REPORT: END OF PANEL SUBSIDENCE MONITORING REPORT

GLENCORE:

Tahmoor Colliery - Longwall 28

End of Panel Subsidence Monitoring Report for Tahmoor Longwall 28

DOCUMENT REGISTER

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MSEC688-R01 to MSEC688-R44 – Subsidence Monitoring Reports, issued during the extraction of Longwall 28 between May 2014 and May 2015.

MSEC689-R01 to MSEC689-R56 – Main Southern Railway Monitoring Reports, issued during the extraction of Longwall 28 between April 2014 and May 2015.

GeoTerra (2015). End of Longwall 28 Surface Water, Dams & Groundwater Monitoring Report, Tahmoor, NSW. Report No. TA20-R1B, August 2015.

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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 28,
- 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 28 is shown in Drawing No. MSEC777-01, 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 27. 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 28

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

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 in this report are based on the subsidence predictions provided in this report.

Longwall 28 was approximately 2,630 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 420 metres to 490 metres. The seam thickness over the panel varied from 1.9 metres to 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 28. This chapter also provides comparisons between the observed and predicted movements resulting from the extraction of Longwall 28.

Chapter 3 of this report summarises the surveys and inspections undertaken during the mining of Longwall 28.

Chapter 4 of this report describes the reported impacts on surface features resulting from the extraction of Longwall 28, 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 28 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 28 (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 LW28 only	774	5.6	2.5	-4.3
Total after LW28	1082	6.3	4.7	-5.2

Maximum observed incremental and total subsidence parameters for monitoring lines surveyed during Longwall 28 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 28 Inc	459	3.8	0.7	-1.6
	Total	781	4.7	4.7	-4.8
Brundah Rd	LW 28 Inc	196	1.0	0.6	-0.4
	Total	1031	4.3	1.8	-4.8
Castlereagh St (incl. creek)	LW 28 Inc	9	0.4	0.4	-0.3 (18m bay)
	Total	935	2.7	0.6	-11.9 (18m bay)
Castlereagh-Myrtle Creek (incl. creek)	LW 28 Inc	9	0.5	1.2	-0.6 (8m bay) -0.2 (14m bay)
	Total	897	2.6	3.7	-32.3 (8m bay) -16.6 (14m bay)
Hilton Park Rd	LW 28 Inc	739	4.9	0.4	-2.1
	Total	966	5.3	0.9	-4.6
Krista Pl	LW 28 Inc	37	0.3	0.2	-0.0
	Total	1028	2.7	0.9	-0.2
Main Southern Railway (2D) (incl. creek)	LW 28 Inc	774	5.6	1.9	-4.3
	Total	905	5.9	2.0	-4.9
Moorland Rd	LW 28 Inc	20	1.0	2.0	-1.2
	Total	1035	8.0	2.3	-5.2
Myrtle Creek Ave	LW 28 Inc	101	0.8	0.3	-1.5
	Total	983	4.7	0.9	-2.9
Optical Fibre Line	LW 28 Inc	547	5.0	1.2	-0.5
	Total	561	5.2	1.2	-1.7
Park Ave	LW 28 Inc	37	0.4	0.6	-0.9
	Total	804	6.3	1.1	-0.3
Remembrance Driveway	LW 28 Inc	541	3.8	2.5	-2.1
	Total	987	5.8	1.8	-3.1
River Rd	LW 28 Inc	2	0.8	0.3	-0.2

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
	Total	24	1.0	0.7	-0.2
River Rd South	LW 28 Inc	0	0.5	0.1	-0.1
	Total	0	0.8	0.3	-0.3
Struan St	LW 28 Inc	29	0.7	0.4	-0.4
	Total	1082	5.5	0.7	-2.2
Tahmoor Carrier	LW 28 Inc	662	5.6	0.7	-2.1
	Total	720	5.6	1.0	-2.3
Thirlmere Carrier	LW 28 Inc	62	0.4	0.2	-0.3
York St	LW 28 Inc	84	1.0	0.5	-0.3
	Total	944	4.0	0.7	-3.0

2.1.2. Observed Subsidence during the extraction of Longwall 28

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 28.

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, generally slightly greater than predicted in areas of low level subsidence (typically less than 100 mm).

While there is generally a good correlation between observed and predicted subsidence, substantially increased subsidence has been observed above most of Longwall 24A and the southern end of Longwall 25, and slightly increased subsidence was observed above the southern ends of Longwalls 26 and 27. This was a very unusual event for the Southern Coalfield.

It is worth repeating the observations above Longwalls 24A to 27 to place observations during the mining of Longwall 28 into perspective.

During the mining of Longwall 24A at Tahmoor Mine, substantially increased subsidence was observed and further increases in observed subsidence compared to the predicted subsidence was observed during Longwall 25.

These increased levels of subsidence were a very unusual event for the Southern Coalfield and immediate investigations were undertaken to identify why it occurred. The conclusions of these studies were published in 2011 in a paper by W. Gale and I. Sheppard (Gale and Sheppard 2011), which advised that the increased levels of subsidence were likely to be associated with the proximity of these areas to the Nepean Fault and the Bargo River Gorge and a recognition of the impact of a weathered zone of joints and bedding planes above the water table, which reduced the spanning capacity of the strata below this highly weathered section. This later recognition was determined after extensive computer modelling of factors that may have caused the increased subsidence.

Further subsidence monitoring has occurred over Longwalls 26, 27 and 28 within and around this zone of increased subsidence since 2011. The zone of increased subsidence extends over the Longwall 24A and the south-eastern ends of Longwalls 25 to 27, however, the magnitude of the ‘increased subsidence’ has reduced for each successive longwall. The maximum observed subsidence only slightly exceeded the maximum predicted for Longwall 28, with the difference being within the accuracy of the subsidence prediction methods.

Further details of the observed zones of increased subsidence over Longwalls 24A to 27 are shown in five longitudinal cross sections along Longwall 24A, Longwall 25, Longwall 26, Longwall 27 and Longwall 28 as Fig. 2.1 to Fig. 2.5 and a discussion on these details is presented below.

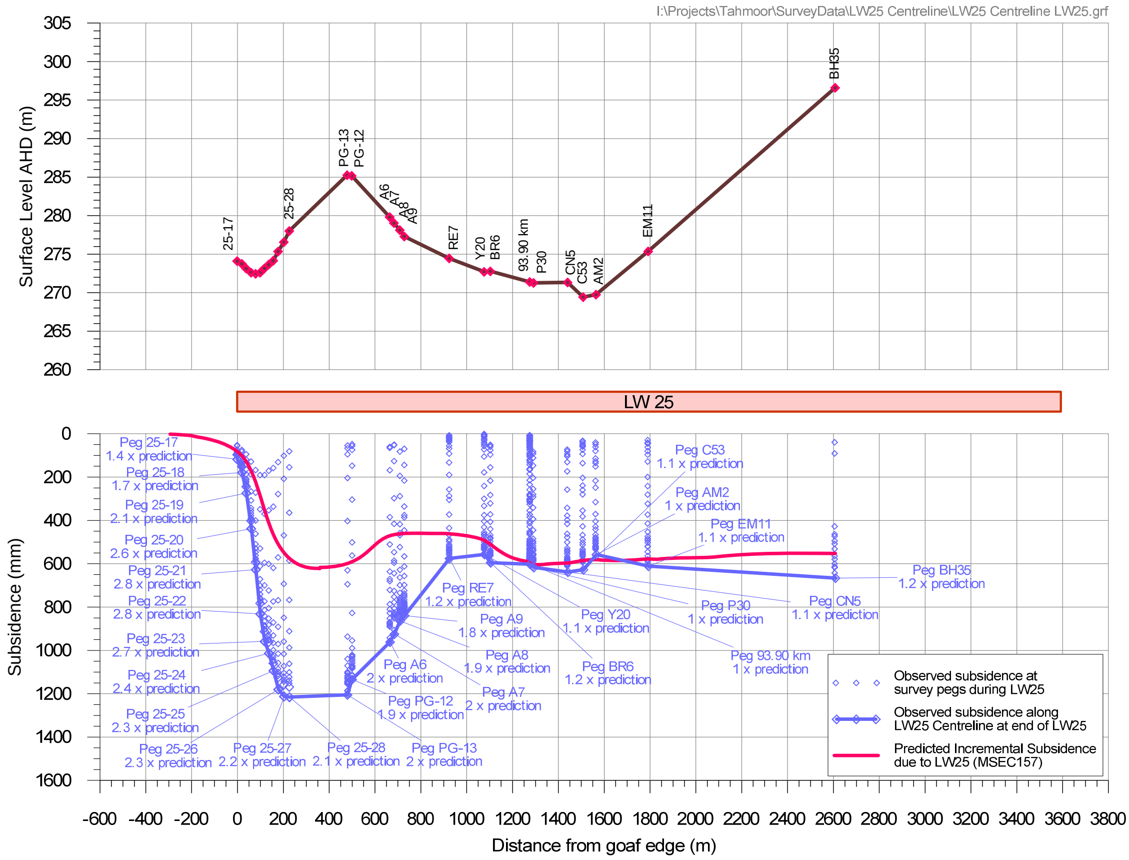

Fig. 2.1 Observed Subsidence along Centreline of Longwall 24A

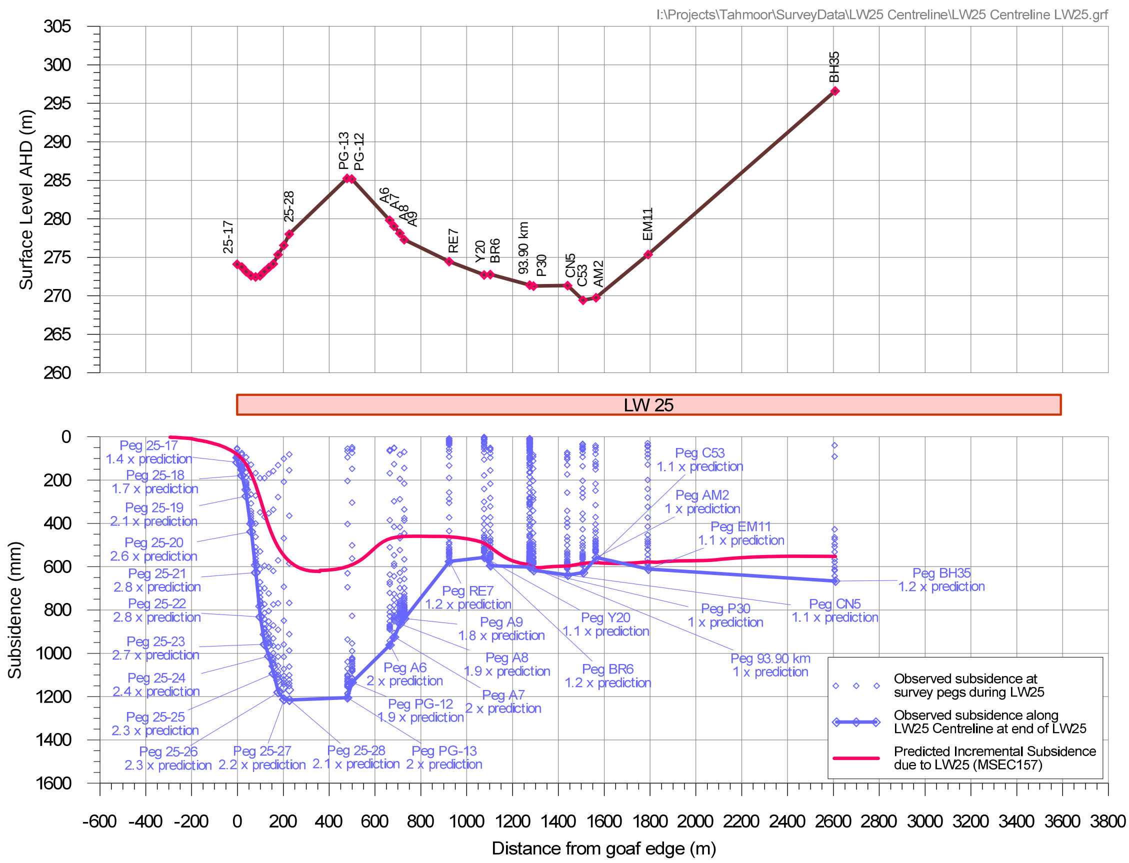

Fig. 2.2 Observed Subsidence along Centreline of Longwall 25

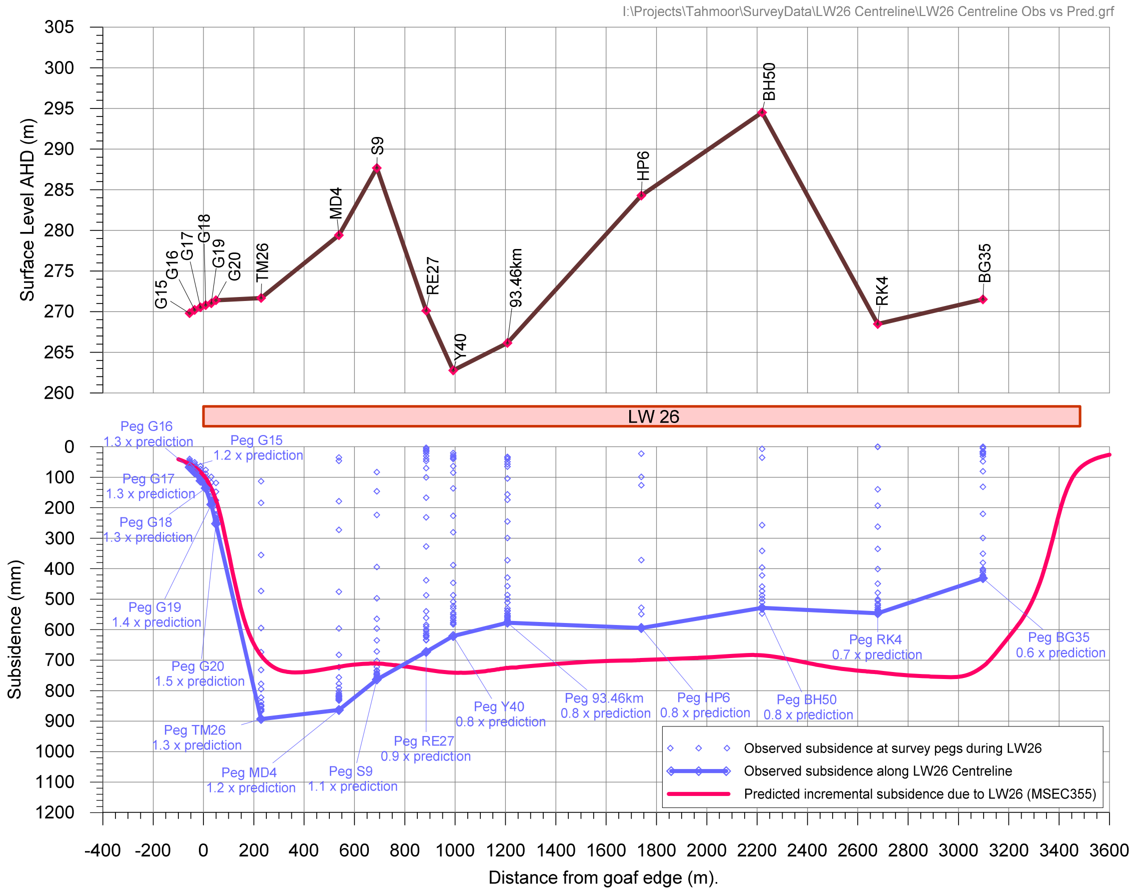

Fig. 2.3 Observed Subsidence along Centreline of Longwall 26

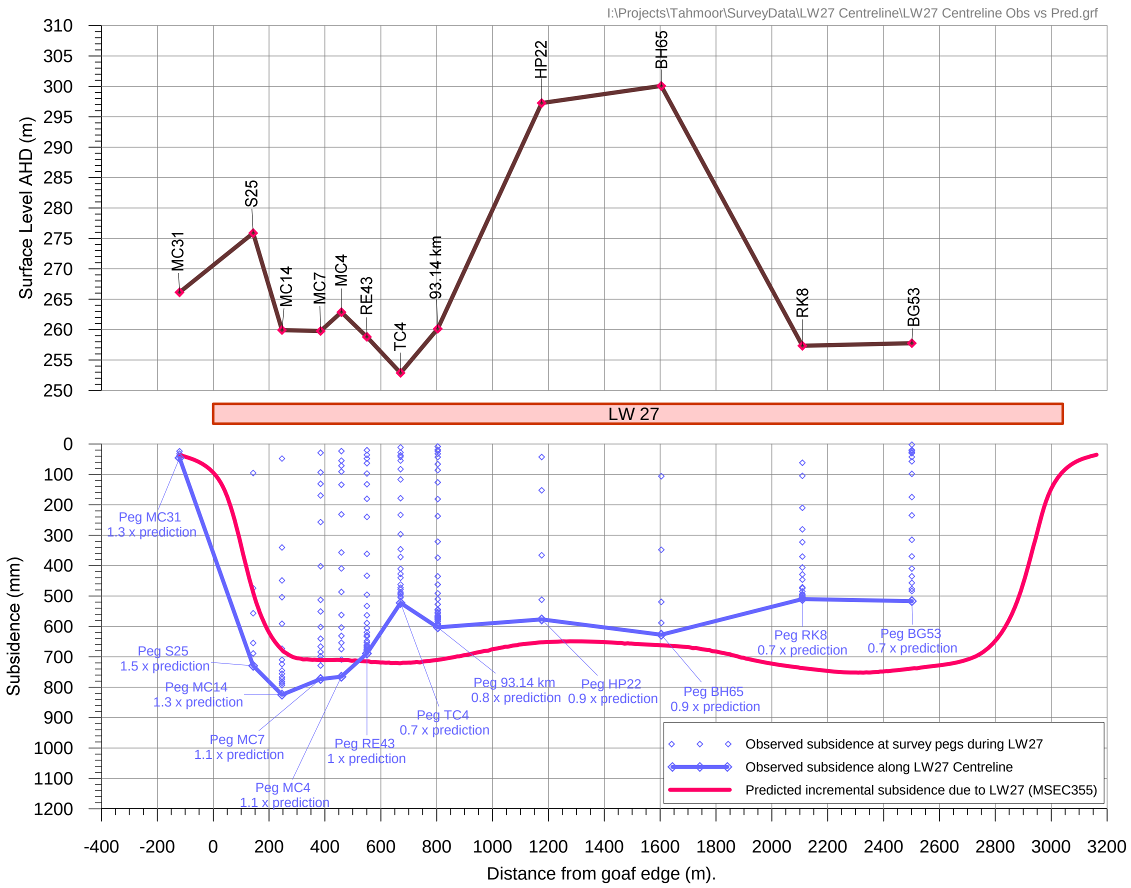

Fig. 2.4 Observed Subsidence along Centreline of Longwall 27

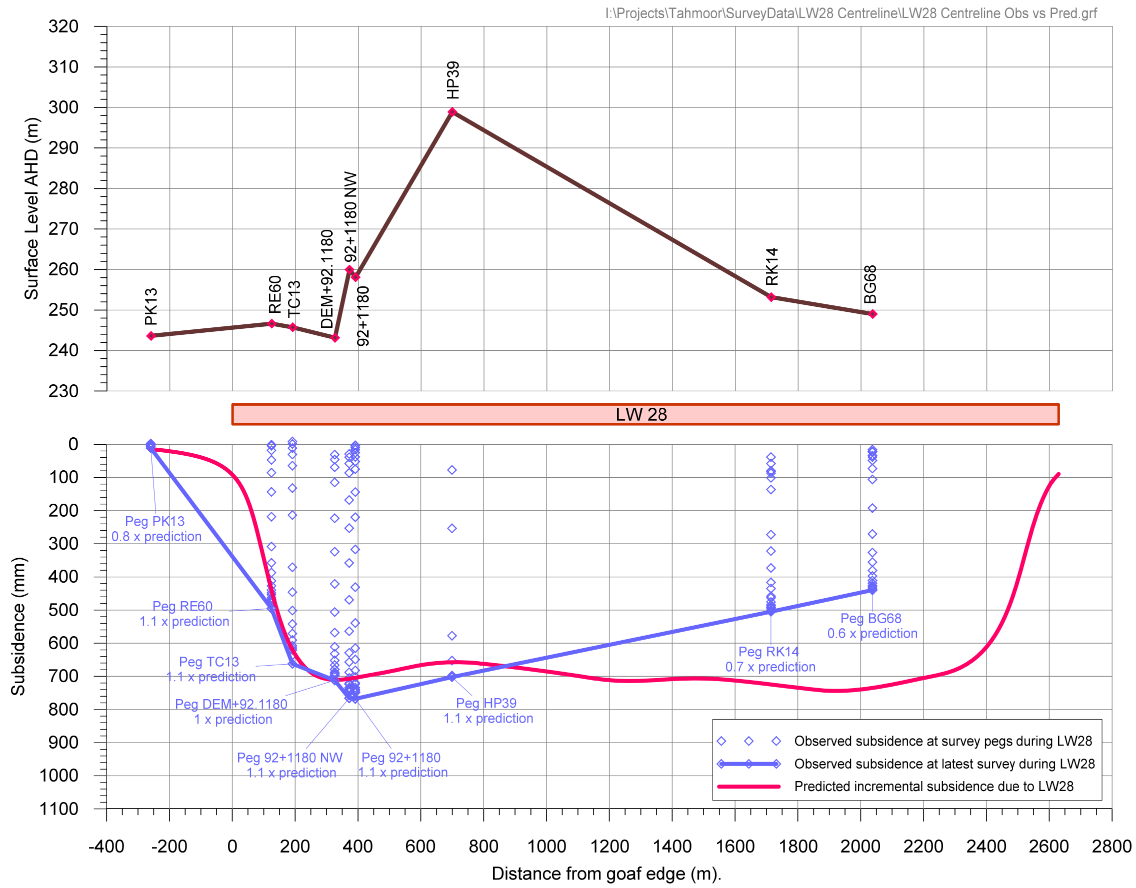

Fig. 2.5 Observed Subsidence along Centreline of Longwall 28

Observed Increased Subsidence during the mining of Longwall 24A

- Fig. 2.1 shows the surface levels, the locations of various survey pegs along the centre of Longwall 24A and the observed incremental subsidence profiles at these survey pegs. It can be seen that the area of greatest increase in observed subsidence was in an area above the southern half of Longwall 24A that is closer to the Bargo River Gorge, closer to the Nepean Fault Zone and within 100 metres of a smaller fault zone that, like several other parallel faults, runs off the Nepean Fault in an en echelon style and within 140 metres of previous total extraction workings in the 204 panel. The extent of the increased subsidence then gradually reduced in magnitude towards the northern half of the longwall, which was directly beneath the urban area of Tahmoor.
- It can be seen from Fig. 2.1 that the observed subsidence was similar to the predicted levels near Peg R15 on Remembrance Drive. Survey pegs RF19 and LA9 were located within a transition zone where subsidence gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

Observed Increased Subsidence during the mining of Longwall 25

- Fig. 2.2 shows the observed incremental subsidence at survey pegs located along the centreline of Longwall 25. It can be seen that the area of greatest increase in observed subsidence was in an area above the southern half of Longwall 25 that is closer to the Bargo River Gorge and closer to the Nepean Fault Zone.
- The observed incremental subsidence is similar to but only slightly more than was predicted at Peg RE7 and is similar to the prediction at Peg Y20 and at all pegs located further along the panel. Survey pegs A6, A7, A8 and A9 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

Observed Increased Subsidence during the mining of Longwall 26

- Fig. 2.3 shows the observed incremental subsidence at survey pegs located along the centreline of Longwall 26. Increased incremental subsidence was observed during the first stages of mining Longwall 26, but at a reduced magnitude compared to the incremental subsidence observed above Longwalls 24A and 25.

- Observed subsidence reduced along the panel until Peg Y40 on York Street, where it was less than prediction. Survey pegs S9 and RE27 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence between Pegs TM26 and MD4 to areas of normal subsidence at Peg Y40 and beyond.

Observed Increased Subsidence during the mining of Longwall 27

- Fig. 2.4 shows the observed incremental subsidence at survey pegs located along the centreline of Longwall 27. Increased incremental subsidence was observed during the first stages of mining Longwall 27, but at a reduced magnitude compared to the incremental subsidence observed above Longwalls 24A, 25 and 26.
- As shown in Fig. 2.4 the observed subsidence reduced along the panel until Peg 93.140 km on the Main Southern Railway. Survey pegs MC4, MC7, RE43 and TC4 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence between Pegs MC14 and 93.140 km to areas of normal subsidence along the Railway and beyond.

Observed Subsidence during the mining of Longwall 28

- Fig. 2.5 shows the observed incremental subsidence at survey pegs located along the centreline of Longwall 28. It can be seen that observed subsidence has returned to near normal levels, within 13% of subsidence predictions.
- As shown in Fig. 2.5, there is a reasonable correlation between the observed and predicted subsidence profile along the centreline of Longwall 28.

Analysis and commentary

The cause for the increased subsidence was investigated during the extraction of Longwall 25 by Strata Control Technology (SCT) on behalf of Tahmoor Colliery as discussed in the previously referenced paper by Gale and Sheppard (2011).

These investigations concluded that the areas of increased subsidence was consistent with localised weathering of joint and bedding planes above a depressed water table adjacent to an incised gorge. This conclusion was further confirmed in further recent report by Gale W. of SCT (2013a), who confirms that:

> "*Longwall panels 24A and 25 both show increased maximum subsidence to approximately 1.0-1.2m, where predicted subsidence was in the order of 0.5 - 0.8m. In the study by Gale and Sheppard, (2011), it became apparent that the increased subsidence is likely to be due to reduction in joint friction and stiffness due to the weathering process in the strata above the water table where the water table is considerably lower due to the Bargo Gorge. The intact rock properties were not changed, only the properties of the joints were altered*."

There have been many locations where monitoring near faults has revealed little increase of observed subsidence and there are many locations where monitoring near deep gorges and valleys has revealed little increases in observed subsidence. In summary, it appears that the location of the zones of increased subsidence is linked to both the;

- close proximity and the alignment of the Nepean Fault, which is within 1,000 metres of these zones; and
- close proximity to the Bargo River Gorge, which is approximately 100 metres deep, within 700 metres of these zones. The presence of the Bargo River Gorge has permitted groundwater flows to weather the joint and bedding plane properties of the surrounding strata.

In light of the above conclusions and observations, three areas or zones have been identified from the observed subsidence monitoring above the extracted Longwalls 24A to 27 at Tahmoor:

- Maximum increased subsidence zone – where the observed vertical subsidence is substantially greater than the predicted subsidence;
- Transition zone – where the subsidence behaviour appears to be transitioned between areas of maximum increased subsidence and normal subsidence; and
- Normal subsidence zone – where the observed vertical subsidence is within the normal range and correlates well with predictions.

The locations of the three zones are plotted on a plan, using the surveyed pegs that were identified along the centrelines above Longwalls 24A to 28 as a guide, as shown in Fig. 2.6, it can be seen that the transition zone is roughly consistent in width above Longwall 24A, Longwall 25 and Longwall 26 and possibly slightly narrower above Longwall 27. The orientation of the transition zone is also roughly parallel to the Nepean Fault and the magnitude of the increased subsidence above Longwalls 26 and 27 is reduced compared to Longwalls 24A and 25. There was little to no increased subsidence identified above Longwall 28.

It can be seen in Fig. 2.6 that the alignment of the surface expression of the Nepean Fault is at a similar distance from the zone of increased subsidence. Two prominent features of the increased subsidence are that its magnitude reduces with increasing distance away from the Bargo River Gorge, and the magnitude reduces as it approaches the termination of the overlapping fault plane. This observation supports the findings of Gale and Sheppard (2011) that the increased subsidence is linked to localised weathering of joint and bedding planes above a depressed water table adjacent to the incised gorge of the Bargo River and the presence of the major fault.

It should be noted that the potential impacts of increased subsidence on the structures and infrastructure within the overlying urban areas of Tahmoor Township were successfully managed by Tahmoor Colliery through the implementation of effective subsidence management plans.

Despite the above observations and projections, it is recognised that substantially increased subsidence could develop above the commencing ends of Longwall 29 and Management Plans have been developed to manage potential impacts if substantial additional subsidence were to occur.

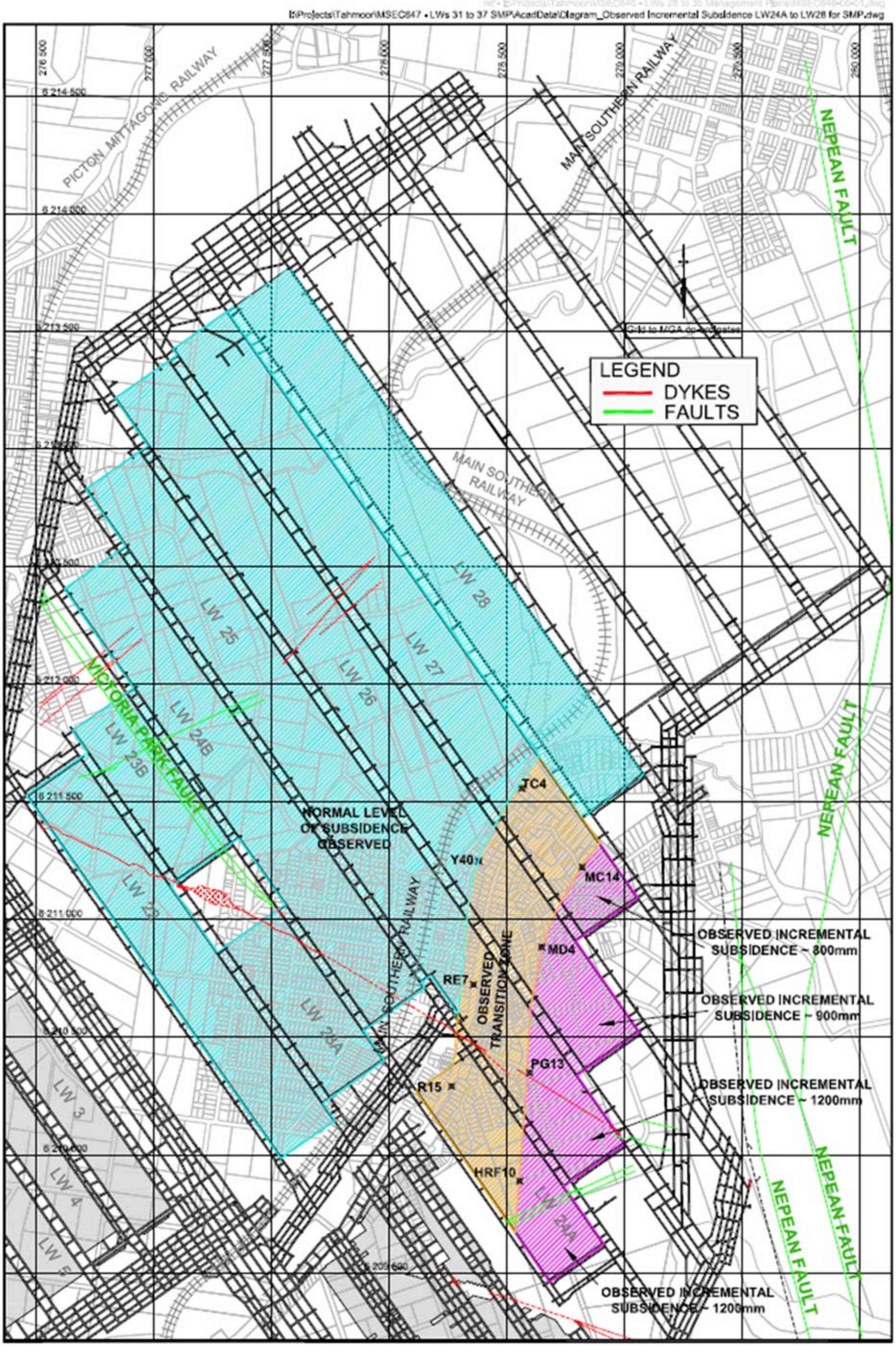

Fig. 2.6 **Figure showing zones of increased subsidence over Longwalls 22 to 28**

2.1.3. Analysis of Measured Strain

The distribution of the observed incremental tensile and compressive strains along monitoring lines from the extraction of Longwall 28, for survey bays located directly above goaf, are shown in Fig. 2.7. 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.

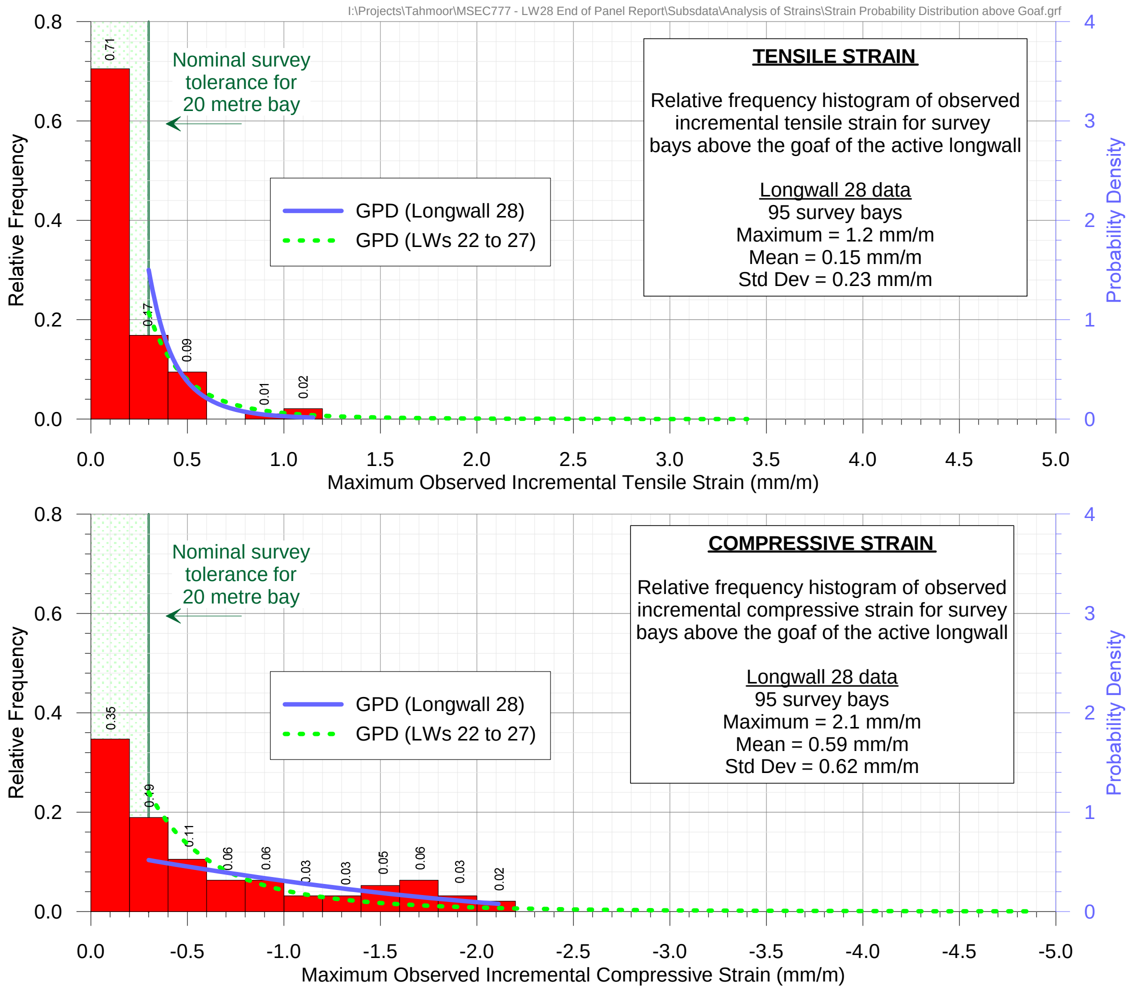

Fig. 2.7 Observed Incremental Strain for Survey Bays above Goaf resulting from the Extraction of Longwall 28

A *Generalised Pareto Distribution (GPD)* has been fitted to the raw strain data for Longwall 28, as shown in the blue lines.

The probability distribution functions for previous monitoring during the mining of Longwalls 22 to 27 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 28 was similar to or less than the magnitude of that observed during the mining of Longwalls 22 to 27.

2.2. Identification of Non-Systematic Subsidence Movements

A plan showing the locations of observed non-systematic movements at Tahmoor is shown in Fig. 2.8. 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 50 locations (not including valleys) have been identified over the extracted Longwalls 22 to 28, of which 5 new locations were observed during the mining of Longwall 28.

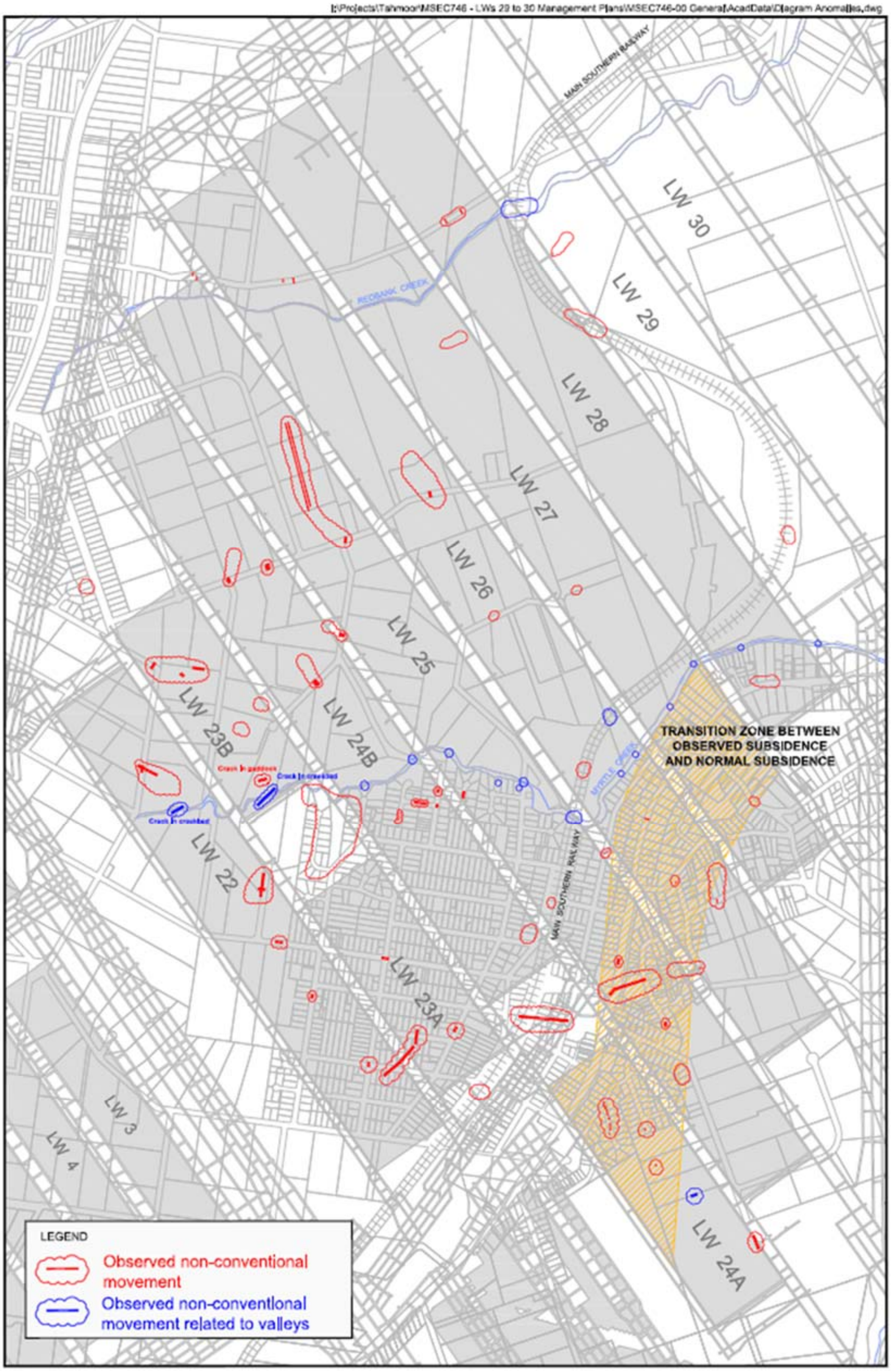

Fig. 2.8 Map of Locations of Potential Non-Systematic Movements

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 28

Monitoring Line or Location	Maximum Change in Vertical Alignment during LW28 (mm)	Maximum Incremental Strain during LW28 (mm/m)	Type	Impacts on Surface Features
Remembrance Drive (Pegs RE55 to RE60)	20mm over 40 metres	-2.1	Anomaly	Impacts on houses. Small bump in pavement. Aligned also with adjacent compressive strain on Tahmoor Carrier pipe Pegs TC15 and TC16.
Main Southern Railway at 92.850km	15mm over 30 metres	< 0.1	Anomaly	Change in horizontal and vertical alignment of track in fault zone, which was adjusted on three occasions. No compressive strain observed along track. Compressive strain may have developed across the track but surveys affected by instability of cutting batter on Up side (not mining related).
Main Southern Railway (91.700km to 91.820km)	28mm over 40 metres	< 0.1	Anomaly	Change in vertical alignment of track. Small hump observed on track at 91.700km.
Main Southern Railway at 91.280km	26mm over 40 metres	-4.2	Valley closure	Substantial valley closure of 178 mm across Redbank Creek. Change in horizontal alignment of track. No changes in track geometry detected visually in the track.
RK Line (Pegs RK18 to RK19)	No bump visible in subsidence profile though pegs are spaced 60m apart	-1.9	Valley closure	Located in farmland with no impacts observed.
Bridge St (Pegs BG66 to BG67)	Small bump visible in subsidence profile	-1.6	Possible non-systematic movement due to higher than normal compressive ground strain.	Compression in pavement shoulder and formation of potholes during wet weather.

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.

It can be seen that the majority of non-systematic movements were located in farmland with no impacts observed.

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. 2.9.

Fig. 2.9 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. 2.10.

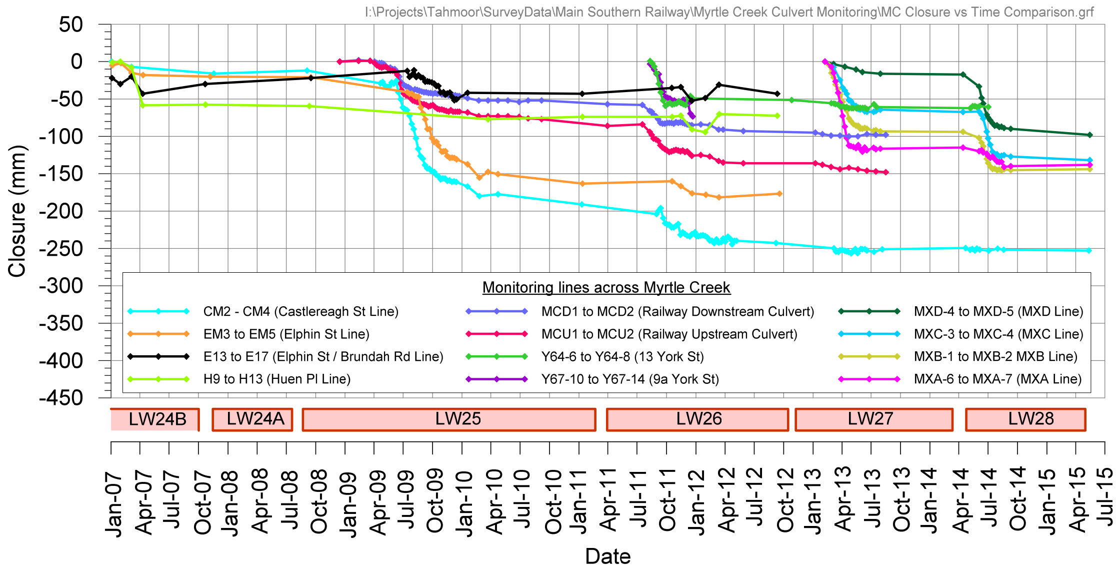

Fig. 2.10 Development of closure across Myrtle Creek during the mining of Longwalls 24B to 28

A detailed map of survey marks and cross lines across the Skew Culvert is shown in Fig. 2.11, overlaid with results from the survey of 5 August 2014.

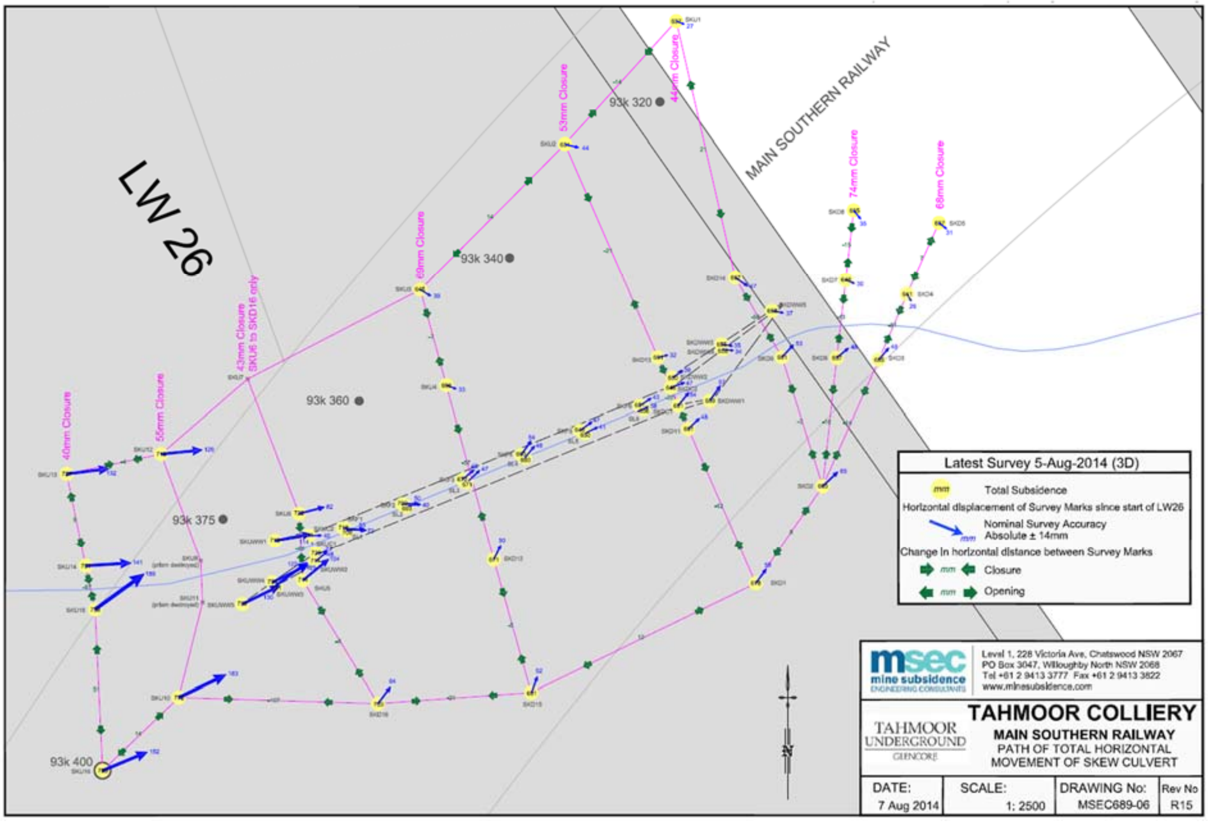

Fig. 2.11 Observed horizontal movements at Skew Culvert during the mining of Longwall 28

The development of valley closure across the creek at the Skew Culvert is shown in Fig. 2.12.

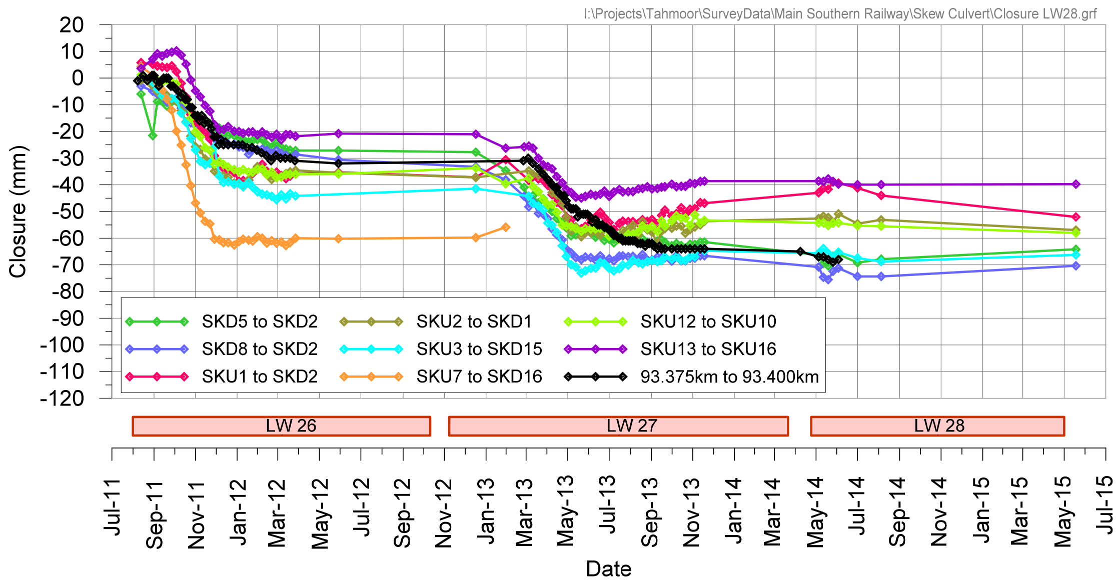

Fig. 2.12 Development of closure across Skew Culvert during the mining of Longwalls 26 to 28

A summary of predicted and observed valley closure across Myrtle Creek is provided Table 2.4. The predictions are consistent with those provided in Report No. MSEC355, in support of Tahmoor Colliery's SMP application to extract Longwalls 27 to 30, where predicted total closure was 75 mm.

Table 2.4 Predicted and Observed Incremental Valley Closure at Monitoring Lines across Myrtle Creek and Skew Culvert

Location	Category	Predicted and Observed Valley Closure due to Mining of Each Longwall (mm)				
		Due to LW24	Due to LW25	Due to LW26	Due to LW27	Due to LW28
Castlereagh St (Pegs CM2 to CM4)	Predicted	30	55	45	25	15
	Observed	12	179	52	8	3
Elphin-Myrtle (Pegs EM3 to EM5)	Predicted	60	70	40	-	-
	Observed	21	142	22	-	-
Elphin St / Brundah Rd (Pegs E13 to E17)	Predicted	75	75	30	-	-
	Observed	0	21	6	-	-
Huen Pl (Pegs H9 to H13)	Predicted	60	35	15	-	-
	Observed	58	15	20	-	-
Main Southern Railway Upstream (MCU1 to MCU4) Downstream (MCD1 to MCD4)	Predicted	15	30	30	15	-
	Observed	-	57 (d/s) to 86 (u/s)	36 (d/s) to 50 (u/s)	5 (d/s) to 12 (u/s)	-
Skew Culvert (8 cross-sections)	Predicted	< 5	10	25	25	10
	Observed	-	-	21 to 60 (average 36)	8 to 36 (average 21)	1 to 5 (average 3)
13 York St (Pegs Y64-6 to Y64-8)	Predicted	-	-	65	50	20
	Observed	-	-	51	9	1
9a York St (Pegs Y67-10 to Y67-14)	Predicted	-	-	85	85	25
	Observed	-	-	73	No access	No access
MXA Line (Pegs MXA-6 to MXA-7)	Predicted	-	-	-	150	75
	Observed	-	-	-	115	138
MXB Line (Pegs MXB-1 to MXB-2)	Predicted	-	-	-	170	150
	Observed	-	-	-	94	144
MXC Line (Pegs MXC-3 to MXC-4)	Predicted	-	-	-	150	170
	Observed	-	-	-	67	132
MXD Line (Pegs MXD-4 to MXD-5)	Predicted	-	-	-	50	70
	Observed	-	-	-	17	98

It can be seen from the above table, that the observed valley closure has substantially exceeded predictions at the Castlereagh Street crossing, at the crossing of the Elphin-Myrtle monitoring line and, to a lesser extent, the crossing of the Main Southern Railway during the mining of Longwall 25. It is considered that the reason for the differences in observations may be linked to the change in orientation of Myrtle Creek as the three above-mentioned monitoring lines are located along the same stretch of Myrtle Creek. It is noted, however, that substantially less closure has developed at Castlereagh Street than predicted during the mining of Longwall 27.

Observed valley closure across Myrtle Creek where it flows directly above Longwalls 27 and 28 (MXA to MXD lines) have generally been less than predictions, but greater in magnitude across monitoring lines above previously extracted longwalls. This was expected because the valley is deeper compared to sections further upstream.

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. 2.13. 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.

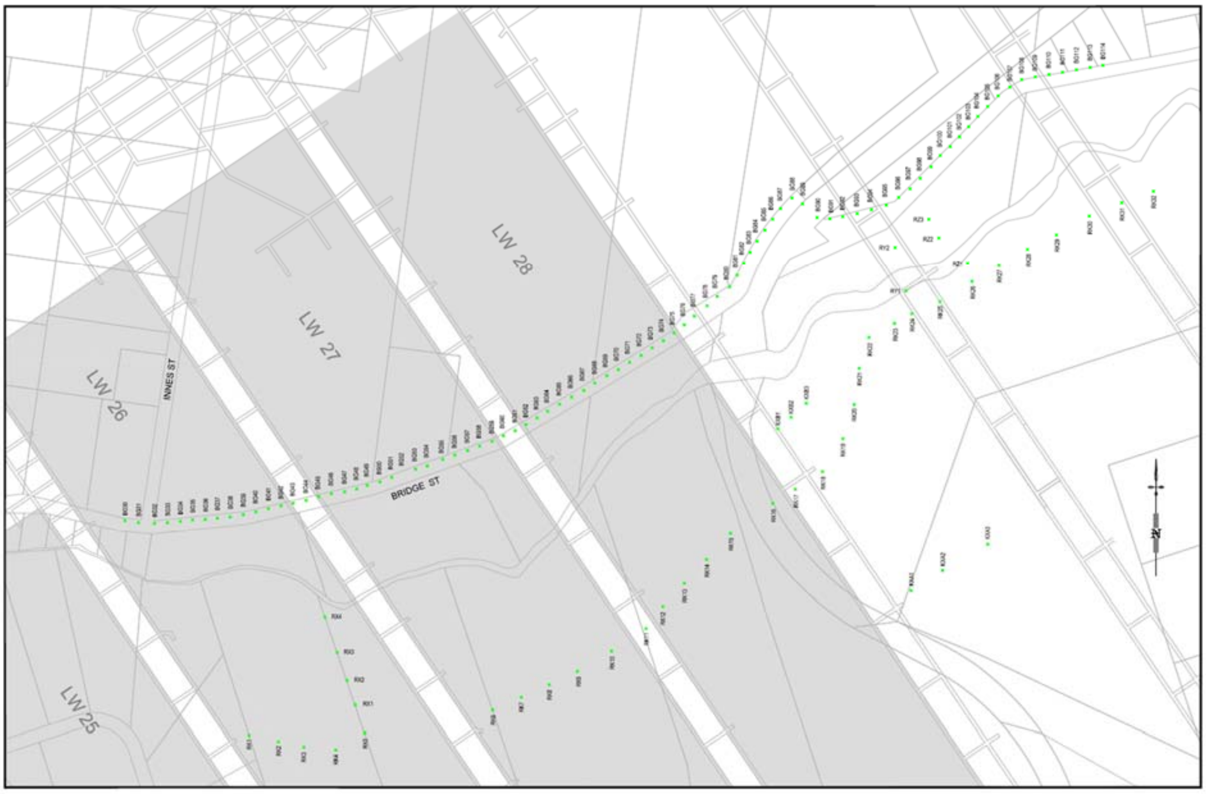

Fig. 2.13 Location of survey marks across Redbank Creek

Graphs showing observed subsidence, tilt and strain along each of the monitoring lines are provided Figs. A.25 to A.32 and drawings showing incremental subsidence and relative horizontal movements are shown in Drawings Nos. MSEC777-02 and MSEC777-03.

The development of incremental valley closure across Redbank Creek and its tributaries during the mining of Longwall 28 against both time and the distance between the survey pegs and the longwall face are shown in Fig. 2.14 and Fig. 2.15, respectively.

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.

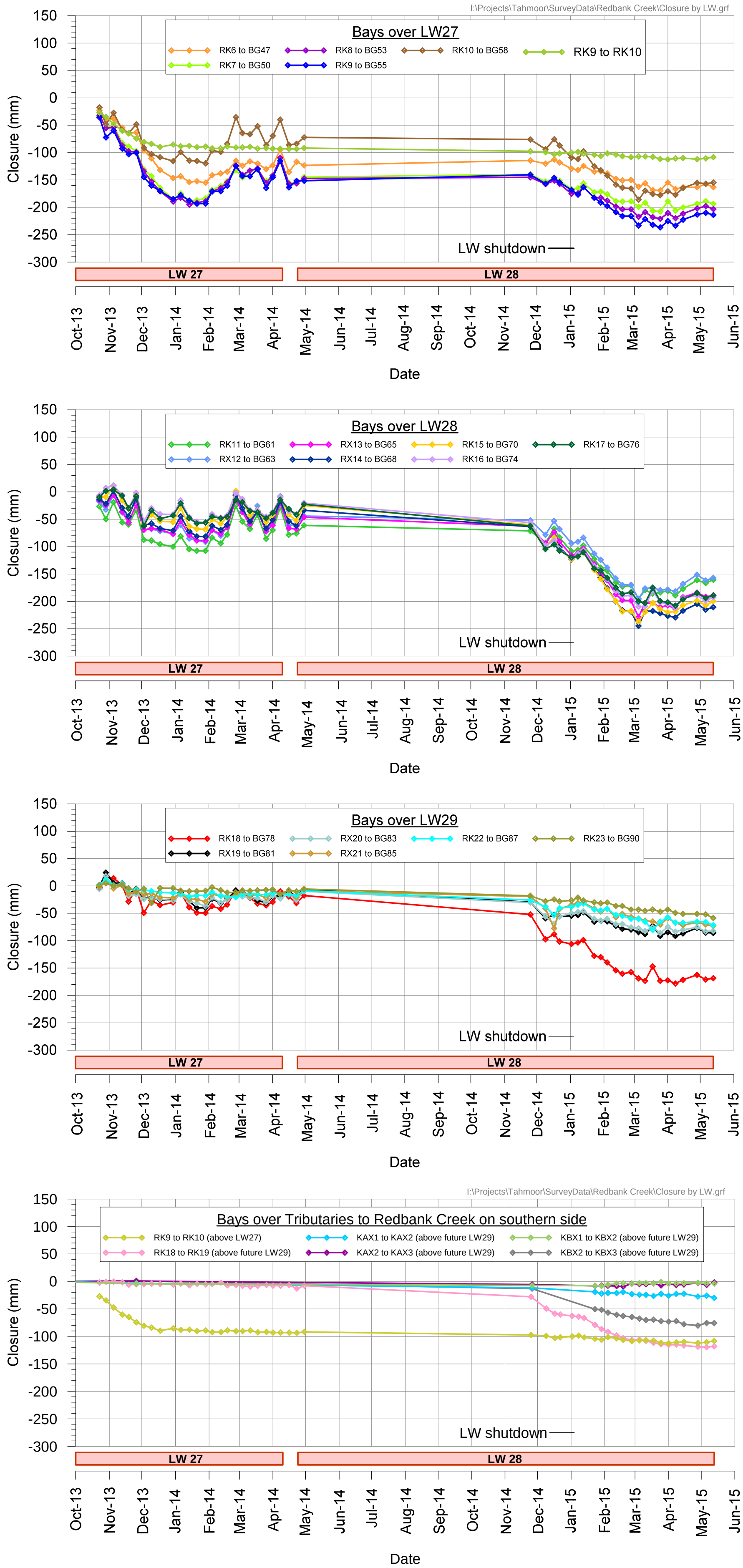

Fig. 2.14 Observed development of closure across Redbank Creek over time

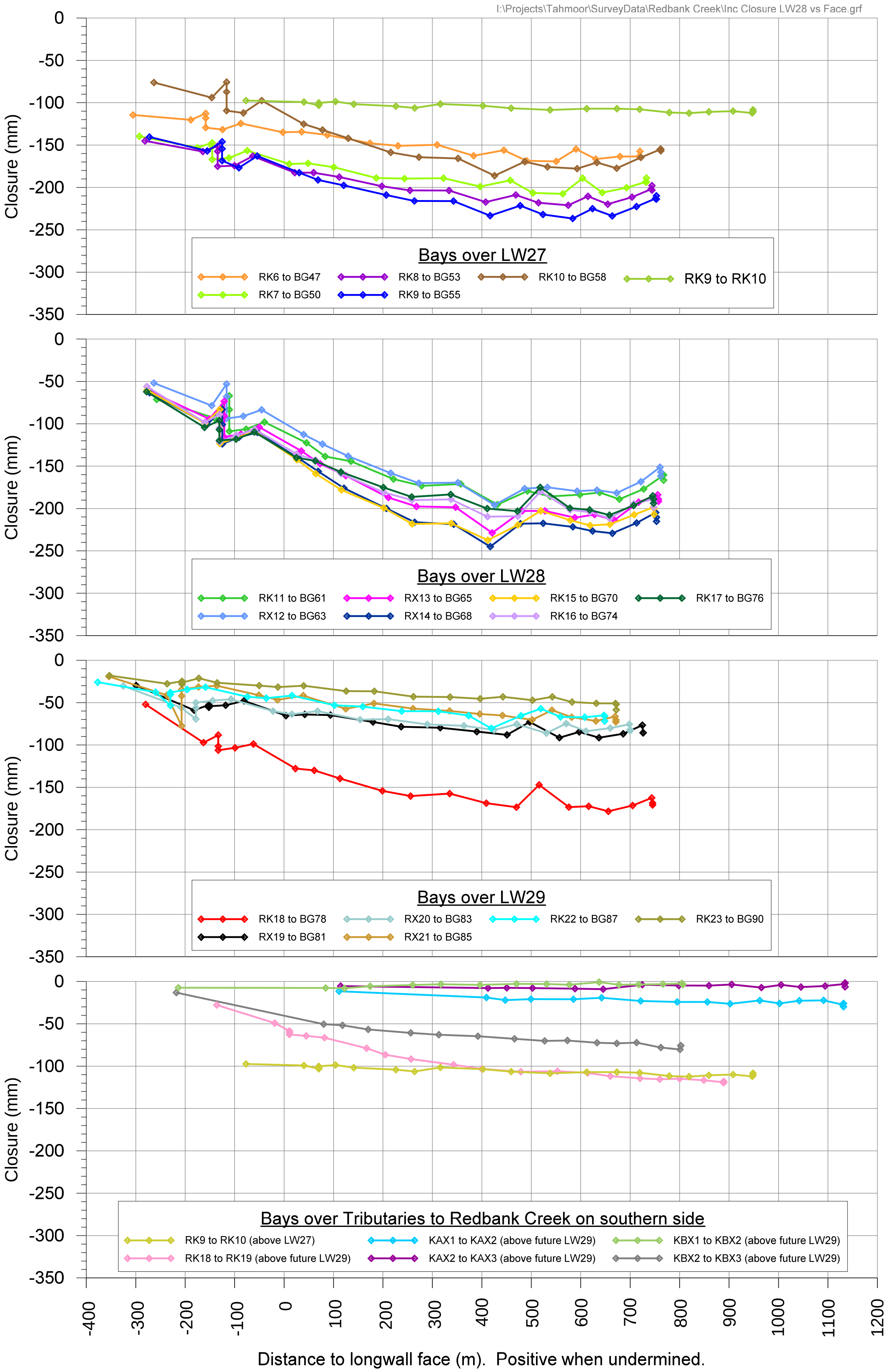

Fig. 2.15 Observed development of closure across Redbank Creek relative to distance to longwall face

A number of observations are made from the monitoring data.

- It can be seen from Fig. 2.14 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 28 was greater than above Longwall 27. This was predicted as the valley is deeper and more incised above Longwall 28.
- Measured closure between Pegs RX18 and BG78 is representative of measured valley closure at Redbank Creek Culvert. It can be seen that this result is larger than other survey bays over solid coal. It is considered that the closure is greater due to the influence of both Redbank Creek and the tributary. As shown in Fig. 2.15, closure across the tributary was approximately 110 mm, which represents more than half the total closure observed across the culvert.
- A similar magnitude of valley closure was observed across a tributary above Longwall 27. Closure did not increase at this location during the mining of Longwall 28.

A comparison between observed and predicted valley closure along Redbank Creek is shown in Fig. 2.16. 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 28.
- Observed total closure from the mining of Longwalls 26, 27 and 28 is less than predicted.
- Above the chain pillar between Longwalls 27 and 28, the incremental of valley closure during the mining of Longwall 28 is similar in magnitude to observed valley closure above Longwall 27.

Maximum predicted valley closure due to extraction of Longwall 28 was 167 mm. As shown in the bottom graph of Fig. 2.16, observed maximum incremental valley closure at the completion of Longwall 28 was 177 mm. It can also be seen from the top graph of Fig. 2.16 that observed total closure from the mining of Longwalls 26, 27 and 28 is less than predicted.

Observed total closure is also less than the predicted total closure of 390 mm due to the mining of Longwalls 22 to 28, as reported in Report No. MSEC355.

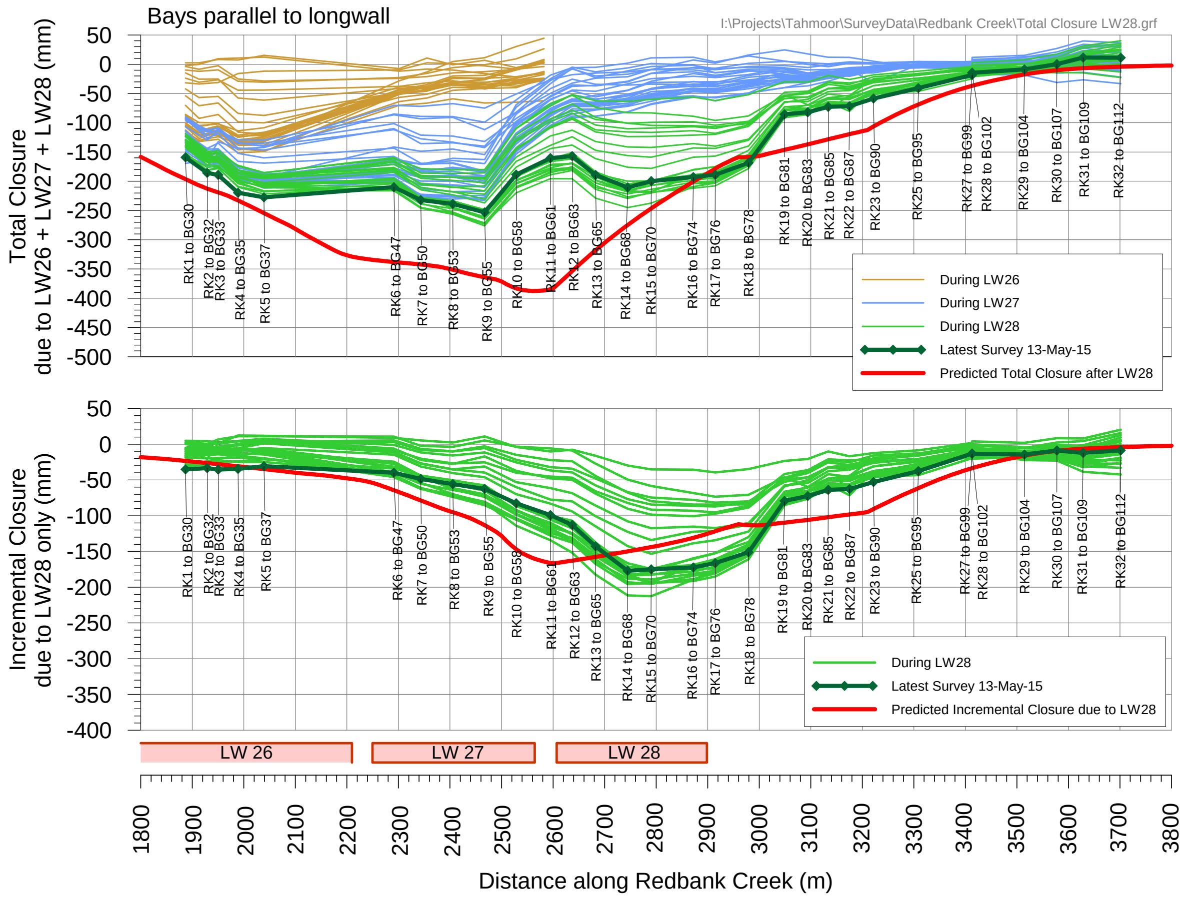

Fig. 2.16 Comparison between observed and predicted valley closure along Redbank Creek

2.5. Main Southern Railway

The Main Southern Railway was surveyed in either 2D or 3D for a total of 55 times on a weekly basis during the extraction of Longwall 28. 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 774 mm of subsidence during the mining of Longwall 28.

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

- Observed maximum subsidence is slightly greater than predicted maximum subsidence.
- 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.47, 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.
- While there is a reasonable relationship between the predicted and observed shapes of the subsidence profile, a pronounced bump was observed in the subsidence profile at 93.560 km. The bump did not coincide with increased compressive strain along the track but, instead, increased compressive strain of approximately 3.5 mm/m over a 20 metre bay length was observed across the track. It is postulated that the bump was oriented sub-parallel to the track. It is noted, that increased compressive strain of approximately 1.8 mm/m was observed south of the bump near 93.620 km and this may be related to the geological feature that caused the bump at 93.560 km.
- Bumps are observed in isolated locations, including between 91.700 km and 91.820 km, and above Redbank Creek Culvert at 91.280 km.
- Observed ground strains along the railway corridor have generally relatively small in magnitude, with increased ground strains observed at a number of isolated locations. Increased ground strains have been observed across Myrtle Creek, the creek at the Skew Culvert, and across Redbank Creek as expected (refer Section 2.3).

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 33 metres. They measured changes in rail strain every 5 minutes during the mining of Longwall 28. Rail stresses exceeded triggers during the mining of Longwall 28 where low SFT had been observed during a period of very high track temperatures.

Expansion switch displacement sensors

Displacement sensors have been installed at each expansion switch. Measurements were recorded every 5 minutes during the mining of Longwall 28. Mining-induced changes were observed, though larger changes were due to thermal effects. 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. Skew Culvert at 93.342 km

A total of 8 ground surveys, 4 extensometer surveys and 7 detailed visual inspections were undertaken for the Skew Culvert on a weekly to monthly basis in accordance with the agreed management plans with ARTC.

Very little additional subsidence and strain was observed during the mining of Longwall 28, with no new impacts observed.

2.5.3. Redbank Creek Culvert and Embankment at 91.265 km

A total of 28 ground surveys, 36 extensometer surveys and 25 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 24 mm and 147 mm in total during the mining of Longwalls 27 and 28.

Observed absolute horizontal movements along the Main Southern Railway are shown in Fig. 2.17. 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. MSEC777-03, 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. 2.18. 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. 2.19. Maximum observed closure was measured between the long bay survey pegs on the track at 91.220 km and 91.360 km, though a very 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 almost 100 mm, the culvert barrel at the inlet closed only 20 mm. Very little closure was observed across the culvert barrel or wingwalls at the downstream inlet.

