appendix 5B

Subsidence Assessment (Peer Review)

West Wallsend Colliery

Peer Review of
Report DGS WWD-012/1

Subsidence Predictions and Impact Assessment of the Proposed Western and Southern Domain Longwalls, West Wallsend Colliery

Prepared in September 2009 by
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Report produced to:- Support a Part 3A Application to the Department of Planning under the Environmental Planning and Assessment Act 1979.

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

Introduction to Longwall Mining and Subsidence (Revision A)
General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Engineering Consultants would like to acknowledge the contribution towards the development of this report by the staff of Oceanic Coal – West Wallsend Colliery and their consultants Ditton Geotechnical Services and Aurecon Australia for their assistance during the course of the study.

EXECUTIVE SUMMARY

West Wallsend Colliery (WWC) proposes to continue its underground coal mining operations in the West Borehole Seam by extracting Longwalls 38 to 50 within the Southern and Western Domains of their existing mining leases ML1451, CCL725 and CCL718. A subsidence prediction and impact assessment report on the proposed longwalls has been prepared by Ditton Geotechnical Services (DGS). WWC has requested that Mine Subsidence Engineering Consultants (MSEC) provide an independent peer review of the DGS report. A version of the DGS Report dated 25th September 2009 and titled "*Subsidence Predictions and General Assessment of the Proposed Western and Southern Domain Longwalls, West Wallsend Colliery DGS Report No WWD-012/1*" was provided for review.

The extents of the existing and the proposed future longwalls at the WWC are shown in Drawing No. MSEC433-01, which is included in Appendix B. WWC is situated within the western portion of the Newcastle Coalfield and the proposed longwalls are located within the West Borehole Seam, which is the coalesced Nobbys, Yard and Borehole Seams. Sandstone and conglomerate of the Teralba Conglomerate Formation dominate the surface ridges and the overburden contains several massive conglomerate and sandstone channel units that have been observed to reduce subsidence ground movements above other areas at WWC.

In order to provide an independent peer review of the subsidence predictions and assessments that were provided in the DGS report, MSEC has;

- studied the available subsidence monitoring data over the previously extracted longwalls at WWC,
- prepared independent predictions of subsidence over these previously extracted longwalls at WWC to confirm that applicability of the Incremental Profile Method (IPM),
- prepared independent predictions of subsidence over the proposed Longwalls 38 to 50 at WWC, and
- reviewed the subsidence impacts and consequences that have been presented in the DGS report.

Where strong and massive conglomerate beams exist above longwalls, the observed subsidence can be less than otherwise expected. Subsidence predictions can allow for the influence of these strong and massive conglomerate channels, i.e. the levels of subsidence can be reduced, or they can be prepared to provide a standard level of subsidence - just in case the thickness of the channels is less than was indicated by nearby boreholes or just in case these channels are highly fractured. The DGS report has provided detailed information on the presence of five conglomerate and sandstone channels and all the subsidence predictions that are provided in the DGS report were prepared empirically based on extensive monitored subsidence at the WWC data and other local mines after allowing for the observed reduction effects of these five conglomerate and sandstone channels.

Where there are no sensitive surface features or manmade structures on the surface above the proposed longwalls then it does not matter if a standard prediction is provided or if the subsidence prediction method allows for the reduction effects of these strong conglomerate beams especially if the assessed subsidence impacts and consequences are similar and the resulting subsidence management strategies are the same.

The land above the proposed longwalls is mainly undeveloped bush land with several fire and access trails. The study area is dominated by a north-western oriented ridge line and is now largely State Conservation Area. The DGS report advises that the most significant natural and manmade surface features above and in the vicinity of the proposed longwalls are several creeks, alluvial aquifers, F3 Freeway and a major utilities easement which has high pressure gas and petroleum pipelines and three optical fibre cables, three communications towers, Wakefield Road, a farm dam and heritage sites.

The DGS report advises that after several risk assessment and planning meetings WWC pulled the proposed longwalls back from the freeway, the services easement, several heritage sites and an area of low depth of cover in the vicinity of Ryhope Creek. These changes to the mine layout have reduced the levels of subsidence impacts and consequences at all of these natural and manmade features to manageable levels.

Accordingly, for this peer review, a standard subsidence prediction without allowance for the reduction effects of the strong channels has been provided for comparison purposes with the DGS subsidence predictions. MSEC has used the standard Incremental Profile Method (IPM) for the Newcastle Coalfield with no geological factors or local calibration factors to provide the independent predictions of standard subsidence over both the previously extracted longwalls and the proposed future longwalls at WWC. These slightly higher subsidence predictions may assist in the development of subsidence management of areas above these longwalls as part of any sensitivity analyses that may be undertaken in the future.

Comparisons have been made at pegs along the monitoring lines that were established along and across the previously extracted longwalls between the observed and predicted subsidence, tilt and stain profiles and the predicted profiles resulting using the standard IPM for the Newcastle Coalfield with no geological factors or local calibration factors. The results of these comparisons are provided in Figures 1 to 7 in Appendix C. These plots indicate that the standard IPM for the Newcastle Coalfield provides conservative subsidence predictions for the proposed longwalls within the project area.

Comparisons have also been made between the predicted subsidence, tilt and stain profiles along five prediction lines that cross the proposed Longwalls 38 to 50 at West Wallsend Colliery, using the standard IPM and the predicted subsidence, tilt and stain profiles that are presented in the DGS report that allows for the reduction effect from the presence of various strong massive conglomerate strata beams. The results of these comparisons are provided in Figures 8 to 11 in Appendix C and, as was anticipated, these plots indicate that the standard IPM provides conservative subsidence predictions for proposed longwalls within the project area.

The DGS subsidence predictions have been reviewed and these predictions compare reasonably well with the standard subsidence predictions prepared by MSEC using the standard IPM. We would anticipate that the actual observed subsidence over these longwalls would be less than subsidence predictions prepared using the standard IPM without geological factors or local calibration factors for the reduction effects of these massive conglomerate beams.

The DGS report provides a description of significant natural and manmade surface features, , provides subsidence predictions at each surface feature, provides an assessment of subsidence impacts and consequences to surface features, identifies that further subsidence monitoring is required and discusses the possible need for minor remedial work. The assessments of subsidence impacts and consequences that are provided in the DGS Report for the natural features and surface improvements have been reviewed and MSEC considers them to be reasonable for both the predicted levels of subsidence provided in the DGS report and the increased levels of subsidence predicted using the standard IPM for the Newcastle Coalfield.

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Drawings

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

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Figures referred to in this report are included in Appendix C at the end of the report.

CHAPTER 1. BACKGROUND

1.1. Introduction

The West Wallsend Colliery is an underground mine that is located in the Newcastle Coalfield of NSW, about 25km southwest of Newcastle. West Wallsend is a town in the City of Lake Macquarie that is located near the Sydney-Newcastle Freeway. The town was founded after the West Wallsend Coal Company was formed in 1885.

West Wallsend Colliery is currently operated by Macquarie Coal Joint Venture, 80% owned by Oceanic Coal Australia Ltd (OCAL), which is a wholly owned subsidiary of Xstrata. The mine supplies both thermal and SSCC products principally to Asian utilities and steel mills. Coal is processed in the Macquarie Coal Preparation Plant and transported by rail to the Port of Newcastle for export.

West Wallsend Colliery (WWC) proposes to continue its underground coal mining operations in the West Borehole Seam by extracting Longwalls 38 to 50 within the Southern and Western Domains of their existing mining leases ML1451, CCL725 and CCL718. The extents of the existing and the proposed future longwalls for the West Wallsend Colliery and the locations of the previously monitored survey lines and five prediction lines are shown in Drawing No. MSEC433-01, which is included in Appendix B.

A subsidence prediction and impact assessment report on the proposed longwalls has been prepared by Ditton Geotechnical Services (DGS). WWC has requested that Mine Subsidence Engineering Consultants (MSEC) provide an independent peer review of the DGS report.

A version of the DGS Report dated 25th September 2009 and titled "*Subsidence Predictions and General Assessment of the Proposed Western and Southern Domain Longwalls, West Wallsend Colliery DGS Report No WWD-012/1*" was provided for review.

1.2. Mining Geometry

The layout of the proposed longwalls is shown in Drawing No. MSEC433-01.

The previous WWC longwalls have been extracted with void widths of 178 metres, 175 metres, 160 metres and150 metres. Chain pillar widths are generally 35 metres, but have ranged from 30 metres to 40 metres.

The proposed longwall void widths are generally 178 metres and the proposed chain pillar widths are generally 35 metres but range from 30 metres to 49 metres.

1.3. Surface and Seam Information

The surface levels above the proposed longwalls vary from RL 26 metres over Longwall 46 to RL 364 metres over Longwall 43.

The West Borehole Seam floor levels dip towards the east and vary over the proposed longwalls from RL +28 metres over Longwall 50 to RL -127 metres at Longwall 46.

The depths of cover above the West Borehole Seam range from 70 metres over Longwalls 48 and 49 to 360 metres over Longwall 43.

The West Borehole Seam varies in thickness from 3.25 metres thick over Longwall 48 to 5.2 metres over Longwall 46, however, the maximum seam height that can be extracted is 4.8 metres.

1.4. Geological Details

The West Borehole Seam at WWC lies within the Newcastle Coal Measures and within the Northern portion of the Sydney Basin. The strata associated with the coal seams were laid down during the Late Permian Period and the stratigraphy of the Newcastle Coalfield, which has been recently revised, (Ives et al, 1999, Moelle and Dean-Jones, 1995, Lohe and Dean-Jones, 1995) is shown in Table 1.1.

Table 1.1 Permian Stratigraphy of the Newcastle Coalfield

STRATIGRAPHY			LITHOLOGY
Group	**Formation**	**Coal Seams**	
Narrabeen			Sandstone, siltstone, mudstone, claystone
Newcastle Coal Measures	Moon Island Beach	Vales Point Wallarah Great Northern	Sandstone, shale, conglomerate, claystone, coal
	Awaba Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert
	Boolaroo	Fassifern Upper Pilot Lower Pilot Hartley Hill	Conglomerate, sandstone, shale, claystone, coal
	Warners Bay Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert
	Adamstown	Australasian Montrose Wave Hill Fern Valley Victoria Tunnel	Conglomerate, sandstone, shale, claystone, coal
	Nobbys Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone chert
	Lambton	Nobbys [Young [Dudley [Wallsend [West Yard [Borehole Borehole [	Sandstone, shale, minor conglomerate, claystone, coal
	Waratah Sandstone		Sandstone

The Newcastle region is characterised by a complex geological setting, with a great variety of rock types occurring over short lateral and vertical distances (Moelle and Dean-Jones, 1995). Folds, normal faults and dykes dominate the region and generally trend north-west to north-north-west (Lohe and Dean-Jones, 1995). High in-situ horizontal stresses relative to depth have been recorded at West Wallsend Colliery, with major horizontal stress typically oriented north to north-north-east, although valley incision has locally reoriented the maximum horizontal stress parallel to the axis of the ridges, which are oriented east-south-east to south-east (Lohe and Dean-Jones, 1995). The major Macquarie Syncline is located to the west of West Wallsend Colliery.

The Newcastle Coal Measures were formed in a high energy terrestrial setting and contain a high proportion of coarse clastic and volcanogenic sediments (Lohe and Dean-Jones, 1995). The lithology includes sandstone, shale, conglomerate, claystone, tuff, tuffaceous sandstone, tuffaceous siltstone, chert and coal.

West Wallsend Colliery is currently extracting the West Borehole Seam which lies in the Lambton Formation which overlies the Waratah Sandstone. The overlying strata in the vicinity of the application area extend as far as the Boolaroo and lower sections of the Moon Island Beach Formations. Strong and thick strata consisting of conglomerate and sandstone (Young Wallsend Channel) has been observed above or near the roof of the seam at West Wallsend Colliery. The presence of these strata has been linked to observations of significantly reduced subsidence in the area.

High horizontal in-situ stresses and valley bulging have been observed at shallow depths affecting civil works in the Central Coast region (McNally, 1995). Large horizontal stresses have also been observed at a number of collieries on either limb of the Macquarie Syncline, including West Wallsend Colliery, where principal stresses up to 27 MPa have been measured at 200 metres depth (McNally, 1995; Enever et al, 1990). Near-surface measurements from Wakefield indicated high but variable sub-horizontal stress fields with respect to depth. The principal stress component is oriented north to north-north-east, although, near the surface, the principal stress direction has been reoriented parallel to the axis of ridges in the Wakefield area, which are oriented east-south-east to south-east. This local reorientation of maximum horizontal stress has occurred due to the incision of flanking valleys. It was further observed that the horizontal stresses were principally retained in stronger and stiffer strata (such as sandstone) in preference to weaker units (Longworth & McKenzie in Lohe and Dean-Jones, 1995).

In contrast, however, recent stress testing above seam level at Longwall 28 reveals that the in-situ horizontal compressive stress is relatively low (6.9 MPa, DGS Operations, 2003). The differences in the results can be attributed to changes in stress measurement techniques in recent years and to regional variations in the levels of in situ stress.

CHAPTER 2. REVIEW OF AVAILABLE SUBSIDENCE MONITORING DATA AND PREDICTION OF SUBSIDENCE PARAMETERS

In order to provide an independent review of the subsidence predictions and assessments in the DGS report the available subsidence monitoring data over WWC has been reviewed and an independent prediction of subsidence over the existing and future longwalls has been made.

