GLENCORE:

Tahmoor Colliery - Longwall 27

End of Panel Subsidence Monitoring Report for Tahmoor Longwall 27

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

MSEC589-R01 to MSEC589-R56 – Subsidence Monitoring Reports, issued during the extraction of Longwall 27 between January 2013 and May 2014.

MSEC5904-R01 to MSEC590-R57 – Main Southern Railway Monitoring Reports, issued during the extraction of Longwall 27 between February 2013 and April 2014.

Geoterra (2014). End of Longwall 27 Surface Water, Dams & Groundwater Monitoring Report, Tahmoor, NSW. Report No. TA20-R1B, August 2014.

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Drawings

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

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 Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS).

This report includes:-

- A summary of the subsidence and environmental monitoring results for Longwall 27,
- 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 27 is shown in Drawing No. MSEC687-01, 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 26. 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 27

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

The predicted movements and impacts resulting from the extraction of Longwalls 24 to 26 were provided in Report No. MSEC157 (Revision C), which was issued in March 2006. The prediction model was re-calibrated, based on the observed movements for Longwalls 22 to 24A, which was described in Report No. MSEC355 (2009, Revision B). The comparisons provided in this report are based on the latest subsidence predictions using the calibrated model.

Longwall 27 was approximately 3,040 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 2.2 metres.

Chapter 2 of this report describes the locations of the ground monitoring lines and points which were surveyed during the extraction of Longwall 27. This chapter also provides comparisons between the observed and predicted movements resulting from the extraction of Longwall 27.

Chapter 3 of this report summarises the surveys and inspections undertaken during the mining of Longwall 27.

Chapter 4 of this report describes the reported impacts on surface features resulting from the extraction of Longwall 27, 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 27 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 27 (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 LW27 only	856	5.7	2.1	-4.9
Total after LW27	1367	8.0	4.1	-6.3

Maximum observed incremental and total subsidence parameters for monitoring lines surveyed during Longwall 27 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)
Abelia St	LW 27 Inc	76	0.8	0.5	-0.5
	Total	1262	4.0	1.4	-6.3
Amblecote Pl	LW 27 Inc	45	0.2	0.2	-0.1
	Total	769	0.9	0.4	-0.1
Bradbury St	LW 27 Inc	65	1.0	0.2	-0.1
	Total	892	2.9	0.3	-0.6
Bridge St	LW 27 Inc	523	4.5	1.3	-2.3
	Total	680	4.5	4.1	-4.4
Brundah Rd	LW 27 Inc	627	1.9	2.1	-2.4
	Total	1024	4.9	2.0	-4.9
Castlereagh St (incl. creek)	LW 27 Inc	77	0.7	0.4	-0.6 (18m bay)
	Total	932	3.7	0.5	-12.2 (18m bay)
Castlereagh-Myrtle Creek (incl. creek)	LW 27 Inc	77	0.7	1.3	-1.8 (8m bay) -0.9 (14m bay)
	Total	897	2.7	3.6	-32.0 (8m bay) -16.5 (14m bay)
Chapman St	LW 27 Inc	18	0.4	0.2	-0.1
	Total	799	3.6	0.3	-0.8
Connor Pl	LW 27 Inc	62	0.6	0.2	-0.1
	Total	877	1.4	0.3	-0.4
Elphin-Myrtle Creek (incl. creek)	LW 27 Inc	47	3.4 (4m bay)	1.7 (9m bay)	-4.9 (4m bay) -1.1 (17m bay)
	Total	905	18.8 (4m bay)	2.0 (9m bay)	-46.1 (4m bay) -13.3 (14m bay)
Elphin St	LW 27 Inc	25	0.6	0.4	-0.3
	Total	942	3.4	0.4	-1.2
Greenacre Dve	LW 27 Inc	44	0.8	0.9	-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	300	3.5	1.7	-0.3
Hilton Park Rd	LW 27 Inc	623	4.1	0.6	-4.9
	Total	850	4.3	1.0	-4.4
Janice Dve	LW 27 Inc	28	0.2	0.1	-0.1
	Total	1144	4.7	2.7	-1.0
Krista Pl	LW 27 Inc	514	1.8	0.1	-0.9
	Total	1012	4.8	0.9	-0.4
Larkin St	LW 27 Inc	12	0.5	0.2	-0.2
	Total	287	1.6	0.3	-0.2
Leiha Pl	LW 27 Inc	61	0.2	0.1	-0.0
	Total	601	1.0	0.4	-0.0
Main Southern Railway (2D) (incl. creek)	LW 27 Inc	603	3.5	0.9	-1.0
	Total	866	5.6	1.4	-4.9
Monica Pl	LW 27 Inc	61	1.6	0.2	-0.2
	Total	557	1.6	0.5	-0.0
Moorland Rd	LW 27 Inc	230	1.5	0.7	-0.8
	Total	1030	7.8	1.1	-5.0
Myrtle Creek Ave	LW 27 Inc	856	4.3	0.8	-3.1
	Total	930	4.6	0.9	-3.4
Optical Fibre Line	LW 27 Inc	16	0.8	0.4	-1.4
Park Ave	LW 27 Inc	609	5.7	1.0	-0.5
	Total	659	6.1	1.1	-0.2
Park St	LW 27 Inc	37	0.2	0.2	-0.2
	Total	944	3.1	0.4	-1.0
Pimelia St	LW 27 Inc	7	1.5	0.1	-0.1
	Total	849	1.2	0.3	-1.9
Progress St	LW 27 Inc	34	0.6	0.6	-0.7
	Total	1367	4.5	0.6	-1.6
Remembrance Dve	LW 27 Inc	694	5.1	1.0	-2.8
	Total	976	6.0	1.5	-3.7
River Rd	LW 27 Inc	17	0.6	0.2	-0.2
	Total	25	1.3	0.6	-0.2
River Rd South	LW 27 Inc	3	0.7	0.1	-0.3
Shopfronts	LW 27 Inc	9	0.2	0.3	-0.2
	Total	356	1.4	0.4	-0.7
Struan St	LW 27 Inc	729	5.2	1.0	-2.5
	Total	1070	5.1	0.9	-2.5
Tahmoor Carrier	LW 27 Inc	556	3.5	0.8	-0.5
Tahmoor Rd	LW 27 Inc	132	1.0	0.4	-0.3
	Total	939	8.0	0.9	-4.5
Thirlmere Way (T64 to T85 only)	LW 27 Inc	440	3.2	1.0	-0.4
	Total	525	3.0	2.4	-2.4
Thompson Pl	LW 27 Inc	20	0.2	0.0	-0.2
Winpara Cl	LW 27 Inc	9	0.4	0.1	-0.1
	Total	851	3.6	0.2	-2.5

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
York St	LW 27 Inc	493	1.9	0.6	-0.6
	Total	920	4.4	0.9	-3.3

2.1.2. Observed Subsidence during the extraction of Longwall 27

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 27.

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 that were located directly above previously extracted areas and areas of low level subsidence (typically less than 100 mm) was generally observed to extend further than predicted.

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 26 to place observations during the mining of Longwall 27 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 in Longwall 25.

Observed Increased Subsidence during the mining of Longwall 24A

Observed subsidence was greatest above the southern half of Longwall 24A, and gradually reducing in magnitude towards the northern half of the longwall, which was directly beneath the urban area of Tahmoor. These observations are shown graphically in Fig. 2.1, which shows observed subsidence at survey pegs located along the centreline of Longwall 24A.

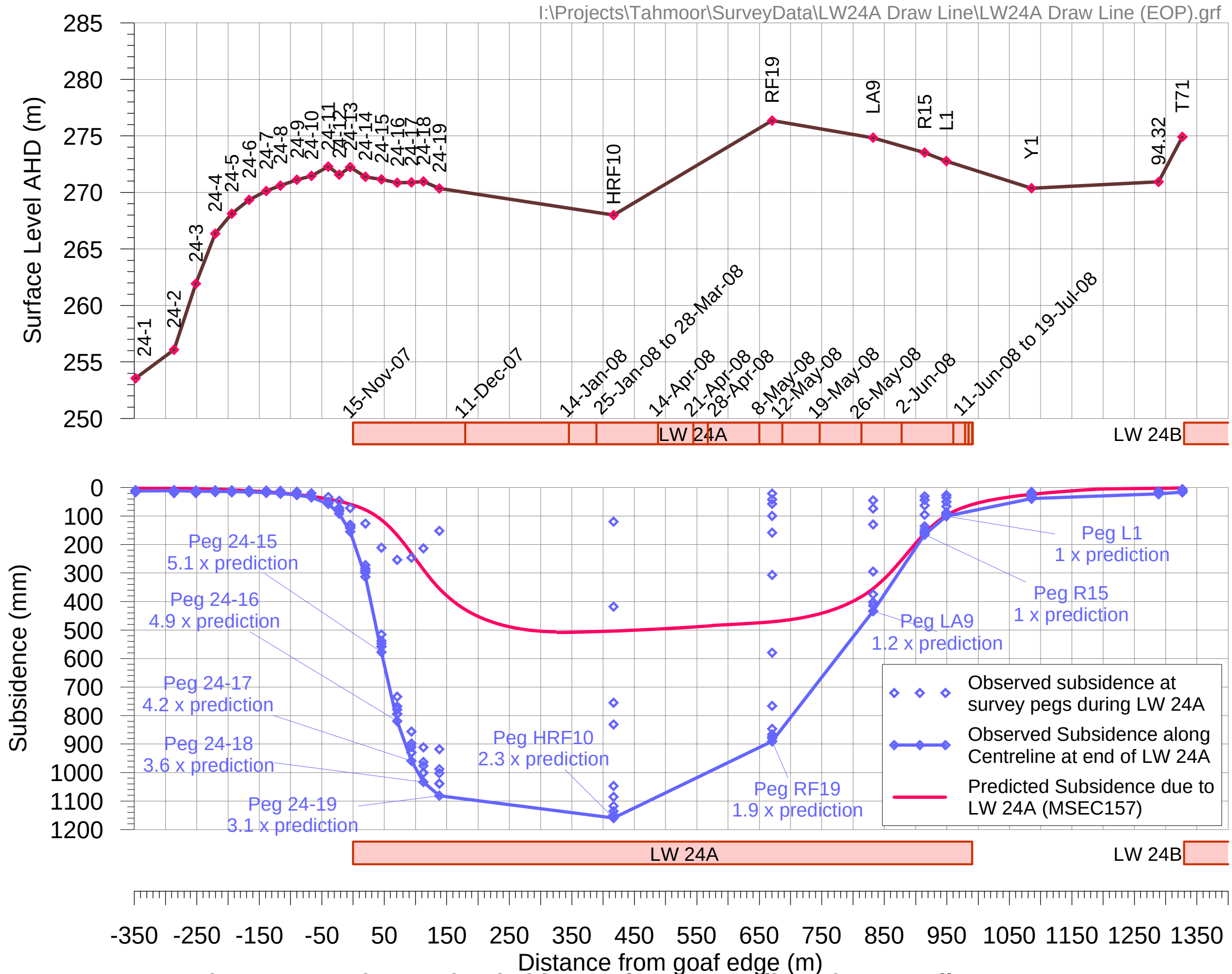


Fig. 2.1 Observed Subsidence along Centreline of Longwall 24A

It can be seen from Fig. 2.1 that observed subsidence was more than twice the predicted maximum value, reaching to a maximum of 1169 mm at Peg HRF10. It is possible that actual maximum subsidence developed somewhere between Pegs HRF10 and RF19, though this was not measured. Observed subsidence was similar to prediction near Peg R15 on Remembrance Drive. Survey pegs RF19 and LA9 are 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

Increased subsidence was observed during the first stages of mining Longwall 25. These observations are shown graphically in Fig. 2.2, which shows observed subsidence at survey pegs located along the centreline of Longwall 25.

It can be seen from Fig. 2.2 that observed subsidence was approximately twice the predicted maximum value, with maximum subsidence of 1216 mm at Peg 25-28.

Observed subsidence is similar to but slightly more than predicted at Peg RE7 and is similar to 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.

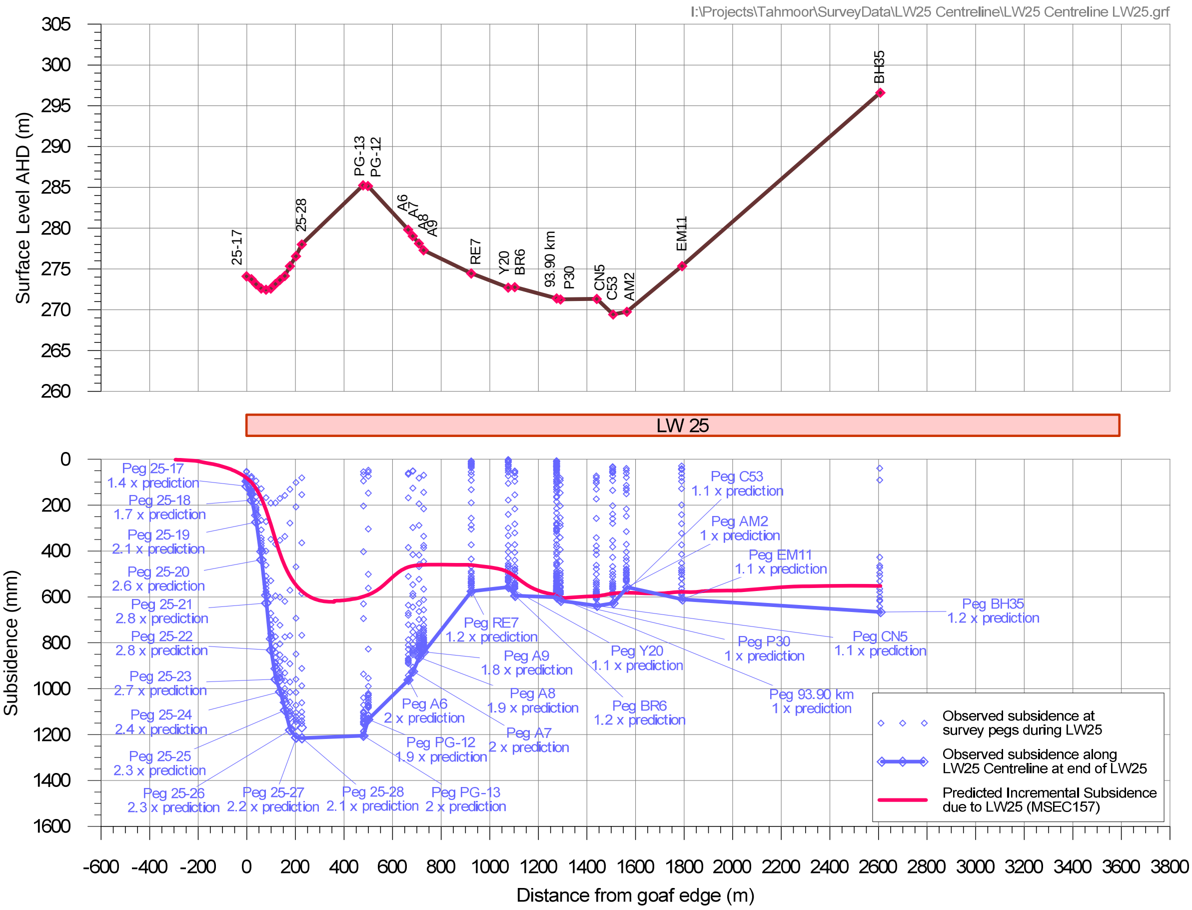


Fig. 2.2 Observed Subsidence along Centreline of Longwall 25

Observed Increased Subsidence during the mining of Longwall 26

Increased subsidence was observed during the first stages of mining Longwall 26, but at a reduced magnitude compared to the subsidence observed above Longwalls 24A and 25. These observations are shown graphically in Fig. 2.3, which shows observed subsidence at survey pegs located along the centreline of Longwall 26.

It can be seen from Fig. 2.3 that observed subsidence was approximately 1.3 times the predicted maximum value, with maximum subsidence of 893 mm at Peg TM26.

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.

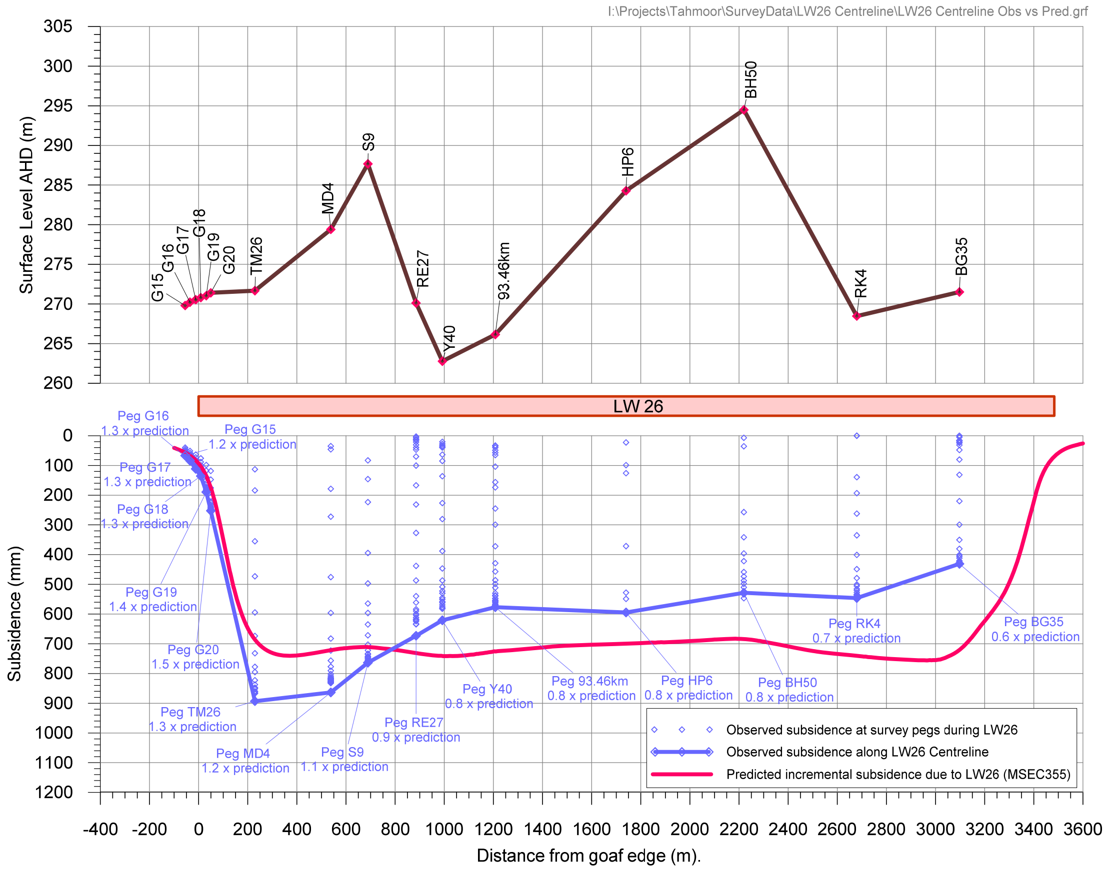


Fig. 2.3 Observed Subsidence along Centreline of Longwall 26

Observed Increased Subsidence during the mining of Longwall 27

Increased subsidence was observed during the first stages of mining Longwall 27, but at a reduced magnitude compared to the subsidence observed above Longwalls 24A to 26. These observations are shown graphically in Fig. 2.4, which shows observed subsidence at survey pegs located along the centreline of Longwall 27.

It can be seen from Fig. 2.4 that observed subsidence is approximately 1.3 times the predicted maximum value, with current maximum subsidence of 825 mm at Peg MC14.

Observed subsidence reduced along the panel from Peg MC14 until Peg TC4, which is located between Remembrance Drive and Myrtle Creek. Observed subsidence along the centreline returned to normal levels as mining progressed beyond Peg TC4.

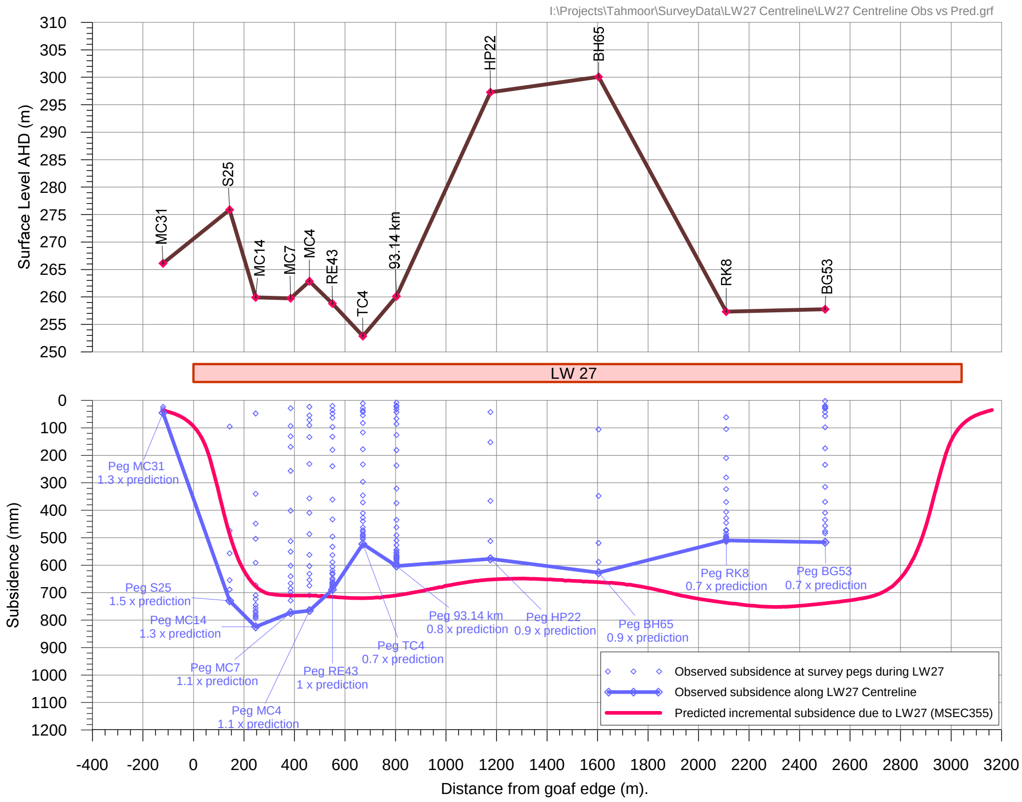


Fig. 2.4 Observed Subsidence along Centreline of Longwall 27

Analysis and commentary

The cause for the increased subsidence has been investigated by Strata Control Technologies on behalf of Tahmoor Colliery (Gale and Sheppard, 2011). The investigations concluded that the increased subsidence is consistent with localised weathering of joint and bedding planes above a depressed water table adjacent to an incised gorge.

In light of the above observations, the region above the extracted longwalls at Tahmoor has been partitioned into three zones:

1. Normal subsidence zone – where the observed vertical subsidence is within the normal range and correlates well with predictions
2. Maximum increased subsidence zone – where the observed vertical subsidence is substantially greater than predictions but has reached it upper limit. Maximum subsidence above the centreline of the longwalls appears to be approximately 1.2 metres above Longwalls 24A and 25, 900 mm above Longwall 26 and 850 mm above Longwall 27.
3. Transition zone – where the subsidence behaviour appears to have transitioned between areas of maximum increased subsidence and normal subsidence.

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 27 as a guide, as shown in Fig. 2.5. 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.

Fig. 2.5 shows that as the alignment of the Nepean Fault moved further away from the Bargo River gorge and above Longwalls 26 and 27, the magnitude of increased subsidence reduced, indicating that the cause of the movements is clearly linked to the proximity of the Bargo River. This observation confirms 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.

As observed maximum subsidence above Longwalls 26 (900 mm) and 27 (850 mm) has reduced compared to observed maximum subsidence above Longwalls 24A and 25 (1200 mm), it expected that the magnitude of maximum subsidence above the commencing end of Longwall 29 will be less than previously observed and may return close to normal levels of subsidence elsewhere at Tahmoor.

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.

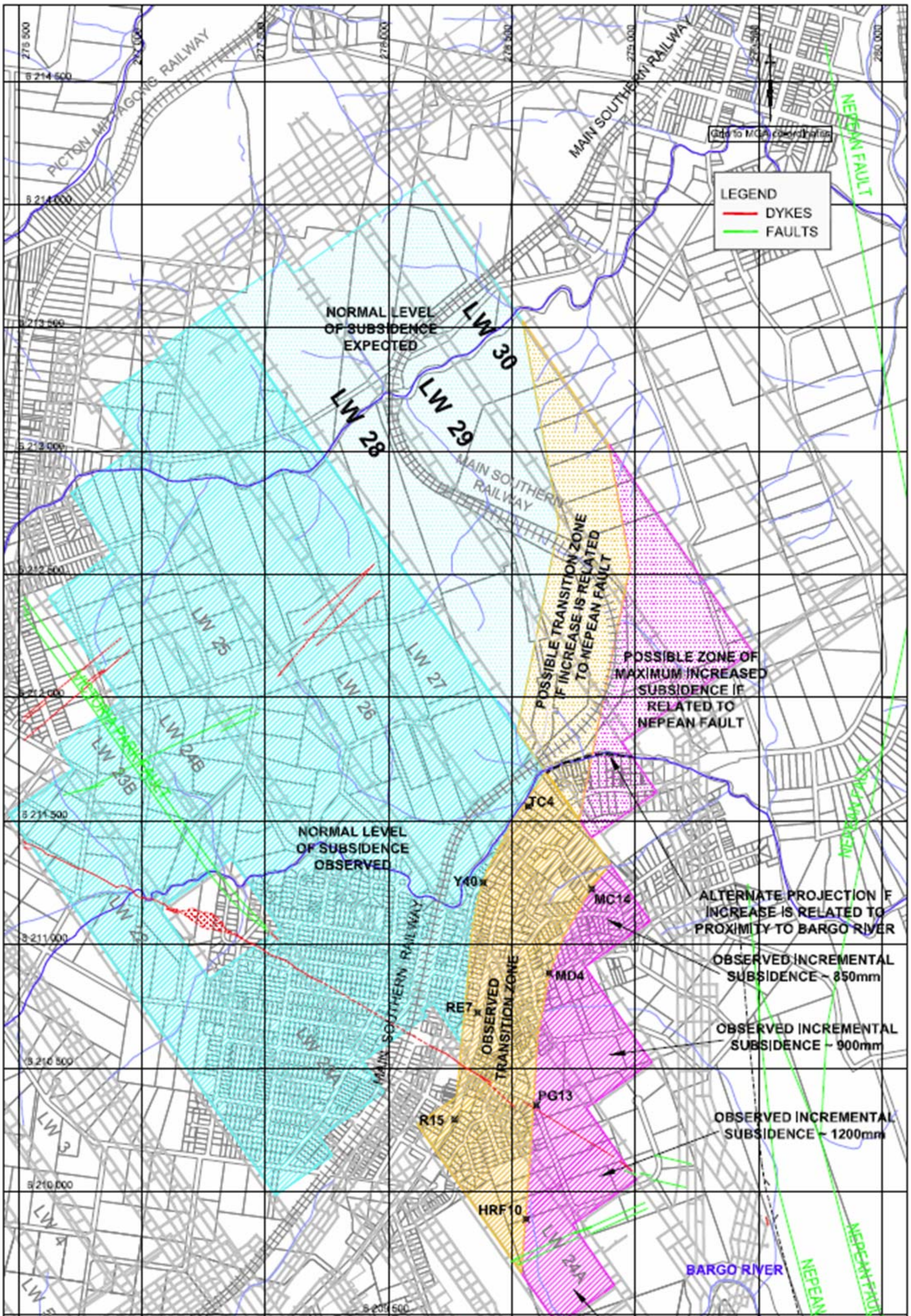


Fig. 2.5 Figure showing zones of increased subsidence over Longwalls 22 to 27

2.1.3. Analysis of Measured Strain

The distribution of the observed incremental tensile and compressive strains along the monitoring lines from the extraction of Longwall 27, for survey bays located directly above goaf, are shown in Fig. 2.6. 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.

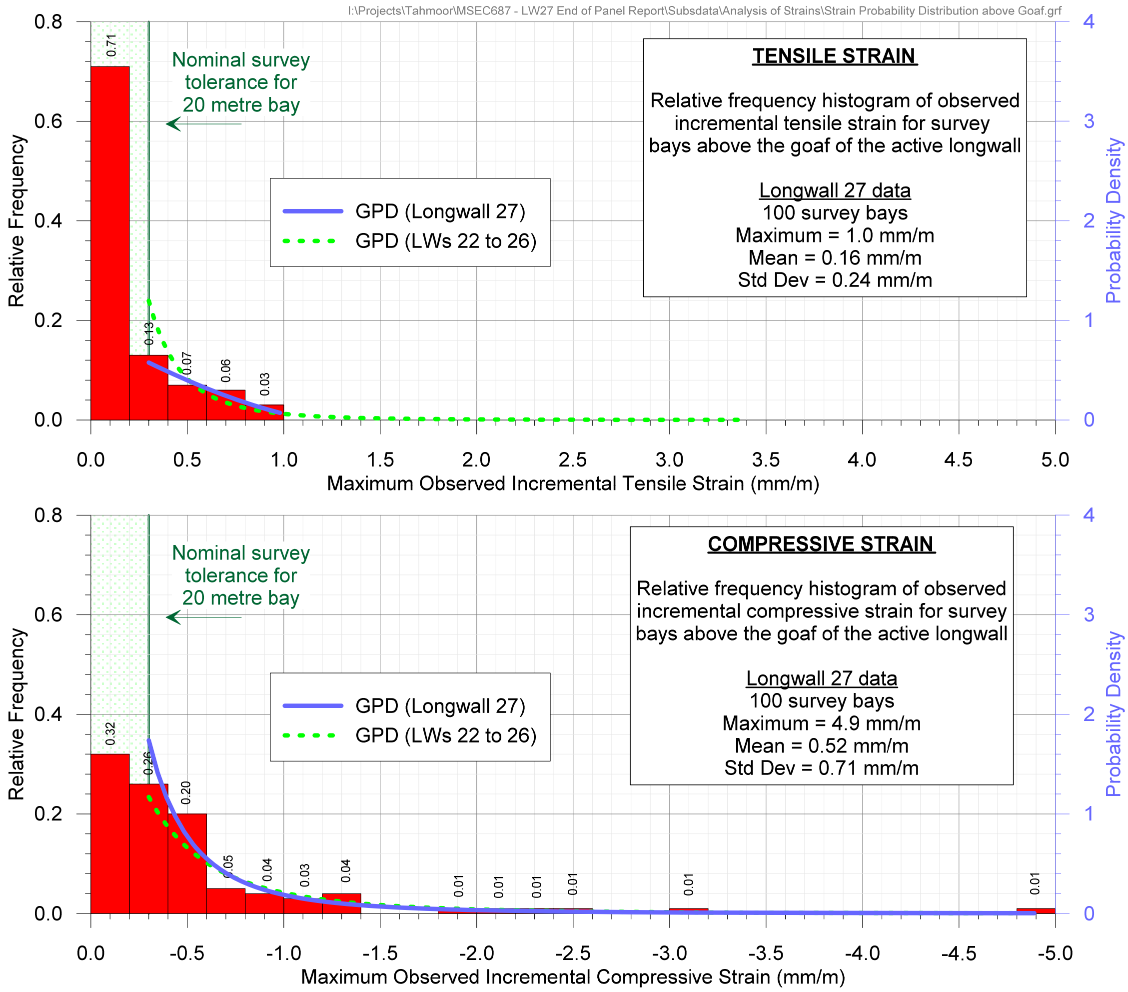


Fig. 2.6 Observed Incremental Strain for Survey Bays above Goaf resulting from the Extraction of Longwall 27

A *Generalised Pareto Distribution (GPD)* has been fitted to the raw strain data for Longwall 27, which are shown as the blue lines.

The probability distribution functions for previous monitoring during the mining of Longwalls 22 to 26 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 27 was similar in magnitude when compared with those observed during the mining of Longwalls 22 to 26.

2.2. Identification of Non-Systematic Subsidence Movements

A plan showing the locations of observed non-systematic movements at Tahmoor is shown in Fig. 2.7. 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 27, of which 3 new locations were observed during the mining of Longwall 27.

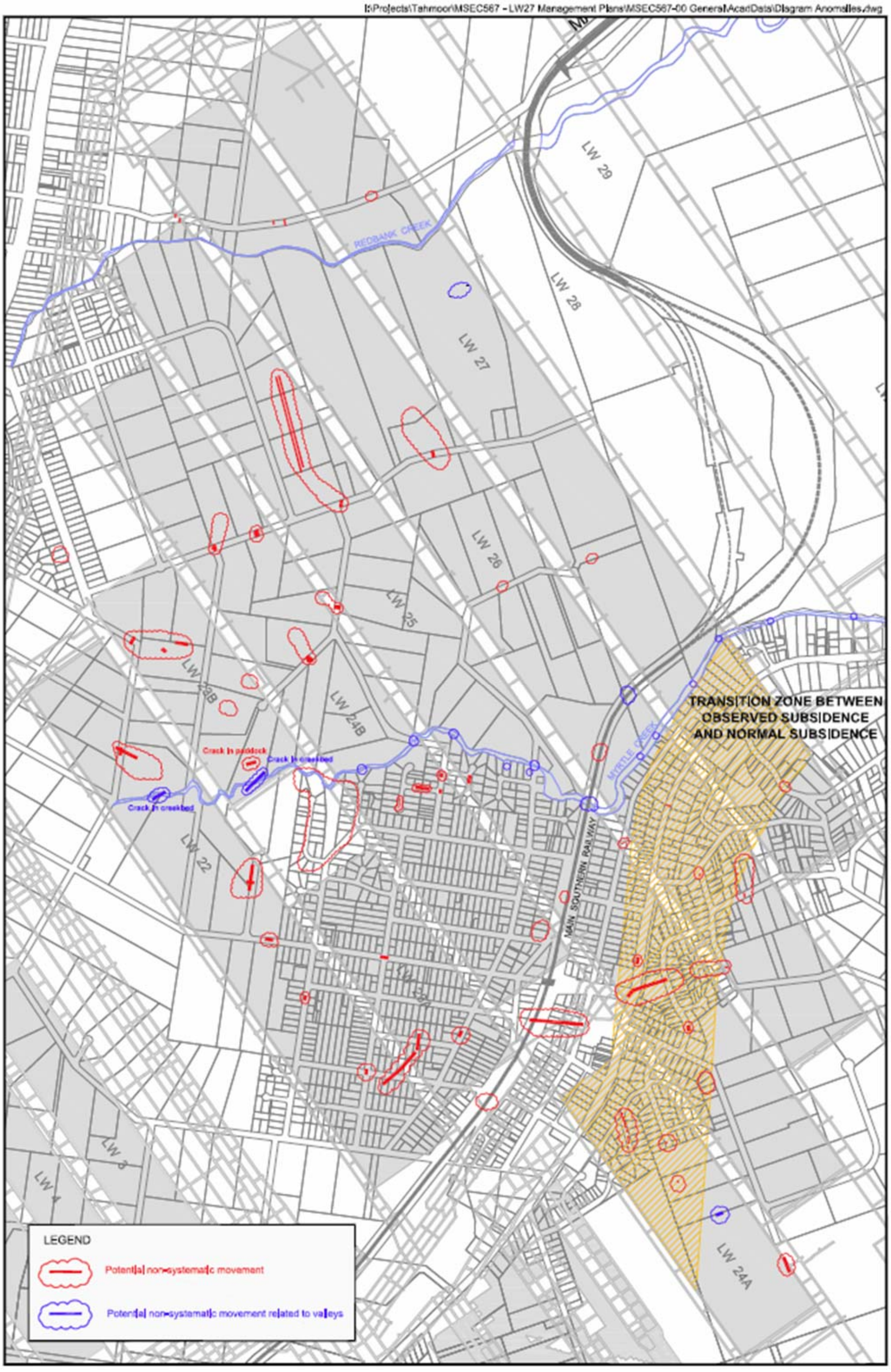


Fig. 2.7 Map of Locations of Potential Non-Systematic Movements

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 27

Monitoring Line or Location	Maximum Change in Vertical Alignment during LW27 (mm)	Maximum Incremental Strain during LW27 (mm/m)	Type	Impacts on Surface Features
Myrtle Creek Ave (Pegs MC13 to MC14)	15mm over 40 metres	-3.1	Anomaly (but within 50m from base of small valley)	Impacts on houses, of which one was moderately impacted Cracking to kerbs. Leak to water main but no impacts on sewer pipes.
Hilton Park Rd (Pegs HP19 to HP22)	85mm over 60 metres	-4.9	Anomaly	Located in farmland. Impact on nearby pool and pool gate (may not be related)
RK Line (Pegs RK9 to RK10)	No bump visible in subsidence profile though pegs are spaced 61m apart	-1.5	Valley closure	Located in farmland with no impacts observed.
Bridge St (Pegs BG53 to BG54)	No bump visible in subsidence profile	-2.3	Possible non-systematic movement due to higher than compressive ground strain. Located across small tributary, which appears to follow the alignment of a valley between Pegs RK9 and RK10.	Located in farmland with no impacts observed.

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. 2.8.

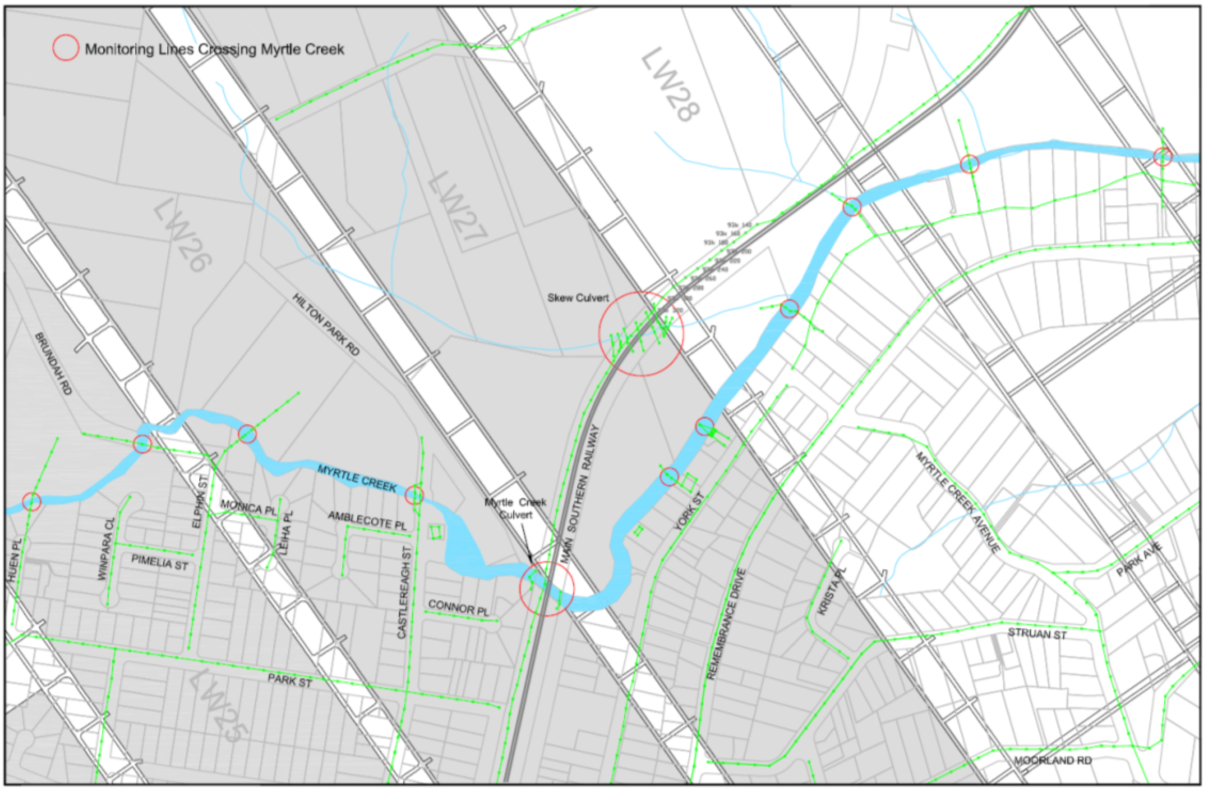


Fig. 2.8 Monitoring lines across Myrtle Creek and Skew Culvert

A summary graph showing the development of valley closure across the Myrtle Creek at each monitoring line is shown in Fig. 2.9.

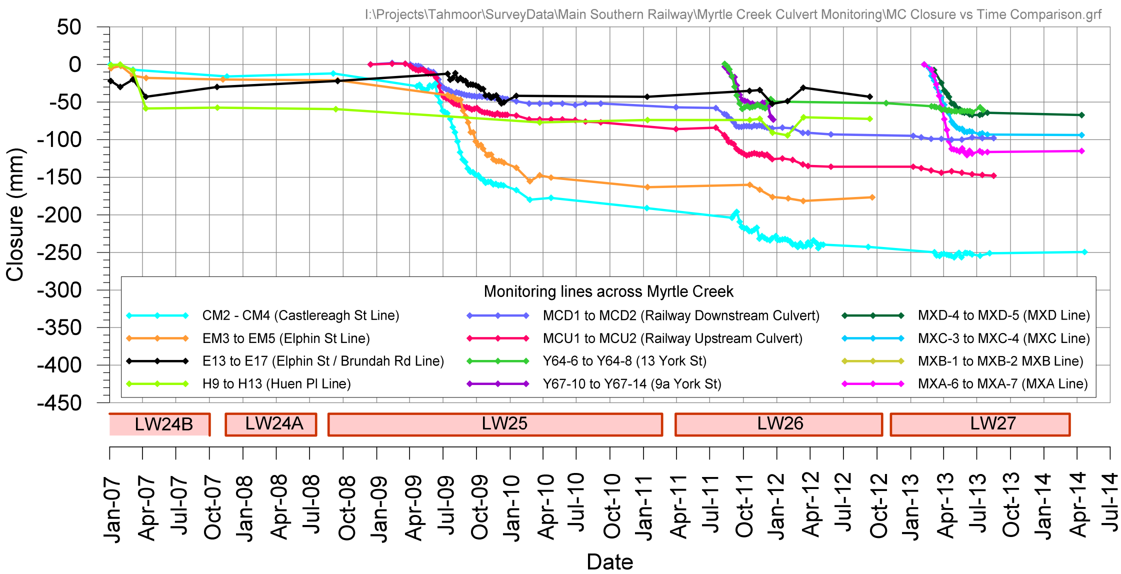


Fig. 2.9 Development of closure across Myrtle Creek during the mining of Longwalls 24B to 27

A detailed map of survey marks and cross lines across the Skew Culvert is shown in Fig. 2.10, overlaid with results from the survey of 18 November 2013.

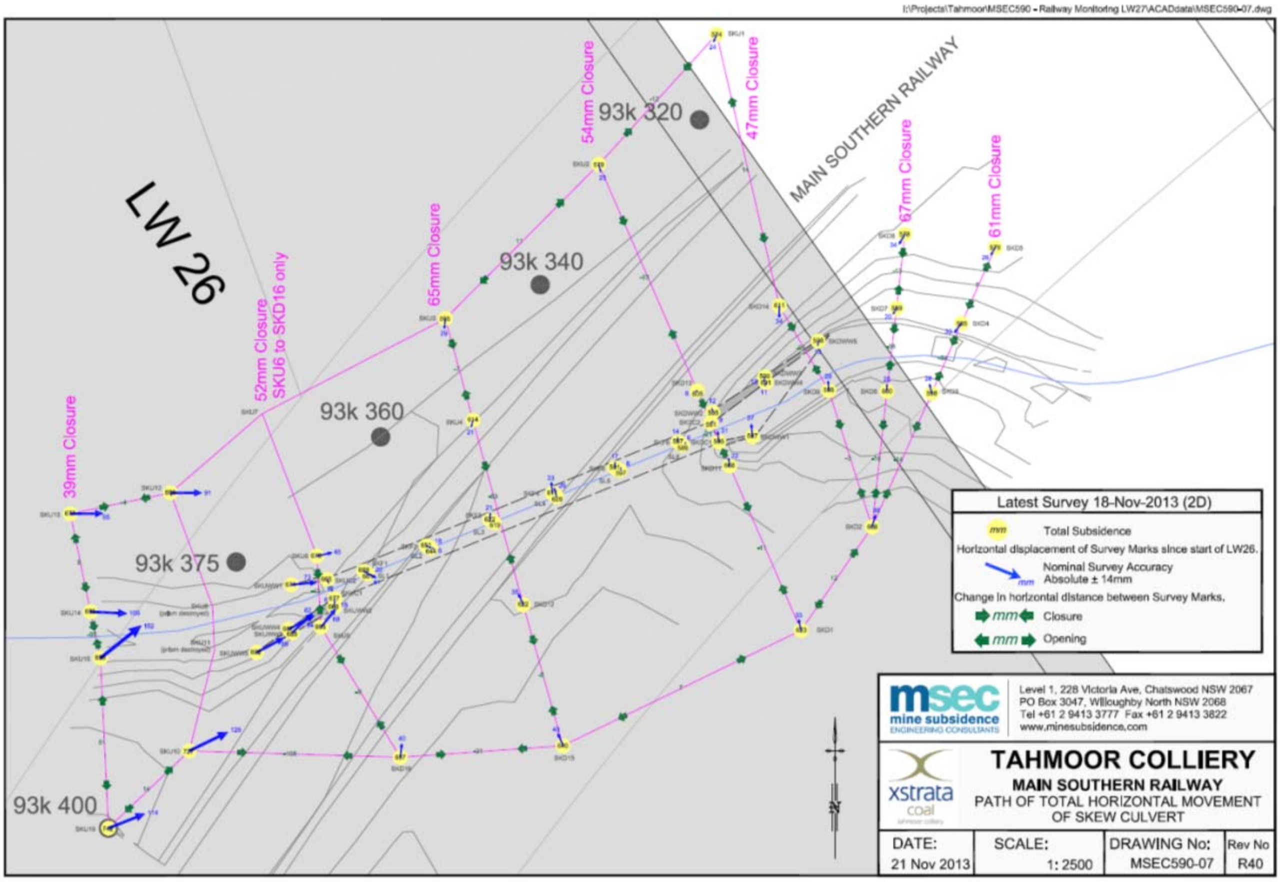


Fig. 2.10 Observed horizontal movements at Skew Culvert during the mining of Longwall 27

The development of valley closure across the creek at the Skew Culvert is shown in Fig. 2.11.

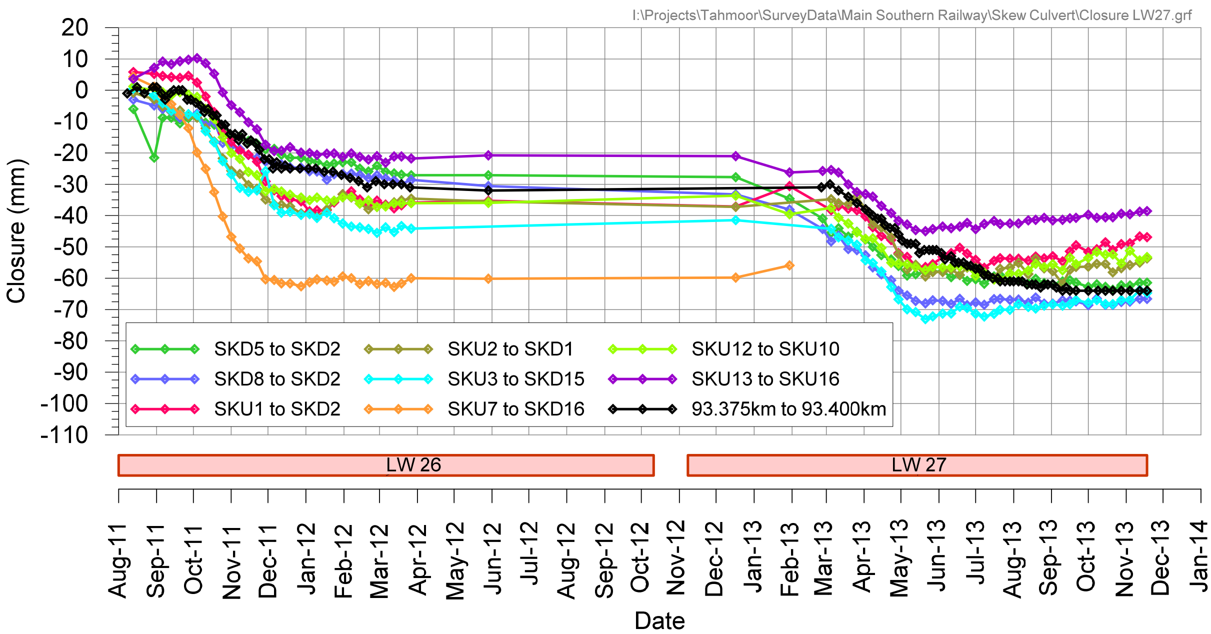


Fig. 2.11 Development of closure across Skew Culvert during the mining of Longwall 27

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.

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
Castlereagh St (Pegs CM2 to CM4)	Predicted	30	55	45	25
	Observed	12	179	52	8
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
	Observed	-	-	21 to 60 (average 36)	8 to 36 (average 21)
13 York St (Pegs Y64-6 to Y64-8)	Predicted	-	-	65	50
	Observed	-	-	51	9
9a York St (Pegs Y67-10 to Y67-14)	Predicted	-	-	85	85
	Observed	-	-	73	No access
MXA Line (Pegs MXA-6 to MXA-7)	Predicted	-	-	-	150
	Observed	-	-	-	115
MXB Line (Pegs MXB-1 to MXB-2)	Predicted	-	-	-	170
	Observed	-	-	-	94
MXC Line (Pegs MXC-3 to MXC-4)	Predicted	-	-	-	150
	Observed	-	-	-	67
MXD Line (Pegs MXD-4 to MXD-5)	Predicted	-	-	-	50
	Observed	-	-	-	17

It can be seen that during the mining of Longwall 25, observed valley closure had 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. 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 the creek at the Skew Culvert has also slightly exceeded predictions, where the differences between predicted and observed closure are relatively small for most cross sections.

Observed valley closure across Myrtle Creek where it flows directly above Longwall 27 (MXA to MXC lines) have 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. 2.12. This has provided measurements of total valley closure. Some survey pegs have been installed along a fenceline 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.

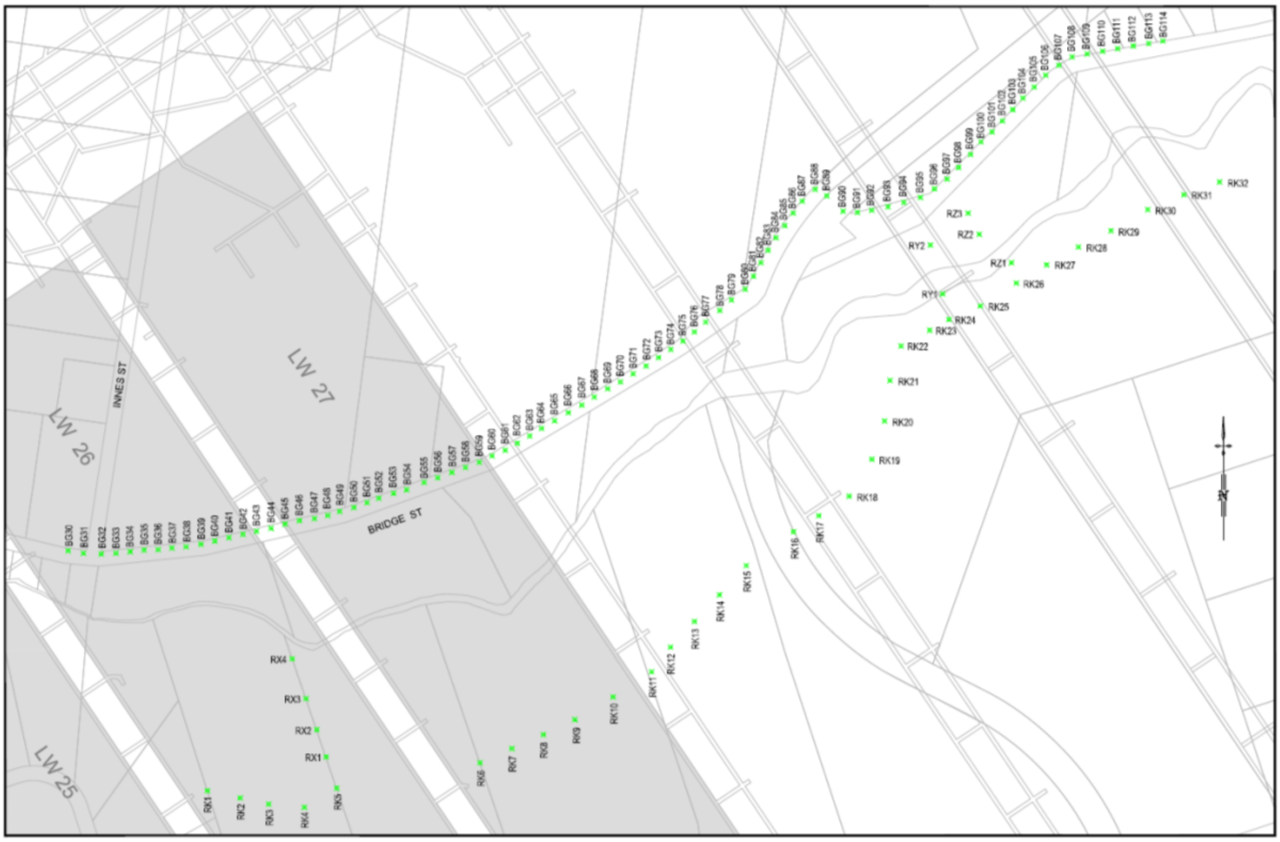


Fig. 2.12 Location of survey marks across Redbank Creek

Graphs showing observed subsidence, tilt and strain along each of the monitoring lines are provided Figs. A.36 to A.40 and drawings showing incremental subsidence and relative horizontal movements are shown in Drawings Nos. MSEC687-02 and MSEC687-03.

The development of incremental valley closure across Redbank Creek during the mining of Longwall 27 against both time and the distance between the survey pegs and the longwall face are shown in Fig. 2.13.

The calculations 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 or systematic 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.

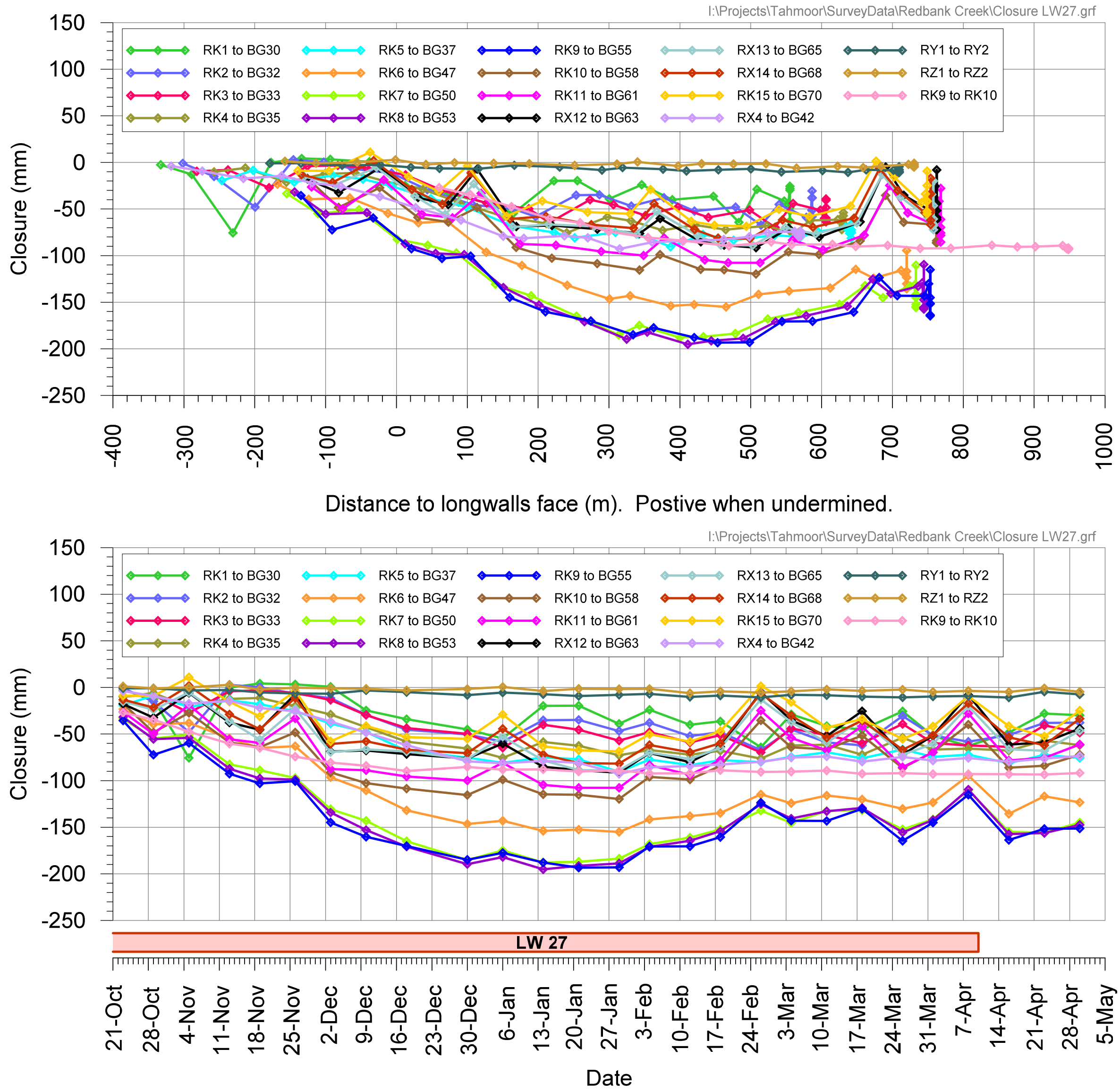


Fig. 2.13 Observed development of closure across Redbank Creek

It can be seen from Fig. 2.13 that valley closure was greater for a temporary period of time, when the transient effects of the subsidence travelling wave passing through the valley. As the longwall face moved away from Redbank Creek by more than 400 metres, the additional compressive strains from the travelling wave reduced. It can also be seen that very little change in valley closure since early March 2014.

A comparison between observed and predicted valley closure along Redbank Creek is shown in Fig. 2.14. It can be seen that there has been a reasonable correlation between predicted and observed closure at the completion of Longwall 27.

Maximum predicted valley closure due to extraction of Longwall 27 was 155 mm. As shown in the bottom graph of Fig. 2.14, observed maximum incremental valley closure at the completion of Longwall 27 was 151 mm. It can also be seen from the top graph of Fig. 2.14 that observed total closure from the mining of Longwalls 26 and 27 is less than observed.

Observed total closure is also less than the predicted total closure of 500 mm due to the mining of Longwalls 22 to 30.

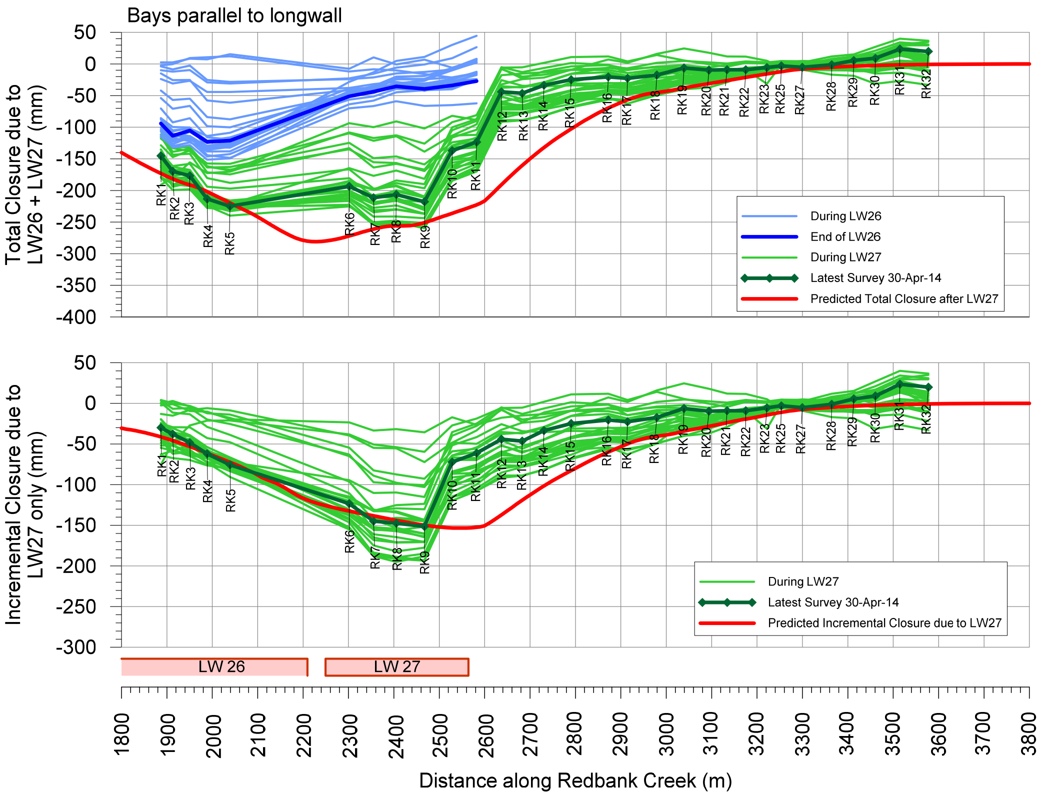


Fig. 2.14 Comparison between observed and predicted valley closure along Redbank Creek

2.5. Main Southern Railway

The Main Southern Railway was surveyed in either 2D or 3D for a total of 85 times on a weekly and twice weekly basis during the extraction of Longwall 27. 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 603 mm of subsidence during the mining of Longwall 27.

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

- Observed maximum subsidence is less 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.58, 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.
- Observed ground strains along the railway corridor were relatively small in magnitude. Increased ground strains were observed across Myrtle Creek and the creek at the Skew Culvert as expected. The overall valley closure across Myrtle Creek and the Skew Culvert was discussed in 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 27. While some false alarms were received due to monitoring system issues, rail stresses did not exceed triggers during the mining of Longwall 27.

Expansion switch displacement sensors

Displacement sensors have been installed at each expansion switch. Measurements were recorded every 5 minutes during the mining of Longwall 27. 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. Myrtle Creek Culvert

A total of 8 ground surveys, 7 extensometer surveys and 7 visual inspections were undertaken for the Myrtle Creek Culvert on a monthly basis in accordance with the agreed management plans with ARTC. Steel stress transducers are located on the steel ribs inside the culvert and measurements were undertaken hourly.

Only minor changes were observed during the mining of Longwall 28 and no triggers were exceeded.

Please refer to Section 2.3 in relation to observations of valley closure movements.

2.5.3. Skew Culvert at 93.342 km

A total of 40 ground surveys, 37 extensometer surveys and 37 detailed visual inspections were undertaken for the Skew Culvert on a weekly to monthly basis in accordance with the agreed management plans with ARTC.

The Culvert has subsided between approximately 580 mm and 750 mm during the mining of Longwall 27. The sides of the valley on either side of the Skew Culvert have closed between 39 mm on the upstream end (SKU13 to SKU16) and 66 mm at the downstream end (SKD2 to SKD5). The ground has closed 42 mm across the upstream culvert inlet (SKU6 to SKD16), 58 mm across the centre of the culvert barrel (SKU3 to SKD12) and 43 mm across the downstream culvert outlet (SKU1 to SKD2).

In addition to the increased valley closure at the upstream culvert inlet, this end has experienced a complex combination of differential ground movements. The ground along the upstream wingwall on the country side has closed approximately 140 mm (SKU15 to SKUC1) during mining and it is clear from relative and absolute 3D surveys that the ground and culvert have experienced horizontal ground shear.

2.5.4. Redbank Creek Culvert and Embankment at 91.265 km

A total of 18 ground surveys, 5 extensometer surveys and 5 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 DTIRIS.

The Culvert has subsided between approximately 20 mm and 32 mm during the mining of Longwall 27.

Small gradual changes in valley closure were also observed during the mining of Longwall 27. The weekly changes have been plotted over time and relative to the distance between the survey marks and active longwall face, as shown in **Error! Reference source not found.** and **Error! Reference source not found.**.

This ground survey has shown 5 mm of closure across the upstream end of the Redbank Creek Culvert wingwalls. The changes were cross checked with tape extensometer measurements by GHD Geotechnics and only sub millimetre changes have been observed. Measured changes in horizontal distances are within survey tolerances across the remainder of the survey points on the wingwalls, headwalls and culvert barrel, and along the length of the culvert.

Ground shortening is also observed across the small tributary to Redbank Creek between Pegs RBCCU2 and RBCCU4.

Tape extensometer readings were undertaken by GHD Geotechnics during the mining of Longwall 27. Minor changes are observed, including across the upstream wingwall. Displacements are currently not inferred to be in response to subsidence nor subsidence related.

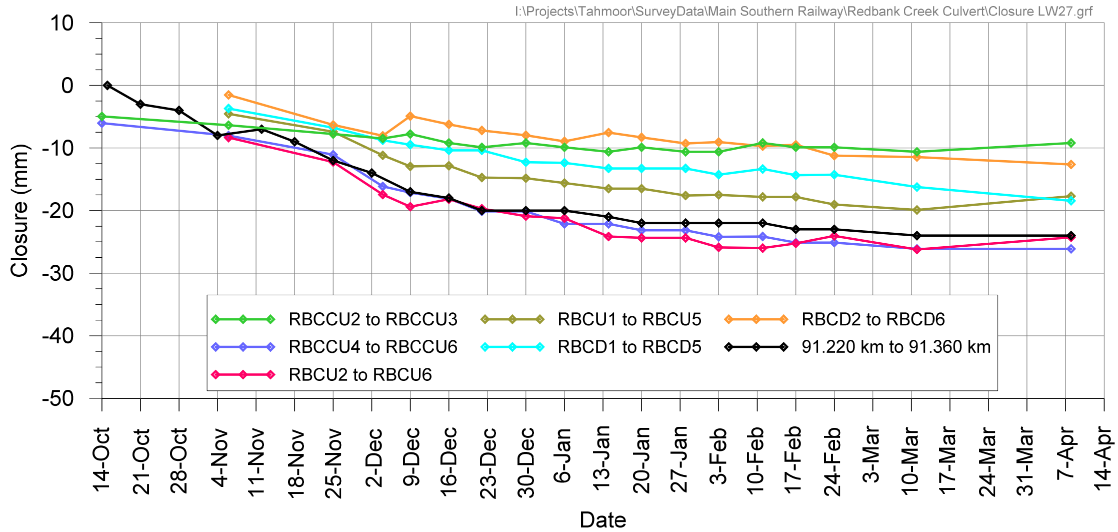


Fig. 2.15 **Observed Valley Closure over time across Redbank Creek Culvert at Main Southern Railway**

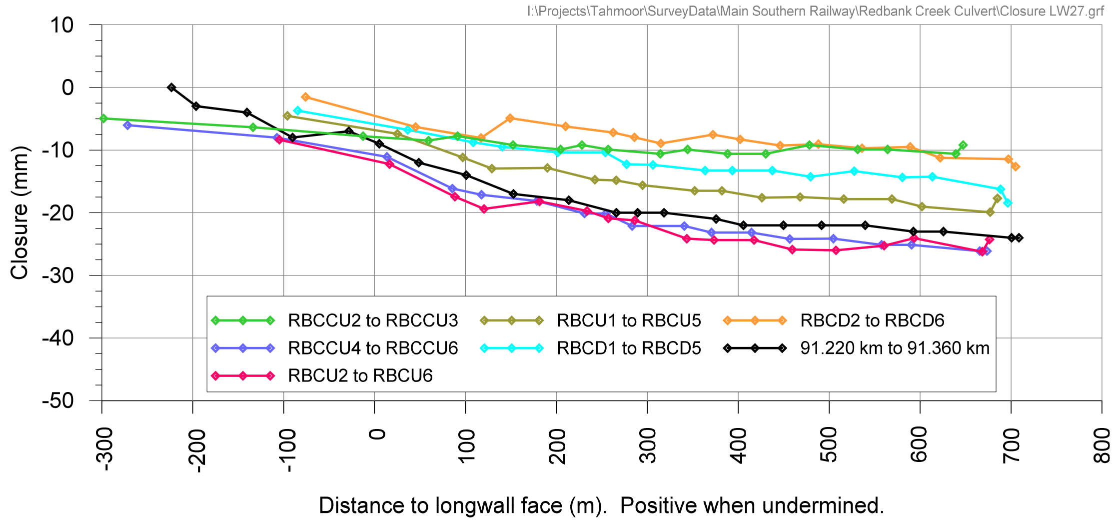


Fig. 2.16 **Observed Valley Closure relative to distance to longwall face across Redbank Creek Culvert at Main Southern Railway**

2.6. Sewer Infrastructure

2.6.1. Sewer grades

One of the key items of infrastructure that had the potential to experience impacts as a result of increased subsidence were the self-cleansing sewer pipes within the urban area. Subsidence monitoring was undertaken along the streets and along the Tahmoor Carrier pipe during mining.