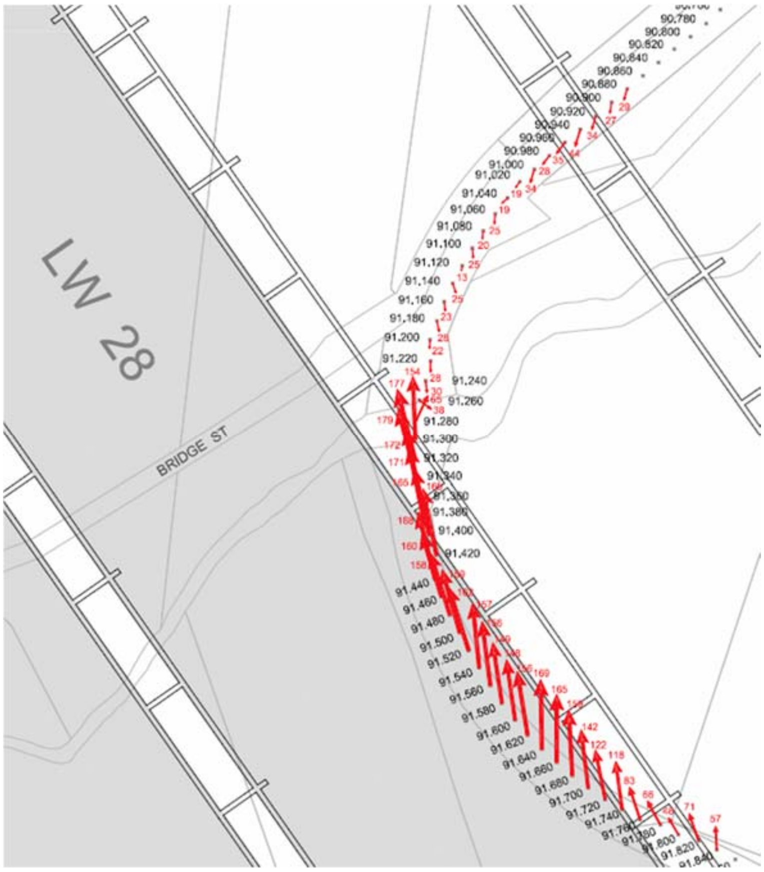

Fig. 2.17 Observed total horizontal movement along Main Southern Railway during the mining of Longwalls 27 and 28 as at 5 May 2015

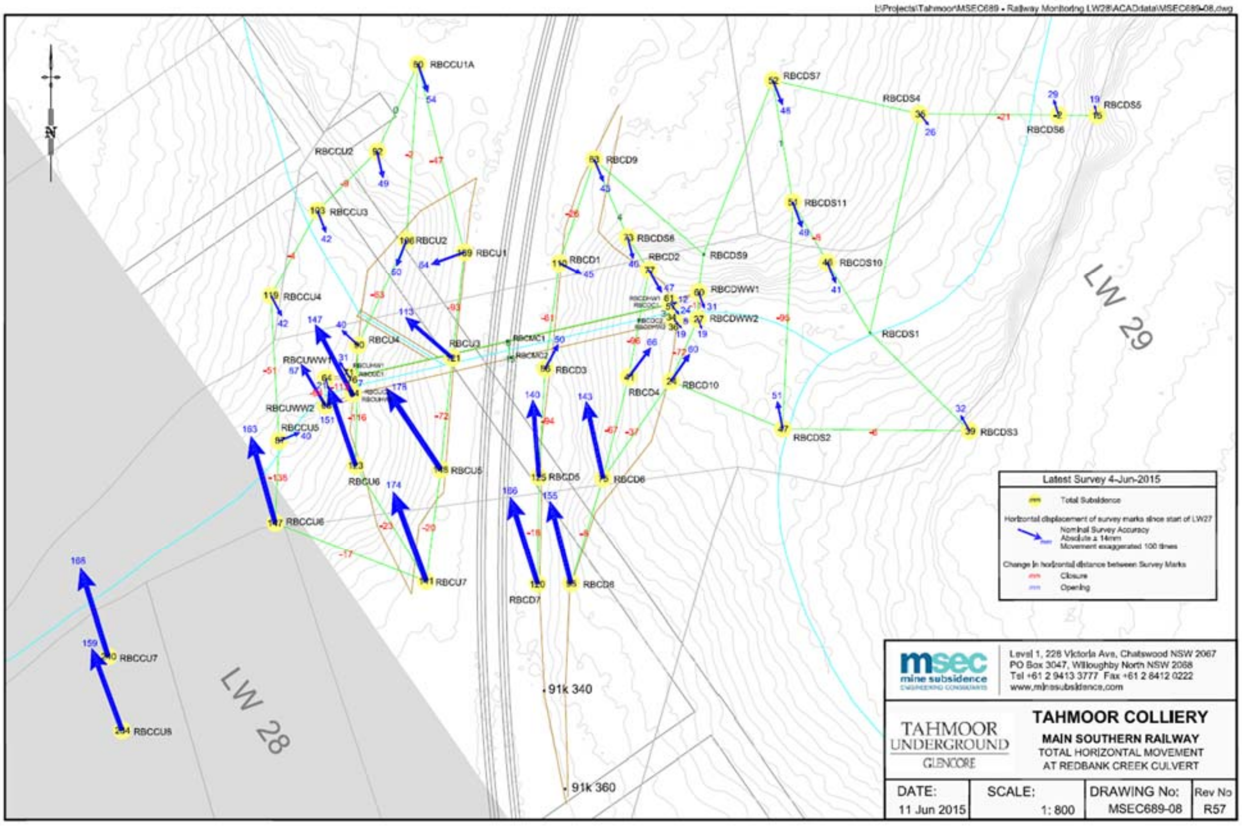

Fig. 2.18 Observed total horizontal movement at Redbank Creek Culvert and embankment during the mining of Longwalls 27 and 28

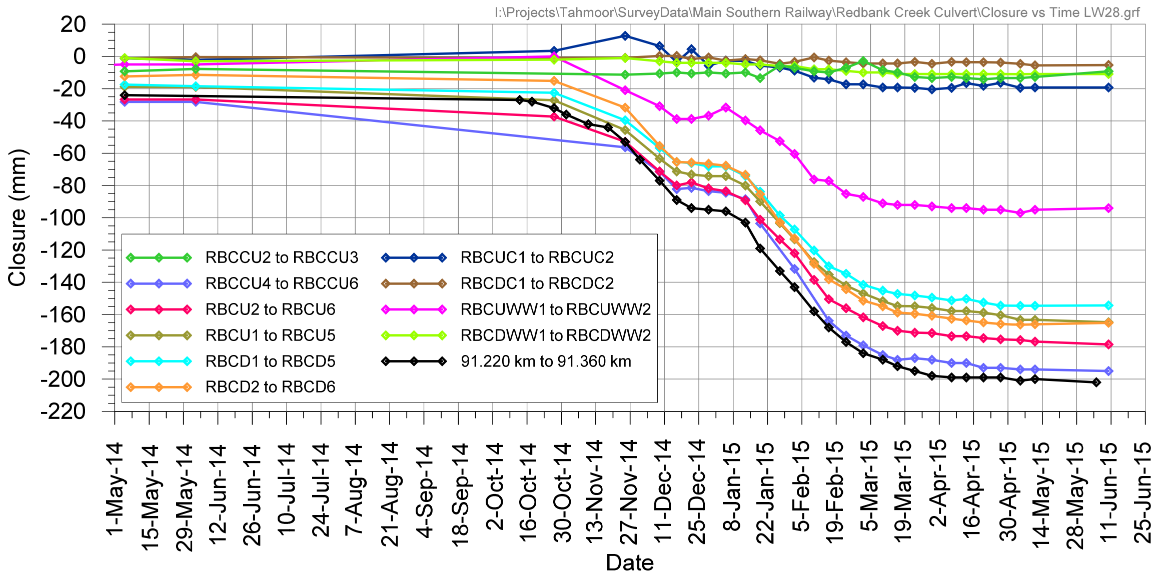

Fig. 2.19 Observed Total Valley Closure over time across Redbank Creek Culvert at Main Southern Railway during the mining of Longwall 28 (includes closure from Longwall 27)

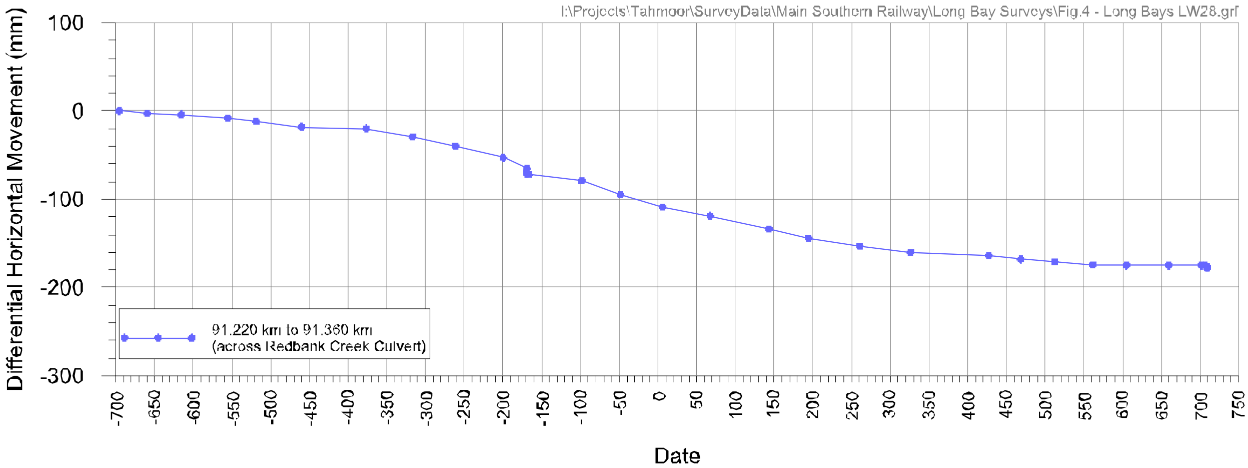

Fig. 2.20 Observed Total Valley Closure as measured by long bay survey, relative to face distance across Redbank Creek Culvert at Main Southern Railway during the mining of Longwall 28 (includes closure from Longwall 27)

It can be seen from Fig. 2.20 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.

Observed along subsidence the base of the embankment on the upstream side is shown in Fig. 2.21. The results show valley closure focussing between Pegs RBCCU4 and RBCCU6, with upsidence observed at Peg RBCCU4.

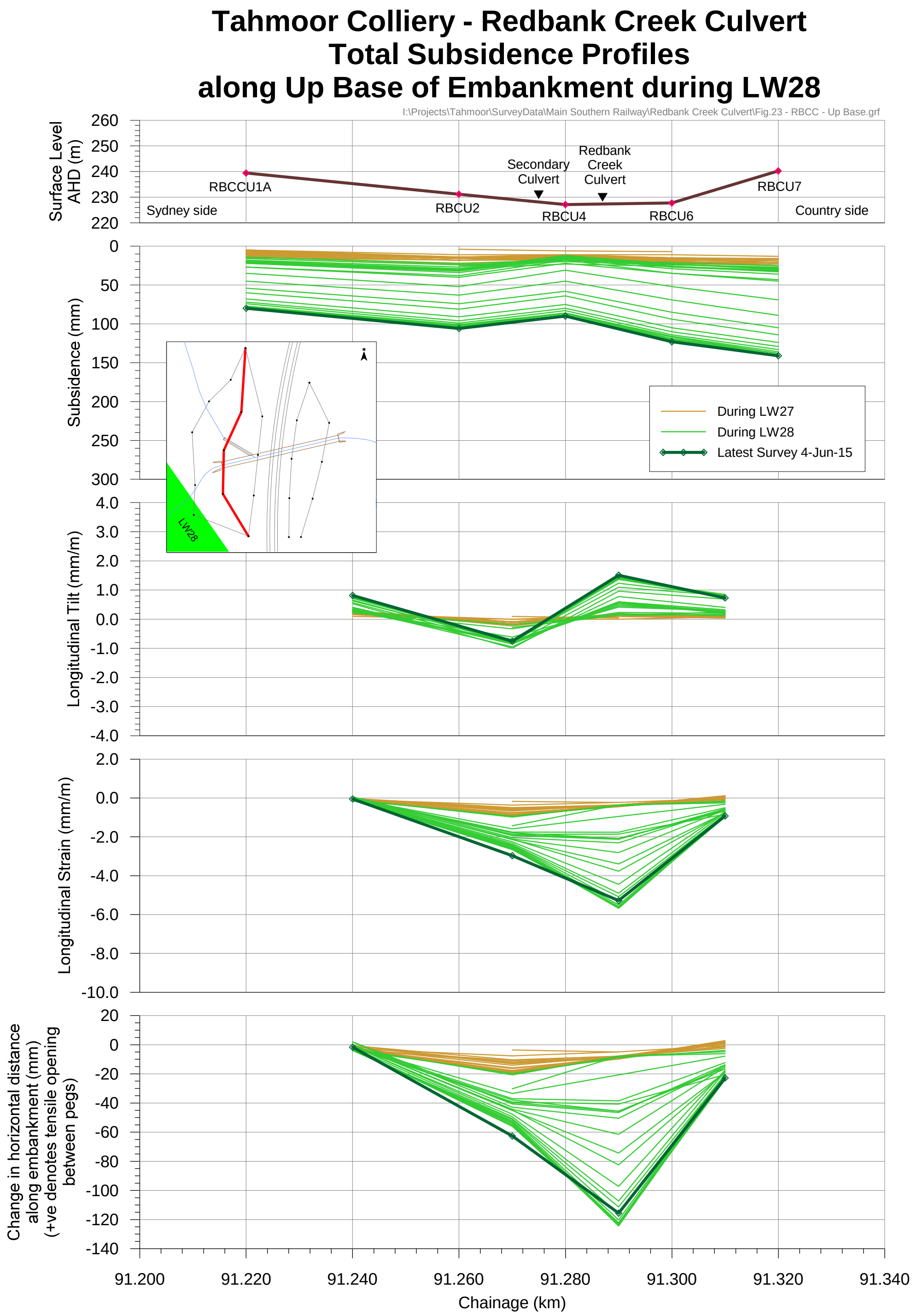

Fig. 2.21 Observed subsidence, tilt and strain across the upstream base of Redbank Creek Culvert during the mining of Longwall 28 as at 4 June 2015

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 mining.

The Tahmoor Carrier is the main branch servicing the majority of Tahmoor township. A total of 17 surveys were undertaken along the Tahmoor Carrier during the mining of Longwall 28. 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 28 increased the predicted grade in this area almost to the pre-mining grade, as shown in Fig. 2.22.

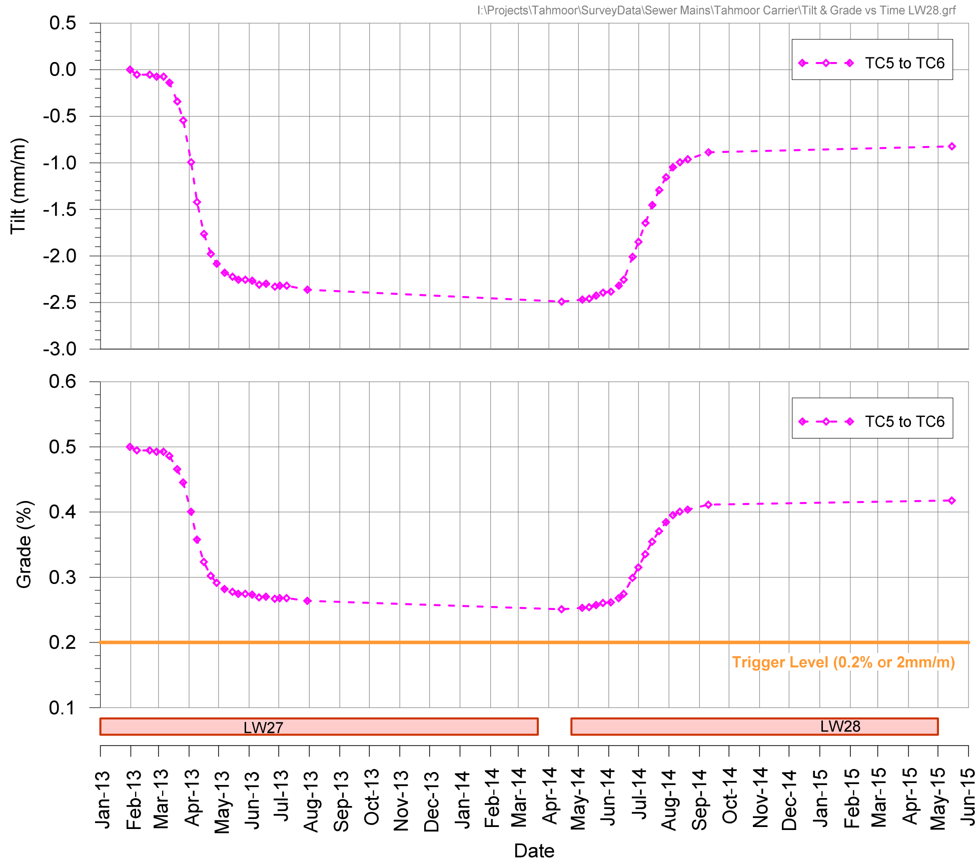

Fig. 2.22 Observed changes in mining-induced tilt and sewer grade at Tahmoor Carrier between Pegs TC5 and TC6

As shown in Fig. A.39, increased compressive ground strain was observed between Pegs TC15 and TC16, and observed changes are shown in Fig. 2.23.

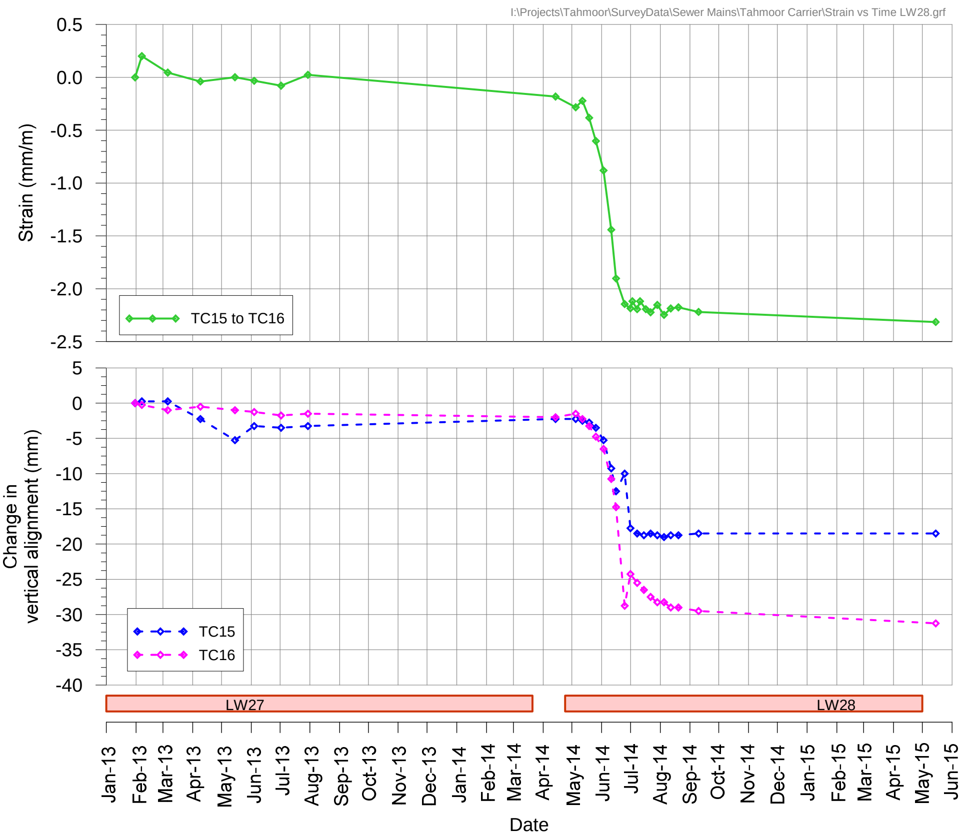

Fig. 2.23 Observed changes in strain and vertical alignment at Tahmoor Carrier between Pegs TC15 and TC16

The affected section of pipe is located directly beneath part of a house. Sydney Water undertook a CCTV inspection in early July, with no issues noted. A follow up CCTV inspection was undertaken in late July, and no issues were found. Visual inspections around the house and driveway have not detected any impacts.

The Thirlmere Carrier is the main branch servicing the majority of Thirlmere township. A total of 25 surveys were undertaken along the Thirlmere Carrier during the mining of Longwall 28. 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 28 increased the predicted grade in this area, as shown in Fig. 2.24. 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.

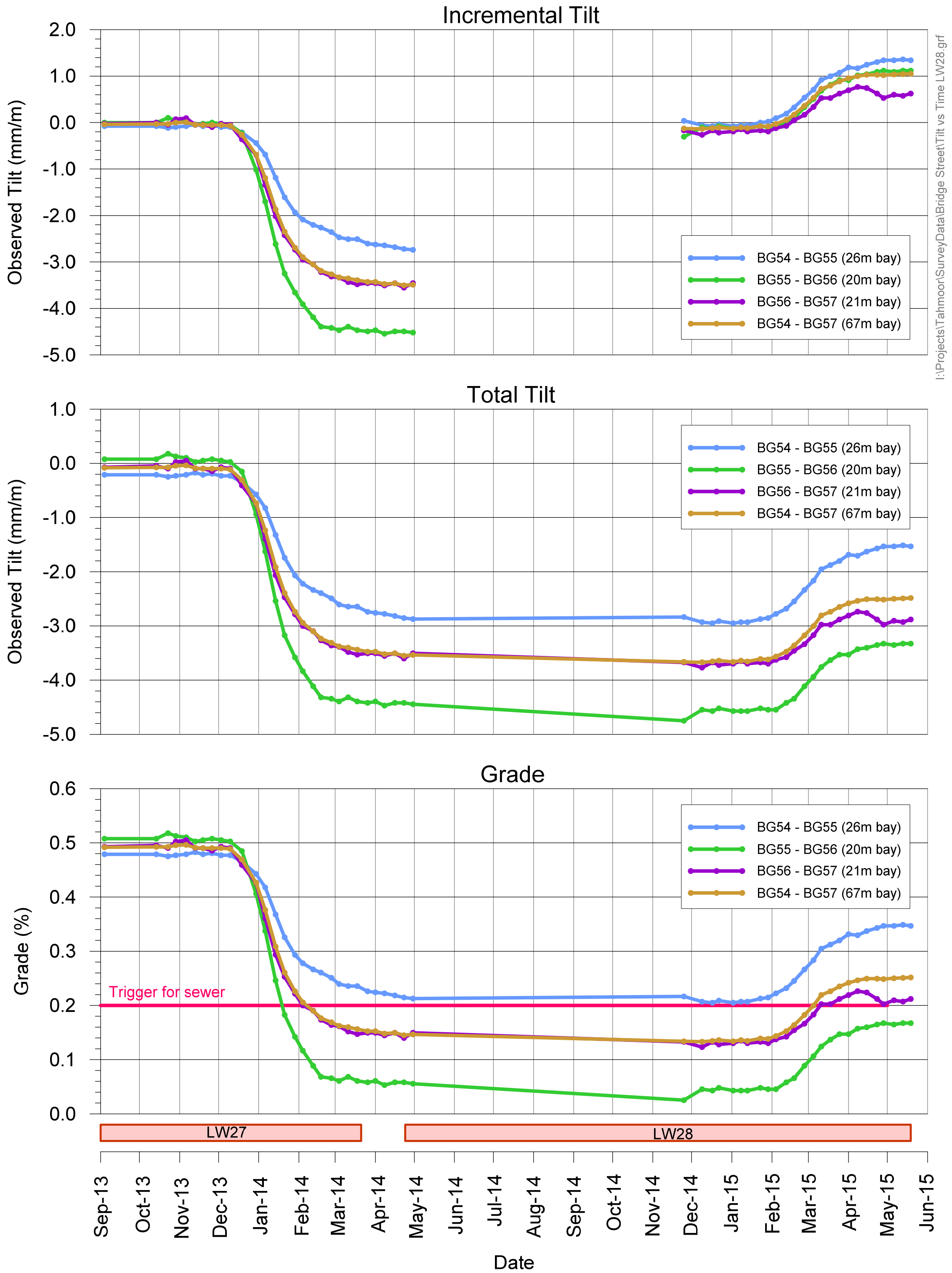

Fig. 2.24 Development of tilt on Bridge Street between pegs BG54 and BG57

2.7. Power Pole Surveys

A total of 121 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 28, as expected.

Of the poles that were surveyed, maximum subsidence of 637 mm was observed at Pole TEL2 on River Road.

2.8. Wollondilly Shire Council

2.8.1. Castlereagh Street Bridge

A total of 5 detailed surveys of the Castlereagh Street Bridge were undertaken in accordance with the agreed management plan and the results are shown in Fig. 2.25.

As discussed in Section 2.3, Castlereagh Street Bridge experienced 3 mm of valley closure during the mining of Longwall 28, which is within survey tolerance.

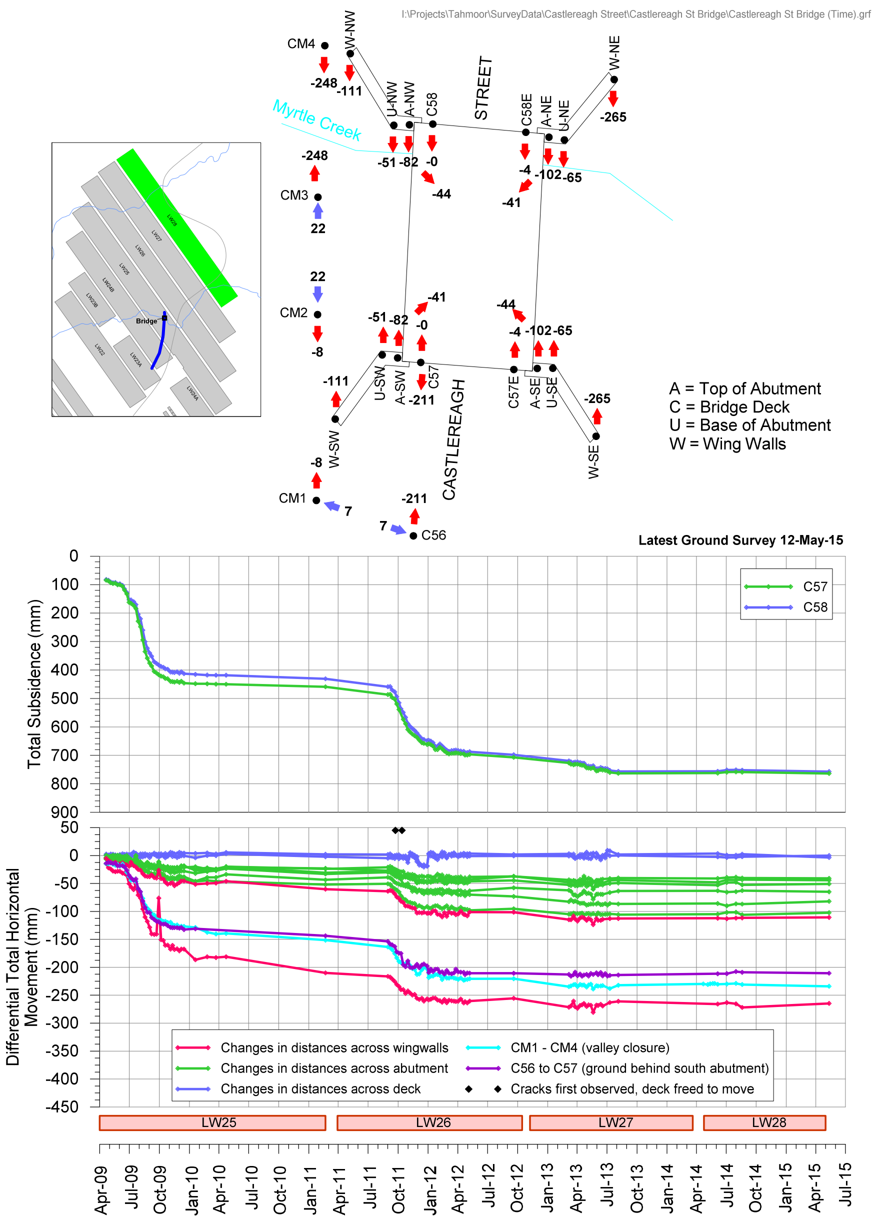

Fig. 2.25 Castlereagh Street Bridge

2.8.2. 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 and close to survey tolerance. Minor closure has been measured, as shown in Fig. 2.26. 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.

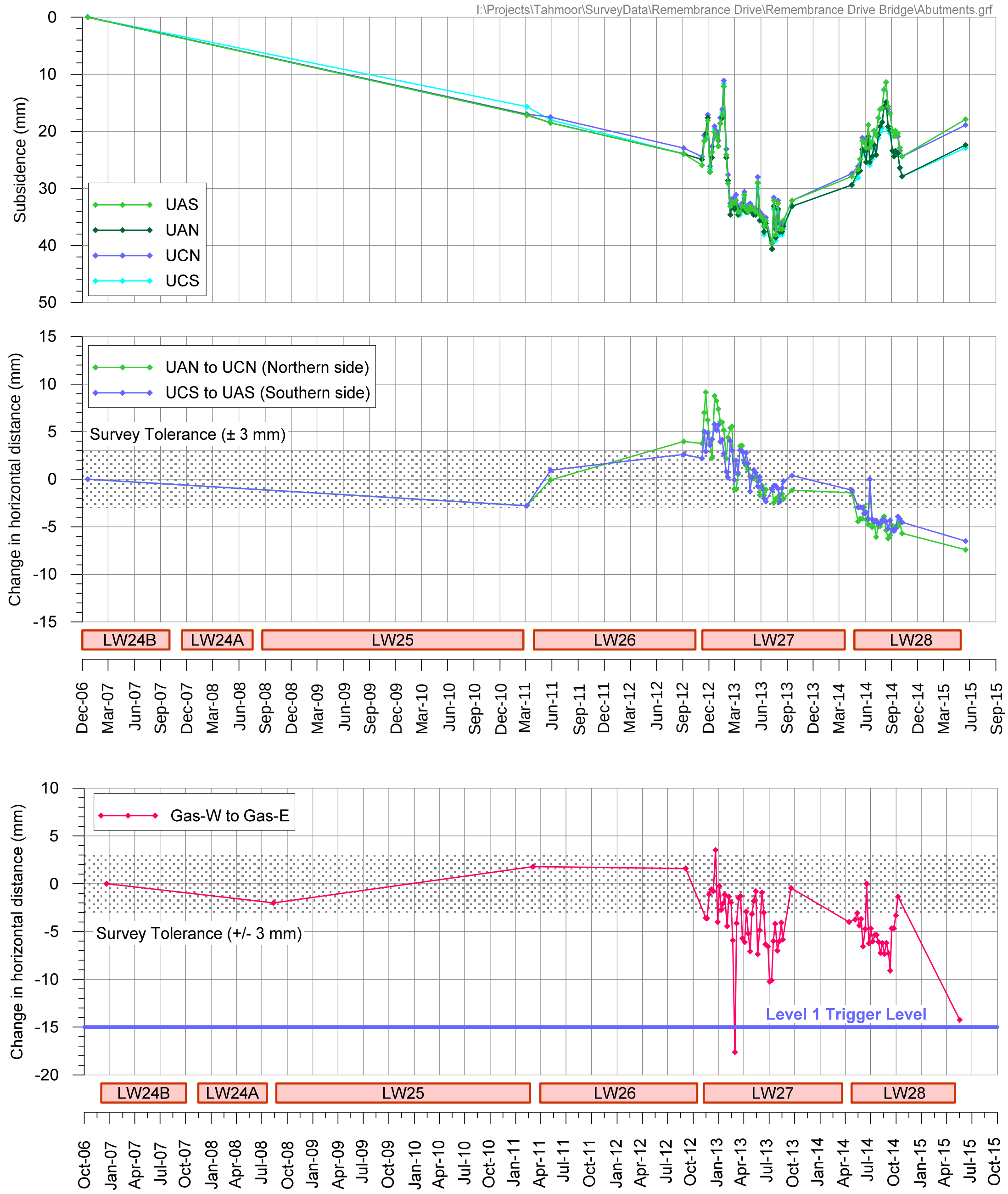

Fig. 2.26 Observed subsidence and changes in horizontal distances across the abutment and gas pipe supports at Remembrance Drive (Myrtle Creek) Road Bridge

2.9. Tahmoor House

Tahmoor House is an item of heritage significance, which is located on Remembrance Drive. A total of 17 detailed surveys of Tahmoor House were undertaken in accordance with the agreed management plan.

A maximum of 408 mm of subsidence has been observed around the perimeter of Tahmoor House during Longwall 28, as shown in Fig. A.43 and a total of 561 mm of subsidence has been observed since the commencement of Longwall 27, as shown in Fig. A.44.

Vertical subsidence around the property has remained relatively uniform. Slightly more subsidence (approximately 10 mm) is observed at the western side of the house compared to the eastern side, as seen in Fig. 2.27.

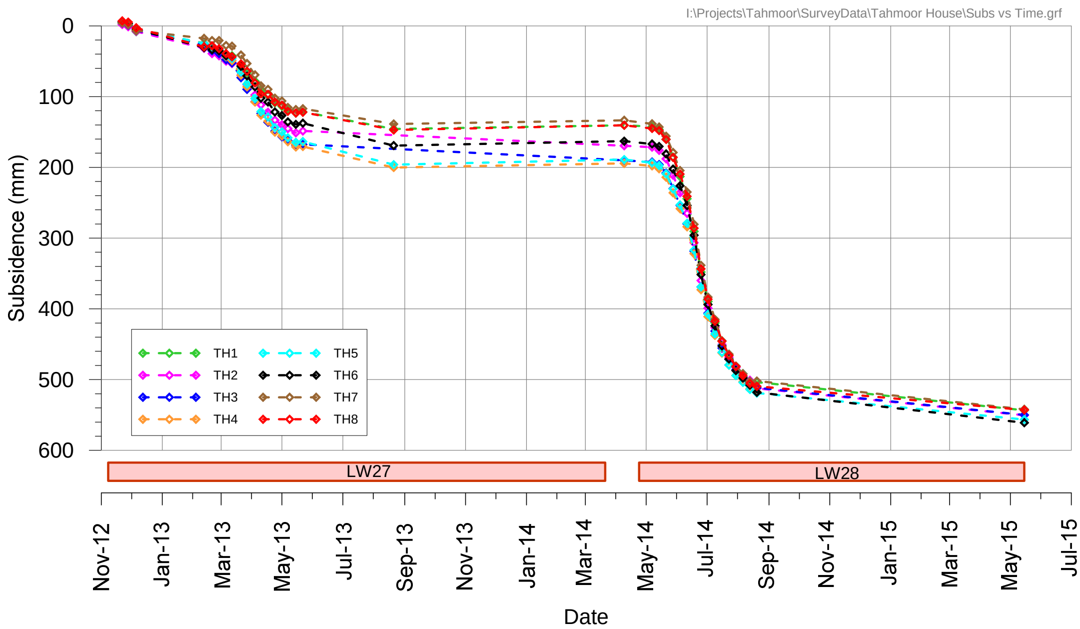

Fig. 2.27 Development of subsidence for ground pegs around Tahmoor House over time

Ground strain is a measure of change in horizontal distance between adjacent survey pegs, divided by their original length. Both ground strain and measured changes in horizontal distance have been shown in Fig. A.43 as the survey pegs are not uniformly spaced around the house. Measured changes in horizontal distances are in the order of 12 mm and ground strains are generally tensile in nature.

3.0 SUMMARY OF SURVEYS AND INSPECTIONS

Many surveys and inspections were conducted to meet the requirements of the Surface, Safety and Serviceability Management Plans. Due to the complexities involved, surveys and inspections were managed using a computer database on a weekly basis. A register was also kept, detailing when each survey and inspection had been completed. A timeline showing when each type of survey and inspection was conducted is shown in Fig. 3.1 and Fig. 3.2 below.

Fig. 3.1 Timeline of Surveys and Inspections during Longwall 28

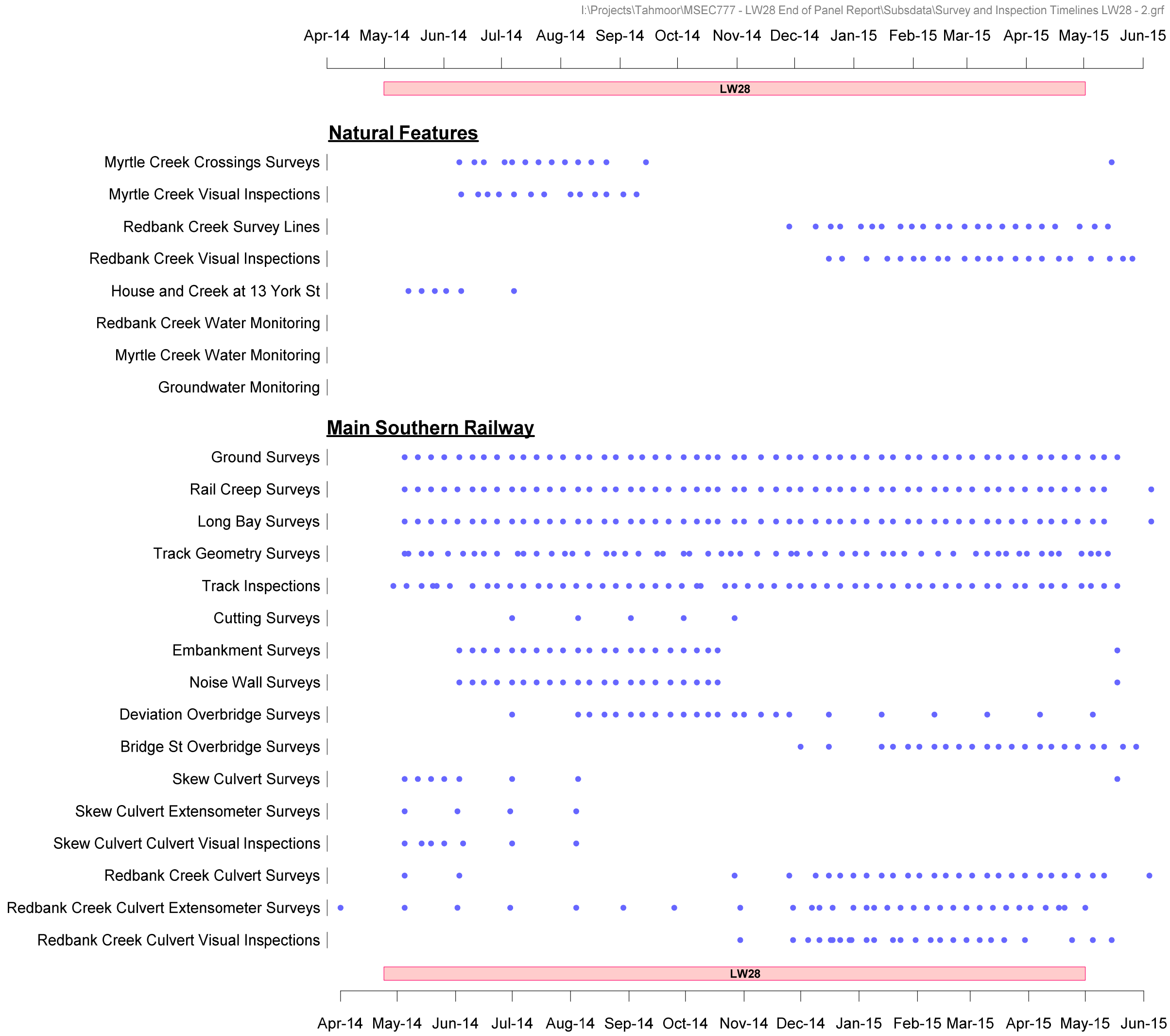

Fig. 3.2 Timeline of Surveys and Inspections during Longwall 28

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 28

Inspection / Survey	Responsibility	Number of Inspections / Surveys
Ground Monitoring Surveys		
	SMEC Urban	70
Sub-Total		**70**
Natural Features		
Myrtle Creek Crossings Surveys	SMEC Urban	14
Myrtle Creek Visual Inspections	GeoTerra	13
Redbank Creek Survey Lines	SMEC Urban	23
Redbank Creek Visual inspections	GeoTerra	22
13 York St Surveys	SMEC Urban	6
Sub-Total		**78**
Main Southern Railway		
Ground Surveys	Meadows Consulting	85
Rail Creep Surveys	Meadows Consulting	55
Long Bay Surveys	Meadows Consulting	55
Track Geometry Surveys	Railcon / BloorRail	56
Track Inspections	Railcon / BloorRail	56
Cutting Surveys	Meadows Consulting	5
Embankment Surveys	Meadows Consulting	22
Noise Wall Surveys	Meadows Consulting	22
Deviation Overbridge Surveys	Meadows Consulting	24
Bridge St Overbridge Surveys	Meadows Consulting	22
Skew Culvert Surveys	Meadows Consulting	8
Skew Culvert Extensometer Surveys	GHD	4
Skew Culvert Visual Inspections	GHD	7
Redbank Creek Culvert Surveys	Meadows Consulting	28
Redbank Creek Culvert Extensometer Surveys	GHD	36
Redbank Creek Culvert Visual Inspections	GHD	25
Sub-Total		**510**
Jemena - Gas		
Remembrance Drive Bridge Surveys	SMEC Urban	24
Sub-Total		**24**
Sydney Water - Sewer		
Tahmoor Carrier Pipe Surveys	SMEC Urban	18
Thirlmere Carrier Pipe Surveys	SMEC Urban	17
CCTV Inspections	Sydney Water	2
Sub-Total		**37**
Endeavour Energy - Electrical		
Power Pole Surveys	SMEC Urban	121
Sub-Total		**121**
Telstra - Telecommunications		
Optical Fibre Line Surveys	SMEC Urban	7
Sub-Total		**7**
Structure Inspections		
Houses and Units	Sergon	110
Pools and Pool Gates	Sergon	169
Dams	GeoTerra	4
Sub-Total		**283**
Wollondilly Shire Council		
Castlereagh St Bridge	SMEC Urban	5
Remembrance Drive Footbridge Surveys	SMEC Urban	24
Remembrance Drive Bridges Visual Inspections	Colin Dove	14
Sub-Total		**43**
Heritage		
Tahmoor House Surveys	SMEC Urban	17
Tahmoor House Visual Inspections	Colin Dove	13
Sub-Total		**20**
Total		**1186**

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, with the exception of locations where non-systematic movements have occurred.

Table 4.1 Summary of Predicted and Observed Impacts during Longwall 28

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 Myrtle and Redbank Creeks over LW's 25 to 28. Increased ferruginous and salinity levels have been observed downstream of both Myrtle and Redbank Creek subsidence zones, along with elevated nickel, zinc, iron and manganese in Redbank Creek due to subsidence. 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 3 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 28.
Natural vegetation	No impacts anticipated	No impacts observed during Longwall 28.
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 along most streets located directly above the longwall. Small bump and dip in pavement on Remembrance Drive, 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 28. 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 28. 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 28, though some CCTV inspections were undertaken to confirm. 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 28. 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 28. Refer Section 4.9 for further details.
Public Amenities	No public amenities affected by Longwall 28	No public amenities affected by Longwall 28
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 28.
Fences	Potential for impacts to fences and gates.	No impacts reported to fences on farm properties during Longwall 28.
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 28. 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 28. Please refer report by GeoTerra
Industrial, Commercial or Business Establishments	No business and commercial establishments affected by Longwall 28.	No business and commercial establishments affected by Longwall 28.
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.
Areas of Heritage Significance	Potential damage to Tahmoor House	Minor impacts on Tahmoor House during Longwall 28. Refer Section 4.10 for details.
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 4.11 for details.	While impacts occurred, houses were safe, serviceable and repairable during Longwall 28. Refer Section 4.11 for details.
Retirement or aged care villages	All dwellings expected to remain safe, serviceable and repairable provided that they are in sound condition prior to mining. Impacts predicted to some dwellings.	No impacts reported to dwellings during Longwall 28.
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.	Impacts to 32 pools during the mining of Longwalls 22 to 28, and no impacts to pools reported during the mining of Longwall 28.
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.	Impacts to 2 retaining walls were reported during Longwall 28.
External residential pavements	Cracking and buckling likely to occur, though majority minor.	Impacts to external pavements were reported by5 properties during Longwall 28.
Fences in urban areas	Some fences and gates could be slightly damaged. Most vulnerable are Colorbond fences.	No impacts to fences reported during Longwall 28.

4.2. Creeks

4.2.1. Myrtle Creek

GeoTerra undertook an investigation into the effects of Longwall 28 on surface and ground waters in the area (GeoTerra, 2015).
During the mining of Longwall 28, new or additional subsidence effects were observed at Sites 9, 10 and 11 over the chain pillar between Longwalls 26 and 27, Sites 12 to 19 directly above Longwall 27, and at Sites 20 to 26 above Longwall 28 (refer to report by GeoTerra for locations of sites). Re-emergence of the stream “through-flow” has been observed downstream of Longwall 28.

Cracking was observed at the above sites and pools were observed to drain at times of low flow.

The creek trended to being slightly more alkaline and then became more acidic downstream of the subsidence zone. Sulphate, bicarbonate, iron, and manganese levels are generally not elevated, with the exception of two isolated occasions during the mining of Longwall 27. No observable trend or change in level of aluminium was observed during the mining of Longwall 28, however notable increases in copper (at one site) and zinc (at two sites) were observed during the mining of Longwall 28.

A new seep has been generated at Site 21A, which maintains flow in Site 22, however the water that flows into a large pool at Site 23 is generally insufficient to maintain above low levels and the pool often dries out. Seepage flow is generally observed in a downstream pool at Site 24, with pool levels often maintained although are now more responsive from Sites 25 to 31.

4.2.2. Redbank Creek

GeoTerra undertook an investigation into the effects of Longwall 28 on surface and ground waters in the area (GeoTerra, 2015).

During the mining of Longwall 28, new or additional subsidence effects were observed at Site 24 directly above Longwall 27, and at Sites 29 to 33 above Longwall 28 (refer to report by GeoTerra for locations of sites). Re-emergence of the stream "through-flow" has been observed downstream of Longwall 28.

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 28. No observable trend or change in levels of aluminium or copper was observed during the mining of Longwall 28.

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 28.

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 28

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	Trigger exceeded during mining of LW28 between Sites 13A and 17, and Site 20 above LWs 27 and 28.	Trigger exceeded during mining of LW28 at Sites 21/21A and Site 24 above LW27.
Significant reduction compared to baseline, predicted impacts last over 2 months and exceed 2 standard deviations compared to baseline	Trigger not exceeded during mining of LW28.	Trigger exceeded at Site 37 over LW29 on 5 March 2015.

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 28. The track condition deteriorated slightly in isolated locations as a result of mining and the track was resurfaced.

During the mining of Longwall 28 some of the triggers associated with the *Tahmoor Colliery Longwall 28 Management Plan for Longwall Mining beneath the Main Southern Railway (Rev B, March 2014)* were exceeded.

Rail stresses exceeded triggers on one occasion during the mining of Longwall 28, as a result of low SFT at time of high track temperatures.

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. Skew Culvert

Tahmoor Colliery has successfully extracted directly beneath the Skew Culvert.

While impacts occurred during the mining of previous longwalls, very little additional valley closure was observed during the mining of Longwall 28 and no changes to existing cracks in the culvert were observed.

4.3.3. Redbank Creek Culvert and Embankment

Tahmoor Colliery has successfully extracted Longwall 28 adjacent to the Redbank Creek Culvert. Substantial ground shortening of approximately 180 mm was observed along the length of the culvert, and ground extension of approximately 110 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 28.

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. Extensive additional measures are being installed in the Culvert in preparation for the influence of Longwall 29.

The Redbank Creek Culvert and Embankment has remained safe and serviceable during the mining of Longwall 28. 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 25 mm to 50 mm, then 75 mm and lastly 100 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 25.2 kilometres of asphaltic pavement lie directly above the extracted longwalls and a total of 48 impact sites have been observed. The observed rate of impact equates to an average of one impact for every 525 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.

York Street

Tahmoor House Court

Remembrance Drive

Bridge Street

Bridge Street

Photographs courtesy of Colin Dove

Fig. 4.1 Photographs of Impacts to Road Pavements and Kerbs during Longwall 28

4.4.2. Castlereagh Street Bridge

Impacts were experienced at Castlereagh Street Bridge during the mining of Longwall 26 and these were documented in the End of Panel report for Longwall 26. No additional impacts were observed during the mining of Longwalls 27 and 28.

4.5. Potable Water Infrastructure

Longwalls 22 to 28 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 28.

4.6. Gas Infrastructure

Longwalls 22 to 28 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 28 have directly mined beneath approximately 28.8 kilometres of sewer pipes. The following observations have been made:

- *Changes to grades of self-cleansing gravity sewers*
  While changes in sewer grades have occurred as a result of mine subsidence, no blockages or reversals of grade have been observed. This includes observations at locations above Longwalls 24A to 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 and 28. 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 new locations during the mining of Longwall 26. In each case the pipes remained serviceable, though repairs were required at each location.

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

The observed impacts to date have been within expectations.

4.8. Electrical Infrastructure

Longwalls 22 to 28 have directly mined beneath approximately 36.2 kilometres of electrical cables and 971 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 28 have directly mined beneath approximately 43.1 kilometres of buried copper cable and 1.3 kilometres of buried optical fibre cable and 4.3 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 and 28.

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

4.10. Tahmoor House

Weekly inspections have found minor impacts during the mining of Longwall 28. The inspections were occasionally undertaken in company with the owner.

Extensive weatherboard re-cladding work has been undertaken in the south eastern corner and western face of the building.

Some gaps present in the sandstone walls have opened slightly. A gap has been observed at the vertical face at the rear of the second sandstone block step. A fine crack has been observed in the sandstone block wall on the ground floor adjacent to the external toilet.

The owner has reported possible changes on the eastern side in the sandstone wall and flagging stones.

4.11. Residential Establishments

All structures remained safe and serviceable during the mining of Longwall 28.

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 and Sergon Building Consultants who inspect structures on behalf of Tahmoor Colliery. 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 28 May 2015, the day before Longwall 29 commenced.

A summary of reported impacts following the completion of Longwall 28 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 28.

Table 4.3 Summary of Observed Impacts to Structures

	Total after LWs 22 to 28	Increment during Longwall 28
Number of structures within zone of influence (predicted subsidence > 20 mm)	1824	275
Number of properties with reported impacts (not including refused claims)	512	20
Number of properties with reported impacts that relate to main structures (e.g. house or shop)	455	18
Number of properties with reported impacts that only relate to associated structures	57	2

The above information can be misleading as many of the claims received during the mining of Longwall 28 were associated with the mining of previous Longwalls 22 to 27. 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 28 in Fig. 4.2. A total of 24 of 30 claims related to the mining of Longwalls 22 to 27, rather than the active Longwall 28.

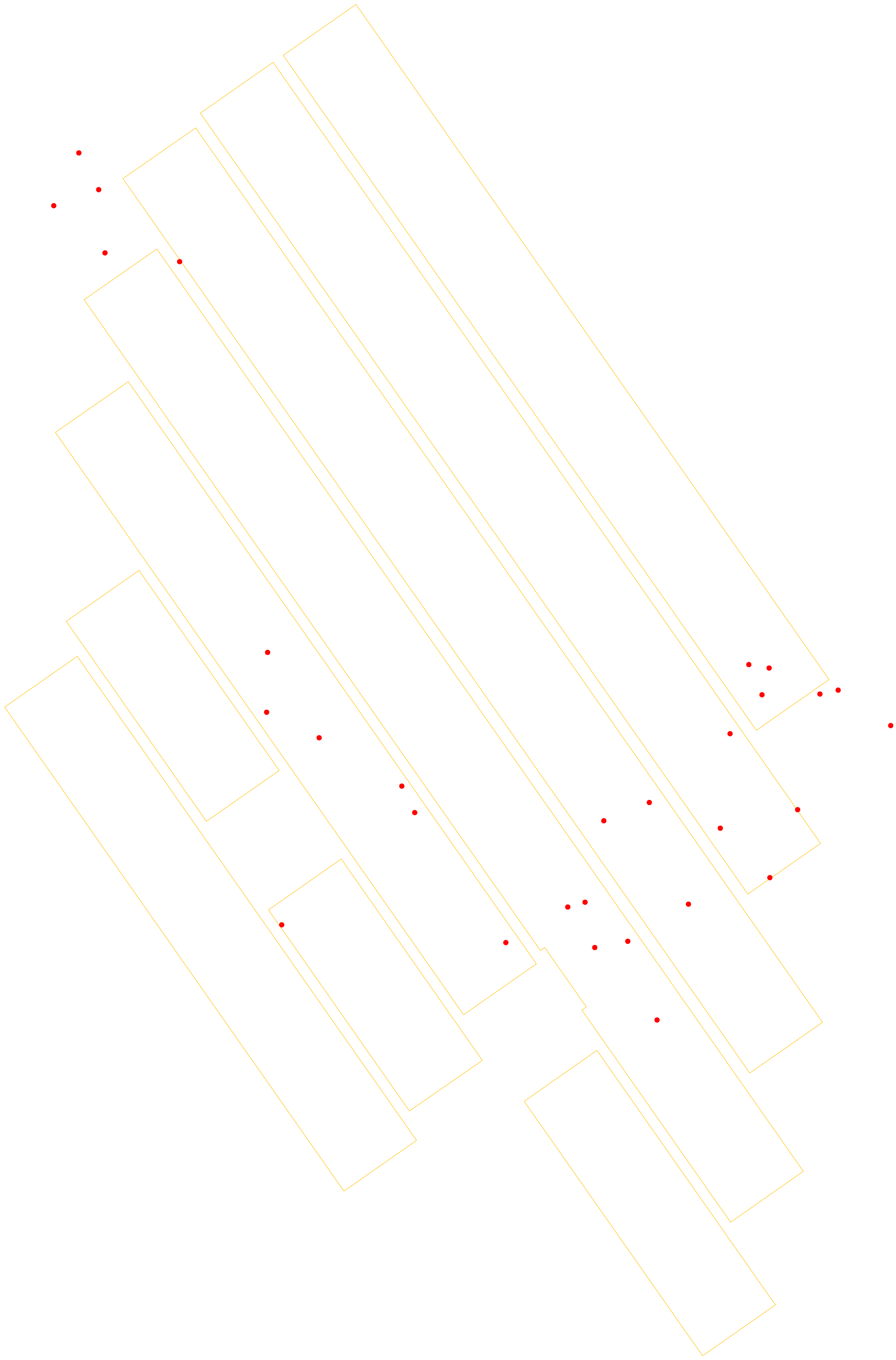

Fig. 4.2 Locations of Impacts Reported during the Mining of Longwall 28

4.11.1. 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 28. 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 28 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 28

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 1824)	1824 **(90 %)**	143 **(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 28 only due to the time lag effect discussed previously. Similarly, some houses that reported impacts during the mining of Longwall 28 were associated with the mining of previous Longwalls 22 to 27.

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 28.

4.11.2. Swimming Pools

No impacts have been observed to swimming pools during the mining of Longwall 28, however, cracking was observed around the coping of one pool.

4.11.3. Associated Structures

Minor impacts have been observed to two (2) retaining walls during the mining of Longwall 28.

4.11.4. 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 28.

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. Observed subsidence was, however, generally slightly greater than predicted in areas of low level subsidence (typically less than 100 mm).

As anticipated prior to mining, little to no increased subsidence was observed during the first stages of mining Longwall 28. The maximum observed incremental subsidence due to the mining of Longwall 28 was 774 mm, which only slightly exceeded the maximum predicted incremental subsidence for Longwall 28, 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. Impacts to road pavements were similar in frequency compared to those observed during the mining of previous longwalls.

All structures remained safe and serviceable during the mining of Longwall 28. The overall claim rate for main structures during the mining of Longwalls 22 to 28 was 25 %.

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 28.

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 28. 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

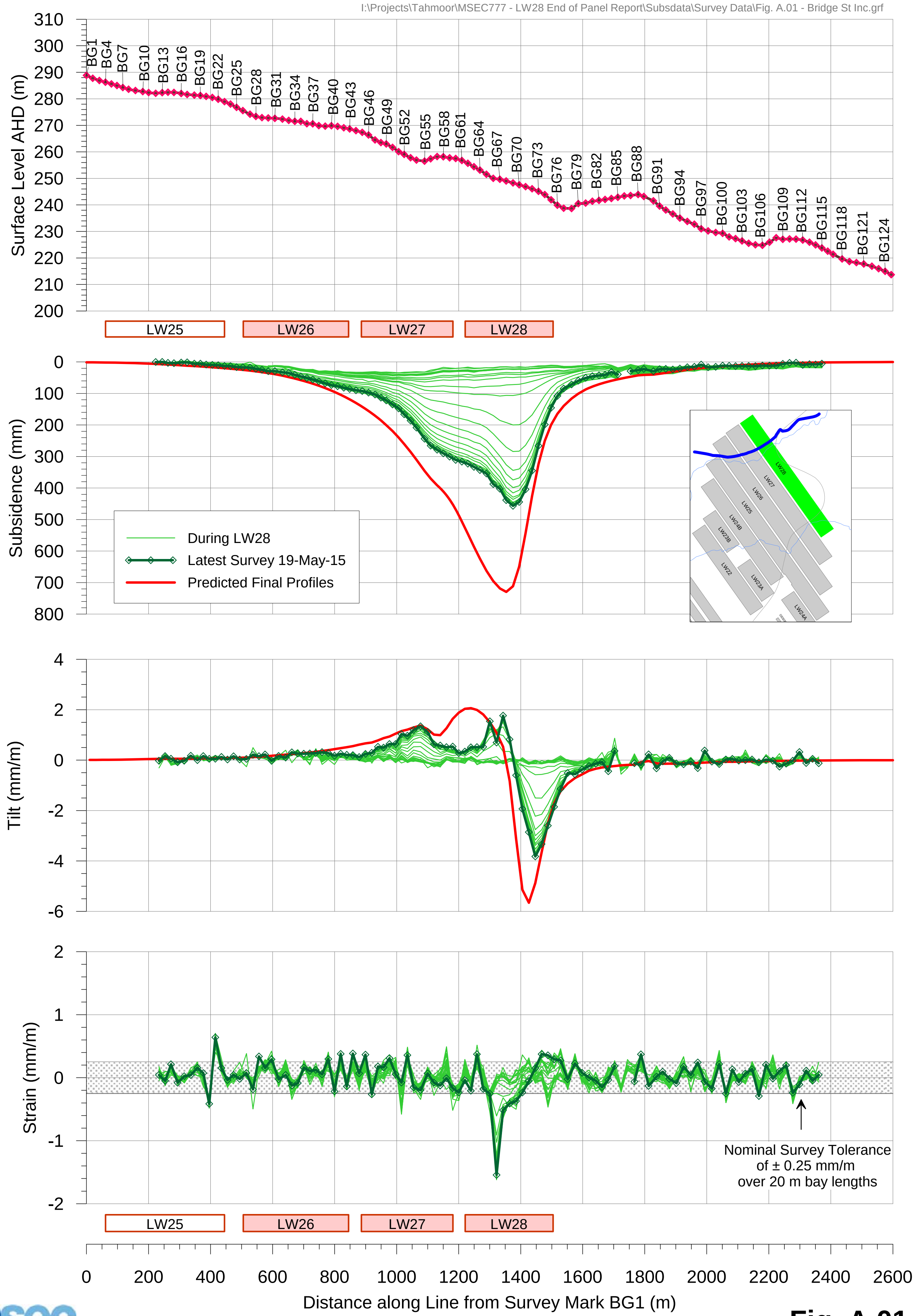

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Fig. A.01

Tahmoor Colliery
Total Subsidence Profiles along Bridge Street

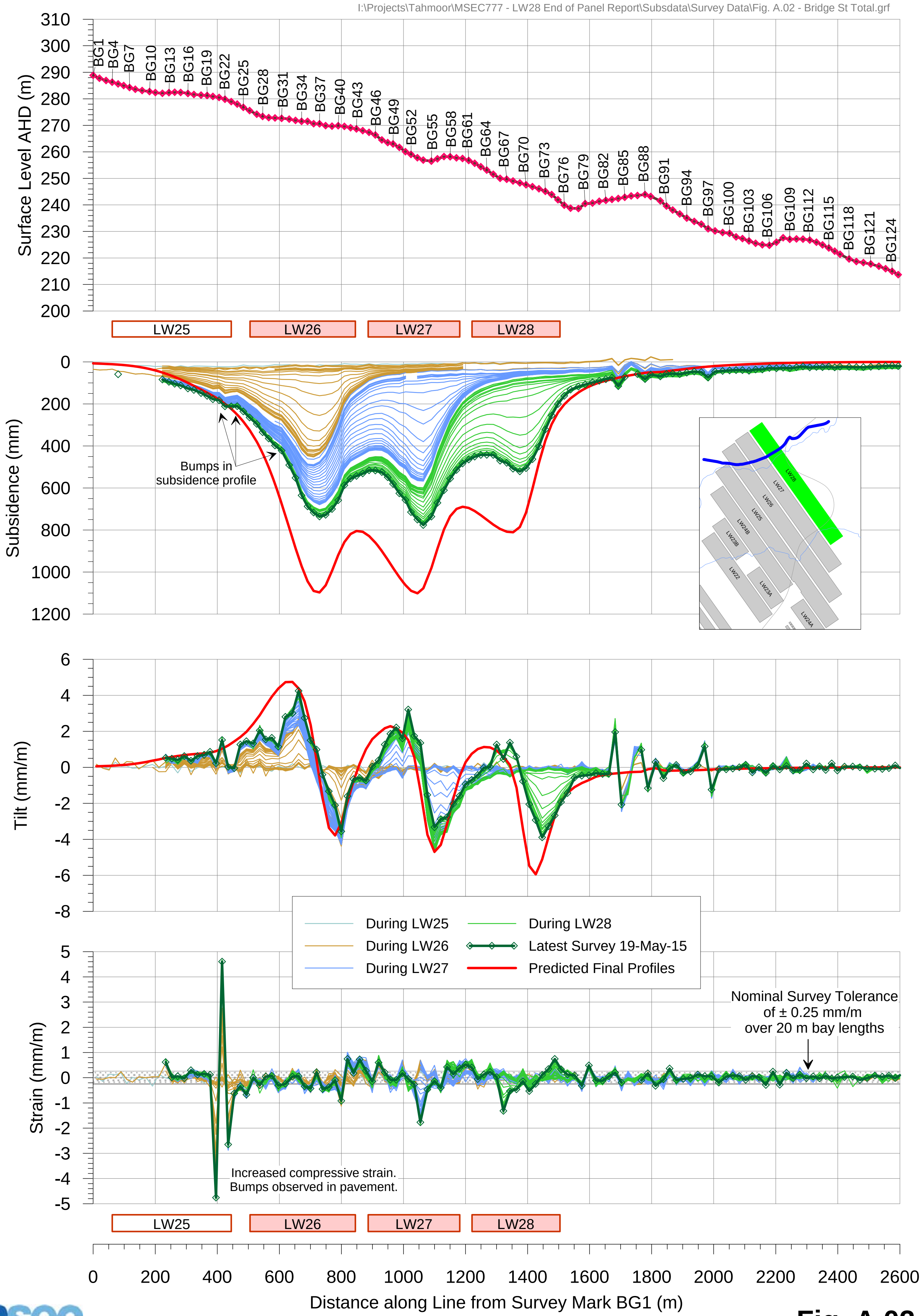

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Fig. A.02

Tahmoor Colliery
Total Subsidence Profiles along Brundah Road

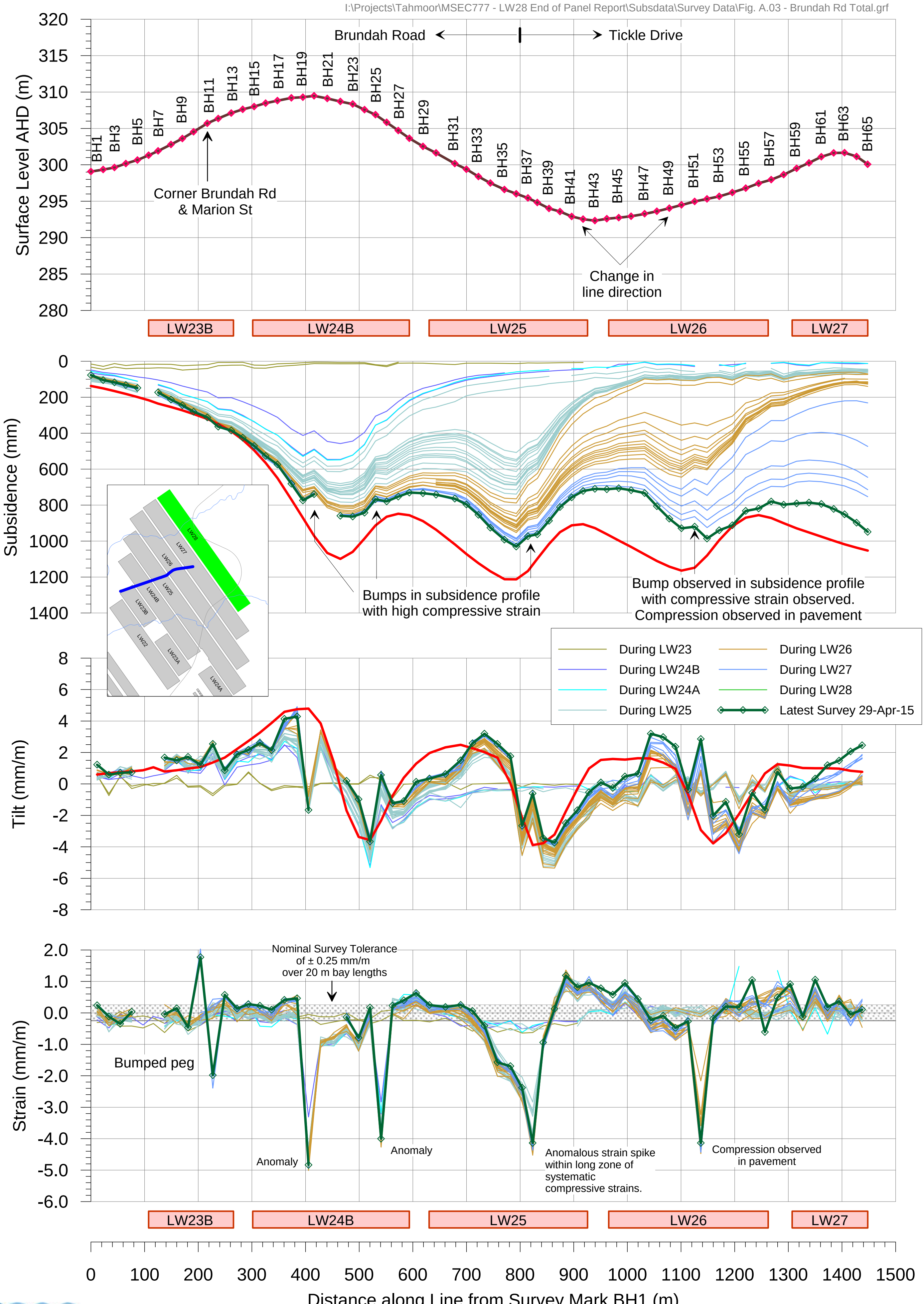

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Fig. A.03

Tahmoor Colliery
Total Subsidence Profiles along Castlereagh Street

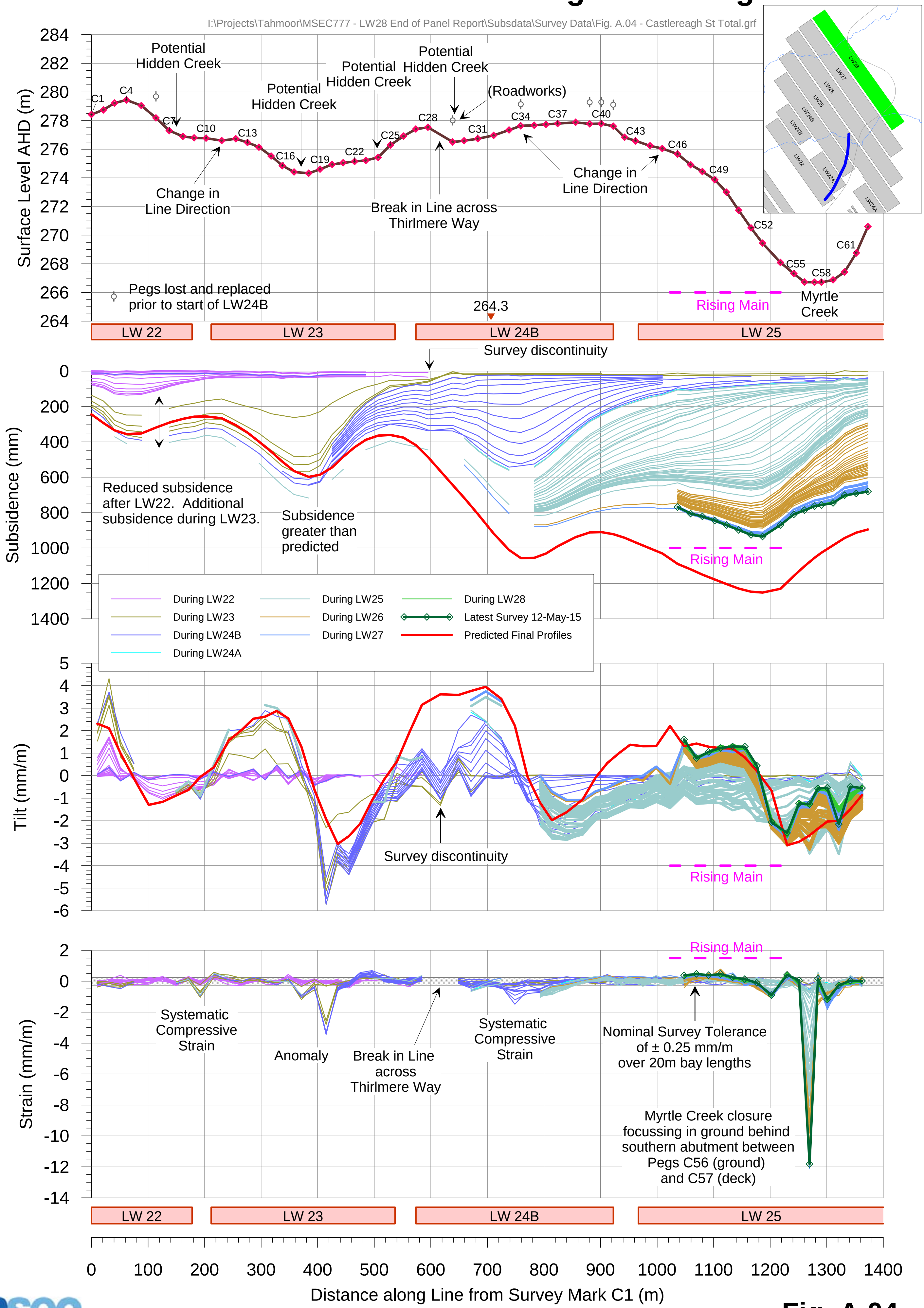

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Fig. A.04

Tahmoor Colliery - Total Subsidence Profiles along Castlereagh St - Myrtle Creek Line