This chapter provides a brief overview of longwall mining, the development of mine subsidence and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the proposed longwalls.

Further details on longwall mining, the development of subsidence and the methods used to predict mine subsidence movements are provided in the background reports entitled *Introduction to Longwall Mining and Subsidence* and *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*.

2.1. Overview of Systematic or Conventional Subsidence Movements

The normal ground movements resulting from the extraction of longwalls are referred to as systematic or conventional subsidence movements. Observed mine subsidence movements can also include non-systematic or non conventional components, which are described in Section 2.2.

A cross-section through a typical single longwall panel showing typical profiles of systematic or conventional subsidence, tilt, curvature and strain is provided in Fig. 2.1.

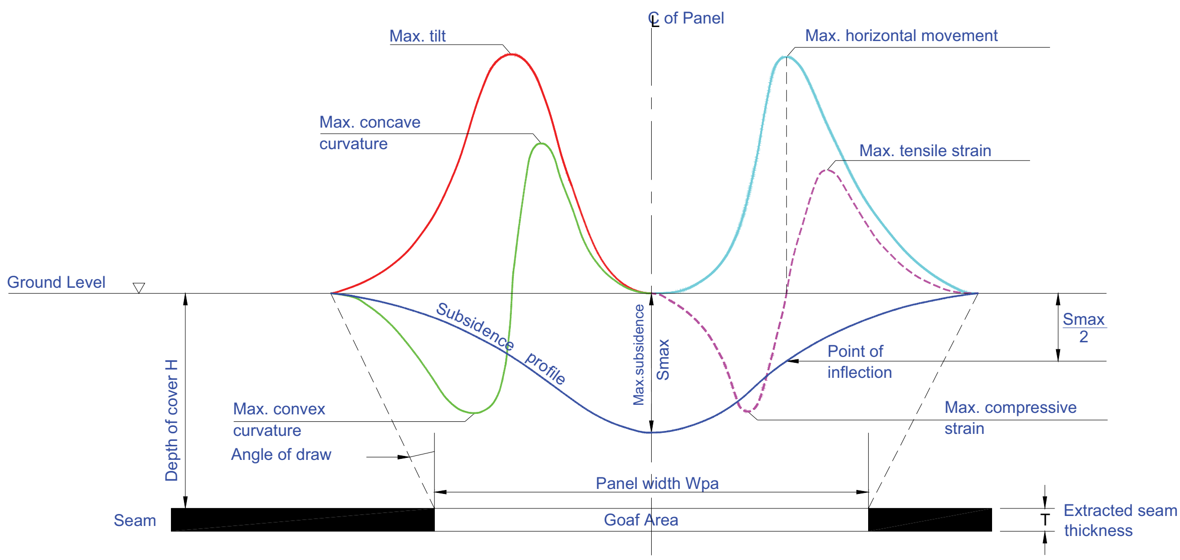


Fig. 2.1 Typical Systematic or Conventional Subsidence Parameters Profiles for a Single Panel

The systematic or conventional ground movements are typically described by the following parameters:-

- **Subsidence** usually refers to vertical movement of a point, but subsidence of the ground actually includes both vertical and horizontal movement. The horizontal movements in some cases, where the subsidence is small, can be greater than the vertical movements. Subsidence is usually expressed in units of *millimetres (mm)*.

- **Tilt** is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.
- **Curvature** is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (1/km)*, but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.
- **Strain** is calculated as the change in horizontal distance between two points on the ground, divided by the original horizontal distance between them. Strain is typically expressed in units of *millimetres per metre (mm/m)*. **Tensile Strains** occur where the distance between two points increases and **Compressive Strains** occur where the distance between two points decreases. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20.

2.2. Overview of Non-Systematic or Non Conventional Subsidence Movements

Conventional subsidence profiles are typically smooth in shape and can be explained by the caving mechanisms associated with overlying strata collapsing into a void. Normal conventional subsidence movements are easy to identify where longwalls are regular in shape, the geological conditions are consistent and surface topography is relatively flat.

As a general rule, the smoothness of the subsidence profiles is governed by the depth of cover and the lithology of the overburden, particularly the near surface strata layers. Where the depth of cover is greater than 400 metres the observed subsidence profiles are generally smooth. Very irregular subsidence movements are observed with much higher tilts and strains at very shallow depths of cover where the collapsed zone above the extracted longwalls extends up to the surface.

Irregular subsidence movements are also observed at the deeper depths of cover along an otherwise smooth subsidence profile and the causes of these occasional irregular subsidence movements are associated with;

- sudden or abrupt changes in geological conditions,
- steep topography,
- valley related mechanisms, and
- issues related to the timing and the method of the installation of monitoring lines.

Approximate predictions of ground movements can be provided for these irregular or non-conventional subsidence movements where the underlying geological or topographic conditions are known in advance.

Non-systematic or non conventional subsidence movements include far-field horizontal movements, although these far-field subsidence movements result in smooth regular subsidence profiles and very low levels of strain.

These non conventional subsidence movements are briefly described below and further details are provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at www.minesubsidence.com.

2.2.1. Irregular Subsidence Movements caused by Changes in Geological Conditions

It is believed that most non-conventional ground movements are a result of the reaction of near surface strata to increased horizontal compressive stresses due to mining operations. The presence of faults, dykes and other igneous structures, cross bedded strata, thin and brittle near surface strata layers and pre-existing natural joints all influence these irregular subsidence movements. The blocky nature of near surface sedimentary strata layers also contributes to irregular subsidence movements. The presence of these geological features near the surface can result in a bump in an otherwise smooth subsidence profile and these bumps are usually accompanied by locally increased tilts and strains. Buckling of surface soils can also occur.

Even though it may be possible to attribute a reason behind most observed non-conventional ground movements, there remain some observed irregular ground movements that still cannot be explained with the available geological information. The term “anomaly” is therefore reserved for those non-conventional ground movement cases that were not expected to occur and cannot be explained by any of the above possible causes.

While the exact cause of an anomaly along an otherwise smooth subsidence profile may not yet be fully understood, it is expected that they will be better understood as the development of mine subsidence knowledge progresses. At the moment these observed non-conventional ground movements are being included, statistically, in current predictions by basing predictions on the frequency of past occurrence of both the conventional and non-conventional observed ground movements.

Such irregular movements can be detected early by regular subsidence monitoring surveys and hence these irregular subsidence movements can be managed.

2.2.2. Far-field Movements

In addition to the systematic horizontal movements which occur above and immediately adjacent to extracted longwalls, far-field horizontal movements have been observed at considerable distances from extracted longwalls. These measured far-field horizontal movements at pegs that are located beyond the longwall panel edges and over solid unmined coal areas are often much greater than the observed vertical movements at those pegs. An empirical database of the observed far-field horizontal movements has been developed and this database allows these far-field horizontal movements to be predicted.

The strata mechanism causing these horizontal movements to be higher than vertical movements beyond the longwall panel edges and over solid unmined coal is believed to result from a redistribution of the insitu horizontal compressive stresses in the strata around the longwalls. Before mining these insitu stresses, which are generally compressive in all directions, are in equilibrium or balance. When mining occurs, the equilibrium is disturbed and the stresses achieve a new balance by shearing through the weaker strata units and allowing the strata to move or expand towards the goaf areas.

Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain. These movements generally do not result in impacts on natural features or built environments, except where they are experienced by large structures which are very sensitive to differential horizontal movements.

2.2.3. Valley Related Movements

The watercourses within the Study Area may be subjected to valley related movements. Valley related movements are a natural phenomenon, resulting from the formation and ongoing development of the valley, as illustrated in Fig. 2.2.

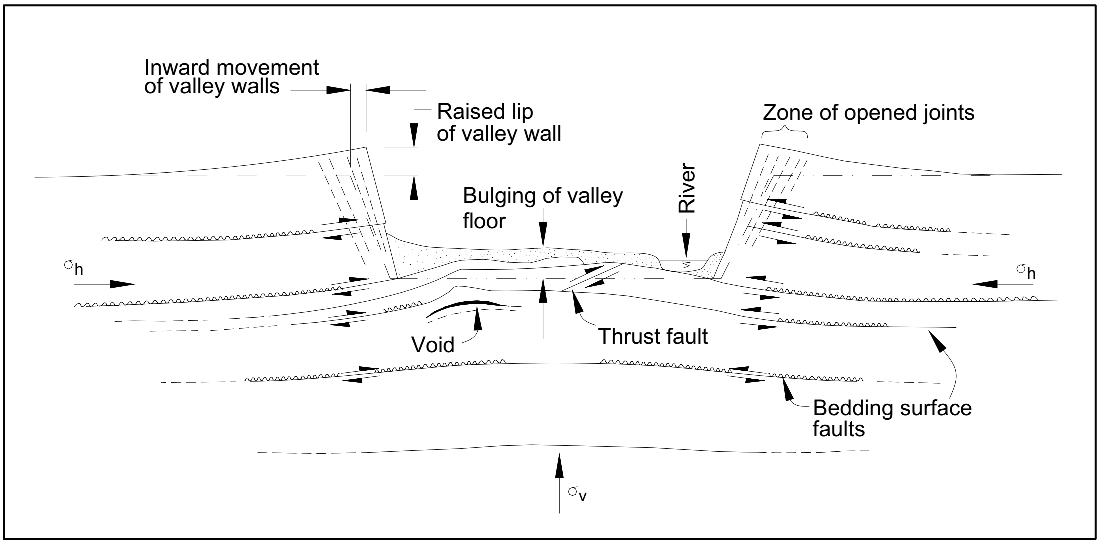


Fig. 2.2 Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)

Valley related movements can be accelerated by mine subsidence as the result of a number of factors, including the redistribution of horizontal in situ stresses and down slope movements. Valley related movements are normally described by the following parameters:-

- **Upsidence** is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the systematic subsidence profile which would have otherwise been expected in flat terrain.
- **Closure** is the reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides.
- **Compressive Strains** occur within the bases of valleys as the result of valley closure and upsidence movements. **Tensile Strains** can also occur in the valley sides and at the tops of the ridges as the result of valley closure movements. The magnitudes of these strains, which are typically expressed in the units of *millimetres per metre (mm/m)*, are calculated as the changes in horizontal distance over a standard bay length, divided by the original bay length. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20.

2.2.4. Definitions of Incremental, Cumulative, Total and Travelling Subsidence Parameters

Incremental, cumulative, total and travelling subsidence parameters are defined as follows:-

- **Incremental** subsidence parameters are the additional movements which occur due to the extraction of a single longwall. Observed incremental subsidence profiles are determined by subtracting the observed subsidence profiles before from the observed subsidence profiles after the extraction of each longwall.
- **Cumulative** subsidence parameters are the accumulated movements which occur due the extraction of a number of longwalls within the series of longwalls.

- **Total** subsidence parameters are the accumulated movements which occur due to the extraction of all longwalls within the series of longwalls.
- **Travelling** subsidence parameters are the transient movements which occur as the longwall extraction face mines directly beneath a point. The maximum travelling tilts, curvatures and strains are typically aligned along the longitudinal axes of the longwalls, with the maximum values typically occurring at the locations of maximum incremental subsidence for each longwall.

2.3. The Incremental Profile Method

The predicted systematic subsidence parameters for the proposed longwalls were determined using the Incremental Profile Method (IPM), which was developed by MSEC, formally known as Waddington Kay and Associates. The method is an empirical subsidence prediction model based on a large database of observed subsidence monitoring data from previous mining within the Southern, Newcastle, Hunter and Western Coalfields of New South Wales. The database consists of detailed subsidence monitoring data from many collieries including: Angus Place, Appin, Baal Bone, Bellambi, Beltana, Bulli, Chain Valley, Clarence, Coalcliff, Cooranbong, Cordeaux, Corrimal, Cumnock, Dartbrook, Delta, Dendrobium, Eastern Main, Ellalong, Fernbrook, Glennies Creek, Gretley, Invincible, John Darling, Kemira, Lambton, Liddell, Mandalong, Metropolitan, Mt. Kembla, Munmorah, Nardell, Newpac, Newstan, Newvale, Newvale 2, Springvale, South Bulga, South Bulli, Stockton Borehole, Teralba, Tahmoor, Tower, Wambo, Wallarah, Western Main, United, Ulan, West Cliff, West Wallsend, and Wyee.

Rather than trying to predict the total subsidence profile directly, the IPM first predicts incremental subsidence profiles for each of the longwall in a series of longwalls, and, then adds the respective incremental profiles to provide a cumulative subsidence profile for any stage in the development of a series of longwalls.

The predicted incremental subsidence profiles for each longwall are based on a large data base of observed incremental subsidence profiles that were derived by subtracting the initial observed subsidence profile (measured prior to mining the longwall) from the final observed subsidence profile (measured after mining the longwall).

Where the mining geometry and local geology are similar the magnitudes of the observed incremental subsidence profiles and the shapes of the observed incremental subsidence profiles are reasonably consistent.

These observed incremental subsidence profiles for each longwall therefore shows the change in the observed subsidence profile caused by the mining of an individual longwall. Studying a range of these observed incremental profile shapes reveals the influence on the shape of subsidence profiles of the;

- extracted longwall panel widths,
- strength and performance of chain pillar,
- ongoing movements over the previously extracted panels,
- number and proximity of adjacent previously extracted panels
- depth of cover of the overburden,
- seam thickness that was extracted, and, the
- immediate and surrounding strata geology.

