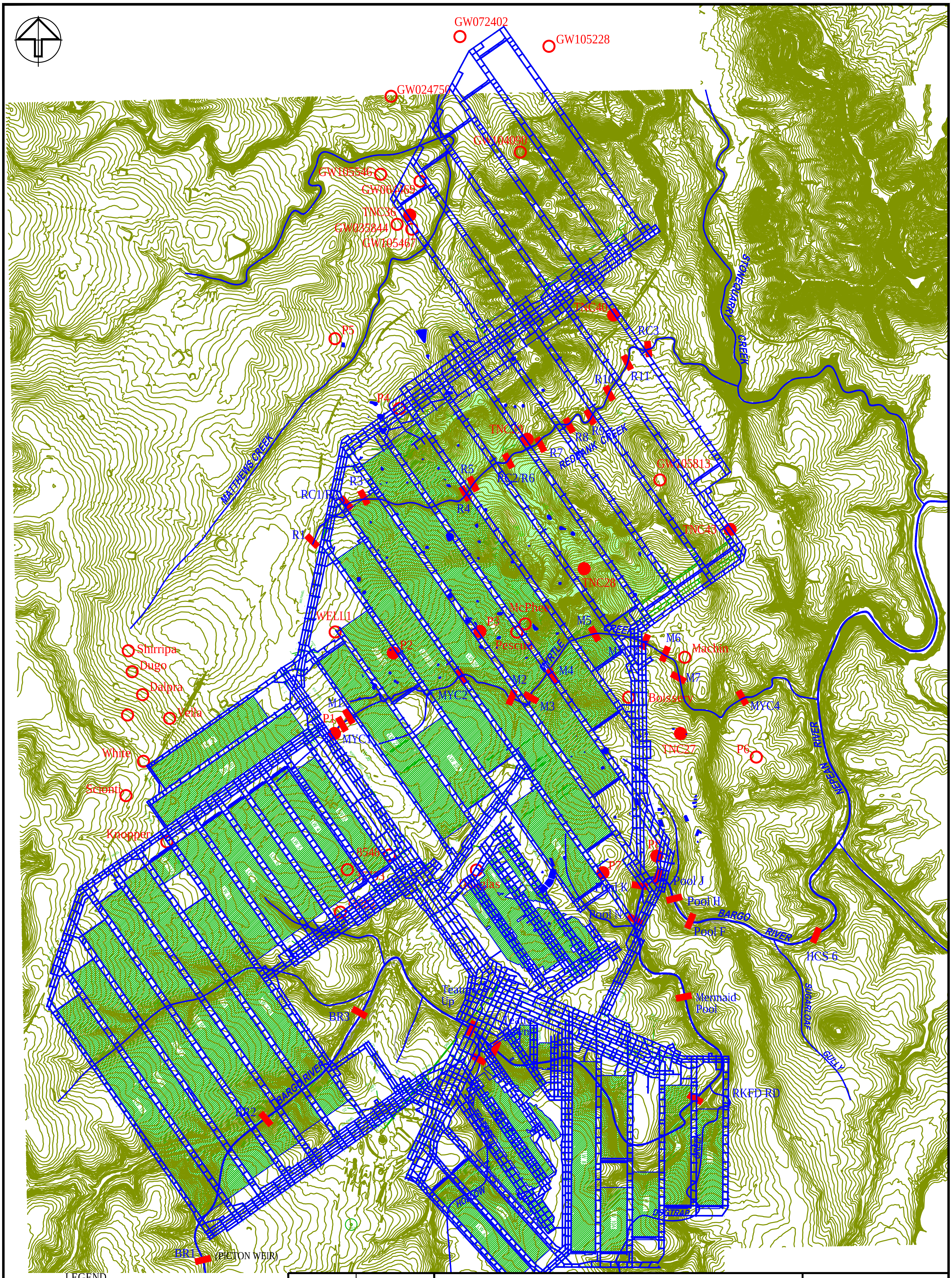
LIMITATIONS

This report was prepared in accordance with the scope of services set out in the contract between GeoTerra Pty Ltd (GeoTerra) and the client, or where no contract has been finalised, the proposal agreed to by the client. To the best of our knowledge the report presented herein accurately reflects the clients requirements when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

In preparing this report, GeoTerra has relied upon information and documentation provided by the client and / or third parties. GeoTerra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. GeoTerra assume the client will make their own enquiries in regard to conclusions and recommendations made in this document. GeoTerra accept no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to GeoTerra.

The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of GeoTerra is solely to its client and it is not intended that this report be relied upon by any third party. This report shall not be reproduced either wholly or in part without the prior written consent of GeoTerra.