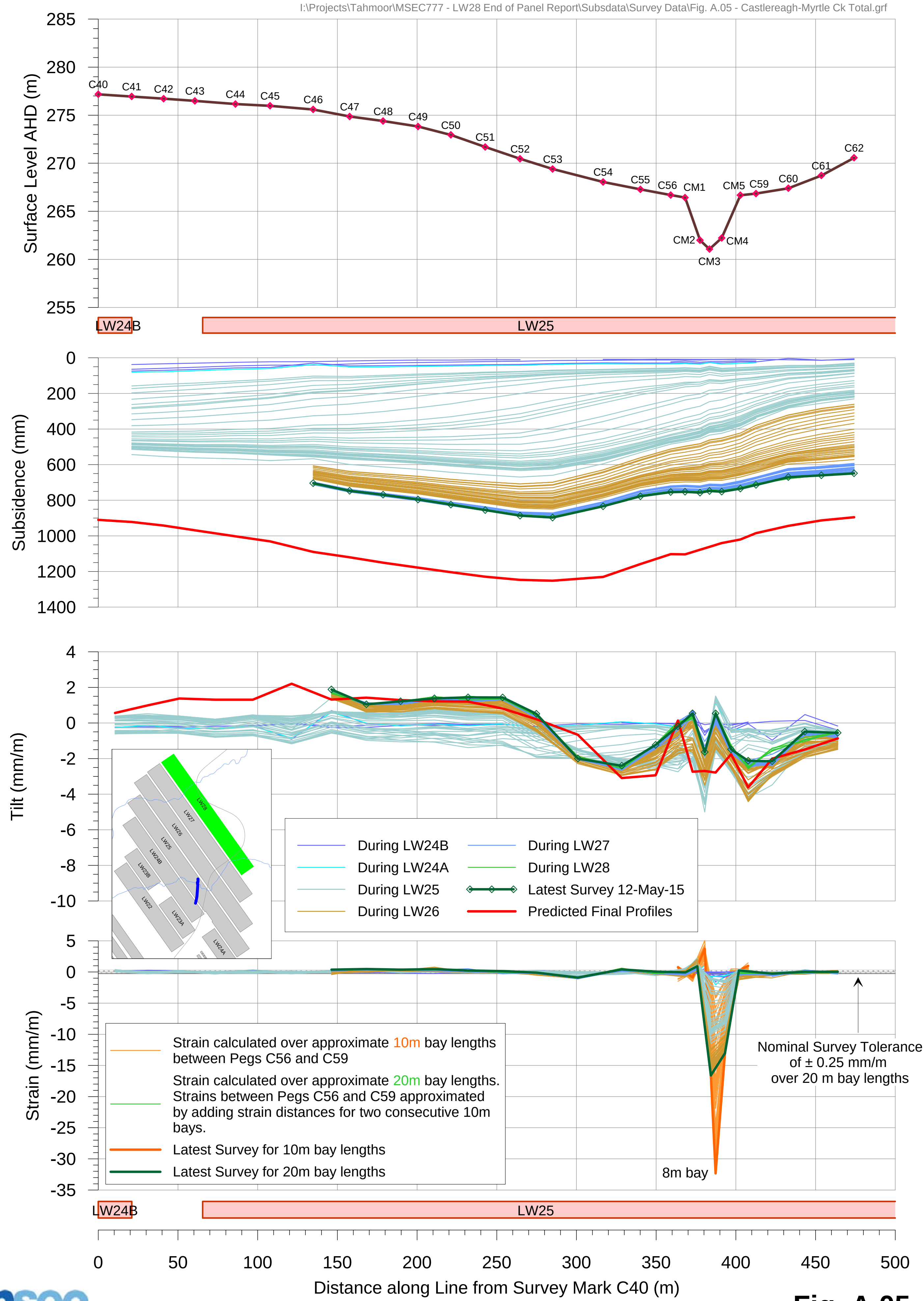

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Fig. A.05

Tahmoor Colliery
Incremental Subsidence Profiles along Hilton Park Road

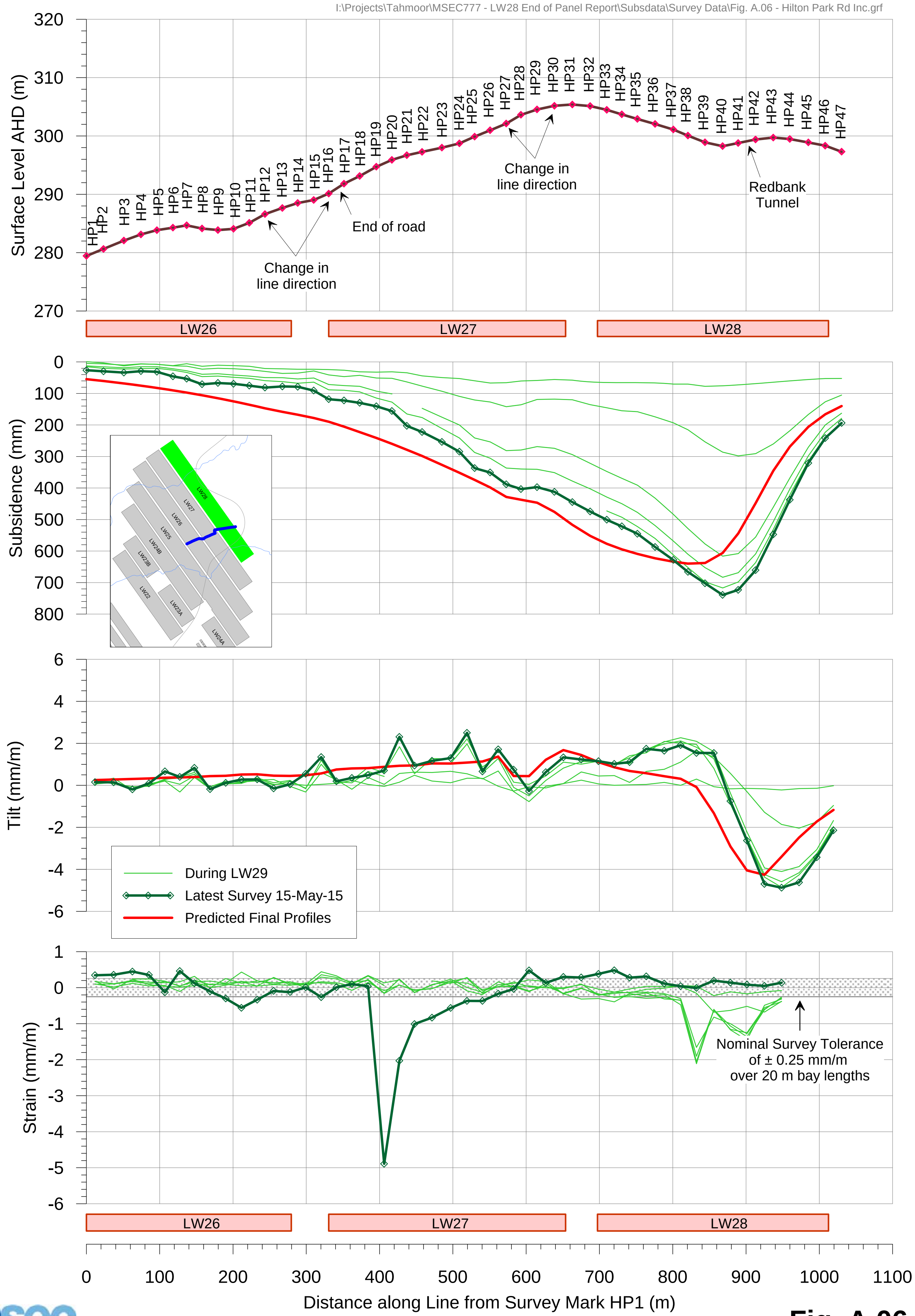

Fig. A.06

Tahmoor Colliery - Total Subsidence Profiles along Hilton Park Road

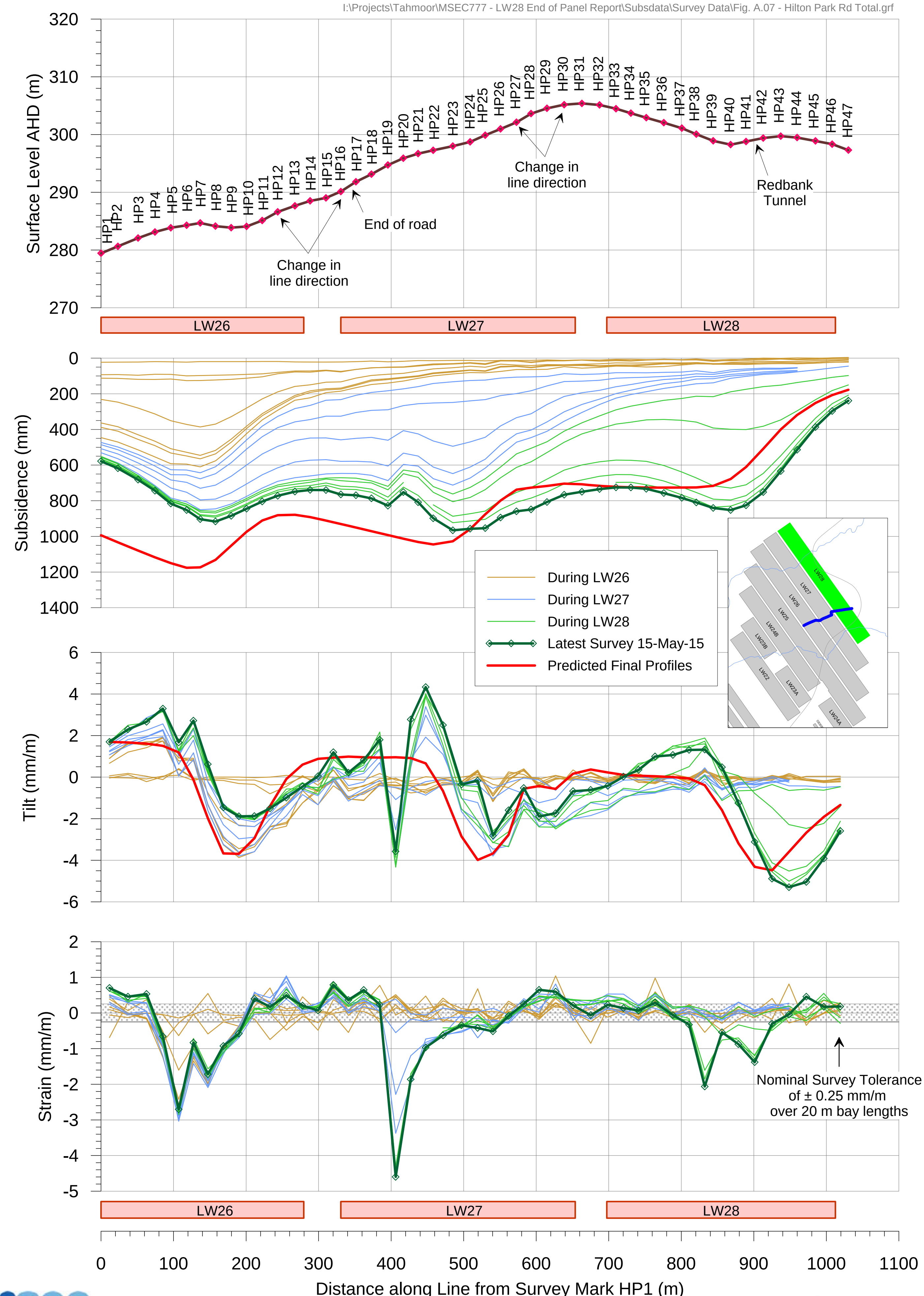

Fig. A.07

Tahmoor Colliery
Total Subsidence Profiles along Krista Place

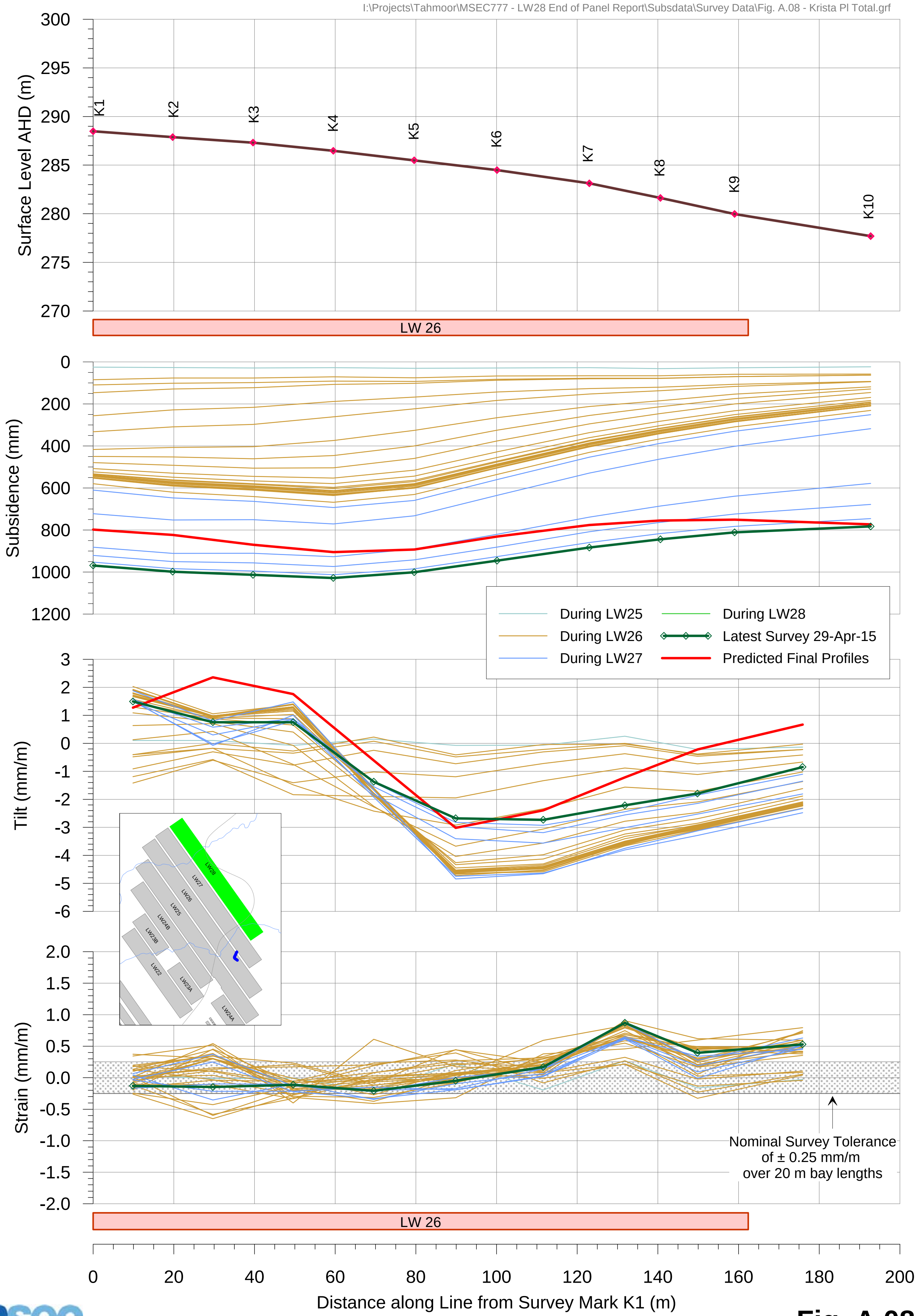

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Fig. A.08

Tahmoor Colliery
Total Subsidence Profiles along KXA Line

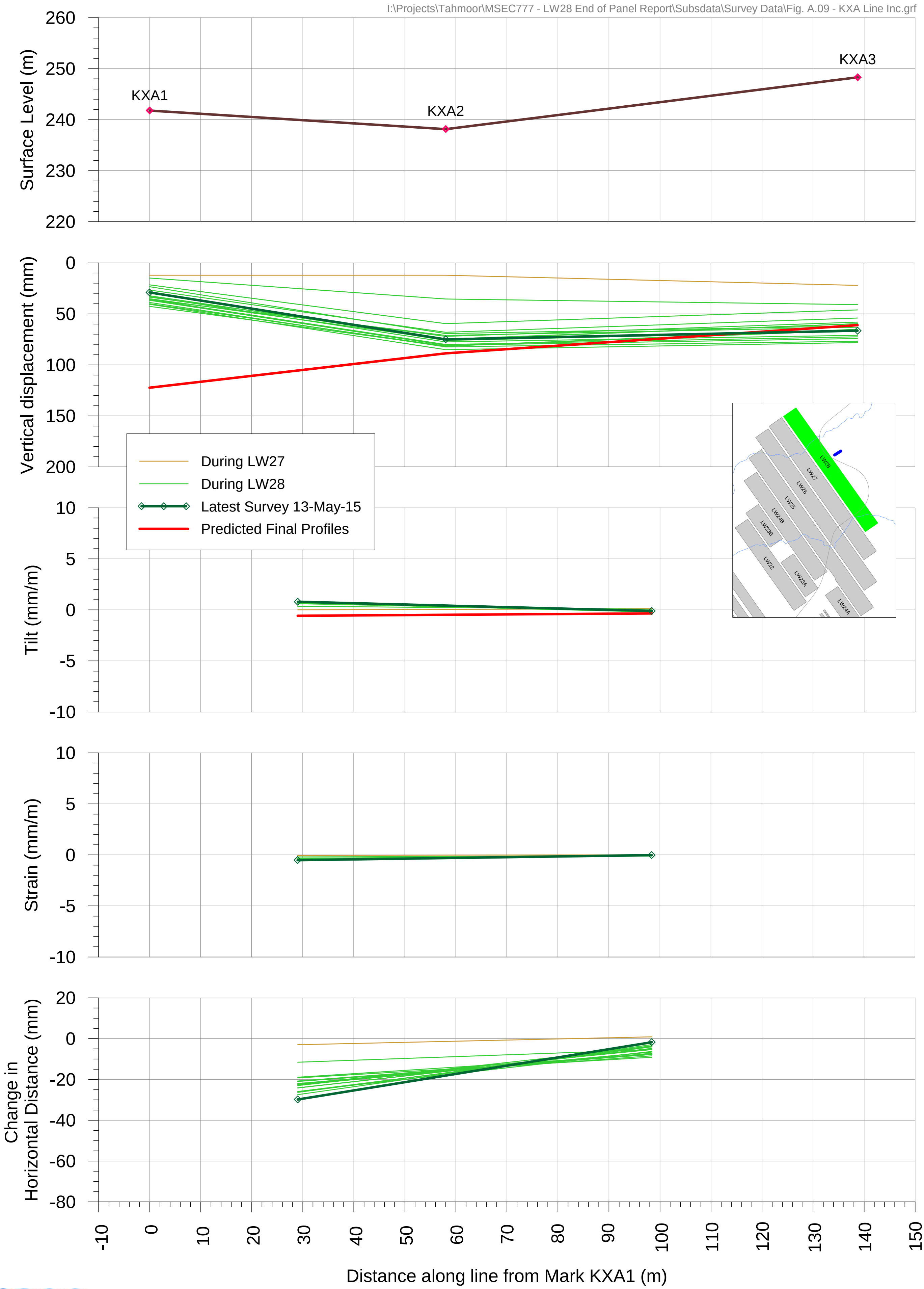

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Fig. A.09

Tahmoor Colliery
Total Subsidence Profiles along KXB Line

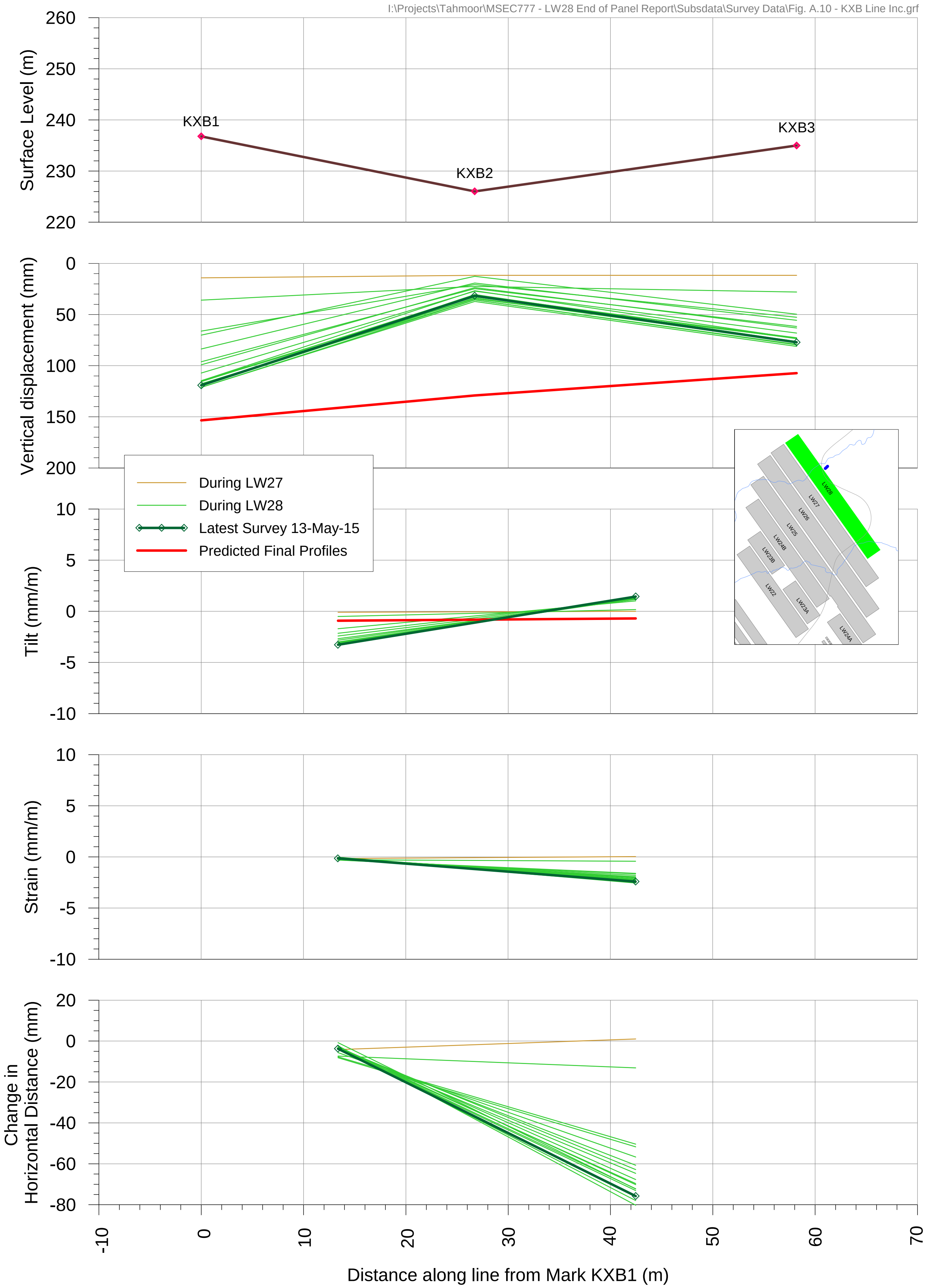

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Fig. A.10

Tahmoor Colliery
Total Subsidence Profiles along Moorland Road

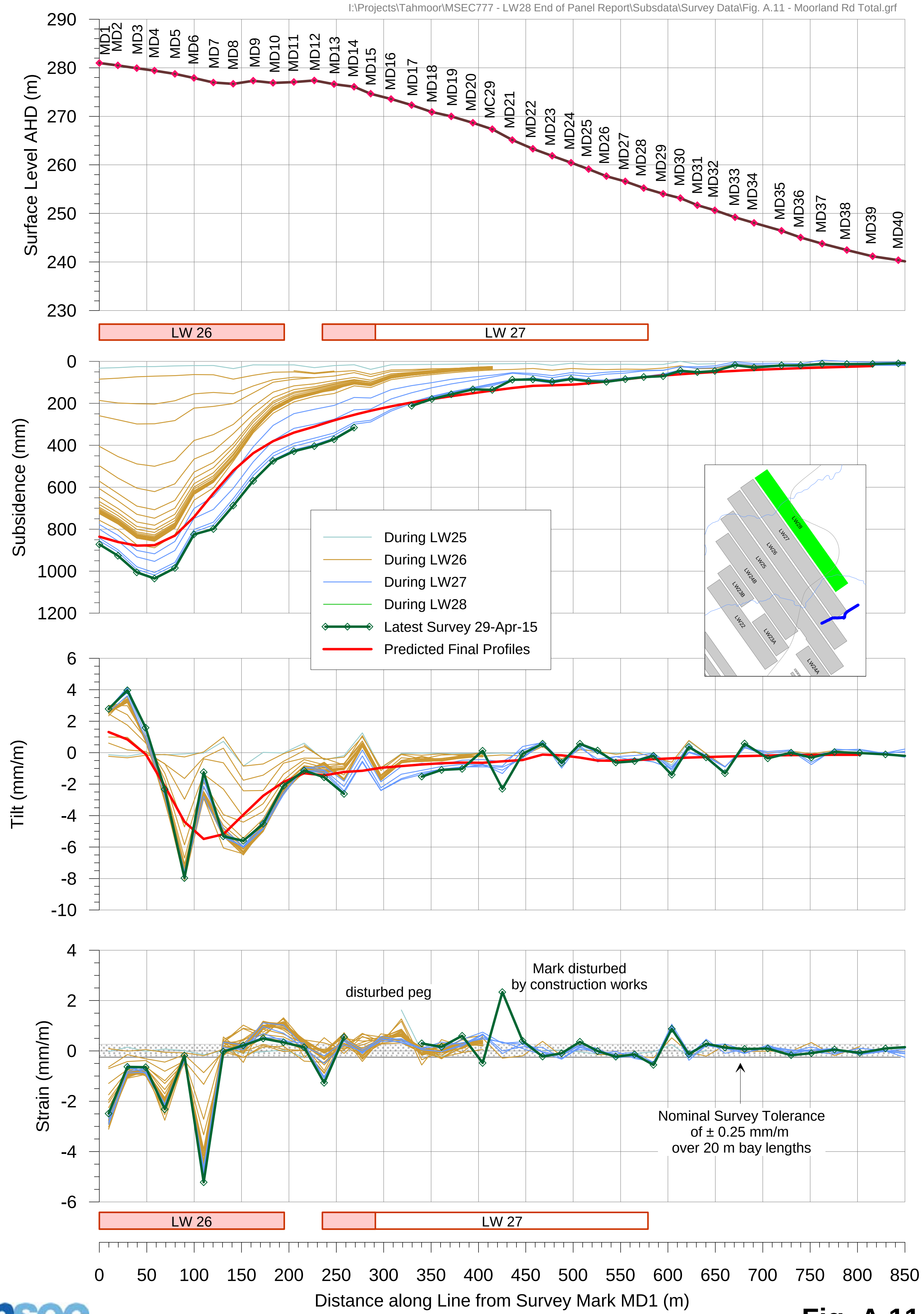

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Fig. A.11

Tahmoor Colliery
Incremental Subsidence Profiles along Myrtle Creek Avenue

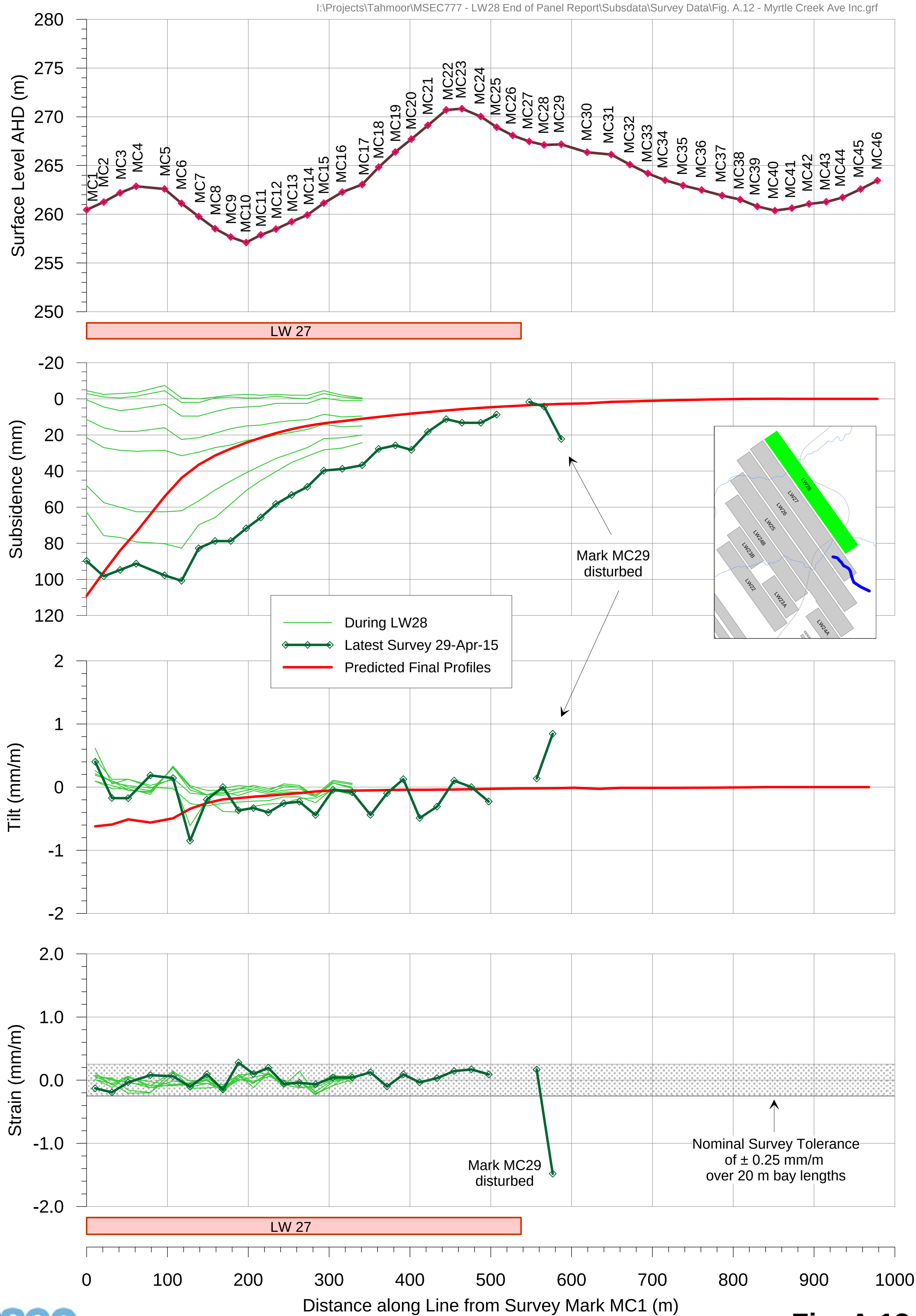

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Fig. A.12

Tahmoor Colliery
Total Subsidence Profiles along Myrtle Creek Avenue

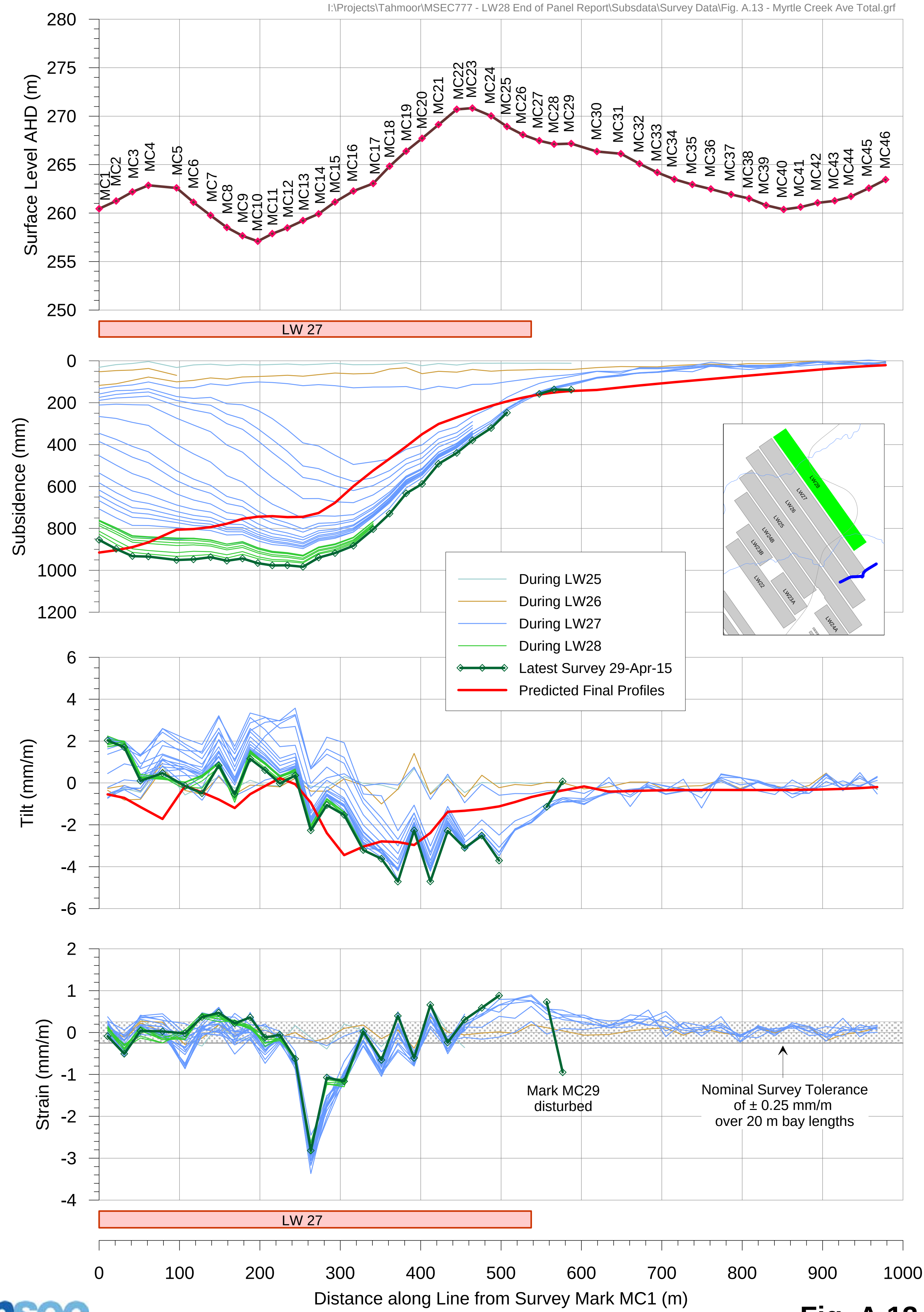

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Fig. A.13

Tahmoor Colliery
Incremental Subsidence Profiles along MXA Line

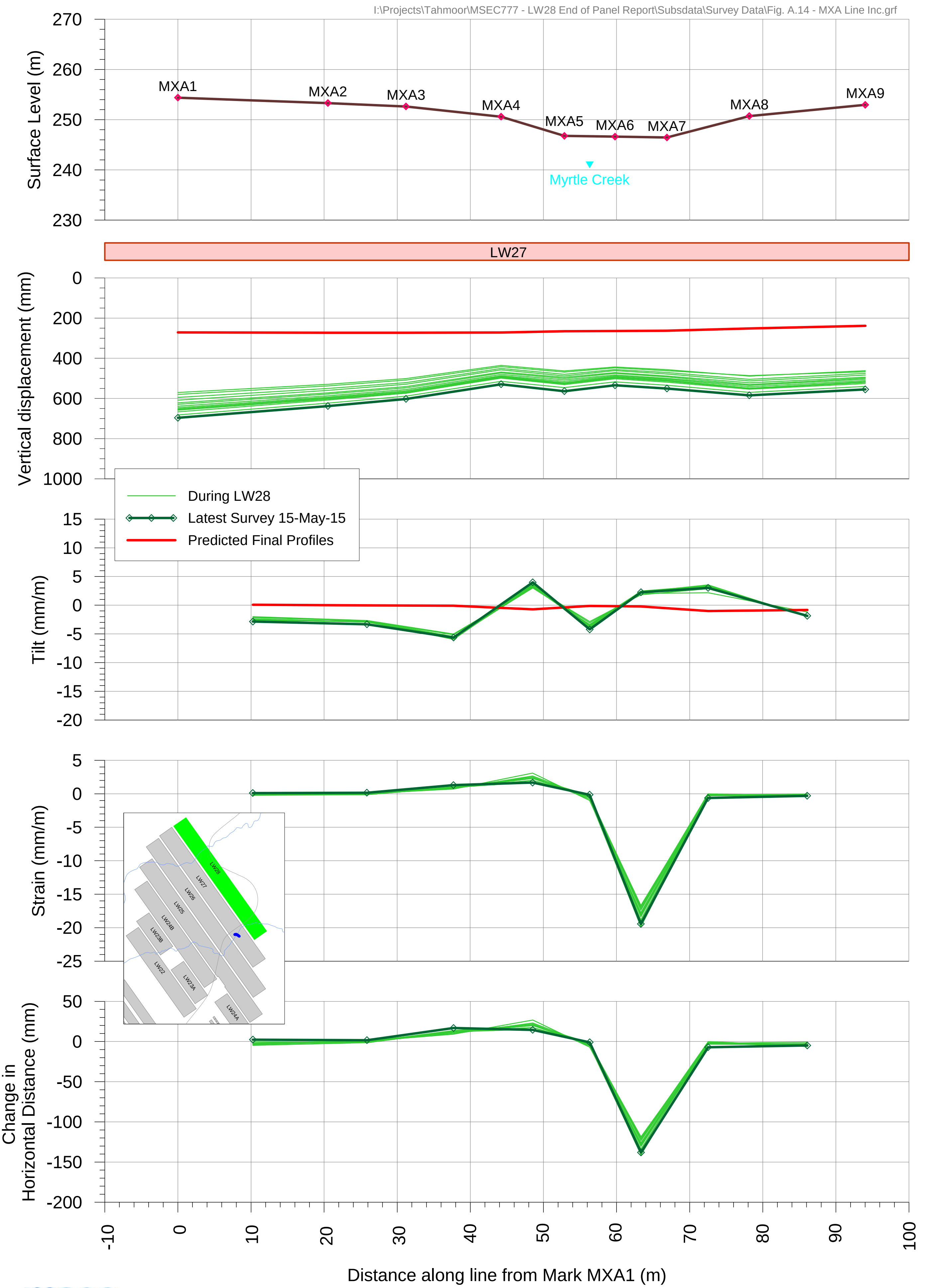

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Fig. A.14

Tahmoor Colliery
Total Subsidence Profiles along MXA Line

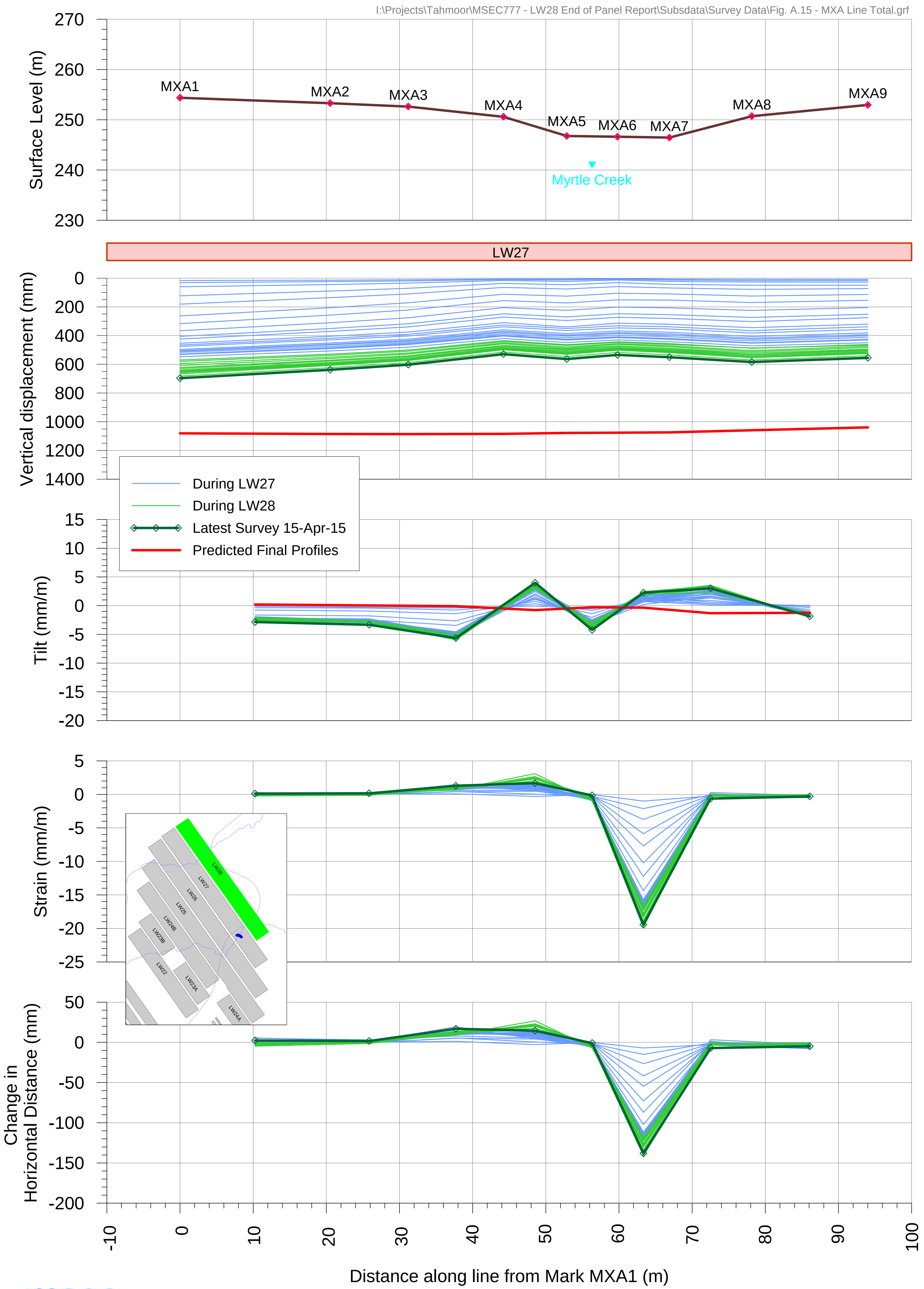


Fig. A.15

Tahmoor Colliery
Incremental Subsidence Profiles along MXB Line

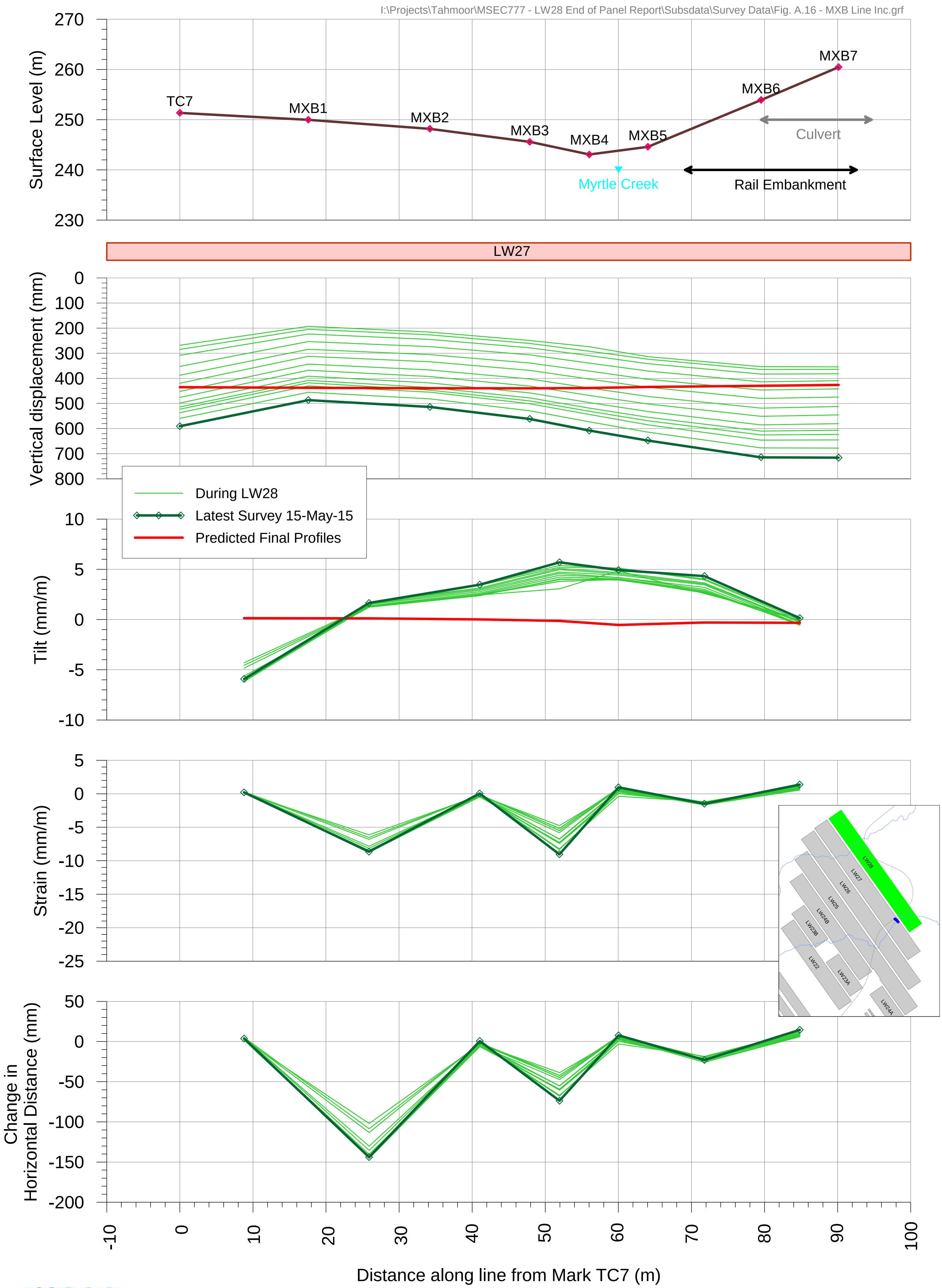
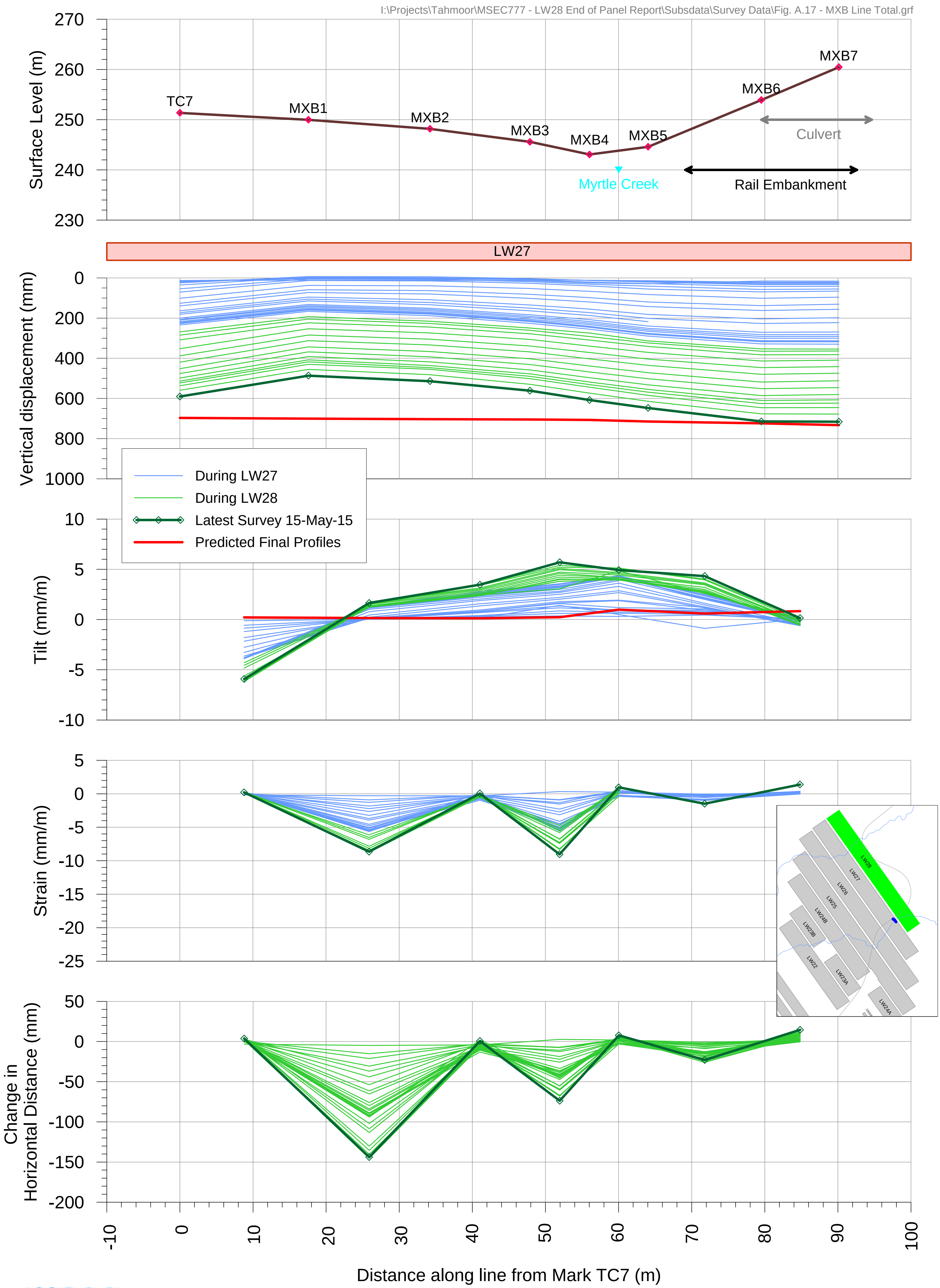


Fig. A16

Tahmoor Colliery
Total Subsidence Profiles along MXB Line



msec

Fig. A17

Tahmoor Colliery
Incremental Subsidence Profiles along MXC Line

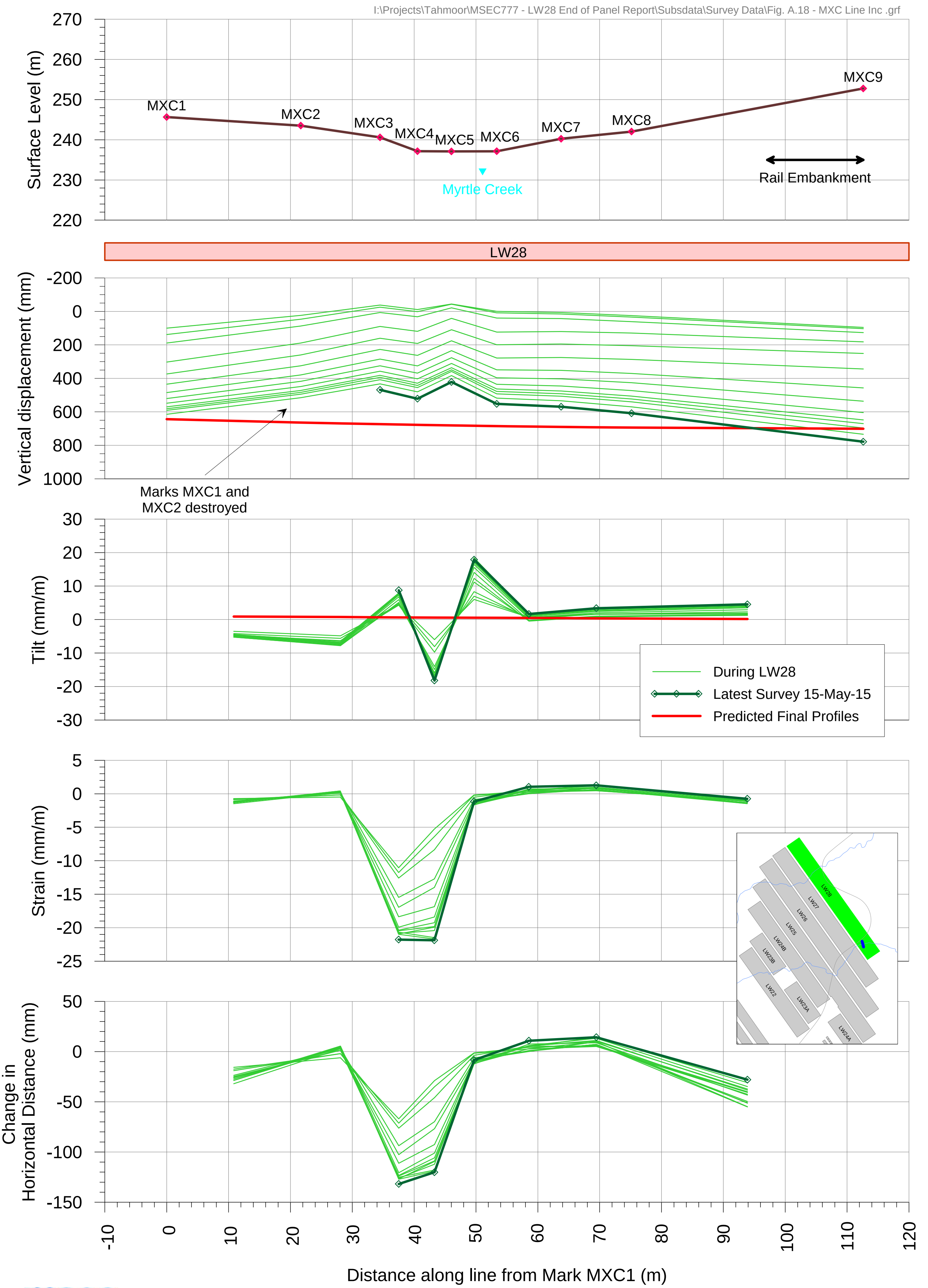


Fig. A.18

Tahmoor Colliery
Total Subsidence Profiles along MXC Line

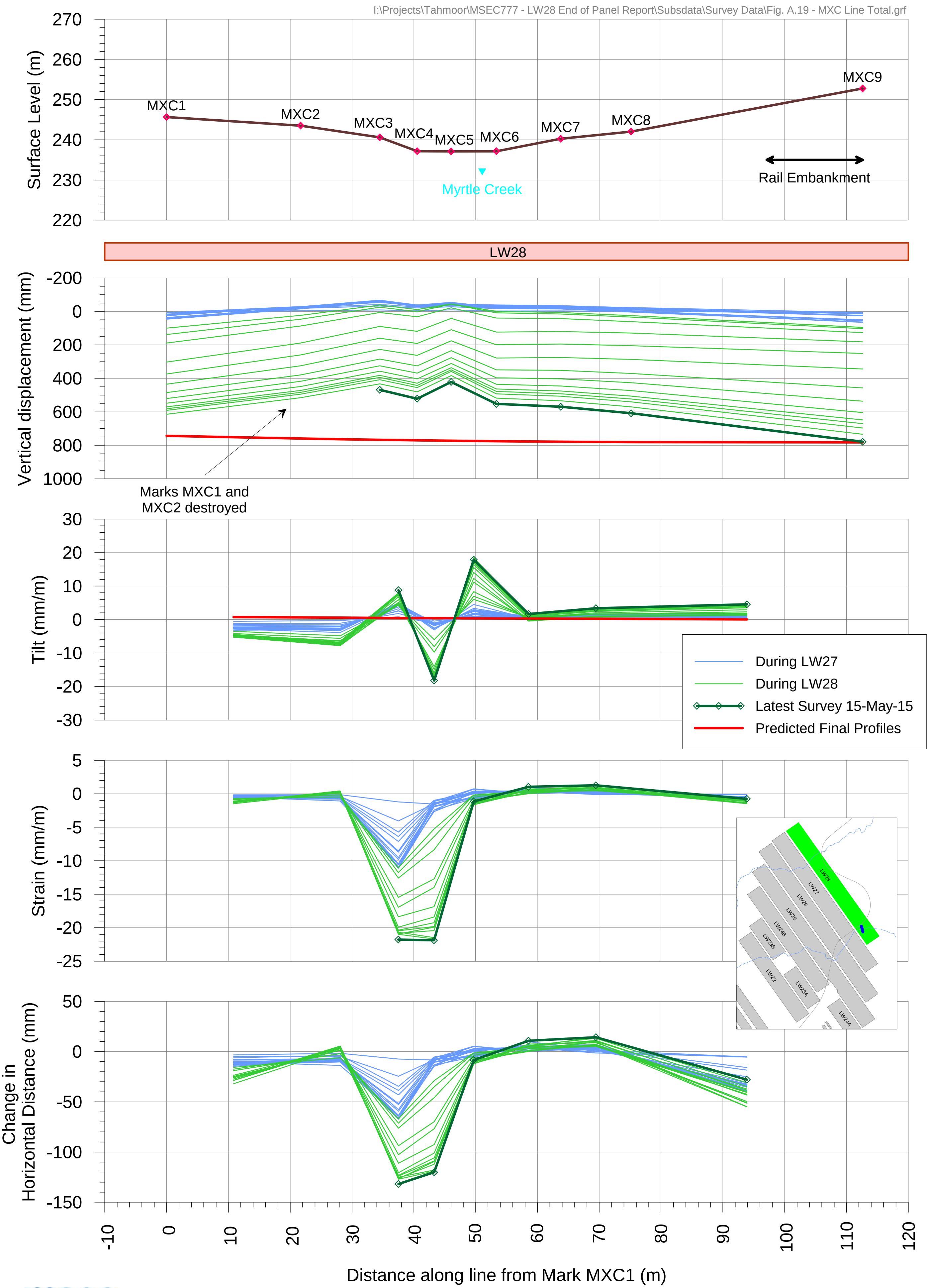


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Fig. A.19

Tahmoor Colliery
Incremental Subsidence Profiles along MXD Line

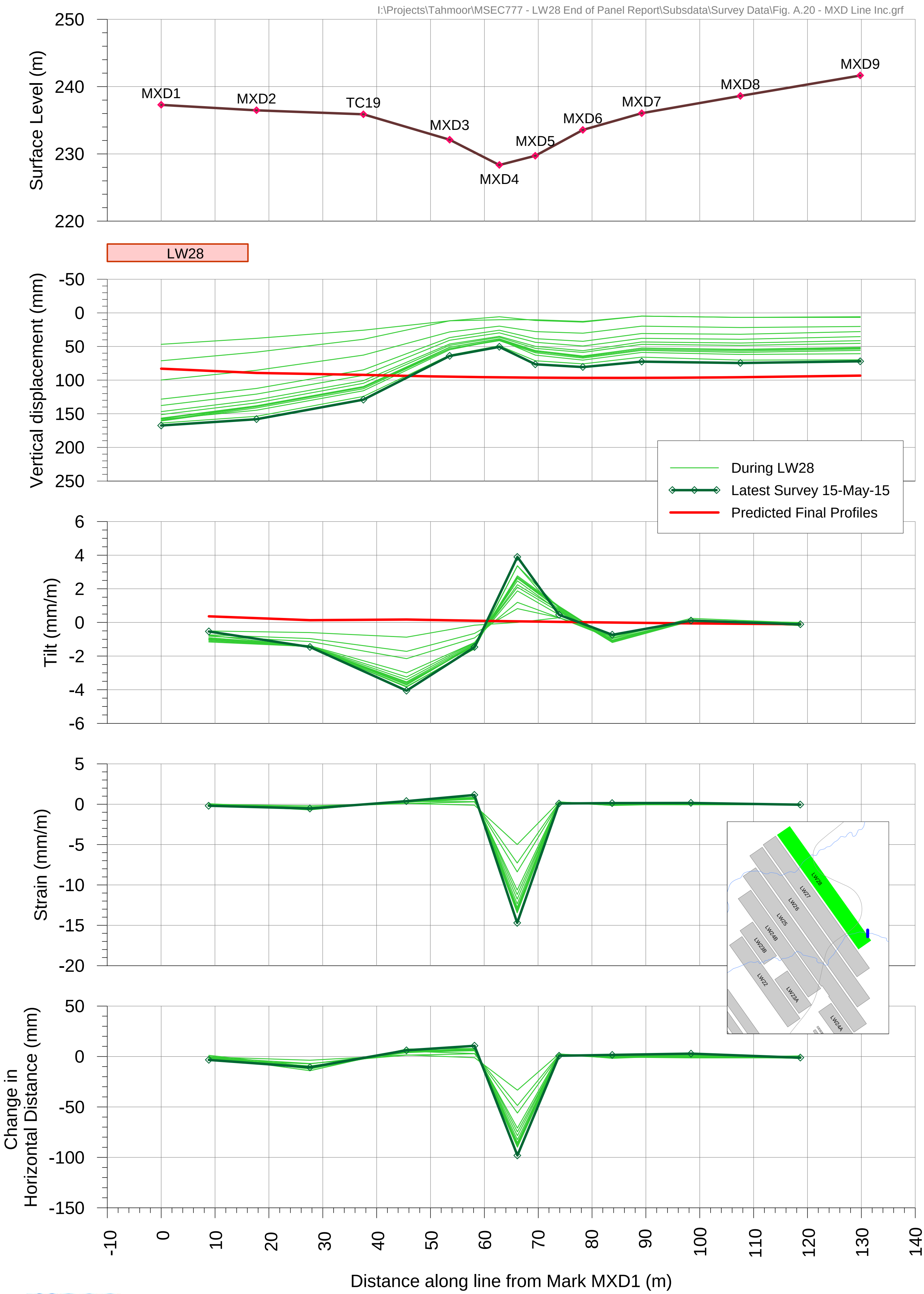

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Fig. A.20

Tahmoor Colliery
Total Subsidence Profiles along MXD Line

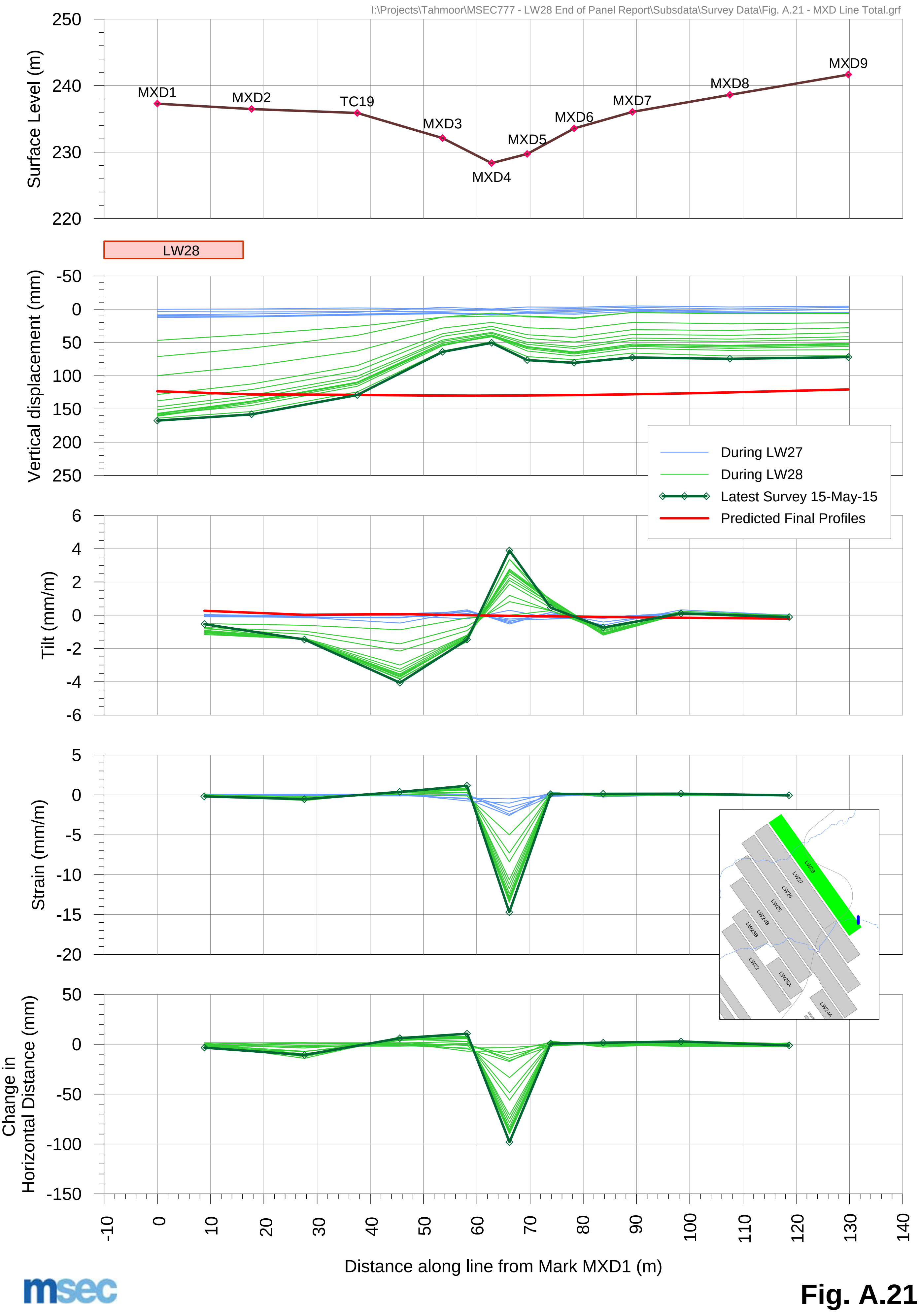

Fig. A.21

Tahmoor Colliery
Total Subsidence Profiles along Optic Fibre Line

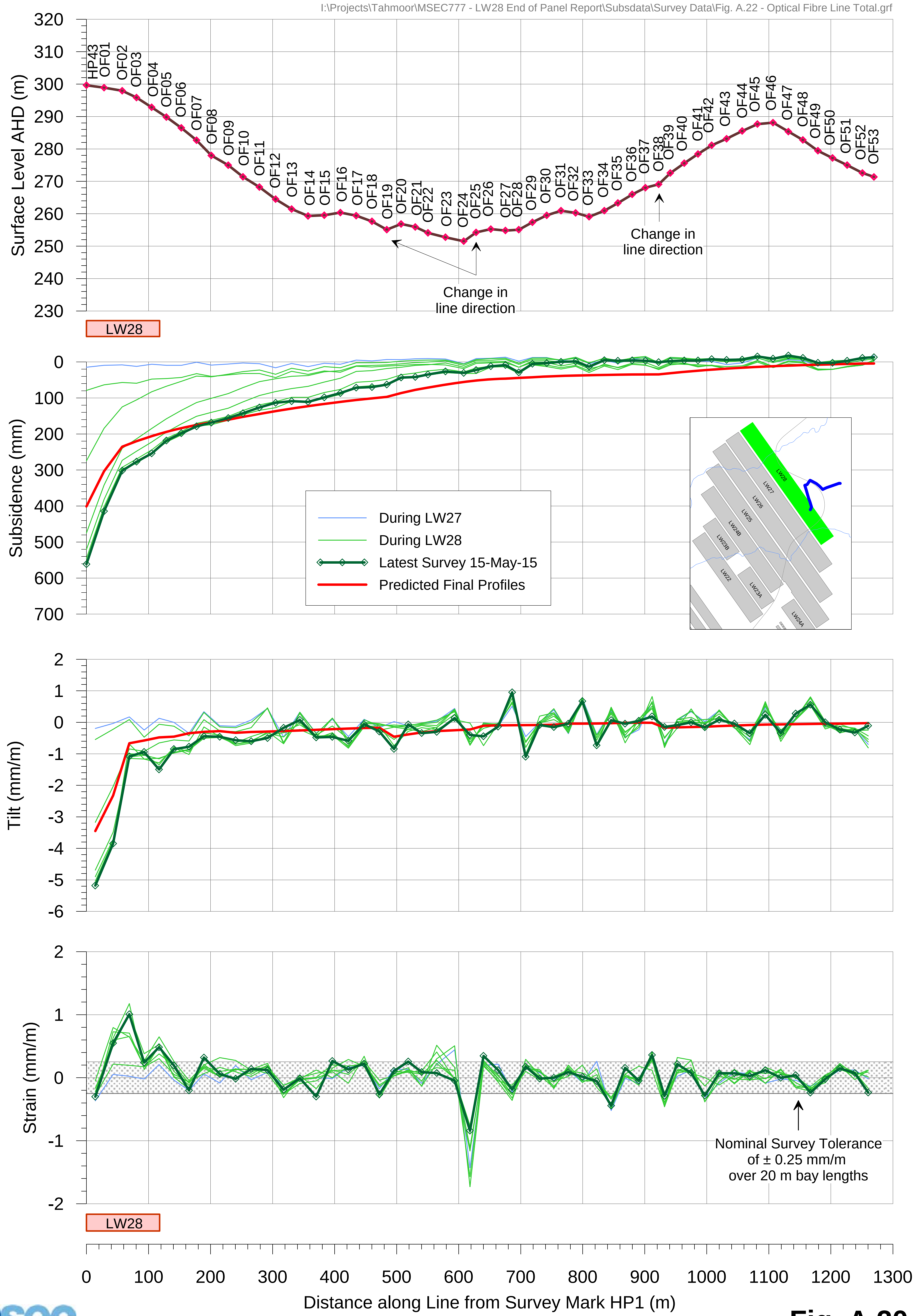

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Fig. A.20

Tahmoor Colliery
Incremental Subsidence Profiles along Park Avenue

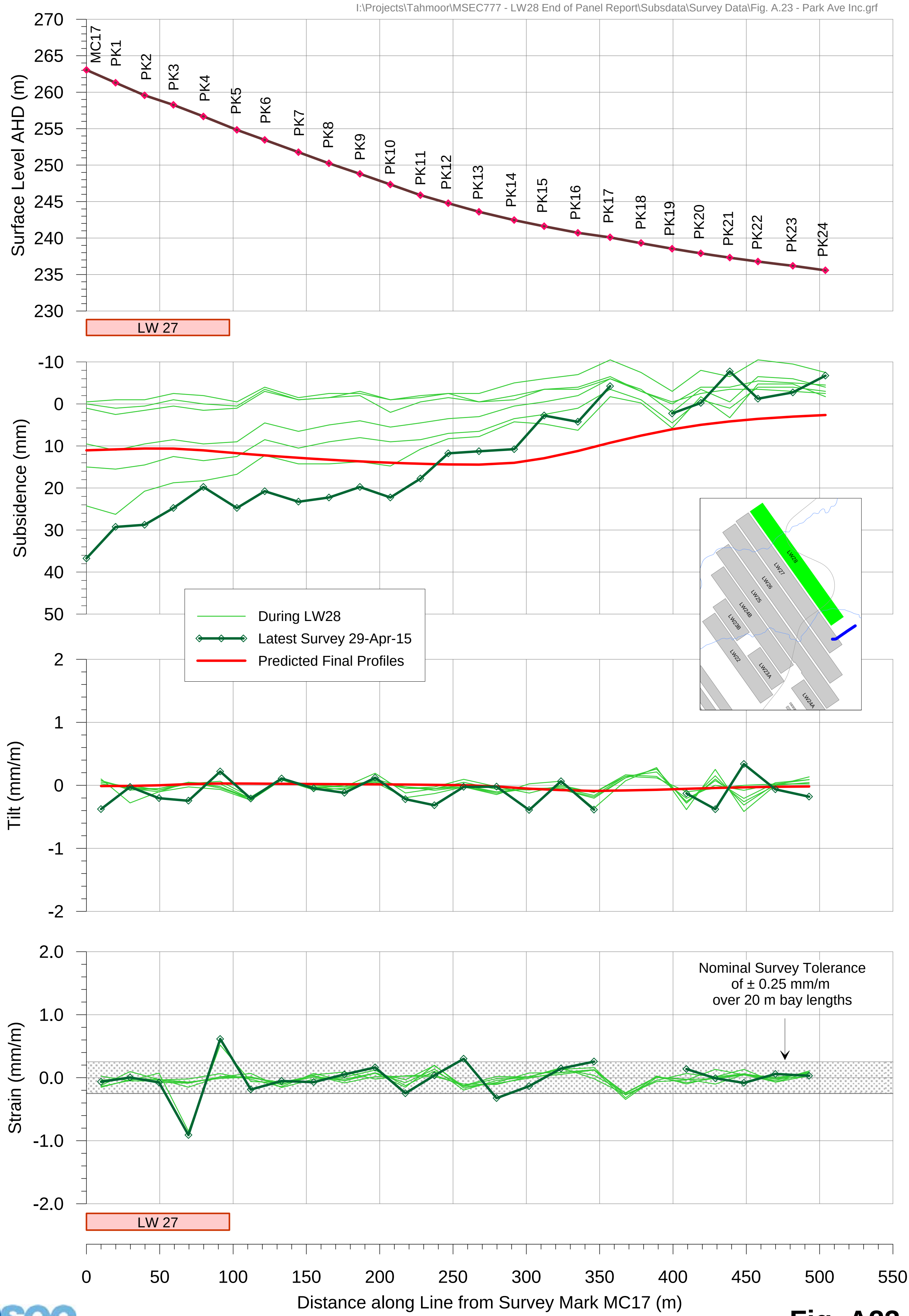

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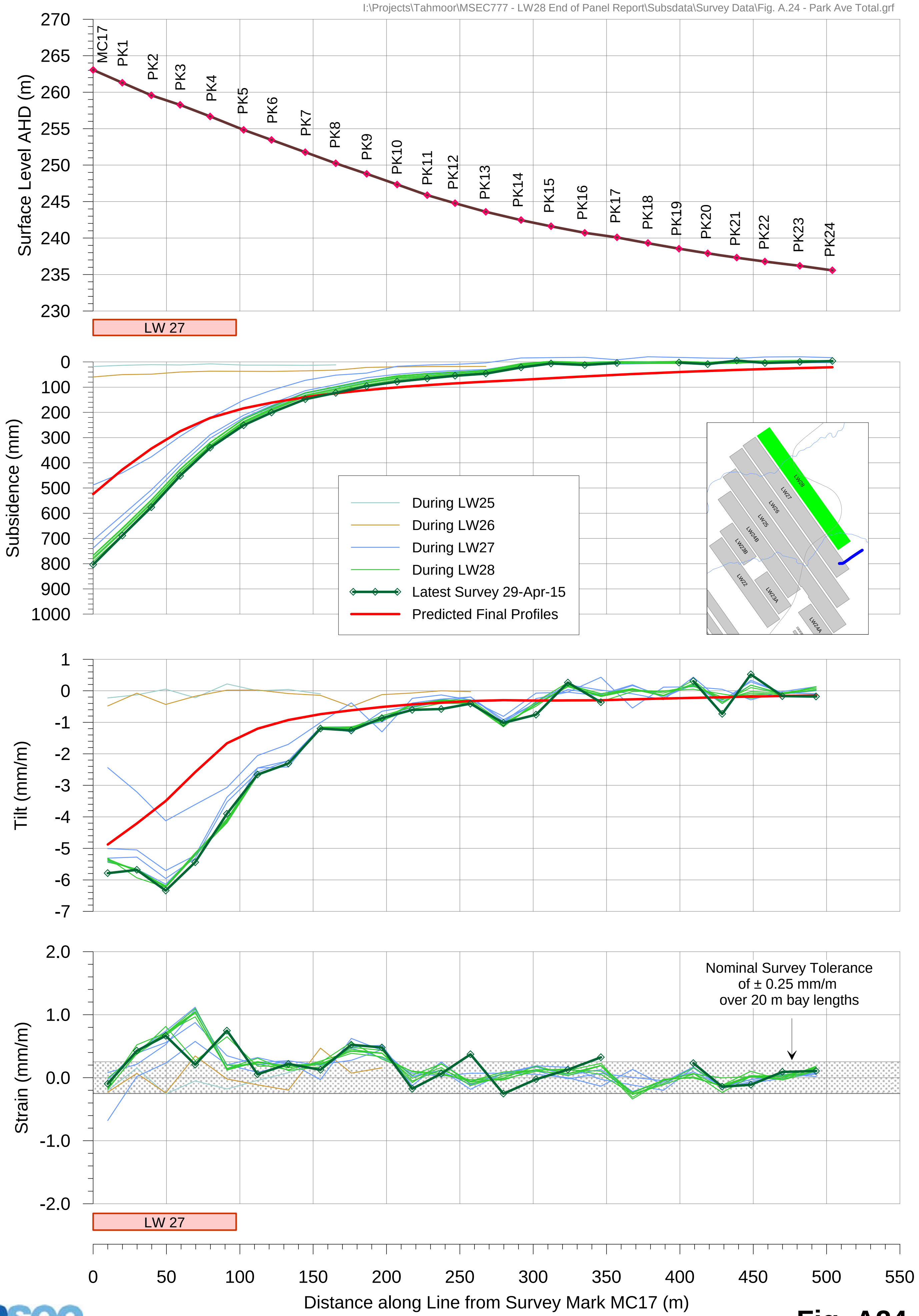
Fig. A23