A wide range of longwall panel and pillar widths and depths of cover is included within the database and the shapes of the observed incremental profiles in the database reflect the behaviour of differing strata over a broad spectrum. The predictions are often tailored to local geological conditions where observed monitoring data is available close to the proposed mining area.

Subsidence predictions made using the IPM use the database of observed incremental subsidence profiles, the proposed longwall geometries, local surface and seam information and local geology.

The method has a tendency to over-predict the systematic subsidence parameters, i.e. it is conservative, where the proposed mining geometry and geology are within the range of the empirical database.

Further details on the Incremental Profile Method are provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained from www.minesubsidence.com.

2.4. Review of Comparison between the Observed and Predicted Subsidence, Tilt and Strain Profiles for the Previously Extracted Longwalls at WWC

Comparisons between the observed and predicted subsidence, tilt and stain profiles resulting from the extraction of previous longwalls at West Wallsend Colliery have been made at the pegs along the monitoring lines that were established along and across those longwalls using the standard IPM with no geological factors or local calibration factors.

The subsidence profiles for the standard IPM for the Newcastle Coalfield were derived from an extensive empirical database and are based on a maximum subsidence factor of 55% of the extracted seam thickness and the surface level contours, seam floor contours and seam thickness contours that were provided by WWC.

The results of this comparison are provided in Figures 1 to 7 in Appendix C as detailed in the list below;

- Fig. 1 Comparison of Observed and Predicted Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Cross Line WX and over WWC LWs 1 to 10
- Fig. 2 Comparison of Observed and Predicted Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Cross Line WN and over WWC LWs 11 to 18
- Fig. 3 Comparison of Observed and Predicted Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Cross Line WN and over WWC LWs 19 to 24
- Fig. 4 Comparison of Observed and Predicted Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Cross Line WN and over WWC LWs 27, 28 and 31
- Fig. 5 Comparison of Observed and Predicted Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Cross Line WO and over WWC LWs 28 and 31 to 34
- Fig. 6 Comparison of Observed and Predicted Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Cross Line WP and over WWC LWs 34 to 36
- Fig. 7 Comparison of Observed and Predicted Profiles of Systematic Subsidence, Tilt and Strain along Monitoring Longitudinal Line WC along LW 28

Further details regarding the mining geometry and the maximum observed subsidence along these monitoring lines are given in the following Table 2.1.

Many factors influence the magnitude of observed subsidence over a mined panel. The overburden geology, the panel widths, the pillar widths and the depths of cover all influence the magnitude of the maximum observed subsidence values.

Increasing subsidence is generally observed with increasing panel width-to-depth ratios, as shown by the prediction curves given in the above figures, but, for a constant panel width-to-depth ratio, the observed subsidence values are also affected by differing pillar widths, cover depths and variations in strata geology.

The maximum subsidence measured along these monitoring lines was 2416 mm which was observed on the WP-Line over LW 36. At this location the depth of cover was only 140 metres, and the extracted seam thickness was the maximum cutting height of 4.8 metres. This maximum observed subsidence represented 50% of the extracted seam thickness.

It is noted that the observed strains at this location were 30 mm/m and localised peak values of strains of 23 mm/m and 39 mm/m have been measured at other locations.

Table 2.1 Showing Maximum Observed Subsidence on the available Monitoring Lines

LW	Fig.	Monitoring Line	Type of Line	Panel Width (m)	Depth of Cover	Panel width on Depth of Cover	Max Observed Total Subs	Seam Thickness Mined	SmaxTotObs'd/ SeamT	Max Pred'd Total Subs (IPM)	Max Obs'd / Max Pred'd
LW1	1	WX	Cross	120	186	0.65	216	2.45	0.09	361	60%
LW2	1	WX	Cross	133	187	0.71	289	2.45	0.12	615	47%
LW3	1	WX	Cross	133	193	0.69	218	2.2	0.10	566	39%
LW4	1	WX	Cross	133	198	0.67	324	2.1	0.15	547	59%
LW5	1	WX	Cross	137	200	0.69	357	2.1	0.17	563	63%
LW6	1	WX	Cross	135	207	0.65	318	2.1	0.15	522	61%
LW7	1	WX	Cross	200	209	0.96	1002	2.1	0.48	1088	92%
LW8	1	WX	Cross	183	225	0.81	853	2.18	0.39	882	97%
LW9	1	WX	Cross	200	208	0.96	885	2.18	0.41	1093	81%
LW10	1	WX	Cross	202	190	1.06	809	2.1	0.39	1124	72%
LW11	2	WN	Cross	202	245	0.82	889	2.5	0.36	899	99%
LW12	2	WN	Cross	150	250	0.60	831	2.5	0.33	872	95%
LW13	2	WN	Cross	150	256	0.59	813	2.5	0.33	816	100%
LW14	2	WN	Cross	150	235	0.64	770	2.5	0.31	799	96%
LW15	2	WN	Cross	150	234	0.64	876	2.6	0.34	961	91%
LW16	2	WN	Cross	150	244	0.61	1197	4.6	0.26	1375	87%
LW17	2	WN	Cross	150	253	0.59	801	4.75	0.17	1138	70%
LW18	2	WN	Cross	120	234	0.51	200	4.7	0.04	450	44%
LW19	3	WN	Cross	150	222	0.68	932	4.8	0.19	997	93%
LW20	3	WN	Cross	150	214	0.70	762	4.8	0.16	1282	59%
LW21	3	WN	Cross	150	209	0.72	477	4.8	0.10	1364	35%
LW22	3	WN	Cross	150	210	0.71	564	4.8	0.12	1329	42%
LW23	3	WN	Cross	150	209	0.72	813	3.7	0.22	1078	75%
LW24	3	WN	Cross	150	200	0.75	481	3.65	0.13	980	49%
LW27	4	WN	Cross	175	157	1.11	1342	4.68	0.29	2272	59%
LW28	4	WN	Cross	175	151	1.16	1739	4.5	0.39	2274	76%
LW31	4	WN	Cross	175	135	1.30	1684	4.5	0.37	2406	70%
LW28	5	WO	Cross	175	192	0.91	1575	4.8	0.33	1839	86%
LW31	5	WO	Cross	175	210	0.83	1248	4	0.31	1561	80%
LW32	5	WO	Cross	175	216	0.81	1160	4.7	0.25	1750	66%
LW33	5	WO	Cross	175	190	0.92	1495	4.75	0.31	2052	73%
LW34	5	WO	Cross	178.6	186	0.96	1834	4.8	0.38	2167	85%
LW34	6	WP	Cross	178.6	175	1.02	1419	4.8	0.30	2213	64%
LW35	6	WP	Cross	178.6	150	1.19	1399	4.8	0.29	2527	55%
LW36	6	WP	Cross	178.6	140	1.28	2416	4.8	0.50	2625	92%
LW28	7	WC	Longitudinal	175	200	0.88	1571	4.8	0.33	1830	86%
LW28	7	WC	Longitudinal	175	170	1.03	1484	4.3	0.35	1728	86%
LW28	7	WC	Longitudinal	175	140	1.25	1561	4.5	0.35	2290	68%
										minimum =	35%
										maximum =	100%
										average =	73%

It is clear from Figures 1 to 7 and from Table 2.1 that the maximum observed subsidence values from the subsidence monitoring lines over the previously extracted longwalls at WWC are smaller than the maximum subsidence values that were predicted using the standard IPM for the Newcastle Coalfield, i.e. with no geological or local calibration factors for the massive conglomerate strata channels. On average the observed maximum subsidence values are 73% of the maximum subsidence values that were predicted using the standard IPM for the Newcastle Coalfield.

The maximum observed subsidence at the WN line over Longwall 21was 477 mm, which is 35% of the standard IPM subsidence prediction of 1364 mm.

It is understood that, where massive conglomerate channels exist, the maximum subsidence reductions were observed and, where no conglomerate channels exist, the maximum predicted subsidence values closely matched the observed maximum subsidence values. No predictions of subsidence, tilt and strain profiles were provided in the DGS report along these previously monitored subsidence lines and, hence, we cannot compare the calibration of the DGS ACARP prediction method or the SDPS Model against the monitored values.

Having reviewed the available subsidence monitoring data, it is recognised that a calibrated prediction method could be developed, based on the local data and knowledge of the existence of the massive conglomerate channels and knowledge of the local depths of cover. However, for this review report, it was considered appropriate to provide only conservative standard subsidence predictions to provide the check on the adequacy of the predicted subsidence values in the DGS report and on the adequacy of the assessed subsidence impacts and consequences. The provision of conservative standard subsidence predictions was also considered appropriate because the Colliery had modified the mine plan so that the proposed longwalls were not located directly beneath the sensitive surface creeks, archaeological sites or manmade features and because this modification of the mine plan resulted in low predicted subsidence ground movements which minimised the potential adverse subsidence impacts at these sensitive natural and manmade structures.

CHAPTER 3. MAXIMUM PREDICTED SUBSIDENCE PARAMETERS FOR THE PROPOSED FUTURE LONGWALLS

3.1. Introduction

The following sections provide the maximum predicted subsidence parameters due to the proposed extraction of the Longwalls 38 to 50 using the conservative subsidence predictions as obtained using the standard IPM for the Newcastle Coalfield, which were based on a 55% maximum subsidence factor with no geological factors.

It should be noted that the maximum predicted systematic subsidence parameters that are provided below only show the systematic or conventional movements, i.e. they do not include the valley related upsidence and closure movements, nor the effects of faults and other geological structures.

3.2. Maximum Predicted Systematic Subsidence, Tilt and Curvature

A summary of the maximum predicted incremental systematic subsidence, tilts and curvatures resulting from the extraction of the proposed longwalls are provided in Table 3.1.

Table 3.1 Maximum Predicted Incremental Subsidence, Tilts and Curvatures

Longwall	Maximum Incremental Subsidence	Maximum Incremental Transverse Tilt	Maximum Incremental Longitudinal Tilt	Maximum Incremental Tilt	Maximum Incremental Transverse Tensile Strain	Maximum Incremental Transverse Compressive Strain	Maximum Incremental Longitudinal Tensile Strain	Maximum Incremental Longitudinal Compressive Strain
LW38	2678	64	70	70	28	-22	24	-25
LW39	2647	73	58	73	40	-28	23	-24
LW40	2769	73	95	95	47	-30	43	-49
LW41	2774	84	102	102	54	-40	69	-68
LW42	2773	101	125	125	83	-57	89	-112
LW43	2709	108	95	108	104	-70	65	-60
LW44	2798	65	92	92	28	-23	44	-48
LW45	2748	55	64	64	20	-15	22	-21
LW46	2392	42	54	55	14	-19	21	-23
LW47	2587	104	75	104	76	-75	32	-37
LW48	2449	88	88	89	71	-41	59	-54
LW49	2238	57	80	83	33	-28	66	-75
LW50	2258	54	99	99	26	-17	71	-74

A summary of the maximum predicted total systematic subsidence, tilts and curvatures resulting from the extraction of the proposed longwalls are provided in Table 3.1 and Table 3.2.

The maximum predicted subsidence parameters provided in these tables occur in the locations where the depths of cover are the shallowest or the extraction heights are the greatest in each mining domain.

3.3. Comparison between IPM Predicted Subsidence and DGS Predicted Subsidence

Comparisons have been made between the predicted subsidence, tilt and stain profiles along five prediction lines that cross the proposed Longwalls 38 to 50 at West Wallsend Colliery, using the standard IPM for the Newcastle Coalfield and the predicted subsidence, tilt and stain profiles that are presented in the DGS report.

These five prediction lines show the likely range of predicted subsidence parameters over the future longwall areas. The five prediction lines were prepared by DGS and are numbered XL5, XL7, XL9, XL10 and XL11. The positions of these five prediction lines are shown in Drawing No. MSEC433-01.

Table 3.2 Maximum Predicted Total Subsidence, Tilts and Curvatures

Longwall	Maximum Total Subsidence	Maximum Total Tilt	Maximum Total Tensile Strain	Maximum Total Compressive Strain
LW38	2687	70	28	-27
LW39	2771	73	40	-28
LW40	2771	95	47	-49
LW41	2858	102	69	-68
LW42	2879	125	89	-112
LW43	2879	125	109	-112
LW44	2879	125	109	-112
LW45	2879	125	109	-112
LW46	2879	125	109	-112
LW47	2891	125	109	-112
LW48	2891	125	109	-112
LW49	2891	125	109	-112
LW50	2891	125	109	-112

The results of the comparisons of predicted subsidence, tilt and strain profiles are provided in Figures 8 to 12 in Appendix C as detailed below;

Fig. 8 Comparison of Predicted IPM Profiles of Subsidence, Tilt and Strain along Prediction Line XL5 with Predicted DGS Profiles of Subsidence, Tilt and Strain

Fig. 9 Comparison of Predicted IPM Profiles of Subsidence, Tilt and Strain along Prediction Line XL7 with Predicted DGS Profiles of Subsidence, Tilt and Strain

Fig. 10 Comparison of Predicted IPM Profiles of Subsidence, Tilt and Strain along Prediction Line XL9 with Predicted DGS Profiles of Subsidence, Tilt and Strain

Fig. 11 Comparison of Predicted IPM Profiles of Subsidence, Tilt and Strain along Prediction Line XL10 with Predicted DGS Profiles of Subsidence, Tilt and Strain

Fig. 12 Comparison of Predicted IPM Profiles of Subsidence, Tilt and Strain along Prediction Line XL11 with Predicted DGS Profiles of Subsidence, Tilt and Strain

As was anticipated, these plots indicate that the standard IPM for the Newcastle Coalfield provides conservative subsidence predictions for proposed longwalls within the project area.