No sewer pipes were observed to experience a reversal of grade during the mining of Longwall 27.

The Tahmoor Carrier is the main branch servicing the majority of Tahmoor township. An 84 metre long section of 375 mm diameter Tahmoor Carrier pipe was laid with a pre-mining grade of 0.5% (5.0 mm/m), which is close to the minimum grade for self-cleansing of 0.2% (2 mm/m). The pipe section is located at the rear of 3 private properties on Remembrance Drive, which back onto Myrtle Creek. The pipe was predicted to experience a maximum reduction in grade of 5.7 mm/m, which would have resulted in a very slight reversal in grade of approximately 0.7 mm/m (0.07%). It was estimated that approximately 50 metres of this pipe was predicted to experience a very slight reversal of grade during the mining of Longwall 27. As seen in Fig. A.47, the trigger level was not exceeded during the mining of Longwall 27.

A water level sensor was installed in the upstream pit prior to the influence of Longwall 27 and no noticeable changes have been observed, as shown in Fig. 2.17.

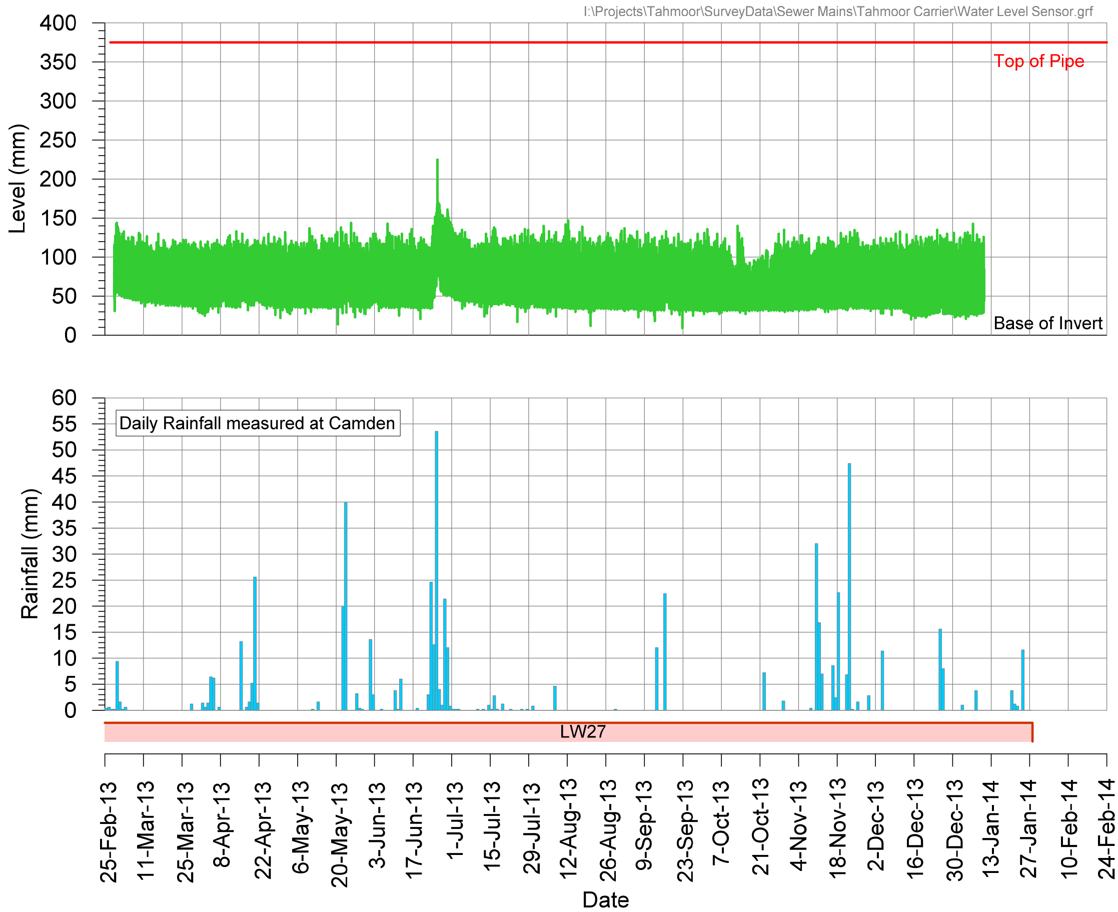


Fig. 2.17 Observed changes in water level in Tahmoor Carrier pipe

The Thirlmere Carrier is the main branch servicing the majority of Thirlmere township. A 67 metre long section of 375 mm diameter Thirlmere Carrier pipe was laid with a pre-mining grade of 0.5% (5.0 mm/m), which is close to the minimum grade for self-cleansing of 0.2% (2 mm/m). The pipe section is located beneath the southern shoulder of Bridge Street directly above Longwall 27. The pipe was predicted to experience a maximum reduction in grade of 5.9 mm/m, which would result in a very slight reversal in grade of approximately 0.9 mm/m (0.09%). It is estimated that approximately 50 metres of this pipe is predicted to experience a very slight reversal of grade during the mining of Longwall 27.

The development of mining-induced ground tilts and changes in sewer grade relative to the position of longwall face relative to the survey pegs are shown in Fig. 2.18. It can be seen that changes in tilt reduced, but the pipe grades did not reverse.

Ground surveys have found that the grade for one 20 metre section (Peg BG55 to BG56) has reduced to 0.06%, below the early warning trigger level of 0.2%. When the survey results between Pegs BG54 and BG57 are used to estimate change over the 67 metre section, the average grade is approximately 0.15% from pit to pit.

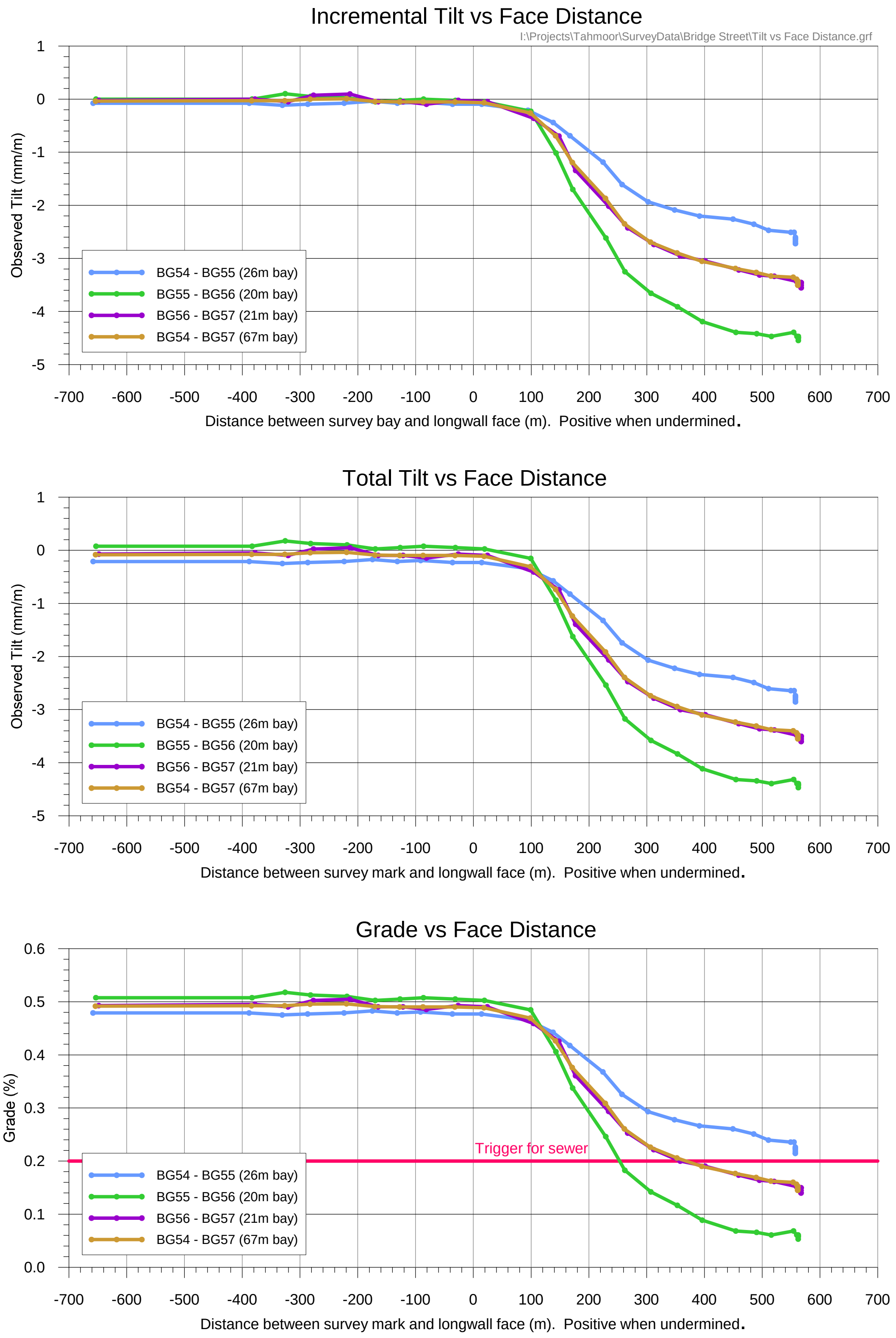


Fig. 2.18 Development of tilt on Bridge Street between pegs BG54 and BG57

2.6.2. Sewer Pumping Station

The Sewer Pumping Station on Castlereagh Street was monitored during the extraction of Longwall 27. A total of 20 ground surveys of pegs at the corners of the Pumping Station were undertaken on a weekly basis during the active subsidence zone. Tiltmeters were installed within the chamber at three locations and readings for tilt and temperature were obtained at ten minute intervals.

Ground monitoring around the pumping station during the mining of Longwall 27 showed that the pumping station subsided approximately 50 mm, as shown in Fig. 2.19. Observed tilts were within expectations.

The majority of ground strains around the pumping station were relatively small. Maximum compressive strain of 1.7 mm/m was observed between Pegs PS1 and PS4 in April 2013.

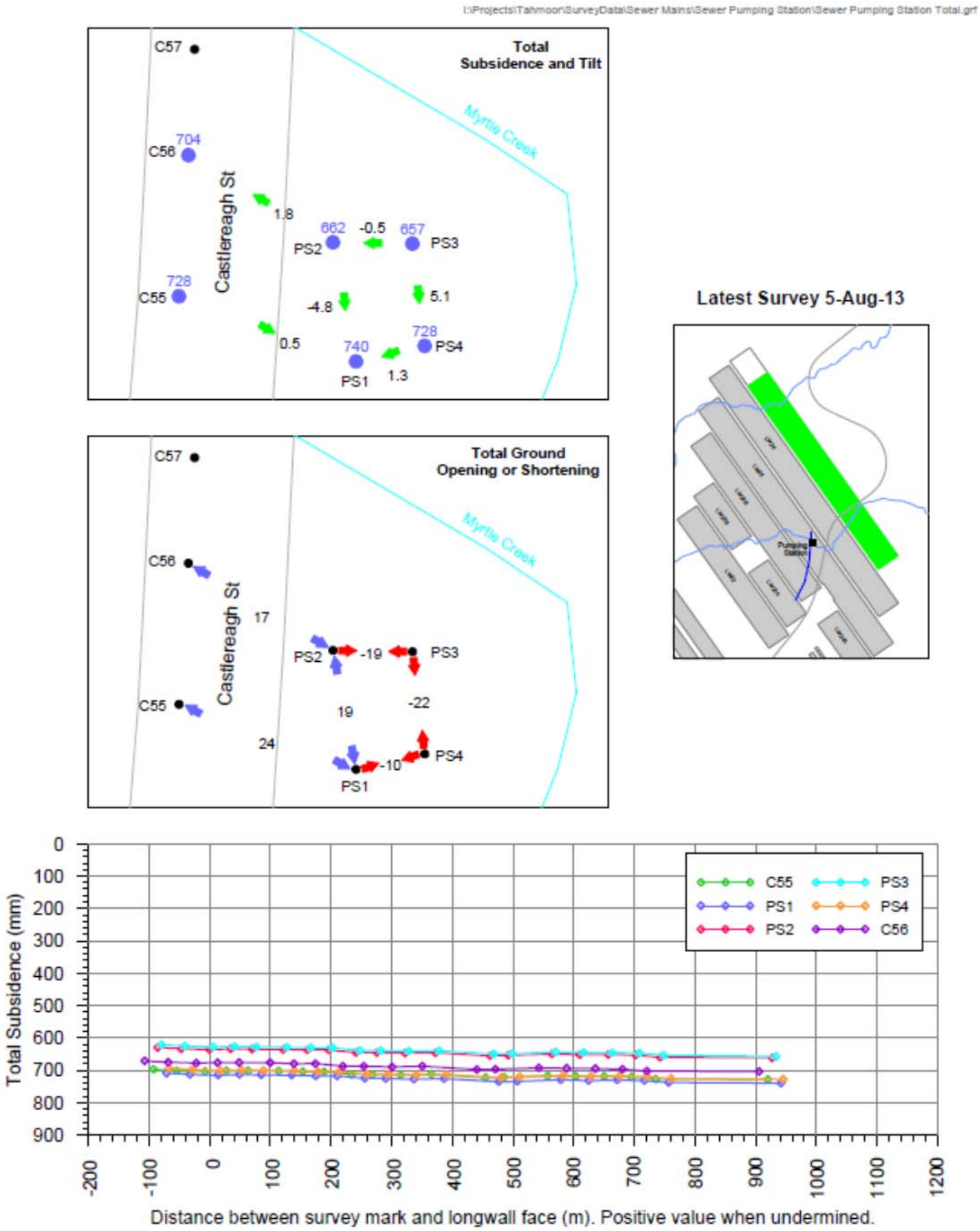


Fig. 2.19 Sewer Pumping Station Monitoring during Longwall 27

Automated continuous tiltmeters monitored changes in tilt in 3 vertical lines, placed at the top, base and mid-point on the internal face of the chamber wall. As shown in Fig. 2.20, observed curvatures are well within trigger levels as defined under the Management Plan. It can be seen that after more than 5 years of operation, some sensors have recorded erratic readings at the 180 degrees position in December 2013. These sensors will not be replaced. The timing of the disturbance coincides with physical works that were undertaken in the chamber.

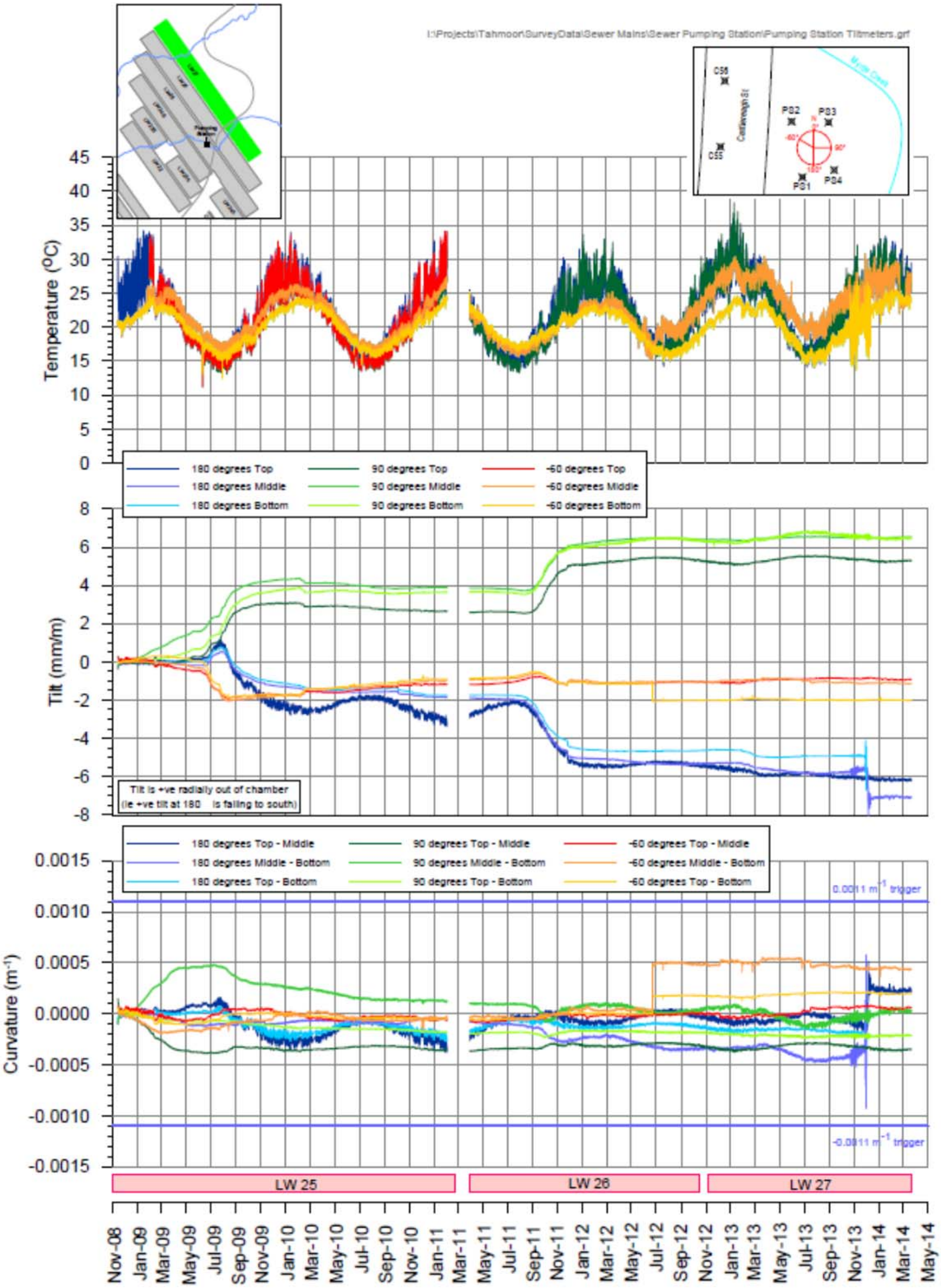


Fig. 2.20 Sewer Pumping Station Tiltmeters during Longwalls 25, 26 and 27

2.6.3. Rising Main

Ground monitoring along Castlereagh Street in the vicinity of the rising main indicated very small differential movements during the mining of Longwall 27 (refer Fig. A.08). No impacts have been observed along this main.

2.7. Power Pole Surveys

A total of 176 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 27, as expected.

Of the poles that were surveyed, maximum subsidence of 733 mm was observed at Pole 188 on Struan Street.

2.8. Tahmoor Town Centre

One detailed survey of the Tahmoor Town Centre and basement carpark was undertaken during Longwall 27. Maximum observed incremental subsidence due to the mining of Longwall 27 was less than 10 mm at the north-west corner of the complex. Maximum observed total subsidence after the mining of Longwall 27 was approximately 310 mm since the commencement of Longwall 24B. Observed profiles along the Exterior line after Longwall 27 are shown in Fig. 2.21 below.

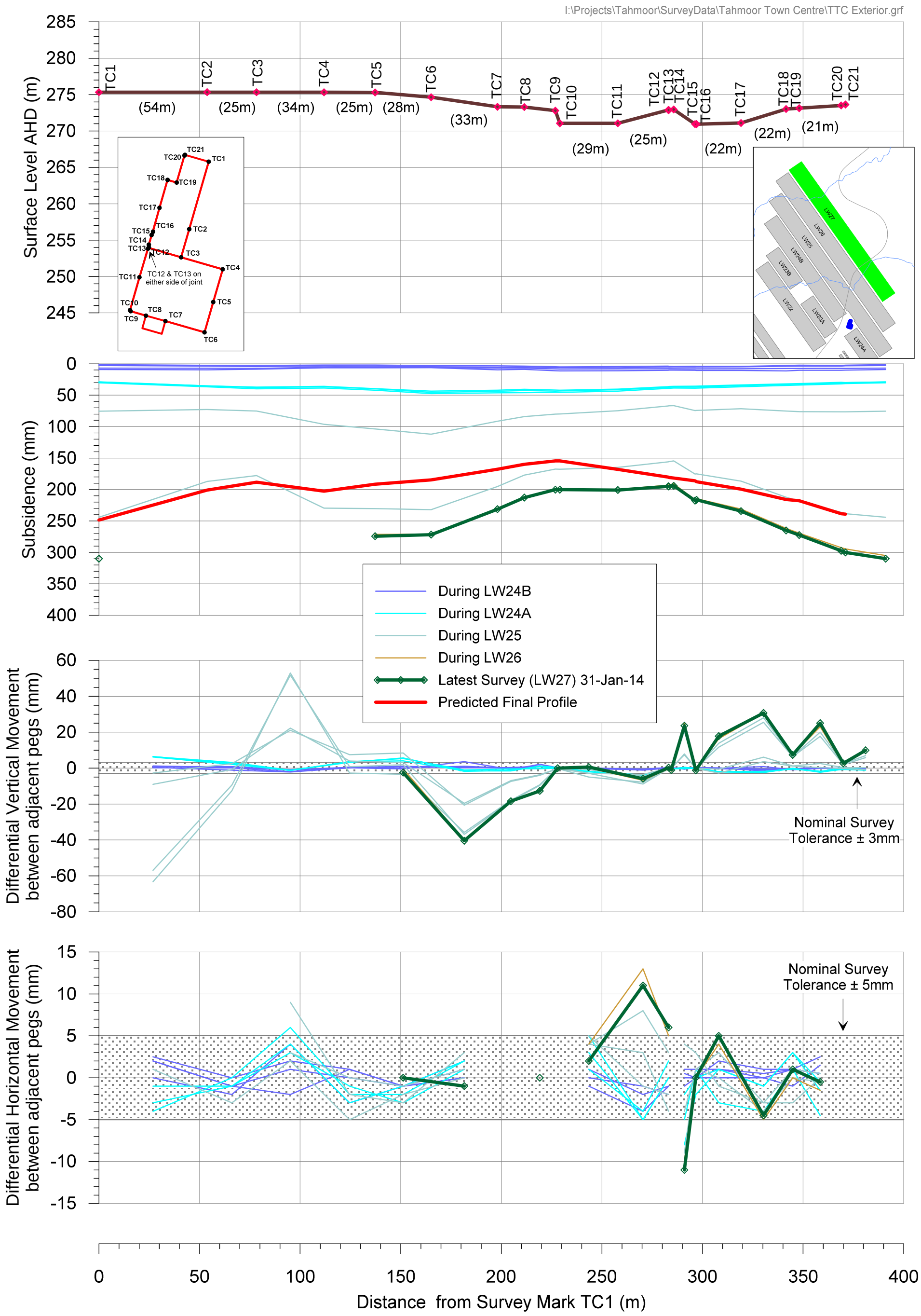


Fig. 2.21 Observed Profiles along Tahmoor Town Centre Exterior Line after Longwall 27

The distances across the width and length of the TTC basement were measured once during Longwall 27. The results indicate small movements in the North-South direction, and slightly greater closure movement across the diagonal NW/SE direction.

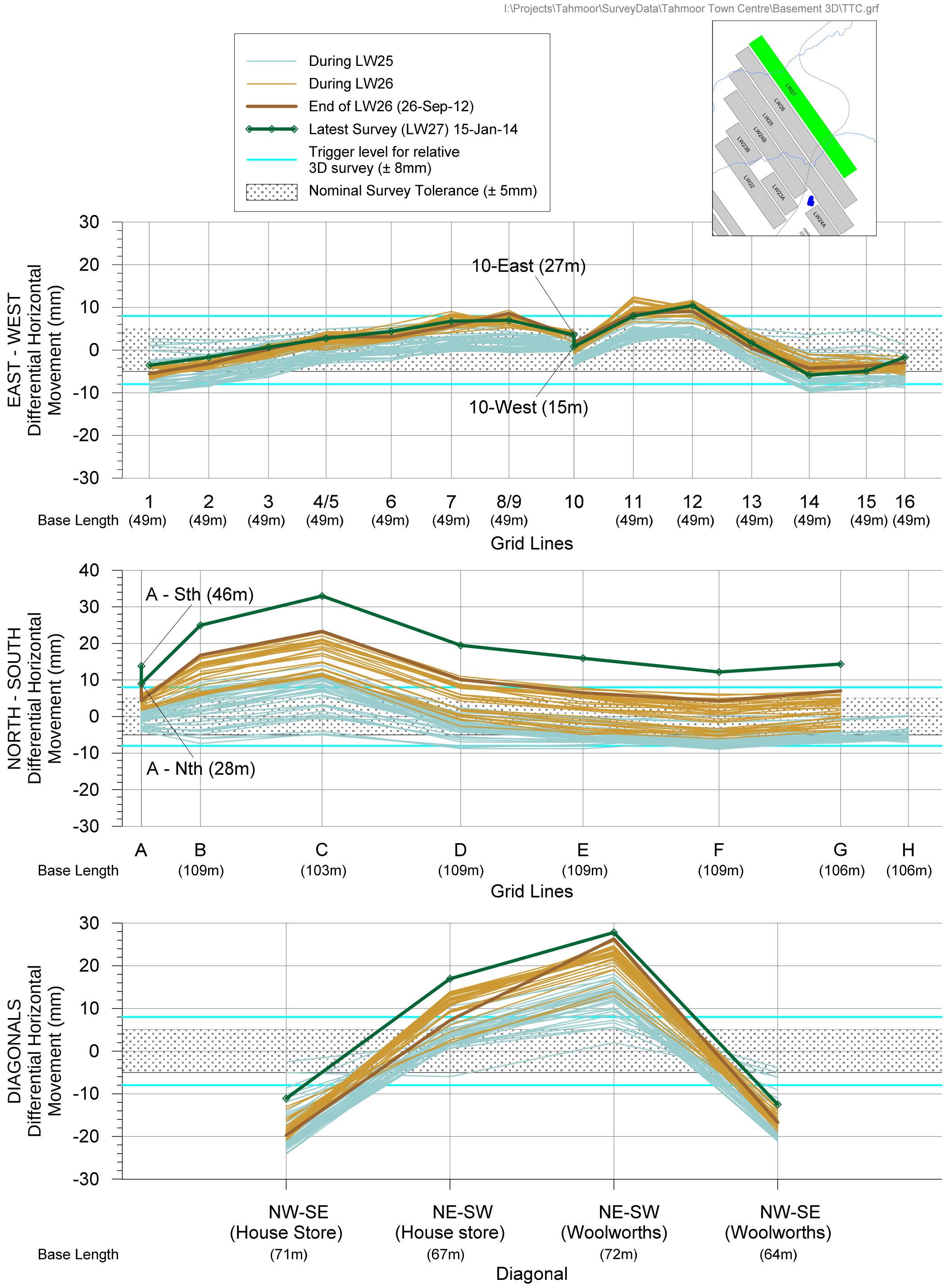


Fig. 2.22 Basement Width and Length Surveys during Longwall 27

2.9. Wollondilly Shire Council

2.9.1. Castlereagh Street Bridge

A total of 21 detailed surveys of the Castlereagh Street Bridge were undertaken in accordance with the agreed management plan and the results are shown in **Error! Reference source not found.**.

As discussed in Section 2.3, Castlereagh Street Bridge experienced 8 mm of valley closure during the mining of Longwall 27.

2.9.2. 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 30 mm of subsidence, measured changes in horizontal distances between the abutments are very small and close to survey tolerance. No closure has been detected and instead, a small opening has been measured, as shown in Fig. 2.23. 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.

An irregular spike was once observed across a survey bay that is only 3 metres long. The measured 8 mm change in horizontal distance equated to an apparent ground strain of more than 2 mm/m. Subsequent surveys confirmed that the previous measurement was erroneous. No corresponding spike in compression was observed across the bridge abutments.

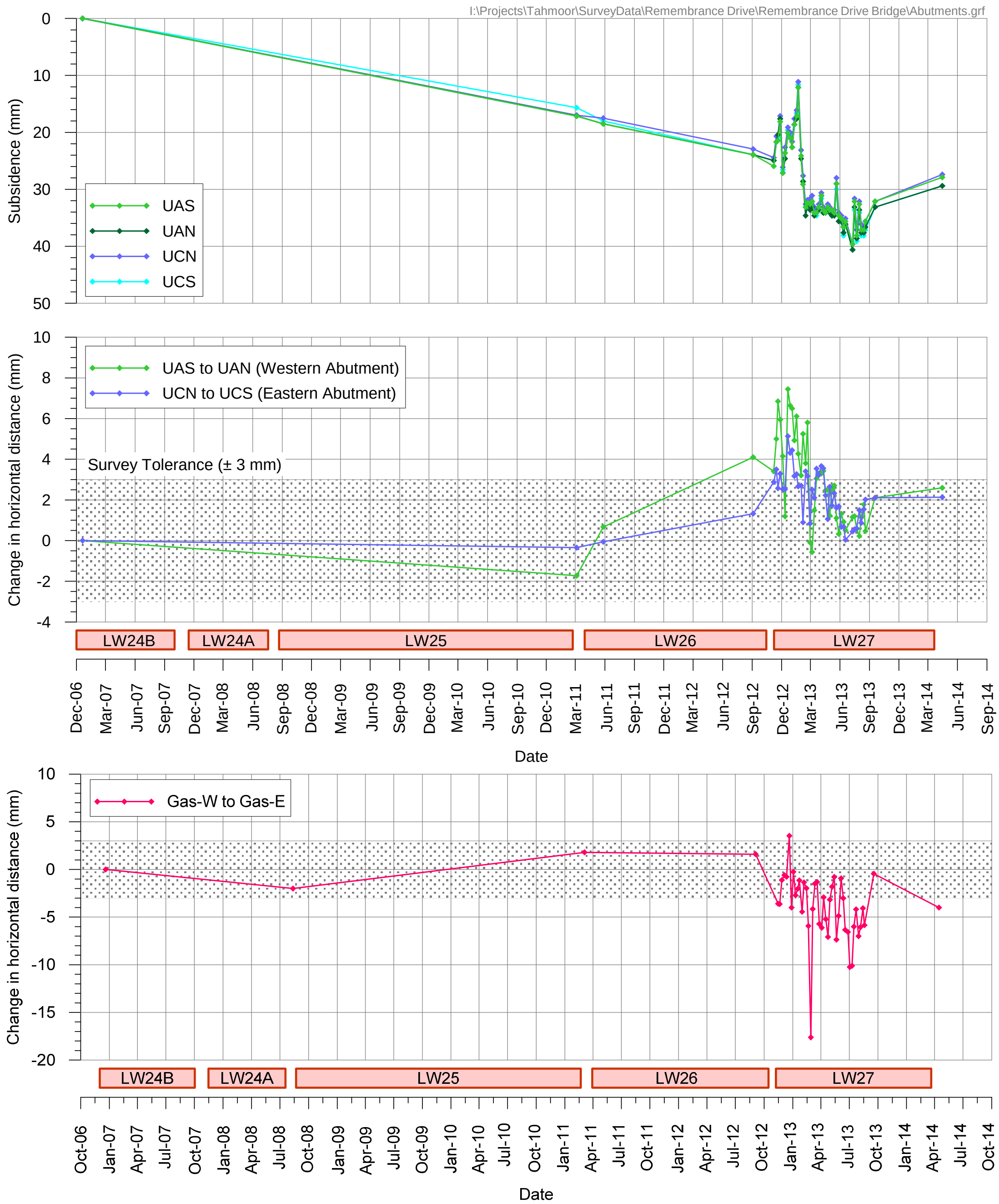


Fig. 2.23 Observed subsidence and changes in horizontal distances across the abutment and gas pipe supports at Remembrance Drive (Myrtle Creek) Road Bridge

2.10. Tahmoor House

Tahmoor House is an item of heritage significance, which is located on Remembrance Drive. A total of 20 detailed surveys of Tahmoor House were undertaken in accordance with the agreed management plan.

A maximum of 194 mm of subsidence was observed around the perimeter of Tahmoor House since the commencement of Longwall 27, as shown in Fig. A.54.

Vertical subsidence around the property has remained relatively uniform. Slightly more subsidence (approximately 40 mm) is observed at the western side of the house compared to the eastern side, as seen in Fig. 2.24.

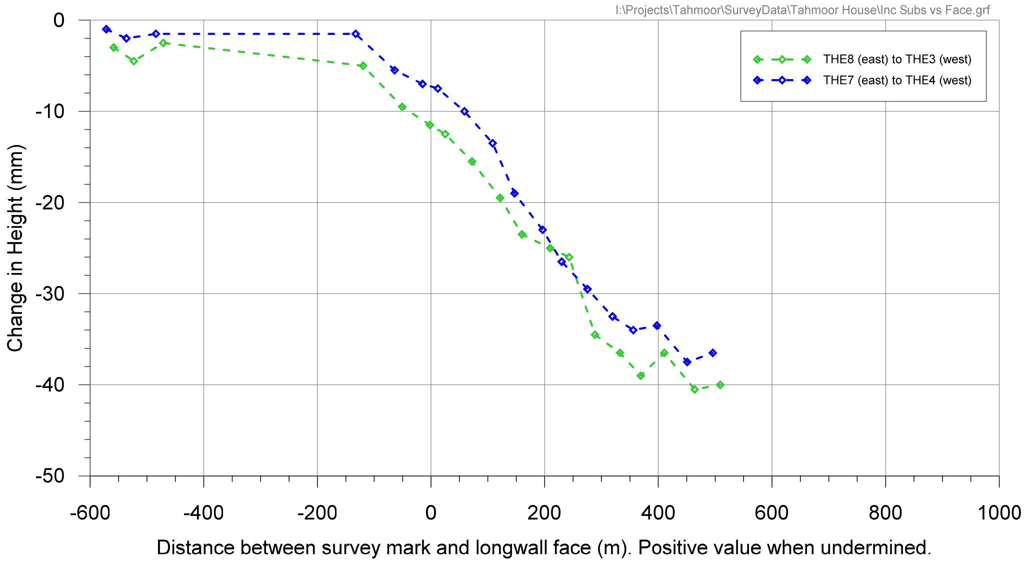


Fig. 2.24 Development of subsidence for ground pegs around Tahmoor House versus distance to longwall face

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.54 as the survey pegs are not uniformly spaced around the house. At this early stage, measured changes in horizontal distances and ground strains are generally within survey tolerance but 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, Fig. 3.2 and Fig. 3.3 below.

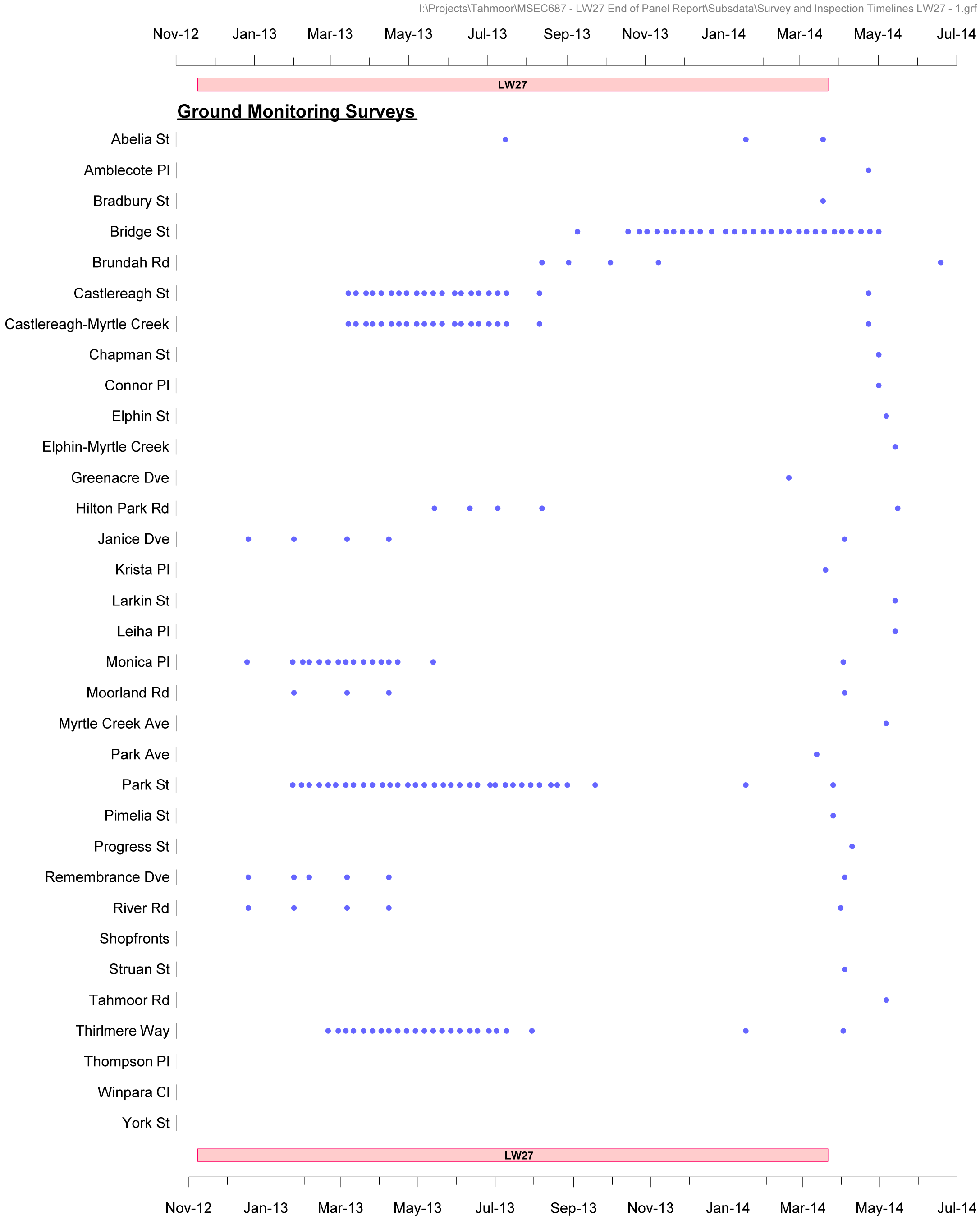


Fig. 3.1 Timeline of Surveys and Inspections during Longwall 27

Fig. 3.2 Timeline of Surveys and Inspections during Longwall 27

Fig. 3.3 Timeline of Surveys and Inspections during Longwall 27

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 27

Inspection / Survey	Responsibility	Number of Inspections / Surveys
Ground Monitoring Surveys		
	SMEC Urban	203
Sub-Total		**203**
Natural Features		
Myrtle Creek Crossings Surveys	SMEC Urban	22
Myrtle Creek Visual Inspections	Sergon	15
Redbank Creek Survey Lines	SMEC Urban	27
Redbank Creek Visual inspections	GeoTerra	20
13 York St Surveys	SMEC Urban	20
19 York St Surveys	SMEC Urban	11
Redbank Creek Water Monitoring	GeoTerra	5
Myrtle Creek Water Monitoring	GeoTerra	6
Groundwater Monitoring	GeoTerra	5
Sub-Total		**131**
Main Southern Railway		
Ground Surveys	Meadows Consulting	85
Rail Creep Surveys	Meadows Consulting	57
Long Bay Surveys	Meadows Consulting	57
Track Geometry Surveys	Railcon / BloorRail	93
Track Inspections	Railcon / BloorRail	39
Cutting Surveys	Meadows Consulting	13
Embankment Surveys	Meadows Consulting	9
Noise Wall Surveys	Meadows Consulting	9
Deviation Overbridge Surveys	Meadows Consulting	10
Bridge St Overbridge Surveys	Meadows Consulting	19
Myrtle Creek Culvert Surveys	Meadows Consulting	8
Myrtle Creek Culvert Extensometer Surveys	GHD	7
Myrtle Creek Culvert Visual Inspections	GHD	7
Skew Culvert Surveys	Meadows Consulting	40
Skew Culvert Extensometer Surveys	GHD	37
Skew Culvert Visual Inspections	GHD	37
Redbank Creek Culvert Surveys	Meadows Consulting	18
Redbank Creek Culvert Extensometer Surveys	GHD	5
Redbank Creek Visual Inspections	GHD	5
Sub-Total		**555**
Agility - Gas		
Remembrance Drive Bridge Surveys	SMEC Urban	44
Sub-Total		**44**
Sydney Water - Sewer		
Tahmoor Carrier Pipe Surveys	SMEC Urban	25
Water Level Sensor Surveys (every 5 mins)	Mace	406 (days)
Sewer Pumping Station Surveys	SMEC Urban	20
Myrtle Creek Water Quality Monitoring	Tahmoor Colliery	71
CCTV Inspections	Sydney Water	1
Sub-Total		**523**
Endeavour Energy - Electrical		
Power Pole Surveys	SMEC Urban	176
Sub-Total		**176**
Telstra - Telecommunications		
Optical Fibre Line Surveys	SMEC Urban	1
Sub-Total		**1**
Tahmoor Town Centre		
Building Surveys	SMEC Urban	1
Sub-Total		**91**
Structure Inspections		
Public Amenities / Commercial District	Sergon	3
Houses and Units	Sergon	948
Pools and Pool Gates	Sergon	525

Inspection / Survey	Responsibility	Number of Inspections / Surveys
Dams	GeoTerra	51
Sub-Total		**1527**
Wollondilly Shire Council		
Castlereagh St Bridge	SMEC Urban	21
Castlereagh St Bridge Visual Inspections	Colin Dove	11
Remembrance Drive Footbridge Surveys	SMEC Urban	44
Remembrance Drive Bridges Visual Inspections	Colin Dove	24
Sub-Total		**100**
Heritage		
Tahmoor House Surveys	SMEC Urban	20
Tahmoor House Visual Inspections	Colin Dove	16
Heritage House Visual Inspections	Colin Dove	14
Sub-Total		**50**
Total		**3284**

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 27

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 both creeks over LW's 25 to 27. 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. 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.	Temporary lowering of piezometer P2 by up to 8.9m near its pre – subsidence levels, then has gradually fallen by approximately 5.8m since mid 2009. Depressurisation of groundwater observed at one piezometer, located above future LW30. 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 27.
Natural vegetation	No impacts anticipated	No impacts observed during Longwall 27.
Public Utilities		
Railway	Bridges 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. Dip and rise in pavement on Remembrance Drive, at the intersection of Myrtle Creek Ave. 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 27. 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 27. Refer Section 4.6 for further details.
Sewer pipelines	Mining induced tilt may reduce grade of some pipes to 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 to rising mains, pumping station or creek crossings. 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 27. 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 27. Refer Section 4.9 for further details.
Public Amenities	Potential impacts to public amenities, particularly to shops along Remembrance Drive. All public amenities expected to remain safe and serviceable due to the mining of Longwall 27.	All public amenities remained safe and serviceable due to the mining of Longwall 27. Minor additional impacts to one public amenity building, Tahmoor Town Centre. Refer Section **Error! Reference source not found.** for further details.
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 27.
Fences	Potential for impacts to fences and gates.	No impacts reported to fences on farm properties during Longwall 27.
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. Two claims reported during Longwall 27. 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 27. Please refer report by Geoterra
Industrial, Commercial or Business Establishments	Negligible to slight impacts predicted for all business and commercial establishments.	All industrial, commercial and business establishments remained safe and serviceable due to the mining of Longwall 27.
Areas of Archaeological Significance	Potential fracturing, rock falls or water seepage affecting artwork on rock shelter on Myrtle Creek	No impacts on archaeological sites observed.
Areas of Heritage Significance	Potential damage to Tahmoor House	Minor impacts on Tahmoor House during Longwall 27. 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 27. 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.	One impact reported to dwellings during Longwall 27 but remained safe and serviceable.
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 27, of which 3 pools were reported with impacts during the mining of Longwall 27.
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 27.
External residential pavements	Cracking and buckling likely to occur, though majority minor.	Impacts to external pavements were reported by 10 properties during Longwall 27.
Fences in urban areas	Some fences and gates could be slightly damaged. Most vulnerable are Colorbond fences.	Impacts to fences reported by 7 urban properties during Longwall 27.

4.2. Creeks

4.2.1. Myrtle Creek

Geoterra undertook an investigation into the effects of Longwall 27 on surface and ground waters in the area (Geoterra, 2014).

During the mining of Longwall 27, 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 to a lesser degree, at Sites 20 to 24 above future Longwall 28 9 (refer to report by Geoterra for locations of sites).

Cracking was observed at the above sites and pools were observed to drain at times of low flow. The number of sites affected reduced following rain in the catchment between May and July 2013. The sub-surface flow diversion was observed to re-emerge downstream of Longwall 27.

Increased salinity has been observed downstream of the subsidence zone, though sulphate, bicarbonate, iron, manganese levels are generally not elevated, with the exception of an isolated occasion during the mining of Longwall 27. No observable trend or change in levels of aluminium, copper or zinc was observed during the mining of Longwall 27.

No new springs have been generated, or reduced, due to subsidence due to the mining of Longwalls 22 to 27.

4.2.2. Redbank Creek

Geoterra undertook an investigation into the effects of Longwall 27 on surface and ground waters in the area (Geoterra, 2014).

During the mining of Longwall 27, new or additional subsidence effects were observed at Sites 13 to 15 above Longwall 26, Sites 17 to 21A above Longwall 26 and the chain pillar between Longwalls 26 and 27, at Site 24 directly above Longwall 27, and at Sites 29 to 33 above future Longwall 28 9 (refer to report by Geoterra for locations of sites).

Cracking was observed at the above sites and pools were observed to drain at times of low flow, though trigger levels were not exceeded during the mining of Longwall 27. The sub-surface flow diversion was observed to re-emerge downstream of Longwall 27.

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 27. No observable trend or change in levels of aluminium or copper was observed during the mining of Longwall 27.

No new springs have been generated, or reduced, due to subsidence due to the mining of Longwalls 22 to 26.

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 27

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 LW27 at a number of sites above LWs 26 and 27. The number of sites affected reduced following rain in the catchment between May and July 2013.	Trigger not exceeded during mining of 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 LW27	Trigger exceeded at Site 37 over LW29 for zinc on an after 12 February 2014, in association with an extended period of drying out of pools between Sites 20 and 29.

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

During the mining of Longwall 27 some of the triggers associated with the *Tahmoor Colliery Longwall 27 Management Plan for Longwall Mining beneath the Main Southern Railway (Rev C, March 2013)* were exceeded.

While some false alarms were received due to monitoring system issues, rail stresses did not exceed triggers during the mining of Longwall 27.

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. Myrtle Creek Culvert

Only very slight changes were observed at the Myrtle Creek Culvert, which remained serviceable at all times during the mining of Longwall 27. The culvert structure has moved largely as a rigid body during mining.

The Culvert has experienced only minor damage in response to subsidence movements.

4.3.3. Skew Culvert

Tahmoor Colliery has successfully extracted Longwall 27 beneath the Skew Culvert.

The barrel of the Culvert has experienced cracking at the upstream and downstream ends in response to subsidence movements, though it remains stable. An air gap remains between the brick arch culvert and the liner. Cracks were also observed in the headwalls at both ends of the culvert and wingwalls on the upstream end. Impacts were also observed in the grout packing at the base of the culvert at the downstream end of the culvert.

In addition to valley closure movements, the upstream end of the culvert has experienced a complex combination of differential ground movements. The ground along the upstream wingwall on the country side has closed approximately 140 mm (SKU15 to SKUC1) during mining and it is clear from relative and absolute 3D surveys that the ground and culvert have experienced horizontal ground shear.

Following an assessment of monitoring data after the mining of Longwall 26, the Rail Management Group decided to cut a slot through the wingwalls on the upstream and downstream ends. The purpose of the slot was to dissipate ground compression along the wingwalls into the slot and avoid impacts on the culvert barrel and headwalls.

Monitoring during the mining of Longwall 27 found that the saw cut closed in response to ground movements. While some additional cracks developed during the mining of Longwall 27, it was reduced from those observed during the mining of Longwall 26. It is assessed that the saw cut has substantially reduced the amount of cracking on the culvert.

A detailed Subsidence Management Plan has been developed to manage potential impacts on the Skew Culvert during the mining of Longwall 28.

4.3.4. Redbank Creek Culvert and Embankment

Tahmoor Colliery has successfully extracted Longwall 27 adjacent to the Redbank Creek Culvert. No impacts were observed to the culvert.

A detailed Subsidence Management Plan is being developed to manage potential impacts on the Redbank Creek Culvert and Embankment during the mining of Longwall 28.

4.4. Roads and Bridges

4.4.1. Roads

Approximately 24.5 kilometres of asphaltic pavement lie directly above the extracted longwalls and a total of 46 impact sites have been observed. The observed rate of impact equates to an average of one impact for every 533 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.

Struan Street — Myrtle Creek Ave

Remembrance Drive — Remembrance Drive

Photographs courtesy of Colin Dove

Fig. 4.1 Photographs of Impacts to Road Pavements and Kerbs during Longwall 27

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 Longwall 27.

4.5. Potable Water Infrastructure

Longwalls 22 to 27 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.

A water leak occurred in a 100 mm diameter water main on Myrtle Creek Avenue in January 2013 during the extraction of Longwall 27. Increased strain and a bump in the subsidence profile at the site. The leak was repaired the same day.

4.6. Gas Infrastructure

Longwalls 22 to 27 have directly mined beneath approximately 16.2 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 27 have directly mined beneath approximately 27.3 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 27 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 Longwall 27. 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.
- *Rising mains*
  No impacts have been observed to rising mains. This includes the rising main that runs from the pumping station SP1045 at Castlereagh Street, which is located directly above previously extracted Longwall 25.
- *Sewer Pumping Station SP1045 at Castlereagh Street*
  Longwall 25 has mined directly beneath, and Longwalls 26 and 27 have mined adjacent to the pumping station. While the pumping station experienced differential movements, they were well below trigger levels. . No impacts have been observed, including during a visual inspection inside the chamber in September 2012 after the mining of Longwall 26.

The observed impacts to date have been within expectations.

4.7.1. Exceedance of Defined Triggers

During the mining of Longwall 27 one trigger associated with the agreed subsidence management plan were exceeded. The grade for one 20 metre section (Peg BG55 to BG56) has reduced to 0.06%, below the early warning trigger level of 0.2%. When the survey results between Pegs BG54 and BG57 are used to estimate change over the 67 metre section, the average grade is approximately 0.15% from pit to pit.

Tahmoor Colliery has consulted directly with Sydney Water in accordance with the Sewer Management Plan to consider whether any additional management measures are required. It is agreed to continue monitoring at this stage but Sydney Water are ready to respond if required to ensure the sewer remains serviceable.

4.8. Electrical Infrastructure

Longwalls 22 to 27 have directly mined beneath approximately 36.2 kilometres of electrical cables and 889 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 27 have directly mined beneath approximately 42.0 kilometres of buried copper cable and 1.2 kilometres of buried optical fibre cable and 4.0 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 Longwall 27.

No impacts were observed to the Telstra Tower, which is located above Longwall 28.

4.10. Tahmoor House

Weekly inspections have found minor impacts during the mining of Longwall 27. The inspections were occasionally undertaken in company with the owner.

There is some indication of very minor differential movement in mortar bedding material at the base of the front steps. On the eastern side of the entry steps from Remembrance Drive, there is minor movement (approx. 20 mm) of the new retaining wall away from the sandstone blocks.

Some very minor cracking of mortar joint lines have been observed on the eastern side of the rear steps. A small wedge of mortar (50 mm long by 20-25 mm high) was found at the base of the first tread.

The owners have reported the development of a gap between a brick internal partition wall and a timber internal partition wall on the ground floor of the house, east of the rear stairs. The gap tapers from zero at the ground, to about 5 mm at the ceiling. No impacts are observed to the sandstone wall.

A single board on the eastern side of the house has moved away from its frame beneath the window. After a period of no change, an additional board and a weather strip have been observed to have moved off the frame.

4.11. Residential Establishments and Public Amenities

All structures remained safe and serviceable during the mining of Longwall 27.

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 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 24 April 2014, the day that Longwall 28 commenced.

A summary of reported impacts following the completion of Longwall 27 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 27.

Table 4.3 Summary of Observed Impacts to Structures

	Total after LWs 22 to 27	Increment during Longwall 27
Number of structures within zone of influence (predicted subsidence > 20 mm)	1834	310
Number of properties with reported impacts (not including refused claims)	492	73
Number of properties with reported impacts that relate to main structures (e.g. house or shop)	437	59
Number of properties with reported impacts that only relate to associated structures	55	14

The above information can be misleading as many of the claims received during the mining of Longwall 27 were associated with the mining of previous Longwalls 22 to 26. 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 27 in Fig. 4.2. A total of 67 of 101 claims related to the mining of Longwalls 22 to 26, rather than the active Longwall 27.

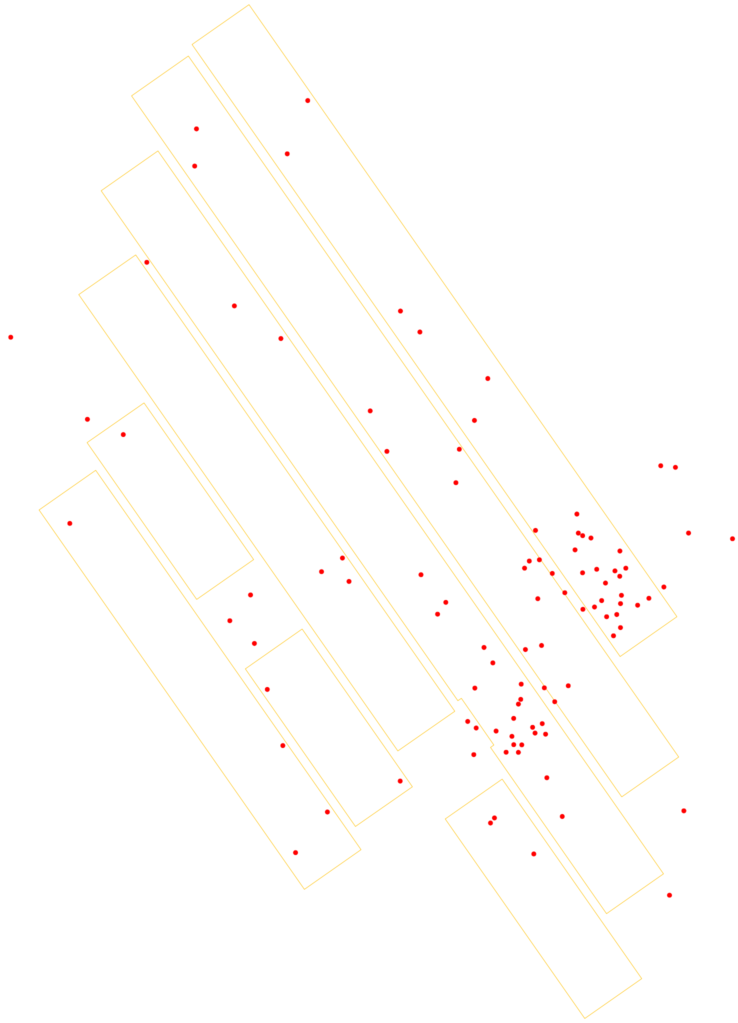


Fig. 4.2 Locations of Impacts Reported during the Mining of Longwall 27

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 27. 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 27 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 27

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 1834)	1834 **(90 %)**	139 **(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 27 only due to the time lag effect discussed previously. Similarly, some houses that reported impacts during the mining of Longwall 27 were associated with the mining of previous Longwalls 22 to 26.

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

At the time of writing ACARP Research Project C12015, the observed proportion of houses where the Mine Subsidence Board and affected landowners had agreed to rebuild rather than repair Category R5) impacts was less than 0.5 %. Since the publication of the research report, the proportion of houses where a decision has been made to rebuild has increased to approximately 0.7% overall.

The decision to rebuild (Cat R5) rather than repair a moderately to severely impacted house (Cat R3 and R4) is based on a variety of factors. From an impact perspective, all houses previously impacted at Tahmoor Colliery could have been repaired rather than replaced, including those where a decision has been made to rebuild them. It is for this reason that repair categories R3 to R5 have been combined in Table 4.4 and Table 4.5.

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 27.

4.11.2. Swimming Pools

Impacts have been observed to 3 swimming pools during the mining of Longwall 27.

4.11.3. Associated Structures

Minor impacts have been observed to 2 retaining walls during the mining of Longwall 27.

4.11.4. Fences

The potential for impacts to fences was raised in the SMP Report and a total of 7 properties in urban areas have claimed impacts to gates and fences during the mining of Longwall 27.

5.0 SUMMARY OF RESULTS

There is generally a good correlation between observed and predicted subsidence, tilt and curvature for areas located between Remembrance Drive in Tahmoor and Thirlmere. Observed subsidence was generally slighter greater than predicted in areas that were located directly above previously extracted longwalls and areas of low level subsidence (typically less than 100 mm) where the subsidence was observed to extend further than predicted.

As anticipated prior to mining, increased subsidence was observed during the first stages of mining Longwall 27, but at a reduced magnitude compared to the subsidence observed above Longwalls 24A to 26.

Maximum observed incremental subsidence from the mining of Longwall 26 was 825 mm, which was approximately 1.3 times the maximum predicted subsidence. While observed tilts and curvature were also substantially greater than predicted above the commencing end of the longwall, observed ground strains were generally within the normal range.

While subsidence has exceeded predictions in most locations at the commencing end of Longwall 26, there remains 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.

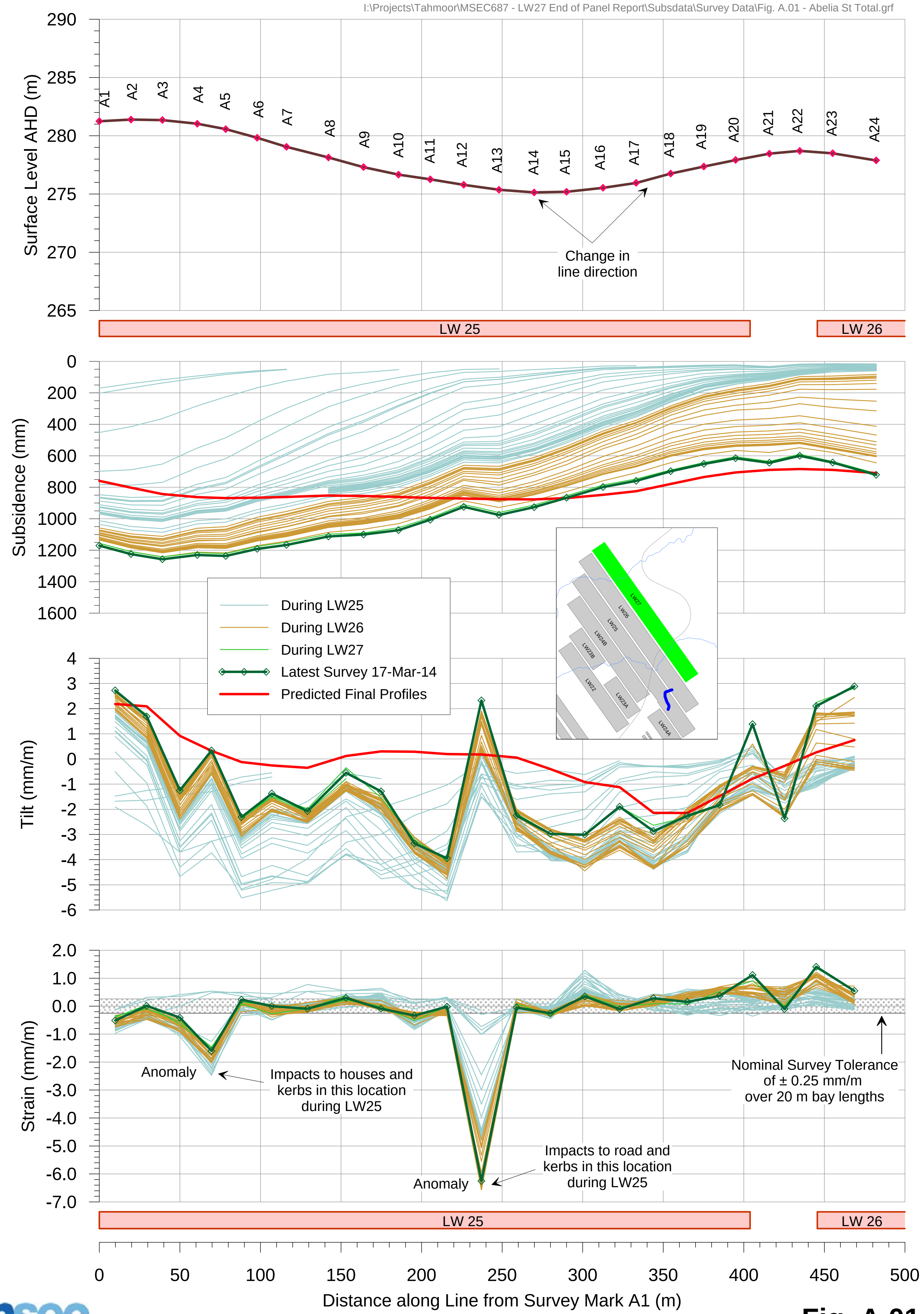
All structures remained safe and serviceable during the mining of Longwall 27. The overall claim rate for main structures during the mining of Longwalls 22 to 27 was 24 %.

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 27.

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 27. Some adverse changes were observed in water quality were observed at times of low flow. The observed impacts are within predictions.