Tahmoor Colliery
Total Subsidence Profiles along Park Avenue



msec

Fig. A24

Tahmoor Colliery
Incremental Profiles along Redbank Creek RK Line

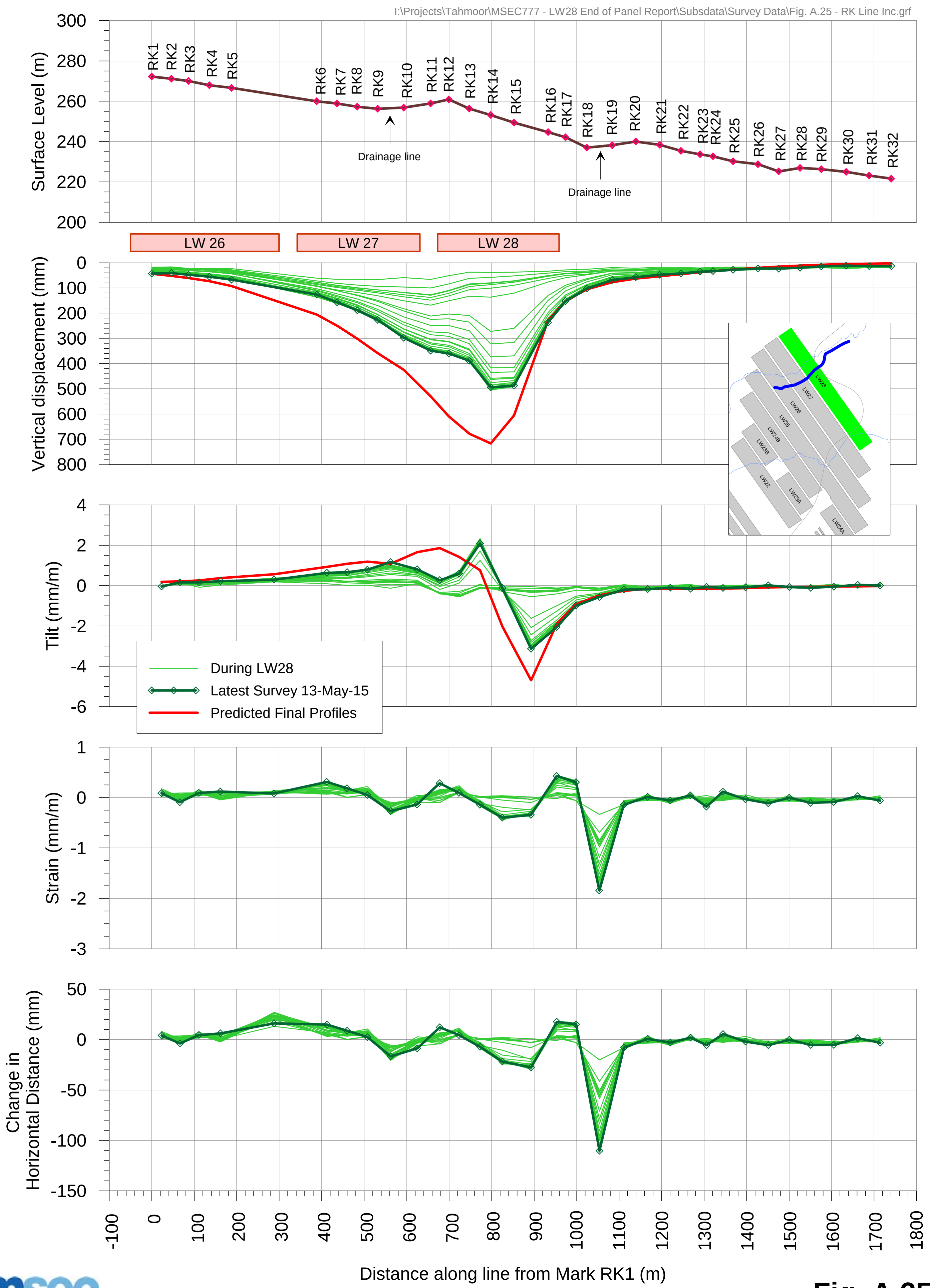


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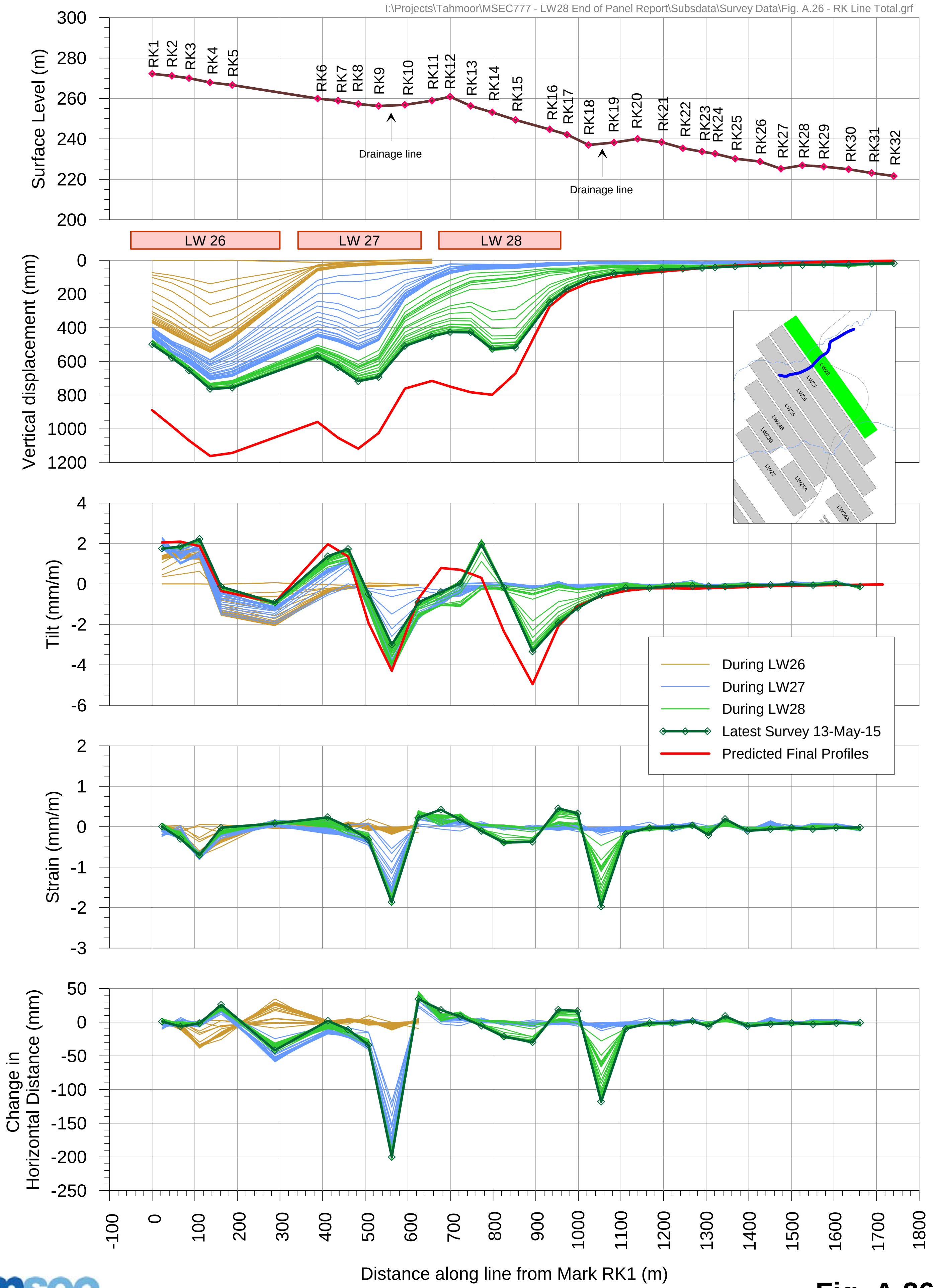
Fig. A.25

Tahmoor Colliery
Total Profiles along Redbank Creek RK Line



msec

Fig. A.26

Tahmoor Colliery
Incremental Profiles along Redbank Creek RX Line

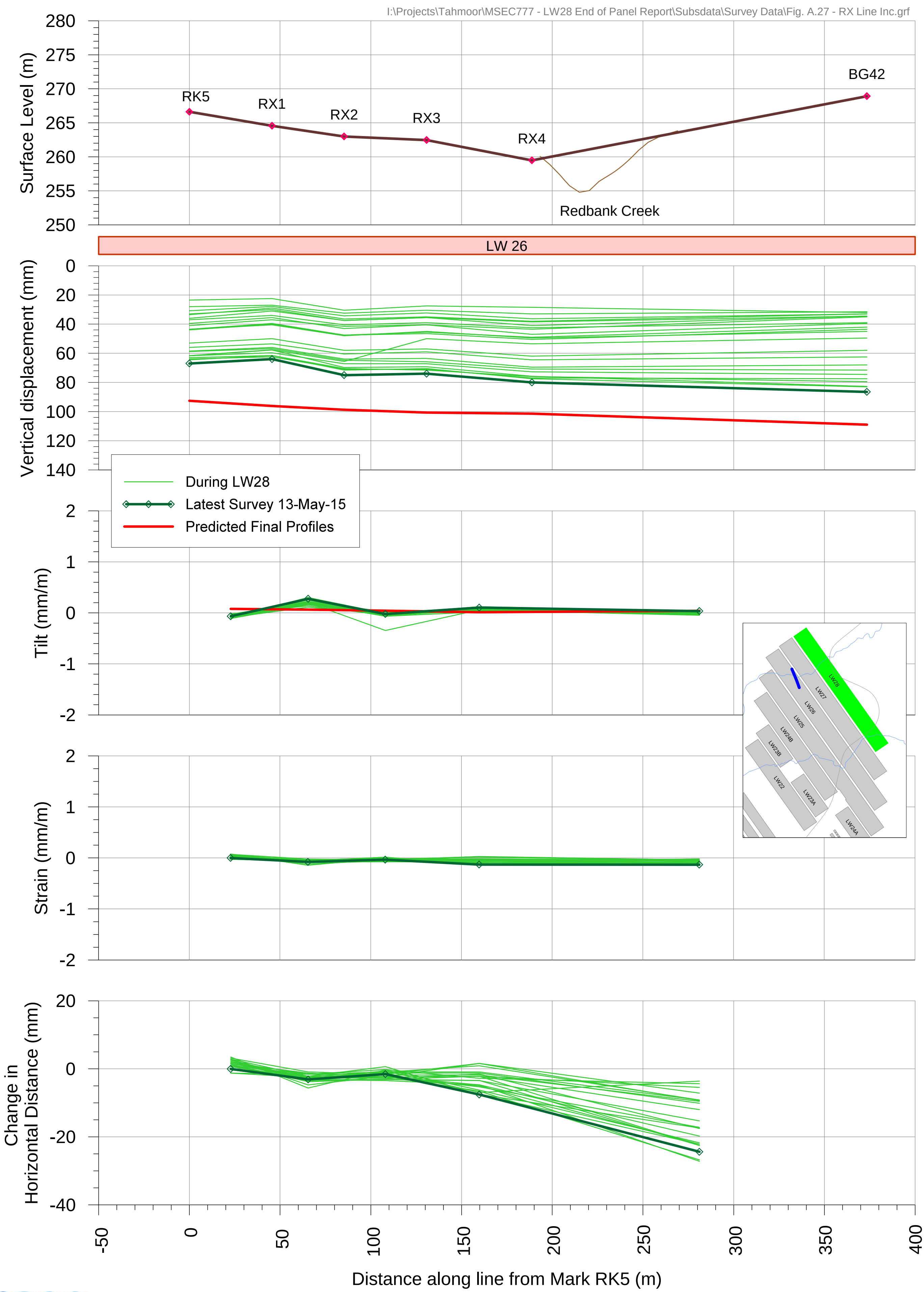


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Fig. A.27

Tahmoor Colliery
Total Profiles along Redbank Creek RX Line

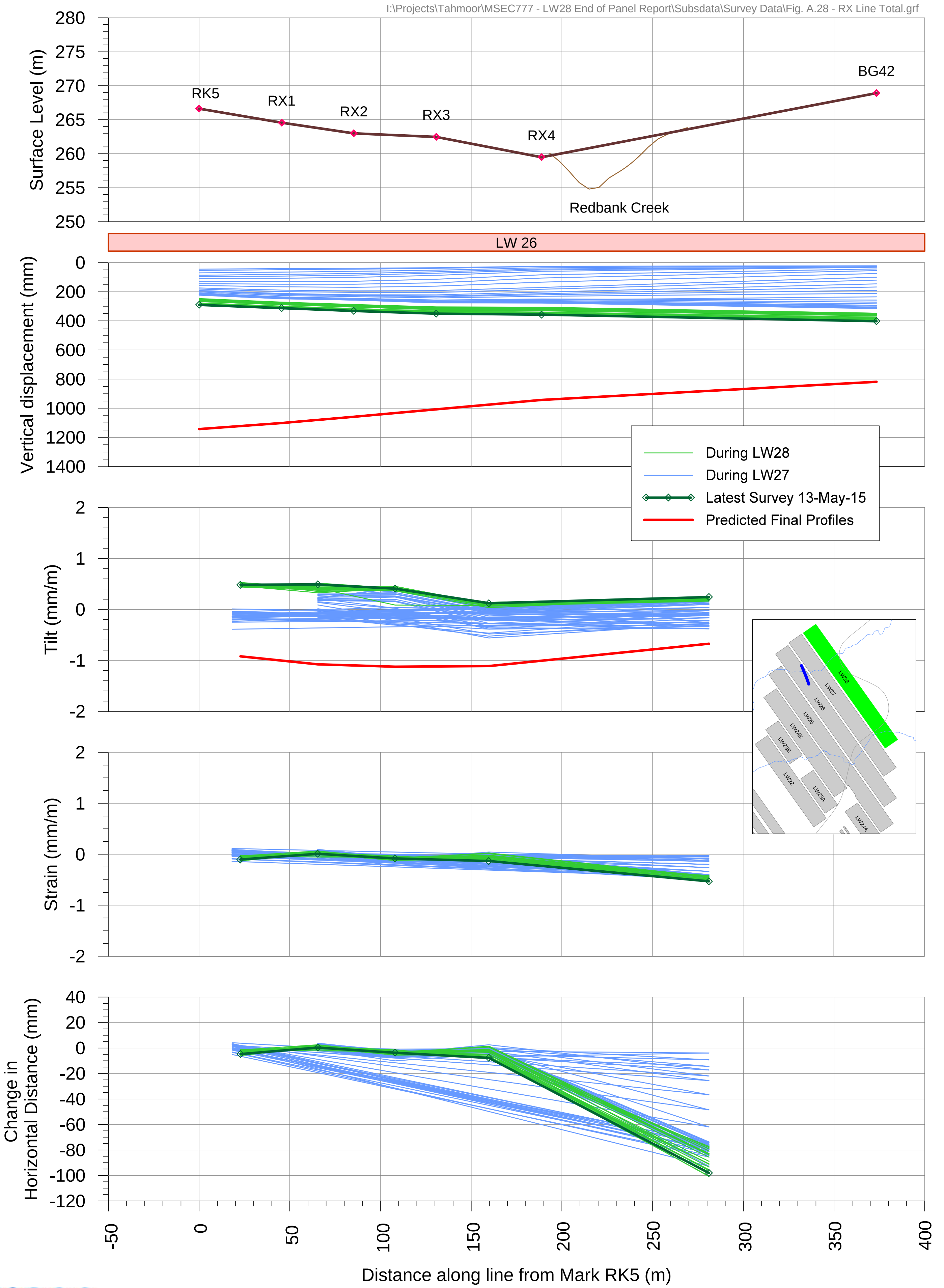

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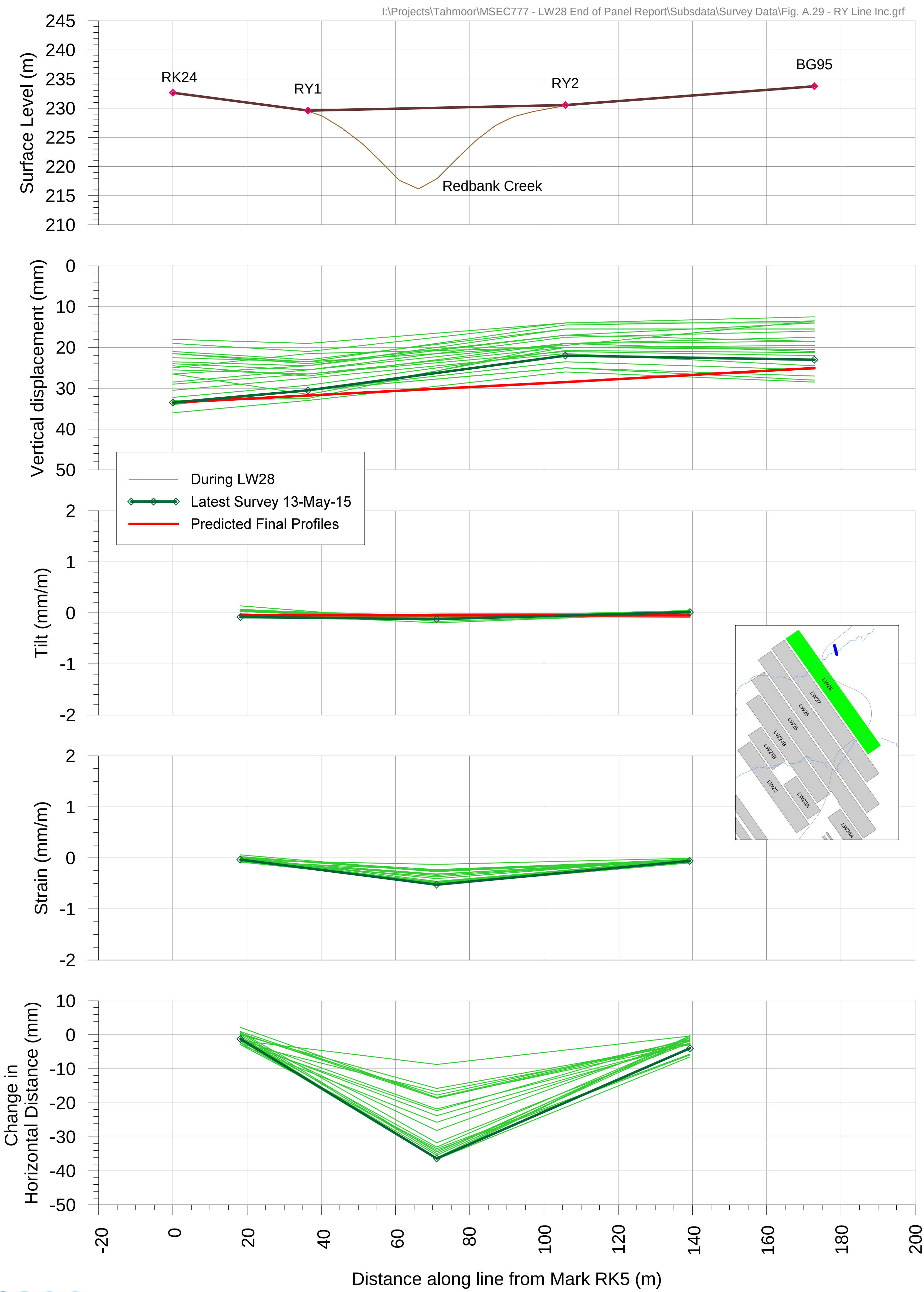
Fig. A.28

Tahmoor Colliery
Incremental Profiles along Redbank Creek RY Line



msec

Fig. A.29

Tahmoor Colliery
Total Profiles along Redbank Creek RY Line

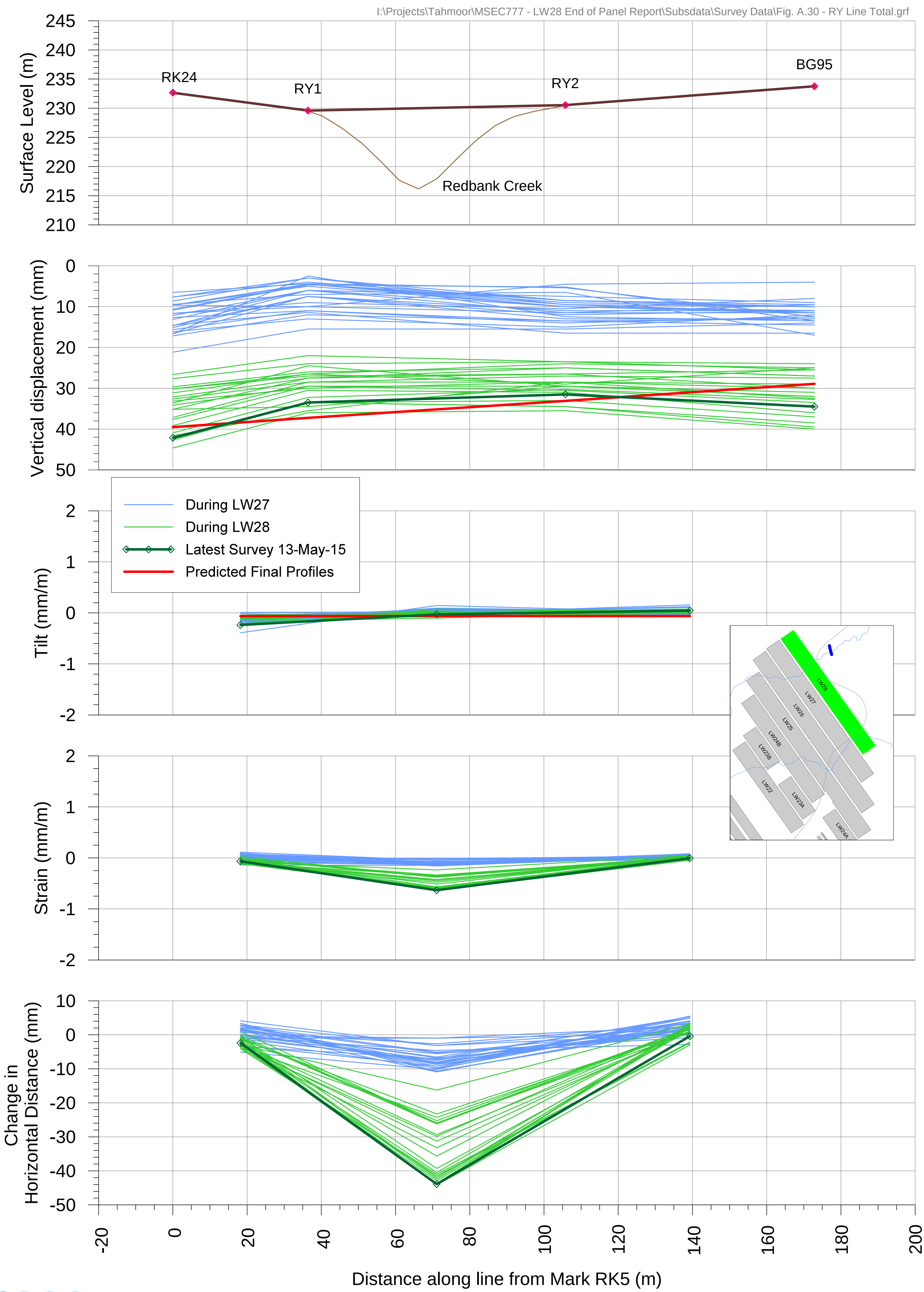


Fig. A.30

Tahmoor Colliery
Incremental Profiles along Redbank Creek RZ Line

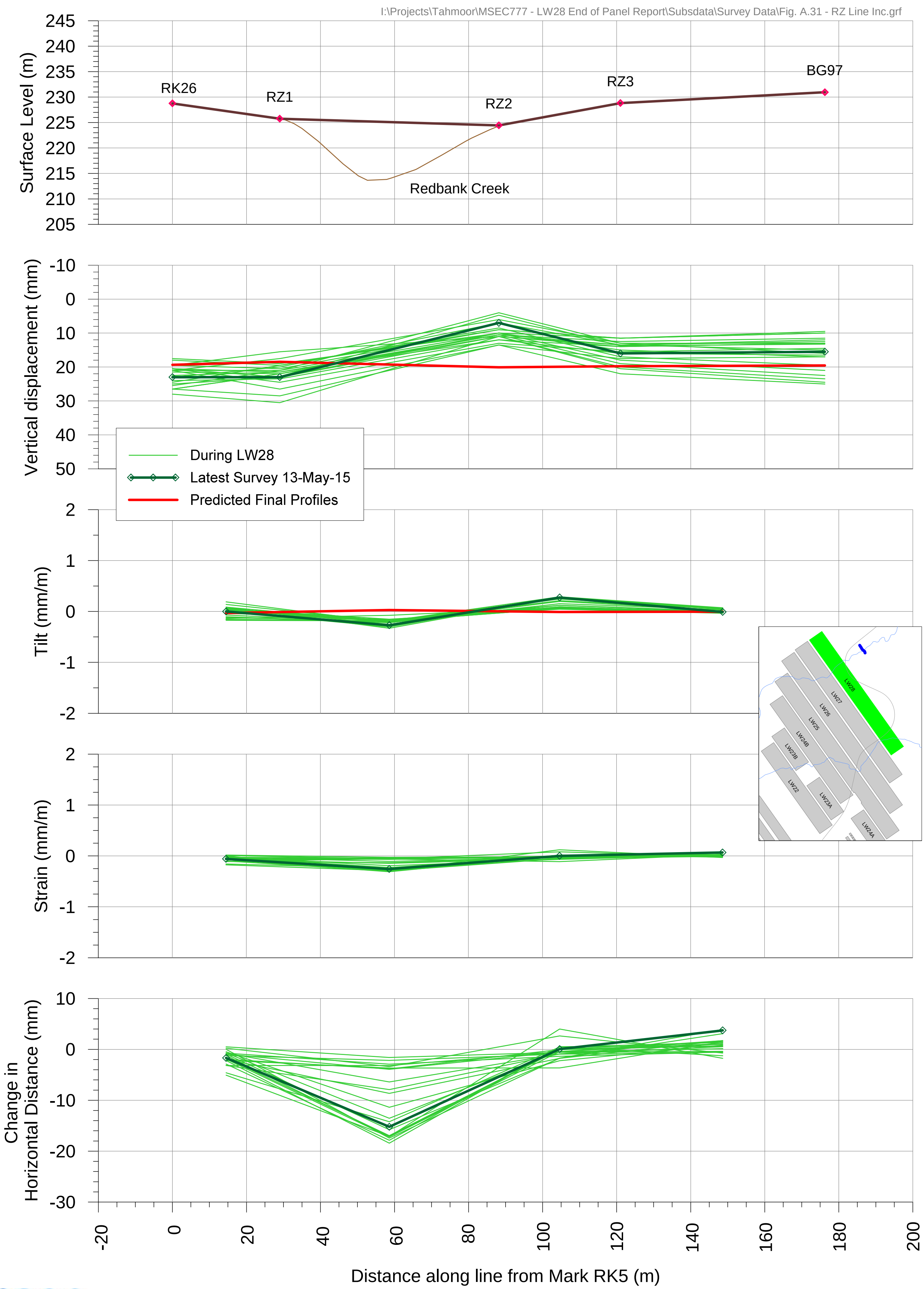


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Fig. A.31

Tahmoor Colliery
Total Profiles along Redbank Creek RZ Line

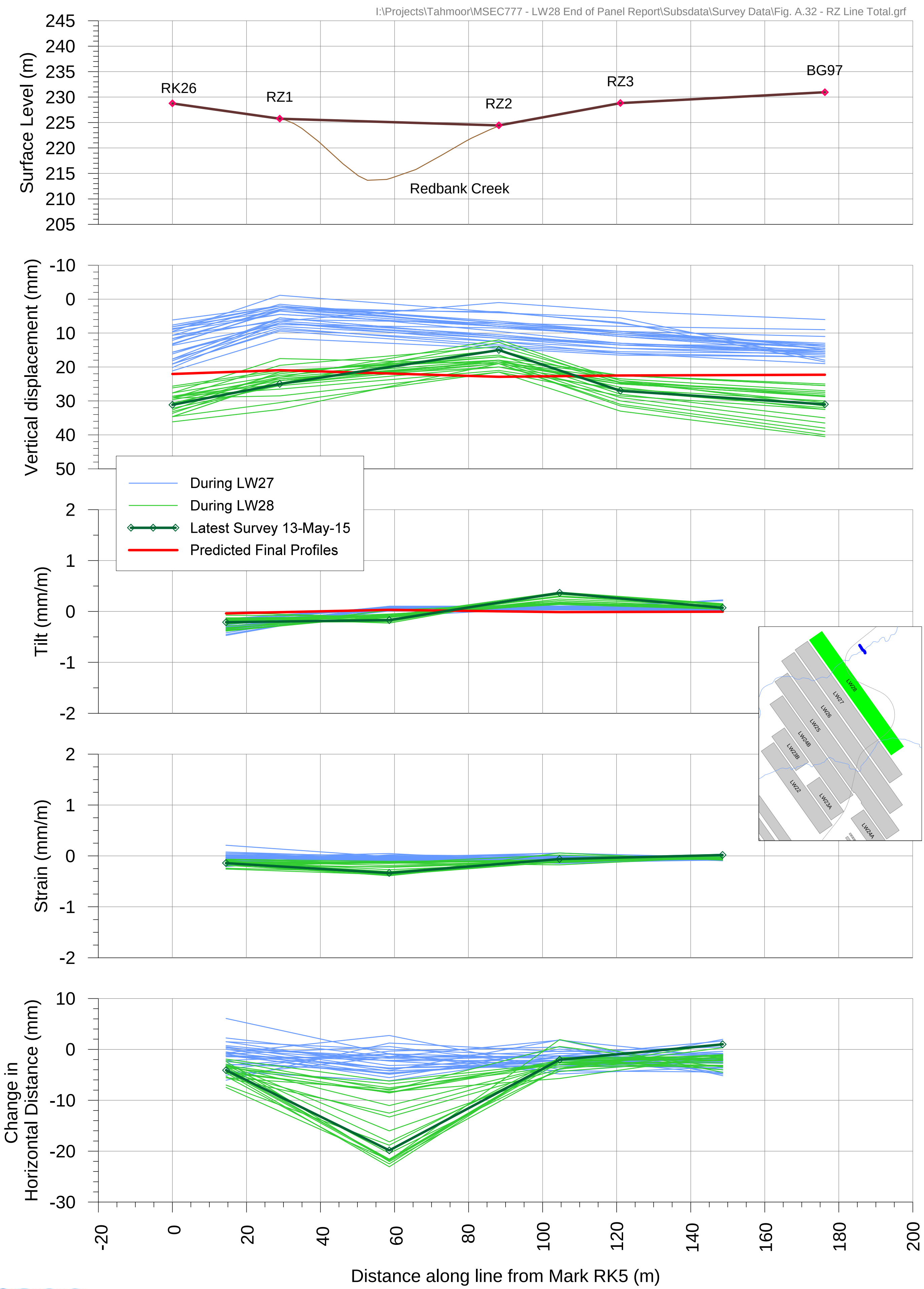

Fig. A.32

Tahmoor Colliery
Incremental Subsidence Profiles along Remembrance Drive

msec

Fig. A.33

Tahmoor Colliery
Total Subsidence Profiles along Remembrance Drive

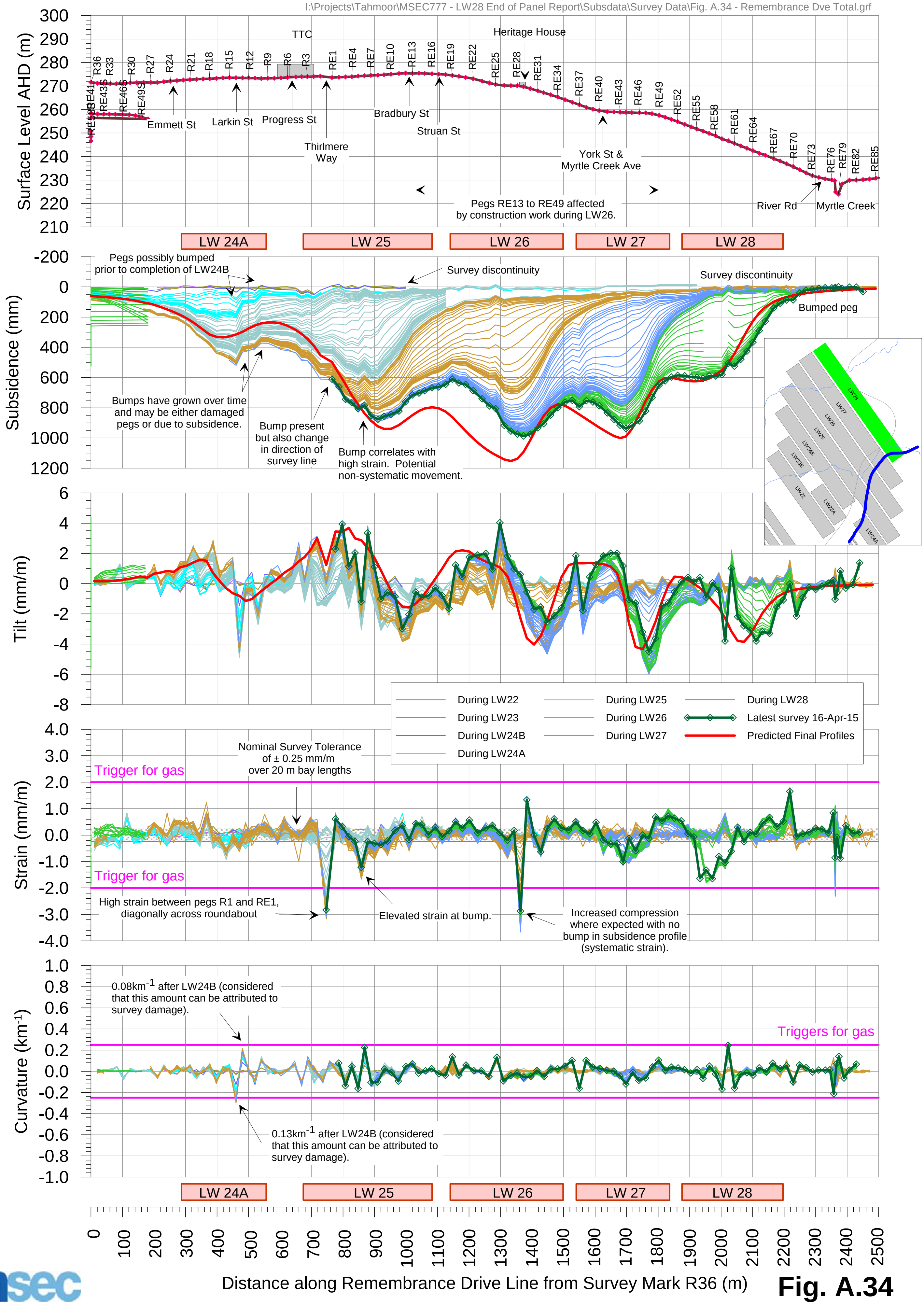

Fig. A.34

Tahmoor Colliery
Total Subsidence Profiles along River Road

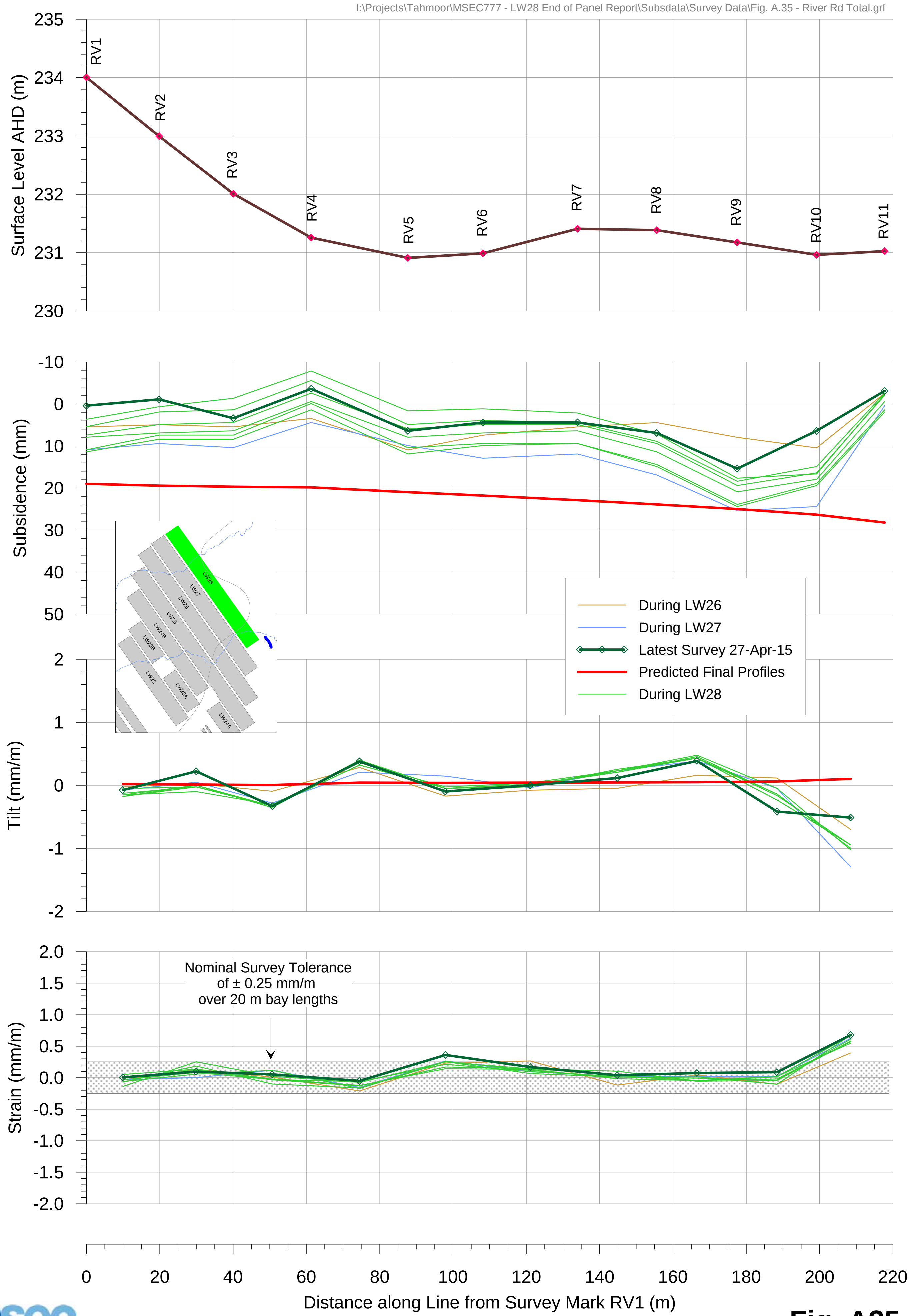

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Fig. A35

Tahmoor Colliery
Total Subsidence Profiles along River Road

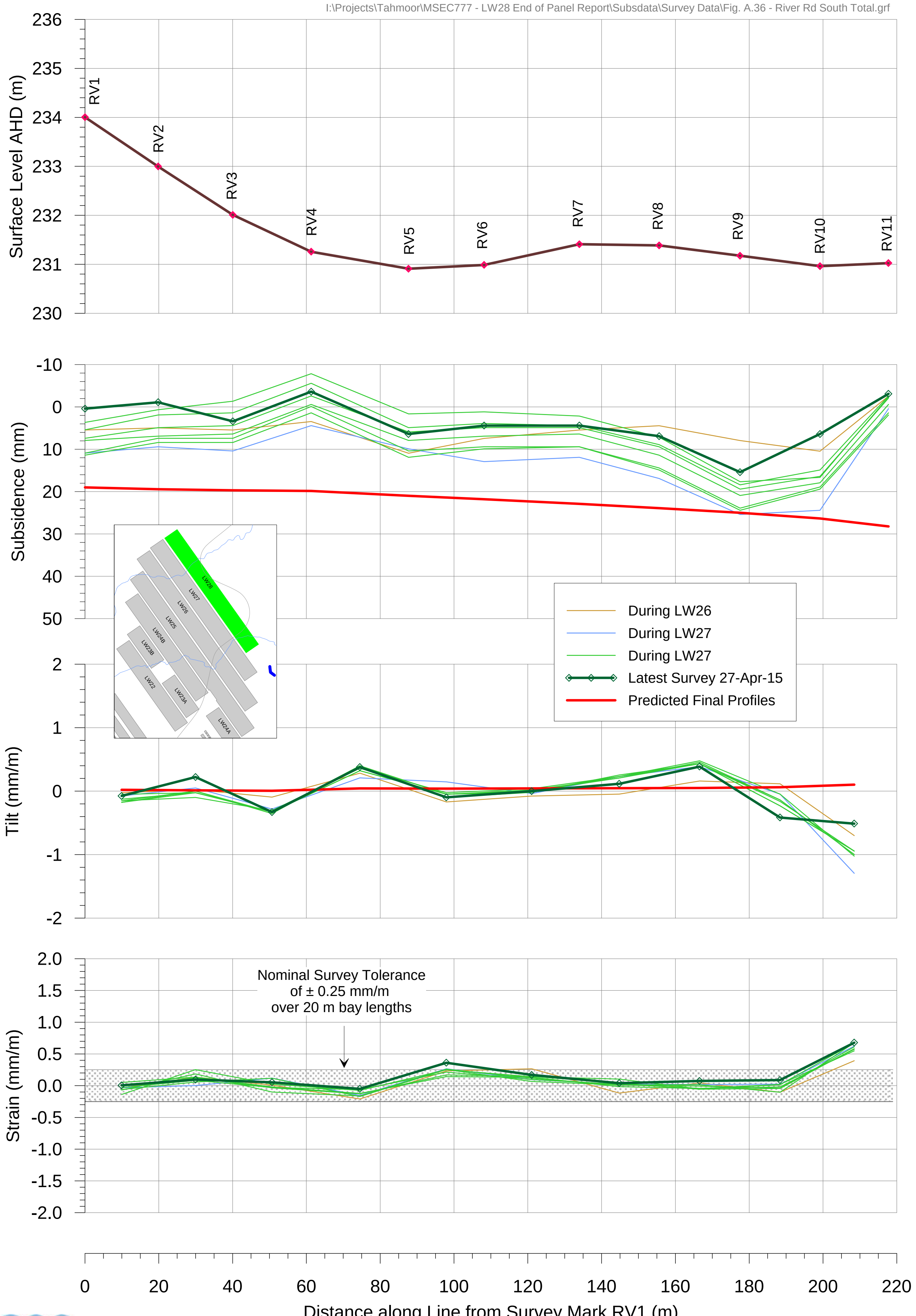

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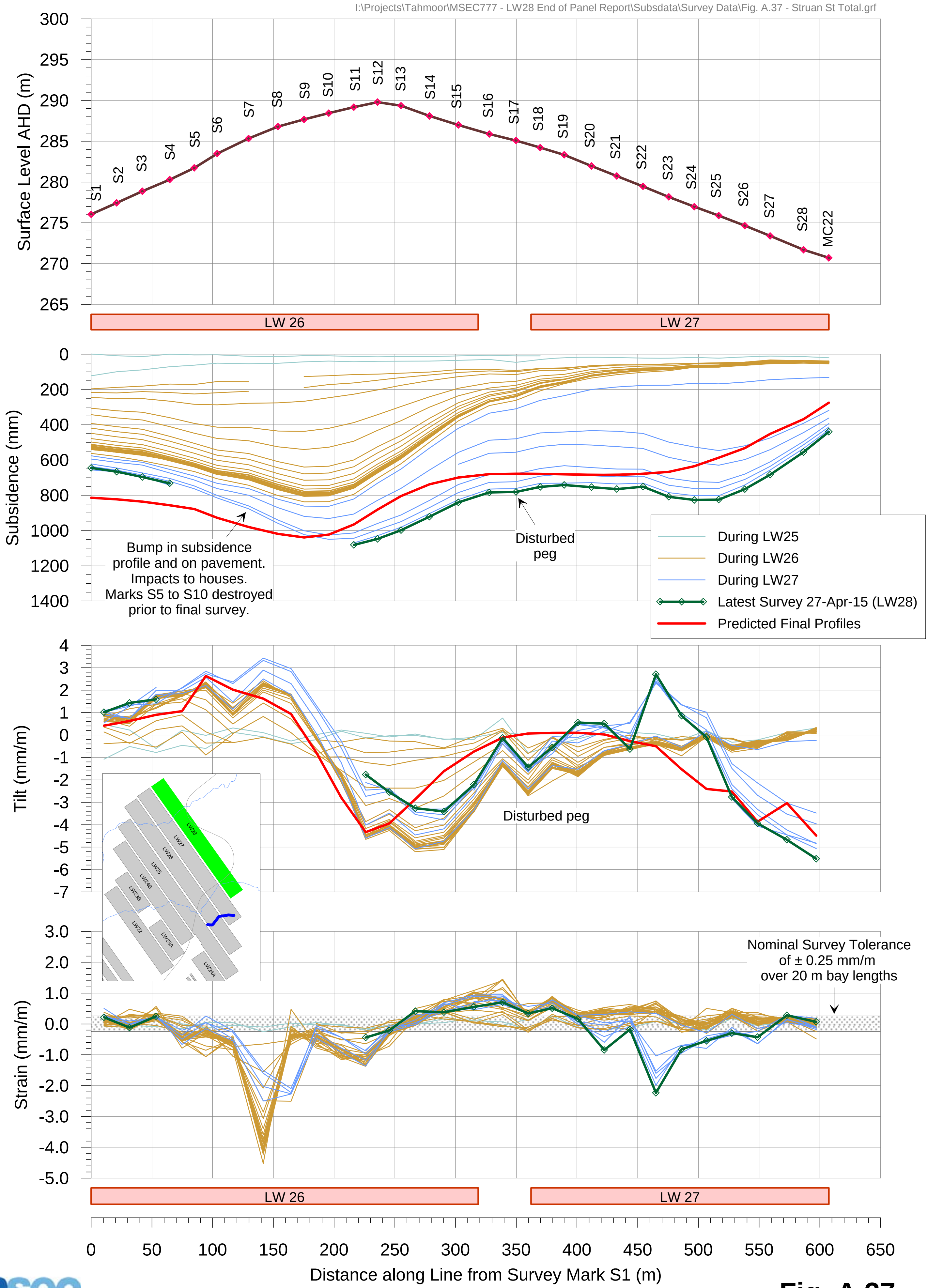
Fig. A36

Tahmoor Colliery
Total Subsidence Profiles along Struan Street



msec

Fig. A.37

Tahmoor Colliery
Incremental Subsidence Profiles along Tahmoor Carrier Pipe

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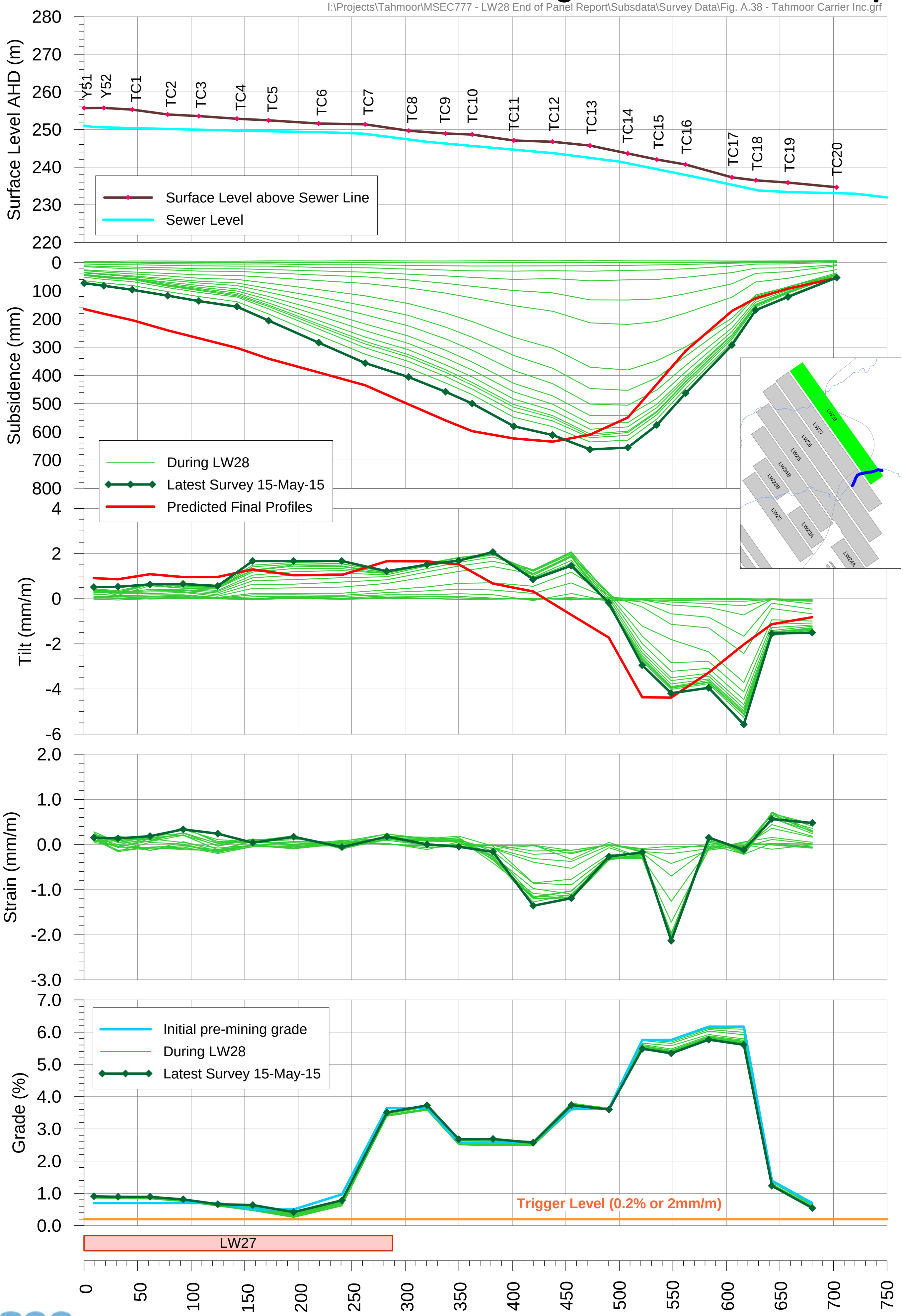

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Fig. A.38

Tahmoor Colliery
Total Subsidence Profiles along Tahmoor Carrier Pipe

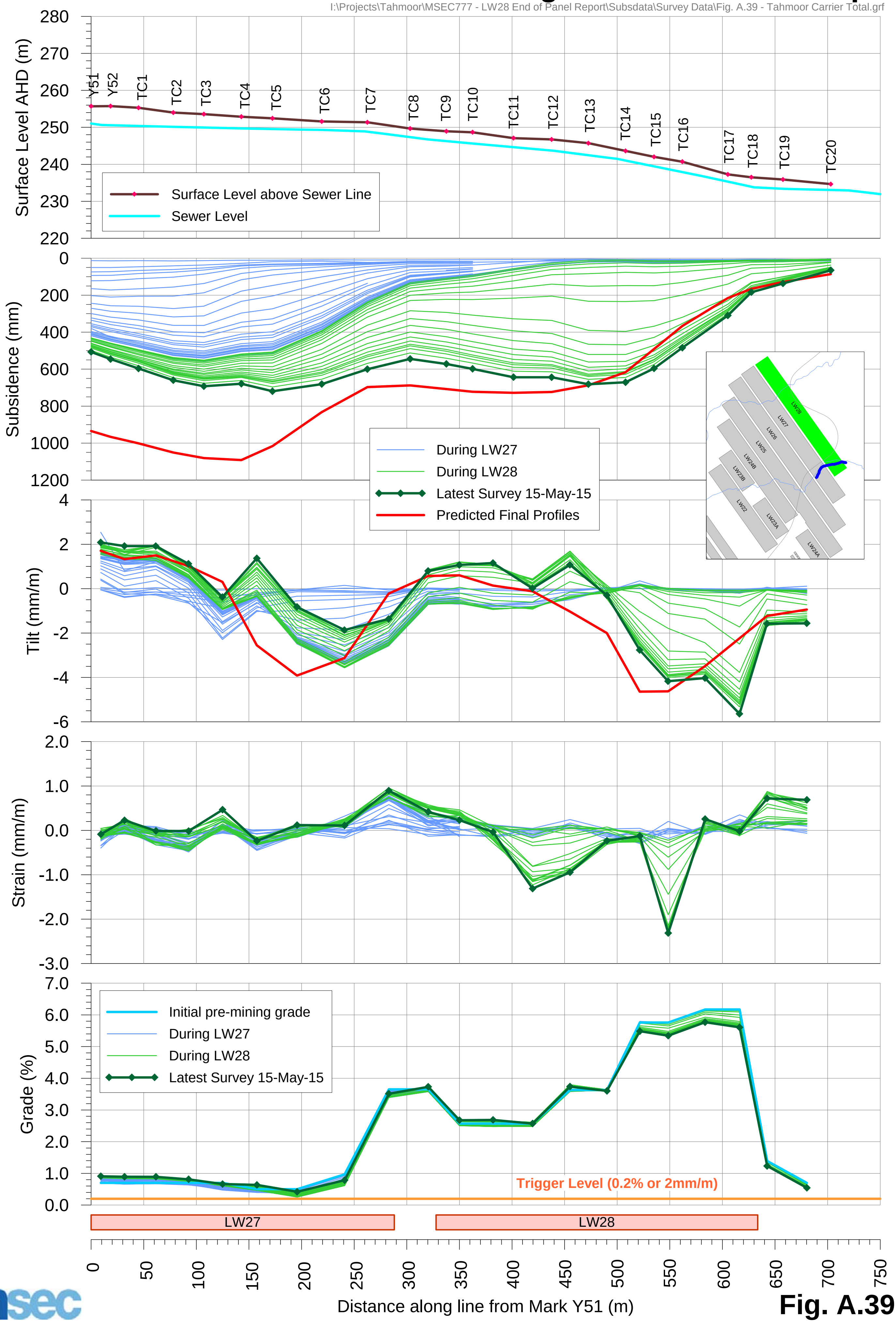

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Fig. A.39

Tahmoor Colliery
Incremental Subsidence Profiles along Thirlmere Carrier Pipe

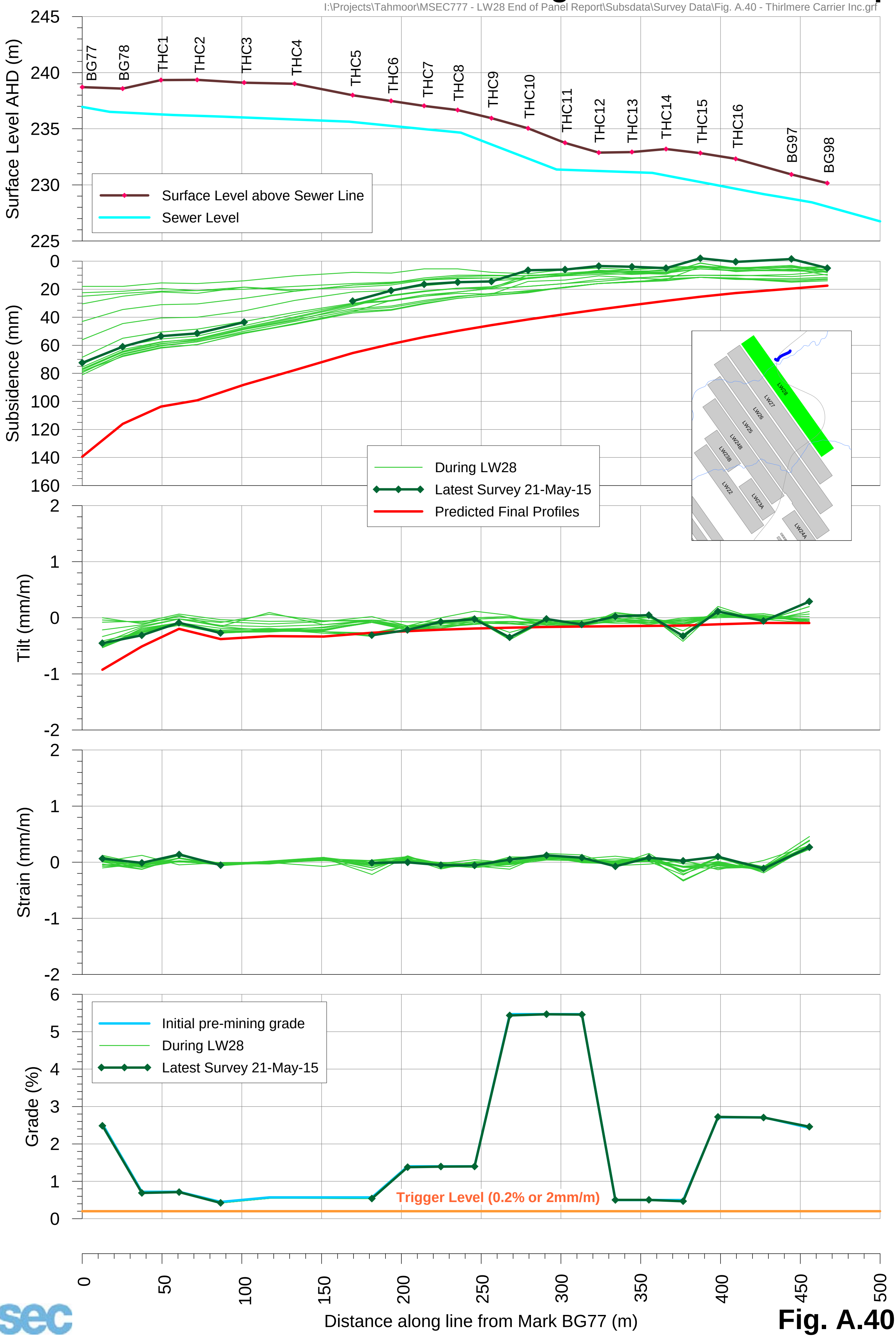

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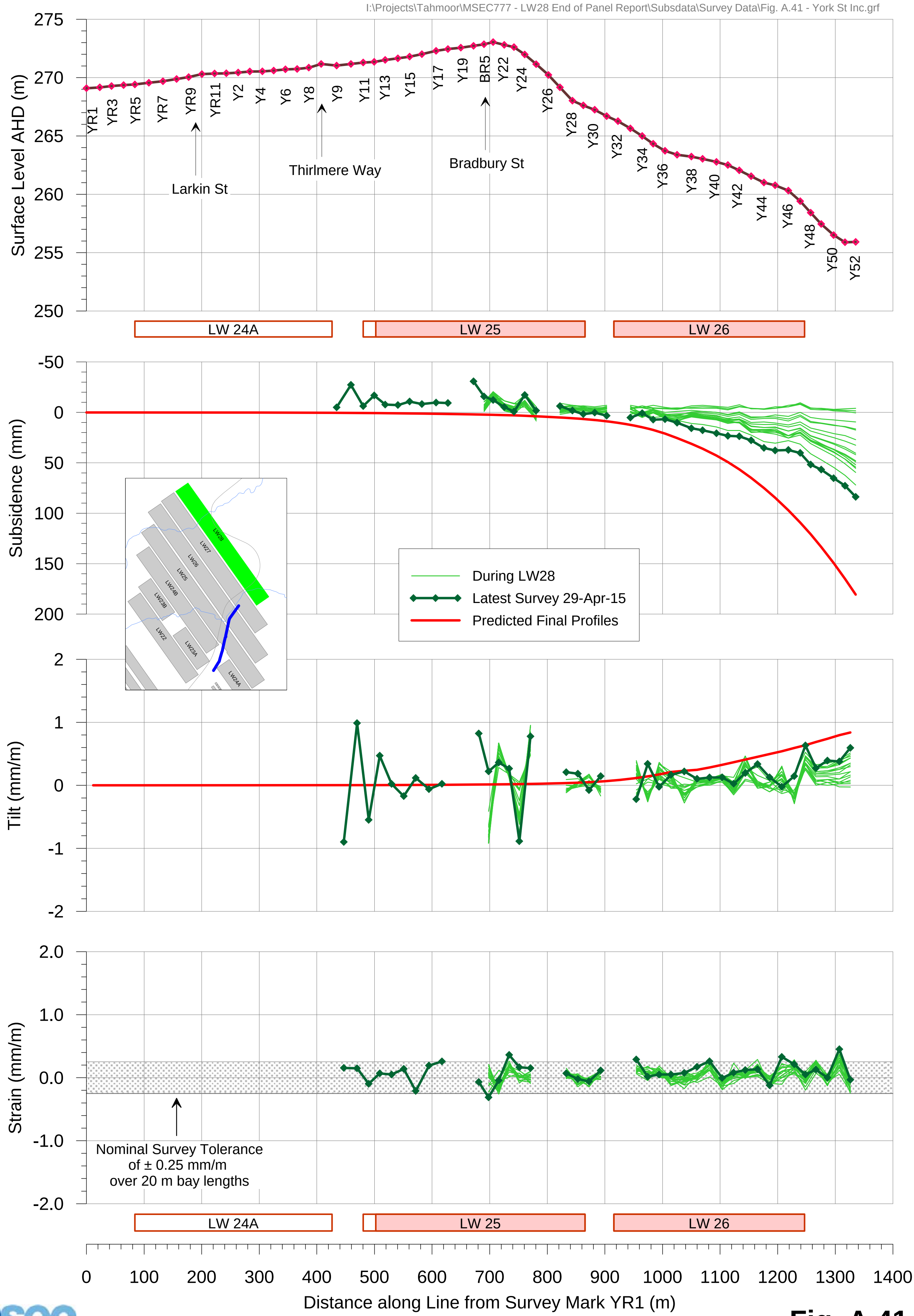
Fig. A.40