LEGEND

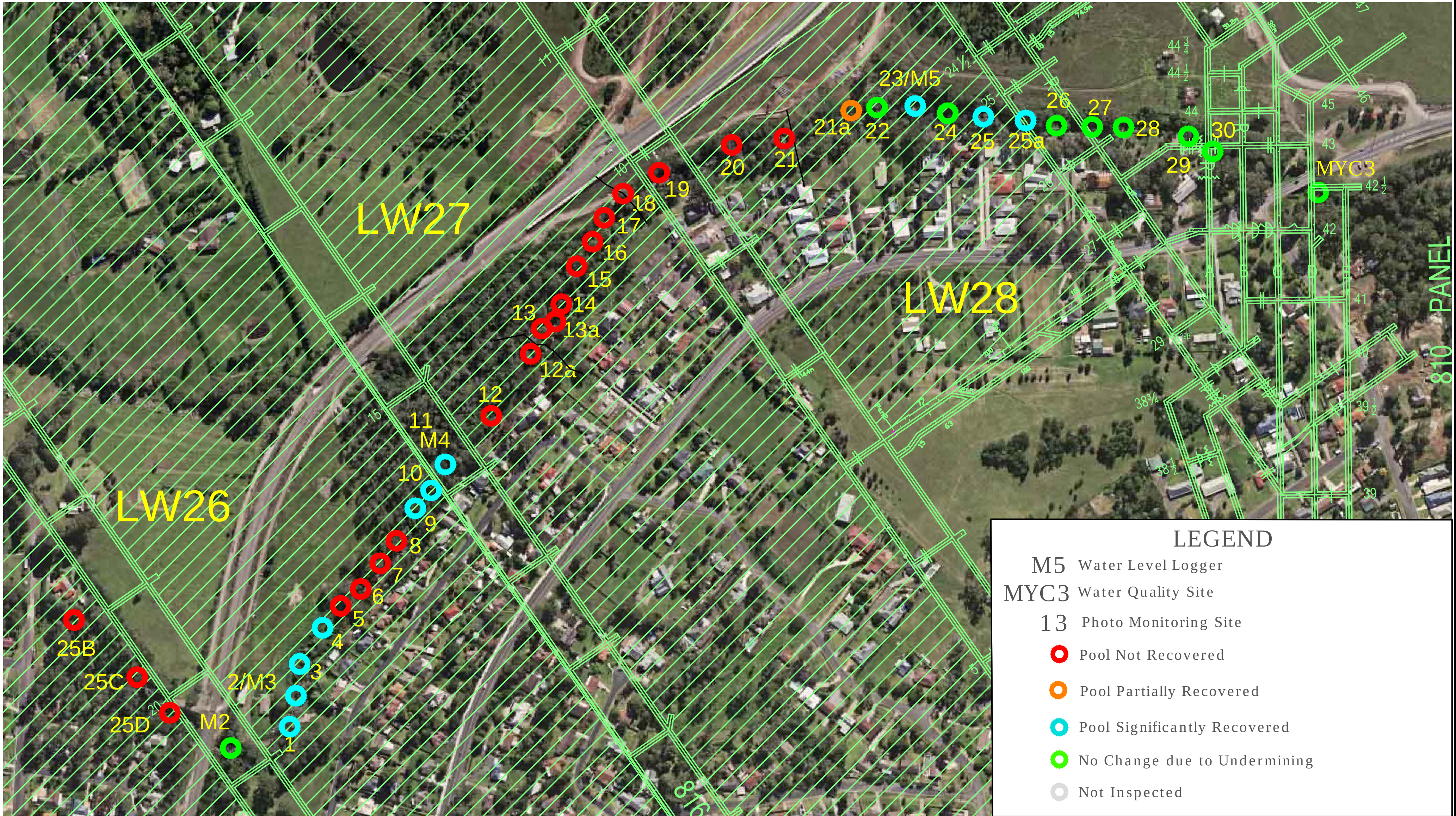
- PIEZOMETER
- STREAM MONITORING SITE
- NOW REGISTERED BORE / WELL

PROJECT:	TA28
DRAWN:	A. DAWKINS
DATE:	15 Aug 2016
SCALE:	1:30 000

TAHMOOR COAL PTY LTD
TAHMOOR COLLIERY
WATER MONITORING LOCATIONS

GeoTerra

DRAWING1



LEGEND

M5 Water Level Logger

MYC3 Water Quality Site

13 Photo Monitoring Site

Pool Not Recovered

Pool Partially Recovered

Pool Significantly Recovered

No Change due to Undermining

Not Inspected

50 0 50 100 150 200 250

Scale 1:5000 (metres)

PROJECT:	TA28
DRAWN:	A. DAWKINS
DATE:	11 AUG 16
SCALE:	As Shown

TAHMOOR COAL PTY LTD
MYRTLE CREEK

CREEK STATUS (11 August 2016)

GeoTerra

DRAWING 2