APPENDIX A. FIGURES

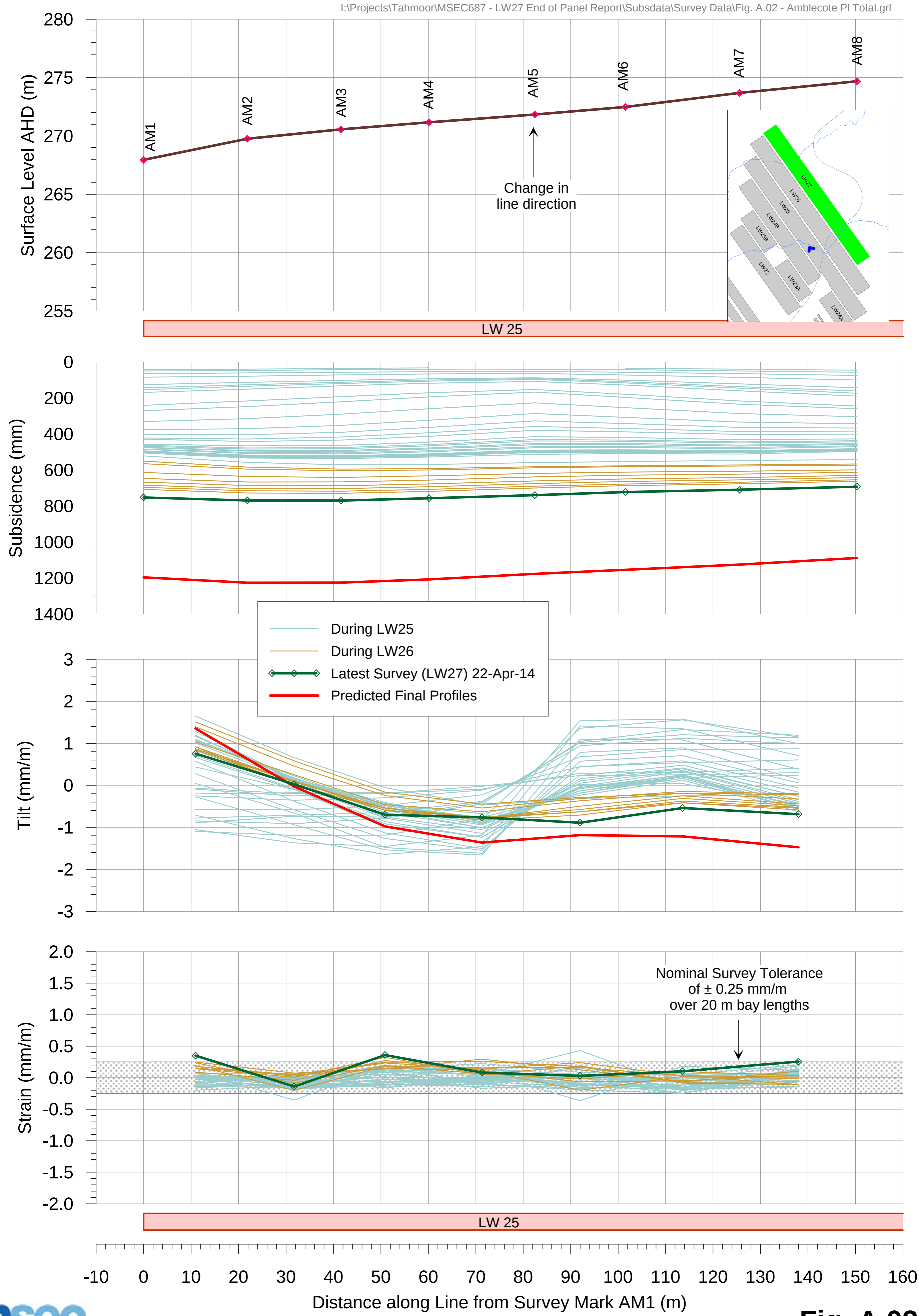
Tahmoor Colliery
Total Subsidence Profiles along Abelia Street



msec

Fig. A.01

Tahmoor Colliery
Total Subsidence Profiles along Amblecote Place



msec

Fig. A.02

Tahmoor Colliery
Total Subsidence Profiles along Bradbury Street

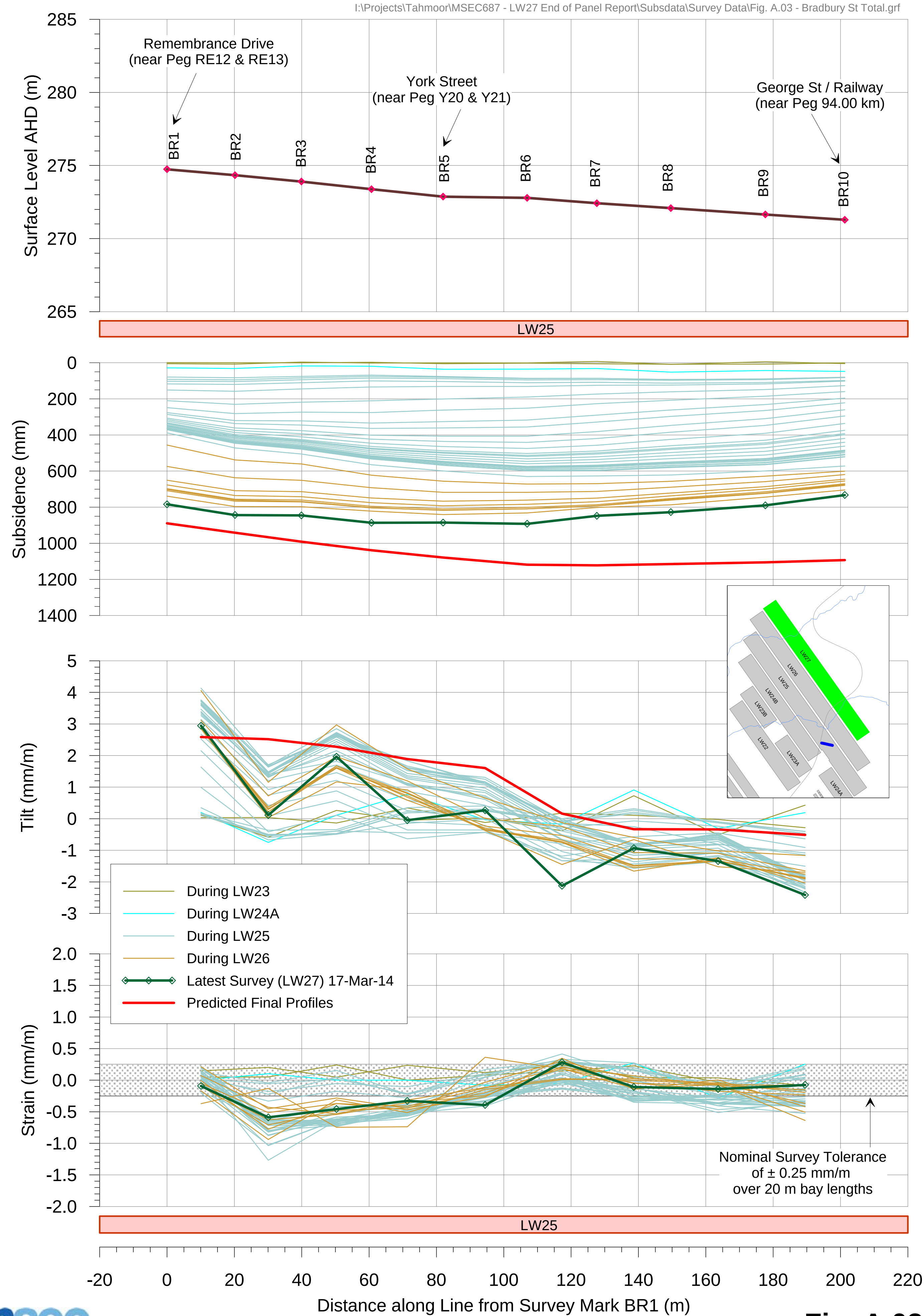


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Fig. A.03

Tahmoor Colliery
Incremental Subsidence Profiles along Bridge Street

I:\Projects\Tahmoor\MSEC687 - LW27 End of Panel Report\Subsdata\Survey Data\Fig. A.04 - Bridge St Inc.grf

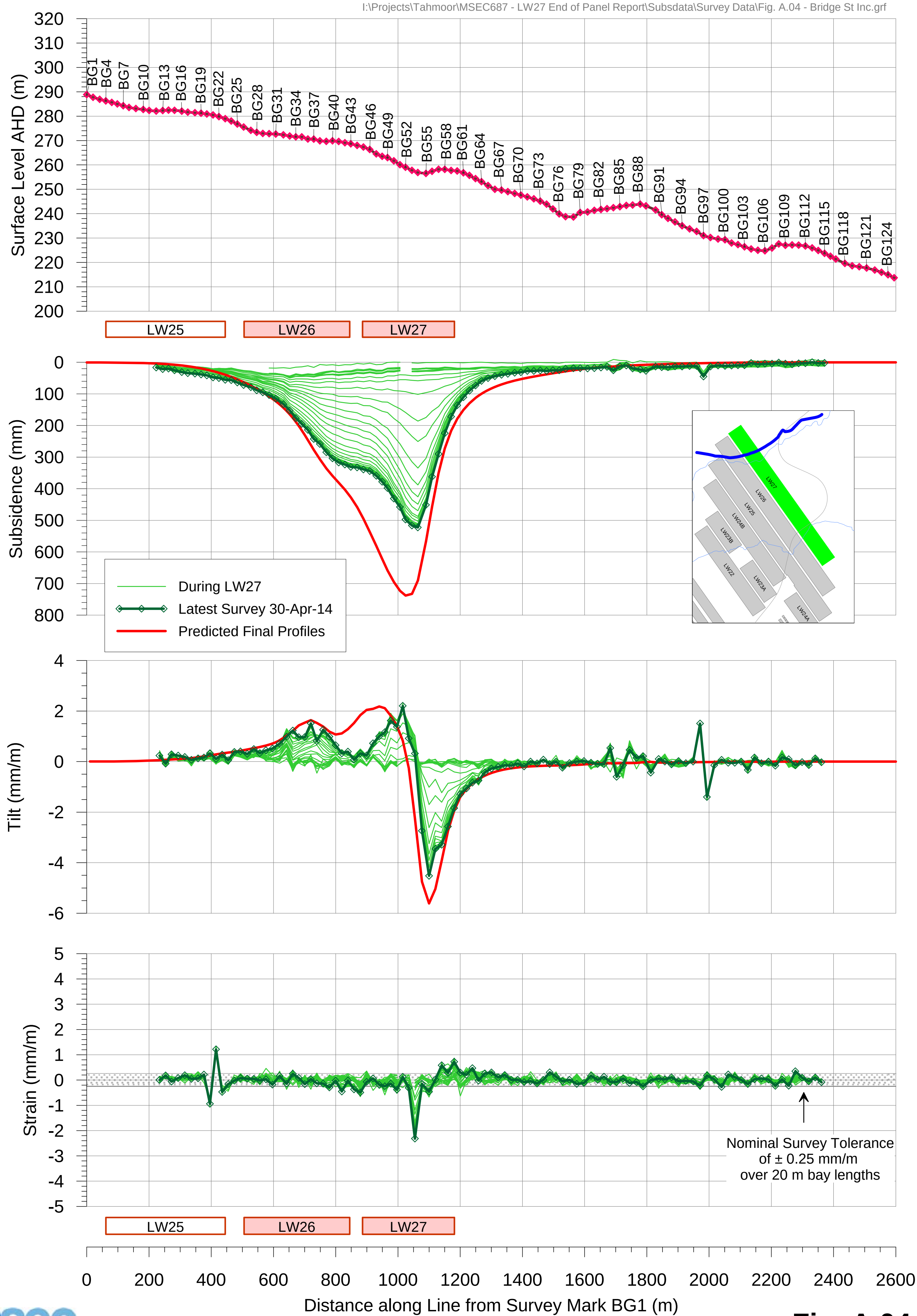

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Fig. A.04

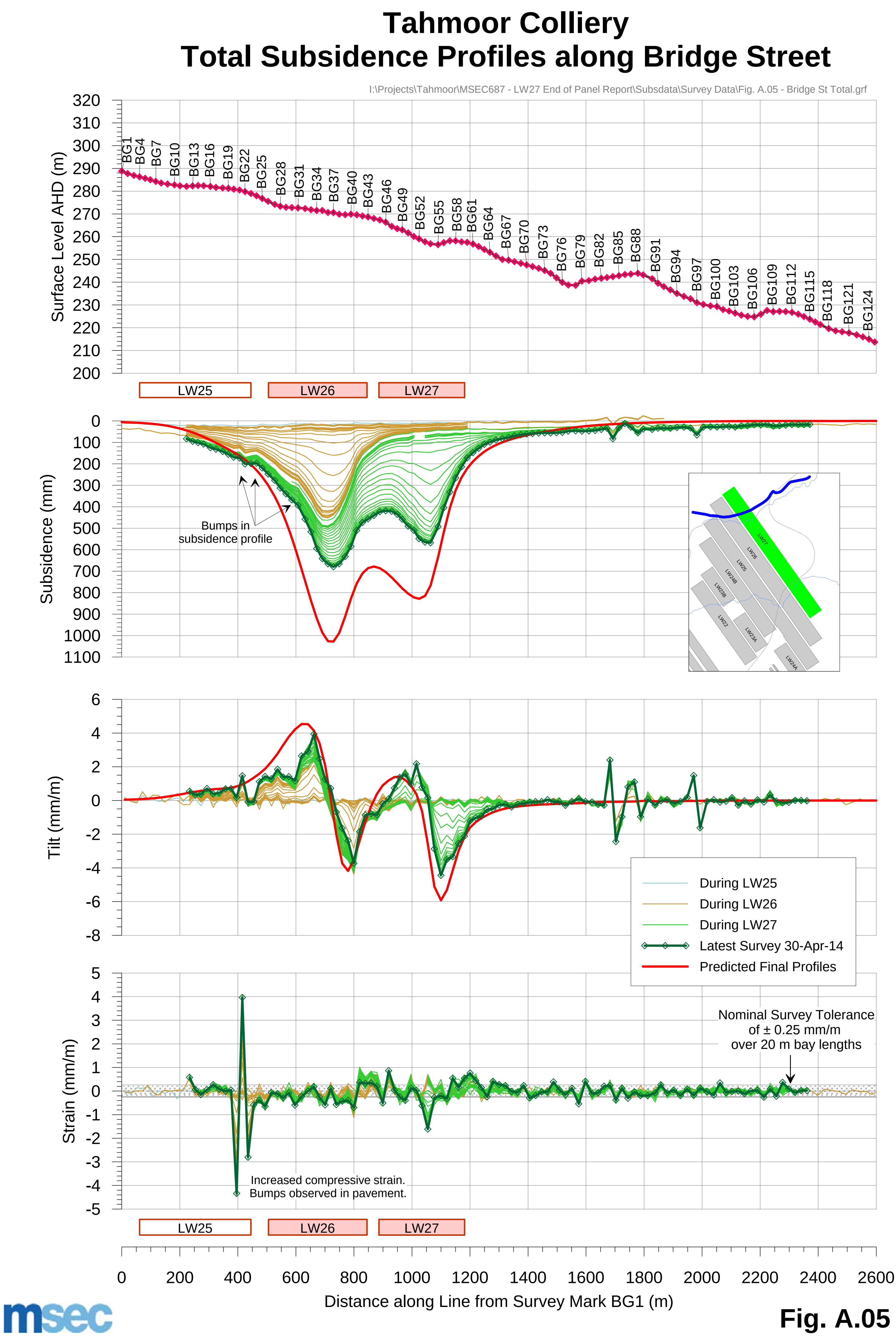

Tahmoor Colliery
Total Subsidence Profiles along Bridge Street
I:\Projects\Tahmoor\MSEC687 - LW27 End of Panel Report\Subsdata\Survey Data\Fig. A.05 - Bridge St Total.grf
Surface Level AHD (m)
Subsidence (mm)
Tilt (mm/m)
Strain (mm/m)
LW25
LW26
LW27
Bumps in subsidence profile
During LW25
During LW26
During LW27
Latest Survey 30-Apr-14
Predicted Final Profiles
Nominal Survey Tolerance of ± 0.25 mm/m over 20 m bay lengths
Increased compressive strain. Bumps observed in pavement.
Distance along Line from Survey Mark BG1 (m)
msec

Fig. A.05

Tahmoor Colliery
Incremental Subsidence Profiles along Brundah Road

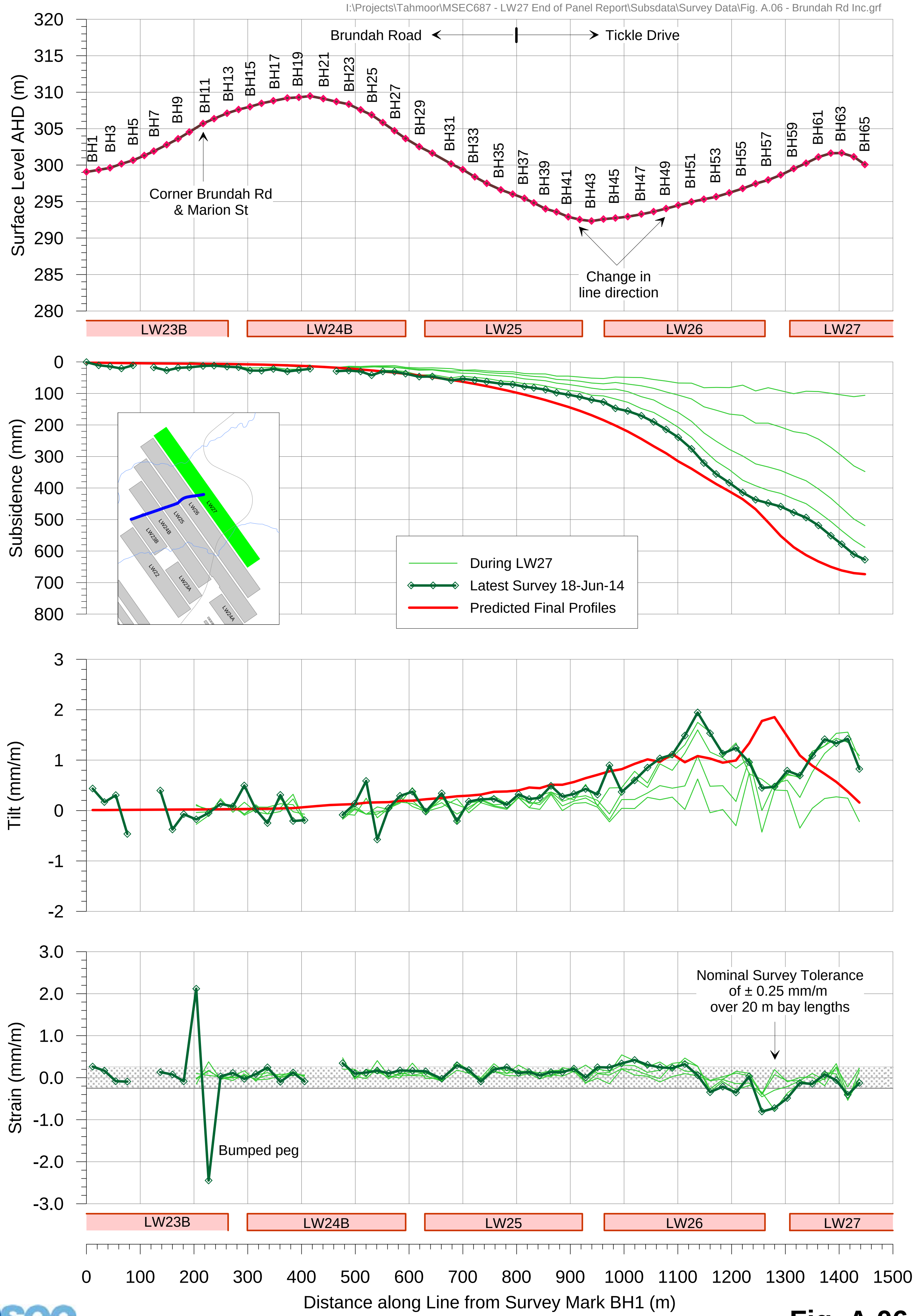
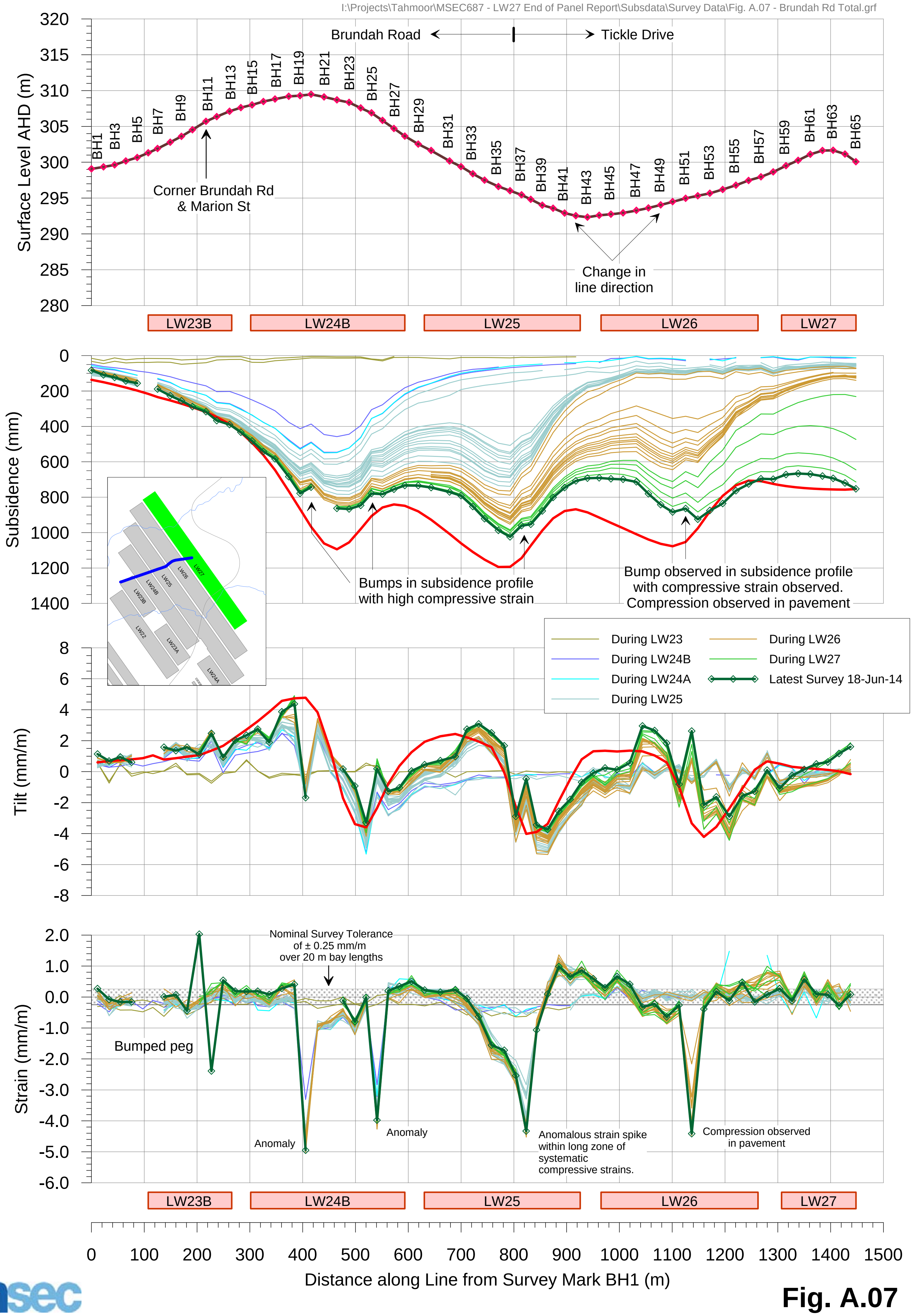


Fig. A.06

Tahmoor Colliery
Total Subsidence Profiles along Brundah Road



msec

Fig. A.07

Tahmoor Colliery
Total Subsidence Profiles along Castlereagh Street

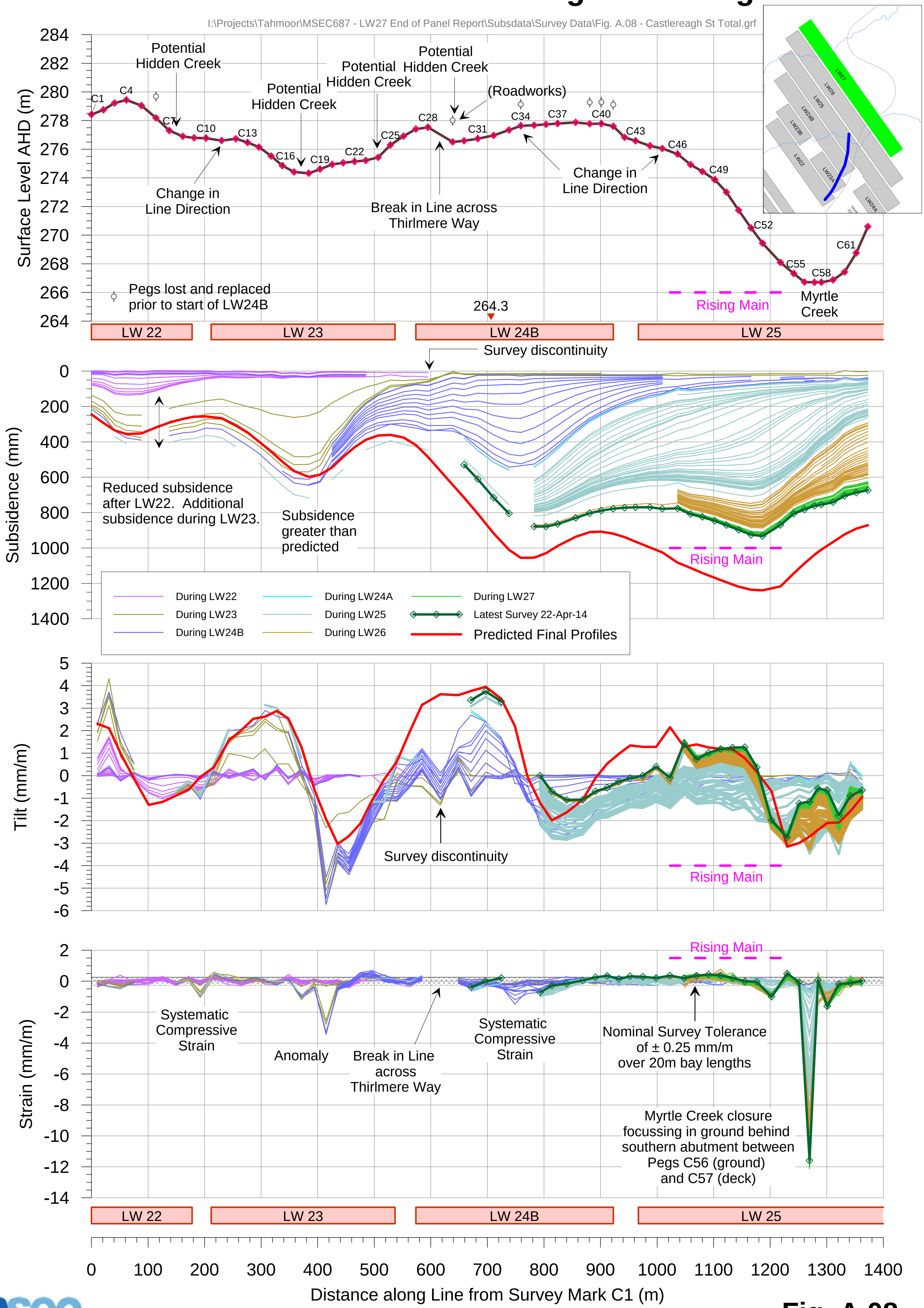


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Fig. A.08

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

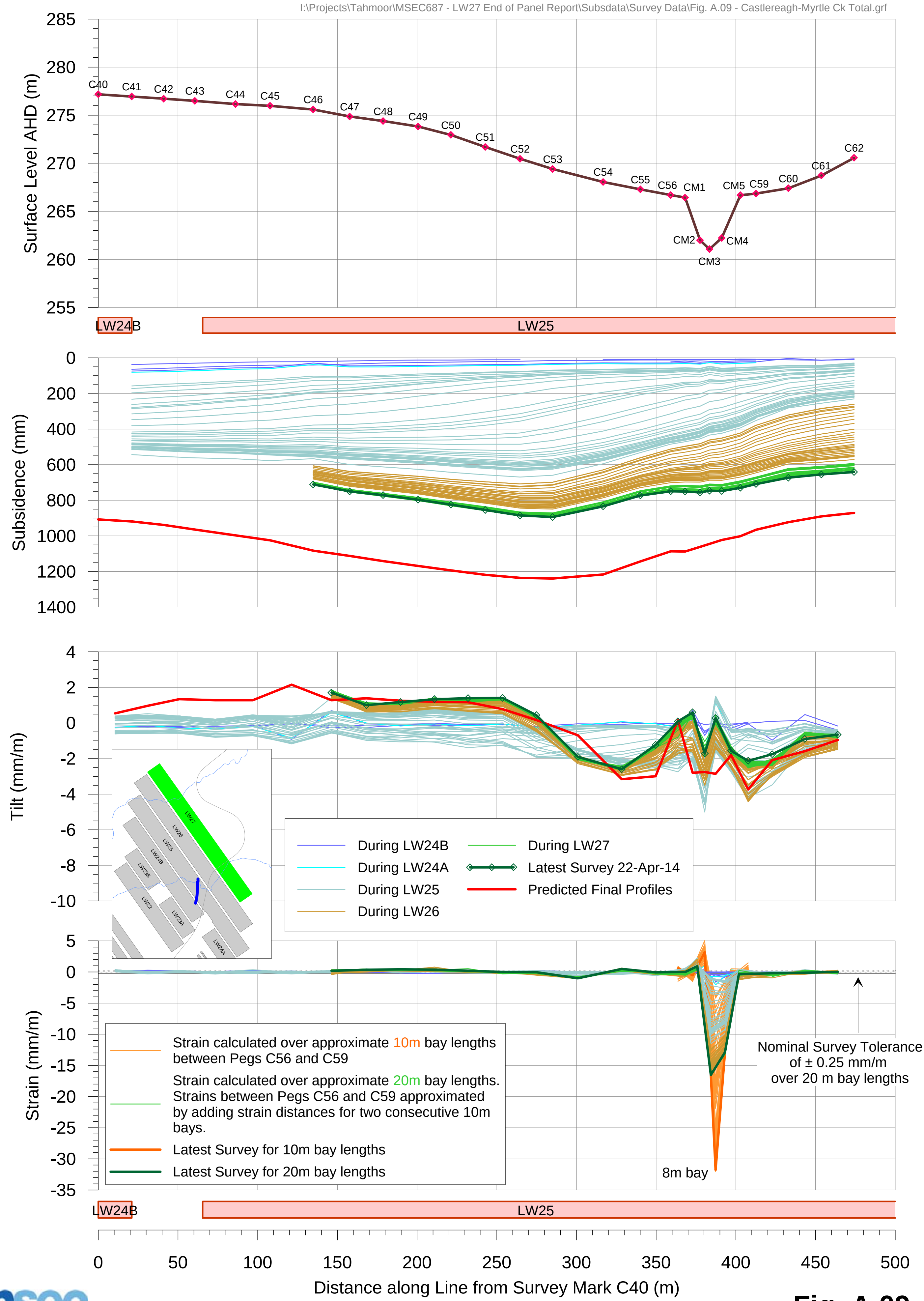


Fig. A.09

Tahmoor Colliery
Total Subsidence Profiles along Chapman Street

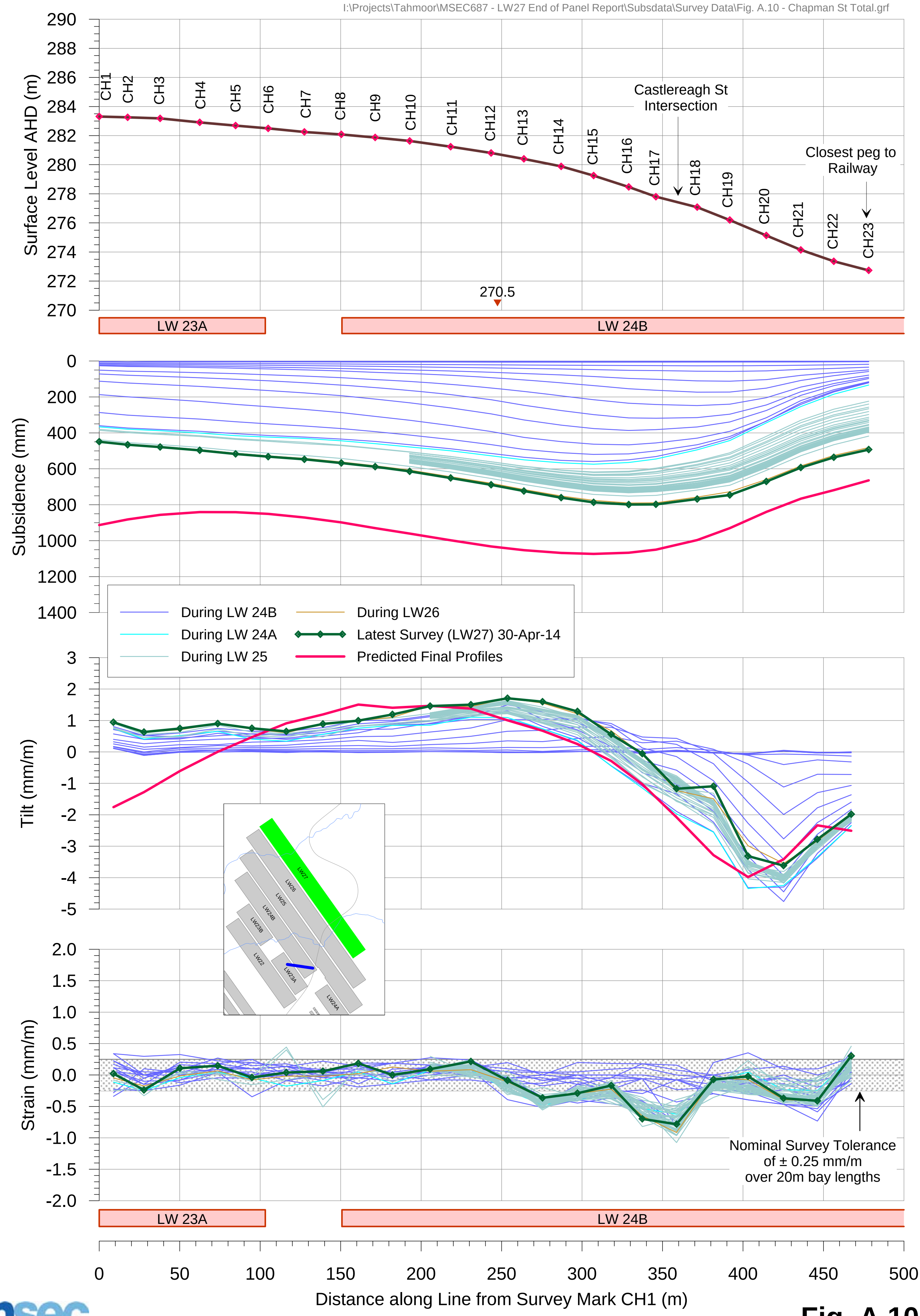
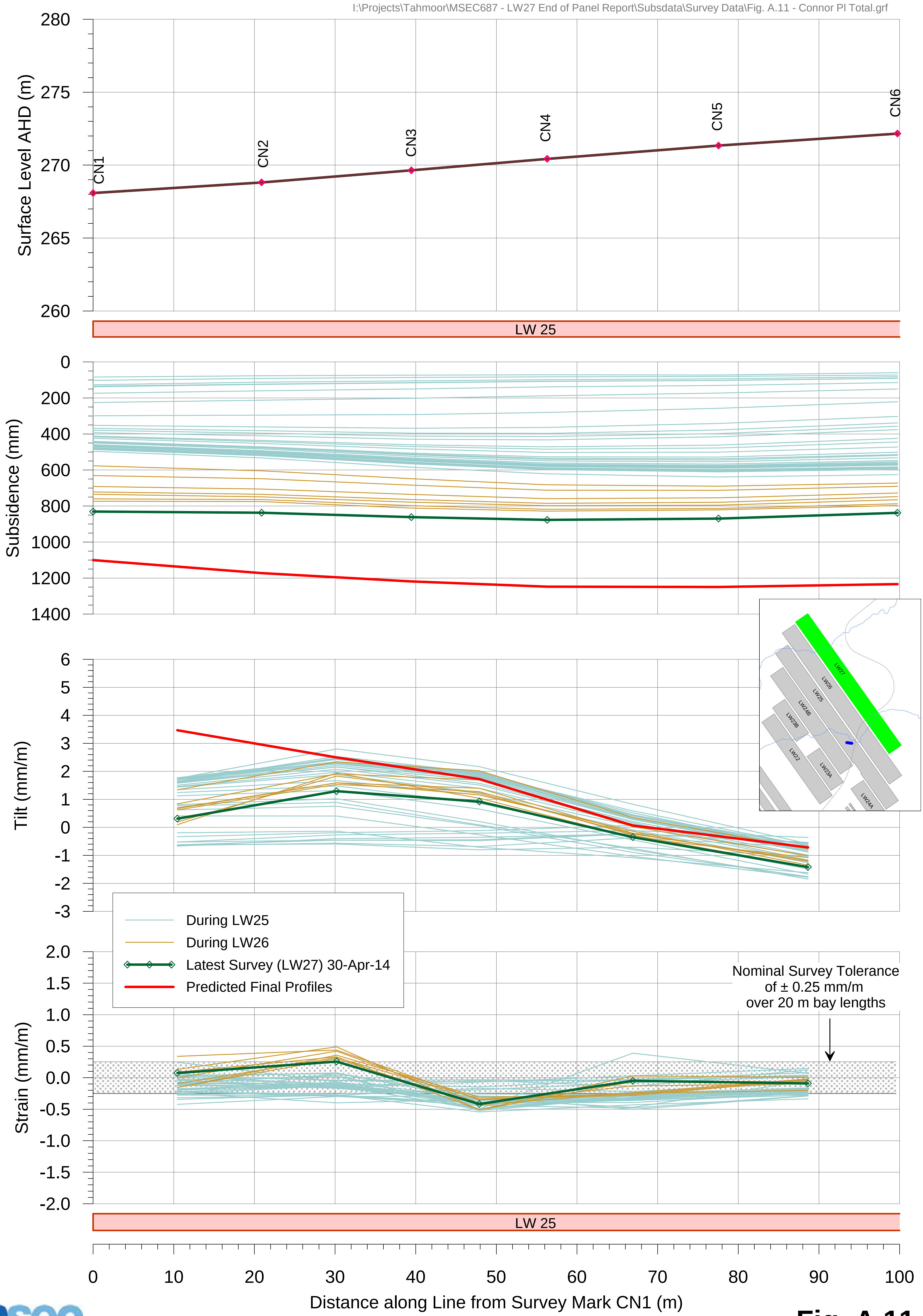


Fig. A.10

Tahmoor Colliery
Total Subsidence Profiles along Connor Place



msec

Fig. A.11

Tahmoor Colliery
Total Subsidence Profiles along Elphin Street

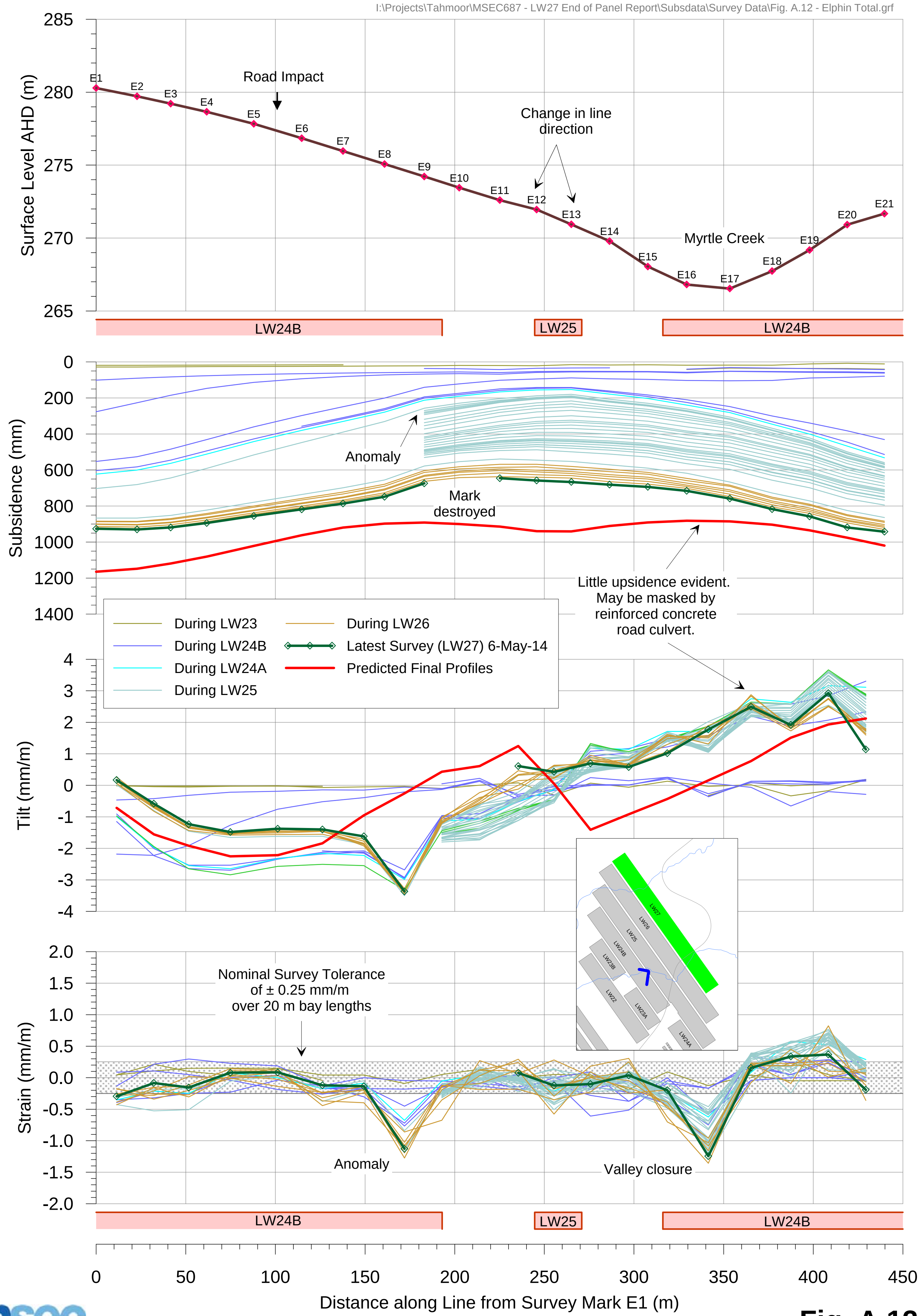
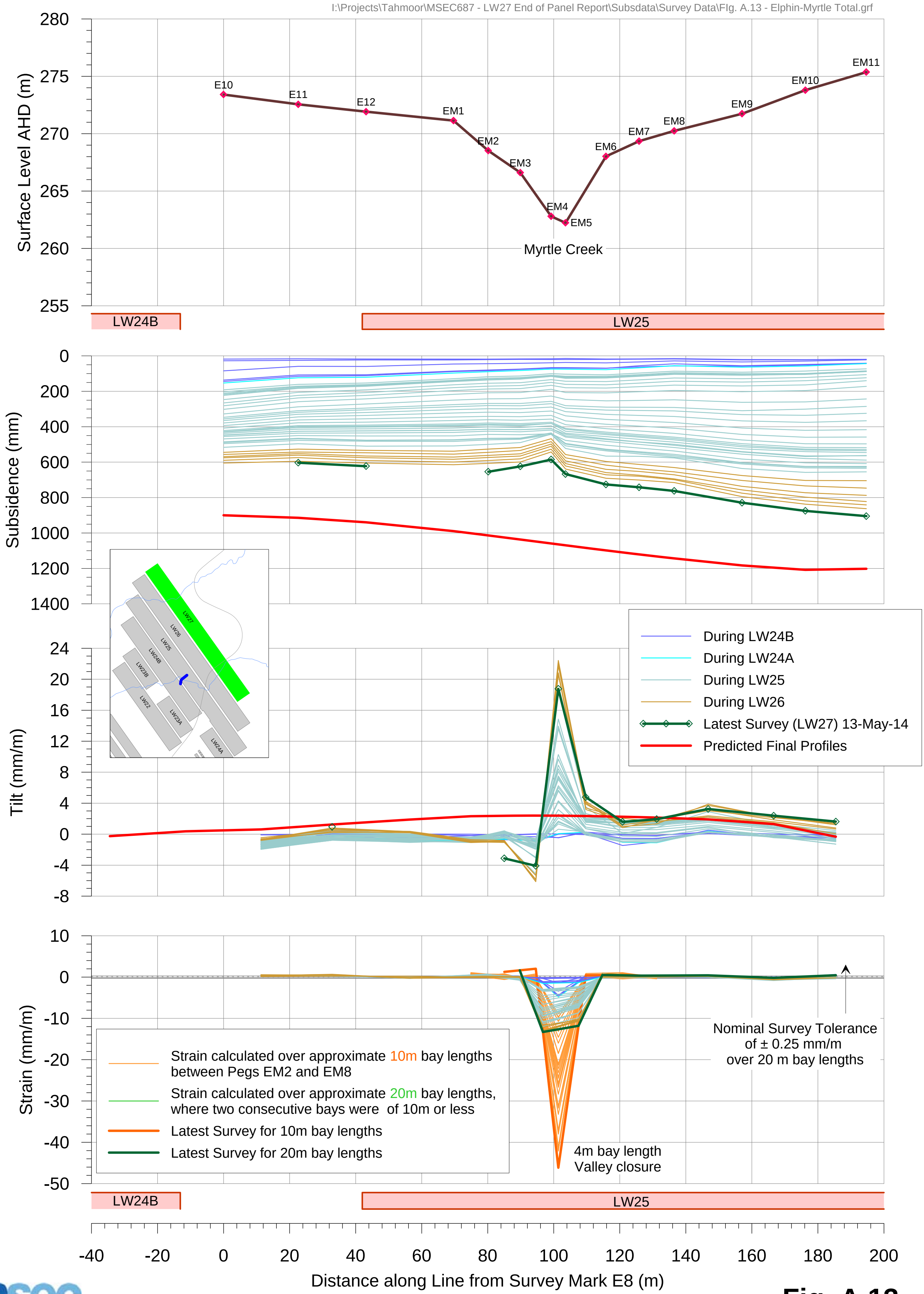


Fig. A.12

Tahmoor Colliery
Total Subsidence Profiles along the Elphin-Myrtle Creek Line



msec

Fig. A.13

Tahmoor Colliery
Total Subsidence Profiles along Greenacre Drive

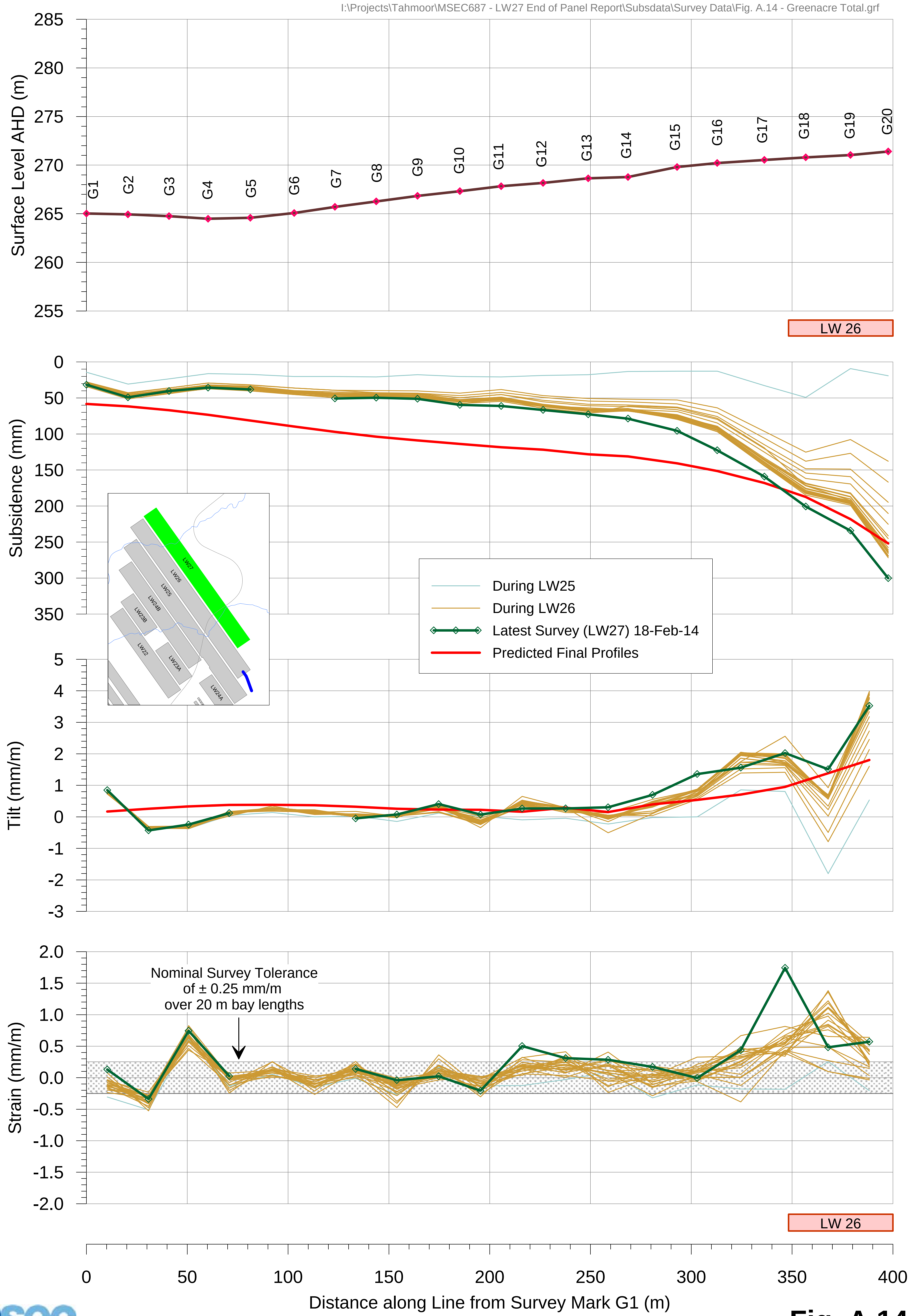


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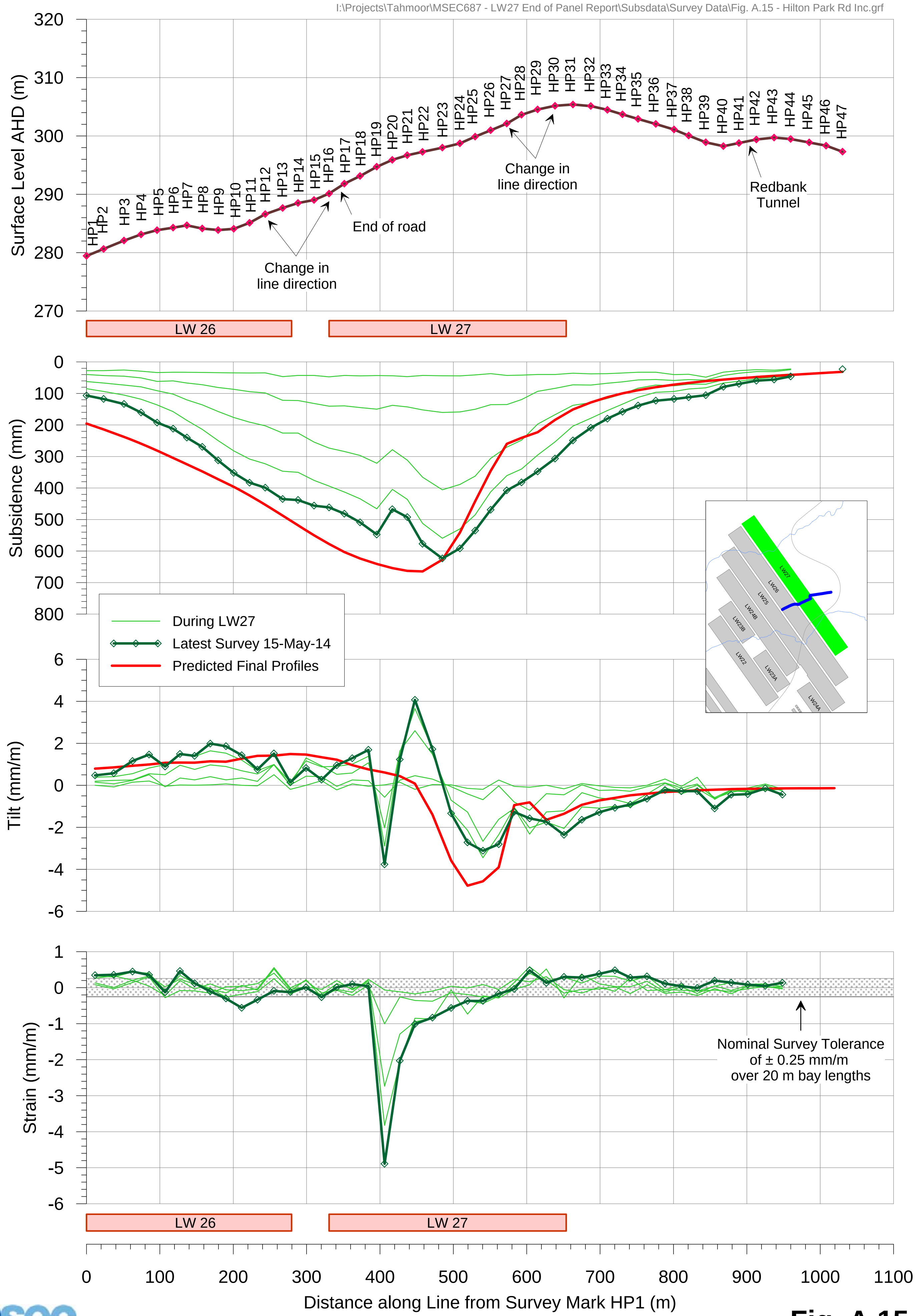
Fig. A.14

Tahmoor Colliery
Incremental Subsidence Profiles along Hilton Park Road



msec

Fig. A.15

Tahmoor Colliery - Total Subsidence Profiles along Hilton Park Road

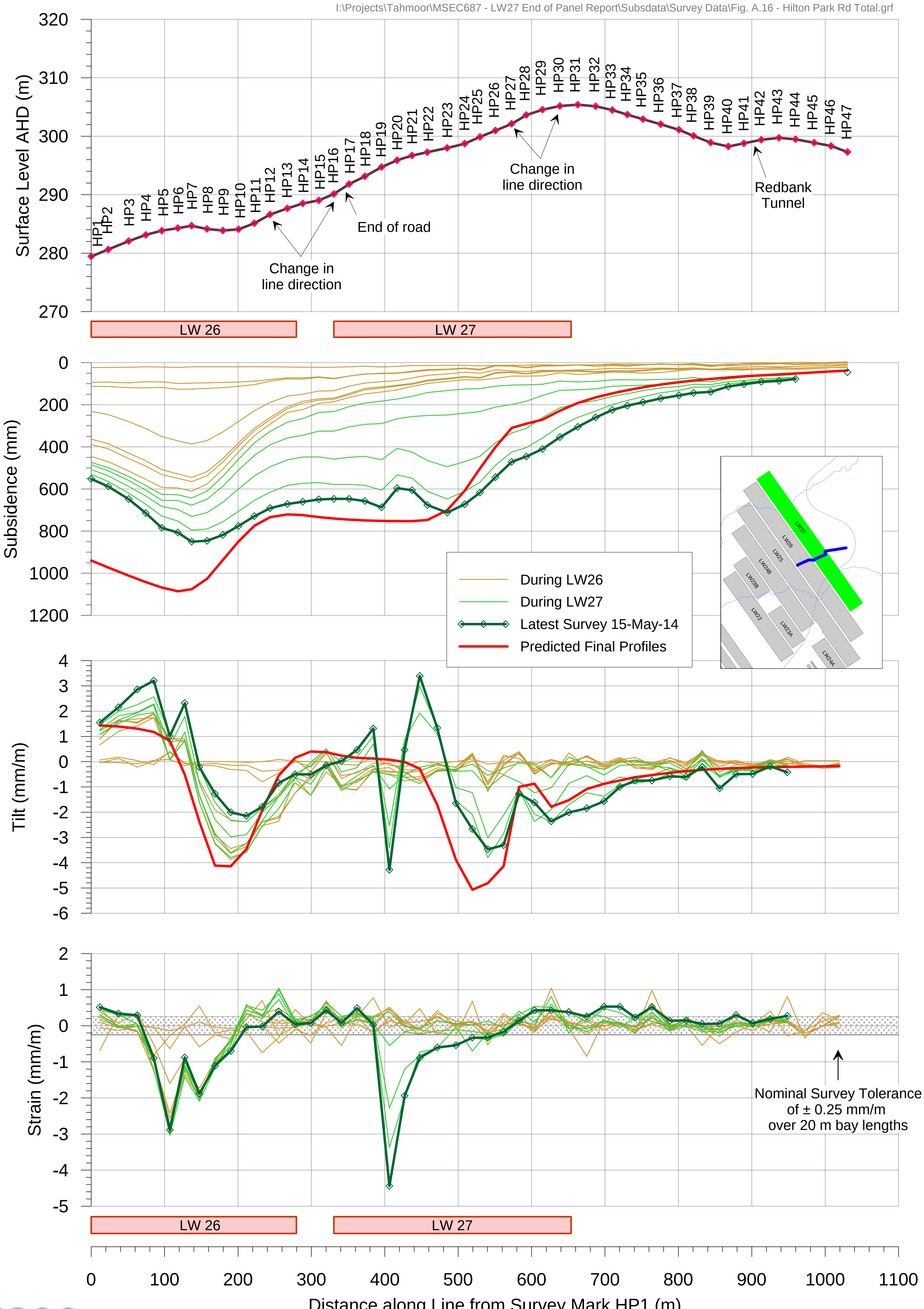


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Fig. A.16

Tahmoor Colliery - Total Subsidence Profiles along Janice Drive

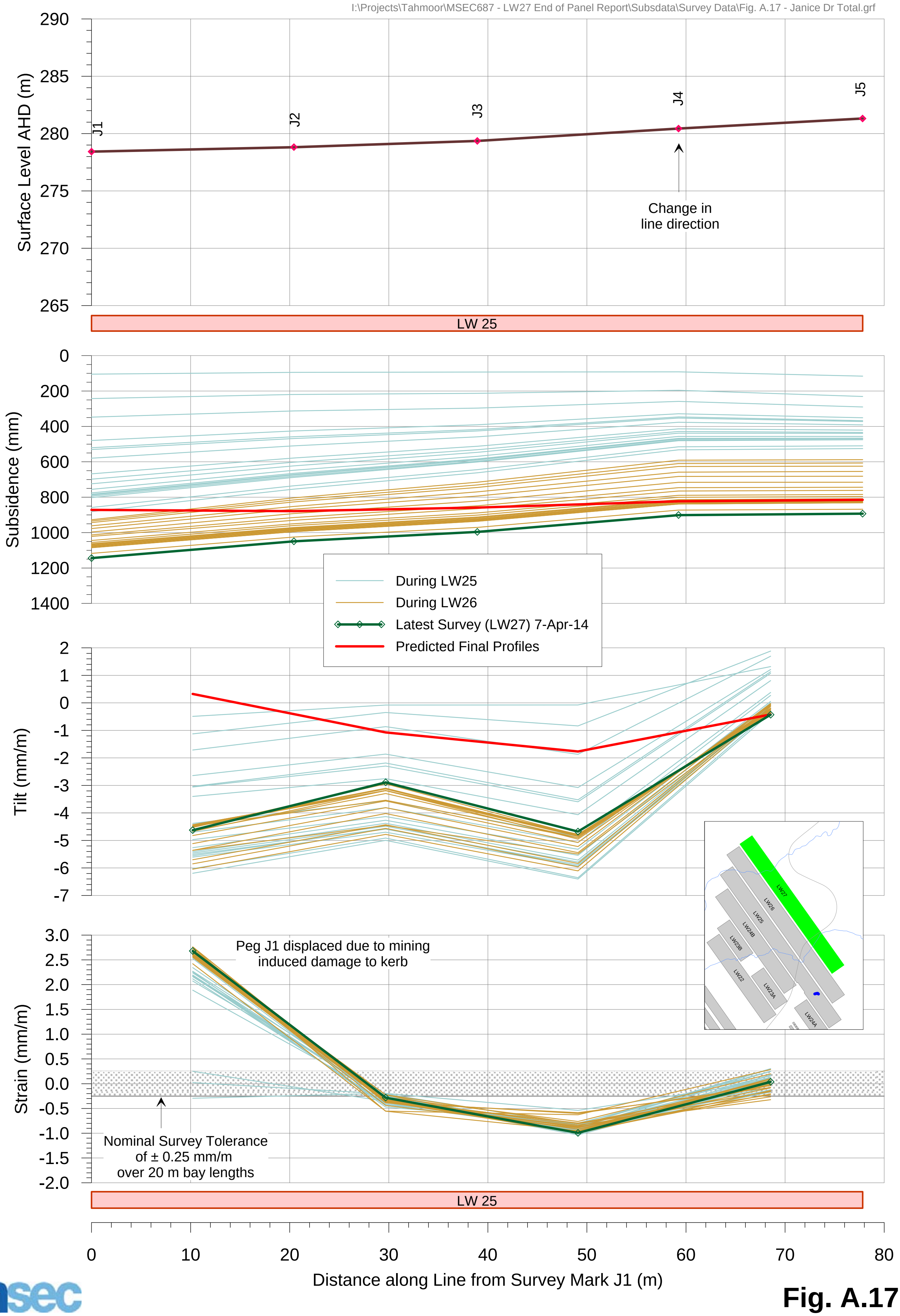

Fig. A.17

Tahmoor Colliery
Incremental Subsidence Profiles along Krista Place

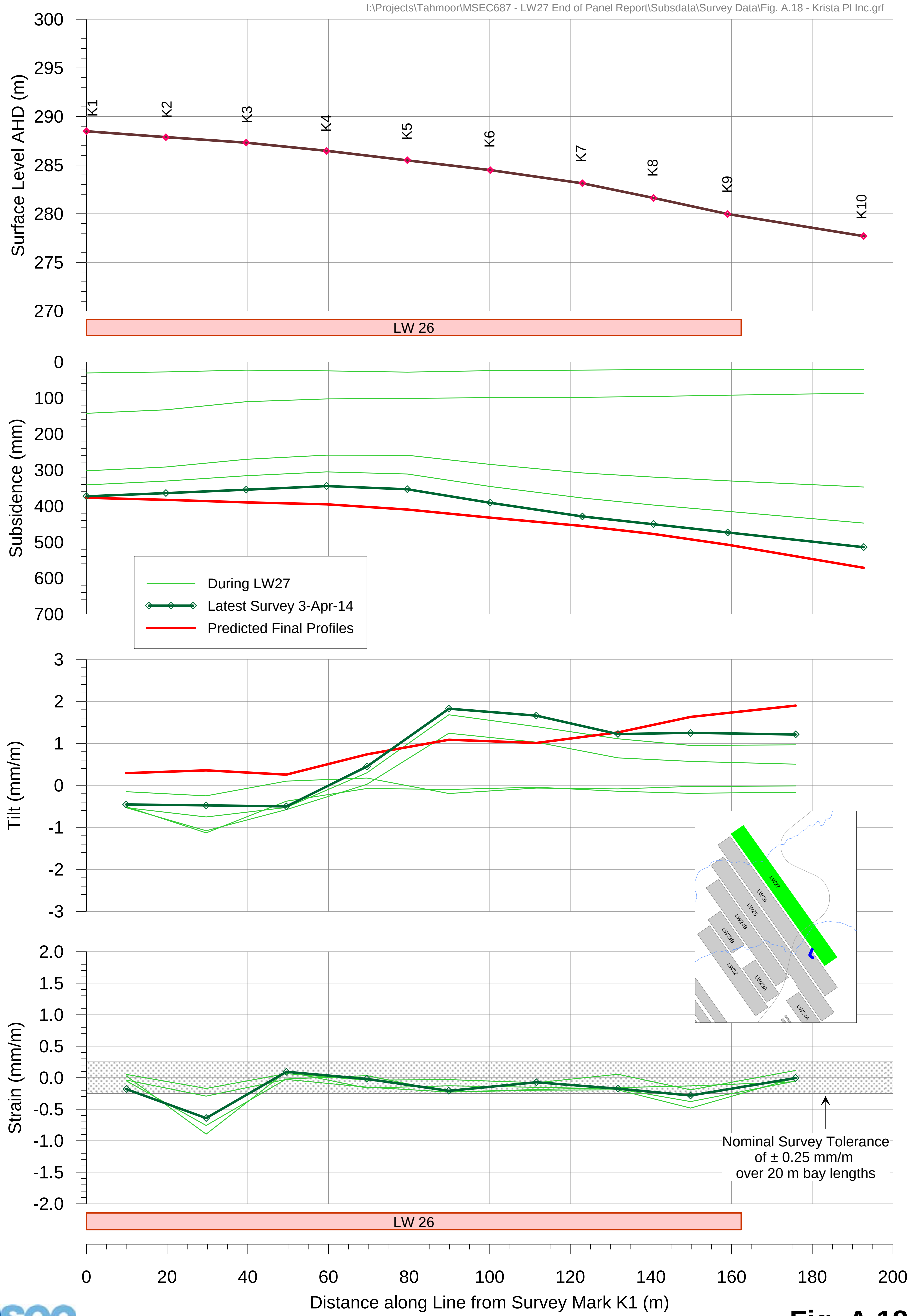

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Fig. A.18

Tahmoor Colliery
Total Subsidence Profiles along Krista Place

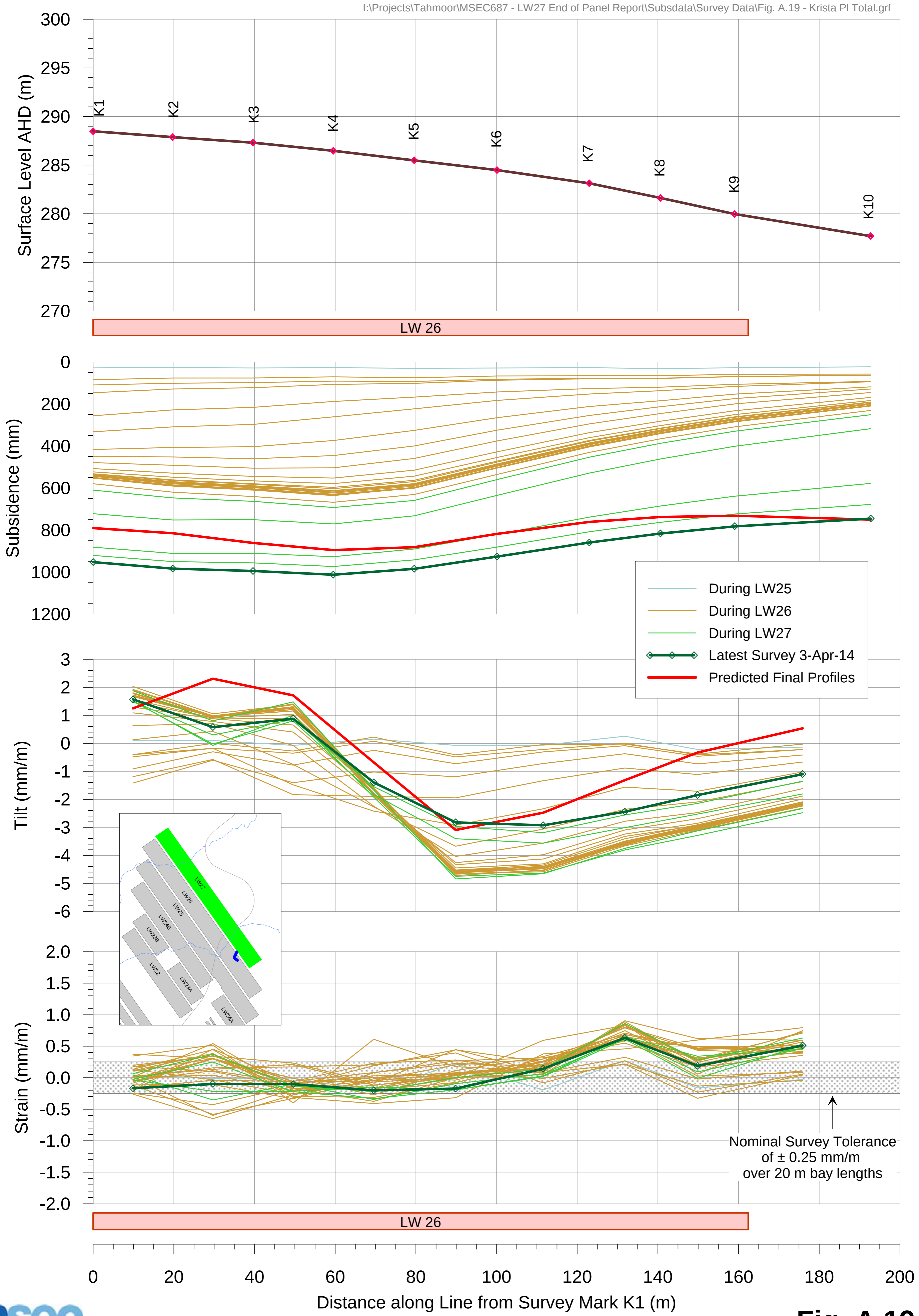
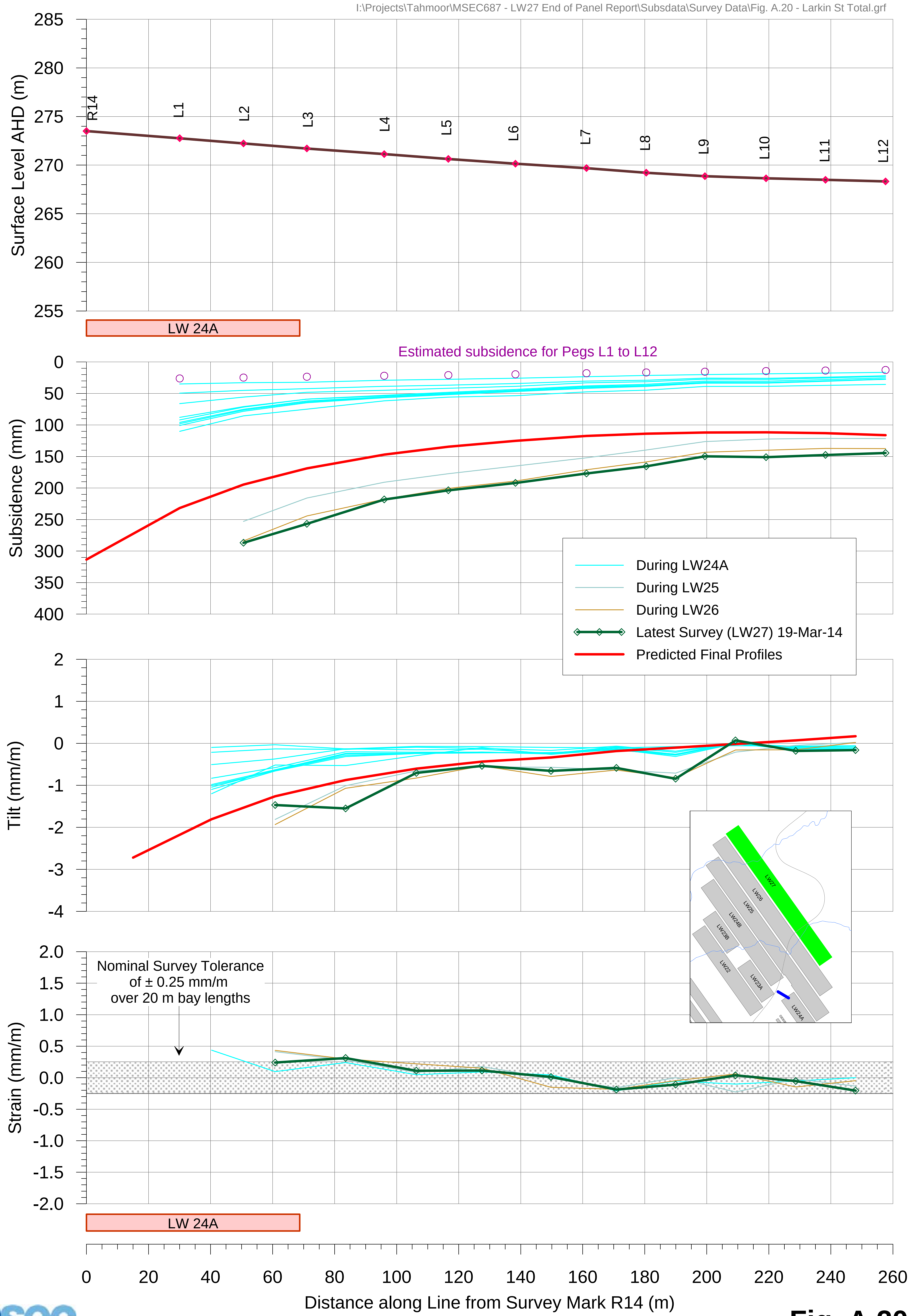