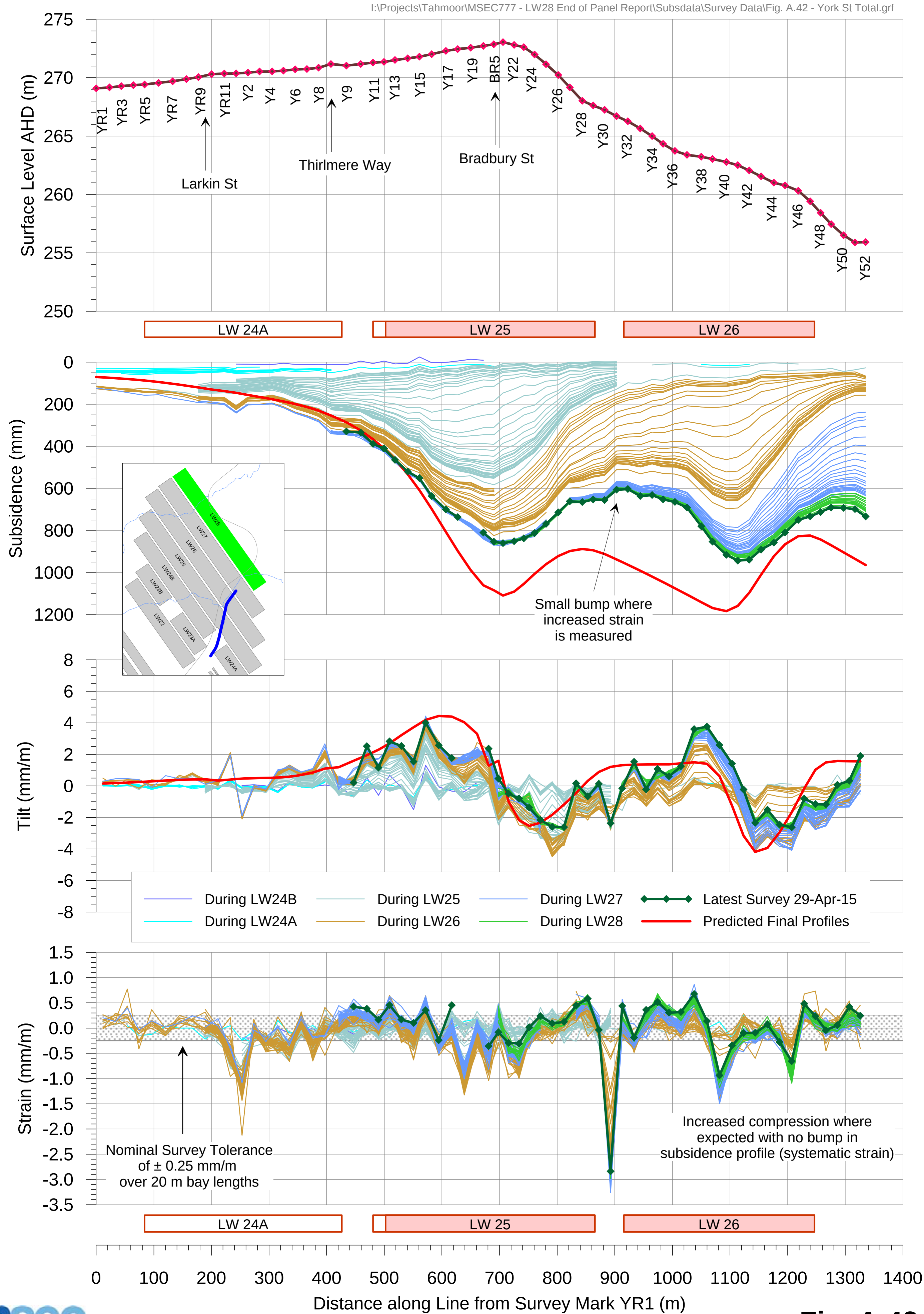
Tahmoor Colliery
Incremental Subsidence Profiles along York Street



msec

Fig. A.41

Tahmoor Colliery
Total Subsidence Profiles along York Street



msec

Fig. A.42

Tahmoor Colliery
Incremental Subsidence Profiles at Tahmoor House

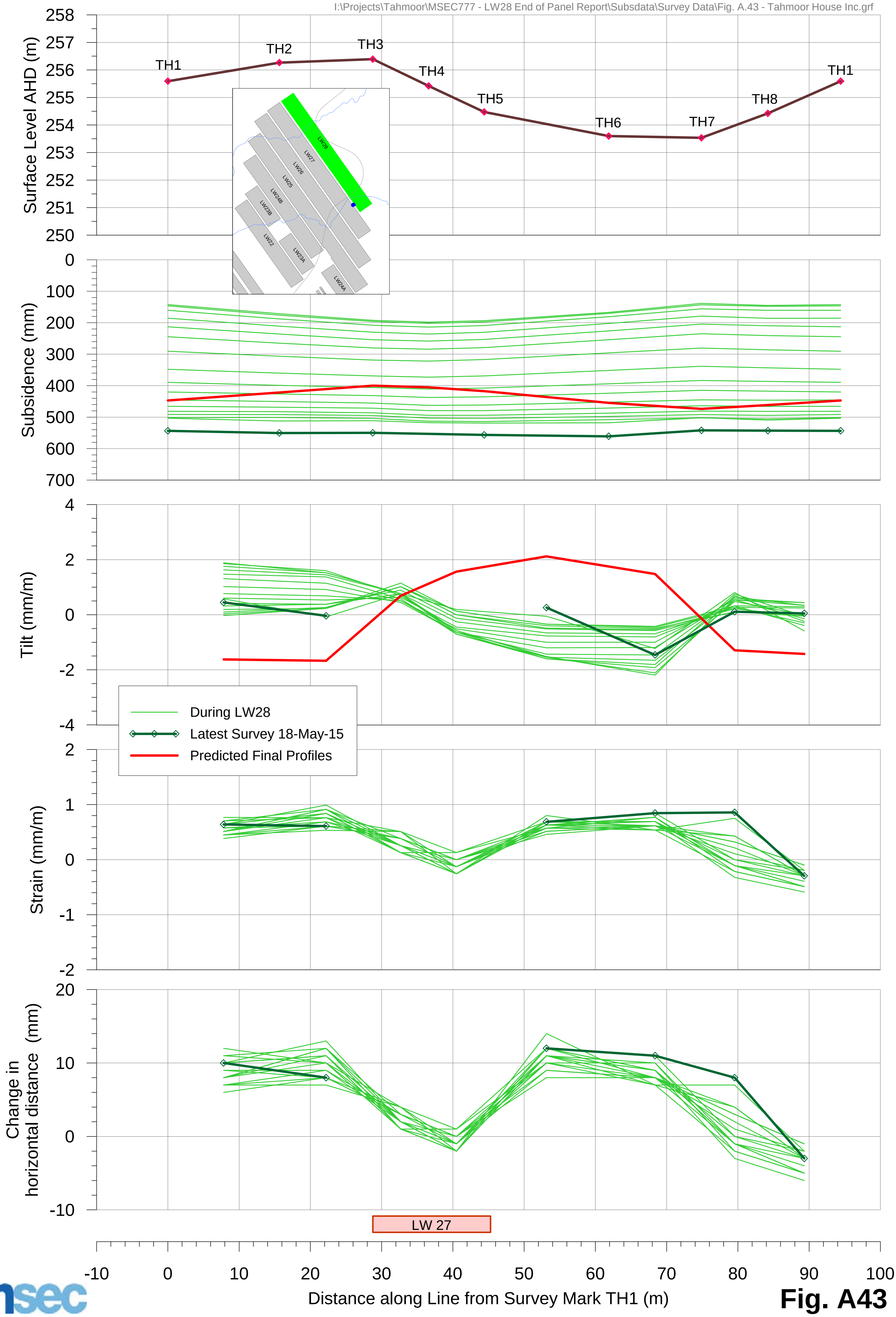


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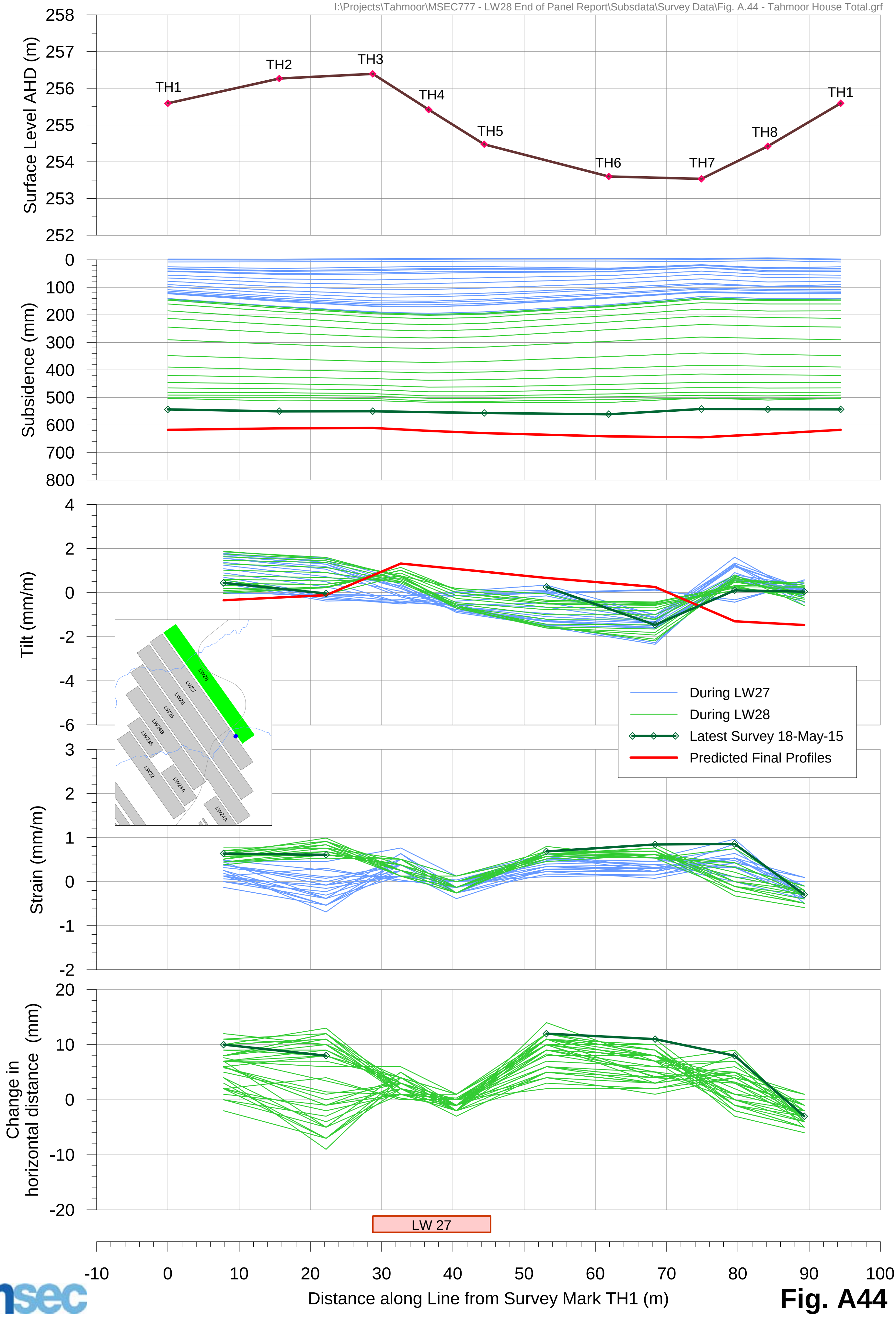
Fig. A43

Tahmoor Colliery
Incremental Subsidence Profiles at Tahmoor House



msec

Fig. A44

Tahmoor Colliery
Total Subsidence Profiles at 13 York Street

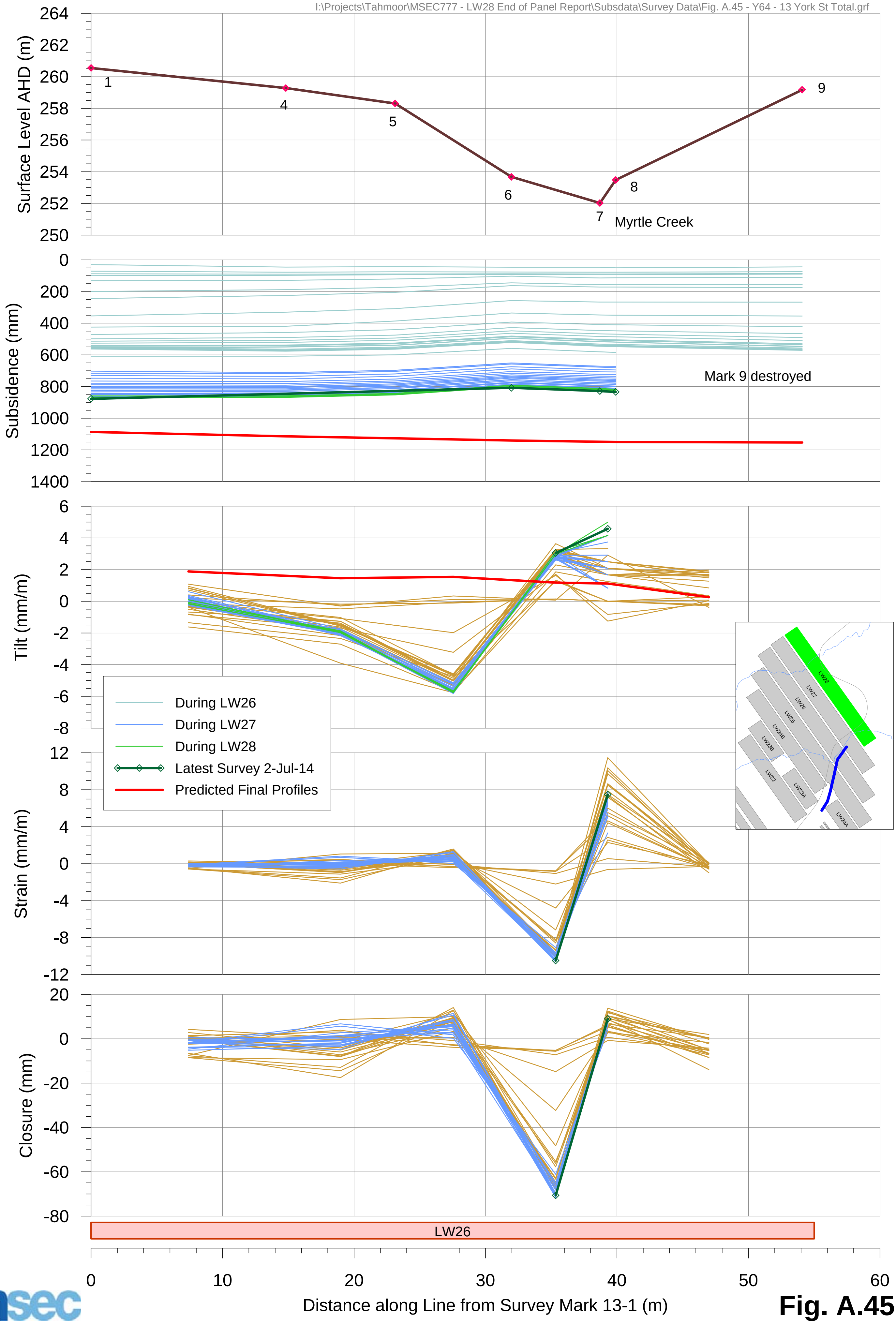


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Fig. A.45

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

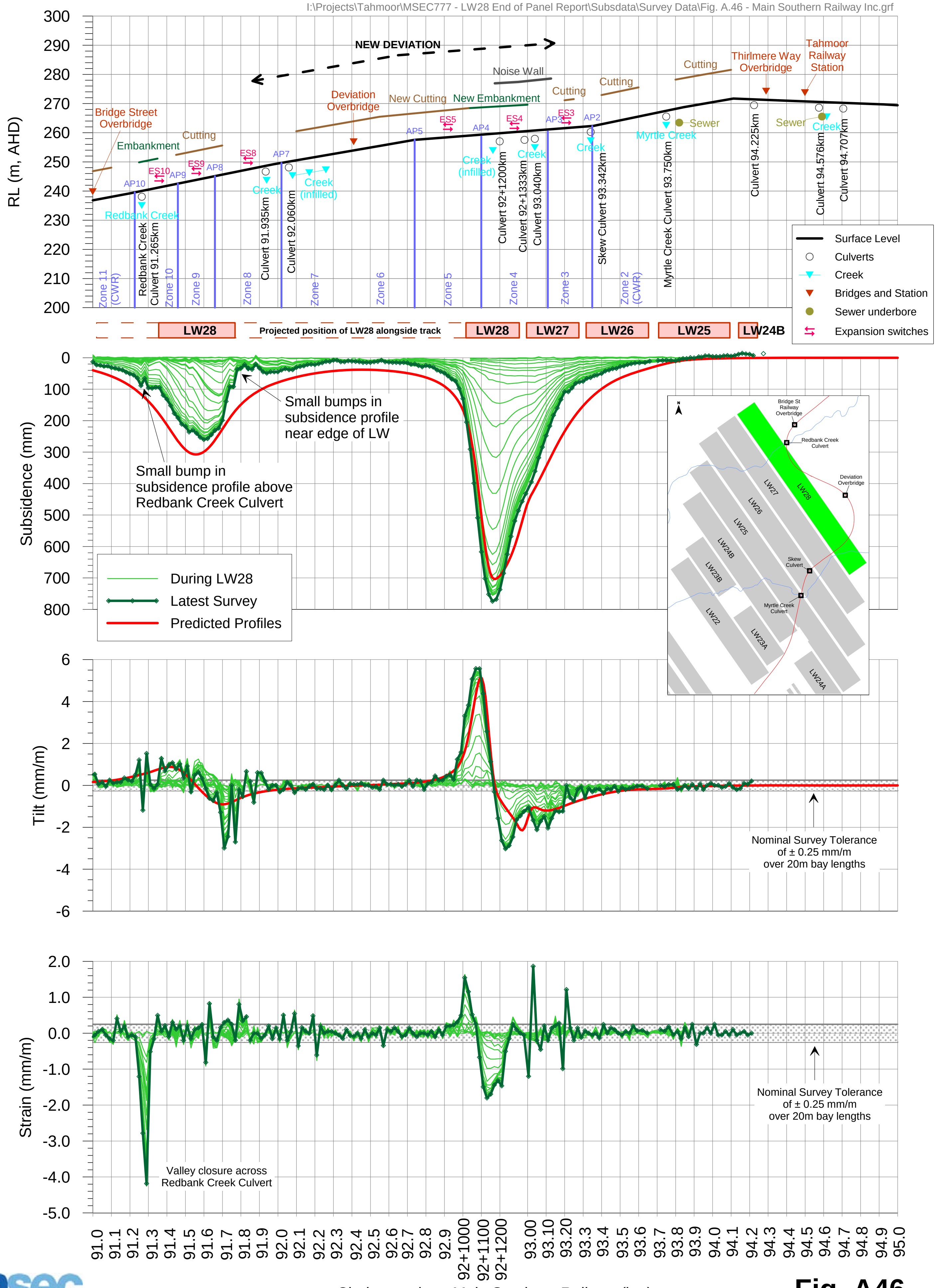

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Fig. A46

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

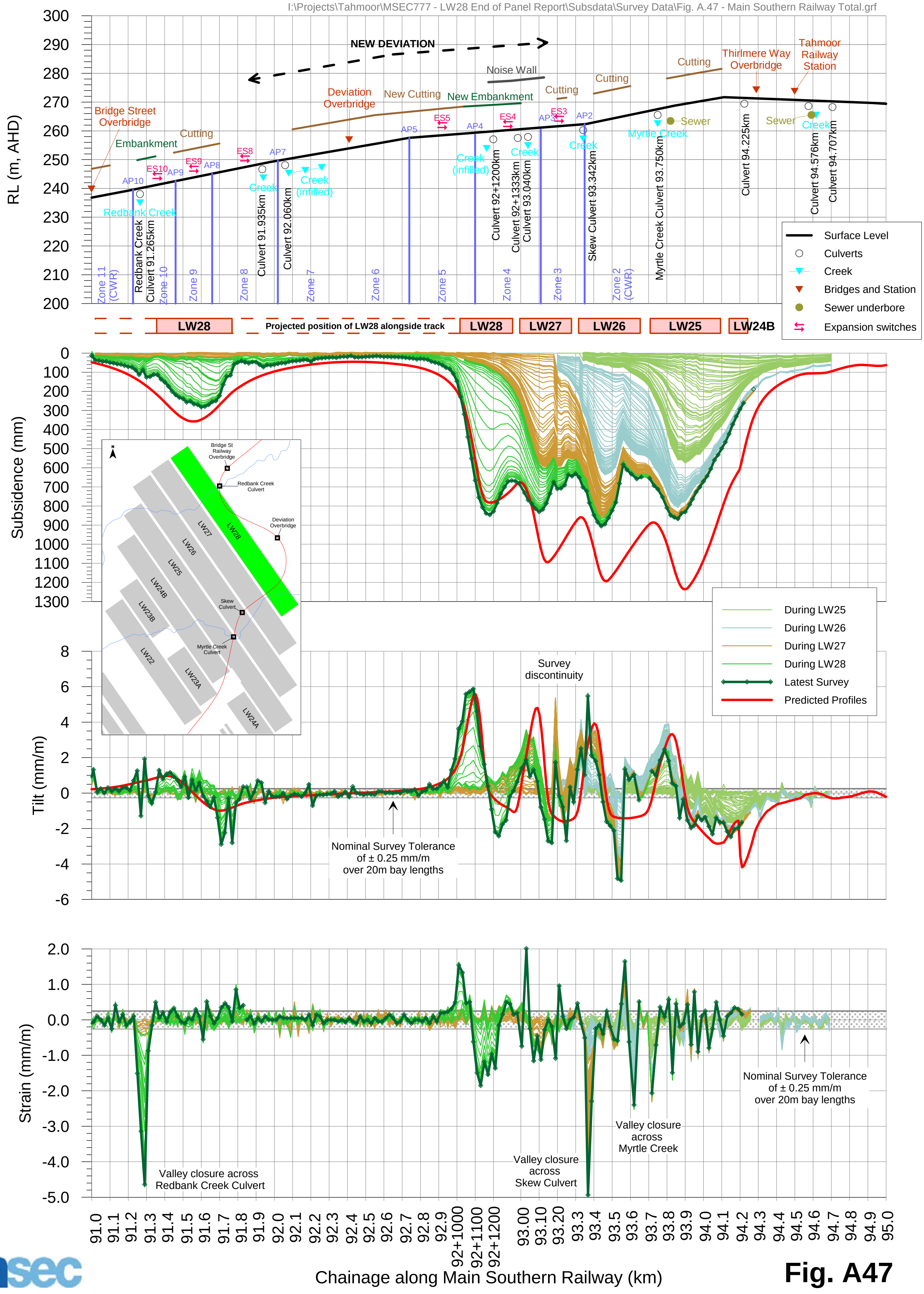

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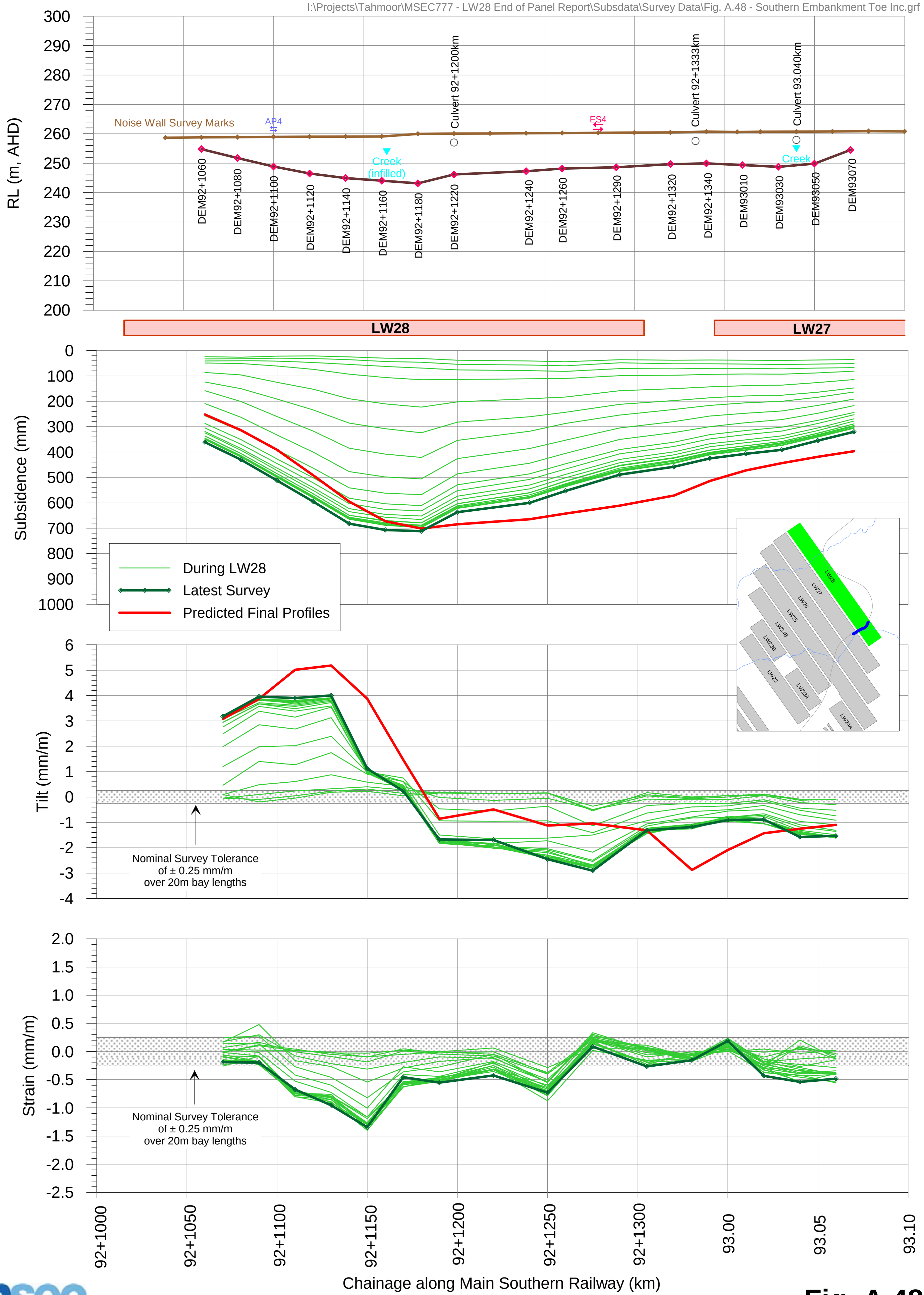
Fig. A47

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



msec

Fig. A.48

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

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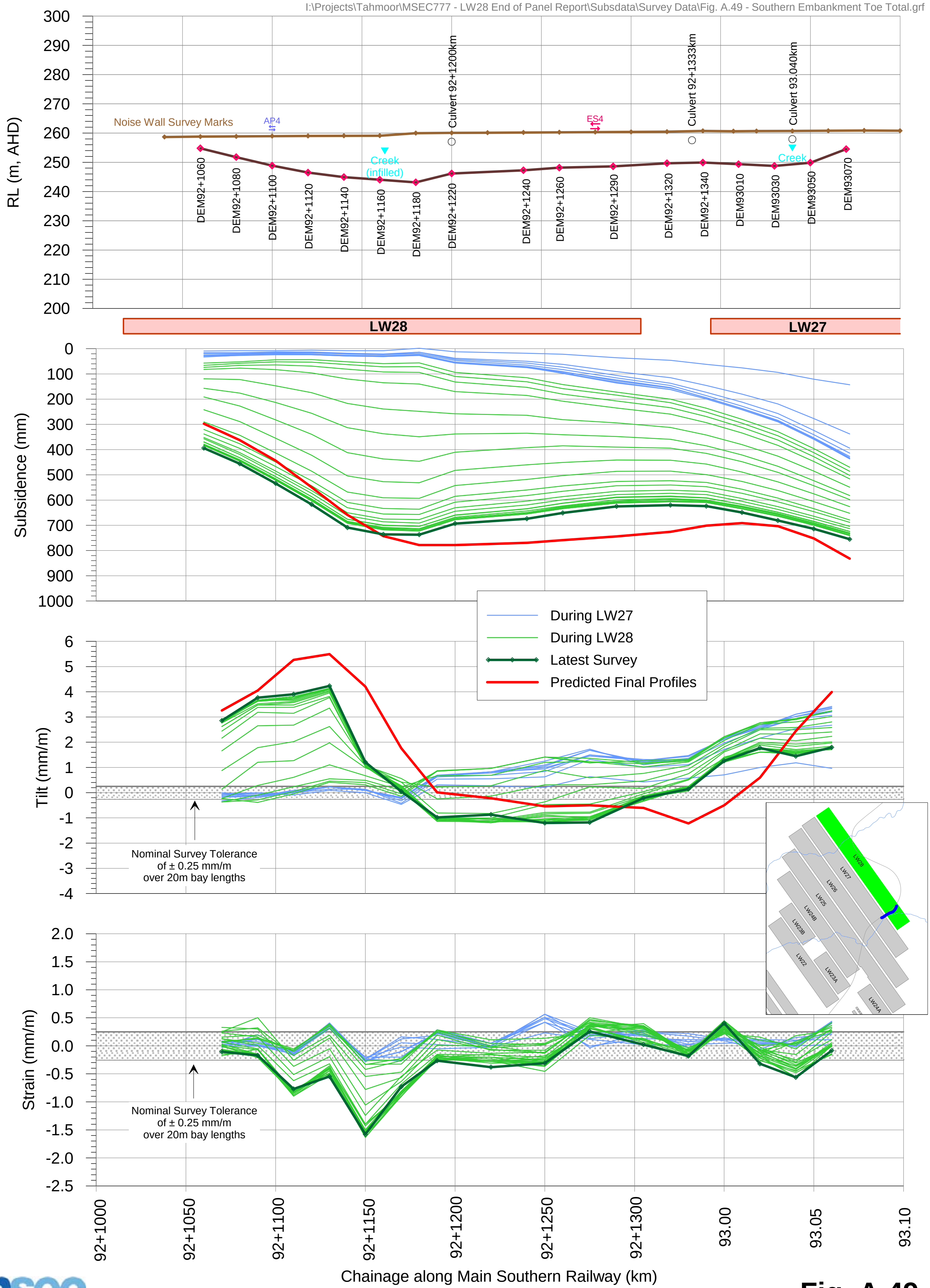

msec

Fig. A.49

Tahmoor Colliery
Incremental Subsidence Profiles along the Railway Corridor Noise Wall

msec

Fig. A.50

Tahmoor Colliery
Total Subsidence Profiles
along the Railway Corridor Noise Wall

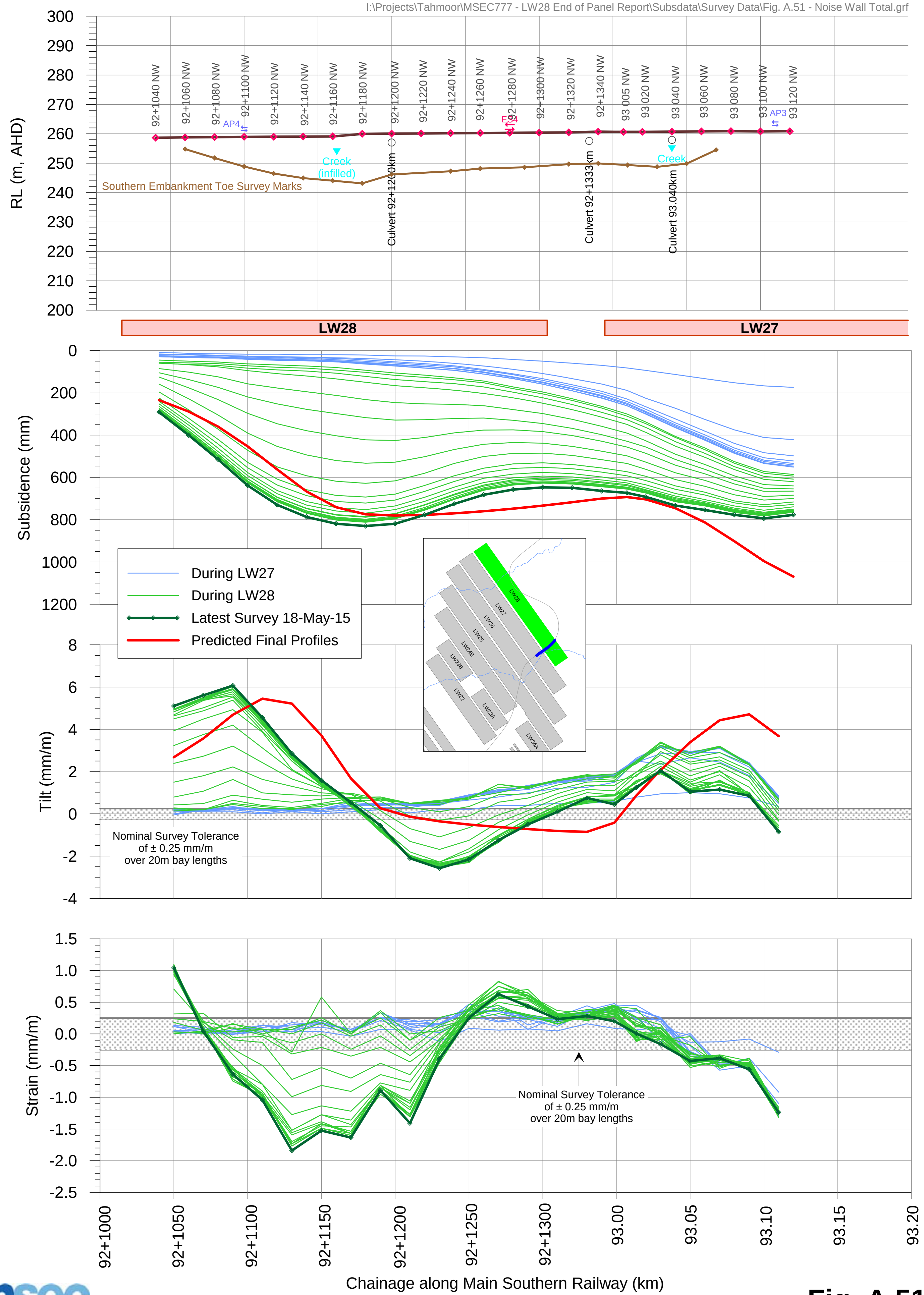

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Fig. A.51

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

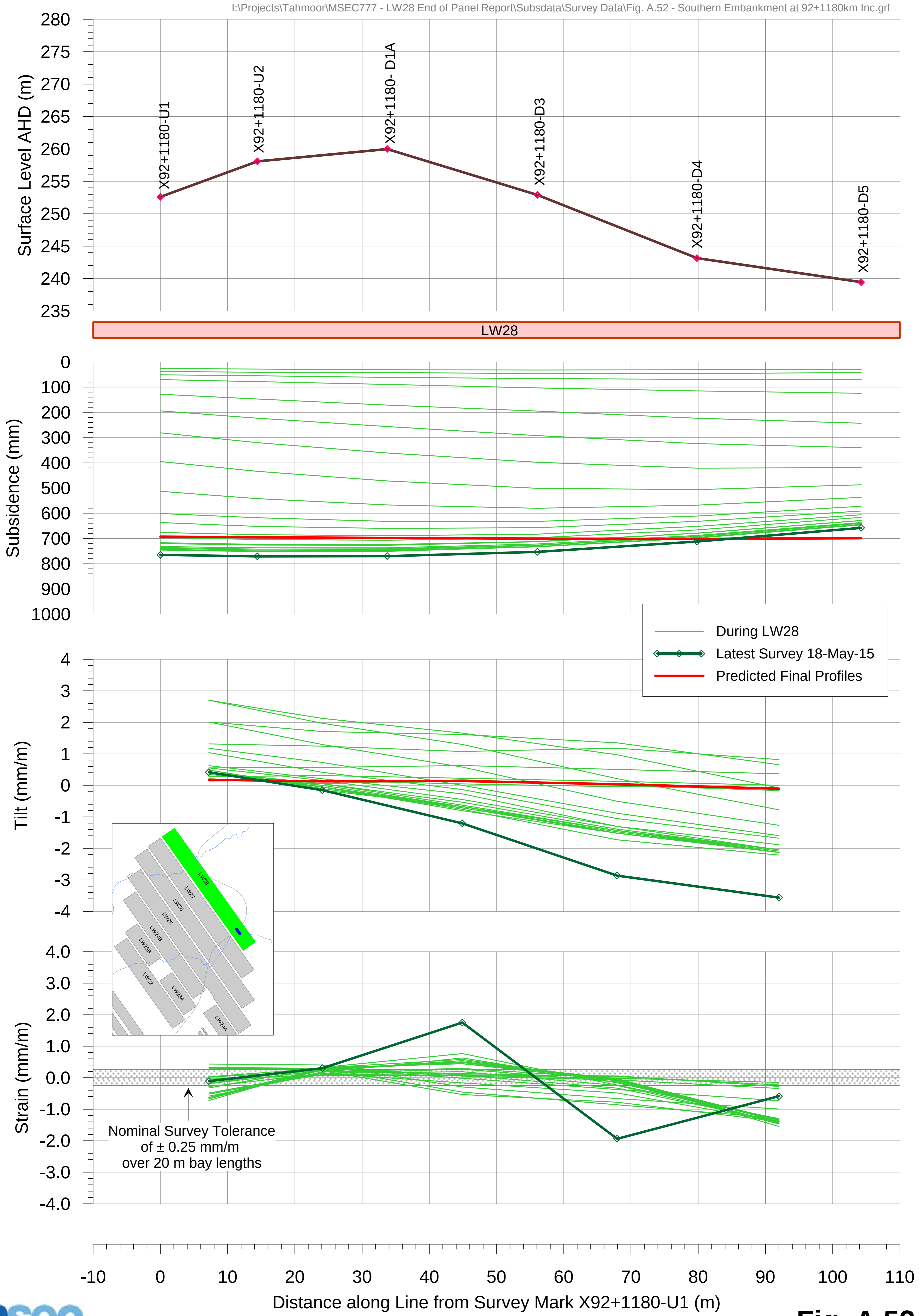

Fig. A.52

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

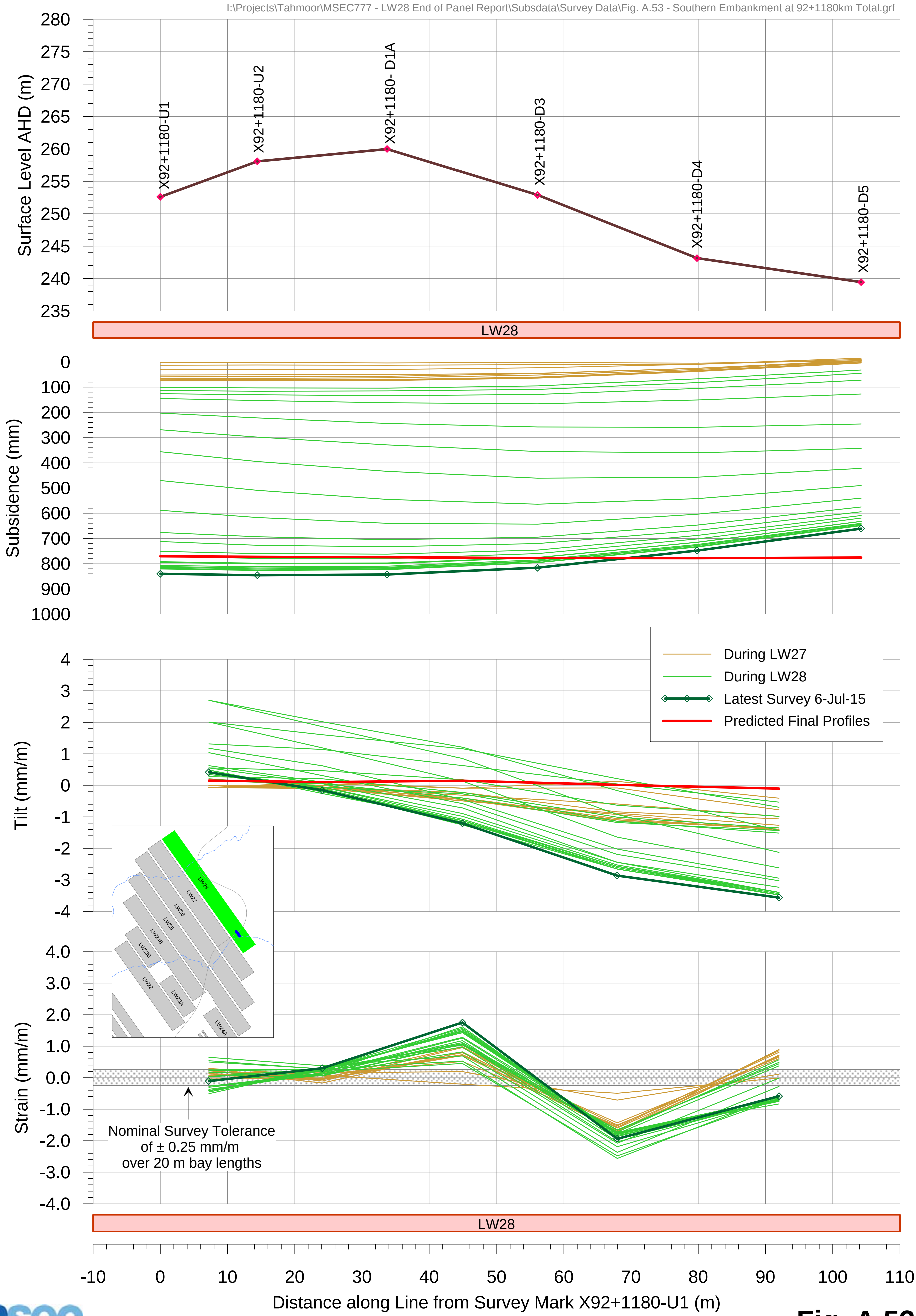

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Fig. A.53

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

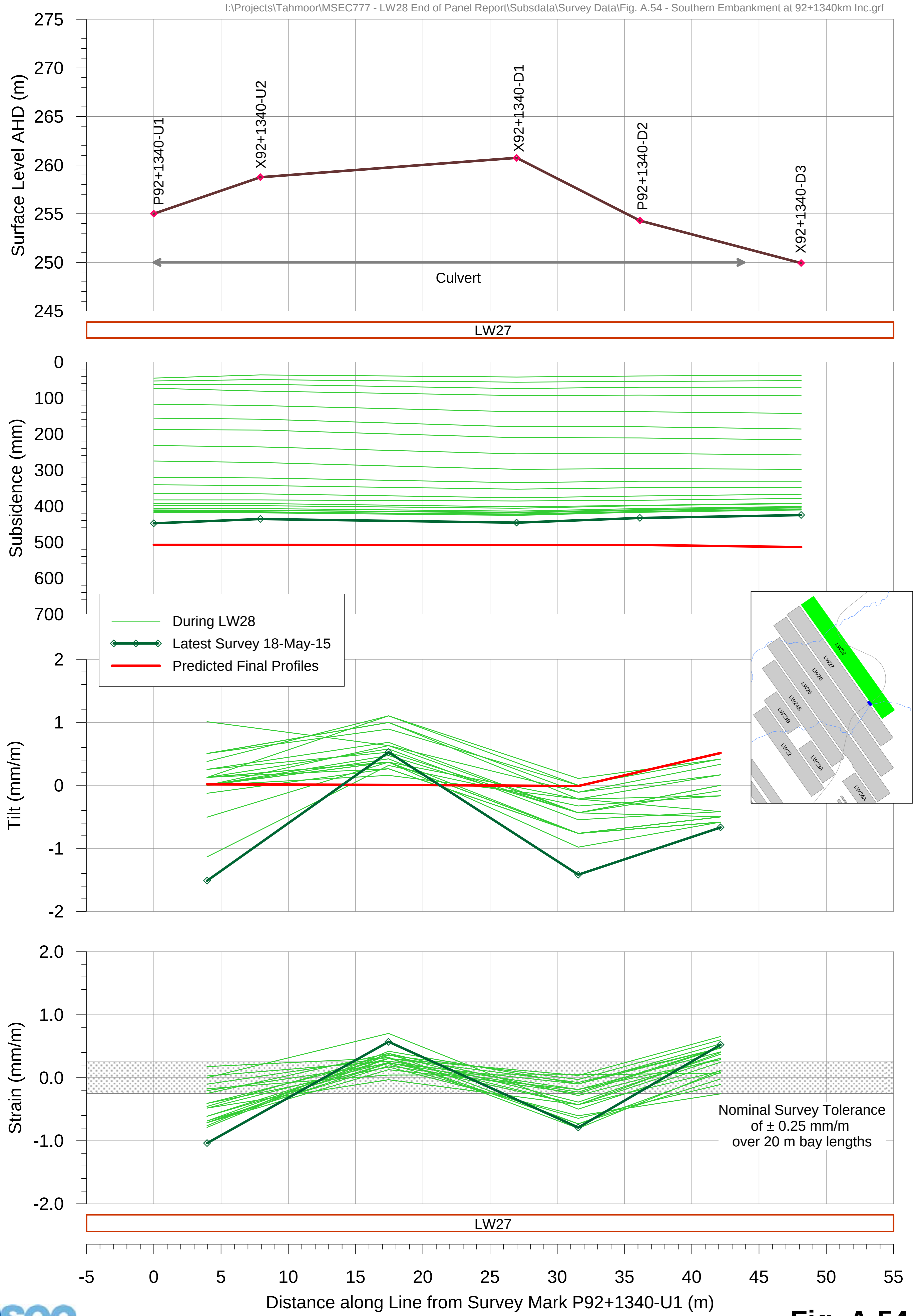

Fig. A.54

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

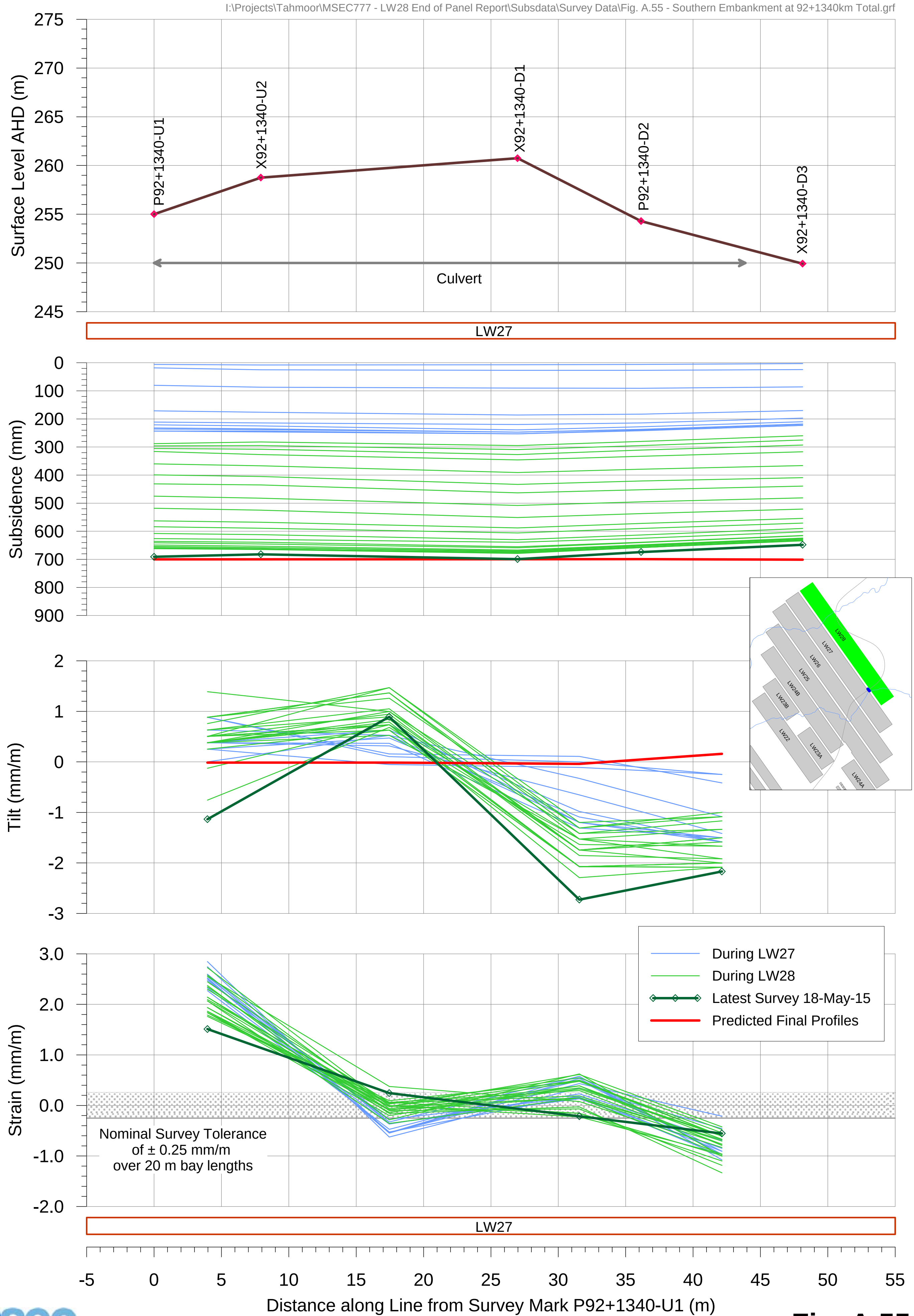

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Fig. A.55

Tahmoor Colliery
Total Differential Movements along Skew Culvert Invert

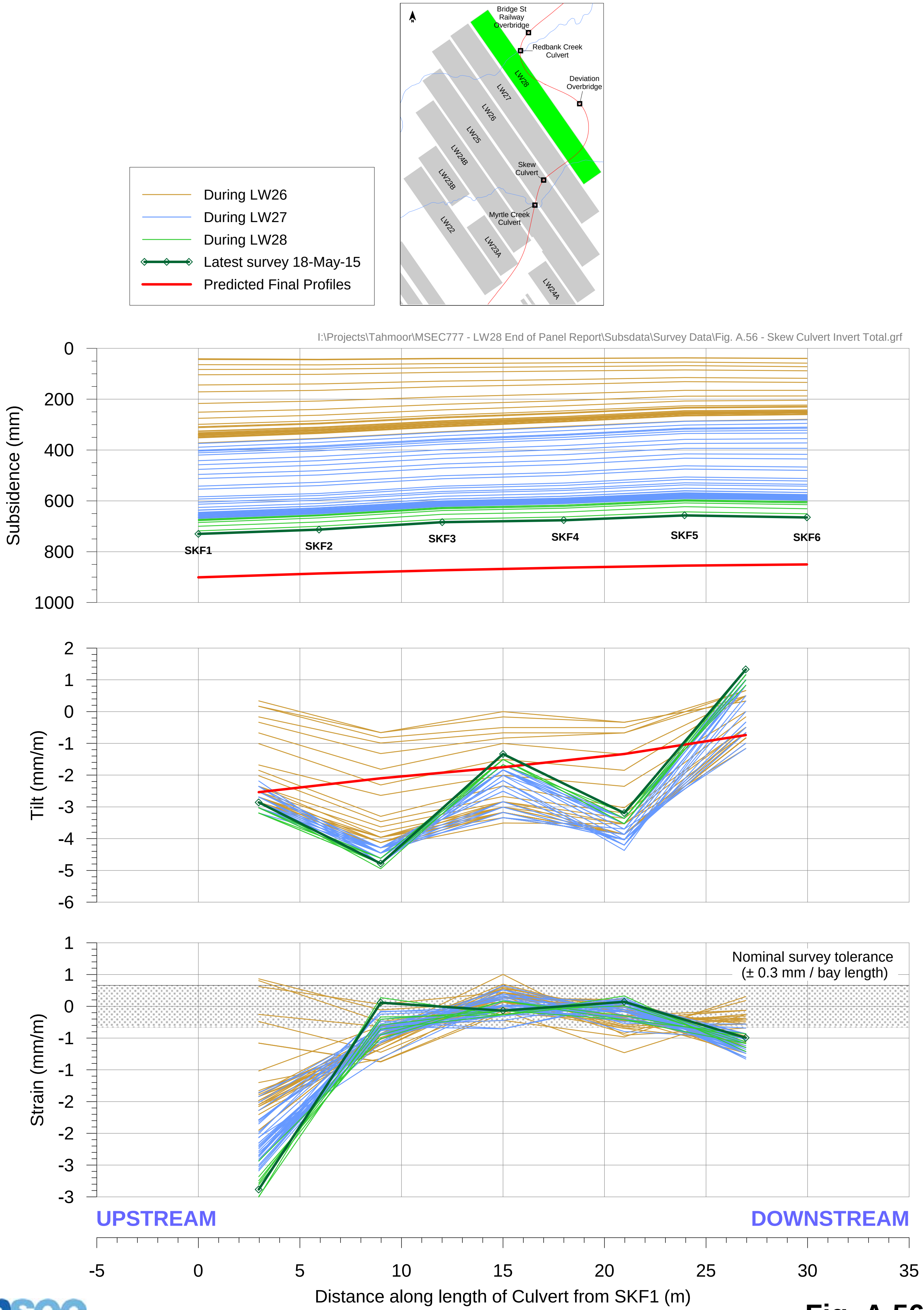

Fig. A.56

Tahmoor Colliery - Redbank Creek Culvert
Total Subsidence Profiles along Upstream Monitoring Line

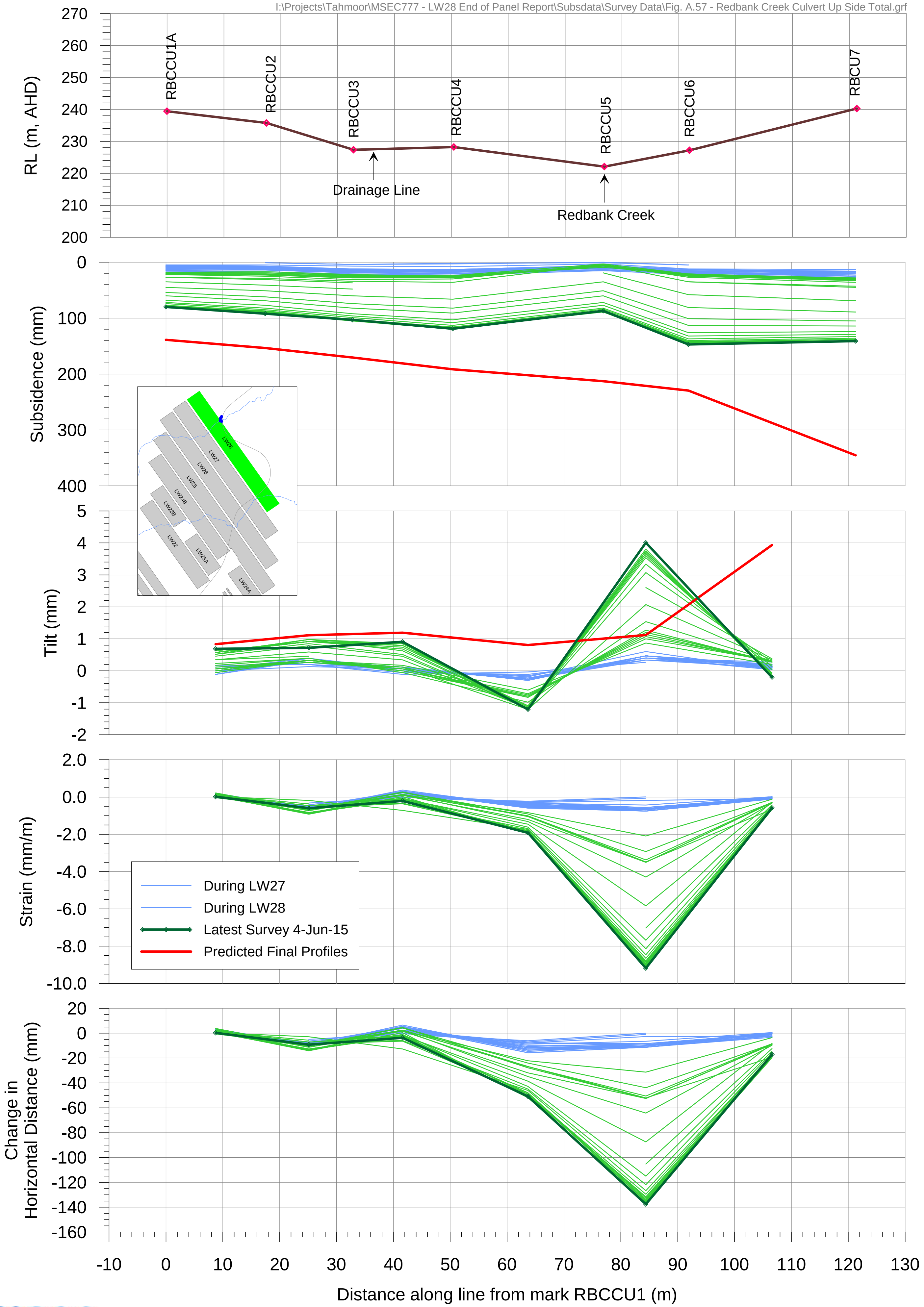

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Fig. A.57

APPENDIX B. DRAWINGS

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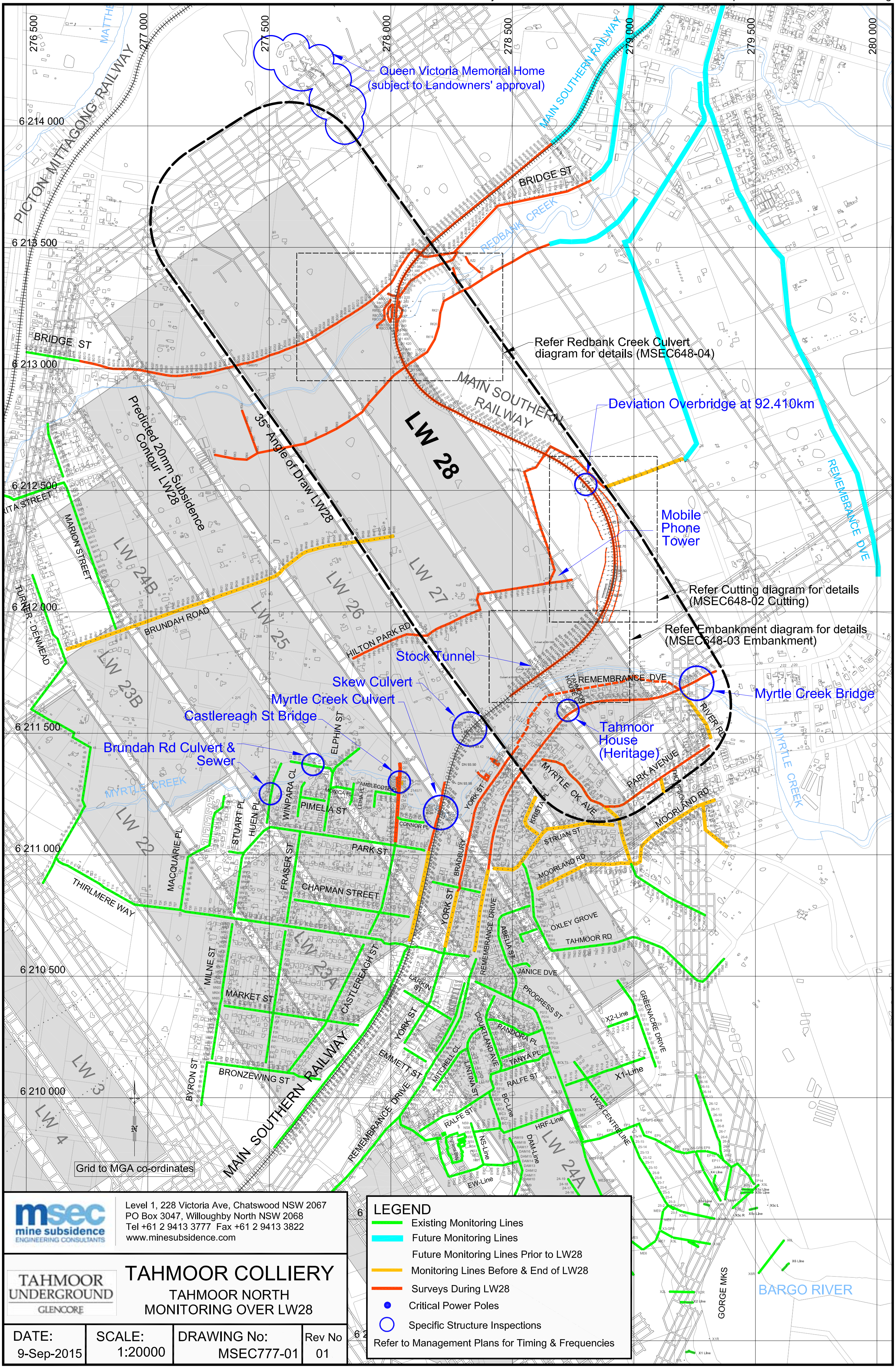

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TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH
MONITORING OVER LW28

DATE:	SCALE:	DRAWING No:	Rev No
9-Sep-2015	1:20000	MSEC777-01	01

LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW28
- Monitoring Lines Before & End of LW28
- Surveys During LW28
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

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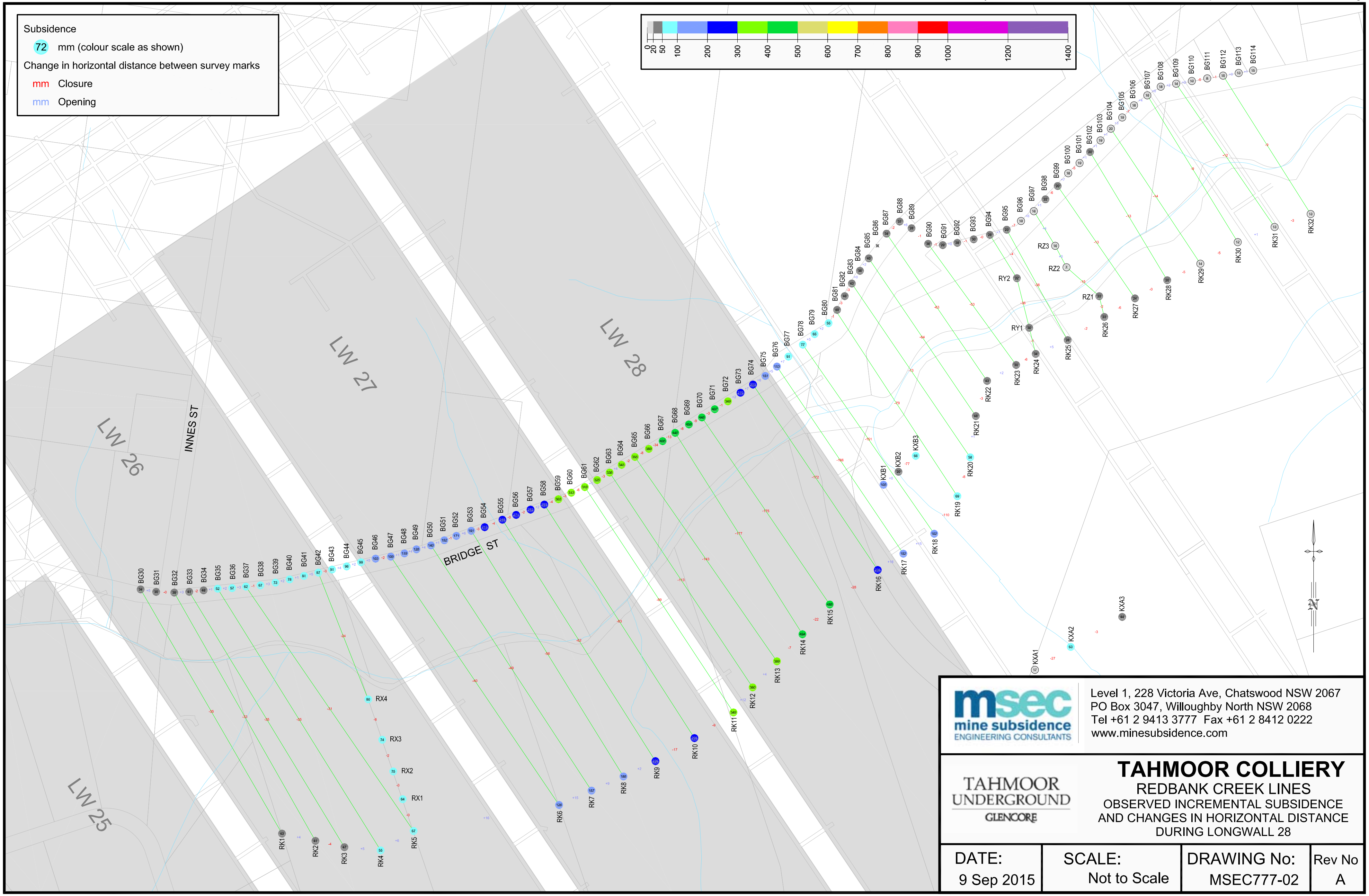

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TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

REDBANK CREEK LINES

OBSERVED INCREMENTAL SUBSIDENCE AND CHANGES IN HORIZONTAL DISTANCE DURING LONGWALL 28

DATE:	SCALE:	DRAWING No:	Rev No
9 Sep 2015	Not to Scale	MSEC777-02	A

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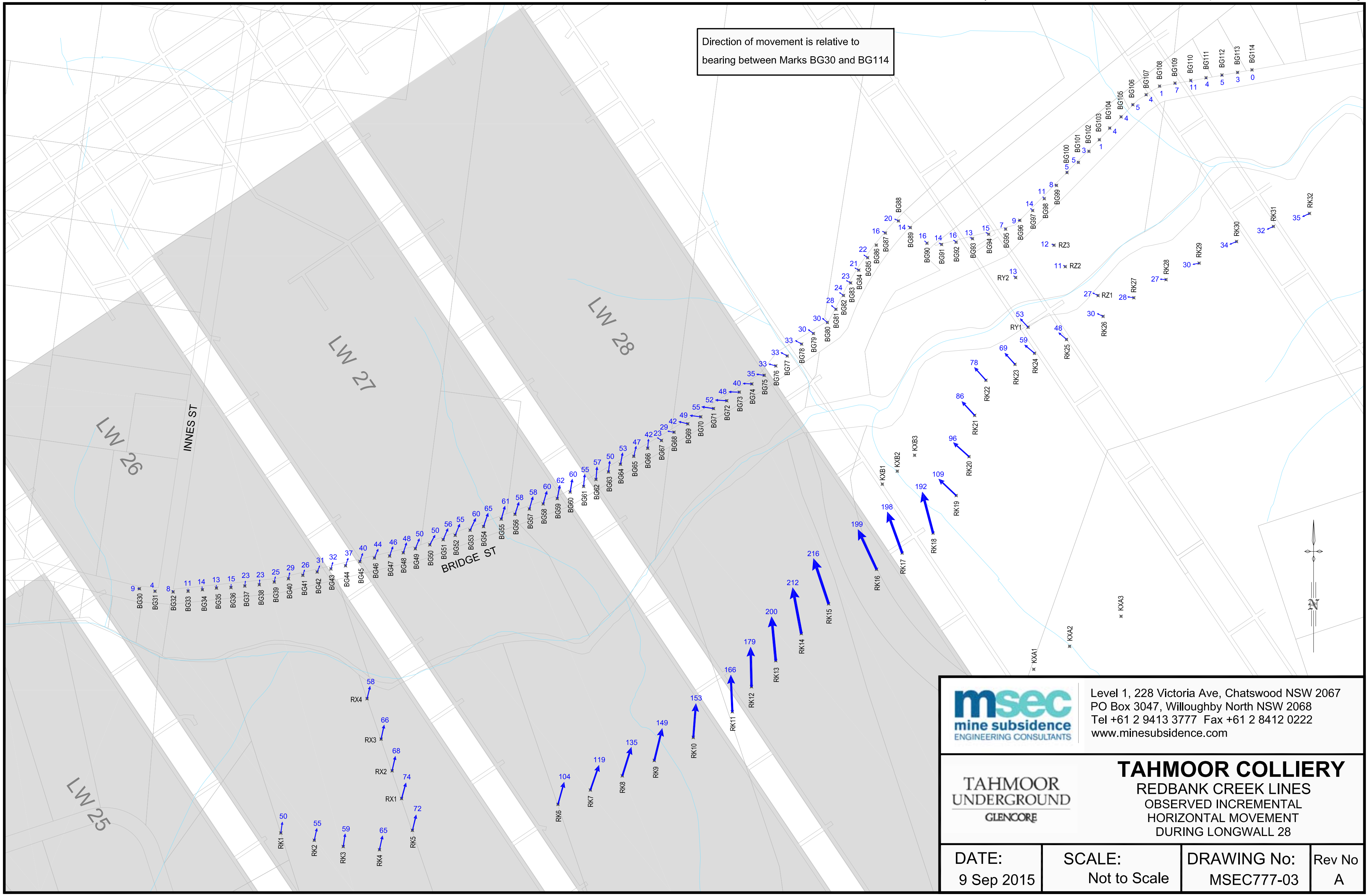

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TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

REDBANK CREEK LINES

OBSERVED INCREMENTAL HORIZONTAL MOVEMENT DURING LONGWALL 28

DATE:	SCALE:	DRAWING No:	Rev No
9 Sep 2015	Not to Scale	MSEC777-03	A

Tahmoor Colliery

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

TA24-R1A
17 September, 2015

GeoTerra Pty Ltd ABN 82 117 674 941

PO Box 220 Canterbury NSW 2193

Phone: 02 9787 2193 Fax: 02 9787 1874 Mobile 0417 003 502 Email: GeoTerra@iinet.net.au

GeoTerra

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

Attention: Belinda Treverrow

Belinda,

RE: Tahmoor Colliery Longwall End of Panel 28 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	Managing Geoscientist

Date	Rev	Comments
20/08/2015		Initial Draft
17/09/2015	A	Incorporate Review Comments

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Executive Summary

The following table summarises the potential effects on surface water and groundwater systems within the Longwall 28, 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 28
Surface Water	
Bedrock cracking and loss of plateau stream flow not anticipated in Myrtle Creek, Redbank Creek or smaller gullies over Longwalls 22 to 27 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 both creeks over LW's 25 to 28
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 both Myrtle and Redbank Creek subsidence zones, along with elevated nickel, zinc iron and manganese in Redbank Creek due to subsidence
Plateau stream bed incision may occur	No plateau stream bed incision
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 have 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	Lowering of piezometric surface due to subsidence by up to 8.9m in piezometer P2
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	Groundwater levels in P2 subsequently recovered to near its pre – subsidence levels, then has gradually fallen by approximately 5.8m since mid-2009
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 28 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 28
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 28 in Redbank Creek and a new ferruginous// elevated salinity seep has been generated over Longwall 28 in Myrtle 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;

- 7th November 2014 between Sites 13A and 17, and on 14th August 2014 at Site 20 in Myrtle Creek;
- Sites 21 / 21A on 16/12/2014 and Site 24 on 17/3/15 in Redbank Creek, and;

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 triggered at Site RC2 (aka Site 37) on 5/3/15.

1. INTRODUCTION

Tahmoor Colliery (Tahmoor Coal Pty Ltd) have extracted the Bulli Seam in Longwalls 22, 23A, 23B, 24A, 24B, 25, 26, 27 and 28 by retreat longwall mining within the Tahmoor North Lease Area since June 2004.

The previous panels and the current panel (Longwall 29) 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 Coalfields of NSW.

This report provides a compilation of physical and geochemical groundwater, stream and dam monitoring that has been conducted and observation of any subsidence related changes due to the extraction of Longwall 28 as well as since August 2004.

This report provides a summary of surface water, dam and groundwater related monitoring.

Surface water and groundwater features within the Longwall 28, 20mm subsidence zone include:

- The main channel and tributaries of Myrtle Creek, which flows ENE to the Nepean River;
- 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 stream channel or banks. Matthews Creek flows to the northeast and joins with Cedar Creek and Stonequarry Creek, then flows into Racecourse Creek and subsequently the Nepean River;
- 4 small to medium, predominantly earthen wall dams that directly overly Longwall 28, and;
- Two vibrating wire piezometer array in bores TNC28 and TNC29 that were installed by Tahmoor Colliery and six NOW licensed private bores (P3, P4, Pescud, McPhee, Boissery and Machin).

Myrtle and Redbank Creeks are Category 2 streams with 3rd order or higher channels, whilst the tributaries of Myrtle and Redbank Creeks are Category 1 streams, being 1st or 2nd order channels.

The dams range from small garden ponds to medium sized urban dams.

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, 25, 26 and 27 by 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 28 to the south, southwest and northwest of the current panel (Longwall 29).

Longwall 28 commenced on 20/04/2014 and was completed on 22/03/14 as outlined in **Table 1**, with mining of Longwall 28 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	29/05/2015	ongoing	2322	425 - 485

Extraction of Panel 28 occurred from 420 – 500m below surface, with the depth increasing to the northeast.

Seam thickness varies from 1.8m at the finish end of Panel 24B / Panel 25 to 2.2m at the start of Longwall 28.

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 28, 20mm subsidence study 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 28 study area is also overlain by the main channel and tributaries of Myrtle and Redbank Creeks, which flow both to the Nepean River, with the Bargo River being approximately 1,875m south, and the Nepean River at least 1,745m east of Longwall 28.

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 28 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 28, 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 1.7km southeast of Longwall 28. 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 28.

Myrtle Creek has been undermined by Longwalls 3, 4, 20, 22, 23B, 24B and 25 to 28.

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 28.

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.

Redbank Creek becomes sequentially deeper and wider over Longwall 27 compared to Longwall 26, and subsequently becomes wider and deeper over Longwall 28.

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.

Over Longwalls 25 to 28, the creek flows out of the Thirlmere residential area, and into the 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 floating 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 on to 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 4 dams that directly overly Longwall 28 as shown in **Drawing 1**.

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

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).

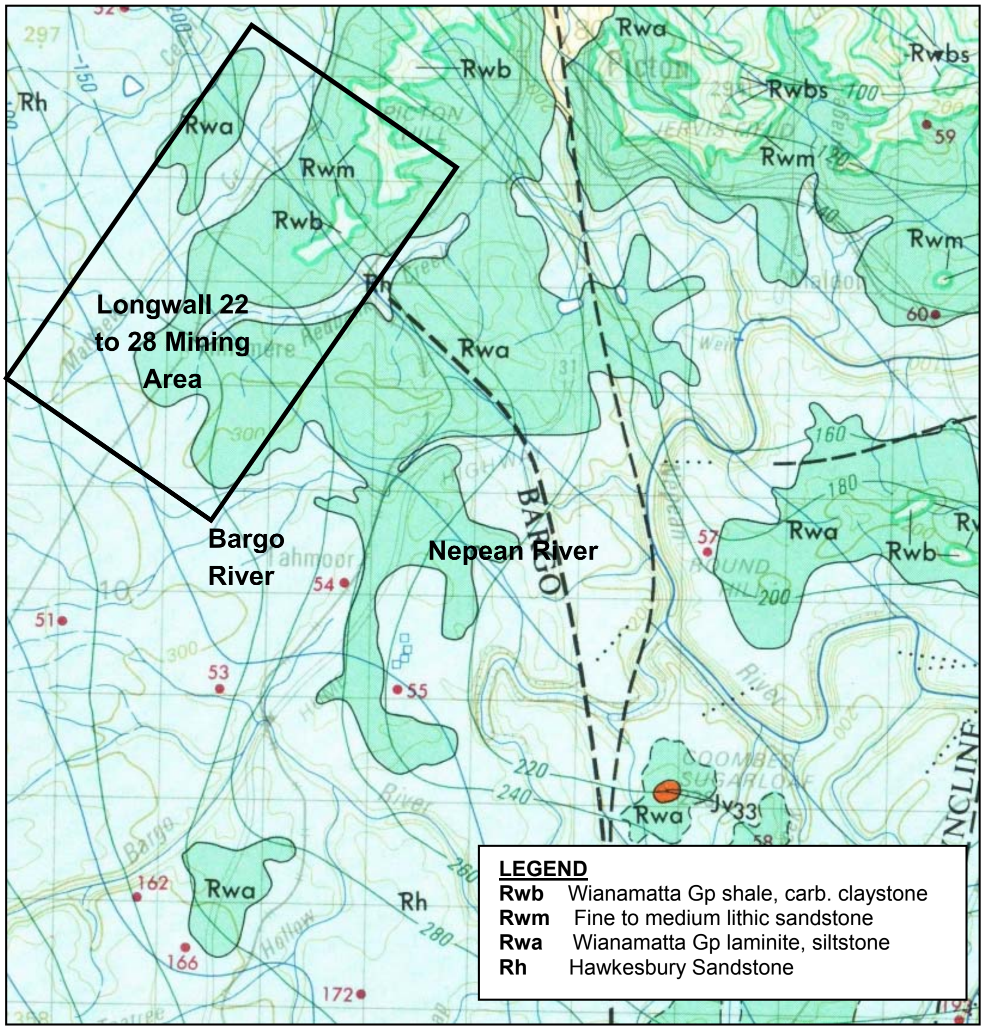

Figure 1 Surficial Geology

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 28 monitoring area as shown in **Drawing 1** and **Table 2**.