Table 3.3 shows details of the mining geometry and the maximum predicted total subsidence above the proposed Longwalls 38 to 50 using the standard IPM for the Newcastle Coalfield without any geological or calibration factors and using the predicted subsidence values provided in the DGS report. From Figures 8 to 12 and from Table 3.3 it can be noted that the standard IPM for the Newcastle Coalfield without any geological or calibration factors are generally 20% higher than the subsidence values predicted in the DGS report.

We note that the DGS subsidence predictions exceeded the subsidence predictions prepared by MSEC for two longwalls across Prediction Line XL5 and this may be related to how the predictions accommodate the increased depth of cover at these locations. We cannot check on the accuracy of the DGS predictions in allowing for the influence from the five identified conglomerate and sandstone channels as we have not set this up in our IPM predictions and the DGS report did not provide a comparison of subsidence along the monitored subsidence lines that were located over the previously extracted longwalls using the DGS ACARP method or the SDPS model. Hence we cannot advise whether the subsidence predictions in the DGS report are conservative or not.

We would anticipate that the actual observed subsidence over these longwalls would be less than subsidence obtained using the standard IPM for the Newcastle Coalfield without geological factors or local calibration factors for the reduction effects due to these massive conglomerate beams.

Nevertheless, it is concluded from this review that the DGS subsidence predictions compare reasonably well with the subsidence predictions prepared by MSEC using the standard IPM for the Newcastle Coalfield.

Table 3.3 Maximum Predicted IPM and DGS Total Subsidence along Prediction Lines XL5 to XL11

LW	Fig.	Monitoring Line	Type of Line	Panel Width (m)	Depth of Cover	Seam Thickness Mined	Panel width on Depth of Cover	Max DGS Pred'd Total Subs	Max Pred'd IPM Total Subs	Max Pred'd DGS/ Max Pred'd IPM
LW38	8	XL5	Cross	178.6	105	4.5	1.70	2600	2767	94%
LW39	8	XL5	Cross	178.6	96	4.3	1.86	2492	2703	92%
LW40	8	XL5	Cross	178.6	93	4.1	1.92	2345	2541	92%
LW41	8	XL5	Cross	178.6	131	4	1.36	2124	2261	94%
LW42	8	XL5	Cross	178.6	210	3.9	0.85	1211	1743	69%
LW43	8	XL5	Cross	178.6	281	3.7	0.64	1527	1282	119%
LW47	8	XL5	Cross	178.6	281	3.6	0.64	1491	1150	130%
LW48	8	XL5	Cross	178.6	260	3.5	0.69	902	1061	85%
LW38	9	XL7	Cross	178.6	152	4.5	1.18	1780	2272	78%
LW39	9	XL7	Cross	178.6	144	4.3	1.24	2362	2298	103%
LW40	9	XL7	Cross	178.6	146	4.2	1.22	1851	2200	84%
LW41	9	XL7	Cross	178.6	165	4	1.08	1717	2015	85%
LW42	9	XL7	Cross	178.6	168	3.9	1.06	1586	1846	86%
LW43	9	XL7	Cross	178.6	138	3.7	1.29	1642	2099	78%
LW47	9	XL7	Cross	178.6	196	3.7	0.91	1304	1686	77%
LW48	9	XL7	Cross	178.6	240	3.7	0.74	1144	1296	88%
LW49	9	XL7	Cross	178.6	188	3.7	0.95	1382	1556	89%
LW40	10	XL9	Cross	178.6	110	4.5	1.62	2553	2785	92%
LW41	10	XL9	Cross	178.6	87	4.3	2.05	2492	2757	90%
LW42	10	XL9	Cross	178.6	78	4	2.29	2316	2589	89%
LW43	10	XL9	Cross	178.6	99	3.9	1.80	2035	2600	78%
LW47	10	XL9	Cross	178.6	113	3.9	1.58	1789	2342	76%
LW48	10	XL9	Cross	178.6	110	3.8	1.62	1912	2334	82%
LW49	10	XL9	Cross	178.6	133	3.8	1.34	1690	2211	76%
LW50	10	XL9	Cross	178.6	156	3.7	1.14	1334	2065	65%
LW42	11	XL10	Cross	178.6	77	4.4	2.32	2531	2867	88%
LW43	11	XL10	Cross	178.6	73	4.2	2.45	2465	2893	85%
LW47	11	XL10	Cross	178.6	83	4.1	2.15	2380	2614	91%
LW48	11	XL10	Cross	178.6	133	3.9	1.34	1709	2267	75%
LW49	11	XL10	Cross	178.6	120	3.7	1.49	1537	2166	71%
LW44	12	XL11	Cross	168	134	4.7	1.25	1823	2587	70%
LW45	12	XL11	Cross	178.6	156	4.8	1.14	1812	2389	76%
LW46	12	XL11	Cross	178.6	174	4.8	1.03	1452	2044	71%
									minimum =	65%
									maximum =	130%
									average =	86%

3.4. Comparison between IPM Predicted Strains and DGS Predicted Strains

The prediction of strain is less accurate and is generally more difficult than the predictions of subsidence, tilt and curvature because, although strain is predominantly affected by ground curvature and horizontal movement, strain is also affected by other factors including; local variations in the near surface geology, the locations of the natural joints at bedrock, the extent of shearing along these joints, the depth of the surface bedrocks, valley related movements, far field movements, en-masse movements, ground moisture changes and survey tolerance. The observed strain profiles can be irregular even when the profiles of observed subsidence and tilt are relatively smooth. The observed profiles of strain and curvature are also sensitive to surveying practices and limitations.

The predictions of strain using the standard IPM that have been provided in this report have been based on a best estimate of the average relationship between curvature and strain. In the Newcastle Coalfield, it has been found that applying a factor of 10 to the predicted curvature provides a reasonable estimate of the maximum predicted strains. Similar or lower relationships have been proposed by other authors. But, as highlighted in previous MSEC reports, measured strains can vary considerably from the predicted averaged systematic values.

Figures 1 to 7, which compare the monitored subsidence, tilt and strain values at pegs along the monitored survey lines against the subsidence, tilt and strain values that were predicted at those pegs using the standard IPM for the Newcastle Coalfield, reveals that, whilst the standard IPM for the Newcastle Coalfield predicted subsidence profiles reasonably well, it did not predict strain values accurately, particularly at the localised peak strain values or the spikes. Some of the localised peak values of strain occurred at survey discontinuities locations and other localised peak values of strain occurred where faults and major disturbed zones are known to exist. In shallow mining situations some of these peak values could have been caused by the behaviour of blocky surface layers. Apart from the localised peak values, the average strain values predicted using the standard IPM for the Newcastle Coalfield reflected the averaged monitored subsidence, tilt and strain values.

Figures 8 to 12, which compare the predicted subsidence, tilt and strain values along the XL Prediction Lines over the proposed Longwalls 38 to 50 with the values that were predicted using the standard IPM for the Newcastle Coalfield, reveal that these predicted strain values are generally similar, although the standard IPM predicts generally higher strain values than the strain values that are presented in the DGS report. At very shallow cover, the IPM predicts much higher strain values than the predicted strain values that are presented in the DGS report.

However, as discussed above, we highlight that neither the standard IPM strain predictions or the DGS strain predictions are capable of matching the observed strains well, particularly since observed strains are not dependant solely on mining induced curvature, and also because the observed strains and curvatures are sensitive to surveying limitations. Neither prediction method would be capable of predicting the location of nor the values of the localised peak strain values.

As highlighted in previous MSEC reports, measured or observed strains can vary considerably from the predicted averaged systematic values. The predicted IPM strains are only claimed to reflect the averaged monitored strain values.

CHAPTER 4. REVIEW OF IMPACT ASSESSMENTS IN THE DGS REPORT

4.1. Review of Impact Assessments in DGS Report

The DGS report provides a description of significant natural and manmade surface features, provides subsidence predictions at each surface feature, assesses of subsidence impacts to these surface features, identifies where further subsidence monitoring is required and discusses the possible need for minor remedial work.

4.1.1. Impacts and Consequences to Creeks and Water Resources

The DGS report includes an assessment of the heights of continuous and discontinuous sub-surface fractures above the proposed Longwalls 38 to 50, the potential for direct hydraulic connection to the surface and the likely increases to rock mass permeability after mining. As a result of this assessment, the DGS report assessed the following surface water and groundwater impacts;

- surface cracking is expected.
- creek flows may be re-routed below-surface pathways and re-surfacing down-stream of the mining extraction limits where shallow surface rock is present until the surface cracking infilled by sediments.
- repairs to some of the wider and deeper creek beds may be required where cracks are unable to ‘self-heal’ and this remediation would be arranged in consultation with the stakeholders and government agencies.
- ponding and scouring is expected along several of the longwalls.
- direct hydraulic connection to the surface could occur where the depth of cover is less than 100 metres.
- indirect connections to the surface could occur where the depths of cover are less than 213 metres.

We also note that the report that was prepared by Ian Forster of Aurecon, on Hydrogeological Assessment for the Proposed Longwalls at WWC, also assessed that there will be areas where the surface water and the groundwater within the near-surface alluvial deposits are likely to be affected by the proposed mining. Whilst assessing that this impact is likely to occur, it also advised that the affected surface water and groundwater resource was not utilised much. Hence, even if cracking does occur and some water is lost, it will be of little consequence.

It can also be noted that if surface cracking does occur and some water is lost then WWC can remediate the cracks and the affected surface areas quickly to prevent any ongoing losses. Following these remediation works there should be no further diversions of surface water or near surface alluvial water resources.

If the levels of observed subsidence are double the predicted subsidence values in the DGS report slightly increased levels of cracking, ponding, scouring and hydraulic connections will occur, but, the management strategy of remediating the observed cracks and remediating the beds of the creeks will be same.

4.1.2. Impacts and Consequences to F3 Freeway and Associated Infrastructure

Small predicted ground movements have been predicted at the F3 freeway, pavement areas, culverts, embankments, cuttings and its bridges. WWC has extracted ten previous longwalls near the F3 freeway and has undertaken detailed survey programmes around the corners of each of these previous longwalls which confirmed that the observed subsidence ground movements were small. Impacts were observed over the edge of Longwall 28 at WWC within a cutting of the F3 freeway and it appeared that the buckling occurred due to release of insitu compressive horizontal stresses.

We understand that the levels of measured insitu stress, within the surface ridges near the proposed Longwalls 38 to 46, may be similar or higher to the levels that were measured near Longwall 28. It is understood that subsidence predictions for the small horizontal movements at the F3 Freeway have been provided to the RTA and a management plan for the proposed Longwalls 38 to 40 has been agreed.

It may be necessary to undertake some preventive measures, if the pavements and bridge movement joints and bearings are not considered capable of accommodating the predicted differential movements. Fortunately the mine plan involves the longwalls being extracted towards the freeway and this allows improved management strategies for protecting the pavements, cuttings and bridges.

It is also recommended that management strategies are developed, in consultation with the RTA, which could include the:-

- Implementation of preventive measures, if required, to provide the necessary capacity at the pavements and bridge movement joints,
- Installation of a monitoring system, which could include, amongst other things, the monitoring of ground movements, structure movements, bridge joint displacements and visual inspections,
- Implementation of a response plan, where actions are triggered by monitoring results, and
- Implementation of a reporting and communication plan.

4.1.3. Impacts and Consequences at Other Items of Surface Features and Infrastructure

The most significant natural and manmade surface features above and in the vicinity of the proposed longwalls are the several creeks, alluvial aquifers, F3 Freeway and a major utilities easement which has high pressure gas and petroleum pipelines and three optical fibre cables, three communications towers, Wakefield Road, a farm dam and heritage sites.

However, as detailed in the DGS report, the Colliery pulled back the starting and finishing ends of the proposed longwalls from the freeway and the services easement, the sensitive heritage sites and from an area of low depth of cover in the vicinity of Ryhope Creek. These changes to the mine layout reduced the levels of subsidence impacts and consequences at these natural and manmade surface features to manageable levels. Even if the predicted subsidence movements at these features are doubled, i.e. increased above both the predicted levels of subsidence provided in the DGS report and increased above the levels of subsidence predicted using the standard IPM for the Newcastle Coalfield, the levels of subsidence impacts and consequences at these natural and manmade surface features are still at manageable levels.

The assessments of subsidence impacts and consequences that are provided in the DGS Report for the other natural features and surface improvements that are located over the proposed longwalls have also been reviewed and MSEC considers them and the proposed management strategies to be reasonable, even if the predicted subsidence movements at these features are increased to the levels of subsidence predicted using the standard IPM for the Newcastle Coalfield.

Nevertheless, it is recommended that detailed monitoring be undertaken near each of the significant natural and manmade surface features during the extraction of the adjacent longwalls to confirm that the observed levels of subsidence impacts are acceptable.

APPENDIX A - GLOSSARY OF TERMS AND DEFINITIONS

Glossary of Terms and Definitions

Some of the more common mining terms used in the report are defined below:-

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Closure	**T**he reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides. It should be noted that the observed closure movement across a valley is the total movement resulting from various mechanisms, including conventional mining induced movements, valley closure movements, far-field effects, downhill soil slumping and other possible strata mechanisms.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections, i.e. curvature is the second derivative of subsidence. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (km-1)*, but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.
Extracted seam thickness	The thickness of coal that is extracted. The extracted seam thickness is normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
Far-field movements	**T**he measured horizontal movements at pegs that are located beyond the longwall panel edges and over solid unmined coal areas. Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Panel	The plan area of coal extraction.

Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.
Shear deformations	The horizontal displacements that are measured across a survey line and these can be described by various parameters including; horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points, i.e. strain is the relative differential displacement of the ground along or across a subsidence monitoring line. Strain is dimensionless and can be expressed as a decimal, a percentage or in parts per notation. **Tensile Strains** are measured where the distance between two points or survey pegs increases and **Compressive** Strains where the distance between two points decreases. Slope strains have occasionally been determined, but, they should not be confused with the horizontal strains that are usually discussed when comparing mine subsidence issues. In most subsidence literature strain is expressed in units of *millimetres per metre (mm/m)*. So that these mining induced strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20. Whilst mining induced **strains** are measured **along** monitoring line, ground **shearing** can occur both vertically, and horizontally **across** the direction of the monitoring line
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel, but, 'subsidence of the ground' in some references can include both a vertical and horizontal movement component. The vertical component of subsidence is measured by determining the change in surface level of a peg that is fixed in the ground before mining commenced and this vertical subsidence is usually expressed in units of *millimetres (mm)*. Sometimes the horizontal component of a peg's movement is not measured, but in these cases, the horizontal distances between a particular peg and the adjacent pegs are measured.
Subsidence Effects	The deformations of the ground mass surrounding a mine, sometimes referred to as 'components' or 'parameters' of mine subsidence induced ground movements including; vertical and horizontal displacements, tilts, curvatures, strains, upsidence and closure

Subsidence Impacts The physical changes or damage to the fabric or structure of the ground, its surface and natural features, or man-made structures that are caused by the subsidence effects. These impacts considerations can include; tensile and shear cracking of the rock mass, localised buckling of strata bed separation, rock falls, collapse of overhangs, failure of pillars, failure of pillar floors, dilation, slumping and also include subsidence depressions or troughs.

Subsidence Consequences The knock-on results of subsidence impacts, i.e. any change in the amenity or function of a natural feature or man-made structure that arises from subsidence impacts. Consequence considerations include; public safety, loss of flows, reduction in water quality, damage to artwork, flooding, draining of aquifers, the environment, community, land use, loss of profits, surface improvements and infrastructure. Consequences related to natural features are referred to as environmental consequences.

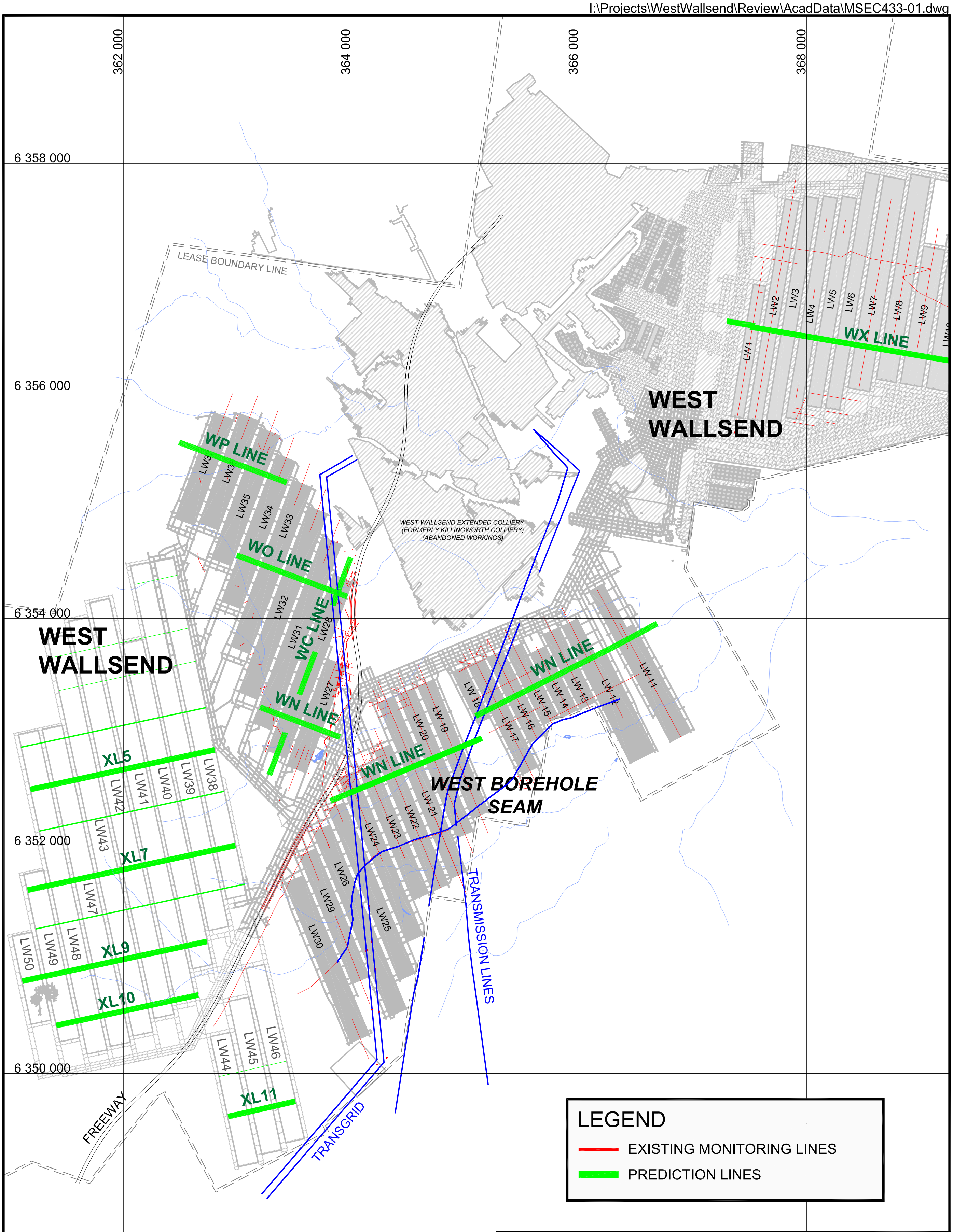
Super-critical area An area of panel greater than the critical area.

Tilt The change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the horizontal distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.

Uplift An increase in the level of a point relative to its original position.

Upsidence A reduction in the expected subsidence at a point, being the difference between the predicted subsidence and the subsidence actually measured. Where upsidence exceeds subsidence a relative uplift of the valley floor can be observed. Upsidence results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.

APPENDIC B DRAWINGS



MINE SUBSIDENCE ENGINEERING CONSULTANTS
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PO Box 3047, Willoughby North, NSW 2068
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REVIEW OF SUBSIDENCE PREDICTIONS FOR PROPOSED WEST WALLSEND LONGWALLS

DATE:	SCALE:	DRAWING No:	Rev No
1-Dec-2009	1:45000	MSEC433-01	

APPENDIX C. FIGURES

West Wallsend Colliery LWs 1 to 10 WX Line

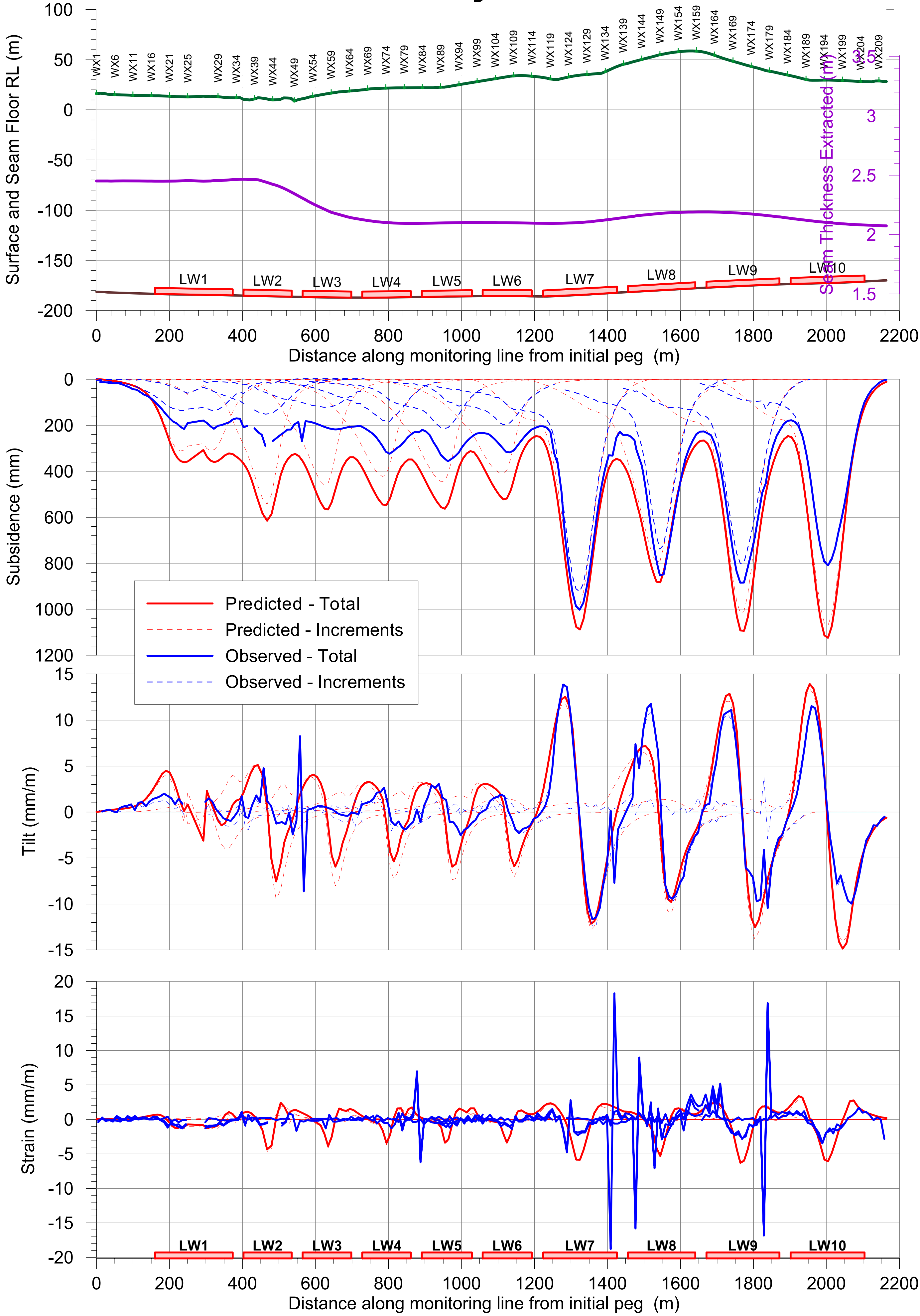

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Fig. 1

I:\Projects\West Wallsend\Review\Subsdata\Monitoring Lines\Grapher 7 - LW11 to 18 WN Line Narrow+wide.grf 04-Dec-09