Fig. A.19

Tahmoor Colliery
Total Subsidence Profiles along Larkin Street



msec

Fig. A.20

Tahmoor Colliery
Total Subsidence Profiles along Leiha Place

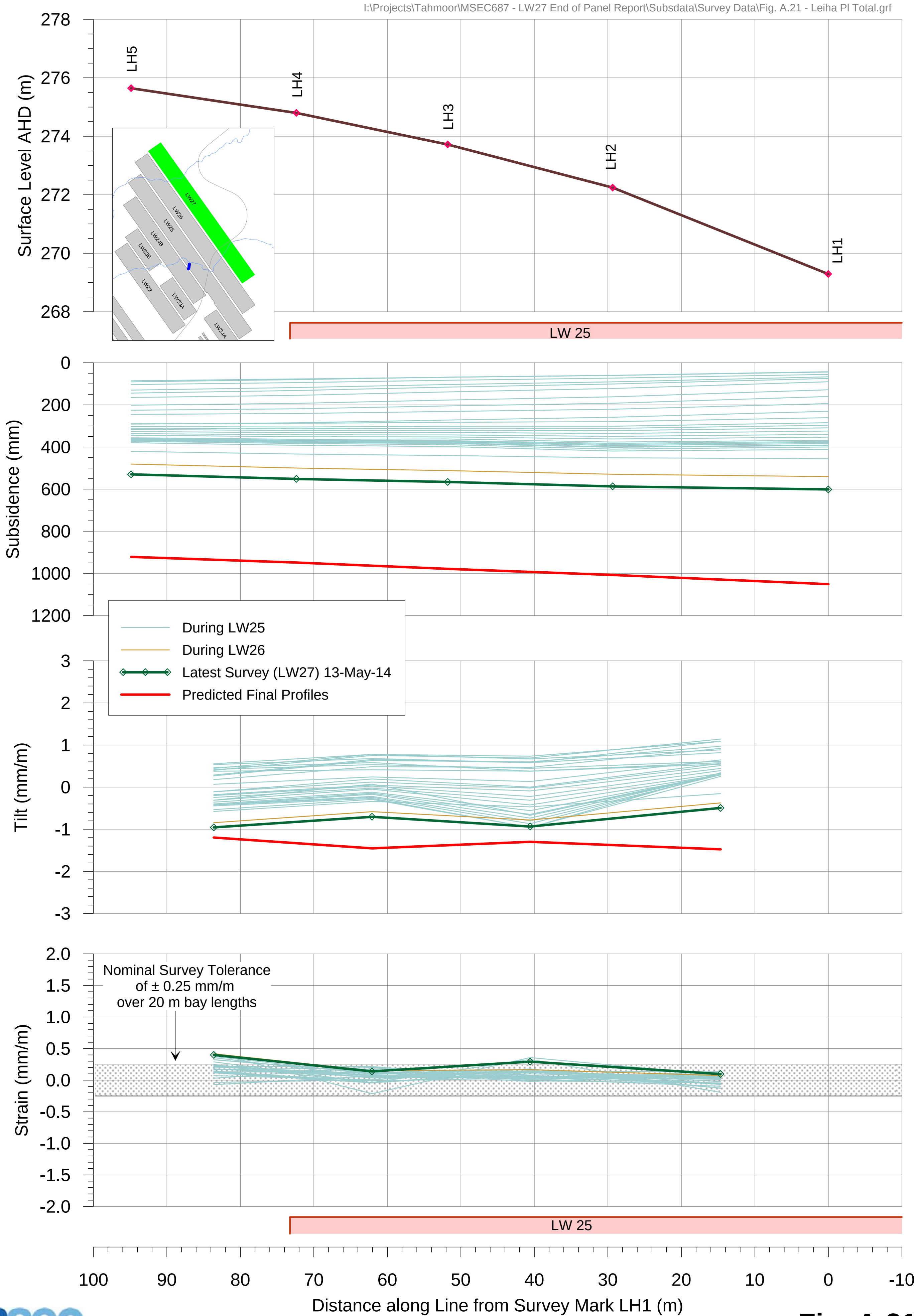


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Fig. A.21

Tahmoor Colliery
Total Subsidence Profiles along Monica Place

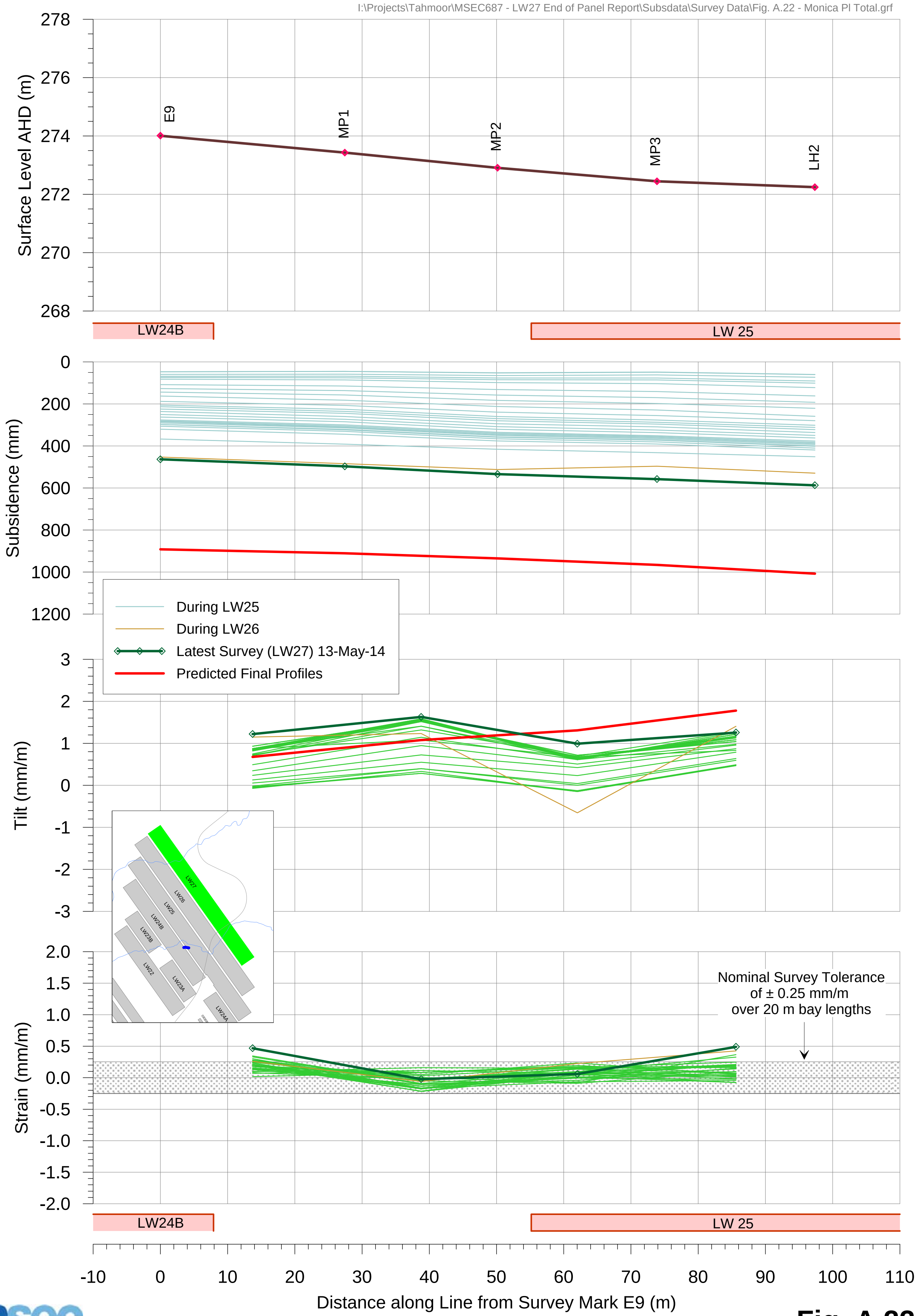

Fig. A.22

Tahmoor Colliery
Incremental Subsidence Profiles along Moorland Road

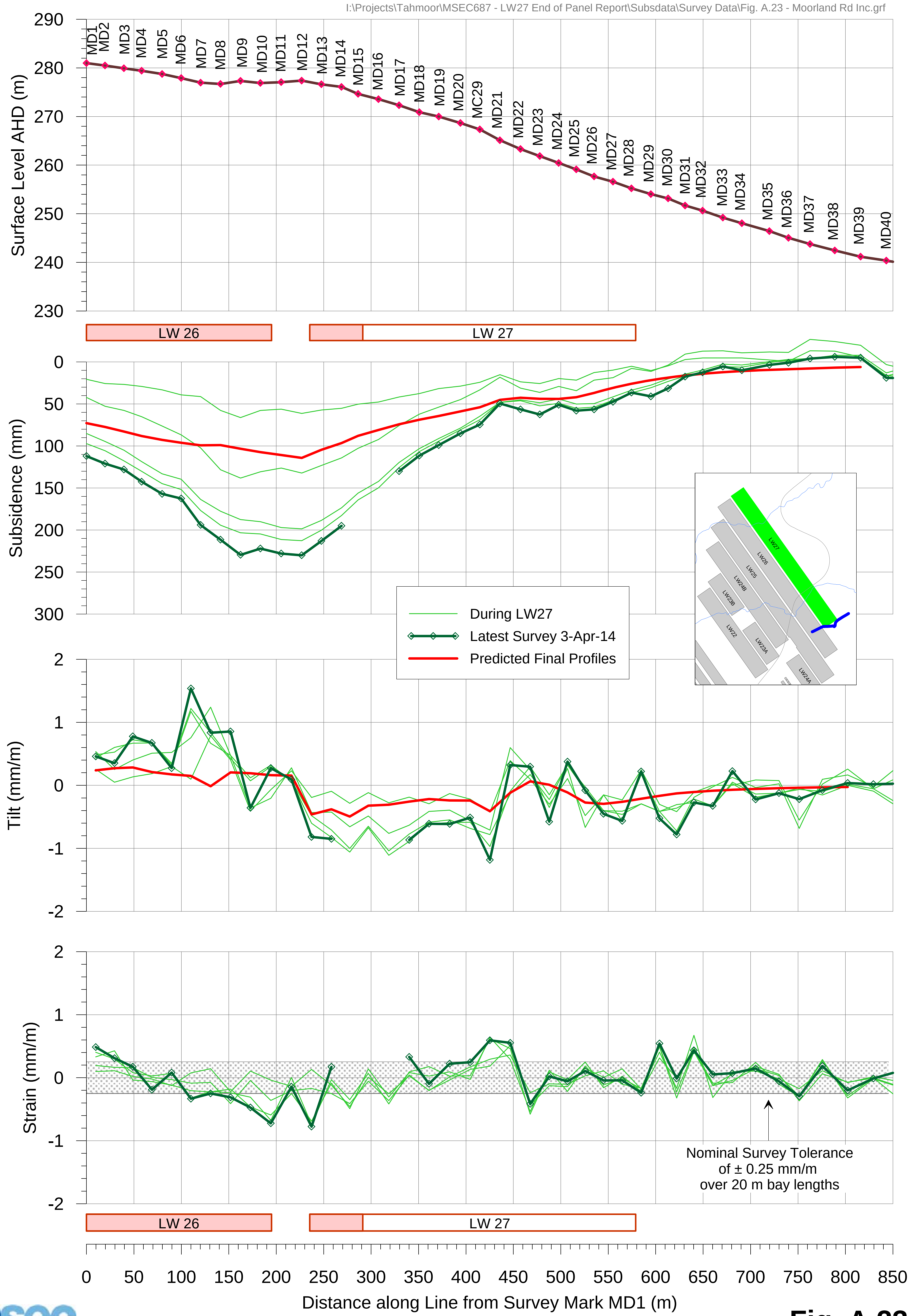

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Fig. A.23

Tahmoor Colliery
Total Subsidence Profiles along Moorland Road

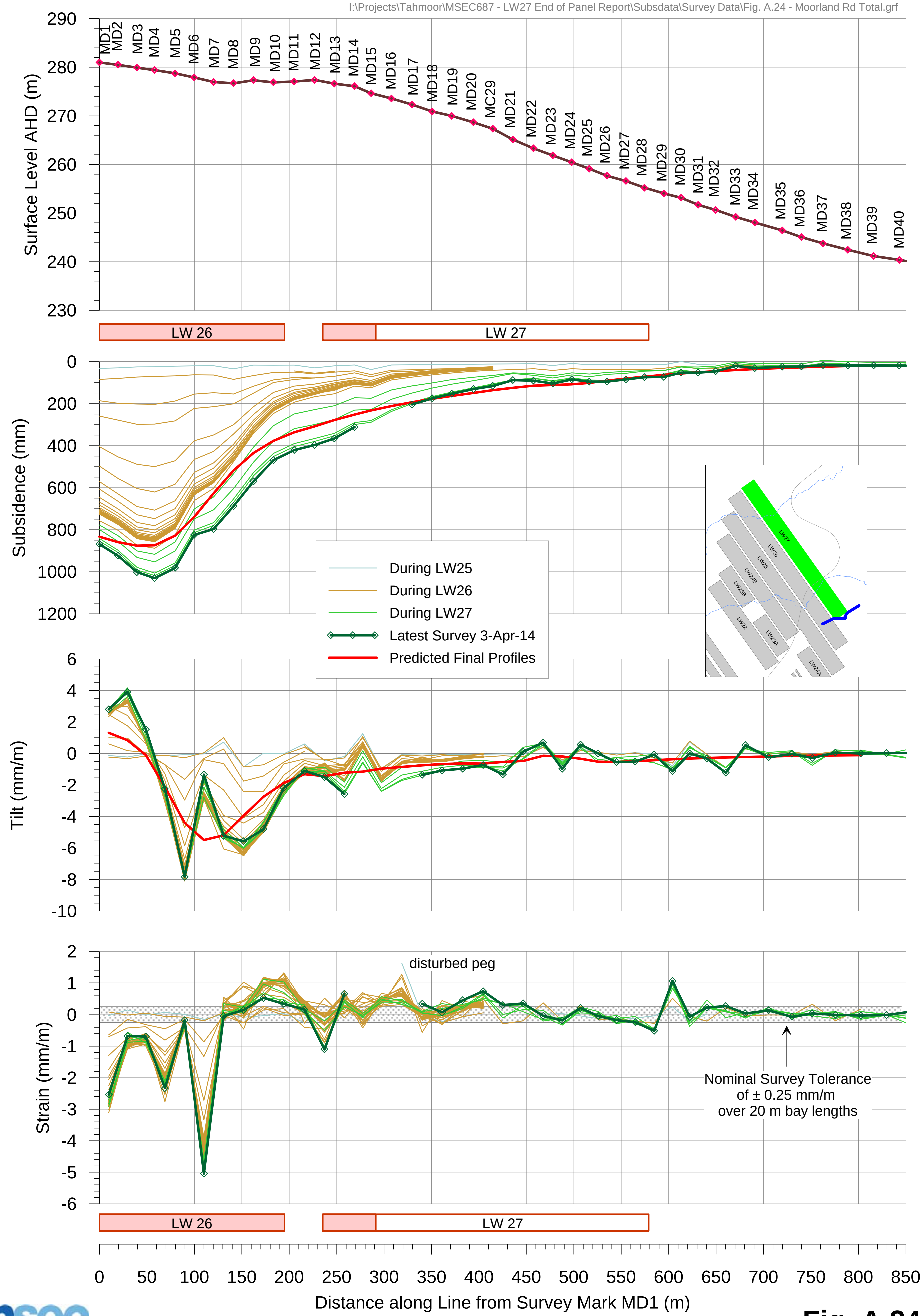

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Fig. A.24

Tahmoor Colliery
Incremental Subsidence Profiles along Myrtle Creek Avenue

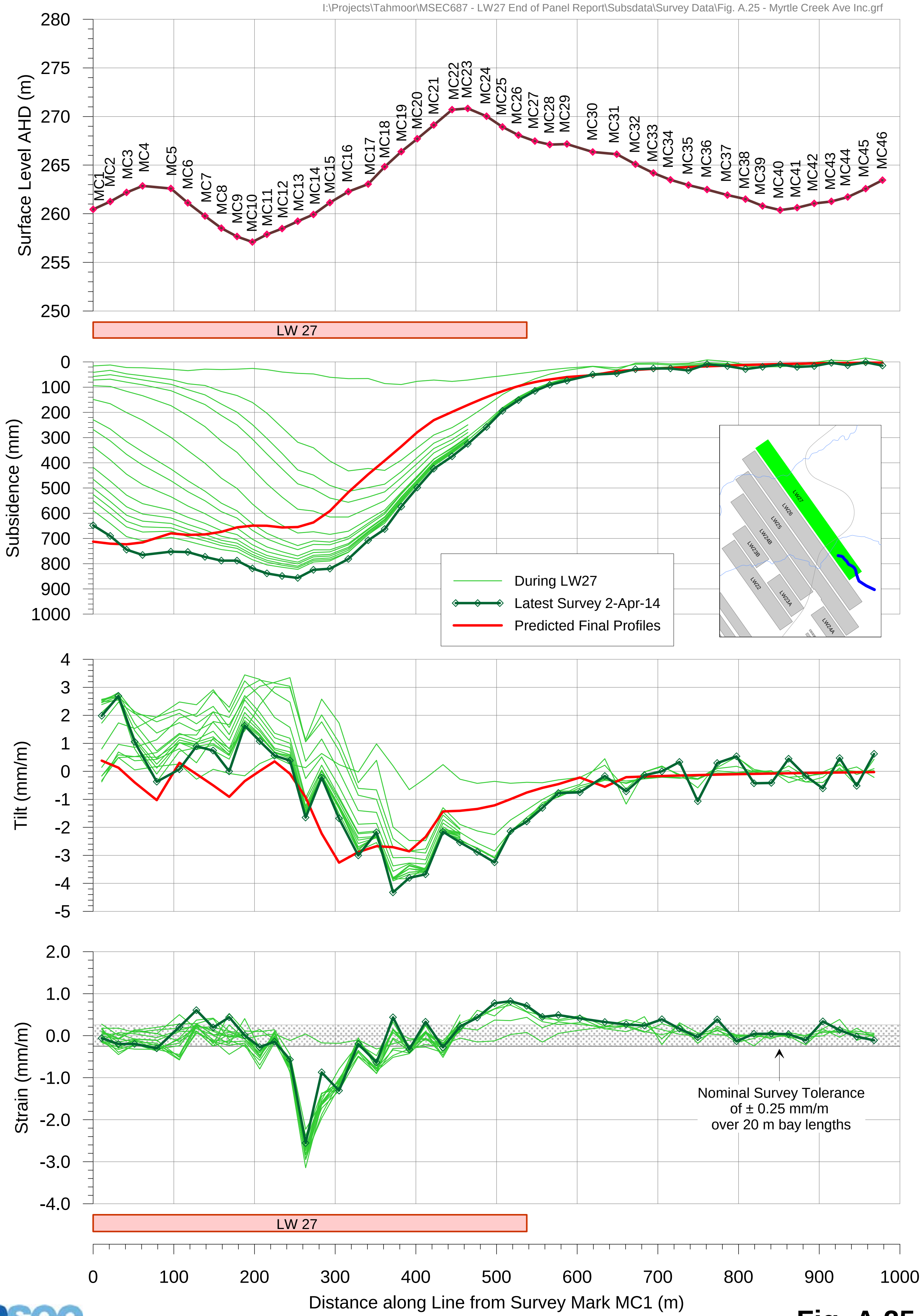

Fig. A.25

Tahmoor Colliery
Total Subsidence Profiles along Myrtle Creek Avenue

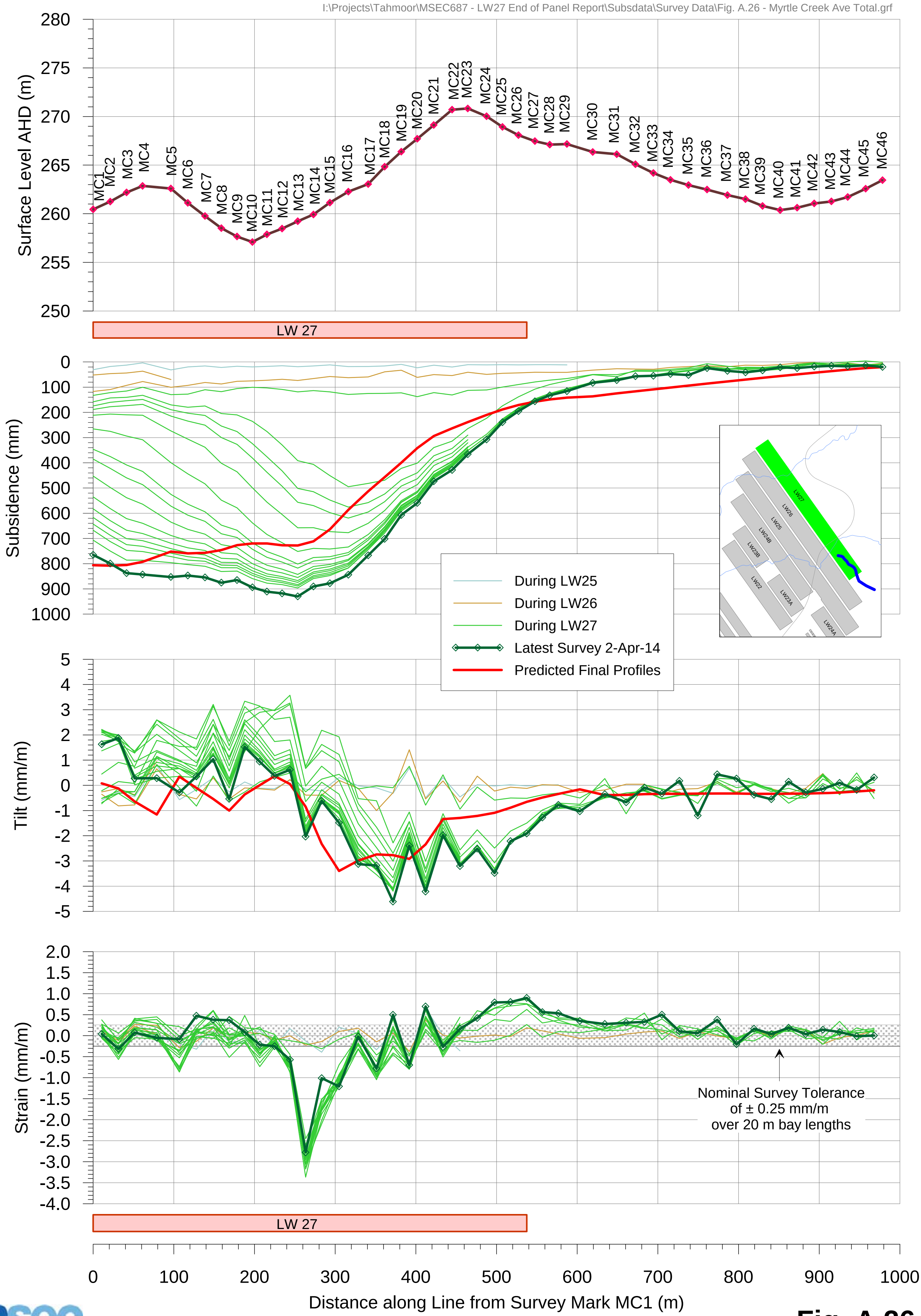

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Fig. A.26

Tahmoor Colliery
Incremental Subsidence Profiles along MXA Line

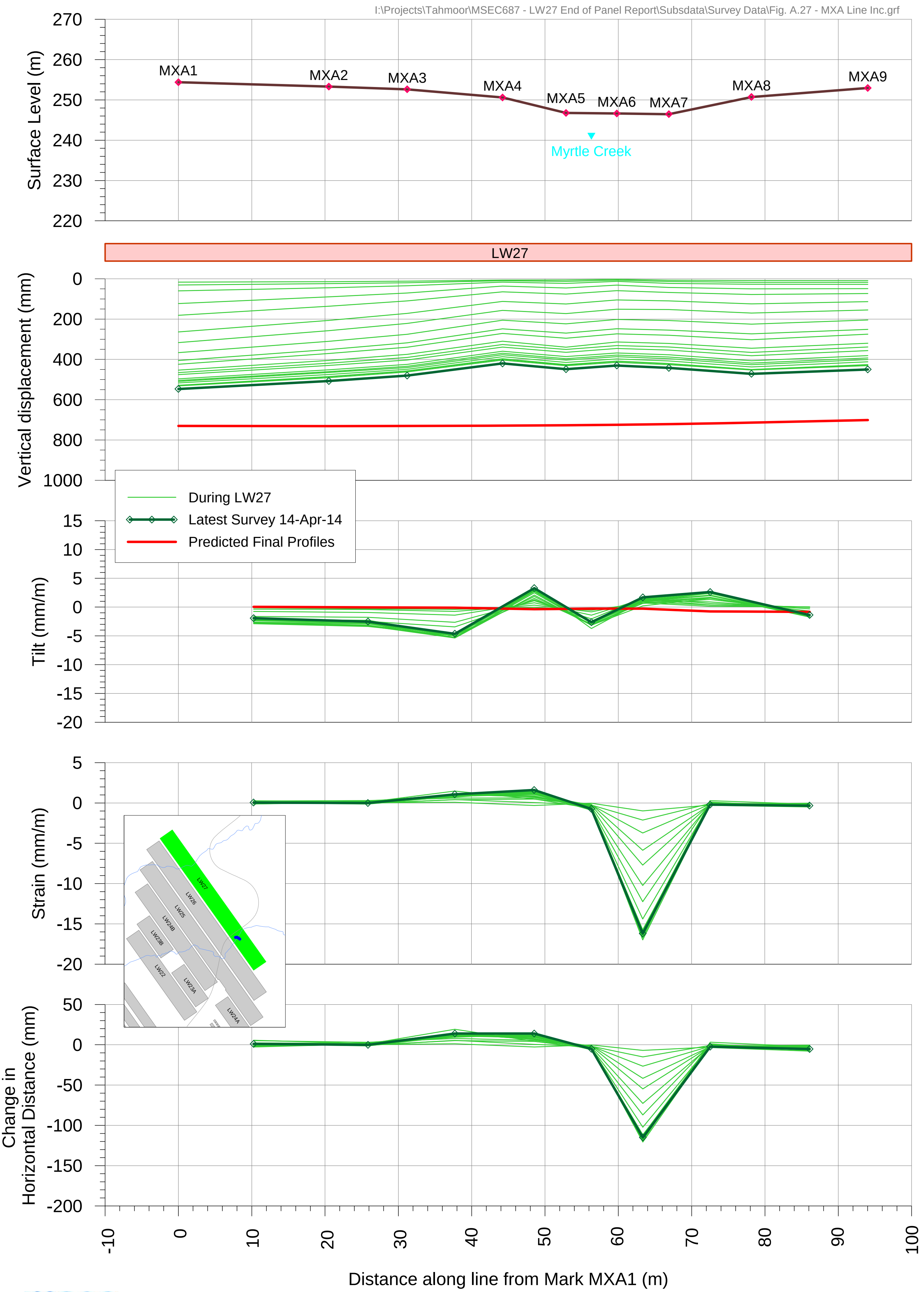

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Fig. A.27

Tahmoor Colliery
Incremental Subsidence Profiles along MXB Line

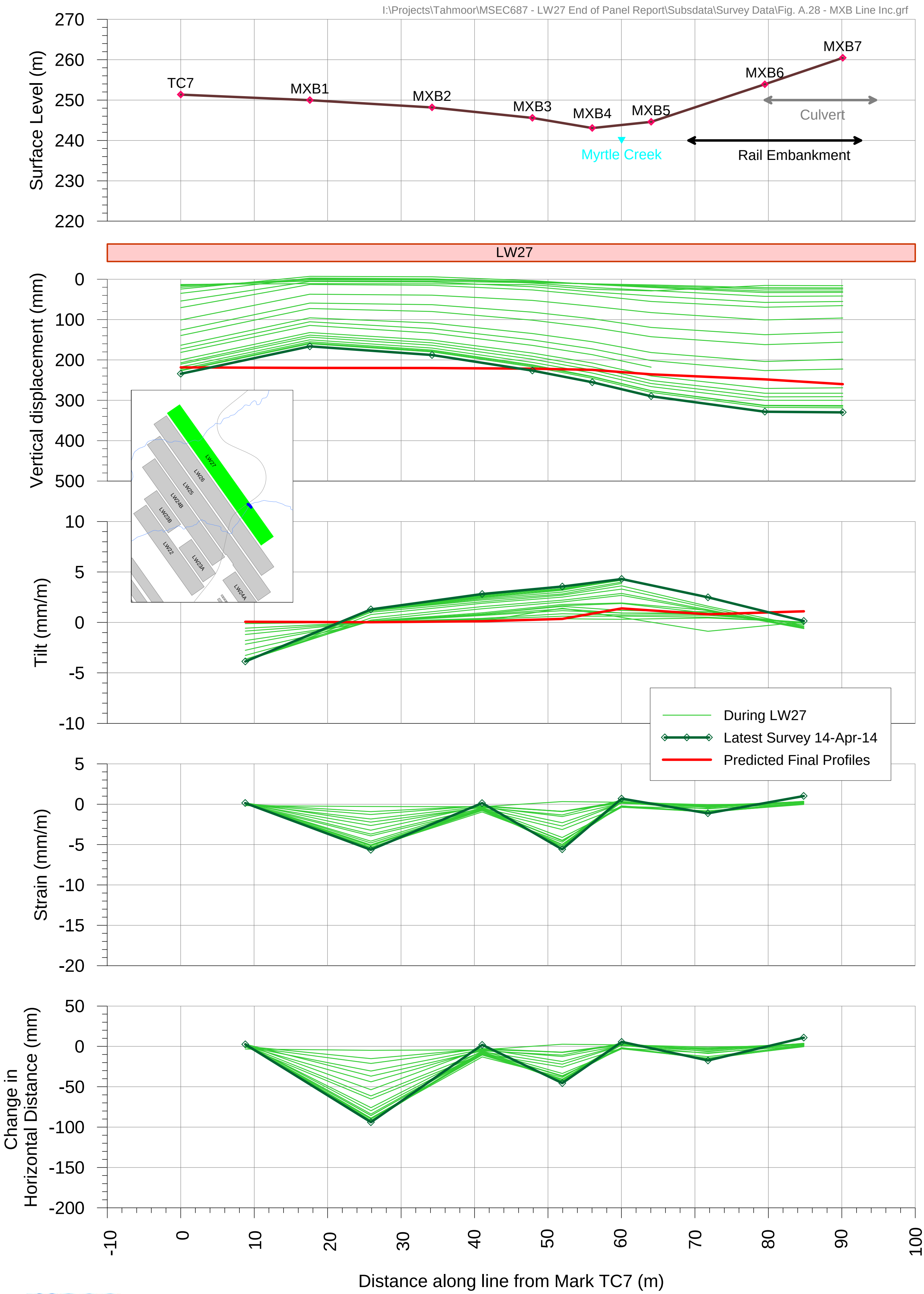

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Fig. A28

Tahmoor Colliery
Incremental Subsidence Profiles along MXC Line

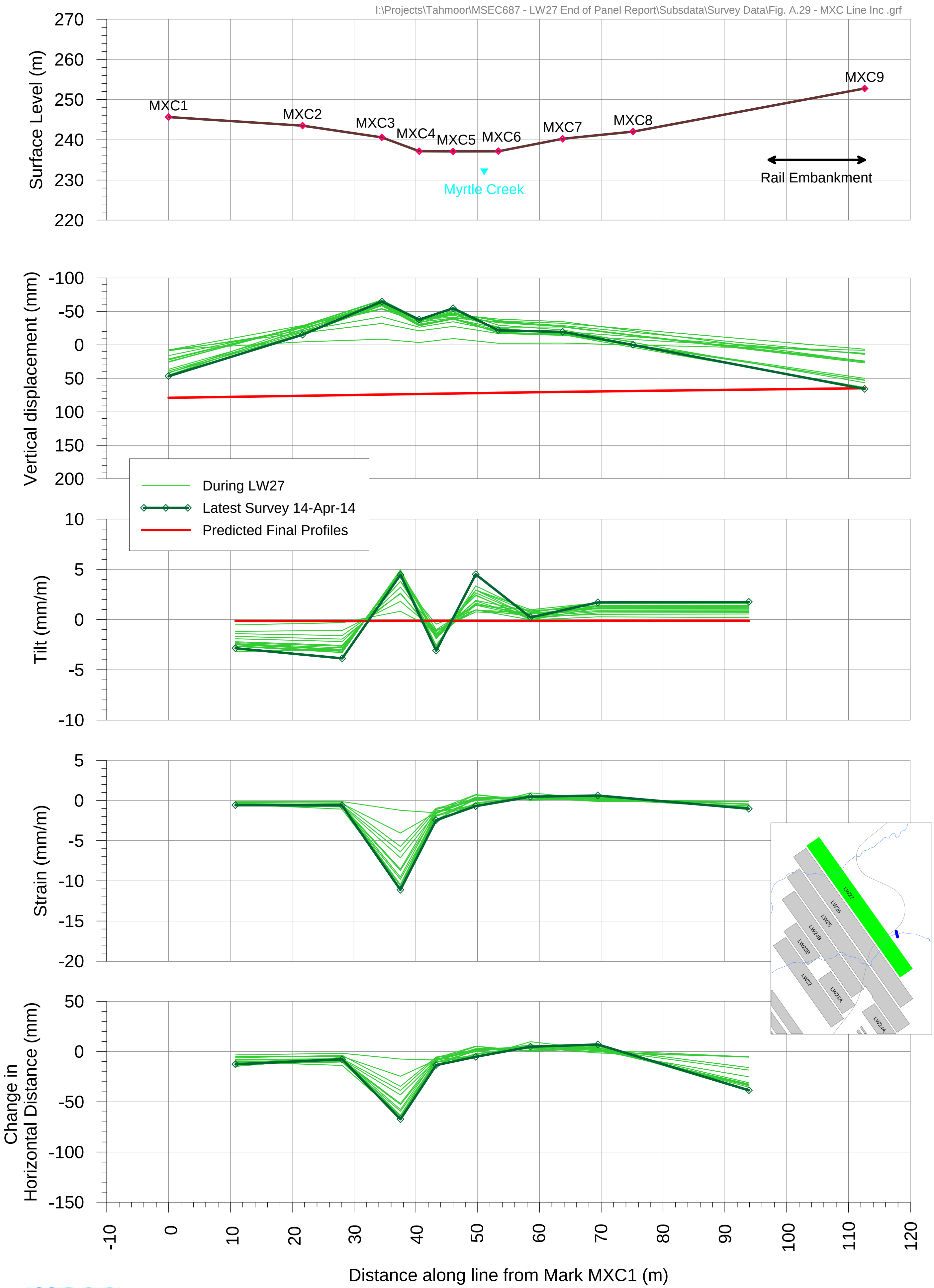

Fig. A.29

Tahmoor Colliery
Incremental Subsidence Profiles along MXD Line

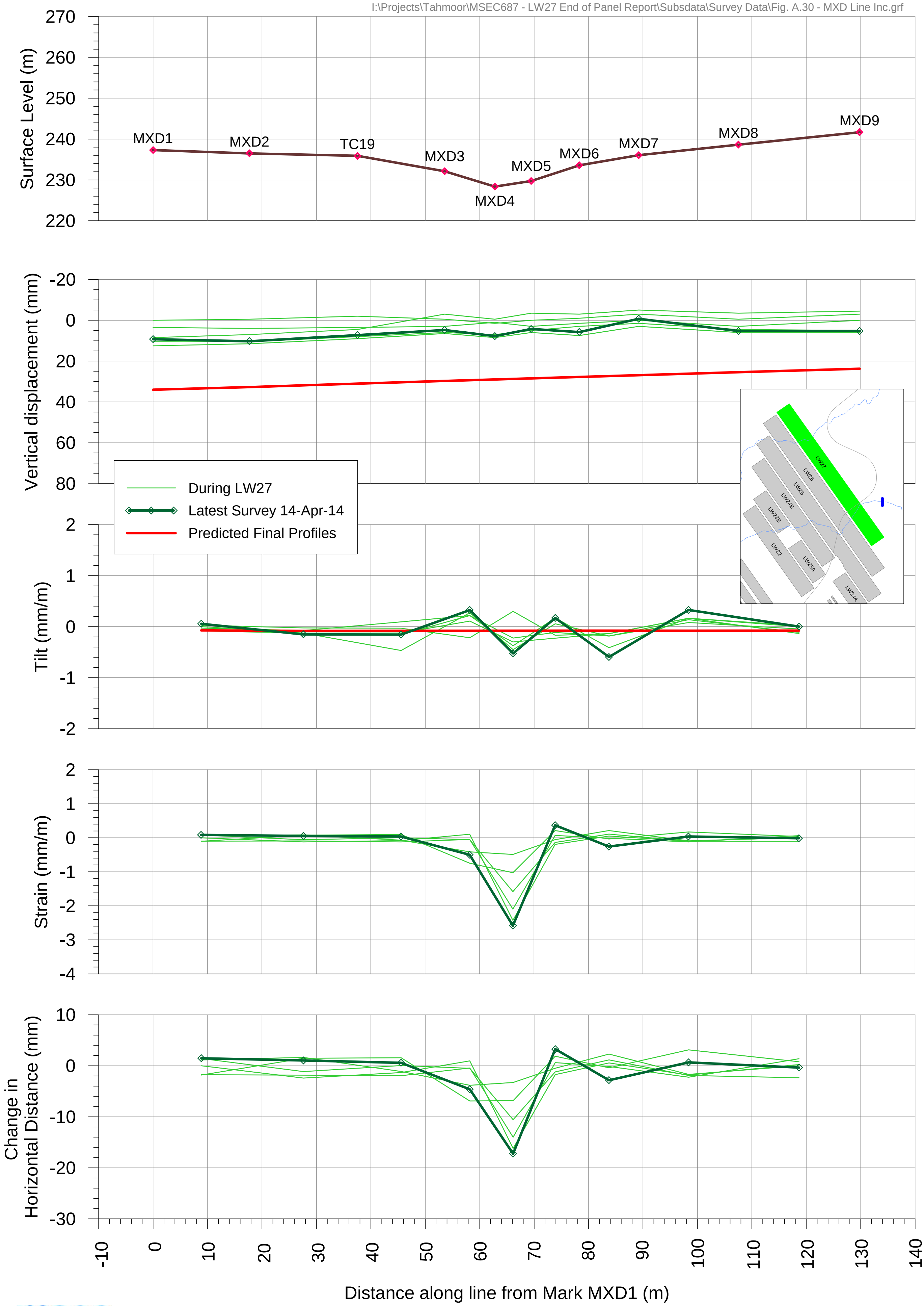

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Fig. A.30

Tahmoor Colliery
Incremental Subsidence Profiles along Optic Fibre Line

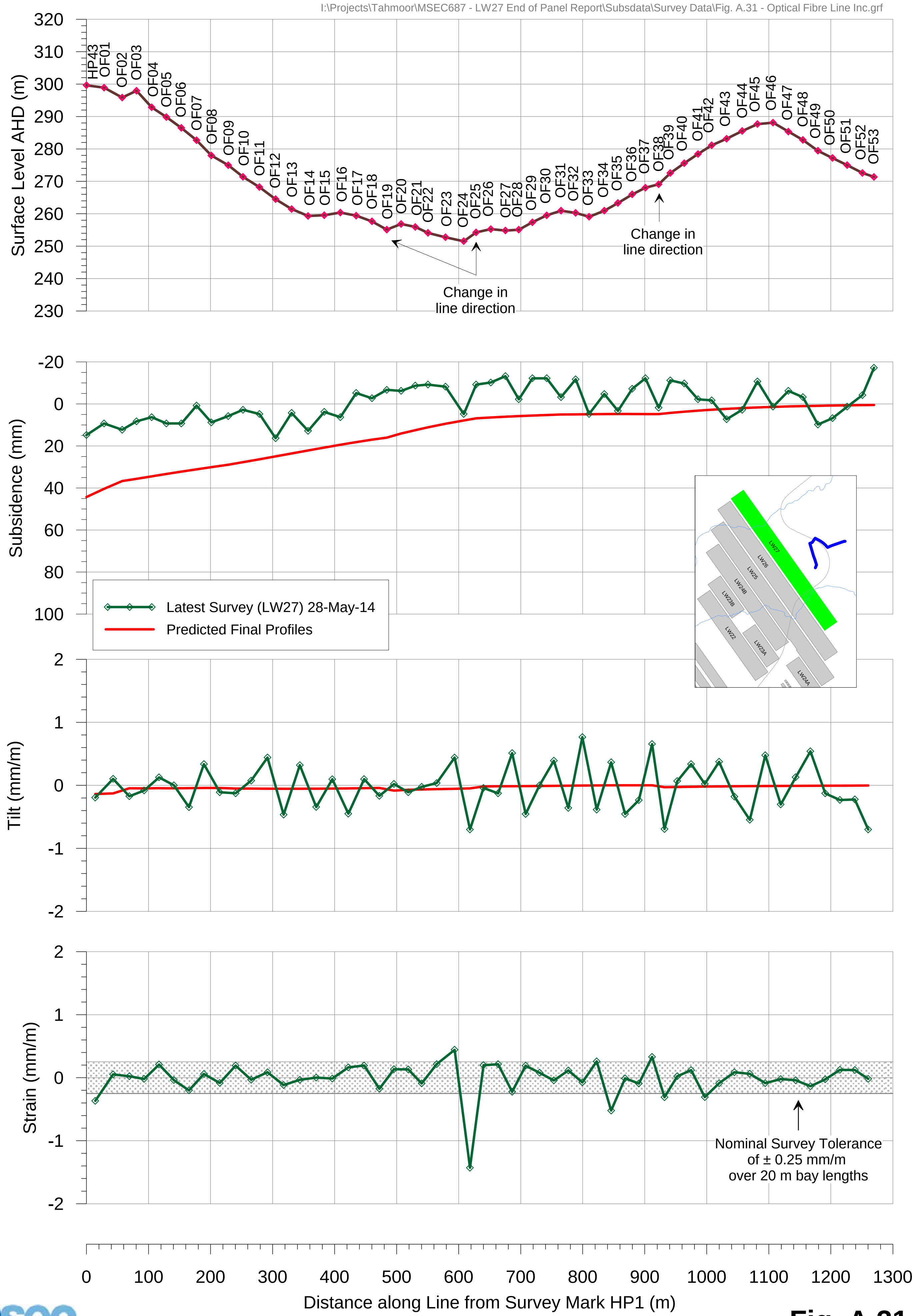

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Fig. A.31

Tahmoor Colliery
Total Subsidence Profiles along Park Avenue

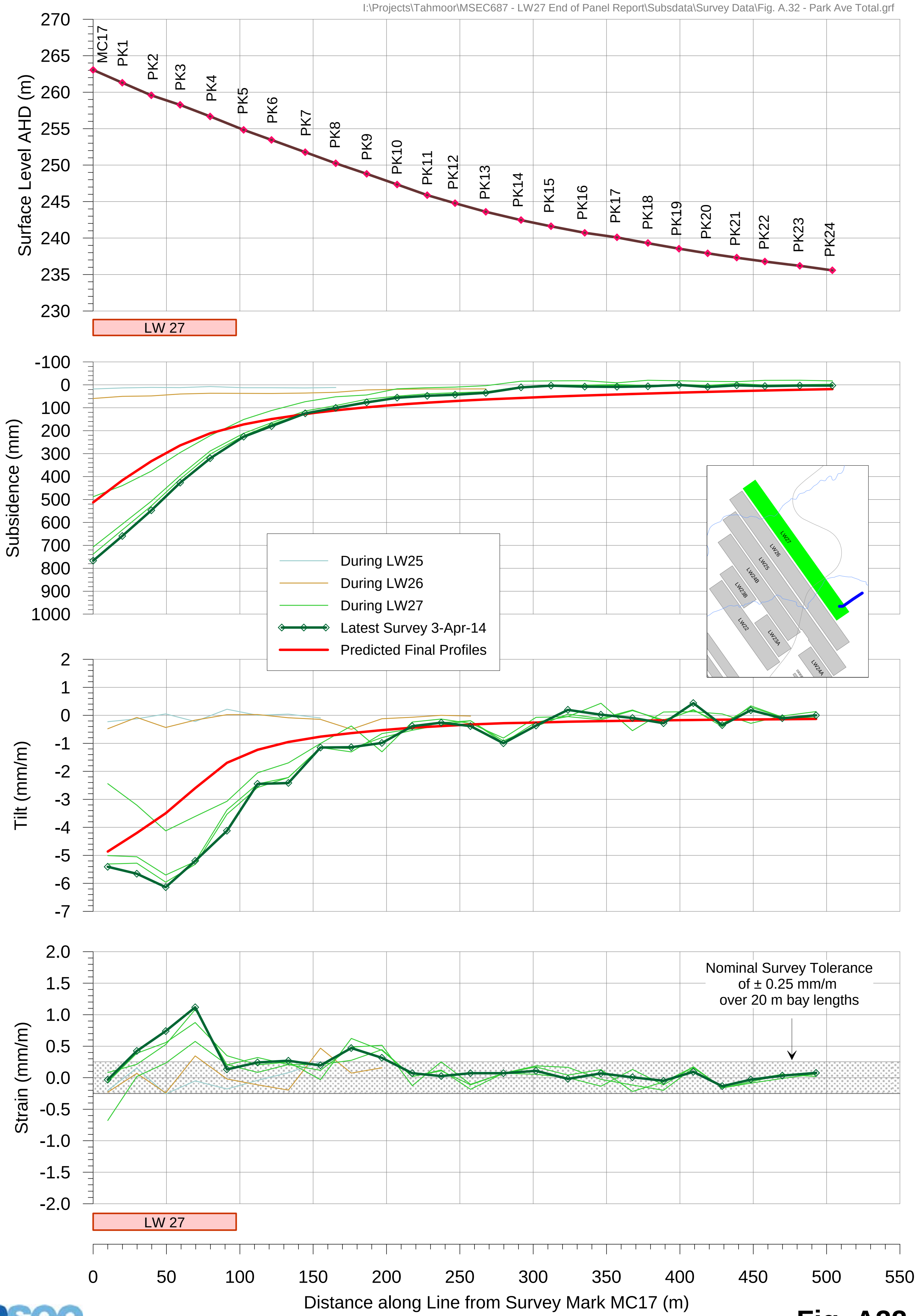

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Fig. A32

Tahmoor Colliery
Total Subsidence Profiles along Park Street

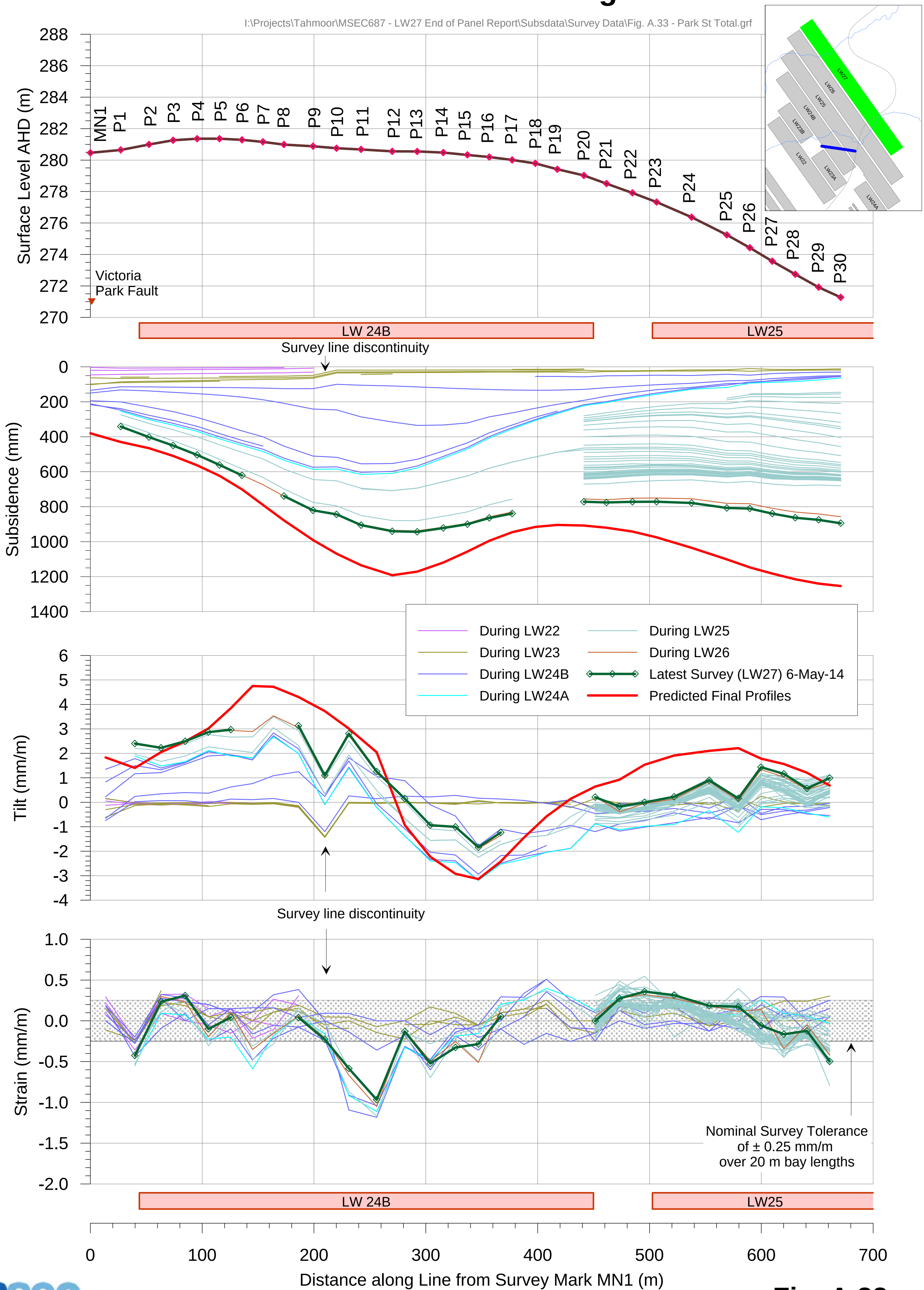

Fig. A.33

Tahmoor Colliery
Total Subsidence Profiles along Pimelia Street

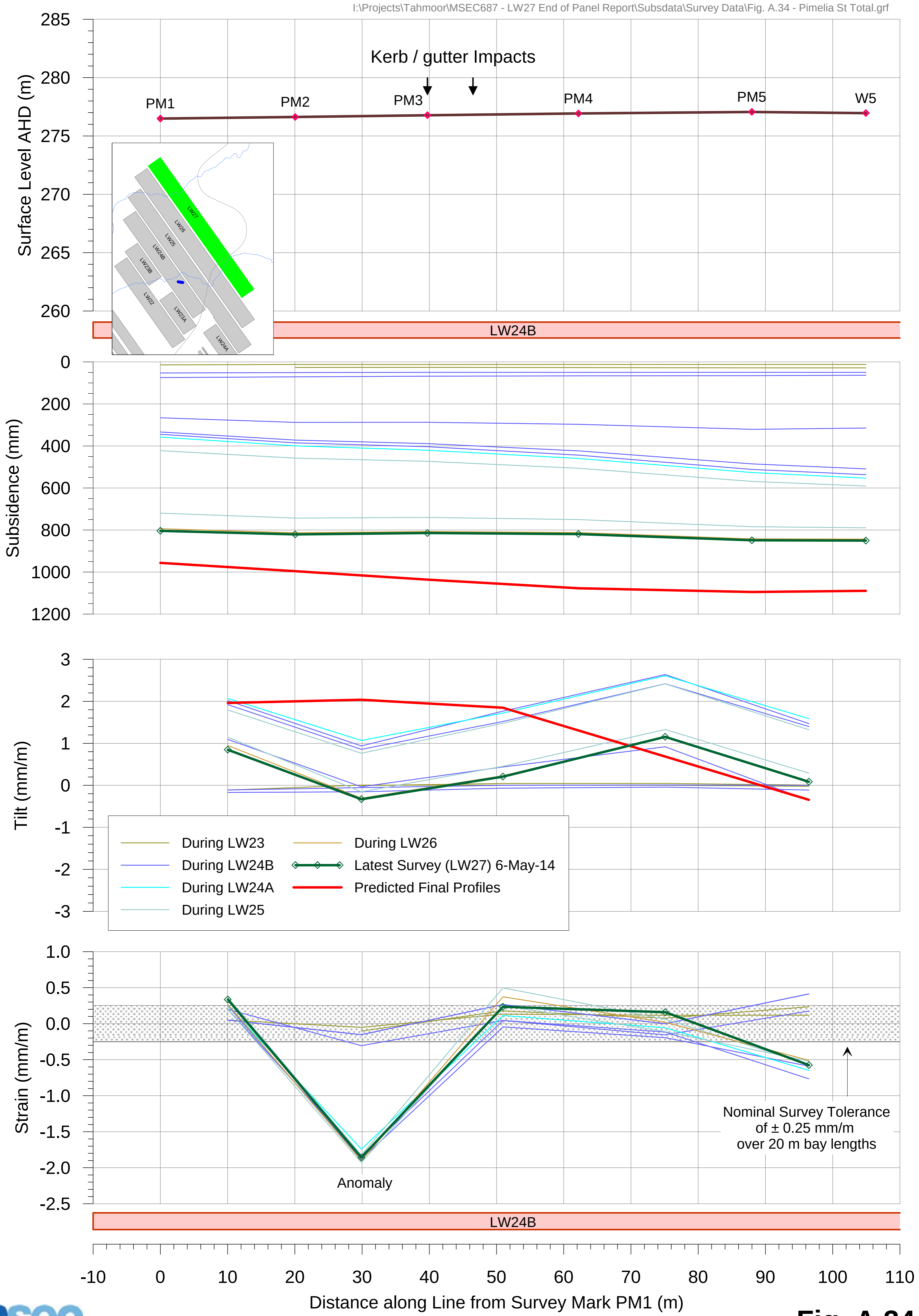

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Fig. A.34

Tahmoor Colliery
Total Subsidence Profiles along Progress Street

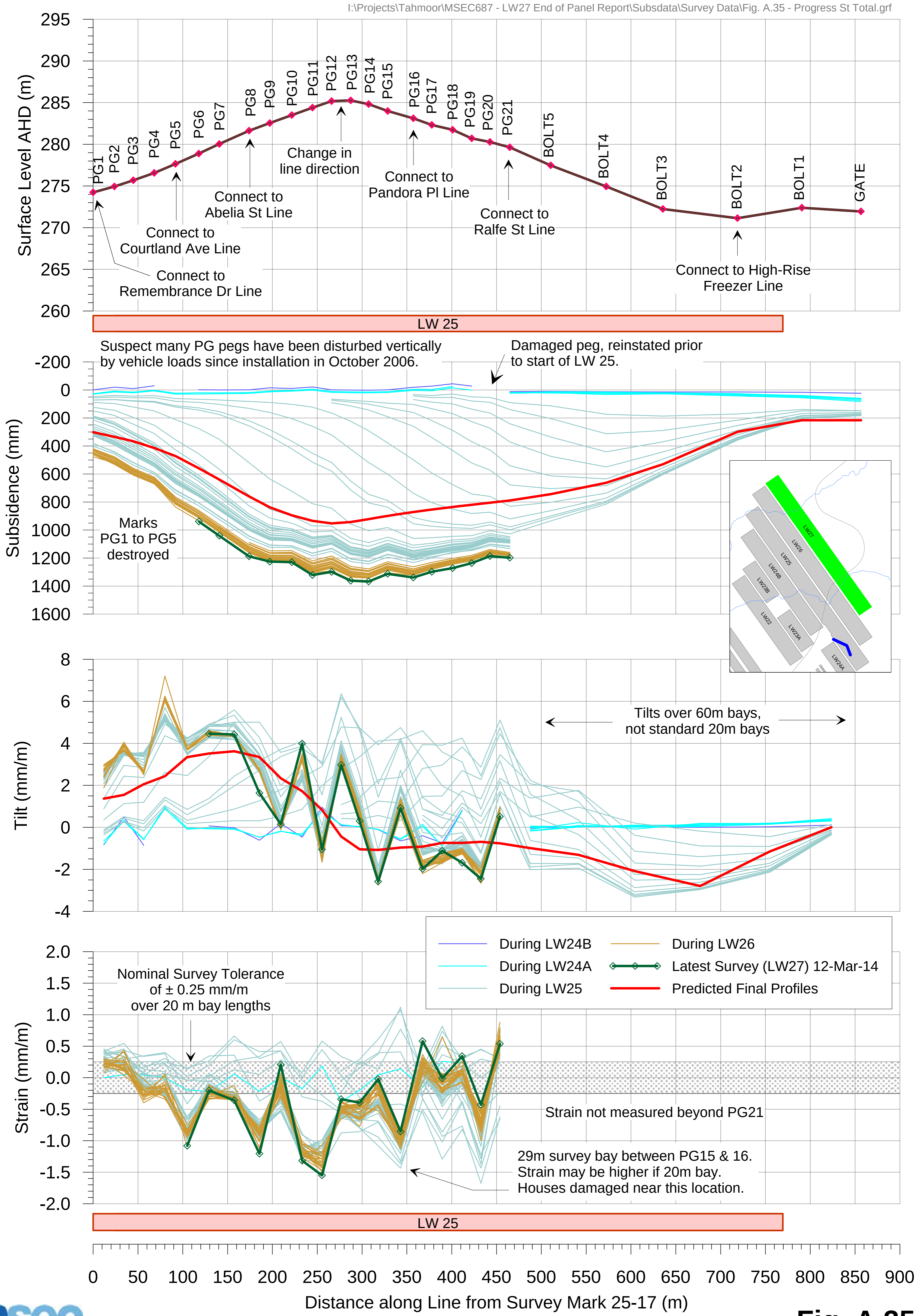

Fig. A.35

Tahmoor Colliery
Incremental Profiles along Redbank Creek RK Line

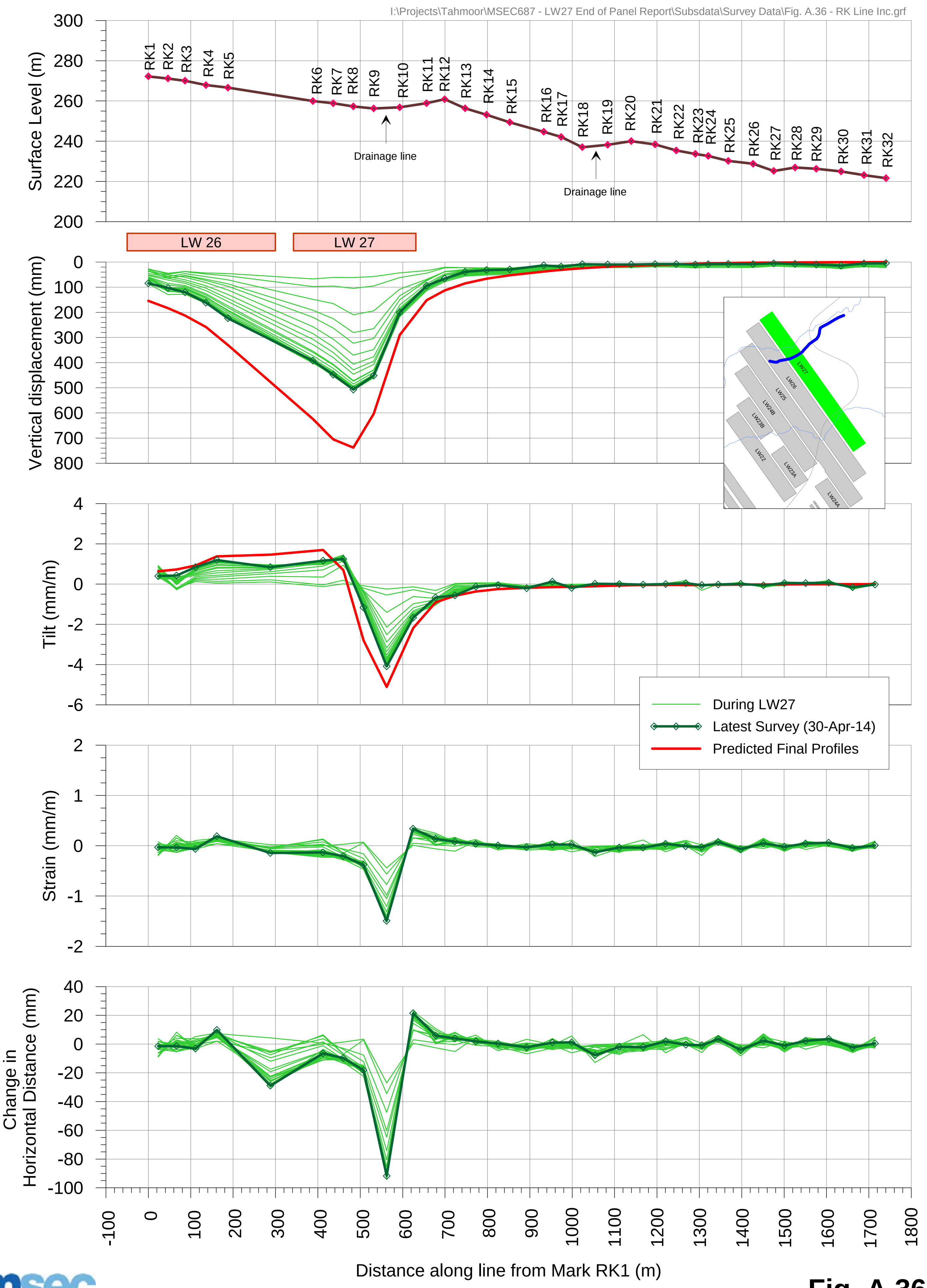

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Fig. A.36

Tahmoor Colliery
Total Profiles along Redbank Creek RK Line

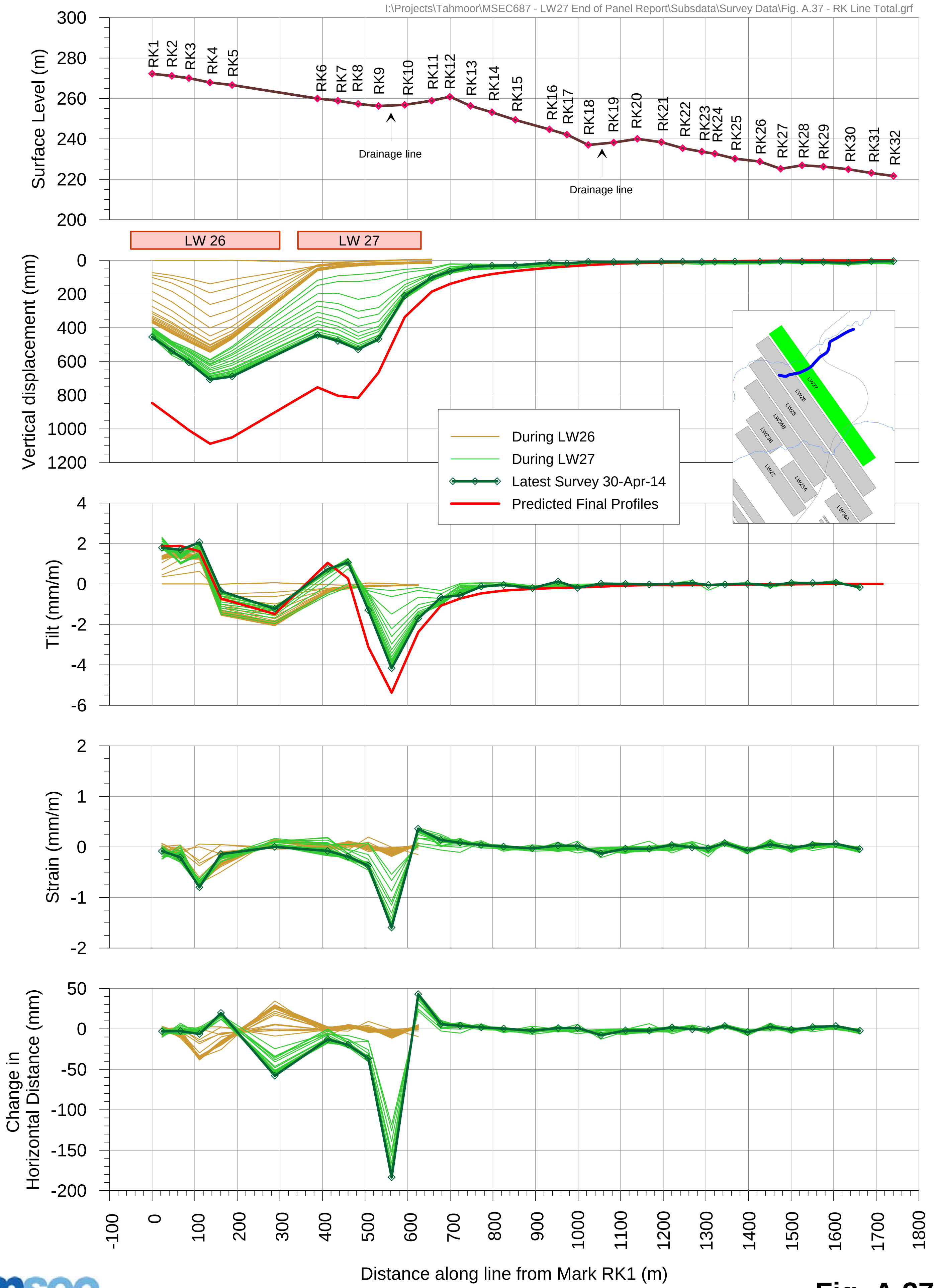

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Fig. A.37

Tahmoor Colliery
Incremental Profiles along Redbank Creek RX Line

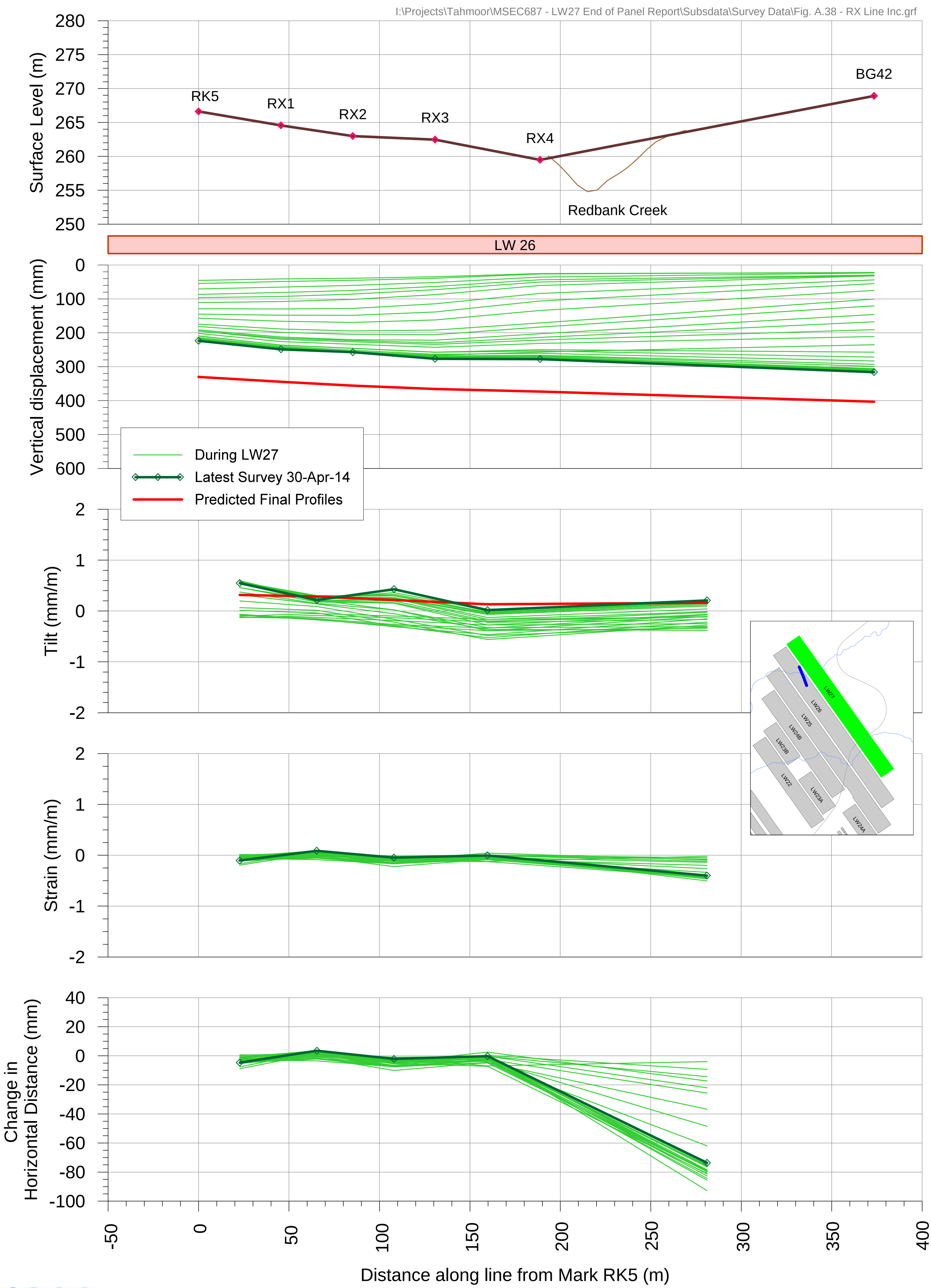

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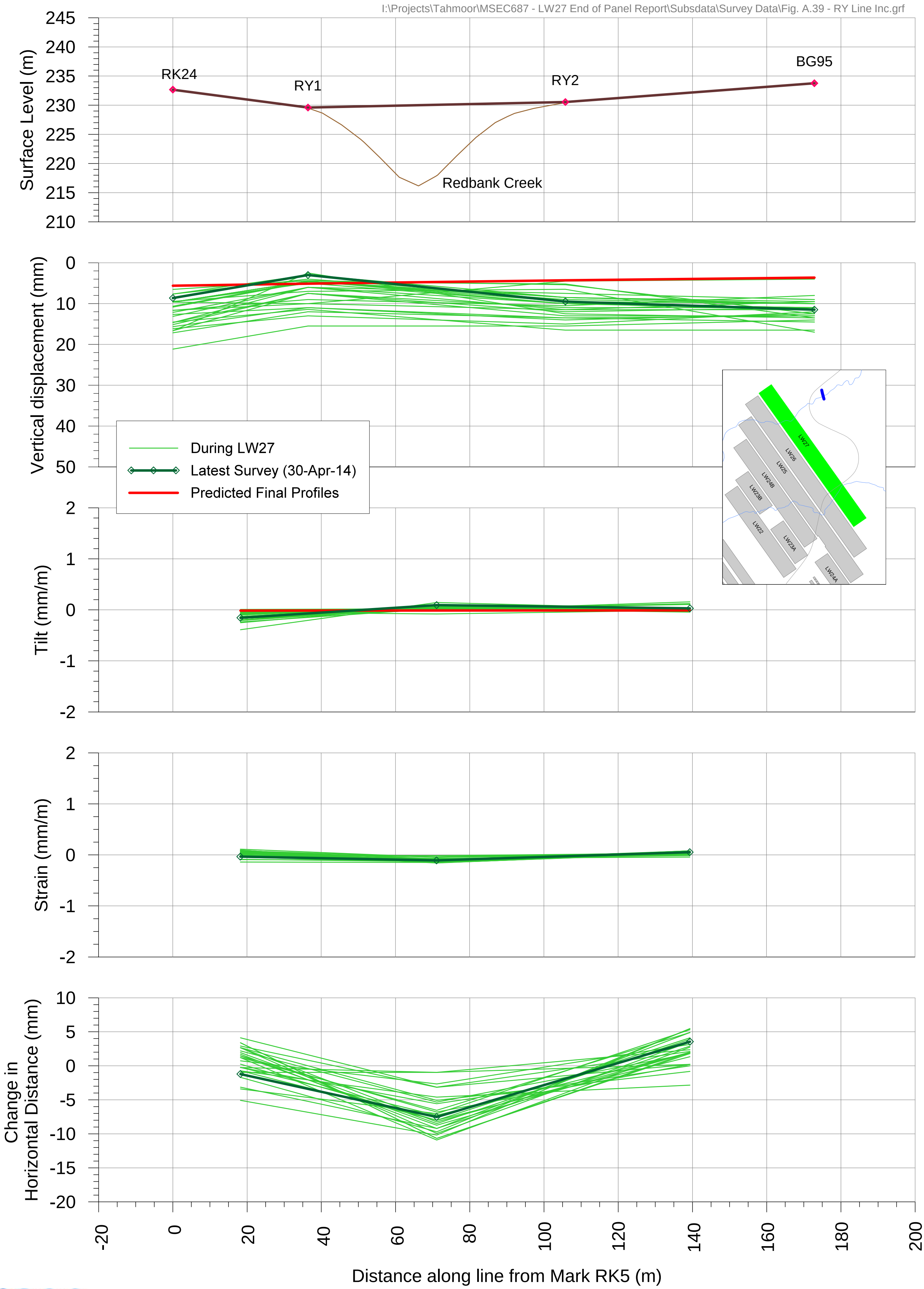
Fig. A.38