Two piezometers, P3 and P4, are in close proximity to Longwall 28.

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 620m south west of the central section of Longwall 28, whilst P4 is an open private bore located approximately 215m northwest of the finishing, northern end, of Longwall 28.

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Table 2 Bore and Piezometer Details

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
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 in close proximity to Longwall 28, with an additional three (TNC36, 40 and 43) located to the north of the proposed Longwall 32 as shown in **Drawing 1** and **Table 3**.

Due to potential monitoring equipment in TNC28 (including cables from the surface to seam) being a potential hazard in the underground workings of Longwall 29, TNC28 was decommissioned on 10 August 2015 prior to Longwall 29 mining through it.

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			

4. MONITORING RESULTS AND DISCUSSION

4.1 Subsidence

The maximum monitored subsidence, tilt and strain following the completion of extraction of Longwall 28 is shown in **Table 4**.

Table 4 Maximum Subsidence at the Completion of Longwall 28

Component	Observed Total Movement
Vertical subsidence	1082 mm
Tilt	6.3 mm/m
Tensile / Compressive Strain	4.7 / - 5.2 mm/m

4.1.1 Myrtle Creek Valley Closure

Valley closure was measured in Myrtle Creek as shown in **Table 5**.

Table 5 Maximum Myrtle Creek Valley Closure up to the Completion of Longwall 28 (mm)

Location	Due to LW24	Due to LW25	Due to LW26	Due to LW27	Due to LW28	Total
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	no access	no access	73+
MXA Line	-	-	-	115	138	253
MXB Line	-	-	-	94	144	238
MXC Line	-	-	-	67	132	199
MXD Line	-	-	-	17	98	115
KXA Line	-	-	-	-	30	30
KXB LIne	-	-	-	-	76	76

Source (MSEC, 2015)

4.1.2 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 2015), with the available survey data shown in **Table 6**.

Table 6 Maximum Redbank Creek Valley Closure up to the Completion of Longwall 28 (mm)

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

Source (MSEC, 2015)

4.2 Myrtle Creek Monitoring

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 7** and shown in **Drawings 1** to **3**.

Table 7 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

4.2.1 Pre Longwall 28

Prior to the completion of extraction of Longwall 25, subsidence effects were observed in Myrtle Creek over Panels 22, 23B and 25 as limited cracking of soil and outcropping sandstone.

Overall, no observable adverse effects on stream flow, water quality and bed or bank stability were observed in Myrtle Creek or the small unnamed gullies over the subsided longwalls up to the end of Longwall 25 monitoring period.

Prior to the 5th March there had been heavy rain in the preceding days and the creek was full and flowing, and it wasn't until the 15th of March, approximately 7 days after the longwall started undermining the creek, that the creek could be inspected critically for any "baseline" subsidence effects due to the preceding panel (Longwall 26).

Prior to the undermining by Longwall 28, Myrtle Creek was showing subsidence effects of pool cracking and significant to total pool water holding capacity reduction due to the extraction of Longwall 27 at observation 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
- To a lesser degree, at sites 20 – 24 over Longwall 28 as shown in **Drawing 2**.

The creek bed cracking and reduction in pool holding capacity that developed at Sites 5 to 9 occurred as a result of Longwall 27 subsidence, as was the case for Sites 12 to 19 over Longwall 27, and sites 20 to 24 over Longwall 28.

Reversal of flow in the creek was also not observed due to subsidence up to the completion of Longwall 27 as the creek gradient exceeds the subsidence tilt in the stream bed as summarised in **Table 8**.

Table 8 Myrtle Creek Subsidence Cracking

Location	North	East	Comments
LW22	277000	6211200	Small isolated cracking in exposed sandstone in ephemeral pool
LW23B	277300	6211285	<5cm wide cracking in soil on a first order tributary of Myrtle Ck
LW25	278155	6211203	Small isolated cracking in exposed sandstone
LW25	278101	6211198	Small isolated cracking in exposed sandstone in ephemeral pool
LW25	277845	6211320	Small isolated spalling of sandstone

4.2.2 Post Longwall 28

Weekly monitoring of Myrtle Creek at sites shown in **Table 9**, which was related to the extraction of Longwall 28, was conducted between 7th May and 5th September 2014.

Myrtle Creek was undermined by Longwall 28 between 23/5/14 and 16/6/14.

Photos of selected pools and stream reaches are shown in **Appendix A**.

Table 9 Myrtle Creek Weekly Observation Sites

Site	Description	Additional Sites
1	pool upstream of culvert	
2	pool with culvert and willow constrained pool and M3 site	M3
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
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
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

As a result of undermining by Longwall 28, Myrtle Creek was observed to have undergone subsidence effects as shown in **Drawing 3**.

Subsidence effects (or additional subsidence effects) due to Longwall 28 were observed at Sites:

- 9, 10 and 11 over the chain pillar between Longwall 26 and 27;
- 12 - 19 over all of Longwall 27, and;
- 20 – 26 over Longwall 28.

As shown in **Table 10**, 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.

Table 10 Myrtle Creek Subsidence Effects During LW28 Extraction

Sites	Relative Location in the Panel	Effect	Date Initially Observed	TARP 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 over exposed sandstone	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	Cracking and no flow over exposed sandstone	during LW27 & 13/06/14	_
23	central - maingate	Cracking and pool dry	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 extended pool	during LW27 & 01/08/14	_
26	LW28 pillar	Drying up of overgrown boulder race	during LW27 & 02/07/14	_

4.3 Redbank Creek

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 11** and shown in **Drawing 1**.

Table 11 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 27, 28 and 29 commenced on 16th December 2014 and continued until 26th May 2015 at the observation sites shown in **Tables 12** and **13**.

Redbank Creek was undermined by Longwall 28 between the 19th and 30th of January 2015.

Table 12 Redbank Creek Weekly Observation 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	
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	

Table 13 Redbank Creek Weekly Observation Sites

Site	Description	Additional Sites
RB4	series of shallow ferruginous rock pools	
RB5	Cracks in narrow ferruginous rock pool	
RB6	series of shallow ferruginous rock pools	
RR7	long sandstone race with ferruginous rock shelf pools	R7
RR8	long shallow sandstone race with ferruginous rock shelf pools	

4.3.1 Pre Longwall 28 Observations

As shown in **Drawing 4**, subsidence effects observed due to extraction of Longwall 27 (i.e. prior to extraction of Longwall 28) 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;
- 26a to 28 - pool desiccation in sandstone based pools, and
- 29 – reduced flow over sandstone rock shelf.

Over Longwall 28

- 30 to 34 – drying up of previously ferruginous pools in boulder and rock bar pools.

4.3.2 Post Longwall 28 Observations

During undermining by Longwall 28, Redbank Creek was observed to have undergone subsidence effects as summarised in **Table 15** and shown in **Drawing 5**.

In addition to the sites over Longwall 28 that had previously been affected by Longwall 27 extraction, subsidence effects (or additional subsidence effects) were observed at:

- Site 24 over the mid to maingate section of Longwall 27, and
- Sites 29 - 33 over all of Longwall 28.

Photos of selected pools and stream reaches are shown in **Appendix A**.

As shown in **Table 14**, the TARP was triggered in regard to *"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"* at;

- Sites 21 / 21A on 16/12/2014
- Site 24 on 17/3/15

In addition, 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 triggered at Site RC2 (aka Site 37) on 5/3/15

Table 14 Redbank Creek Subsidence Effects During LW27 Extraction

Sites	Relative Location	Effect	Date Initially Observed	TARP Triggered
Over Longwall 27				
21 / 21a	tailgate	new cracking, rock bar constrained pool very low	21/11/13	16/12/14
22	tailgate	creek bed dry, tree fallen over	16/01/14	_
22a / 23	tailgate / centre	new cracking, plus expansion of old cracks, rock bar constrained pool very low	21/11/13	_
24	centre / maingate	ferruginous pool level reduced, no obvious cracks	17/12/13	17/3/15
25	centre / maingate	ferruginous pool level reduced, no obvious cracks	03/12/13	_
25a	maingate	continued lack of overland flow due to old cracks	during LW26	_
26	chain pillar	old cracks widening, pool very low	17/12/13	_
26a	chain pillar	pool dried up, no obvious cracking	03/12/13	_
27	chain pillar	pool dried up, minor cracking	17/12/13	_
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	n/a	_
RB3	centre	shallow boulder race and large ferruginous rock pool without cracking or pool level reduction	n/a	_
RB4	centre	series of shallow ferruginous rock pools without cracking or pool level reduction	n/a	_
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	n/a	_
RR7	maingate – chain pillar	long sandstone race with ferruginous rock shelf pools without cracks		_
RR8	LW30 tailgate	long shallow sandstone race with ferruginous rock shelf pools without cracks		_

4.4 Pool Depth and Creek Flow Monitoring

4.4.1 Myrtle Creek

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 stream water level monitoring in March 2010, at an expanded (and different) suite of locations, with the original monitoring sites (MYC1-3) being decommissioned at that time.

HCS are endeavouring to convert stream heights to flows when sufficient manual flow data is collected, however insufficient readings are currently available for the conversion, and the flows in the creek are very "flashy" at the Myrtle Creek sites.

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, M5 and M6 show evidence of subsidence related pool holding capacity effects, whilst M7 shows no subsidence effects on its pool holding capacity as shown in **Figure 2**.

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.

A new seep has been generated at Site 21A, which maintains flow in Site 22, however the water that flows into a large pool at Site 23 is generally insufficient to maintain above low levels and the pool often dries out. Seepage flow is generally observed in a downstream pool at Site 24, with pool levels often maintained although are now more responsive from Sites 25 to 31 as shown in **Drawing 3**.

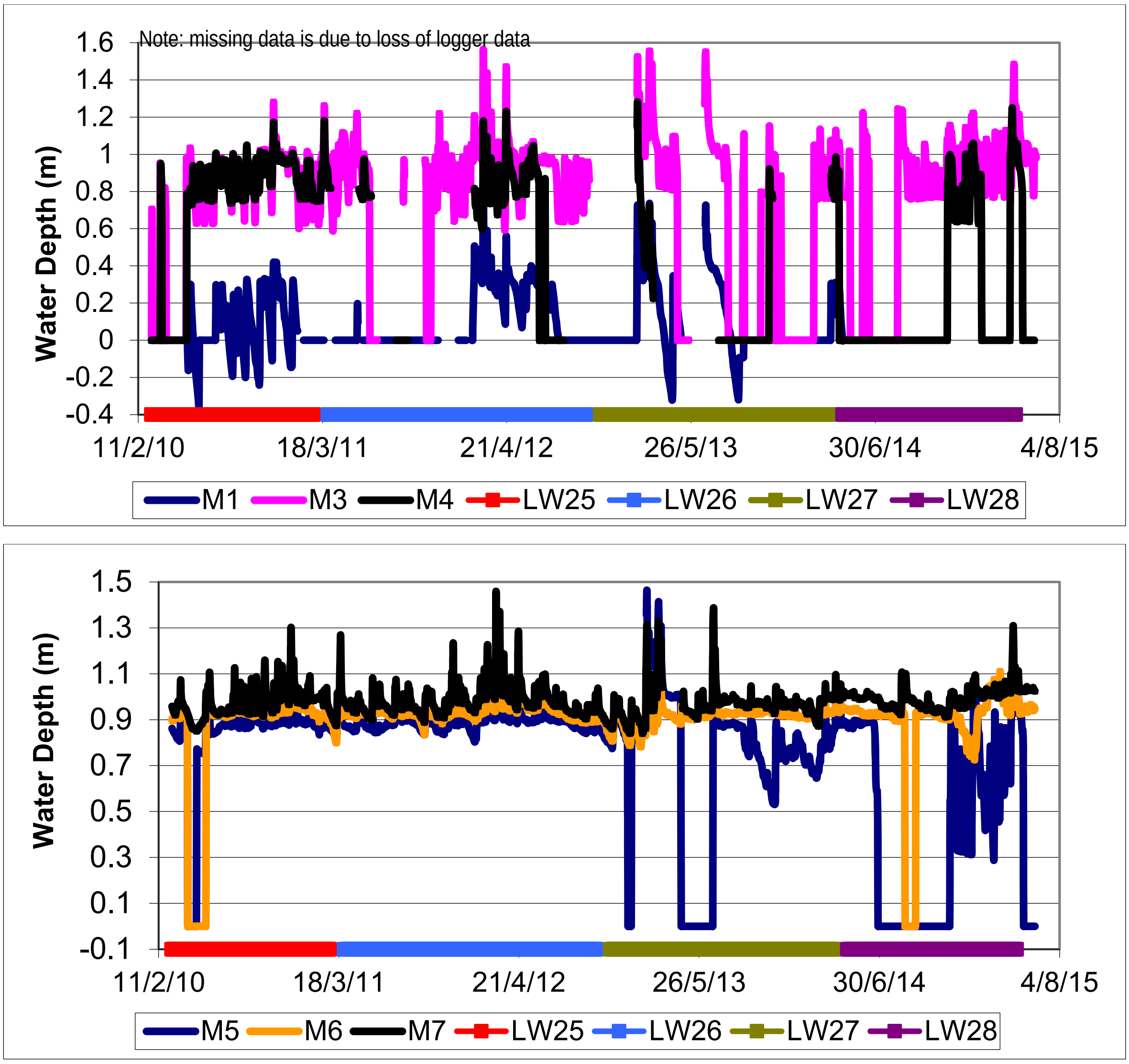


Figure 2 Myrtle Creek Stream Pool Depth

4.4.2 Redbank Creek

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.

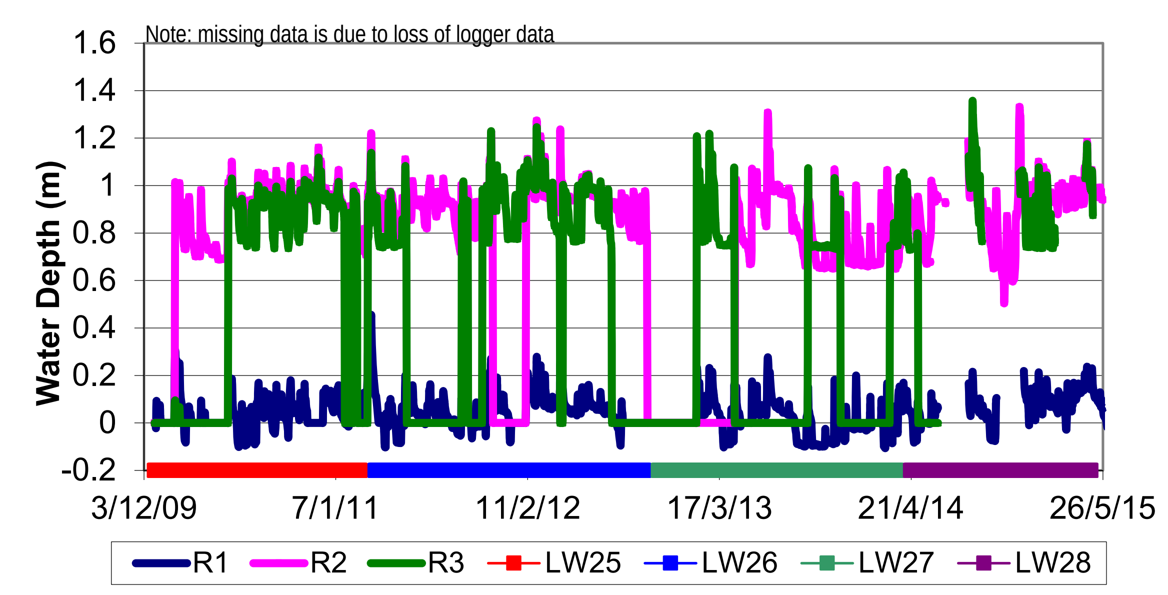
Pool R3 is located at the northern western end of Longwall 25 and upstream of Longwall 26 and R4 is located over Longwall 27 as shown in **Drawing 1**.

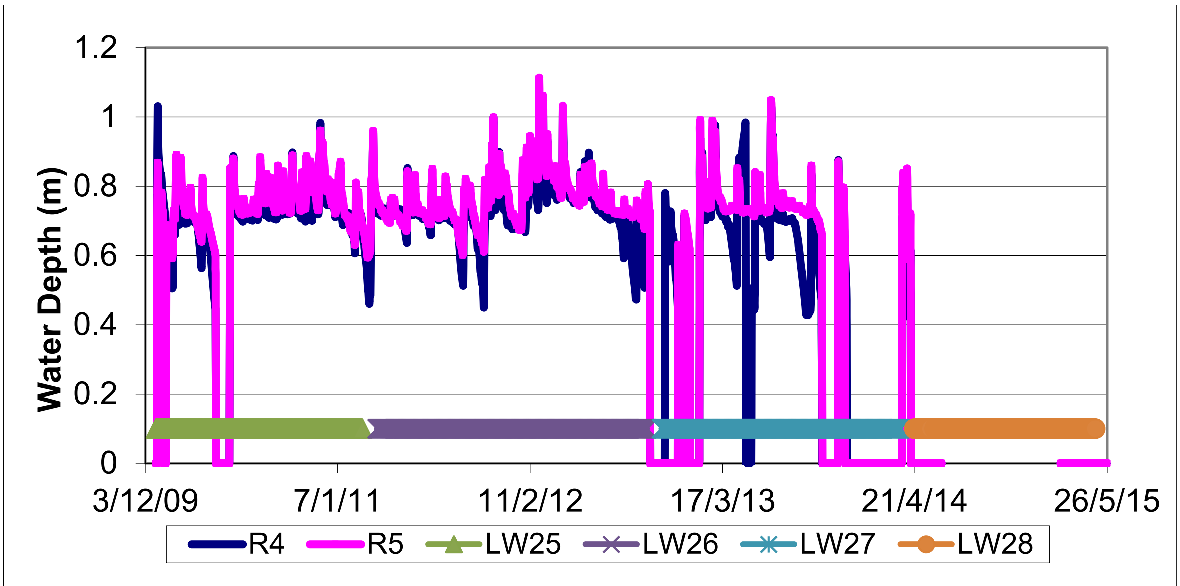
Pool R5 is located downstream of Longwall 27, whilst R6 is situated over the middle of Longwall 29 and contains the permanently ferruginous pool RC2.

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 and R6, which overlie Longwalls 25 to 29, show evidence of subsidence related pool holding capacity effects, whilst R7 to 11 do not, as shown in **Figure 3**.

Observation of weekly monitoring sites 19 to 37 (over Longwalls 27 to 29) were monitored during extraction of Longwall 28, as well as Sites Rock Race 2 (RR2), rock bar pools RB3 – 6, RR7 as well as RR8, which extend to the tailgate section of Longwall 30, indicate that stream flow and pool depths have been significantly affected by subsidence associated with Longwalls 26 to 28 between Sites 19 – 34, which overlie Longwalls 27 and 28 as shown in **Drawing 5**.





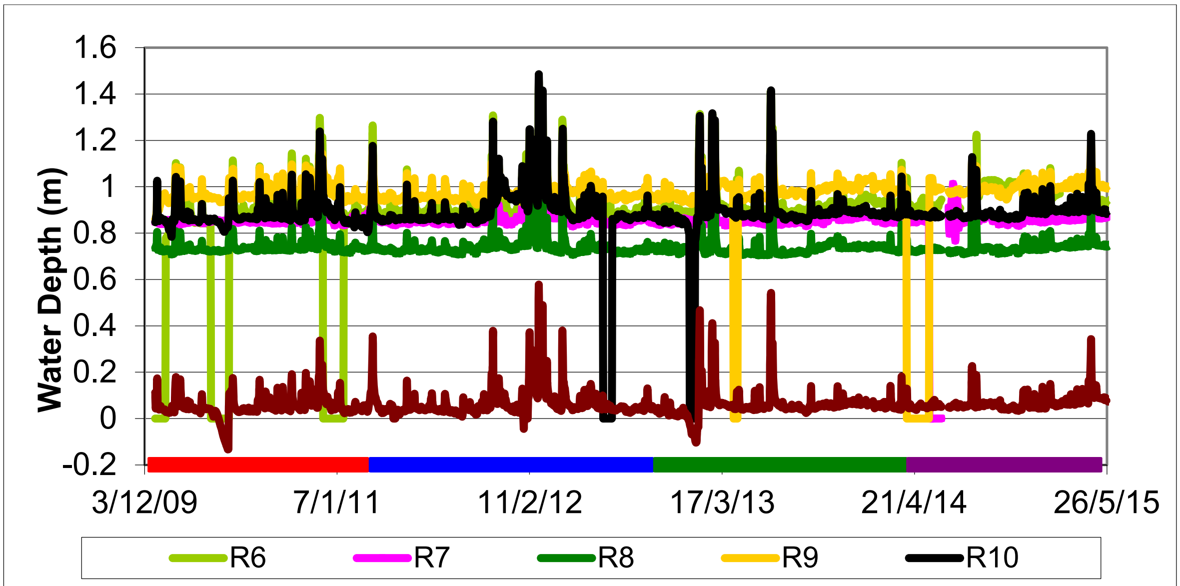


Figure 3 Redbank Creek Stream Pool Depth

4.5 Creek Water Quality

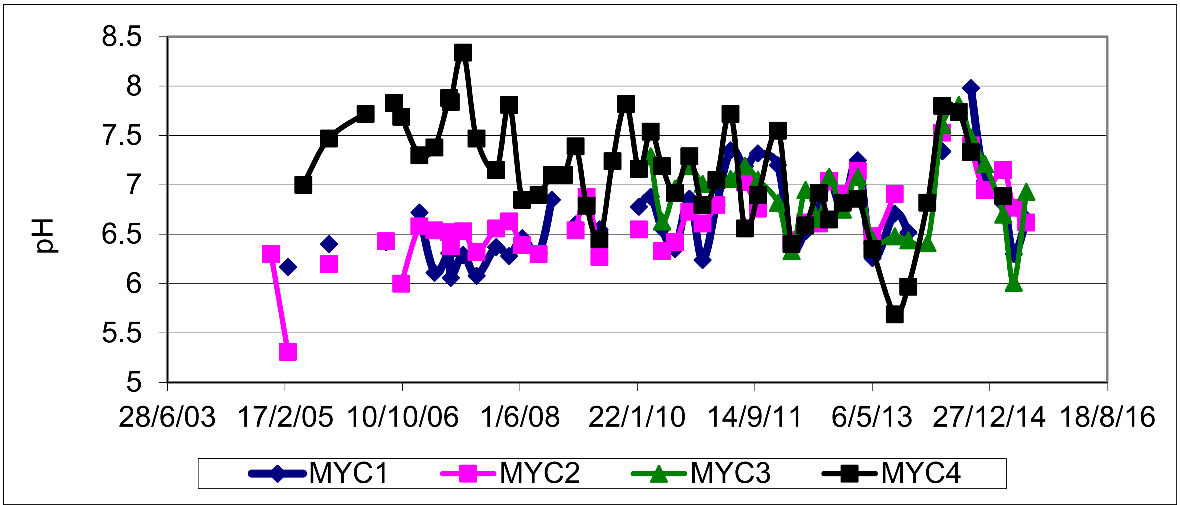
4.5.1 Myrtle Creek

Myrtle Creek has been generally dry at MYC1 during the extraction period of Longwall 28, however MYC2, MYC3 and MYC4 are generally ponded.

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

The creek becomes mildly more alkaline and slightly more saline with flow downstream as shown in **Figure 4** and **Appendix B**.

During the Longwall 28 mining period, the Myrtle Creek pH trended to being slightly more alkaline then became more acidic at all four monitoring sites, whilst salinity peaked at around 2070uS/cm at MYC3 (approximately 285m downstream of Longwall 28) and at MYC4.



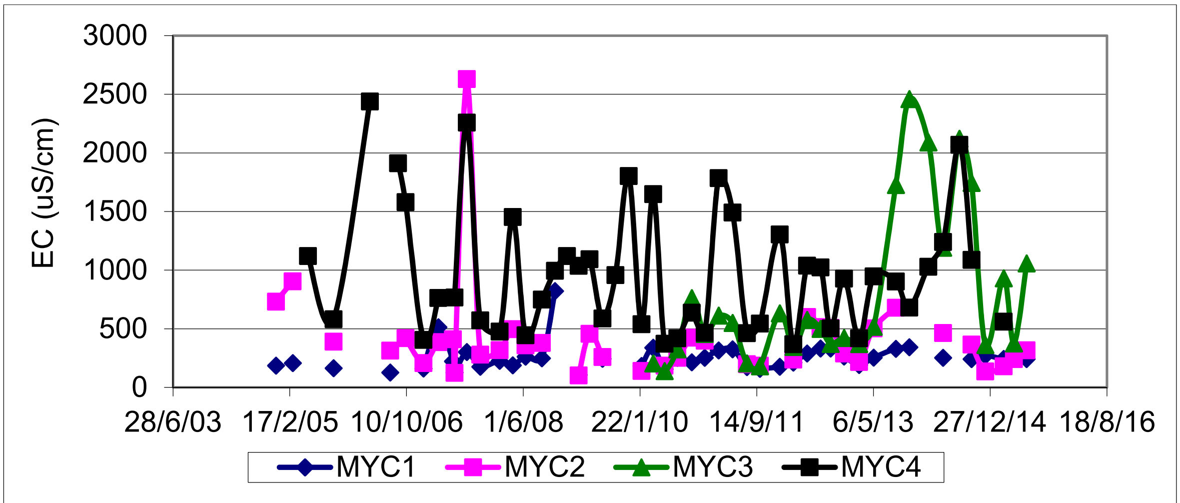


Figure 4 Myrtle Creek Field Water Quality

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 5**.

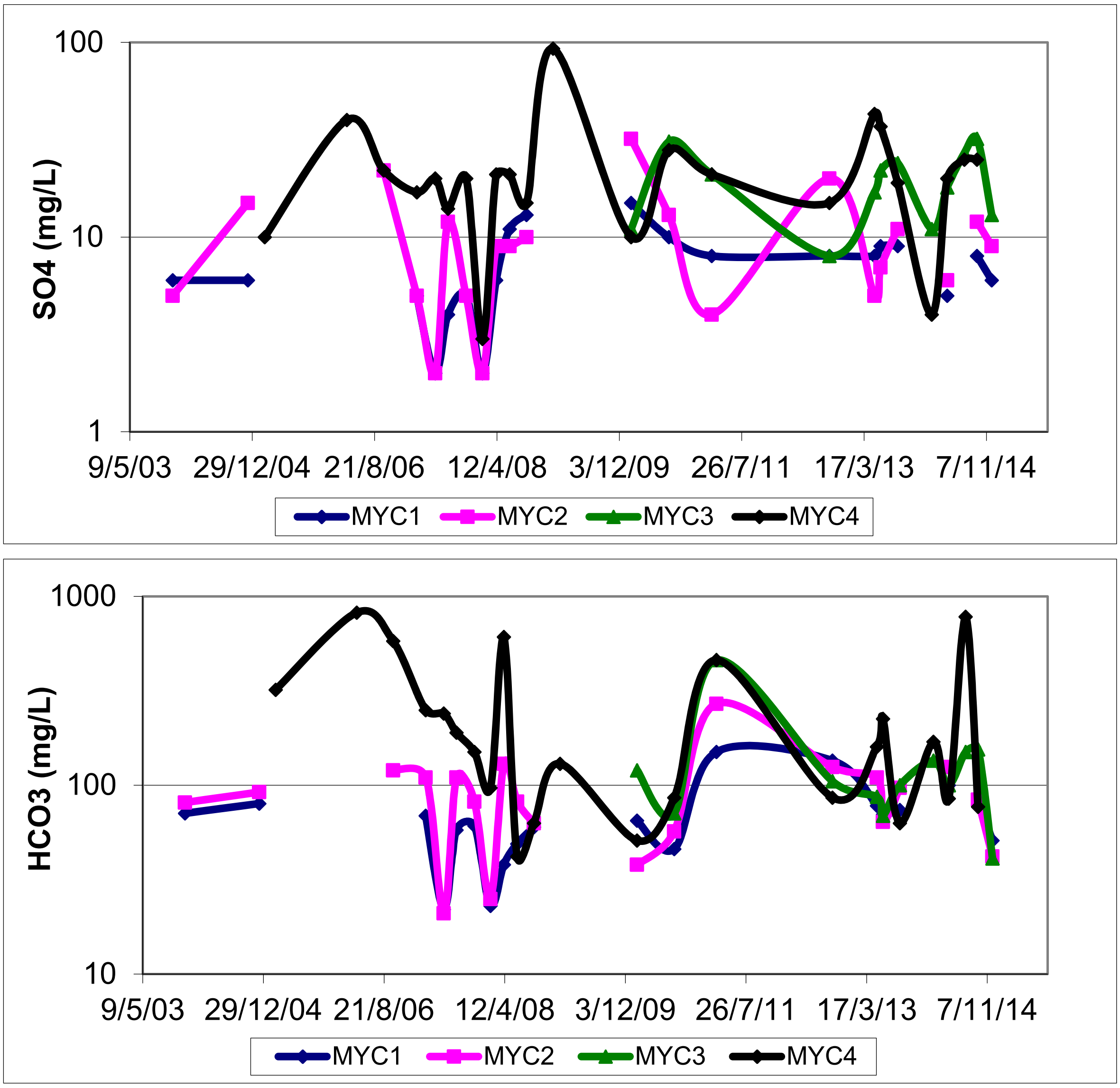


Figure 5 Myrtle Creek Sulfate and Bicarbonate

Iron and manganese levels are generally not elevated in Myrtle Creek, apart from isolated occasions at MYC1 and MYC2 during extraction of Longwall 27, with no long term trend or increase over subsided areas as shown in **Figure 6**.

A new ferruginous seep was generated downstream of a small (<1.5m high) waterfall at Site 21A during extraction of Longwall 28.

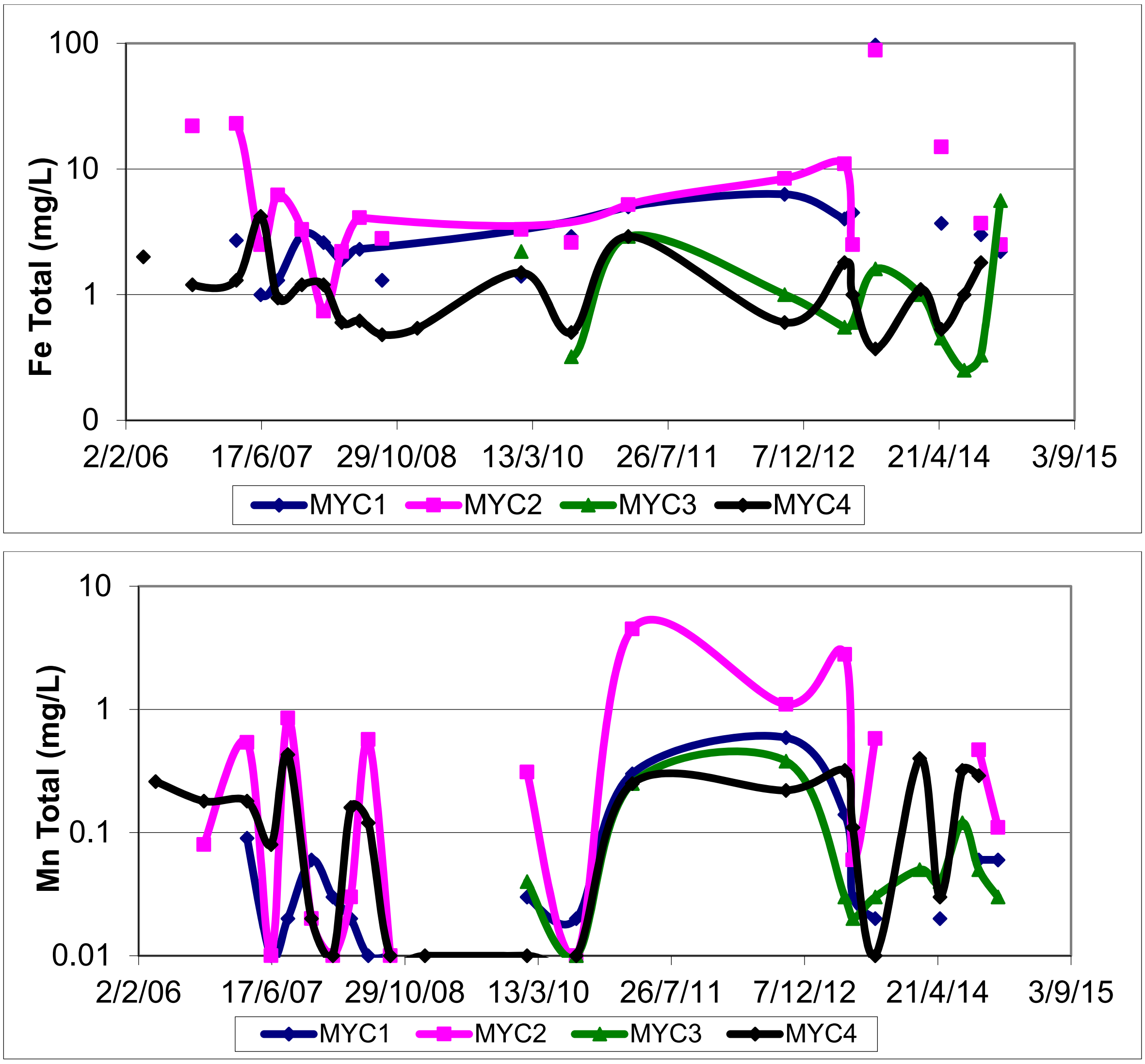


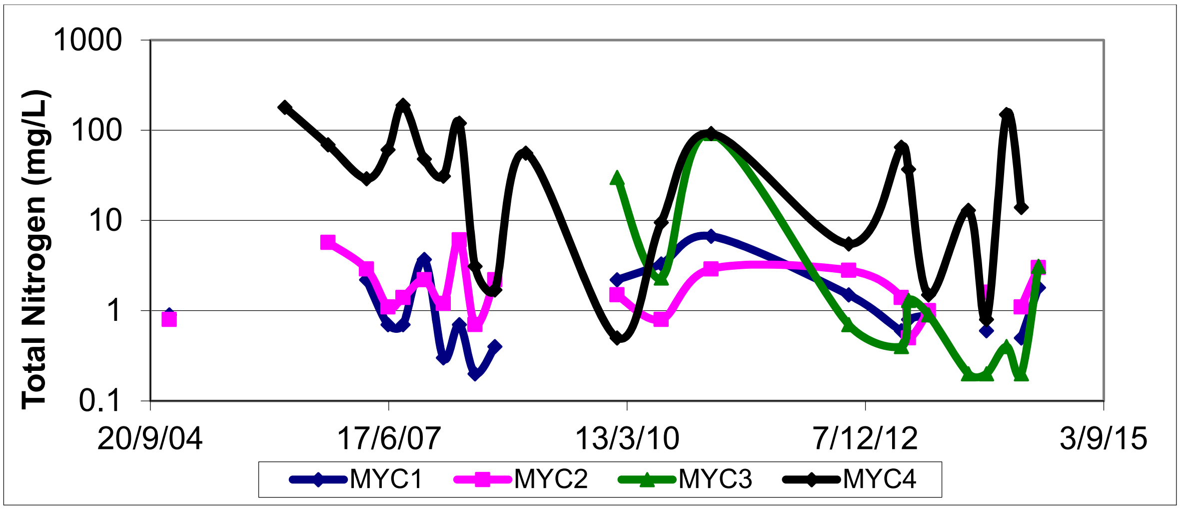
Figure 6 Myrtle Creek Iron and Manganese

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 7** and **Appendix B.**

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 3 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.



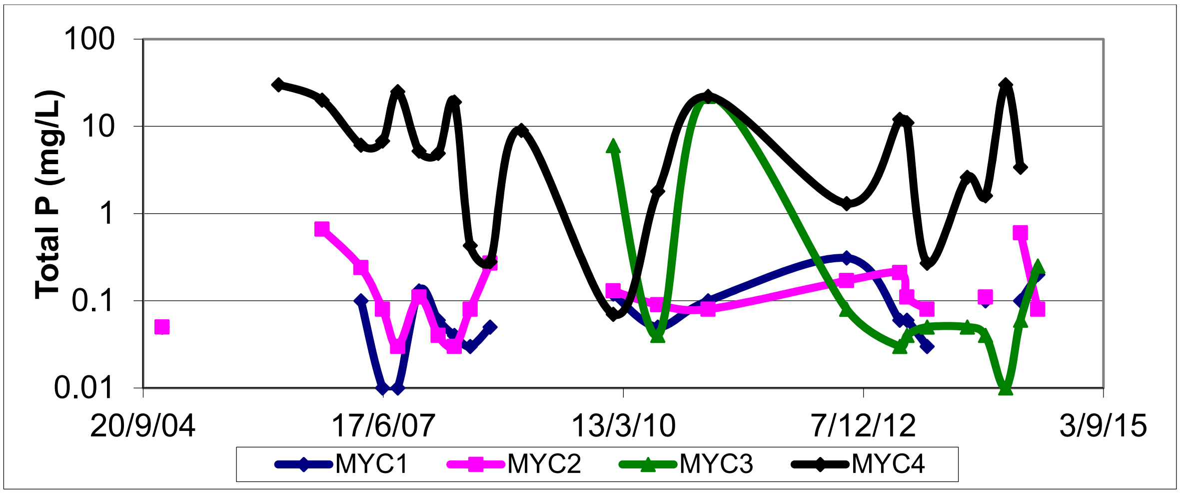


Figure 7 Myrtle Creek Nutrients

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 water quality 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 8** and **Appendix B**.

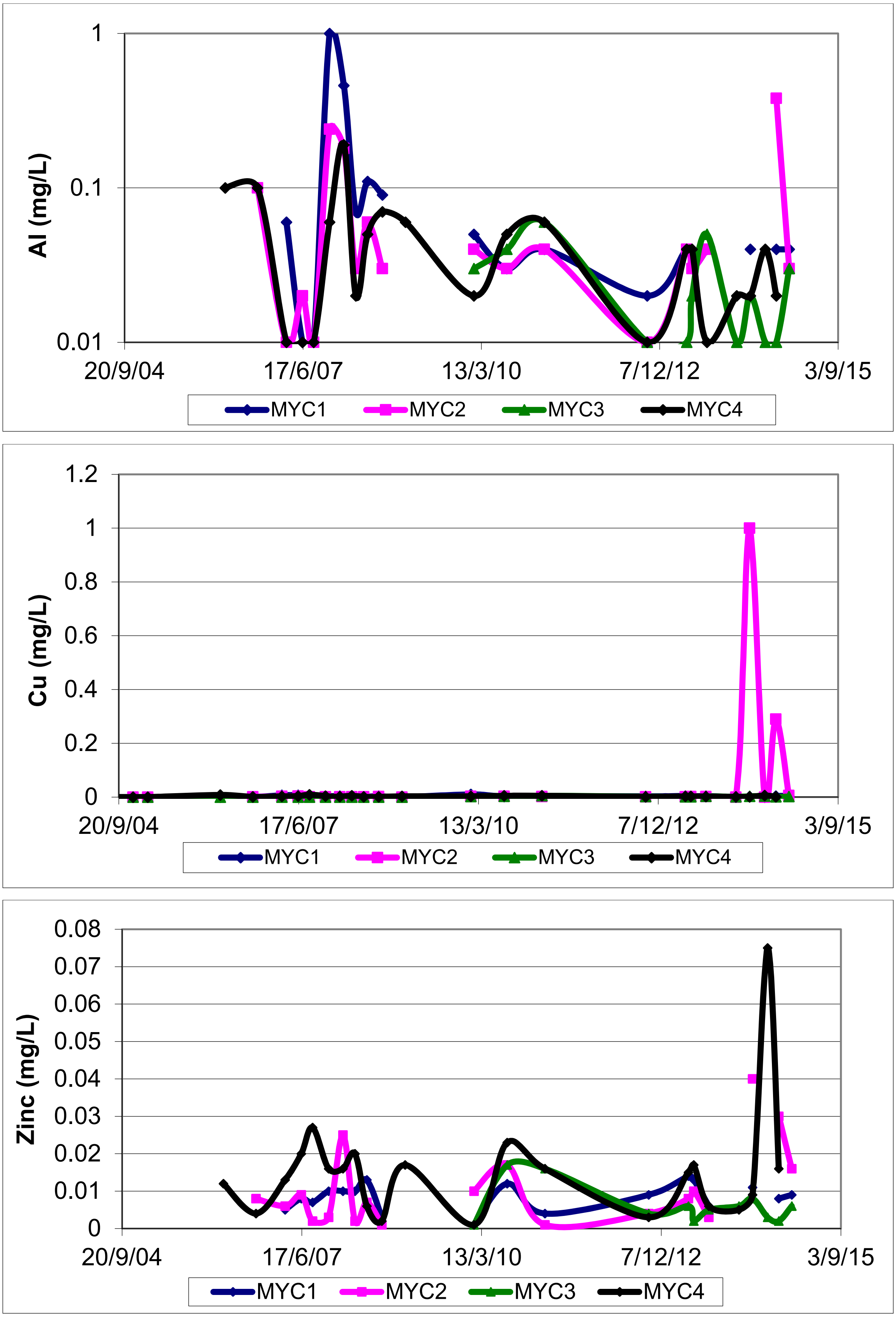


Figure 8 Myrtle Creek Metals

4.5.2 Redbank Creek

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 12** and **Appendix B**.

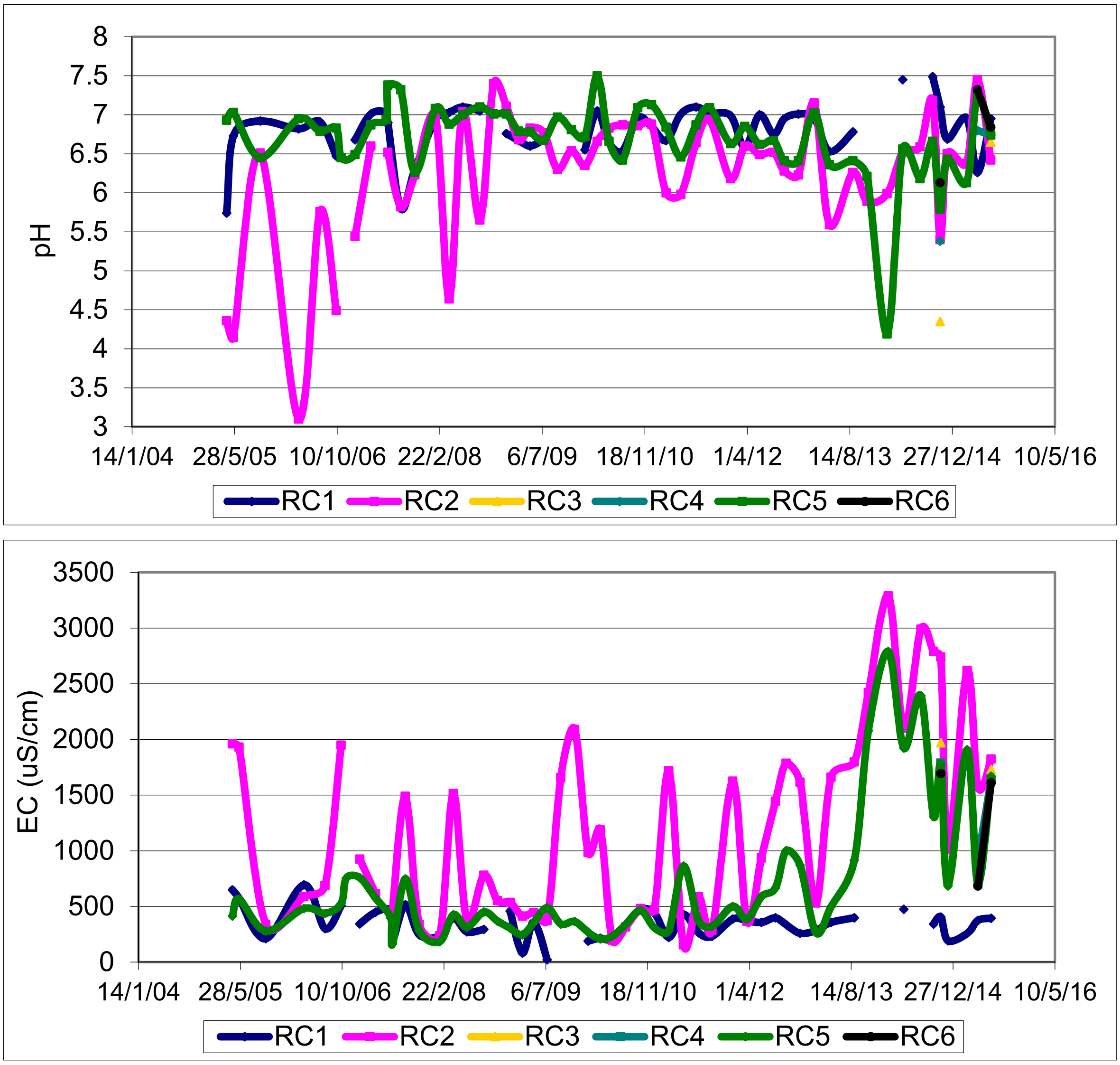


Figure 9 Redbank Creek Field Water Quality

During the Longwall 28 extraction period, Redbank Creek pH maintained its variability between 5.5 and 7.5, whilst salinity showed a freshening, although variable, trend at RC2 and RC5.

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 10** and **Appendix B**.

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 and RR8.

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.

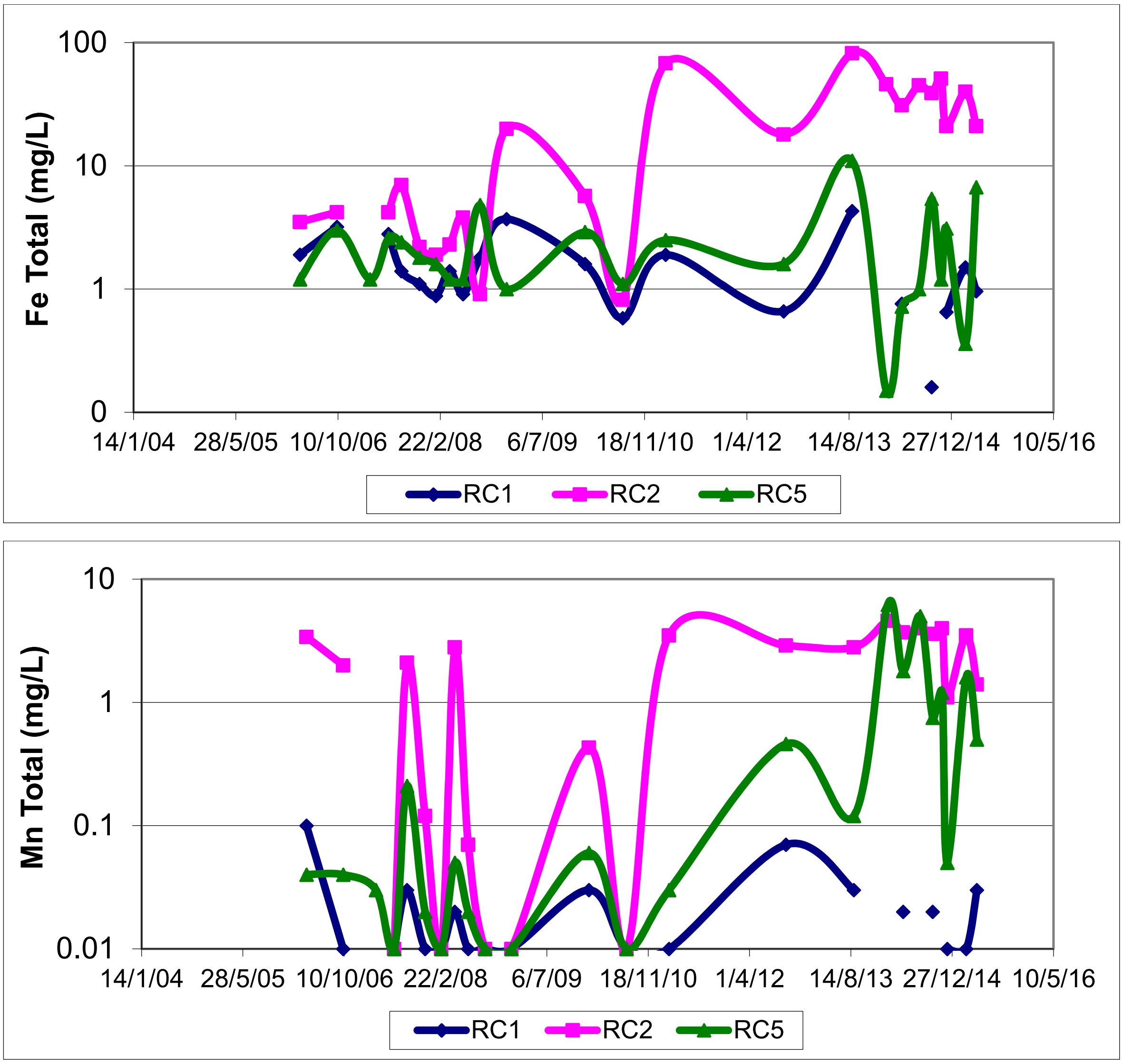
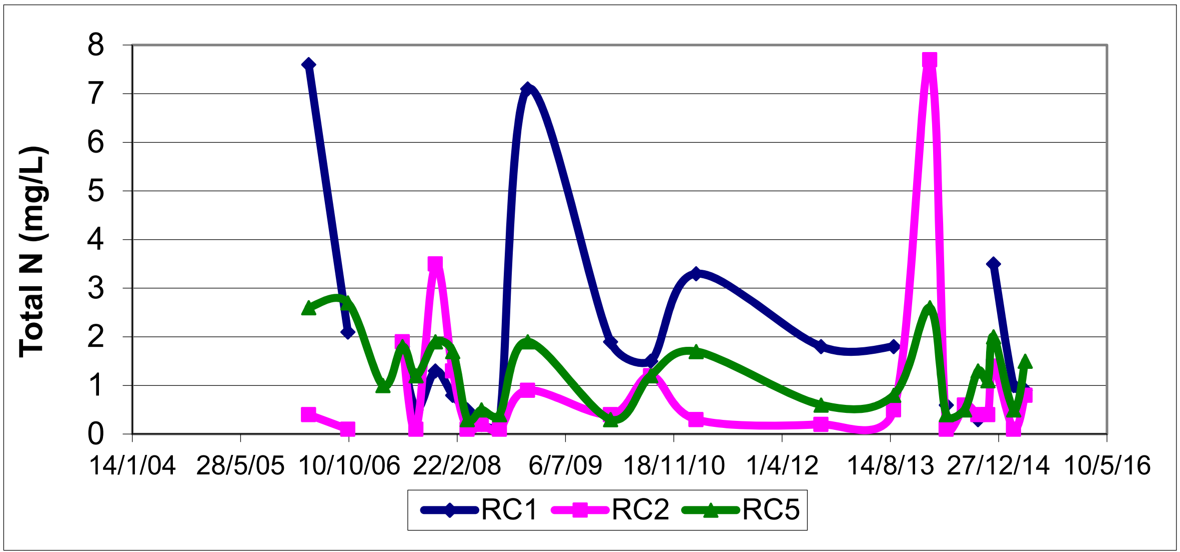


Figure 10 Redbank Creek Iron and Manganese

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 11** and **Appendix B.**

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.



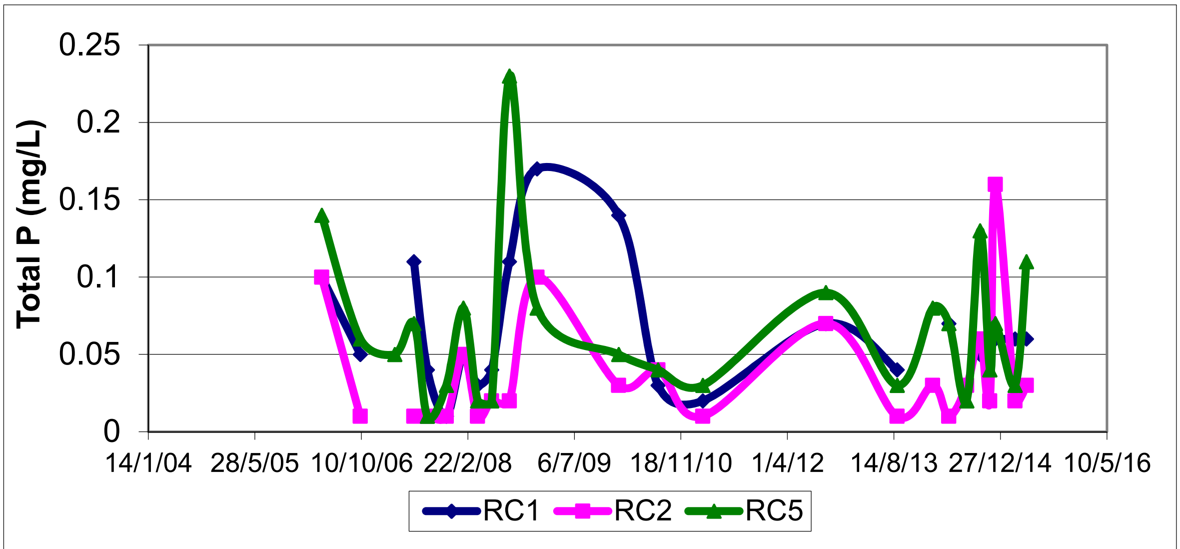
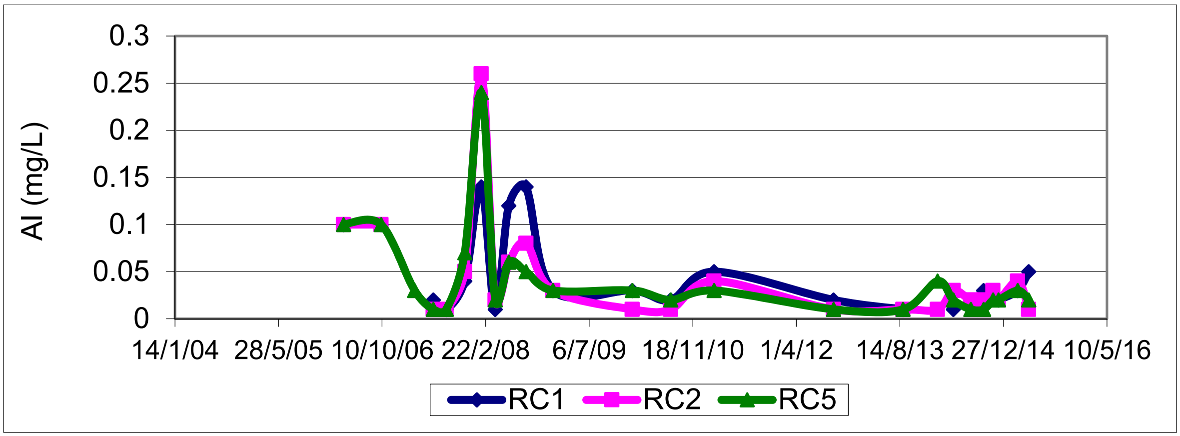
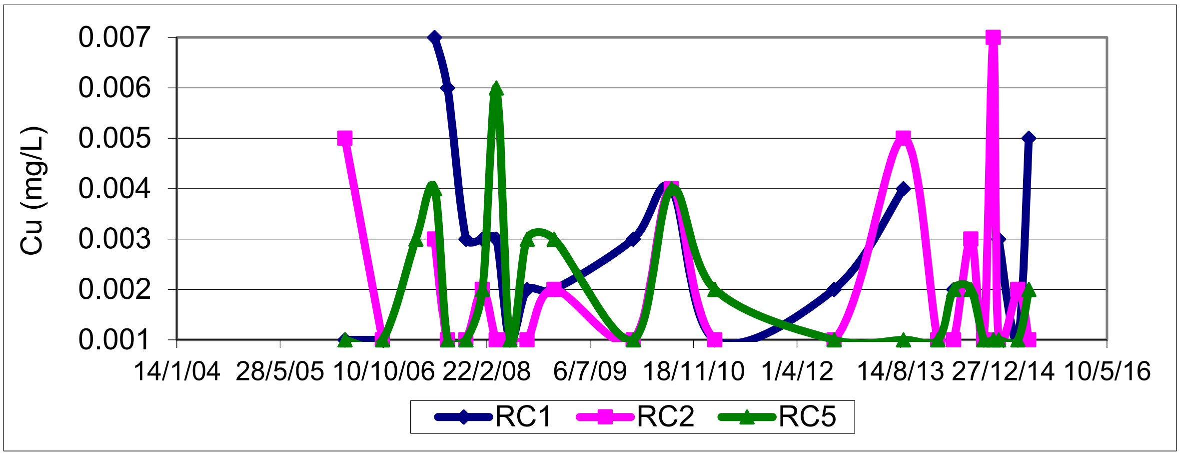


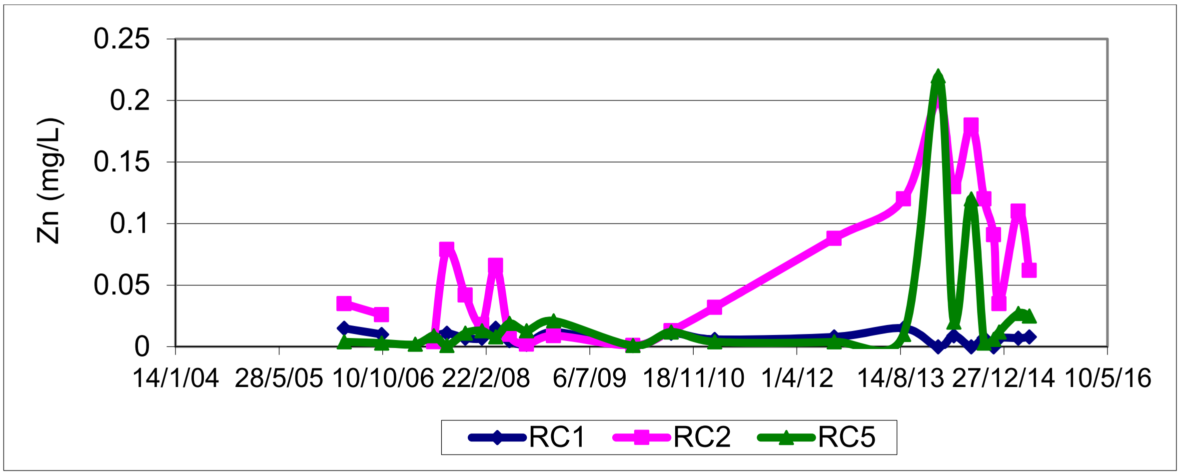
Figure 11 Redbank Creek Nutrients

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 definitive sustained increase downstream of Longwall 28 is observed as shown in **Figure 12** and **Appendix B**.







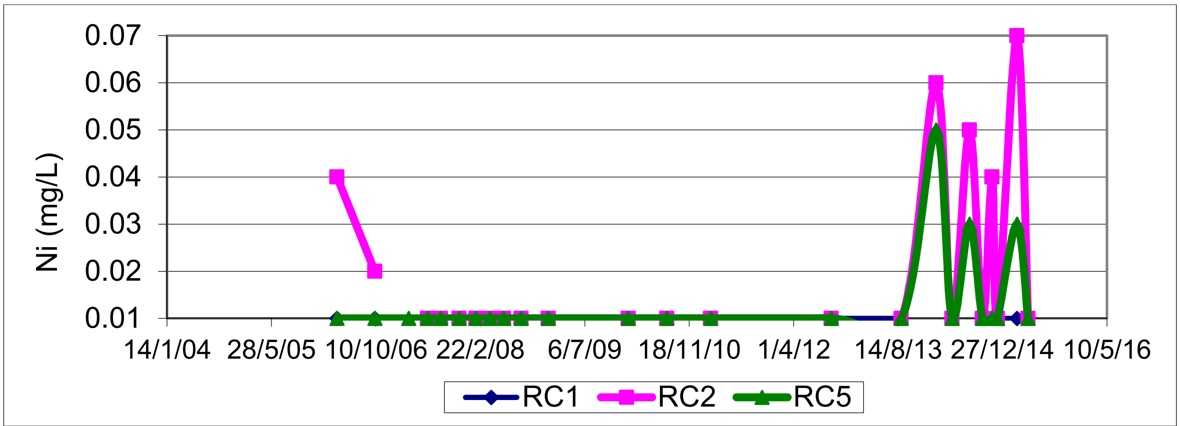


Figure 12 Redbank Creek Metals

Zinc can reach up to 0.22mg/L as shown in **Figure 12** and **Appendix B**, 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.

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 and 28.

4.6 Dams

Four dams directly overlie Longwall 28 as shown in **Drawing 2** and **Table 15**. All of the dams are located within rural residential properties.

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

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 28.

Table 15 Dams Over Longwall 27 and Adjacent Chain Pillars

Dam	Construction	Subsidence Effects
W37c	Small earth bank on slopes	None reported
W37a	Small earth bank on slopes	None reported
W55c	Small earth bank on slopes	None reported
V02/2f	Small earth bank on slopes	None reported

4.7 Groundwater

4.7.1 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 are fully sealed with pump equipment and their water levels are not monitored.

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

All piezometers and bores are located as shown in **Drawing 1** and their water levels are shown in **Figure 13**.

No open standpipe piezometer water level reduction in response to Longwall 28 has been observed, and no complaints of adverse effects on private bore water levels or yield have been received by the Colliery.

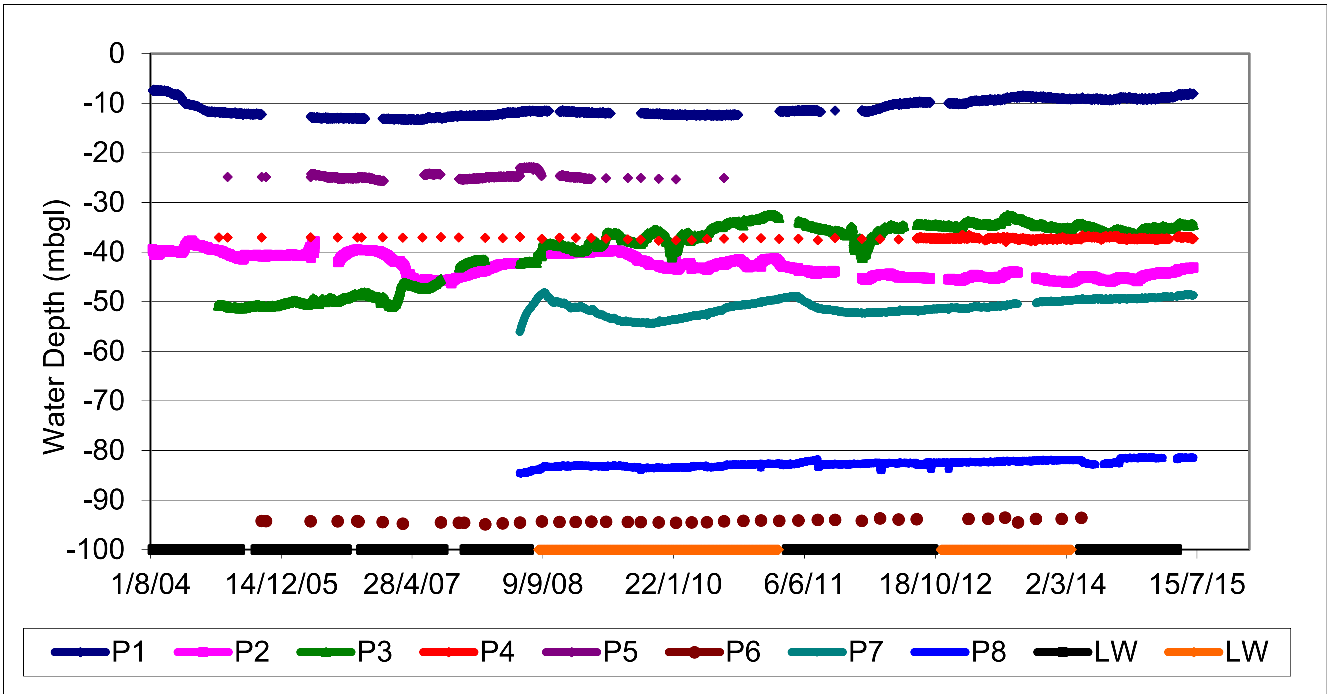


Figure 13 **Standing Water Levels and Panel Extraction**

4.7.2 Vibrating Wire Piezometers

Monitoring data from the vibrating wire piezometers (VWP) TNC28 and 29 are shown in **Figure 14**, whilst TNC36, 40 and 43 are shown in **Figure 15**.

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.

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 28, whilst TNC40 is located approximately 1600m north east and TNC43 is approximately 1350m north east of Longwall 28.

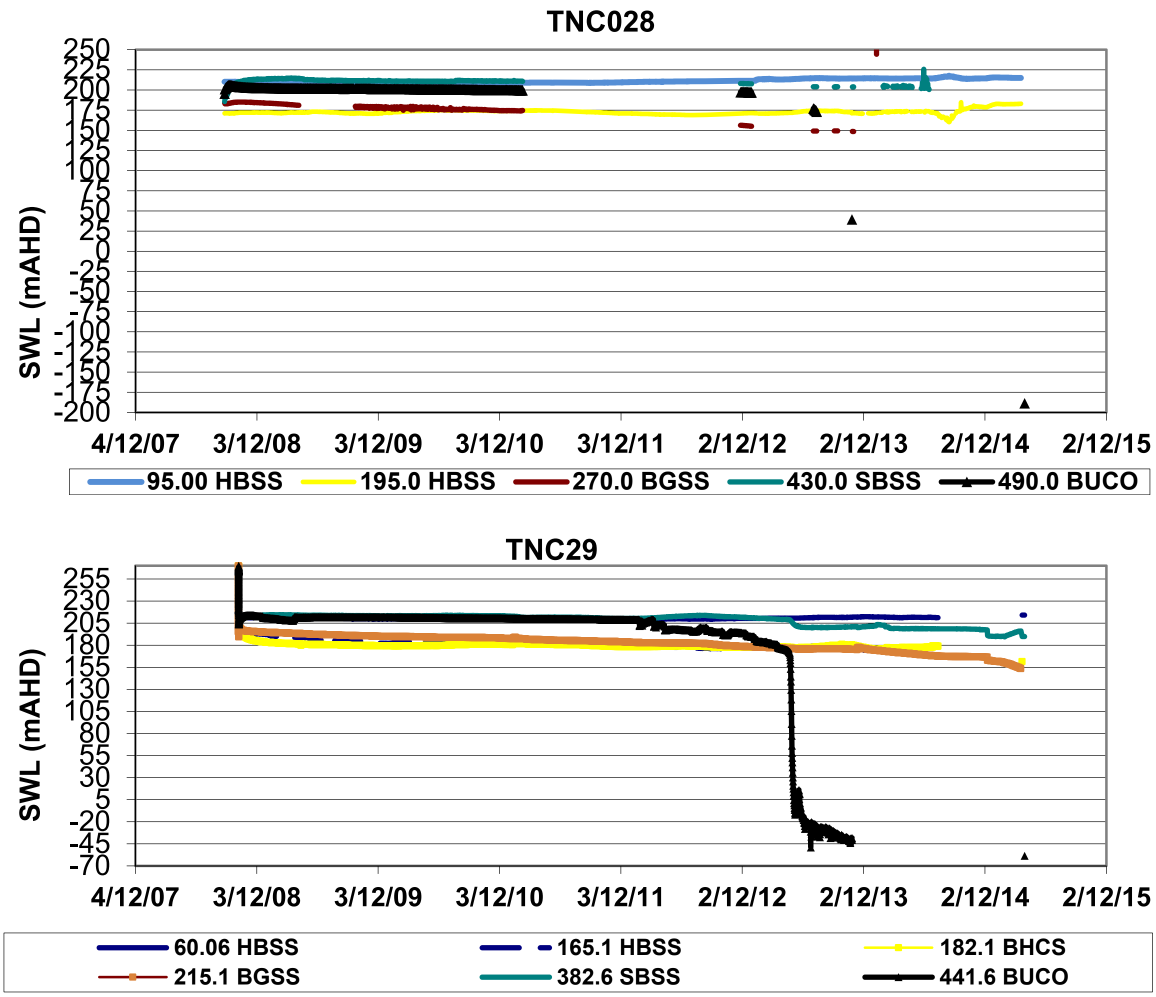
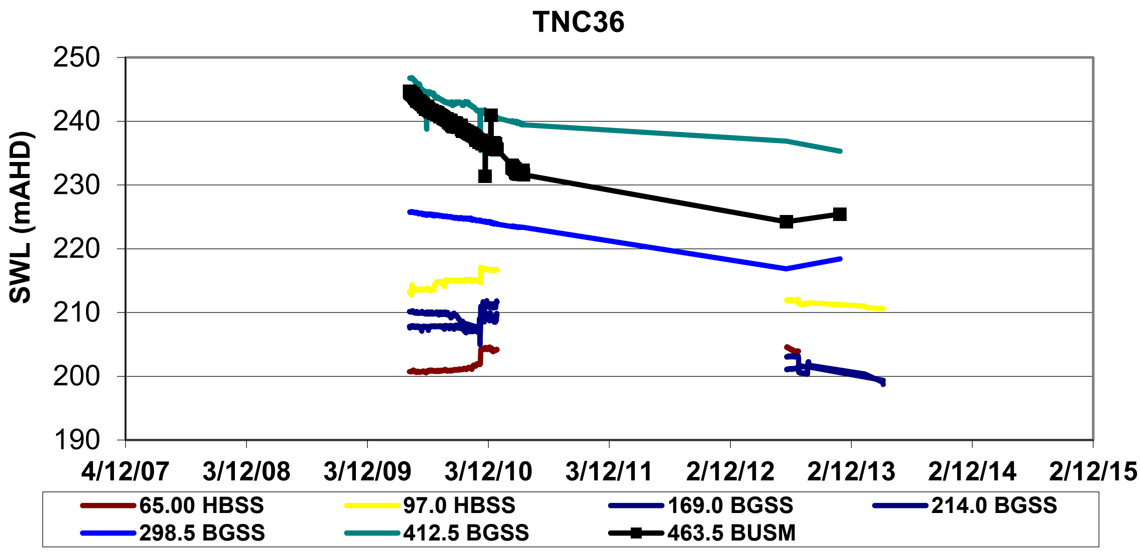
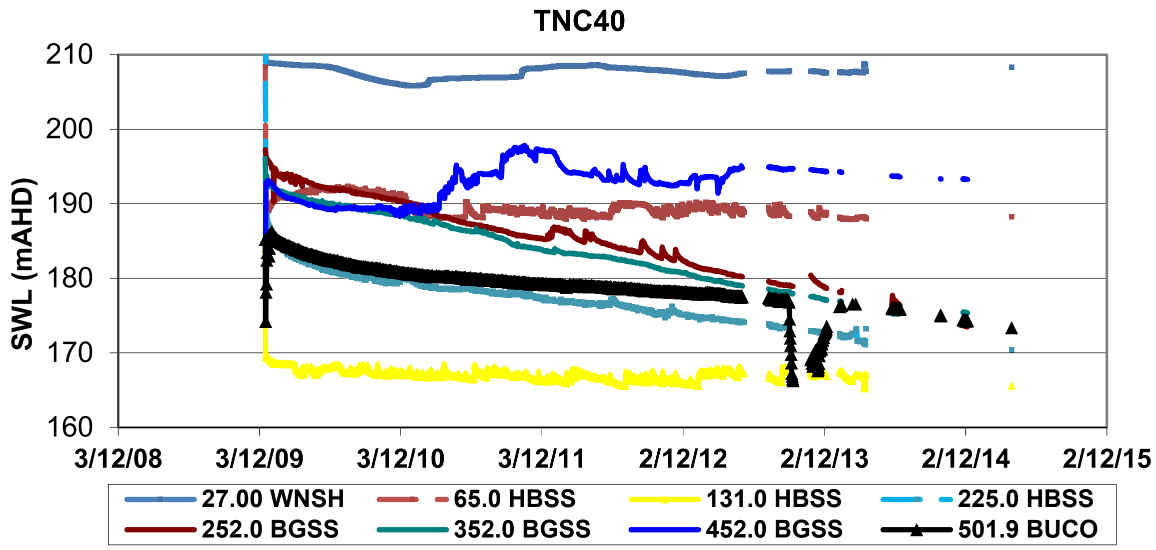


Figure 14 Vibrating Wire Piezometer TNC28 and 29 Groundwater Levels





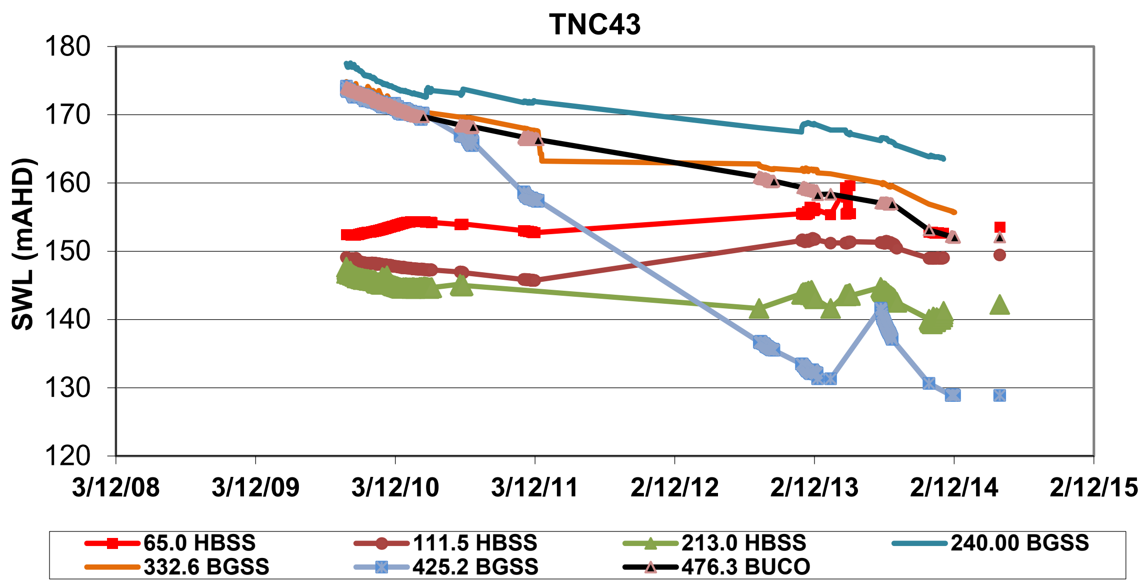


Figure 15 Vibrating Wire Piezometer TNC36, 40 and 43 Groundwater Levels

4.7.3 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 16**.