West Wallsend Colliery LWs 11 to 18 WN Line

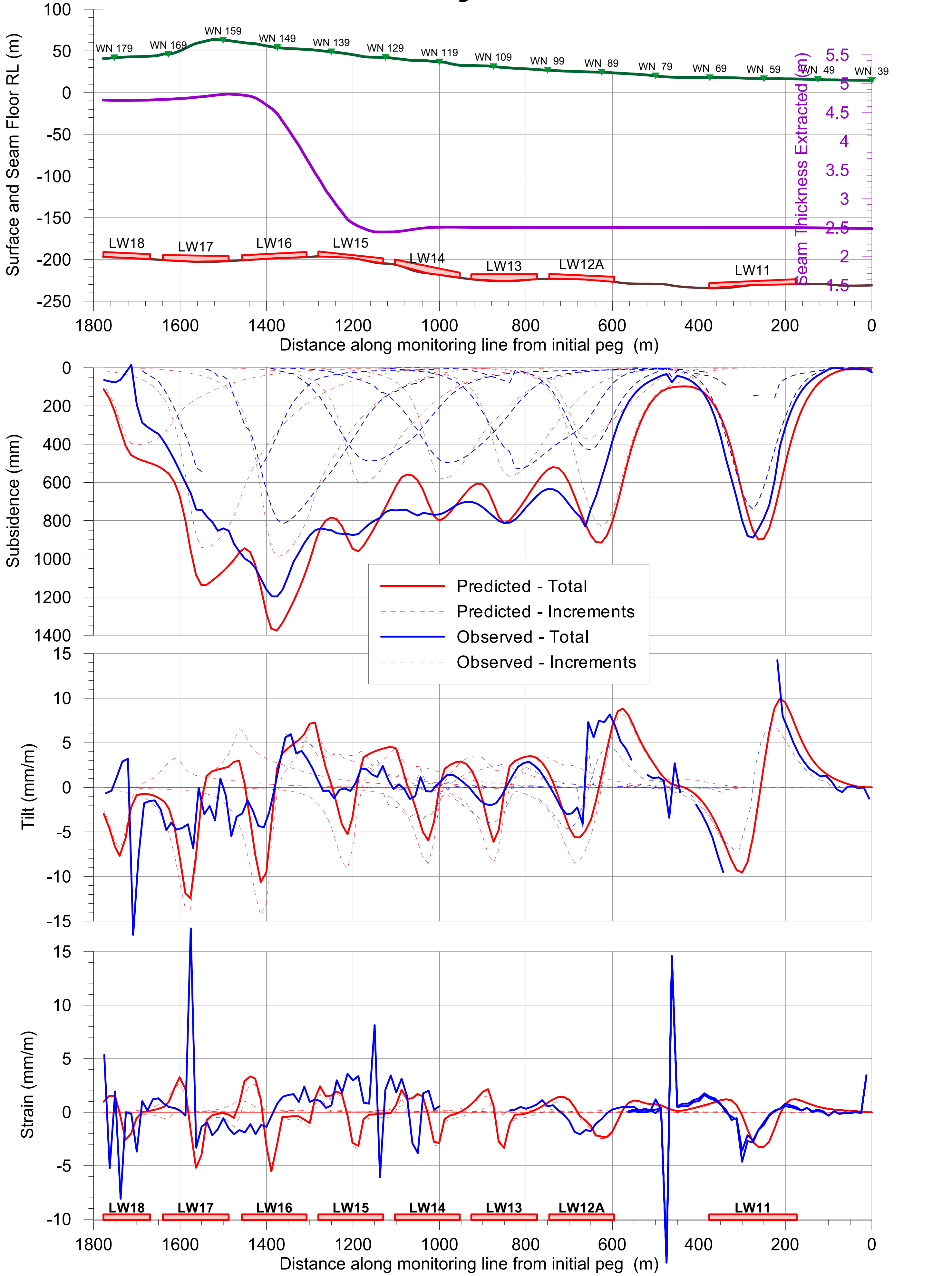

Fig. 2

West Wallsend Colliery LWs 19 to 24 WN Line

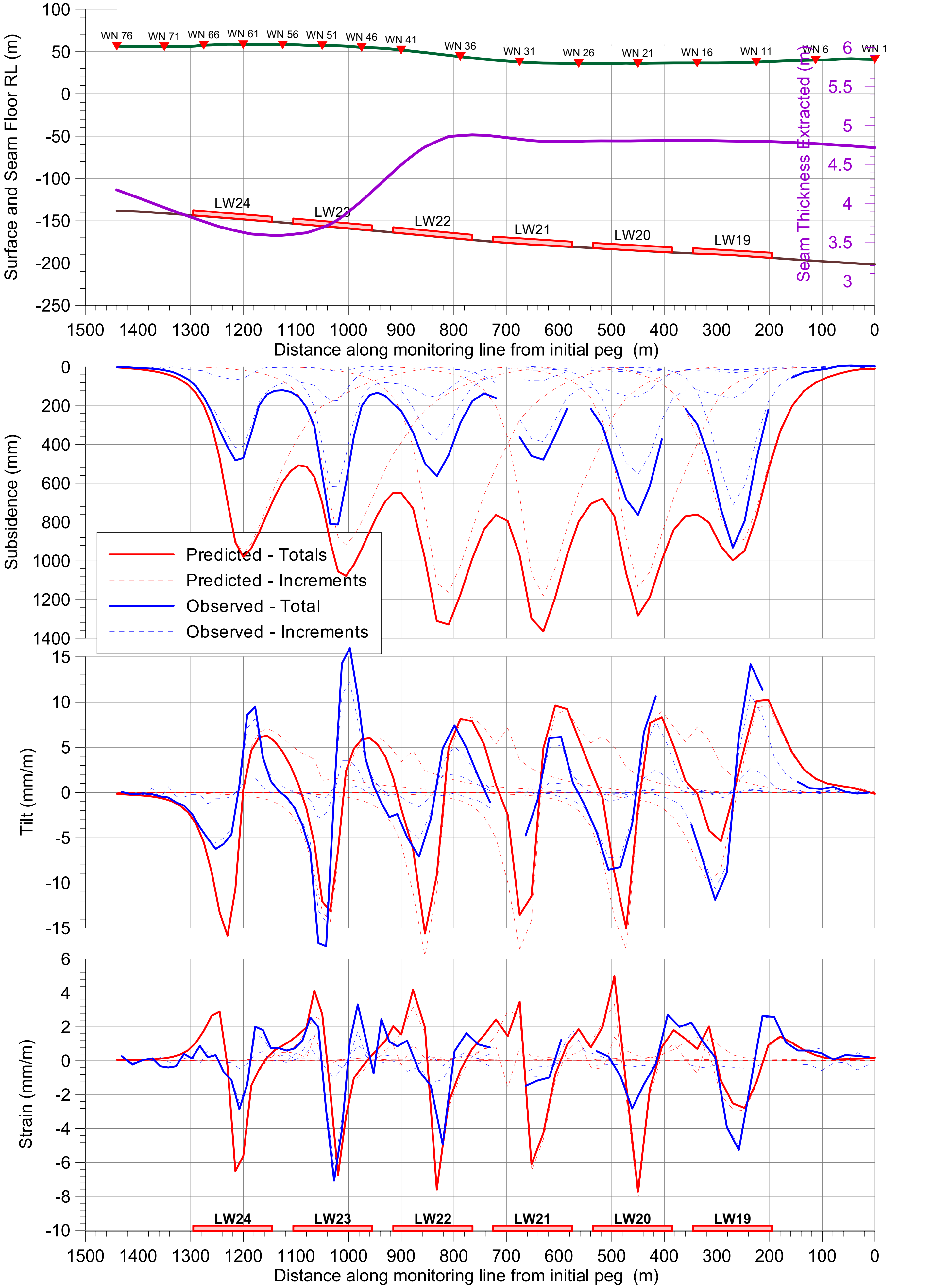

Fig. 3

West Wallsend Colliery LWs 27 to 31 WN Line

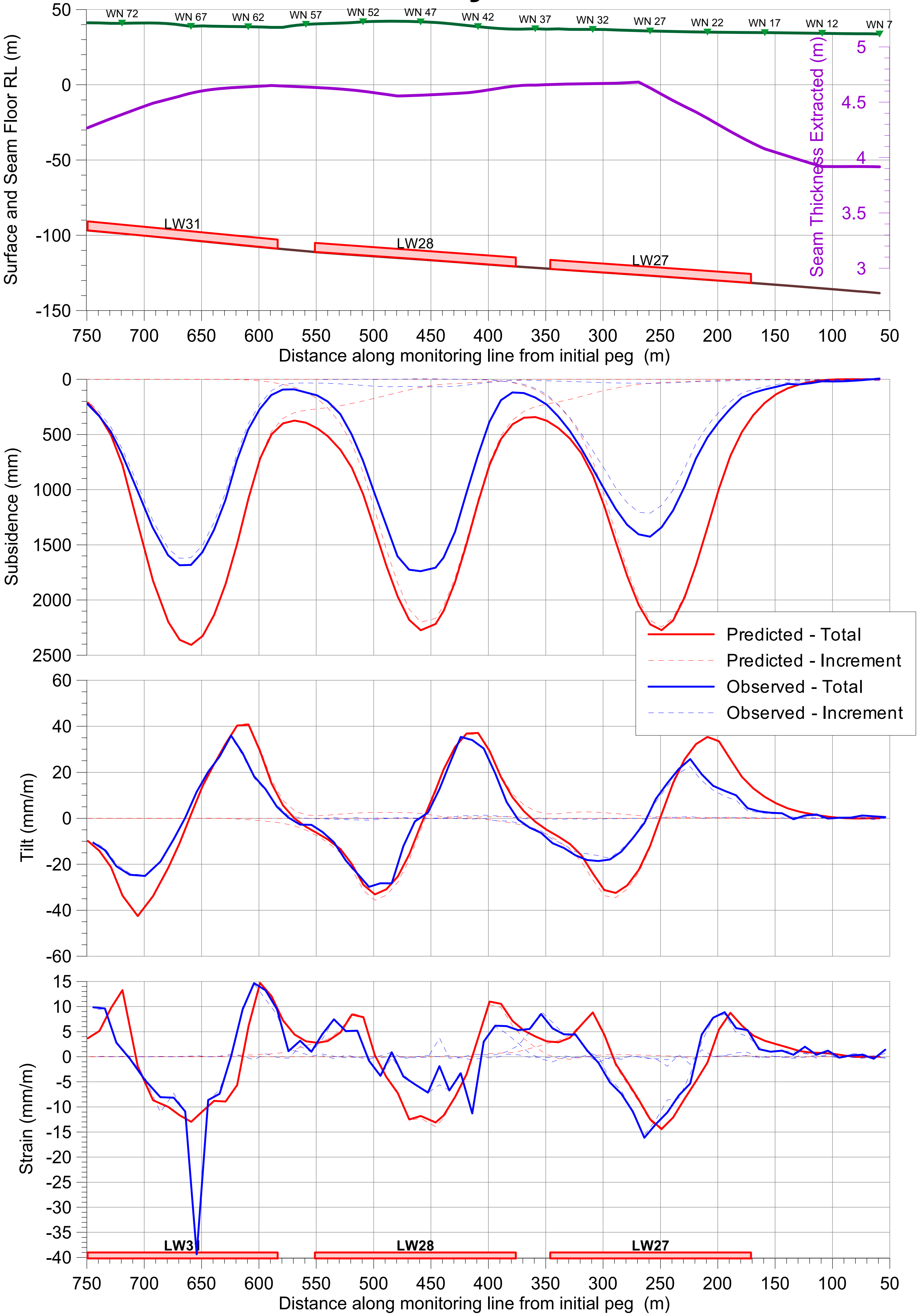

Fig. 4

West Wallsend Colliery LWs 28 to 34 WO Line

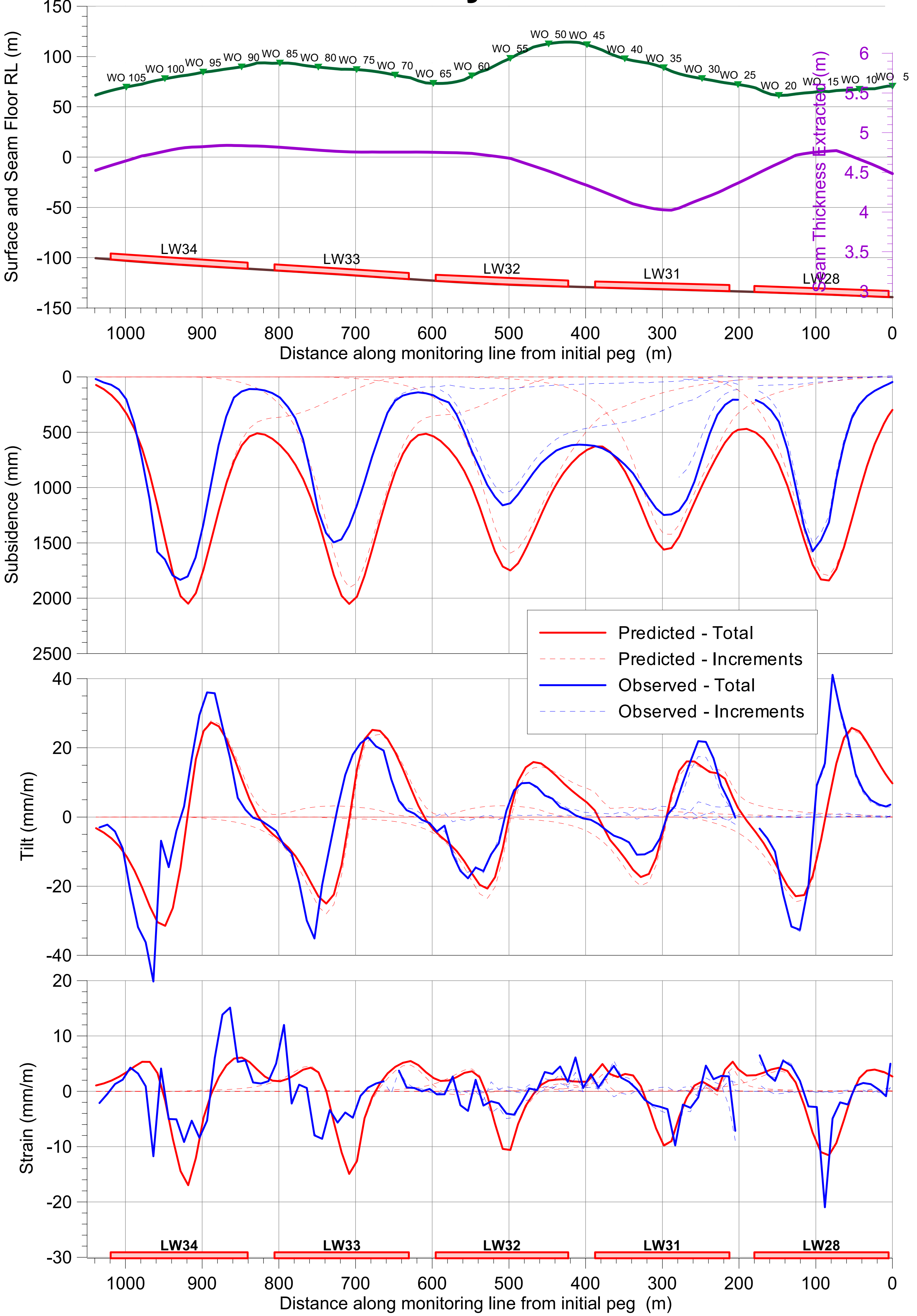