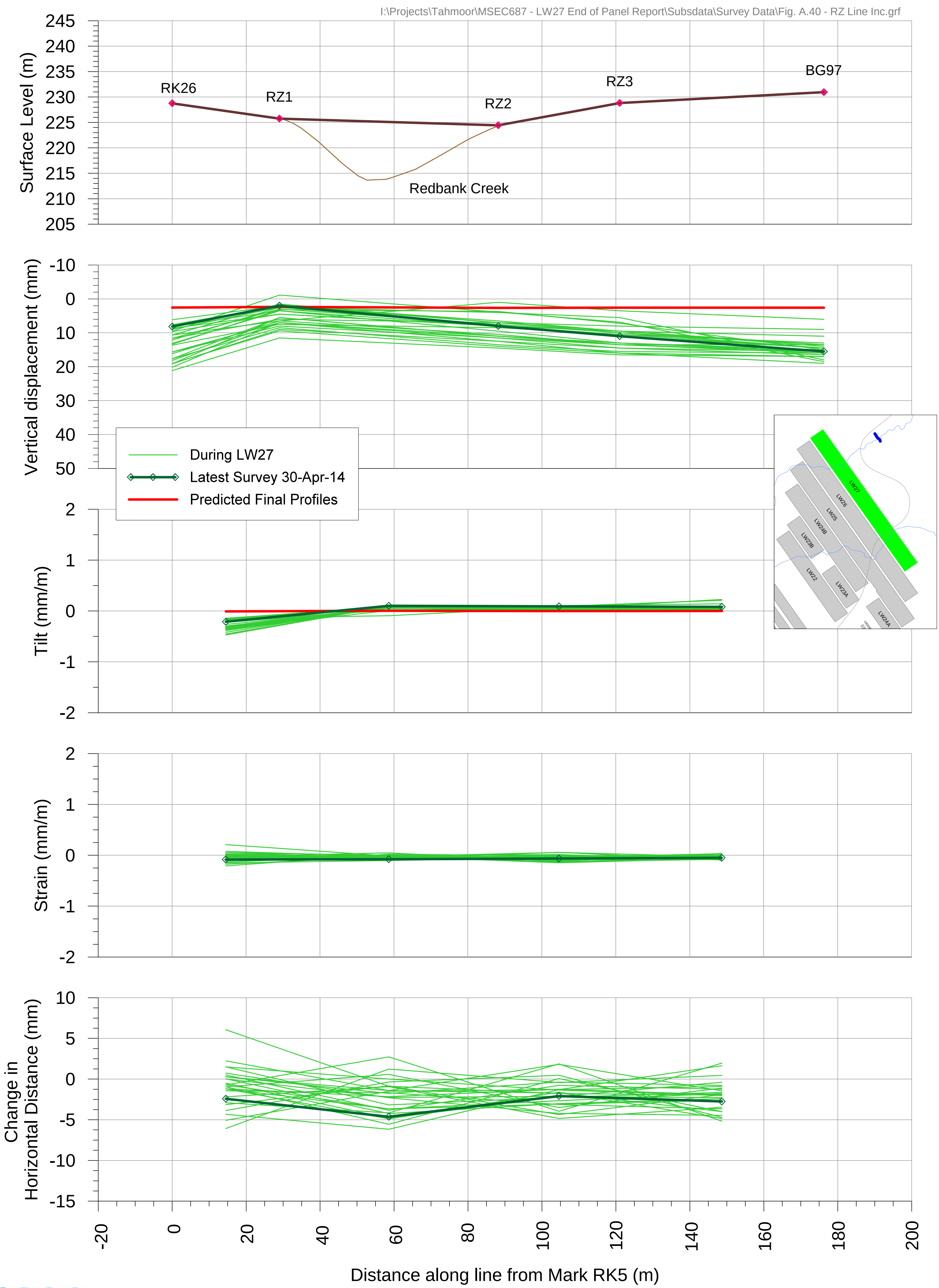
Tahmoor Colliery
Incremental Profiles along Redbank Creek RY Line



msec

Fig. A.39

Tahmoor Colliery
Incremental Profiles along Redbank Creek RZ Line



msec

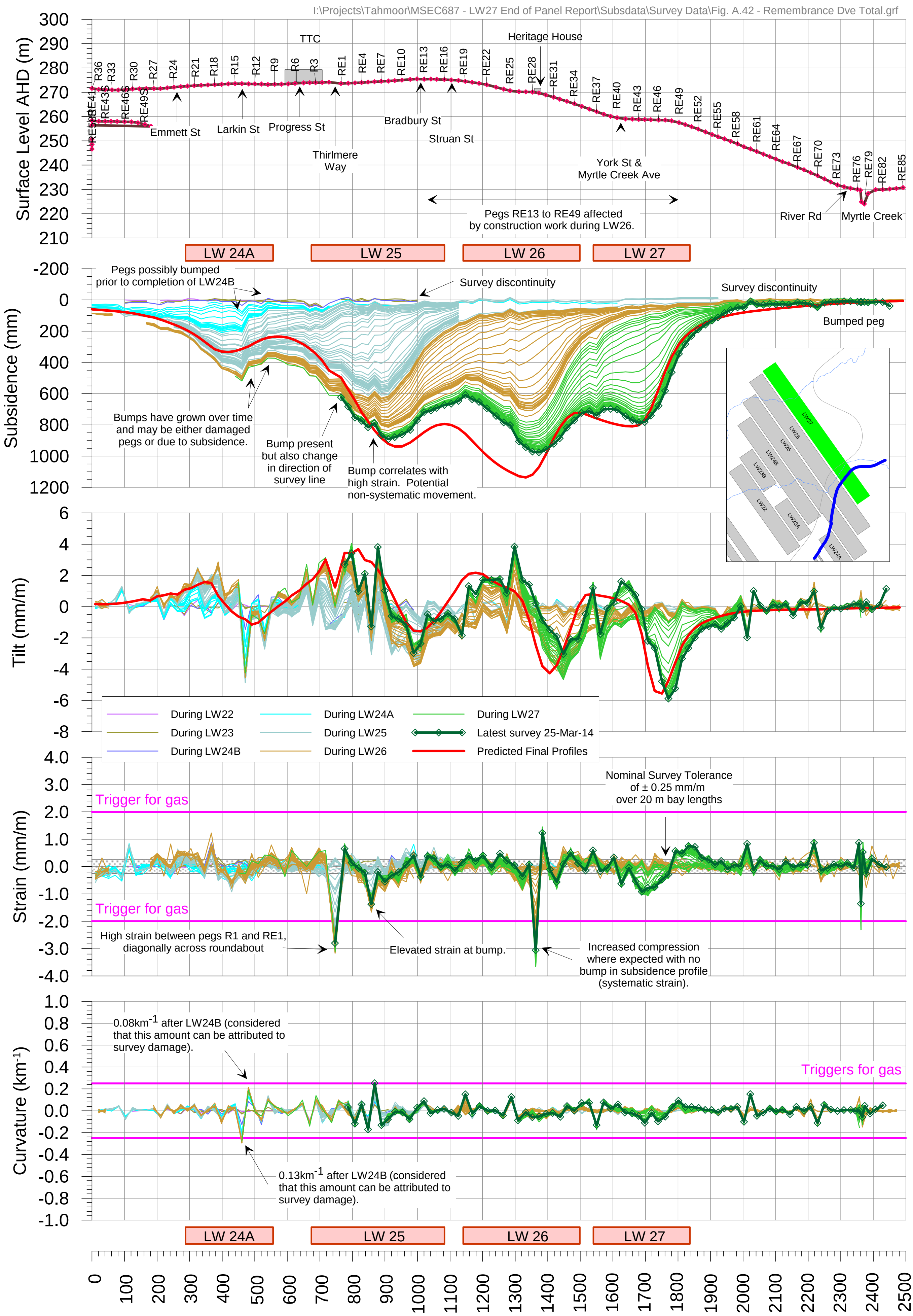
Fig. A.40

Tahmoor Colliery
Incremental Subsidence Profiles along Remembrance Drive

msec

Fig. A.41

Tahmoor Colliery
Total Subsidence Profiles along Remembrance Drive



Distance along Remembrance Drive Line from Survey Mark R36 (m)

msec

Fig. A.42

Tahmoor Colliery
Total Subsidence Profiles along River Road

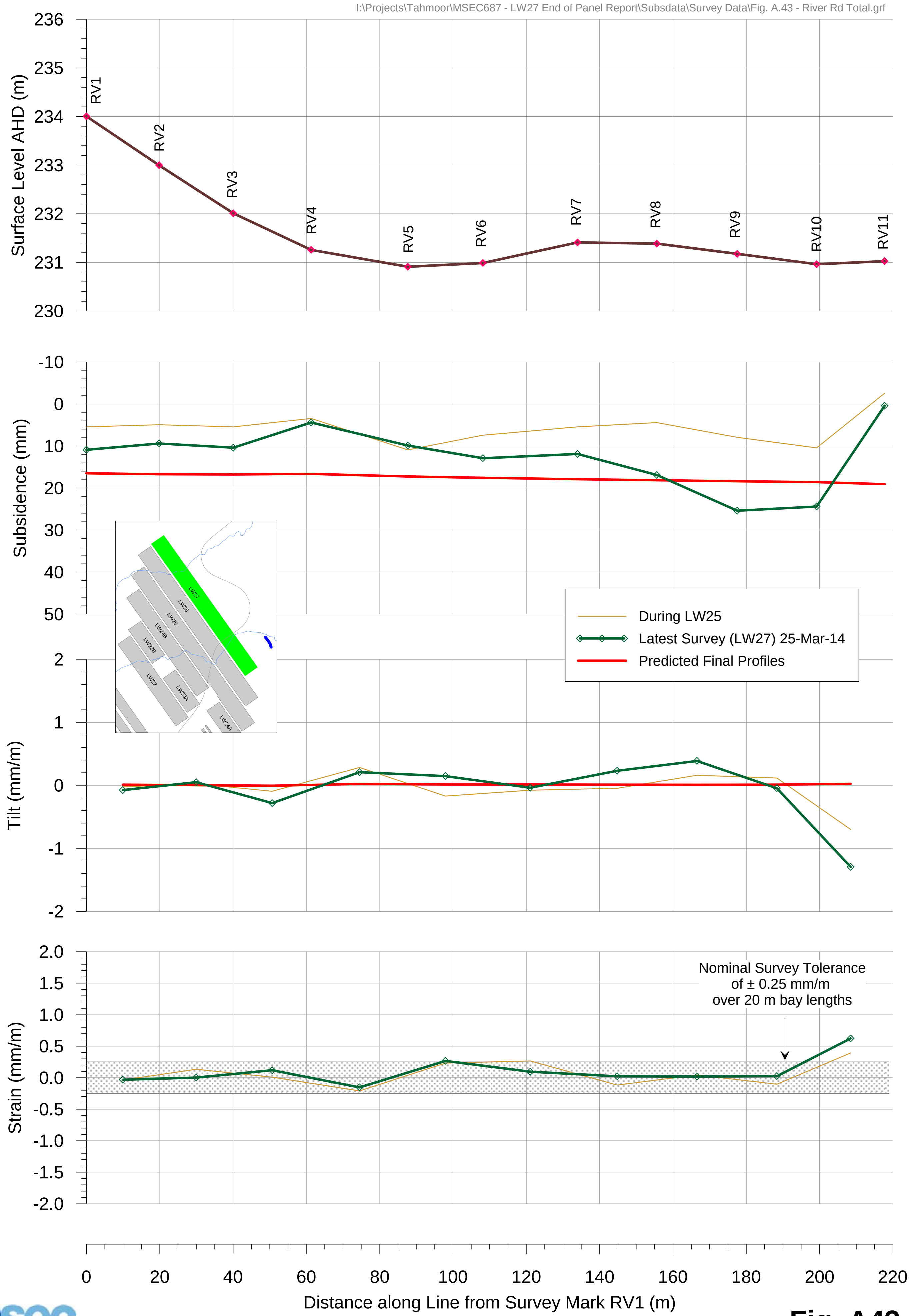
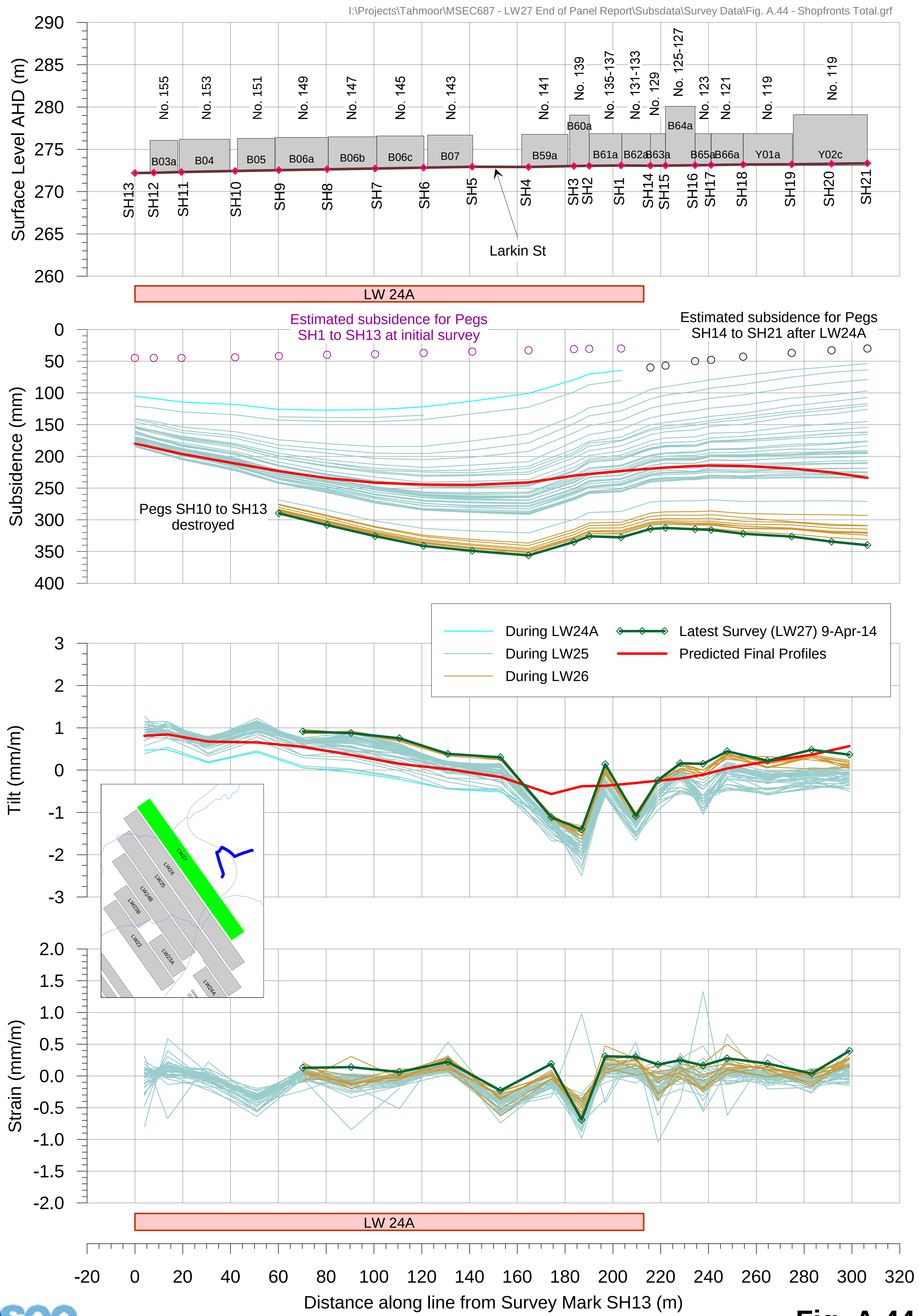


Fig. A43

Tahmoor Colliery
Total Subsidence Profiles along Remembrance Drive Shopfronts



msec

Fig. A.44

Tahmoor Colliery
Incremental Subsidence Profiles along Struan Street

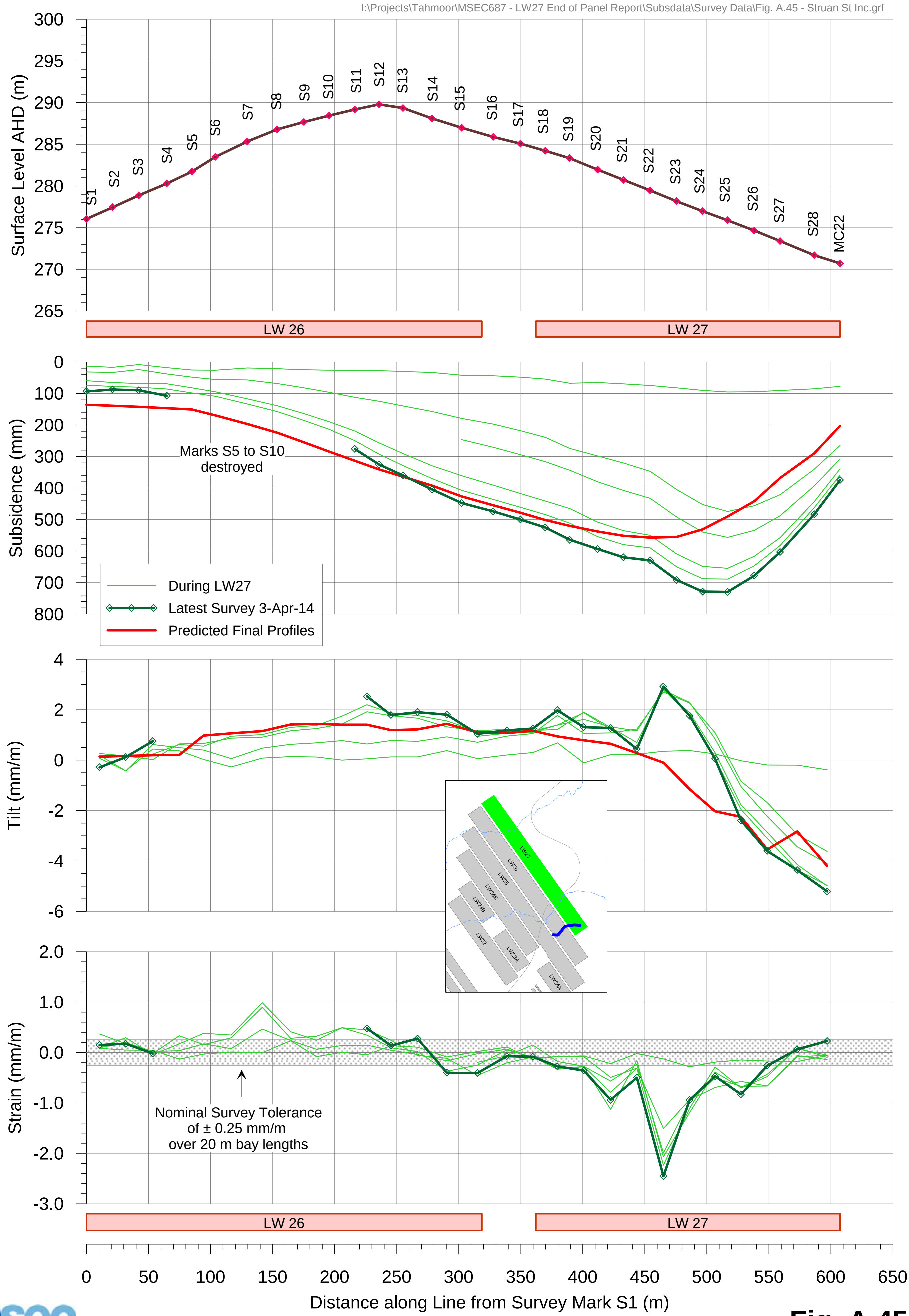


Fig. A.45

Tahmoor Colliery
Total Subsidence Profiles along Struan Street

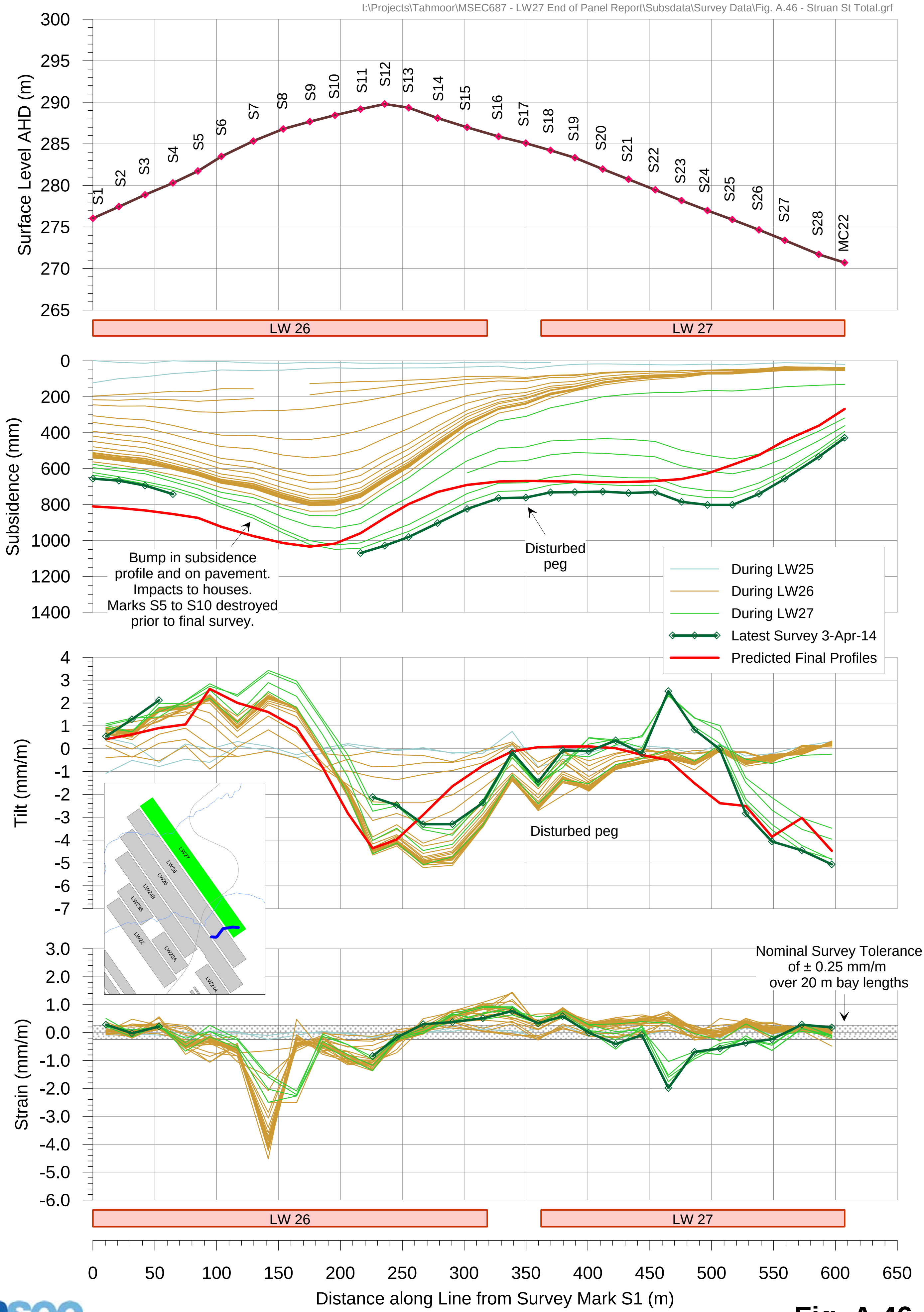


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Fig. A.46

Tahmoor Colliery
Incremental Subsidence Profiles along Tahmoor Carrier Pipe

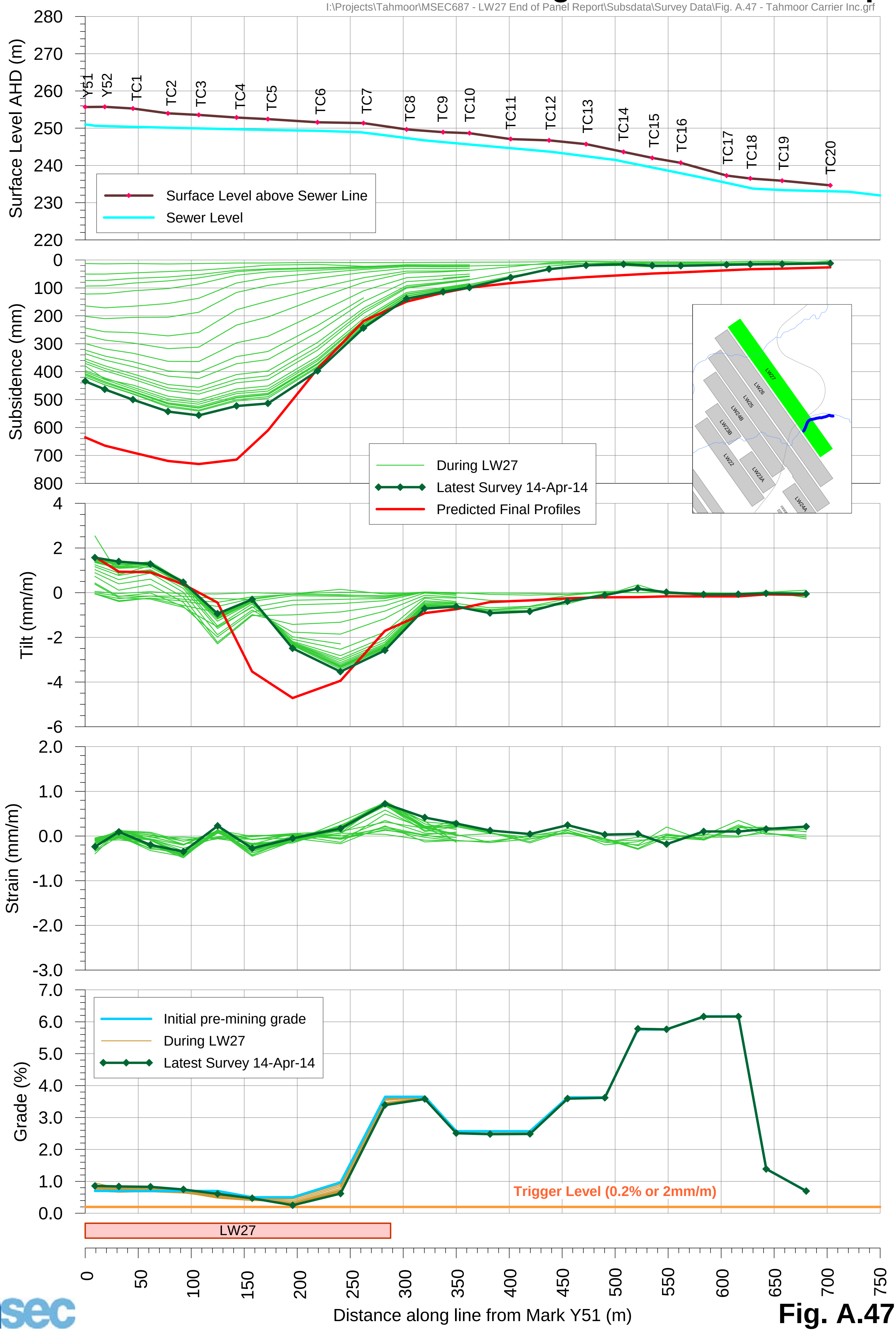

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Fig. A.47

Tahmoor Colliery
Total Subsidence Profiles along Tahmoor Road

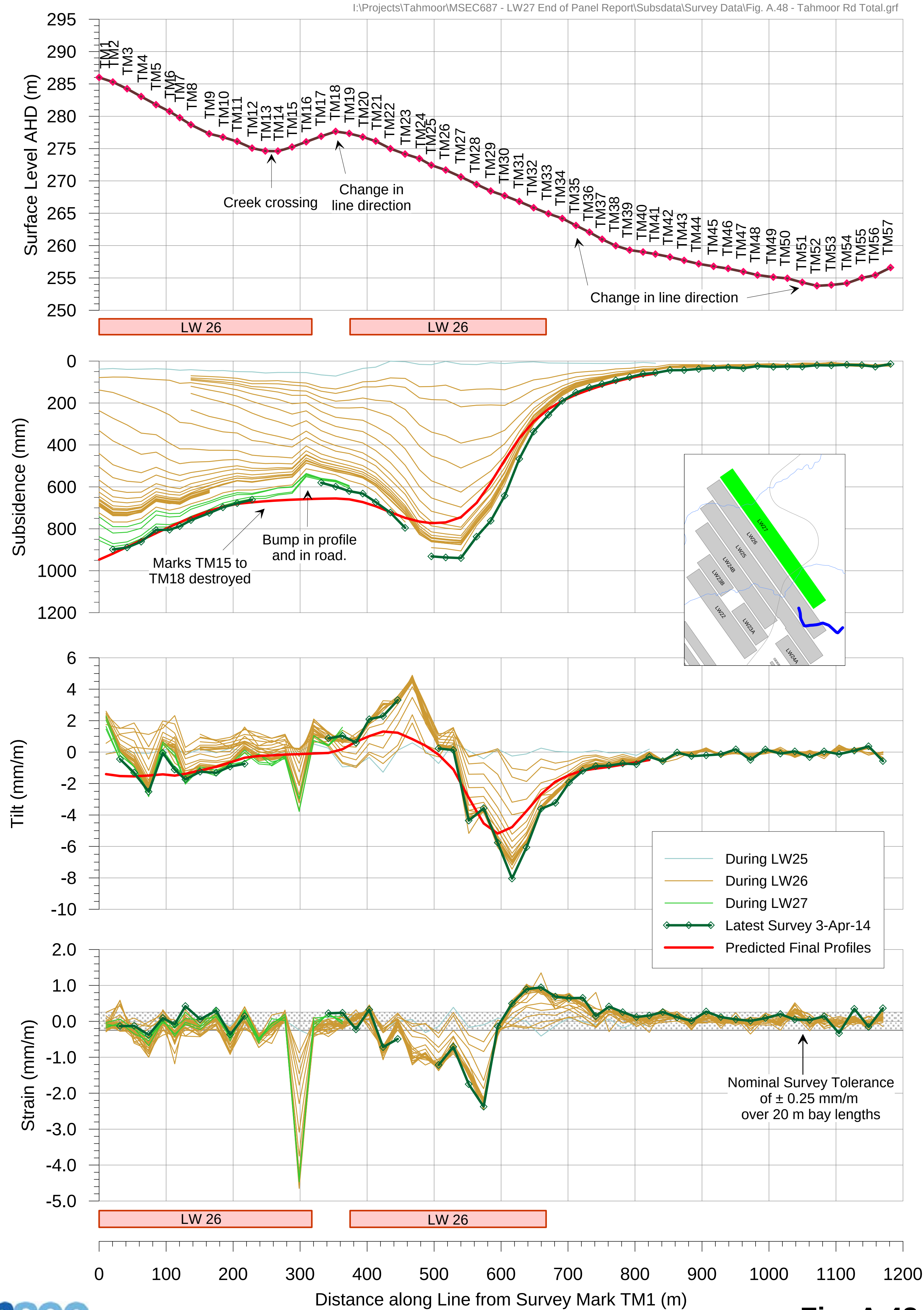

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Fig. A.48

Tahmoor Colliery
Total Subsidence Profiles along Thirlmere Way

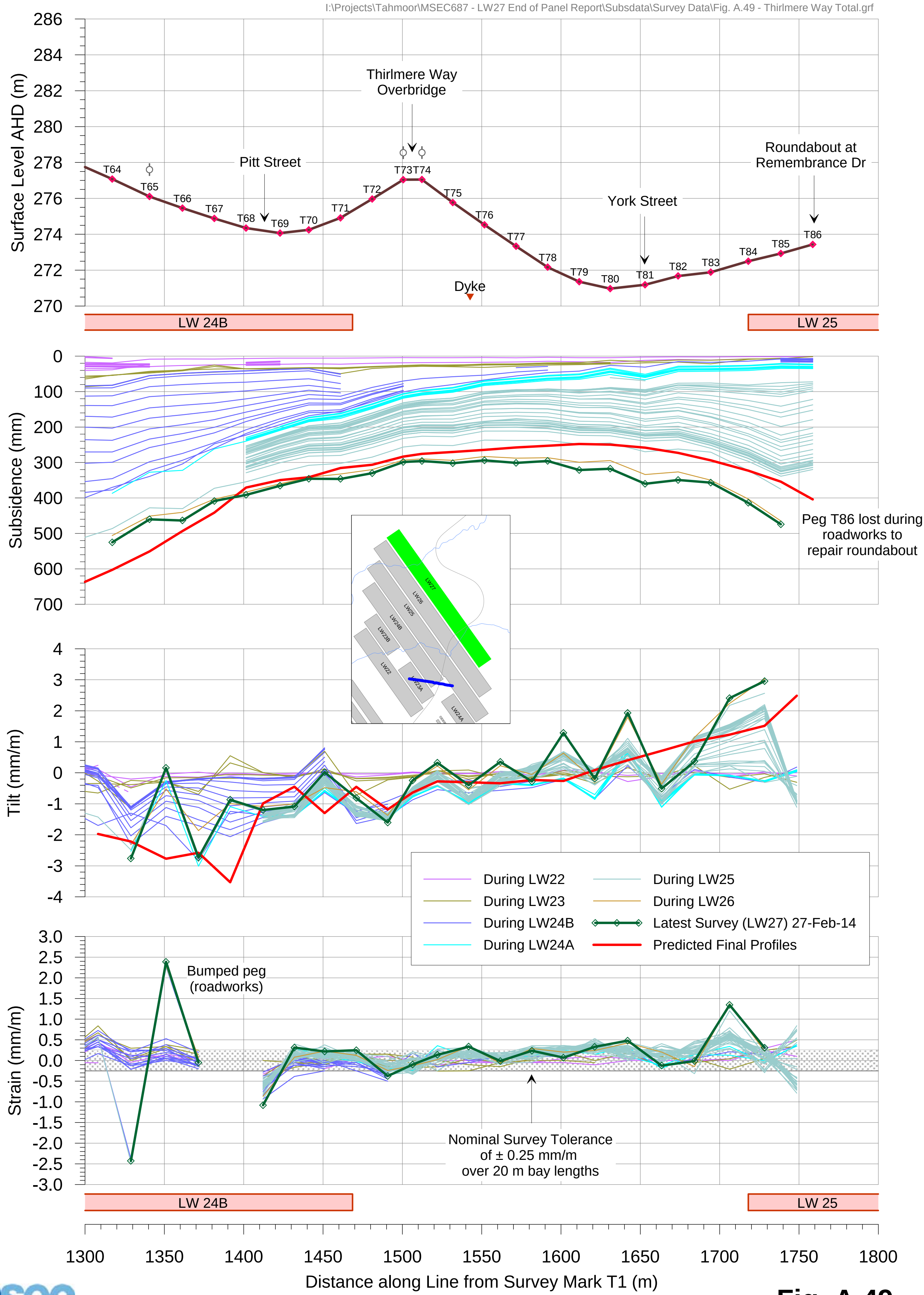

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Fig. A.49

Tahmoor Colliery
Incremental Subsidence Profiles along Thompson Place

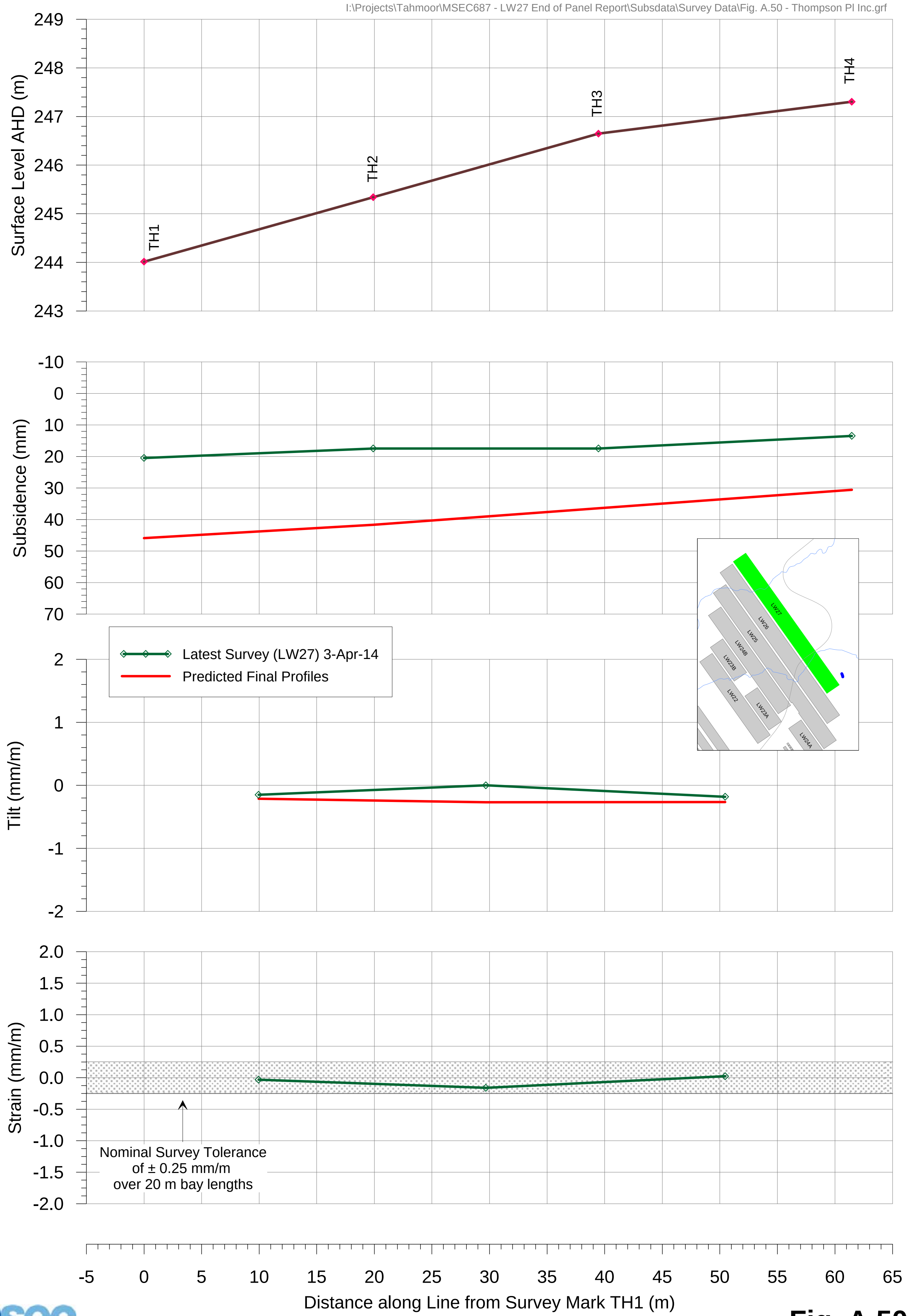

Fig. A.50

Tahmoor Colliery
Total Subsidence Profiles along Winpara Close

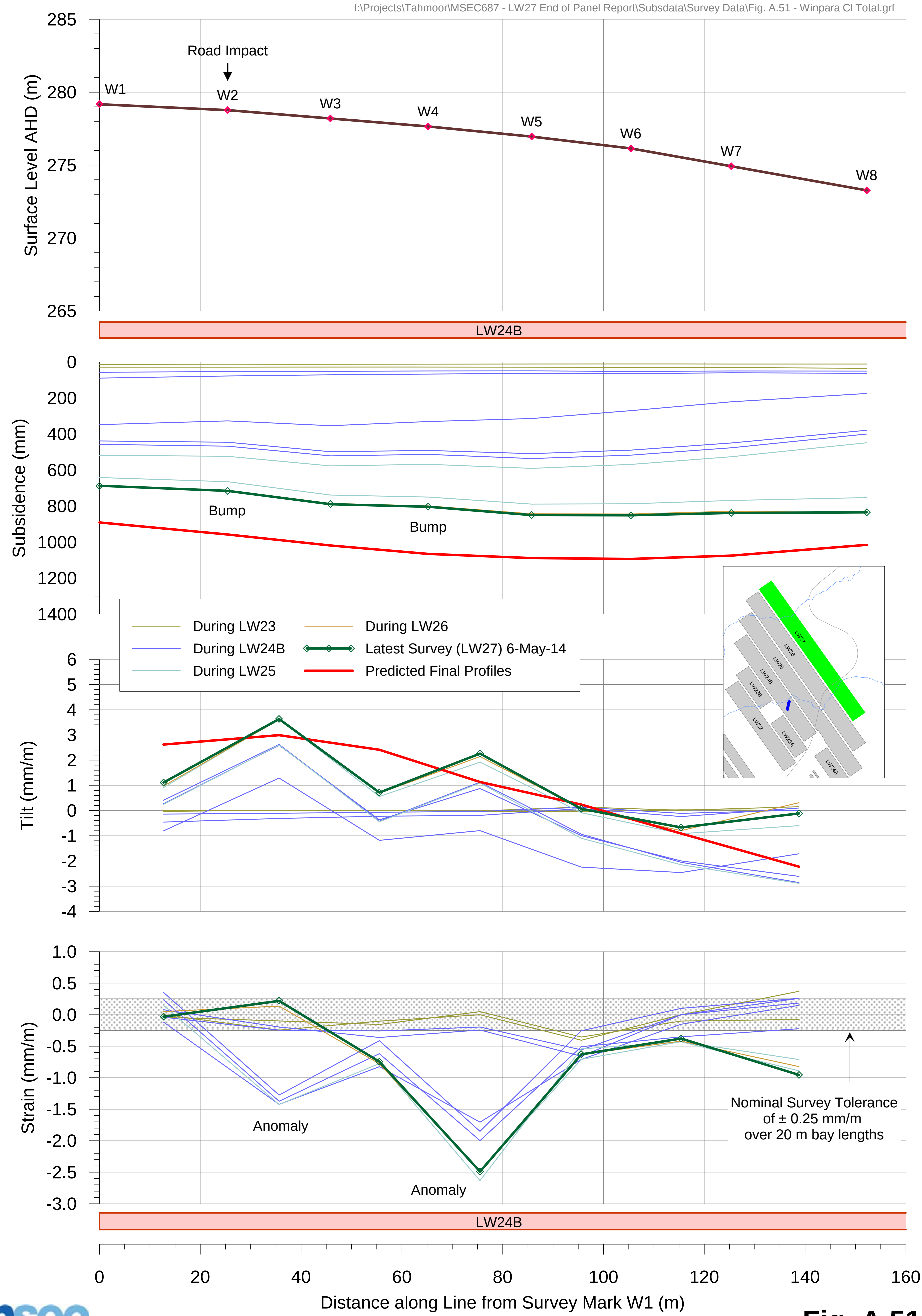

Fig. A.51

Tahmoor Colliery
Incremental Subsidence Profiles along York Street

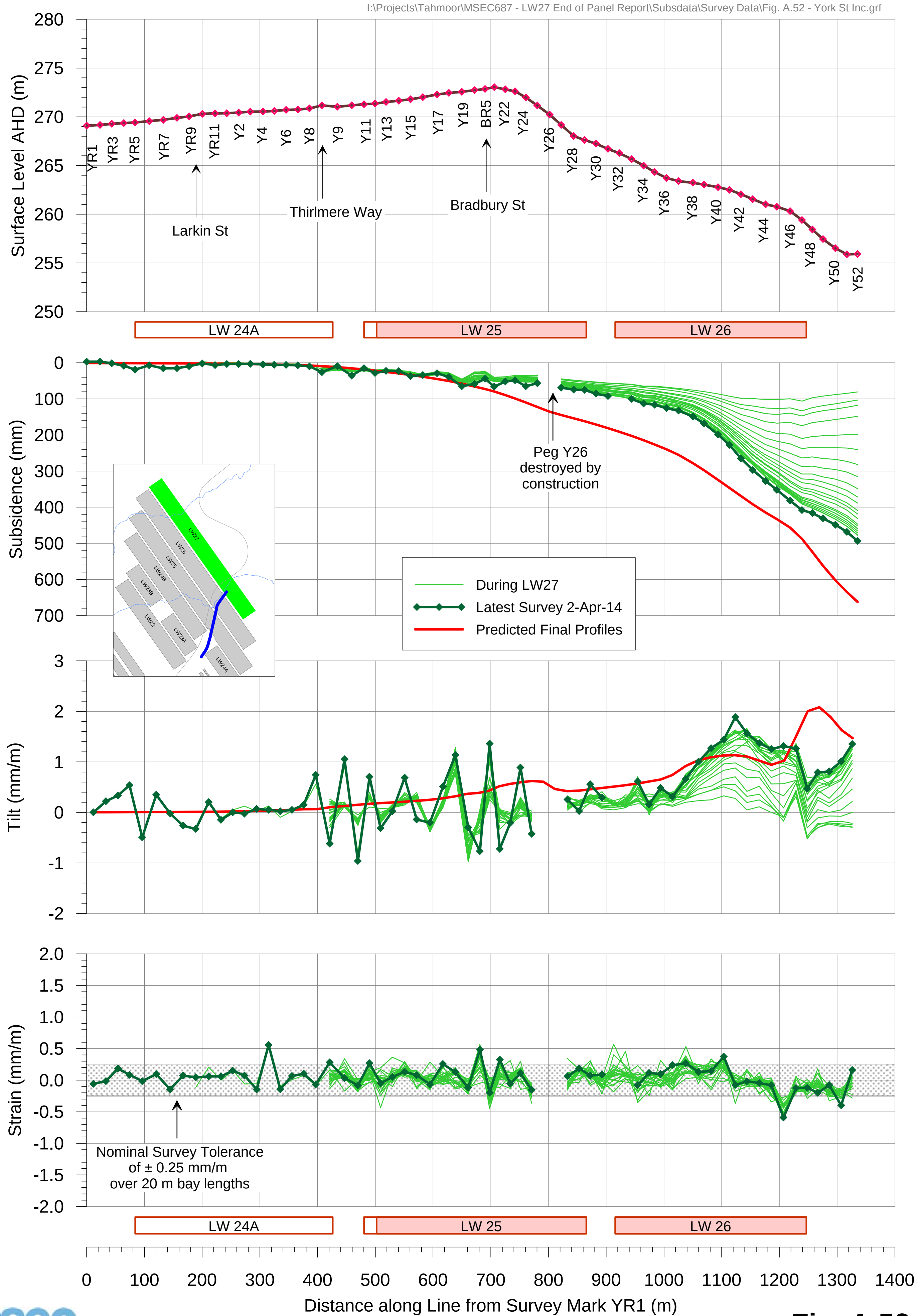

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Fig. A.52

Tahmoor Colliery
Total Subsidence Profiles along York Street

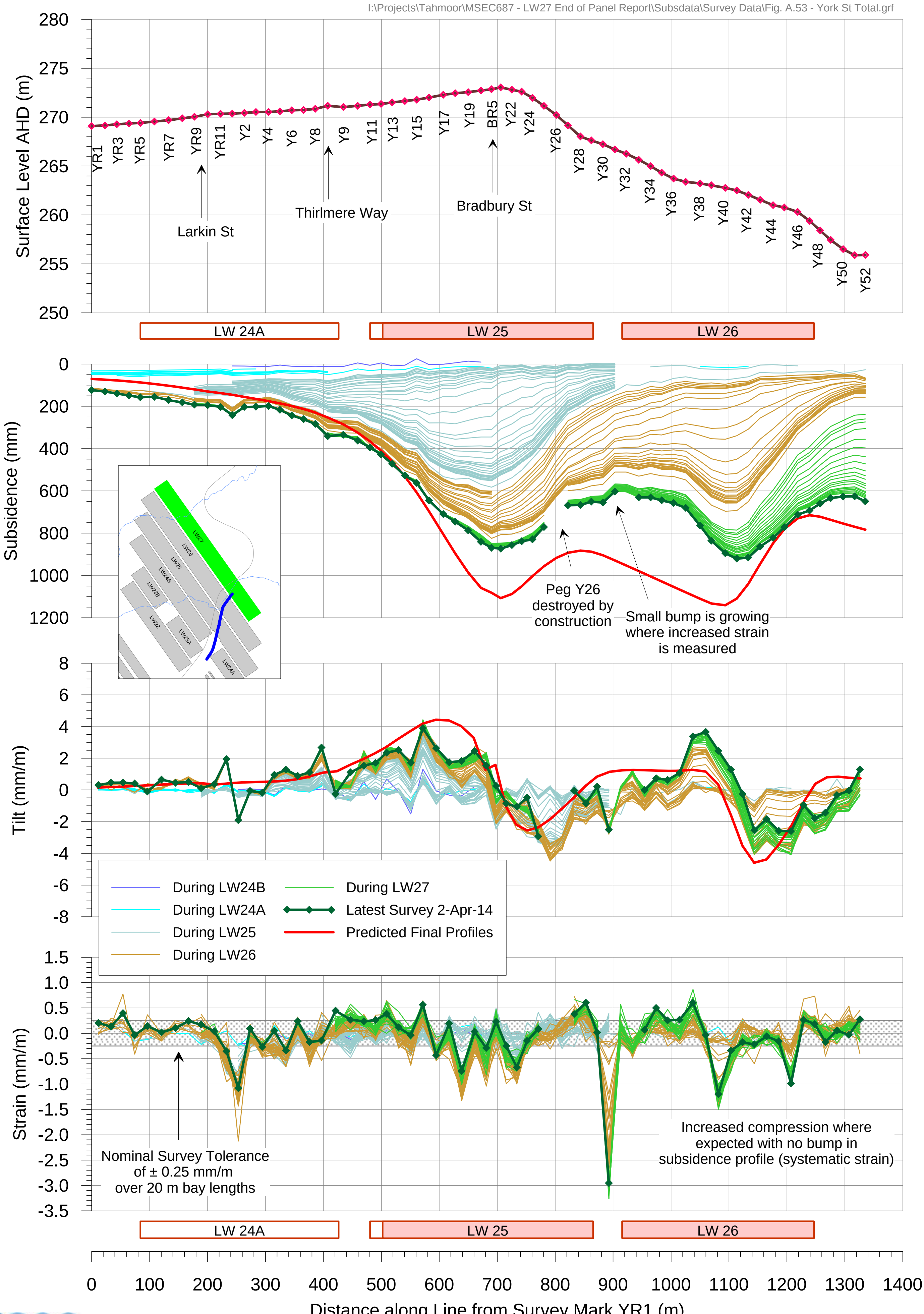

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Fig. A.53

Tahmoor Colliery
Incremental Subsidence Profiles at Tahmoor House

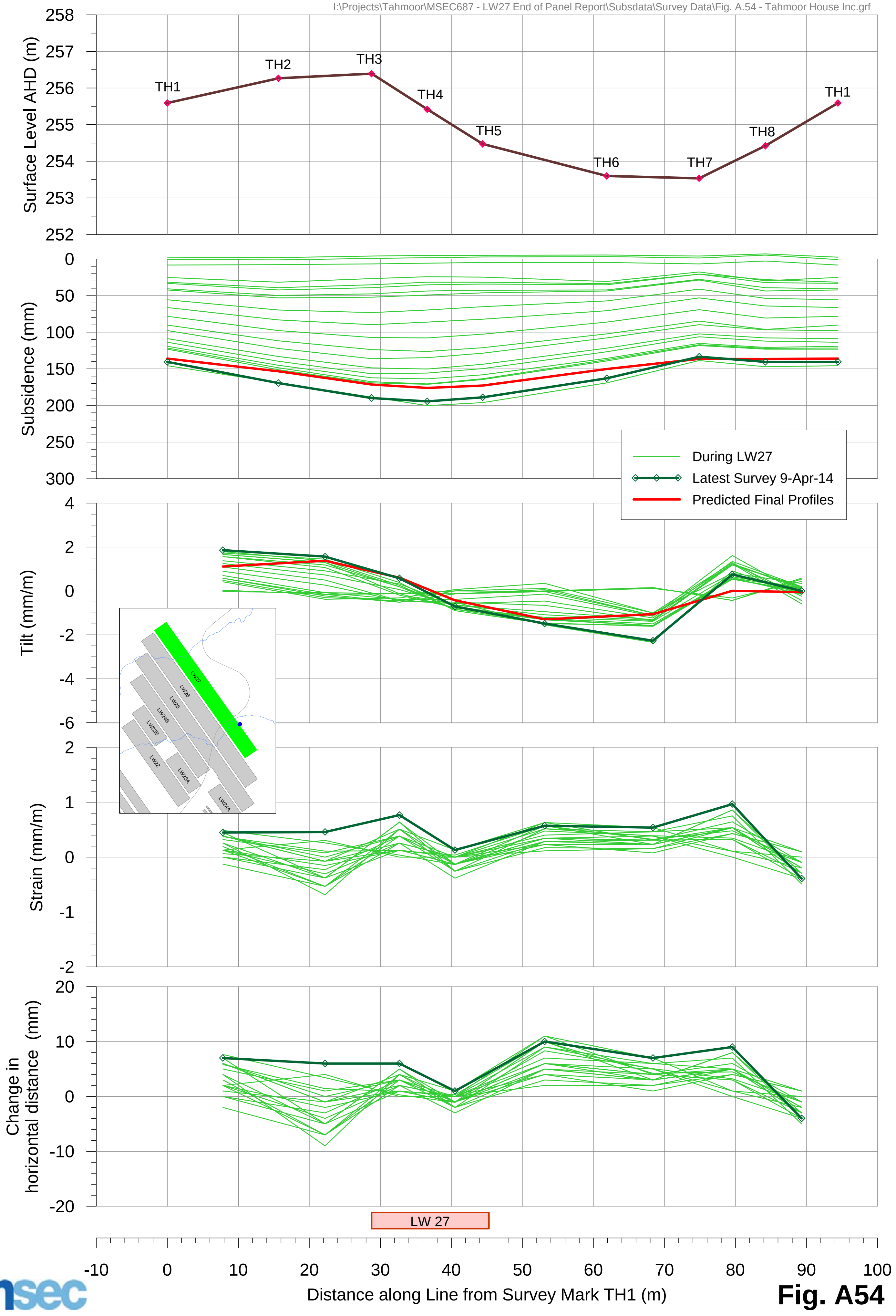

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Fig. A54

Tahmoor Colliery
Total Subsidence Profiles at 13 York Street

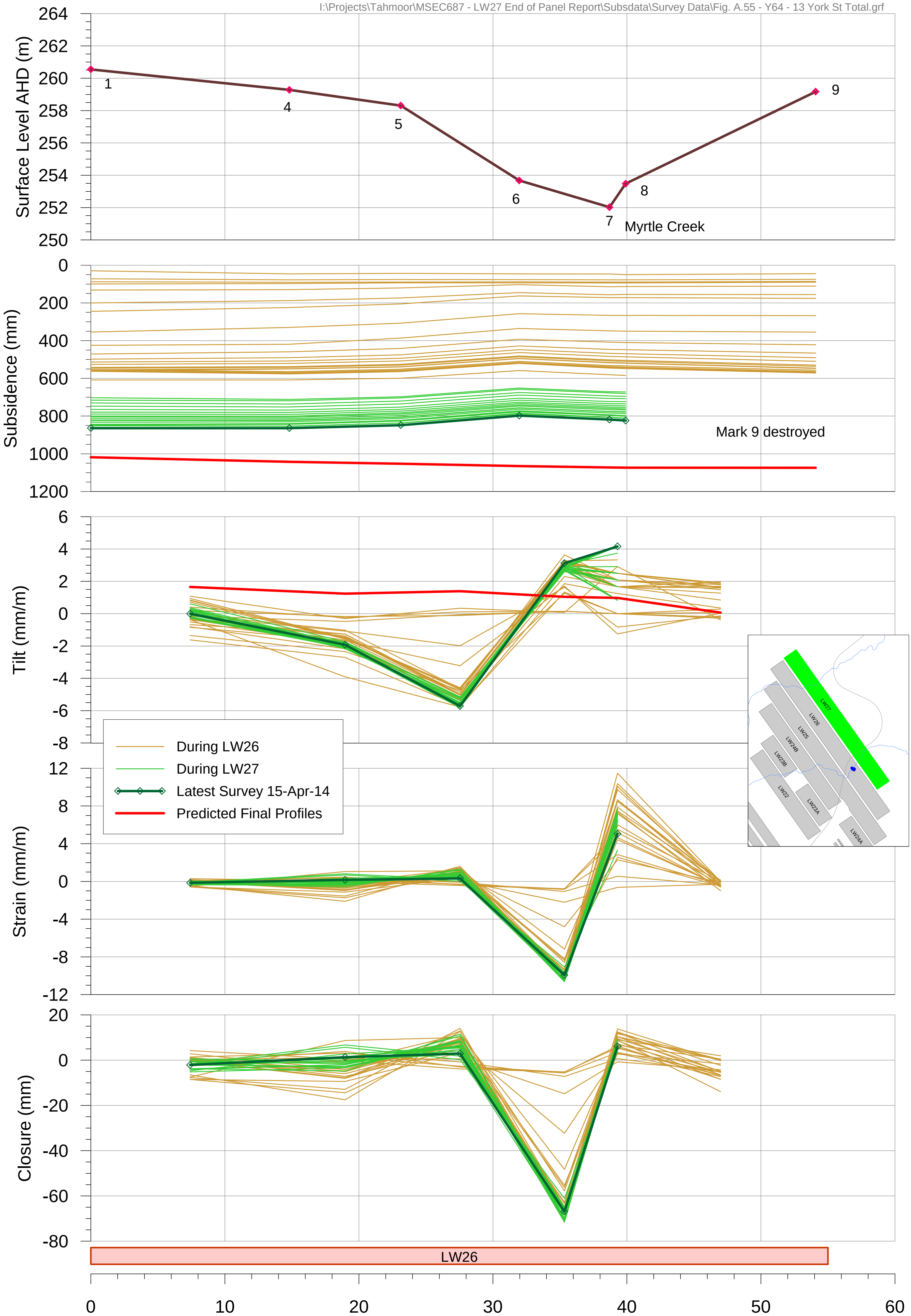

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Fig. A.55

Tahmoor Colliery
Total Subsidence Profiles at 19 York Street

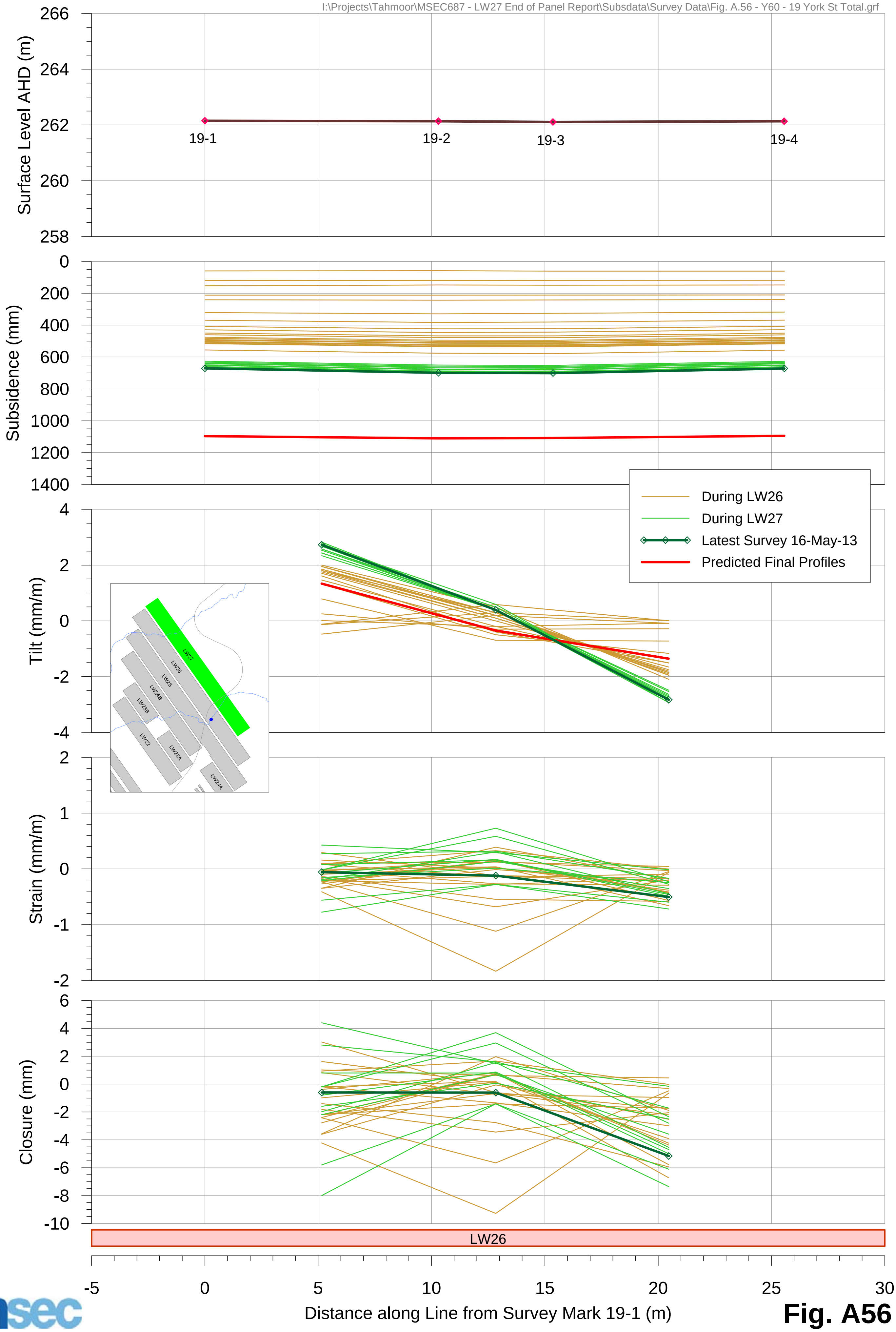

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Fig. A56

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

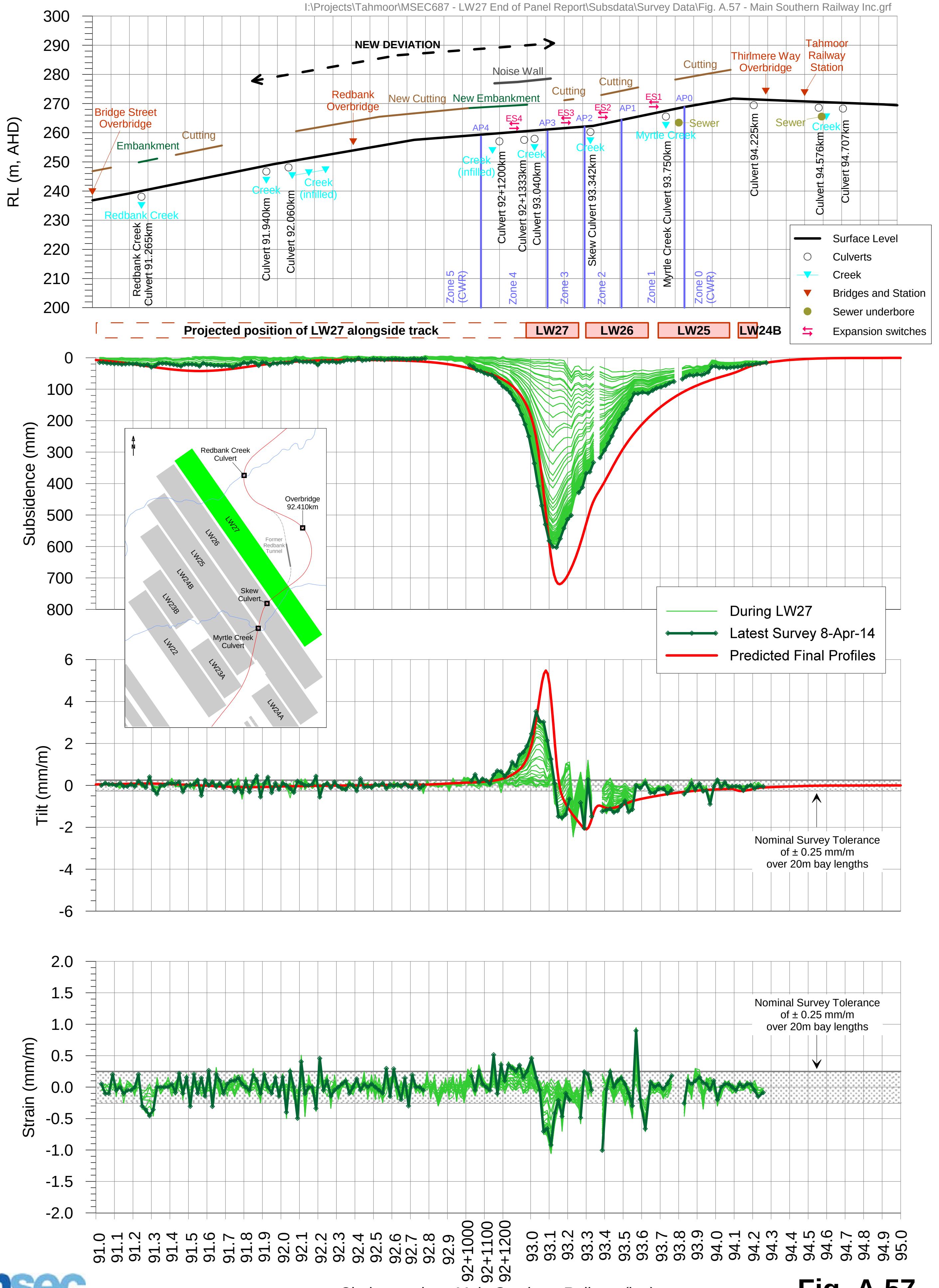

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Fig. A.57

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

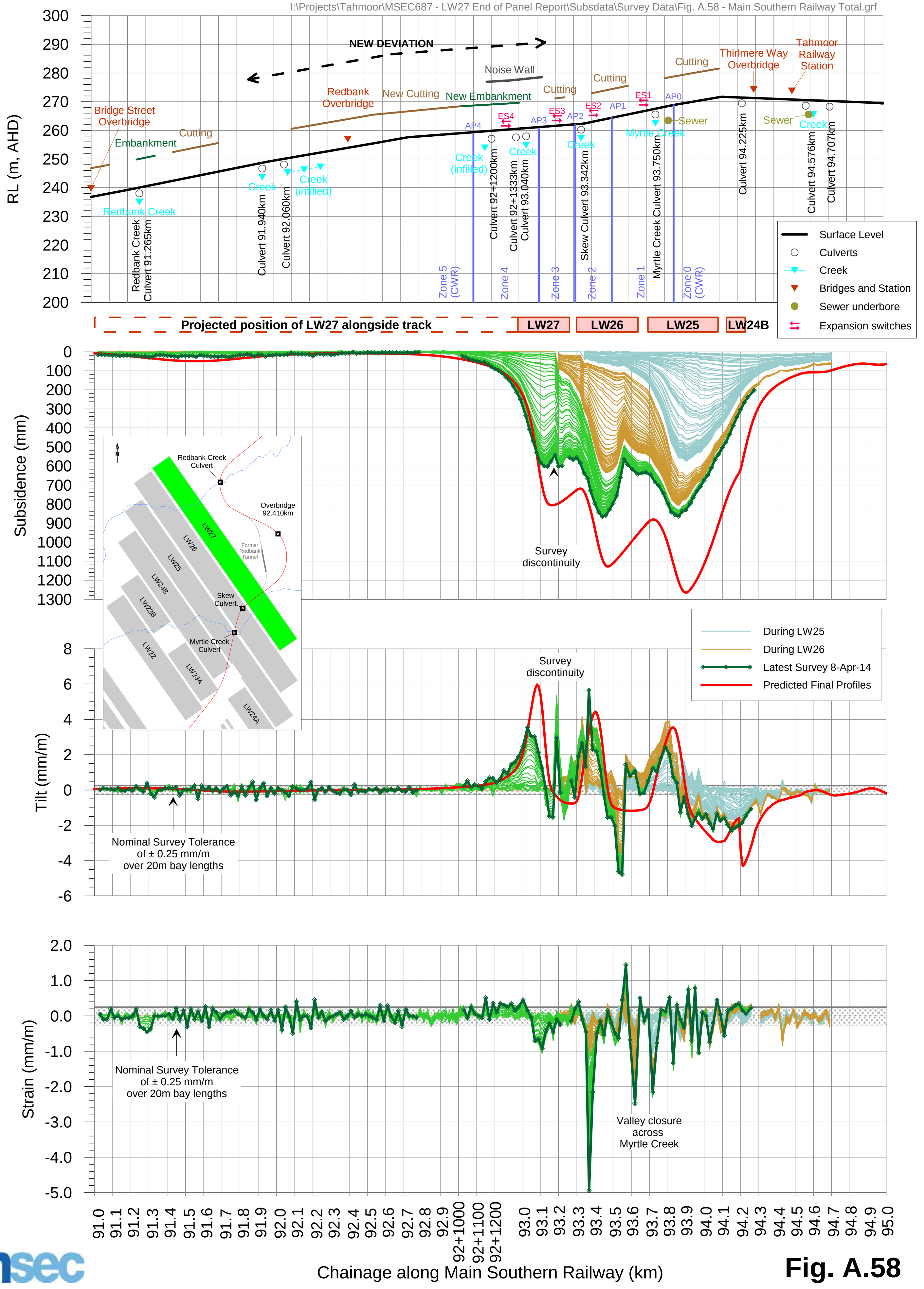

Fig. A.58

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

I:\Projects\Tahmoor\MSEC687 - LW27 End of Panel Report\Subsdata\Survey Data\Fig. A.59 - Southern Embankment Toe Inc.grf