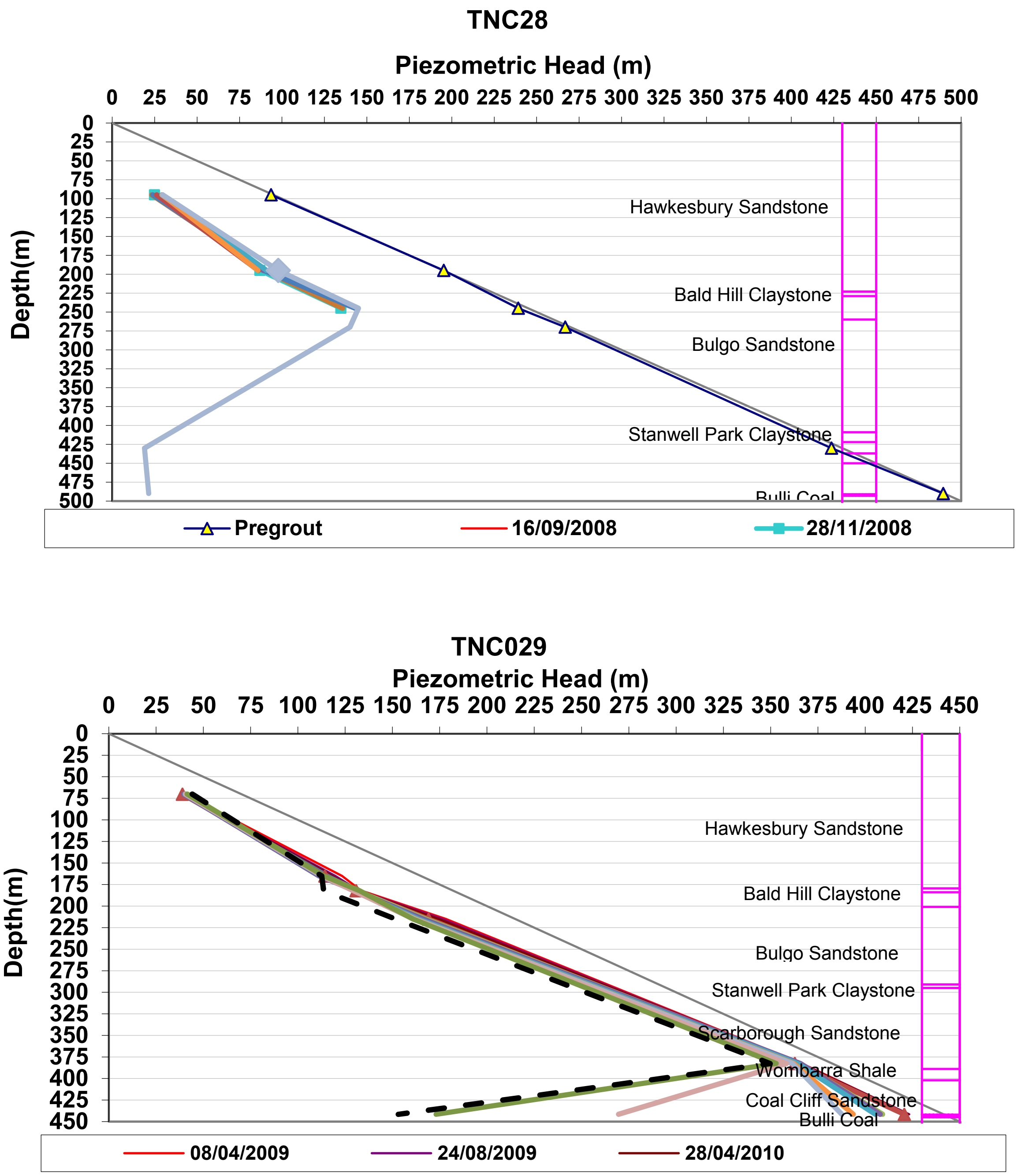


Figure 16 Vibrating Wire Piezometer Head vs Depth

4.7.4 Groundwater Seepage To or From Streams

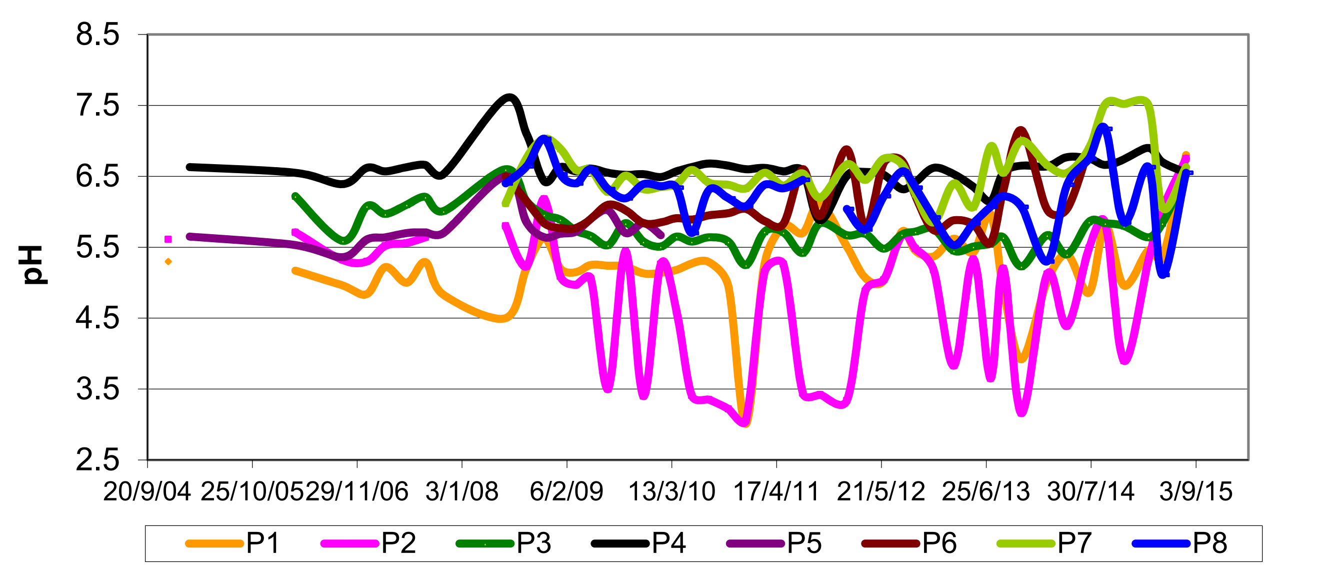
To date, no loss of stream flow from Myrtle Creek or Redbank Creek into the Tahmoor workings has occurred.

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.

4.7.5 Groundwater Quality

Groundwater in the study area has generally brackish salinity (564µS/cm to 14,940µS/cm) with acid to circum-neutral pH (3.53 to 7.36) as shown in **Figure 17** and **Appendix C**.



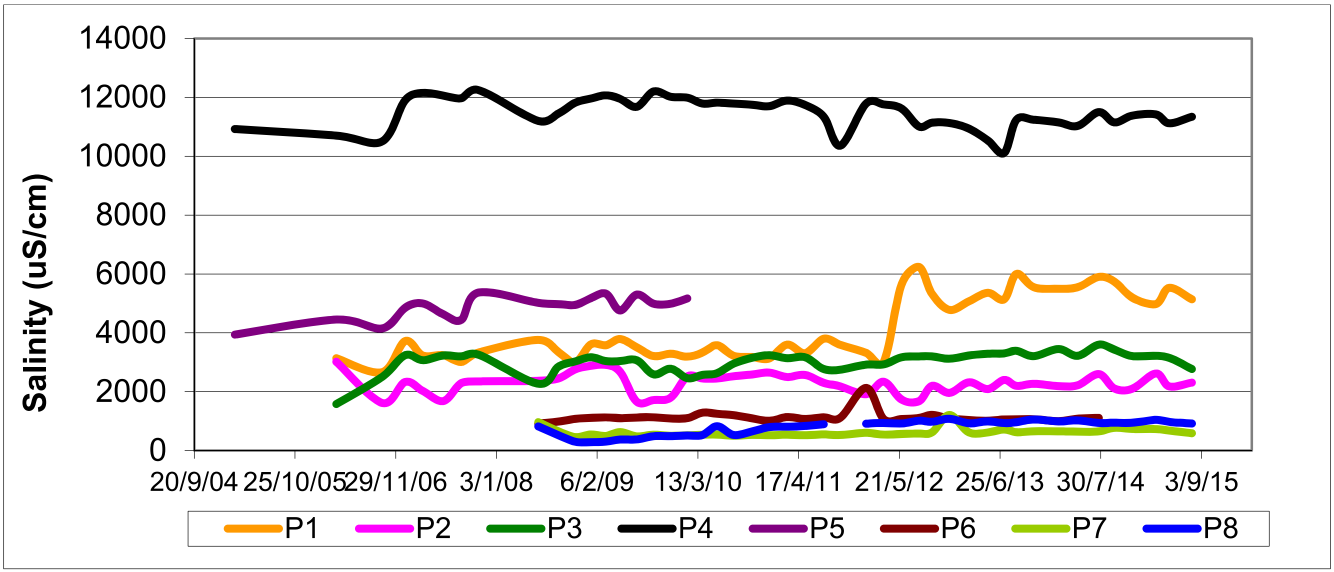


Figure 17 Field Groundwater Quality

Laboratory analyses as shown in **Appendix C** 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 28 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.

5. CONCLUSION

Based on monitoring of streams, dams and groundwater conducted prior to, during and after extraction of Longwall 28, the following conclusions can be made:

- Significant stream bed cracking, associated with a reduction in stream flow and pool desiccation has been observed in both Redbank Creek and Myrtle Creek due to extraction of Longwall 28 (and preceding panels);
- Re-emergence of the stream "through-flow" has been observed downstream of the active panel (longwall 28) in both streams;
- 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 on 14th August 2014 at Site 20 in Myrtle Creek;
- 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 at Sites 21 / 21A on 16/12/2014 and Site 24 on 17/3/15 in Redbank Creek;
- 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 triggered at Site RC2 (aka Site 37) on 5/3/15;
- 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 28 extraction period.

6. 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

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

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)

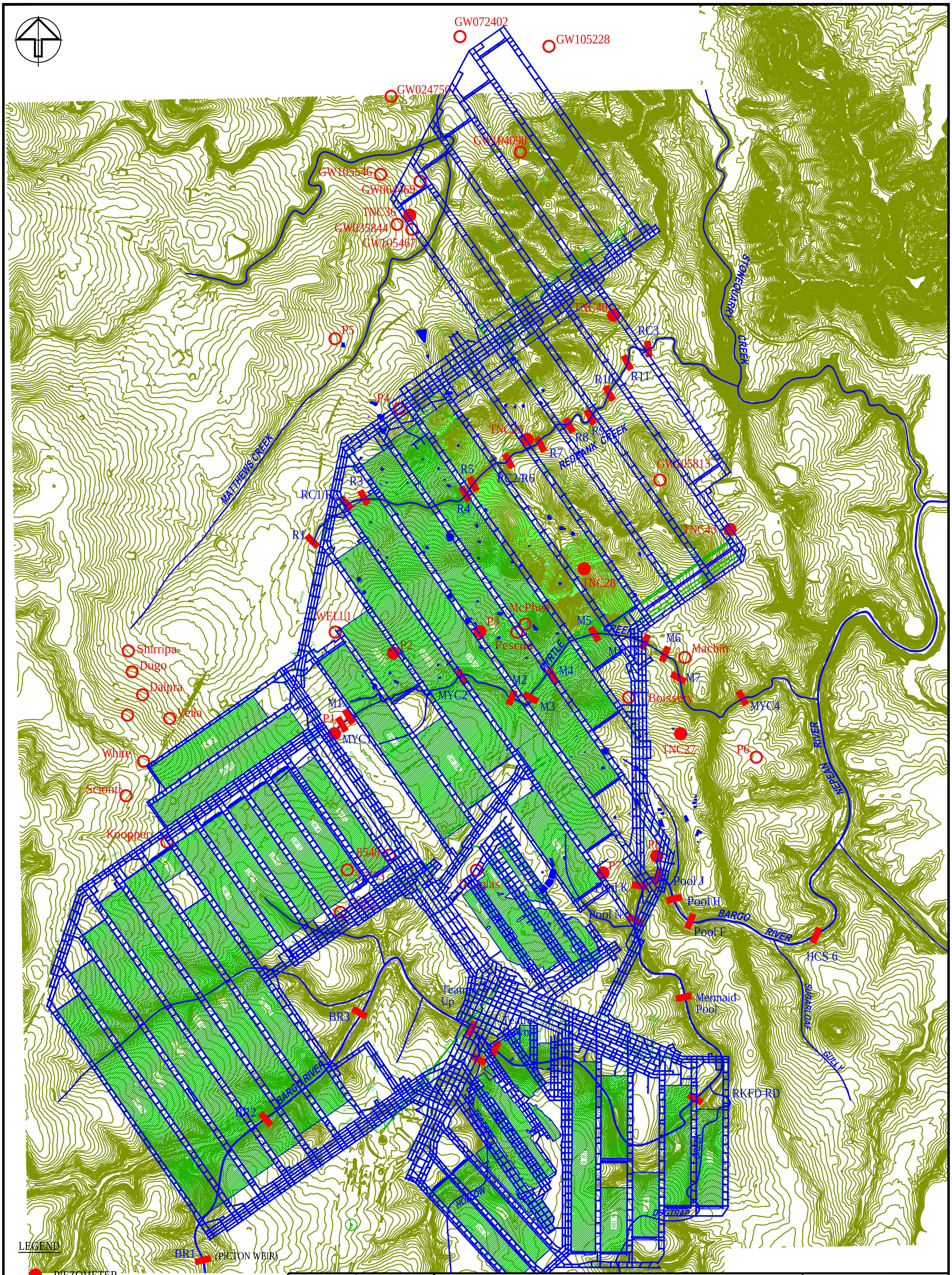
LIMITATIONS

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

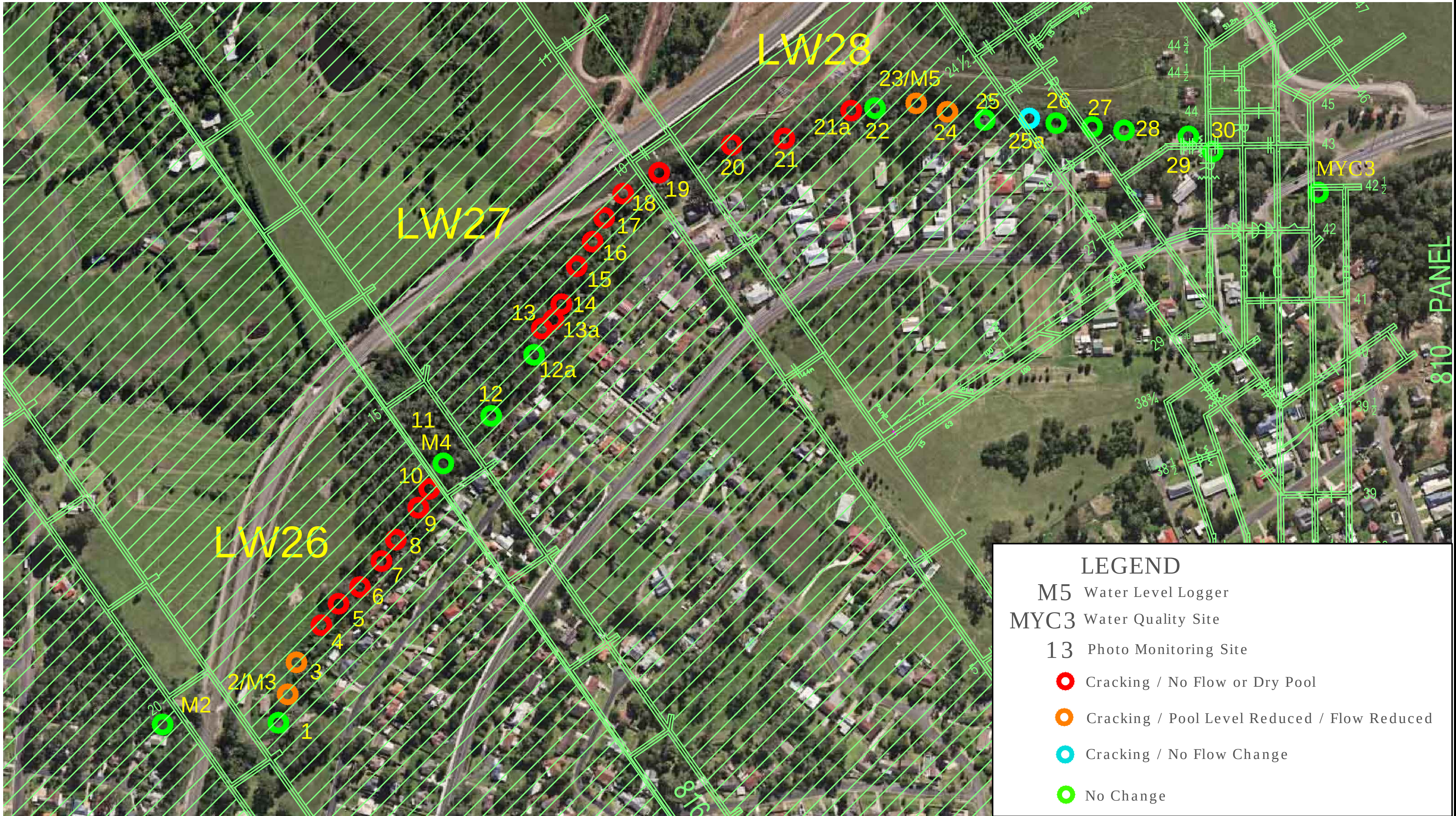
- PIEZOMETER
- STREAM MONITORING SITE
- NOW REGISTERED BORE / WELL

PROJECT:	TA24
DRAWN:	A. DAWKINS
DATE:	20 Aug 2015
SCALE:	1:30 000

TAHMOOR COAL PTY LTD
TAHMOOR COLLIERY
WATER MONITORING LOCATIONS

GeoTerra

DRAWING1



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Scale 1:5000 (metres)

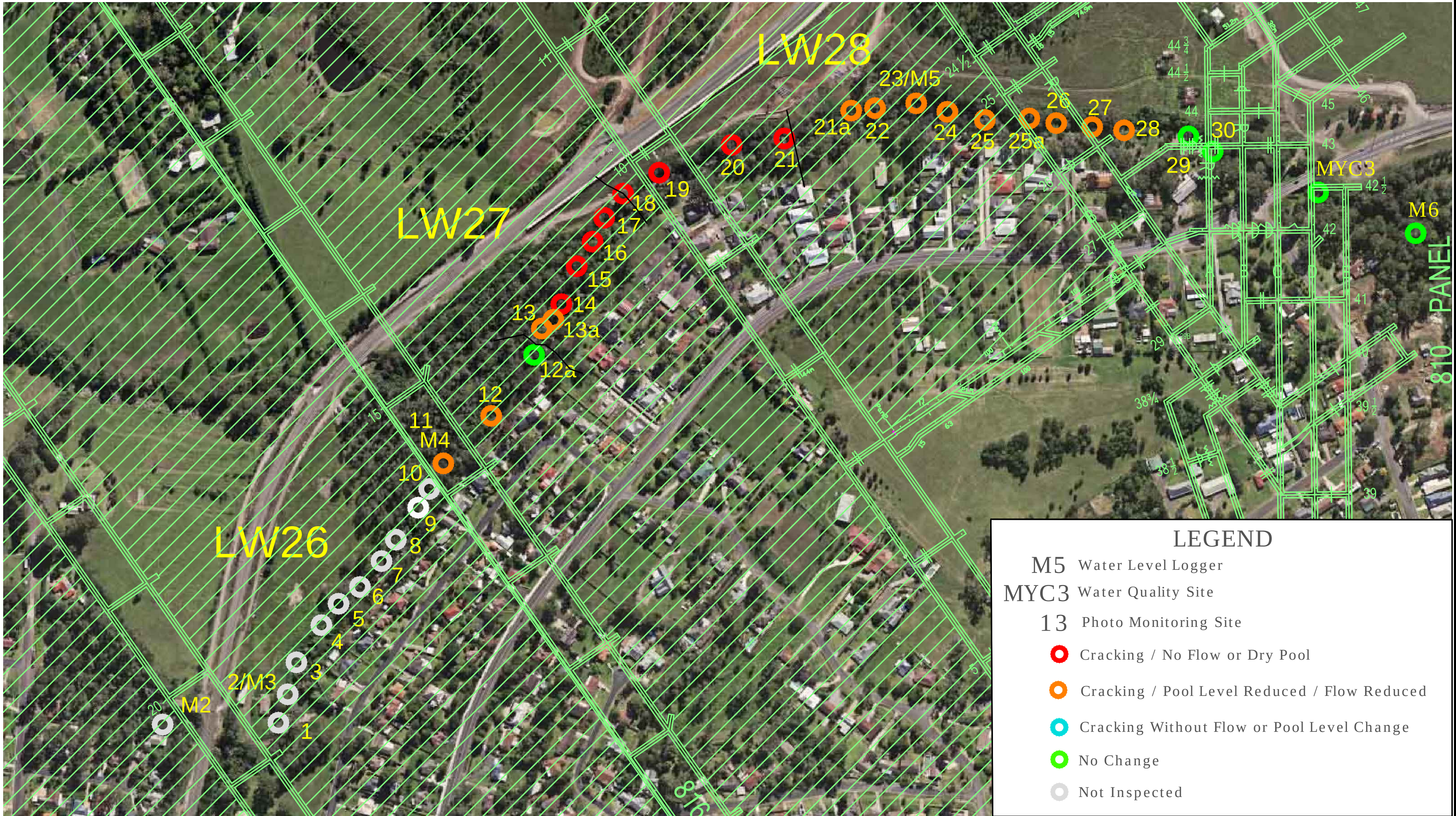
PROJECT:	TA24
DRAWN:	A. DAWKINS
DATE:	15 JULY 2014
SCALE:	AS SHOWN

TAHMOOR COAL PTY LTD
MYRTLE CREEK

CREEK STATUS (2 JULY, 2014)

GeoTerra

FIGURE 1



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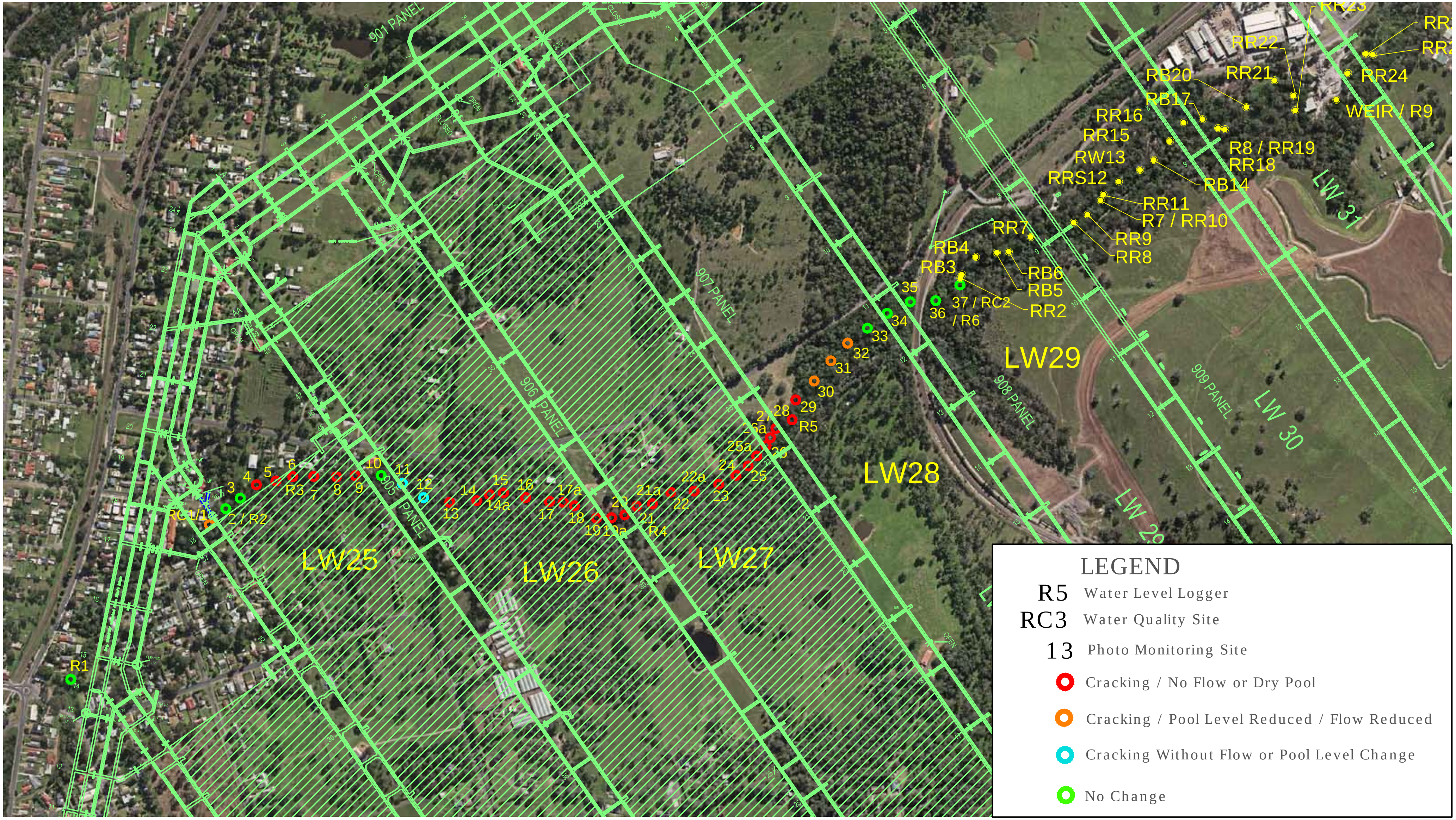
PROJECT:	TA24
DRAWN:	A. DAWKINS
DATE:	9 June 2015
SCALE:	As Shown

TAHMOOR COAL PTY LTD
MYRTLE CREEK

CREEK STATUS (9 June 2015)

GeoTerra

FIGURE 1



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Scale (metres)

PROJECT:	TA24
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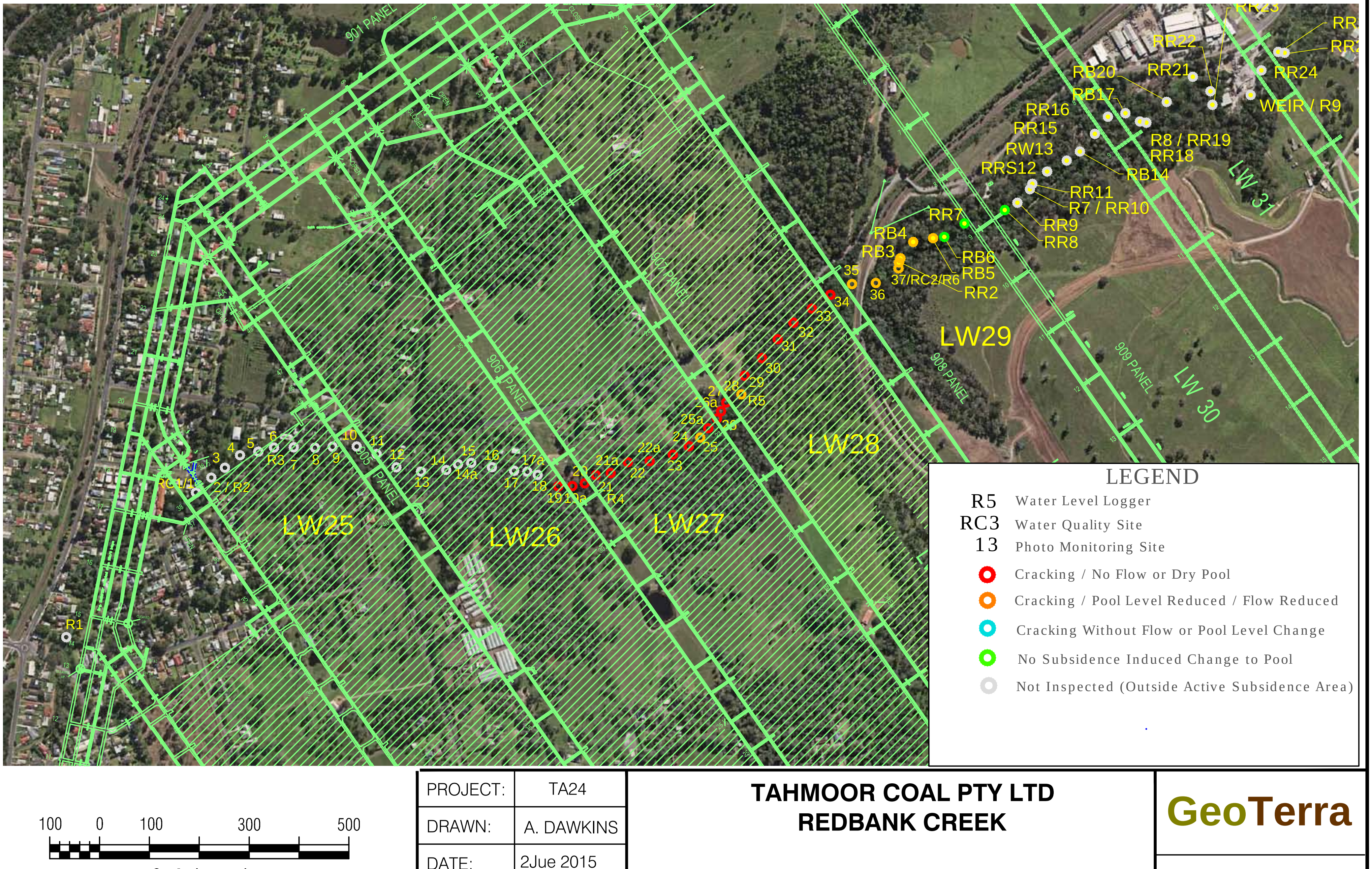
DATE:	15 DEC 2014
SCALE:	AS SHOWN

TAHMOOR COAL PTY LTD
REDBANK CREEK

CREEK STATUS (16 DEC, 2014)

GeoTerra

FIGURE 1



PROJECT:	TA24
DRAWN:	A. DAWKINS
DATE:	2Jue 2015
SCALE:	As Shown

TAHMOOR COAL PTY LTD
REDBANK CREEK

CREEK STATUS (2 JUNE, 2015)

GeoTerra

FIGURE 1

APPENDIX A

Myrtle Creek Site 11 (7/5/2014)

Myrtle Creek Site 15 (7/5/14)

(6/8/14)

(6/8/14)

(23/7/15)

(23/7/15)

Myrtle Creek Site 18 (7/5/2014)

Myrtle Creek Site 20 (7/5/14)

(6/8/14)

(6/8/14)

(23/7/15)

(23/7/15)

Myrtle Creek Site 23 (7/5/2014)

(6/8/14)

(23/7/15)

Myrtle Creek Site 27 (7/5/14)

(6/8/14)

(23/7/15)

Myrtle Creek Site 30 (7/5/2014)

(6/8/14)

(23/7/15)

Redbank Creek Site 21 (23/12/14)

Redbank Creek Site 22A (23/12/14)

(11/3/15)

(11/3/15)

(2/6/15)

(2/6/15)

Redbank Creek Site 25 (23/12/14)

Redbank Creek Site 28 (23/12/14)

(11/3/15)

(11/3/15)

(2/6/15)

(2/6/15)

Redbank Creek Site 31 (23/12/14)

Redbank Creek Site 35 (23/12/14)

(11/3/15)

(11/3/15)

(2/6/15)

(2/6/15)

Redbank Creek Site 37–RC2 (23/12/14)

(11/3/15)

(2/6/15)

Redbank Creek Site RR2 (23/12/14)

(11/3/15)

(2/6/15)

Redbank Creek Site RB5 (23/12/14)

Redbank Creek Site RR8 (23/12/14)

(11/3/15)

(11/3/15)

(2/6/15)

(2/6/15)

APPENDIX B

Redbank Creek Water Quality (mg/L)

		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
ANZECC	SITE										0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.024 (III) 0.013(V)	0.011					
28/2/05	RC1	300	40	54	6.8	11	42	0.13	2	270	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
7/4/06	RC1	300	57	38	7.2	10	60	0.19	14	210	7.6	0.1	1.90	0.07	_	0.1	0.1	0.001	0.001	0.015	0.01	0.01	0.01	_	_	_	11	_
5/10/06	RC1	265	53	33	5	7.3	44	0.2	19	190	2.1	0.05	3.20	0.29	_	0.01	0.1	0.001	0.001	0.01	0.01	0.01	0.01	_	_	_	9	_
14/6/07	RC1	55	11	6.4	1.7	3.5	19	0.12	5	30	1.8	0.11	2.80	0.08	_	0.01	0.02	0.007	0.001	0.008	0.01	0.01	0.01	0.02	0.09	0.01	7	_
16/8/07	RC1	290	58	30	3.8	10	84	0.1	29	120	0.5	0.04	1.4	0.28	_	0.03	0.01	0.006	_	0.011	0.01	0.01	_	0.04	0.03	0.002	8	_
13/11/07	RC1	120	17	14	3.5	7.4	27	0.14	8	71	1.3	0.01	1.10	0.8	_	0.01	0.04	0.003	_	0.007	0.01	0.01	_	0.04	0.01	0.001	7	_
1/2/08	RC1	125	18	14	5	5.7	34	0.1	14	49	0.8	0.05	0.88	0.66	_	0.01	0.14	0.003	_	0.007	0.01	0.01	_	0.03	0.01	0.001	9	_
8/4/08	RC1	220	43	21	4.8	8.1	66	0.16	9	110	0.5	0.03	1.40	0.58	_	0.02	0.01	0.003	_	0.015	0.01	0.01	_	0.13	0.11	0.001	9	_
13/6/08	RC1	150	30	13	2	7.1	42	0.1	15	65	0.2	0.04	0.91	0.35	_	0.01	0.12	0.001	_	0.005	0.01	0.01	_	0.07	0.02	0.002	7	_
04/09/2008	RC1	100	28	10	1.8	2.5	42	0.1	7	32	0.2	0.11	1.8	0.76	0.01	0.01	0.14	0.002	_	0.002	0.01	0.01	_	0.05	0.003	0.11	5	_
12/1/09	RC1	225	36	32	7.5	9.5	45	0.1	6	160	7.1	0.17	3.70	0.02	_	0.01	0.03	0.002	_	0.012	0.01	0.01	_	0.17	0.03	0.009	12	_
30/1/10	RC1	110	17	13	4.6	4.3	29	0.1	11	52	1.9	0.14	1.60	0.79	_	0.03	0.03	0.003	0.001	0.001	0.01	0.01	_	0.05	0.02	0.001	11	_
03/08/2010	RC1	175	32	18	3.4	6.9	56	0.1	19	61	1.5	0.03	0.58	0.20	0.02	0.01	0.02	0.004	_	0.011	0.01	0.01	_	0.10	0.036	0.001	8	2
01/03/2011	RC1	100	13	17	5.9	5.0	21	0.1	11	72	3.3	0.02	1.9	0.63	0.02	0.01	0.05	0.001	_	0.006	0.01	0.01	_	0.071	0.039	0.001	13	63
28/09/2012	RC1	175	38	16	4.9	7.7	57	0.1	16	78	1.8	0.07	0.66	0.06	0.07	0.05	0.02	0.002	_	0.008	0.01	0.01	_	0.09	0.024	0.001	7	10
29/08/13	RC1	215	36	25	4.3	8.5	62	0.1	18	92	1.8	0.04	4.3	0.08	0.03	0.01	0.01	0.004	0.001	0.015	0.01	0.01	_	0.11	0.039	0.001	_	9
29/4/14	RC1	240	31	36	6.7	12	42	0.1	60	1	0.6	0.07	0.76	0.06	0.02	0.01	0.01	0.002	0.001	0.009	0.01	0.01	_	0.17	0.055	0.004	7	8
22/9/14	RC1	170	37	17	3.2	7.4	54	0.1	19	73	0.3	0.05	0.16	0.05	0.02	0.01	0.03	0.001	_	0.007	0.01	0.01	_	0.091	0.033	0.001	4	2
03/12/14	RC1	105	23	9.6	3.1	3.6	37	0.1	7	35	3.5	0.06	0.65	0.17	0.01	0.01	0.02	0.003	_	0.007	0.01	0.01	_	0.045	0.035	0.003	9	16
6/3/15	RC1	130	23	17	2.5	5.8	25	0.20	6	95	1.0	0.06	1.5	0.25	0.01	0.01	0.03	0.001	0.001	0.007	0.01	0.01	_	0.063	0.023	0.002	8	_
28/4/15	RC1	205	42	19	3.9	9.0	65	0.1	20	78	0.9	0.06	0.96	0.47	0.03	0.02	0.05	0.005	0.001	0.008	0.01	0.01	_	0.088	0.031	0.001	9	3
	max	300	58	54	7.5	12.0	84	0.2	60	270	7.6	0.17	4.30	0.80	0.07	0.10	0.14	0.007	0.001	0.015	0.01	0.01		0.17	0.110	0.110	13	63
	min	55	11	6	1.7	2.5	19	0.1	2	1	0.2	0.01	0.16	0.02	0.01	0.01	0.01	0.001	0.001	0.001	0.01	0.01		0.02	0.003	0.001	4	2
	median	175	32	17	4.3	7.4	42	0.1	14	73	1.3	0.05	1.40	0.27	0.02	0.01	0.03	0.002	0.001	0.008	0.01	0.01		0.07	0.031	0.001	8	10
	St. Dev.	73	14	12	1.7	2.6	17	0.0	12	66	2.1	0.04	1.11	0.28	0.02	0.02	0.04	0.002	0.000	0.004	0.00	0.00		0.04	0.027	0.025	2	20

0.6	**exceeds ANZECCC 2000**	0.6	exceeds Water quality TARP
	LW27 extraction period		LW28 extraction period

		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
ANZECC	**SITE**										**0.25**	**0.02**			**1.9**	**1.9**	**0.055**	**0.0014**	**0.0034**	**0.008**	**0.011**	**0.024 (III) 0.013(V)**	**0.011**					
28/2/05	RC2	860	220	14	3.4	59	540	0.1	5	1	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_		_
7/4/06	RC2	1030	220	15	3.6	56	610	0.1	7	1	0.4	0.1	3.50	0.35	_	3.4	0.1	0.005	0.003	0.035	0.04	0.01	0.01	_	_	_	1	_
5/10/06	RC2	950	210	75	3.2	53	490	0.25	13	200	0.1	0.01	4.20	0.02	_	2	0.1	0.001	0.001	0.026	0.02	0.01	0.01	_	_	_	1	_
14/6/07	RC2	225	51	12	3.7	13	110	0.14	12	35	1.9	0.01	4.20	1.3	_	0.01	0.01	0.003	0.001	0.004	0.01	0.01	0.01	0.04	0.05	0.01	8	_
16/8/07	RC2	720	180	19	4.7	48	440	0.1	11	1	0.1	0.01	7	0.01	_	2.1	0.01	0.001		0.079	0.01	0.01	_	0.05	0.1	0.024	3	_
13/11/07	RC2	170	32	10	3.9	11	71	0.23	8	40	3.5	0.01	2.20	1.5	_	0.12	0.05	0.001	_	0.042	0.01	0.01	_	0.04	0.03	0.003	6	_
1/2/08	RC2	110	14	7.7	8.4	7.9	40	0.11	3	38	1.3	0.05	1.90	0.94	_	0.01	0.26	0.002	_	0.018	0.01	0.01	_	0.03	0.02	0.001	13	_
8/4/08	RC2	780	200	16	6.5	47	480	0.13	11	2	0.1	0.01	2.30	0.74	_	2.8	0.02	0.001	_	0.066	0.01	0.01	_	0.2	0.24	0.015	2	_
13/6/08	RC2	200	43	11	3	10	88	0.12	13	42	0.2	0.02	3.80	2.1	_	0.07	0.06	0.001	_	0.01	0.01	0.01	_	0.07	0.03	0.009	8	_
04/09/2008	RC2	135	25	9.8	4.6	8.4	53	0.10	9	38	0.1	0.02	0.91	0.46	0.01	0.01	0.08	0.001	_	0.002	0.01	0.01	_	0.05	0.001	0.03	7	_
12/1/09	RC2	250	50	17	6.2	17	120	0.21	2	64	0.9	0.1	20.00	0.07	_	0.01	0.03	0.002	_	0.009	0.01	0.01	_	0.12	0.05	0.004	11	_
30/1/10	RC2	525	115	23	9.1	34	310	0.1	5	43	0.4	0.03	5.70	1.3	_	0.43	0.01	0.001	0.001	0.001	0.01	0.01	_	0.09	0.1	0.01	10	_
03/08/2010	RC2	160	33	13	4.8	8.4	63	0.1	17	46	1.2	0.04	0.82	0.71	0.02	0.01	0.01	0.004	_	0.013	0.01	0.01	_	0.086	0.036	0.001	10	4
01/03/2011	RC2	845	190	22	5.5	54	510	0.1	8	1	0.3	0.01	68	8.7	3.6	3.5	0.04	0.001	_	0.032	0.01	0.01	_	0.17	0.28	0.043	2	74
28/09/2012	RC2	890	220	28	5.7	58	560	0.1	11	1	0.2	0.07	18	6.7	2.9	2.8	0.01	0.001	_	0.088	0.01	0.01	_	0.19	0.28	0.029	1	15
29/08/13	RC2	835	200	31	6.7	57	540	0.1	13	1	0.5	0.01	82	0.02	2.8	2.7	0.01	0.005	0.001	0.12	0.01	0.01	_	0.22	0.28	0.026	_	31
12/02/14	RC2	1520	410	22	5.3	100	930	0.1	27	25	7.7	0.03	46	42	4.6	4.4	0.01	0.001	0.001	0.20	0.06	0.01	_	0.17	0.45	0.083	1	52
29/4/14	RC2	1390	340	26	5.9	87	830	0.11	25	17	0.1	0.01	31	12	3.7	3.5	0.03	0.001	0.001	0.13	0.01	0.01	_	0.2	0.4	0.078	2	51
22/7/14	RC2	1480	385	25	10	94	860	0.12	25	36	0.6	0.03	45	42	4.0	3.8	0.02	0.003	0.001	0.18	0.05	0.01	_	0.26	0.34	0.095	2	36
22/9/14	RC2	1190	295	29	5.6	84	760	0.1	22	1	0.4	0.06	39	12	3.6	3.5	0.02	0.001	_	0.12	0.01	0.01	_	0.17	0.34	0.068	2	68
7/11/14	RC2	1250	325	27	8.3	84	770	0.11	23	4	0.4	0.02	51	25	4.0	3.6	0.03	0.007	0.003	0.091	0.04	0.01	_	0.17	0.32	0.084	3	70
03/12/14	RC2	490	120	17	6.5	31	260	0.22	30	44	1.4	0.16	21	0.42	1.1	1.0	0.02	0.001	_	0.035	0.01	0.01	_	0.12	0.13	0.036	12	110
6/3/15	RC2	1180	295	19	5.0	83	725	0.14	27	11	0.1	0.02	40	36	3.5	3.3	0.04	0.002	0.001	0.11	0.07	0.01	_	0.26	0.44	0.14	2	_
28/4/15	RC2	680	165	15	6.1	46	385	0.15	25	41	0.8	0.03	21	12	1.4	1.3	0.01	0.001	0.001	0.062	0.01	0.01	_	0.10	0.16	0.045	2	47
	max	1520	410	75	10.0	100	930	0.25	30	200	7.7	0.16	82	42	4.6	4.4	0.26	0.007	0.003	0.200	0.07	0.01		0.26	0.450	0.140	13	110
	min	110	14	8	3.0	8	40	0.10	2	1	0.1	0.01	1	0	0.0	0.0	0.01	0.001	0.001	0.001	0.01	0.01		0.03	0.001	0.001	1	4
	median	808	195	18	5.6	51	485	0.11	13	30	0.4	0.02	18	1	3.2	2.1	0.03	0.001	0.001	0.039	0.01	0.01		0.12	0.160	0.029	3	51
	St. Dev.	455	120	13	1.9	30	288	0.05	9	41	1.7	0.04	24	14	1.6	1.6	0.06	0.002	0.001	0.058	0.02	0.00		0.07	0.152	0.038	4	30

0.6	**exceeds ANZECCC 2000**	0.6	exceeds Water quality TARP		LW27 extraction period		LW28 extraction period

		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
ANZECC	SITE										0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.024 (III) 0.013(V)	0.011					
7/11/14	RC3	910	235	22	5.5	60	560	0.1	14	1	0.1	0.02	1.5	1.0	3.6	3.5	0.04	0.006	0.002	0.064	0.03	0.01	_	0.15	0.28	0.049	1	4

		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
ANZECC	SITE										0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.024 (III) 0.013(V)	0.011					
7/11/14	RC4	825	155	24	5.8	83	500	0.12	12	14	0.1	0.04	2.3	0.42	2.8	2.6	0.01	0.002	0.001	0.027	0.01	0.01	_	0.17	0.23	0.044	2	16
28/4/15	RC4	450	110	15	6.4	29	255	0.12	21	36	1.2	0.01	1.9	0.11	0.82	0.76	0.02	0.004	0.001	0.021	0.01	0.01	_	0.11	0.11	0.023	5	13

		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
ANZECC	SITE										0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.024 (III) 0.013(V)	0.011					
28/2/05	RC5	290	51	32	6.4	16	55	0.2	6	230	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
7/4/06	RC5	220	44	26	5.6	11	57	0.31	13	150	2.6	0.14	1.20	0.08	_	0.04	0.1	0.001	0.001	0.004	0.01	0.01	0.01	_	_	_	10	_
5/10/06	RC5	250	50	24	4.2	11	64	0.24	11	150	2.7	0.06	3.00	0.95	_	0.04	0.1	0.001	0.001	0.003	0.01	0.01	0.01	_	_	_	9	_
16/3/07	RC5	290	61	19	6.9	16	120	0.18	10	87	1	0.05	1.20	0.52	_	0.03	0.03	0.003	0.001	0.002	0.01	0.01	0.01	_	_	_	13	_
14/6/07	RC5	75	12	7	3.1	4.3	19	0.14	8	34	1.8	0.07	2.60	0.37	_	0.01	0.01	0.004	0.001	0.009	0.01	0.01	0.01	0.02	0.02	0.01	6	_
16/8/07	RC5	360	78	24	5.8	18	150	0.1	14	110	1.2	0.01	2.4	0.25	_	0.21	0.01	0.001	_	0.001	0.01	0.01	_	0.05	0.04	0.003	9	_
13/11/07	RC5	145	26	7.3	4.4	9.7	47	0.17	9	55	1.9	0.03	1.80	1.3	_	0.02	0.07	0.001	_	0.011	0.01	0.01	_	0.04	0.02	0.002	9	_
1/2/08	RC5	75	5.4	6.7	9	5.6	26	0.1	2	30	1.7	0.08	1.60	0.9	_	0.01	0.24	0.002	_	0.013	0.01	0.01	_	0.03	0.02	0.001	13	_
8/4/08	RC5	230	46	17	5.8	11	92	0.22	6	81	0.3	0.02	1.20	0.28	_	0.05	0.02	0.006	_	0.008	0.01	0.01	_	0.12	0.05	0.006	7	_
13/6/08	RC5	165	31	15	2.7	8	59	0.38	12	55	0.5	0.02	1.20	0.52	_	0.02	0.06	0.001	_	0.019	0.01	0.01	_	0.08	0.03	0.01	6	_
04/09/2008	RC5	240	45	19	6.6	14	120	0.12	9	35	0.4	0.23	4.8	0.21	0.05	0.01	0.05	0.003	_	0.013	0.01	0.01	_	0.10	0.010	0.05	5	_
12/1/09	RC5	165	19	25	3.8	8.6	28	0.18	32	80	1.9	0.08	1.00	0.02	_	0.01	0.03	0.003	_	0.021	0.01	0.01	_	0.13	0.05	0.007	15	_
30/1/10	RC5	160	21	13	3.4	7.4	40	0.14	7	66	0.3	0.05	2.90	0.43	_	0.06	0.03	0.001	0.001	0.001	0.01	0.01	_	0.01	0.04	0.001	23	_
03/08/2010	RC5	180	35	15	5.0	9.8	64	0.1	20	56	1.2	0.04	1.1	0.60	0.03	0.01	0.02	0.004	_	0.012	0.01	0.01	_	0.082	0.044	0.001	10	2
01/03/2011	RC5	135	18	23	3.4	7.6	23	0.20	16	97	1.7	0.03	2.5	0.32	0.05	0.03	0.03	0.002	_	0.004	0.01	0.01	_	0.14	0.068	0.008	8	48
28/09/2012	RC5	650	165	28	6.9	27	370	0.15	8	75	0.6	0.09	1.6	0.10	0.46	0.11	0.01	0.001	_	0.004	0.01	0.01	_	0.22	0.11	0.006	5	10
29/08/13	RC5	440	96	28	7.8	24	220	0.17	18	86	0.8	0.03	11	0.11	0.12	0.11	0.01	0.001	0.001	0.010	0.01	0.01	_	0.19	0.10	0.001		5
12/02/14	RC5	1280	330	32	6.6	88	800	0.1	8	1	2.6	0.08	0.15	0.13	6.2	6.2	0.04	0.001	0.001	0.22	0.05	0.01	_	0.24	0.63	0.060	1	4
29/4/14	RC5	915	250	27	6.9	62	585	0.1	16	1	0.4	0.07	0.72	0.69	1.8	1.7	0.02	0.002	0.001	0.020	0.01	0.01	_	0.21	0.26	0.041	7	5
22/7/14	RC5	1170	285	29	7.2	77	730	0.1	10	9	0.5	0.02	1.0	0.91	5.0	4.7	0.01	0.002	0.001	0.12	0.03	0.01	_	0.24	0.38	0.059	2	16
22/9/14	RC5	620	155	27	5.4	41	355	0.16	25	45	1.3	0.13	5.4	0.21	0.75	0.12	0.01	0.001	_	0.003	0.01	0.01	_	0.16	0.12	0.023	4	44
7/11/14	RC5	820	210	29	6.9	55	500	0.17	8	29	1.1	0.04	1.2	0.25	1.2	1.1	0.02	0.001	0.001	0.006	0.01	0.01	_	0.19	0.15	0.037	3	10
03/12/14	RC5	355	84	13	9.1	20	185	0.15	22	26	2.0	0.07	3.1	0.11	0.05	0.01	0.02	0.001	_	0.012	0.01	0.01	_	0.089	0.084	0.021	11	54
	max	1280	330	32	9.1	88	800	0.4	32	230	2.7	0.23	11.00	1.30	6.20	6.20	0.24	0.006	0.001	0.220	0.05	0.01		0.24	0.63	0.06	23	54
	min	75	5	7	2.7	4	19	0.1	2	1	0.3	0.01	0.15	0.02	0.03	0.01	0.01	0.001	0.001	0.001	0.01	0.01		0.01	0.01	0.001	1	2
	median	250	50	24	5.8	14	92	0.2	10	56	1.2	0.06	1.60	0.30	0.46	0.04	0.03	0.001	0.001	0.010	0.01	0.01		0.12	0.05	0.008	8	10
	St. Dev.	345	94	8	1.8	24	236	0.1	7	54	0.8	0.05	2.31	0.34	2.16	1.62	0.05	0.001	0.000	0.050	0.01	0.00		0.08	0.15	0.021	5	20

		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
ANZECC	SITE										0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.024 (III) 0.013(V)	0.011					
7/11/14	RC6	785	190	30	6.0	43	460	0.20	5	53	1.0	0.09	2.5	0.51	1.8	1.5	0.02	0.003	0.001	0.019	0.01	0.01	_	0.23	0.14	0.032	5	18

Myrtle Creek Water Quality (mg/L)

ANZECC	SITE										0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.024 (III) 0.013(V)	0.011					
		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
5/12/03	MYC1	87	10	11	4.8	5.6	11	<0.1	6	71			_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
8/12/04	MYC1	120	10	15	4.3	4.5	10	0.1	6	80	0.9	0.05	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
16/3/07	MYC1	120	21	6.1	8.1	8.8	40	0.1	5	69	2.2	0.1	2.70	1.2	_	0.09	0.06	0.007	0.001	0.005	0.01	0.01	0.01	_	_	_	18	_
14/6/07	MYC1	45	8.1	2.3	1.5	3.5	15	0.1	2	22	0.7	0.01	1.00	0.33	_	0.01	0.01	0.007	0.001	0.008	0.01	0.01	0.01	0.01	0.02	0.01	11	_
16/8/07	MYC1	120	21	8.2	6	7.4	40	0.1	4	58	0.7	0.01	1.30	0.54	_	0.02	0.01	0.002	_	0.007	0.01	0.01	_	0.01	0.02	0.001	11	_
13/11/07	MYC1	92	7.5	12	6.1	5.6	15	0.13	5	61	3.7	0.13	3.00	2	_	0.06	1	0.003	_	0.01	0.01	0.01	_	0.01	0.02	0.001	27	_
1/2/08	MYC1	80	12	2.4	8.2	5.6	31	0.1	2	23	0.3	0.06	2.60	1.3	_	0.03	0.46	0.004	_	0.01	0.01	0.01	_	0.02	0.02	0.001	13	_
8/4/08	MYC1	110	22	3.3	6.6	5	37	0	6	38	0.7	0.04	1.90	1.1	_	0.02	0.07	0.003	_	0.01	0.01	0.01	_	0.04	0.02	0.008	10	_
13/6/08	MYC1	120	21	11	3.9	6.5	36	0.1	11	49	0.2	0.03	2.30	0.8	_	0.01	0.11	0.001	_	0.013	0.01	0.01	_	0.05	0.02	0.012	10	_
04/09/2008	MYC1	140	23	17	5.4	11	55	0.1	13	60	0.4	0.05	1.3	0.65	0.01	0.01	0.09	0.004	_	0.003	0.01	0.01	_	0.09	0.012	0.05	12	_
30/1/10	MYC1	90	5.4	15	7.3	4.7	8	0.1	15	65	2.2	0.12	1.40	0.91	_	0.03	0.05	0.01	0.001	0.001	0.01	0.01	_	0.05	0.02	0.01	20	_
03/08/2010	MYC1	80	7	13	4.8	6.0	22	0.1	10	46	3.3	0.05	2.9	0.71	0.03	0.02	0.03	0.002	_	0.012	0.01	0.01	_	0.067	0.034	0.001	15	2
01/03/2011	MYC1	175	13	33	7.9	9.5	18	0.1	8	150	6.7	0.10	5.0	1.5	0.34	0.30	0.04	0.003	_	0.004	0.01	0.01	_	0.11	0.043	0.003	22	65
28/09/2012	MYC1	240	53	19	8.2	14	100	0.15	15	86	5.5	1.3	0.60	0.57	0.22	0.20	0.01	0.001	_	0.003	0.01	0.01	_	0.13	0.035	0.001	9	28
7/5/13	MYC1	125	19	12	9.0	7.8	27	0.14	8	78	0.6	0.06	4.0	0.37	0.14	0.06	0.04	0.004	0.001	0.014	0.01	0.01	_	0.053	0.034	0.003	10	17
06/06/13	MYC1	115	14	12	5.9	8.1	24	0.14	9	70	0.8	0.06	4.5	0.26	0.03	0.01	0.03	0.002	0.001	0.013	0.01	0.01	_	0.084	0.030	0.005	8	16
29/08/13	MYC1	125	26	12	6.3	7.0	40	0.14	9	74	0.9	0.03	97	0.41	0.02	0.01	0.04	0.004	0.001	0.006	0.01	0.01	_	0.053	0.027	0.001		15
29/4/14	MYC1	135	16	17	8.8	6.1	19	0.1	5	100	0.6	0.1	3.7	0.43	0.02	0.01	0.04	0.002	0.001	0.011	0.01	0.01	_	0.064	0.028	0.002	10	28
22/9/14	MYC1	125	17	17	6.5	6.2	24	0.1	8	83	0.5	0.10	3.0	0.38	0.06	0.02	0.04	0.004		0.008	0.01	0.01		0.048	0.021	0.001	8	15
03/12/14	MYC1	74	8.5	10	7.0	3.7	12	0.1	6	51	1.8	0.20	2.2	1.6	0.06	0.05	0.04	0.004	_	0.009	0.01	0.01	_	0.038	0.022	0.004	17	18
28/04/15	MYC1	96	16	5.3	10	5.8	30	0.1	8	38	1.7	0.13	1.0	0.33	0.01	0.01	0.03	0.004	0.001	0.016	0.01	0.01	_	0.033	0.016	0.001	16	9
	max	240	53	33	10.0	14.0	100	0.15	15	150	6.70	1.30	97.0	2.00	0.34	0.30	1.00	0.010	0.001	0.016	0.01	0.01		0.130	0.043	0.050	27	65
	min	45	5	2	1.5	3.5	8	0.00	2	22	0.20	0.01	0.6	0.26	0.01	0.01	0.01	0.001	0.001	0.001	0.01	0.01		0.010	0.012	0.001	8	2
	median	120	14	12	6.1	6.5	27	0.10	8	65	0.85	0.06	2.6	0.71	0.03	0.02	0.04	0.003	0.001	0.008	0.01	0.01		0.052	0.020	0.003	12	17
	St. Dev.	40	10	7	2.0	2.5	20	0.03	4	28	1.80	0.28	21.7	0.51	0.11	0.08	0.24	0.002	0.000	0.004	0.00	0.00		0.034	0.008	0.011	5	17

0.6 **exceeds ANZECCC 2000**

0.6 exceeds Water quality TARP

LW27 extraction period

LW28 extraction period

ANZECC	SITE										0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.024 (III) 0.013(V)	0.011					
		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
5/12/03	MYC2	170	27	20	2.8	13	68	0.1	5	81	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
8/12/04	MYC2	475	55	32	4.3	25	160	0.1	15	92	0.8	0.05	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
5/10/06	MYC2	210	28	17	3.5	13	55	0.14	22	120	5.7	0.66	22.00	13	_	0.08	0.1	0.001	0.001	0.008	0.01	0.01	0.01	_	_	_	17	_
16/3/07	MYC2	185	27	19	5.8	15	55	0.12	5	110	2.9	0.24	23.00	10	_	0.54	0.01	0.003	0.001	0.006	0.01	0.01	0.01	_	_	_	18	_
14/6/07	MYC2	50	10	4.3	2.2	3.2	19	0.1	2	21	1.1	0.08	2.50	0.4	_	0.01	0.02	0.004	0.001	0.009	0.01	0.01	0.01	0.02	0.02	0.01	7	_
16/8/07	MYC2	550	105	28	5.3	46	290	0.1	12	110	1.4	0.03	6.20	0.06	_	0.85	0.01	0.001	_	0.002	0.01	0.01	_	0.05	0.04	0.029	10	_
13/11/07	MYC2	145	20	11	4.9	13	39	0.13	5	82	2.2	0.11	3.30	1.8	_	0.02	0.24	0.001	_	0.003	0.01	0.01	_	0.05	0.03	0.001	13	_
1/2/08	MYC2	140	14	15	7.2	11	70	0.1	2	25	1.2	0.04	0.74	0.38	_	0.01	0.18	0.001	_	0.025	0.01	0.01	_	0.04	0.05	0.001	13	_
8/4/08	MYC2	260	44	19	6	19	84	0.15	9	130	6.1	0.03	2.20	0.63	_	0.03	0.03	0.001	_	0.002	0.01	0.01	_	0.13	0.05	0.006	9	_
13/6/08	MYC2	175	29	15	3.2	13	57	0.11	9	82	0.7	0.08	4.10	0.46	_	0.57	0.06	0.001	_	0.007	0.01	0.01	_	0.11	0.05	0.007	9	_
04/09/2008	MYC2	135	17	15	4.5	12	46	0.1	10	63	2.2	0.27	2.8	0.32	0.05	0.01	0.03	0.002	_	0.001	0.01	0.01	_	0.08	0.001	0.04	8	_
30/1/10	MYC2	115	15	9.3.	5.2	7.3	20	0.1	32	38	1.5	0.13	3.30	1.1	_	0.31	0.04	0.003	0.001	0.01	0.01	0.01	_	0.06	0.03	0.01	17	_
03/08/2010	MYC2	125	17	14	3.9	11	43	0.1	13	57	0.8	0.09	2.6	0.41	0.04	0.01	0.03	0.003	_	0.017	0.01	0.01	_	0.11	0.050	0.002	13	10
01/03/2011	MYC2	325	36	51	9.5	19	53	0.21	4	270	2.9	0.08	5.2	1.5	4.6	4.5	0.04	0.002	_	0.001	0.01	0.01	_	0.32	0.25	0.004	24	51
28/09/2012	MYC2	175	38	16	4.9	7.7	57	0.14	16	78	1.8	0.07	0.66	0.06	0.07	0.05	0.02	0.002	_	0.008	0.01	0.01	_	0.09	0.024	0.001	7	10
7/5/13	MYC2	250	39	18	5.5	25	99	0.14	5	110	1.4	0.21	11	5.8	2.8	2.6	0.04	0.001	0.001	0.008	0.01	0.01	_	0.094	0.085	0.008	10	160
06/06/13	MYC2	115	18	10	4.5	7.9	28	0.14	7	64	0.5	0.11	2.5	0.57	0.06	0.01	0.03	0.002	0.001	0.010	0.01	0.01	_	0.059	0.030	0.006	10	10
29/08/13	MYC2	310	54	15	5.5	26	130	0.12	11	97	1.0	0.08	88	0.45	0.58	0.54	0.04	0.002	0.001	0.003	0.01	0.01	_	0.088	0.046	0.007		37
29/4/14	MYC2	215	30	25	7.2	20	77	0.12	6	125	1.6	0.11	15	12	1.1	1	0.04	0.001	0.001	0.005	0.01	0.01	_	0.12	0.081	0.008	13	40
22/9/14	MYC2	195	27	18	4.8	17	68	0.1	12	84	1.1	0.16	3.7	0.47	0.38	0.29	0.03	0.007		0.18	0.01	0.01	_	0.12	0.060	0.004	7	28
03/12/14	MYC2	70	10	7.3	4.0	4.6	13	0.1	9	42	3.0	0.08	2.5	1.1	0.11	0.08	0.03	0.006	_	0.016	0.01	0.01		0.042	0.024	0.001	14	16
28/04/15	MYC2	105	15	8.3	8.5	7.0	31	0.1	9	45	0.9	0.09	1.2	0.76	0.02	0.01	0.04	0.003	0.001	0.010	0.01	0.01	_	0.042	0.022	0.001	17	5
	max	550	105	51	9.5	46	290	0.21	32	270	6.1	0.66	88.00	13.00	4.60	4.50	0.24	0.007	0.001	0.180	0.01	0.01		0.320	0.250	0.040	24	160
	min	50	10	4	2.2	3	13	0.1	2	21	0.5	0.03	0.66	0.06	0.02	0.01	0.01	0.001	0.001	0.001	0.01	0.01		0.020	0.001	0.001	7	5
	median	175	27	16	4.9	13	56	0.1	9	82	1.4	0.09	3.30	0.60	0.25	0.08	0.04	0.002	0.001	0.008	0.01	0.01		0.084	0.043	0.006	13	22
	St. Dev.	122	21	10	1.8	9	60	0.03	7	52	1.5	0.14	19.48	4.14	1.48	1.11	0.06	0.002	0.000	0.039	0.00	0.00		0.066	0.054	0.010	5	46

0.6 **exceeds ANZECCC 2000**

0.6 exceeds Water quality TARP

LW27 extraction period

LW28 extraction period

	ANZECC										0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.024 (III) 0.013(V)	0.011					
		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
30/1/10	MYC3	230	44	15	24	8.1	59	0.14	11	120	30	6	2.20	0.65	_	0.04	0.03	0.002	0.001	0.001	0.01	0.01	_	0.08	0.02	0.01	23	_
03/08/2010	MYC3	170	25	22	4.3	10	45	0.1	31	71	2.3	0.04	0.32	0.29	0.03	0.01	0.04	0.003	_	0.017	0.01	0.01	_	0.15	0.054	0.004	10	2
01/03/2011	MYC3	650	105	27	65	12	110	0.50	21	460	92	22	2.9	0.62	0.28	0.25	0.06	0.005	_	0.016	0.01	0.01	_	0.13	0.040	0.002	57	580
28/09/2012	MYC3	890	220	28	5.7	58	560	0.1	11	1	0.2	0.07	18	6.7	2.9	2.8	0.01	0.001	_	0.088	0.01	0.01	_	0.19	0.28	0.029	1	15
07/05/13	MYC3	255	36	27	6.8	19	98	0.13	17	87	0.4	0.03	0.55	0.13	0.03	0.01	0.01	0.001	0.001	0.006	0.01	0.01	_	0.15	0.087	0.001	7	7
06/06/13	MYC3	245	47	20	5.1	14	94	0.14	22	69	1.3	0.04	0.6	0.14	0.02	0.01	0.02	0.001	0.001	0.002	0.01	0.01	_	0.12	0.057	0.002	6	5
29/08/13	MYC3	825	190	32	9.6	64	480	0.11	24	100	0.9	0.05	1.6	0.06	0.03	0.03	0.05	0.003	0.001	0.005	0.01	0.01	_	0.27	0.16	0.013	_	13
12/02/14	MYC3	1000	230	40	8.9	80	560	0.18	11	135	0.2	0.05	1.0	0.10	0.05	0.02	0.01	0.001	0.001	0.006	0.01	0.01	_	0.32	0.18	0.020	5	6
29/4/14	MYC3	605	145	18	6.4	46	310	0.12	18	100	0.2	0.04	0.45	0.41	0.04	0.03	0.02	0.003	0.001	0.008	0.01	0.01	_	0.17	0.11	0.027	3	5
22/7/14	MYC3	1080	220	35	10	93	580	0.11	27	150	0.4	0.01	0.25	0.10	0.12	0.10	0.01	0.004	0.001	0.003	0.01	0.01		0.34	0.28	0.060	3	4
22/9/14	MYC3	845	180	30	6.4	85	455	0.1	32	155	0.2	0.06	0.33	0.09	0.05	0.03	0.01	0.001		0.002	0.01	0.01		0.29	0.28	0.065	1	4
03/12/14	MYC3	155	30	9.3	5.3	12	65	0.13	13	41	3.1	0.25	5.6	0.14	0.03	0.01	0.03	0.002	_	0.006	0.01	0.01	_	0.071	0.062	0.008	8	84
28/04/15	MYC3	200	40	12	6.9	13	76	0.1	17	60	1.2	0.06	0.72	0.23	0.01	0.01	0.04	0.003	0.001	0.007	<0.01	0.01	_	0.047	0.047	0.006	13	2
	max	1080	230	40	65.0	93	580	0.50	32	460	92.0	22.00	18.00	6.70	2.90	2.80	0.06	0.005	0.001	0.088	0.01	0.01		0.34	0.280	0.065	57	580
	min	155	25	9	4.3	8	45	0.10	11	1	0.2	0.01	0.25	0.06	0.01	0.01	0.01	0.001	0.001	0.001	0.01	0.01		0.05	0.020	0.001	1	2
	median	605	105	27	6.8	19	110	0.12	18	100	0.7	0.05	0.72	0.14	0.04	0.03	0.03	0.002	0.001	0.006	0.01	0.01		0.150	0.087	0.010	7	6
	St. Dev.	351	83	9	16.5	33	225	0.11	7	111	25.9	6.17	4.85	1.80	0.82	0.77	0.02	0.001	0.000	0.023	0.00	0.00		0.10	0.098	0.021	16	165