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Fig. 5

West Wallsend Colliery LWs 34 to 36 WP Line

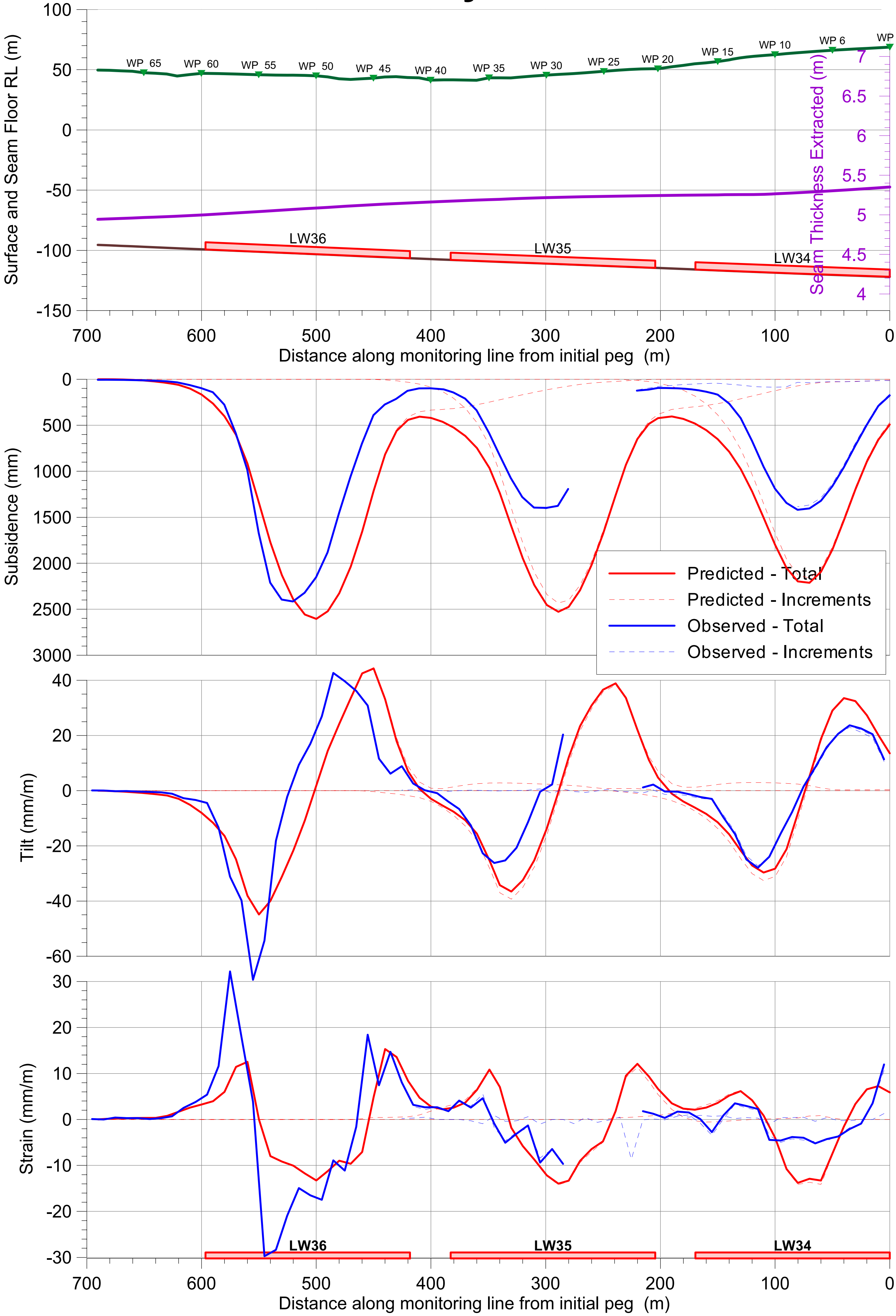

Fig. 6

West Wallsend Colliery LW 28 WC Line

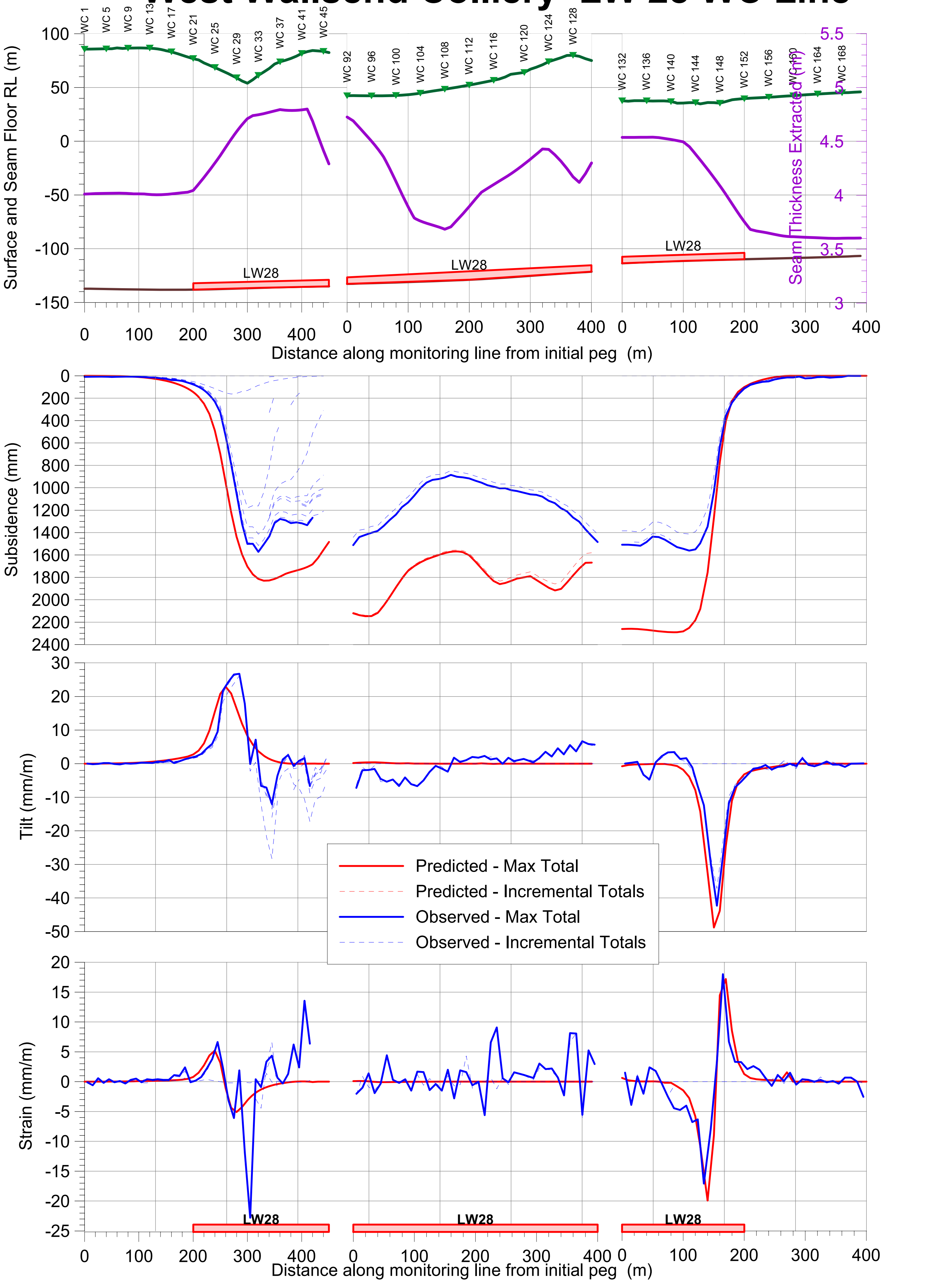

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Fig. 7

West Wallsend Colliery XL5 Prediction Line

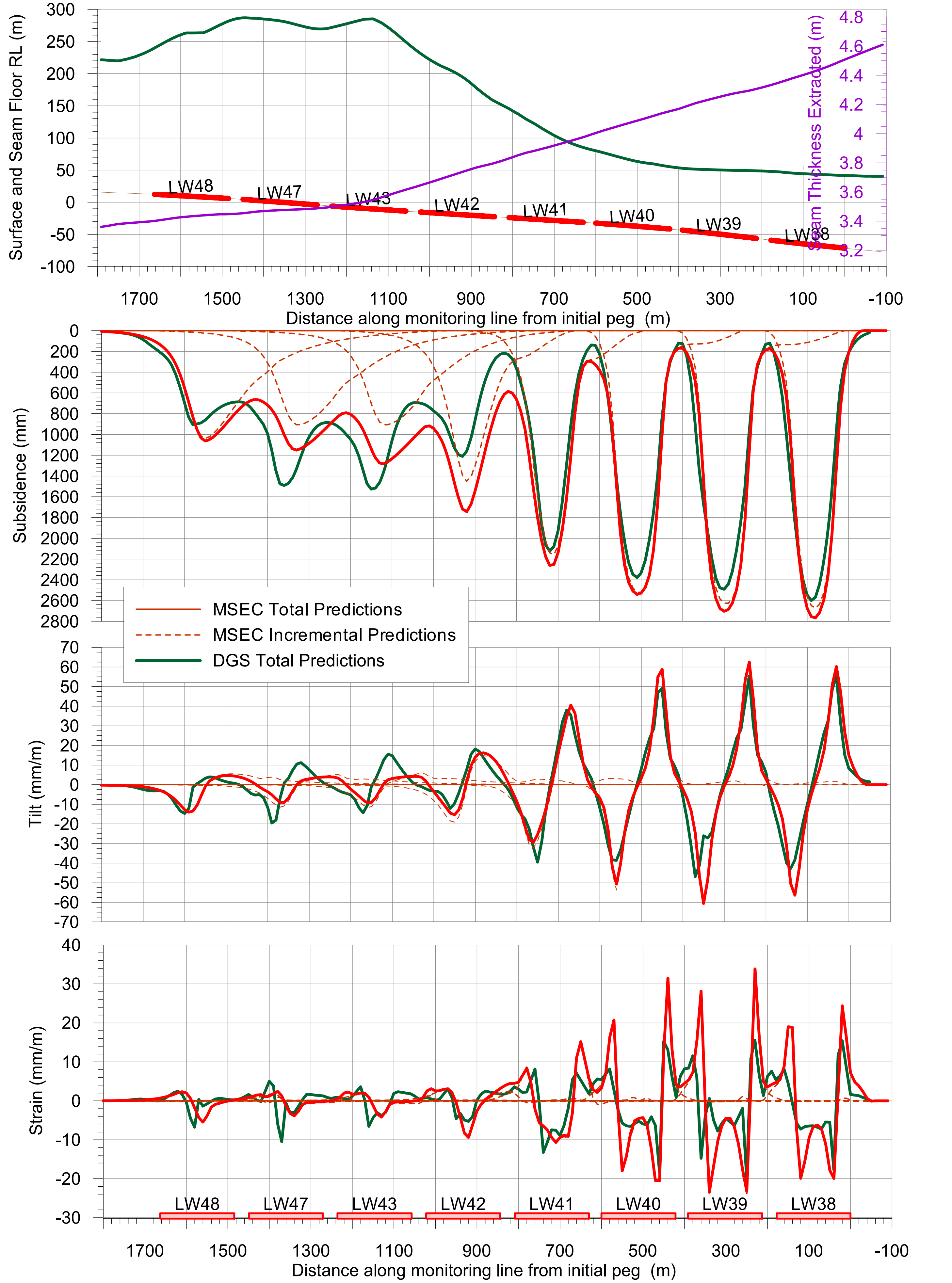

Fig. 8