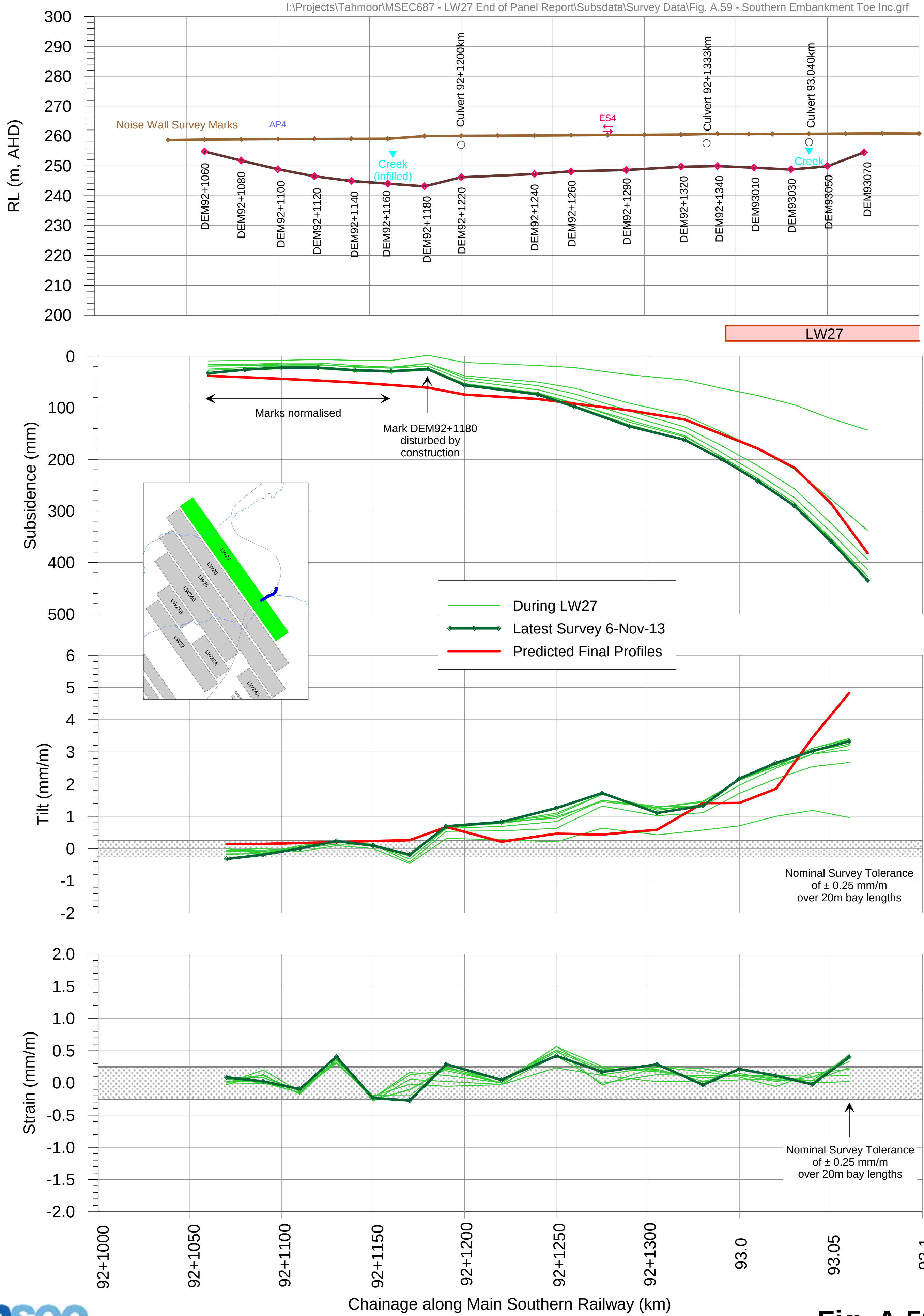

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Fig. A.59

Tahmoor Colliery
Incremental Subsidence Profiles
along the Railway Corridor Noise Wall

I:\Projects\Tahmoor\MSEC687 - LW27 End of Panel Report\Subsdata\Survey Data\Fig. A.60 - Noise Wall Inc.grf

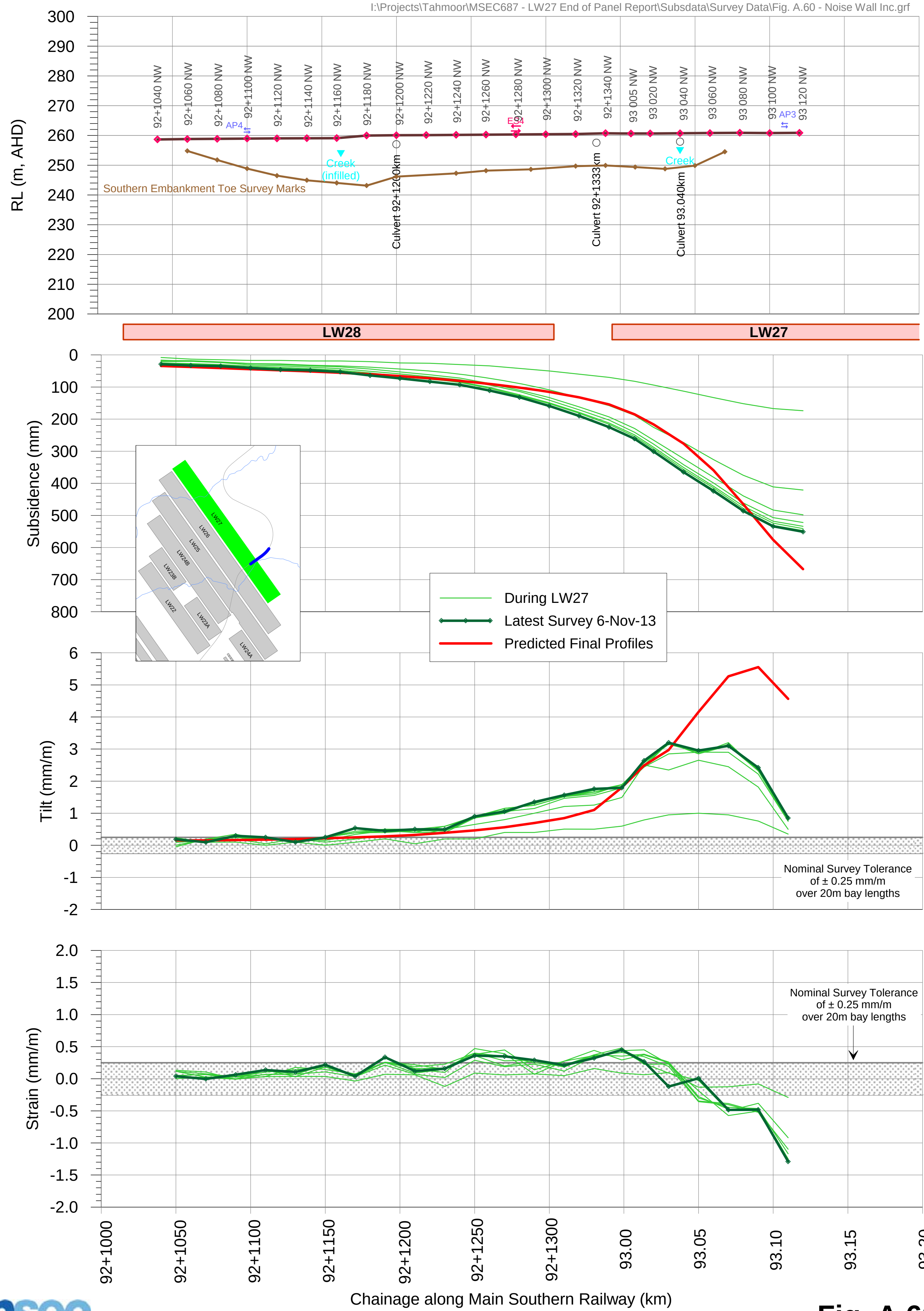

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Fig. A.60

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

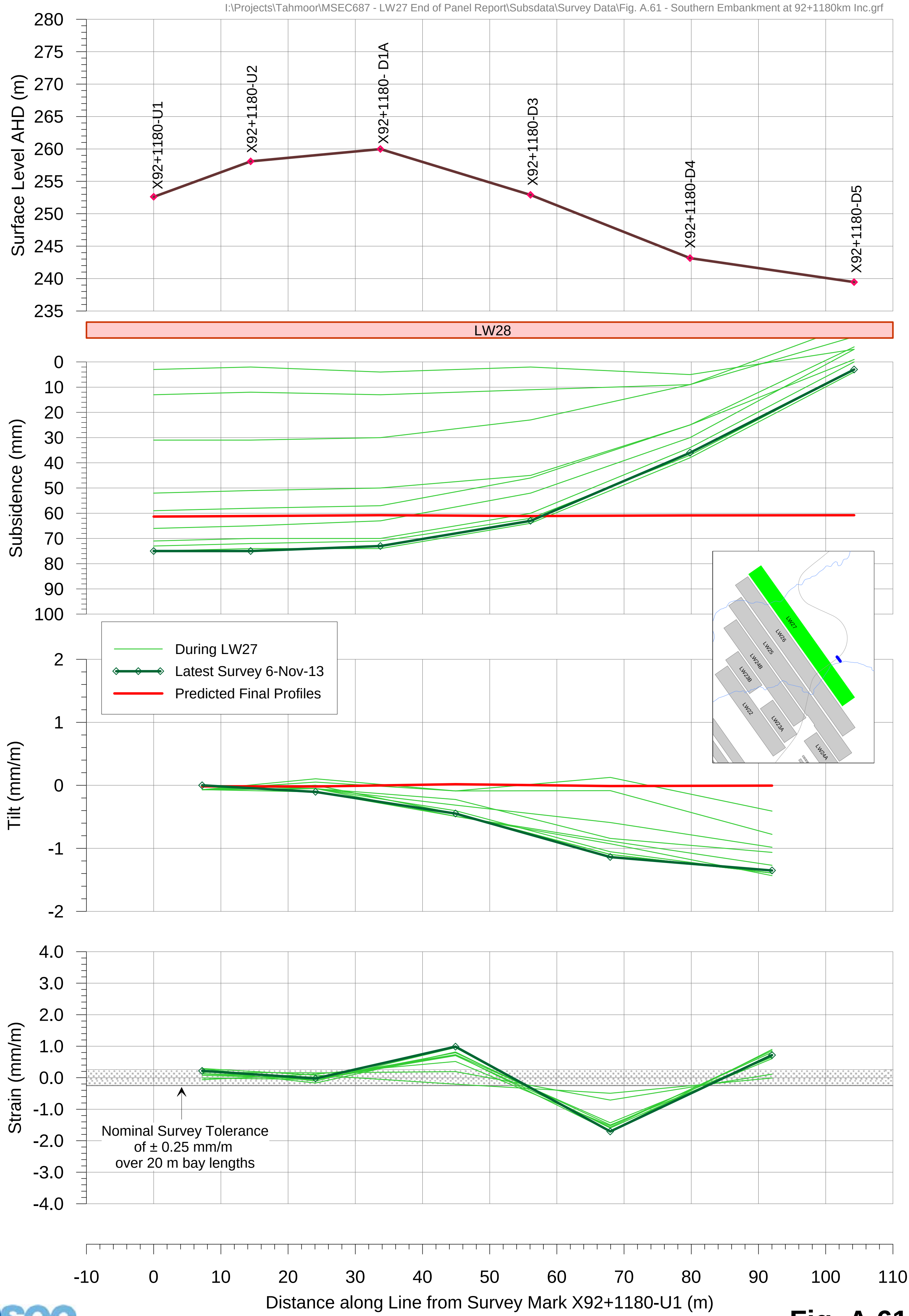

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Fig. A.61

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

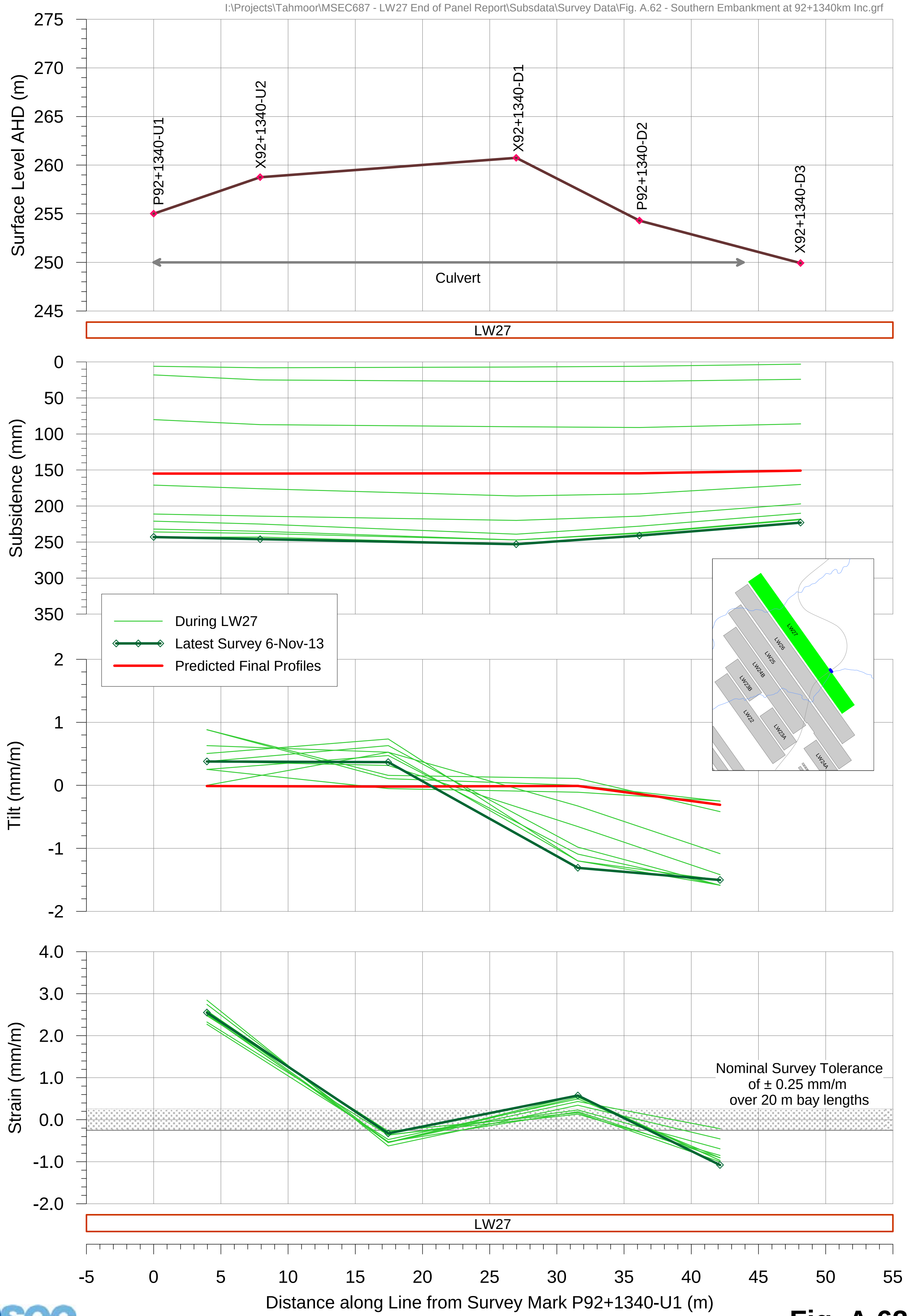

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Fig. A.62

Tahmoor Colliery - Total Subsidence Profiles along Monitoring Line Downstream of Myrtle Creek Culvert

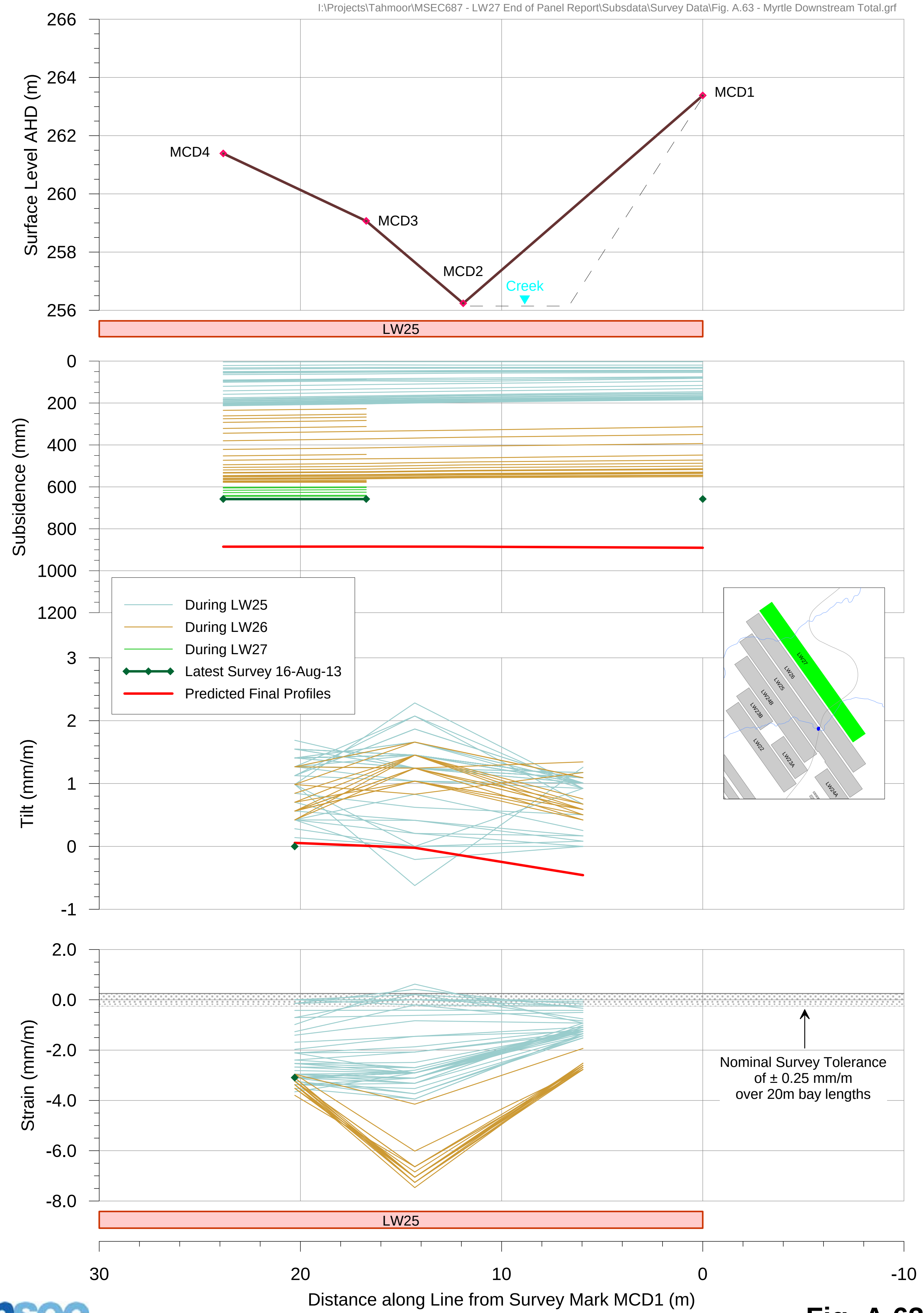

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Fig. A.63

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

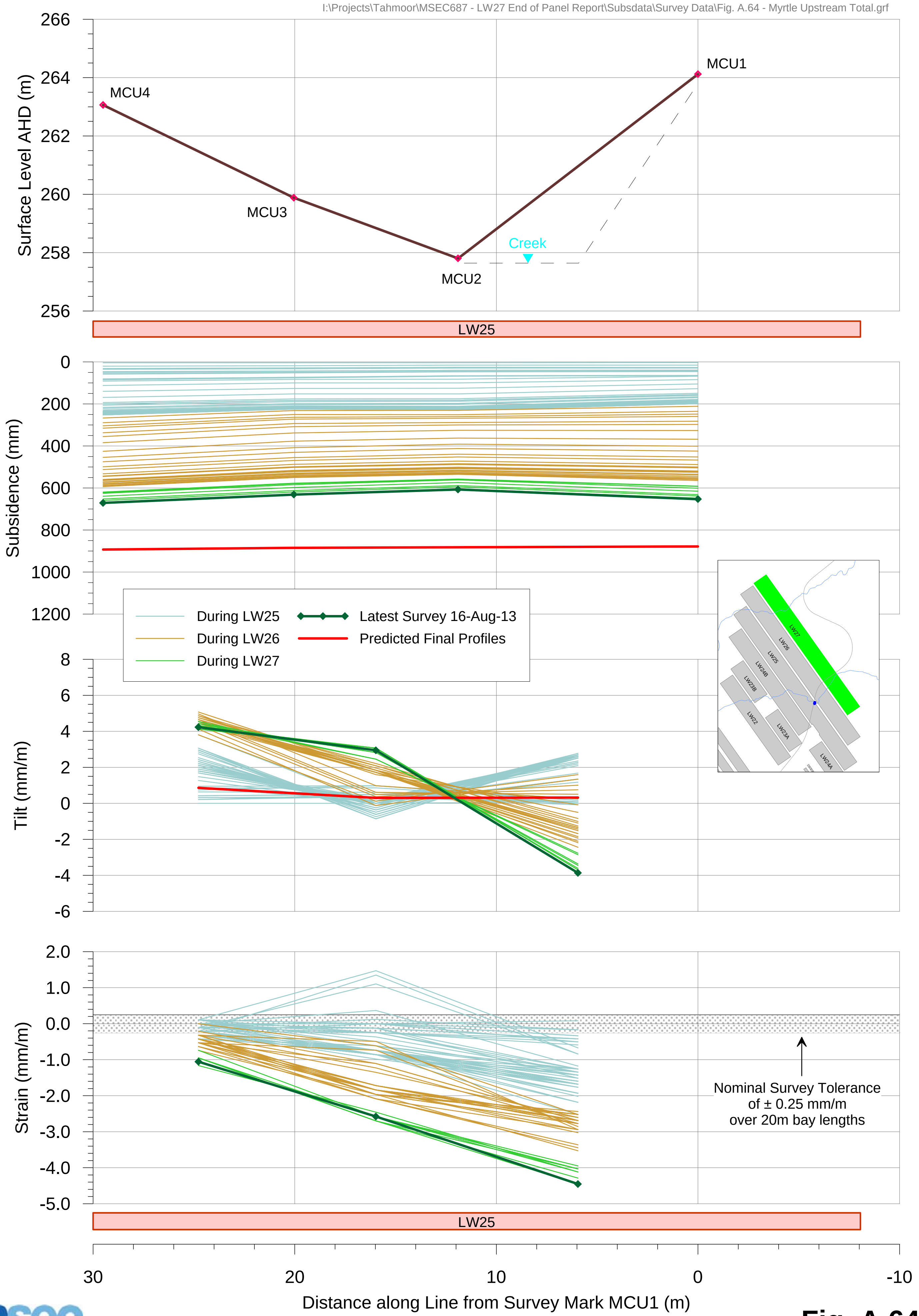
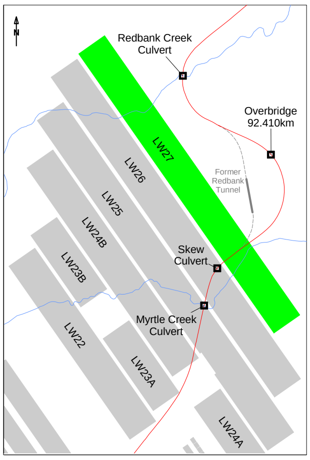


Fig. A.64

Tahmoor Colliery
Total Differential Movements along Skew Culvert Invert



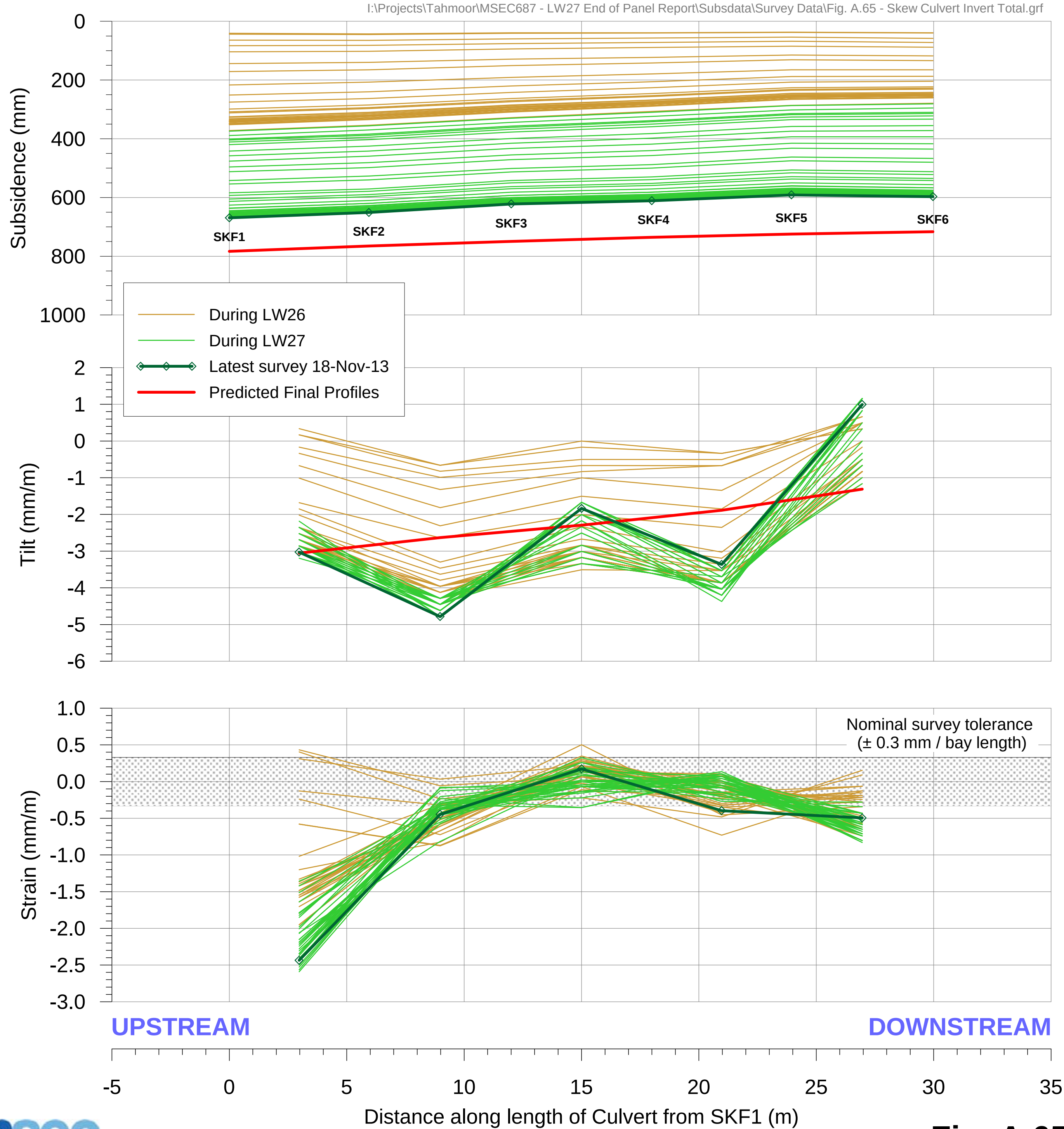


Fig. A.65

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

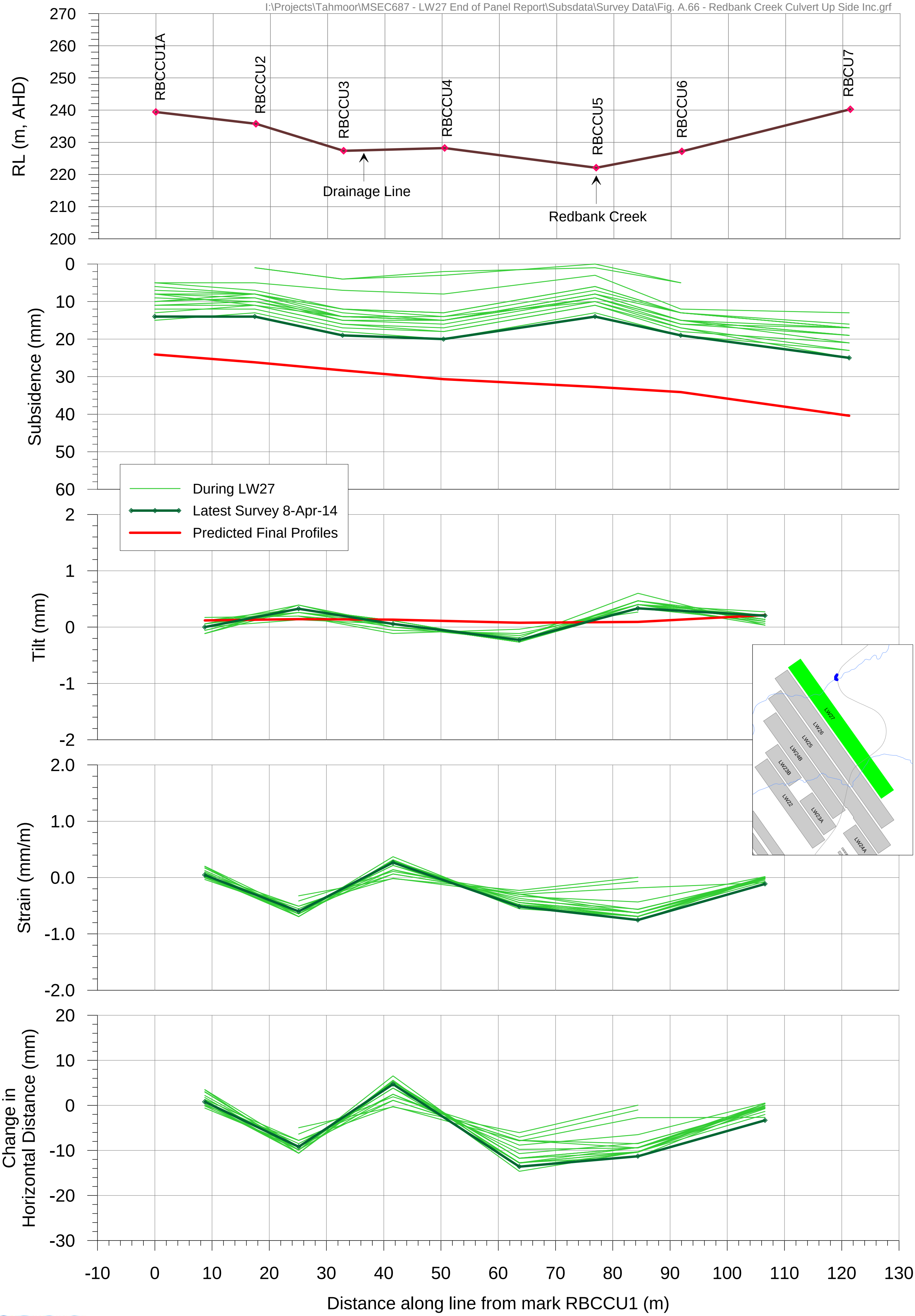


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Fig. A.66

APPENDIX B. DRAWINGS

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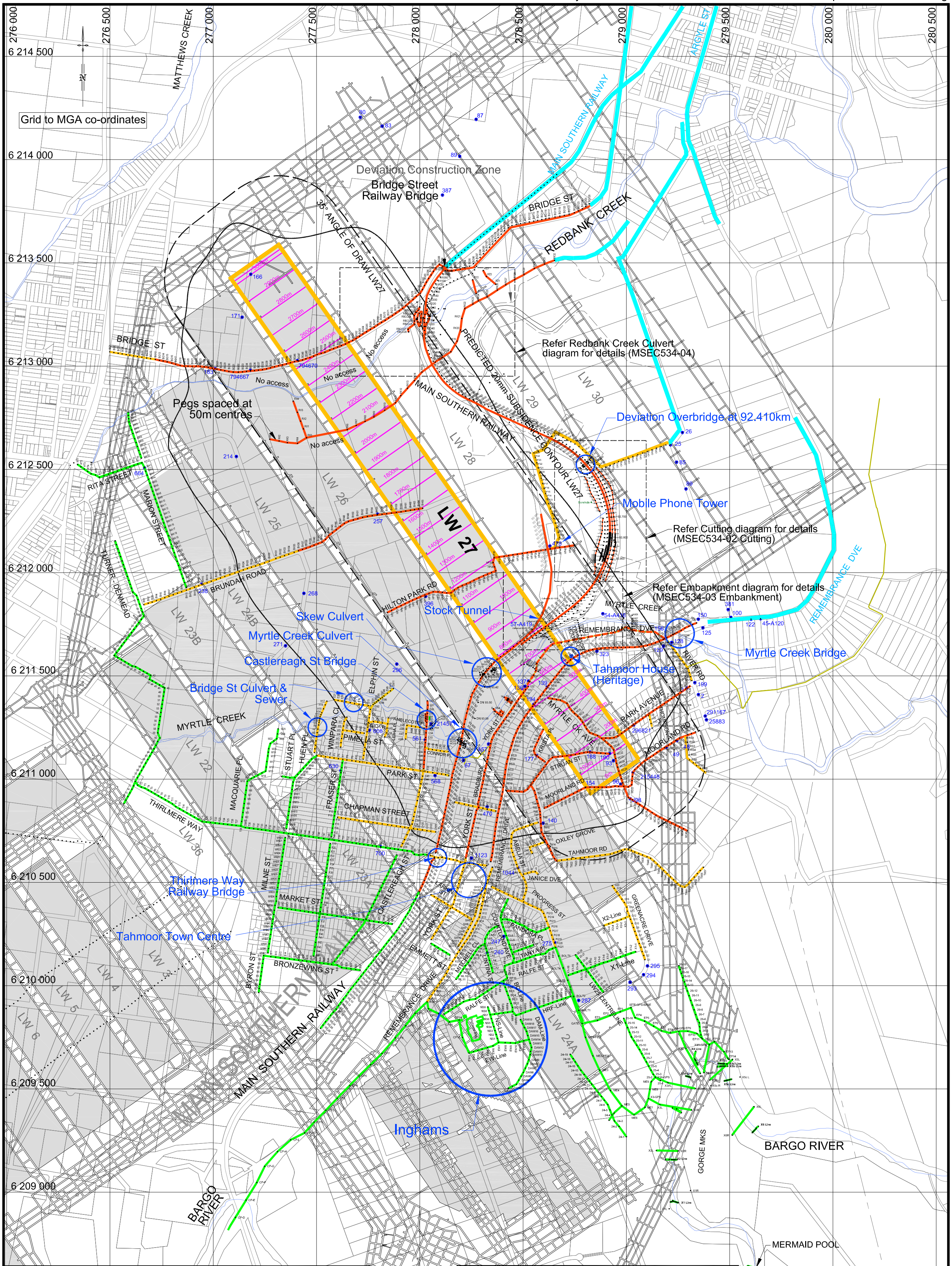

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Tel +61 2 9413 3777 Fax +61 2 8412 0222
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TAHMOOR COLLIERY

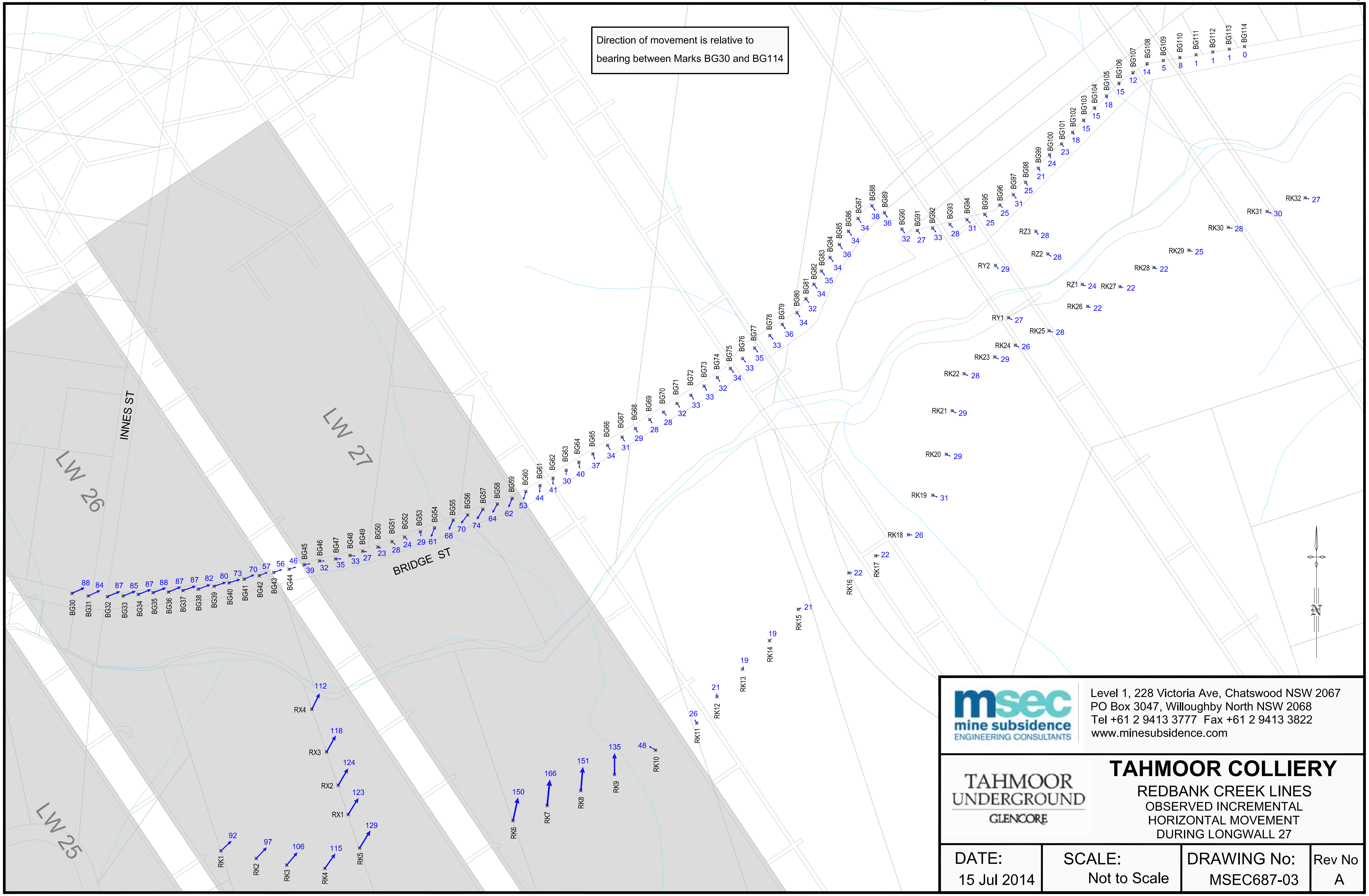
TAHMOOR NORTH MONITORING OVER LW27

DATE:	SCALE:	DRAWING No:	Rev No
15 Jul 2014	1:25000	MSEC687-01	A

LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW27
- Monitoring Lines Before & End of LW27
- Surveys During LW27
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies



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mine subsidence
ENGINEERING CONSULTANTS
Level 1, 228 Victoria Ave, Chatswood NSW 2067
PO Box 3047, Willoughby North NSW 2068
Tel +61 2 9413 3777 Fax +61 2 9413 3822
www.minesubsidence.com

TAHMOOR UNDERGROUND
GLENCORE

TAHMOOR COLLIERY

REDBANK CREEK LINES
OBSERVED INCREMENTAL
HORIZONTAL MOVEMENT
DURING LONGWALL 27

DATE:	SCALE:	DRAWING No:	Rev No
15 Jul 2014	Not to Scale	MSEC687-03	A

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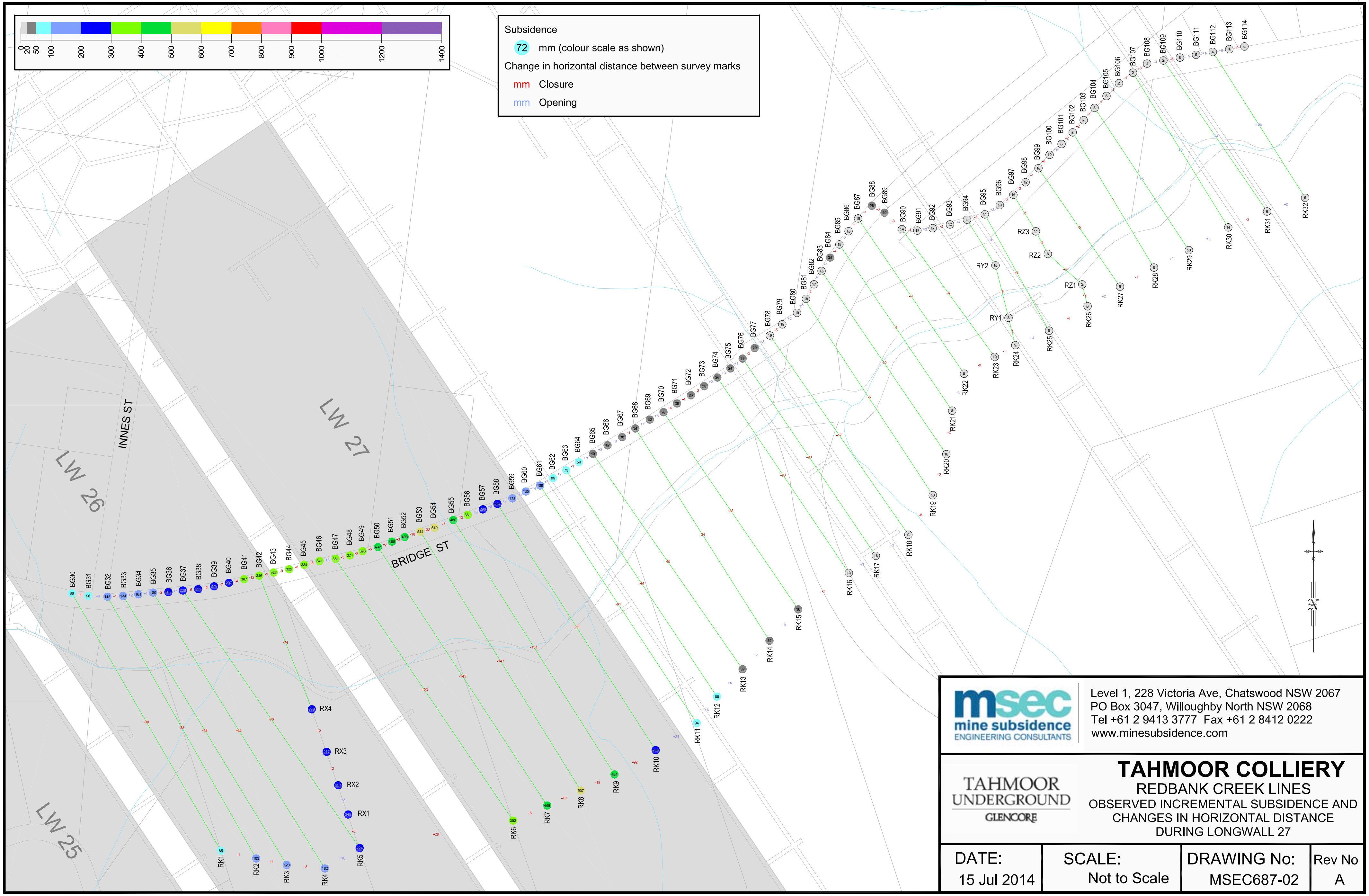

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TAHMOOR UNDERGROUND
GLENCORE

TAHMOOR COLLIERY

REDBANK CREEK LINES

OBSERVED INCREMENTAL SUBSIDENCE AND CHANGES IN HORIZONTAL DISTANCE DURING LONGWALL 27

DATE:	SCALE:	DRAWING No:	Rev No
15 Jul 2014	Not to Scale	MSEC687-02	A

GeoTerra

Tahmoor Colliery

Longwall 27

End of Panel
Surface Water, Dams and Groundwater
Monitoring Report

TA20-R1B
1AUGUST, 2014

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

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

Attention: Belinda Treverrow

Belinda,

RE: Tahmoor Colliery Longwall End of Panel 27 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
21.07.2014		Initial Draft.
28.07.2014	A	Incorporate reviewer changes
01.08.2014	B	Incorporate reviewer changes

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Executive Summary

The following table summarises the potential effects on surface water and groundwater systems within the Longwall 27, 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 27
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 27
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 observed. To date, two reduced dam holding capacity reports have been received over LW26
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 27 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 27
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 "*redirection of surface water flows and pool level / flow decline of >20% during mining compared to baseline for > 2 months, considering rainfall / runoff variability*" TARP trigger was exceeded as a result of extraction of Longwall 27 under Myrtle Creek at Sites 4 to 10 (over Longwall 26) as well as Sites 13 to 20 (over Longwall 27) between 10th May, 2013 and 16th May, 2013. Following rain in the catchment, the Myrtle Creek TARP exceedance stream reach contracted to Sites 6 to 8, as well as Sites 15 and 19 between 24th May 2013 and 25th July 2013, at which time the Myrtle Creek monitoring was discontinued.

The *"significant reduction compared to baseline, predicted impacts last over 2 months and exceed 2 standard deviations compared to baseline"* TARP trigger was exceeded in Redbank Creek at Site 37 (a.k.a. RC2), over Longwall 29, for zinc on and after 12th February 2014, in association with an extended pool drying out period between Sites 20 and 29 (over Longwall 27).

1. INTRODUCTION

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

The previous panels and the current panel (Longwall 28) 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 document provides a compilation of physical and geochemical groundwater, upland plateau stream and private dam monitoring that has been conducted in the vicinity of the subject longwall panels since August 2004.

Surface water and groundwater features within the Longwall 27, 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;
- 14 small to medium, predominantly earthen wall dams directly overly Longwall 27, and;
- Three NSW Office of Water (NOW) licensed piezometers (P1, P7, P8) that were installed by Tahmoor Colliery, two unlicensed, open and uncased coal exploration bores (P2, P3) and an additional seven NOW licensed private bores (P4, P5, P6, Pescud, McPhee, Boissery and Machin).

Myrtle and Redbank Creeks are classified as 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, and are defined as minor watercourses in the State Dams Policy.

The dams range from small garden ponds to medium sized urban dams and industrial effluent storage / treatment ponds.

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.

This report provides a summary of surface water, dam and groundwater related monitoring and observation of any subsidence related changes due to the extraction of Longwall 27.

2. PREVIOUS STUDIES

Potential subsidence levels and impacts for Panels 24 to 28 were studied in 2005 (MSEC, 2006).

Assessment of the baseline characteristics and prediction of possible subsidence related effects on the surface water and groundwater system were developed in 2006 (GeoTerra, 2006).

A Surface Water and Groundwater Monitoring End of Panel Report for Longwalls 22, 23A, 23B, 24A, 24B, 25 and 26 was prepared 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 28 by colliery staff, GeoTerra Pty Ltd and Hydrometric Consulting Systems Pty Ltd (HCS).

3. GENERAL DESCRIPTION

3.1 Mine Layout and Progression

Tahmoor Colliery has extracted coal by longwall mining Panels 1 to 27 to the south, southwest and northwest of the current panel (Longwall 28).

Longwall 27 commenced on 10/11/2012 and was completed on 22/3/14 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	2/6/04	11/7/05	1877	420 – 432
23A	7/9/05	20/2/06	775.9	430 – 450
23B	15/3/06	21/8/06	771	430 – 440
24B	15/10/06	26/8/07	2071.8	430 – 440
24A	15/11/07	19/7/08	983	420 - 448
25	22/8/08	27/2/11	3730	440 - 460
26	30/3/11	11/10/12	3480	440 - 470
27	10/11/12	22/3/14	3030	420 - 495
28	20/4/14	ongoing	2615	420 - 500

Extraction of Panel 27 occurred from 420 – 495m 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 27.

The panels are 283m wide rib to rib, with 34.5m to 40m wide chain pillars and are between 784m to 4,140m 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 27, 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 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 at least 1200m south, and the Nepean River at least 1500m east of the Longwall 27, 20mm subsidence zone.

Both 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 27 monitoring area, which covers approximately 1130m 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 26 and 27, 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 1.5km east of the Longwall 27, 20mm subsidence zone. 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 27.

Myrtle Creek has been undermined by Longwalls 3, 4, 20, 22, 23B, 24B, 25, 26 and 27.

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 over the proposed Panel 34, which subsequently flows to the Nepean River approximately 3km downstream of the SMP area.

Redbank Creek has been undermined by Longwalls 25, 26 and 27.

Within the monitoring area it has a poorly defined, small channel with a wetland upstream of the Longwall 23, 20mm subsidence envelope. The creek overlies the western end of Longwall 25 as a small channel with an incised bed 1m to 2m deep which evolves into a channel up to 3m deep and 10m wide downstream of Panel 26.

The channel of Redbank Creek becomes sequentially deeper and wider over Longwall 27 compared to Longwall 26.

The headwaters of Redbank Creek, outside of the 20mm subsidence based 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 27, the creek flows out of the main residential area, through the urban fringe of Thirlmere.

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-exist mining related subsidence in Redbank Creek have been observed in the stream reach between stream observation sites 24 and 25, as well as sites 30 to 37 (a.k.a. RC2 and R6).

3.2.4 Dams

Surface runoff into the local streams and subsequently, the Bargo or Nepean Rivers is regulated by 14 dams that directly overly Longwall 27 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.

3.3 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).

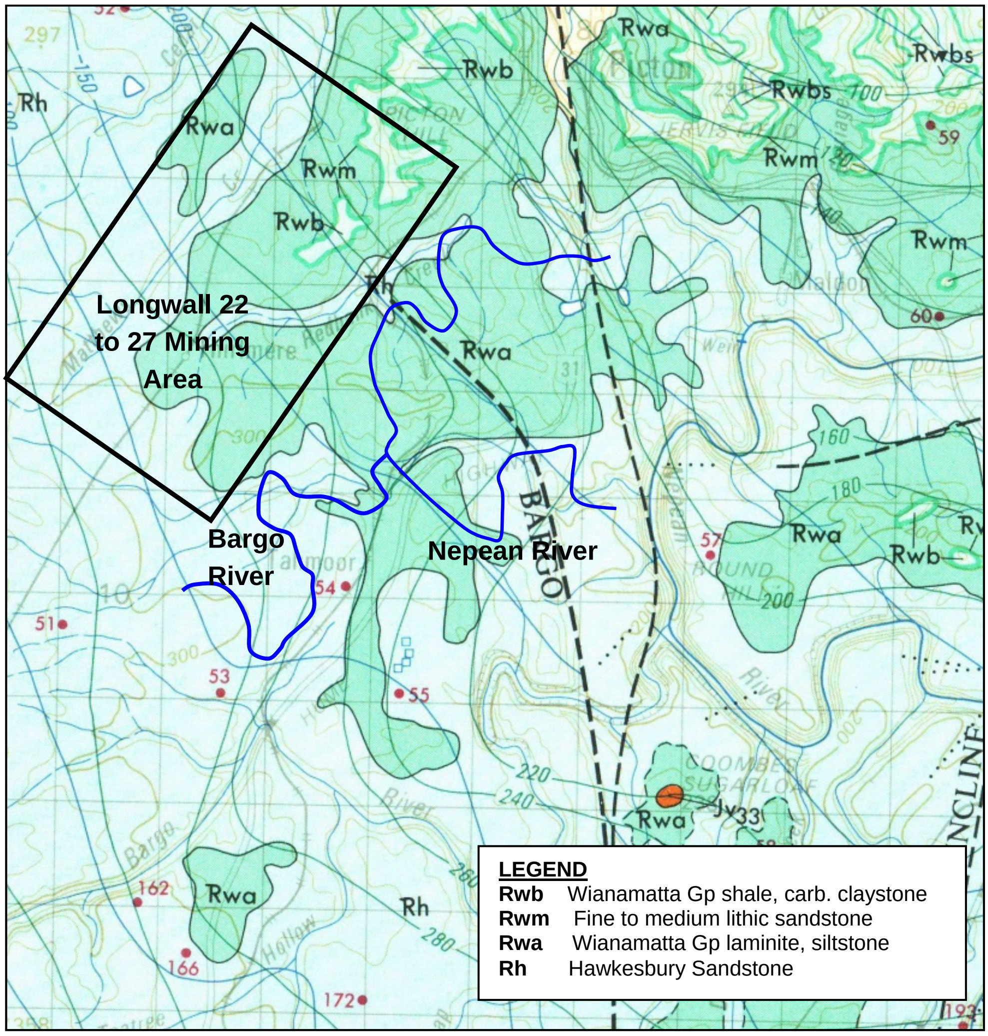


Figure 1 Surficial Geology

3.4 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 27 monitoring area as shown in **Drawing 1** and **Table 2**.

Piezometer P1 was installed to the south of the Panel 22 20mm subsidence zone prior to extraction of Longwall 22, whilst P7 and P8 were installed during May 2008 between Panel 25, Panel 26 and the Bargo River, prior to the start of extraction in Longwall 25.

Piezometer P1 was installed to monitor the phreatic water table levels and water quality prior to, during and after extraction of Longwall 22, whilst P7 and P8 were drilled down to the equivalent depth of the base of the Bargo River Gorge (100 to 105 mbgl) and are being used to monitor any groundwater level or groundwater quality changes in the piezometers prior to, during and after extraction of Panels 25, 26 and 27.

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.

Drilling and installation of the P7 and P8 piezometers between the Bargo Gorge and the eastern end of Longwalls 24 and 25 indicated the sandstone plateau is dry down to approximately 90m to 95m below surface, which is approximately 5m above the base of the Bargo River gorge in the proximity of the piezometers, and that low airlift flows (<0.76L/sec) were generated from fractures within the sandstone.

3.4.1 Vibrating Wire Piezometer Arrays

Two cement / bentonite sealed exploration bores (TNC28 and 29) are installed with vibrating wire piezometer arrays in close proximity to Longwall 27, 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**.

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 27 is shown in **Table 4**.

Table 4 Maximum Subsidence at the Completion of Longwall 27

Component	Observed Movement
Vertical subsidence	1367 mm
Tilt	8.0 mm/m
Tensile / Compressive Strain	4.1 / - 6.3 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 27 (mm)

Location	Due to LW24	Due to LW25	Due to LW26	Due to LW27	Total
Castlereagh St	12	179	52	8	**251**
Elphin – Myrtle Sts	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	**60**
9A York St	-	-	73	no access	**73+**
MXA Line	-	-	-	115	**115**
MXB Line	-	-	-	94	**94**
MXC Line	-	-	-	67	**67**
MXD Line	-	-	-	17	**17**

Source (MSEC, 2014)

4.1.2 Redbank Creek

No direct valley closure was measured in Redbank Creek due to landowner access restrictions, however the available extrapolated data is shown in **Table 6**, with accuracy to 20 - 30mm (MSEC, 2014).

Table 6 Maximum Redbank Creek Valley Closure up to the Completion of Longwall 27 (mm)

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

Source (MSEC, 2014)

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 Sreet Lane near Sydney Water pump station	Concrete weir

4.2.1 Pre Longwall 27

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 27, Myrtle Creek was showing subsidence effects of pool cracking and significant to total pool water holding capacity reduction due to the extraction of Longwall 26 at observation sites:

- 5 to 9, over the central to maingate section of Longwall 26, as well as;
- Sites 14 to 16 over the central to maingate section of Longwall 27 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 26 subsidence, as was the case for Sites 14 to 15, even though they actually overlie Longwall 27.

Reversal of flow in the creek was also not observed not occurred due to subsidence up to the completion of Longwall 25 as the creek gradient exceeds the subsidence tilt in the stream bed as summarised in **Table 8** (GeoTerra 2011).

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 27

Weekly monitoring of the Myrtle Creek stream reach overlying Longwalls 26, 27 and 28 commenced prior to Longwall 27 undermining the creek on 5/3/2013 at the visual observation sites shown in **Table 9**.

Myrtle Creek was undermined by Longwall 27 between 8/3/2013 and 26/3/2013 (for 626 – 739m of extraction).

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	

During undermining by Longwall 27, Myrtle Creek was observed to have undergone subsidence effects as summarised in **Table 10** and shown in **Drawing 3**.

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

- 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 **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 10 May 2013.

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

Table 10 Myrtle Creek Subsidence Effects During LW27 Extraction

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

In accordance with the TARP, weekly monitoring of Myrtle Creek ceased in regard to monitoring the effects of Longwall 27 on 25 July 2013.

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 stream reach overlying Longwalls 25, 26, 27 and 28 commenced prior to Longwall 27 undermining the creek on 5 November 2013 at the visual observation sites shown in **Tables 12**, **13** and **14**.

Redbank Creek was undermined by Longwall 27 between 8 November 2013 and 22 November 2013 (for 2265 – 2351m of extraction).

Table 12 Redbank Creek Weekly Observation Sites (Longwall 26)

Site	Description	Additional Sites
1	open channel in weed infested area	RC1
2	pool with sandstone / sediment base	R2
3	open channel with sandstone / cobble base	
4	open channel with cobble base	
5	pool with sandstone / cobble base	R3
6	open channel with cobble base	
7	pool with sediment / gravel base	
8	open channel with cobble base	
9	open channel with cobble base	
10	pool with sandstone / cobble base	

Table 13 Redbank Creek Weekly Observation Sites (Longwall 27)

Site	Description	Additional Sites
11	pool with sandstone / cobble base	
12	rock shelf and downstream pool	
13	sandstone based pool	
14	sandstone based pool	
14A	sandstone based pool	
15	sandstone / sand based pool	
16	sandstone based pool	
17	two sandstone based pools	
18	boulder / sand based pool next to cliff	
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	

Table 14 Redbank Creek Weekly Observation Sites (Longwall 28)

Site	Description	Additional Sites
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

4.3.1 Pre Longwall 27 Observations

Subsidence effects were previously observed in Redbank Creek at RC1, with a limited extent of pool desiccation in a clay incised section of the creek that contains some cobbles over Longwall 25.

Prior to 5th November 2013, there had been an extended period of no rain in the preceding weeks and the creek was very dry, and it wasn't until the 21st November 2013, approximately 14 days after the longwall started undermining the creek, that the creek could be inspected critically for any "baseline" subsidence effects (particularly due to pool holding capacity) due to the preceding panel (Longwall 26)

As shown in **Drawing 4**, subsidence effects observed due to extraction of Longwall 26 (i.e. prior to extraction of Longwall 27) 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.