0.6 **exceeds ANZECCC 2000**

0.6 exceeds Water quality TARP

LW27 extraction period

LW28 extraction period

		TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt As	Filt Se	Filt Sr	Filt Ba	Filt Li	DOC	TSS
ANZECC	**SITE**										**0.25**	**0.02**			**1.9**	**1.9**	**0.055**	**0.0014**	**0.0034**	**0.008**	**0.011**	**0.024 (III) 0.013(V)**	**0.011**					
28/2/05	MYC4	600	120	25	50	13	120	0.24	10	320	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
7/4/06	MYC4	1390	250	34	120	16	240	0.34	40	820	180	30	2.00	0.85	_	0.26	0.1	0.008	0.001	0.012	0.01	0.01	0.01	_	_	_	47	_
5/10/06	MYC4	740	180	22	63	13	110	0.32	22	580	69	20	1.20	1	_	0.18	0.1	0.001	0.001	0.004	0.01	0.01	0.01	_	_	_	32	_
16/3/07	MYC4	400	63	16	26	11	83	0.18	17	250	29	6.1	1.30	0.69	_	0.18	0.01	0.003	0.001	0.013	0.01	0.01	0.01	_	_	_	27	_
14/6/07	MYC4	375	84	23	25	11	76	0.17	20	240	61	6.8	4.20	0.41	_	0.08	0.01	0.004	0.003	0.02	0.01	0.01	0.01	0.05	0.02	0.01	28	_
16/8/07	MYC4	1150	120	31	58	16	130	0.26	14	190	190	25	0.94	0.3	_	0.43	0.01	0.009	_	0.027	0.01	0.01	_	0.03	0.02	0.002	40	_
13/11/07	MYC4	265	45	12	23	12	47	0.19	20	150	48	5.2	1.20	0.53	_	0.02	0.06	0.004	_	0.016	0.01	0.01	_	0.04	0.03	0.001	17	_
1/2/08	MYC4	190	26	12	25	8.4	47	0.14	3	97	31	4.9	1.20	0.62	_	0.01	0.19	0.002	_	0.016	0.01	0.01	_	0.04	0.02	0.001	19	_
8/4/08	MYC4	730	67	27	73	12	110	0.3	21	610	120	19	0.60	0.35	_	0.16	0.02	0.005	_	0.02	0.01	0.01	_	0.13	0.02	0.006	9	_
13/6/08	MYC4	210	42	16	5.2	11	88	0.13	21	42	3.1	0.43	0.62	0.26	_	0.12	0.05	0.001	_	0.006	0.01	0.01	_	0.1	0.03	0.009	9	_
04/09/2008	MYC4	210	46	12	4.6	10	82	0.13	15	63	1.7	0.28	0.48	0.24	0.01	0.01	0.07	0.001	_	0.002	0.01	0.01	_	0.10	0.002	0.03	10	_
12/1/09	MYC4	760	150	30	57	16	140	0.17	93	130	56	9	0.54	0.3	_	0.01	0.06	0.003	_	0.017	0.01	0.01	_	0.17	0.03	0.009	55	_
30/1/10	MYC4	93	12	11	4	5	20	0.1	10	51	0.5	0.07	1.5	1	_	0.01	0.02	0.003	0.001	0.001	0.01	0.01	_	0.06	0.02	0.01	8	_
03/08/2010	MYC4	215	37	20	11	9.9	58	0.12	28	86	9.5	1.8	0.50	0.38	0.03	0.01	0.05	0.005	_	0.023	0.01	0.01	_	0.14	0.041	0.004	16	6
01/03/2011	MYC4	650	105	27	65	12	110	0.50	21	460	92	22	2.9	0.62	0.28	0.25	0.06	0.005	_	0.016	0.01	0.01	_	0.13	0.040	0.002	57	580
28/09/2012	MYC4	650	165	28	6.9	27	370	0.15	8	75	0.6	0.09	1.6	0.10	0.46	0.11	0.01	0.001	_	0.004	0.01	0.01	_	0.22	0.11	0.006	5	10
07/05/13	MYC4	655	120	32	53	16	120	0.21	43	160	65	12	1.8	0.26	0.32	0.28	0.04	0.003	0.001	0.015	0.01	0.01	_	0.14	0.020	0.001	24	140
06/06/13	MYC4	490	96	24	40	14	120	0.32	37	225	37	11	1.0	0.36	0.11	0.09	0.04	0.003	0.001	0.017	0.01	0.01	_	0.13	0.025	0.001	24	64
29/08/13	MYC4	540	110	32	10	32	270	0.12	19	63	1.5	0.27	0.37	0.04	0.01	0.01	0.01	0.002	0.001	0.006	0.01	0.01	_	0.22	0.074	0.002		10
12/02/14	MYC4	530	110	36	20	28	230	0.17	4	170	13	2.6	1.1	1.0	0.40	0.37	0.02	0.001	0.001	0.005	0.01	0.01	_	0.18	0.030	0.001	14	18
29/4/14	MYC4	350	68	24	17	22	160	0.14	20	85	0.8	1.6	0.53	0.07	0.03	0.01	0.02	0.001	0.001	0.009	0.01	0.01	_	0.16	0.043	0.006	12	37
22/7/14	MYC4	1210	210	36	77	20	160	0.31	25	780	150	30	1.0	0.32	0.32	0.26	0.04	0.006	0.001	0.075	0.01	0.01	_	0.19	0.022	0.007	49	84
22/9/14	MYC4	490	120	22	14	25	240	0.12	25	77	14	3.4	1.8	0.22	0.29	0.21	0.02	0.001	_	0.016	0.01	0.01	_	0.21	0.059	0.006	8	210
	max	1390	250	36	120	32	370	0.50	93	820	190.00	30.00	4.20	1.00	0.46	0.43	0.19	0.009	0.003	0.075	0.01	0.01		0.22	0.110	0.030	57	580
	min	93	12	11	4	5	20	0.10	3	42	0.50	0.07	0.37	0.04	0.01	0.01	0.01	0.001	0.001	0.001	0.01	0.01		0.03	0.002	0.001	5	6
	median	530	105	24	25	13	120	0.17	20	160	34.00	5.65	1.15	0.36	0.28	0.12	0.04	0.003	0.001	0.016	0.01	0.01		0.13	0.030	0.006	19	51
	St. Dev.	379	68	8	35	8	97	0.12	23	264	64.32	10.74	1.06	0.31	0.18	0.14	0.05	0.003	0.001	0.019	0.00	0.00		0.06	0.029	0.008	18	218

0.6	**exceeds ANZECCC 2000**
0.6	exceeds Water quality TARP
	LW27 extraction period
	LW28 extraction period

APPENDIX C

TAHMOOR / THIRLMERE PIEZOMETER WATER QUALITY (mg/L)

ANZECC											0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.013(V)	0.011				
		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Cu	Pb	Zn	Ni	As	Se	Sr	Ba	Li	DOC
08/12/2004	P1		850	11	1.6	150	1800	0.10	1	5	**0.8**	**0.1**	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
07/04/2006	P1	2010	600	7.6	2.1	110	1250	0.10	1	10	**0.3**	**0.1**	65.0	37.0	_	**4.5**	**0.1**	**0.002**	0.001	**0.38**	**0.11**	0.01	0.01	_	_	_	_
05/10/2006	P1	1720	480	13	1.3	99	1110	0.10	1	5	**0.9**	0.01	37.0	21.0	_	**2.8**	**0.1**	**0.003**	0.002	**0.31**	**0.12**	0.01	0.01	_	_	_	_
16/03/2007	P1	2600	460	7.7	1.2	91	990	0.10	1	7	**0.4**	0.01	48.0	36.0	_	**3.4**	0.04	**0.008**	**0.006**	**0.27**	**0.11**	0.01	0.01	_	_	_	_
17/06/2008	P1	2070	550	6	4.1	125	1250	0.10	1	8	**1**	**0.06**	59.0	52.0	_	**4.5**	0.01	0.001	0.001	**0.58**	**0.19**	0.01	_	0.12	0.57	0.042	_
12/01/2009	P1	1900	5450	8.8	2.1	110	1190	0.10	1	8	0.1	**0.03**	66.0	1.3	**4.6**	**4.1**	**0.06**	**0.004**	_	**0.47**	**0.12**	0.01	_	0.12	0.61	0.021	1
18/09/2009	P1	1480	430	10	4.5	98	980	0.10	1	6	0.1	**0.37**	47.0	1.3	**3.7**	**3.6**	**0.08**	**0.096**	_	**0.54**	**0.11**	0.01	_	0.17	0.50	0.023	1
01/03/2011	P1	1810	500	8.5	2.5	105	1110	0.10	1	6	0.1	0.01	145.0	64.0	**4.5**	**4.3**	0.03	**0.003**	_	**0.44**	**0.12**	0.01	_	0.13	0.68	0.032	1
28/9/12	P1	2810	850	12	3.1	150	1800	0.14	3	8	0.2	**0.08**	110	64	**5.7**	**5.1**	**0.40**	**0.032**	_	**1.0**	**0.18**	0.01	_	0.15	0.82	0.034	1
29/08/13	P1	3100	850	22	8.0	180	1930	0.32	1	2	**0.3**	**0.05**	120	31	**6.4**	**5.9**	**2.0**	**0.013**	**0.004**	**0.89**	**0.20**	0.01	_	0.16	0.85	0.043	
29/4/14	P1	2810	835	12	4.9	180	1730	0.1	1	75	0.1	**0.04**	130	70	**6.4**	**5.8**	0.04	**0.013**	0.003	**0.59**	**0.15**	0.01	_	0.15	0.89	0.036	320
3/12/14	P1	2520	740	9.8	2.4	160	1580	0.1	1	5	0.1	0.02	94	83	**7.2**	**5.7**	0.04	**0.042**	_	**0.61**	**0.18**	0.01	_	0.14	0.88	0.036	7
28/4/15	P1	2690	820	9.5	3.7	150	1750	0.30	1	8	0.1	**0.03**	95	69	**6.0**	**5.3**	**0.75**	**0.007**	0.004	**0.71**	**0.17**	0.01		0.12	0.75	0.038	1
	Min	1480	430	6	1.2	91	980	0.1	1	2	0.1	0.01	37	1.3	3.7	2.8	0.01	0.001	0.001	0.27	0.11	0.01	0.01	0.12	0.5	0.021	1
	Max	3100	5450	22	8	180	1930	0.32	3	75	1	0.37	145	83	7.2	5.9	2	0.096	0.006	1	0.2	0.01	0.01	0.17	0.89	0.043	320
	Median	2295	740	9.8	2.5	125	1250	0.1	1	7	0.2	0.04	80	44.5	5.85	4.5	0.07	0.0075	0.003	0.56	0.135	0.01	0.01	0.14	0.75	0.036	1

		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Cu	Pb	Zn	Ni	As	Se	Sr	Ba	Li	DOC
08/12/2004	P2		370	27	7.2	110	940	0.19	1	31	**0.9**	**0.1**	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
07/04/2006	P2	1910	495	35	9.6	135	1200	0.27	9	47	**0.3**	**0.13**	28.0	12.0	_	**5.4**	**0.1**	0.001	0.001	**0.45**	**0.13**	0.01	0.01	_	_	_	_
05/10/2006	P2	1050	250	14	2.7	76	650	0.10	1	12	**0.3**	**0.13**	7.2	1.7	_	**3.5**	**0.1**	**0.002**	**0.004**	**0.53**	**0.08**	0.01	0.01	_	_	_	_
16/03/2007	P2	1600	225	13	4.6	67	590	0.13	1	22	**0.6**	**0.06**	41.0	28.0	_	**3.5**	**0.07**	**0.003**	**0.007**	**0.34**	**0.11**	0.01	0.01	_	_	_	_
17/06/2008	P2	1420	340	17	4.7	105	870	0.10	1	25	0.1	**0.15**	58.0	50.0	_	**5.9**	0.03	0.001	0.001	**0.67**	**0.18**	0.01	_	0.14	0.28	0.098	_
12/01/2009	P2	1340	340	20	5.2	105	865	0.15	1	28	0.1	**0.04**	67.0	1.0	**6.8**	**6.2**	0.05	0.001	_	**0.63**	**0.15**	0.01	_	0.14	0.30	0.098	1
18/09/2009	P2	830	200	12	3.4	63	530	0.10	1	9	0.1	**0.28**	40.0	1.1	**4.0**	**4.0**	**0.06**	**0.008**	_	**0.30**	**0.10**	0.01	_	0.085	0.21	0.050	1
01/03/2011	P2	1170	270	18	4.8	91	730	0.10	1	11	0.1	**0.09**	210.0	42.0	**6.6**	**6.2**	0.05	0.001	_	**0.72**	**0.16**	0.01	_	0.14	0.32	0.11	1
28/9/12	P2	1000	240	14	4.0	78	630	0.11	1	6	**0.5**	**0.20**	300	25	**5.4**	**5.2**	**0.21**	0.001	_	**0.69**	**0.14**	0.01	_	0.11	0.25	0.063	1
29/08/13	P2	1020	235	16	5.1	75	630	0.1	1	13	**0.3**	**0.08**	135	18	**5.1**	**4.9**	**0.25**	**0.004**	0.003	**0.60**	**0.13**	0.01	_	0.10	0.24	0.051	1
29/4/14	P2	1030	235	15	5.3	84	655	0.1	1	13	0.1	**0.17**	125	22	**5.3**	**5.1**	0.04	**0.017**	**0.004**	**0.65**	**0.13**	0.01	_	0.11	0.25	0.082	2
03/12/14	P2	950	220	14	3.3	70	600	0.1	7	1	0.2	**0.13**	95	71	**5.9**	**5.0**	0.05	**0.004**	_	**0.67**	**0.14**	0.01	_	0.10	0.23	0.069	3
28/4/15	P2	1020	250	16	4.2	78	660	0.1	1	9	0.1	**0.16**	100	42	**5.6**	**5.2**	0.03	**0.005**	0.003	**0.65**	**0.13**	0.01		0.10	0.21	0.075	1
	Min	830	200	12	2.7	63	530	0.1	1	1	0.1	0.04	7.2	1	4	3.5	0.03	0.001	0.001	0.3	0.08	0.01	0.01	0.085	0.21	0.05	1
	Max	1910	495	35	9.6	135	1200	0.27	9	47	0.9	0.28	300	71	6.8	6.2	0.25	0.017	0.007	0.72	0.18	0.01	0.01	0.14	0.32	0.11	3
	Median	1040	250	16	4.7	78	655	0.1	1	13	0.2	0.13	81	23.5	5.5	5.15	0.055	0.0025	0.003	0.64	0.13	0.01	0.01	0.11	0.25	0.075	1

TAHMOOR / THIRLMERE PIEZOMETER WATER QUALITY (mg/L)

		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Cu	Pb	Zn	Ni	As	Se	Sr	Ba	Li	DOC
07/04/2006	P3	1020	275	20	3.9	61	600	0.20	88	5	**1**	**0.11**	75.0	36.0	_	**3.6**	**0.1**	0.001	0.001	**0.011**	**0.07**	0.01	0.01	_	_	_	_
05/10/2006	P3	1600	390	22	3	105	960	0.21	4	27	0.1	**0.04**	64.0	50.0	_	**3.6**	**0.1**	0.001	0.001	**0.1**	**0.09**	0.01	0.01	_	_	_	_
16/03/2007	P3	2790	365	18	4.5	110	970	0.21	33	19	**1.3**	**0.11**	150.0	85.0	_	**4.3**	**0.06**	0.001	0.003	**0.85**	**0.21**	0.01	0.01	_	_	_	_
17/06/2008	P3	1830	460	19	4.4	110	990	0.14	130	31	**0.5**	**0.11**	360.0	68.0	_	**4.3**	0.01	0.001	0.001	**0.025**	**0.08**	0.01	_	0.21	0.25	0.1	_
12/01/2009	P3	1650	425	20	4.7	115	960	0.20	98	44	0.1	0.02	78.0	50.0	**4.9**	**4.4**	0.02	**0.002**	_	**3.70**	**0.18**	0.01	_	0.18	0.29	0.084	1
18/09/2009	P3	1280	305	19	4.8	97	800	0.10	1	27	**0.8**	**0.13**	230.0	52.0	**4.6**	**4.3**	0.05	**0.004**	_	**1.2**	**0.42**	0.01	_	0.15	0.24	0.073	1
01/03/2011	P3	1500	390	22	5.5	115	970	0.13	21	13	0.1	0.01	120.0	105.0	**5.0**	**4.9**	0.02	0.001	_	**0.10**	**0.08**	0.01	_	0.20	0.33	0.12	10
28/9/12	P3	1560	385	22	5.4	120	985	0.16	22	17	**1.9**	**0.30**	125	110	**4.6**	**4.5**	0.04	0.001	_	**0.056**	**0.08**	0.01	_	0.21	0.31	0.090	11
29/08/13	P3	1630	400	21	7.9	120	1020	0.20	31	14	**0.7**	**0.04**	145	97	**4.7**	**4.6**	0.01	0.001	0.002	**0.33**	**0.09**	0.01	_	0.19	0.30	0.073	
29/4/14	P3	1580	350	24	6.9	125	970	0.1	1	14	0.2	**0.03**	94	71	**4.6**	**4.4**	0.02	**0.004**	0.002	**0.17**	**0.07**	0.01	_	0.19	0.28	0.092	45
03/12/14	P3	1520	375	25	5.2	120	980	0.14	17	15	0.2	**0.03**	105	79	**5.2**	**4.1**	0.01	**0.003**	_	**0.87**	**0.12**	0.01	_	0.21	0.29	0.10	3
28/4/15	P3	1620	415	22	5.8	120	1050	0.14	4	16	0.1	0.02	120	110	**5.0**	**4.7**	0.02	0.001	0.002	**0.096**	**0.07**	0.01	_	0.19	0.32	0.087	1
	Min	1020	275	18	3	61	600	0.1	1	5	0.1	0.01	64	36	4.6	3.6	0.01	0.001	0.001	0.011	0.07	0.01	0.01	0.15	0.24	0.073	1
	Max	2790	460	25	7.9	125	1050	0.21	130	44	1.9	0.3	360	110	5.2	4.9	0.1	0.004	0.003	3.7	0.42	0.01	0.01	0.21	0.33	0.12	45
	Median	1590	387.5	21.5	5	115	970	0.15	21.5	16.5	0.35	0.04	120	75	4.8	4.35	0.02	0.001	0.002	0.135	0.085	0.01	0.01	0.19	0.29	0.09	3
ANZECC											**0.25**	**0.02**			**1.9**	**1.9**	**0.055**	**0.0014**	**0.0034**	**0.008**	**0.011**	**0.013(V)**	**0.011**				
		TDS	**Na**	**Ca**	**K**	**Mg**	**Cl**	**F**	**HCO3**	**SO4**	**Tot N**	**Tot P**	**Fe Tot**	**Fe Filt**	**Tot Mn**	**Mn Filt**	**Filt Al**	**Cu**	**Pb**	**Zn**	**Ni**	**As**	**Se**	**Sr**	**Ba**	**Li**	**DOC**
28/02/2005	P4	7100	1600	180	55	585	3830	0.31	1210	150	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
07/04/2006	P4	6890	1580	185	59	565	3740	0.37	1160	145	0.2	**0.1**	1.3	0.0	_	0.66	0.01	**0.002**	0.001	0.005	0.01	0.01	0.01	_	_	_	_
05/10/2006	P4	6750	1490	185	58	625	3690	0.27	1240	150	0.1	0.01	0.5	0.5	_	0.59	0.01	0.001	0.001	0.006	0.01	0.01	0.01	_	_	_	_
16/03/2007	P4	11100	1630	185	54	580	3780	0.25	1250	140	**0.3**	**0.1**	1.8	0.4	_	0.63	0.01	**0.002**	0.001	**0.01**	0.01	0.01	0.01	_	_	_	_
17/06/2008	P4	6950	1600	160	41	580	3730	0.22	1220	165	0.1	**0.04**	56.0	0.3	_	0.79	0.03	0.001	0.001	**0.036**	**0.03**	0.01	_	1	0.08	1.1	_
12/01/2009	P4	6820	1480	165	63	590	3740	0.25	1100	160	0.1	**0.04**	3.8	0.1	0.8	0.72	0.02	0.001	_	**0.17**	**0.03**	0.01	_	1.1	0.10	1	1
18/09/2009	P4	7040	1550	170	53	630	3720	0.24	1280	140	**0.9**	**0.38**	21.0	0.1	1.1	0.51	0.04	**0.002**	_	**0.009**	0.01	0.01	_	1.1	0.09	1.0	1
01/03/2011	P4	7120	1420	210	64	610	3660	0.21	1300	135	0.1	0.01	5.9	1.3	1.0	1.0	0.04	**0.002**	_	**0.024**	**0.02**	0.01	_	1.3	0.12	1.2	8
28/9/12	P4	6260	1410	180	53	560	3310	0.24	1220	150	0.2	**0.19**	21	0.15	1.9	0.76	0.02	**0.002**	_	**0.026**	**0.02**	0.01	_	1.1	0.089	1.0	1
29/08/13	P4	6220	1380	180	65	570	3260	0.32	1260	150	0.2	**0.06**	95	3.4	0.84	0.80	0.03	0.001	0.001	**0.012**	0.01	0.01	_	1.0	0.075	0.87	
29/4/14	P4	6210	1380	160	52	520	3200	0.24	1240	140	0.1	**0.06**	0.43	0.14	0.75	0.71	0.01	0.001	0.001	**0.026**	0.01	0.01	_	1	0.082	0.97	1
03/12/14	P4	6310	1510	140	45	560	3400	0.19	120	1230	**1.1**	**0.10**	3.1	1.2	1.3	0.84	0.01	0.001	_	**0.12**	**0.02**	0.01	_	1.1	0.11	1.1	1
	Min	6210	1380	140	41	520	3200	0.19	120	135	0.1	0.01	0.43	0.03	0.75	0.51	0.01	0.001	0.001	0.005	0.01	0.01	0.01	1	0.075	0.87	1
	Max	11100	1630	210	65	630	3830	0.37	1300	1230	1.1	0.38	95	3.4	1.9	1	0.04	0.002	0.001	0.17	0.03	0.01	0.01	1.3	0.12	1.2	8
	Median	6855	1500	180	54.5	580	3705	0.245	1230	150	0.2	0.06	3.8	0.31	1	0.72	0.02	0.001	0.001	0.024	0.01	0.01	0.01	1.1	0.087	1	1

TAHMOOR / THIRLMERE PIEZOMETER WATER QUALITY (mg/L)

		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Mn Filt	Filt Al	Cu	Pb	Zn	Ni	As	Se	Sr	Ba	Li	DOC
28/02/2005	P5	2560	730	8.3	21	145	1510	0.77	86	67	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
07/04/2006	P5	2880	850	8.8	23	145	1700	79.00	82	72	**0.6**	**0.1**	3.4	0.1	_	**5**	0.01	0.001	0.001	**0.3**	**0.14**	0.01	0.01	_	_	_	_
05/10/2006	P5	2900	795	8.4	22	155	1620	0.70	96	72	0.1	0.01	4.8	0.1	_	**4.2**	0.01	0.001	0.001	**0.28**	**0.11**	0.01	0.01	_	_	_	_
16/03/2007	P5	4100	765	7.9	21	155	1590	0.85	89	66	**0.6**	0.01	4.2	0.1	_	**4.2**	0.01	0.001	0.001	**0.23**	**0.15**	0.01	0.01	_	_	_	_
17/06/2008	P5	3020	850	7	24	180	1720	0.53	1720	86	**0.4**	**0.03**	6.4	0.1	_	**6.6**	0.04	0.001	0.001	**0.45**	**0.23**	0.001	_	0.22	0.11	0.22	_
12/01/2009	P5	2610	700	11	25	165	1520	0.72	78	83	**0.4**	**0.03**	120.0	0.1	**6.7**	**6.1**	0.03	0.001	_	**0.52**	**0.019**	0.01	_	0.22	0.11	0.19	1
18/09/2009	P5	2530	700	11	23	160	1520	0.83	83	70	**0.4**	**0.04**	20.0	0.1	**6.0**	**5.8**	0.04	**0.002**	_	**0.23**	**0.15**	0.01	_	0.22	0.09	0.19	1
	Min	2530	700	7	21	145	1510	0.53	78	66	0.1	0.01	3.4	0.06	6	4.2	0.01	0.001	0.001	0.23	0.019	0.001	0.01	0.22	0.093	0.19	1
	Max	4100	850	11	25	180	1720	79	1720	86	0.6	0.1	120	0.1	6.7	6.6	0.04	0.002	0.001	0.52	0.23	0.01	0.01	0.22	0.11	0.22	1
	Median	2880	765	8.4	23	155	1590	0.77	86	72	0.4	0.03	5.6	0.085	6.35	5.4	0.02	0.001	0.001	0.29	0.145	0.01	0.01	0.22	0.11	0.19	1

		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Filt Al	Cu	Pb	Zn	Ni	As	Se	Sr	Ba	Li	DOC
17/06/2008	P6	570	145	10	2.5	37	280	0.68	110	21	0.1	**0.12**	14.0	0.0	_	1.1	0.01	0.001	0.001	**0.047**	0.01	0.01	_	0.1	0.09	0.039	_
12/01/2009	P6	510	130	12	2.9	37	265	0.17	73	22	0.1	**0.09**	34.0	0.1	0.8	0.41	0.01	0.001	_	**0.04**	**0.02**	0.01	_	0.1	0.07	0.029	1
18/09/2009	P6	580	145	16	3.7	40	290	0.20	93	25	**0.5**	**0.20**	31.0	0.1	**2.0**	1.8	0.02	0.001	_	**0.047**	**0.02**	0.01	_	0.12	0.10	0.033	1
01/03/2011	P6	550	120	12	3.3	36	270	0.11	72	19	0.1	**0.20**	29.0	0.2	1.1	1.0	0.03	0.001	_	**0.022**	0.01	0.01	_	0.12	0.16	0.066	1
28/9/12	P6	550	140	12	4.3	36	290	0.12	77	22	0.1	**0.11**	46	10	**2.8**	1.9	0.04	**0.002**	_	**0.088**	**0.02**	0.01	_	0.10	0.15	0.028	130
29/08/13	P6	535	120	12	3.8	35	270	0.14	73	19	0.2	**0.28**	26	0.17	1.2	1.2	0.04	**0.003**	0.001	**0.033**	0.01	0.01	_	0.13	0.12	0.051	_
29/4/14	P6	555	120	15	4.5	35	275	0.12	67	23	0.1	**0.04**	8.1	0.12	1.3	1.2	0.01	**0.002**	0.001	**0.027**	0.01	0.01	_	0.12	0.12	0.035	1
	Min	510	120	10	2.5	35	265	0.11	67	19	0.1	0.04	8.1	0.04	0.75	0.41	0.01	0.001	0.001	0.022	0.01	0.01	_	0.1	0.07	0.028	1
	Max	580	145	16	4.5	40	290	0.68	110	25	0.5	0.28	46	10	2.8	1.9	0.04	0.003	0.001	0.088	0.02	0.01	_	0.13	0.16	0.066	130
	Median	550	130	12	3.7	36	275	0.14	73	22	0.1	0.12	29	0.12	1.25	1.2	0.02	0.001	0.001	0.04	0.01	0.01	_	0.12	0.12	0.035	1

TAHMOOR / THIRLMERE PIEZOMETER WATER QUALITY (mg/L)

ANZECC											0.25	0.02			1.9	1.9	0.055	0.0014	0.0034	0.008	0.011	0.013(V)	0.011				
		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Mn Filt	Filt Al	Cu	Pb	Zn	Ni	As	Se	Sr	Ba	Li	DOC
31/05/2008	P7	250	46	30	3	11	96	0.77	87	13	0.1	0.03	0.3	0.0		0.43	0.04	0.002	_	0.14	0.01	0.01	_	0.17	0.06	0.017	_
12/01/2009	P7	235	40	35	2.8	12	92	0.62	110	5	0.1	0.02	0.6	0.0	1.1	1.1	0.01	0.001	_	0.041	0.01	0.01	_	0.14	0.05	0.013	16
18/09/2009	P7	285	48	34	3.6	16	110	0.73	120	3	0.4	0.06	12.0	0.3	1.6	1.6	0.01	0.001	_	0.062	0.01	0.01	_	0.24	0.08	0.017	12
01/03/2011	P7	265	46	39	3.2	13	98	0.56	130	4	0.7	0.01	5.9	0.2	1.6	1.5	0.01	0.001	_	0.040	0.01	0.01	_	0.18	0.06	0.018	9
28/9/12	P7	255	25	43	4.4	16	110	0.57	83	5	2.5	0.31	17	15	2.5	2.4	0.04	0.001	_	0.076	0.01	0.01	_	0.22	0.070	0.014	17
29/08/13	P7	310	55	41	4.6	17	120	0.65	155	4	1.4	0.01	42	0.05	2.3	2.3	0.05	0.002	0.001	0.029	0.01	0.01	_	0.21	0.057	0.013	_
29/4/14	P7	360	62	41	8.1	18	135	0.56	140	11	1.9	0.28	4.4	0.93	2.9	2.8	0.02	0.001	0.001	0.02	0.01	0.01	_	0.024	0.081	0.021	7
03/12/14	P7	360	61	49	5.0	18	130	0.60	13	160	2.6	0.05	4.8	4.2	3.6	3.0	0.03	0.001	_	0.028	0.01	0.01	_	0.25	0.080	0.025	13
28/4/15	P7	370	64	48	6.1	16	130	0.52	160	18	2.0	0.05	3.2	2.9	3.1	2.9	0.03	0.001	0.001	0.023	0.01	0.01	_	0.19	0.073	0.017	32
	Min	235	25	30	2.8	11	92	0.52	13	3	0.1	0.01	0.3	0.01	1.1	0.43	0.01	0.001	_	0.02	0.01	0.01		0.024	0.05	0.013	7
	Max	370	64	49	8.1	18	135	0.77	160	160	2.6	0.31	42	15	3.6	3	0.05	0.002	_	0.14	0.01	0.01		0.25	0.081	0.025	32
	Median	285	48	41	4.4	16	110	0.6	120	5	1.4	0.05	4.8	0.31	2.4	2.3	0.03	0.001	_	0.04	0.01	0.01		0.19	0.07	0.017	13
		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Mn Filt	Filt Al	Cu	Pb	Zn	Ni	As	Se	Sr	Ba	Li	DOC
31/05/2008	P8	380	105	9.1	6.2	19	210	0.20	17	15	0.4	0.01	0.5	0.2		1.4	0.01	0.001	_	0.065	0.03	0.026	_	0.01	0.1	0.11	
12/01/2009	P8	135	21	16	2.6	7.5	37	0.34	62	14	0.1	0.05	6.7	0.0	0.23	0.05	0.01	0.001	_	0.072	0.01	0.01	_	0.11	0.01	0.003	20
18/09/2009	P8	240	50	26	4.7	11	90	0.37	93	18	1.3	0.03	8.5	0.2	0.51	0.65	0.02	0.001	_	0.16	0.01	0.01	_	0.17	0.04	0.008	20
01/03/2011	P8	445	91	45	6.6	12	180	0.25	110	29	2.4	0.01	0.2	0.0	1.2	1.1	0.01	0.002	_	0.45	0.07	0.01	_	0.25	0.07	0.025	20
28/9/12	P8	470	120	11	14	26	255	0.12	50	14	1.2	0.20	44	0.10	2.3	1.7	0.03	0.002	_	0.12	0.02	0.01	_	0.084	0.11	0.048	2
29/08/13	P8	480	115	7.4	9.5	25	255	0.14	19	12	0.3	0.05	57	0.01	2.1	2.0	0.01	0.001	0.001	0.042	0.01	0.01	_	0.062	0.14	0.029	
29/4/14	P8	545	110	51	4.3	25	255	0.15	115	16	0.1	0.16	34	0.11	2	2	0.01	0.001	0.001	0.027	0.01	0.01	_	0.067	0.13	0.027	1
03/12/14	P8	425	95	11	2.6	26	250	0.11	15	9	0.3	0.10	26	25	2.5	2.1	0.03	0.003	_	0.24	0.03	0.01	_	0.066	0.16	0.032	2
28/4/15	P8	440	120	13	3.1	26	270	0.11	13	17	0.2	0.06	3.5	0.09	2.1	2.0	0.02	0.001	0.001	0.095	0.02	0.01	_	0.069	0.14	0.025	9
	Min	135	21	7.4	2.6	7.5	37	0.11	13	9	0.1	0.01	0.22	0.01	0.23	0.05	0.01	0.001	_	0.027	0.01	0.01	_	0.01	0.01	0.003	1
	Max	545	120	51	14	26	270	0.37	115	29	2.4	0.2	57	25	2.5	2.1	0.03	0.003	_	0.45	0.07	0.026	_	0.25	0.16	0.11	20
	Median	440	105	13	4.7	25	250	0.15	50	15	0.3	0.05	8.5	0.1	2.05	1.7	0.01	0.001	_	0.095	0.02	0.01	_	0.069	0.11	0.027	9

Niche Environment and Heritage
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16 September 2015

Belinda Treverrow
Approvals & Community Co-ordinator
Tahmoor Colliery
Remembrance Drive
Tahmoor, NSW 2573

Dear Belinda,

Re: Tahmoor Colliery Longwall 28 End of Panel Reporting: Cultural heritage review and reporting

As outlined in the Management Plan and Aboriginal Heritage Impact Permit (AHIP #3781) for the Aboriginal archaeological site Redbank Creek-1 (52-2-3254), Niche Environment and Heritage (Niche) has undertaken a further site inspection of Redbank Creek-1 with representatives from the following Registered Aboriginal Parties (RAPs), to assess any observable impacts that have occurred to the site, identified during the extraction of Longwall 28:

- Cubbitch Barta Native Title Claimants
- Tharawal Local Aboriginal Land Council (TLALC) and
- Peter Falk Consultancy

An inspection was also carried out on Aboriginal archaeological site Tahmoor 1 (52-2-2076). The inspections found that no new impacts have occurred at Redbank Creek-1 or Tahmoor 1 and the following recommendations have been made:

- Tahmoor Colliery should continue their consultation with the Aboriginal community in regards to Redbank Creek-1 (52-2-3254) as required by AHIP # 3781; and
- Redbank Creek-1 (52-2-3254) should continue to be monitored during the extraction of Longwalls 29, 30 and 31.

Please do not hesitate to contact me should you require any further information.

Yours sincerely

Renée Regal
Niche Environment and Heritage

Appendix 1: Redbank Creek-1 and Tahmoor-1 End of Panel assessment for Longwall 28

Statement of management objective

The management objective of Redbank Creek-1 (52-2-3254) and Tahmoor-1 (52-2-2076) is to ensure that any impacts to the sites resulting from the extraction of Longwall 28 are reduced and minimised over the long term. The impacts to be minimised include adverse effects to the art panels of the sites, through further movements of the shelter or through changes to water seepage patterns due to subsidence related cracking.

Background and introduction

Niche was commissioned by Tahmoor Colliery to conduct an End of Panel assessment of the Aboriginal cultural heritage and archaeological sites within the limit of subsidence of Longwall 28 at Tahmoor Colliery.

The site inspections for this End of Panel were carried out by Renée Regal (Archaeologist-Niche) on 24 June and 14 July 2015, Glenda Chalker (RAP-Cubbitch Barta Native Title Claimants), Abbi Whillock (RAP-Tharawal Local Aboriginal Land Council), Duncan Falk (RAP-Peter Falk Consultancy) and Belinda Treverrow (Approvals and Community Co-ordinator-Tahmoor Colliery) on 14 July 2015.

Strata Control Technologies (SCT) (2014) predicted that the extraction of Longwalls 28 will have less than 20% chance of harming Redbank Creek-1. Such a risk is considered relatively high in the context of the Southern Coalfields, therefore an Aboriginal Heritage Impact Permit (AHIP) for Redbank Creek-1 (52-2-3254) has been obtained.

During this assessment no observable impacts as a result of mining were identified at the Aboriginal sites of Redbank Creek-1 (52-2-3254) and Tahmoor-1 (52-2-2076). However, some damage has been observed to the back of the shelter at site Redbank Creek-1 and its deposit, from wild goats rubbing against the sandstone and living in the shelter.

Subsidence results summary (MSEC)

The End of Panel Subsidence Report for Longwall 28 prepared by MSEC (MSEC777_Revision A) is a comprehensive report which addresses all aspects of the recorded subsidence parameters resulting from the extraction of Longwall 28.

In relation to matters that may affect Aboriginal cultural heritage values, MSEC notes the following (MSEC777: Table 4.1):

- In relation to Redbank Creek, stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over Longwall 28.
- No impacts were observed during the extraction of Longwall 28 to the steep slopes and cliffs.
- There were no impacts observed to Redbank Creek-1 and Tahmoor-1.

Aboriginal community consultation

Aboriginal community consultation has continued as outlined in the recommendations made by Biosis Research (2009) and Niche (2014).

The following Aboriginal groups were contacted via email and telephone in June 2015 to organise a site inspection and sent a copy of the Longwall 28 End of Panel report:

- Cubbitch Barta Native Title Claimants
- Tharawal Local Aboriginal Land Council
- Peter Falk Consultancy

The following RAPs registered their interest to attend:

- Mrs Glenda Chalker, Cubbitch Barta Native Title Claimants
- Mr Duncan Falk, Peter Falk Consultancy
- Ms Abbi Whillock, Tharawal Local Aboriginal Land Council

A draft copy of this report was sent to the RAPs on 17 September 2015. All comments have been incorporated into this finalised report with each RAPs response being collated when received.

Previous site assessment summaries

Tahmoor-1 (52-2-2076) was recorded with AHIMS in the 1990s prior to any detailed assessments of the site due to potential subsidence effects associated with longwall mining. The site was inspected and assessed by Biosis Research (Biosis) in 2009.

Tahmoor-1 52-2-2076

The site is described as a shelter with art and deposit. The site was assessed in 2009 by Biosis, who recorded the following details on the site:

This shelter with art and deposit site is situated on the top of a creek line, just behind a new housing subdivision. The site comprises of a single cavernously weathered shelter. The weathered cavern forms a moderately sized overhang that measures 8 x 3.2 x 1.6 m, and has a 6 x 1.5 m floor space of about 1 x 2 m each (Biosis 2009:71).

The art comprises of charcoal indeterminate lines and a single white hand stencil.

Redbank Creek-1 (52-2-3254) was also recorded with AHIMS in the 1990s prior to any detailed assessments of the site due to potential subsidence effects associated with longwall mining. The site was inspected and assessed by Biosis in 2009 and Redbank Creek-1 was re-recorded by Niche in 2014, as part of Tahmoor Colliery's AHIP application process. Summaries of both assessments are outlined below.

Redbank Creek-1 52-2-3254

This site is a shelter with art and deposit. The site was assessed in 2009 by Biosis, who recorded the following details of the site:

The site has a large overhang that measures 24x4x3m with a living area approximately 10x5m; The shelter was formed by blockfall and cavernous weathering and faces north west; Grey loamy sand to an approximate depth of 35cm covers the floor of the shelter and 18 artefacts were identified; The art consists of one complete infill macropod and one infill indeterminates. Biosis also identified a number of new indeterminates under graffiti (Biosis 2009:72).

Biosis assessed that the condition of the shelter remained the same as its original recording, with the exception of faded and damaged artwork due to graffiti. The shelter was relatively dry with little microflora damage. The deposit had been disturbed by goats (Biosis 2009:72).

Niche (2014) conducted a detailed condition assessment of the site to be used as a baseline for any future assessments of the site's condition prior to any subsidence induced movements. The recording of the site included completing a revised site plan and section drawing (Drawing 1) and additional photographs were taken of the entire site, and features that will act as monitoring points. Attempts were made to find the previously identified stone artefacts within the drip-line, but they could not be located. It was considered that the artefacts had been disturbed through the extensive disturbance to the site by goats. The art was concluded to be in similar condition to its original recording in 1994.

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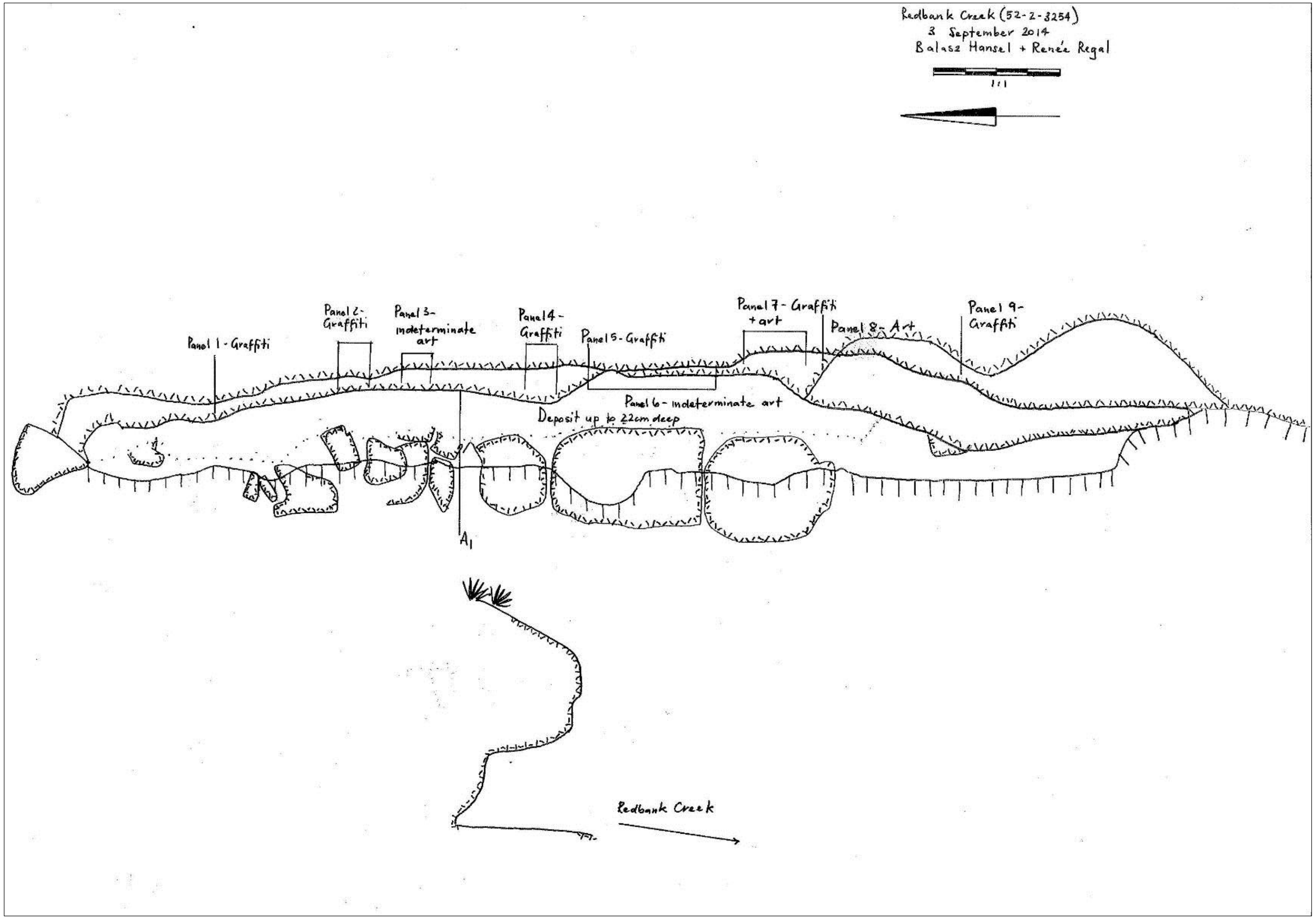


Drawing 1. Revised site plan and section drawing of Redbank Creek-1 (Source: Niche 2014)

Subsidence summary

Strata Control Technologies (SCT) (2014) undertook a subsidence assessment for Redbank Creek-1. The assessment found that:

Site 52-2-3254 is associated with a sandstone cliff formation that is approximately 40m long, 6m high, and has an overhang of up to 4m. The probability of a rock fall at this site is assessed as being approximately 3 % based on experience of subsiding similar cliff formations elsewhere at Tahmoor Mine. The probability of perceptible impacts to the cliff formation such as cracking, shear movements, and possible dislocation of small pieces is assessed as being less that 20%. The bed of Redbank Creek adjacent to the site is considered likely to become fractured with surface flow diversion into the sub-surface fracture network (SCT 2014:i).

The assessment also found that intense rainfall in early 2013 had resulted in high levels of natural ground movement particularly in the vicinity of Dog Trap Creek, located near Redbank Creek. Natural rock falls, block movements, opening up of cracks in the ground, tree root invasion, and sediment rick water flowing out from the back of the overhanging rock formations caused discolouration of the back walls and the depositing of sediment. No mining had occurred in this area and demonstrates that such natural changes have the potential to degrade archaeological sites, irrespective of mining activity (SCT 2014:i).

MSEC (2014) prepared a management plan for potential impacts to Redbank Creek-1. The level of risk associated with impacts on the rock overhang, resulting in impacts on the artwork were assessed as moderate to very slight to low.

Monitoring measures of the site outlined in the plan are:

Ground Survey

Survey pegs are located along the valley sides of Redbank Creek to monitor subsidence and horizontal movements. They will be surveyed by Tahmoor Colliery on a minimum frequency of once per month when Redbank Creek is located with the active subsidence zone for each of Longwalls 28 to 31.

The survey results will inform the CHMG of the general nature of subsidenec movements in the vicinity of the site and when the rates of change in subsidenec have reduced to low levels.

Visual Inspections

Visual inspections of Redbank Creek will be undertaken by Tahmoor Colliery on a weekly basis during the period of active subsidence. The inspector will check the condition of Redbank Creek 1 from a remote distance as part of these inspections. For safety reasons, detailed inspections will not be undertaken during periods of active subsidence as if a rock fall occurs, there may be little warning beforehand.

*A detailed visual inspection will be undertaken by an archaeologist within 4 months of the completion of extraction of each of Longwalls 28, 29, 30 and 31 and findings distributed to Office of Environment and Heritage and Aboriginal Stakeholders in the End of Panel Report (*MSEC 2014:11).

This End of Panel report has been written in accordance with the MSEC 2014 Management Plan for Redbank Creek-1.

Site inspection and results

A site inspection and assessment was carried out on 24 June 2015 and 14 July 2015 by Renée Regal (Archaeologist), Belinda Treverrow (Community and Approvals Co-ordinator, Tahmoor Colliery) and the following Registered Aboriginal Parties (RAPs) attended the field Assessment on 14 July 2015:

- Mrs Glenda Chalker (Cubbitch Barta Native Title Claimants)
- Abbi Whillock (Tharawal Local Aboriginal Land Council)
- Duncan Falk (Peter Falk Consultancy)

The purpose of the assessment was to observe and document the current conditions of Redbank Creek-1 so that any changes since the previous recordings could be documented. A summary of the findings are outlined in Table 1.

Table 1: Results

AHIMS Site #	Site Name	Results of Inspection	Photos
52-2-2076	Tahmoor-1	The condition of this site has not changed since the Biosis 2009 condition assessment of the site.	 Plate 1: Southern end of Tahmoor-1 (Source: Biosis 2009)

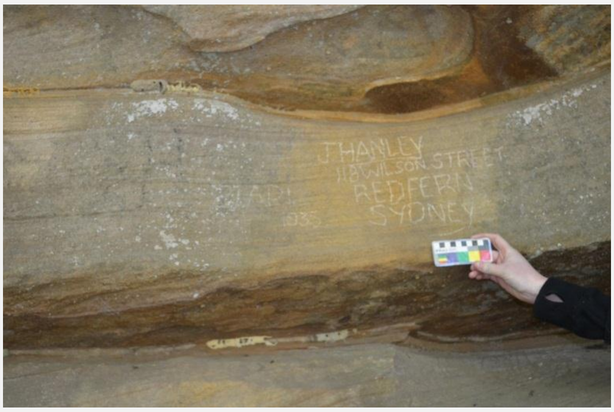
52-2-3254	Redbank Creek-1	The condition of the site has not changed due to mining related impacts since the Niche 2014 condition assessment of the site. The floor and back wall of the shelter however have suffered some damage as a result of wild goats living in the shelter.	 Plate 2: View of Redbank Creek-1, photograph taken facing north (Source: Niche)  Plate 3: Example of scratched graffiti at the southern end of the shelter (Source: Niche)  Plate 4: Overview photograph of graffiti on panel 3. See Drawing 1 for location at site (Source: Niche)

Plate 5: Overview photograph of art on panel 7; a charcoal infill macropod, left hand side of the photograph. See Drawing 1 for location at site (Source: Niche)

Discussion and Conclusion

There were no observable changes as a result of the extraction of Longwall 28 to Redbank Creek-1 and Tahmoor-1.

The Trigger Action Response Plan (TARP) (Table 2) contains the Performance Measures along with the proposed Corrective Management Actions for Aboriginal heritage sites; as outlined in the Longwalls 27 to 30 (Xstrata Coal Tahmoor 2013).

The recommendations made below are designed to allow Tahmoor Colliery to discharge its obligations under the afore mentioned management plan.

Recommendations

Based on community consultation with Aboriginal Stakeholders, baseline recordings, geotechnical assessments by Dr Ken Mills and Daryl Kay of MSEC and Aboriginal Cultural Heritage Assessments by Niche (2014) and Biosis (2009), the following recommendations have been made for Redbank Creek-1 (52-2-3254).

Recommendation 1:

Tahmoor Colliery should continue their consultation with the Aboriginal Community in regards to Redbank Creek-1 (52-2-3254).

Recommendation 2:

Redbank Creek-1 (52-2-3254) should continue to be monitored during the extraction of Longwalls 28, 29, 30 and 31.

Table 2: Trigger Action Response Plan

Feature	Monitoring			Management	
	Prior to Mining	**During Mining**	**Post Mining**	**Trigger**	**Action**
Aboriginal sandstone shelter sites: 52-2-3254 52-2-2078 And other sites identified	Baseline archival recording prior to Longwall mining Re-recording of the principal components identified by Sefton (Sefton 2000) Macro and micro recording using digital photography (Navin Officer 2003) Detailed elevation plans of shelter walls recording structural and surface features including but not limited to the art itself, graffiti, joints, bedding planes, exfoliation scars, cracks, mineral and micro-organism growth, drip line and water seepage locations.	First impact assessment recording following initial subsidence movement of site Sandstone shelter and sites will be monitored during mining.	Further impact assessment recording twelve months after subsidence movement of the sites.	**Negligible** Change in shelter conditions not attributable to natural weathering or preservation that do not alter the heritage values of the place- e.g. mineral growth or micro-organism growth. Changes external to the shelter that effect cracking, boulder slumping, rock and/or tree falls.	Continue with monitoring program if safe to do so. COMPLETED BY THIS REPORT Condition assessment and photographic record COMPLETED BY THIS REPORT Notify other relevant specialists COMPLETED BY THIS REPORT Notify key Stakeholders e.g. Aboriginal Groups, DRE and OEH COMPLETED BY THIS REPORT Report in End of Panel report and AEMR. COMPLETED BY THIS REPORT
				Major Change in shelter condition not attributable to natural weathering or preservation- change in drip line or seepage, e.g. cracking or exfoliation of overhang or shelter, movement or opening of existing planes and joints. NO MAJOR TRIGGERS	Continue with proposed monitoring program Condition assessment recorded Notify relevant technical specialists and seek advice on any Corrective Management Action (CMA) required. Notify key stakeholders e.g.

	OBSERVED, SO NO ACTION REQUIRED.	Aboriginal Groups, DRE, OEH. Implement agreed CMAs as approved. Report in mitigation report, End of Panel Report and AEMR.
	Severe Change in shelter conditions not attributable to natural weathering or preservation- e.g. cracking or exfoliation of art panel, movement of existing planes and joints in panel, block fall within the shelter or overhang, shelter or overhang collapse. NO SEVERE TRIGGERS OBSERVED, SO NO ACTION REQUIRED.	Continue with proposed monitoring program Condition assessment recorded Immediately notify relevant Aboriginal Groups, government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. Site visits with stakeholders if required. Develop site CMA in consultation with key stakeholders within 1 month. Completion of works following approvals Issue CMA report within 1 month of works completion Conduct initial follow up monitoring and reporting within 2 months of CMA completion if required.

		Report in mitigation report, End of Panel Report and AEMR.

References

Biosis Research 2009 *Longwalls 27-30 Subsidence Management Plan.* An unpublished report for Xstrata, Tahmoor Colliery

MSEC 646-46 RevA 2014. *Glencore Tahmoor Colliery- Longwalls 28-31: Management Plan for Potential Impacts to Item of Cultural Significance; Redbank Creek 1.* An unpublished Management Plan for Tahmoor Colliery

Niche Environment and Heritage 2014. *Redbank Creek 1 Archaeological Report*. Prepared for Tahmoor Colliery.

Strata Control Technologies TAH4182_REV1. 2014. Subsidence Assessment for Archaeological Site 52-2-3254, Redbank Creek. An unpublished report for Tahmoor Colliery

Xstrata Coal Tahmoor 2013 *Longwalls 27 to 30 Environment Management Plan*. An unpublished report for Tahmoor Colliery.

Appendix 2 Aboriginal Community responses to the draft report

(To be included once received).

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Belinda Treverrow
Approvals & Community Coordinator
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Remembrance Drive, Tahmoor,
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16 September 2015

via e-mail

Belinda.Treverrow@glencore.com.au

Dear Belinda,

RE: Terrestrial ecological assessment for Longwall 28 – Tahmoor North End of Panel report

As requested Niche Environment and Heritage Pty Ltd (Niche) has undertaken a review of the predicted and observed impacts resulting from the extraction of Longwall 28 at Tahmoor North on terrestrial ecology values. An assessment against the Trigger Action Response Plans (TARPs) toward biodiversity values has also been made. The assessment is attached for inclusion in Tahmoor Coal's End of Panel Report for Longwall 28.

Our assessment is based on results of environmental monitoring undertaken by MSEC and GeoTerra, and a field survey of Redbank Creek and Myrtle Creek conducted on the 24th of June 2015 by Luke Baker (Niche).

Our assessment concludes that the environmental impacts observed in relation to mining Longwall 28 are within the predicted level assessed in the Tahmoor Colliery Longwalls 27-30 Impacts of Subsidence on Terrestrial Flora and Fauna report (Biosis Research 2009).

The assessment concludes that there were no significant impacts to threatened flora and fauna or their habitats as outlined in the Trigger Action Response Plans (TARPs).

I trust that the following report is adequate for your purposes. Please do not hesitate to contact me should you require any further information.

Yours sincerely

Luke Baker

Senior Botanist

Introduction

Glencore Coal Assets Pty Ltd (Tahmoor Colliery) is required to develop an End of Panel (EoP) Report for Longwall 28, to comply with Subsidence Management Plan Approval. Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Tahmoor Colliery to conduct an EoP assessment of the terrestrial ecological values within the limit of subsidence of Longwall 28.

Background review

This report takes into consideration the predicted and observed impacts on terrestrial ecological values within this area from previous assessments. Previous assessments include:

- Mine Subsidence Engineering Consultants (MSEC) (2015) Glencore: Tahmoor Colliery - Longwall 28 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 28.
- Biosis Research (2009) Tahmoor Colliery Longwalls 27-30 Impacts of Subsidence on Terrestrial Flora and Fauna Final Report.
- Geoterra (2015). End of Longwall 28 Streams, Dams & Groundwater Monitoring Report, Tahmoor, NSW. Report No. TA24-R1.

Field survey

A field assessment was conducted by Luke Baker (Botanist – Niche) on the 24th of June 2015. The field survey targeted areas along Redbank Creek and Myrtle Creek that were in the limits of subsidence as shown in Figure 1. The field assessment involved traversing the creek habitat, and general observation of habitat and vegetation health, threatened flora searches, and any potential impacts as a result of subsidence to habitat. No vegetation validation was considered necessary and as such, no formal vegetation plots were conducted.

Subsidence Monitoring Results (MSEC)

The EoP Subsidence Report for Longwall 28 prepared by MSEC (2015 – MSEC777) is a comprehensive report which addresses all aspects of the recorded subsidence parameters resulting from the extraction of Longwall 28.

Subsidence has the potential to impact terrestrial ecological values. Table 1 outlines the observed subsidence impacts and the potential consequences for terrestrial ecological values. Overall, the recorded subsidence on natural landscape features resulting from the extraction of Longwall 28 was similar to those predicted.

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Table 1. Observed impacts from Longwall 28 due to subsidence and their correlation to potential terrestrial ecology impacts

Natural feature	Summary of predicted impacts (MSEC 2015)	Subsidence monitoring results (MSEC 2015)	Correlation to Terrestrial Ecological Values	Terrestrial Ecology Impacts Due to Longwall 28
Myrtle Creek and Red Bank 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 both creeks over LW's 25 to 28. Increased ferruginous and salinity levels have been observed downstream of both Myrtle and Redbank Creek subsidence zones, along with elevated nickel, zinc, iron and manganese in Redbank Creek due to subsidence.	Change in water levels due to ponding, flooding and the resultant inundation or desiccation has the potential to alter the distribution of water plant habitat for amphibians, drown riparian vegetation or remove foraging and breeding habitat for any fauna dependant on pools.	No observed impacts to terrestrial ecological values for threatened species. No threatened flora or fauna have previously been recorded in the vicinity of Longwall 28.
Steep slopes	Potential soil slippage and cracking to slopes. Large scale slope failures or cliff instabilities unlikely.	No impacts observed during the mining of Longwall 28.	Soil slippage may result in erosion causing vegetation loss, direct impacts to threatened fauna and disruption of habitat.	No observed impacts. No die back of riparian vegetation observed. Impact to terrestrial ecological values unlikely.

Environmental Monitoring

The surface water, dams and groundwater monitoring program for Longwall 28 has been conducted by GeoTerra since June 2004. The monitoring is consistent with the Tahmoor Coal (2013) Tahmoor Colliery Longwalls 27 to 30 Environment Management Plan.

No threatened flora and fauna species were identified in field surveys undertaken by Biosis (2009). Impact assessments concluded that mining Longwalls 27-30 would not have a significant impact on any threatened species or an Endangered Ecological Community (EEC) listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and/or *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Therefore no formal terrestrial ecology monitoring program was proposed for Longwall 28. However, monitoring by GeoTerra has assessed the following features which relate to terrestrial ecology:

- 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 level
- Presence and use of groundwater bores
- Assessment of standing water levels and water quality.

Monitoring results

GeoTerra has reported minor impacts from the ongoing monitoring of environmental values within the limit of subsidence of Longwall 28:

- Stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in both creeks over LW's 25 to 28;
- No adverse effect on stream ecology has been reported;
- No localised stream ponding due to subsidence has been observed;
- Increased salinity has been observed downstream of both Myrtle and Redbank Creek subsidence zones, along with elevated nickel, zinc iron and manganese in Redbank Creek due to subsidence;
- No plateau stream bed incision.

Impacts on threatened biodiversity

The following is based on information from the flora and fauna assessment undertaken by Biosis Research (2009) and the results of the monitoring undertaken by GeoTerra (2014). No separate field inspections were undertaken by Niche as no impacts exceeding the predicted impacts were identified and the current monitoring was deemed acceptable for the assessment.

The impact assessment conducted by Biosis Research (2009) assumed the following impacts as a result of subsidence:

- Minor fracturing would be observed in some locations in the beds of Redbank and Myrtle creeks during the mining of Longwalls 27-30
- Major fracturing and surface water flow diversion could occur along some sections of Redbank and Myrtle creeks during the mining of longwalls 27-30
- It was considered unlikely that there would be any net loss of water from the catchment, as diverted flow would be expected to emerge further downstream
- It was anticipated that no significant change to the creek water quality will occur due to extraction of longwalls 27-30
- It was considered possible that should substantial gas emissions at the surface be observed that localised vegetation die back could result
- It was considered that localised slope slippages along the Redbank Range may occur during mining.

Threatened Ecological Communities

Four Threatened Ecological Communities (TECs) were recorded within the vicinity of Longwall 28: Cumberland Plain Woodland, Shale Sandstone Transition Forest, River-flat Eucalypt Forest and Moist Shale Woodland. These communities are listed as TECs under the TSC Act and/or EPBC Act. Biosis Research (2009) concluded mining of Longwalls 27-30 is unlikely to have a significant impact on any of these EEC's.

Subsidence associated with the extraction of Longwall 28 is consistent with the subsidence impact assumptions in the Biosis (2009) report and no changes in any of these vegetation communities has been reported (GeoTerra 2014).

Threatened flora

No threatened flora species were recorded in the study area during the survey conducted by Biosis Research or during the Niche field survey. However, within the vicinity of Longwall 28, potential habitat was determined for four threatened flora species that may potentially be impacted by subsidence: *Epacris purpurascens* var. *purpurascens*, *Persicaria elatior*, *Pomaderris brunnea* and *Pterostylis saxicola*. Biosis Research (2009) concluded mining of Longwalls 27-30 would be unlikely to have a significant impact on any threatened flora.

Subsidence associated with the extraction of Longwall 28 is consistent with the subsidence impact assumptions in the Biosis (2009) report. None of the four threatened plant species considered to have potential habitat within the limit of subsidence (Biosis Research 2009) have subsequently been recorded from the study area and therefore it is unlikely that the extraction of coal from Longwall 28 will have led to any impacts on these four threatened plant species.

Threatened Fauna

Thirty-one threatened and/or migratory fauna were considered to have limited potential habitat within the study area (Biosis Research 2009). Three of these species: Large-footed Myotis (*Myotis macropus*), Spotted-tailed Quoll (*Dasyurus maculates*), and Large-eared Pied-bat (*Chalinolobus dwyeri*) were considered to have potential habitat that may be impacted by subsidence, through cliff and rock falls. Biosis Research (2009) concluded that the mining of Longwall 28 was unlikely to have a significant impact on a local population of any of these threatened fauna species as potential roosting/sheltering habitat for these species is outside the subsidence footprint of Longwall 28. Furthermore, no rocks slips or falls were recorded by MSEC.

Subsidence associated with the extraction of Longwall 28 is consistent with the subsidence impact assumptions in the Biosis (2009) report and the extraction of coal from the Longwall is not likely to have had a significant impact on any threatened fauna species.

Assessment of predicted and observed impacts

The predicted and observed impacts on EEC's and threatened species (and their habitats) resulting from the Longwall 28 is provided in Table 2. The table focuses on the three main ecological values which were the subject of the assessment undertaken by Biosis Research (2009) for the development of Longwalls 27 to 30.

Table 2: Summary of the predicted and observed impacts on general habitat and threatened flora and fauna Associated with Longwall 27

Ecological Values	Predicted Impact*	Observed Impact**	Within Prediction (yes/no)
Endangered Ecological Communities (and other vegetation)	Potential gas emissions may result in small, isolated areas of vegetation dieback. Potential surface fracturing and gas emissions considered unlikely to result in alteration of species composition or distribution. Unlikely to have a significant impact on any plant communities.	No vegetation impacts have been observed or reported. No significant impacts to EECs or vegetation are likely to have occurred.	Yes
Threatened flora	Volume of water available for plant use is unlikely to be significantly impacted. It is considered unlikely that subsidence impacts would result in a broad change in the floristic composition of the riparian zone. No significant impact to threatened flora.	No vegetation impacts have been observed or reported. No significant impacts to flora and flora habitat. The Biosis Research (2009) report assumed flow diversion and pool level changes would occur as a result of mining Longwalls 27 to 30. Given, such predictions were considered in the impact assessment, and no threatened amphibians were regarded as having potential habitat in the watercourses of Longwall 28, impact to threatened amphibians are unlikely.	Yes
Threatened fauna and fauna habitat	Changed surface water conditions, such as effects to pools and streams. Impacts to steep slopes and cliffs. Impacts of gas emissions on water quality and riparian vegetation. No significant impacts to any threatened fauna.	No vegetation impacts have been observed or reported. No significant impacts to fauna and fauna habitat. The Biosis Research (2009) report assumed flow diversion and pool level changes would occur as a result of mining Longwalls 27 to 30. Given, such predictions were considered in the impact assessment, and no threatened amphibians were regarded as having potential habitat in the watercourses of Longwall 28, the exceeding TARP does not affect threatened flora, fauna or EECs.	Yes

** Based on GeoTerra (2015) and MSEC (2015) and observations by Niche during field assessment.

Trigger Action Response Plan

TARPs related to terrestrial ecology and responses are provided in Appendix A. No TARPs have been triggered to terrestrial ecology impacts to date. GeoTerra (2014) reports the following TARP triggers were exceeded: -

'Redirection of surface water flows and pool level / flow decline of >20% during mining compared to baseline for > 2 months, considering rainfall / runoff variability. The above TARP trigger was exceeded as a result of Longwall 27 extraction on (and after) 7th November 2014 between Sites 13A and 17, and on 14th August 2014 at Site 20 in Myrtle Creek; Sites 21 / 21A on 16/12/2014 and Site 24 on 17/3/15 in Redbank Creek'.

'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 triggered at Site RC2 (aka Site 37) on 5/3/15'.

The Biosis Research (2009) report assumed flow diversion and pool level changes would occur as a result of mining Longwalls 27 to 30. Given, such predictions were considered in the impact assessment, and no threatened amphibians were regarded as having potential habitat in the watercourses of Longwall 28, the exceeding of the TARP does not affect threatened amphibians.

Conclusion

This report compares the observed impacts of subsidence associated with the extraction of Longwall 28 at Tahmoor Colliery against the impacts predicted prior to extraction of coal from the Longwall in relation to terrestrial ecological values. This assessment is based on a review of monitoring observations and measurements undertaken by MSEC, and GeoTerra.

The impacts which have occurred within the limit of subsidence for Longwall 28 are within the parameters of the predicted impacts outlined in the terrestrial ecological assessment for Longwalls 27 to 30 (Biosis 2009).

It is concluded that the extraction of Longwall 28 is not likely to have led to a significant impact on threatened terrestrial ecological values.

Recommendations

The following are recommended:

- Continue the subsidence monitoring as per the Tahmoor Coal (2013) Tahmoor Colliery Longwalls 27 to 30 Environment Management Plan.

References

Biosis Research (2009). Tahmoor Colliery Longwalls 27-30 Impacts of Subsidence on Terrestrial Flora and Fauna Final Report.

GeoTerra (2015). End of Longwall 28 Streams, Dams & Groundwater Monitoring Report, Tahmoor, NSW. Report No. TA19-R1. Mine Subsidence Engineering Consultants

MSEC (2015). Glencore: Tahmoor Colliery - Longwall 28 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 28.

Tahmoor Coal (2013). Tahmoor Colliery Longwalls 27 to 30 Environment Management Plan.

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Appendix A: Subsidence Predictions, TARP Trigger Observations and Impacts associated with Longwall 28

Feature	Trigger level		Impacts observed (GeoTerra 2015)	Impacts within predication	Further actions and recommendations
General Stream Sites MYC1,2,3,4 RC1,2,3 M1 - M6 R1- R11	NORMAL No observable mining induced change	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of stream condition	Ponding. Flow diversion. These impacts have not resulted in any recorded or observed increases in erosion or impacts to vegetation. All impacts do not indicate any long terms increases as detailed in GeoTerra (2014).	Yes – no baseline conditions were established for native vegetation, however given no evidence of die back is likely within the prediction.	Continue monitoring as per Environmental Management Plan
	WITHIN PREDICTIONS No observable change to stream bed or bank; erosion turbidity iron staining algal growth vegetation compared to baseline conditions	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of stream condition			
	EXCEEDS PREDICTIONS Observable increase in stream bed or bank; erosion turbidity iron staining algal growth vegetation compared to pre mining conditions	Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer. Notify technical specialists immediately. Site visit with stakeholders within 1 month. Record photographically immediately. Review monitoring program within 2 weeks and review accordingly. Inform NOW and DRE of investigation results. Prepare and implement a site mitigation/action plan within 1 month (pending stakeholder availability) and seek approvals from key agencies if required. Complete works ASAP. Additional post works monitoring and reporting within 1 month as required.			

Feature	Trigger level		Impacts observed (GeoTerra 2015)	Impacts within predication	Further actions and recommendations
Aquatic Ecology	NORMAL No change in aquatic habitat compared to baseline observed	Continue monitoring.	Loss of water within pools. Flow diversion. No increase in erosion or impacts to vegetation. No significant change in stream ecology observed by GeoTerra (2014).	Habitat unlikely for any threatened aquatic species. This is consistent with the Biosis (2009) report. Therefore any exceedances are unlikely to result in impacts to aquatic habitat supporting these species.	Continue monitoring as per Environmental Management Plan
	WITHIN PREDICTIONS Water flow and quality results within predictions. Observational monitoring within baseline variability.	Continue monitoring. Report in end of panel report.			
	EXCEEDS PREDICTIONS Water flow and quality results exceed predictions. Observational monitoring shows significant change observed in aquatic habitat compared to baseline observed	Report in end of panel report Notification to DRE/NOW immediately Proposal for any proposed additional aquatic ecology monitoring and management measures within 1 week if required Completion of agreed management tasks following Approval from DRE/NOW. Additional monitoring as required by the relevant government agencies Report in end of panel report Reporting in Incident and AEMR			
Stream Water Quality	NORMAL No observable mining induced change	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of water quality data	'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 triggered at Site RC2 (aka Site 37) on 5/3/15'.	TARP trigger was exceeded as a result of Longwall 28. Detailed in GeoTerra (2015).	See GeoTerra (2015)
	WITHIN PREDICTIONS <2 mth change within baseline variability or water quality reduction over minimum 2 month period Increase in stream Fe hydroxide precipitation compared to baseline	Continue monitoring program, review monitoring frequency, discuss in end of panel report or AEMR as required. Ongoing review of water quality data			

Feature	Trigger level		Impacts observed (GeoTerra 2015)	Impacts within predication	Further actions and recommendations
	EXCEEDS PREDICTIONS Significant reduction compared to baseline and predicted impacts last over >2mthsand > 2 STD deviation reduction in water quality at downstream monitoring site compared to baseline and / or significant observable increase in Fe hydroxide precipitate compared to baseline observations	Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Notify technical specialists immediately Site visit with stakeholders within 1 month Record photographically immediately Collect laboratory samples within 2 weeks and analyse for standard analytes Review sampling program within 1 mth and review accordingly Inform NOW & DRE of investigation Prepare and implement a site mitigation/action plan within 1 mth (pending stakeholder availability) and seek approvals from key agencies if required Complete works ASAP and additional post works monitoring / reporting within 1 mth as required Discuss in EoP or AEMR reports as required			
Stream Flow / Water Level Sites M1 - M6 R1- R11	NORMAL No observable mining induced change	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of stream flow / level data	Redirection of surface water flows and pool level / flow decline observed on 7th November 2014 between Sites 13A and 17, and on 14th August 2014 at Site 20 in Myrtle Creek; Sites 21 / 21A on 16/12/2014 and Site 24 on 17/3/15 in Redbank Creek'.	TARP trigger was exceeded as a result of Longwall 28. Detailed in GeoTerra (2015).	See GeoTerra (2015)
	WITHIN PREDICTIONS (< 2mths) - within baseline variability or temporary reduction over < 2mth period for pool levels and stream flow, considering rainfall / runoff variability. WITHIN PREDICTIONS (>2 mths) fracturing of bedrock in directly undermined channels Pool level / flow decline <20% during mining compared to baseline for > 2 mths	Continue monitoring program, review monitoring frequency, discuss in end of panel report or AEMR as required. Ongoing review of water pressure data			

Feature	Trigger level		Impacts observed (GeoTerra 2015)	Impacts within predication	Further actions and recommendations
	EXCEEDS PREDICTIONS fracturing of bedrock in stream reach directly or not directly undermined re-direction of surface water flows and pool level / flow decline >20% during mining compared to baseline for > 2mths, considering rainfall / runoff variability	Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Notify technical specialists immediately Site visit with stakeholders within 1 mth Record photographically immediately Review monitoring program within 2 weeks and review accordingly Inform NOW and DRE of investigation results Prepare and implement a site mitigation/action plan within 1 mth (pending stakeholder availability) and seek approvals from key agencies if required Complete works ASAP Additional post works monitoring and reporting within 1 mth as required Discuss in EoP or AEMR reports as required			