West Wallsend Colliery XL7 Prediction Line

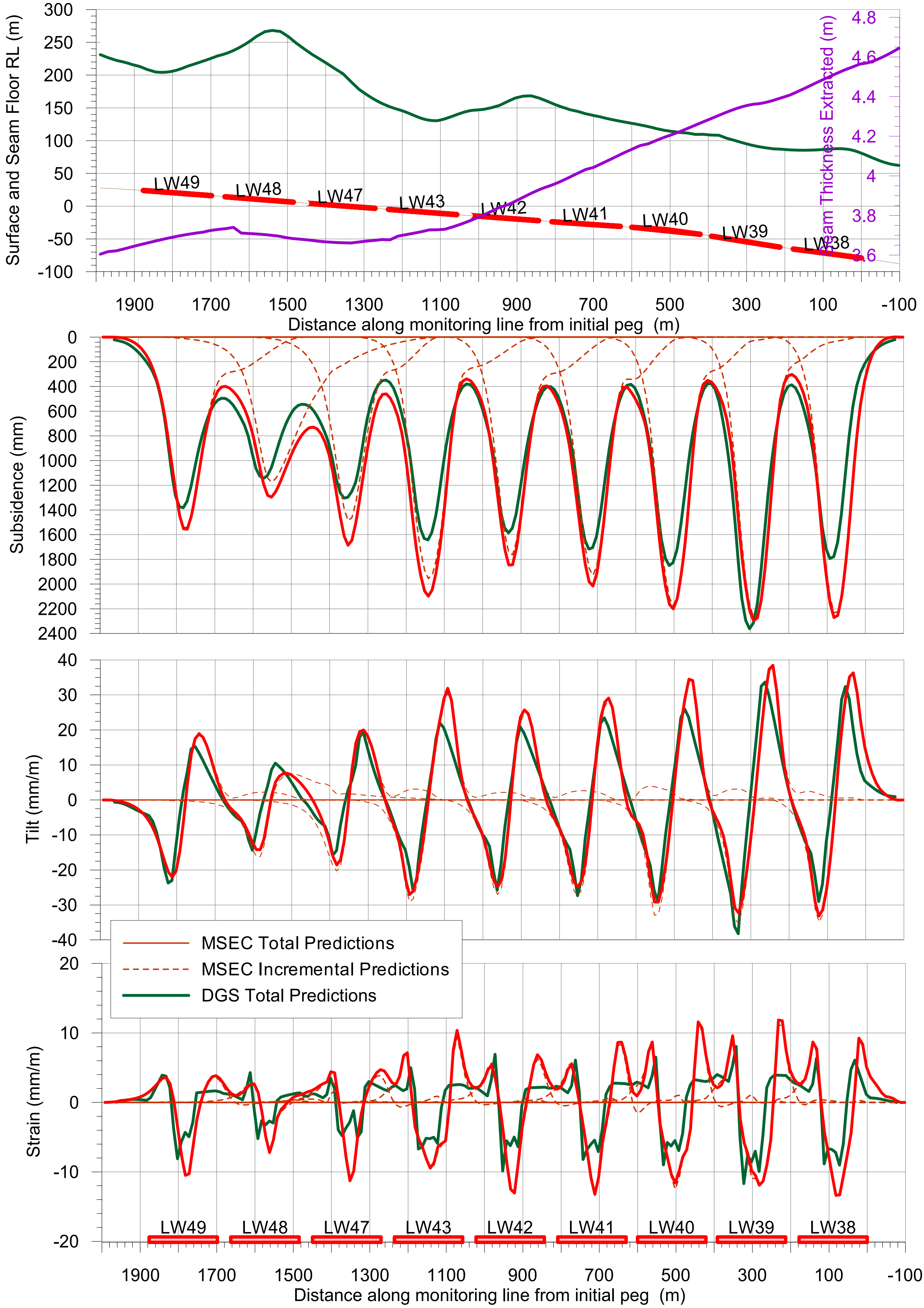

Fig. 9

West Wallsend Colliery XL9 Prediction Line

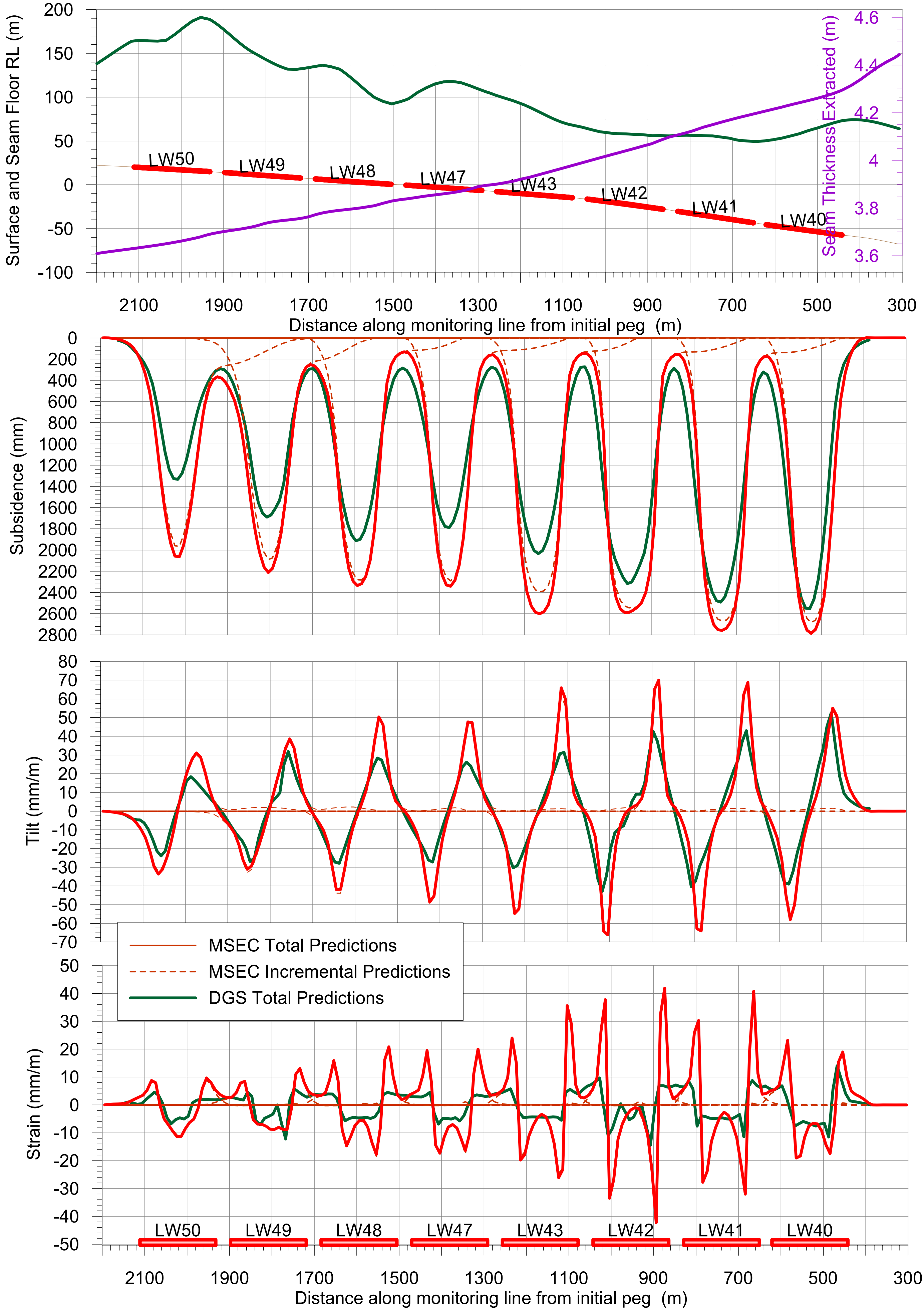

Fig. 10

West Wallsend Colliery XL10 Prediction Line

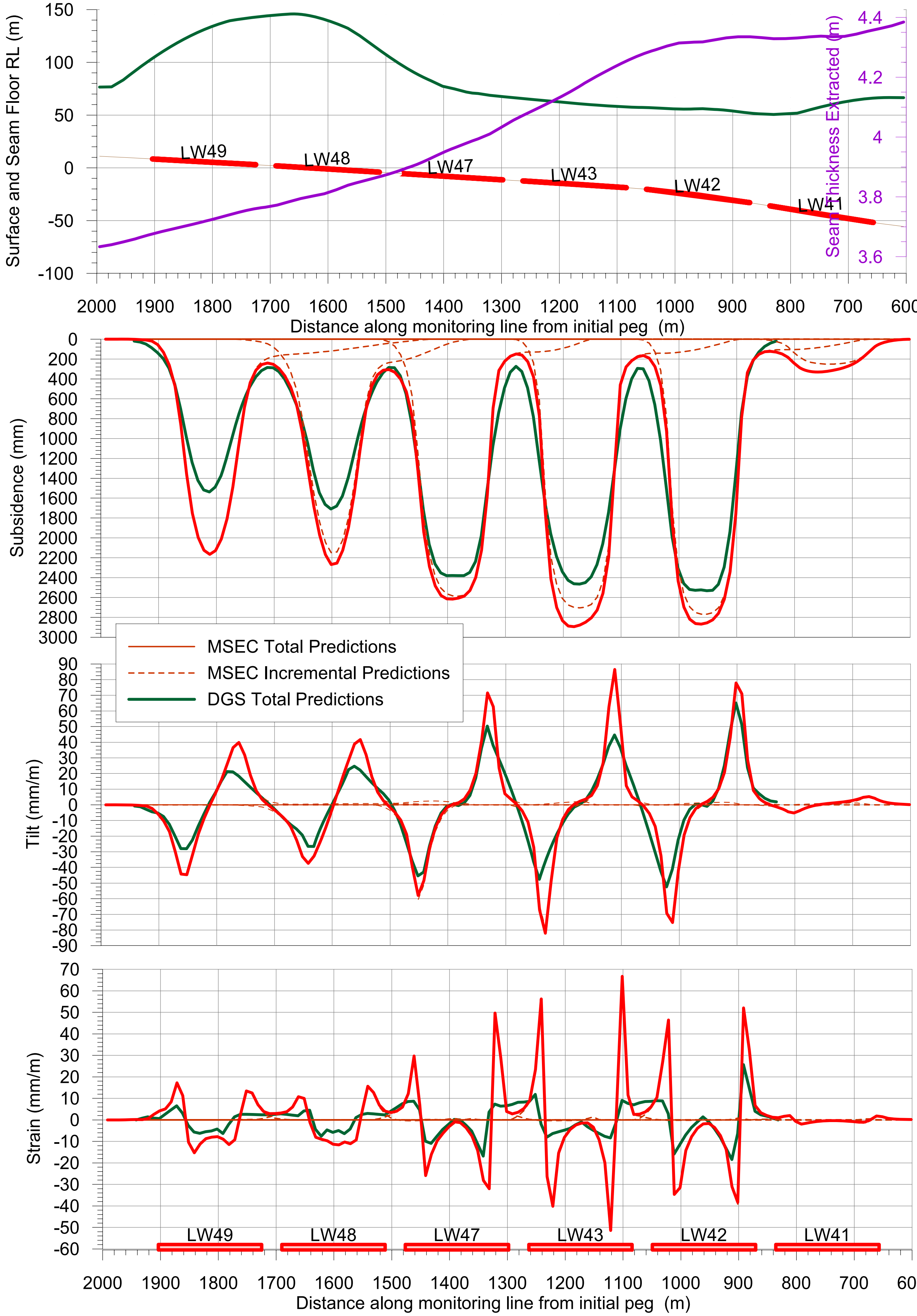

Fig. 11

West Wallsend Colliery XL11 Prediction Line

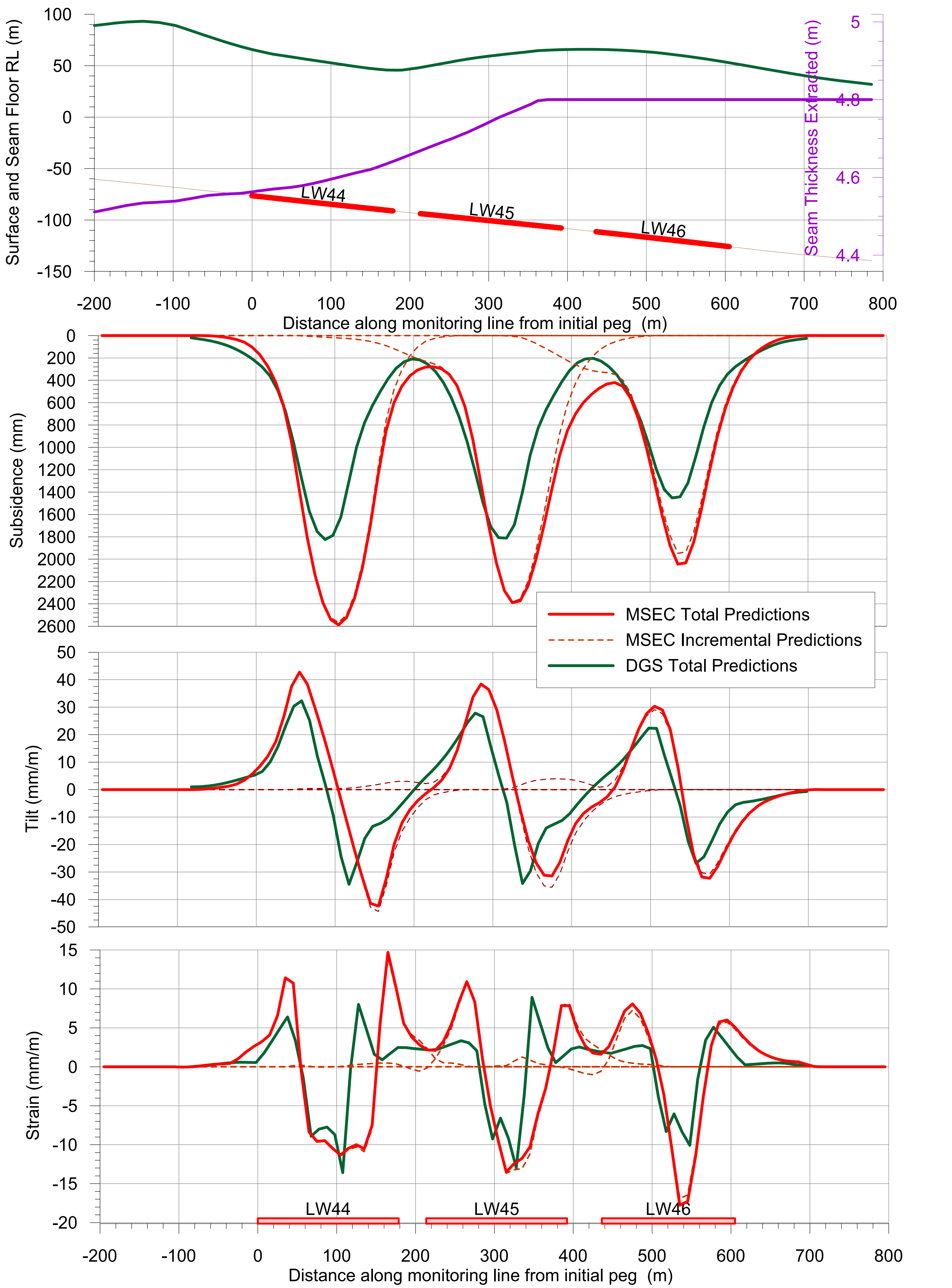

Fig. 12