Although creek bed cracking was observed due to extraction of Longwall 26, no adverse effects were observed on the stream bed or bank stability or water quality during the monitoring period.

4.3.2 Post Longwall 27 Observations

During undermining by Longwall 27, 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 26 that had previously been affected by Longwall 26 extraction, subsidence effects (or additional subsidence effects) were observed at:

- Sites 13 - 15 over the mid section of Longwall 26;
- Sites 17 – 21a over the maingate section of Longwall 26 as well as the chain pillar between Longwalls 26 and 27;
- 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**.

Table 15 Redbank Creek Subsidence Effects During LW27 Extraction

Sites	Relative Location	Effect	Observed	TARP Triggered
Over Longwall 26				
11	chain pillar / tailgate	continuation of dry pool due to cracking	during LW26	no
12	tailgate	continuation of dry pool due to cracking	during LW26	no
13	tailgate	continuation of dry pool due to cracking	during LW26	no
14	tailgate / centre	continuation of dry pool due to cracking	during LW26	no
14a	centre	continuation of dry pool due to cracking	during LW26	no
15	centre	continuation of dry pool due to cracking	during LW26	no
16	centre	continuation of dry pool due to cracking	during LW26	no
17	centre / maingate	new cracks, pool dry	16/01/2014	no
17a	maingate	continuation of dry pool due to cracking	during LW26	no
18	maingate	continuation of dry pool due to cracking	during LW26	no
19	Maingate / chain pillar	continuation of dry pool due to cracking	during LW26	no
20	chain pillar	continuation of dry pool due to cracking	during LW26	no
Over Longwall 27				
21 / 21a	tailgate	new cracking, rock bar constrained pool very low	21/11/13	no
22	tailgate	creek bed dry, tree fallen over	16/01/2014	no
22a / 23	tailgate / centre	new cracking, plus expansion of old cracks, rock bar constrained pool very low	21/11/13	no
24	centre / maingate	ferruginous pool level reduced, no obvious cracks	17/12/2013	no
25	centre / maingate	ferruginous pool level reduced, no obvious cracks	3/12/13	no
25a	maingate	continued lack of overland flow due to old cracks	during LW26	no
26	chain pillar	old cracks widening, pool very low	17/12/2013	no
26a	chain pillar	pool dried up, no obvious cracking	3/12/13	no
27	chain pillar	pool dried up, minor cracking	17/12/13	no
Over Longwall 28				
28	tailgate	pool dried up, no obvious cracking	17/12/13	no
29	tailgate	further cracks in rock shelf, pools very low	21/11/13	no
30	centre	ferruginous pool dried up, no obvious cracking	3/1/14	no
31	centre	new cracks, pool holding but increased iron	21/11/13	no
32	centre / maingate	ferruginous pool dried up, no obvious cracking	3/1/14	no
33	maingate	ferruginous pool dried up, no obvious cracking	3/1/14	no

As shown in **Table 15**, no TARPs were 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”*, as the subsidence affected pools did not stay dry for longer than 2 months during the observation period.

In accordance with the TARP, weekly monitoring of Redbank Creek ceased in regard to monitoring the effects of Longwall 27 on 30 April 2014.

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 commenced monitoring water levels in the creek in August 2004 (GeoTerra, 2011). HCS took over stream water level monitoring in March 2010, at an expanded (and different) suite of locations, and the original monitoring sites (MYC1-3) were decommissioned.

The raw data is contained in an “EXCEL” spreadsheet, which is not included with this report, with data summaries and plots are presented in GeoTerra (2013).

Both creeks had extended periods of no-flow during the monitoring period due to lack of rainfall runoff prior to the February 2007 rains, with interspersed short periods of flow followed by static pondage as the creeks gradually dried up. More regular flows have been observed in the Plateau streams during and since June 2007.

Periods of dry pools were observed in Myrtle Creek during and after extraction of Longwall 26 at Sites M3 and M4, and at M5 and M6 during extraction of Longwall 25 as shown in **Figures 2** and **3** from locations shown in **Drawing 1**.

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 and shows subsidence effects on its pool holding capacity due to subsidence associated with Longwall 26, and subsequent additional cracking associated with extraction of Longwall 27.

M4 is located over the chain pillar between Longwall 26 and 27 and also shows a reduction in pool holding capacity due to extraction of Longwall 26 and subsequently Longwall 27.

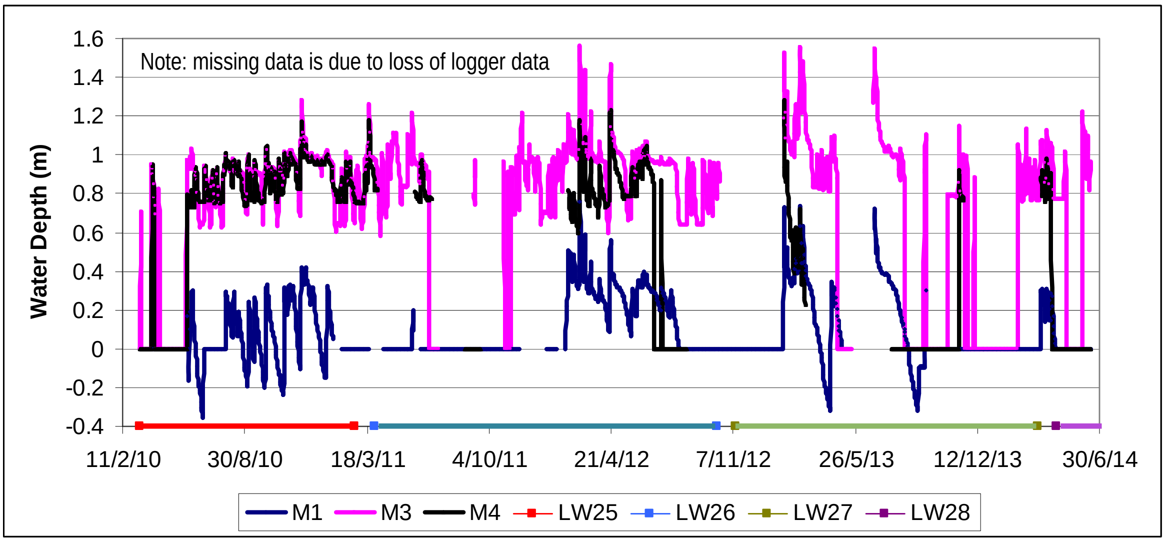


Figure 2 **Myrtle Creek Depth Upstream of LW27**

Site M5 is located over the central to maingate section of Longwall 28 and showed no effects on its pool holding capacity due to extraction of Longwalls 22 to 27.

Sites M6 and M7 are located downstream of Longwall 28 and show no subsidence effects on their pool holding capacity.

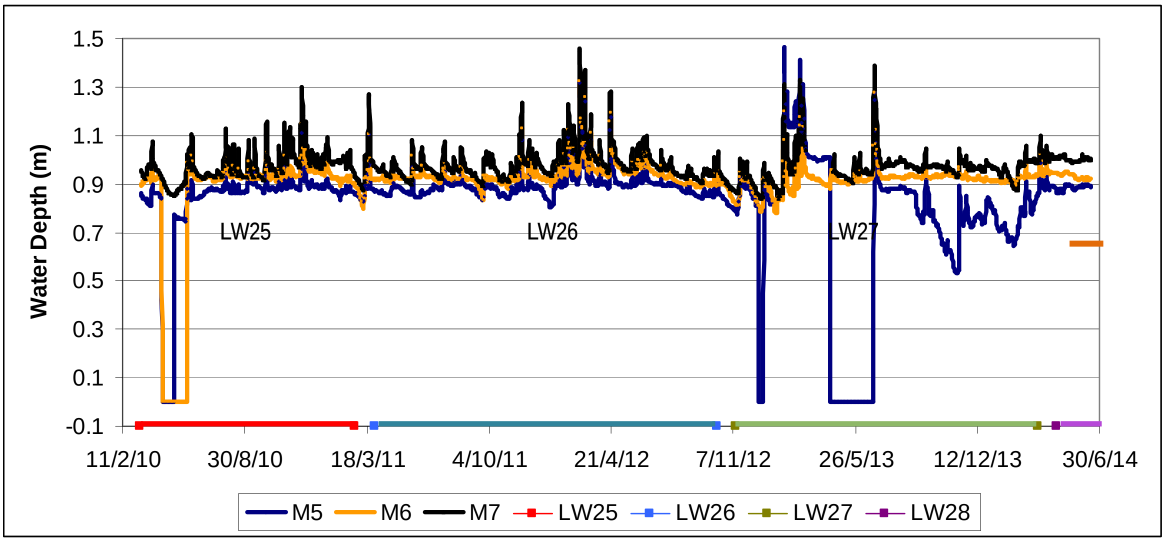


Figure 3 **Myrtle Creek Depth Over and Downstream of LW27**

No new ferruginous seeps were generated in Myrtle Creek during extraction of Longwall 27.

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.

The raw data is contained in an “EXCEL” spreadsheet, which is not included with this Report, however data summaries and plots are presented this document.

The creek had extended periods of no-flow during the monitoring period due to lack of rainfall runoff prior to the February 2007 rains, with interspersed short periods of flow followed by static pondage as the creeks gradually dried up. More regular flows have been observed since the June 2007 rains.

Pool levels and creek flow at monitoring locations R1 – R3, as monitored by HCS, are shown in **Figure 4**.

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.

The pool at Site R1, which is upstream of Longwall 24, is generally low, but does not often dry out for extended periods.

Pool R2, on the north eastern upstream corner of Longwall 25, and upstream of Longwall 26, ceased on 17 October 2012 because the pool ran dry due to lack of rainfall in the catchment. Since then, the pool has dried out on two occasions during and after extraction of Longwall 26.

Pool R3, located at the northern western end of Longwall 25 and upstream of Longwall 26, has dried out on numerous occasions since and after extraction of Longwall 25.

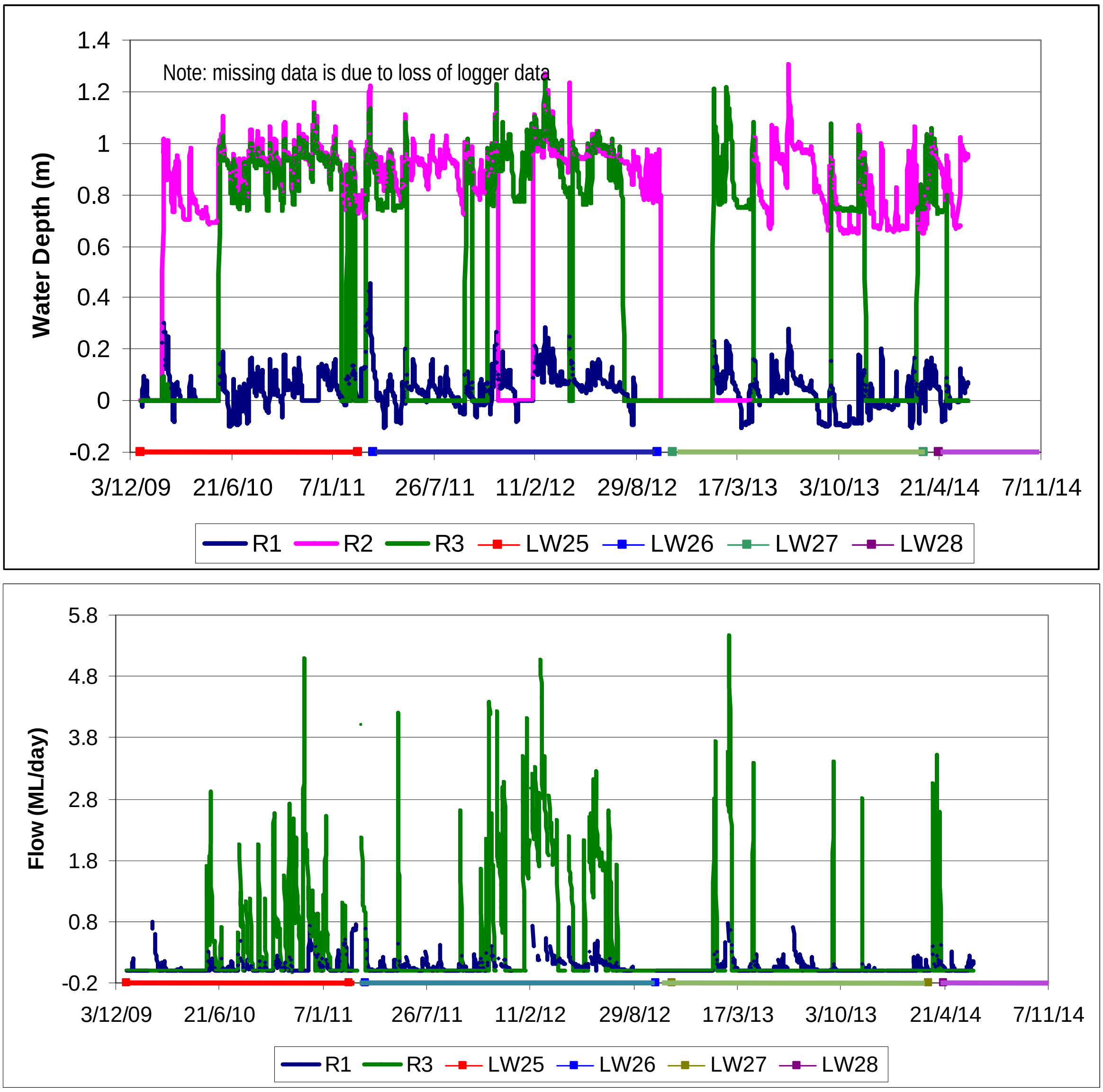


Figure 4 Redbank Creek Depth and Flow Upstream of Longwall 27

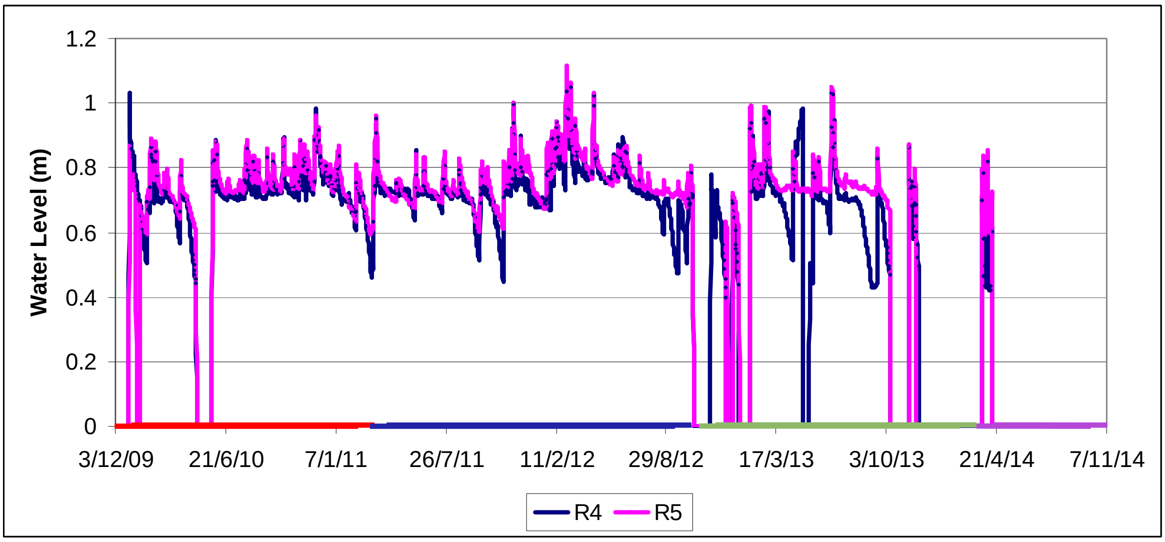
Redbank Creek was undermined by Longwall 27 between 8 November 2013 and 22 November 2013, with the panel being completed on 22 March 14.

Pool R4, which is located over Longwall 27 did not dry out until it was undermined by Longwall 27, as shown in **Figures 5** and **6**.

Pool R5, which is located downstream of Longwall 27, dried up on two occasions during extraction of Longwall 25, but did not dry up during extraction of Longwall 26, with a notable increase in dry periods during and after extraction of Longwall 27.

Pool R6, which is located over the middle of Longwall 29 and contains the permanently ferruginous pool RC2, dried up on three occasions during extraction of Longwall 25, but has not dried up since then.

Pools 7 and 8 have not dried up in the monitoring period, whilst Pool 9 has dried up on two occasions during extraction of Longwall 27 and Pool 10 dried up on two occasions during extraction of the end of Longwall 26 and the beginning of Longwall 27.



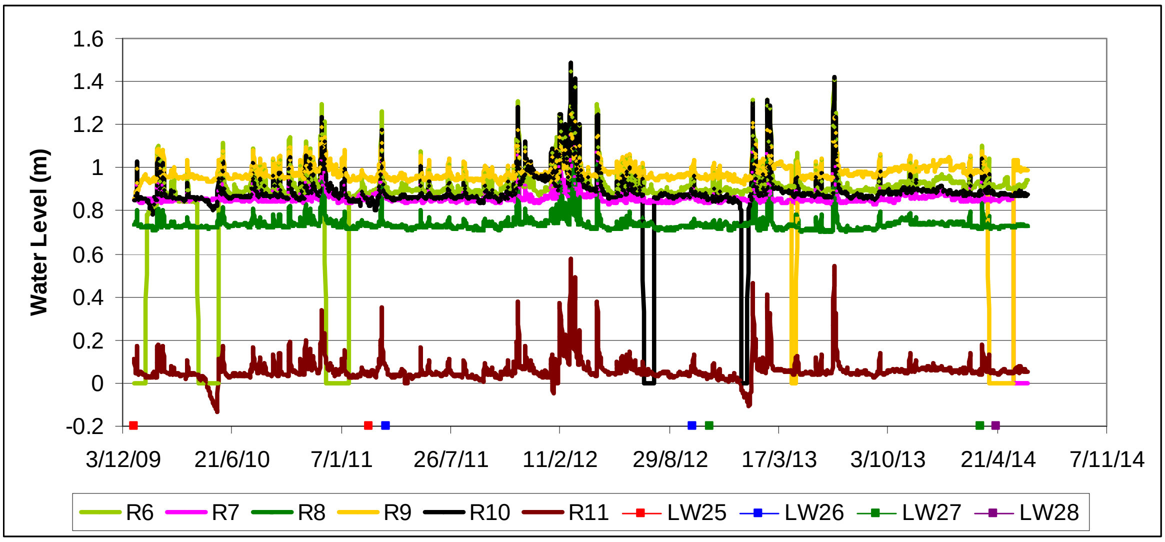


Figure 5 Redbank Creek Depth Over and Downstream of Longwall 27

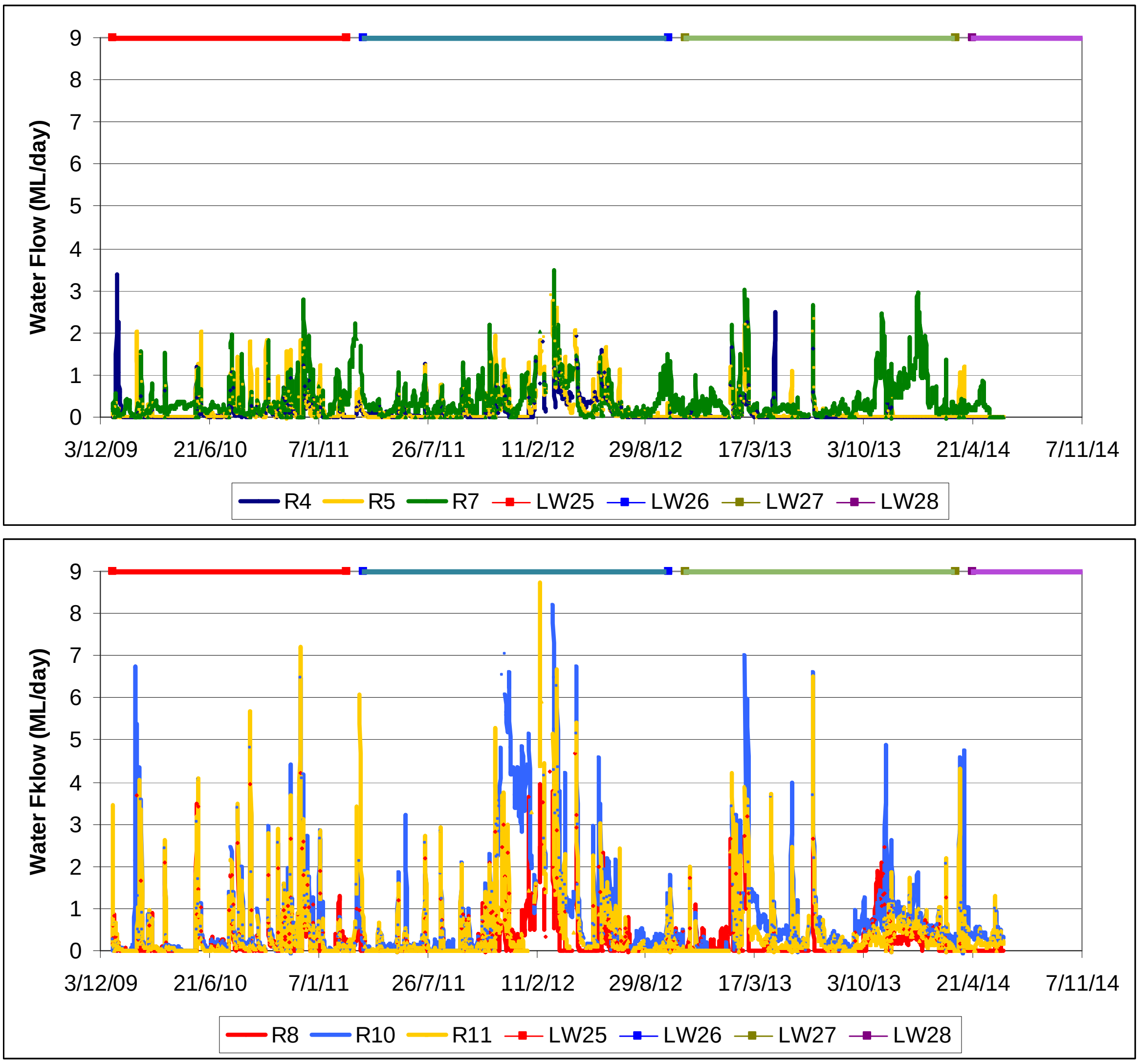


Figure 6 Redbank Creek Flow Over and Downstream of Longwall 27

4.5 Creek Water Quality

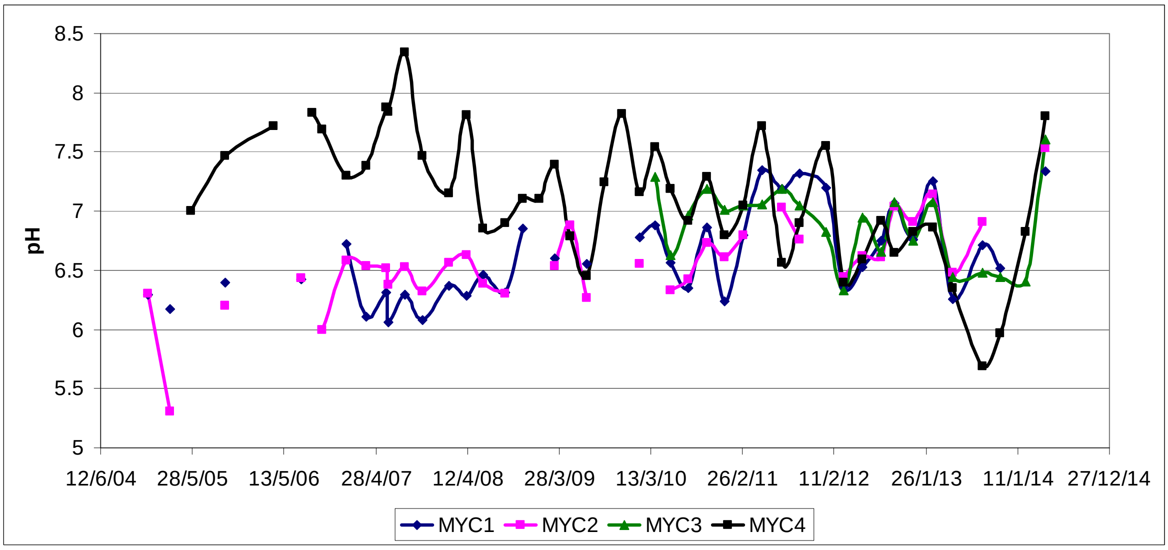
4.5.1 Myrtle Creek

During the extraction period of Longwall 27 (10 November 2012 to 22 March 2014) Myrtle Creek has been generally dry at MYC1, however MYC2 and MYC3 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 7** and **Appendix B**.

During the Longwall 27 mining period, the Myrtle Creek pH trended to being slightly more alkaline at all three monitoring sites, whilst salinity peaked at around 2460uS/cm at MYC3.



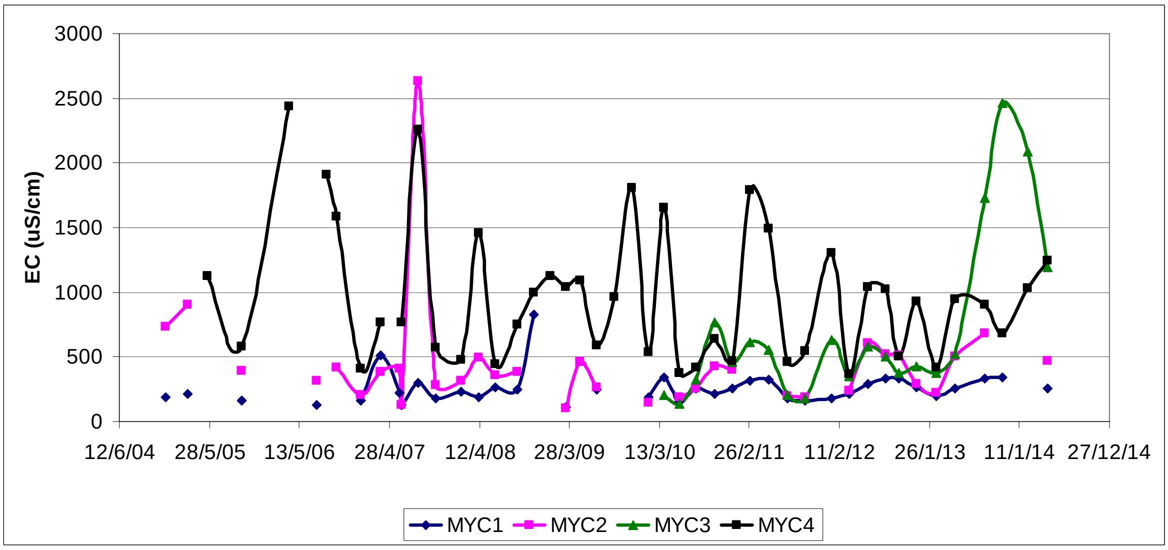


Figure 7 Myrtle Creek Field Water Quality

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 8**.

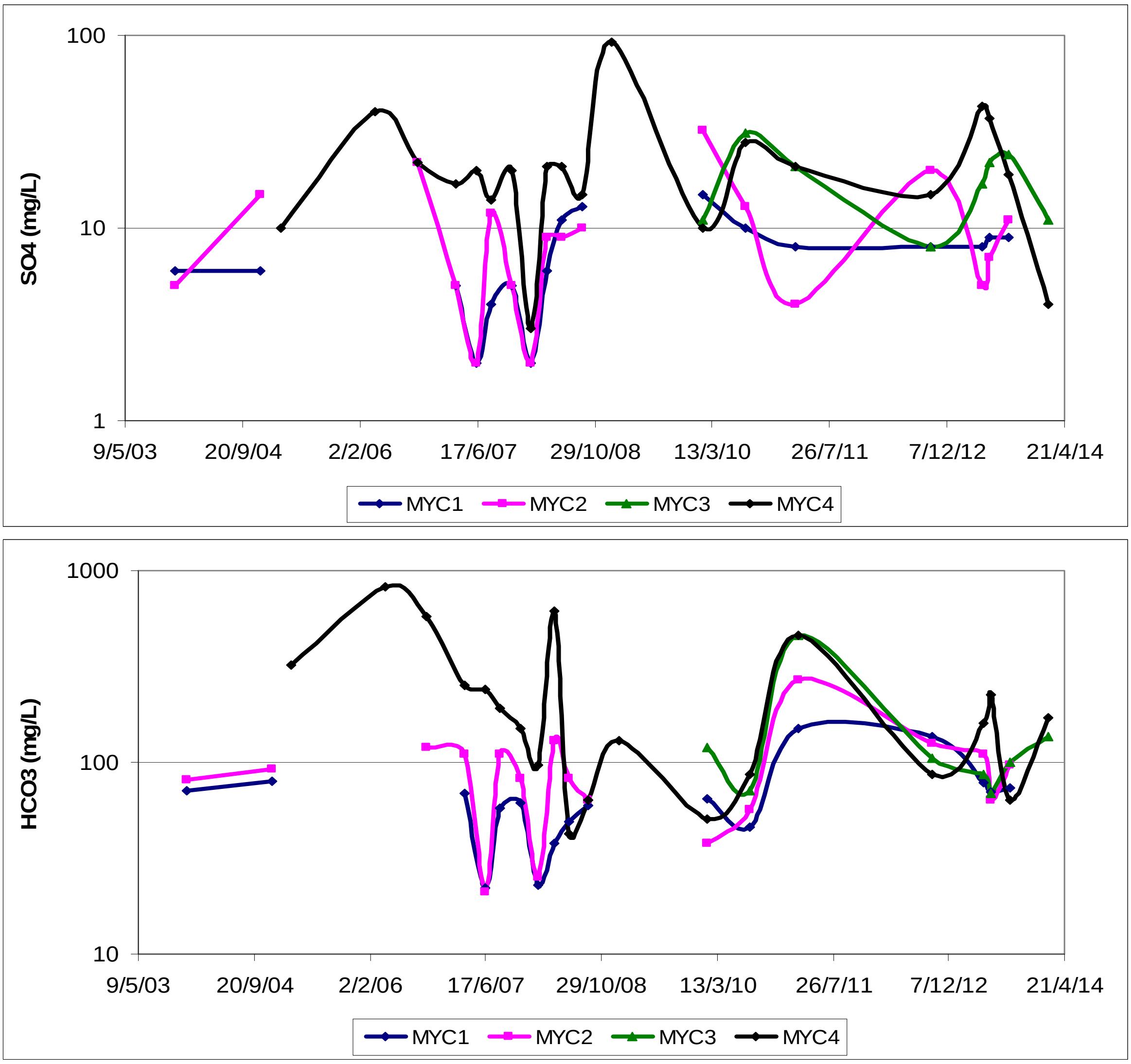


Figure 8 Myrtle Creek Sulfate and Bicarbonate

Iron and manganese levels are generally not elevated in Myrtle Creek, apart from an isolated occasion at MYC1 and MYC2 during extraction of Longwall 27, with no long term trend or increase over subsided areas as shown in **Figure 9**.

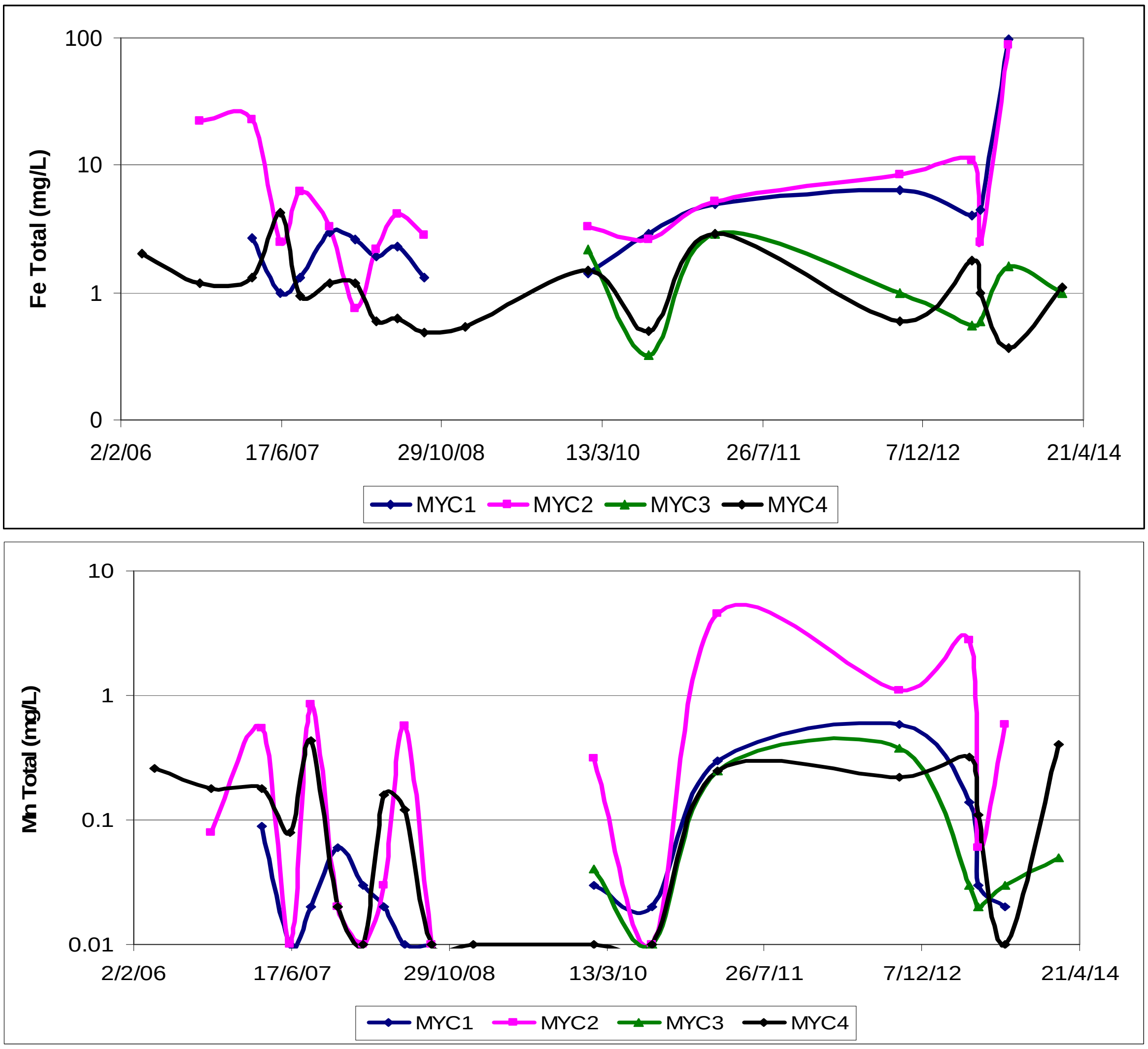


Figure 9 Myrtle Creek Iron and Manganese

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 10** 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.

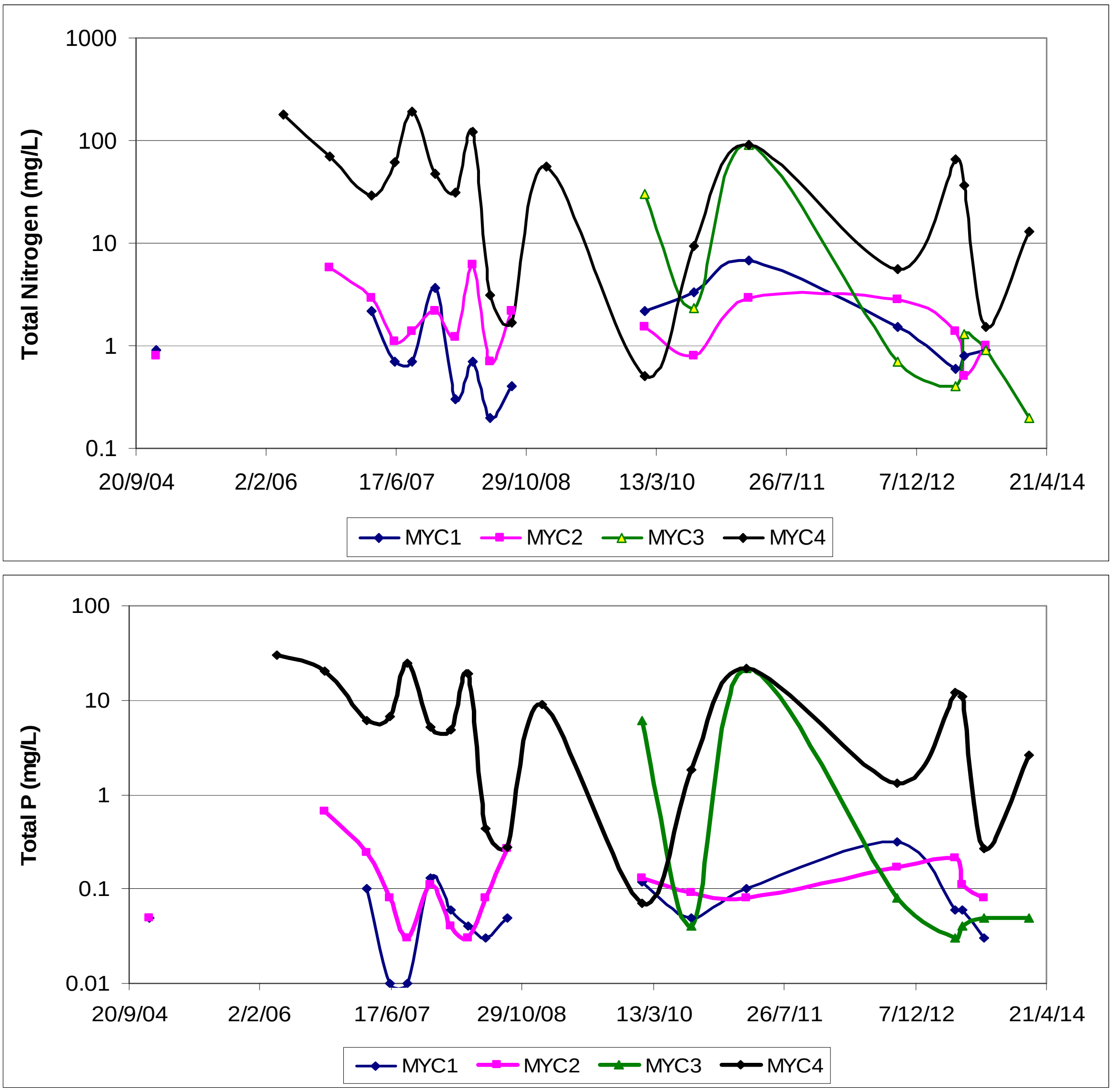


Figure 10 Myrtle Creek Nutrients

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, with no observable trend or change due to mine subsidence with these metals as shown in **Figure 11** and **Appendix B**.

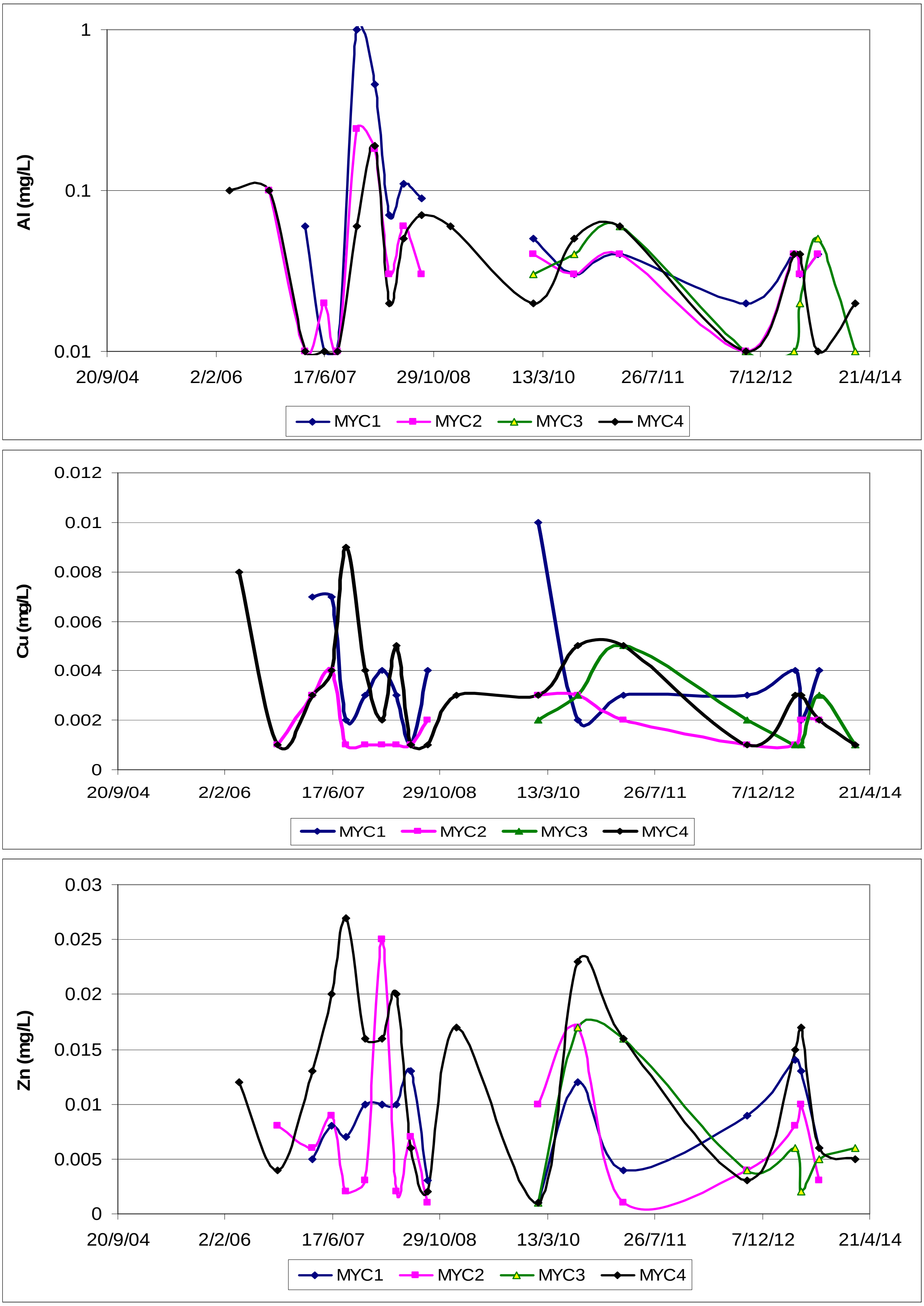


Figure 11 Myrtle Creek Metals

4.5.2 Redbank Creek

During the extraction period of Longwall 27 (10 November 2012 to 22 March 2014) Redbank Creek was often dry at RC1, however a perennial pond is located at RC2, and RC3 is generally ponded.

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**.

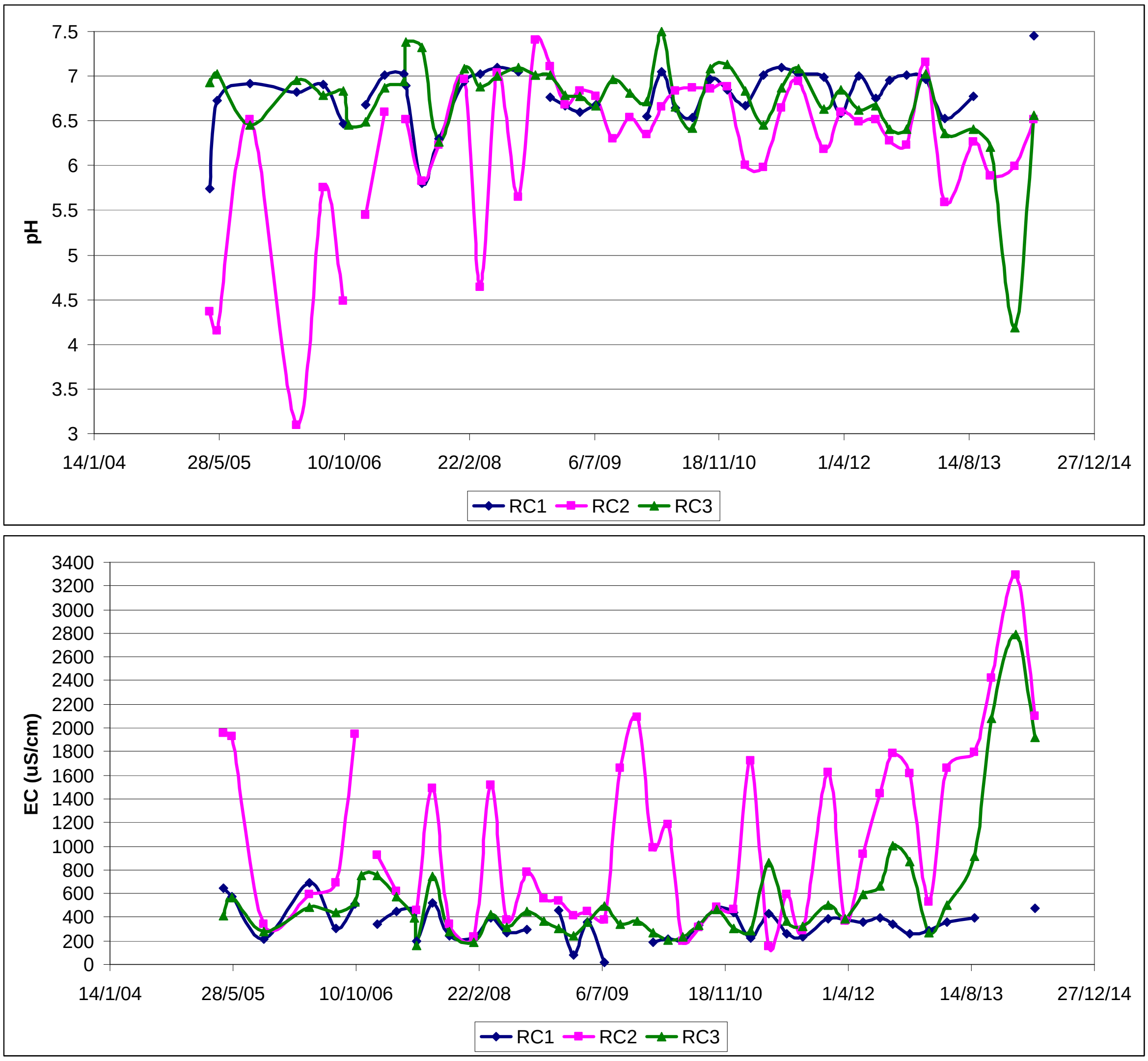


Figure 12 Redbank Creek Field Water Quality

During the Longwall 27 mining period, Redbank Creek pH trended to being slightly more acidic at RC2, and more acidic at RC3, whilst salinity peaked at around 3290uS/cm at RC2 and 2790uS/cm at RC3, which are both significantly above previous salinity levels.

The enhanced salinity and lower pH at RC2 is due to a ferruginous seep draining off the interface between Ashfield Shale and Hawkesbury Sandstone that enters the creek from an unnamed tributary between RC2 and the Railway culvert.

Redbank Creek generally contains elevated iron and, occasionally, above ANZECC 2000 Protection of 95% of Freshwater Aquatic Species manganese trigger levels in the creek at RC2 in association with the upstream tributary seepage as shown in **Figure 13** 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.

The iron and manganese levels tend to vary with rainfall in the catchment, with lower concentrations after wetter periods, however a definitive rise in iron and manganese has been observed at RC2 since Longwall 27 undermined Redbank Creek

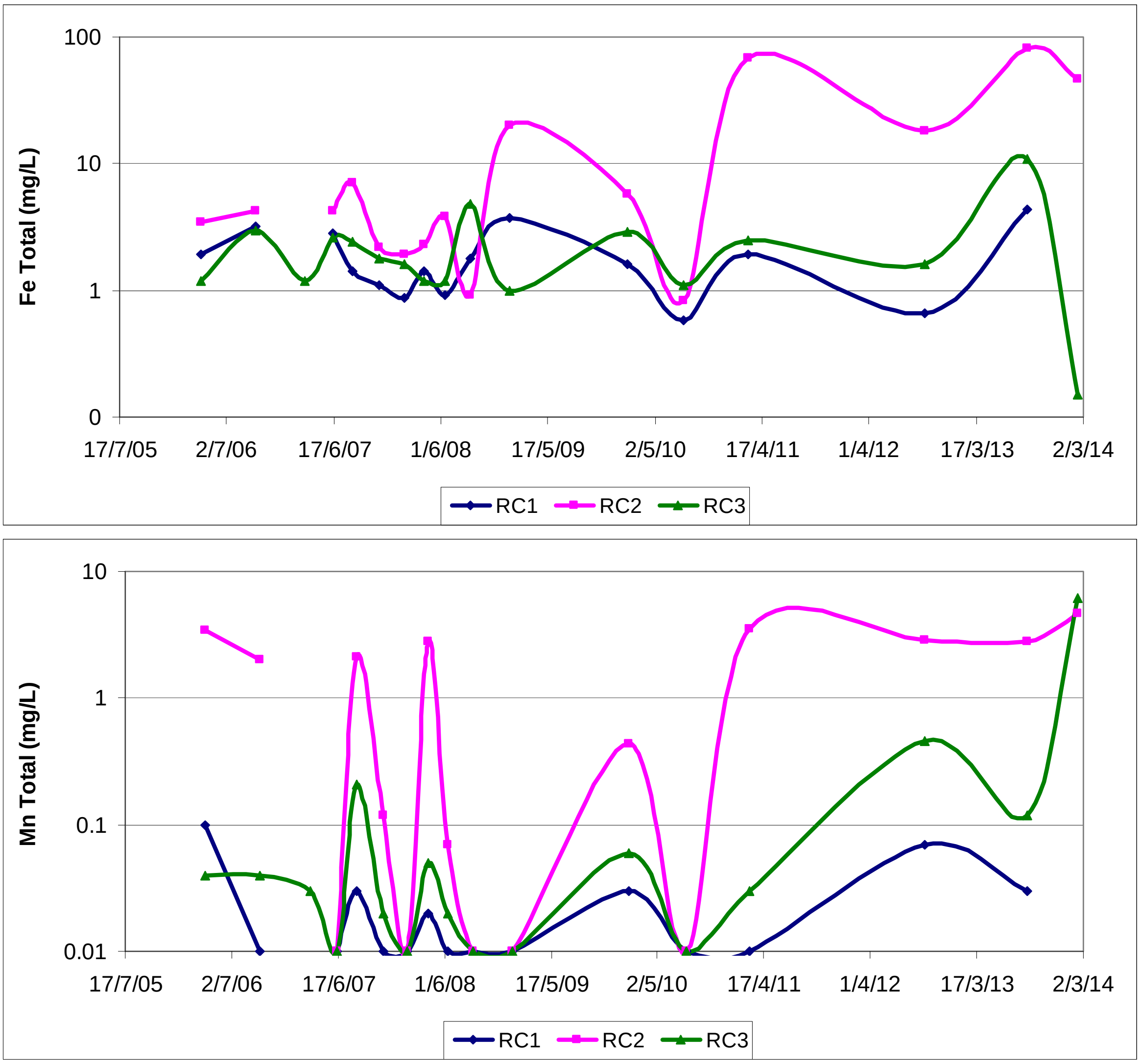


Figure 13 Redbank Creek Iron and Manganese

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 14** 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.

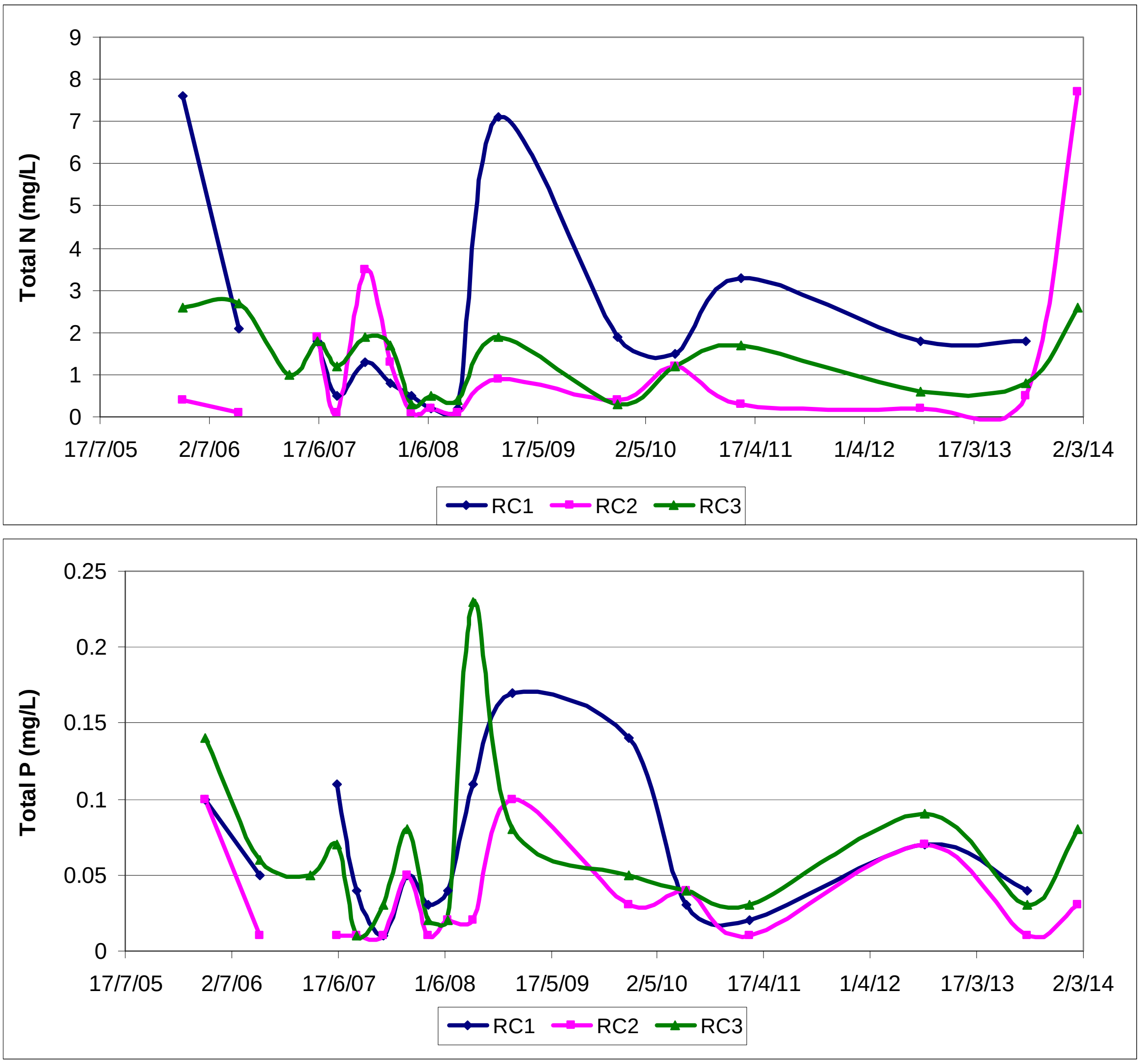


Figure 14 Redbank Creek Nutrients

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 or 27 mining periods

Copper can reach up to 0.007mg/L at the three water quality monitoring sites, however no definitive increase downstream of Longwall 27 is observed as shown in **Figure 15** and **Appendix B**.

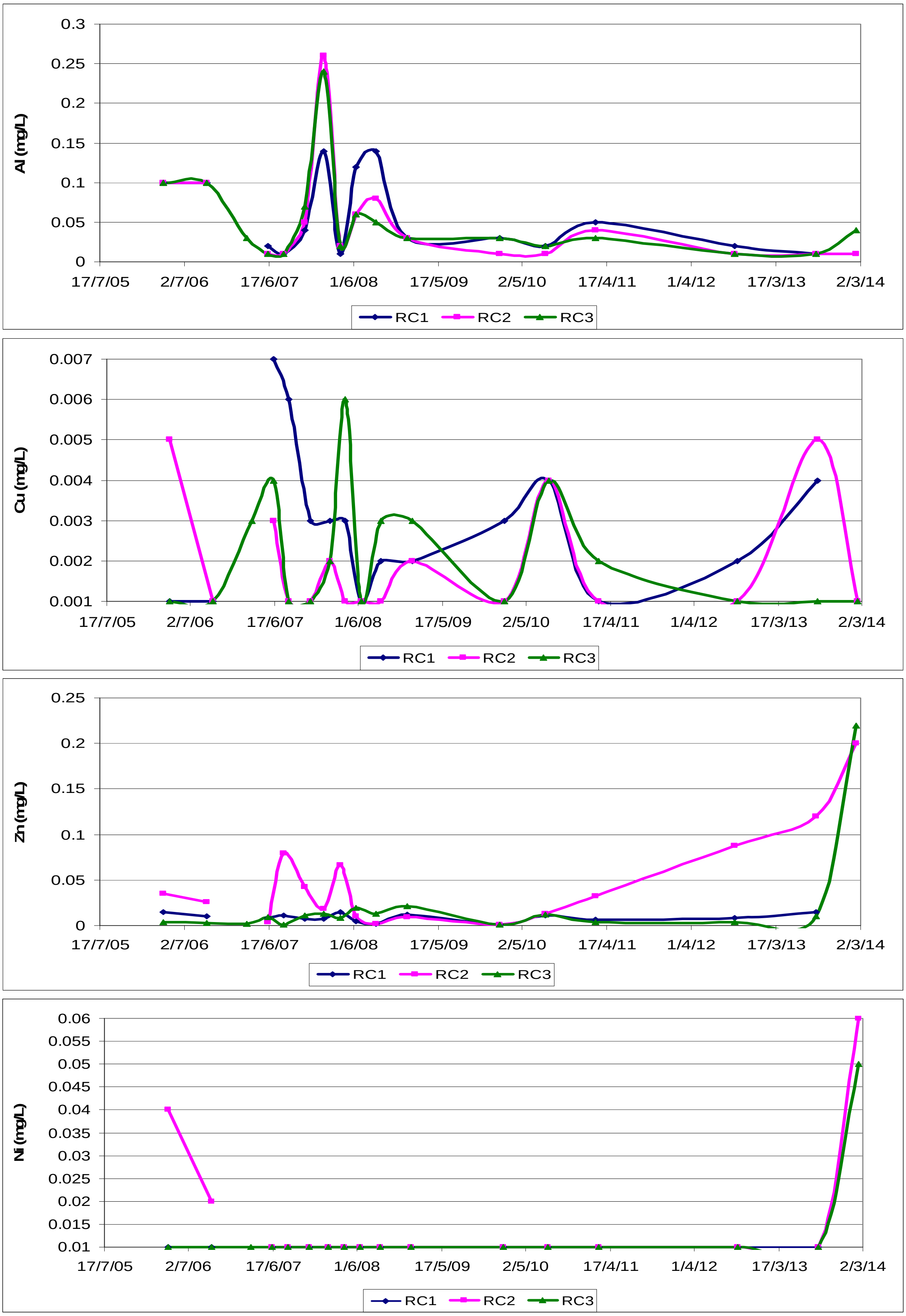


Figure 15 Redbank Creek Metals

Zinc can reach up to 0.088mg/L as shown in **Figure 15** and **Appendix B**, with its concentration being observed to rise at RC2 since late 2010, and since August 2013 at RC3

Nickel has also significantly increased at RC2 and RC3 since August 2013, reaching up to 0.06mg/L.

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

4.6 Dams

Twenty one dams directly overlie Longwall 27 and its adjoining chain pillars as shown in **Drawing 2** and **Table 16**. All of the dams are located within rural residential properties.

Field inspection and photographing of the dams was conducted prior to and after undermining of each dam by Longwall 27.

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.

Table 16 Dams Over Longwall 27 and Adjacent Chain Pillars

Dam	Construction	Subsidence Effects
W37b	Small earth bank on slopes	None observed or reported
W42d	Medium earth bank on slopes	None observed or reported
W44f	Small / medium earth bank on slopes	Loss of water holding capacity reported
W39c	Small earth bank on slopes	None observed or reported
W24d	Small earth bank on slopes	None observed or reported
W40/1i	Small earth bank on slopes	None observed or reported
W40/1j	Small earth bank on slopes	None observed or reported
W55d	Small earth bank on slopes	None observed or reported
W23e	Small earth bank on slopes	None observed or reported
W21c	Large earth bank on slopes	None observed or reported
W23c	Small earth bank on slopes	None observed or reported
W23d	Small / medium earth bank on slopes	None observed or reported
W55c	Small / medium earth bank on slopes	None observed or reported
V02i	Small / medium earth bank on slopes	None observed or reported
V02/1f	Small earth bank on slopes	None observed or reported
V02/1e	Small earth bank on slopes	None observed or reported
V03/1d	Small earth bank on slopes	None observed or reported
V03/1e	Small earth bank on slopes	None observed or reported
U06d	Large earth bank on slopes	None observed or reported
U07h	Small earth bank on slopes	None observed or reported
U07c	Large earth bank on slopes	None observed or reported

No direct evidence of dam wall or floor cracking was observed, and the associated adverse water level, water storage or water quality effects due to subsidence associated with Longwall 27, during site inspections by GeoTerra.

However, loss of dam water holding capacity was reported to GeoTerra by the landowner of dam U01i at 5 Innes Street, which overlies Longwall 26, and its dam level was low after extraction of Longwall 26. The issue was subsequently reported again to GeoTerra after extraction of Longwall 27. In addition, loss of water holding capacity has been reported to the Mine Subsidence Board (MSB) at 90 Innes Street in dam W44f. An inspection of dam W44f is planned by the MSB / GeoTerra for late July 2014.

An indirect report of the dam water holding capacity being affected by subsidence associated with Longwall 26 (by a friend on the property on 19 December 2012) was recorded for dam U03e at 25 Innes Street. However, an inspection of the dam after undermining by Longwall 27 did not indicate any direct evidence of cracking in the dam wall or floor, even though the dam level was low.

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 with the drilling of P1 by the Colliery, which is located 450m south west of Panel 22.

The piezometers are located as summarised below;

- 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.
- 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 GW109010 (Pescud) and GW105254 (McPhee) are fully sealed with pump equipment and their water levels are not monitored.

All piezometers and bores are located as shown in **Drawing 1** and their water levels are shown in **Figure 16**.

Piezometer P3 and the Pescud / McPhee private bores are located over Longwall 26.

During the period of Longwall 26 extraction (30 March 2011 to 11 October 2012), the water level in P3 fell by 8.16m, then recovered by 6.46m. In the same period, P2 fell by 2.26m whilst P7 fell by 3.1m, with neither P2 nor P7 being located within the Longwall 26 20mm subsidence zone.

The remaining piezometers in the monitoring area maintained relatively static water levels.

No monitoring of water levels is possible in the private McPhee and Pescud bores as they are fully sealed, however no complaints of adverse effects on water levels or bore yield have been received by the Colliery.

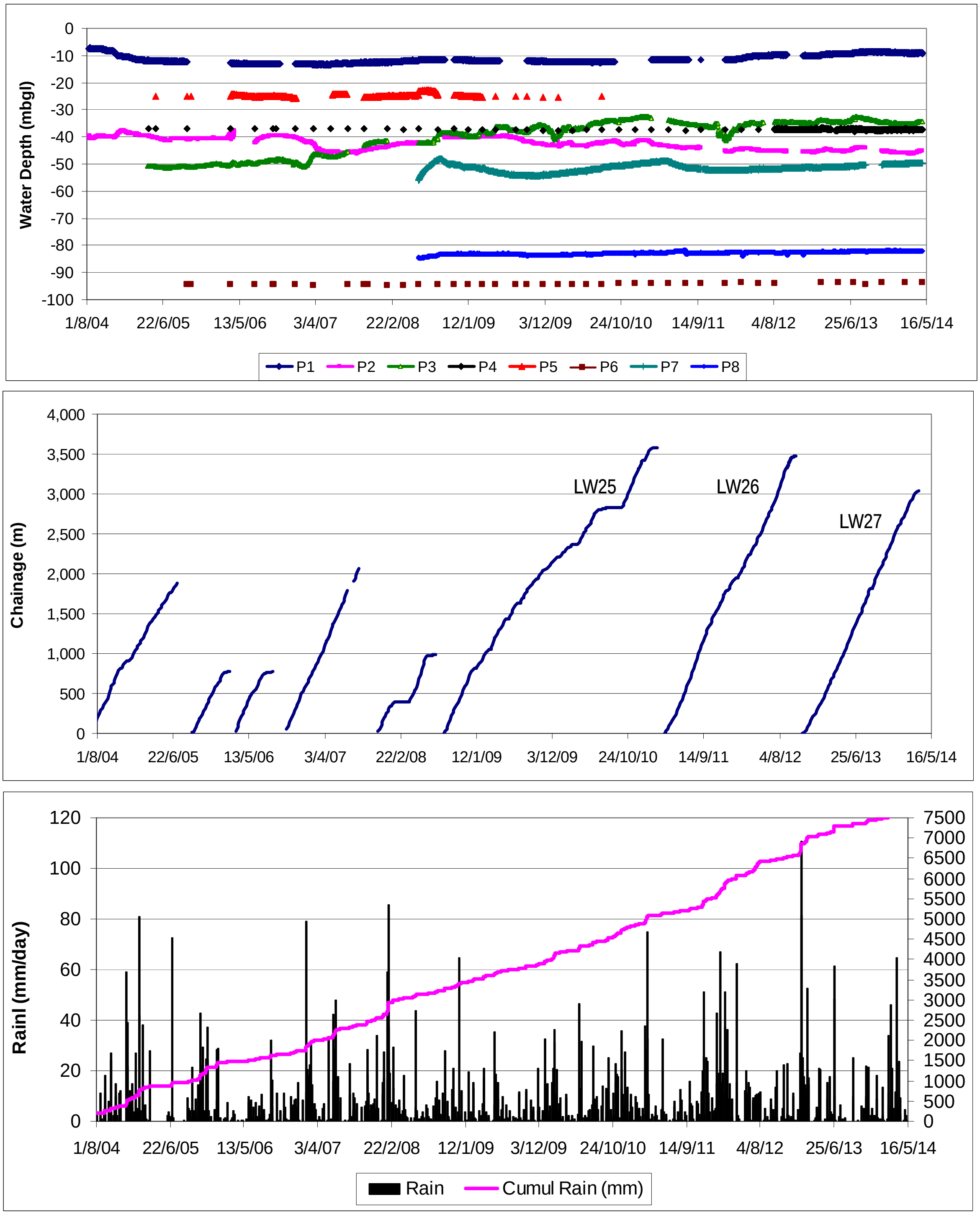


Figure 16 Standing Water Levels and Panel Extraction

4.7.2 Vibrating Wire Piezometers

Monitoring data from the vibrating wire piezometers (VWP) TNC28 and 29 are shown in **Figures 17** and **18** and summarised in **Table 17**.

Although TNC36 and 40 are also completed with VWP they are not discussed further in this document as they are outside the current SMP area.

The maximum groundwater level reduction of 17.7m occurred in the Bald Hill Claystone, along with 13.2m in the lower Hawkesbury Sandstone in TNC29, however the majority of the reduction would be due to the VWP intake equilibrating with the surrounding formation shortly after its installation.

The following sections describe the water pressure changes in the TNC28 and TNC 29 VWP arrays.

Table 17 Water Pressure Changes in TNC28 and TNC29

Geology	Intake	Description
TNC28 (since 28 August 2008)		
Hawkesbury Sandstone	95mbgl	static to gradually rising
Hawkesbury Sandstone	165.1mbgl	variable, although essentially static over the long term
Bald Hill Claystone	245mbgl	11.64m depressurisation (data suspect)
Bulgo Sandstone	270mbgl	notable continuous depressurisation of 27.5m
Scarborough Sandstone	430mbgl	gradual minor (<5m) depressurisation
Bulli Seam	490mbgl	gradual minor (<5m) depressurisation
TNC29 (since 10 October 2008)		
Hawkesbury Sandstone	70.06mbgl	essentially static to minor (<3m) depressurisation
Hawkesbury Sandstone	165.1mbgl	notable (16.75m) continual depressurisation
Bald Hill Claystone	182.1mbgl	notable (10m+) continual depressurisation
Bulgo Sandstone	215.1mbgl	notable (17.7m) continual depressurisation
Scarborough Sandstone	382.6mbgl	(intake 382.6mbgl) – variable although essentially static
Bulli Seam	441.6mbgl	gradual minor depressurisation (<3m) until late January 2012, then gradual depressurisation up to early April 2013, followed by a significant depressurisation of up to 215m of head in mid April 2013

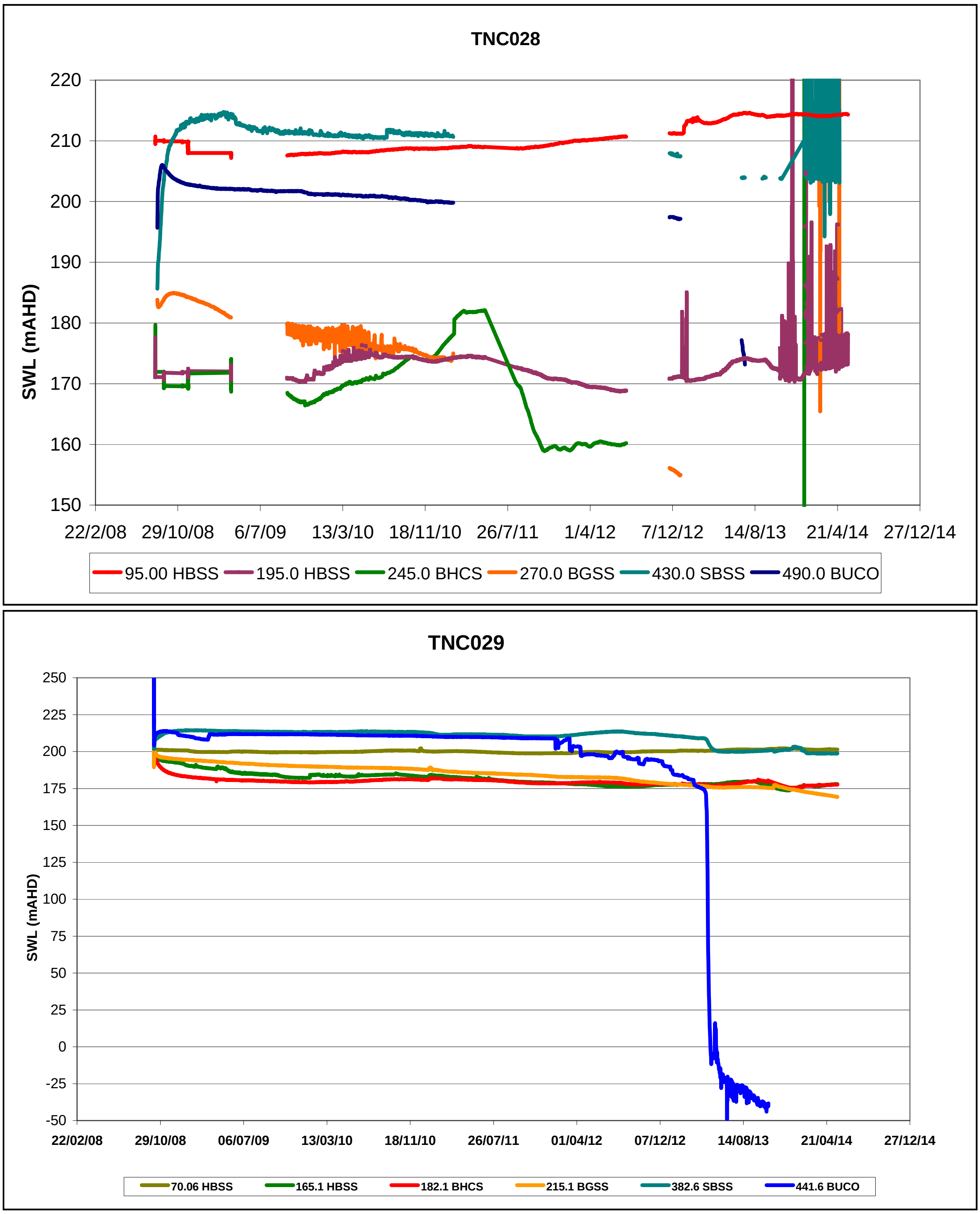
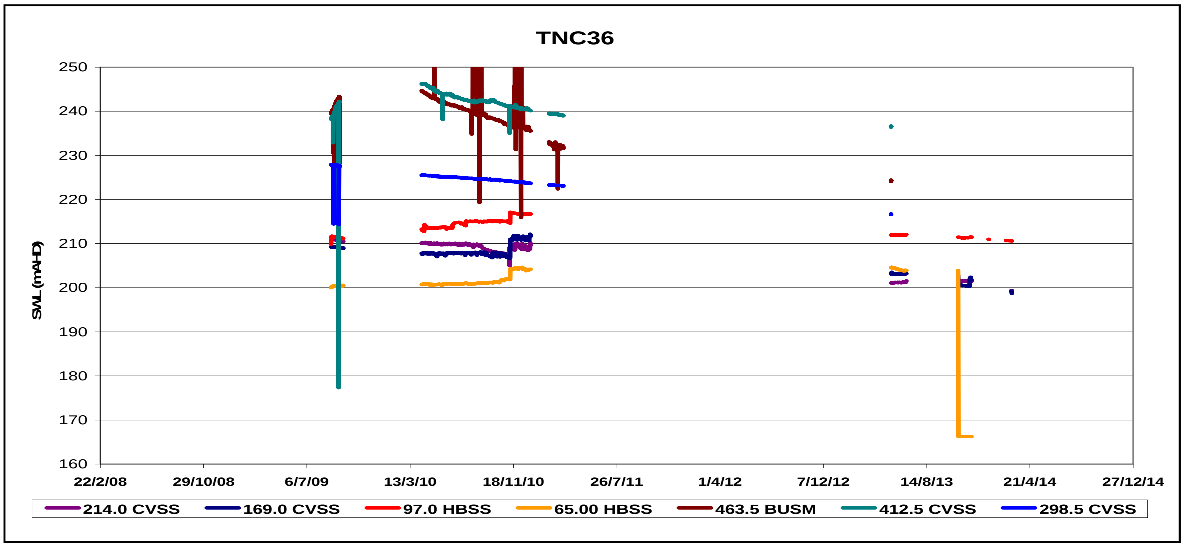
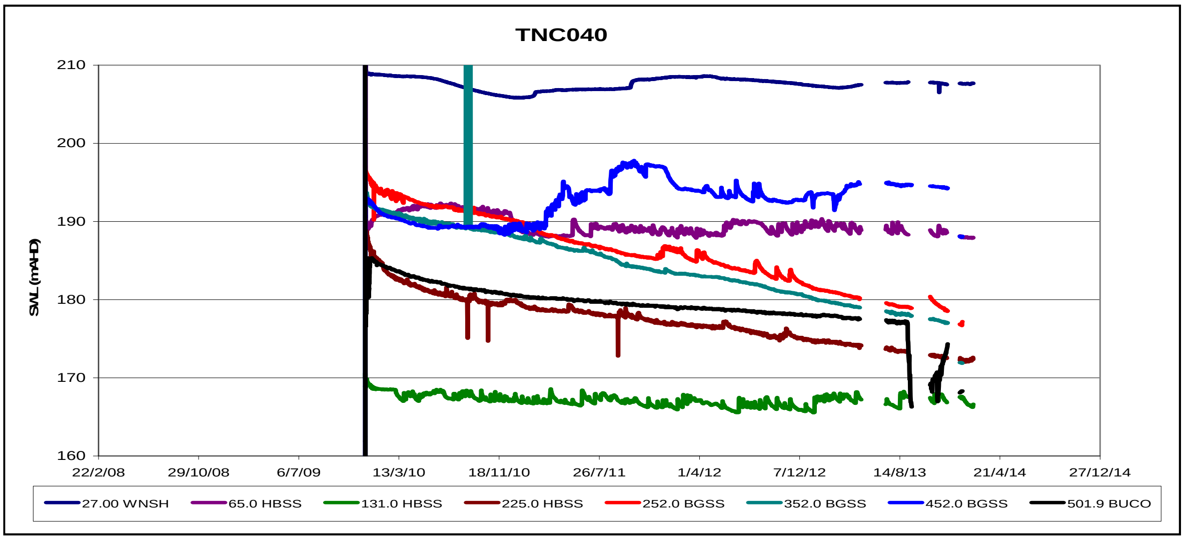


Figure 17 Vibrating Wire Piezometer Groundwater Levels





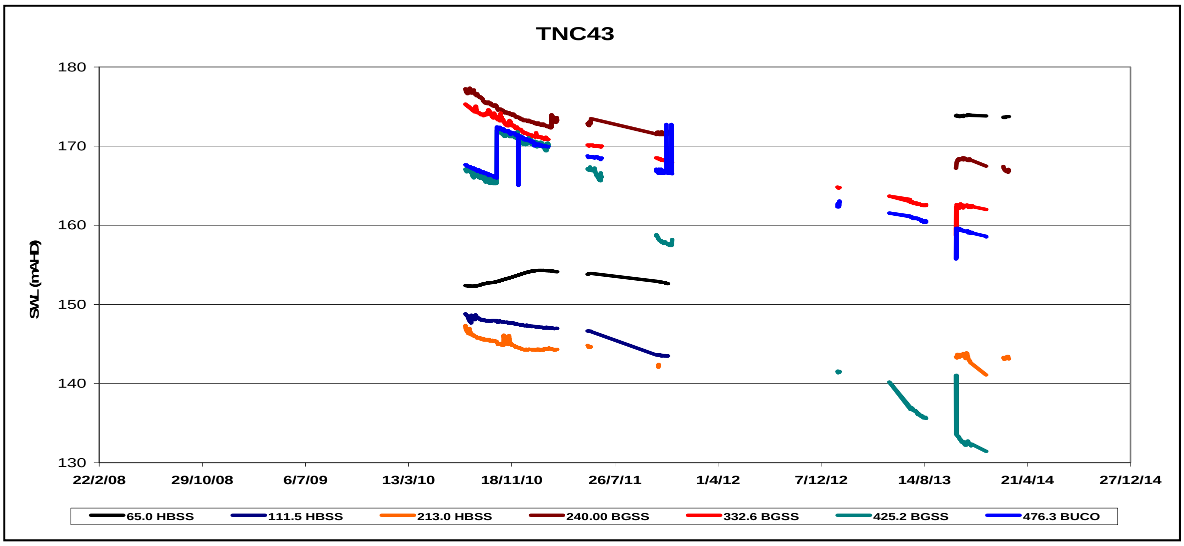


Figure 18 Vibrating Wire Piezometer Groundwater Levels

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, through the Bald Hill Claystone or any other aquitards during extraction of Longwalls 22 to 26 as shown in **Figure 19**.

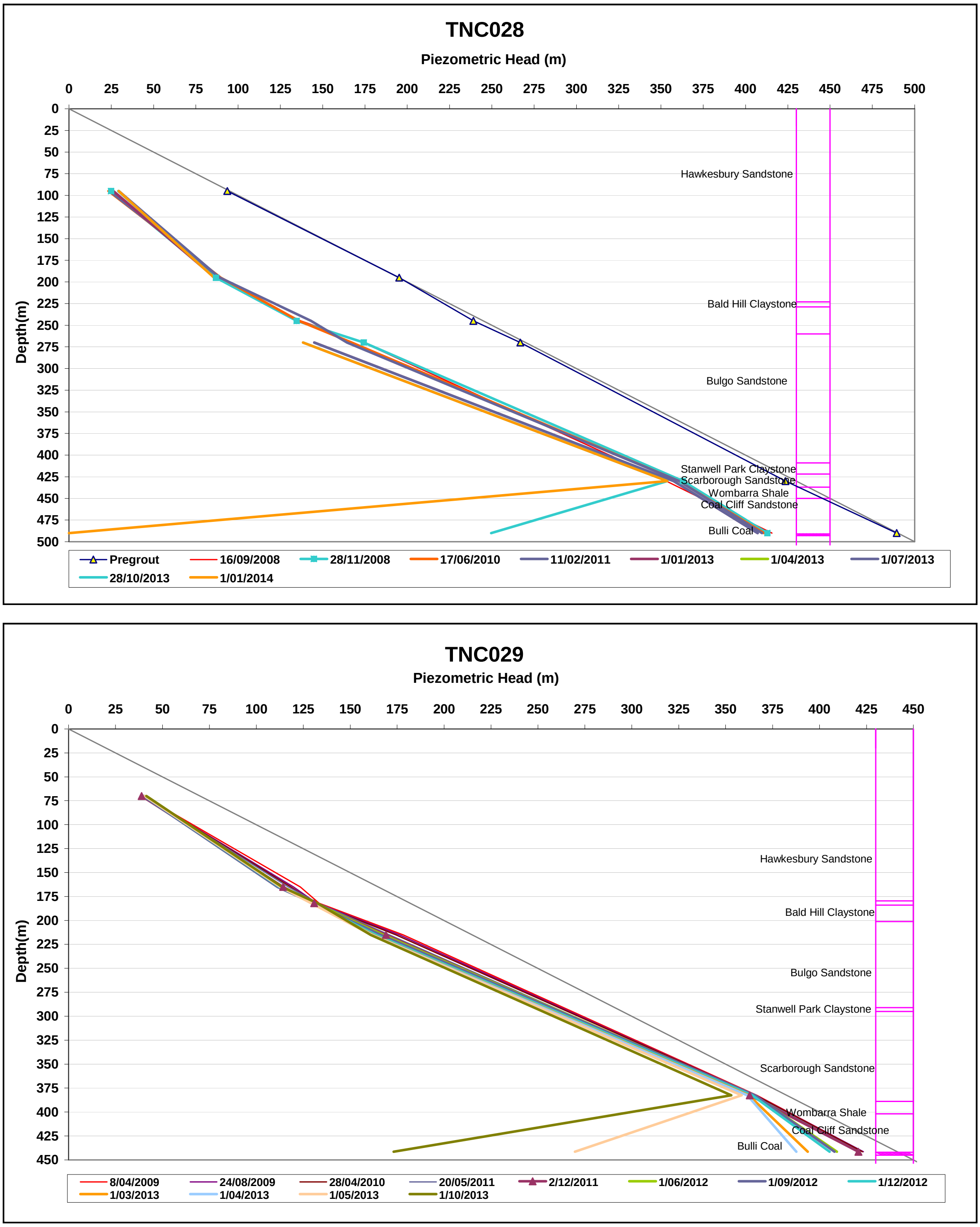


Figure 19 Vibrating Wire Piezometer Head vs Depth

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.

No generation or alteration of groundwater seep flow volumes or water quality in Myrtle or Redbank Creek has been observed.

No known springs are present on the plateau within the Panel 24 to 26 SMP area, although ferruginous seeps are present at the photo sites 24 and 25 over Longwall 27, as well as at the RC2 water quality monitoring site over Longwall 29.

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 20** and **Appendix C**.

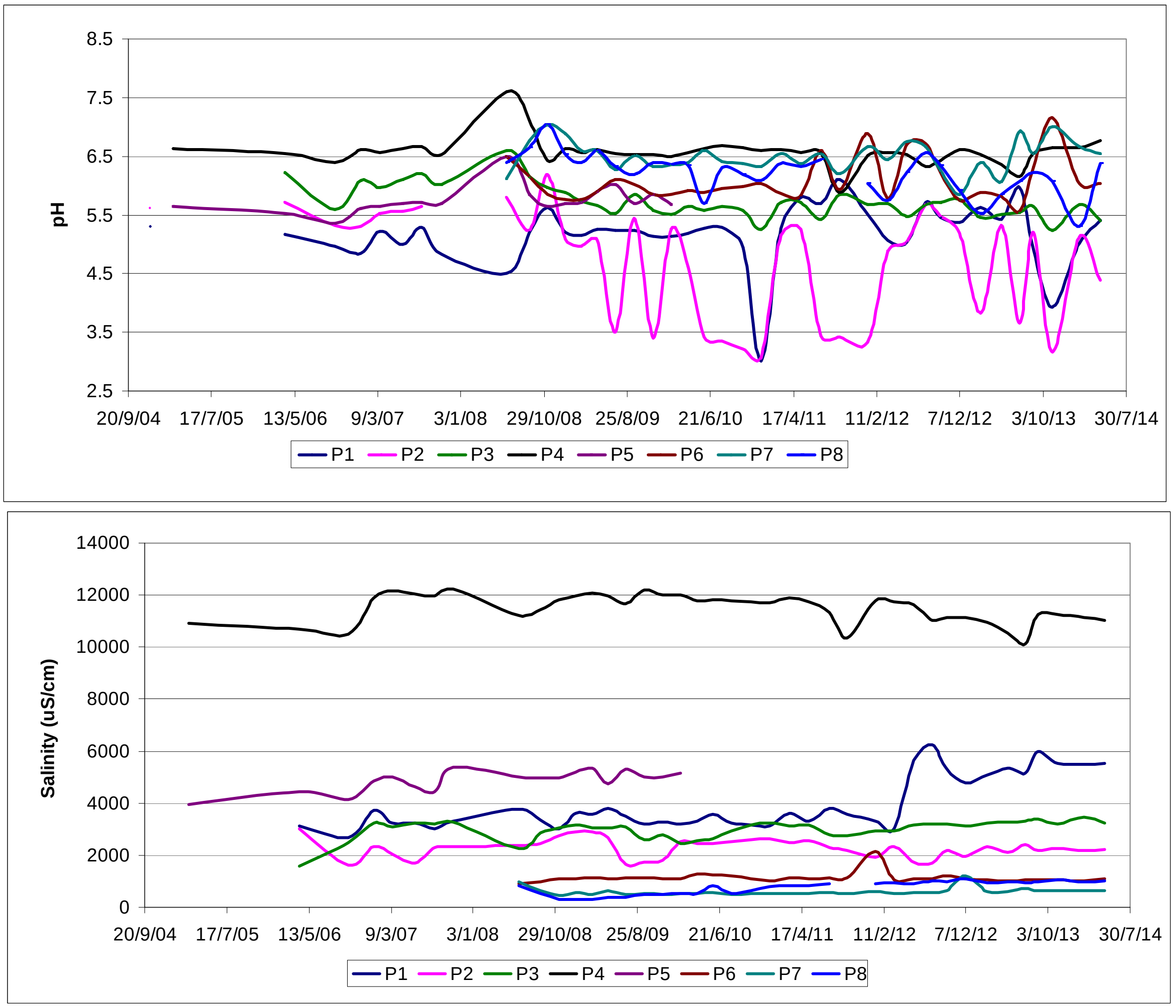


Figure 20 Field Groundwater Quality

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,
- 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 26 SMP 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.

Increased acidity (as lower pH) by up to 2.5 units has been observed in P2.

5. CONCLUSION

Based on monitoring of streams, dams and groundwater conducted prior to, during and after extraction of Longwall 27, 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 27 (and preceding panels);
- re-emergence of the stream “through-flow” has been observed downstream of the active panel (longwall 27) in both streams;
- the TARP trigger in relation to reduced stream flow connectivity and significantly reduced (or dry) pool holding capacity was observed between Sites 4 to 10 (over Longwall 26) and Sites 13 to 20 (over Longwall 27) in Myrtle Creek;
- the TARP trigger in relation to reduced water quality (specifically zinc) was observed at Site 37 (RC2), downstream of Longwall 27 in Redbank Creek, in association with drying out of pools and lack of stream connectivity over Longwall 27, with subsequent re-emergence of the under-flow back into the stream and enhanced ferruginous hydroxide precipitation over Longwall 28;
- one report of reduced dam holding capacity was received from a property at 90 Hilton Park Road, over Longwall 26, with the Mine Subsidence Board assessing rehabilitation requirements of for the dam.
- significant depressurisation of the Bulli Seam has been observed in the vibrating wire piezometer bore at TNC29
- no adverse effects on private bore yield or water quality have been reported during or after the Longwall 27 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, 2011 End of Longwall 25 Streams Dam and Groundwater Monitoring Report

GeoTerra, 2013 End of Longwall 26 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 2014 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 27

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)

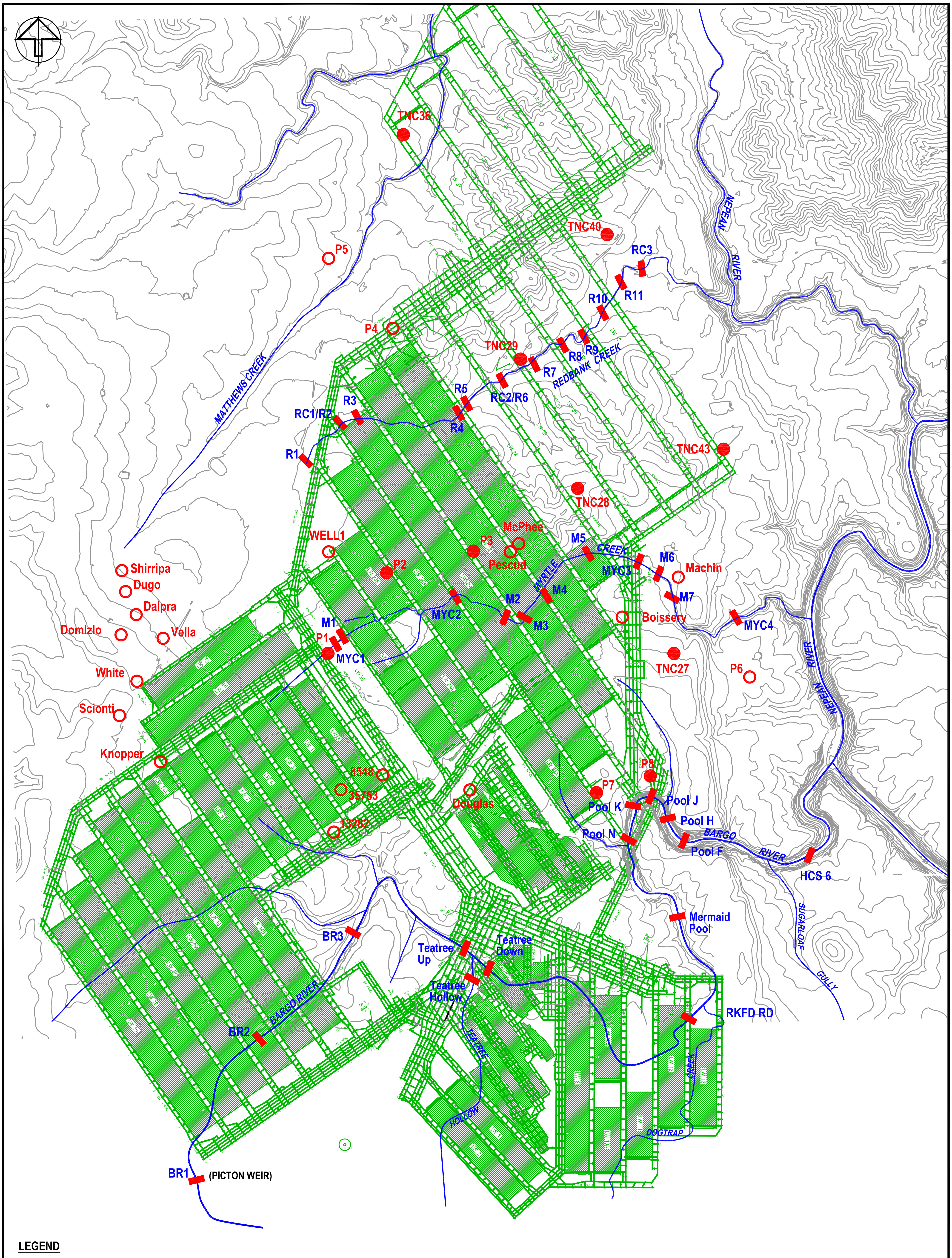
LIMITATIONS

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

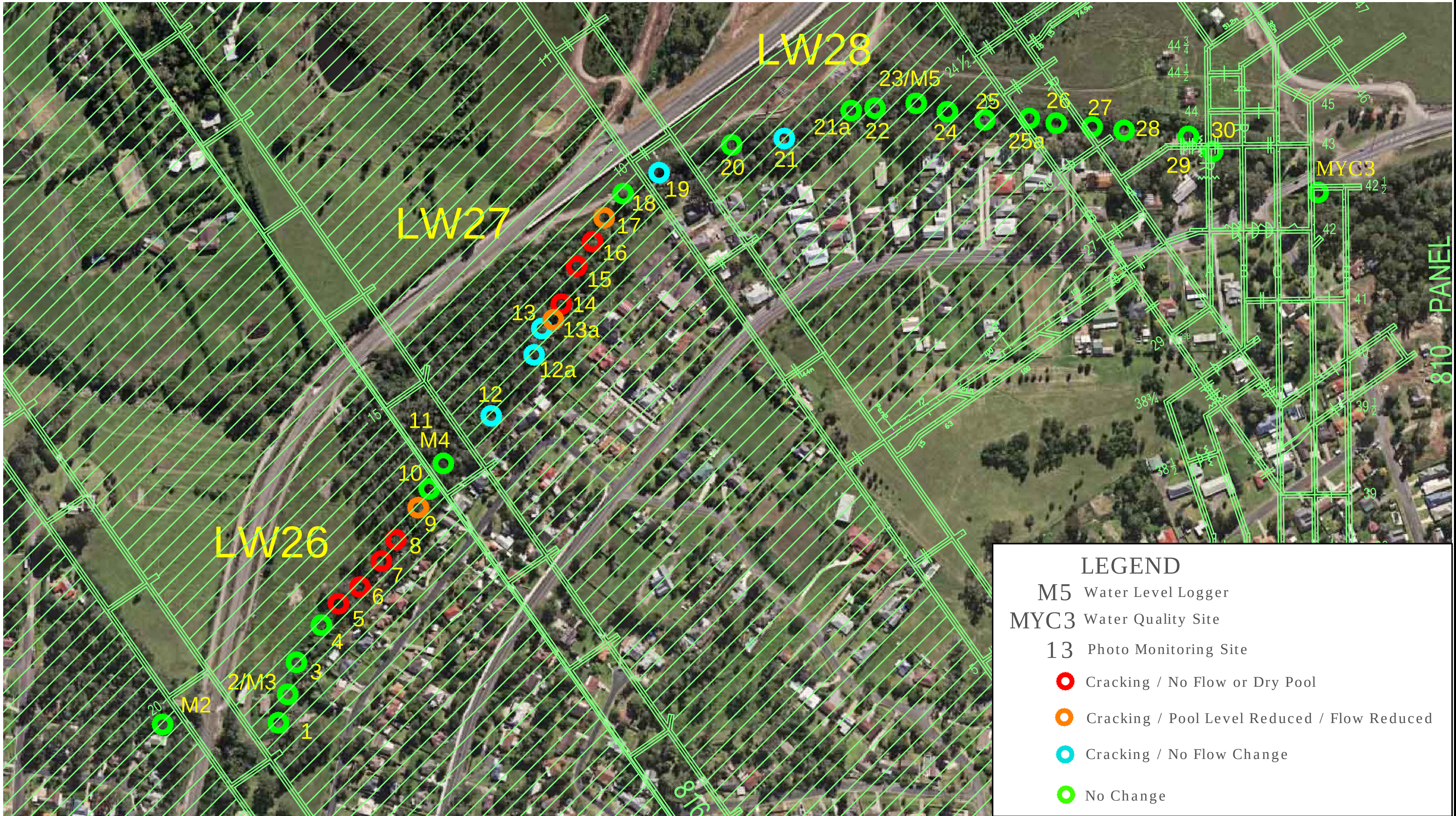
- PIEZOMETER
- STREAM MONITORING SITE
- NOW REGISTERED BORE / WELL

PROJECT:	TA20
DRAWN:	A. DAWKINS
DATE:	21 JULY 2014
SCALE:	1:30 000

TAHMOOR COAL PTY LTD
TAHMOOR COLLIERY
WATER MONITORING LOCATIONS

GeoTerra

DRAWING1



50 0 50 100 150 200 250

Scale 1:5000 (metres)

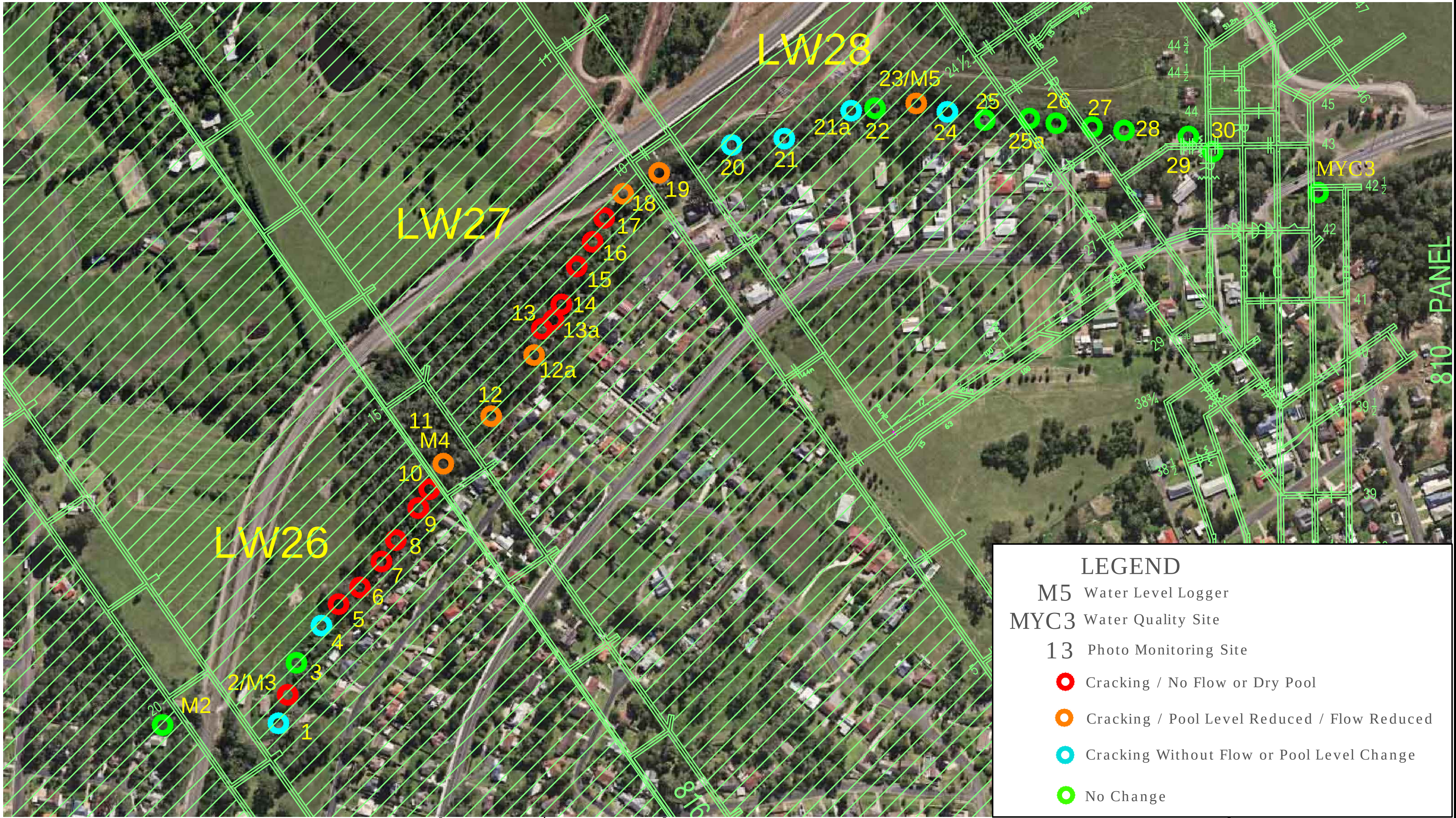
PROJECT:	TA24
DRAWN:	A. DAWKINS
DATE:	15 JULY 2014
SCALE:	AS SHOWN

TAHMOOR COAL PTY LTD
MYRTLE CREEK

CREEK STATUS (Pre LW27 - 15/3/13)

GeoTerra

DRAWING 2



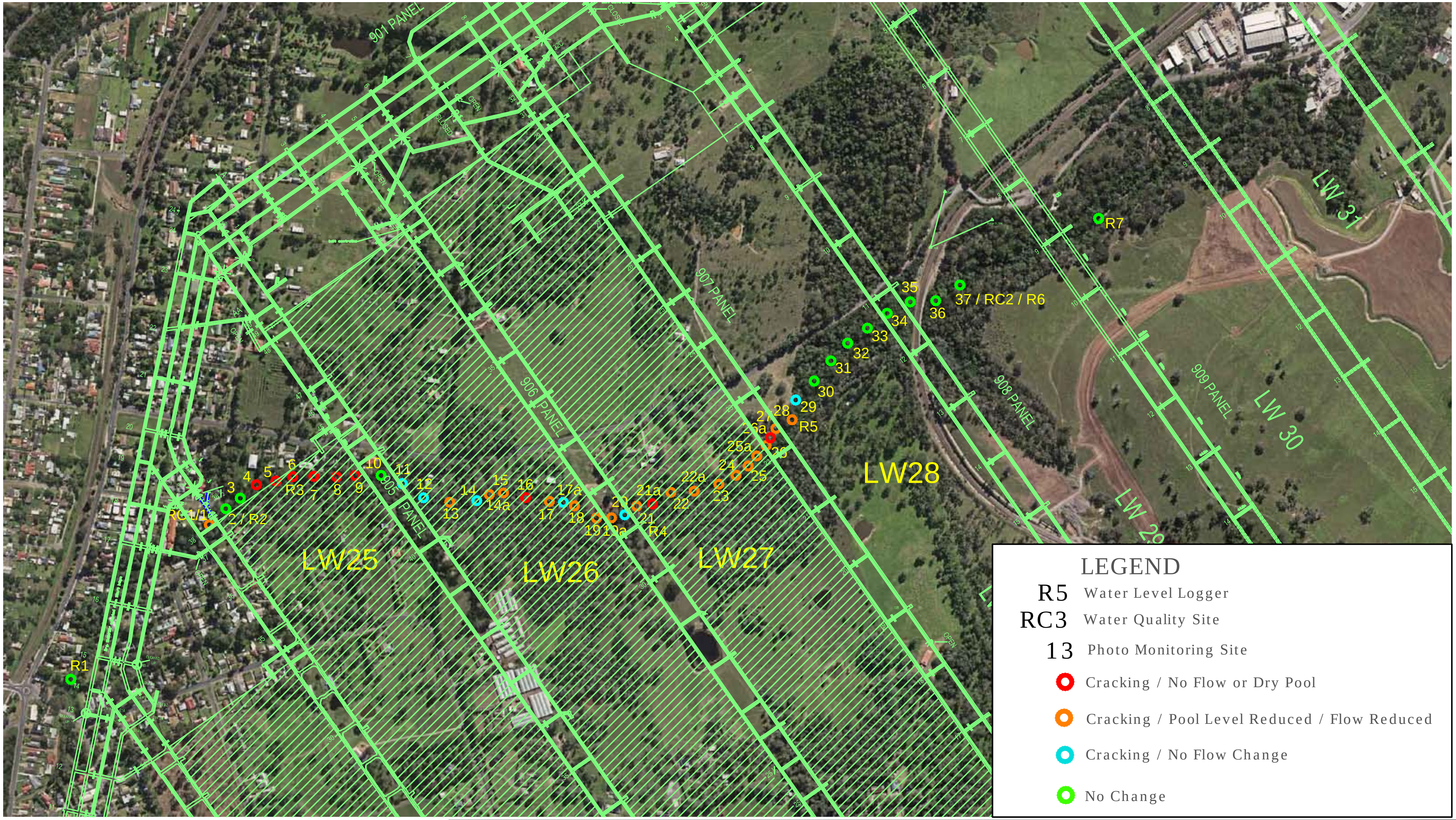
PROJECT:	TA24
DRAWN:	A. DAWKINS
DATE:	21 JULY 2014
SCALE:	AS SHOWN

TAHMOOR COAL PTY LTD
MYRTLE CREEK

CREEK STATUS (POST LW27 - 21/6/13)

GeoTerra

DRAWING 3



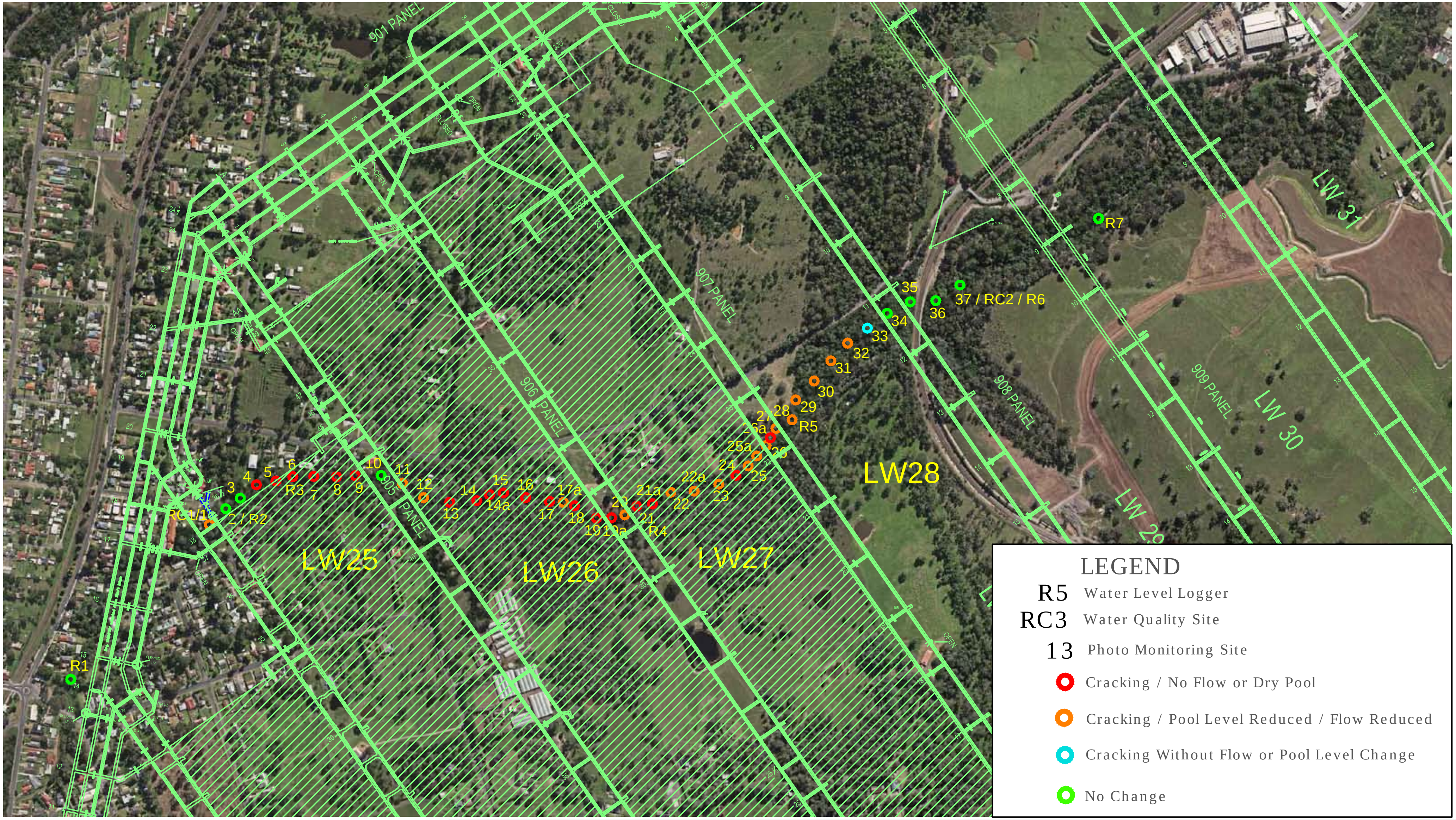
PROJECT:	TA24
DRAWN:	A. DAWKINS
DATE:	21 JULY 2014
SCALE:	AS SHOWN

TAHMOOR COAL PTY LTD
REDBANK CREEK

CREEK STATUS (PRE LW27 - 21/11/13)

GeoTerra

DRAWING 4



100 0 100 300 500

Scale (metres)

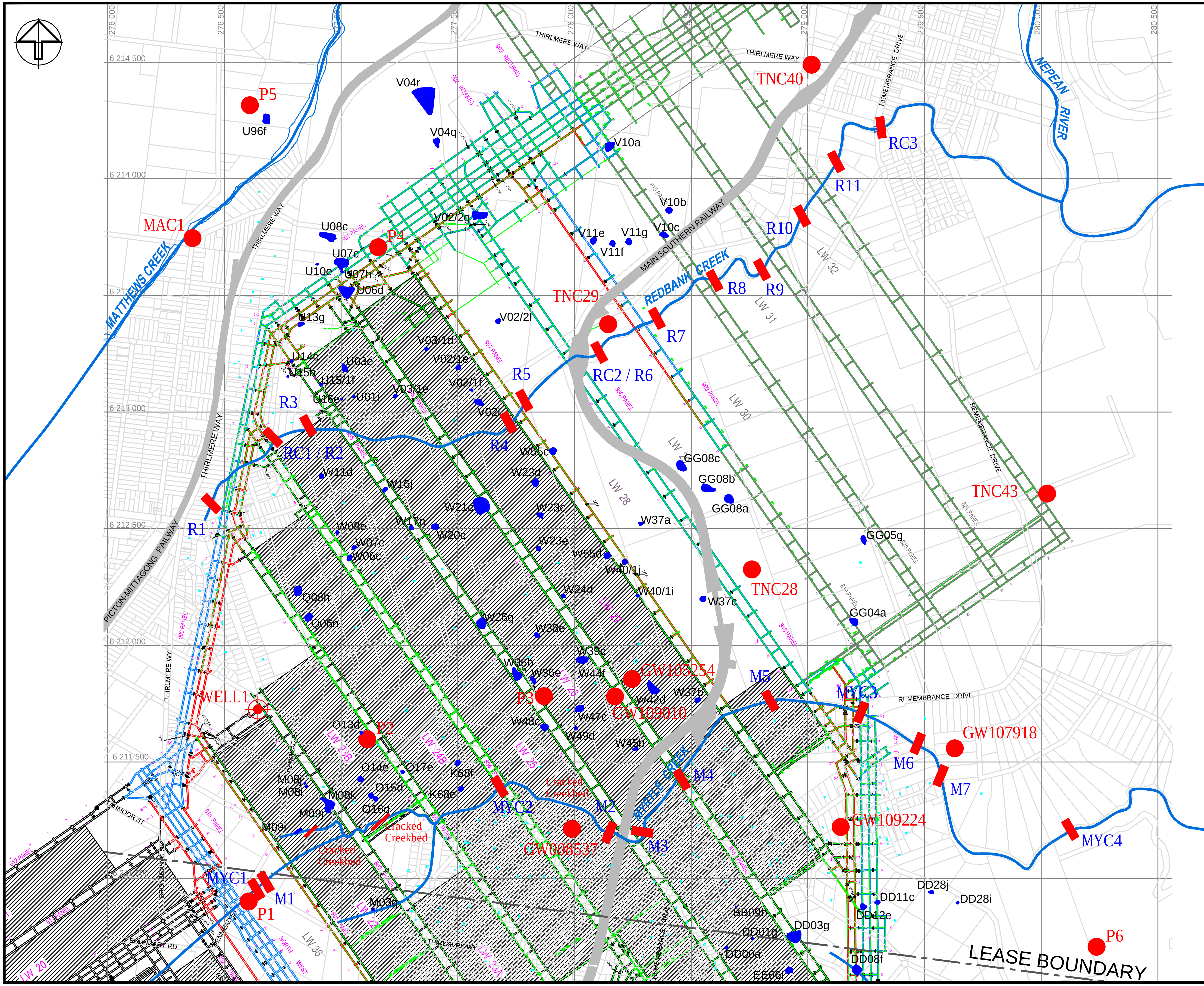
PROJECT:	TA24
DRAWN:	A. DAWKINS
DATE:	21 JULY 2014
SCALE:	AS SHOWN

TAHMOOR COAL PTY LTD
REDBANK CREEK

CREEK STATUS (POST LW27 - 16/4/14)

GeoTerra

DRAWING 5



LEGEND

- DAMS
- PIEZOMETER / BORE
- STREAM SITE
- WELL

PROJECT:	TA20-R1
DRAWN:	A. DAWKINS
DATE:	21 JULY 2014
SCALE:	1:15 000

TAHMOOR COAL TAHMOOR COLLIERY

LONGWALLS 22 TO 28

Monitoring Sites

DRAWING 6

GeoTerra

APPENDIX A

Myrtle Creek Site 11 (5/3/13)

(16/5/13)

(25/7/13)

Myrtle Creek Site 15 (5/3/13)

(16/5/13)

(25/7/13)

Myrtle Creek Site 18 (5/3/13)

(16/5/13)

(25/7/13)

Myrtle Creek Site 20 (5/3/13)

(16/5/13)

(25/7/13)

Myrtle Creek Site 23 (5/3/13)

Myrtle Creek Site 27 (5/3/13)

(16/5/13)

(16/5/13)

(25/7/13)

(25/7/13)

Redbank Creek Site 13 (1/11/13)

(20/3/14)

(30/4/14)

Redbank Creek Site 17 (1/11/13)

(20/3/14)

(30/4/14)

Redbank Creek Site 21 (1/11/13)

Redbank Creek Site 22A (1/11/13)

(20/3/14)

(20/3/14)

(30/4/14)

(30/4/14)

Redbank Creek Site 25 (1/11/13)

Redbank Creek Site 28 (1/11/13)

(20/3/14)

(20/3/14)

(30/4/14)

(30/4/14)

Redbank Creek Site 31 (1/11/13)

Redbank Creek Site 35 (1/11/13)

(20/3/14)

(20/3/14)

(30/4/14)

(30/4/14)

Redbank Creek Site 37 (1/11/13)

(20/3/14)

(30/4/14)

APPENDIX B

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	_
4/09/2008	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	_
3/08/2010	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
1/03/2011	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

	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
max	240	53	33	9	14	100	0.15	15	150	6.7	1.3	97	2	0.34	0.3	1	0.01	0.001	0.014	0.01	0.01	0.01	0.13	0.043	0.05	27	65
min	45	5.4	2.3	1.5	3.5	8	0	2	22	0.2	0.01	0.6	0.26	0.01	0.01	0.01	0.001	0.001	0.001	0.01	0.01	0.01	0.01	0.012	0.001	8	2
median	120	14	12	6.1	6.5	27	0.1	8	65	0.85	0.055	2.6	0.71	0.03	0.02	0.04	0.003	0.001	0.008	0.01	0.01	0.01	0.0515	0.02	0.003	11.5	16.5
St. Dev.	41.819	10.961	7.156	1.971	2.569	21.661	0.033	3.938	29.147	1.933	0.302	23.648	0.488	0.122	0.081	0.255	0.002	0.000	0.004	0.000	0.000	0.000	0.036	0.008	0.012	5.561	19.957

0.6 exceeds ANZECCC 2000

0.6 exceeds Water quality TARP

LW27 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	_
4/09/2008	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	_
3/08/2010	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
1/03/2011	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

max	550	105	51	9.5	46	290	0.21	32	270	6.1	0.66	88	13	4.6	4.5	0.24	0.004	0.001	0.025	0.01	0.01	0.01	0.32	0.25	0.04	24	160
min	50	10	4.3	2.2	3.2	19	0.1	2	21	0.5	0.03	0.66	0.06	0.04	0.01	0.01	0.001	0.001	0.001	0.01	0.01	0.01	0.02	0.001	0.001	7	10
median	175	27.5	16	4.9	13	56	0.12	9	82	1.4	0.08	3.3	0.515	0.325	0.08	0.04	0.002	0.001	0.008	0.01	0.01	0.01	0.084	0.043	0.007	10	23.5
St. Dev.	125.281	21.78	10.2	1.71	9.64	62.65	0.03	7.43	53.649	1.584	0.147	20.918	4.4312	1.6796	1.1845	0.0622	0.001	0	0.0062	0	0	0	0.0699	0.0579	0.011	4.67	53.27

0.6 exceeds ANZECCC 2000

0.6 exceeds Water quality TARP

LW27 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	_
3/08/2010	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
1/03/2011	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

max	1000	230	40	65	80	560	0.5	31	460	92	22	18	6.7	2.9	2.8	0.06	0.005	0.001	0.088	0.01	0.01	0	0.32	0.28	0.029	57	580
min	170	25	15	4.3	8.1	45	0.1	11	1	0.2	0.03	0.32	0.06	0.02	0.01	0.01	0.001	0.001	0.001	0.01	0.01	0	0.08	0.02	0.001	1	2
median	452.5	76	27	7.85	16.5	104	0.14	19	93.5	0.9	0.05	1.3	0.215	0.04	0.03	0.03	0.0014	0.001	0.006	0.01	0.01	0.011	0.15	0.072	0.007	7	7
St. Dev.	322.663	82.82	7.68	19.6	27.6	221.9	0.13	6.86	130.59	30.75	7.339	5.6681	2.1447	1.0048	0.9198	0.0186	0.0014	0	0.0274	0	0	#DIV/0!	0.0755	0.0835	0.011	18.6	202.4

0.6 exceeds ANZECCC 2000

0.6 exceeds Water quality TARP

LW27 extraction period

ANZECC	SITE	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
											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	_
4/09/2008	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	_
3/08/2010	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
1/03/2011	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

	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
max	1390	250	36	120	32	370	0.5	93	820	190	30	4.2	1	0.46	0.43	0.19	0.009	0.003	0.027	0.01	0.01	0.01	0.22	0.11	0.03	57	580
min	93	12	11	4	5	20	0.1	3	42	0.5	0.07	0.37	0.04	0.01	0.01	0.01	0.001	0.001	0.001	0.01	0.01	0.01	0.03	0.002	0.001	5	6
median	530	96	24	25	13	110	0.17	20	160	34	5.65	1.15	0.37	0.11	0.1	0.04	0.003	0.001	0.014	0.01	0.01	0.01	0.13	0.03	0.004	19	27.5
St. Dev.	371.902	66.82	8.32	34.8	7.75	99.13	0.12	24.2	248.59	63.5	10.25	1.1079	0.3218	0.1923	0.1433	0.0531	0.0026	0.0008	0.0079	2E-18	1.78E-18	0	0.0635	0.0301	0.009	17.2	241.5

0.6 exceeds ANZECCC 2000

0.6 exceeds Water quality TARP

LW27 extraction period

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	_
4/09/2008	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	_
3/08/2010	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
1/03/2011	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
	max	300	58	54	7.5	12	84	0.2	60	270	7.6	0.17	4.3	0.8	0.07	0.1	0.14	0.007	0.001	0.015	0.01	0.01	0.01	0.17	0.11	0.11	13	63
	min	55	11	6.4	1.7	2.5	19	0.1	2	1	0.2	0.01	0.58	0.02	0.01	0.01	0.01	0.001	0.001	0.001	0.01	0.01	0.01	0.02	0.003	0.001	5	2
	median	175	32	18	4.8	7.4	42	0.1	14	72	1.5	0.05	1.50	0.285	0.02	0.01	0.03	0.002	0.001	0.008	0.01	0.01	0.01	0.0705	0.03	0.001	8	9.5
	St. Dev.	77.792	14.689	12.524	1.819	2.642	17.190	0.033	13.210	71.706	2.225	0.046	1.131	0.297	0.021	0.024	0.049	0.002	0.000	0.004	0.000	0.000	0.000	0.049	0.030	0.029	2.225	25.126

0.6 **exceeds ANZECCC 2000**

0.6 exceeds Water quality TARP

LW27 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	_
4/09/2008	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	_
3/08/2010	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
1/03/2011	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

	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
max	1520	410	75	9.1	100	930	0.25	27	200	7.7	0.1	82	42	4.6	4.4	0.26	0.005	0.003	0.2	0.06	0.01	0.01	0.22	0.45	0.083	13	74
min	110	14	7.7	3	7.9	40	0.1	2	1	0.1	0.01	0.82	0.01	0.01	0.01	0.01	0.001	0.001	0.001	0.01	0.01	0.01	0.03	0.001	0.001	1	4
median	750	185	16.5	5.05	47.5	460	0.1	11	30	0.35	0.02	4.2	0.94	2.85	1.95	0.03	0.001	0.001	0.029	0.01	0.01	0.01	0.09	0.1	0.015	4.5	41
St. Dev.	441.928	114.674	15.131	1.725	28.259	280.031	0.049	6.668	46.481	1.914	0.031	24.949	10.230	1.810	1.607	0.063	0.001	0.001	0.056	0.014	0.000	0.000	0.069	0.150	0.026	4.209	26.057

0.6 **exceeds ANZECCC 2000**

0.6 exceeds Water quality TARP

LW27 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	RC3	290	51	32	6.4	16	55	0.2	6	230	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
7/4/06	RC3	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	RC3	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	RC3	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	RC3	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	RC3	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	RC3	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	RC3	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	RC3	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	RC3	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	_
4/09/2008	RC3	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	RC3	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	RC3	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	_
3/08/2010	RC3	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
1/03/2011	RC3	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	RC3	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	RC3	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	RC3	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	RC3	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

	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
max	1280	330	32	9	88	800	0.38	32	230	2.7	0.23	11	1.3	6.2	6.2	0.24	0.006	0.001	0.22	0.05	0.01	0.01	0.24	0.63	0.06	23	48
min	75	5.4	6.7	2.7	4.3	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	0.01	0.001	1	2
median	230	45	23	5.8	11	64	0.17	10	75	1.2	0.055	1.6	0.345	0.12	0.035	0.03	0.0015	0.001	0.0095	0.01	0.01	0.01	0.1	0.044	0.006	9	5
St. Dev.	308.047	85.719	8.099	1.753	21.076	210.394	0.075	6.685	55.104	0.831	0.052	2.416	0.349	2.276	1.480	0.056	0.001	0.000	0.050	0.009	0.000	0.000	0.076	0.159	0.020	4.927	17.671

0.6 **exceeds ANZECCC 2000**

0.6 exceeds Water quality TARP

LW27 extraction period

APPENDIX C

TAHMOOR / THIRLMERE PIEZOMETER WATER QUALITY (mg/L)

ANZECC											0.25	0.02			1.9	1.9	0.001	0.003	0.008	0.01	0.055	0.013(V)	0.01				
		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	DOC
8/12/2004	P1		850	11	1.6	150	1800	0.10	1	5	0.8	0.1															
7/04/2006	P1	2010	600	7.6	2.1	110	1250	0.10	1	10	0.3	0.1	65.0	37.0		4.5	0.002	0.001	0.38	0.11	0.1	0.01	0.01				
5/10/2006	P1	1720	480	13	1.3	99	1110	0.10	1	5	0.9	0.01	37.0	21.0		2.8	0.003	0.002	0.31	0.12	0.1	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	0.008	0.006	0.27	0.11	0.04	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	0.001	0.001	0.58	0.19	0.01	0.01		0.042	0.57	0.12	
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	0.004		0.47	0.12	0.06	0.01		0.021	0.61	0.12	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	0.096		0.54	0.11	0.08	0.01		0.023	0.50	0.17	1
1/03/2011	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	0.003		0.44	0.12	0.03	0.01		0.032	0.68	0.13	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	0.032		1.0	0.18	0.40	0.01		0.034	0.82	0.15	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	0.013	0.004	0.89	0.20	2.0	0.01		0.043	0.85	0.16	

Min	1480	430	6	1.2	91	980	0.1	1	2	0.1	0.01	37	1.3	3.7	2.8	0.001	0.001	0.27	0.11	0.01	0.01	0.01	0.021	0.5	0.12	1
Max	3100	5450	22	8	180	1930	0.32	3	10	1	0.37	145	64	6.4	5.9	0.096	0.006	1	0.2	2	0.01	0.01	0.043	0.85	0.17	1
Median	2010	575	9.4	2.3	110	1220	0.1	1	6.5	0.3	0.055	65	36	4.6	4.3	0.004	0.002	0.47	0.12	0.08	0.01	0.01	0.033	0.645	0.14	1

		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	DOC
8/12/2004	P2		370	27	7.2	110	940	0.19	1	31	0.9	0.1															
7/04/2006	P2	1910	495	35	9.6	135	1200	0.27	9	47	0.3	0.13	28.0	12.0		5.4	0.001	0.001	0.45	0.13	0.1	0.01	0.01				
5/10/2006	P2	1050	250	14	2.7	76	650	0.10	1	12	0.3	0.13	7.2	1.7		3.5	0.002	0.004	0.53	0.08	0.1	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	0.003	0.007	0.34	0.11	0.07	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	0.001	0.001	0.67	0.18	0.03	0.01		0.098	0.28	0.14	
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	0.001		0.63	0.15	0.05	0.01		0.098	0.30	0.14	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	0.008		0.30	0.10	0.06	0.01		0.050	0.21	0.085	1
1/03/2011	P2	1170	270	18	4.8	91	730	0.10	1	11	0.1	0.09	210.0	42.0	6.6	6.2	0.001		0.72	0.16	0.05	0.01		0.11	0.32	0.14	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	0.001		0.69	0.14	0.21	0.01		0.063	0.25	0.11	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	0.004	0.003	0.60	0.13	0.25	0.01		0.051	0.24	0.10	

Min	830	200	12	2.7	63	530	0.1	1	6	0.1	0.04	7.2	1	4	3.5	0.001	0.001	0.3	0.08	0.03	0.01	0.01	0.05	0.21	0.085	1
Max	1910	495	35	9.6	135	1200	0.27	9	47	0.9	0.28	300	50	6.8	6.2	0.008	0.007	0.72	0.18	0.25	0.01	0.01	0.11	0.32	0.14	1
Median	1170	260	17	4.8	85	690	0.11	1	17.5	0.3	0.115	58	18	5.4	5.2	0.001	0.003	0.6	0.13	0.07	0.01	0.01	0.081	0.265	0.125	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	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	DOC
7/04/2006	P3	1020	275	20	3.9	61	600	0.20	88	5	1	0.11	75.0	36.0		3.6	0.001	0.001	0.011	0.07	0.1	0.01	0.01				
5/10/2006	P3	1600	390	22	3	105	960	0.21	4	27	0.1	0.04	64.0	50.0		3.6	0.001	0.001	0.1	0.09	0.1	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	0.001	0.003	0.85	0.21	0.06	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	0.001	0.001	0.025	0.08	0.01	0.01		0.1	0.25	0.21	
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	0.002		3.70	0.18	0.02	0.01		0.084	0.29	0.18	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	0.004		1.2	0.42	0.05	0.01		0.073	0.24	0.15	1
1/03/2011	P3	1500	390	22	5.5	115	970	0.13	21	13	0.1	0.01	120.0	105.0	5.0	4.9	0.001		0.10	0.08	0.02	0.01		0.12	0.33	0.20	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	0.001		0.056	0.08	0.04	0.01		0.090	0.31	0.21	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	0.001	0.002	0.33	0.09	0.01	0.01		0.073	0.30	0.19	

	TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	DOC
Min	1020	275	18	3	61	600	0.1	1	5	0.1	0.01	64	36	4.6	3.6	0.001	0.001	0.011	0.07	0.01	0.01	0.01	0.073	0.24	0.15	1
Max	2790	460	22	7.9	120	1020	0.21	130	44	1.9	0.3	360	110	5	4.9	0.004	0.003	3.7	0.42	0.1	0.01	0.01	0.12	0.33	0.21	11
Median	1600	390	20	4.7	110	970	0.2	31	19	0.7	0.11	125	68	4.7	4.3	0.001	0.001	0.1	0.09	0.04	0.01	0.01	0.087	0.295	0.195	5.5

		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Tot Mn	Mn Filt	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	DOC
ANZECC											**0.25**	**0.02**			**1.9**	**1.9**	**0.001**	**0.003**	**0.008**	**0.01**	**0.055**	**0.013(V)**	**0.01**				
28/02/2005	P4	7100	1600	180	55	585	3830	0.31	1210	150																	
7/04/2006	P4	6890	1580	185	59	565	3740	0.37	1160	145	0.2	0.1	1.3	0.0		0.66	0.002	0.001	0.005	0.01	0.01	0.01	0.01				
5/10/2006	P4	6750	1490	185	58	625	3690	0.27	1240	150	0.1	0.01	0.5	0.5		0.59	0.001	0.001	0.006	0.01	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	0.002	0.001	0.01	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	0.001	0.001	0.036	0.03	0.03	0.01		1.1	0.08	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	0.001		0.17	0.03	0.02	0.01		1	0.10	1.1	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	0.002		0.009	0.01	0.04	0.01		1.0	0.09	1.1	1
1/03/2011	P4	7120	1420	210	64	610	3660	0.21	1300	135	0.1	0.01	5.9	1.3	1.0	1.0	0.002		0.024	0.02	0.04	0.01		1.2	0.12	1.3	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	0.002		0.026	0.02	0.02	0.01		1.0	0.089	1.1	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	0.001	0.001	0.012	0.01	0.03	0.01		0.87	0.075	1.0	

	TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Tot Mn	Mn Filt	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	DOC
Min	6220	1380	160	41	560	3260	0.21	1100	135	0.1	0.01	0.52	0.03	0.79	0.51	0.001	0.001	0.005	0.01	0.01	0.01	0.01	0.87	0.075	1	1
Max	11100	1630	210	65	630	3830	0.37	1300	165	0.9	0.38	95	3.4	1.9	1	0.002	0.001	0.17	0.03	0.04	0.01	0.01	1.2	0.12	1.3	8
Median	6920	1520	180	57	583	3725	0.25	1230	150	0.2	0.06	5.9	0.31	1	0.72	0.002	0.001	0.012	0.01	0.02	0.01	0.01	1	0.087	1.1	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	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	DOC
28/02/2005	P5	2560	730	8.3	21	145	1510	0.77	86	67																	
7/04/2006	P5	2880	850	8.8	23	145	1700	79.00	82	72	0.6	0.1	3.4	0.1		5	0.001	0.001	0.3	0.14	0.01	0.01	0.01				
5/10/2006	P5	2900	795	8.4	22	155	1620	0.70	96	72	0.1	0.01	4.8	0.1		4.2	0.001	0.001	0.28	0.11	0.01	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	0.001	0.001	0.23	0.15	0.01	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	0.001	0.001	0.45	0.23	0.04	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	0.001		0.52	0.02	0.03	0.01		0.19	0.11	0.22	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	0.002		0.23	0.15	0.04	0.01		0.19	0.09	0.22	1

Min	2530	700	7	21	145	1510	0.53	78	66	0.1	0.01	3.4	0.06	6	4.2	0.001	0.001	0.23	0.02	0.01	0.001	0.01	0.19	0.093	0.22	1
Max	4100	850	11	25	180	1720	79	1720	86	0.6	0.1	120	0.1	6.7	6.6	0.002	0.001	0.52	0.23	0.04	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	0.001	0.001	0.29	0.15	0.02	0.01	0.01	0.19	0.11	0.22	1

		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Filt Mn	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	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	0.001	0.001	0.047	0.01	0.01	0.01		0.039	0.09	0.1	
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	0.001		0.04	0.02	0.01	0.01		0.029	0.07	0.1	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	0.001		0.047	0.02	0.02	0.01		0.033	0.10	0.12	1
1/03/2011	P6	550	120	12	3.3	36	270	0.11	72	19	0.1	0.20	29.0	0.2	1.1	1.0	0.001		0.022	0.01	0.03	0.01		0.066	0.16	0.12	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	0.002		0.088	0.02	0.04	0.01		0.028	0.15	0.10	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	0.003	0.001	0.033	0.01	0.04	0.01		0.051	0.12	0.13	

Min	510	120	10	2.5	35	265	0.11	72	19	0.1	0.09	14	0.04	0.75	0.41	0.001	0.001	0.022	0.01	0.01	0.01		0.028	0.07	0.1	1
Max	580	145	16	4.3	40	290	0.68	110	25	0.5	0.28	46	10	2.8	1.9	0.003	0.001	0.088	0.02	0.04	0.01		0.066	0.16	0.13	130
Median	550	135	12	3.5	37	275	0.16	75	21.5	0.1	0.16	30	0.135	1.2	1.15	0.001	0.001	0.044	0.02	0.025	0.01		0.036	0.11	0.11	1

TAHMOOR / THIRLMERE PIEZOMETER WATER QUALITY (mg/L)

ANZECC											0.25	0.02			1.9	1.9	0.001	0.003	0.008	0.01	0.055	0.013(V)	0.01				
		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Mn Filt	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	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	0.002		0.14	0.01	0.04	0.01		0.017	0.06	0.17	
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	0.001		0.041	0.01	0.01	0.01		0.013	0.05	0.14	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	0.001		0.062	0.01	0.01	0.01		0.017	0.08	0.24	12
1/03/2011	P7	265	46	39	3.2	13	98	0.56	130	4	0.7	0.01	5.9	0.2	1.6	1.5	0.001		0.040	0.01	0.01	0.01		0.018	0.06	0.18	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	0.001		0.076	0.01	0.04	0.01		0.014	0.070	0.22	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	0.002	0.001	0.029	0.01	0.05	0.01		0.013	0.057	0.21	

Min	235	25	30	2.8	11	92	0.56	83	3	0.1	0.01	0.3	0.01	1.1	0.43	0.001		0.029	0.01	0.01	0.01		0.013	0.05	0.14	9
Max	310	55	43	4.6	17	120	0.77	155	13	2.5	0.31	42	15	2.5	2.4	0.002		0.14	0.01	0.05	0.01		0.018	0.076	0.24	17
Median	260	46	37	3.4	15	104	0.64	115	4.5	0.55	0.025	8.95	0.11	1.6	1.55	0.001		0.052	0.01	0.025	0.01		0.016	0.0595	0.195	14

		TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe Tot	Fe Filt	Mn Tot	Mn Filt	Cu	Pb	Zn	Ni	Filt Al	As	Se	Li	Ba	Sr	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	0.001		0.065	0.03	0.01	0.026		0.11	0.1	0.01	
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	0.001		0.072	0.01	0.01	0.01		0.003	0.01	0.11	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	0.001		0.16	0.01	0.02	0.01		0.008	0.04	0.17	20
1/03/2011	P8	445	91	45	6.6	12	180	0.25	110	29	2.4	0.01	0.2	0.0	1.2	1.1	0.002		0.45	0.07	0.01	0.01		0.025	0.07	0.25	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	0.002		0.12	0.02	0.03	0.01		0.048	0.11	0.084	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	0.001	0.001	0.042	0.01	0.01	0.01		0.029	0.14	0.062	

Min	135	21	7.4	2.6	7.5	37	0.12	17	12	0.1	0.01	0.22	0.01	0.23	0.05	0.001		0.042	0.01	0.01	0.01		0.003	0.01	0.01	2
Max	480	120	45	14	26	255	0.37	110	29	2.4	0.2	57	0.19	2.3	2	0.002		0.45	0.07	0.03	0.026		0.11	0.14	0.25	20
Median	412.5	98	14	6.4	16	195	0.23	56	14.5	0.8	0.04	7.6	0.065	1.2	1.25	0.001		0.096	0.02	0.01	0.01		0.027	0.0825	0.097	20